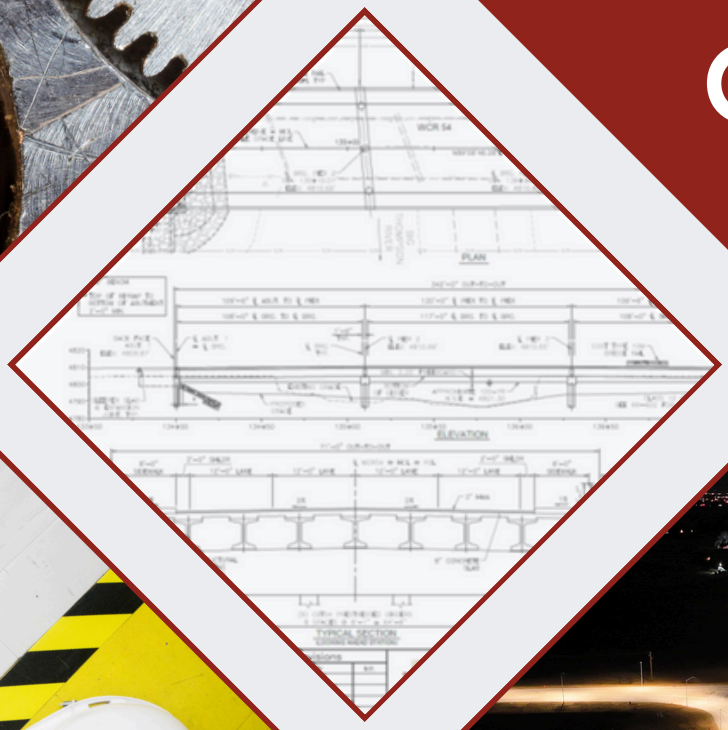

WELD COUNTY ENGINEERING AND CONSTRUCTION CRITERIA

MARCH 2024

APPENDIX 8-Q WELD COUNTY ENGINEERING & CONSTRUCTION CRITERIA

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CHAPTER 1 GENERAL PROVISIONS

1.1 TITLE

This manual is called the Weld County Engineering & Construction Criteria and will be referred to throughout the text as the WCECC.

1.2 PURPOSE AND BACKGROUND

Communities and counties often provide engineering criteria for the repair and construction of infrastructure, outlining specific "must build" requirements. In Weld County, Colorado, which covers 4,000 square miles, the range of soil types and site conditions is so varied that it is not practical or advisable to develop specific requirements. In Weld County, one size does not fit all.

However, recognizing the need in the engineering community for basic information about the County's criteria for acceptable infrastructure, the County has developed this document. It outlines design and material options and guidelines for the design, construction, location, improvement, and maintenance of infrastructure in Weld County.

The criteria outlined in this manual are intended to provide the designer with guidance to facilitate the development of infrastructure that is well suited to County needs and is safe, efficient, and economical. Some cases may arise where conformance to these criteria will be exceptionally difficult. In such cases, requests for variance to these criteria will be considered on a case-by-case basis. The overriding requirement is that all improvements must be designed and constructed with professional integrity and quality at the forefront. Additionally, designs will consider sustainability (reuse of existing materials where practical) and long-term total cost of ownership through life-cycle cost analysis.

1.3 APPLICABILITY

The WCECC applies to all lot dividers, developers, landowners, and owners of facilities adjacent to or located in the County's rights of way or easements—and to the employees, agents, or contractors of these entities—when they design, construct, and maintain facilities or conduct other activities subject to review and approval under the provisions of the Weld County Code. The WCECC also applies to the County and its employees, agents, and contractors.

1.4 REFERENCE DOCUMENTS

The WCECC hereby adopts the latest versions of the following documents by reference. However, some of these references represent nationwide and statewide standards, respectively, which do not always satisfy County conditions. When standards differ, the instructions and guidance in this manual will govern.

- American Association of State Highway and Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets*
- AASHTO *Guide for Design of Pavement Structures*
- AASHTO *Roadside Design Guide*
- AASHTO *Standard Specifications for Transportation Materials and Methods of Sampling and Testing*
- AASHTO *Standard Specifications for Highway Bridges*

- AASHTO *Load & Resistance Factor Design (LRFD) Bridge Design Specifications*
- AASHTO *LRFD Bridge Construction Specifications*
- American Society for Testing and Materials (ASTM) *Annual Book of ASTM Standards*
- Colorado Department of Transportation (CDOT) *Access Control Plans*
- CDOT *Bridge Design Manual*
- CDOT *Construction Manual*
- CDOT *Drainage Design Manual*
- CDOT *Field Materials Manual*
- CDOT *M&S Standard Plans*
- CDOT *M-E Pavement Design Manual*
- CDOT *Roadway Design Guide*
- CDOT *State Highway Access Code*
- CDOT *Standard Specifications for Road and Bridge Construction with Weld County Special Revisions (aka Weld County Department of Public Works Conformed Standard Special Revisions to CDOT's Standard Specifications for Road and Bridge Construction)*
- CDOT *Survey Manual*
- Colorado Revised Statutes
- Relevant Federal Emergency Management Agency (FEMA) documents
- Federal Highway Administration (FHWA) *Manual on Uniform Traffic Control Devices (MUTCD)*
- FHWA *Roundabouts: An Informational Guide (NCHRP Report 672)*
- FHWA *Railroad/Highway Crossing Grade Handbook*
- FHWA *Real Estate Acquisition Guide for Local Public Agencies ("The Uniform Act")*
- Institute of Transportation Engineers (ITE) *Trip Generation Manual*
- Mile High Flood District (MHFD) *Urban Storm Drainage Criteria Manual (USDCM)*
    - MHFD is formerly Urban Drainage and Flood Control District (UDFCD)
- Transportation Research Board (TRB) *Highway Capacity Manual*
- Weld County Code
- Weld County Transportation Plan

1.5 INTERPRETATION

This manual presents the basic criteria that must be met to ensure that infrastructure facilities are safe, efficient, economical, and appropriate for use in the County. Where minimum values are stated, greater values for safety, durability, or functional limits are encouraged whenever practical and consistent with federal, state, and local requirements. Situations might arise where the application of individual criteria from the WCECC will not ensure the protection of public health, safety, and welfare. Accordingly, Weld County may choose not to accept the infrastructure for taxpayer-funded maintenance; may impose additional or more stringent criteria than those contained in the WCECC; or may require the modification of plans, specifications, or operations to protect public health, safety, and welfare.

1.6 ROAD ACCEPTANCE

Acceptance of a road for maintenance by the County is at the discretion of the Board of County Commissioners (BOCC) and requires passage of a resolution. The Weld County Road Acceptance Policy requirements are available in Section 8-6-150 of the Weld County Code.

1.7 IMPROVEMENTS AGREEMENTS

Subdivisions, Planned Unit Developments, Final Plats, Uses by Special Review (USR) and Access Permits may require the developer to sign an improvements agreement with the County and provide collateral to guarantee the improvements are completed as required for one or all the following reasons:

- Off-site public improvements
- Road Maintenance Agreement
- Construction Maintenance Agreement
- Access Improvements Agreement
- On-site improvements for subdivisions/PUDs

More information can be found in Chapter 8, Article II, of the Weld County Code.

An Improvements and Road Maintenance Agreement will detail the approved haul route(s), outline when offsite improvements will be triggered, and include a maintenance agreement for the haul routes. Possible mitigations included in the road maintenance agreement may include, but are not limited to, dust control, specified haul routes, damage repairs, and future improvement triggers. An example agreement is available at:

https://www.weld.gov/files/sharedassets/public/v/1/departments/public-works/documents/usr-spr-permits-improvements-agreement-template.pdf

Weld County uses the Equivalent Single Axle Load (ESAL) methodology when calculating an Improvements Agreement proportional share. The ESAL methodology is a national standard for normalizing traffic counts to reflect the actual damage caused by large vehicles. The ESAL method data is as follows:

*Add factors & equation.

CHAPTER 2 ROAD CLASSIFICATIONS AND TYPICAL SECTIONS

2.1 ROAD CLASSIFICATION SYSTEM

The County classifies roadways based on their function and whether they are urban or rural. These two classifications help designers determine the appropriate design characteristics for the road, including cross section and geometric standards. The functional classifications and urban/rural classification consider anticipated traffic volume and access requirements on a road and determine the minimum right-of-way required. Together, these classifications help determine the minimum level of service (LOS). They are a rational, cost-effective basis for the selection of geometric criteria within the range of values available to the designer.

The BOCC adopts a Road Classification Map by ordinance and reviews it every two years. Changes made between the two-year reviews typically are based on development reviews and are made on a case-by-case basis via a public hearing process. The current Weld County Functional Classification Map can be found on the Public Works Department's Transportation Planning web page. In addition, the Weld County Transportation Plan includes recommendations for when to modify road classifications.

2.1.1 Functional Classifications

Function is determined based on the degree to which a roadway provides access and allows mobility. Roadways provide access when they allow travelers to easily reach most of the destinations within a given area. Roadways provide mobility when they allow travelers to easily go longer distances.

The classification of Weld County roads is comprised of a hierarchy of roadways whose functional classifications are defined by their usage. The relative degree to which a road serves these functions defines its functional classification. Roads in Weld County are classified as Arterial, Collector, Local, or Private Roads. The functional classifications of roadways used by Weld County are described below.

2.1.1.1 Arterials

A county highway refers to a highway defined in House Bill 16-1155. In Weld County a county highway is a four-lane controlled-access arterial road intersecting with an interstate highway, United States numbered highway, or State Highway. Roads that were annexed before the County's designation of the road as a county highway also may be included by intergovernmental agreement (IGA) with the municipality. Weld County has designated Weld County Road 49 (WCR 49) between Interstate 76 (I-76) and U.S. Highway 34 (US 34) Weld County Parkway, and Weld County Road 47 (WCR 47) from the Parkway to State Highway 392 (SH 392) as county highways. See the Weld County Functional Classification Map, available on the County's Transportation Planning webpage. The county highway designation means Weld County will govern all substantive aspects of the road, including access, maintenance, traffic control, speed limits, and overweight limits, even if municipalities later annex the road.

Arterials provide good mobility, carrying significant traffic volumes at high speeds for long distances. They are seldom spaced at closer than one-mile intervals and serve to connect larger communities. The primary difference between interstate highways and arterials is access. Interstate highways have fully controlled accesses with no at-grade intersections, while arterials include limited at-grade intersections.

2.1.1.2 Collectors

Collectors link local roads with the arterial road system and connect smaller communities. Both mobility and access are of equal importance on these roadways. Travel speeds and volumes are moderate, and distances traveled are short to medium. Traffic on collector roads typically has an origin or destination within the nearby area. Weld County has both paved and unpaved collector roads.

2.1.1.3 Local Roads

Local roads primarily provide access to adjacent land in rural and urban areas. Local roads are closely spaced and carry relatively lower traffic volumes for short distances. They generally are internal to—or serve an access function for—a residence, farm, single neighborhood, or development. Generally, they should lead traffic to a collector road.

2.1.1.4 Privately Maintained Roads

Weld County may review privately maintained roads that are planned to be used by the public, such as a road within the boundaries of a residential subdivision, but the roads will be maintained by a homeowner's association (HOA) or other private entity.

2.1.2 Primary vs Secondary Classifications

In addition to classifying roads by function, Weld County classifies roads as Primary or Secondary per (C.R.S.) § 43-2-101.

Primary roads usually serve more developed areas and diverse uses (e.g., bicyclists, pedestrians, on-street parking, etc.). Primary roads usually are paved, with curbs, gutters, and sidewalks. Often, they connect to an existing stormwater drainage system rather than making use of roadside ditches (which are found commonly beside rural roads).

Secondary roads primarily serve less developed areas and lower volumes of vehicular traffic. Most of the roads in Weld County are classified as secondary. However, roads that are in municipal Urban Growth Boundaries may be classified as urban/primary.

2.2 RIGHT-OF-WAY WIDTHS

The minimum right-of-way widths are as follows, unless otherwise approved by the BOCC:

Arterial	140 feet
Collector	80 feet
Local	60 feet

2.3 RIGHT-OF-WAY USE PERMIT

Permits are required when working within the County road right-of-way. More information can be found in Section 11.2 of this document. See also Weld County Code, Chapter 8, Article XIII, Sec. 8-13-10, et seq.

It is not the intent to allow new private irrigation systems to be located within County road right-of-way.

2.4 RIGHT-OF-WAY DETERMINATION

On October 12, 1889, the BOCC declared all section and township lines on the public domain of the United States in Weld County to be public highways with the intent of constructing roadways on these

lines. With this order and for this purpose, the BOCC also established 30 feet of road right-of-way on each side of the section or township line (a total of 60 feet). Sections not included in the public domain are railroad sections, school sections (usually 16 and 36), and sections patented prior to October 12, 1889. Not all County roads are a result of the 1889 Resolution. Many Weld County rights of way have been conveyed by landowners through road petitions and dedications, as well as Weld County acquisitions working with landowners.

Due to topography, cost, and other factors, not every county road is situated within the 60-foot road right-of-way and/or centered on the section line. In some places, additional right-of-way has been acquired or reserved. The right-of-way section of the Public Works web page discusses this in more detail. The County recommends that designers review this information and also do their own research into right of way in the areas of their projects.

The Weld County right-of-way road files are located in the office of the Clerk to the Board at 1150 O Street in Greeley, Colorado. Please call (970) 400-4225 to set up a time to come in.

2.5 RIGHT-OF-WAY ACQUISITIONS

Acquisition of road right-of-way will substantially follow the Real Estate Acquisition Guide for Local Public Agencies published by the FHWA, the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, 42 United States Code (U.S.C.) Ch. 61 (the "Uniform Act"), and Title 38 of the Colorado Revised Statutes (CRS).

2.6 TYPICAL CROSS-SECTIONS

While it is important to try to preserve the ultimate road right-of-way, funding availability does not always allow for construction of the ultimate section and, in such cases, an interim section should be constructed until funding becomes available.

The Public Works Department determines whether a road is designed to the interim or ultimate (or combinations thereof) road cross section. This determination is based on funding, existing and projected traffic volumes, connectivity, continuity, mobility, and capacity. If only a portion of the ultimate cross section is being constructed, the interim design will need to allow for eventual widening of the road to the ultimate cross section. The interim design should ensure that the first phase of the roadway will not need to be removed to complete the full cross section. Storm drainage designs and floodplain analysis will be considered and be constructed to accommodate the ultimate section, unless written approval is obtained from the Public Works Department.

All designs should consider how the roadway is used, long-term traffic predictions, location and density of nearby development, and topographical characteristics. A roadway constructed to the ultimate cross section still may require more right-of-way and roadway width in the future for additional lanes, pedestrian or bicycle facilities, landscaping, utilities, or construction requirements, such as cut or fill slopes. Designers should try to anticipate such needs. Other chapters within this manual will discuss design considerations in more detail.

Table 2-1 (Rural Conditions) and Table 2-2 (Urban Conditions) summarize some of the features incorporated into the typical cross section drawings for the different road classifications. Figure 2-1 through Figure 2-8 present examples of typical cross section drawings for interim and ultimate roadway types found in the County. Note that the tables and typical sections in this manual usually reflect minimum requirements. The Public Works Department may impose additional requirements on a case-by-case basis.

Table 2-1 Typical Cross Sections Summary (Rural)

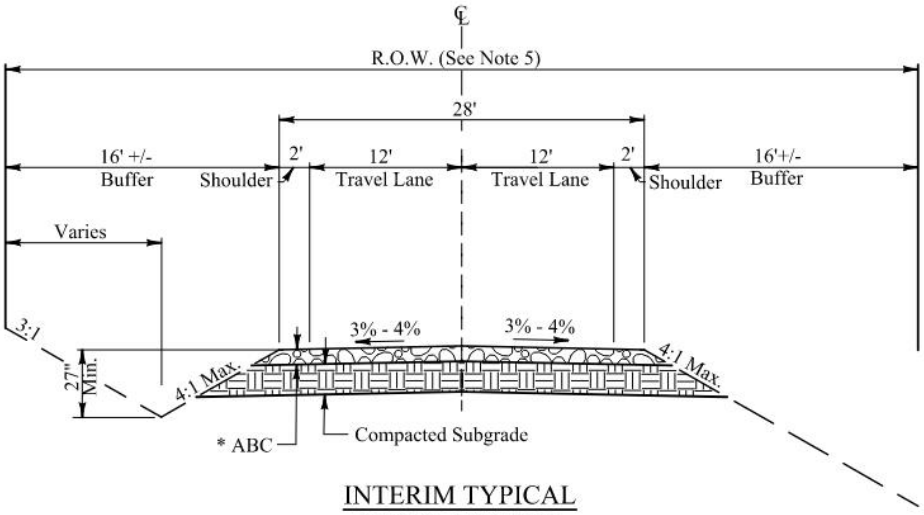
Roadway Classification	Right-of-Way Width (min.)	Road Surface	Number of Travel Lanes (min.)	Travel Lane Width (min.)	Shoulder Width (min.)/Type	Median Width (min.)/Type	Drainage Type	Sidewalk Width (min.)
RURAL ROADS (INTERIM)								
Arterial	140 ft	Paved	2	12 ft	6 ft Paved 2 ft Gravel	N/A	Roadside Ditch	N/A
Collector	80 ft	Paved	2	12 ft	4 ft Paved 2 ft Gravel	N/A	Roadside Ditch	N/A
Collector (Unpaved)	80 ft	Gravel	2	12 ft	2 ft Gravel	N/A	Roadside Ditch	N/A
Local (Unpaved)	60 ft	Gravel	2	12 ft	2 ft Gravel	N/A	Roadside Ditch	N/A
RURAL ROADS (ULTIMATE)								
County Highway	140 ft	Paved	4	12 ft	8 ft Paved 2 ft Gravel	16 ft Paved	Roadside Ditch	N/A
Arterial	140 ft	Paved	4	12 ft	8 ft Paved 2 ft Gravel	0 ft to 28 ft Paved or Unpaved Separation	Roadside/Median Ditch or Storm Sewer	N/A
Collector	80 ft	Paved	2	12 ft	6 ft Paved 2 ft Gravel	0 ft to 16 ft Paved	Roadside Ditch	N/A
Local	60 ft	Paved	2	12 ft	1 ft Paved 1 ft Gravel	N/A	Roadside Ditch	N/A
Non-maintained Local - Residential	30 ft	Unpaved RAP	2	10 ft	2 – 5 ft Gravel	N/A	Roadside/Utility Ditch Culverts need to be located outside of ROW on landowner property	N/A
Non-maintained Local – Residential	30 ft	Unpaved Gravel	2	13 ft	2-2 ft Gravel	N/A	Ditch swale Culverts need to be located outside of ROW on landowner property	N/A

Table 2-2 Typical Cross Sections Summary (Urban)

Roadway Classification	Right-of-Way Width (min.)	Road Surface	Number of Travel Lanes (min.)	Travel Lane Width (min.)	Shoulder Width (min.)/Type	Median Width (min.)/Type	Drainage Type	Sidewalk Width (min.)
URBAN ROADS (INTERIM)								
Arterial	140 ft	Paved	2	12 ft	6 ft Paved 2 ft Gravel	N/A	Roadside Ditch or Storm Sewer	N/A
Collector	80 ft	Paved	2	12 ft	5 ft Paved 1 ft Gravel	N/A	Roadside Ditch	N/A
Local	60 ft	Paved	2	12 ft	1 ft Paved 1 ft Gravel	N/A	Roadside Ditch	N/A
URBAN ROADS (ULTIMATE)								
Arterial	140 ft	Paved	4	12 ft	16 ft Paved*	16 ft to 28 ft Paved or Raised Median	Curb & Gutter and Storm Sewer	10 ft
Collector	80 ft	Paved	2	12 ft	8 ft Paved*	0 ft to 16 ft Paved	Curb & Gutter and Storm Sewer	5 ft
Local	60 ft	Paved	2	12 ft	8 ft Paved*	N/A	Curb & Gutter and Storm Sewer	5 ft

*includes gutter pan width

Figure 2-1 Rural Local and Collector Roads (Unpaved) (Interim)



INTERIM TYPICAL
CROSS SECTION
Typical Gravel Road

Notes:

1. * The allowable class and thickness of Aggregate Base Course (ABC) shall be determined by the guidelines described in the Pavement Design Chapter.
2. The foreslopes and backslopes shall be no steeper than 4:1 with a preference of 6:1 or flatter where it can be accommodated.
3. All sideslopes shall be seeded and mulched.
4. Additional ROW may be required by Public Works to meet site specific requirements.
5. Width of ROW shall be determined by classification of road.
6. Signing per approved plan.

NOT TO SCALE

Computer File Information			WELD COUNTY PUBLIC WORKS DEPARTMENT		INTERIM RURAL LOCAL AND COLLECTOR ROADS	
Creation Date: 02/10/10	Initials: KH					
Last Modification Date: 04/08/16	Initials: ddd					
Full Path: T:\PBSC\Admin\Proposals\Weldc						
Drawing File Name:						
Microstation Ver. XM	Scale: N.T.S.	Units: English	1111 H Street/Post Office Box 758 Greeley, Colorado 80632-0758 Phone: (970) 304-6496 Fax: (970) 304-6497	Approved: Revised: Revised:	Designer: Weld County Detailer: K. Hinnenkamp	FIGURE NO. 1

Figure 2-2 Rural Local (Ultimate)

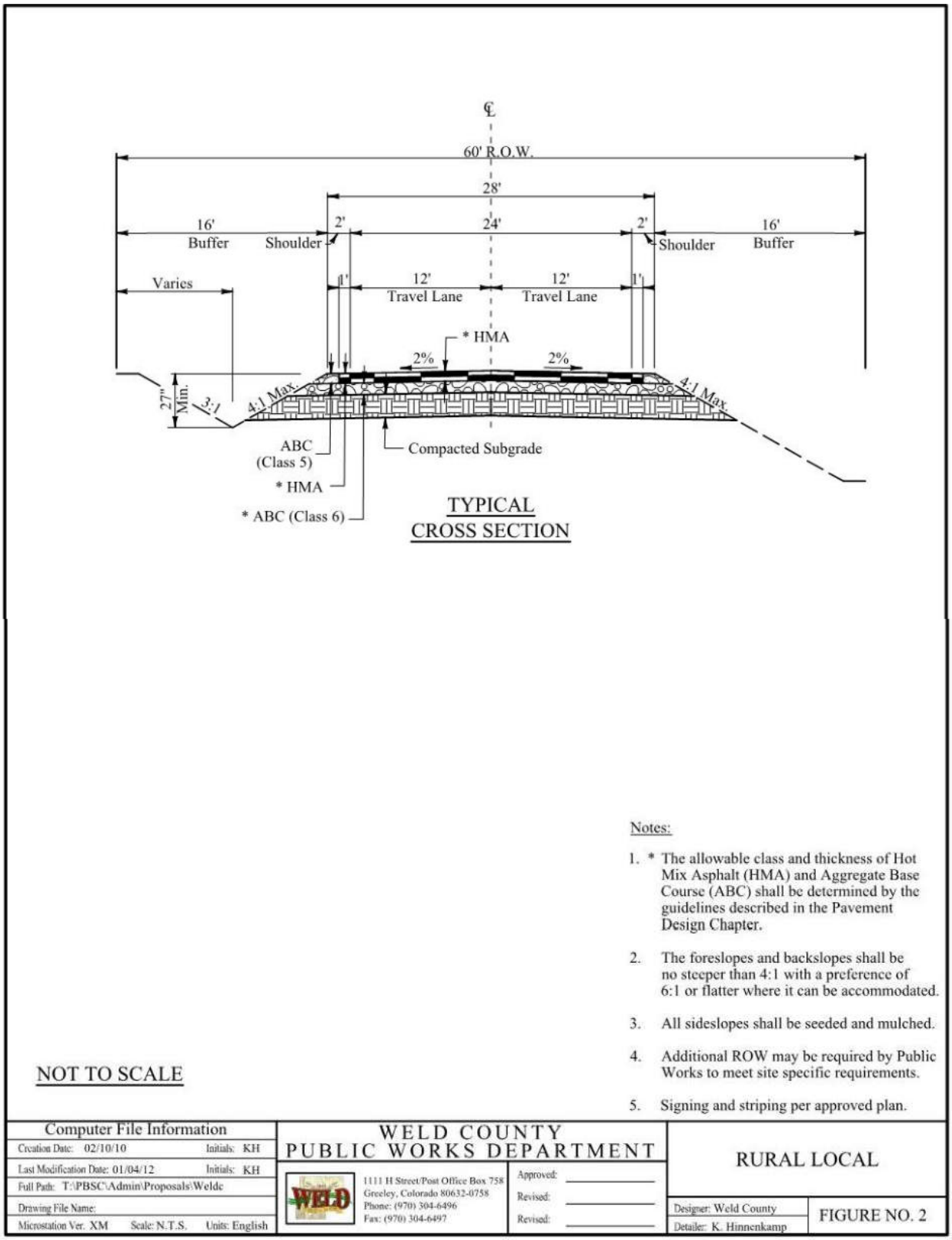
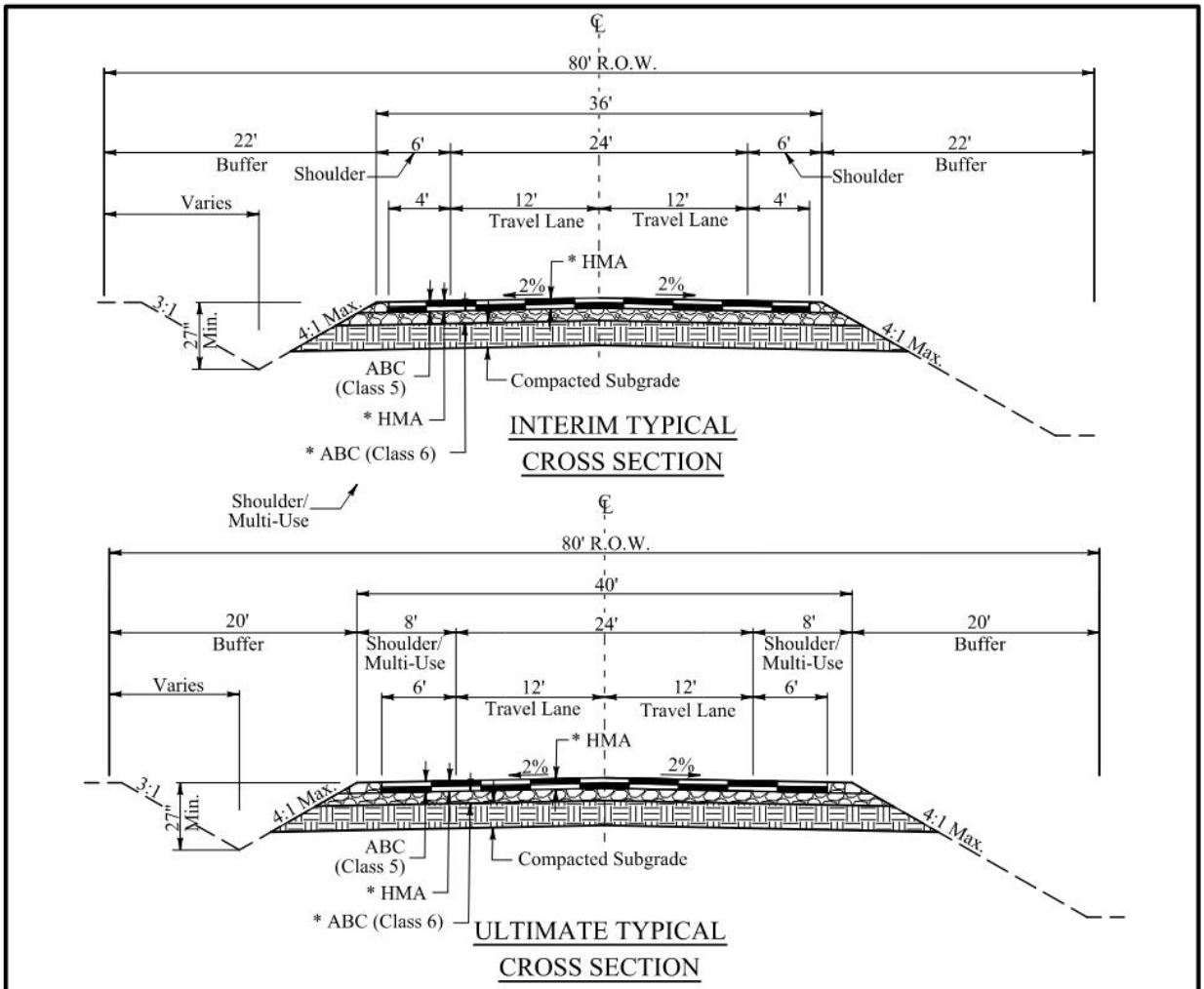


Figure 2-3 Rural Collector (Paved)



Notes:

1. * The allowable class and thickness of Hot Mix Asphalt (HMA) and Aggregate Base Course (ABC) shall be determined by the guidelines described in the Pavement Design Chapter.
2. The foreslopes and backslopes shall be no steeper than 4:1 with a preference of 6:1 or flatter where it can be accommodated.
3. All sideslopes shall be seeded and mulched.
4. Additional ROW may be required by Public Works to meet site specific requirements.
5. Signing and striping per approved plan.

NOT TO SCALE

Computer File Information			WELD COUNTY PUBLIC WORKS DEPARTMENT		RURAL COLLECTOR	
Creation Date: 02/10/10	Initials: KH		1111 H Street/Post Office Box 758 Greeley, Colorado 80632-0758 Phone: (970) 304-6496 Fax: (970) 304-6497	Approved:	Designer: Weld County	FIGURE NO. 3
Last Modification Date: 01/04/12	Initials: KH			Revised:	Detailer: K. Hinnenkamp	
Full Path: T:\PBSC\Admin\Proposals\Weldc				Revised:		
Drawing File Name:						
Microstation Ver. XM	Scale: N.T.S.	Units: English				

Figure 2-4 Rural Arterial

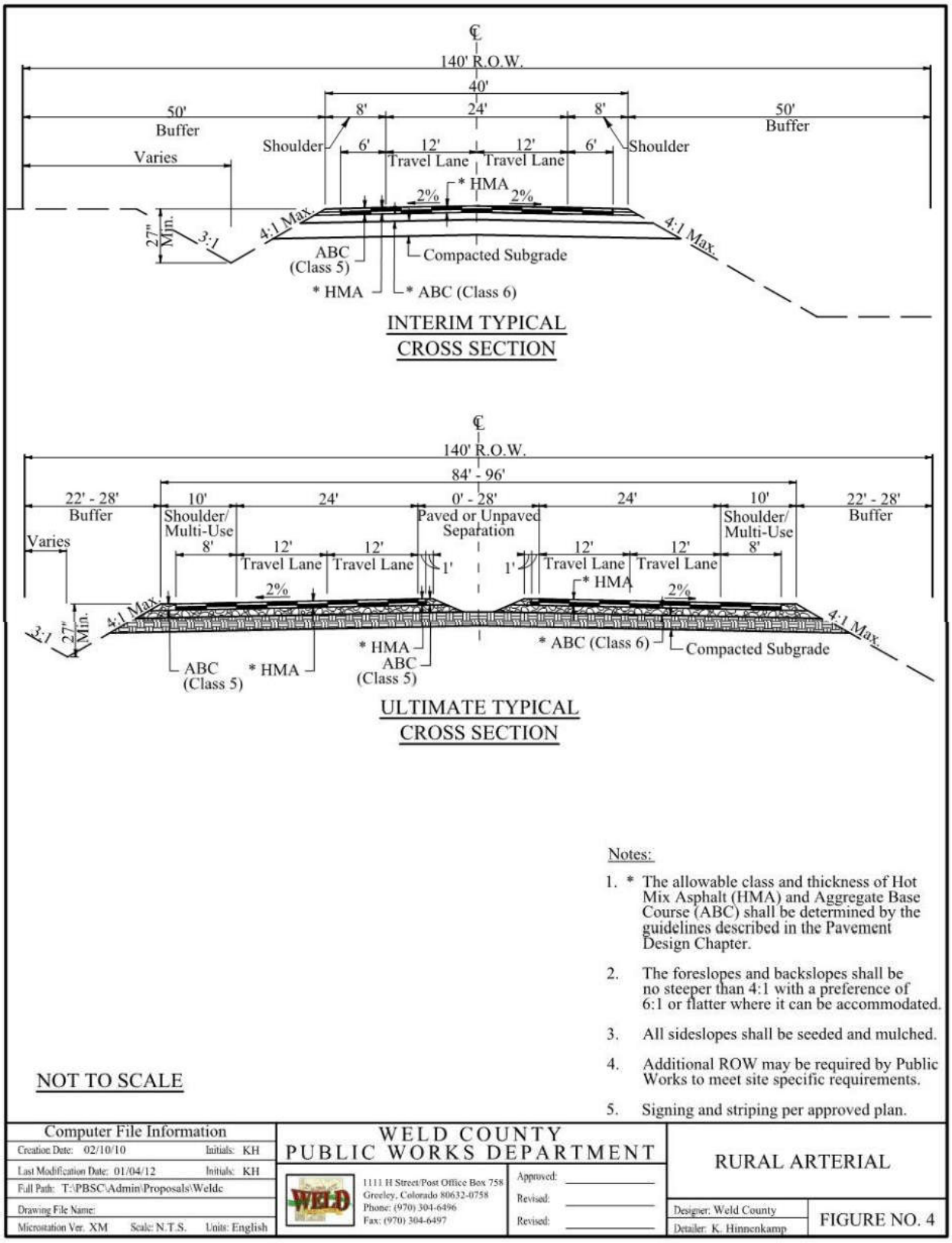


Figure 2-5 County Highway

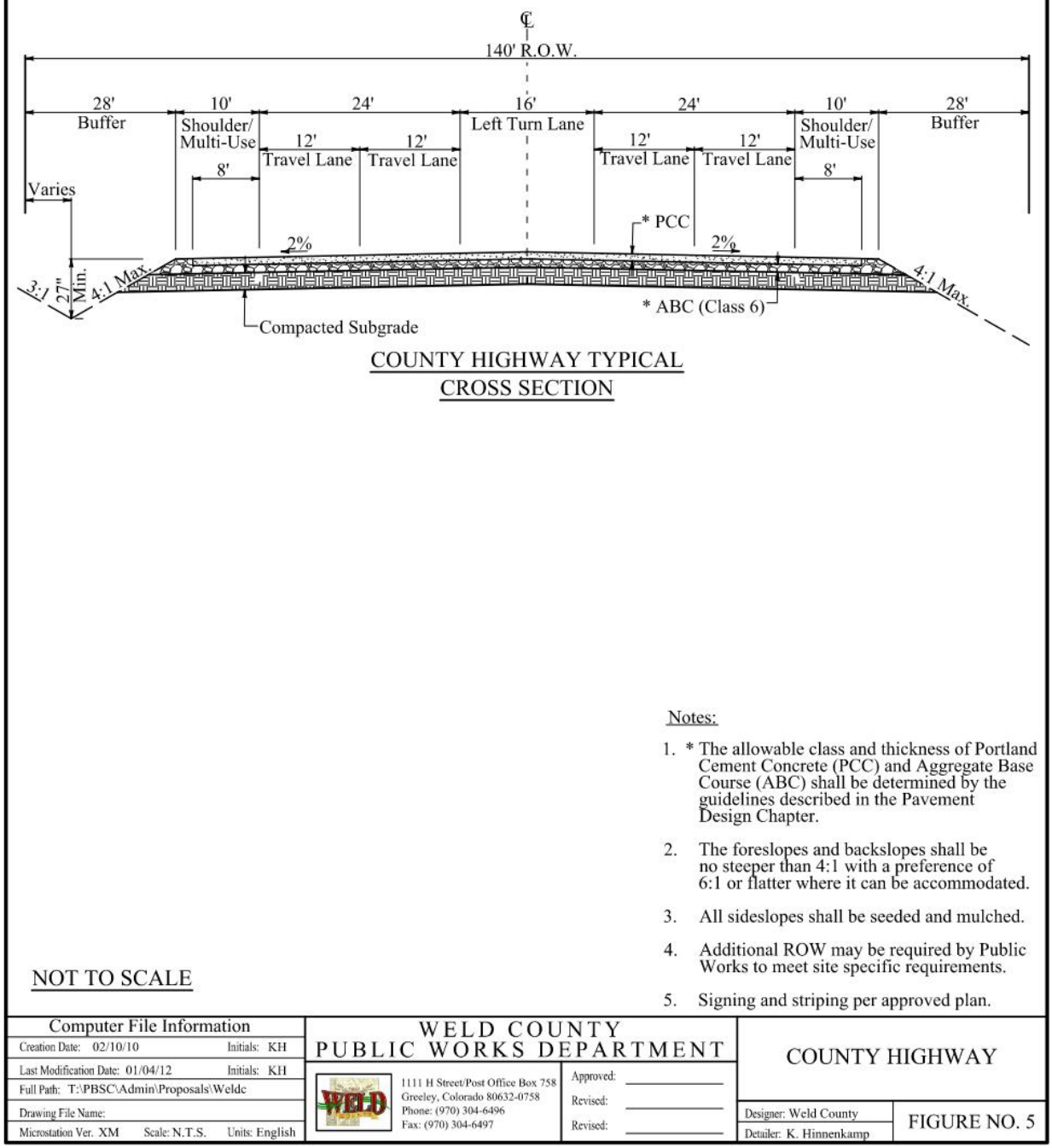


Figure 2-6 Urban Local

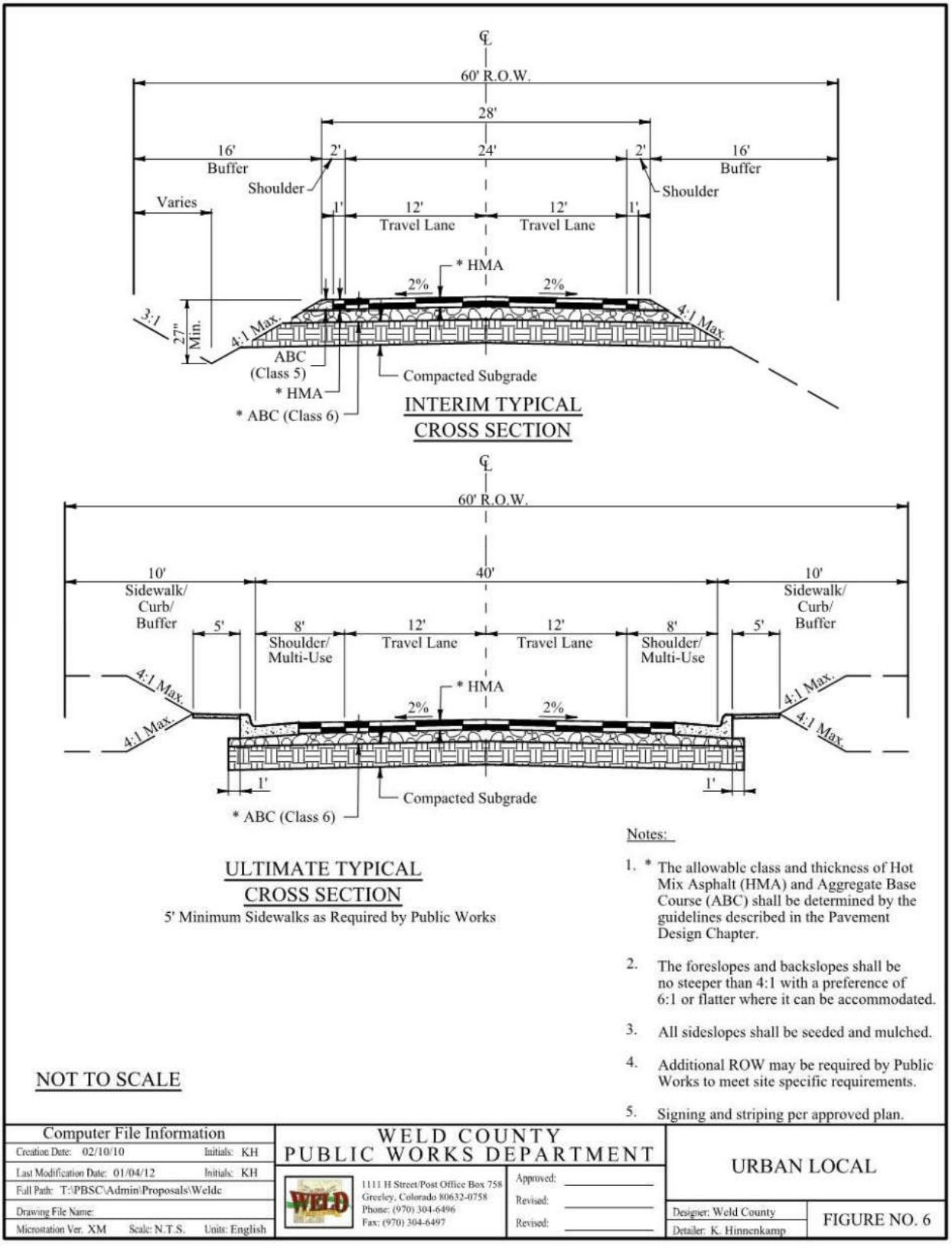
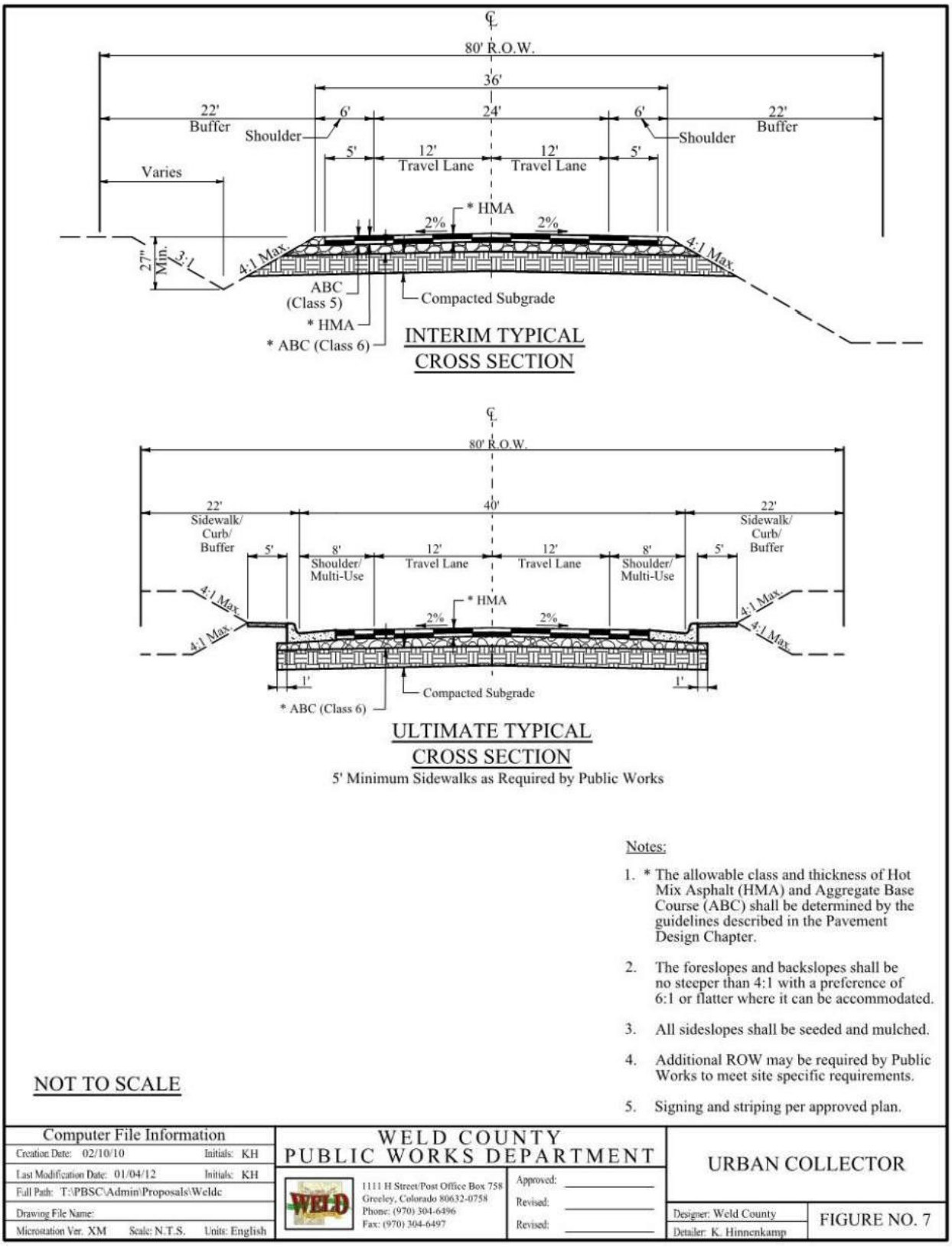


Figure 2-7 Urban Collector



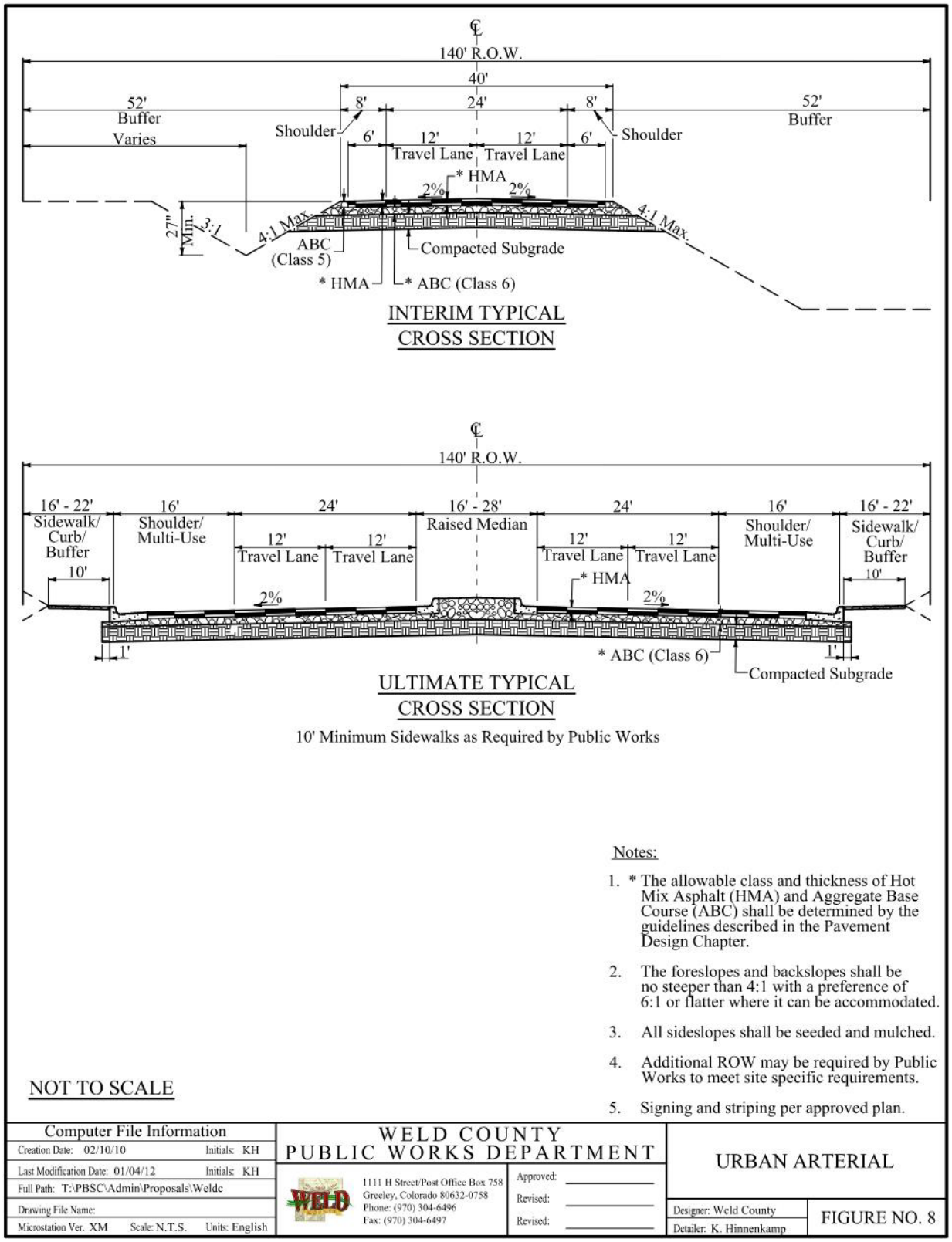
Notes:

1. * The allowable class and thickness of Hot Mix Asphalt (HMA) and Aggregate Base Course (ABC) shall be determined by the guidelines described in the Pavement Design Chapter.
2. The foreslopes and backslopes shall be no steeper than 4:1 with a preference of 6:1 or flatter where it can be accommodated.
3. All sideslopes shall be seeded and mulched.
4. Additional ROW may be required by Public Works to meet site specific requirements.
5. Signing and striping per approved plan.

NOT TO SCALE

Computer File Information			WELD COUNTY PUBLIC WORKS DEPARTMENT		URBAN COLLECTOR	
Creation Date: 02/10/10	Initials: KH		1111 H Street/Post Office Box 758 Greeley, Colorado 80632-0758 Phone: (970) 304-6496 Fax: (970) 304-6497	Approved:	Designer: Weld County	FIGURE NO. 7
Last Modification Date: 01/04/12	Initials: KH			Revised:	Detailer: K. Hinnenkamp	
Full Path: T:\PBSC\Admin\Proposals\Weldc				Revised:		
Drawing File Name:						
Microstation Ver. XM	Scale: N.T.S.	Units: English				

Figure 2-8 Urban Arterial



10' Minimum Sidewalks as Required by Public Works

Notes:

1. * The allowable class and thickness of Hot Mix Asphalt (HMA) and Aggregate Base Course (ABC) shall be determined by the guidelines described in the Pavement Design Chapter.
2. The foreslopes and backslopes shall be no steeper than 4:1 with a preference of 6:1 or flatter where it can be accommodated.
3. All sideslopes shall be seeded and mulched.
4. Additional ROW may be required by Public Works to meet site specific requirements.
5. Signing and striping per approved plan.

NOT TO SCALE

Computer File Information			WELD COUNTY PUBLIC WORKS DEPARTMENT		URBAN ARTERIAL	
Creation Date: 02/10/10	Initials: KH		1111 H Street/Post Office Box 758 Greeley, Colorado 80632-0758 Phone: (970) 304-6496 Fax: (970) 304-6497	Approved:	Designer: Weld County	FIGURE NO. 8
Last Modification Date: 01/04/12	Initials: KH			Revised:	Detailer: K. Hinnenkamp	
Full Path: T:\PBSC\Admin\Proposals\Weldc				Revised:		
Drawing File Name:						
Microstation Ver. XM	Scale: N.T.S.	Units: English				

CHAPTER 3 SURVEYING

3.1 SURVEY DATA - REQUIRE A SURVEY CONTROL SHEET

The required horizontal datum for surveying in Weld County is North American Datum of 1983, NAD-83. The required vertical datum is North American Vertical Datum of 1988, NAVD-88.

3.2 STATE PLANE

It is required that survey control be tied into a National Geodetic Survey (NGS) monument for state plane conversion. Please refer to the NGS website for monument information and location.

3.3 MONUMENT BOXES

Monument boxes are available at no charge for surveyors with valid permits who are upgrading aliquot corners on paved Weld County Roads or placing monumentation for aliquot corners on new paved Weld County Roads. Please contact Public Works in advance at (970) 400-3750.

3.4 ROAD SAFETY

Appropriate traffic control devices and safety equipment are required when surveying within the County right-of-way.

For the safety of the traveling public, monument box covers must be replaced, or the holes created must be backfilled. To minimize damage to the asphalt, concrete collars will be required around newly installed monument boxes.

CHAPTER 4 ROADWAY DESIGN CRITERIA

4.1 GENERAL

4.1.1 Policy on the Use of Referenced Publications

This chapter summarizes and/or supplements standards that have been prepared by AASHTO. The County expects and recommends that transportation designers reference the most recent edition of AASHTO's *A Policy on Geometric Design of Highways and Streets* as a primary guide when designing roadways in the County. Designers also are expected to reference CDOT design manuals. However, AASHTO and CDOT policies represent nationwide and statewide standards, respectively, which do not always satisfy County conditions. When standards differ, the instructions and guidance in this manual will govern.

For the design of auxiliary turn lanes, please see Chapter 8 of this document. All traffic control devices and road striping will be in accordance with the latest version of the MUTCD or as shown in the latest version of CDOT's *M&S Standard Plans*.

4.1.2 Typical Plan Set Guidelines

Typical plan sets should include enough detail and documentation to allow successful construction of the proposed transportation improvements. Plan sets found to be incomplete, or of insufficient quality to be easily readable by the reviewer(s), will be rejected by the Public Works Department. Plan sets will be produced on 11-inch x 17-inch paper and may be submitted electronically. All plan sets will be prepared by or under the direct supervision of a Professional Engineer licensed in the state of Colorado. Each sheet will be stamped and signed by the Professional Engineer of record. The following elements also must be included:

- **Cover Sheet**. Must include a vicinity map with scale and north arrow, an index of sheets, design data, the phone number and address of the company and/or engineer responsible for the drawings, a utility contact list with phone numbers and email addresses, the Utility Notification Center of Colorado (UNCC) phone number (811), the project title, and the date printed.
- **M&S Standards Sheet**. Must show which M&S standards from the most recent CDOT *M&S Standard Plans* are applicable to the project.
- **Typical Section Sheet(s)**. Must include functional classification of the roadway, rural or urban classification of the roadway, right-of-way width, lane and shoulder widths, road centerline (crown) location, typical cross-slope, and pavement structural section elements and thicknesses.
- **General Notes**. Must include all notes that are applicable to the construction of the project. May also include notes on pavement design, Best Management Practice (BMP) design, etc.
- **Summary of Approximate Quantities and Earthwork Quantities Sheet(s)**. Must include tables showing the bid tabulation quantities and breakdowns of all quantities by location.
- **Survey Control Sheet(s)**. Must include the basis of elevation control, basis of bearings, and project coordinates datum.
- **Right-of-Way Plan Sheet(s)**. Must be included when temporary or permanent easements are needed or right-of-way will be acquired. Must include scale and north arrow, existing right-of-way lines, parcel lines and data, ownership information, proposed easement or right-of-way lines, and existing and proposed improvements.

- **Utility Plans Sheet(s)**. Provide existing (SUE) and proposed utility relocations. Both plan sets must include scale and north arrow, utility ownerships, utility locations, utility conflicts. The SUE sheets shall provide the appropriate level of mapping meeting Colorado state legislative subsurface utility engineering (SUE) requirements. County requires Quality Level B or better for all utility impacts. The utility plan should also show the location of where utilities are proposed to relocate.
- **Demolition and Removal Sheet(s)**. Must show existing conditions and include all items that are to be removed or demolished by the contractor as part of the project.
- **Plan and Profile Sheet(s)**. Must include horizontal and vertical scales and north arrow, location of right-of-way, location of easements, location of property lines, location of utilities, centerline stationing, horizontal and vertical curve information, existing and finished road grades, and design elevations. Separate plan and profiles sheets will be included for each access point, irrigation structures, and other structures as applicable.
- **Intersection Detail Sheet(s)**. Must include roadway centerline with stationing, north arrow, horizontal scale (1 inch = 20 feet preferred), proposed and existing contours (1 foot minimum), grade flow arrows, location of right-of-way, curb type label (if applicable), and critical spot elevations.
- **Grading and Erosion Control Sheet(s)**. Must include existing and final elevation contours at a minimum one-foot contour interval, spot elevations at critical drainage points to facilitate review and construction, slope/flow arrows and labels, limits of construction disturbance, and location of permanent erosion control features. If the project requires a Stormwater Permit per the National Pollutant Discharge Elimination System (NPDES), a detailed stormwater management plan (SWMP) and landscaping/vegetation plan will be required. (Additional information can be found in Chapter 6 of this document.)
- **Drainage Sheet(s)**. Must include location and type of all drainage features (e.g., pipes, ditches, inlets, manholes), details for pond spillways and outlet structures, plan and profile views of all pipes and culverts (unless new pipes or culverts are replacing existing ones of the same size and at the same location), location of all existing utilities, utility potholing, identification of utilities that conflict with new drainage features, and construction details. Labeling is required for any pond water surface elevations (WSEL), volumes, water quality capture volumes (WQCV), and elevations. Drainage sheets must correspond to the accepted drainage report.
- **Signage and Striping Plan Sheet(s)**. Must include driving lane and shoulder widths; stationing locations for striping beginnings, endings, and changes; color and size of striping; striping material type; stationing location for signs; type and size of signs; and quantities tabulation tables.
- **Landscaping Plan Sheet(s)**. Must include all areas that are to be seeded and/or landscaped. If trees are to be replaced, they must be shown on this plan subset.
- **Phasing Plan Sheet(s)**. If the project is to be phased, the phasing plans must be included.
- **Construction Traffic Control Plan Sheet(s)**. Must include plan view of all existing roads within the limits of the detour or within one mile of the project, whichever is larger; type and size of signs or other traffic control features; locations for all traffic control features; and quantities tabulation table. These sheets also must show any anticipated detour routes for road closures during construction.

- **Cross Section Sheet(s)**. Cross sections on 50-foot interval must include depiction of existing and final ground elevations, location of existing and proposed right-of-way and easement lines, utilities, station labeling, and roadway centerline location.
- **Stormwater Management Plan**. Must determine whether site is located in a Municipal Separate Storm Sewer System (MS4) area and must be included for temporary and permanent control measures. See Chapter 6 of this document for more information.

These guidelines are not intended to replace specific guidelines related to preparation and submission of plat maps and property description maps prepared by a licensed professional surveyor. These guidelines also are not inclusive of all the specific items that may be required by the Weld County Public Works, Planning or Building Departments. There may be additional requirements for more complex projects, such as bridge replacement and County Highway projects.

Table 4-1 below summarizes the roadway design criteria that can be found in this document for each roadway classification. For additional details refer to the sections below that discuss each topic.

Table 4-1 Roadway Design Criteria

Design Element	Arterial	Collector	Local
Design Speed			
Within Subdivisions	60 mph	50 mph	40 mph
Outside Subdivisions	See Note 1		
Posted Speed			
Within Subdivisions	50 mph	40 mph	30 mph
Outside Subdivisions	See Note 1		
Design Vehicle	WB-67	WB-67	WB-67
Maximum Superelevation			
Rural	6%	6%	6%
Urban	4%	4%	4%
Minimum Tangent Between Curves in Addition to Superelevation Transition Length Required	100 ft	100 ft	50 ft
Minimum Intersection Tangent (Measured from Pavement Edge) (See Note 2)	200 ft	150 ft	100 ft
Minimum Centerline Radius	See Note 3		
Minimum K Value for Vertical Curves	See Note 4		
Minimum Stopping Sight Distance	See Note 4		
Minimum Centerline Grade on Road with Curb and Gutter	0.40%	0.40%	0.40%
Maximum Centerline Grade	5%	6%	8%
Maximum Vertical Grade Change Not Requiring a Vertical Curve	≤0.2%	≤0.2%	≤0.2%
Minimum length for Vertical Curves			
Preferred:	300 ft	300 ft	300 ft
Allowed (3 x Design Speed):	180 ft	150 ft	120 ft

Notes:

1. *See Section 4.1.3 to determine an appropriate design speed and posted speed limit. Enforceable speed limit for roads without a posted speed limit is 55 mph.*
2. *See Figure 4-2.*
3. *See AASHTO's A Policy on Geometric Design of Highways and Streets superelevation tables for minimum radii based on design speed and maximum superelevation.*
4. *See Table 4-2 for minimum stopping sight distance and K values for vertical curves.*

4.1.3 Design Speed

Weld County requires designers to use a design speed that is 10 miles per hour (mph) above the required posted speed limit. Any change to the existing posted speed limit on a County road requires review by the Public Works Department and approval by the BOCC.

To determine an appropriate speed limit, traffic investigations should consider the following factors applicable to the portion of road being studied:

- Vehicle speed data (85th percentile)
- Crash history
- Hazardous locations (curves, sight distance, etc.)
- Parking practices

- Roadside development
- Road characteristics

The enforceable speed limit on roads within the County (not including roads within a subdivision) is 55 mph unless posted otherwise or within business districts, residential areas, or other areas where special conditions require a lower speed limit. Section 42-4-1102 of the Colorado Revised Statutes requires that speed limits not be higher or lower than the basic prima facie (reasonable and prudent under normal conditions) speed limit unless a traffic investigation has justified the change.

Posted speed limits for roads within subdivisions shall be as follows:

- 50 mph for arterial roads;
- 40 mph for collector roads;
- 30 – 40 mph for local commercial/industrial uses; and
- 25 – 30 mph for local residential uses.

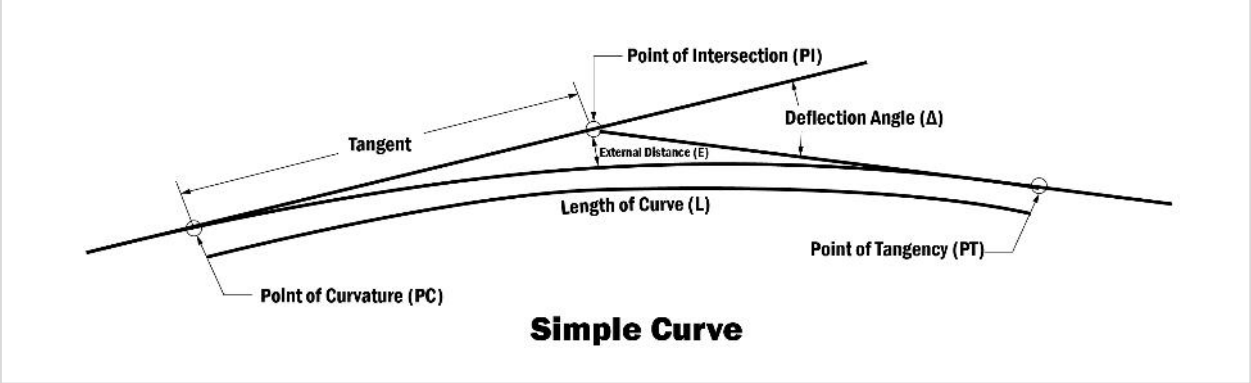
4.2 HORIZONTAL ALIGNMENT

4.2.1 Horizontal Curves

Horizontal alignment of the roadway is critical for safe and economical operation of motor vehicles traveling the roadway at the design speed. Horizontal curve design should be based on an appropriate relationship between design speed, right-of-way, profile grades, and construction costs—and on their joint relationships with superelevation and side friction. Curves are not required when the deflection angle (Δ) (total central angle of the circular curve) is less than 1 degree. Curves should be at least

500 feet long for a deflection angle of 5 degrees, and the minimum length should be increased 100 feet for each 1 degree increase in the deflection angle. Figure 4-1 illustrates a simple horizontal curve.

Figure 4-1 Horizontal Curve

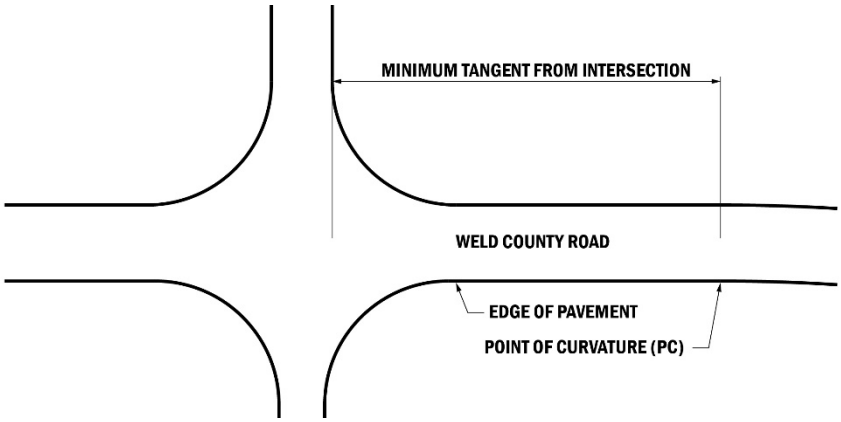


The formulas can be found in AASHTO's *A Policy on Geometric Design of Highways and Streets* and CDOT's *M&S Standard Plans*. Minimum radius values may also be taken from the AASHTO superelevation tables, using the "NC" (normal crown) line item. For rural areas, use the AASHTO table for minimum radii normal crown rates with e_{max} = 6 percent. For urban areas, use the AASHTO table for minimum radii for normal crown rates with e_{max} = 4 percent.

Designers should use every effort to exceed the minimum curve radius recommended by AASHTO when practical. Simple curves should be used for all roadways. Broken back, compound, or reverse curves are not recommended. The tangent between curves should be sufficient to accomplish the superelevation transitions required for adjacent curves. An additional 50 feet to 100 feet of tangent length, graded as a normal crown, should be provided between the end of the transition out of one curve and the beginning transition into the next for ease of driving.

Minimum intersection tangents (measured from the pavement edge of the intersected road at intersections) shall be as follows: 200 feet for arterial roadways; 150 feet for collector roadways; and 100 feet for local roadways as illustrated in Figure 4-2.

Figure 4-2 Minimum Tangent from Intersection



4.2.2 Superelevation

Proper design of horizontal curves often requires the use of superelevation (roadway banking). Factors controlling the use of superelevation include climate conditions, terrain conditions, classification of the road, and the frequency of slow-moving vehicles on the roadway. In general, a lower rate of superelevation is used in urban areas than in rural areas. For rural areas, use the AASHTO table for minimum radii for design superelevation rates with e_{max} = 6 percent. For urban areas, use the AASHTO table for minimum radii for design superelevation rates with e_{max} = 4 percent. If possible, superelevation rates of 4 percent or less should be used in roadway designs.

4.2.3 Transitions

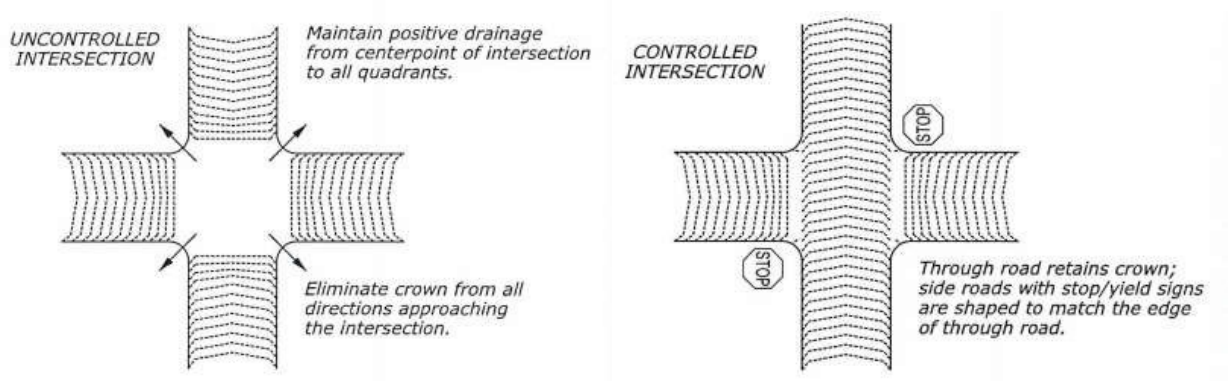
The superelevation transition section consists of the superelevation runoff and tangent runout sections. The superelevation runoff is the length of roadway needed to accomplish a change in outside lane cross slope from zero to full superelevation, or vice versa. The tangent runout section is the length of roadway needed to accomplish a change in outside lane cross slope from normal cross slope rate to zero, or vice versa. Additional information pertaining to the lengths and use of transitions for simple and spiral curves can be found in AASHTO's *A Policy on Geometric Design of Highways and Streets* and CDOT's *M&S Standard Plans*. The design should allow for 60 percent of the superelevation transition length to occur before the horizontal curve starts and after it ends. The remaining 40 percent of the transition occurs within the horizontal curve. This includes the lengths for all the transitions including normal crown, level crown, reverse crown and full superelevation.

4.2.4 Cross Slope

Cross slope is necessary to ensure adequate roadway drainage. The paved typical cross sections (described in Chapter 2 of this document) all show a cross slope of 2 percent, and this is the County's preferred value for a paved roadway. Non-paved roadways should have a cross slope closer to 3 to 4 percent to help accommodate surface drainage. Undivided roads should have a normal crown that is a two-way cross slope, with the high point of the cross section located on the road centerline. Divided roads should have a cross slope on each side of the divide, with the high point of each section located where the pavement meets the median.

Unusual conditions and transition areas may cause the 2-percent cross slope requirement to vary. Cross slopes varying from a minimum of 1 percent to a maximum of 4 percent may be allowed depending upon surface type. Intersections of roads with curbs and gutters sometimes require the use of crosspans for drainage. At these areas, the normal two-way 2-percent cross slope will transition to a one-way slope adjacent to the cross pan, with a slope range of 1 percent to 3 percent. For intersections not requiring cross pans, see Figure 4-3 for the desired cross slope configuration.

Figure 4-3 Intersection Cross Slope Detail



The rate of change for cross slope in an area of transition, should not exceed 1.5 inches over a 50-foot horizontal distance. This rate helps to ensure ride quality for the traveling public.

4.3 VERTICAL ALIGNMENT

Weld County's topography generally is flat with gentle slopes, but some areas have steep drainage basins and rolling hills. When designing roadway vertical alignment, designers must consider stopping sight distance requirements for the given speed limit and the challenges of large cut-and-fill sections.

Vertical curves are classified as either sag or crest curves. Typically, sag curves are controlled by nighttime driving conditions with headlight visibility restrictions, and crest curves are controlled by stopping sight distances. Vertical curves should be simple in application and should result in a design that is safe and comfortable in operation, aesthetically pleasing, and adequate for drainage—especially when a curb and gutter are used.

4.3.1 Maximum and Minimum Grades

Grade lines typically are controlled by topography and structure clearances, but very flat grade can be controlled by drainage considerations. Other factors that should be considered are road classifications, design speed, safety, and construction costs.

A minimum grade value of 0.4 percent is preferred for road sections with curbs and gutters. In certain conditions, a grade as low as 0.3 percent may be used with approval of the Department of Public Works. The designer must consider the ultimate design of the roadway, however, recognizing if a curb and gutter may be required in the future, and then design for those conditions during the interim design.

Maximum allowable grades are as identified in Table 4-1 above; 5 percent on arterials, 6 percent on collectors, and 8 percent on local roads. Grades of 4 percent or steeper will require special consideration for drainage or erosion protection.

When using combinations of horizontal and vertical curves, it is important to recognize the driver's perspective. Sharp horizontal curvature should not be introduced at or near the top of a pronounced crest vertical curve. If unavoidable, the horizontal curve should be made longer than the vertical curve to help minimize the driver's inability to perceive the horizontal change, especially at night. For further details, see AASHTO's *A Policy on Geometric Design of Highways and Streets* and CDOT's *Roadway Design Guide*.

The length of vertical curves can be determined by dividing the rate of vertical curvature by the grade change or algebraic difference in intersecting grades (%).

L (Length)(ft) = K (rate of curvature) / A (grade change)(%)

A vertical curve is not required when a grade change or the algebraic difference is ≤ 0.2 percent. The Weld County preferred minimum length of a vertical curve is 300 feet. The allowed minimum is three times the roadway design speed.

4.4 SIGHT DISTANCE

At intersections, accesses, and points along County roadways, sight distance is essential to protect the traveling public. In evaluating the overall performance of a roadway, there are several sight distances to consider when designing a roadway. When items such as walls, buildings, bridge piers, cut slopes, or vegetation growth are near the roadway on the inside of a curve, they can block a driver's view of the road ahead. If they are too close, the driver will not have sufficient distance along the curved roadway to stop when a hazardous condition comes into view. Sight distance related to accesses is discussed in Chapter 8 of this document.

4.4.1 Stopping Sight Distance

Stopping sight distance is the length of roadway it takes for a driver to bring a vehicle to a complete stop. Stopping sight distance is measured from the driver's point of view, which, according to AASHTO's *A Policy on Geometric Design of Highways and Streets*, is 3.5 feet above the road surface, to an object's height of 2 feet within the roadway. Stopping sight distance includes the reaction time of the driver and braking distance of the vehicle, as well as roadway grades (see Table 4-2). Additional information regarding reaction time and braking distance can be found in AASHTO's *A Policy on Geometric Design of Highways and Streets* and in Chapter 8 of this document.

As shown in Table 4-2, stopping sight distance varies depending on the percent in grade up or down within the vertical curve. The designer should account for the varying grades within his or her profile design and select the appropriate values of stopping sight distance.

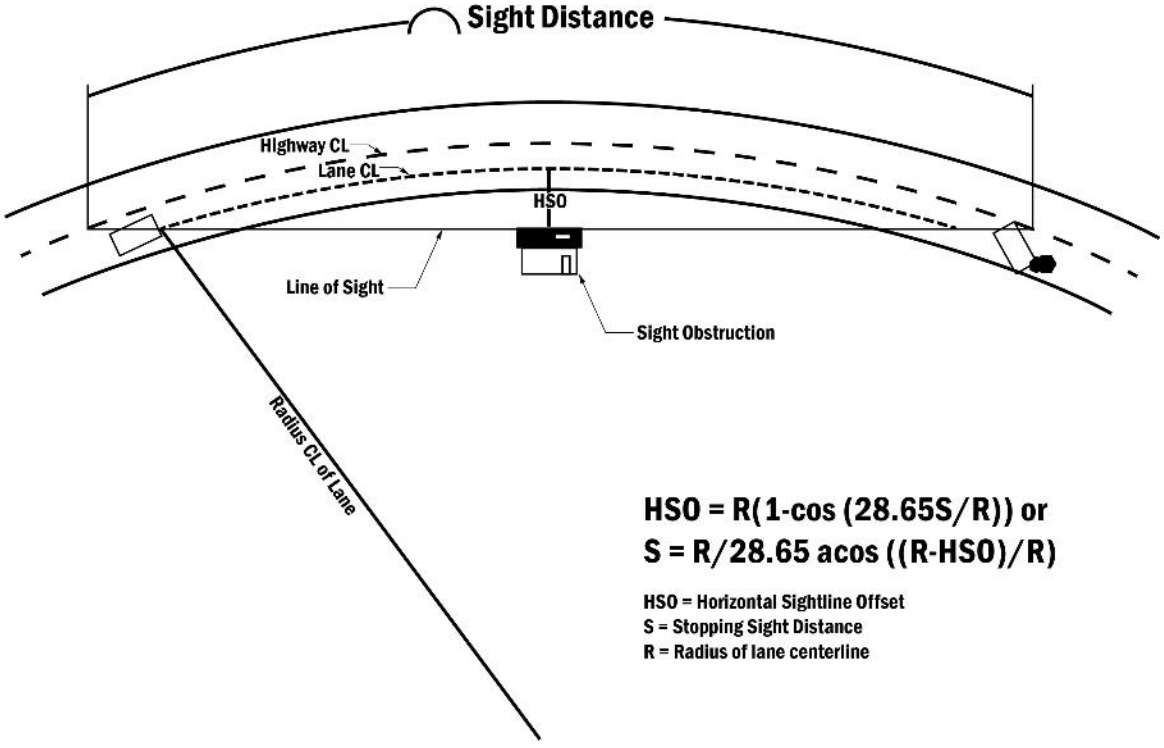
Table 4-2 lists stopping and passing sight distances for various percent grades up or down.

Table 4-2 Stopping and Passing Sight Distances and K Values

Design Speed (mph)	Stopping Sight Distance (feet)									Passing Sight Distance	
	No Grade	% Down Grade			% Up Grade			Crest	Sag	Crest Curve	
	(0)	3	6	9	3	6	9	K	K	(feet)	K
25	155	158	165	173	147	143	140	12	26	450	72
30	200	205	215	227	200	184	179	19	37	500	89
35	250	257	271	287	237	229	222	29	49	550	108
40	305	315	333	354	289	278	269	44	64	600	129
45	360	378	400	427	344	331	320	61	79	700	175
50	425	446	474	507	405	388	375	84	96	800	229
55	495	520	553	593	469	450	433	114	115	900	289
60	570	598	638	686	538	515	495	151	136	1,000	357
65	645	682	728	785	612	584	561	193	157	1,100	432

For horizontal curves (see Figure 4-4), the sight line is measured along the chord of the curve, while the stopping sight distance is measured along the centerline of the inside lane around the curve.

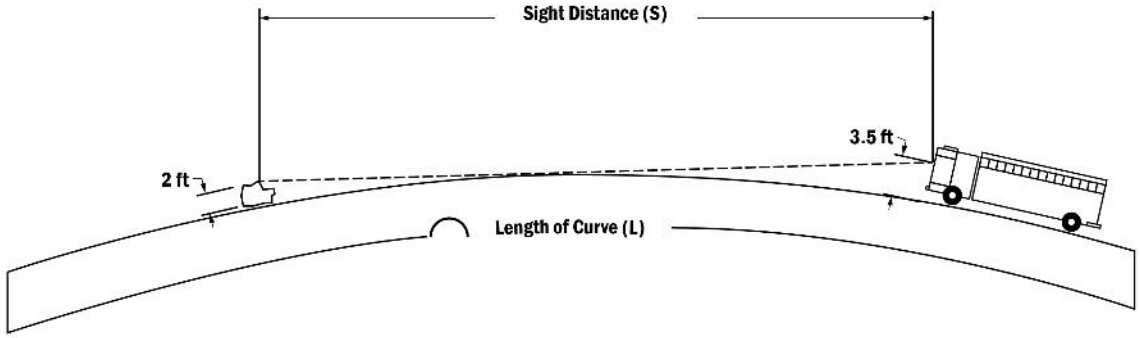
Figure 4-4 Horizontal Sight Distance



Horizontal sight distance may be restricted by obstacles along the roadway or even by cut slopes through a hillside. Other normal roadside objects, such as guardrail, concrete barriers, and privacy fences, should be studied for interference with sight distance.

Vertical sight distance is determined by the geometrics of the curve. Figure 4-5 is an example of the crest vertical curve.

Figure 4-5 Crest Vertical Curve



Sag vertical curves usually are controlled by headlight distance. Under certain conditions, the minimum stopping sight distance values used for design exceed the length of visible roadway. This is because of the limitations of vehicle headlights, especially low-beam headlights.

Formulas to determine stopping sight distance on both crest and sag curves can be found in AASHTO's *A Policy on Geometric Design of Highways and Streets*.

4.4.2 Passing Sight Distance

Passing sight distance is the length of roadway required for the driver of a vehicle to pass another vehicle safely and comfortably, without interfering with the speed of an oncoming vehicle traveling at the design speed if it came into view after the passing maneuver was started. Passing sight distance is measured from the driver's point of view, which is to be measured at 3.5 feet above the road surface, to an object's height of 3.5 feet. Typically, passing sight distance will be limited on crest vertical hills. A significant amount of cut may be required to achieve adequate passing sight distance. Table 4-2 lists appropriate passing sight distances for various speeds.

4.4.3 Decision Sight Distance

The stopping sight distances shown in Table 4-2 are distances for reasonable and alert drivers to come to a complete stop. They do not include the time it takes drivers to make a decision when unexpected or unusual maneuvers are required. Decision sight distances (see Table 4-3) are substantially greater than stopping sight distances. Locations where these kinds of decisions are required include interchanges, cluttered or confusing intersections, and short lane drops. (See AASHTO *A Policy on Geometric Design of Highways and Streets* for more information.)

Table 4-3 Decision Sight Distance

Decision Sight Distance					
Design Speed (mph)	Decision Sight Distance for Avoidance Maneuver (ft)				
	A	B	C	D	E
30 or less	220	490	450	535	620
40	330	690	600	715	825
50	465	910	750	890	1,030
60	610	1,150	990	1,125	1,280
70	780	1,410	1,105	1,275	1,445

Where:
Avoidance Maneuver A = stop on rural road (t = 3.0 seconds) Avoidance Maneuver B = stop on urban road (t = 9.1 seconds)
Avoidance Maneuver C = speed/path/direction change on rural road (t = 10.2 sec to 11.2 sec)
Avoidance Maneuver D = speed/path/direction change on suburban road (t = 12.1 sec to 12.9 sec)
Avoidance Maneuver E = speed/path/direction change on urban road (t = 14.0 sec to 14.5 sec)

4.4.4 Intersection Sight Distance

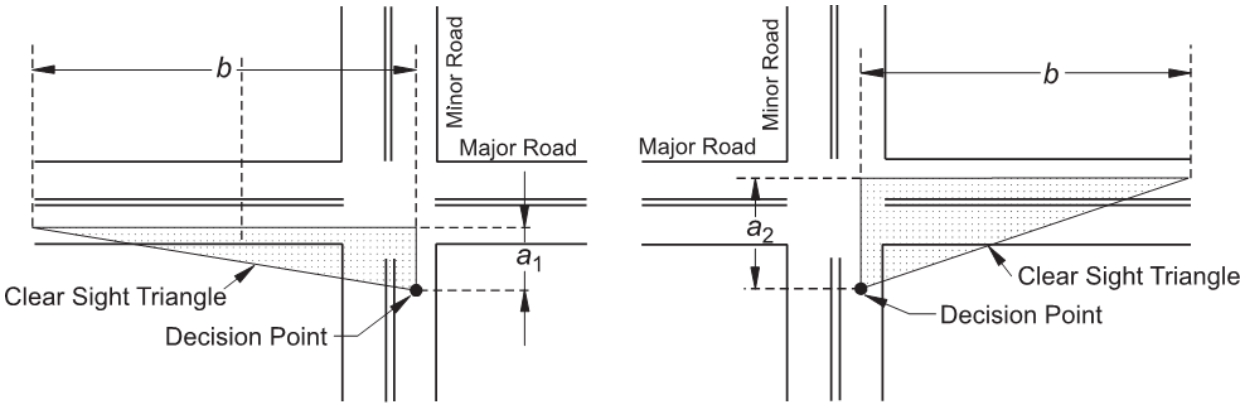
There are numerous intersections within Weld County; most are controlled, but some are uncontrolled, which means there is no signing in either direction. Ideally, intersections would have adequate sight distance in all directions and along approaches to allow drivers to see obstructions or approaching vehicles. However, many of the County intersections do not have unobstructed views for various reasons. Utility appurtenances, embankments, vegetation, and privacy fences are just a few examples of sight restrictions. In these circumstances, and where no traffic control devices are present, the basic rule of the road is the vehicle on the left is to yield to the vehicle on the right if they arrive at about the same time. If drivers cannot see due to sight obstructions at the intersection, it is the responsibility of every driver to slow down and determine if it is safe to continue through the intersection. Additional information regarding intersection sight distance can be found in AASHTO's *A Policy on Geometric Design of Highways and Streets*.

The recommended dimensions of the sight triangles vary with the type of control used at the intersection because different types of control impose different constraints on drivers and, therefore, result in different behavior. AASHTO's *A Policy on Geometric Design of Highways and Streets* presents procedures to determined sight distances at intersections for the following types of traffic control:

1. Intersections with no control
2. Intersections with stop control on the minor road
3. Intersections with yield control on the minor road
4. Intersections with traffic signal control
5. Intersections with all-way stop control
6. Left turns from the major road
7. Roundabouts

Figure 4-6 below, illustrates an intersection with stop control on the minor road. For information regarding the variable definitions and equations used to calculate these distances, see Section 8.6.2 of this document and AASHTO's *A Policy on Geometric Design of Highways and Streets.*

Figure 4-6 Departure Sight Triangles at Intersection (Stop Control)



Departure Sight Triangle for Viewing Traffic Approaching the Minor Road from the Left

Departure Sight Triangle for Viewing Traffic Approaching the Minor Road from the Right

Private accesses need to take into consideration these sight distance requirements just as other roadways would. More information regarding access sight distance can be found in Chapter 8 of this document.

4.5 INTERSECTIONS

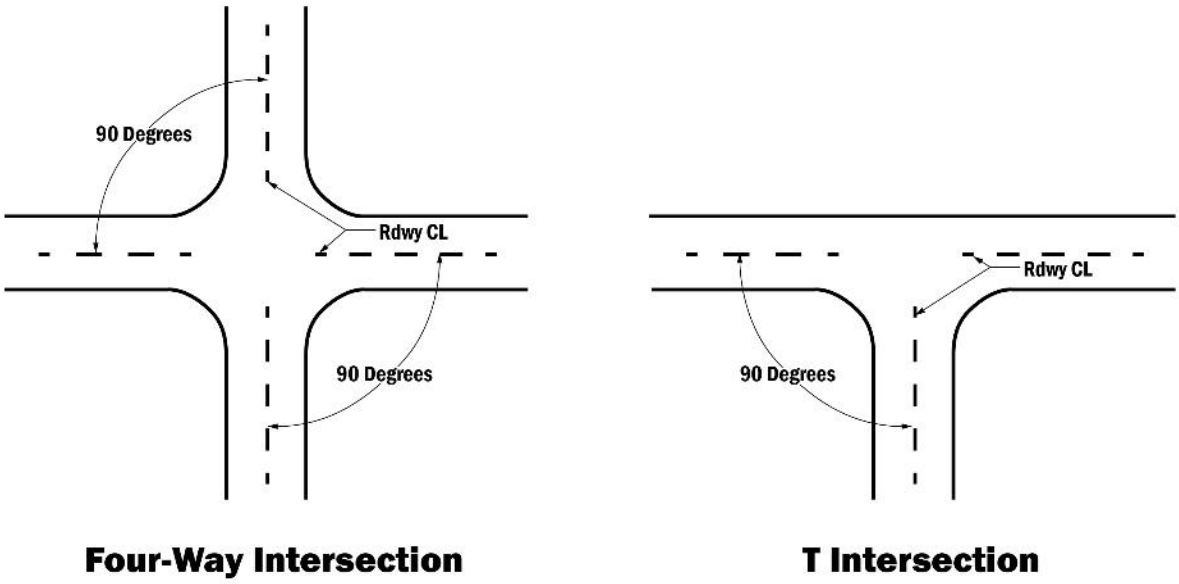
By definition, an intersection is the location where two or more roadways meet or join together. This occurs at at-grade crossings, interchanges, or grade separations without ramps. All of the County-owned intersections in Weld County are at-grade intersections.

Generally, there is more potential for conflict at intersections than on straight sections of roadway, so intersections usually have higher accident rates. Chapter 9 of AASHTO's *A Policy on Geometric Design of Highways and Streets* discusses intersections and provides guidance on design details. Designers also should refer to CDOT's *Roadway Design Guide*. The sections below highlight a few key aspects of intersection design. See also Chapter 2 of this document for typical cross-section drawings.

4.5.1 Alignment and Profile

It is very important for the success and safety of any intersection that it is aligned with the intersecting roadway. For standard, at-grade, four-way intersections and T-intersections, the roadways should meet as close to perpendicular as possible. Skewed intersections are difficult for drivers and create unsafe conditions. The required angle between centerlines of the intersecting roadways is 90 degrees, as shown in Figure 4-7. Any deviations from 90 degrees will need to be approved by the Department of Public Works.

Figure 4-7 Typical Intersections



Four-Way Intersection **T Intersection**

The alignments and grades of the intersecting roadways should permit the maneuvers needed for cars to pass through the intersection with minimal interference. Alignments should be as straight and flat as practical, and substantial grade changes should be avoided.

All lanes shall be in general alignment through each intersection; however, a maximum 2-foot shift is allowed across an intersection without a variance approval by the County Engineer.

The profile grade lines should be adjusted back a distance from the intersection to provide a smooth transition. It may be desirable to remove the cross slopes coming into the intersection, as steep cross slopes or grade changes create an undesirable bump at the intersection and may require reconstruction to correct. Refer back Figure 4-3 for an intersection cross slope detail. A smooth transition is particularly important at intersections where drivers do not reduce their speed or come to a stop. Designers should remember that intersections which are currently stop-controlled may not be stop-controlled in the future.

4.5.2 Corner Radii

Corner radii are another critical aspect of intersection design. Corner radii are selected based on the turning radii of different design vehicles. Chapter 2 of AASHTO's *A Policy on Geometric Design of Highways and Streets* discusses design vehicles and their different turning radii. The four classes of design vehicles are: passenger cars, buses, trucks, and recreational vehicles. The Weld County design vehicle is the **WB-67 truck**.

4.5.3 Approval Requirements

Chapter 9 of AASHTO's *A Policy on Geometric Design of Highways and Streets* summarizes the minimum edge of traveled way design for the four classes of design vehicles. Usually, the simplest curves to construct are the simple curve with taper and the three-centered compound (symmetric) radii. Other compound curves can be difficult to implement in the field. For intersections on arterial and collector roadways, designers should consider a minimum radius of 65 feet, following a simple curve with taper

radii. This allows larger trucks to make right turns without the rear tires going off the road and without veering into opposing vehicle paths. An exhibit from AutoTURN software or equivalent roadway design turning template software must be provided to the County to demonstrate the corner radius is appropriate.

4.5.4 Auxiliary Lanes

See Chapter 8 of this document for information on auxiliary lanes.

4.6 CUL-DE-SACS

Cul-de-sacs and dead-end roadways are not common in the County but are sometimes found in subdivision and residential areas. Cul-de-sacs should be designed with a radius large enough to allow a standard fire truck to use the cul-de-sac to make a u-turn without having to back up. The minimum outside curb or pavement edge radius allowed for a cul-de-sac is 55 feet. The minimum right-of-way turnaround radius is 65 feet. The maximum cul-de-sac length between intersecting streets (from centerline to centerline) is 1,500 feet. No more than 20 lots may be served by a permanent cul-de-sac. The most common design is a circular cul-de-sac with or without a center island. Chapter 5 of *A Policy on Geometric Design of Highways and Streets* offers additional design criteria and other types of cul-de-sacs. The designer must consult the relevant fire protection authority for its minimum criteria as well.

4.7 BRIDGES

This section is not intended to cover bridge design in detail. It covers only general guidelines. More detailed bridge design information can be found in the latest editions of AASHTO's *LRFD Bridge Design Specifications*, the *Culverts and Bridges* chapter in the USDCM, Volume 2, and CDOT's *Drainage Design Manual* and *Bridge Design Manual*, as updated.

4.7.1 Bridge Hydraulic Capacity

During preliminary design, the designer shall complete a hydrologic and hydraulic analysis of the waterway to correctly size the opening of a new bridge, coordinating with owners as necessary. Bridges over canals require less hydrologic analysis than bridges over natural drainage ways. Designers shall gather and analyze background information, such as past inspection reports, measurable high-water marks, past maintenance issues, scour, and flood records. The storm design frequency for the different types of roadways and drainage types is shown in Table 4-4.

Table 4-4 Design Frequencies

Drainage Type	Design Frequency
Multi-Lane Roads	
Urban area	100-year
Rural area	100-year
Two-Lane Roads	
Urban area	100-year
Rural area	
Q_{50} > 4000 cfs Q_{50} < 4000 cfs	50-year 25-year
Drainage Type	**Design Frequency**
Bridge foundation scour	Based on Q_{design} if: Q_{25} requires Q_{50} scour design and Q_{100} Check Flood Q_{50} requires Q_{100} scour design and Q_{200} Check Flood Q_{100} requires Q_{200} scour design and Q_{500} Check Flood

In areas that contain the FEMA mapped 100-year floodplain, designers shall use the 100-year discharge in their designs. If a bridge is being constructed in a 100-year floodplain, all applicable floodplain regulations and codes apply, including the need to submit a Letter of Map Revision (LOMR) to FEMA for review and acceptance and the need to obtain a Floodplain Hazard Permit from the County.

On wide floodplains, structure loss can be prevented by lowering approach embankments to provide overflow sections that pass unusual floods over the roadway. This may require relief structures to be constructed to allow minor flooding without upstream ponding. Factors such as traffic delays and alternative routes should be considered.

Additional and detailed information can be found in CDOT's *Drainage Design Manual* and CDOT's *Bridge Design Manual*.

4.7.2 Freeboard

A minimum clearance, or freeboard, shall be provided between the water surface elevation and the low girder of the bridge. The freeboard is required to allow for wave action, ice, debris, and uncertainty during estimation.

The minimum freeboard for a bridge should follow these guidelines:

- For a high-debris stream, freeboard should be 4 feet or more. A "high-debris" stream designation often will be site-specific and shall be determined through consultation with Public Works officials and local landowners, as well as through a thorough investigation of the debris potential in the watershed.
- For low- to moderate-debris streams, the minimum freeboard will be 2 feet.

The water surface elevation at a distance of 50 feet to 100 feet upstream of the face of the bridge will be the elevation to which the freeboard is added to get the low girder elevation of the bridge as a rough estimate of maximum backwater.

4.7.3 Bridge Scour

Increased flow velocities at bridge constrictions often lead to scour of the bridge foundations, which can cause the potential for collapse of the structure. Localized bridge scour is comprised of contraction scour and local scour at piers and abutments. These three components are added together to create the final scour envelope.

Methodologies for estimating scour at bridges can be found in the following FHWA guidelines:

- FHWA, Evaluating Scour at Bridges, Hydraulic Engineering Circular No. 18 (HEC-18), latest edition
- FHWA, Stream Stability at Highway Structures, Hydraulic Engineering Circular No. 20 (HEC-20), latest edition

Methodologies for designing scour countermeasures at bridges, piers, and abutments can be found in FHWA's Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance, Hydraulic Engineering Circular No. 23 (HEC-23), latest edition.

4.7.4 Use of HEC-RAS

It is acceptable to use the U.S. Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) to determine the hydraulic characteristics at bridges. Standard modeling practices accepted by FEMA should be used when performing HEC-RAS modeling.

It is not acceptable to rely on HEC-RAS output for estimating maximum velocities for erosive or hazardous considerations or local scour in a channel. A more-detailed hydraulic analysis of the specific cross section, accounting for variable velocities across the channel, is necessary.

4.7.5 Bridge Railing

Bridge railing should be provided along bridge edges to protect both drivers and in applicable situations pedestrians. Weld County follows CDOT M&S Standards for bridge rail and guardrail design. CDOT's *M&S Standard Plan*s, as well as the CDOT Bridge Structural Worksheets, identify several different railing options and configurations that the designer may consider. AASHTO's bridge design documents provide additional information as well.

4.7.6 Minimum Structural Requirements

Design loadings for bridges shall comply with the latest editions of AASHTO's *LRFD Bridge Design Specifications* and CDOT's bridge design publications.

CHAPTER 5 DRAINAGE CRITERIA

5.1 GENERAL

The intent of Weld County's storm drainage criteria WCECC is to protect the health, safety, general welfare, and economic well-being of the County and residents, while also protecting property and infrastructure. The drainage characteristics of Weld County vary greatly throughout the 4,000 square miles of the county. This chapter aims to provide greater detail on the expectations and guidance for drainage-related portions of a project.

Weld County has adopted the following master drainage plans:

- South I-25 Corridor Master Drainage Plan, also known as "Godding Hollow and Tri-Town Study" (adopted in 1999). The South I-25 "Tri-Town" Master Drainage Plan from 1999 can be found on the City of Dacono's website.
- Master Drainage Plan for the Area Surrounding Weld County Parkway (adopted in 2016). This Master Drainage Plan can be found on the County's Parkway webpage.

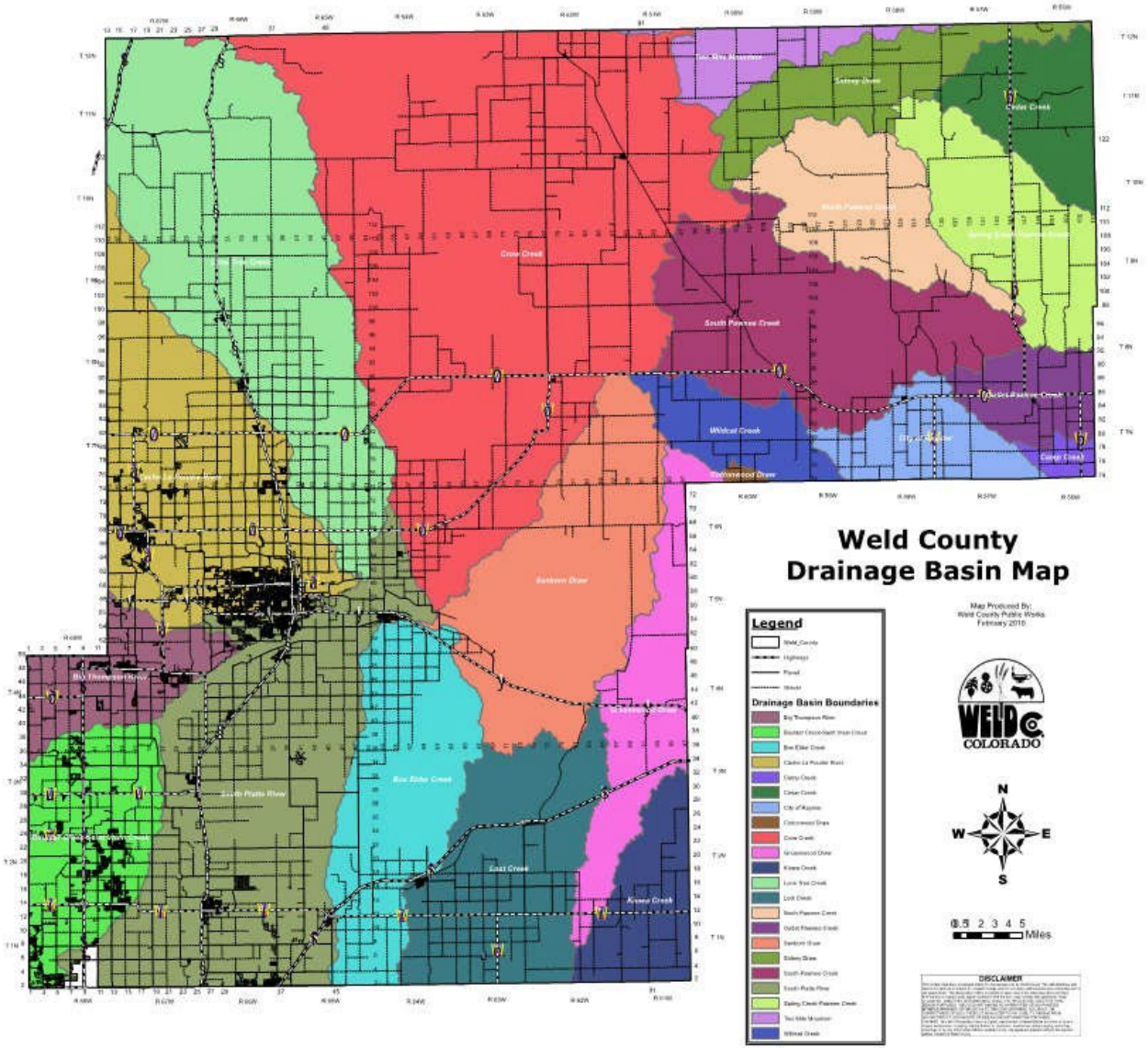
A map of Weld County's drainage basins is shown in Figure 5-1. A full-sized version is provided in Appendix A.

This manual refers to both the current and older, archived versions of Urban Drainage and Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual* (USDCM), Volumes 1 through 3. This manual will explicitly state when to use an older version of the USDCM. UDFCD has rebranded as of 2019 and is now referred to as the Mile High Flood District (MHFD). The MHFD acronym will be used exclusively throughout the chapter.

It shall be noted that specifically to drainage, some of these references have provided updated values and equations in recent years that are in accordance with Full Spectrum detention pond design. Weld County does not support Full Spectrum design and, as such, when standards differ, the instructions and guidance in the following Drainage Chapter will govern.

All Storm Drainage Guidance documents provided by the County can be found on the Weld County Planning and Zoning's Development Review webpage.

Figure 5-1 Weld County Watersheds



5.2 DRAINAGE LAW

Refer to the *Drainage Law* chapter of the USDCM, Volume 1, for more information on drainage law as it relates to stormwater runoff and floodplain management.

5.3 DRAINAGE POLICY

The drainage policies set forth are intended to provide adequate stormwater management to preserve and promote the health, safety, general welfare, and economic well-being of the County. Weld County embraces the basic principles defined in the *Drainage Policy* chapter of the USDCM, Volume 1.

5.3.1 Submittal Requirements

The Weld County Planning Services Department is the agency responsible for reviewing drainage in the development review process. The submittal requirements for each project (commercial and residential

developments, new roadways, new bridges, channel restorations, etc.) will differ based on the scope and location of the improvements.

The Drainage Report Checklist provided in Appendix B shall serve as a guideline for designers throughout the entire design and construction process. The Drainage Report Checklist provides a framework of Weld County's requirements for the drainage report, construction drawings, and operations and maintenance (O&M) plan. The designer shall include this checklist with the preliminary and final deliverables for the project.

- The drainage report must fully document all assumptions and methodologies and shall contain copies of all applicable tables and reference materials in an appendix. A drainage basin map shall be included showing basin delineations, flow arrows, design points, pond volumes, and any other information pertinent to the design.
- Grading and drainage plans shall be submitted as a single PDF document, printable to scale on 11- inch x 17-inch paper.
- To assist owners with maintenance, an Operations and Maintenance (O&M) plan for stormwater facilities and associated infrastructure shall be included with the final drainage report. The O&M plan should include instructions on safe and correct operations, repair and maintenance of all installed equipment and facilities, and recommended inspection schedules. The O&M plan to be distributed to any applicable homeowners' association or business park association (or equivalent). Weld County has adopted CDOT's guidelines for the O&M plan and is provided in Appendix C.
- Electronic copies of drainage design spreadsheets, models, etc., may be requested for submittal to Weld County for reviewing purposes. AutoCAD base files (including site layout, roadways, utilities, survey coordinate system information) shall be included with the project's final submittal for inclusion into the County's GIS mapping system. Electronic pdf copies of all calculations relevant to the design of the project shall be included in the drainage report appendices for review.
- Each plan and report must be prepared by or under the supervision of a professional civil engineer licensed to practice in the State of Colorado. Plan sheets will contain the Engineer's seal; signed, dated, and sealed per State requirements. Electronic stamps are acceptable.
- The report shall contain the Weld County Drainage Code *Certificate of Compliance* stating that the design meets all applicable drainage requirements set forth in this WCECC, with the exception of County-approved variances. The *Certificate of Compliance* is available on the Department of Planning and Zoning's Development Review webpage. Design variance request information is to be included on the lower portion of the Certification of Compliance sheet. The consulting engineer should provide information supporting the variance request in the form of a drainage memo or letter. Any necessary engineering calculations or explanation should be provided in the submittal.
- The designer/contractor is to provide an as-built survey, when requested, of the constructed stormwater facilities upon final completion of the project for acceptance by Weld County and issuance of any Certificate of Occupancy. An As-Built Drawing Checklist is included in Appendix D. The survey will be conducted, signed, dated, and sealed by a Professional Land Surveyor licensed to practice in the State of Colorado. At a minimum, the as-built drawings shall include:

1. Drawing showing design contours versus as-built contours of constructed pond/site (1-foot contour intervals, labeled)
2. Spot elevations at critical drainage design points:
   - Pond outlet structure
   - Pond emergency spillway, start and end of riprap or other required protection
   - Pipe/inlet elevations
   - Structure inverts
   - Exposed groundwater elevation, if applicable
3. Pond design volume (stage-storage tables) versus as-built volumes. The designer/contractor shall submit a Statement of Compliance signed and stamped by a Colorado Professional Engineer that verifies in writing that the pond as-built volume meets the design volume requirements.
4. Drawings shall be properly scaled and sized to clearly show the work that was done through construction. The contractor shall provide signed and stamped Engineered copies of relevant plans and details with updates including the following, but not limited to, updated elevations, dimensions, and pipe sizes.
5. All appurtenances and related features shall be located horizontally and vertically by the surveyor.

Due to a project's scope and/or location, special permits may be required. Such permits may include construction permits, floodplain permits, and environmental permits. Requirements for special permits are dictated by the approving department or agency.

5.3.2 Data Collection

The County uses information and data provided by FEMA, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), private consulting engineers, and the Colorado Water Conservation Board (CWCB). Before commencing design of any drainage project, designers should collect and evaluate data for the particular watershed area under consideration.

Unless explicitly stated otherwise, Weld County will allow the use of data collection methodologies other than what is recommended in this WCECC on a case-by-case basis when complete documentation of all assumptions is provided. Weld County reserves the right to review alternatives and compare with other commonly used approaches, including those discussed in the USDCM.

5.4 RAINFALL

The designer should use the most appropriate and best available data for the project area in determining the rainfall quantities. Local rainfall data shall be obtained from NOAA *Atlas 14: Precipitation-Frequency Atlas of the United States*, *Volume 8* (Atlas 14) unless otherwise approved by the Department of Public Works, or unless otherwise specified in urbanized jurisdictions and existing master plans. The use of synthetic rainfall distribution data is not permitted.

5.4.1.1 Intensity Duration Curves for Rational Method

To develop depth-duration curves or intensity-duration curves for the Rational Method of runoff analysis, the 1-hour depth(s) obtained from NOAA Atlas 14 can be applied to Equation 5-1 below for the duration (or durations) of interest:

$$I = \frac{28.5P_1}{(10+T_d)^{0.786}}$$ Eq. 5.4.1

Where:

- I = rainfall intensity (inches per hour)
- P_1 = 1-hour point rainfall depth (inches)
- T_d = storm duration (minutes)

For more details regarding the development of rainfall information, refer to the *Rainfall* chapter of the USDCM, Volume 1.

5.5 RUNOFF

For more details regarding the development of runoff information, refer to Chapter 8, Article XI, of the Weld County Code and the *Runoff* chapter of the USDCM, Volume 1. The County explicitly uses the 2007 version of the *Runoff* chapter of USDCM, Volume 1 and, as such, it has been made available on the Weld County website. Depending on the size and location of a project, there are three allowable stormwater runoff calculation methods. Table 5-1 below summarizes the allowable methodology. When designing a site with multiple detention basins in parallel or series, the use of Stormwater Management Model (SWMM) is required for routing. Weld County does not allow the use of CUHP.

Table 5-1 Runoff Coefficient Equations for Weld County/2008 MHFD (HSG-a)

Size of Basin	Allowable Runoff Calculation Method
Less than 5 acres	Rational Method required
5 to 160 Acres	Rational Method or SWMM allowable
Greater than 160 acres	SWMM is required

5.5.1 The Rational Method

The Rational Method is a simplistic method for determining peak runoff from a proposed development or road construction project. It should not be used for basins greater than 160 acres. Refer to the *Runoff* chapter of the USDCM, Volume 1 provided on the County Website for more information regarding application of the Rational Method.

The design engineer shall use the Rational Method to perform runoff calculations (for basin sizes under 160 acres). The spreadsheet used to perform runoff calculations, UD-Rationalv1.02, is available for download on the Department of Public Works Zoning's Development Review webpage. This spreadsheet utilizes the rational method "C-values" from the 2007 design manual (shown in Table 5-3 through Table 5-5 below). The design consultant may use the downloadable spreadsheets or may create their own based on the information provided in the following portion of this document. The created spreadsheets must use the older 2007 C-values to be accepted. A copy of these runoff coefficients are provided in Appendix E and on the Department of Planning and Zoning's Development Review webpage. The rational formula is as follows:

$$Q = C \times I \times A \qquad \text{Eq. 5.5.1}$$

Where:

Q = peak runoff rate, cfs
C = runoff coefficient, dimensionless
I = rainfall intensity at the time of concentration, in/hr
A = area of the basin, acres

The runoff coefficient, C, represents the effects of infiltration, evaporation, retention, and interception and is calculated based on the soil type and impervious percentages. Higher impervious percentage values (roofs, parking lots) mean the area does not readily allow water to infiltrate into the ground, whereas lower impervious percentage values (parks, green space) mean the area does allow water to infiltrate into the ground. The recommended impervious percentage values, I, for Weld County are provided in Table 5-2, below.

Table 5-2 Percentage Impervious Values for Weld County

Land Use or Surface Characteristics	Percent Impervious (%)
Commercial	95
Residential:	
Single-Family	
Greater than 2.5 acres or larger	12
Greater than 0.75 acre to 2.5 acres	20
Greater than 0.25 acre to 0.75 acre	30
0.25 acre or smaller	45
Multi-Unit Detached	60
Multi-Unit Attached	75
Apartments	80
Industrial:	
Light	80
Heavy	90
Solar Facilities:	
A & B Soils	2
C & D Soils	Site-specific
Parks, Cemeteries	10
Playgrounds	25
Schools	55
Railroad Yard Areas	50
Roofs	90
Undeveloped Areas:	
Historic Flow Analysis	2
Greenbelts, Agricultural	2
Streets:	
Paved	100
Packed Gravel (Includes Road Base and Compacted, Cleared, Earthen Areas typically used for Roads/Parking/Storage)	40
Recycled Asphalt Pavement	75
Drives and Walks	90

Table 5-3 through Table 5-5 use the impervious percent value (expressed as a decimal) to calculate the runoff coefficients for Natural Resources Conservation Service (NRCS) hydrologic soil groups A, B, and C/D for various storm return periods.

Table 5-3 Runoff Coefficient Equations for Weld County/2007 MHFD (HSG-A)

Equation	Hydrologic Soil Group A		
	5-Year	10-Year	100-Year
	$C_5 = (-0.08i + 0.09) + (1.31i^3 - 1.44i^2 + 1.135i - 0.12)$	$C_{10} = (-0.14i + 0.17) + (1.31i^3 - 1.44i^2 + 1.135i - 0.12)$	$C_{100} = (-0.25i + 0.32) + (1.31i^3 - 1.44i^2 + 1.135i - 0.12)$
2%	0.00	0.07	0.22
5%	0.02	0.10	0.24
10%	0.06	0.14	0.28
15%	0.10	0.17	0.30
20%	0.13	0.20	0.33
25%	0.16	0.23	0.35
30%	0.19	0.25	0.37
35%	0.22	0.28	0.39
40%	0.25	0.30	0.41
45%	0.27	0.33	0.43
50%	0.30	0.35	0.45
55%	0.33	0.38	0.47
60%	0.37	0.41	0.50
65%	0.41	0.45	0.53
70%	0.45	0.49	0.56
75%	0.50	0.54	0.61
80%	0.56	0.60	0.66
85%	0.63	0.66	0.72
90%	0.71	0.73	0.79
95%	0.80	0.82	0.86
100%	0.90	0.92	0.96

Table 5-4 Runoff Coefficient Equations for Weld County/2007 MHFD (HSG-B)

Equation	Hydrologic Soil Group B		
	5-Year	10-Year	100-Year
	$C_5 = (C_a + C_{cd})/ 2$	$C_{10} = (C_a + C_{cd})/ 2$	$C_{100} = (C_a + C_{cd})/ 2$
2%	0.08	0.17	0.36
5%	0.10	0.19	0.38
10%	0.14	0.22	0.40
15%	0.17	0.25	0.42
20%	0.20	0.27	0.44
25%	0.22	0.30	0.46
30%	0.25	0.32	0.47
35%	0.27	0.34	0.48
40%	0.30	0.36	0.50
45%	0.32	0.38	0.51
50%	0.35	0.40	0.52
55%	0.38	0.43	0.54
60%	0.41	0.46	0.56
65%	0.45	0.49	0.59
70%	0.49	0.53	0.62
75%	0.54	0.58	0.66
80%	0.59	0.63	0.70
85%	0.66	0.69	0.75
90%	0.73	0.75	0.81
95%	0.81	0.83	0.88
100%	0.90	0.92	0.96

Table 5-5 Runoff Coefficient Equations for Weld County/2007 MHFD (HSG C/D)

Equation	Hydrologic Soil Group C/D		
	5-Year	10-Year	100-Year
	$C_5 = (-0.10i + 0.11) + (0.858i^3 - 0.786i^2 + 0.774i + 0.04)$	$C_{10} = (-0.18i + 0.21) + (0.858i^3 - 0.786i^2 + 0.774i + 0.04)$	$C_{100} = (-0.39i + 0.46) + (0.858i^3 – 0.786i^2 + 0.774i + 0.04)$
2%	0.16	0.26	0.51
5%	0.18	0.28	0.52
10%	0.21	0.30	0.53
15%	0.24	0.32	0.54
20%	0.26	0.34	0.55
25%	0.28	0.36	0.56
30%	0.30	0.38	0.57
35%	0.33	0.40	0.57
40%	0.35	0.42	0.58
45%	0.37	0.44	0.59
50%	0.40	0.46	0.60
55%	0.43	0.48	0.62
60%	0.46	0.51	0.63
65%	0.49	0.54	0.65
70%	0.53	0.57	0.68
75%	0.58	0.62	0.71
80%	0.63	0.66	0.74
85%	0.68	0.71	0.79
90%	0.75	0.77	0.83
95%	0.82	0.84	0.89
100%	0.90	0.92	0.96

5.5.1.1 Time of Concentration

The time of concentration is calculated based on the length, slope, and cover in the basin. The time of concentration is calculated by adding the initial or overland flow time and the channelized travel time.

$$t_c = t_i + t_t \qquad \text{Eq. 5.5.1.1}$$

Where:

t_c = Time of concentration, minutes
t_i = Initial or overland flow time, minutes
t_t = Channelized travel time, minutes

5.5.1.2 Initial or Overland Flow Time

The initial or overland flow time will be calculated as follows:

$$t_i = \frac{0.395(1.1-C_5)\sqrt{L_i}}{S_o^{0.33}}$$ Eq. 5.5.1.2

Where:

L_i = Length of overland flow, ft (500 ft maximum for non-urbanizing undeveloped areas, 300 ft maximum for urbanizing or developed areas)
S_o = Overland basin slope, ft/ft

5.5.1.3 Channelized Flow Time

The channelized flow time (travel time) will be calculated as follows:

$$t_t = \frac{L_t}{60K\sqrt{S_o}} = \frac{L_t}{60V}$$ Eq. 5.5.1.3

Where:

L_t = Waterway length, ft
S_o = Waterway slope, ft/ft
K = NRCS Conveyance Factor (see Table 5-6)
V = Travel time velocity, ft/s

Table 5-6 NRCS Conveyance Factor, K

Type of Land Surface	NRCS Conveyance Factor
Tillage/Field	5
Short pasture and lawns	7
Nearly bare ground	10
Grassed waterway	15
Paved areas and shallow paved swales	20

5.5.1.4 Urban Check

For developed and urbanizing basins, the maximum time of concentration shall not exceed the time of concentration calculated by the urban check equation as follows:

$$t_c = \frac{L_t}{180} + 10$$ Eq. 5.5.1.4

Where:

L_t = Waterway length, ft

The minimum time of concentration for urbanizing areas is 5 minutes and the minimum time of concentration for non-urbanizing areas is 10 minutes.

5.5.2 Larger Basin Rainfall Methods

Based on Table 5-1, areas larger than 160 acres require use of the SWMM, developed by the Environmental Protection Agency (EPA). The designer should use the most up-to-date version of SWMM.

Any supporting modeling data should be included in the drainage report appendices, so that review staff can adequately review the model. Supporting documentation should include basin information, infiltration method used (with supporting coefficients, curve numbers, soil types), rainfall data, stage-storage curves for ponds and any other pertinent information for the model. Electronic submittals of the SWMM model are required with each submittal package for review by County staff.

5.6 ROADS, INLETS, AND STORM DRAINS

Stormwater collection and conveyance systems (roads, inlets, and storm drains) for new developments shall be designed to convey the 100-year storm event to the proposed detention/retention pond. Street flooding may occur, in which case traffic is disrupted as the street functions as an open channel (see Section 5.8). In these cases, the design engineer shall ensure that any flooding or surcharge of the system shall maintain public safety, minimize flood damages, and allow for emergency vehicle access as required by the local agency.

Sizing of inlets, pipe systems, culverts or other drainage collection systems on private development sites should be designed to safely convey flows through the site, in a manner that will protect the site's users from harm and will not cause damage to on-site structures. The design engineer for the project shall provide calculations for pipe sizes, overtopping of roads, ditches, etc., such that the County's review engineers can verify that the drainage on-site is safe for users. The County reserves the right to comment on private drainage systems that they see as being unsafe or inadequate for the intended site use. The 100-year developed flows must be transported safely to the site's detention pond for a controlled release.

For information regarding the design of stormwater collection and conveyance systems, refer to Chapter 8, Article XI, of the Weld County Code and the *Streets, Inlets, and Storm Drains* chapter of the USDCM, Volume 1.

5.6.1 Applicable Software

It is acceptable to use HydroFLOW, CivilStorm, HY-8, FlowMaster, and StormCAD softwares to determine the hydraulic characteristics of storm networks/culverts. Inlet spread calculations and street capacities with curb and gutter to be analyzed using newest version available of MHFD's UD-Inlet spreadsheets provided on their website. Alternative modeling software may be used upon approval by the Department of Public Works.

5.6.2 Roadway Drainage

Roadway classifications in Weld County are described in Section 2.1 of this WCECC and include freeways (interstates), county highways, arterials, collectors, local roads, and privately maintained roads. For collector roads, local roads, and privately maintained roads, the maximum encroachment depth over the roadway crown is 6 inches during the 10-year storm and 18 inches during the 100-year storm.

Allowable roadway overtopping for interstates, county highways, and arterials shall be determined by the Public Works Director or Designee.

5.6.3 Inlets

The design guidelines provided in the *Streets, Inlets, and Storm Drains* chapter of the USDCM, Volume 1 should be used when designing stormwater inlets. In general, the allowable road capacity and maximum encroachment depth shall dictate the placement of inlets. Inlets should be placed at low points (sumps), median breaks, intersections, super-elevation transitions, and before cross walks and bridges, as required. The standard inlets permitted for use in Weld County streets and roads are shown in Table 5-7. Weld County has adopted CDOT (Type C, Type D, Type R and Type 13) and Greeley (Combination Type 3) Inlet detail, with modifications as provided in details sheets. See Appendix J. Note: Inlet Types C and D will require close mesh grates as directed by Weld County.

Table 5-7 Inlets for Weld County

Inlet Type	Permitted Use
Curb Opening Inlet Type R	All street types with 6-inch vertical curb
Grated Inlet Type C, D	Roadside ditches or swales
Grated Inlet Type 13	Alleys or private drives with a valley gutter
Combination Inlet Type 3	All street types with 6-inch vertical curb

Various factors, such as debris clogging, pavement overlaying, and variations in design assumptions can decrease the capacity of inlets. To account for these factors, Weld County recommends that the theoretical capacity calculated for inlets be reduced by the factors presented in Table 5-8.

Table 5-8 Theoretical Capacity of Inlets for Weld County

Condition	Inlet Type	Percent of Theoretical Capacity Allowed
Sump or continuous grade	Curb Opening Type R (5-ft Length) [2]	88
	Curb Opening Type R (10-ft Length) [2]	92
	Curb Opening Type R (15-ft Length) [2]	95
Continuous grade	Combination Inlet Type 3	66
Sump	[1]Grated Inlet Type C or D[2]	50
	Grated Inlet Type 13[2]	50
	Combination Inlet Type 3	65

[1] Type C and D inlets shall not be placed in roadways

[2] CDOT Standards, with modifications

5.6.4 Pipes

The design guidelines provided in the *Streets, Inlets, and Storm Drains* chapter of the USDCM, Volume 1 should be used when designing stormwater pipes. Pipe networks shall be sized to convey the 10-year

storm event while flowing at 80 percent of the full pipe capacity. In the 100-year event, the hydraulic grade line (HGL) shall be kept at least one foot below manhole lids, inlet grates, and inlet curb openings.

The calculated HGL for both the minor and major storm events shall be provided on all proposed final storm profile views. The minimum flow velocity (for both storm events) shall be 3 ft/s to minimize sediment deposition. Maximum flow velocity (for both storm events) shall not exceed 18 ft/s to minimize scour at the outlet. Erosion protection at the pipe outlet is required for all velocities greater than or equal to 3 ft/s. Riprap should be used at pipe outlets and have a minimum D_{50} of 9 inches (Type L).

The minimum allowable size for a storm sewer within a public right-of-way or public drainage easement shall be 15 inches in diameter or equivalent. The Department of Public Works should be contacted to determine which types of storm sewer pipes are permissible for use in public rights of way or public drainage easements. Pipes constructed under the travel lanes of a new public roadway shall be reinforced concrete pipe (RCP), Class 3 strength or greater, depending on traffic loading, or an approved equivalent. All RCPs shall have a minimum cover of 12 inches above the pipe crown and bell to the bottom of pavement section (asphalt or concrete) at the edge of the roadway. A minimum of 12 inches of cover above the pipe crown to the top of the finished grade is required for gravel roads. If 12 inches of cover is not possible, the pipe material must be rated for a minimum of HS-20 loading or the largest expected loads crossing it (i.e., oil rigs, semi-trucks, etc.). The contractor must provide shop drawings for any precast concrete box culvert (CBC) to be approved for use by the engineer.

The Manning's roughness coefficient "n" for all storm sewer capacity calculations in Weld County shall be 0.013 regardless of pipe material (e.g., concrete, polyvinyl chloride [PVC], or high-density polyethylene [HDPE])—with the exception of aluminized corrugated metal pipe (CMP), which shall have a coefficient of 0.025. However, the designer should take note that only RCP and CMP are allowed in public ROW due to ditch burning. Any other pipe material used shall only be placed outside of public ROW, or upon approval by the Department of Public Works.

5.6.5 Manholes

Manholes shall be provided to allow for inspection and maintenance of stormwater systems. At a minimum, manholes shall be placed at all pipe junctions, changes in pipe size or material, and changes in grade and alignment. For long straight runs of pipe, the distance between manholes shall be limited to 400 feet (for pipe diameters < 42 inches) and 500 feet (for pipe diameters ≥ 42 inches). Manhole lids shall not be located within the vehicle wheel path.

Table 5-9 Manhole Sizes

Storm Pipe Diameter (inches)	Manhole Diameter (ft)
15 inches to 18 inches	4 ft
21 inches to 30 inches	5 ft
36 inches to 54 inches	6 ft
60 inches +	CDOT Standard M-604-20

It shall be noted that the designer should review the incoming and outcoming pipe angles to ensure that the manhole diameter can accommodate the pipe skew, when the pipe sewer alignment is not straight

through, or when more than one sewer line goes through the manhole. Steps shall be provided to allow safe access into the manhole. Manhole details are provided in Appendix J

5.7 OPEN CHANNELS, ROADSIDE DITCHES, AND GRASS SWALES

It is important to distinguish the difference between channels, ditches, and swales. Open channels and grass swales often are existing drainage conveyances that either carry large offsite flows around a site or carry onsite flows to a detention pond on-site. County-owned roadside ditches are common along rural roads and provide runoff conveyance for the County's roadway infrastructure. Irrigation ditches are not considered to fall under any of these definitions and shall be treated as separate infrastructure altogether.

Open channels, grass swales, storm pipe systems, and culverts located on new development sites need to ensure runoff from the developed site for the 100-year storm event can safely reach the on-site detention pond with adequate capacity and freeboard. This can be a combination of overland flow, pipes, or swales to get the runoff to the pond, without it leaving the site. The design engineer needs to provide calculations to show that the 100-year developed flows make it to the pond without overtopping or exceeding the capacity of the proposed drainage system. Any off-site flows that are planned to be routed around the developed site must be designed using a 100-year runoff value, so that no unplanned flows enter the proposed site that were not planned for in the detention pond's spillway calculations.

Roadway ditches that are designed by consultants for the County (for County-owned and maintained roadways only) may use a developed runoff from the 10-year, 1-hour storm event in their ditch designs. For more information regarding the design of open channels, refer to Chapter 8, Article XI, of the Weld County Code and the *Open Channels* chapter of the USDCM, Volume 1. Information regarding the design of roadside ditches is provided in the *Streets, Inlets, and Storm Drains* chapter of the USDCM, Volume 1. If grass swales are used, they shall be designed in accordance with the Grass Swales Fact Sheet (T-2) of the USDCM, Volume 3.

5.7.1 Applicable Software

The design of open channels, grass swales, and roadside ditches is to be completed in FlowMaster or Hydraflow Express Extension for Autodesk software. Channels, swales, and roadside ditches will be designed to account for any erosive or hazard conditions.

It is acceptable to use USACE's HEC-RAS software to determine the hydraulic characteristics of large open channels. HEC-RAS modeling shall be performed to align with standard modeling practices accepted by FEMA.

It is the designer's responsibility to effectively model erosive, hazard, or local scour in a channel for estimating maximum velocities. The designer shall create a model that adequately places the correct number of cross sections in the necessary locations to accurately make an evaluation of velocities throughout the channel to determine its erosive and scour potential.

5.7.2 Open Channels and Swales

Generally, channels and swales should be designed as a trapezoidal shape with a minimum two-foot bottom width and side slopes no steeper than 4:1. If, however, steeper slopes are required due to site

constraints, the design engineer should address how the channels will be maintained, since it may not be safe to mow on slopes that are greater than 4:1. The design engineer also should consider the appropriate seed mix and seeding application method when determining side slopes. More information on seed mixes and revegetation can be found in Chapter 6 of this WCECC.

Open channels and swales shall be designed to allow the 100-year design flow plus a minimum of one foot of freeboard. However, channels conveying less than 20 cfs may reduce the minimum one-foot freeboard requirement to the freeboard required to convey 1.33 times the 100-year design flow. The reduced freeboard may only occur if a one-foot minimum freeboard is not physically possible and calculations are submitted.

Hydraulic structures (check/drop structures, bridges, transitions, constrictions, bends, confluences, rundowns) associated with open channels shall be designed for the 100-year storm event. For more information regarding the design of hydraulic structures, refer to Chapter 8, Article XI, of the Weld County Code, the most recent version of *Hydraulic Structures* chapter of the USDCM, Volume 2, and Chapter 4.7 - Bridges of this WCECC.

MHFD has published guidelines for typical Manning's n values and other design criteria for "V" and trapezoidal swales. Table 5-10 through Table 5-12 and Figure 5-2 and Figure 5-3 below provide guidance for channel design.

Table 5-10 Roughness Coefficients ("n") for Channel Design (After Chow 1959)

Channel Type	Roughness Coefficients (n)		
	Minimum	Typical	Maximum
I. Excavated or Dredged			
1. Earth, straight and uniform			
a. Gravel, uniform section, clean	0.022	0.025	0.030
b. With short grass, few weeds	0.022	0.027	0.033
2. Earth, winding, and sluggish			
a. Grass, some weeds	0.025	0.030	0.033
b. Dense weeds or aquatic plants	0.030	0.035	0.040
c. Earthy bottom and rubble/riprap sides	0.028	0.030	0.035
3. Channels not maintained, weeds and brush uncut			
a. Dense weeds, high as flow depth	0.050	0.080	0.120
b. Clean bottom, brush on sides	0.040	0.050	0.080
II. Natural streams (top width at flood stage 100 ft)			
1. Streams on plain			
a. Clean, straight, full stage, no rifts or deep pools	0.025	0.030	0.033
b. Clean, winding, some pools and shoals, some weeds and stones	0.035	0.045	0.050
c. Very weedy reaches, deep pools, or floodways with heavy stand of timber and underbrush	0.075	0.100	0.150
III. Lined or Built-Up Channels			
1. Concrete			
a. Trowel/float finish	0.011	0.015	0.016
b. Shotcrete	0.016	0.020	0.025
2. Gravel bottom with sides of:			
a. Formed concrete	0.017	0.020	0.025
b. Random stone in mortar	0.020	0.023	0.026
c. Dry rubble or riprap	0.023	0.033	0.036
3. Wetland Bottom Channels	See Figure 5-2		
4. Grass-Lined Channels and Swales	See Figure 5-3		

Figure 5-2 Manning's n vs. Depth for Low-Flow Section in a Composite Channel

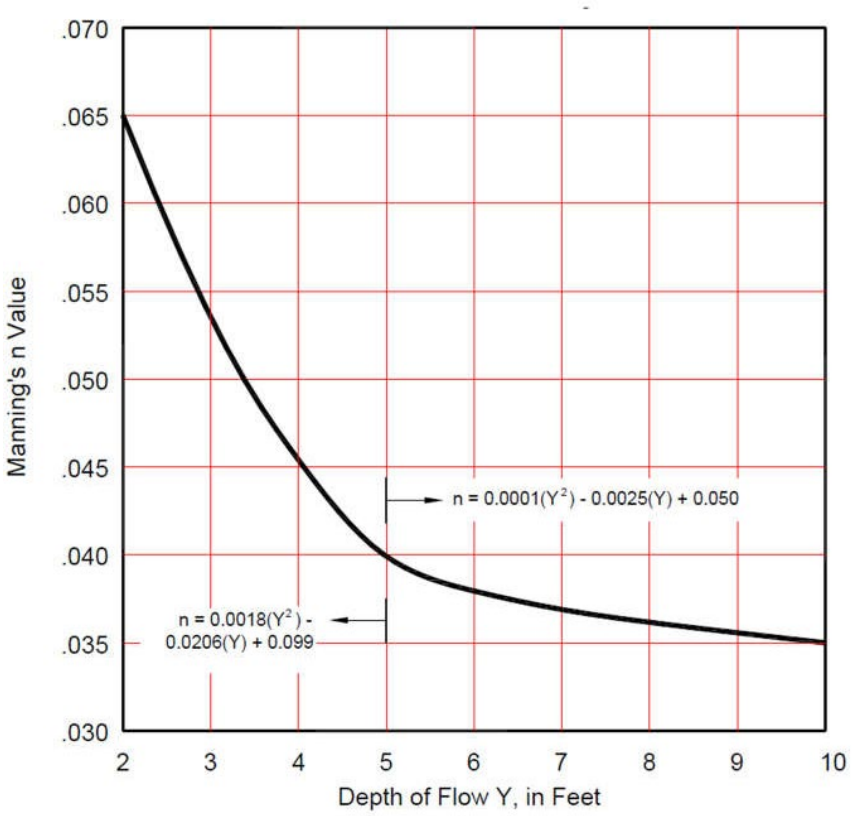
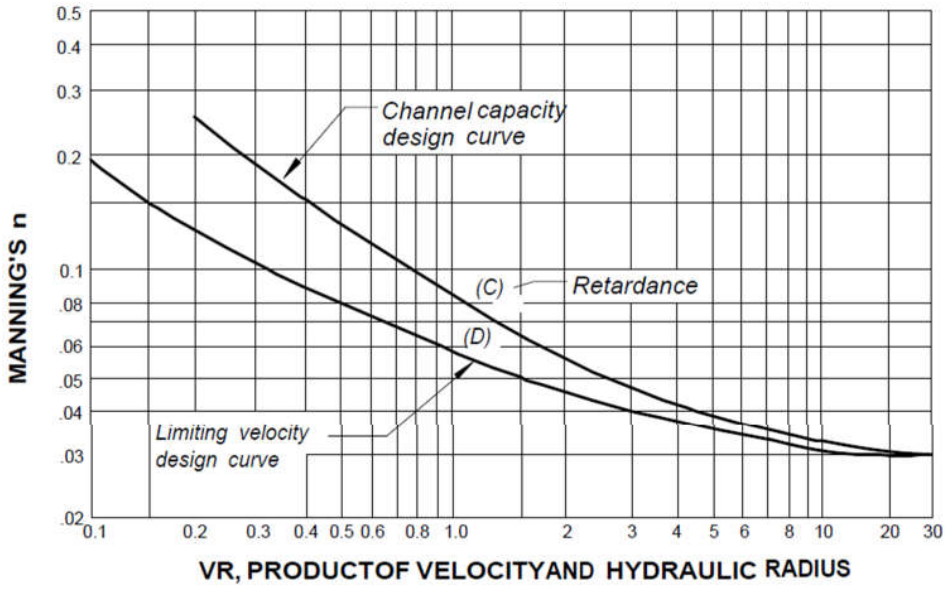


Figure 5-3 Manning's n vs. VR for Two-Retardances in Grass-Lines Channels



From "Handbook of Channel Design For Soil and Water Conservation,: U.S. Department of Agriculture, Soils Conservation Service, No. SCS-TP-61 March, 1947, Rev. June, 1954

Table 5-11 Trapezoidal Channel Design Guidance/Criteria

Design Item	Criteria for Various Types of Channel Lining			
	Grass: Erosive Soils	Grass: Erosion Resistant Soils	Riprap	Concrete
Maximum 100-yr Velocity	3.0 ft/sec	5.0 ft/sec	12.0 ft/sec	18.0 ft/sec
Minimum Manning's n - capacity check	0.030	0.030	0.030	0.011
Maximum Manning's n - capacity check	0.035	0.035	0.040	0.013
Maximum Froude Number	0.5	0.8	0.8	n/a
Maximum side slope	4H:1V	4H:1V	2.5H:1V	1.5H:1V
Minimum centerline radius for a bend	2 x top width	2 x top width	2 x top width	2 x top width
Minimum freeboard	1.0 ft	1.0 ft	1.0 ft	1.0 ft

5.7.3 Roadside Ditches

The designer shall design flexible ditch linings based on FHWA's *Design of Roadside Channels with Flexible Linings*, Hydraulic Engineering Circular No. 15 (HEC-15) guidelines and should coordinate with the Department of Public Works for approval of the chosen lining. Riprap-lined ditches shall have a minimum D_{50} of 9 inches (Type L).

Roadside ditches shall be designed to maintain a minimum of one foot of freeboard during the 10-year storm event. Design criteria, provided in the previous Open Channels and Swales section, should be used in the design of roadside ditches as well.

5.8 CULVERTS

Culverts are structures that convey flow through embankments such as roadways and railroads and should not be confused with storm drainage systems. If a project uses culverts in any facet and connects to County facilities, then the culvert and associated facilities must convey the 100-year storm event flow. A culvert is required for every new access point or supporting documentation must be provided to the County to show that a culvert is not needed. For more information regarding the design of culverts, refer to Chapter 8, Article III, Article XI, and Appendix 8-B of the Weld County Code and the *Culverts and Bridges* chapter of the USDCM, Volume 2. See also the latest edition of AASHTO's *Roadside Design Guide*.

5.8.1 Applicable Software

It is acceptable to use FHWA's HY-8 or CulvertMaster culvert analysis software to determine the hydraulic characteristics of culverts. Alternative modeling software may be used upon approval by the Department of Public Works.

5.8.2 Sizing

Culverts shall be sized such that any roadway overtopping meets allowable street capacity and maximum encroachment depth requirements. The minimum allowable size for a culvert within a public right-of-way or public drainage easement shall be 15 inches in diameter or equivalent. Weld County may require additional culvert capacity to prevent flooding and backwater effects on adjacent properties.

The storm drainage system for a developed site, via culverts, inlets, swales, pipe systems, must provide adequate capacity to safely convey the 100-year developed runoff to the site's detention/retention pond without leaving the site. If the culvert/pipe system is undersized and results in flooding, the flooding must be contained onsite. It should be shown that on-site flooding does not impact permanent structures or buildings on-site. Developed runoff from the site may not adversely impact adjacent or downstream properties.

The maximum overtopping of local or collector County roads during the 10-year storm event is 6 inches and 18 inches in the 100-year event. However, the County prefers to minimize overtopping to the greatest extent possible. Allowable roadway overtopping for county highways and arterials shall be determined by the Public Works Director or Designee. Private culverts/swales within developments must be sized to provide adequate capacity to carry runoff from the 100-year event safely to the proposed detention/retention pond.

Additionally, culverts must be sized to meet the maximum headwater to depth ratios (HW/D) listed in Table 5-12.

Table 5-12 Maximum HW/D Requirements for Weld County

Range of Diameter or Height or Rise (Inches)	Maximum HW/D
Less than 36 inches	2.0
36 inches to 60 inches	1.7
Larger than 60 inches but less than 84 inches	1.5
84 inches to less than 120 inches	1.2
120 inches or larger	1.0

Culverts shall be installed to the minimum slope required to achieve a minimum flow velocity of 3 ft/s to minimize sediment deposition within the pipe. The slope should be checked for each design, and if the proper minimum velocity is not obtained, other design options should be evaluated. Maximum velocity at the culvert exit should be consistent with the velocity in the channel to which it discharges so as to reduce the risk of scouring at the culvert outlet. Energy dissipators may be required and shall be designed per the most recent version of *Hydraulic Structures* chapter of the USDCM, Volume 2, and the guidelines in the FHWA *Hydraulic Design of Energy Dissipators for Culverts and Channels*, Hydraulic Engineering Circular No. 14 (HEC-14).

5.8.3 Materials

Weld County allows the installation and use of commonly available culvert types such as RCP and aluminized CMP within the public right-of-way. Weld County will allow the use of other culvert types on a case-by-case basis when complete documentation of all culvert specifications is provided. It should be noted that pipe materials that do not withstand high temperatures (burning of roadside ditches), should not be used within the County ROW.

5.8.4 Cover

All culverts must be installed with a minimum of 12 inches of cover above the pipe crown and bell to the bottom of asphalt at the edge of pavement (for paved roads) and a minimum of 12 inches of cover above the pipe crown to the top of the finished grade (for gravel roads). If 12 inches of cover is not possible, the culvert material must be rated for a minimum of HS-20 loading or the largest expected loads crossing it (i.e., oil rigs, semi-trucks, etc.).

5.8.5 End Sections and Safety Grate

At a minimum, culverts installed in public rights-of-way must be equipped with a flared end section or headwalls on the culvert entrance and outlet, as directed by Public Works. Cutoff walls below the outlet end section shall be 4,500 psi concrete with epoxy coated #5 rebar 12” on center each way, three inches clear from all earthen edges, 8” wide x 3’ deep and 2’ beyond each outside edge of the end section. There may be situations in which other types of culvert inlets are necessary. In those situations, the design methodologies outlined in the *Culverts and Bridges* chapter of the USDCM, Volume 2 should be used.

Safety grates are strongly recommended at culvert entrances to prevent people, animals, and large debris from inadvertently entering a culvert. Safety grates shall not be placed at the outlet of culverts or storm drains. The following conditions may require use of a safety grate:

- It is not possible to see daylight from one end of the culvert to the other.

- The culvert is less than 42 inches in diameter.
- Conditions within the culvert (bends, obstructions, vertical drops) or at the outlet are likely to trap or injure a person.

Exceptions to the above criteria consist of street curb-opening inlets and driveway culverts that are subject to ponding depths no greater than 12 inches at the flowline and culvert entrances that are made inaccessible to the public by fencing.

Sound engineering judgement should be used to determine the need for a safety grate while also considering hydraulic forces and clogging potential. Undersized or poorly designed grates can become clogged during heavy runoff and the culvert may be rendered ineffective. Additionally, the surrounding site features and depth and velocity of flow may increase the risk of pinning a human or animal against the grate. To minimize these hazards, safety grates should be sized according to the *Outlet Structures* Fact Sheet (T-12) of the USDCM, Volume 3 and designed to meet the following criteria:

- Grates should be inclined at a slope no steeper than 3:1 (flatter is better) and have a clear opening at the bottom of no more than 9 inches to permit passage of debris and bed load at lower flows.
- Weld County does not allow the use of collapsible gratings.

5.8.6 Maintenance

The County will maintain culverts located within the County ROW. Private property owners are responsible for maintenance of their culverts. Culverts that are part of a subdivision drainage plan are maintained by the respective homeowner's association. Those culverts should be maintained and cleaned out on an as-needed basis to ensure proper drainage of the subdivision. Safety grates should be inspected and cleaned after every large storm event (at a minimum) to ensure that the systems remain effective and that clogging and pinning risks are minimized.

5.9 RIPRAP

Riprap should be included on the downstream end of culverts and pipe systems to provide erosion protection. The following direction should be used when designing riprap aprons at the outlet of culverts and pipe systems. Mirafi FW-300 or approved equivalent shall be installed under all riprap.

5.9.1.1 Configuration of Riprap Apron

Figure 5-4 illustrates typical riprap protection of culverts outlets.

5.9.1.2 Extent of Protection

The length of the riprap protection downstream from the outlet depends on the degree of protection desired. If it is necessary to prevent all erosion, the riprap must extend until the velocity decreases to an acceptable value. The acceptable major event velocity is set at 3 ft/sec for non-cohesive soils and at 5 ft/sec for erosion resistant soils. The rate at which the velocity of a jet from a conduit outlet decreases is not well known. The procedure recommended here assumes the rate of decrease in velocity is related to the angle of lateral expansion, θ, of the jet. The velocity is related to the expansion factor, $\left(\frac{1}{2\tan\theta}\right)$, which can be determined directly using Figure 5-5 or Figure 5-6 by assuming the expanding jet has a rectangular shape:

$$L_p = \left(\frac{1}{2\tan\theta}\right)\left(\frac{A_t}{Y_t} - W\right)$$ Eq. 5.9.1

Where:

L_p = Length of protection (ft)
W = Width of the conduit (ft, use diameter for circular conduits)
Y_t = Tailwater depth (ft)
θ = The expansion angle of the culvert flow

and:

$$A_t = \frac{Q}{V}$$ Eq. 5.9.2

Where:

A_t = required area of flow at allowable velocity (ft^2)
V = the allowable non-eroding velocity in the downstream channel (ft/sec)
Q = design discharge (cfs)

For **Eq. 5.9.1**:

- If the tailwater elevation is unknown or unable to be calculated, a value of 0.4 x the culvert height or pipe diameter may be used for Y_t.
- The expansion factor $\left(\frac{1}{2\tan\theta}\right)$ can be found from Figure 5-5 and Figure 5-6 shown below, after calculating $Q/D^{2.5}$.
- In the calculations for A_t, the allowable non-eroding velocity in the downstream channel should be:
    - 3.0 ft/sec for erosive soils
    - 5.0 ft/sec for non-erosive soils

In certain circumstances, Eq. 5.9.1 may yield unreasonable results. Therefore, in no case should L_p be less than 3H or 3D, nor does L_p need to be greater than 10H or 10D whenever the Froude parameter, $Q/WH^{1.5}$ or $Q/D^{2.5}$, is less than 8.0 or 6.0, respectively. Whenever the Froude parameter is greater than those maximums, increase the maximum L_p required by ¼D_c or ¼H for circular or rectangular (box) culverts, respectively, for each whole number by which the Froude parameter is greater than 8.0 or 6.0, respectively.

Once L_p has been determined, the width of the riprap protection at the furthest downstream point should be verified. This dimension is labeled "T" on Figure 5-4. The first step is to solve for θ using the results from Figure 5-5 or Figure 5-6:

$$\theta = tan^{-1}\left(\frac{1}{2(ExpansionFactor)}\right)$$ Eq. 5.9.3

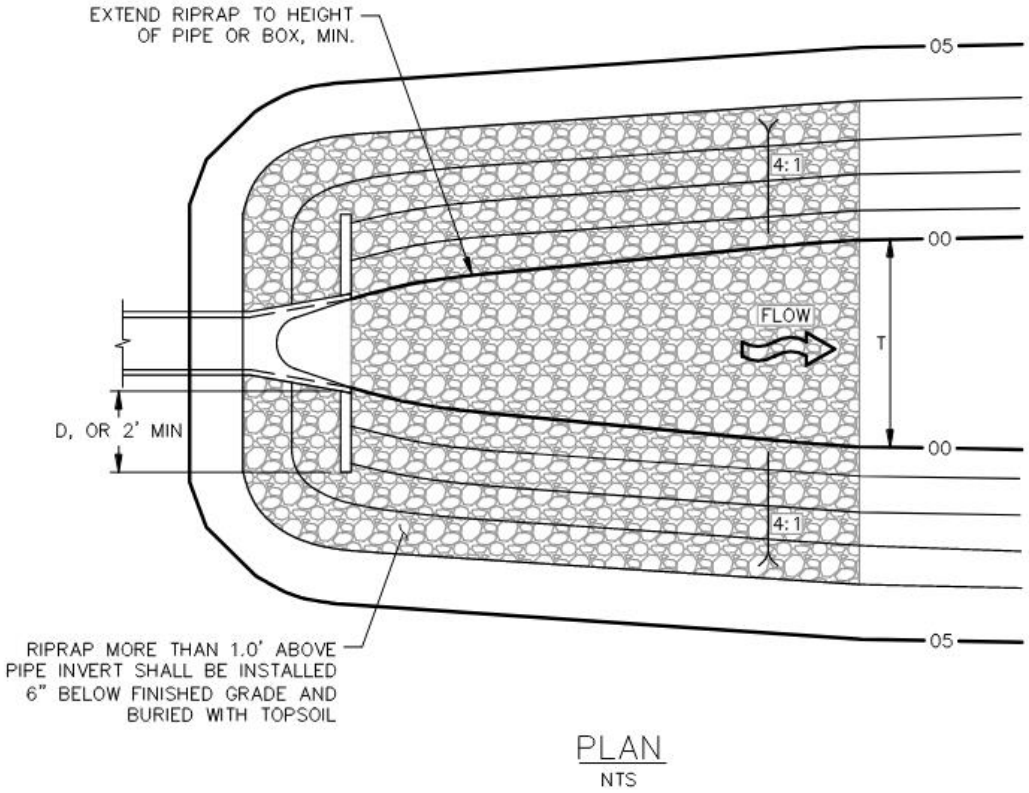
Where:

- Expansion Factor = determined using Figure 5-5 or Figure 5-6

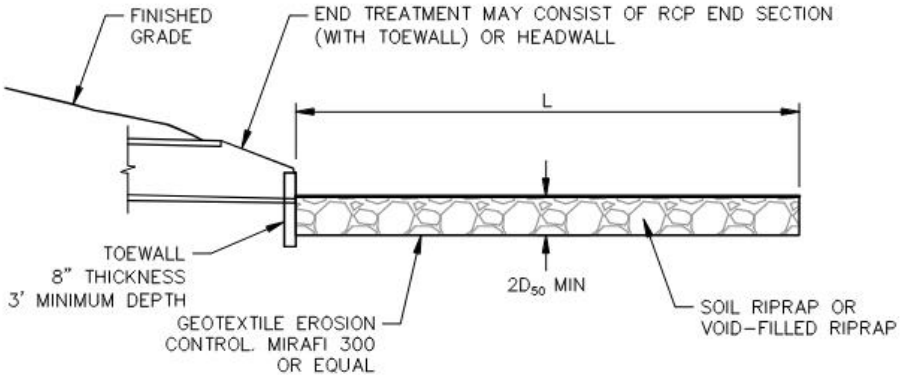
T then is calculated using the following equation:

$$T = 2(L_p tan\theta) + W \qquad \text{Eq. 5.9.4}$$

Figure 5-4 Riprap Apron Detail for Culverts In Line with the Channel (USDCM, Vol 2 Figure 9-34)



PLAN
NTS



PROFILE
NTS

Figure 5-5 Expansion Factor for Circular Conduits (USDCM, Vol 2 Figure 9-35)

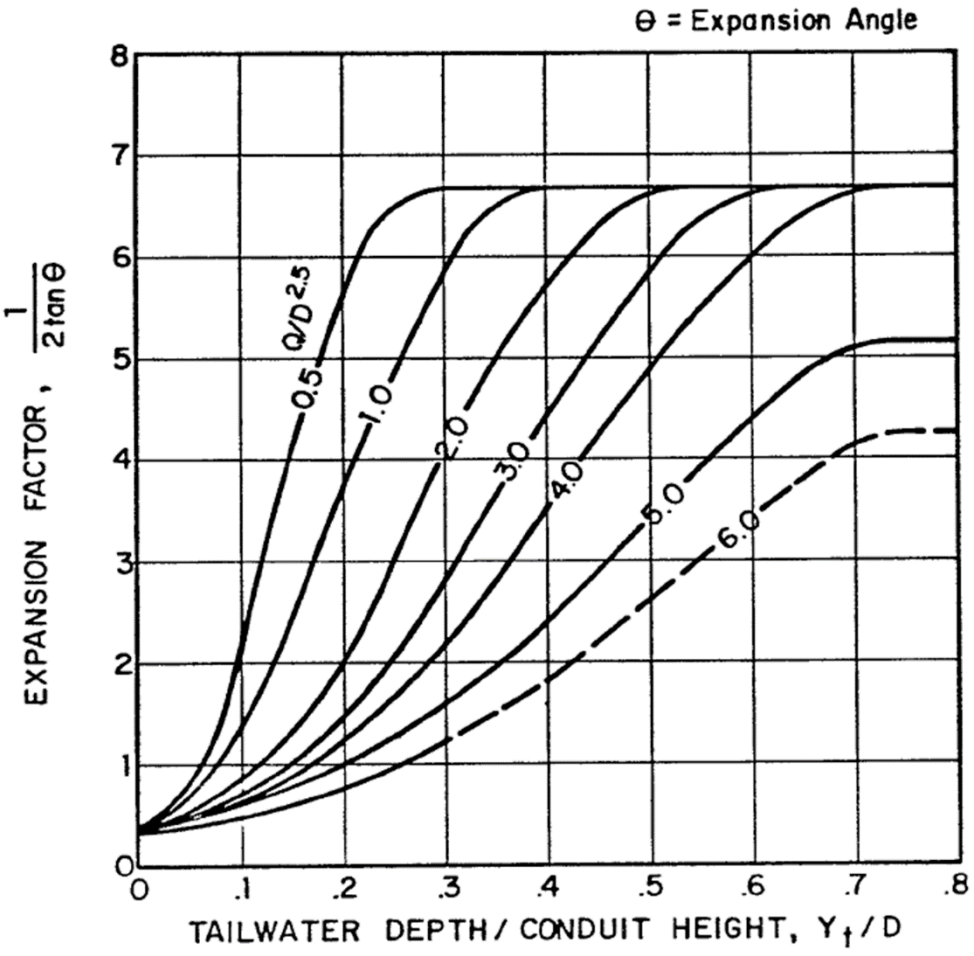
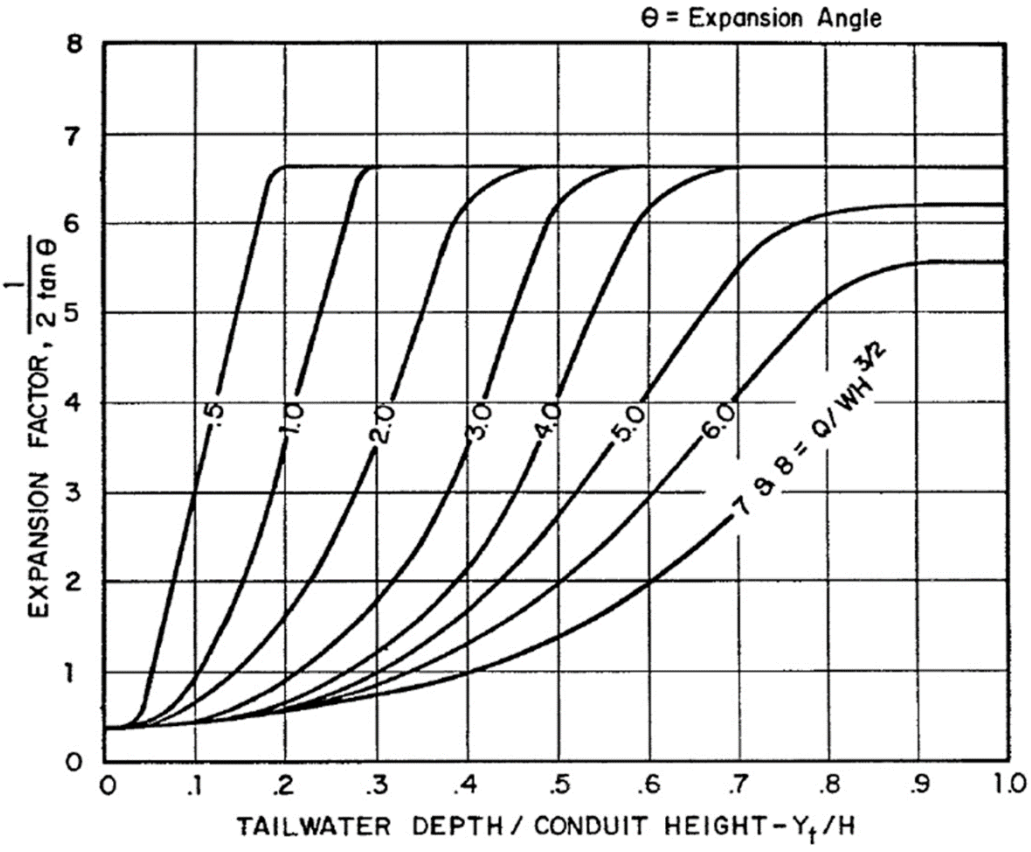


Figure 5-6 Expansion Factor for Rectangular Conduits (USDCM, Vol 2 Fig 9-36)



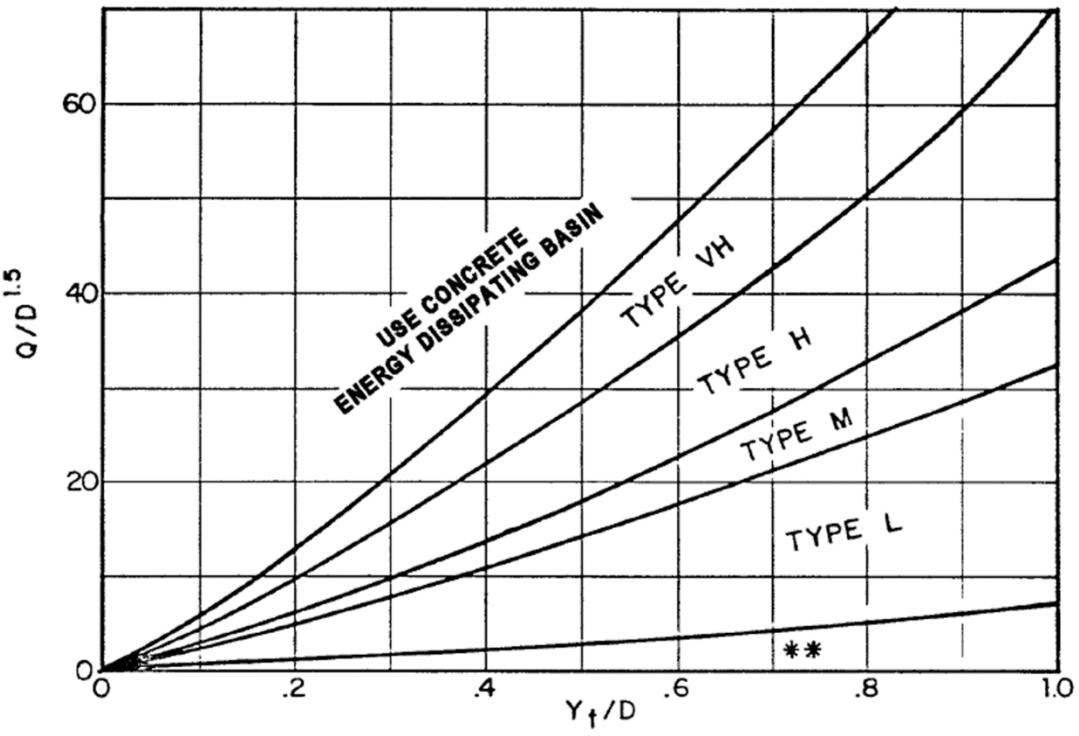
The size of riprap can be found using the following graph after calculating $Q/D^{1.5}$ and Y_t/D_c and reading the value from Figure 5-7 and Figure 5-8, shown below.

Use Figure 5-7 to determine the required rock size for circular conduits and Figure 5-8 for rectangular conduits. Figure 5-7 is valid for $Q/D_c^{2.5}$ of 6.0 or less and Figure 5-8 is valid for $Q/WH^{1.5}$ of 8.0 or less. The parameters n these two figures are:

$Q/D^{1.5}$ or $Q/WH^{0.5}$ in which Q is the design discharge in cfs, D_c is the diameter of a circular conduit in feet, and W and H are the width and height of a rectangular conduit in feet.

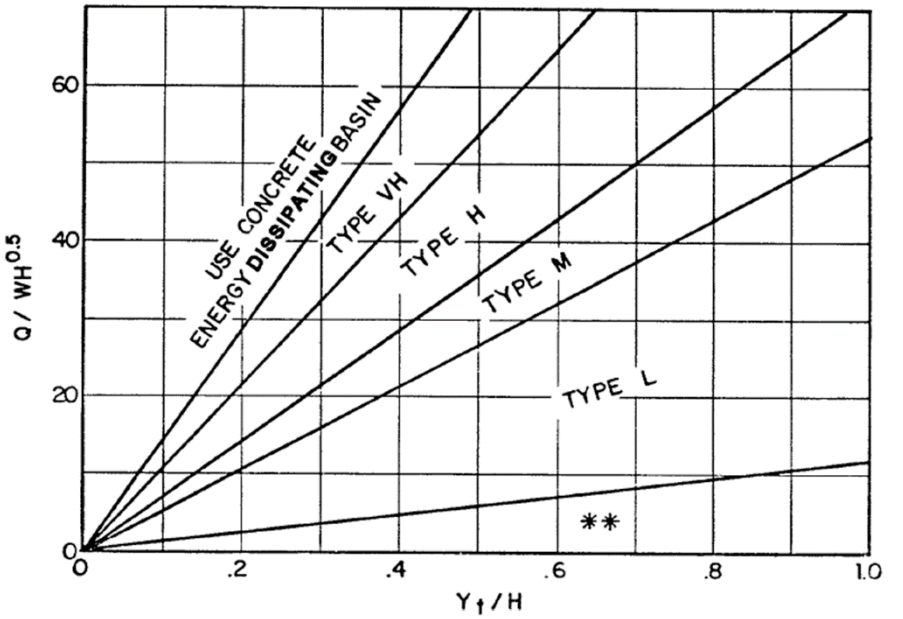
Y_t/D_c or Y_t/H in which Y_t is the tailwater depth in feet, D_c is the diameter of a circular conduit in feet, and H is the height of a rectangular conduit in feet. In cases where Y_t is unknown or a hydraulic jump is suspected downstream of the outlet, use $Y_t/D_t = Y_t/H = 0.40$ when using Figure 5-7 and Figure 5-8.

Figure 5-7 Riprap Erosion Protection at Circular Conduit (Valid for Q/D2.5≤6.0) (USDCM, Vol 2 Figure 9-38)



Use D_a instead of D whenever flow is supercritical in the barrel.
** Use Type L for a distance of 3D downstream.

Figure 5-8 Riprap Erosion Protection at Rectangular Conduit Outlet (Valid for Q/WH1.5≤8.0) (USDCM, Vol 2 Figure 9-39)



Use H_a instead of H whenever culvert has supercritical flow in the barrel.
**Use Type L for a distance of 3H downstream.

After selecting the riprap size, the minimum thickness of the riprap layer is defined as:

$$T = 2D_{50} \qquad \text{Eq. 5.9.5}$$

Table 5-13, below, identifies d_{50} based on riprap classification and gradation.

Table 5-13 Classification and Gradation of Ordinary Riprap

Riprap Designation	% Smaller Than Given Size by Weight	Intermediate Rock Dimensions (inches)	d_{50} (inches)*
Type VL	70-100 50-70 35-50 2-10	12 9 6 2	6**
Type L	70-100 50-70 35-50 2-10	15 12 9 3	9**
Type M	70-100 50-70 35-50 2-10	21 18 12 4	12**
Type H	70-100 50-70 35-50 2-10	30 24 18 6	18
Type VH	70-100 50-70 35-50 2-10	42 33 24 9	24

* d_{50} = mean particle size (intermediate dimension) by weight.

** Mix VL and L riprap with 30% (by volume) topsoil and bury it with 6+ inches of topsoil, all vibration compacted, and revegetate.

5.10 STORAGE

Weld County requires regional and/or on-site detention for all future developments. The County shall be contacted to verify if any existing drainage master plans exist in the area of work. If it is determined that there is an existing master plan for the area of work, the designer shall incorporate that information into the design and ensure that the design follows the drainage requirements set forth in the masterplan.

The designer also should keep the following things in mind:

- Weld County does not allow detention release rates based on soil types.
- Weld County does not allow **full spectrum detention** to be used in sizing ponds (see Weld County's spreadsheets for storage capacity).

5.10.1 Retention

Stormwater retention facilities (stormwater infiltration facilities) normally are not allowed in Weld County but shall be considered for special circumstances with the issuance of a variance. Variance requests shall only be considered in situations where there is a proven hardship on the proposed site. A hardship would be considered where there is not adequate topography to physically drain a pond (sump in basin), refusal of an irrigation ditch to accept additional drainage, or some other physical site constraint. Variances shall be reviewed on a case-by-case basis to determine the validity of the hardship and shall be signed by the Development Review Engineer. Upon the determination that a retention pond is applicable, the volume should be calculated as 1.5 x the developed site runoff for the 100-year,

24-hour storm event plus 1 foot of additional freeboard. An emergency spillway is required for retention ponds.

Retention ponds may be sized using the "Modified FAA" tab on the spreadsheet referenced in the "Detention" portion of this document, using a near zero release rate per acre and extending the rainfall duration to 1440 minutes (24-hours x 60 minutes). The resulting volume at the 1440-minute interval shall be the value that must be multiplied by 1.5 for the final retention pond volume.

A second method for calculating retention pond volume is:

Volume = 1.5 x Area x C-Value x Rainfall

- Area = Site area draining to pond (acres)
- C-Value = Composite C-Value for area draining to pond (based on soil type and overall, developed impervious percentage for site)
- Rainfall – NOAA Atlas rainfall depth for site location, 100-year storm at 24-hours (in feet, divide NOAA rainfall depth in inches by 12)
- Volume = Required Volume for Retention Pond in acre-ft

The retention pond/infiltration facility shall be designed to meet Colorado Revised Statute 37-92-602 (8) drain time requirements. In order to meet the State Statute requirements, soil infiltration rates may be used to calculate pond drain times. However, soil infiltration rates cannot be used in the overall sizing of the detention/retention ponds. These requirements state that retention facilities:

- Be solely operated for stormwater management;
- Be owned and operated by a governmental entity or is subject to oversight by a governmental entity;
- Continuously releases or infiltrates at least 97 percent of all runoff from a rainfall event that is less than or equal to the 5-year storm within 72 hours after the end of the event;
- Continuously releases or infiltrates at least 99 percent of the runoff from a rainfall event that is greater than the 5-year storm within 120 hours after the end of the event; and
- Operates passively and does not provide active water treatment processes for the stormwater.

5.10.2 Detention

Developments are required to detain the runoff (developed site condition) produced by the 100-year, 1-hour storm event with 1 foot of additional freeboard. Pond release rates are based off the calculated undeveloped runoff value for the site. A 2-percent site imperviousness should be used to calculate the historic runoff rate for pond release values, regardless of site conditions prior to new site improvements.

Release rates are calculated using the 5-year, 1-hour storm for urbanizing areas and the 10-year, 1-hour storm for non-urbanizing areas. Urbanizing areas are defined as areas within one-quarter mile of any municipal boundary, as amended. Non-urbanizing areas are greater than one-quarter mile in distance from a municipal boundary. Municipal boundaries may be found on the County's GIS online mapping website. If the project site is within an urbanizing area or adjacent to a municipal boundary, the governing entity's drainage criteria must be taken into consideration. Weld County requires that the

more restrictive of the criteria (if municipality is more conservative) must be used in the drainage design of the site.

The design engineer shall submit all design worksheets for pond designs in the appendices of the drainage report for review. Rainfall data/depths should be site specific and taken from the NOAA Atlas 14, online precipitation frequency data server webpage. A UD-Detention v2.34 worksheet is available on the Weld County Planning and Zoning Development Review webpage. This spreadsheet is an older, archived version of the MHFD's spreadsheet, which utilizes the "Modified FAA" procedure for pond sizing with the County approved C-values. The County DOES NOT accept the full spectrum detention pond design method. The design consultant may use the downloadable spreadsheets or may create their own based on the information provided in this document. If created spreadsheets are utilized, they must comply with the design requirements in this document.

Rainfall duration times should be extended until the pond reaches a peak volume, after which the pond volume falls. If the peak is not reached within a reasonable time period (less than two to three hours ±) the volume at the 60-minute interval may be taken as the required detention volume for the site. If a series of detention ponds are proposed on-site, the County may require a SWMM model be created for the development, so that the pond volumes/water surface elevations can be analyzed as routed ponds.

An excerpt from a previous version of USDCM, Volume 2 on the Modified FAA procedure has been provided on the Weld County Planning and Zoning Development Review Webpage, and in Appendix F for reference, if the consultant would like to create their own pond-sizing spreadsheet.

The outlet works for detention and water quality facilities shall be designed to meet Colorado Revised Statute 37-92-602 (8), drain time requirements. In order to meet the State Statute requirements, soil infiltration rates may be used to calculate pond drain times. However, soil infiltration rates cannot be used in the overall sizing of the detention/retention ponds. These requirements state that detention facilities:

- Be solely operated for stormwater management;
- Be owned and operated by a governmental entity or be subject to oversight by a governmental entity;
- Continuously release or infiltrate at least 97 percent of all runoff from a rainfall event that is less than or equal to the 5-year storm within 72 hours after the end of the event;
- Continuously release or infiltrate at least 99 percent of the runoff from a rainfall event that is greater than the 5-year storm within 120 hours after the end of the event; and
- Operate passively and do not provide active water treatment processes for the stormwater.

5.10.2.1 Pond Layout Considerations

The geometry of a stormwater detention facility depends on specific site conditions such as adjoining land uses, topography, geology, preserving or creating wildlife habitat, and volume requirements.

Several key features must be incorporated in all detention facilities:

- Embankments and side slopes shall have a maximum slope of four feet horizontal to one foot vertical (4:1) and shall be stabilized. Slopes steeper than 4:1 in detention basin areas will not be accepted.

- Detention basin embankments shall be designed to withstand the 100-year and larger storm. Poorly compacted native soils shall be excavated and replaced. Embankment soils shall be compacted to at least 95 percent maximum density (Modified Proctor) or as specified in the geotechnical report for the site.
- Detention basin bottoms shall have a minimum slope of 1 percent for vegetated surfaces. If the desired slope is not attainable, a bottom slope of 0.5 percent may be used with a concrete trickle channel.
- Water quality and detention flows are released through an outlet structure. The minimum outlet pipe size for use in detention facilities is 12-inch diameter (or equivalent). Orifice/restrictor plates may be used to reduce flows from the minimum pipe sizes.
- When possible, place inflow culverts as far from the pond outlet as possible for increased water quality through pond vegetation.
- Inflow points shall enter the detention basin at or near the toe of the basin to prevent erosion along the basin embankments. If providing an inflow point at the toe of the basin is not feasible, then erosion protection must be provided from the inflow all the way to the toe of the basin.
- Detention basin bottom must be a minimum of 24 inches above the groundwater elevation. (Groundwater elevation data must be determined during high groundwater months.)
- Detention basins must be located a minimum of 20 feet away from an irrigation ditch or other facility, or more if specified by the owner of the irrigation canal and protected from seepage from the irrigation canal.
- Stormwater infiltration facilities shall not be placed in the FEMA mapped floodway and should not be placed in the FEMA mapped 100-year floodplain. Any berming within the floodplain will require a floodplain study, which may result in the need for a LOMR/CLOMR.

5.10.2.2 Water Quality

With drain time requirements in mind, the outlet works for an extended detention basin shall be designed to release the water quality capture volume (WQCV) over a 40-hour period. The WQCV may be calculated, along with the orifice hole sized, on the MHFD spreadsheet. An alternate method to calculate the required WQCV is to use the equations taken from USDCM, Volume 3 as shown below.

The WQCV is calculated as a function of imperviousness and BMP drain time using Eq. 5.10.2.1, and as shown in Figure 5-9:

$$WQCV = a(0.91i^3 - 1.19i^2 + 0.78i) \qquad \text{Eq. 5.10.2.1}$$

Where:

$WQCV$ = Water Quality Capture Volume (watershed inches)
a = Coefficient corresponding to WQCV drain time (5-)
i = Imperviousness (%/100)

Figure 5-9 Water Quality Capture Volume (WQCV) Based on BMP Drain Time (USDCM, Vol 3 Fig 3-1)

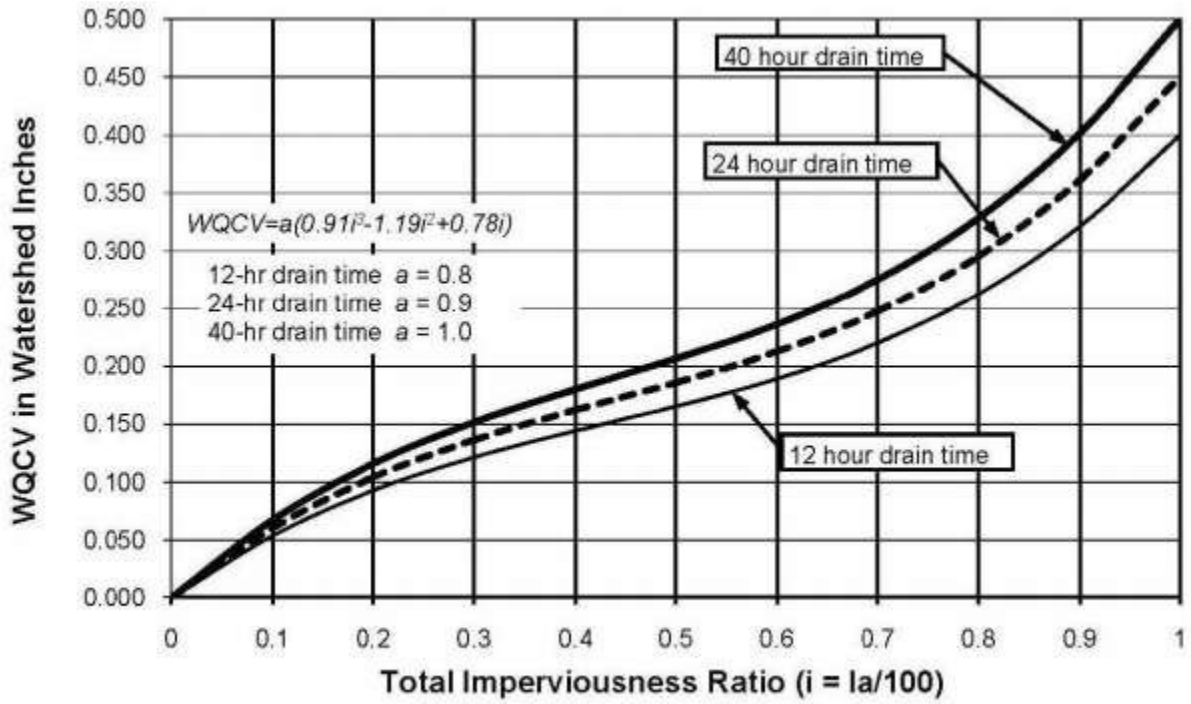


Figure 3-1. Water Quality Capture Volume (WQCV) Based on BMP Drain Time

Table 5-14 Drain Time Coefficients for WQCV Calculations

Drain Time (hrs)	Coefficient, a
12 hours	0.8
24 hours	0.9
40 hours	1.0

Weld County does not require the use of trash racks be placed in front of the water quality plate. It shall be at the discretion of the design engineer if trash racks are included. The WQCV is considered a part of the overall detention/retention volume requirement and should not be added to the volume.

The water quality orifice plate perforations also may be found using the chart in Table 5-15 only.

Table 5-15 WQCV Outlets Orifice Plate Perforation Sizing

Orifice Plate Perforation Sizing

Circular Perforation Sizing

This table may be used to size perforation in a vertical plate of riser pipe.

Hole Dia. (in.) *	Hole Dia. (in.)	Min. S_c (in.)	Area per Row (sq. in.)		
			n = 1	n = 2	n = 3
1/4	0.250	1	0.05	0.10	0.15
5/16	0.313	2	0.08	0.16	0.24
3/8	0.375	2	0.11	0.22	0.33
7/16	0.438	2	0.15	0.30	0.45
1/2	0.500	2	0.20	0.40	0.60
9/16	0.563	3	0.25	0.50	0.75
5/8	0.625	3	0.31	0.62	0.93
11/16	0.688	3	0.37	0.74	1.11
3/4	0.750	3	0.44	0.88	1.32
13/16	0.813	3	0.52	1.04	1.56
7/8	0.875	3	0.60	1.20	1.80
15/16	0.938	3	0.69	1.38	2.07
1	1.000	4	0.79	1.58	2.37
1 1/16	1.063	4	0.89	1.78	2.67
1 1/8	1.125	4	0.99	1.98	2.97
1 3/16	1.188	4	1.11	2.22	3.33
1 1/4	1.250	4	1.23	2.46	3.69
1 5/16	1.313	4	1.35	2.70	4.05
1 3/8	1.375	4	1.48	2.96	4.44
1 7/16	1.438	4	1.62	3.24	4.86
1 1/2	1.500	4	1.77	3.54	5.31
1 9/16	1.563	4	1.92	3.84	5.76
1 5/8	1.625	4	2.07	4.14	6.21
1 11/16	1.688	4	2.24	4.48	6.72
1 3/4	1.750	4	2.41	4.82	7.23
1 13/16	1.813	4	2.58	5.16	7.74
1 7/8	1.875	4	2.76	5.52	8.28
1 15/16	1.938	4	2.95	5.90	8.85
2	2.000	4	3.14	6.28	9.42
n = Number of columns of perforations					
Minimum steel plate thickness			1/4"	5/16"	3/8"
* Designer may interfere to the nearest 32nd inch to better match the needed area if desired.					

Rectangular Perforation sizing

Use only one rectangular column whenever two 2;inch diameter circular perforations cannot provide needed outlet area.

Rectangular Height = 2-inches

Rectangular Width = Required Area per Row / 2"

Rectangular hole Width	Min. Steel Thickness
5"	1/4 "
6"	1/4 "
7"	5/32 "
8"	5/16 "
9"	11/32 "
10"	3/8 "
> 10"	1/2 "

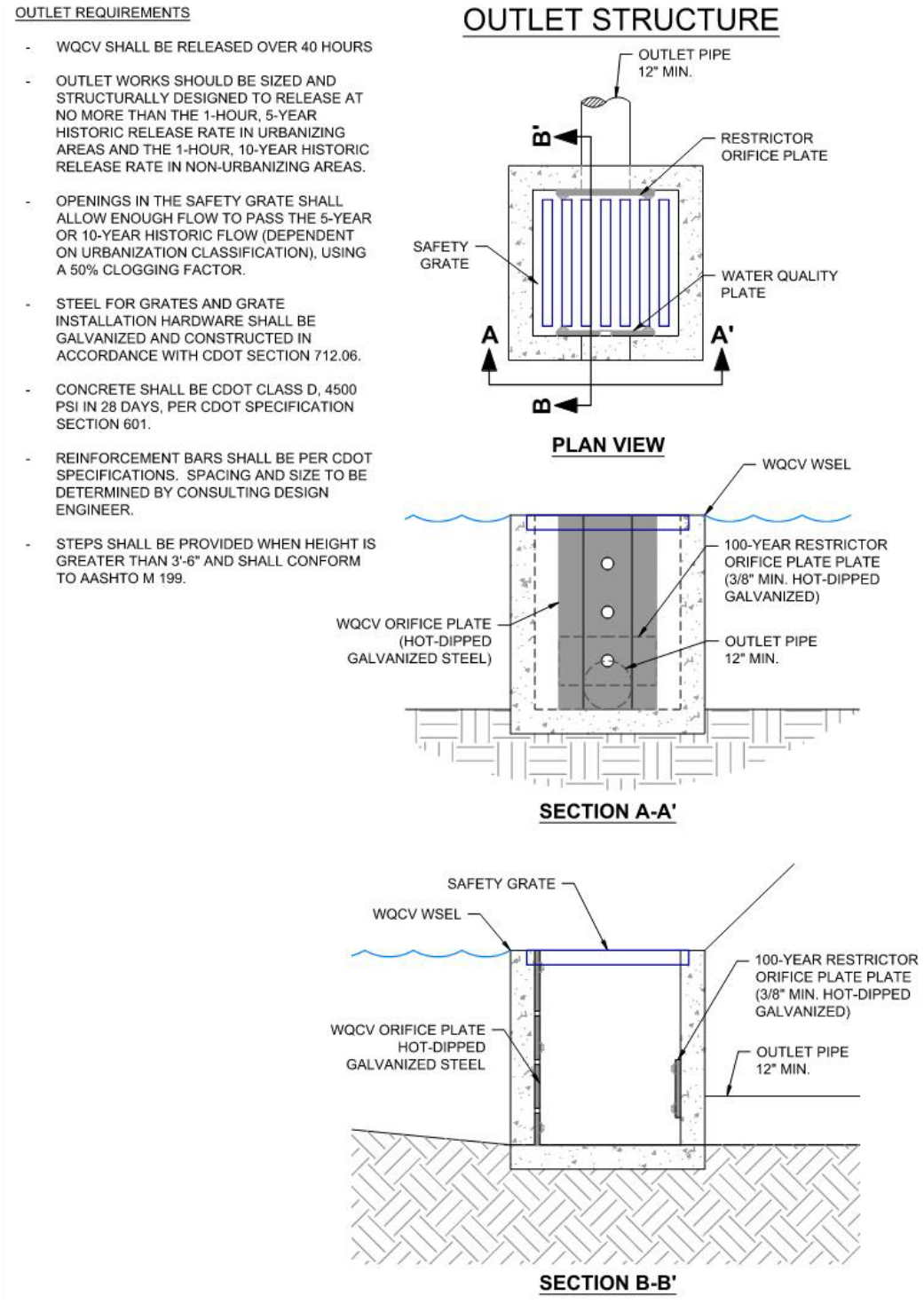
5.10.2.3 Outlet Structure

Included below is a typical configuration for a detention pond outlet structure. The detail shows the general features and layout of the basic components of a typical outlet structure. Figure 5-10 is not a construction detail. The design engineer will be required to design the outlet structure to meet the needs of the individual site plan and topography.

In addition, the following items must be included in the outlet structure design:

- The outlet pipe must contain a minimum of two concrete cutoff walls embedded a minimum of 18 inches into undisturbed earthen soil. The cutoff walls must be a minimum of 8 inches thick.
- The outlet pipe bedding material must consist of native earthen soil, not granular bedding to at least the first downstream manhole or daylight point.
- A water quality plate designed to release the WQCV in 40-hours attached to the front of the structure. Plate should be a tight fit with no gaps. Gasket or seal could help facilitate this fit.
- A restrictor plate attached to the back wall of the structure to limit the pond release to the calculated 5-year or 10-year historic runoff rate for the site (see detention pond section for details).
- The outlet pipe must be a minimum diameter of 12-inches.
- To reduce maintenance and avoid operational problems, outlet structures must be designed with no moving parts other than the trash rack (i.e. use only pipes, orifices, and weirs). Manually and/or electrically operated gates shall be avoided. To reduce maintenance, outlets should be designed with openings as large as possible, compatible with the depth-discharge relationships desired and with water quality, safety, and aesthetic objectives in mind.
- Outlets should be robustly designed to lessen the chances of damage from debris or vandalism. Avoid the use of thin steel plates as sharp-crested weirs to help prevent potential accidents, especially with children. Trash racks must be provided on all outlet structures.

Figure 5-10 Outlet Structure Plan and Profile Example



5.10.2.4 Stage Storage Curves

A relationship between the water surface elevation and detention basin volume, commonly referred to as a "stage-storage" curve, needs to be developed for each pond. The afore mentioned MHFD spreadsheet will calculate a stage-storage table based on overall pond dimensions, however the County

requires the stage-storage volumes be based on the actual site design contours. The volumes may be calculated in the “Basin” tab of the spreadsheet by using the "Surface Area at Stage (ft2) override” column or by using the equation below.

Another method of calculating the stage-storage volume is called the “Conic” method and is based on the following formula:

$$V = \frac{D}{3}(A + B + \sqrt{AB}) \qquad \textit{Eq. 5.10.2.2}$$

Where:

V = Volume between two contours, ft^3
D = Depth between contours, feet
A = Area of bottom contour, ft^2
B = Area of top contour, ft^2

A cumulative volume should be provided for the progressing stages/depth of the pond. The required pond volume for water quality and detention should be compared to the available pond volume provided in the design. The information should be clearly shown in the project’s drainage report.

5.10.2.5 Spillway

Detention ponds and stormwater infiltration facilities (retention ponds) shall contain an emergency spillway capable of conveying the peak 100-year storm discharge (from developed site) draining into the pond/infiltration facility. The spillway also should be capable of passing any off-site flows that are routed through the pond un-detained. The spillway location should be placed so that downstream properties or residences are not adversely affected. The invert of the emergency spillway must be equal to or above the 100-year WSEL. The elevation of the top of the embankment should be a minimum of 1 foot above the water surface elevation when the emergency spillway is conveying the maximum design or emergency flow. The depth of flow over the emergency spillway shall be 6 inches or less. Additional spillway details are shown in Appendix J.

Flow over a horizontal spillway can be calculated using the following equation for a horizontal broad-crested weir, shown below.

$$Q = C_{BCW} L H^{1.5} \qquad \text{Eq. 5.10.2.3}$$

Where:

Q = Discharge, cfs
C_{BCW} = Broad-crested weir coefficient, dimensionless (ranges from 2.6 to 3.0)
L = Length of weir, ft
H = Head above weir crest, ft

In addition, the County requires the following items be included in the spillway design.

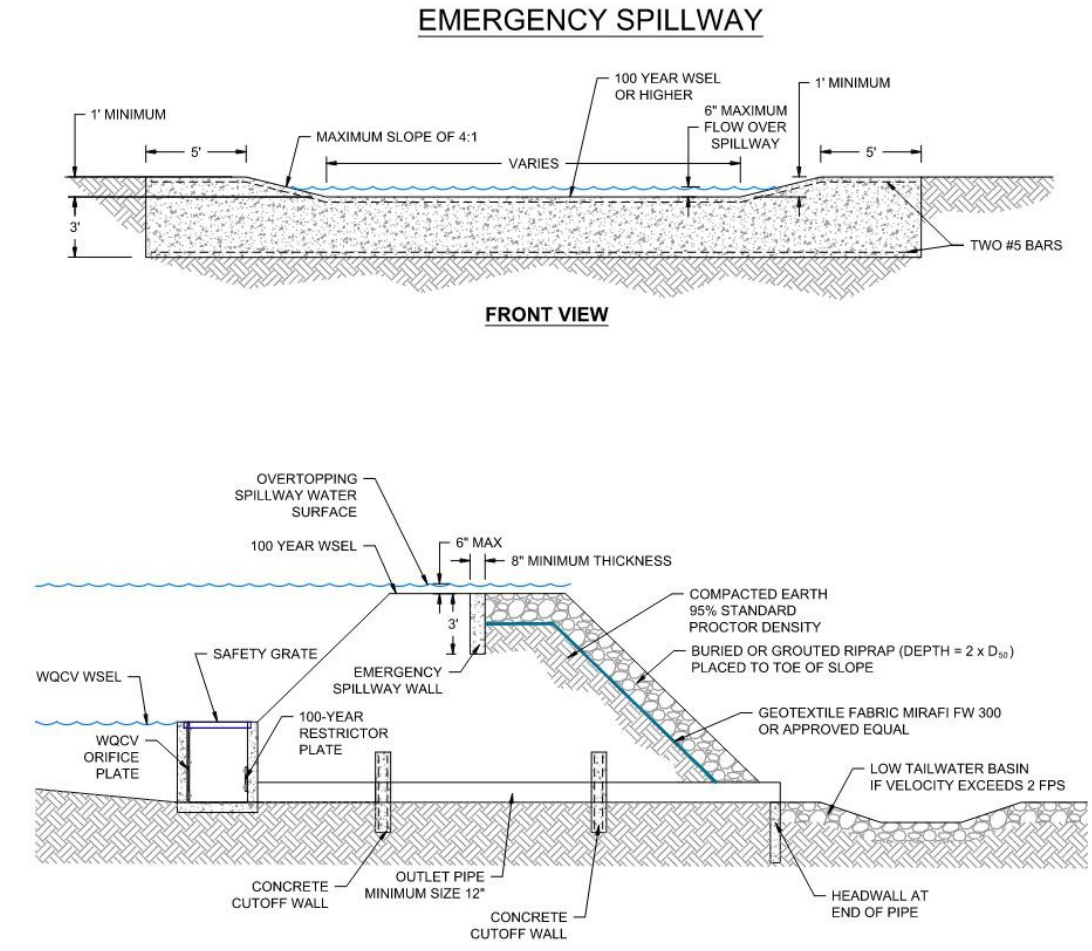
- A concrete cutoff wall 8 inches thick, 3 feet deep, and extending a minimum of 5 feet into the embankment on each side of the emergency spillway opening is required on all privately maintained detention ponds/infiltration facilities and regional detention ponds/infiltration

facilities. The concrete cutoff wall permanently defines the emergency spillway opening. The emergency spillway elevation shall be tied back into the top of the embankment using a maximum slope of 4:1.

- To protect the emergency spillway from catastrophic erosion failure, riprap shall be placed from the emergency spillway downhill to the embankment toe of slope, with a toe-down constructed to a depth of $4xD_{50}$. The minimum D_{50} for riprap on the emergency spillway shall be 12 inches (Type M). Riprap may be either grouted or buried. If buried, the protected area shall be covered with 6 inches of topsoil and seeded. Revegetation requirements for storage facilities can be found in Chapter 8 of this WCECC.

A detail of the preferred spillway design is in Figure 5-11 below.

Figure 5-11 Emergency Spillway Typical Design



EMERGENCY SPILLWAY REQUIREMENTS

- EACH DETENTION POND SHALL CONTAIN AN EMERGENCY SPILLWAY CAPABLE OF CONVEYING THE PEAK 100-YEAR STORM AT A DEPTH OF SIX (6) INCHES OR LESS. BURIED OR GROUTED RIPRAP SHALL BE PLACED FORM THE EMERGENCY SPILLWAY DOWNHILL TO THE EMBANKMENT TOE OF SLOPE AND COVERED WITH SIX (6) INCHES OF TOPSOIL, IF BURIED. THE RIPRAP MUST BE SIZED AT THE TIME OF FINAL ENGINEERING DESIGN. GROUTING OF THE RIPRAP MAY BE REQUIRED.
- IN ORDER TO PREVENT DAMAGE TO PUBLICLY-OWNED INFRASTRUCTURE (ROADS, ROADSIDE DITCHES), A CONCRETE CUTOFF WALL EIGHT (8) INCHES THICK, THREE (3) FEET DEEP, AND EXTENDING A MINIMUM OF FIVE (5) FEET INTO THE EMBANKMENT ON EACH SIDE OF THE SPILLWAY OPENING IS REQUIRED ON ALL DETENTION PONDS. THE EMERGENCY SPILLWAY ELEVATION MUST BE TIED BACK INTO THE TOP OF THE EMBANKMENT USING A MAXIMUM SLOPE OF 4:1.
- CONCRETE SHALL BE CDOT CLASS D, 4500 PSI IN 28 DAYS, PER CDOT SPECIFICATION SECTION 601.

5.10.2.6 Maintenance

Maintenance for stormwater storage facilities should follow the recommendations in the USDCM, Volume 3, unless otherwise specified by the design engineer. It is recommended that stormwater infiltration facilities be scraped/plowed every few years to prevent sedimentation and/or clogging and to ensure proper infiltration is being achieved. Areas designated for stormwater drainage, detention, or stormwater infiltration, are not to be used for materials storage, building, or parking, and should not be modified without approval from the Department of Public Works. Access also must be provided to the drainage facilities for long-term maintenance. Refer to Section 5.3.1 of this WCECC for O&M submittal requirements.

5.10.2.7 Exceptions to Detention Requirements

Exceptions to stormwater detention shall not jeopardize the public health, safety, and welfare of public and private property. The following exceptions are provided in Chapter 8, Article XI, of the Weld County Code and are subject to updates:

- Use by right or accessory use in the A (Agricultural) Zone District
- Zoning permits for accessory storage, commercial vehicles, home occupations, or manufactured homes in the A (Agricultural) Zone District
- A second dwelling permit in the A (Agricultural) Zone District
- Towers, including but not limited to wind and telecommunication towers
- Pipelines or transmission lines, excluding laydown yards, metering sites, substations, and any other above ground appurtenances
- Gravel pits, if the stormwater drains into the gravel pit. Releases from the site shall comply with this Engineering and Construction Criteria Manual, including dewatering. Topographical information will be provided.
- Rural residential developments with no historic flooding, where all the following conditions exist. This exception shall be supported by calculations provided by the Applicant. Additional information may be requested and will be signed and stamped by a Colorado licensed Professional Engineer:
  a. Nine (9) lots or fewer.
  b. The minimum lot size is equal to, or greater than, three (3) acres per lot.
  c. The total post-development imperviousness for the rural residential development does not exceed ten percent (10%), assuming that all internal roads and driveways are paved.
- Development of sites where the change of use does not increase the imperviousness of the site. Note: This exception cannot be applied to sites where impervious surfaces were added for, or in conjunction with, a business that is/was operating in violation and/or without the required Weld County land use permit.
- A parcel of land or project site where the "total developed stormwater runoff" from the 100-year, 1-hour storm is less than, or equal to, five (5) cfs. The "total developed stormwater runoff" includes cumulative runoff from the proposed project site plus runoff from any previously developed project site on the subject parcel. A project site is the area of land that lies within the project's limits of disturbance during construction. This exception shall be supported by calculations signed and stamped by a Colorado Licensed Professional Engineer.
- In-fill development parcels with total area less than, or equal to, one (1.0) gross acre.

- An individual parcel with an unobstructed flow path and no other parcel(s) between the channel within a Federal Emergency Management Administration (FEMA) regulatory floodplain and the project.
- A parcel greater than one (1) gross acre and less than, or equal to, five (5) gross acres in size is allowed a one-time exception for a new four thousand (4,000) sq. ft. building or equivalent imperviousness.
- A parcel > 5 gross acres in size is allowed a one-time exception for a new 4,500 sq. ft. of 100% impervious area or equivalent imperviousness.
- A parcel greater than five (5) gross acres in size is allowed a one-time exception for a new nine thousand (9,000) sq. ft. of 100% imperviousness area or equivalent imperviousness.
- Concentrated Animal Feeding Operations (CAFOs), Animal Feeding Operations (AFOs), and Housed Commercial Swine Feeding Operations (HCSFOs) which are covered and approved by the Colorado Discharge Permit System (CDPS) regulations. Portions of the site not included or covered by the CDPS permit shall comply with the criteria set forth in this Chapter.

Exception requests shall be supported with an approved drainage narrative, which must describe the following minimum criteria:

- The exception being requested for consideration.
- Any existing and proposed improvements to the property.
- Where the water originates if it flows onto the property from an offsite source.
- Where the water flows as it leaves the property.
- The direction of flow across the property.
- Previous drainage problems with the property, if any.
- The location of any irrigation facilities adjacent to or near the property.
- Any additional information pertinent to the development.

During the review of the application, the Weld County Department of Planning and Zoning will determine if the exception is applicable and will not jeopardize the health, safety, and welfare of public and private property.

5.10.3 Dam Information

All detention ponds shall be evaluated to verify if the detention facility would be classified as a non-jurisdictional or jurisdictional dam, per the State of Colorado Department of Natural Resources criteria. Refer to Table 5-16.

Table 5-16 Non-Jurisdictional vs Jurisdictional Dam Criteria Summary

	Non-Jurisdictional Dam	Jurisdictional Dam
Jurisdictional Height of Berm	< 10 ft	> 10 ft
Water Storage Area (at High Water Line)	< 20 ac	> 20 ac
Water Storage Volume	< 100 ac-ft	> 100 ac-ft

**This table is a general summary of the required State Criteria. The Designer shall be required to determine which category their design would be classified as and determine the required protocol. This information will then be supplied to the County for record keeping purposes.*

If it is determined that the detention facility is classified as a jurisdictional dam, state procedures must be followed. It should be noted that non-jurisdictional-size dams are regulated and subject to the authority of the State Engineer consistent with Sections 37-87-012 and 37-87-105 C.R.S., Implementation of detention ponds, and will require the design engineer to consult with the State Engineer's Office to verify the legal right to store water.

5.10.4 Irrigation Ditches/Private Irrigation Systems

It is not the intent to allow new private irrigation systems to be located within County right-of-way.

Irrigation ditches shall not be used as conveyance systems and/or outfall points for stormwater runoff for all land use cases including, but not limited to: Uses by Special Review, Site Plan Reviews, Subdivisions, or Planned Unit Developments, unless such use is approved, in writing, by the ditch owner(s). The approval shall be in the form of signature on the construction plans/documents or other formal legal agreements as required by the ditch company or owner. Should direct discharge of stormwater runoff be permitted, water quality treatment may still be required.

In the instance where an irrigation ditch serves as the outfall for a stormwater detention facility, the following items must be met:

- The maximum water surface elevation must be determined based on the maximum amount of irrigation flow in the ditch. The appropriate owner/ditch or reservoir company is the determining authority regarding the maximum irrigation flow in the ditch. Written verification of the maximum irrigation flow from the owner/ditch or reservoir company must be submitted with the hydraulic analysis of the ditch water surface elevation.
- The detention outlet must be designed such that backflow from the ditch into the detention facility is prevented.
- The backwater effects caused by the design of a detention outlet, if any, must be reviewed and approved by both the County and the appropriate ditch or reservoir company.
- The outlet design must consider tailwater effects on the outlet pipe resulting from the combination of the maximum irrigation flow and the 100-year storm discharge within the ditch.
- Drain times need to adhere to Colorado Revised Statute 37-92-602 (8) drain time requirements as listed in the "Detention Pond" section of this document.

If new developments are adjacent to irrigation facilities but no flows are being directed into the ditch, the owner/ ditch or reservoir company must still be notified of the proposed development. In such cases, it shall be the developer's engineer responsibility to provide drawings and calculations to support the fact the irrigation ditch is not impacted. These drawings and calculation shall be supplied to the County and ditch company owner.

The party seeking modifications to existing ditch conditions must obtain the appropriate owner / ditch or reservoir company approvals and signatures prior to seeking Weld County approval for such modifications.

The party seeking modifications to the existing irrigation facilities must coordinate with the irrigation system owner/operator to provide an adequate design to make the irrigation system function as it did prior to the improvements. When modifications to existing irrigation systems are necessary, the following must be provided to the County review staff:

- Information on how the existing private irrigation facilities are to be protected or routed through the project site.
- Plan and profile drawings of any new irrigation pipes should be included in the drawing set, similar to information for proposed storm lines.
- A hydraulic model showing the irrigation pipe system at full irrigation flows should be provided in the drainage report for review by County staff.
- Irrigation flows should be provided by the owner of the irrigation system, not estimated on existing pipe or ditch sizes.
- Details of any irrigation structures required should be provided in the plan set for the development. Dimensions of the structures, concrete type and thickness, rebar type and spacing, grates, weir boards, bridge, trash racks, connecting hardware, air vents etc. should be included in the details of the irrigation structures.
- Owner approval of the new system is required before construction can proceed.
- Proposed private irrigation facilities for new developments or reconfigured existing irrigation systems should be located outside of the public right-of-way.

As-built survey is required documenting all changes in direction and structure critical elements plus video of all pipes installed verifying pipe connections and debris removal.

5.11 STORMWATER DRAINAGE CRITERIA VARIANCES

In cases of hardship, an applicantmay apply for a variance from a requirement of the storm drainage criteria. Weld County will not approve design variances found to be detrimental to the public health, safety, and general welfare or when the request is contrary to the purpose and intent of the criteria set forth in this document or the Weld County Code. The variance procedure is intended to address cases of hardship, and requests will not be granted when the hardship is brought about solely through the actions of the appellant.

Variance requests shall be stamped and signed by a professional civil engineer licensed to practice in the State of Colorado and shall be submitted with the Certificate of Compliance. Variance requests will be reviewed by the Development Review Engineer. To be reviewed, the variance request must:

- State the hardship that is causing the request for a variance from Weld County Code. Provide proof of the hardship in the drainage memo/letter provided.
- Describe the design criteria of the Weld County Code from which a variance is being requested.
- Describe the proposed alternative with engineering rationale that supports the intent of the Weld County Code.
- Meet the design intent of the Weld County Code.
- Demonstrate that granting of the variance will still adequately protect public health, safety, and general welfare.
- Demonstrate there are no adverse impacts from stormwater runoff to the public rights of way and/or offsite properties as a result of the project.

Applicants may appeal the denial of a variance to the BOCC pursuant to the provisions in Chapter 2, Article IV, Section 2-4-10 of the Weld County Code. Variance requests, if accepted, are not precedent setting and are based on site-specific constraints.

5.12 OIL AND GAS STORMWATER MANAGEMENT

The following standards apply only to the development of oil and gas exploration and production in the Weld Mineral Resource (Oil and Gas) Area. These standards shall be supported by calculations signed and stamped by a Colorado licensed Professional Engineer and accepted by the Weld County Department of Public Works. See also Chapter 21 of the Weld County Code.

- Oil and Gas Tank battery secondary containment. When calculating the Oil and Gas Location imperviousness and pervious areas, secondary containment areas may be excluded from the total site imperviousness and pervious calculations provided that the secondary containment area is appropriately sized to hold the originally designed safety containment volumes plus the 100-year, 1-hour storm rainfall event.
- Detention pond storage volume. In non-urbanizing areas during the Construction Phase, detention ponds shall be sized to store the stormwater runoff generated by the 1-hour, 100-year storm falling on the developed site and release of the detained water at the historic runoff rate of the 1-hour, 10- year storm falling on the undeveloped site or at 5 cfs, whichever is greater. Historic is defined as an undeveloped site (before any development) with an assumed 2.0 percent imperviousness maximum. During the Production Phase or in urbanizing areas, detention ponds shall adhere to Sec. 8-11-100.A.1. of the Weld County Code.
- Detention pond freeboard. During the Construction Phase, less than 1 foot of freeboard may be allowed on a case-by-case basis. This exception shall be supported by calculations signed and stamped by a Colorado licensed Professional Engineer and accepted by the Weld County Department of Public Works. During the Production Phase, the detention pond shall adhere to Sec. 8-11-100.A.4 of the Weld County Code.
- Emergency spillway. To prevent damage to publicly owned infrastructure (roads, roadside ditches), a cutoff wall is required on all privately maintained detention ponds and retention ponds. The cutoff wall permanently defines the emergency spillway opening. The emergency spillway elevation must be tied back into the top of the embankment using a maximum slope of 4:1. The cutoff wall must either be constructed of concrete or galvanized steel sheet pile. Concrete cutoff walls must adhere to Sec. 8-11-100.A.7 of the Weld County Code. Steel sheet pile cutoff walls must be hot dipped galvanized steel of ¼-inch thickness or 3-gauge and extend 3 feet below the bottom of the pond or per manufacturer's recommendation, whichever is greater. If steel sheet pile is proposed for the cutoff wall, the native soils must be tested for sulfate levels. If the sulfate levels are above 1.0 percent, the sheet pile shall be coated with a corrosion-resistant epoxy.
- Retention pond. Retention facilities shall be allowed without a variance only during the Construction Phase. Retention facilities that are proposed for the Production Phase require the issuance of a variance requested by the Applicant and accepted by the Weld County Department of Public Works.

Additionally, as part of the application for a 1041 WOGLA Permit, an Operator shall provide proof of a valid stormwater discharge permit issued by CDPHE. The Operator shall submit a drainage report to comply with required Storm Drainage Criteria pursuant to Chapter 8, Article XI of the Weld County Code. Additional requirements for Municipal Separate Storm Sewer System (MS4) areas may be applicable pursuant to Chapter 8, Article IX of the Weld County code.

CHAPTER 6 GRADING AND MS4 REQUIREMENTS

6.1 EROSION CONTROL & GRADING REQUIREMENTS

Weld County requires an erosion control and grading plan. Erosion control methods are implemented to prevent the offsite transport of sediment from land- disturbing activities. Erosion has the potential to damage adjacent properties and County drainage systems, as well as contributing to the degradation of water quality. When properly installed and maintained, temporary control measures provide effective erosion control for a site. At a minimum, a stormwater management plan (SWMP) shall include erosion control and grading plans.

6.1.1 Applicability

Sites disturbing more than one acre (Sec. 8-12-30.B) of land disturbance require a Grading Permit. For MS4 areas a grading permit may be required for any disturbance. The definition of disturbance in the Weld County Code is when the surface area is disturbed by any work activity upon the property by means including, but not limited to, grading; excavating; stockpiling soil, fill, or other materials; clearing; vegetation removal; removal or deposit of any rock, soil, or other materials; or other activities that expose soil. Disturbed area does not include the tillage of land that is zoned agricultural or the tillage of a parcel zoned PUD (planned unit development) within the area identified for agricultural uses. For Grading Permit exemptions, refer to Section 8-12-30 of the Weld County Code.

6.1.2 Grading and Erosion Control Plans

When applying for a Grading Permit, a Grading Plan, a Utility Map (Sec. 8-12-50.C), a Drainage Plan and a Sediment & Erosion Control Plan shall be submitted for review. A Grading Permit Checklist, provided in Appendix G, should be used for guidance in developing the Grading Plan and Sediment & Erosion Control Plan to expedite the review process.

The main components of the Grading Plan and Sediment & Erosion Control Plan are:

1. Site Drainage—identifying existing and proposed grading and drainage features (swales, inlets, manholes, curb and gutter, concrete pans, culverts, roof drains, ponds, and outlet structures) designed to convey stormwater runoff. Site grading will be consistent with accepted Drainage Plan for the site.
2. Temporary Control Measures (BMPs)—identifying, detailing, and locating all structural and non-structural temporary control measures used during each phase of construction, from initial disturbance to final stabilization, to prevent the discharge of sediment from the site. Additionally, the plan will include installation, implementation, maintenance, and removal specifications for each structural control measure and a narrative description of each non-structural control measure.
3. Permanent Stabilization—identifying the means and methods used to achieve stabilization for all disturbed areas. Stabilization includes, but is not limited to; seed mix, seed application method, mulch type, mulch application method, soil testing, soil amendments, and erosion control blankets. Additionally, the plan will include installation, implementation, and maintenance specifications for each structural control measure and a narrative description of each non-structural control measure.

A complete set of plans will include separate plan sheets for all three phases of construction identified as follows:

1. Initial Phase—depicting current site conditions, including existing structures, drainage patterns, topography, etc.
2. Interim Phase—depicting temporary control measures used during active construction. Depending on construction phasing, multiple sheets may be required. At a minimum, vehicle tracking, perimeter control and inlet/outlet protection will be addressed with temporary control measures. In addition, the plans should note that a state-issued Dewatering Permit will be obtained and submitted to Weld County prior to any dewatering activities.
3. Final Phase—depicting temporary control measures to remain in place after construction until the site reaches final stabilization. Final stabilization is when all landscaping is complete and seeding has reached at least 70 percent permanent vegetative cover. At a minimum, perimeter control will remain in place and maintained until final stabilization is reached. In addition, other temporary control measures may be required to remain in place and maintained, if necessary, to prevent offsite sediment transport while waiting for vegetative growth.

Plan sheets will be submitted electronically and should be clear and legible. The Development Review Engineer reserves the right to require plan modifications for readability purposes. In addition, each temporary control measure used will be located on the applicable site plan and referenced in the legend, and an installation and implementation specification will be attached. Public Works recommends using USDCM Volume 3, Chapter 7, *Construction BMPs*, for clear and specific installation and implementation specifications. Other methods may be approved on a case-by-case basis.

6.1.3 Implementation

During construction, the Grading Plan, Utility Map, Drainage Plan and Sediment & Erosion Control Plan shall be kept onsite and available for reference by site workers and County inspectors. In accordance with the state- issued Construction Permit, temporary control measures should be inspected by a Qualified Stormwater Manager at a minimum of every two weeks and after storm runoff events; however, more frequent inspections may be necessary to properly maintain temporary control measures.

If changes to the approved Grading Plan and Erosion & Sediment Control Plan are necessary, Weld County shall be contacted to determine if a Grading Permit modification is necessary. Weld County inspectors shall verify site conditions with the approved set of plans. Violations may occur if site conditions do not reflect the approved plans.

6.1.4 Grading Permit Deadline (Fee) & Extension

6.1.5 Tracking Control

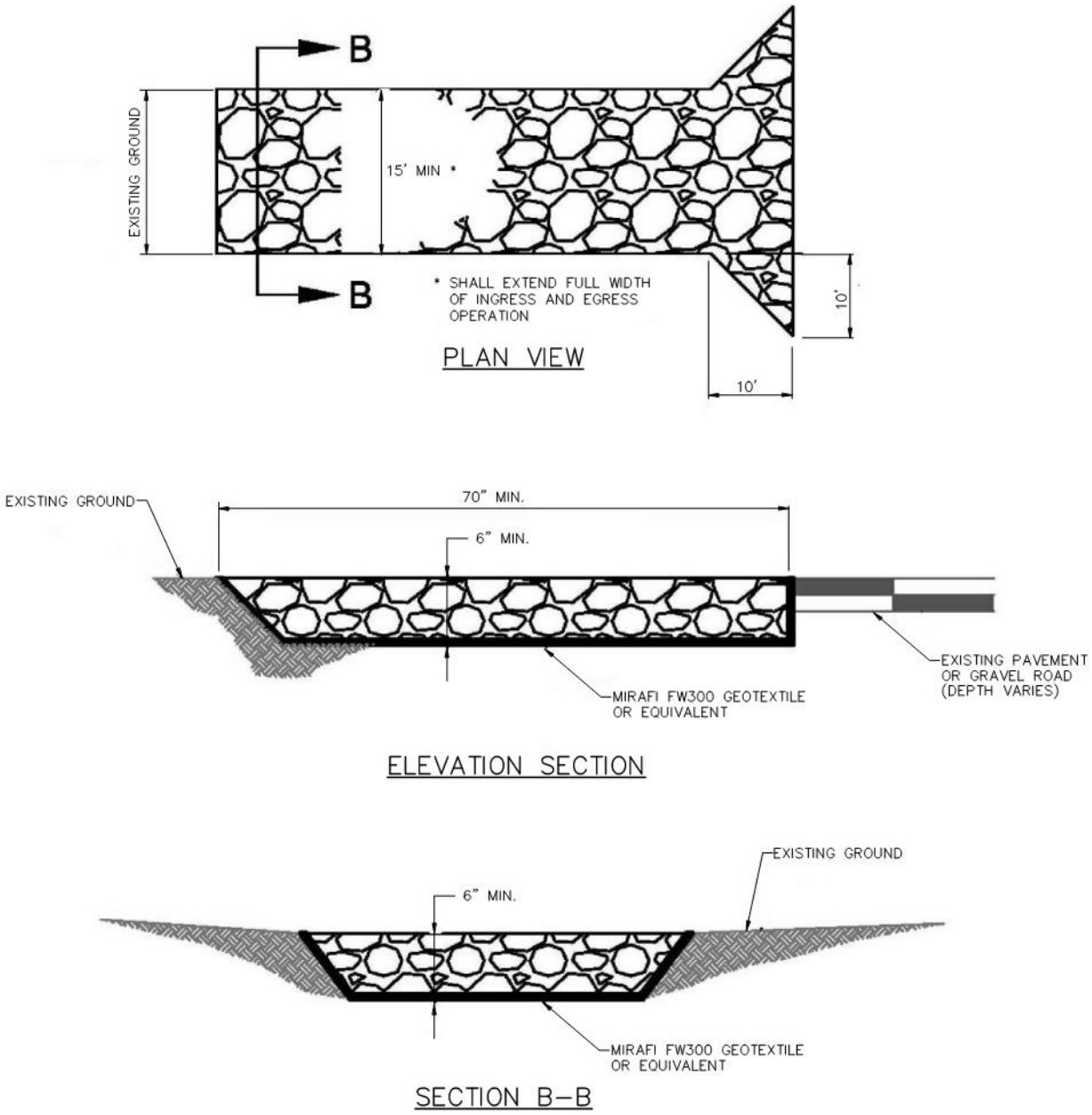
Tracking control is required when construction activity is accessing onto a roadway surface other than gravel. There are three tracking control options when required to mitigate impacts to the public road, including damages and/or offsite tracking of mud or other materials. Regardless of option, drainage and/or culverts must be maintained. The associated appropriate tracking control devices for each situation are listed below.

- Permanent access onto concrete, asphalt, or recycled asphalt (RAP) public road

a. Double cattle guards used in combination with 100 feet of asphalt
b. Or 300 feet of asphalt

- Permanent access onto gravel public road
  a. Double cattle guards with 100 feet of aggregate surface course (See Section 9.6.6)
  b. Or 300 feet of aggregate surface course (See Section 9.6.6)
  c. Aggregate surface course (See Section 9.6.6) on all drive surfaces
- Temporary access onto either concrete, asphalt, or recycled asphalt (RAP) or gravel public road. Culverts or accepted drainage report may be required for temporary access control pads.
  a. County accepted prefabricated tracking pad
  b. Aggregate with base and a minimum of 70 feet long (per Figure 6-1)

Figure 6-1 Tracking Control for Temporary Accesses



NOTES:

1. AGGREGATE SHALL CONFORM TO CDOT SPECIFICATIONS, SUBSECTION 208

2. THE CONTRACTOR SHALL PROTECT CURB AND GUTTER, EDGE OF PAVEME OF GRAVEL ROAD THAT CROSSES OR IS ADAJACENT TO THE ENTRANCE FR(WHILE NOT BLOCKING FLOW OF WATER. IN THE CASE THERE IS AN EXISTING CULVERT IS REQUIRED. PROTECTION OF THE ADJACENT ROADWAY MATERIAL: ABOVE SHALL BE INCLUDED IN THE COST OF THE WORK AND NOT PAID FOI

3. ALL MATERIALS AND LABOR TO COMPLETE THE VEHICLE TRACKING PAD INCLUDED IN THE COST OF THE WORK AND NOT PAID FOR SEPARATELY.

4. THE PAY ITEM NUMBER FOR VEHICLE TRACKING PAD (EACH) IS CDOT ST SPECIFICATION 208–00070.

6.2 MS4 REQUIREMENTS

Sites located in Weld County's state-permitted Municipal Separate Storm Sewer System (MS4) area are required to comply with the Grading Permit requirements as well as additional MS4 requirements. Weld County is categorized as Phase II. An MS4 is a conveyance or system of conveyances that is:

- Owned by a state, county, city, town, or other public entity that discharges to waters of the United States
- Designed or used to collect or convey stormwater (including storm drains, pipes, ditches, etc.)
- Not a combined sewer
- Not part of a publicly owned treatment works (sewage treatment plant)

EPA's Stormwater Phase II Rule established a management program that is intended to reduce the quantity of pollutants that enter MS4s from stormwater. Common pollutants include oil and grease from roadways, pesticides and fertilizers, sediment from construction sites, and discarded trash. When deposited into nearby waterways through MS4 discharges, these pollutants can impair the waterways, discourage recreational use, contaminate water supplies, and interfere with the habitat for aquatic organisms, fish, and wildlife.

In compliance with the provisions of the Federal Water Pollution Control Act (commonly referred to as the Clean Water Act), as amended (33 USC 1251 et seq.), the EPA promulgated rules establishing Phase I of the NPDES stormwater program in 1990. The 1990 Phase I program requires operators of medium and large MS4s (defined as those serving populations of 100,000 or greater) to implement a stormwater management program to control pollution. State law has similar provisions (Colorado Water Quality Control Act, CRS 25-8-101 et seq).

The 1999 Stormwater Phase II Rule extended coverage of the NPDES stormwater program to certain "small" MS4s in urbanized areas (those serving populations of 10,000 to 100,000). Small MS4s located in urbanized areas are defined by the Census Bureau based on the most recent Census. New urbanized areas will be identified in each subsequent Census, occurring every 10 years. Generally, Phase I MS4s are covered by individual permits, and Phase II MS4s are covered by a general permit. Each regulated MS4 is required to develop and implement a program to reduce the contamination of stormwater runoff and prohibit illicit discharges. Operators of small MS4s are required to design their programs to reduce the discharge of pollutants to the "maximum extent practicable." In Colorado, the program is administered by the Colorado Department of Public Health & Environment (CDPHE) Water Quality Control Division. (The Colorado program is referred to as the Colorado Discharge Permit System, or CDPS, instead of NPDES.)

6.2.1 Designated MS4 Areas and Responsibilities

The MS4 mapped areas arereviewed annually by Weld County and are designated by CDPHE based on population density. Currently, MS4 municipalities in Weld County include Greeley, Evans, Windsor, Firestone, Erie, LaSalle, Brighton, Longmont, and a small portion of Northglenn and Thornton. As Weld County continues to grow in population, each of these MS4 areas will continue to expand, potentially encompassing urbanized parts of Frederick and Dacono.

The MS4 permit requires the County to implement a Construction Sites Program to prevent the discharge of pollutants to the MS4 from applicable construction activities. The MS4 permit also requires

a Post-Construction Program to treat stormwater runoff from applicable development sites. These responsibilities are handled through coordination between the departments of Planning and Public Works.

6.2.2 Applicability of MS4 Requirements

The MS4 Permit mandates specific requirements for construction activities resulting in a land disturbance of greater than or equal to one (1) acre. The same requirements apply to land disturbance that is less than one (1) acre but is part of a larger common plan of development or sale with a planned disturbance of greater than or equal to one acre. For subdivisions, planned disturbance is equal to the cumulative potential development area as specified by Chapter 23 of the Weld County Code and/or the Master Drainage Plan for the subdivision, if more restrictive.

The MS4 Permit defines construction activity as ground-surface-disturbing activity, which includes, but is not limited to, clearing; grading; excavation; demolition; and installation of new or improved haul roads, access roads, staging areas, stockpiling of fill materials, and borrow areas. Activities that include routine maintenance to maintain original line and grade, hydraulic capacity, or original purpose of the facility are not considered construction activities. Activities to conduct repairs that are not part of regular maintenance and activities that are for replacement are considered construction activities and are not considered routine maintenance. Repaving activities where underlying or surrounding soil is cleared, graded, or excavated as part of the repaving operation are construction activities unless they are an excluded site under Part I.E.4.a.i. of the permit.

6.2.3 Required Permits

6.2.3.1 CDPS Construction Stormwater Permit

When construction activities result in land disturbance of one (1) acre or more, or less than one acre but part of a larger common plan of development, the owner and operator must obtain a CDPS Construction Stormwater Permit, issued by CDPHE, prior to the start of land- disturbing activities. Under certain conditions, an R-Factor waiver may be obtained from CDPHE.

As part of the permit, a Stormwater Management Plan (SWMP) must be kept onsite at all times. Additionally, the site must have a Qualified Stormwater Manager (QSM), a person knowledgeable about stormwater requirements and capable of implementing the SWMP in its entirety.

Refer to the CDPHE website for more information on the CDPS Construction Stormwater Permit, R-Factor Waiver, and a SWMP preparation guidance document.

6.2.3.2 CDPS Construction Dewatering Permit

When construction activities require dewatering, the owner and operator must obtain a CDPS Construction Dewatering Permit, issued by CDPHE, prior to the start of dewatering activities. Under certain conditions, as specified in CDPHE's *Low Risk Discharge Guidance for Discharges of Uncontaminated Groundwater to Land*, a dewatering permit may not be required. However, if the dewatering activity is not complying with the guidance document and/or there is a threatened discharge of pollutants to the MS4, the Department of Public Works will issue a Stop Work Order until a CDPS Construction Dewatering Permit is obtained and the threatened discharge no longer exists.

Refer to the CDPHE website for more information on the CDPS Construction Dewatering Permit and CDPHE's *Low Risk Discharge Guidance for Discharges of Uncontaminated* *CDPHE's Low Risk Discharge Guidance for Discharges of Uncontaminated Groundwater to Land*.

6.2.3.3 Weld County Grading Permit

When construction activities will result in land disturbance of one acre or more, or less than one acre but part of a larger common plan of development, the owner or operator must obtain a Grading Permit, issued by Weld County, prior to the start of land-disturbing activities. In some cases, when disturbing less than one acre within a developing subdivision, a Grading Permit may be required depending on other construction activities in the area. Additionally, a Grading Permit may be required for sites not located within the MS4 area but discharge into an MS4 drainage system. Exemptions to the Grading Permit do not apply to properties located within the MS4 area, and variances to MS4 requirements will not be granted.

6.2.4 MS4 Requirements for Pre-Construction

The following requirements apply to any applicable development or construction activity within the MS4 area. This includes the resubdivision of land since it is considered a "larger common plan of development." The Department of Public Works will review each case and determine the applicability of the site and if any exclusions are approved (see Post-Construction exclusions below).

6.2.4.1 Site Plan Review

The following documents shall be submitted, reviewed, and accepted by Weld County staff prior to any applicable construction activity requiring a Grading Permit. In addition, construction activity not requiring a Grading Permit may be required to submit applicable documents if determined necessary to comply with MS4 requirements.

6.2.4.2 Drainage Report

Drainage Reports shall be signed and stamped by a Colorado licensed Professional Engineer. A Drainage Report Checklist, provided in Appendix B, should be completed and submitted with the report. The four main components of the Drainage Report relating to MS4 requirements are:

a. General Content—describing the nature of the development, basic characteristics of the site, and proposed drainage improvements designed to comply with Weld County drainage and MS4 requirements. This includes specifying the MS4 "Base Design Standard" used in the design of the permanent water quality control measure.
b. Hydrology and Hydraulic Analysis—including the calculations, narratives, and design details for permanent structural control measures and associated drainage features to show compliance with the MS4 Permit's "Base Design Standards."
c. Construction Drawings—detailing the existing and proposed drainage, permanent water quality control measure(s) to be installed, and specifications for structural components.
d. Long-Term Operations and Maintenance Plan—for permanent water quality control measures and associated drainage features. The plan shall include frequencies of inspections and maintenance and narratives for non-structural control measures, if applicable. Refer to USDCM Volume 3 Chapter 6 for guidance on maintaining permanent water quality control measures.

When designing a permanent water quality control measure and developing maintenance procedures, Public Works will conduct routine inspections for the life of the control measure to ensure proper functioning and adequate maintenance is being performed. Inspections generally occur every year; however, some sites may qualify for inspections every five years based on factors such as the control measure type/design, facility type, pollutant load, and historical compliance. If there are no structural components to visually confirm volume capacity, such as a concrete trickle channel, micro-pool, or forebay, a survey conducted by a Professional Land Surveyor may be required.Additionally, a Colorado licensed Professional Engineer shall provide confirmation of the existing volume capacity meeting the approved Drainage Report calculations. The survey and report may be required to be submitted every five years for the life of the facility.

6.2.4.3 Grading and Sediment & Erosion Control Plans

Grading and Sediment & Erosion Control Plans shall be signed and stamped by a Colorado licensed Professional Engineer. A Grading Permit Checklist, provided in Appendix G, should be used in developing plans to expedite the review process. For details, refer to Section 6.1.

The main components of the Grading Plan and Sediment & Erosion Control Plan have been identified in Section 6.1.2 above.

6.2.4.4 MS4 Pollution Prevention Plan

The MS4 Pollution Prevention Plan Checklist and Manual is availablein Appendix H. The checklist shall be completed and submitted with the plan The manual contains County-approved installation and maintenance specifications for temporary control measures. Specifications for proprietary temporary control measures, such as concrete washout structures and vehicle tracking pads, shall be submitted and approved prior to use.

The MS4 Pollution Prevention Plan Checklist and Manual was developed to help the Qualified Stormwater Manager (QSM) with implementation of structural and non- structural temporary control measures used during each phase of construction, from initial disturbance to final stabilization, to prevent the discharge of pollutants from the site. It is the QSM's responsibility to identify all potential pollutants onsite and to implement temporary control measures for each pollutant.

A list of potential pollutants include:

- Vehicle tracking of sediments
- Land disturbance and storage of soils
- Loading and unloading operations
- Outdoor storage of construction site materials, building materials, fertilizers, and chemicals.
- Bulk storage of materials
- Vehicle/equipment maintenance and fueling
- Significant dust- or particulate-generating processes
- Routine maintenance activities involving fertilizers, pesticides, detergents, fuels, solvents, and oils
- Concrete truck/equipment washing, including the chute and associated fixtures and equipment
- Dedicated asphalt/concrete batch plants or masonry mixing station
- Waste sources such as sanitary waste, construction site waste, and worker trash

- Other non-stormwater discharges, including construction dewatering or power washing
- Other areas or operations where spills can occur (if so, specify)

6.2.4.5 Future Development

For developments not requiring a Grading Permit, such as a re-subdivision of land or phased construction sites, MS4 requirements remain applicable. If no land-disturbing activities are planned, the applicant may only be required to submit a Drainage Report, including, but not limited to, the design of a permanent water quality feature and associated drainage features and a Long-Term Operation and Maintenance Plan. Upon commencement of land-disturbing activities, additional documents, such as a Grading Plan, Sediment & Erosion Control Plan, and MS4 Pollution Prevention Plan will be required.

6.2.5 MS4 Requirements for Construction Activity

6.2.5.1 Stormwater Inspections

As required by the MS4 Permit, the County is required to routinely inspect construction sites at a frequency of at least every 45 days. The Department of Public Works maintains the authority to increase inspection frequencies based on historical violations.

It is the responsibility of the applicant to contact the Department of Public Works to schedule the first inspection, at which time, the temporary control measures necessary to begin construction will be inspected (I.e. perimeter control and vehicle tracking control). The applicant shall provide notice a minimum of seven days prior to commencing construction activity. Failure to schedule an inspection is considered a violation of MS4 requirements, and a stop work order or other enforcement actions may be pursued.

During routine inspections, the inspector shall review the current site conditions using the documents submitted during the review process. Significant changes in plans may require modifications to be submitted for approval. Minor changes should be noted in the Grading Plan and Sediment & Erosion Control Plan, MS4 Pollution Prevention Plan, or SWMP, which are to be kept onsite at all times.

The inspector shall assess all onsite control measures, pollutant sources, and discharge points to determine if an illicit discharge has occurred or has the potential to occur. If violations are found, the applicant will be notified verbally, via email and/or certified mail, depending on the severity of the violations.. A compliance inspection then will be scheduled no later than 14 days from the date of the violation.

If violations are not corrected by the time of the compliance inspection, and a schedule for compliance is not being followed, escalating enforcement procedures shall be followed until the site reaches compliance. This may include a formal Notice of Violation (NOV),the issuance of a Stop Work Orderand holding all permits for the site until violations have been corrected. If violations continue to exist, judicial enforcement responses may be pursued depending on the severity and recalcitrance of the violations. Refer to the Enforcement section below.

Indicator (drive-by) inspections may be conducted at any time to assess site conditions. However, if violations are found during indicator inspections, the applicant will be contacted to remedy the violations and to schedule a follow-up compliance inspection.

When construction activity is completed, inspections shall occur at least every 90 days until the site has reached final stabilization and all temporary control measures have been removed. If the contractor is no longer associated with the site, the CDPS permit shall be transferred to the landowner, and the completed transfer shall be emailed to Public Works. A final walkthrough will be performed to release the Grading Permit.

6.2.5.2 Construction Enforcement

Upon finding a stormwater violation that does not require emergency suspension, the inspector will verbally inform the owner and/or operator of the necessary corrective action. If the violation is corrected during the inspection, no further action is required. For all remaining violations, the inspector will notify the owner and/or operator detailing the required corrective actions, and a follow-up compliance inspection will be scheduled. Depending on the severity of the violation, alternatives to the follow-up compliance inspection may be allowed, such as submitting photos of the corrective action. When the site reaches compliance, the routine inspection frequency will resume.

If violations were not corrected by the follow-up compliance inspection, an NOV will be issued, specifying a date by which compliance must be obtained to avoid further enforcement action. If corrective actions are found adequate during the compliance inspection, the routine inspection frequency will resume.

If the violations detailed in the NOV were not corrected by the specified date, additional NOVs may be issued, in combination with additional enforcement actions, such as Stop Work Orders and placing holds on permits.

If compliance is not being achieved through previous methods, the Department of Public Works may decide to pursue an administrative entry and seizure warrant for abatement in addition to any potential civil and/or criminal enforcement. A hearing with the BOCC will be scheduled to assess the costs of the abatement, and these costs will become a lien against the property from which the causes of violation have been remediated.

Additionally, the County may, without prior notice, seek the suspension of MS4 discharge access, such as issuing a Stop Work Order, to stop an illicit discharge or threatened discharge which presents, or may present, imminent and substantial danger to the environment, to the health or welfare of persons or to any MS4 or waters of the state. If the violator fails to comply with a suspension order issued in an emergency, the Department of Public Works may take such steps as deemed necessary to prevent or minimize damage to any MS4 or waters of the state. The BOCC may assess the costs of the abatement and such costs will become a lien against the property from which the causes of violation have been remediated. A person commits an offense if the person reinstates access to the MS4 without prior approval of the Department of Public Works.

For more information on enforcement procedures, refer to Weld County Code Section 8-9.

6.2.6 MS4 Requirements for Post Construction

When developing a site within the MS4 area, stormwater drainage shall be treated by use of a permanent water quality control measure prior to discharging into any MS4. The MS4 Permit allows for several exemptions; however, exemptions must be reviewed and accepted by Weld County staff prior to use.

6.2.6.1 Exemptions

The following exemptions are allowed in the MS4 area:

1. Large-Lot Single-Family Sites: A single-family residential lot, or agricultural zoned lands, greater than or equal to 2.5 acres in size per dwelling and having a total lot impervious area of less than 10 percent. A total lot imperviousness greater than 10 percent may be allowed when a study specific to the watershed demonstrates the expected soil and vegetation conditions are suitable for infiltration/filtration of the WQCV for the site. The maximum total lot impervious covered under this exclusion shall be 20 percent.

2. Undeveloped Land: Sites with land disturbance to undeveloped land (land with no human-made structures such as buildings or pavement) that will remain undeveloped.

3. Above Ground and Underground Utilities: Activities for installation or maintenance of underground utilities or infrastructure that does not permanently alter the terrain, ground cover, or drainage patterns from those present prior to the construction activity. This exclusion includes, but is not limited to, activities to install, replace, or maintain utilities under roadways or other paved areas that return the surface to the same condition.

This list contains the most common exemptions, but other exemptions are listed in the MS4 Permit and may be allowed. All exemptions will be approved on a case-by-case basis.

6.2.6.2 Permanent Water Quality Control Measure Design

Permanent water quality control measures must meet at least one of the "Base Design Standards" detailed in the MS4 Permit. No exemptions or variances to the standards are allowed for applicable development within the MS4 area. For the purposes of this section, the "permittee" is the landowner.

The following italicized "Base Design Standards" were excerpted from the MS4 Permit, and all references made can be found within that document. The entire permit is available on the CDPHE website.

1. WQCV Standard

The control measure(s) is designed to provide treatment and/or infiltration of the WQCV and:

- 100 percent of the applicable development site is captured, except the permittee may exclude up to 20 percent, not to exceed 1 acre of the applicable development site area when the permittee has determined that it is not practicable to capture runoff from portions of the site that will not drain towards control measures. In addition, the permittee must also determine that the implementation of a separate control measure for that portion of the site is not practicable (e.g., driveway access that drains directly to street).
- The exclusion of up to 20 percent of the site will be approved only in extreme cases when other forms of treatment are infeasible. Use of this exclusion will not be approved if flows can be diverted to the main permanent water quality control measure, or a separate permanent water quality control measure can be installed. It is the duty of the Engineer to demonstrate the hardship and prove that alternative methods cannot be employed. Cost in this case is not considered a hardship.

Evaluation of the minimum drain time shall be based on the pollutant removal mechanism and functionality of the control measure implemented. Consideration of drain time shall include maintaining vegetation necessary for operation of the control measure (e.g., wetland vegetation).

Most commonly, applicable development will require a detention pond, sized for the 100-year storm event and releasing within 72 hours, for flood control purposes. Detention ponds designed to current standards and rainfall data meet the WQCV Standard. However, if the site drains to a detention pond designed under previous standards and/or rainfall data that do not meet the WQCV Standard, a new permanent water quality control measure is required. Additionally, a permanent water quality control measure is required even if a site qualifies for an exception to detention.

In order to show compliance with this design standard, the plan must detail the percentage of the site is being captured and treated by the permanent water quality control measure. If there are any excluded areas proposed, a hardship must be demonstrated. Public Works will assess these on a case-by-case basis.

Examples of permanent water quality control measures meeting the WQCV Standard include detention ponds (with orifice plates), bioretention (with underdrains), and sand filters (with underdrains).

Calculations for the WQCV Standard can be found in the USDCM, Volume 3.

2. Runoff Reduction Standard

The control measure(s) is designed to infiltrate into the ground where site geology permits, evaporate, or evapotranspire a quantity of water equal to 60 percent of what the calculated WQCV would be if all impervious area for the applicable development site discharged without infiltration. This base design standard can be met through practices such as green infrastructure. "Green infrastructure" generally refers to control measures that use vegetation, soils, and natural processes or mimic natural processes to manage stormwater. Green infrastructure can be used in place of or in addition to low impact development principles.

The Runoff Reduction Standard is most commonly used for sites qualifying for an exception to detention or sites draining to a detention pond which was not originally designed to meet the WQCV Standard.

Examples of permanent water quality control measures meeting the Runoff Reduction Standard include grass swales, grass buffers, bioretention (full infiltration), and sand filters (full infiltration). Calculations for the Runoff Reduction Standard can be found in the USDCM, Volume 3.

3. Applicable Development Site Draining to a Regional WQCV Control Measure

The regional WQCV control measure must be designed to accept the drainage from the applicable development site. Stormwater from the site must not discharge to a water of the state before being discharged to the regional WQCV control measure. The regional WQCV control measure must meet the requirements of the WQCV Standard listed above.

The design engineer is encouraged to use guidance documents, spreadsheets and programs provided by MHFD to assist in designing the BMPs. Other software programs may be used, but the designs will be verified using the MHFD spreadsheets. The most current versions of MHFD spreadsheets can be downloaded from the MHFD website at https://udfcd.org/software.

Control measure technology is changing constantly. Weld County will evaluate the use of newly developed control measures on a case-by-case basis when complete documentation of all assumptions is provided. Weld County reserves the right to review alternative methods and compare with other commonly used approaches, including those discussed in the USDCM.

6.2.6.3 Certificate of Occupancy

Upon completion of the permanent water quality control measure, the applicant will submit an As-Built Drawing, certified by a Colorado licensed Professional Engineer, of the permanent water quality control measure and associated drainage features. An As-Built Drawing Checklist, can be found o in Appendix D. Upon receiving the As-Built drawing, Public Works will schedule an inspection of the permanent water quality control measure and associated drainage features to visually confirm site conditions with the submitted drawing. If the inspector has no concerns, the Certificate of Occupancy (CO) may be obtained. If not, the CO will be withheld until all concerns are addressed. For redevelopment sites or sites in violation, an 'MS4 hold' will be placed on the parcel, under which no permits will be issued until MS4 requirements are met.

6.2.6.4 Release from Grading Permit

A site reaches final stabilization when all construction, paving, and landscaping is complete, and has reached at least 70 percent permanent vegetative cover. Upon achieving final stabilization of the site and release of the CDPS Construction Stormwater Permit, a final inspection will be conducted to verify final site conditions with the previously submitted Site Plans and As-Built Drawing. When confirmation is obtained, the site can be released from the Grading Permit. If the inspector observes conditions other than in the approved documents, additional actions and/or submittals may be required. Grading Permits may be subject to a permit renewal fee.

6.2.6.5 Long-Term Inspections of Permanent Water Quality Control Measures

Permanent water quality control measures and associated drainage features shall be routinely maintained to function properly. Long-term operation and maintenance of the permanent water quality control measure will be verified by an annual inspection or at a rate determined by Public Works staff, not to exceed five years.

If the volume capacity of the permanent water quality control measure cannot be visually verified, such as with a concrete trickle channel or other structural marker, Public Works may require a survey to be completed by a Professional Land Surveyor. Confirmation of the volume capacity will be confirmed in a report stamped by a Colorado licensed Professional Engineer. The survey and report may be required every five years.

Upon change in ownership, the new landowner will be responsible for the proper operation and maintenance of the control measure. O&M Plans may be updated at any time by contacting the Public Works Department.

6.2.6.6 Post-Construction Enforcement

When a violation is determined by an inspection, the owner will be notified either informally or formally based on the severity of the violation. Informal notification may be verbally communicated, or a written notice will be sent, usually by email.. If corrective actions are made within a reasonable amount of time, no further action is required. If corrective actions are not made within an agreed-upon schedule, a

formal NOV will be issued by certified mail. Additionally, an NOV may be issued if violations are severe or occur repeatedly at the site. If corrective actions are not made within the specified amount of time, the an 'MS4 hold' will be placed on the parcel. Additionally, a hearing may be scheduled with the BOCC. If an illicit discharge has occurred or will likely occur, the Department of Public Works may take immediate action in cleaning up or preventing the contaminant from discharging into the MS4. Specific details concerning enforcement can be found in the Weld County Code.

6.2.7 MS4 Requirements for As-Built Drawing Checklist

6.3 THE PURPOSE OF THIS CHECKLIST, PROVIDED IN APPENDIX D, IS TO ASSIST THE APPLICANT IN SUBMITTING THE REQUIRED AS-BUILT DRAWING FOR SITE DRAINAGE (PONDS, SWALES, INLETS, OUTLET STRUCTURES, SPILLWAYS, ETC.) IMPLEMENTED WITHIN THE MS4 AREA AS-BUILTS ARE TYPICALLY A RED-LINED COPY OF THE ORIGINAL PLANS, CLEARLY DEPICTING ALL CHANGES MADE IN THE FIELD. ELEVATIONS SHOWN IN THE PLANS SHALL BE VERIFIED THROUGH SURVEY. MATERIALS, DIMENSIONS, POND CAPACITY AND OTHER ASPECTS OF THE DESIGN SHALL BE VERIFIED BY THE ENGINEER. ADDITIONAL SHEETS MAY BE ADDED TO THE AS-BUILT DRAWINGS IF THERE IS NOT ENOUGH ROOM ON THE ORIGINAL PLAN.REVEGETATION

Guidelines for revegetation in Weld County are provided in the *Weed Management* section of the Weld County Public Works website. For more information regarding revegetation, refer to the *Revegetation* chapter of the USDCM, Volume 2, and the *Temporary and Permanent Seeding Fact Sheet* (EC-2) of the USDCM, Volume 3.

6.3.1 Site Preparation

An initial evaluation of site conditions is necessary for successful revegetation. Site preparation activities should include, at a minimum:

- Initial hydrologic evaluation
- Initial weed evaluation and control
- Topsoil preservation (including existing wetland soil)
- Soil testing
- Soil amendment
- Seed bed preparation
- Tree protection

A list of noxious weeds is provided in Chapter 15, Article I of the Weld County Code. In the case that noxious weeds exist onsite, the appropriate steps need to be taken before, during, and after work is completed to control their spread.

Soil amendments may be needed to improve the existing soil conditions prior to revegetating the site. Recommendations for soil amendments are provided in the Revegetation chapter of the USDCM, Volume 2 and include, but are not limited to, fertilizers, compost, peat, humates, sulfur, gypsum, lime, wood chips, and soil micro-organisms.

For disturbance of soils within the Weld County right-of-way, soils should be tested to determine requirements for fertilizing and conditioning. Based upon the test results, hydraulic growth medium (HGM) may be required. Contact Public Works for fertilizer and HGM requirements.

6.3.2 Seeding and Planting

In addition to the site preparation guidelines outlined in the Revegetation chapter of the USDCM, Volume 2, seed mixtures should be coated with Mycorrhiza at the rate of 2 pounds per acre at the time of seeding. The *Weed Management* page of the Weld County Public Works website provides recommended seed mixes for use within Weld County. The design engineer is encouraged to work with Weld County Public Works in selecting a suitable seed mix.

The two applicable seeding styles in Weld County are drill seeding and broadcast seeding. Drill seeding involves placing the seed in a firm seed bed just under the surface, which provides the best seed-to-soil contact and yields higher success rates. Typical application for this method uses 11 pounds to 14 pounds of pure live seed (pls) per acre. Broadcast seeding involves placing the seed directly to the surface of the soil, and typically uses 20 pounds to 24 pounds pls per acre. Ideal seeding dates are from April 1, or spring thaw, to June 15 and from September 15 until consistent ground freeze for non-irrigated areas. Winter and early spring seeding should not be conducted if the soil is frozen, snow covered, or wet (muddy). Hydro-seeding will be approved by Weld County only on a case-by-case basis. In order for a project to come to completion, it will be required that the project site achieve 70% plant density during full growing season.

6.3.3 Mulching

Mulching is the practice of applying a protective layer of material onto the soil surface of plantings or a seeded area. Mulching may be achieved through straw or rolled erosion control product (RECP) installations. If mulching with straw, the straw must be certified weed-free. Mulching will not be conducted in wetland areas. Hydromulch will be approved only on a case-by-case basis.

6.3.4 Maintenance

A maintenance and management plan should be established for each project to ensure successful revegetation post-construction. Recommended maintenance activities include, but are not limited to:

- Weed control and long-term management
- Reseeding bare areas where grasses did not establish
- Repairing erosion control fabrics, if applicable
- Stabilizing eroded areas, particularly following large storm events
- Installing protection from animal damage
- Temporary or permanent irrigation, as needed
- Removing debris
- Installing and/or repairing temporary fencing to control foot traffic, particularly in heavily used park areas

Wetland areas usually require specific post-construction monitoring as part of the Clean Water Act Section 404 permitting process. These requirements should be coordinated with Weld County Public Works. Refer to the *Revegetation* chapter of the USDCM, Volume 2 for more information.

The property owner/developer is fully responsible for site maintenance and revegetation.

6.3.5 Erosion Protection Design Criteria

Protecting major drainage channels from erosion is critical for maintaining channel stability. Channels need to be designed so that they remain stable until they are fully constructed or vegetated. It may be necessary to install riprap, straw bales, erosion control logs, or erosion control blankets in the channels to ensure that they remain stable. The BMPs outlined in the USDCM, Volume 3, shall be used to ensure stability.

CHAPTER 7 FEMA FLOODPLAIN REQUIREMENTS

All development, as defined by FEMA, shall comply with, all floodplain regulations and codes, including the need to submit a CLOMR and a LOMR to FEMA for review and acceptance if applicable. For more information regarding floodplain regulations, refer to Chapter 23, Article XI, of the Weld County Code; the 2022 Colorado Water Conservation Board (CWCB) *Rules and Regulations for Regulatory Floodplains in Colorado*; and Title 44 Code of Federal Regulations (CFR) 59, 60, and 65 of FEMA's regulations.

Floodplain-related work will be reviewed by the Weld County Department of Planning Services and a permit will be issued for all compliant submittals. For more information regarding floodplain modeling and mapping requirements refer to FEMA's *Guidance for FEMA's Risk Mapping, Assessment and Planning*.

7.1 BACKGROUND INFORMATION

Weld County is a participant in FEMA's National Flood Insurance Program (NFIP) therefore Weld County is responsible for ensuring that floodplain regulations per FEMA, the state of Colorado, and Weld County are administered. Failure to administer the floodplain regulations can result in the suspension of Weld County from the NFIP. Suspension from the NFIP results in the inability of Weld County residents to obtain flood insurance and the suspension of disaster assistance funding from FEMA in the event of a natural disaster.

7.2 FLOODPLAIN MANAGEMENT OBLIGATIONS

Weld County has several cases that govern many of the requirements set forth in this WCECC:

- The boundaries of the floodplain should be accurately determined and based on a reasonable standard. *Mallett v. Mamarooneck*, 125 N.E. 2d 875 (N.Y. 1955).
- Adoption of a floodplain regulation to regulate flood-prone areas is a valid exercise of police power and is not a taking as long as the regulation does not go beyond protection of the public's health, safety, morals, and welfare. *Hermanson v. Board of County Commissioners of Fremont*, 595 P.2d 694 (Colo. App. 1979).
- The adoption by a municipality of floodplain ordinances to regulate flood-prone areas is a valid exercise of police power and is not a taking. *Morrison v. City of Aurora*, 745 P.2d 1042 (Colo. App. 1987).

7.3 FEMA FLOODPLAINS

There are several hundred square miles of FEMA mapped floodplains in Weld County. Refer to the Flood Insurance Rate Maps (FIRMs) that are published by FEMA to determine if a proposed project is located within a mapped floodplain. The floodplain maps can be obtained from the FEMA Flood Map Service Center and the floodplain boundaries are depicted on the Property Portal Map maintained by Weld County. The Weld County Department of Planning Services should be contacted to determine if there have been any LOMRs or other changes to the floodplain boundaries that affect the project area.

7.3.1 Floodplain Requirements

All development, as defined by FEMA, requires a Floodplain Permit (FP) or Floodplain Development Permit (FHDP) from Weld County. The applications can be found on Weld County's Planning and Zoning

website. Contact the Weld County Department of Planning Services to determine which application is required. The designer should also be aware that a CLOMR and a LOMR are required if there is an increase greater than 0.00 feet or a decrease greater than 0.3 feet in regulatory floodways. A CLOMR and a LOMR are also required if there is an increase or a decrease greater than 0.3 feet in the WSEL in regulatory floodplains.

Sections 4.7 and 5.7 of this WCECC discuss the criteria for constructing hydraulic structures within an open channel. All design engineering of the hydraulic structures must follow accepted FEMA methodology. Construction of hydraulic structures within FEMA floodplains must not increase the WSEL for Zone A or Zone AE. Per FEMA regulations, a Floodplain Development Permit (FHDP) shall be required for the construction of channels and other major drainage system components within the floodplain. It may be necessary to submit a CLOMR and a LOMR to FEMA as part of the development process.

CHAPTER 8 TRAFFIC CRITERIA

This Chapter discusses the requirements for developing and submitting Traffic Impact Studies, traffic control devices, access to county roads, access design, auxiliary lane requirements, access construction within County right-of-way, and tracking control standards.

8.1 TRAFFIC IMPACT STUDIES

A Traffic Impact Study (TIS) is required to analyze the effects of a proposed development or other land use action on the transportation system to determine if adequate public facilities exist to serve the proposed development, and to clearly identify any improvements required to mitigate the impacts on the transportation system.

When a plan for development or redevelopment is submitted, the applicant is responsible for assessing the traffic impacts of the additional traffic to the surrounding transportation system under existing (current), short-range and long-range horizons.

If a project is adjacent to a road that is under the jurisdiction of another entity (CDOT, City, Town, or adjacent County), the applicant is responsible for contacting that entity to determine the traffic analysis and access approvals that may be required. Any proposed access to a State Highway will require a CDOT Access Permit and direct coordination with CDOT.

8.1.1 Traffic Impact Study Area

Traffic impacts shall be analyzed within the traffic impact area. The determination of a traffic impact area is done on a case-by-case basis; however, at a minimum the limits of the study should include:

1. Internal roads.
2. Adjacent roads.
3. Access locations and/or new intersections.
4. Off-site roads to the nearest paved County collector or arterial road or state highway.
5. Off-site roads where traffic from the proposed development or land use action will account for at least 20 percent of the average daily traffic upon build-out.
6. Off-site intersections where traffic from the proposed development or land use action:
    a. Contributes a 10-percent impact of the peak hour traffic on any approach leg of an intersection where the intersection is operating at a level of service (LOS) C or better upon build-out.
    b. Contributes a 5-percent impact of the peak hour traffic on any approach leg of an intersection where the intersection is operating at a LOS D or worse upon build-out.
    c. Impacts a specific turning movement that currently does not have an auxiliary turn lane by at least 50 percent of the peak hour volume warrant for an auxiliary turn lane.

8.1.2 Preliminary Traffic Impact Analysis

A preliminary traffic impact analysis (traffic narrative) shall be submitted with every project application for the application to be considered complete. The intent of the analysis is to determine the project's cumulative development impacts, appropriate project mitigation and improvements necessary to offset a specific project's impacts. This analysis shall include the following information:

1. Describe how many roundtrips/day are expected for each vehicle type: Passenger Cars/Pickups, Tandem Trucks, Semi-Truck/Trailer/RV (Roundtrip = One trip in and One trip out of a site).
2. Describe the expected travel routes or haul routes for site traffic.
3. Describe the travel distribution along the routes (e.g. 50 percent of traffic will come from the north, 20 percent from the south, 30 percent from the east, etc.).
4. Describe the time of day that you expect the highest traffic volumes.

Public Works will review the narrative and advise the applicant if more information or an engineered traffic impact study is required.

8.1.3 Traffic Impact Study Requirements

A full TIS is required for any proposed development or land use zoned Commercial or Industrial, any residential subdivision greater than nine (9) lots, or when determined necessary by the Engineer. The TIS should address impacts to on-site and off-site roadways and highways within the County and shall be prepared, stamped, and signed by a Professional Engineer licensed in the state of Colorado. The TIS shall include, at a minimum, the following information:

1. Describe the traffic impact area, including at a minimum those elements described in the traffic impact study area section of this document.
2. A location map showing the development site, the boundaries of the traffic impact area, and all roads, intersections, bridges, or other roadway structures in the traffic impact area.
3. Define the following study horizons for the Full Traffic Impact Study: the existing (current), short- range, and long-range horizons.
    a. Existing Horizon: The intent is to establish a baseline traffic condition.
    b. Short-Range Horizon: The intent is to evaluate the immediate impacts of the project on the transportation system. The short-range horizon year is defined as the point of full buildout of the proposed development or land use action. If the project is proposed to occur over multiple phases, the impacts shall be analyzed at the point of full buildout of each phase. In no case shall the short-range horizon exceed five (5) years.
    c. Long-Range Horizon: The intent is to evaluate the impacts of the fully developed project in the context of regional transportation planning efforts. The long-range impacts are analyzed as of the end of the current Regional Transportation Plan 20-year planning horizon.
4. Identify the existing, approved, and proposed land uses within the traffic impact area.
5. Describe existing traffic conditions within the traffic impact area, including average daily traffic volumes for roadways and impacted intersections and a.m. and p.m. peak hour levels of service for intersections.
    a. Existing daily traffic data must be obtained from the Department of Public Works. If the data are not available for the area in question or data is outdated (older than 24 months for daily counts or 12 months for intersection counts), then the designer may obtain new traffic data. Daily traffic counts must be collected over a 72-hour period starting on a Tuesday and ending on a Thursday of a normal week, excluding any holidays or events that may skew results. Daily traffic counts must have been collected within the past 24 months. Intersection turning movement counts must be collected for at least two hours each of the morning and evening peak hours of a typical weekday (Tuesday,

Wednesday, or Thursday) and must have been collected within the past 12 months. Existing daily roadway and intersection peak hour traffic counts must be included for the study area. Any traffic counts collected for the study should be included in Appendix I.

6. For short-range traffic projections, provide references, calculations, and data sources for all trip generation estimates. The trip generation results shall be shown in a table with the following information:
    a. Land Use
    b. Unit of Measurement (for example, per dwelling unit, per 1,000 sq. ft., etc.)
    c. Total number of units
    d. Trip generation rates per unit for average daily traffic and peak hour volumes
    e. Total number of trips generated for average daily traffic and a.m. and p.m. peak hours
7. Short-range and long-range traffic projections must also include forecasts for the growth in background traffic
8. Provide trip distribution estimates for the roads and intersections in the traffic impact area based on the following:

    Tables in the report need to show the trip generation rates used, based on the most recent version of the Institute of Transportation Engineer's *Trip Generation Manual*.

    If no *Trip Generation Manual* information is available, the site-specific number of trips can be calculated based on the number of employee trips for each shift time, number of deliveries, additional trips entering/exiting, and other applicable trips that may enter and exit the site throughout a typical day.

    a. Vehicle Types

        The number or percentage of anticipated trucks should be included in the trip generation. In the analysis, a Passenger Car Equivalent (PCE) should be used to account for slower-moving trucks in the traffic stream. The procedures for converting trucks to PCEs can be found in the latest edition of TRB's *Highway Capacity Manual* or in the CDOT *State Highway Access Code*.

        If a haul route is associated with the development, the route should be called out in the report.

    b. Trip Distribution

        The directional analysis for the site-generated traffic should be presented clearly. If internal trip reductions or pass-by trips are used in the calculations, they must be clearly documented.

    c. Total Proposed Volumes

        The total proposed trips and corresponding turning movement counts should be clearly shown for both the short-range horizon (project opening year) and for the long-range horizon (20-year planning horizon).

9. Present the volumes for short-range and long-range traffic including the projected traffic for the proposed development or land use action for the a.m. and p.m. peak hour and average daily conditions. These volumes must include turning movements at intersections as well as volumes for roads in the traffic impact area.
10. Analyze the adequacy of the transportation system to handle the projected traffic for short-range and long-range planning years. Key elements in this analysis should include:

    a. Generalized daily traffic volume level of service for roadways and intersection levels of service for a.m. and p.m. peak hours, based on the following guidance:

       The LOS must be analyzed at each intersection within the study area. For unsignalized intersections, the worst-movement approach must be reported. The County has established LOS C as the minimum acceptable threshold at both signalized and unsignalized intersections. If LOS C cannot be achieved in the existing, opening year, or horizon year analysis, mitigation should be recommended and documented.

       The existing peak hour LOS and delay calculations should be based on the procedures outlined in the latest edition of the TRB's *Highway Capacity Manual*. Typically, the weekday morning and evening peak hour will be used for analysis, but if the site's peak hours are anticipated at other times of day, the proposed peak hours of analysis should be approved by the County.

       The following traffic analysis scenarios must be included:

       - Existing (Current) Year, without project
       - Short-Range Analysis, Project Opening Year with Project Traffic
       - Long-Range Analysis (20-year planning horizon) without Project (Background Traffic)
       - Long-Range Analysis (20-year planning horizon) with Project

       If the project is proposed to open in phases, the analysis of multiple opening year scenarios may be required. An additional Background Traffic Project Opening Year scenario may be required if background traffic volumes are anticipated to be significantly higher than under Existing Year conditions.

       Each analysis scenario should be presented clearly, with graphics showing the proposed access locations, assumptions used for trip distribution, trip assignment, intersection turning movements, daily traffic volumes, and LOS. Any existing or background intersection or roadway operational and geometric deficiencies in the study area should be clearly noted.

    b. The appropriateness of access locations and if necessary, a traffic signal warrant analysis.

       Requirements for access spacing are included in Section 8.5. All existing and proposed intersections within the study area should be assessed to determine if spacing criteria are met.

If an intersection within the study area may be signalized, a traffic signal warrant analysis should be performed based on the warrant criteria in the latest edition of the MUTCD. Both the opening year and horizon year conditions should be evaluated to determine if the intersection may meet warrants.

c. The need for auxiliary lanes (turn lanes, deceleration, and acceleration lanes), including explanations of how acceleration/deceleration lengths, storage lengths, and taper lengths were determined.

   Requirements for auxiliary lanes are included in Section 8.7 and are based on the CDOT *State Highway Access Code* Rural Highway (Category R-B) classification requirements. If the roadway has characteristics differing from a Rural Highway, the designer should refer to the Access Code to utilize a more appropriate classification to calculate auxiliary lane needs. All intersections and site access points within the study area should be evaluated to determine if auxiliary lane warrants are met. If auxiliary lanes are in place, the study should determine if the storage length, taper length, and deceleration/acceleration lane distances meet minimum requirements with the added site traffic.

d. Sight Distance

   All site accesses should be evaluated to ensure sight distance minimum requirements are met based on the requirements in Section 8.6. If applicable, the study should evaluate if changes to passing zones are recommended in the vicinity of the site due to the proposed development.

e. Crash History

   A crash history and safety analysis may be required if the site is proposed to access a

f. location where the County has identified a safety concern. Consultants may need to purchase third-party software, such as DiExSys, to analyze the safety performance functions of a location based on existing and proposed new traffic. If a location is found to perform at a level of service of safety greater than 3, then improvements must be determined to reduce the level of service of safety. Weld County will accept locations that have a level of service of safety of 1, 2, or 3.Sites Accessing Gravel Roads

   If the site is proposed to access gravel roads, an assessment should be performed to determine if development of the site requires consideration of paving the road. See Section 8.9 for Tracking Control requirements.

g. Parking Needs

   For non-residential development, ensure that the site has adequate on-site or on-street parking available.

h. Safe Routes to School and/or School Bus Stops

For residential development, identify existing or proposed school bus stops within the study area, existing and proposed sidewalks, and note any deficiencies and proposed improvements.

i. Access to Public Transit

If there is public transit within the study limits, identify accessibility to public transit and safe pedestrian/bicycle access to the nearest transit stop within half a mile of the project site.

j. Haul Route

If applicable, the site's proposed haul route should be identified. Any deficiencies along the haul route (such as pavement, bridge deficiencies, etc.) must be called out along the haul route, even if it is outside of the project study area.

11. Provide a summary of conclusions and recommendations from the full Traffic Impact Study, including at least the following items:
    a. A summary listing of traffic impacts from the proposed development on existing and proposed roads and intersections within the traffic impact area.
    b. A summary listing of the improvements needed to assure adequate service and safety levels on the roadway system affected by the proposed development, identify and describe each proposed improvement, how and when it will be funded, and expected completion dates.
        i. The TIS should clearly state recommended improvements to the site accesses, intersections, and roadway system for the short-range and long-range years. Include any auxiliary lane recommendations, modifications to existing storage bay lengths, intersections recommended to be signalized, proposed turning restrictions at intersections or access points, modifications to roadway surface, or improvements required along the roadway.
        ii. An updated LOS analysis should be performed where mitigation is recommended to ensure that acceptable operations can be achieved for both short-range and long-range conditions.
        iii. Identify and describe each proposed improvement, how and when it will be funded, and expected completion dates.
12. Any reasonable additional information deemed necessary for review–special considerations.

    Public Works will review the TIS and advise the applicant if more information is needed or provide technical comments on the submittal.

8.1.4 Traffic Impact Study Checklist

A stand-alone checklist will be provided to developers along with the Pre-Submittal Requirements packet found in Appendix I of this document.

8.1.5 Updating Existing Traffic Impact Studies

The following scenarios will require the preparation of an update (or amendment) to a previous study, or the preparation of an entirely new study.

1. When the time or circumstances of the original study fall within the parameters presented in Table 8-1, the applicant shall prepare the appropriate documentation identified in Table 8-1.
2. When the original study was prepared for a large, complex, or phased project and was designed, organized, and written to function as a “base” or master plan document for future development applications, it must include updates to the County comprehensive plan. (These types of studies require scoping consultation with the County prior to their preparation.)

Table 8-1 Updating an Existing TIS

Changes to the Original Development		
Original Report is:	Access changed, or trip generation increased by 15% or more	Access did not change, **and** trip generation did not increase by 15% or more
< 2 years old	Amendment letter: identify and discuss only items that changed	Letter documenting change; include level of service (No other traffic requirements)
> 2 years old	New study	Amendment letter, including: • Updated traffic counts (daily counts taken over 72 hours) • Revised trip generation • Revised LOS analysis • Meet all current TIS requirements

8.2 CHANGE IN ACCESS USE

If the use of an existing access to County right-of-way changes or there is a change in the use of the property, a new Access Permit will be required, in accordance with Chapter 8, Article 14 of the Weld County Code. Change in access or property use may include, but is not limited to, change in the amount or type of traffic, structural modification, remodeling, change in use or type of business, expansion of existing business, change in zoning, change in property division, and creation of new parcels.

8.3 TEMPORARY ACCESS

Any road access that will be closed after being used for a limited time may be considered a temporary road access, or a road that will be temporarily used for a different purpose may be considered a temporary upgrade in use. The time in use of temporary accesses will not exceed 18 months. A Temporary Access Permit may be granted only if the temporary access meets minimum County traffic safety and operational requirements (Weld County Code Sec. 8- 14-10, et seq), including sight distance and tracking control that is discussed in further detail in Section 8.9. For a Temporary Upgrade in Use Access Permit, the access must meet prior use standards and regulations including use, width, and turning radii after the permit expires.

8.4 TRAFFIC CONTROL DEVICES AND PLANS

All road signs, striping, delineators, barricades, signals, and other traffic control devices will conform to the most current edition of MUTCD and any applicable Colorado supplement, as amended. The applicant will be required to install all necessary signage and will bear all expenses for the fabrication and installation of road name signs, permanent barricades, and signs for implementing the approved project design (e.g., one way, no parking, no outlet, stop sign, speed limit). Necessary signage will include signs required on County roads as a consequence of the applicant's project, such as regulatory, guide, or warning signs. Signs and barricades will be in place prior to road acceptance.

8.4.1 Signage and Striping Plans

All road improvement and/or land development projects must incorporate a separate signage and striping plan in accordance with the criteria of this section. Striping plans may not be required for local subdivision roads. However, sign plans are still required for all subdivisions. All signing and striping plans

will conform to the most current edition of the MUTCD. All traffic control devices will be fabricated and installed in accordance with the MUTCD. Permanent signage and striping will be complete and in place before any new roadway is opened to the public for use.

8.4.1.1 Signage Plan Elements

1. Show the general longitudinal location of each sign (horizontal offset and station).
2. Specify the sign legend and sign type.
3. Specify the sign size.

8.4.1.2 Striping Plan Elements

1. Include stripe color and type.
2. Include lane width, taper lengths, storage lengths, etc.
3. Include striping/skip interval.
4. All permanent pavement marking materials, except point location markings, must meet current CDOT specifications for thermoplastic traffic marking paint unless another material is specified by the engineer and approved by the County.
5. All point location markings (stop bars, turn arrows, words, symbols, etc.) must meet specifications.
6. Include station and offset or dimensions for all angle points, symbol locations, and line terminations.
7. Include stripe dimensions.
8. Delineate raised median islands.

8.4.2 Striping guidance

A stop line (stop bar) should be placed a minimum of 4 feet in advance of the nearest crosswalk line at controlled intersections. In the absence of a marked crosswalk, the stop line should be placed at the desired stopping point but should not be placed more than 30 feet or less than 4 feet from the nearest edge of the intersecting traveled way. Preferred distance is 10-12 feet from edge of traveled way.

8.4.3 Type and Location of Signs

The Department of Public Works will make the final determination regarding the type and location of traffic control devices within the right-of-way or access easement. These controls will include traffic control signs, road name signs, delineators, and permanent barricades.

8.4.4 New Roadway Signage

Permanent signage, unless otherwise approved by the Department of Public Works, will be installed before any new road or access easement is opened for use.

8.4.5 Memorial Sign Applications

A memorial sign must be requested by the victim's family or another sponsor with the consent of the victim's family, in accordance with Weld County Code, Chapter 8, Article VI, Sec. 8-6-180. Upon submittal of a Roadside Memorial Sign Application with fee to the Weld County Public Works Department, Public Works will review the application for acceptance. See also Appendix 8-L and 8-M of the Weld County Code.

8.4.6 Construction Criteria

Refer to Section 10.9.1 and Section 10.9.2 for more-detailed information on construction criteria of pavement marking and traffic control devices.

8.5 ACCESS POINTS

The Weld County Code defines an access as the place, means. or way vehicles or pedestrians shall have safe, adequate and legal ingress and egress to a lot, trail, open space, off-street parking space or use. Weld County recognizes that property owners have a right of reasonable access to the County road system. However, within an environment where population growth will increase traffic volumes and operational pressure on the general transportation system, be it rural or urban, access control is crucial to protect the public health, safety, and welfare. Access control is used to maintain smooth traffic flow, to provide road right-of-way drainage, and to protect the functional level of the County roads while meeting state, regional, local, and private transportation needs and interests. Weld County Code Sec. 8-14-10, et seq., contains the County's Road Access Policy. Also refer to the Weld County Functional Classification Map and Transportation Plan, available on the County's Transportation Planning webpage.

An access permit application must be submitted for any new proposed access to a County-maintained road. If a property is proposed to directly access a State Highway, access must be approved and obtained by CDOT as described in Section 8.3.1.1.a. If a property is proposed to directly access a road under the jurisdiction of a local municipality, access must be approved and obtained by the local municipality.

If a property has frontage on two roads, it is recommended access should be obtained from the lower volume road when possible.

Intersection and access spacing criteria (as measured from centerline to centerline) for local roads, collector roads, and arterial roads are shown in Table 8-2.

Table 8-2 Minimum Intersection & Access Spacing Criteria (feet)

Access Element	Arterial	Collector	Local
Distance between intersections			
Signalized	2,640	N/A	N/A
Unsignalized	1,320	1,320	330
Distance between access points and intersections	660	660	330
Distance between access points	660	330	150
Distance between access points in Subdivisions	N/A	N/A	75

If design criteria cannot be met for auxiliary lane requirements or if an operational threshold of LOS C cannot be maintained, the proposed access may be approved as restricted movement, as described in Section 8.5.6.

8.5.1 Local Roadways

Access standards to local roadways will be governed by Weld County recognizing that property owners have a right of reasonable access to the County road system. However, within an environment where

population growth will increase traffic volumes and operational pressure on the general transportation system, be it rural or urban, access control is crucial to protect the public health, safety, and welfare.

Access control is used to maintain smooth traffic flow, to provide road right-of-way drainage, and to protect the functional level of the County roads while meeting state, regional, local, and private transportation needs and interests. Weld County Code Sec. 8-14-10, et seq., contains the County's Road Access Policy. Also refer to the Weld County Functional Classification Map and Transportation Plan, available on the County's Transportation Planning webpage.

Whenever possible, shared accesses will be given priority.

8.5.2 Collector Roadways

Access standards to collectors are shown in Table 8-2. An access or new intersection onto a collector is not permitted unless it meets the spacing requirements in Table 8-2 and an alternative access or intersection to a lower classified road is not feasible. No more than one access will be allowed to an individual or to contiguous parcels under the same ownership unless it can be shown that the additional access would not be in conflict with local safety regulations; the additional access would not be detrimental to public health, safety, and welfare; and the additional access is necessary for the efficient use of the property.

8.5.3 Arterial Roadways

Access standards onto arterial roadways are shown in Table 8-2. An access or new intersection onto an arterial is not permitted unless an access/intersection to a lower classified road is not feasible and the proposed access meets the spacing requirements in Table 8-2 and does not interfere with the location, planning, and operation of the general street system or access to nearby properties. Whenever possible, shared accesses will be given priority. No more than one access will be allowed to an individual or to contiguous parcels under the same ownership unless it can be shown that allowing only one access would be in conflict with local safety regulations; the additional access would not be detrimental to public health, safety, and welfare; and the additional access is necessary for the efficient use of the property. Intersections will be spaced no less than one-quarter mile apart on arterials, unless such spacing is impractical or impossible due to topographic or other physical limitations as determined by the Department of Public Works. The type of access—full movement, three-quarter movement, or right-in/right-out movement—will be determined by the Department of Public Works.

8.5.4 State Highway and Interstate Systems

CDOT and FHWA rules and regulations will apply to all highway and interstate accesses. Weld County takes no jurisdictional authority over access onto a highway or interstate.

8.5.5 Shared Accesses

Whenever possible and feasible, shared access will be provided to serve two or more adjacent properties. A shared access is to be centered on the common property line. For shared accesses, the County strongly recommends the property owner establish a written access road maintenance agreement so future owners of the properties will be aware of their requirements for shared maintenance of the access road. Shared access and utility easements shall be a minimum of 30 feet wide and shall contain a minimum 20-foot-wide, all-weather roadway.

8.5.6 Restricted Movement Access

If the minimum spacing criteria cannot be met, or if the minimum level of service threshold of LOS C cannot be achieved, the County may require that the movements at an access be restricted to ensure traffic safety. The following types of access are most common:

1. Full movement access. All potential movements for the access are allowed.
2. Three-quarter access. All movements are allowed except a left turn out of the access.
3. Right-in/right-out access. Only right turn in and right turn out movements are allowed.

8.5.7 Access Control Plans

On corridors with an adopted Access Control Plan in effect, recommendations for each existing and future access location and policies that guide future access management efforts will be enforced.

8.6 ACCESS DESIGN

Access points will be designed to provide safe movement for traffic entering and traveling on roadways within the County. Like intersections, access points are conflict locations. The basic design of access points includes adequate spacing, proper alignments, and clear sight distances.

8.6.1 Geometric Design

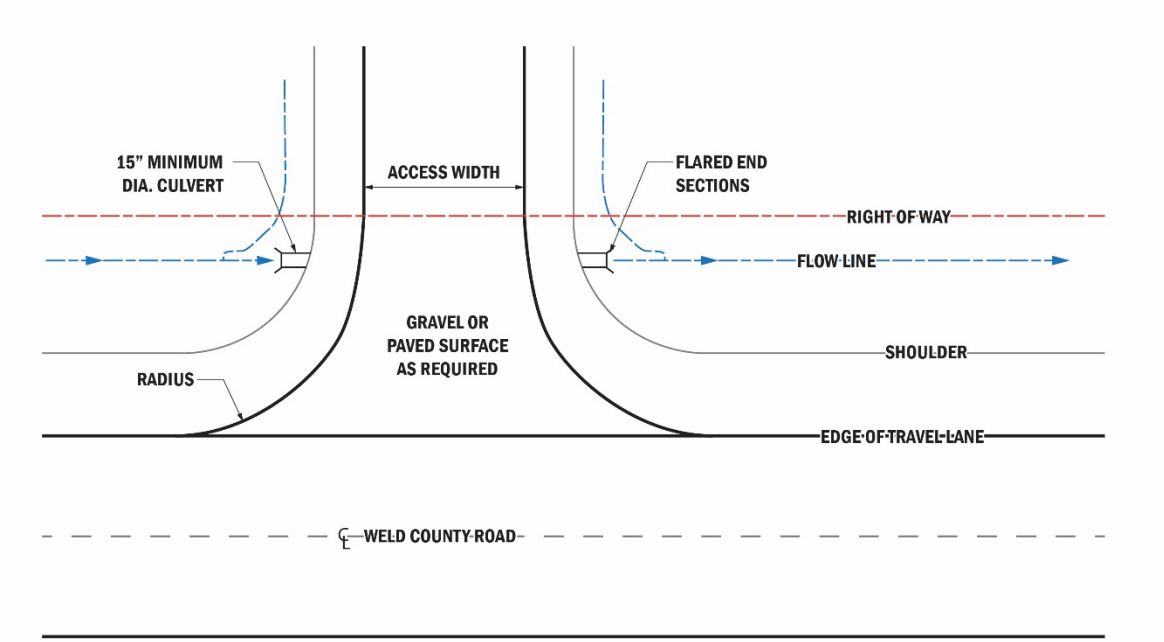
Accesses shall enter onto Weld County roads at an 80- to 100-degree angle, for a minimum of one vehicle length. An access approach that is gated will be designed so that the longest vehicle (including trailers) using the access can completely clear the traveled way when the gate is closed. In no event will the distance from the gate to the edge of the traveled surface be less than 35 feet. Any overhead entry structures shall have at least a 14-foot, 6-inch clearance, measured from the access surface. When the access is intended for commercial or industrial use, the access radii shall accommodate the turning movements of anticipated vehicle types. AutoTURN exhibits may be required by the County if there is a safety or operational concern. Table 8-3 shows the access width and access radii for properties based on land use.

Table 8-3 Access Geometry

Type of Land Use	Maximum Access Width at ROW	Access Radii
Single-family residential	24 feet wide	25 feet minimum
Commercial/Industrial/Agricultural	40 feet wide	65 feet minimum

Fill slopes and cut slopes will be constructed to match the slopes of the existing County road adjacent to the maximum access width as identified at the ROW line. It is desirable that all side slopes be no steeper than 4:1 (H:V). Drainage culverts are required for new access points unless otherwise approved by the County. Minimum required size is a 15-inch aluminized CMP or RCP. See Section 5.8.3 of this document for allowable culvert types. Minimum cover requirement will be 12 inches above the pipe crown to the bottom of asphalt at the edge of pavement (for paved roads) and a minimum of 12 inches of cover above the pipe crown to the top of the finished grade (for gravel roads). All culverts should be sized to convey the flow water based on the existing capacity of the ditch and meet the HW/D requirements specified in Chapter 5 of this document. Figure 8-1 shows a typical access approach. Dimensions of radius and access width should be determined by Table 8-3, above.

Figure 8-1 Access Approach



8.6.2 Access Sight Distance

Accesses are stop controlled so the access sight distance discussed in this section is the distance required for vehicles to enter traffic and accelerate to the average running speed. There shall be an unobstructed sight distance along both approaches and both sides at an access (within the right-of-way) for distances sufficient to allow the operators of vehicles that are approaching simultaneously to see each other in time to prevent collisions at the access. All clear sight triangles must be within the public right-of-way or a sight distance easement. See also Figure 8-2.

Distance a_2 in Figure 8-2 is equal to distance a_1 plus the width of the lane(s) departing from the intersection on the major road to the right. Distance a_2 also should include the width of any median present on the major road. The appropriate measurement of distance a_1 and distance a_2 for departure sight triangles depends on the placement of any marked stop line that may be present and, thus, may vary with site-specific conditions. In Weld County, the typical distance behind the traveled way to the stop bar is 14 feet.

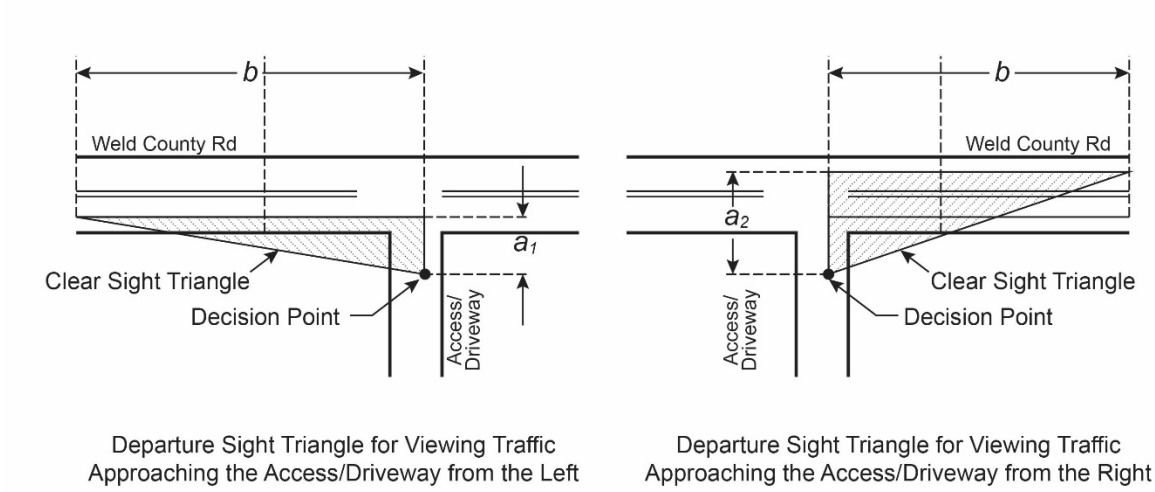
$$b = 1.47 V_{major} t_g \qquad \text{Eq. 8.6.1}$$

b = Access Sight Distance (see Figure 8-2)
V_{major} = Design Speed of major road (MPH)
t_g = time gap needed for vehicle entering major road (sec)
- t_g = 7.5 Car, 9.5 Single-Unit Truck, 11.5 Combo-Unit Truck
- Adjust t_g for crossing more than 2 lanes:
  - +0.5/extra lane for cars
  - +0.7/extra lane for trucks
- Also adjust t_g for starting grade of the vehicle if it exceeds 3%
  - +0.2 sec/percent grade for cars and trucks (only for starting uphill)

The value calculated should be rounded up to the nearest 5 feet.

Additional information regarding sight distance for intersections and cases other than the stop control condition can be found in AASHTO's *A Policy on Geometric Design of Highways and Streets*.

Figure 8-2 Departure Sight Triangles at Access (Stop Control)



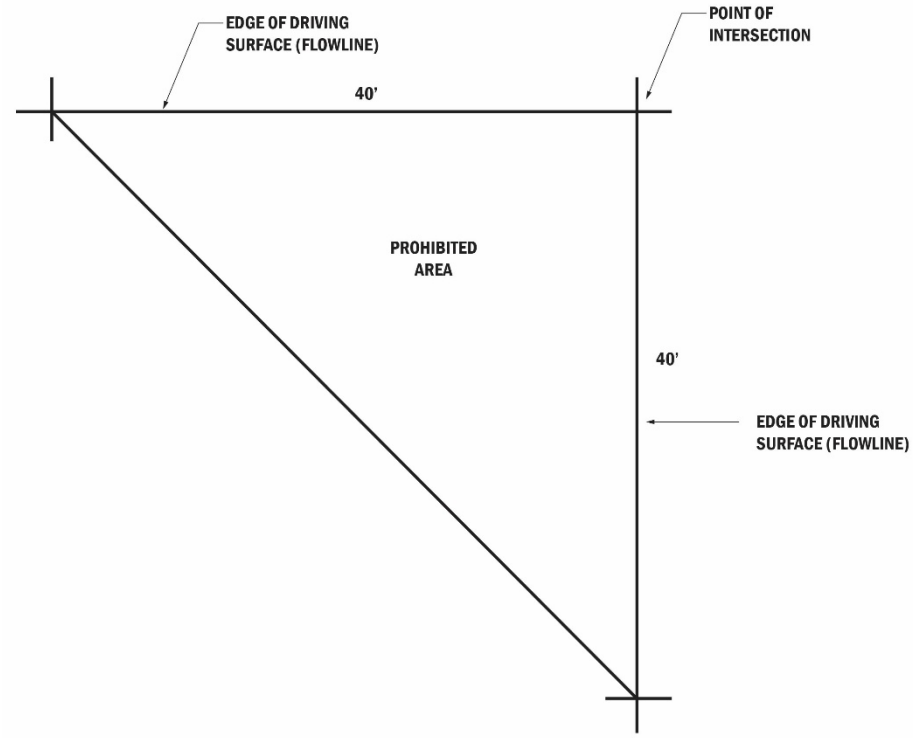
Departure Sight Triangle for Viewing Traffic Approaching the Access/Driveway from the Left

Departure Sight Triangle for Viewing Traffic Approaching the Access/Driveway from the Right

8.6.3 Subdivision Roads Sight Distance

Roads should not have visible impediments between 3 feet and 8 feet in height at subdivision intersections within a triangular area, as shown in Figure 8-3.

Figure 8-3 Subdivision Road Sight Distance Triangle



8.7 AUXILIARY TURN LANES

Auxiliary lanes are useful in maintaining the safety, traffic flow, and operation of a roadway or access. When auxiliary lanes are required by the County or warranted by information obtained during the development review process, the applicant is responsible for design, installation, and any purchase of right-of-way to accommodate the required lane width. Auxiliary lanes are required when unique location factors (e.g., roadway speed and traffic density, access volume, the volume of commercial trucks, the

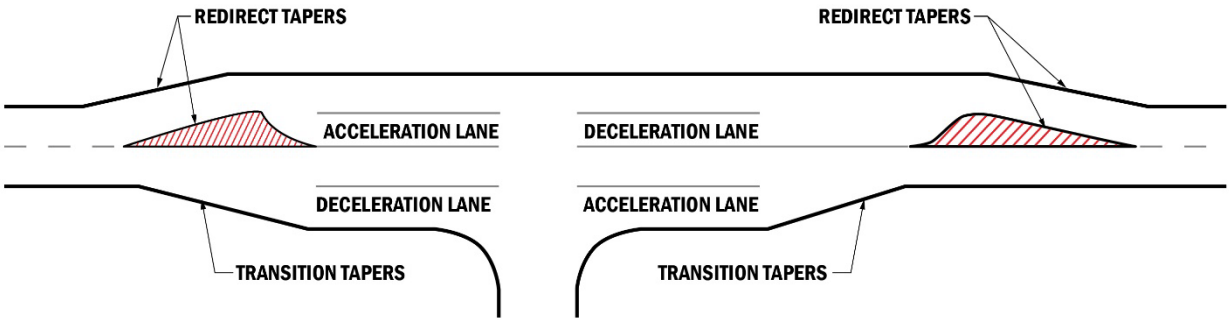
influence of nearby accesses, existing auxiliary lanes close to the proposed access, nearby traffic control devices, available stopping sight distance, and other topographic or roadway design factors) exist that determine the need for auxiliary lanes.

Auxiliary lanes are required to mitigate specifically identified and documented locations with safety and/or operational problems. These include:

- Any access where high traffic volume or lack of gaps in traffic make an auxiliary lane necessary for vehicles to safely and efficiently enter/exit the roadway.
- Any locations where conditions such as horizontal or vertical curves and sight obstructions exist that cannot be removed and may negatively affect public safety or traffic operations.

Auxiliary lanes typically consist of one or more of the following: transition taper, acceleration or deceleration length, and storage length (see Figure 8-4). The use of these components varies based on speed limit, through street classification, and site-specific conditions (grades).

Figure 8-4 Auxiliary Lanes Layout



Auxiliary turn lanes shall be installed on local, collector, and arterial roadways according to the criteria in Table 8-4, which is consistent with the requirements for Rural Highways in the CDOT *State Highway Access Code*. Auxiliary lanes may be also required at the County's discretion if safety needs or unique location factors discussed above warrant the addition of an auxiliary lane. Auxiliary lane thresholds should incorporate a passenger car equivalent factor based on the existing and projected bus, truck, and combination volumes.

Table 8-4 Auxiliary Lane Requirements

Classifications	Auxiliary Lane Criteria to be Checked			
	Minimum Ingress Left Turns Required for Left- Turn Deceleration Lane	**Minimum Ingress Right Turns Required for Right-Turn Deceleration Lane**	**Minimum Egress Right Turns to Require Right- Turn Acceleration Lane**	**Minimum Egress Left Turns to Require Left-Turn Acceleration Lane**
Arterial	10 vph	25 vph	50 vph	May be required if it would benefit the safety and operation of the roadway
Collector	10 vph	25 vph	50 vph	May be required if it would benefit the safety and operation of the roadway
Local	10 vph	25 vph	Generally not applicable	Generally not applicable
Geometric Components	Deceleration Length + Taper Length + Storage Length	Deceleration Length + Taper Length + Storage Length	Acceleration Length (Includes Taper)	Acceleration Length (Includes Taper)

The geometric components of a deceleration lane are shown in Figure 8-5 and of an acceleration lane in Figure 8-6.

Figure 8-5 Geometric Components of A Deceleration Lane

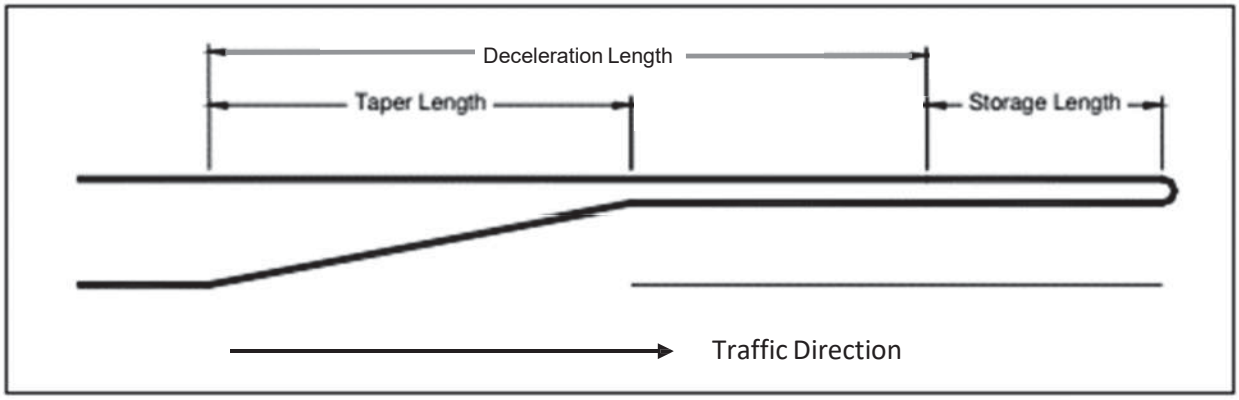
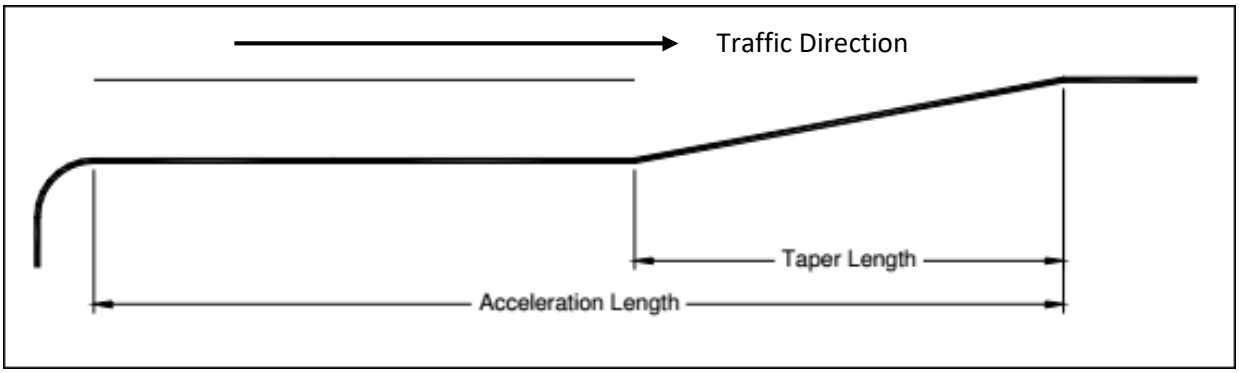


Figure 8-6 Geometric Components of an Acceleration Lane



8.7.1 Auxiliary Lane Length

To determine the required acceleration and deceleration lane and transition taper length, see the design criteria presented in Table 8-5 and Table 8-6. Table 8-5 is an excerpt taken from Table 4-5 of the *State Highway Access Code*, August 31, 1998 for a Category R-B—Rural Highway. A rural highway is described as, "highways that have the capacity for moderate to high travel speeds and low traffic volumes providing for local rural needs. This category may be assigned to low volume minor arterials, secondary collectors and local highway sections that do not normally provide for significant regional, state or interstate travel demands. "The Category R-B meets the needs for most Weld County maintained roadways. The designer should refer to the *State Highway Access Code* for roadways with characteristics differing from the R-B description above.

The length of the required transition taper is determined by multiplying the distance offset (lateral shift) by the transition taper ratio value associated with the posted speed in Table 8-6. The beginning and ending point of all tapers shall be rounded.

- Acceleration Transition tapers: The purpose of an acceleration lane and transition taper is to provide sufficient length for a vehicle to accelerate to the appropriate speed and merge into the through traffic lanes without disrupting traffic flow. Table 8-6 provides the required acceleration lane and transition taper lengths by design speed. Acceleration lane lengths in Table 8-6 will be adjusted for a grade of 3 percent or more by the factors shown in Table 8-7. The total length of the acceleration lane includes the values of both the lane and transition taper. The length of a transition taper is calculated by multiplying the width of the lane by a standard ratio shown in Table 8-6. The beginning and ending point of all tapers will be rounded.
- Deceleration Lane lengths: Deceleration lengths shown in Table 8-6 represent the estimated distance to maneuver from the lane into an auxiliary lane and brake to stop. The transition taper is calculated based on design speed and deceleration lane lengths in Table 8-6 will be adjusted for a grade of 3 percent or more by the factors shown in Table 8-7. The storage lane lengths will be included in the calculation, which are shown in Table 8-8 or based on the results of a Traffic Study.
- Redirect or straight tapers: Redirect tapers will be used where an exclusive turn lane, median, or other redirection of vehicles is necessary and where redirection of the flow of traffic is necessary to accommodate the exclusive turn lane or median. Redirect tapers required for redirecting through travel lanes will be installed in conformance with Table 8-6. If the redirect taper would

result in a horizontal curve design deficiency for the through movement, the horizontal curve will be corrected. Redirect tapers should be designed as straight tapers with the beginning and ending points rounded.

- In cases where there is constrained right-of-way, restrictive topography, or limited distance between intersections, a design waiver may be obtained to construct a shorter auxiliary lane.

Table 8-5 Components of Speed Change Lane Lengths for Rural Highways (R-B) from *State Highway Access Code*

Access Category	Left-Turn Deceleration Lane	Right-Turn Deceleration Lane	Acceleration Lane
R-B	*decel. Length + storage	*decel. Length	*accel. length

**Taper length is included within stated accel. Or decel. length*

Table 8-6 Acceleration/Deceleration Lane and Taper Design Criteria and Redirect Taper for Through Lanes

Acceleration/Deceleration Lane Design Criteria									
Posted speed limit (MPH)	25	30	35	40	45	50	55	60	65
Deceleration length (ft)	180	250	310	370	435	500	600	700	800
Acceleration length (ft)	N/A	190	270	380	550	760	960	1170	1380
Accel/Decel Transition taper (ratio)	7.5:1	8:1	10:1	12:1	13.5:1	15:1	18.5:1	25:1	25:1
Redirect (Straight) taper for Through Lanes (ratio)	15:1	15:1	20:1	30:1	45:1	50:1	55:1	60:1	65:1

Table 8-7 Grade Adjustment Factors for Acceleration Lanes

Grade	Posted Speed Limit (mph)				
	25 to 45	50	55	60	65
3 to 4.9% Up Grade	1.3	1.4	1.5	1.5	1.7
5 to 7% Up Grade	1.5	1.8	2.0	2.3	2.5
3 to 4.9% Down Grade	0.7	0.65	0.65	0.6	0.6
5 to 7% Down Grade	0.6	0.55	0.55	0.5	0.5

8.7.2 Storage Lengths

The storage length for an auxiliary lane can be determined by the information summarized in Table 8-8. These lengths are based on the average length of a passenger vehicle and the estimated turning vehicles per hour. Estimated lengths for buses, larger trucks, and recreational vehicles must be determined and submitted to the County for review, or a "passenger car equivalent" (PCE) should be incorporated into the storage length calculation. Use a PCE of 3 for each bus and all trucks and combinations of 40 feet in length or longer. Use a passenger car equivalent of 2 for each vehicle or combination at or over 20 feet in length but less than 40 feet.

Table 8-8 Auxiliary Lane Storage Lengths

Auxiliary Lane Storage Lengths						
Turning vehicles per hour	< 30	30-59	60-100	100	200	300
Minimum required storage length (ft)	25	40	50	100	200	300
Truck traffic generators (ft)	100	100	200	200	200	300

The basis for designing the length of required storage is to provide sufficient length for vehicles to queue within the lane without affecting other movements. Table 8-8 provides the required storage lengths for stop-controlled intersections. Storage lengths for signal-controlled intersections may be determined from highway capacity nomographs in the *Highway Capacity Manual* or may be based on the recommendations of the submitted Traffic Impact Study for the development. If the Department of Public Works determines that meeting the required storage length is impractical or will result in an unsafe condition, the minimum storage length will be based on the mean arrival rate.

8.7.3 Auxiliary Lane Conflicts

The following standards also apply for auxiliary lane design.

1. No driveway will be permitted within the transition area of any auxiliary lane.
2. In the event that a portion of an auxiliary lane extends across one or more adjacent properties, the County may require the applicant to obtain any necessary right-of-way.
3. In the event an auxiliary lane is constructed within 100 feet of an arterial-arterial intersection, the applicant is responsible for design, acquisition of required right-of-way, relocation of utilities, and construction of the lane to such intersection.
4. Where two intersections have exclusive turn lanes that overlap or the ending points of the exclusive turn lanes have less than 300 feet or one-half their length of separation (whichever is shorter), and a significant structure or topographical feature does not preclude widening, a continuous exclusive turn lane will be constructed between the intersections to improve roadway consistency and safety, and to maintain edge of pavement continuity.
5. If restrictive topography allows only one exclusive turn lane, normally a left-turn deceleration lane is given first priority. Where a left-turn lane is installed and the travel lanes must be redirected, an overlay of pavement is required.

8.8 ACCESS CONSTRUCTION

All roadway access construction that affects existing structures within the County right-of-way—such as pavement, curbs, gutters, sidewalks, drainage structures, ditches, and auxiliary lanes—is required to incorporate modifications to existing structures as part of the final access design. An Access Permit is required prior to any new access construction. The Access Permit allows construction of the access without the need for obtaining a separate Right-of-Way Use Permit unless the proposed access point is located within section line County Right-of-Way or if the access is to be paved with asphalt or concrete.

8.8.1 Gravel Requirements

Gravel or recycled asphalt gravel base will be permitted for individual residential access or field access adjacent to County roads with gravel surfacing. The gravel surface will include a minimum of 6 inches of

compacted aggregate base course or equivalent material from the right-of-way line to the edge of the traveled roadway. Specifications for this material can be found in Section 9.6.6.

8.8.2 Pavement Requirements

Access pavement thickness shall match roadway pavement thickness. If required by the weather, a delay of one season in placement of hot bituminous pavement may be allowed, provided adequate gravel surfacing is substituted and maintained until asphalt placement.

8.8.3 Access Drainage

Accesses shall be constructed in a manner that minimizes erosion and does not result in deposition of silt and debris on the County roadway or in roadside ditches. Accesses that slope down toward the public road will be constructed to assure that water does not run onto or across the traveled public way. This may include designing the crown, borrow ditches, pans, or other elements so that they direct water to the existing drainage facilities along the road. The owner of the property shall pay for materials and the cost of installation for new access culverts whenever the installation of a culvert is made necessary by the creation of a new access from private property to a County roadway. The applicant is responsible for any alterations of the natural flow of water across private properties.

8.8.4 Structures

For efficiency and to avoid maintenance or public safety concerns, the County reserves the right to maintain the full width of the road right-of-way without structures located thereon. Structures include, but are not limited to, fences, trash cans, gates, mailboxes, and irrigation structures regardless of whether they are physically located on the traveled portion or right-of-way will be removed from the right-of-way upon written request by the Department of Public Works. Mailboxes may be located in the public road right-of-way only where they do not create a roadside hazard, obstruct or hinder vehicular or pedestrian traffic, or interfere with road maintenance activities such as snowplowing and mowing. Mailboxes will be located at least 8 feet away from the edge of the traveled way.

Wear, damage, or breakage to mailboxes, fencing, decorative items, signage, or any other appurtenances throughout the property roadside frontage due to thrown snow and inclusions from snow removal activities on a County-maintained road will not be the responsibility of the County.

8.9 AVERAGE DAILY TRAFFIC COUNT

Volume counts are expressed as average daily traffic (ADT) counts or annual average daily traffic (AADT) counts. ADT is the unadjusted, average number of vehicles passing in both directions at a specified location of a roadway. AADT is the term used to show the average traffic volume in both directions on a section of road, adjusted for seasonal variation. Traffic count information for pavement designs must be obtained from the Weld County Public Works Department. If the count information is not available for the area needed, then a traffic count must be completed by the designer and approved by Weld County. The count must be a 72-hour continuous count and completed on Tuesday, Wednesday, and Thursday of a normal week (no holidays or special events taking place). The traffic count cannot be a raw volume count; it must include a Vehicle Classification. If known changes to the traffic volumes exist since the latest count, such as new development or changes to existing development that could modify the counts, then a new traffic count may be warranted.

Table 8-9 Traffic Count Seasonal Adjustment Factors

SEASONAL ADJUSTMENT FACTORS	
Timeframe	**Adjustment Factor**
Jan. 1–Feb. 28/29	1.08
Mar. 1–Apr. 4	1.00
Apr. 5–May 16	0.98
May 17–Jun. 20	0.96
Jun. 21–Aug. 22	0.94
Aug. 23–Sep. 26	0.94
Sep. 27–Nov. 1	0.97
Nov. 2–Nov. 29	1.04
Nov. 30–Dec. 31	1.08

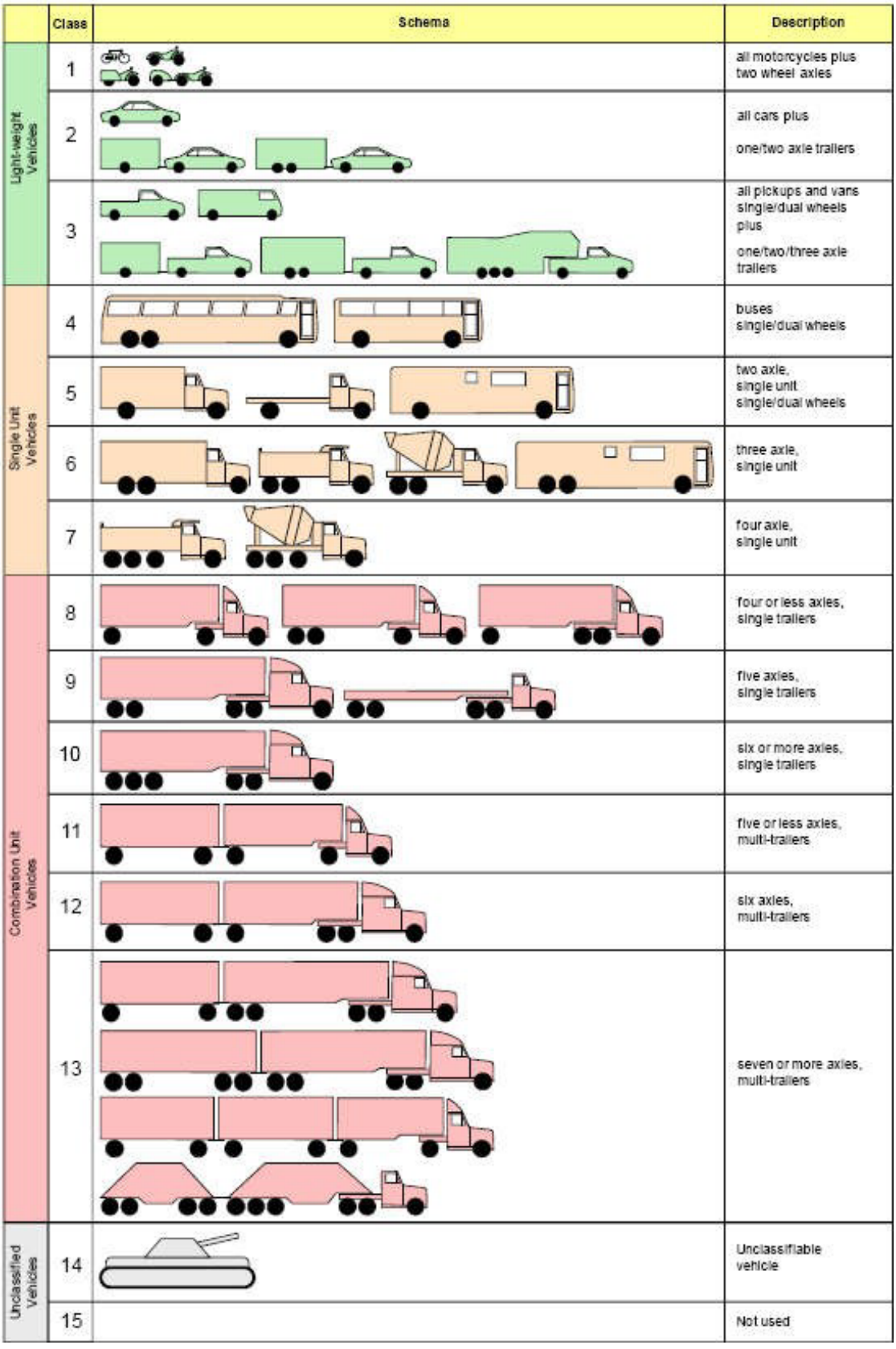
8.9.1 Vehicle Classification

Vehicle classification categorizes vehicles into three types, as described below.

- Lightweight vehicles: All motorcycles, cars, pickups, vans, and single/dual wheels
    - Class 1 through Class 3
- Single units: Buses and other units up to three axles
    - Class 4 through Class 7
- Combo units: Vehicles of four axles and more
    - Class 8 through Class 13

Figure 8-7 shows the most common types of vehicles found on the nation's highways. Designers can use this information to determine which vehicle classification category should be used for the vehicles identified in the traffic count.

Figure 8-7 FHWA Vehicle Classification (CDOT *M-E Pavement Design Manual*, Figure 3.6)



CHAPTER 9 SOIL INVESTIGATION AND PAVEMENT DESIGN

9.1 INTRODUCTION AND PURPOSE

The design of a pavement structure involves the consideration of many factors and conditions—the most important being traffic volumes, vehicle classifications, design materials, existing materials, local climate, and drainage conditions. The purpose of this chapter is to give general guidance and to supplement the existing design information contained within the latest editions of the 1993 AASHTO *Guide for Design of Pavement Structures* and the CDOT *M-E Pavement Design Manual*, as well as AASHTO or ASTM Material Manuals. AASHTO 1993 should be used only for onsite roadway pavement designs and M-E should be used for any offsite pavement designs maintained by Weld County. These criteria provide the basic design procedures and reporting guidelines for flexible and rigid pavements. The final design should be based on a thorough investigation of specific project conditions, projected traffic, life- cycle economics, and on the performance of comparable projects with similar structural sections under similar conditions. An adequate pavement design will reduce long-term maintenance costs and provide a long-lasting driving surface.

9.2 FIELD INVESTIGATION AND SOIL SAMPLES

Designers should visit each site to gather information that may help determine the appropriate design. Whether this is a new design or rehabilitation of an existing pavement, information such as current distress, drainage conditions, roughness, traffic control options, and surrounding land usage should be collected and will be used later during the actual design.

9.2.1 Testing Frequency

Soil samples within the project limits will be obtained for each soil type as defined in the Soil Survey of Weld County, Colorado (http://websoilsurvey.nrcs.usda.gov/app/) or at a spacing of not more than 500 linear feet. These boring locations will include, but not be limited to, travel lanes, shoulders, auxiliary lanes, and roadside ditches.

9.2.2 Sampling Procedures

Borings can be performed by either an auger or core drill. The depth of each hole generally should be at least 5 feet to 10 feet, depending on the anticipated depths of cuts or fills of a new roadway. Borings for rehabilitation of existing surfaces generally can be on the lower side of the range unless major reconstructions are necessary at certain locations. All borings will be field logged and visually classified.

9.3 SUBGRADE TESTING

9.3.1 Classification

Each boring location will be tested to determine liquid limit, plastic limit, plasticity index, and the percentage passing the U.S. Standard No. 200 sieve. Test results will be used to calculate the AASHTO Classification and Group Index using AASHTO M 145.

These data will be determined using the following methods:

- Liquid limit: AASHTO T 89 or ASTM D 4318
- Plastic limit: AASHTO T 90 or ASTM D 4318
- Percent passing No. 200 sieve: AASHTO T 11 or ASTM C 117

- Gradation: AASHTO T 27 or ASTM D 422

9.3.2 Swell Test

Swell potential evaluation will be required when a soil is classified as an A-6 to A-7 type.

- Swell test: AASHTO T 216 or ASTM D2435

9.3.3 pH and Sulfate

pH and Sulfate testing will be performed at each boring location. It is important not only to identify the presence of sulfates but also the depth of occurrence. The designer or project manager should know what depths are crucial to the success of the design.

- Sulfate ion content: CP-L2103
- pH of soils: AASHTO T 289

9.3.4 Moisture Density

Standard test methods for moisture density are described in AASHTO T 99 and AASHTO T 180.

9.3.5 Hveem Stabilometer

Representative samples will be tested to determine the subgrade support value using Hveem Stabilometer (R-value) testing. These values will be used in the design of the pavement section. R-value will be performed on each soil group (AASHTO classification) but will never be less than a minimum of two per soils report. These tests will be conducted in accordance with the following procedures. We suggest performing the hydrometer testing for all applicable soil of interest since the percent silt and clay content in soil are identified as important independent variables.

- R-Value: CP (Colorado Procedure) 3101 (AASHTO T190 & ASTM D 2844-07) where the reference documents used to develop CP 3101

Table 9-1 Test Requirement and Frequency

Test	Testing Frequency	Notes/Exception
Liquid limit	Each Boring Location	
Plastic limit	Each Boring Location	
Gradation	Each Boring Location	
AASHTO Classification	Each Boring Location	
pH	Each Boring Location	
Sulfate	Each Boring Location	
Swell	Each Clay Soil Type	A-6 through A-7-6 soil types
Moisture—Density	Per Report	Bulk sample of material governing pavement design
CBR or R-value	See Section 9.3.5	

9.4 PAVEMENT DESIGN CRITERIA FOR ONSITE ROADWAYS

Weld County's pavement design method for onsite roadways is based on the 1993 AASHTO *Guide for Design of Pavement Structures* equations and CDOT guidelines. This section provides the criteria used for the design of these pavements. These criteria will ensure adequate strength and durability to carry

the predicted traffic loads for the design life of each project. Alternative designs will be considered as advances are made in pavement design methods and paving materials. Any deviation from the criteria presented in this document must be technically justified and approved by the Public Works Department. Weld County does not allow the use of full-depth asphalt paving and does not accept maintenance of any full-depth paved roads.

9.4.1 Design Equivalent Single Axle Loads (ESAL)

There are certain input requirements needed to obtain an 18,000-pound (18 KIPS) Equivalent Single Axle Load calculation or design ESAL.

- Annual average daily traffic count (see chapter 8)
- Vehicle classification (see chapter 8)
- Traffic equivalence load factors
- Traffic growth rate
- Design period
- Lane factor

9.4.2 Traffic Equivalence Load Factors

The equivalence load factor is a numerical factor that expresses the relationship between axle loads of the three types of vehicles. Table 9-3 presents equivalence loads factors from CDOT's *M-E Pavement Design Manual.*

Table 9-2 Equivalence Load Factors (CDOT *M-E Pavement Design Manual*, Table H.2)

3-Bin Vehicle Classification	Flexible Pavement	Rigid Pavement
Lightweight vehicles	0.003	0.003
Single units	0.249	0.285
Combo units	1.087	1.692

9.4.3 Traffic Growth Rate

The number of vehicles using a road tends to increase with time. Weld County uses a 20-year growth rate to estimate the future traffic on roadways. The growth rate is applied to all of the vehicle classifications. A growth rate assumes that the AADT percent growth rate for any given year is applied to the volume during the preceding year. Contact the Public Works Department for assistance in determining an appropriate growth rate.

9.4.4 Lane Factor

The number of vehicles or ADT on the roadway will be split according to the number of lanes in the proposed roadway. Table 9-4 lists the acceptable values.

Table 9-3 Lane Factors (Modified from CDOT *M-E Pavement Design Manual*, Table 3.3)

Lanes per Direction	Design Lane Factor
One lane	0.60
Two lanes	0.45
Three lanes	0.309

Four lanes	0.25

9.5 FLEXIBLE PAVEMENT DESIGN

9.5.1 Serviceability and Reliability

The initial serviceability for asphalt at construction normally will fall in the range of 4.2 to 4.6 and generally will be assumed to be 4.5. The terminal serviceability is based on the current ADT. These factors can be found in Table 9-5.

Table 9-4 Serviceability

Serviceability Loss	ADT
2.0	>750
2.5	<750

The reliability factor, shown in Table 9-6, is based on the functional classification of the roadway. Weld County's functional classification map can be found on the transportation planning section of the Public Works Department web page.

Table 9-5 Reliability Factor

Functional Classification	Urban/Rural
Arterial	90
Collector	85
Local	80

9.5.2 Standard Deviation

Weld County uses an overall standard deviation of 0.44 for all pavement designs.

9.5.3 Drainage Factor

The drainage factor shown in Table 9-7 may be incorporated into the pavement design to account for the drainage characteristics of the site.

Table 9-6 Drainage Factor

Quality of Drainage	Water Removed Within:	Percent of Time Pavement Structure is Exposed to Moisture Levels Approaching Saturation			
		Less than 1%	1% to 5%	5% to 25%	>25%
Excellent	2 hours	1.40-1.35	1.35-1.30	1.30-1.20	1.20
Good	1 day	1.35-1.25	1.25-1.15	1.15-1.00	1.00
Fair	1 week	1.25-1.15	1.15-1.05	1.00-0.80	0.80
Poor	1 month	1.15-1.05	1.00-0.80	0.80-0.60	0.60
Very poor	Will not drain	1.05-0.95	0.95-0.75	0.75-0.40	0.40

9.5.4 Strength Coefficients

The strength coefficients are used in the structural number equation to determine the thickness of the various layers of the pavement structure. Table 9-8 lists the strength coefficients for various potential components of the pavement section.

Table 9-7 Strength Coefficient

Component	Strength Coefficients (per inch of material)	Test Criteria
Conventional Materials		
HMA	0.44	See Section 9.6.3
*Existing bituminous pavement	0.20-0.40	N/A
Aggregate base course	0.14	R-value ≥83
Aggregate base course	0.12	77≤ R-value <83
Aggregate base course	0.11	69≤ R-value <77
Existing aggregate base course	0.09	N/A
Treated Materials		
Fly ash	0.10	7-day, 150 psi
Lime treated subgrade	0.14	7-day, 160 psi
Cement treated base	0.22	7-day, 100-200 psi
Cement treated base	0.23	7-day, 200-300 psi

**Falling Weight Deflectometer or CDOT structural layer coefficients of existing pavements forms will be used to determine the structural coefficient for existing bituminous pavements.*

9.5.5 Pavement Thickness

Full-depth pavement sections will not be allowed within the County-maintained right-of-way. A composite section of hot mix asphalt (HMA) and free draining sub-base material will be used. Total HMA thickness will not be placed in lifts less than three times the nominal maximum aggregate size of the mix being used.

9.5.6 Pavement Design

All pavement design will be prepared in accordance with AASHTO and CDOT pavement design procedures. A computer-generated printout of the design and/or other design calculations must be included with the design submittal.

In lieu of design, 12 inches of HMA over 12 inches of aggregate base course (ABC) will be the minimum.

9.6 MATERIAL SPECIFICATION

9.6.1 General

All sources of mined or manufactured materials used within the County-maintained right-of-way must be approved annually by the Public Works Department.

9.6.2 Procedure for Material Source Approval

On or before April 1 of each year, or a minimum of 14 calendar days before beginning construction, materials suppliers will supply written documentation and material test results from a materials testing laboratory. These will indicate the following:

- That the material(s) being tested meet(s) the minimum specifications
- The test procedure employed
- The material test results

A signed statement will be provided by the material suppler certifying that the materials tested are representative of the materials to be provided during the coming 365-day period.

9.6.3 Hot Mix Asphalt

HMA will meet the requirements of and be placed according to Table 9-9 below and the latest edition of CDOT's *Standard Specifications for Road and Bridge Construction*. The 100 gyration mixes should be used on arterial and collector roads. 75 gyration mixes to be used on minor and major residentials roadways. HMA leveling courses, mid mats, and residential wear courses to be 64-22 mixes with a maximum of 20% RAP used in aggregate gradation. HMA topping or wear course should be an SX 64-28 mix with a maximum of 20% RAP, on arterial and collector roads.

Table 9-8 Master Range Table for Hot Mix Asphalt from Table 703-4 in CDOT's *Standard Specifications for Road and Bridge Construction*

Sieve Size	Percent by Weight Passing Square Mesh Sieves				
	Grading SF	Grading ST	Grading SX	Grading S	Grading SG
37.5 mm (1½")					100
25.0 mm (1")				100	90 – 100
19.0 mm (¾")			100	90 – 100	
12.5 mm (½")		100	90 – 100	*	*
9.5 mm (⅜")	100	90 – 100	*	*	*
4.75 mm (#4)	90 – 100	*	*	*	*
2.36 mm (#8)	*	28 – 58	28 – 58	23 – 49	19 – 45
1.18 mm (#16)	30 – 54				
600 µm (#30)	*	*	*	*	*
300 µm (#50)					
150 µm (#100)					
75 µm (#200)	2 – 12	2 – 10	2 – 10	2 – 8	1 – 7
* These additional Form 43 Specification Screens will initially be established using values from the As Used Gradation shown on the Design Mix.					

9.6.4 Portland Cement Concrete Pavement

Portland Cement Concrete Pavement (PCCP) materials will meet the requirements of and be placed according to Table 9-10 below and the latest editions of CDOT's *Standard Specifications for Road and Bridge Construction* and CDOT's *M&S Standard Plans*.

Table 9-9 Concrete Aggregate Gradation Table from Table 703-1 in CDOT's *Standard Specifications for Road and Bridge Construction*

Sieve Size	Coarse Aggregates (from AASHTO M43)									Fine Aggregate
	No. 3	No. 357	No. 4	No. 467	No. 57	No. 6	No. 67	No. 7	No. 8	
	50 mm to 25.0 mm (2" to 1")	50 mm to 4.75 mm (2" to No. 4)	37.5 mm to 19.0 mm (1½" to ¾")	37.5 mm to 4.75 mm (1½" to #4)	25.0 mm to 4.75 mm (1" to #4)	19.0 mm to 9.5 mm (¾" to 3/8")	19.0 mm to 4.75 mm (¾" to #4)	12.5 mm to 4.75 mm (½" to #4)	9.5 mm to 2.36 mm (3/8 " to #8)	4.75 mm to 150 µm (#4 to #100)
63 mm (2½")	100	100								
50 mm (2")	90–100	95–100	100	100						
37.5 mm (1½")	35–70		90–100	95–100	100					
25.0 mm (1")	0–15	35–70	20–55		95–100	100	100			
19.0 mm (¾")			0–15	35 – 70		90–100	90–100	100		
12.5 mm (½")	0–5	10–30			25–60	20–55		90–100	100	
9.5 mm (3/8")			0–5	10–30		0–15	20–55	40–70	85–100	100
4.75 mm (#4)		0–5		0–5	0–10	0–5	0–10	0–15	10–30	95–100
2.36 mm (#8)					0–5		0–5	0–5	0–10	80–100
1.18 mm (#16)									0–5	50–85
600 µm (#30)										25–60
300 µm (#50)										10–30
150 µm (#100)										2–10

9.6.5 Aggregate Base Course

ABC used in the pavement sections shall be crushed angular manufactured aggregate Class 6, unless otherwise approved. Class 6 Aggregate Base Course will meet the requirements in Table 9-11, which shows the gradation requirements, PI requirements, and LA Abrasion requirements. The minimum R-value shall be 69. Angularity of aggregate shall have a minimum fractured faces of one or more as per ASTM D 5821 of 45% or more. Recycled Concrete Product (RCP) aggregate base course shall not be used as shouldering material or as an exposed layer. RCP will be covered by a subsequent layer.

The liquid limit shall be as shown in Table 9-11 and the plasticity index shall not exceed six when the aggregate is tested in accordance with AASHTO T 89 and T 90 respectively.

Table 9-10 Aggregate Base Course Requirements

Sieve Designation		Mass Percent Passing Square Mesh Sieves							
		LL not greater than 35			LL not greater than 30				
Standard (mm)	Mesh (in)	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7	ABC RAP
150	6”			100					
100	4”		100						
75	3”		95-100						
63	2.5”	100							
50	2”	95-100			100				100
37.5	1.5”				90-100	100			
25.4	1”					95-100		100	85-100
19	3/4”				50-90		100		75-100
12.5	1/2”								55-90
9.5	3/8”								45-80
4.76	No. 4	30-65			30-50	30-70	30-65		25-55
2.38	No. 8						25-55	20-85	
1.18	No. 16								5-55
0.42	No. 40								
0.07	No. 200	3-15	3-15	20 max	3-12	3-15	3-12	5-15	0-5
Plasticity index		0	0	0	<6	<6	<6	<6	<6
LA wear test (T96)						50 max	50 max		

9.6.6 Aggregate Surface Course (Gravel)

Aggregate used as surface course will meet the following requirements, unless otherwise approved.

Furnish hard, durable particles or fragments of crushed stone, crushed slag, or crushed gravel conforming to the following:

1. Los Angeles abrasion, AASHTO T96 40%
2. Mechanically Fractured faces, one or more, ASTM D 5821, crushed material,

not screened , to attain fractured face45% min.

3. Free from organic matter and lumps or balls of clay
4. Liquid Limit, AASHTO T89 30 max.
5. Dust ratio: $\frac{\%passing\ \#200}{\%passing\ \#40}$ 2/3 max.
6. Gradation and plasticity index, AASHTO T90 As shown in Table 9-12

Do not use material that breaks up when alternately frozen and thawed or wetted and dried.

Obtain the aggregate gradation by crushing, screening, and blending processes as necessary. Fine aggregate, material passing the No 4 sieve, will consist of natural or crushed sand and fine mineral particles.

Do not furnish material that contains asbestos fibers. Recycled concrete cannot be used as surfacing gravel.

Table 9-11 Aggregate Surface Course Requirements

Sieve Designation		Mass Percent Passing Square Mesh Sieves
Standard(mm)	**Mesh (in)**	**Aggregate Surfacing**
150.00	6	
100.00	4	
75.00	3	
63.00	2.5	
50.00	2	
37.50	1.5	100
25.40	1	90-100
19.00	3/4”	
12.50	1/2”	55-80
4.76	No. 4	45-65
2.38	No. 8	33-53
0.42	No. 40	15-35
0.07	No. 200	4-15
Plasticity index		6-16
LA wear test (T96)		40 max

9.7 SOILS/PAVEMENT DESIGN REPORT

The soils/pavement design report will include the following information:

1. Vicinity map of investigated area
2. Transparent overlay of proposed project “plan view” on vicinity and boring location drawings.
3. Scaled drawing showing the location of borings
4. Scaled drawing showing the estimated extent of subgrade soil types, thickness of base material, thickness of and HMA
5. A spreadsheet showing all the factors used to calculate the design ESALs
6. Summary sheet listing all sample designations, liquid limit, plasticity index, percent passing the No. 200 sieve, AASHTO classifications, group index, soil description, R-value, moisture content, percent soluble sulfate, and pH
7. A discussion regarding potential subgrade soil problems, including, but not limited to, soils with swelling potential, frost-susceptible soils, groundwater, drainage considerations (surface and subsurface), cold weather construction (if appropriate), soluble sulfates and pH in the subgrade, and other factors or properties that could affect the design or performance of the pavement system
8. Recommendations to alleviate or mitigate the impact of potential subgrade soil problems
9. Pavement design alternatives for roadway
10. Pavement mix types to be used for the project
11. Any deviations from the County criteria and discussion/justification of the deviation, a formal request will be submitted for approval of the design alternative

12. Signed and stamped by a Professional Engineer licensed in the state of Colorado.

CHAPTER 10 CONSTRUCTION CRITERIA

10.1 GENERAL

For the public safety, health, and well-being, it is crucial to ensure that proper construction practices and industry standards are followed. The construction criteria defined within this chapter will be used for any work within the County right-of-way and any infrastructure proposed for County maintenance. In this chapter, the "contractor" is the individual, company, landowner, developer, or other entity legally responsible for the construction work. Unless otherwise indicated, the term "engineer" refers to the current County Engineer or his/her authorized representative, the term "department" refers to the Weld County Public Works Department, and the term "inspector" refers to the current Weld County lead construction inspector or his/her authorized representative.

10.1.1 Policy on the Use of Referenced Publications

The information provided herein summarizes and/or supplements minimum standards that have been prepared in great detail by CDOT. The most recent publications of the *Weld County Department of Public Works Conformed Standard Special Revisions to CDOT Standard Specifications for Road and Bridge Construction* and *M&S Standard Plans* are recognized by Weld County as being the primary documents used by transportation contractors and construction crews. However, CDOT policies represent statewide standards, which do not always satisfy local conditions. When standards differ, the most recent version of the *Weld County Department of Public Works Conformed Standard Special Revisions to CDOT Standard Specifications for Road and Bridge Construction* will govern followed by the instructions and guidance in this chapter will govern.

All construction traffic control devices and their use must be in accordance with the latest version of the MUTCD.

10.1.2 Control of Work and Inspection

The Department is responsible for oversight and inspection of construction that takes place within the County right-of-way and for infrastructure proposed for County maintenance. In addition to the primary goal of promoting public safety, the goal of County oversight—which takes the form of establishing standards and conducting inspections—is to help ensure quality construction and thereby minimize the long-term maintenance costs associated with County-maintained infrastructure. The County has the authority to impose standards on construction work and determine whether it has been constructed in accordance with approved plans.

The contractor is responsible for staying informed about and complying with all federal, state, and local laws, ordinances, and regulations that may affect the work or impact those employed to do the work. The contractor will indemnify the County against any claim or liability arising from the County's actions. Failure to meet these conditions can result in suspension of the work by the Department.

The Department will have the authority to suspend work if the contractor has failed to maintain safe conditions for the public. Such notification will be presented to the contractor in written form, at which time work will cease immediately—except for any activities necessary to position traffic control devices and put other safety measures in place to leave the project site in a safe condition during the shutdown, as directed by the engineer. The engineer will be the final authority in matters related to the proper

interpretation of approved plans and will make final determinations when discrepancies in the plans or disputes between the inspector and the contractor occur.

The inspector will have the authority to inspect all work and materials being used. The role of the inspector is to use acceptable engineering techniques and professional judgment to determine if the construction is being accomplished according to the methods described in the standards. The contractor will cooperate fully with inspection efforts, allow access to all parts of the work, and furnish any information required for complete and detailed inspections. Inspection by the department will not relieve the contractor or its designated representatives of the responsibility to control the work and ensure compliance with the approved plans and specifications for the project.

10.1.3 Project Acceptance and Warranty

All work that does not conform to the standards and the approved plans—whether resulting from poor workmanship, use of defective materials, or lack of care—will be considered unacceptable work.

Unacceptable work will be subject to removal and restoration prior to final acceptance of the project by the County. Disputes related to the acceptability of work will be subject to a final determination by the engineer.

Upon written notice from the contractor of the completion of all work, the inspector will make a final inspection. If all project work is determined to be in compliance with the standards, the approved plans, the performance guarantee, the subdivision improvement agreement, and the contract agreement or other applicable agreements, the County will initiate the procedure for final acceptance and perform an inspection for final acceptance. If the inspection discloses any work as being unacceptable, the Public Works Department will notify the contractor in writing. After corrections have been made, another final inspection will be scheduled.

The contractor will be responsible for maintenance and traffic control until final acceptance of the project has been granted by the Public Works Department. Final acceptance does not relieve the developer and/or contractor of a minimum two-year warranty on all workmanship and materials incorporated into the project, unless specified otherwise by the County. The warranty period will commence on the same date that written final acceptance is granted. Prior to the end of the warranty period, the inspector will arrange for the project to be inspected and will notify the contractor of any work items to be completed.

10.2 CONTRACTOR RESPONSIBILITIES

10.2.1 Qualifications, Insurance Requirements, and Licensing

Any contractor performing work within the right-of-way will have the qualifications to complete the work in an acceptable and timely manner and will receive the necessary permit(s) from the Public Works Department before beginning work. Contractors will be fully licensed, insured, and possess a valid IRS Taxpayer Identification Number. The Department reserves the right to suspend or deny work being performed by any contractor or business that has been determined by the engineer to be unqualified to perform construction within the right-of-way.

The contractor will indemnify the County from lawsuits and claims of any type that may occur as a result of its actions while performing work within the right-of-way. Until final acceptance of the project, the

contractor will procure and maintain insurance coverage in the minimum amounts specified in the most recent version of the Weld County Department of Public Works Conformed Standard Special Revisions to CDOT Standard Specifications for Road and Bridge Construction from an insurance company authorized to do business in the State of Colorado.

10.2.2 Pre-Construction Meetings

Contractors shall be required to schedule and attend a pre-construction meeting prior to starting work on complicated projects. The engineer can waive this requirement if the project is small or straightforward and it is determined that a meeting is not necessary. Attendees at the meeting typically are the contractor's key personnel, subcontractors, material suppliers, utility companies, material testing firms, the County inspector, and the County engineer. The meeting typically is held at least one week prior to start of construction.

The pre-construction meeting agenda likely will include the following:

- Exchange of contact information (phone numbers, fax numbers, etc.)
- Applicable safety requirements, contact information, and emergency procedures
- Construction traffic control requirements and methods
- Construction schedule with key dates and benchmarks
- Required contract paperwork (insurance, bonds, escrow, permits, etc.)
- Material submittals and testing requirements
- Special conditions and access requirements

10.2.3 Permits

Permitting requirements are discussed in Chapter 11 of this document. In addition to approved construction plans, Weld County often will require obtaining and adhering to all requirements of a Transport Permit, Right-of-Way Use Permit, Access Permit, Grading Permit, and Floodplain Development Permit.

The contractor will be fully informed and knowledgeable of all required state and federal permits. Weld County is not responsible for ensuring the contractor has satisfied permit requirements from other agencies. However, copies of fully executed permits will be furnished to the engineer or inspector upon request.

10.2.4 Public and Worker Safety

All work will be conducted in a manner that minimizes obstructions to traffic and pedestrians. The safety of the traveling public and adjacent landowners is the most important issue on every construction project. Contractors must inspect and maintain the project to ensure safety, as they bear the sole responsibility for any accidents or injuries related to the construction. The Department has the authority to suspend work if the contractor has failed to maintain safe conditions.

The contractor will observe all rules and regulations of federal, state, and local health officials and departments. No workers are allowed to be required to work in unsafe surroundings or under conditions that are unsanitary, hazardous, or dangerous. Contractors will be fully informed and knowledgeable of all current construction safety practices and protective equipment to be used for specific work conditions.

The contractor is responsible for complying with all safety regulations governed by the Occupational Safety and Health Administration (OSHA). The inspector is not responsible for enforcing these regulations, but will monitor construction activities for obvious or suspected noncompliance with OSHA regulations and will report any such issues to the contractor and the engineer. If imminent danger potentially resulting in serious injury or death is identified in the construction area, and the contractor has failed to act immediately to correct the dangerous condition, the engineer can issue a written work suspension order.

10.2.5 Utility Coordination

When excavating or grading in the area of underground utilities, the contractor will comply with Article 1.5 of Title 9, Colorado Revised Statutes, "Excavation Requirements." as modified by SB-18-167. The contractor will notify all affected utilities at least two business days prior to commencing work and will contact the Utility Notification Center of Colorado (UNCC) at 8-1-1 to have locations of UNCC-registered utilities marked onsite. All other underground facilities will be located by contacting the respective utility owner. Affected utility company representatives should be invited to the pre-construction meeting. Where the contractor's operations are adjacent to a utility owner's facilities, work will not commence until arrangements (acceptable to both parties) for the protection of the utilities have been made.

The approved plans will clearly indicate those utility items that are to be relocated or adjusted by the utility owner and those utility items that are to be constructed by the contractor. The contractor will meet with the utility owners as often as necessary to coordinate and schedule relocations or adjustments. Weld County is not responsible for the actions of utility owners, and the contractor will not seek damages or claims against the County for coordination, inconvenience, delay, or damages sustained due to interference from the utility owners.

10.2.6 Dust Control

The contractor is responsible for dust control related to its construction project. The contractor also is responsible for compliance with the Colorado Air Quality Control Act. The majority of construction sites can achieve adequate dust control by providing a water-spray truck to keep moisture in the exposed soil. Water trucks may be required on any construction sites that disturb an area of land greater than 1 acre, or for projects that are using gravel roads as the main access to the construction site. The goal of dust control is to prevent airborne particulates (dust) from leaving the construction site or access roads. Damages or health issues caused by dust leaving the construction site are the sole responsibility of the contractor. The contractor will be responsible for cleaning up and removing any dirt or dust that has left the construction site.

Closure of a roadway often requires the contractor to set up a designated detour route for traffic. If the detour route uses an existing gravel road, dust mitigation and road deterioration can quickly become a problem. Such detours often will require the contractor to apply a durable dust treatment, such as magnesium chloride. The department will determine the quantity, frequency, and locations of such dust treatments. The contractor will need to use a county approved vendor which has a Right-of-way Use permit with the county for the application.

The inspector will monitor the construction site and let the contractor know if dust control measures are inadequate. Reasonable complaints received by the County or contractor from adjacent landowners, or

the traveling public will be addressed by the contractor in 24 hours or less. Failure to respond to reasonable requests (as determined by the County) to provide dust control or failure to provide a water truck on the construction site can result in a written suspension of work order from the engineer.

10.2.7 Traffic Control

During construction, the contractor will be responsible for supplying and maintaining traffic control devices according to the requirements of the MUTCD. Any work within the right-of-way requires approval of the Method of Handling Traffic (MHT) by the department prior to work commencing. In addition, any road closure within the right-of-way that will last for three days or more requires approval by the BOCC prior to work commencing. The contractor should allow at least two weeks prior to the planned road closure to obtain required approvals from the County.

The contractor's MHT will be prepared by a person knowledgeable and qualified in the area of traffic control, who is a certified Traffic Control Supervisor (TCS). The MHT will be easily readable, prepared in a professional manner, and include the following elements:

- A project site location map
- A diagram showing the location of all traffic control devices
- A tabulation of the sizes, types, and quantities of all traffic control devices
- Location of all existing roads and accesses within the traffic control zone
- Certifications of all TCSs and flaggers working on the jobsite

Traffic control devices will be inspected by the contractor's TCS for proper placement on at least a daily basis and will be inspected during the nighttime at least once per week. The reflective surfaces of all signs will be checked and cleaned on a regular basis, no less frequently than every two weeks. For safety reasons, the contractor will not store materials or equipment near open travel lanes. Portions of the roadway that are open to traffic will be maintained, kept clean, and kept free of snow and ice by the contractor.

The inspector will monitor the traffic control set-up to ensure the MHT is being followed and to look for any problems that need to be corrected. If the inspector deems that changes to the traffic control are necessary, this will be communicated to the contractor and/or TCS.

10.2.8 Removal of Unacceptable or Unauthorized Work

Unacceptable work resulting from any cause found to exist prior to final acceptance of the project will be removed and replaced in an acceptable manner at the contractor's expense. The construction of transportation facilities requires a high degree of precision and quality from the contractor. These facilities will eventually be used by the traveling public, who assume that safe and predictable driving and drainage conditions exist. Failure to remove and/or replace unacceptable or unauthorized work within the right-of-way can expose the contractor to liability.

The inspector is authorized to ensure the contractor is following approved plans and specifications, to identify work that is unacceptable or unauthorized, and to communicate such findings to the contractor. The contractor will correct the identified work in a timely manner. If the contractor and the inspector disagree about whether work is unacceptable or unauthorized, the final determination will be made by the engineer.

10.2.9 Record Drawings and Record Keeping

Preparation and organization of project records and record (as-built) drawings is an important step for ensuring proper future maintenance of transportation facilities. This is especially true when the project includes construction of underground facilities.

Changes in the scope of work, geometric design, structural plans, typical sections, standard plans, specifications, and corrections of design errors must be incorporated into the as-built plans. These as-built plans shall be sealed by the engineer responsible for changes.

Information shown on the as-constructed plans should include, but is not limited to the following:

Structures:

- Show tip elevation of piling for each pier, wall, or abutment.
- Show structure changes for both minor and major structures.
- Show type, manufacturer, manufacturer's project number, and shop drawing number of bridge expansion and bearing devices installed.
- Show elevation and placement of brass cap benchmarks, when used. The elevation should be project specific and marked on the plans. All temporary benchmarks on the plans will be lined out.
- Vertical and lateral clearances should be indicated

Plan and Profile:

- Show the final location of new utility placements, unknown utility discoveries, relocations, and changes. Abandoned utilities should be shown and noted.
- Show all geometric revisions to alignment, super elevation, and grade.
- Show significant changes in revised slope catches specifically ordered in the field
- Show final locations of minor structures.
- Show locations of discovered underground features, such as foundations or pipes, which are left in place.
- Show detailed information on the location of all buried material within the County right- of-way or project limits.
- Detail any new or deleted accesses.

Drainage Plans:

- Meet the requirements of the As-Built Drawing Checklist provided in Appendix D of this document

Prior to final acceptance of construction work, the contractor will turn in all requested as-constructed information, materials testing information, electronic files, and submittals to the inspector for review. The As-Built drawings shall follow the requirements for As-Constructed drawings that are set for in the *Weld County Department of Public Works Conformed Standard Special Revisions to CDOT Standard Specifications for Road and Bridge Construction*

10.3 MATERIALS QUALITY CONTROL AND TESTING

10.3.1 Qualifications of Testing Personnel and Laboratories

Materials Process Control testing is an important and necessary part of any successful transportation project. Testing of construction materials (soil, concrete, asphalt, etc.) ensures the owner and contractor that suppliers are providing the materials specified and adequate construction methods are being used.

CDOT qualifications related to materials are covered extensively in CDOT's Colorado Procedure 10 (CP10). It should be noted that Weld County does require the contractor to meet the qualifications for testing personnel described in CP10. All process control testing by consultant or material testing firms should be done in accordance to AASHTO and (CP) Colorado Procedures as directed in the CDOT *Field Materials Manual* - OA Frequency Guide Schedule for Minimum Materials Sampling, Testing and Inspection.

The AASHTO and CDOT *Field Materials Manuals* have developed and published detailed and specific standard procedures to be used for materials testing. The contractor will be responsible for providing material testing that meets the requirements of the applicable testing standard. The inspector will provide oversight to ensure material testing is being performed properly and that testing laboratories being used are adequate.

10.3.2 Minimum Testing Types and Frequencies

The contractor will make arrangements to provide material testing of the types and frequencies described in the latest version of the *Weld County Department of Public Works Conformed Standard Special Revisions to CDOT Standard Specifications for Road and Bridge Construction*. The inspector may accept some reduction in inspection and testing procedures under certain conditions. If the contractor does not intend to meet the minimum testing frequencies listed in the frequency guide schedule in the latest version of the *Weld County Department of Public Works Conformed Standard Special Revisions to CDOT Standard Specifications for Road and Bridge Construction*, it must provide a written explanation to the inspector at least 48 hours prior to start of the related construction.

Examples of conditions under which the minimum testing frequencies may be reduced by the inspector could include:

- Very small quantities of materials are being used.
- The construction work is taking place outside of the roadway structural prism.
- The construction work is temporary in nature.
- The inspector has determined that construction methods being used easily exceed minimum requirements, thereby resulting in predictable passing test results.

10.3.3 Material Sources and Sampling

All material sources used will meet the requirements of the approved plans and specifications. If the contractor intends to use any materials that do not meet the requirements as described in the County criteria, it must provide a written description and request prior to or at the pre-construction meeting. The engineer then may choose to review the information and grant a variance prior to construction starting.

The inspector will be granted access by the contractor to sample and test all material to be incorporated into the work. Failure to allow such access will result in a suspension of work order being issued by the engineer. The inspector reserves the right to request proof from the contractor that materials being delivered to the jobsite are coming directly from approved sources.

All materials will be handled and delivered in a manner such that their quality and acceptability are not adversely affected during the process. Aggregates and pavement mixes will be delivered to the jobsite in trucks designed to prevent loss or segregation of materials. The contractor will be aware that if materials delivered to the jobsite show excessive segregation, disturbance, or contamination, they may be rejected by the inspector. HMA that has cooled excessively also may be rejected by the inspector.

10.3.4 Required Submittals

Contractor submittals given to the County for review and approval will vary for each project, depending on the scope and complexity of the work to be performed. A simple Access Permit or utility crossing may not justify multiple submittals, while a large-scale bridge or roadway construction project may require many submittals. The contractor will consult with the engineer prior to the pre-construction meeting for a specific list of required submittals. A typical large-scale project could include submission, review, and approval of the following documents:

- MHTs
- Construction schedule
- Shop drawings or fabrication details
- Concrete and asphalt mix designs
- Soils laboratory test information
- Manufacturer's product data and installation instructions
- Copies of required worker's certifications and qualifications
- Certificates of compliance and material samples
- Documents required by County Codes or by the Planning Department

10.3.5 Soils Reports and Pavement Designs

To ensure proper design of roads and bridges, the department will require the contractor to provide a soils report and associated pavement design. In certain cases, the engineer may waive these requirements. Specific requirements are described in Chapter 9 of this document.

10.3.6 Materials Rejection

Materials that do not meet the requirements of the approved construction plans and specifications will be rejected by the inspector. Rejected materials will be removed from the right-of-way in a timely manner at the contractor's sole expense. The contractor may choose to perform additional third-party materials testing in an effort to reverse the inspectors' decision. However, in no case will rejected materials be covered up or incorporated into the work without approval. In cases where the contractor and the inspector disagree on a materials rejection issue, the engineer will make the final decision.

10.4 EXCAVATION AND EMBANKMENT

10.4.1 Utility Trenching and Backfill Requirements

All utility trenches underneath or within 5 feet of a public roadway will be backfilled with suitable materials and mechanically compacted to not less than 95 percent of maximum density, as determined by AASHTO T99. This work will require the contractor to arrange and pay for the applicable materials quality control testing. The exception to this requirement is underground utilities that are bored into place or installed by similar methods which do not disturb the surrounding soils. Alternative backfill using an approved flowable cement fill (flow-fill) mix design can be used instead of soil materials, eliminating the need for onsite compaction testing.

Weld County Standard Flow-Fill Mix:

- Slump of 7 to 10 inches - ASTM C143
- Compressive Strength F'C—1,000 PSI @ 28 days
- ASTM 150 Type I-II, minimum 329 pounds
- Course Aggregate ASTM-33—Minimum 1,000 pounds
- Fine Grain Aggregate ASTM-33—Minimum 2,000 pounds
- Air Entraining Agent (SIKA Air) ASTM-C260—Minimum 1.0 oz./cubic yard
- Water—Minimum 150 pounds

All utility trenches located more than 5 feet away from a public roadway will be backfilled with suitable materials and mechanically compacted to not less than 90 percent of maximum density, as determined by AASHTO T99. The inspector may choose to waive the requirement for materials testing in these cases if s/he believes that proper construction methods are being used to ensure good compaction, or if flow-fill is being used.

The department reserves the right to perform material testing on any utility trench being constructed within the right-of-way. If the material testing performed by the department shows that the contractor has failed to meet or exceed the compaction requirements described above, the contractor will be directed to remove and recompact the backfill and/or pavement materials at its own expense.

See Section 10.7.5 for Pavement Cuts and Patching Requirements.

10.4.2 Unsuitable Materials

Soil materials used in embankment construction will be as recommended in the approved soils report for the project. Soil materials that do not meet the requirements of the soils report are identified as being "unsuitable materials" and will be removed from the jobsite.

Projects that do not have an approved soils report will follow more general requirements for the materials to be used. Embankment and fill material will be free of ice, organics, trash, glass, chemicals, and other deleterious materials. When tested by a Hveem Stabilometer, the soils will have a minimum R-value of at least R-20 and a maximum dry density of not less than 120 pounds per cubic foot.

10.4.3 Moisture and Density Control

Moisture and density control will follow CDOT's *Standard Specifications for Road and Bridge Construction*.

The contractor will be responsible for material testing to confirm that proper construction methods are being used and that the moisture and density requirements are being met. Moisture and density testing requirements may be waived by the inspector in cases where the amount of embankment being constructed is small or the embankment being constructed is not intended to be used for a public roadway. However, the inspector is not authorized to waive or relax the testing requirements described in an approved soils report.

10.5 SUBGRADE CONSTRUCTION METHODS

10.5.1 Unsuitable Materials

Suitability of subgrade materials is equal to that described for embankment materials in Section 10.4.2. Subgrade materials that are deemed unsuitable for construction will be removed from the jobsite.

10.5.2 Soft Spots

Subgrade areas that cannot be constructed initially to meet compaction requirements or support traffic loads using standard, acceptable construction methods are commonly referred to as "soft spots." Repair of soft spots typically is addressed by first trying methods that require little time and expense, then progressing to more costly methods if necessary. In cases where soft spots are numerous and extensive, where the soft spots are so bad that standard construction equipment cannot access the area, or where soft spots present a dangerous work condition, the contractor will consult a Professional Engineer or Professional Geologist for recommendations for proper construction methods. The following are some of the methods used to repair soft spots:

- Scarifying/drying/blending the onsite soils and then recompacting
- Over-excavating and backfilling with suitable onsite soils
- Over-excavating and backfilling with imported granular fill
- Over-excavating and placing geogrid or geotextiles, then backfilling with imported granular fill
- Subgrade treatment of onsite soils with cement, fly ash, or other approved materials

The success or failure of any of these methods will be determined by extensive proof rolling and inspection.

10.5.3 Moisture and Density Control

Subgrade moisture and compaction requirements are similar to the requirements for embankments but are a little more stringent since subgrade materials are a component of the overall roadway structural section. If the subgrade materials fail to meet the conditions required in the overall pavement design, the aggregate base and pavement sections are likely to fail prematurely. Moisture and density control for subgrade will follow CDOT's *Standard Specifications for Road and Bridge Construction*.

The contractor will be responsible for material testing to confirm that proper construction methods are being used and that the moisture and density requirements are being met. When the final subgrade surface elevations have been established, proofrolling and inspection will be performed before any aggregate base is placed on top of the subgrade.

10.5.4 Subgrade Proof Rolling

The department requires proof rolling of subgrade materials, observed by the inspector, to determine their adequacy to support heavy loads. This work typically is accomplished with a heavy rubber-tire

truck, such as a water truck, that can generate a minimum axle load of 18,000 pounds per axle. The inspector may require the contractor to provide a certified weight ticket as proof that adequate proof rolling equipment is being used. The subgrade will be proof rolled after the required compaction has been verified with materials testing equipment and the subgrade has been graded to the required elevations called for in the plans.

The inspector will be notified at least 48 hours prior to any subgrade proof rolling. No proof rolling will be accepted without the inspector or designee present.

Upon approval of the proof rolling, the contractor will place the aggregate base course on top of the approved subgrade materials within 48 hours. If the contractor fails to place the aggregate base course within 48 hours or the moisture conditions of the subgrade change due to inclement weather or other conditions, proof rolling will need to be repeated.

10.5.5 Treated Subgrades

Subgrade soils can be treated with cement, fly ash, lime, or other approved stabilizing agents. This approach is a cost-effective way to avoid over-excavation of unsuitable soils over large areas. Subgrade treatment also is used to raise the structural value of the soils, thereby allowing the designer to require less thickness of aggregate base course and pavement. Another reason for the use of stabilizing agents is to reduce the swell potential of certain clay soils.

Specific moisture and density control requirements vary, depending on the type of stabilizing agent used. Prior to placement of any subgrade treatment, the contractor will submit a mix design to the inspector for approval. The contractor also will supply the inspector with information regarding the type of delivery, mixing, watering, grading, and compaction equipment to be used during construction.

10.6 BASE COURSE CONSTRUCTION METHODS

10.6.1 Gradation and Moisture and Density Control

Overall pavement quality, including structural longevity and riding smoothness, is greatly affected by the quality of the underlying subgrade and base course materials. Base course materials must meet specified gradation and moisture and density control requirements to adequately support the traffic loads. The department requires a minimum of 4 inches of compacted aggregate base course underneath any permanent paved road surface. Depending on the pavement design, subgrade R-value, predicted traffic loading, and other applicable factors, greater thicknesses of aggregate base course often are required. The base course provides the pavement structure with a free-draining, non-frost-susceptible material layer that distributes the traffic loads from the pavement surface to the underlying subgrade.

Aggregates for bases will be crushed rock, native or crushed gravels, crushed recycled concrete, or crushed recycled asphalt materials. Base course gradation will be as specified in CDOT Specifications: Class 5 or Class 6 materials. Class 6 Aggregate Base Course typically is used for areas directly underneath the permanent paved surface. Class 5 Aggregate Base Course typically is used for “shouldering” the areas adjacent to the edges of the permanent paved surface. Shouldering materials shall not contain crushed or recycled concrete materials. Prior to any placement of materials, the contractor will submit a laboratory gradation test to the inspector verifying specifications are being met. The contractor also will grant the inspector access to any stockpiles or sources of base course to be used on the project.

The maximum compacted thickness of any individual lift of base course will not exceed 6 inches. Multiple lifts will be required when the thickness is greater than 6 inches. Compaction of each layer will meet a density of at least 95 percent of the maximum density determined in accordance with AASHTO T-180. Water should be uniformly applied to ensure this compaction requirement has been met. The final surface elevations of the base course will be graded to within .04' of the elevations specified on the plans. Placement shall be performed utilizing side-dump or belly dump haul equipment. With the exception of smaller area placement where material can be placed with little segregation using loader or skid steer equipment. Mixing, moisture conditioning and grading shall be done with rubber-tired equipment to prevent breakdown of aggregate and gradation. End dumping and Dozer grading is not allowed unless authorized by a Weld County Engineer. If material is stockpiled for any length of time, care should be taken in the maintenance of the pile to prevent segregation of the material.

10.6.2 Base Course Proof Rolling

The department requires proof rolling of base course materials under observation of the inspector to determine the adequacy to support heavy loads. This work typically is accomplished with a heavy rubber-tire truck, such as a water truck, that can generate a minimum axle load of 18,000 pounds per axle. The inspector may require the contractor to provide a certified weight ticket as proof that adequate proof rolling equipment is being used. The base course will be proof rolled after the required compaction has been verified with materials testing equipment and the base course has been graded to the required elevations called for on the approved construction plans.

The inspector will be notified at least 48 hours prior to any base course proof rolling. No proof rolling will be accepted without the inspector or designee present.

10.6.3 Treated Base Courses

Base courses can be treated with cement to obtain a stiffer and stronger material than an unbound base. A stiffer base reduces deflections due to traffic loads, which results in lower strains on the pavement surface. This approach can be a cost-saving measure that allows the designer to require less thickness of pavement. Cement-treated bases need to be designed for each specific project. The structural properties of cement-treated base depend on the soil/aggregate material, quantity of cement, curing conditions, and age. The contractor will be responsible for submitting a mix design to the inspector for review and approval prior to construction.

Specific moisture and density control requirements vary, depending on the cement-treated base mix design. In addition to having an approved mix design, samples of the cement-treated base will be taken during construction, and laboratory tests will be conducted to verify that the minimum strength properties specified have been achieved. The contractor also will supply the inspector with information regarding the types of delivery, mixing, watering, grading, and compaction equipment to be used during construction. In addition, the inspector may require copies of certified weight tickets for the cement to verify proper quantities have been incorporated into the base course. All testing of processed cement-treated base material or its individual components, unless otherwise provided specifically in the approved construction plans and specifications, will be in accordance with the latest applicable AASHTO or ASTM material specifications. The final surface elevations of the cement-treated base course will be graded to within one-quarter inch of the elevations specified on the plans.

10.6.4 Acceptance Prior to Paving

Upon approval of the proof rolling, the contractor will place the pavement surface (if applicable) on top of the approved base course materials within 48 hours. If the contractor fails to place the pavement surface within 48 hours or the moisture conditions of the base course change due to inclement weather, excessive drying, or other conditions, proof rolling will need to be repeated.

The inspector is responsible for giving the contractor final approval to proceed with placement of the pavement surface on roads and bridges within the right-of-way. The contractor will furnish copies of certified load tickets for the base course materials as proof that the correct type and quantity of base course was delivered to the jobsite. When the inspector determines that base course placement is acceptable, a pre-paving meeting can be held.

10.7 PAVEMENT CONSTRUCTION METHODS

10.7.1 Pre-Paving Meetings

Pre-paving meetings are mandatory on any road or bridge project that requires placement of asphalt or concrete permanent pavement more than 500 tons of HMA Pavement or 2,000 SY of Concrete Pavement. The meetings will be scheduled and arranged with the inspector. Attendees at the pre-paving meeting generally include the contractor superintendent, paving foreman, materials quality control tester, TCS, material supplier representative, engineer, and inspector. The asphalt or concrete mix design will be submitted, reviewed, and approved by the inspector prior to the pre-paving meeting.

Pre-paving meetings typically are held on the jobsite. Following is a partial list of the general items for discussion:

- Introductions and attendance roster with contact information
- Assignment of specific duties
- Scheduling, construction sequencing, and traffic control requirements
- Materials quality control methods and requirements
- Types of hauling equipment and paving equipment to be used
- Construction details, such as lift thicknesses, joint construction, and pavement striping
- Conditions under which paving will cease (bad weather, darkness, holidays, etc.)

10.7.2 Recycled Asphalt Pavement Surfaces

Weld County has constructed roads using recycled asphalt pavement (RAP) as the pavement surface for interim cross sections instead of gravel. This typically is accomplished as a permanent means of dust control and is less costly than HMA. Candidate roads for RAP pavement are gravel roads that have a high enough ADT to make grading and dust control maintenance a significant effort, but low enough ADT to not warrant permanent HMA pavement placement.

10.7.3 Hot Mix Asphalt Surfaces

Most County roads with permanent paved surfaces are constructed with HMA. This type of surfacing suits the County needs well since our road crews are knowledgeable and well equipped to properly maintain asphalt roads.

The current edition of the CDOT *Standard Specifications for Road and Bridge Construction*, Sections 400, 403, 702 and 703 provide material specifications and construction methods generally acceptable to

Weld County. Table 9-9 has the Master Range gradation requirements for Grading S (¾") on bottom, intermediate lifts and SX (½") for top lift placement are acceptable. Designs will require Performance Graded Binder of 64-22 on bottom and intermediate lifts, while top lifts will have 64-28 (Table 702-1 in *CDOT's Standard Specifications for Road and Bridge Construction*), other binder grades must be approved in writing by Weld County Engineer. Design air voids will be targeted at 3.5-4.5% under 100 gyrations. No more than 20% Recycled Asphalt may be used in the bottom and intermediate lifts. Top lift will utilize virgin aggregate in the mix design. No asphalt shingles can be used in the recycled asphalt products.

Prior to any asphalt placement, the contactor will submit an asphalt mix design to the inspector for approval, as described in Section 401.02(a) (1) and (2) of the CDOT Standard Specifications.

The inspector reserves the right to perform a site visit and inspect the facilities of any asphalt supplier used. During construction, the contractor will furnish copies of certified load tickets for the pavement materials as proof that the correct type and quantity of pavement materials were delivered to the jobsite.

The minimum and maximum layer thickness will be as specified by CDOT Specifications for the type of asphalt mix being used, or as otherwise specified in an approved pavement design report. The use of geosynthetics associated with asphalt pavement or mill/overlay operations will be approved by the engineer prior to use.

10.7.4 Concrete (PCCP) Surfaces

PCCP construction is encouraged for high-volume intersections, industrial developments, and heavy truck routes. CDOT Specifications Section 412 provides material specifications and construction methods generally acceptable to the department. Prior to any concrete placement, the contactor shall submit construction plans which follow all the requirements in this guide but also include a joint layout plan and a construction phasing plan. The following standards including but not limited to the following shall be included in the project:

1. The Contractor shall also submit an optimized gradation concrete mix design to be reviewed and approved by the County.
2. A PCCP design shall be provided using the mechanistic empirical (ME) design criteria. If the recommended pavement thickness is less than 9 inches, the minimum concrete thickness shall be 9 inches. If the recommended concrete pavement thickness is more than 9 inches, the greater thickness shall be used. The minimum thickness of Class 6 ABC is 6 inches unless a greater thickness is recommended by the design.
3. A minimum of 1 layer of Tensar INTERAX NX650 geogrid or approved equivalent shall be placed beneath the Class 6 ABC and the subgrade on all PCCP project. The manufacturer's requirements for overlap shall be followed. Additional layers of INTERAX NX650 shall be required if stability and compaction of the subgrade cannot be achieved.
4. The concrete mix design shall contain no more than 20% fly-ash
5. Only non-chloride High early strength concrete mix designs may be used in some situations if submitted and approved by the County prior to construction.
6. All acceleration and deceleration lanes shall have a 4-foot PCCP shoulder and a 2-foot gravel shoulder. The gravel shoulder shall be composed of either Class 6 ABC or RAP.

7. All other PCCP travel lanes shall have an 8-foot PCCP shoulder and a 2-gravel shoulder.
8. A safety edge is required for the full length of the PCCP lanes except at driveway locations.
9. If an existing PCCP road is being widened, the existing safety edge and shoulder shall be removed prior to the construction of additional lanes. The additional lanes shall be constructed with a safety edge.
10. The minimum 28-day flexural strength for concrete paving shall be a minimum of 650 psi. Any concrete paving found to be less than this shall be removed and replaced.
11. All other material submittals such as aggregates, cement, joint sealant, curing compound, dowel bars, and tie bars shall be approved by the County prior to any concrete being placed.
12. Non-flexible fusion bonded epoxy coated (purple or black) carbon steel bars (dowels) shall be used in the wheel paths for load transfer between panels. The Simplex Time Capsule or ArmorCoat dowel bars are acceptable.
13. Dowel bar sizes vary depending on pavement thickness and expecting loading. Never to be less than 1.25".
14. All epoxy coated Tie Bars used in concrete pavement jointing will have no bare steel ends and require coating of epoxy paint prior to placement.
15. The transition between PCCP and HMA shall follow the Weld County PCCP to HMA transition detail.
16. Concrete paving shall be finished using a moistened doubled burlap drag for texture. Concrete texturing shall occur prior to curing compound being placed.
17. All non-standard sized concrete panels shall be reinforced with 6-gauge welded wire mesh
18. Concrete curing compound shall be White Water Linseed Oil Concrete Curing and Anti-spalling Compound or approved equivalent.
19. Joint sealant shall be Dow Corning 890 SL joint sealant or approved equivalent.
20. Pavement markings placed onto finished concrete pavement shall follow Table 10-1 below.

Table 10-1 Pavement Marking Types on Asphalt and Concrete Roadways

Surface Type	Line Type	Material Type	CDOT ITEM #
Existing Asphalt	6" White Edge Line	Modified Epoxy	627-00008
	4" Yellow Edge Line	Modified Epoxy	627-00008
	4" Double-Yellow Centerline	Modified Epoxy	627-00008
	4" White Extension Line	Modified Epoxy	627-00008
	4" White Skip Lane Line	Modified Epoxy	627-00008
	8" White Gore Area	Modified Epoxy	627-00008
	8" White Channelizer	Modified Epoxy	627-00008
	8" White Lane Drop	Modified Epoxy	627-00008
	8" White Double-Left Guide	Modified Epoxy	627-00008

	Stop Bar/Xwalk	Preformed Thermoplastic (Inlaid) or Preformed Plastic Type I (Inlaid)	627-30411 or 627-30328
	Word Message/Symbol	Preformed Thermoplastic (Inlaid) or Preformed Plastic Type I (Inlaid)	627-30407 or 627-30323
New Asphalt	6" White Edge Line	Modified Epoxy	627-00008
	4" Yellow Edge Line	Modified Epoxy	627-00008
	4" Double-Yellow Centerline	Modified Epoxy	627-00008
	4" White Extension Line	Modified Epoxy	627-00008
	4” White Skip Lane Line	Modified Epoxy	627-00008
	8" White Gore Area	Modified Epoxy	627-00008
	8" White Channelizer	Modified Epoxy	627-00008
	8" White Lane Drop	Modified Epoxy	627-00008
	8" White Double-Left Guide	Modified Epoxy	627-00008
	Stop Bar/Xwalk	Preformed Thermoplastic (Inlaid) or Preformed Plastic Type I (Inlaid)	627-30411 or 627-30328
	Word Message/Symbol	Preformed Thermoplastic (Inlaid) or Preformed Plastic Type I (Inlaid)	627-30407 or 627-30323
Existing & New Concrete	6" White Edge Line	Preformed Plastic Type II (Inlaid)	627-02010
	4" Yellow Edge Line	Modified Epoxy	627-00008
	4" Double-Yellow Centerline	Modified Epoxy	627-00008
	4" White Extension Line	Modified Epoxy	627-00008
	4” White Skip Lane Line	Preformed Plastic Type II (Inlaid)	627-02010
	8" White Gore Area	Modified Epoxy	627-00008
	8" White Channelizer	Preformed Plastic Type II (Inlaid)	627-02010
	8" White Lane Drop	Preformed Plastic Type II (Inlaid)	627-02010
	8" White Double-Left Guide	Preformed Plastic Type II (Inlaid)	627-02010
	Stop Bar/Xwalk	Preformed Thermoplastic (Inlaid) or Preformed Plastic Type I (Inlaid)	627-30411 or 627-30328
	Word Message/Symbol	Preformed Thermoplastic (Inlaid) or Preformed Plastic Type I (Inlaid)	627-30407 or 627-30323

	Rollover Curb in Roundabouts	Modified Epoxy – Yellow with reflective beads	627-00008

21. For epoxy pavement markings, the concrete curing compound must be removed along the marking layouts prior to placement of the epoxy. This can be accomplished using pressurized water or other methods as approved by the County.

The County reserves the right to perform a site visit and inspect the facilities of any material supplier used during construction. The contractor shall furnish copies of certified load tickets for the pavement materials as proof that the correct type and quantity of pavement materials were delivered to the jobsite.

Traffic control requirements for PCCP construction are a major concern because of the concrete curing time requirements.

10.7.5 Pavement Cut and Patching Requirements

Some roadways in Weld County have a "No Cut" policy in place. Consult with the Public Works Department to find out which roads fall under this policy. Construction work that requires removal of existing paved surfaces will require replacement with similar new pavement materials within a period of 48 hours, unless otherwise approved by the inspector. Traffic control devices will not be removed until after the paved surface has been replaced. Removed RAP surfaces will be replaced with HMA.

Where pavement is to abut existing pavement, the existing pavement shall be removes to a neat vertical line, using a saw or other method as approved, to create a clean construction "T-Joint". The contractor will also be required to paint the edge with diluted emulsified asphalt (slow setting) prior to paving operations. The rate of application shall be as determined by the engineer at the time of application. Contractor shall mill existing roadway to a minimum depth of 2 inches. The milling shall be a minimum of 2 feet wide or a greater width so that the joint will not fall within the intersecting travel lane wheel path.

Construction in the winter will require temporary asphalt patching using cold-mix materials, then returning to the site to reconstruct with permanent patching using hot-mix materials when weather conditions allow. All pavement removals will be saw-cut a minimum of 1 foot wider than the patching area. The new pavement patch material will be placed and compacted to a thickness at least 1 inch greater than the adjacent in-place pavement. The minimum dimension of both length and width of any pavement patch will be at least 4 feet to ensure adequate compaction can be obtained. The inspector may choose to waive the requirement for pavement surface materials testing if they believe that proper construction methods are being used to ensure good compaction.

Pavement cut and patching requirements for concrete pavements will require review and approval by the inspector. Concrete patching typically requires insertion of steel dowel bars into the adjacent pavement. Proper curing and jointing methods also must be used.

Improper construction of pavement patches is a problem in Weld County. Poor construction methods may result in dangerous bumps or dips in the traveled roadway. If such conditions are identified by the department within two years after construction, the contractor will be notified in writing to reconstruct

the pavement patch properly. Failure to meet the conditions described in the written notice from the department can result in emergency repairs being performed by County crews. In such cases, the contractor will be invoiced to reimburse the County for all costs associated with the road repairs.

10.8 STRUCTURES AND DRAINAGE FEATURES

10.8.1 Bridges

Unless otherwise approved by the engineer, bridges will be designed and constructed according to the most current requirements of AASHTO's *LRFD Bridge Design Specifications*, CDOT's *Bridge Design Manual*, CDOT Standard Specifications, and CDOT Standard Plans. If alternate designs or construction methods are being proposed by the contractor, the engineer will provide specific submittal requirements. The design and construction of any bridge within the County right-of-way will be overseen by a Professional Engineer licensed in the state of Colorado.

10.8.2 Culvert and Pipe Installation

Culvert and pipe installation will be completed according to the requirements of CDOT Specifications Section 603 and Standard Plans, unless otherwise described in Chapter 5.6.4 and Chapter 5.8 of this document. Pipes constructed in right-of -ay for private driveway access in rural areas will be at least CMP, or an approved equal, and will have a minimum diameter of 15 inches. Pipes constructed under the travel lanes of a new public roadway will be RCP, or an approved equal, and will have a minimum diameter of 15 inches. All culverts and pipes must be installed with a minimum of 12 inches of cover above the pipe crown and bell to the bottom of asphalt at the edge of pavement (for paved roads) and a minimum of 12 inches of cover above the pipe crown to the top of the finished grade (for gravel roads). If 12 inches of cover is not possible, the culvert material must be rated for a minimum of HS-20 loading or the largest expected loads crossing it (i.e., oil rigs, semi-trucks, etc.).

The contractor must provide shop drawings for any precast concrete box culvert (CBC), which will be reviewed and approved for use by the engineer. HDPE, ADS, or other plastic pipes that cannot withstand fire will not be allowed.

It will be the responsibility of the contractor to protect pipe materials from damage during shipping, unloading, and installation. Any damaged pipe materials (as determined by the inspector) will be removed from the jobsite. The construction elevation tolerance for pipes will be within 0.5 inches of the design elevation called for on the approved plans.

10.8.3 Curbs, Gutters, and

Construction will be according to the requirements of CDOT Specifications Section 609 and Standard Plans, or as otherwise described in Chapter 5 of this document. All curbs, gutters, and crosspans will be constructed of CDOT Class D concrete or an approved equal. All gutters and cross pans shall be 8" thick minimum. Asphalt curbs are permitted for bridge construction only.

All outflow curb and gutter will be CDOT Type 2—Section IB, unless otherwise approved. All inflow curb and gutter will be CDOT Type 2—Section IIB, unless otherwise approved. All mountable curb shall be CDOT Type 2 Section IM or Section IIM, unless otherwise approved. All crosspans will be CDOT Gutter Type 2 with a minimum thickness of 6 inches, unless otherwise approved. The minimum vertical slope for all gutters and crosspans will be 0.5 percent. Minimum width of 8 feet.

10.8.4 Concrete Structures, Manholes, and Inlets

Construction will be according to the requirements of CDOT Specifications Section 601 and Standard Plans, or as otherwise described in Chapter 5.6 of this document. All irrigation structures will be reviewed and approved by the applicable irrigation company or board prior to construction.

All concrete structures, manholes, and inlets will be constructed with steel reinforcement as shown on the approved construction plans. The contractor will be responsible for concrete quality control testing for all cast-in-place concrete construction. The contractor will request an inspection of the concrete formwork by the inspector a minimum of 24 hours prior to concrete placement.

10.8.5 Retaining Walls and Slope Stabilization Measures

Any retaining walls 4 feet tall or higher that are to be constructed in the right-of-way will be designed (and designs will be stamped) by a Professional Engineer licensed in the state of Colorado. The contractor will submit detailed plans for approval by the department prior to construction. Retaining wall foundations must follow the recommendations provided by the geotechnical engineer. Modular block retaining walls will be constructed per the manufacturer's specifications. Retaining walls will be located such that they ensure adequate clear distance from the wall to the edge of the roadway and so do not pose a risk to the traveling public. Any retaining wall constructed in an urban or residential area and greater than 4 feet in height will incorporate a railing or fence for fall protection.

Non-structural erosion control measures for slopes (blankets, turf reinforcement mats, etc.) will be installed per the manufacturer's specifications. Structural slope stabilization measures (riprap, gabions, soil anchors, slope mattresses, etc.) will be designed, and designs will be stamped, by a Professional Engineer licensed in the state of Colorado. The contractor will submit detailed plans for approval by the department prior to construction.

10.9 OTHER ROADWAY FEATURES

10.9.1 Pavement Markings

All roadways and bridges constructed will receive permanent pavement markings (striping) prior to the construction traffic control devices being removed. The contractor will ensure that all pavement markings have been designed and located according to the requirements of the MUTCD. All permanent line striping will be done with epoxy paint materials applied according to the manufacturer-recommended methods at 15 mils minimum thickness, unless otherwise approved by the department. Both pavement and air temperatures will be at least 50 degrees and rising at the time of pavement marking. All permanent words, symbols, stop bars, crosswalks, etc., will be pre-formed thermoplastic pavement markings capable of being affixed to the asphalt pavement surface by heating, unless otherwise approved by the department. The minimum pavement and air temperature will be as recommended by the manufacturer. The contractor will submit a copy of the manufacturer installation recommendations to the inspector prior to application.

10.9.2 Traffic Control Devices (Signs and Signals)

Installation of all permanent traffic control devices within the right-of-way is to be approved and overseen by the department. Traffic control device materials and manufacturers will meet the requirements of CDOT Specifications Section 713 and the latest version of the MUTCD. Installation of

traffic control devices will meet the requirements of CDOT Specifications Section 614 and the latest version of the MUTCD.

Construction of traffic signals within the right-of-way with the intention of turning over ownership of the traffic signal to the County will require specific design guidance and approval by the department.

10.9.3 Trees and Plantings

Weld County does not encourage the placement of any trees or plantings within the right-of-way that require an irrigation system. Any trees or plantings proposed to be used will be able to survive under non-irrigated conditions.

Trees and plantings will be located such that they do not present a safety hazard to the traveling public by ensuring adequate clear zone distance from the trees and plantings to the edge of the roadway.

Trees and plantings will be of the species and varieties previously approved for use by the department. The contractor will obtain certificates of inspection of plant materials that are required by federal, state, or local laws, and will submit the certificates to the department for approval prior to planting. All delivered plant materials will be free from plant diseases and insect pests. All plant materials are subject to the two-year warranty period. The contractor is responsible for removing and replacing any dead plant materials that have been identified by the department prior to the end of the warranty period.

10.9.4 Sidewalks and Trails

Any permanent sidewalk, bikeway, or trail within the right-of-way will be constructed with concrete or HMA, with a minimum thickness of 4 inches. The minimum width of the completed surface will be

5 feet. All completed surfaces will have a maximum cross slope of 1.8 percent to ensure proper drainage and comply with the Americans with Disabilities Act (ADA). Sidewalks will be constructed with concrete curb ramps and will comply with ADA requirements.

Before any surfacing is placed, clearing and grubbing, tree removal, grass and brush removal, and topsoil removal will be completed. The existing ground then will be thoroughly compacted to not less than

90 percent of maximum density as determined by AASHTO T99. Materials testing requirements may be waived by the inspector if the amount of sidewalk being constructed is minimal or the construction methods being used are obviously adequate to ensure required results.

10.9.5 Guardrails

All new guardrail placed within the right-of-way will be CDOT Midwest Guardrail System (MGS). Any contractor installing guardrail will be pre-qualified with CDOT for this specific type of construction (work type 14). The contractor will be responsible for providing and maintaining traffic control devices until the guardrail construction has been entirely completed, inspected, and approved for use by the inspector.

10.9.6 Fences

New fences constructed within the right-of-way will be in accordance with CDOT Specifications Section 607 and Standard Plans No. M-607-1 (Wire Fences and Gates). In cases where a contractor is replacing an existing fence, the adjacent landowner and the inspector should be consulted regarding acceptable fencing materials. In all cases, the contractor will obtain permission to enter upon adjacent private land.

Construction of fences intended to be located on the right-of-way line will be surveyed and staked prior to construction. If the locations of the right-of-way line or adjacent property lines are in question, the department will be consulted for assistance. All fences will be designed and constructed in a manner that does not adversely impact the sight distance for vehicles, especially near roadway intersections.

In urban or developed areas, standard barbed-wire fences are not the preferred type. Developers and landowners can make use of many other fence types that will better fit the needs. The department will be consulted and will review specific requests prior to construction.

The contractor will perform clearing and grubbing as necessary to construct the fence to the required grade and alignment. At locations where fence posts or anchors need to be imbedded in concrete, adequate bracing will be left in place until the concrete has hardened. The tops of all posts will be set to the required grade and alignment. Avoid cutting off the tops of treated wooden posts. All gates will be galvanized steel or factory-painted, unless otherwise approved.

10.9.7 Cattle Guards

In Weld County, cattle guards are used to keep cattle or other grazing animals off the right-of-way. New cattle guards constructed within the right-of-way will be in accordance with CDOT Specifications Section 611 and Standard Plans No. M-611-1 (Cattle Guard). A written agreement similar to the agreement found in Appendix 8-C of the Weld County Code must be received by the Public Works Department prior to installation. The contractor will obtain permission to enter upon adjacent private land, if necessary, for construction and will make arrangements for temporary access with the affected landowner(s).

The deck area of all cattle guards will be constructed of steel, and all hardware will be galvanized steel. The contractor will ensure that concrete has sufficient time for curing and strength gain prior to allowing traffic to use the new cattle guard. The contractor will be responsible for providing a temporary means of controlling cattle or other grazing animals during construction.

CHAPTER 11 PERMITTING

The following permits are issued by the Public Works Department or the Planning and Zoning Department, as indicated. Additional information regarding any of the permits, including application forms, can be found on the Weld County website.

11.1 TRANSPORT PERMIT

The Transport Permit is issued by the Public Works Department and is required when vehicles using the County road network are overweight, over-sized, or both. It is issued for standard overweight or over-sized load vehicles and for oil rigs drilling in the County. Permit conditions or restrictions may apply to these vehicles and are listed on the application form. When a permit for this application is issued by Weld County, the permit is subject to the conditions described with the understanding that no liability is assumed by Weld County by reason of its issuance. With regard to the condition of roads or capacity of culverts and bridges, the applicant must examine and inspect the adequacy of roads and bridges for traffic movement. In case of an emergency, an authorized Weld County employee or an authorized agent may suspend the permit until emergency conditions have passed. (See Weld County Code, Chapter 8, Article XV, Sec. 8-15-10, et seq.)

11.2 RIGHT-OF-WAY USE PERMIT

The Right-of-Way Use Permit, issued by the Public Works Department, is a tool to help regulate unauthorized obstructions of, excavations in, and use of the County's rights of way and easements by requiring permits for all construction activities within the Weld County rights of way or easement and provide for the subsequent restoration upon completions. A Right-of-Way Use Permit grants a permit holder permission to occupy, excavate, survey, perform locations, or construct facilities within the County rights of way or easements and provide for the subsequent restoration upon completion. (See Weld County Code, Chapter 8, Article XIII, Sec. 8-13-10, et seq.)

Right-of-way Use Permit instructions and application can be found at:
https://www.weld.gov/Government/Departments/Public-Works/Permits/Right-of-Way-Permits.

11.3 ACCESS PERMIT

Land use, natural resources recovery, general utilities, and development have impacts on County roads. The requirement for Access Permits, issued by the Public Works Department, recognizes that the efficiency and safety of County roads depends on minimizing roadside interference and its detrimental effect upon the movement of traffic. The Access Permit sets out minimum requirements for the design, construction, and maintenance of accesses. (See Weld County Code, Chapter 8, Article XIV, Sec. 8-14-10, et seq.)

11.4 GRADING PERMIT

The Grading Permit, issued by the Public Works Department, is a tool to ensure that the County has reviewed the grading plan, the erosion and sediment control plan, and the utility map for proposed construction activities with the goal of avoiding potential damages. A Grading Permit grants the Permit Holder permission to conduct construction activities within the requirements of applicable state regulations and provides the County with sufficient oversight to minimize the potential for offsite damages.

A Grading Permit will be required if disturbing more than one acre or any earth disturbance in an MS4 area per the MS4 criteria within this document. (See Weld County Code, Chapter 8, Article XII, Sec. 8-12-10, et seq.)

11.5 FLOODPLAIN DEVELOPMENT PERMIT

The Floodplain Development Permit is issued by the Planning and Zoning Department. (See Weld County Code, Chapter 23, Article XI, Sec. 23-11-200, et seq.)

CHAPTER 12 VARIANCE REQUESTS

The County recognizes that in certain limited instances it may be exceptionally difficult to conform to the criteria set forth in this manual and the Weld County Code. The County will consider requests for variances on a case-by-case basis. The variance request will be submitted in a written attachment to the initial submittal of construction plans. Drainage variances are addressed in Section 8-11-160 of the Weld County Code. All other requests will consist of the following:

1. Identification of the criteria or Weld County Code section to be waived or varied
2. Identification of the construction criteria adhered to
3. Justification for the variance, which will demonstrate the following:
    - Hardship is created if the variance is not approved. The hardship shall be specific to the subject property, rather than general in nature such as cost, and shall not have been self-imposed by the applicant or their predecessors in title to the property.
    - There will be only minimal impact on public safety.
    - The variance is not contrary to best engineering practices.
    - The variance is not contrary to the intent and general purpose of these criteria and the Weld County Code.
    - The variance does not result in a significant impact to the public due to maintenance of the improvement.
    - The variance does not result in a significant impact to the aesthetic appearance of the improvement.
    - The variance is the minimum exception from the criteria necessary to afford relief from the hardship.
    - The variance is reasonably necessary for the health, safety, and welfare of the public.

The variance request shall be prepared, stamped, signed, and dated by a professional civil engineer licensed to practice in the State of Colorado. Requests will be reviewed by the Public Works and/or Planning Services Director or his/her designee. The Public Works Director, or his or her designee, shall only approve the variance request if the applicant has demonstrated the justification required above.

The Public Works and/or Planning Services Director or his/her designee reserves the right to deny, or allow his or her designee to deny, any request for variance if doing so is in the interest of public health, safety, and welfare.

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APPENDIX A – Weld County Drainage Basin Map

Weld County
Drainage Basin Map

Map Produced By:
Weld County Public Works
February 2010

WELD COUNTY COLORADO

4

0 0.5 1 2 3 4 5
Miles

Legend

- Weld_County
- Highways
- Paved
- Gravel

Drainage Basin Boundaries

- Big Thompson River
- Boulder Creek-Saint Vrain Creek
- Box Elder Creek
- Cache La Poudre River
- Camp Creek
- Cedar Creek
- City of Raymer
- Cottonwood Draw
- Crow Creek
- Greasewood Draw
- Kiowa Creek
- Lone Tree Creek
- Lost Creek
- North Pawnee Creek
- Outlet Pawnee Creek
- Sanborn Draw
- Sidney Draw
- South Pawnee Creek
- South Platte River
- Spring Creek-Pawnee Creek
- Two Mile Mountain
- Wildcat Creek

APPENDIX B – Drainage Report Checklist

Drainage Report Checklist

Project Name:

The purpose of this checklist is to assist the applicant's Engineer with developing a drainage report that supports the intent of the Weld County Code using commonly accepted engineering practices and methodologies.

Is the project in the **MS4**? ☐Yes ☐ No If yes, the following requirements in blue apply. See Chapter 8, Article IX of the Weld County Code.

Report Content

- ☐Weld County Case Number
- ☐ Certificate of Compliance signed and stamped by a Colorado Licensed PE
- ☐ Description/Scope of Work
- ☐ Location (County Roads, S-T-R)
- ☐ Nearby water features and ownership
- ☐ Total acres vs. developed acres
- ☐ Hydrological soil types/maps
- ☐ FEMA Flood Zones
- ☐ Urbanizing or non-urbanizing
- ☐ Methodologies used for report & analysis (full spectrum is not accepted)
- ☐ Base Design Standard used for permanent control measure design in the MS4
- ☐ Discussion of offsite drainage routing
- ☐ Conclusion statement indicating that the design will adequately protect public health, safety, and general welfare and have no adverse impacts on public rights-of-way or offsite properties

Hydrology and Hydraulic Analysis

- ☐ Design Storm / Rainfall Information (NOAA Atlas or Local Data)
- ☐ Release Rate calculations
- ☐ Post construction site imperviousness
- ☐ Hydrologic calculations (historic & developed basins)
- ☐ Hydraulic calculations for proposed drainage improvements (swales, culverts, riprap, pond, outlet, spillway, WQCV outlet, etc.)
- ☐ Detention/WQCV calculations

Comments:

Construction Drawings

- ☐ Stamped by PE
- ☐ Engineering scale & north arrow
- ☐ Property lines, rights-of-way, and easements
- ☐ 1' Contours & elevations (existing & proposed)
- ☐ Pre- and post-development drainage basins
- ☐ Arrows depicting flow direction
- ☐ Time of concentration critical path
- ☐ Drainage design points
- ☐ Improvements labeled
- ☐ Permanent control measure and associated drainage features labeled 'No Build/No Storage', include design volume
- ☐ Cross sections for open channels, profiles for pipes
- ☐ Elevations for inverts, flow lines, top of grates, orifice(s), etc.
- ☐ Pipe specs (size, material, length, slope)
- ☐ Outlet and spillway details

Maintenance Plan

- ☐ Frequency of onsite inspections
- ☐ Repairs, if needed
- ☐ Cleaning of sediment and debris
- ☐ Vegetation maintenance
- ☐ Manufacturer maintenance specifications, if applicable

Other Required Documents (If Applicable)

- ☐ Variance Request and documentation– explain hardship, applicable code section, and proposed mitigation. Variances will not be granted for the Base Design Standard requirement in the MS4.

Drainage Report Checklist

1.

2. Once the revised design and drainage report have been submitted, the County may provide additional comments in addition to the ones listed above. Depending on the complexity of the changes made, a full 28-day review period may be required.

3. Please provide a written response on how the above comments have been addressed when resubmitting the drainage report. Thank-you.

APPENDIX C – CDOT Operations and Maintenance Plan Guidelines

COLORADO
Department of
Transportation

Preparation Guidelines for Operations and Maintenance Plans (O&M Plans) for Permanent Water Quality Control Measures (PWQ CMs)

This document will guide CDOT staff and consultants, including Design Engineers, Project Engineers, Hydraulic Engineers, and Environmental and Maintenance staff, in the development of an Operations and Maintenance Plan (O&M Plan) for Permanent Water Quality Control Measures (PWQ CM) installed during a project's active construction phase for long-term treatment of runoff from the project area after construction is complete. PWQ CMs include extended detention basins, sand filters, media filter drains, and other constructed and proprietary structures.[1] The CDOT Drainage Design Manual and Maintenance Manual provide additional general direction on the design and maintenance of PWQ CMs.

The development of an O&M Plan for each PWQ CM needs to occur for compliance with the requirements of the Municipal Separate Storm Sewer System (MS4) Permit issued by the Colorado Department of Public Health and Environment (CDPHE), specifically Part I.E.2.v. The O&M Plan is intended to serve as a reference document for maintenance staff to review prior to leaving the maintenance yard so that they arrive at each PWQ CM site with the staff and equipment required to maintain the PWQ CM, an understanding of access requirements and maintenance expectations, and a knowledge of necessary procedures required to maintain the PWQ CM to its original design specifications. The O&M Plan will reflect as-built conditions.

An example O&M Plan has been provided. The example O&M Plan is representative only. The information and text included in the example O&M Plan are not reflective of what should or should not be done at any site; it is reflective only of the *type* of information that should be provided. All O&M Plans for PWQ CMs shall generally conform to the example regarding the type of information provided; however, not all necessary contents may be included on the example O&M Plan. Unique features may warrant inclusion of additional information. This guidance document provides a thorough discussion of the elements that will be required, if applicable, on an O&M Plan for PWQ CMs. The O&M Plan will be a doubled-sided 11x17 with a font size of at least 11 point. If an item is not required, note that is it not required rather than omitting it from the O&M Plan.

No.	Front of 11x17 Sheet
1.	<u>Title block and title text</u> The front and back of each O&M Plan shall include a title block and title text that includes the facility name, the type of PWQ CM (one of seven SAP PWQ CM categories), the SAP number, the project subaccount number, the Colorado county the CM is in, the CDOT Region the CM is in, the route and route segment the PWQ CM is treating, and the month and year the facility was constructed. It will also include the CDOT Region Maintenance Section or Local Agency responsible for maintenance.
2.	<u>Location map</u> A large-scale location map shall cover enough area and include enough major roadways that the O&M Plan user can find the PMQ CM. The location map shall show CDOT roadway(s) with mileposts, north arrow, and location of PWQ CM. Scale shall be between 1"=1000' and 1"=5000'.
3.	<u>Detailed as-built plan view</u> A smaller scale detailed plan view of the PWQ CM location shall show all nearby roadways; all maintenance access points, turn-arounds, and sediment/debris stockpile areas; at least one hard maintenance control point including elevation; right-of-way, property boundaries, ownership, and easements; areas to remain undisturbed by maintenance activities such as areas regulated by a 404 permit or any other sensitive areas; and areas to be mowed or to receive other weed control activities including weed spraying. Major features shall be identified such as forebays, micropools, inlets, outlets, structures, trickle channels, etc. Include the 100-year floodplain if applicable. If a power source usable by maintenance staff is present at the site, it shall be shown in the detailed plan view. Any weight-restricted areas shall be shown. Detailed instructions need not be provided on the detailed plan view if they are included in the notes. Scale shall be between 1"=20' and 1"=100'. The location of the access point to the PWQ CM may need to be delineated by dimensions from roadway centerline, edge of pavement, or other hard, visible structure if it is below grade or otherwise may be difficult to find. For

[1] Refer to the PWQ Section of the Drainage Design Manual for more information (https://www.codot.gov/programs/environmental/water-quality/documents/drainage-design-manual-1).

	example, if the PWQ CM is a below-grade vault with manhole access, and there are multiple manholes in the vicinity, it will be necessary to indicate which specific manhole(s) access the PWQ CM.
4.	Profile While not required for every PWQ CM, if critical information cannot be sufficiently in sections and/or the plan view, a profile view of the main flow path through the PWQ CM may be added to show critical elevations and information. Such information may include variations in slope of the main channel invert or pipes and culverts, the extents and depth of the filter media, and underdrains and other structures. The profile shall show permanent pool elevations, crossing utilities, flow direction, and any design water surface elevations used such as the elevation of the water quality capture volume (WQCV) or any specific design storm event. General maintenance notes may be included on the profile or reserved for the detailed notes on the back of the O&M Plan.
5.	Sections Enough PWQ CM sections shall be included to detail all tops of walls, inverts, rims, dimensions, and flowline elevations of all CM components including, but not limited to, forebays, inlets, micropools, outlets, trickle channels, storm sewers, underdrains, sumps, headwalls, wingwalls, overflow weirs, orifice plates, grates, screens, gates, trash racks, and filter media dimensions and specifications. Sections of proprietary structures may be as provided by the manufacturer. Nearby utilities shall be shown in the sections as applicable. A section showing the maintenance access roads shall also be included with the access road surfacing material and thickness, minimum width, maximum grade, and any weight limitations.
6.	Grate Details Details of all grates must be included with enough information that the maintaining agency can reorder grates if they are stolen. This includes exterior dimensions, materials, and bar spacing in both directions.
7.	Front page notes While the first page of the O&M Plan is generally reserved for plans, sections, profiles, and details, any notes of high importance may be added here as well as on the second page of the O&M Plan. These may include detailed notes on critical items such as how to handle wetlands or weeds on site, unique access instructions, or IGA conditions. These notes may also be included on the back page to provide redundancy.
No.	Back of 11x17 Sheet
1.	Notes on general project information The notes shall include the project subaccount number; name(s) of the receiving water; the name, phone number, email of the CDOT Project Engineer for the design of the PWQ CM; the property owner's name(s), contact name, address, phone number, and contact email address if available; the maintaining agency's name(s), contact name, address, phone number, and contact email address if available; the design engineer's name(s), contact name, address, phone number, PE license number, and contact email address if available. If CDOT is the maintaining agency, the name of the Maintenance Section Superintendent shall be included.
2.	Notes on the general facility description The notes shall include a general facility description that includes what type of PWQ CM the facility is; how it functions (filtration, sedimentation, etc.); and the origin of the runoff it treats, including tributary area. A brief note about the overall project under which the PWQ CM was constructed, if applicable, should be included as well as the CDOT Maintenance Section and Local Agency (if applicable) that approved the design. If the facility will not treat the 100-year storm event but will receive inflow exceeding its volumetric capacity, a note should be added on how those flows are safely conveyed through and beyond the facility. If flows are bypassed prior to reaching the PWQ CM, a note shall be included that details the function and location of the bypass structure.
3.	Notes on the anticipated inspection and maintenance frequency and procedure

	Initial PWQ CM inspection shall be annually plus after storms producing more than 1 inch of rainfall per hour. at a minimum, with an inspection form filled out for each inspection. Inspection frequency may be adjusted based on findings of inspections during the first year. PWQ CM maintenance shall be annually at a minimum. Maintenance frequency may be increased based on findings of inspections during the first year and any requirements issued by the EPA or CDPHE. Examples of items to be inspected include pond forebays, low water crossings, riprap side slopes and inverts, grouted riprap, inlets, access ramps, storm sewer outfalls, incoming and outgoing pipes, pond outlet structure including interior of structure, canal gate (to be exercised), restrictor plate, micropool, trash rack, well screen. The maintenance procedure shall include the following at a minimum, provided they are applicable: Traffic control plan; confined space entry protocols; dewatering and water control requirements such that a dewatering permit is not required; sediment and debris removal and disposal requirements, including longest reach distance from access road; mowing and weed control; information on wetlands and other sensitive areas; any other maintenance required maintenance activities; items to be replaced; any materials testing requirements if sediment must be tested for contaminants prior to disposal; post-maintenance considerations such as restoring flow patterns, removing temporary dewatering and water control measures such as stop logs, or additional cleanup requirements.
4.	<u>Notes on required maintenance equipment, materials, staffing, and responsibility</u> The notes shall include all equipment, materials, and labor that is anticipated to be required to maintain the PWQ CM. Equipment may include, but not be limited to mowers, pumps, hoses, vac trucks (note reach required), air compressors, shovels, buckets, excavators (note reach required), inflatable coffer dams, weed killer, generators, and sprayers. Anticipated sizes of all equipment shall be included. Materials may include proprietary replacement products such as filter bags or media that need to be ordered in advance or more general filter media. Materials notes should include approximate quantities. Staffing notes shall include the minimum number of maintenance staff expected to be required to complete the maintenance activities. For example, if two employees are required to operate a pump or install a coffer dam, this should be noted in this section. These notes shall include a description and details of any inter-governmental agreements (IGAs) regarding maintenance of the PWQ CM and which entity is responsible for which aspects of maintenance. The IGA description and details should include the dates and parties subject to the agreement and a general summary of the agreement, including what happens if one party does not fulfill its contractual obligations. Also note if CDOT or a Local Agency is relying on C.R.S. 43-2-135 as the maintenance mechanism.
5.	<u>Notes on ROW, adjacent ownership, and access</u> The notes shall include a general description of the right-of-way shown in the detailed plan view, the adjacent property ownership, and locations and dimensions of maintenance access. These notes shall include property access requirements such as whether locked gates might be encountered, locations of keys, access codes, and vehicular weight limitations. Notes shall also include additional applicable specific instructions (e.g., must approach access drive from the south).
6.	<u>Notes on vegetation management</u> The notes are specific to seed mixes, mowing, and weed control. There may be some redundancy with the notes on the anticipated inspection and maintenance procedure and frequency. These notes are intended to be more detailed. The notes shall include all seed mixes (dryland/upland and/or wetland mixes) and any trees or shrubs that have been planted at the site. Seed mixes shall include all genus, species, variety, and pounds pure live seed per acre of each type of seed that was planted as well as the location (e.g. above elevation XXXX.XX, on the low flow channel side slopes, etc.). These notes shall also indicate the total area to be mowed, in acres, and any notes on mowing. How weed control is to be accomplished (e.g. mowing, spraying, etc.) shall be included in the notes. Different areas may require different methods, and these shall be noted. These notes shall also include criteria on replacement of seed or other vegetation.

7.	Notes on hydraulic design The notes shall include all flow rates used in the hydraulic design including base flow and the 2- and 100-year peak inflow and outflow at a minimum. The notes shall include other calculated flow rates as applicable, the WQCV and associated water surface elevation, the excess urban runoff volume (EURV) and associated water surface elevation, if applicable, the 100-year volume and associated water surface elevation if applicable, and the volumes of major structures that can accumulate sediment including forebays, micropools, and sumps. Depths of major structures shall be noted. The WQCV drain time and EURV drain time shall be noted if applicable.
8.	Notes on sensitive areas, wetlands, and permits The notes shall include descriptions of any environmentally sensitive areas, wetlands to remain undisturbed, and areas covered by a 404 permit or other environmental permit and how maintenance activities are different for these areas, if applicable. The notes shall include any monitoring or inspections required by 404 or other environmental permits. The notes shall also include information on any current or retired groundwater monitoring wells, any hazardous materials that were or could reasonably be anticipated to be encountered on site, and any known unmitigated hazards. Permits that may be required include a floodplain development permit if the CM is within the 100-year floodplain and CDPHE permits such as construction dewatering, stormwater discharge, groundwater, etc.
9.	Notes on snow and ice control Notes shall include descriptions of locations where maintenance staff are responsible for snow and ice control if necessary for sidewalks and/or roadways within the PWQ CM and the methods by which snow and ice are to be controlled. If requirements for snow and ice control exist, they are likely a Local Agency requirement.
10.	Notes on miscellaneous information Notes shall include any other items or details that are important for understanding the inspection and maintenance requirements of the site or for general informational purposes. One required item is the approximate survey date, horizontal and vertical datum, and coordinate system information.
11.	Notes on homeless encampments The note included on the O&M Plan template shall be included on all O&M Plans. The contact person for all PWQ CMs maintained by CDOT should be the Maintenance Section Superintendent. For PWQ CMs maintained by a local agency, contact the local agency to determine who should be contacted.

APPENDIX D – As-Built Drawing Checklist

As-Built Drawing Requirements

As-built drawings are required for all projects within, or draining to, the MS4 area or when requested by Development Review for sites outside of the MS4 area.

While it is expected that a project will be built in accordance with the accepted construction plans, it is understood that unforeseen site conditions may require deviations. Therefore, as-built drawings are required to be submitted for all site drainage and shall clearly demonstrate the construction of drainage features as designed and in accordance with Weld County Code. As-built drawings shall verify critical public safety elements and document all modifications/changes to the original plans as described below.

As-built drawings are typically a red-lined copy of the original, accepted grading plans, unless otherwise allowed by Public Works.

As-Built Drawing Requirements:

- ✓ Surveyor's and Engineer's Statements of Substantial Compliance are required on the cover sheet only and as follows:
  - **Registered Colorado Professional Land Surveyor:** A registered land surveyor in the State of Colorado shall certify the construction of drainage and stormwater infrastructure with the following statement:

    "A field survey was conducted by (Surveyor), on (Dates). Unless explicitly marked, constructed condition should not be assumed. I, (Surveyor), hereby state that in my professional opinion the information shown on these plans accurately represents the improvements constructed."

  - **Registered Colorado Professional Engineer:** The responsible P.E. for the project shall certify the construction of drainage and stormwater infrastructure with the following statement:

    "Based upon review of and reliance on the field survey data and other pertinent data provided by (Name of Firm(s) or Surveyor), on (Date), and a final site investigation conducted on (Date), I hereby state that to the best of my knowledge, information and belief, it is my professional opinion that the facilities shown in these drawings were constructed in substantial compliance with the accepted Drainage Report and/or Construction Drawings and the Engineer's intent. This statement is based only on a review of the field survey data and a final site investigation."

- ✓ The As-Built drawings are a standalone document and shall provide an exact rendering of the construction as it appears in the field. Any modifications to the original plans, whether minor or major, shall be included. The changes shall be color coded, bubbled, clouded, or outlined and they shall be explained clearly in writing. Any deviation from the plans shall be specified, whether the change was in design, location, or the materials used. Small details like materials used shall be documented if they differ from those indicated in the original plans. The intended but unused materials shall be crossed out to acknowledge the changes that emerged during the construction process. If necessary, additional sheets may be added to clearly show all required information.
- ✓ The verification of public safety elements (i.e., detention/retention pond volume, stormwater conveyance structure capacity, etc.) shall be based on a field survey prepared by a Colorado licensed surveyor.
  - As-Built Drawings for Storm Sewer shall verify the material, size and longitudinal grade of all storm sewer pipes and culverts. Elevations are required for all pipes, inlets, riprap, headwalls, and all other storm drainage infrastructure shown on the accepted plans.
  - As-Built Drawings for Open Channels shall verify all drainageway grades/slopes, channel cross-sections and horizontal and vertical information for all grade control structures.
  - As-Built Drawings for Detention / Water Quality Facilities shall verify horizontal/vertical information of all facilities including pipe or channel inlets, low flow or trickle channels, outlet structures, emergency overflow spillways, and water surface elevations (WQCV and 100-yr storm event). Provide spot elevations for critical stormwater infrastructure locations (spillways, top of ponds, outlet structures, etc.). A stage/storage table of the surveyed pond may be required if topography (1' contours) significantly differs from the original plans.

APPENDIX E – USDCM 2007 Runoff Coefficients

Table RO-5— Runoff Coefficients, *C*

Percentage Imperviousness	Type C and D NRCS Hydrologic Soil Groups					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
0%	0.04	0.15	0.25	0.37	0.44	0.50
5%	0.08	0.18	0.28	0.39	0.46	0.52
10%	0.11	0.21	0.30	0.41	0.47	0.53
15%	0.14	0.24	0.32	0.43	0.49	0.54
20%	0.17	0.26	0.34	0.44	0.50	0.55
25%	0.20	0.28	0.36	0.46	0.51	0.56
30%	0.22	0.30	0.38	0.47	0.52	0.57
35%	0.25	0.33	0.40	0.48	0.53	0.57
40%	0.28	0.35	0.42	0.50	0.54	0.58
45%	0.31	0.37	0.44	0.51	0.55	0.59
50%	0.34	0.40	0.46	0.53	0.57	0.60
55%	0.37	0.43	0.48	0.55	0.58	0.62
60%	0.41	0.46	0.51	0.57	0.60	0.63
65%	0.45	0.49	0.54	0.59	0.62	0.65
70%	0.49	0.53	0.57	0.62	0.65	0.68
75%	0.54	0.58	0.62	0.66	0.68	0.71
80%	0.60	0.63	0.66	0.70	0.72	0.74
85%	0.66	0.68	0.71	0.75	0.77	0.79
90%	0.73	0.75	0.77	0.80	0.82	0.83
95%	0.80	0.82	0.84	0.87	0.88	0.89
100%	0.89	0.90	0.92	0.94	0.95	0.96
	TYPE B NRCS HYDROLOGIC SOILS GROUP					
0%	0.02	0.08	0.15	0.25	0.30	0.35
5%	0.04	0.10	0.19	0.28	0.33	0.38
10%	0.06	0.14	0.22	0.31	0.36	0.40
15%	0.08	0.17	0.25	0.33	0.38	0.42
20%	0.12	0.20	0.27	0.35	0.40	0.44
25%	0.15	0.22	0.30	0.37	0.41	0.46
30%	0.18	0.25	0.32	0.39	0.43	0.47
35%	0.20	0.27	0.34	0.41	0.44	0.48
40%	0.23	0.30	0.36	0.42	0.46	0.50
45%	0.26	0.32	0.38	0.44	0.48	0.51
50%	0.29	0.35	0.40	0.46	0.49	0.52
55%	0.33	0.38	0.43	0.48	0.51	0.54
60%	0.37	0.41	0.46	0.51	0.54	0.56
65%	0.41	0.45	0.49	0.54	0.57	0.59
70%	0.45	0.49	0.53	0.58	0.60	0.62
75%	0.51	0.54	0.58	0.62	0.64	0.66
80%	0.57	0.59	0.63	0.66	0.68	0.70
85%	0.63	0.66	0.69	0.72	0.73	0.75
90%	0.71	0.73	0.75	0.78	0.80	0.81
95%	0.79	0.81	0.83	0.85	0.87	0.88
100%	0.89	0.90	0.92	0.94	0.95	0.96

TABLE RO-5 (Continued)—Runoff Coefficients, *C*

Percentage Imperviousness	Type A NRCS Hydrologic Soils Group					
	2-yr	5-yr	10-yr	25-yr	50-yr	100-yr
0%	0.00	0.00	0.05	0.12	0.16	0.20
5%	0.00	0.02	0.10	0.16	0.20	0.24
10%	0.00	0.06	0.14	0.20	0.24	0.28
15%	0.02	0.10	0.17	0.23	0.27	0.30
20%	0.06	0.13	0.20	0.26	0.30	0.33
25%	0.09	0.16	0.23	0.29	0.32	0.35
30%	0.13	0.19	0.25	0.31	0.34	0.37
35%	0.16	0.22	0.28	0.33	0.36	0.39
40%	0.19	0.25	0.30	0.35	0.38	0.41
45%	0.22	0.27	0.33	0.37	0.40	0.43
50%	0.25	0.30	0.35	0.40	0.42	0.45
55%	0.29	0.33	0.38	0.42	0.45	0.47
60%	0.33	0.37	0.41	0.45	0.47	0.50
65%	0.37	0.41	0.45	0.49	0.51	0.53
70%	0.42	0.45	0.49	0.53	0.54	0.56
75%	0.47	0.50	0.54	0.57	0.59	0.61
80%	0.54	0.56	0.60	0.63	0.64	0.66
85%	0.61	0.63	0.66	0.69	0.70	0.72
90%	0.69	0.71	0.73	0.76	0.77	0.79
95%	0.78	0.80	0.82	0.84	0.85	0.86
100%	0.89	0.90	0.92	0.94	0.95	0.96

APPENDIX F – Rational Formula-Based Modified FAA Procedure

3.2.3 Rational Formula-Based Modified FAA Procedure

The Rational Formula-based Federal Aviation Administration (FAA) (1966) detention sizing method (sometimes referred to as the "FAA Procedure"), as modified by Guo (1999a), provides a reasonable estimate of storage volume requirements for on-site detention facilities. Again, this method provides sizing for one level of peak control only and not for multi-stage control facilities.

The input required for this Rational Formula-based FAA volume calculation procedure includes:

A = the area of the catchment tributary to the storage facility (acres)

C = the runoff coefficient

Q_{po} = the calculated 5-year or 10-year historic runoff release rate from pond (cfs)

T_c = the time of concentration for the tributary catchment (see the RUNOFF chapter) (minutes)

P_1 = the 1-hour design rainfall depth (inches) at the site taken from the NOAA Atlas website using a site specific gage, for the relevant return frequency storms

The calculations are best set up in a tabular (spreadsheet) form with each 5-minute increment in duration being entered in rows and the following variables being entered, or calculated, in each column:

1. Storm Duration Time, *T* (minutes), up to 180 minutes.
2. Rainfall Intensity, *I* (inches per hour), calculated using Equation RA-3 from the RAINFALL chapter.
3. Inflow volume, V_i (cubic feet), calculated as the cumulative volume at the given storm duration using the equation:

$$V_i = CIA\left(60T\right) \qquad \text{(SO-6)}$$

4. Outflow adjustment factor *m* (Guo 1999a):

$$m = \frac{1}{2}\left(1 + \frac{T_c}{T}\right) \qquad 0.5 \le m \le 1 \text{ and } T \ge T_c \qquad \text{(SO-7)}$$

5. The calculated average outflow rate, Q_{av} (cfs), over the duration T:

$$Q_{av} = mQ_{po} \qquad \text{(SO-8)}$$

6. The calculated outflow volume, V_o, (cubic feet), during the given duration and the adjustment factor at that duration calculated using the equation:

$$V_o = Q_{av}\left(60T\right) \quad \text{(SO-9)}$$

7. The required storage volume, V_S (cubic feet), calculated using the equation:

$$V_s = V_i - V_o \quad \text{(SO-10)}$$

The value of V_s increases with time, reaches a maximum value, and then starts to decrease. The maximum value of V_s is the required storage volume for the detention facility. Sample calculations using this procedure are presented in Design Example 6.2. The modified *FAA Worksheet* of the UD-Detention Spreadsheet performs these calculations (download from Weld County website).

6.0 DESIGN EXAMPLES

6.2 Example—Rational Method Analysis

Use the FAA method to determine the required detention volume for the 100-year storm event for a 15-acre site that will have a developed percentage imperviousness of 45%. The NRCS soil survey shows the site has hydrologic soil group B soils. The allowable release rate from the basin has to be limited to the 10-year historic runoff value for the basin (based on a 2% imperviousness value). The time of concentration has been calculated at 12 minutes. The 100-year, 1-hour point precipitation is 2.6 inches.

A runoff coefficient, C, of 0.51 is determined using Table RO-5 of the RUNOFF chapter (the 45% row and 100-year storm column of the type B soils table equals 0.51). The calculations are shown in spreadsheet form UD-Detention workbook in Table SO-2.

Determination of Detention Volume Using Modified FAA Method

Rainfall durations must be entered in an increasing order.

Rainfall Duration minutes (input)	Rainfall Intensity inch/hr (output)	Inflow Volume cubic feet (output)	Adjustment Factor (output)	Average Outflow cfs (output)	Outflow Volume cubic feet (output)	Storage Volume cubic feet (output)
0.00	12.02	0				
5.00	8.72	20,021	1.00	12.75	3,825	16,196
10.00	6.95	31,902	1.00	12.75	7,650	24,252
15.00	5.83	40,119	0.90	11.48	10,328	29,791
20.00	5.05	46,316	0.80	10.20	12,240	34,076
25.00	4.47	51,257	0.74	9.44	14,153	37,105
30.00	4.02	55,351	0.70	8.93	16,065	39,286
35.00	3.66	58,838	0.67	8.56	17,978	40,861
40.00	3.37	61,873	0.65	8.29	19,890	41,983
45.00	3.13	64,559	0.63	8.08	21,803	42,757
50.00	2.92	66,967	0.62	7.91	23,715	43,252
55.00	2.74	69,150	0.61	7.77	25,628	43,522
60.00	2.58	71,147	0.60	7.65	27,540	43,607
65.00	2.45	72,987	0.59	7.55	29,453	43,535
70.00	2.32	74,694	0.59	7.47	31,365	43,329
75.00	2.22	76,287	0.58	7.40	33,278	43,010
80.00	2.12	77,780	0.58	7.33	35,190	42,590
85.00	2.03	79,186	0.57	7.28	37,103	42,083
90.00	1.95	80,514	0.57	7.23	39,015	41,499
95.00	1.88	81,774	0.56	7.18	40,928	40,846
100.00	1.81	82,972	0.56	7.14	42,840	40,132
105.00	1.75	84,114	0.56	7.10	44,753	39,362
110.00	1.69	85,206	0.55	7.07	46,665	38,541
115.00	1.63	86,252	0.55	7.04	48,578	37,675
120.00	1.58	87,256	0.55	7.01	50,490	36,766
125.00	1.54	88,222	0.55	6.99	52,403	35,820
130.00	1.49	89,152	0.55	6.96	54,315	34,837
135.00	1.45	90,050	0.54	6.94	56,228	33,823
140.00	1.41	90,917	0.54	6.92	58,140	32,777
145.00	1.38	91,757	0.54	6.90	60,053	31,704
150.00	1.34	92,569	0.54	6.89	61,965	30,604
155.00	1.31	93,358	0.54	6.87	63,878	29,480
160.00	1.28	94,123	0.54	6.85	65,790	28,333
165.00	1.25	94,867	0.54	6.84	67,703	27,164
170.00	1.23	95,590	0.54	6.83	69,615	25,975
175.00	1.20	96,295	0.53	6.81	71,528	24,767
180.00	1.17	96,981	0.53	6.80	73,440	23,541

Stormwater Detention Volume (Cubic Feet) = **43,607**

The required storage volume is 43,607 cubic feet (approx. 1.0 acre-foot).

APPENDIX G – Grading Permit Checklist

Grading Permit Checklist

Project Name:

The purpose of this checklist is to assist the applicant's Engineer in developing a plan to prevent offsite discharge of sediment during active construction and to support the intent of the Weld County Code.

Is the project in the **MS4**? ☐ Yes ☐ No

If yes, the following requirements in blue apply. See Chapter 8, Article IX of the Weld County Code.

Grading Permit Requirements

- ☐ Weld County Grading Permit Application
- ☐ Grading & Drainage Plan
- ☐ Sediment & Erosion Control Plan
- ☐ Utility Map (per SUE/811 Law Level B, SB18-167)

General Requirements for Plans

The following items are required both the Grading Plan and Sediment & Erosion Control Plan:

- ☐ Scanned electronic (pdf) or 11" x 17" hard copy
- ☐ Signed and stamped by Colorado PE
- ☐ Engineering scale & north arrow
- ☐ Weld County case number, if applicable
- ☐ Property lines, rights-of-way and easements
- ☐ Limits of disturbance (include acreage) and temporary construction easements/agreements, if applicable

Grading Plans

The following items are required for Grading Plans in addition to the general requirements above:

- ☐ Existing and Proposed Grading (1' annotated contours)
- ☐ Arrows depicting flow direction and grade flow
- ☐ Locations and design details for proposed drainage improvements (pond, culverts, swales, spillway, trickle channel, outlet, etc.) – Include finish grade, flowline, invert and crown elevations as applicable.
- ☐ Onsite or adjacent springs, streams, wetlands and/or other surface waters, including irrigation ditches
- ☐ Vicinity Map with the drainage route to the nearest receiving water
- ☐ Notes on the major phases of construction
- ☐ Final stabilization (pavement, gravel, >70% vegetative growth, etc.)

Sediment & Erosion Control Plans

The following items are required for Sediment & Erosion Control Plans in addition to the general requirements above:

- ☐ Provide an Interim Construction Plans and Final Construction Plans clearly depicting, describing and locating all temporary control measures to be implemented.
- ☐ Include installation and implementation specifications (BMP details) for structural control measures (silt fence, straw wattles, vehicle tracking control, etc.), including maintenance and removal notes.
- ☐ Provide a narrative description of non-structural control measures (preservation of vegetation, traffic control, surface roughening, street sweeping, etc.).
- ☐ Clearly depict, describe and locate all permanent stabilization methods to be implemented.
- ☐ Include installation and implementation specifications for final stabilization methods (seed, crimped mulch, soil amendment, soil retention blanket, turf reinforcement mat, etc.).

Other Required Documents (If Applicable)

- ☐ MS4 Pollution Prevention Plan Checklist for sites located within the MS4 area
- ☐ Weld County Access Permit
- ☐ Weld County Right-of-Way Permit
- ☐ Weld County Early Release Request for Grading Permits (Land Use cases must be conditionally approved by BOCC, Planning Director or designee.)
- ☐ CDPS Permit for Construction Stormwater Discharges (COR400000)
- ☐ CDPS Permit for Construction Dewatering Discharges (COG070000)
- ☐ USACE Section 404 Permit for Dredge/Fill in WOTUS

1.
2. Once the revised Grading Plan and/or Sediment & Erosion Control Plan (with responses) have been submitted, the County may provide additional comments.
3. Please provide a written response on how the above comments have been addressed when resubmitting. Thank-you.

APPENDIX H – MS4 Pollution Prevention Plan Checklist and Manual

MS4 Pollution Prevention Plan Checklist

Site Name or Case No: _____

Complete the table below and submit with the Grading Permit application. At a minimum, items in **red** are required to be included in the Grading Plans or Sediment & Erosion Control Plans. Mark other applicable items with a check mark. Items not listed below may be added to "Other Control Measures", which will be reviewed and accepted on a case-by-case basis.

Temporary Control Measures	✓ If applicable to the site	If applicable to the site, include the following:	
		Narratives *(Pages located in Part I)*	Details *(Pages located in Part II)*
Sediment and Erosion Control Measures:			
SC-1: Silt Fence (SF)	✓	SF-1 to SF-2	SF-3 to SF-4
SC-2: Sediment Control Log (SCL)	✓	SCL-1 to SCL-2	SCL-3 to SCL-5
SC-3: Straw Bale Barrier (SBB)		SBB-1	SBB-2 to SBB-3
SC-5: Rock Sock (RS)		RS-1	RS-2 to RS-3
SC-6: Inlet Protection (IP)		IP-1 to IP-3	IP-4 to IP-8
EC-8: Temporary Outlet Protection (TOP)		TOP-1	TOP-2 to TOP3
EC-12: Check Dams (CD)		CD-1 to CD-2	CD-3 to CD-6
Materials and Site Management:			
MM-1: Concrete Washout Area (CWA)	✓	CWA-1 to CWA-2	CWA-3 to CWA-4
MM-2: Stockpile Management (SP)	✓	SP-1 to SP-2	SP-3 to SP-6
MM-3: Good Housekeeping Practices (GH)	✓	GH-1 to GH-6	N/A
SM-4: Vehicle Tracking Control (VTC)	✓	VTC-1 to VTC-2	VTC-3 to VTC-6
SM-6: Stabilized Staging Area (SSA)	✓	SSA-1 to SSA-2	SSA-3 to SSA-4
SM-7: Street Sweeping and Vacuuming (SS)	✓	SS-1	N/A
SM-9: Dewatering Operations (DW) *If no dewatering is anticipated, include a statement in the notes.*		DW-1 to DW-2	DW-3 to DW-5
SM-11: Temporary Batch Plant (TBP) *If no temporary batch plants are associated with the site, include a statement in the notes.*		TBP-1 to TBP-2	N/A
EC-14: Wind Erosion/Dust Control (DC)	✓	DC-1	N/A
Site Stabilization:			
EC-1: Surface Roughening (SR)	✓	SR-1 to SR-2	SR-3 to SR-4
EC-2: Temporary/Permanent Seeding (TS/PS)	✓	TS/PS-1 to TS/PS-2	N/A
Weld County Guidance for Reseeding	✓	WC Reseeding Tips and Seed Mixes	N/A
EC-4: Mulching (MU)	✓	MU-1 to MU-2	N/A
EC-6: Rolled Erosion Control Products (RECP)		RECP-1 to RECP-5	RECP-6 to RECP-9
Other Control Measures (i.e. proprietary products):			

APPENDIX I – Traffic Impact Study Checklist

Traffic Impact Study Checklist

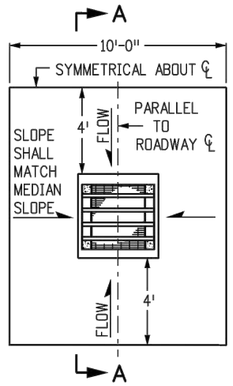
Project Name:

If a Traffic Impact Study is determined to be required, this checklist is intended to assist the applicant's engineer with developing a Traffic Impact Study that supports the intent of the Weld County Code using commonly accepted engineering practices and methodologies.

Traffic Impact Study Report Content

- ☐ Weld County Case Number
- ☐ Signed and stamped by a Colorado licensed PE
- ☐ Project Location and Traffic Impact Area Map
- ☐ Location Map, including existing and proposed roadway network and intersections
- ☐ Site description
- ☐ Existing and proposed land uses in vicinity of site
- ☐ Existing traffic conditions, including:
  - ☐ Daily traffic volumes (counts conducted over 72 hours and within the previous 24 months)
  - ☐ Intersection turning movement counts (AM/PM peak hour) (minimum of 2 hours per peak period and collected within the previous 12 months)
  - ☐ Roadway classification
  - ☐ Roadway characteristics and auxiliary lanes
  - ☐ Access points and traffic control devices
- ☐ Background traffic projections for Short-Range and Long-Range Scenarios, including growth rate used
- ☐ Trip Generation (ITE or site-specific) and proposed truck percentages
- ☐ Vehicle types
- ☐ Trip distribution (proposed)
- ☐ Total proposed volumes for short-range (project opening) and long-range analysis years
- ☐ Operational analysis for existing year, short-term horizon with project traffic, and long-term horizon with and without project traffic along mainline roadways and existing and proposed intersections.
- ☐ Existing and background operational and geometric deficiencies
- ☐ Identify deficiencies, including pedestrian/bicycle connections
- ☐ Identify any structurally or capacity deficient roads, intersections, or bridges within the study area or along a proposed haul route
- ☐ Appropriateness of existing and proposed access locations compared to the required access spacing in the Weld County Code
- ☐ Is a CDOT Access Permit required?
- ☐ Signal warrant analysis (if proposed)
- ☐ Identify need for auxiliary lanes (right/left turn lanes), including storage capacity and length based on County guidelines and *State Highway Access Code* requirements for Rural Highways (Classification R-B)
- ☐ Sight distance analysis at access points
- ☐ Safety analysis based on crash history (if requested by County)
- ☐ Paving threshold analysis
- ☐ Tracking control measures
- ☐ Are parking needs for development met?
- ☐ Identify safe route to school and/or school bus stops
- ☐ Identify accessibility to public transit
- ☐ Proposed haul route (if applicable)
- ☐ Identify proposed mitigation and recommendations
- ☐ Summary of findings
- ☐ Include any assumptions and adjustment factors
- ☐ Any additional information necessary for special considerations

APPENDIX J – Weld County Standard Details

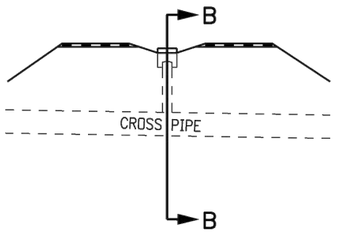


INLET WITH DITCH PAVING

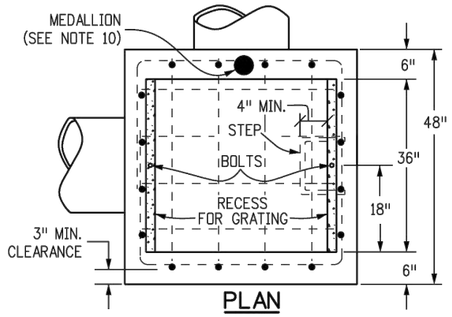
STEEL GRATE QUANTITIES

NO. PIECES	DESCRIPTION	LENGTH	LBS PER FT.	WEIGHT (LBS.)
4	S4 x 7.7 BEAM	41"	7.90	106
2	3½" x ¼" FLAT	26⅝"	2.98	13
2	3" x ¼" FLAT	26⅝"	2.55	12

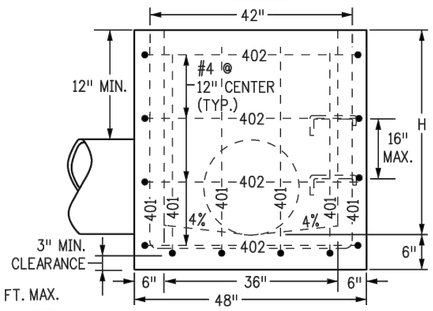
TOTAL LBS. - 131



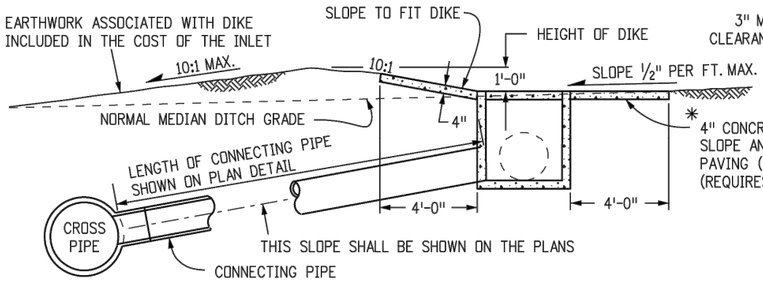
SECTION VIEW



PLAN



ELEVATION CONCRETE INLET

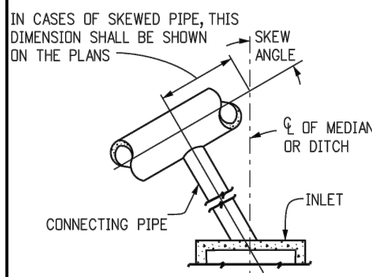


SECTION B-B

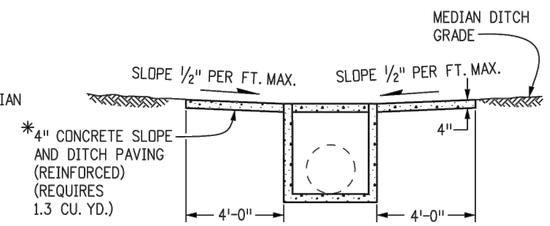
INLET CONNECTED TO A CROSS PIPE

SECTION A-A

INLET ON GRADE (FLOW FROM ONE DIRECTION)



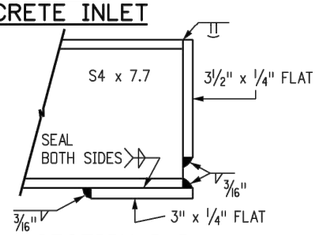
INLET CONNECTED TO A SKEWED CROSS PIPE



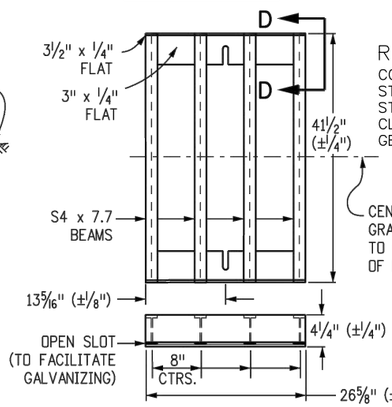
SECTION A-A

*CONCRETE SLOPE AND DITCH PAVING WILL BE REQUIRED WHEN SHOWN ON THE PLANS.

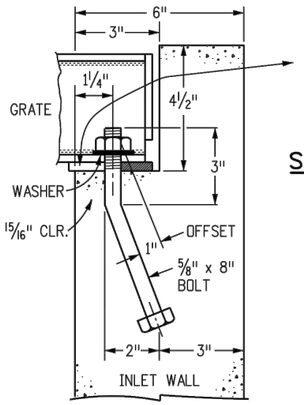
INLET AT BOTTOM OF VERTICAL CURVE (FLOW FROM TWO DIRECTIONS)



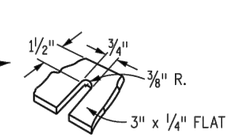
SECTION D-D



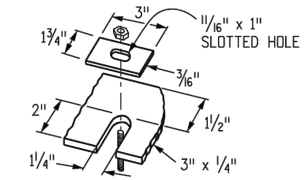
STANDARD INLET GRATE



GRATE INSTALLATION DETAIL



SLOT DETAIL



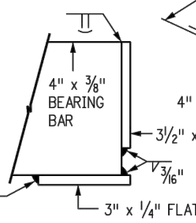
ALTERNATE SLOT AND HOLD DOWN PLATE DETAIL

GENERAL NOTES

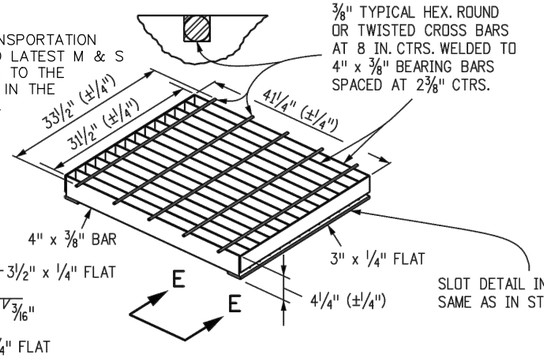
1. INLET TYPE C IS NOT HS-20 RATED AND SHALL NOT BE PLACED IN PAVED ROADWAYS. THIS INLET SHALL BE USED ONLY OUTSIDE PAVED ROADWAYS.
2. CONCRETE SHALL BE CLASS D. INLET MAY BE CAST-IN-PLACE OR PRECAST.
3. REINFORCING BARS SHALL BE GRADE 60, EPOXY COATED, AND DEFORMED #4, AND SHALL HAVE A MIN. 2 INCH CLEARANCE. CUT OR BEND AROUND PIPES AS REQUIRED.
4. CONCRETE SLOPE AND DITCH PAVING SHALL BE IN ACCORDANCE WITH SECTION 507. REINFORCEMENT FOR CONCRETE SLOPE PAVING SHALL BE 6 X 6 - W1.4 X W1.4 OR 6 X 6 - W2.1 X W2.1.
5. STRUCTURAL STEEL FOR GRATES AND GRATE INSTALLATION HARDWARE SHALL BE GALVANIZED, AND SHALL BE IN ACCORDANCE WITH SUBSECTION 712.06.
6. THE STANDARD INLET GRATES SHALL BE USED ON ALL TYPE C INLETS UNLESS CLOSE MESH INLET GRATES ARE SPECIFIED ON THE PLANS.
7. CLOSE MESH GRATES ARE RECOMMENDED WHERE FOOT TRAFFIC OR BICYCLE ROUTES ARE IN CLOSE PROXIMITY TO GRATE. THIS GRATE IS NOT ADA COMPLIANT OR BI FRIENDLY AND SHALL NOT BE PLACED DIRECTLY IN SIDEWALKS, CROSSWALKS OF
8. STEPS SHALL BE PROVIDED WHEN INLET DIMENSION "H" IS EQUAL TO OR GREAT THAN 3 FEET - 6 INCHES AND SHALL CONFORM TO AASHTO M 199.
9. SEE STANDARD PLAN M-604-11, FOR REINFORCEMENT AROUND THE PIPE OPENING.
10. ALL INLETS SHALL HAVE A 4 INCH DIA. METAL MEDALLION WITH A "NO DUMPING MESSAGE ON IT. THE MEDALLION SHALL HAVE A FISH SYMBOL WITH A BLUE BAC IT SHALL BE FIRMLY ATTACHED TO THE TOP OF THE INLET WITH A PERMANENT

REFERENCE:

COLORADO DEPARTMENT OF TRANSPORTATION STANDARD M-604-10. REFER TO LATEST M & S STANDARDS, WITH MODIFICATIONS TO THE CLASS OF CONCRETE AS SHOWN IN THE GENERAL NOTES ON THIS DETAIL.



SECTION E-E



CLOSE MESH INLET GRATE

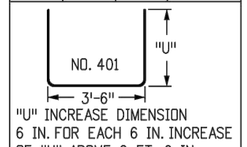
QUANTITIES FOR ONE INLET

H ▼	CONCRETE (CU. YDS.) ▼	STEEL (LBS.) ▼	NO. STEPS REQ'D.
2'-6"	1.0	76	0
3'-0"	1.1	81	0
3'-6"	1.2	97	0
4'-0"	1.3	102	1
4'-6"	1.5	117	2
5'-0"	1.6	123	2
5'-6"	1.7	138	2
6'-0"	1.9	143	3
6'-6"	2.0	159	3
7'-0"	2.1	164	3
7'-6"	2.2	180	4
8'-0"	2.4	185	4
8'-6"	2.5	200	4
9'-0"	2.6	206	5
9'-6"	2.8	221	5
10'-0"	2.9	236	6
11'-6"	3.3	252	6

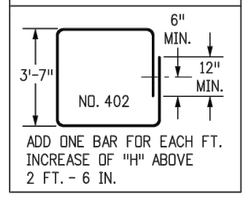
▼ PIPE INSIDE DIAMETER SHALL BE 30 IN. OR LESS. CONCRETE AND STEEL QUANTITIES ARE FOR ONE ENTIRE INLET BEFORE DEDUCTION FOR VOLUME OCCUPIED BY PIPE. WEIGHT OF STEEL INCLUDES A RING FOR THE MAXIMUM PIPE DIAMETER.

BAR LIST FOR H = 2 FT.-6 IN. AND BENDING DIAGRAM

MARK	NO. REQ'D.	HEIGHT	LENGTH
401	2	2'-2½"	8'-0"
401	6	2'-7"	8'-8"
402	4	"U"	15'-4"



"U" INCREASE DIMENSION 6 IN. FOR EACH 6 IN. INCREASE OF "H" ABOVE 2 FT.-6 IN.

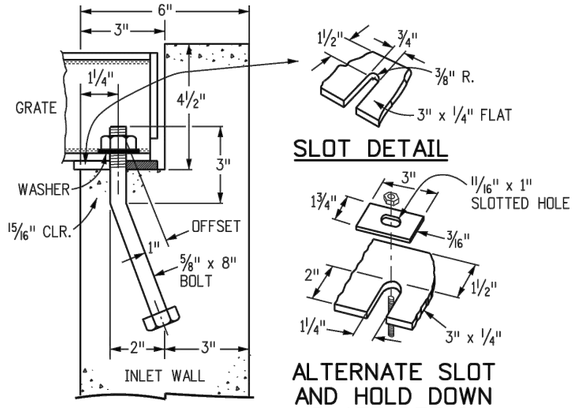


ADD ONE BAR FOR EACH FT. INCREASE OF "H" ABOVE 2 FT. - 6 IN.

402 BARS SHALL BE EQUALLY SPACED FROM EACH OTHER.

Know what's **below.** **Call** before you dig.

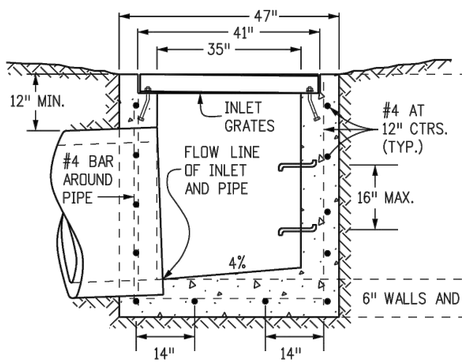
Computer File Information		Index of Revisions			WELD COUNTY	As Constructed	INLET, TYPE C		Project No./Code
Creation Date: 07/31/2019		Date:	Comments:	Initials:	PUBLIC WORKS DEPARTMENT 1111 H. STREET P.O. BOX 758 GREELEY, CO 80632-0758 PHONE: (970) 356-4000 FAX: (970) 304-6497	No Revisions:			
Last Modified Date: 07/31/2019						Revised:	Designer: CDOT		
Full Path:							Detailer: CDOT		
Drawing File Name:						Void:	Sheet Subset:	Sheet Subset: 1 of 1	Sheet Number of
AutoCAD Version: 2018 Scale: AS NOTED Units: English									



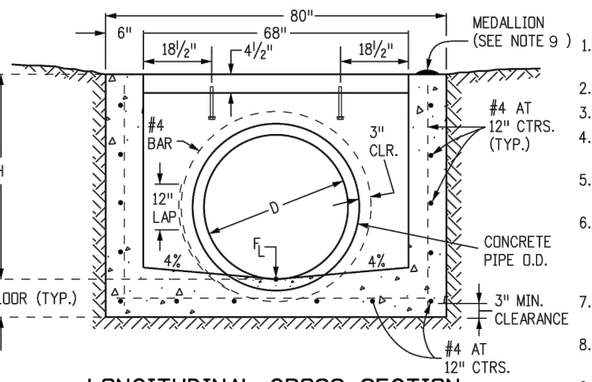
SLOT DETAIL

ALTERNATE SLOT AND HOLD DOWN PLATE DETAIL

GRATE INSTALLATION DETAIL



TRANSVERSE CROSS SECTION

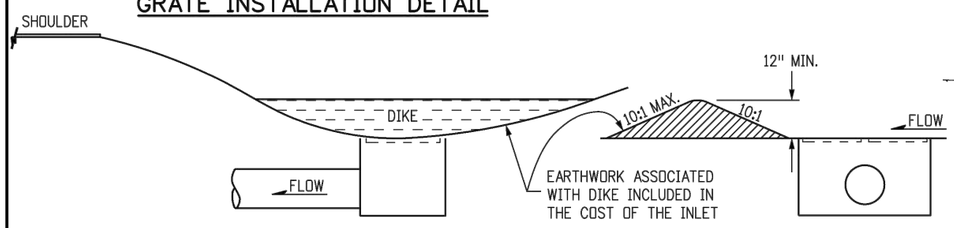


LONGITUDINAL CROSS SECTION

LEVEL GRATE INSTALLATION

GENERAL NOTES

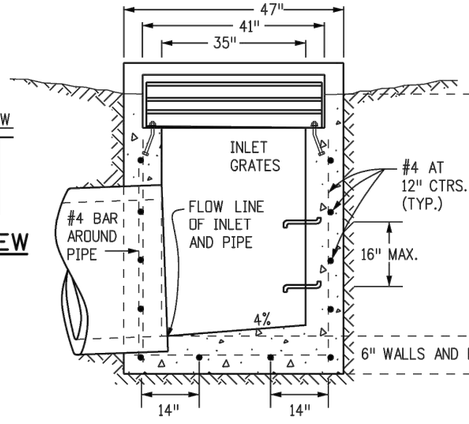
1. INLET TYPE D IS NOT HS-20 RATED AND SHALL NOT BE PLACED IN PAVED ROADWAYS. THIS INLET SHALL BE USED ONLY OUTSIDE PAVED ROADWAYS.
2. CONCRETE SHALL BE CLASS D. INLET MAY BE CAST-IN-PLACE OR PRECAST.
3. SEE PLANS FOR SIZE AND LOCATION OF PIPE.
4. STRUCTURAL STEEL FOR GRATES AND GRATE INSTALLATION HARDWARE SHALL BE GALVANIZED AND SHALL BE IN ACCORDANCE WITH SUBSECTION 712.06.
5. STANDARD INLET GRATES SHALL BE USED ON ALL TYPE D INLETS UNLESS CLOSE MESH GRATES ARE SPECIFIED ON THE PLANS.
6. CLOSE MESH GRATES ARE RECOMMENDED WHERE FOOT TRAFFIC OR BICYCLE ROUTES ARE IN CLOSE PROXIMITY TO GRATE. THIS GRATE IS NOT ADA COMPLIANT OR BICYCLE FRIENDLY AND SHALL NOT BE PLACED DIRECTLY IN SIDEWALKS, CROSSWALKS OR BIKE PATHS.
7. STEPS SHALL BE PROVIDED WHEN INLET DIMENSION "H" IS EQUAL TO OR GREATER THAN 3 FEET-6 INCHES AND SHALL CONFORM WITH AASHTO M 199.
8. REINFORCING BARS SHALL BE GRADE 60, EPOXY COATED, AND DEFORMED #4, AND SHALL HAVE A 2 INCH MIN. CLEARANCE. CUT OR BEND BARS AROUND PIPE AS REQUIRED.
9. ALL INLETS SHALL HAVE A 4 INCH DIA. METAL MEDALLION WITH A "NO DUMPING DRAINS TO STREAM" MESSAGE ON IT. THE MEDALLION SHALL HAVE A FISH SYMBOL WITH A BLUE BACKGROUND. IT SHALL BE FIRMLY ATTACHED TO THE INLET'S SURFACE WITH A PERMANENT FASTENER.



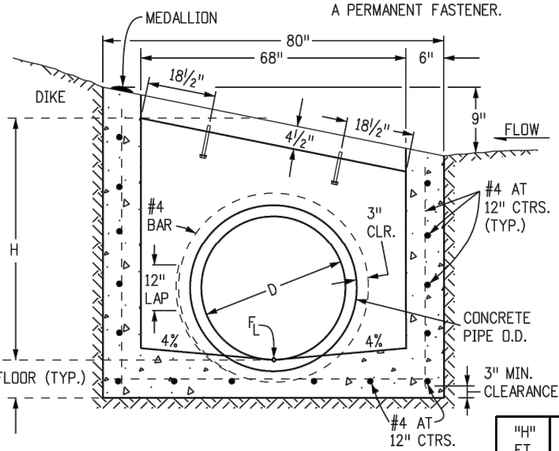
TRANSVERSE VIEW

LONGITUDINAL VIEW

DIKE

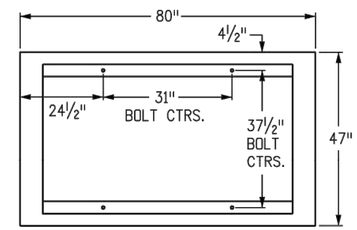


TRANSVERSE CROSS SECTION

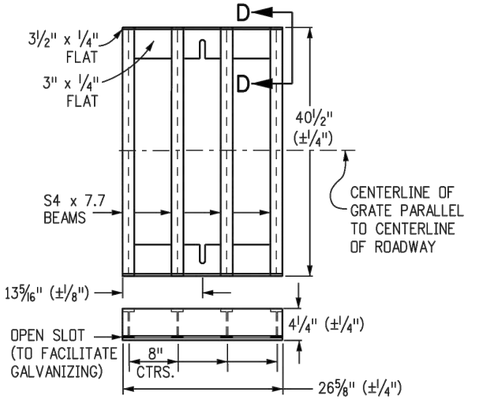


LONGITUDINAL CROSS SECTION

SLOPING GRATE INSTALLATION



PLAN VIEW
(SHOWING ANCHOR BOLT LAYOUT)

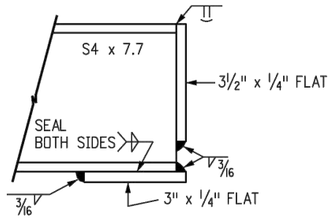


STANDARD INLET GRATE

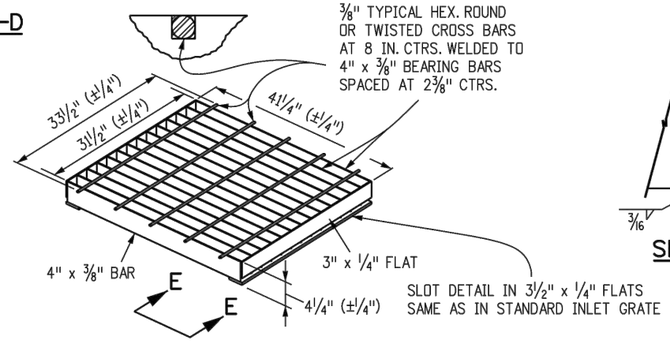
TWO STEEL GRATE PER INLET QUANTITIES

NO. PIECES	DESCRIPTION	LENGTH	LBS PER FT.	WEIGHT (LBS.)
8	S4 x 7.7 BEAM	40"	7.70	206
4	3½" x ¼" FLAT	26⅝"	2.98	26
4	3" x ¼" FLAT	26⅝"	2.55	24

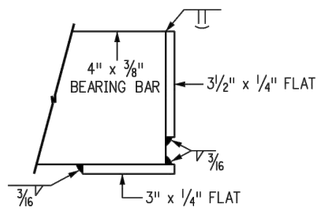
TOTAL LBS. - 256



SECTION D-D



CLOSE MESH GRATE



SECTION E-E

OUTLET PIPE INSIDE DIA. FT. - "D"	MIN. "H" FT.
1.5	3.0
2.0	3.5
2.5	4.0
3.0	4.5
3.5	5.0

REFERENCE:
COLORADO DEPARTMENT OF TRANSPORTATION STANDARD M-604-11. REFER TO LATEST M & S STANDARDS, WITH MODIFICATIONS TO THE CLASS OF CONCRETE AS SHOWN IN THE GENERAL NOTES ON THIS DETAIL.

"H" FT.	CONCRETE CU. YDS.	STEEL LBS.	CIRCULAR PIPE RANGE INSIDE DIA., IN. - "D"
3.0	1.5	127	18
3.5	1.7	149	18-24
4.0	1.9	157	18-30
4.5	2.0	179	18-36
5.0	2.2	187	18-42
5.5	2.4	208	18-42
6.0	2.6	215	18-42
6.5	2.8	236	18-42
7.0	2.9	243	18-42
7.5	3.1	264	18-42
8.0	3.3	271	18-42
8.5	3.5	292	18-42
9.0	3.6	299	18-42
9.5	3.8	320	18-42
10.0	4.0	327	18-42

▼ CONCRETE AND STEEL QUANTITIES ARE FOR ONE ENTIRE INLET BEFORE DEDUCTION FOR VOLUME OCCUPIED BY PIPE. WEIGHT OF STEEL INCLUDES A RING FOR THE MAXIMUM PIPE DIAMETER.

QUANTITIES FOR ONE INLET

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INLET, TYPE D

Designer: CDOT

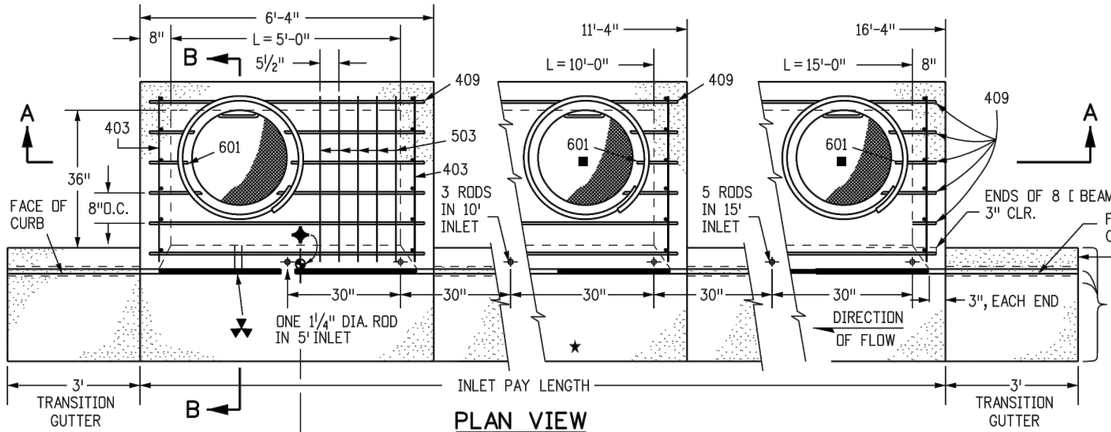
Detailer: CDOT

Sheet Subset:

Sheet Subset: 1 of 1

Project No./Code

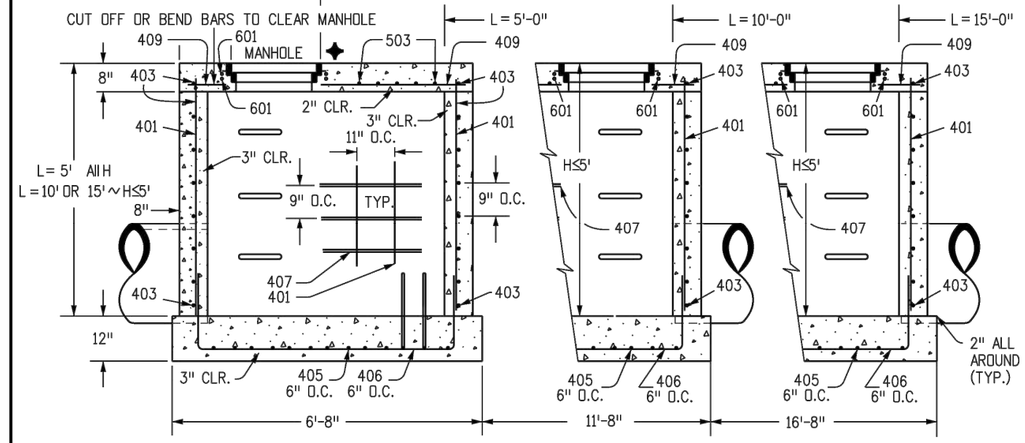
Sheet Number of



PLAN VIEW

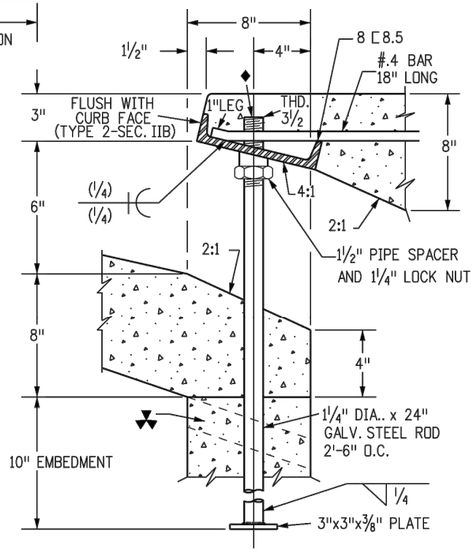
★ FOR LENGTH (L) 10 FT. OR MORE, PROVIDE MAINTENANCE ACCESS AT BOTH ENDS WITH AN ADDITIONAL MANHOLE RING AND COVER. CUT REINFORCEMENT BAR ACCORDINGLY.

✦ STATION POINT AT MIDPOINT OF INLET ALONG FLOWLINE



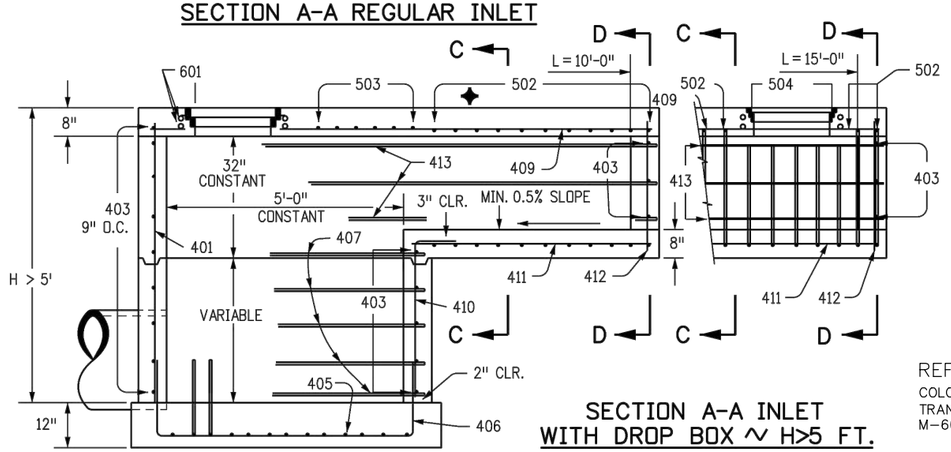
SECTION A-A REGULAR INLET

SEE CHANNEL LAYOUT ON SHEET 2.

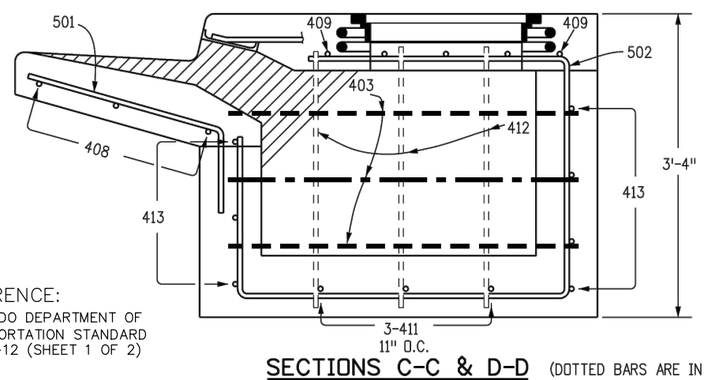


CURB FACE ASSEMBLY

◆ PLACE ENTIRE ASSEMBLY BEFORE POURING CONCRETE.

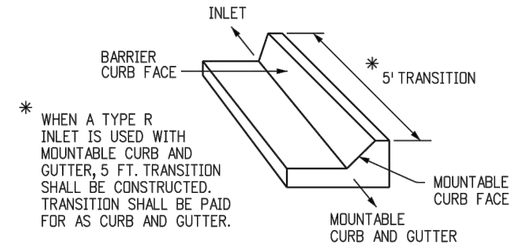


SECTION A-A INLET WITH DROP BOX ~ H>5 FT.



SECTIONS C-C & D-D (DOTTED BARS ARE IN SECTION D-D)

REFERENCE:
COLORADO DEPARTMENT OF TRANSPORTATION STANDARD M-604-12 (SHEET 1 OF 2)



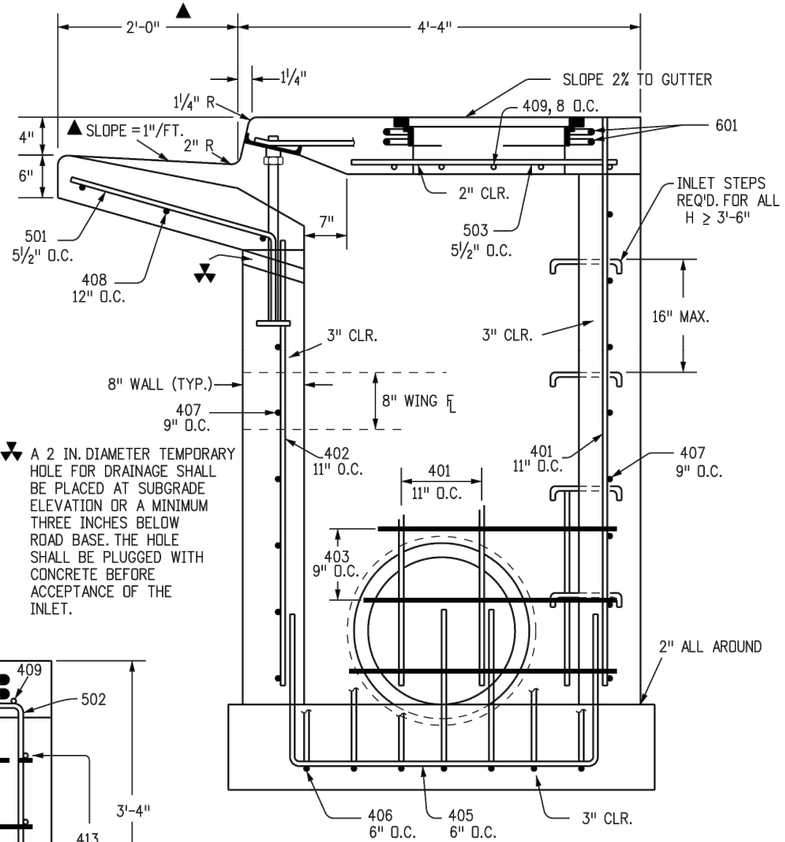
✱ WHEN A TYPE R INLET IS USED WITH MOUNTABLE CURB AND GUTTER, 5 FT. TRANSITION SHALL BE CONSTRUCTED. TRANSITION SHALL BE PAID FOR AS CURB AND GUTTER.

TRANSITION CURB

GENERAL NOTES:

SEE SHEET 2.

▲ - FOR A 1'-0" PAN SLOPE 2" PER FT.



SECTION B-B END VIEW

✱✱ A 2 IN. DIAMETER TEMPORARY HOLE FOR DRAINAGE SHALL BE PLACED AT SUBGRADE ELEVATION OR A MINIMUM THREE INCHES BELOW ROAD BASE. THE HOLE SHALL BE PLUGGED WITH CONCRETE BEFORE ACCEPTANCE OF THE INLET.

NOTE: MANHOLE RING AND COVER, STATION POINT AND OUTFLOW PIPE SHALL BE LOCATED AT THE SAME END OF THE INLET.

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CURB INLET TYPE R

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Sheet Subset: 1 of 2

Project No./Code

Sheet Number of

MARK	BAR # OR SIZE	D.C. SPACING	TYPE	ALL INLETS L = 5 FT. NO. REQ'D.	ALL INLETS L = 5 FT. LENGTH	INLETS: H ≤ 5 FT. L = 10 FT. NO. REQ'D.	INLETS: H ≤ 5 FT. L = 10 FT. LENGTH	INLETS: H ≤ 5 FT. L = 15 FT. NO. REQ'D.	INLETS: H ≤ 5 FT. L = 15 FT. LENGTH	INLETS: H > 5 FT. L = 10 FT. NO. REQ'D.	INLETS: H > 5 FT. L = 10 FT. LENGTH	INLETS: H > 5 FT. L = 15 FT. NO. REQ'D.	INLETS: H > 5 FT. L = 15 FT. LENGTH
401	4	11"	II	15	*	21	*	26	*	11	*	11	*
402	4	11"	II	7	*	13	*	18	*	7	*	7	*
403	4	9"	II	*	4'-0"	*	4'-0"	*	4'-0"	*	4'-0"	*	4'-0"
405	4	6"	VI	11	6'-10"	21	6'-10"	31	6'-10"	11	6'-10"	11	6'-10"
406	4	6"	VIII	7	8'-10"	7	13'-10"	7	18'-10"	7	8'-10"	7	8'-10"
407	4	9"	II	*	5'-10"	*	10'-10"	*	15'-10"	*	5'-10"	*	5'-10"
408	4	12"	II	3	6'-10"	3	11'-10"	3	16'-0"	3	11'-10"	3	16'-0"
409	4	8"	II	6	5'-10"	6	10'-10"	6	15'-10"	6	10'-10"	6	15'-10"
410	4	11"	VII							3		3	*
411	4	11"	II							3	5'-2"	3	10-2"
412	4	11"	II							3	2'-9"	3	2'-9"
413	4	9"	II							7	10'-10"	7	15'-10"
501	5	5½"	IV	11	3'-4"	22	3'-4"	33	3'-4"	22	3'-4"	33	3'-4"
502	5	5½"	III							11	11'-5"	17	11'-5"
503	5	5½"	II	5	3'-6"	16	3'-6"	27	3'-6"	6	3'-6"	6	3'-6"
504	5	5½"	IX									5	8'-4"
601	6	2½"	V	2	8'-10"	2	8'-10"	2	8'-10"	2	8'-10"	4	8'-10"
■8[8.5				1	5'-10"	1	10'-10"	1	15'-10"	1	10'-10"	1	15'-10"
				2 BARS, 1 RODS	——	4 BARS, 3 RODS	——	8 BARS, 5 RODS	——	4 BARS, 3 RODS	——	8 BARS, 5 RODS	——

* VARIABLE REFER TO TABLE TWO.

■ INCLUDE #4, 18 IN. BARS (SEE CHANNEL LAYOUT).

REGULAR INLETS

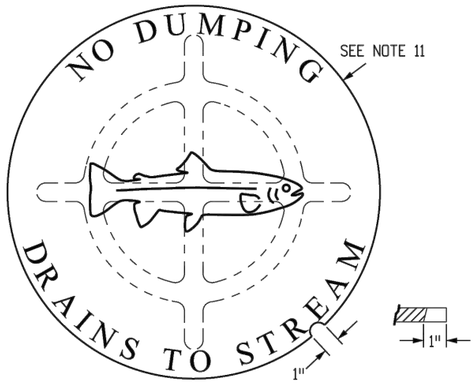
DROP BOX INLETS

TABLE ONE ~ BAR LIST FOR CURB INLETS, TYPE "R"

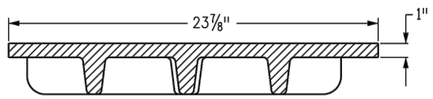
"H"	LENGTH 401	LENGTH 402	LENGTH 410	NO. REQ'D. REGULAR 403	NO. REQ'D. REGULAR 407	NO. REQ'D. DROP BOX 403	NO. REQ'D. DROP BOX 407	L = 5 FT. CONC. CU. YDS.	L = 5 FT. STEEL LBS.	L = 10 FT. CONC. CU. YDS.	L = 10 FT. STEEL LBS.	L = 15 FT. CONC. CU. YDS.	L = 15 FT. STEEL LBS.
3'-0"	2'-8"	1'-8"		10	7			3.2	285	5.3	497	7.4	706
3'-6"	3'-2"	2'-2"		10	7			3.4	305	5.7	528	7.9	747
4'-0"	3'-8"	2'-8"		12	9			3.7	326	6.0	559	8.4	786
4'-6"	4'-2"	3'-2"		12	9			3.9	334	6.4	571	8.8	803
5'-0"	4'-8"	3'-8"		14	11			4.1	354	6.7	602	9.3	844
5'-6"	5'-2"	4'-2"	3'-5"	16	13	15	6	4.4	375	6.0	607	7.4	850
6'-0"	5'-8"	4'-8"	3'-11"	16	13	16	6	4.6	382	6.2	616	7.6	860
6'-6"	6'-2"	5'-2"	4'-5"	18	15	18	8	4.8	402	6.4	637	7.8	880
7'-0"	6'-8"	5'-8"	4'-11"	20	17	19	10	5.0	423	6.6	654	8.0	897
7'-6"	7'-2"	6-2"	5'-5"	20	17	20	10	5.3	430	6.9	664	8.3	907
8'-0"	7'-8"	6'-8"	5'-11"	22	19	22	12	5.5	451	7.1	684	8.5	927
8'-6"	8'-2"	7'-2"	6'-5"	24	21	23	14	5.7	471	7.3	702	8.7	944
9'-0"	8'-8"	7'-8"	6'-11"	24	21	24	14	6.0	479	7.6	711	9.0	954
9'-6"	9'-2"	8'-2"	7'-5"	26	23	26	16	6.2	499	7.8	732	9.2	974
10'-0"	9'-8"	8'-8"	7'-11"	28	25	27	18	6.4	520	8.0	749	9.4	992
10'-6"	10'-2"	9'-2"	8'-5"	28	25	28	18	6.7	527	8.3	759	9.7	1001
11'-0"	10'-8"	9'-8"	8'-11"	30	27	30	20	6.9	547	8.5	779	9.9	1022

NOTES: FOR L = 5 FT., L = 10 FT., AND L = 15 FT.
REGULAR INLETS: TOTAL QUANTITIES NEEDED ARE OUTSIDE THE HEAVY BLACK LINE.
DROP BOX INLETS: TOTAL QUANTITIES NEEDED ARE INSIDE THE HEAVY BLACK LINE.
STEEL WEIGHTS DO NOT INCLUDE STRUCTURAL STEEL CHANNEL.

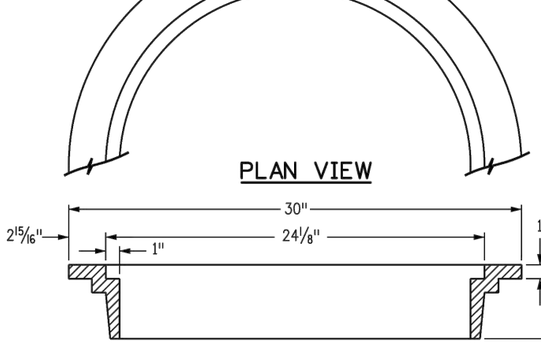
TABLE TWO ~ BARS AND QUANTITIES VARIABLE WITH "H"



PLAN VIEW



ELEVATION VIEW
MANHOLE COVER (TYP.)



PLAN VIEW

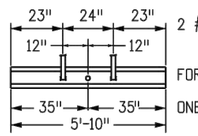
ELEVATION VIEW
MANHOLE RING (TYP.)

WEIGHTS: COVER = 125 LBS.
+ RING = 135 LBS.
TOTAL = 260 LBS.

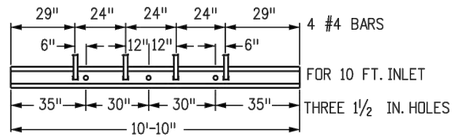
GENERAL NOTES

1. CONCRETE SHALL BE CLASS D. INLET MAY BE CAST-IN-PLACE OR PRECAST.
2. CONCRETE WALLS SHALL BE FORMED ON BOTH SIDES AND SHALL BE 8 INCHES THICK.
3. INLET STEPS SHALL BE IN CONFORMANCE WITH AASHTO M 199.
4. CURB FACE ASSEMBLY SHALL BE GALVANIZED AFTER WELDING.
5. EXPOSED CONCRETE CORNERS SHALL BE CHAMFERED ¾ OF A INCH. CURB AND GUTTER CORNERS SHALL BE FINISHED TO MATCH THE EXISTING CURB AND GUTTER BEYOND THE TRANSITION GUTTER.
6. REINFORCING BARS SHALL BE DEFORMED AND SHALL HAVE A 2 INCH MINIMUM CLEARANCE. ALL REINFORCING BARS SHALL BE GRADE 60 AND EPOXY COATED.
7. DIMENSIONS AND WEIGHTS OF TYPICAL MANHOLE RING AND COVER ARE NOMINAL.
8. MATERIAL FOR MANHOLE RINGS AND COVERS SHALL BE GRAY OR DUCTILE CAST IRON IN ACCORDANCE WITH SUBSECTION 712.06.
9. SINCE PIPE ENTRIES INTO THE INLET ARE VARIABLE, THE DIMENSIONS SHOWN ARE TYPICAL. ACTUAL DIMENSIONS AND QUANTITIES FOR CONCRETE AND REINFORCEMENT SHALL BE AS REQUIRED IN THE WORK. QUANTITIES INCLUDE VOLUMES OCCUPIED BY PIPES.
10. STRUCTURAL STEEL SHALL BE GALVANIZED AND SHALL BE IN ACCORDANCE WITH SUBSECTION 712.06.
11. ALL MANHOLE COVERS SHALL BE CAST WITH A "NO DUMPING DRAINS TO STREAM" MESSAGE AND A FISH SYMBOL. THE SURFACE OF THE MANHOLE COVER SHALL HAVE A NON-SLIP PATTERN.

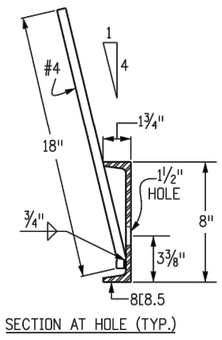
REFERENCE:
COLORADO DEPARTMENT OF TRANSPORTATION STANDARD M-604-12 (SHEET 2 OF 2). REFER TO LATEST M & S STANDARDS, WITH MODIFICATIONS TO THE CLASS OF CONCRETE AS SHOWN IN THE GENERAL NOTES ON THIS DETAIL.



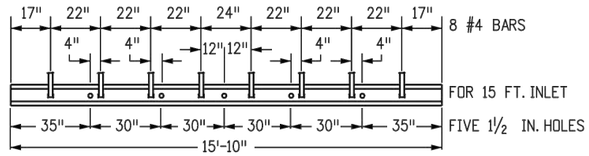
2 #4 BARS
FOR 5 FT. INLET
ONE 1½ IN. HOLE



4 #4 BARS
FOR 10 FT. INLET
THREE 1½ IN. HOLES



SECTION AT HOLE (TYP.)



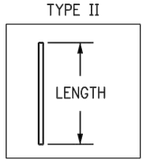
8 #4 BARS
FOR 15 FT. INLET
FIVE 1½ IN. HOLES

CHANNEL LAYOUT DETAILS

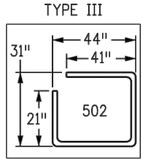
SEE CURB FACE ASSEMBLY ON SHEET 1.

Know what's below. Call before you dig.

TYPE II



TYPE III



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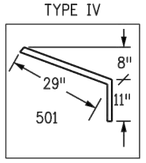

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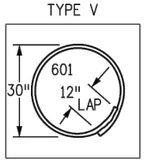
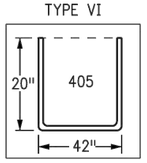
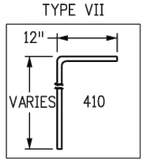


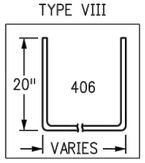
TYPE VI



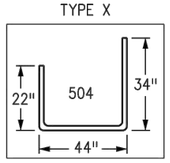
TYPE VII



TYPE VIII



TYPE X



BAR BENDING DIAGRAMS ~ (DIMENSIONS ARE OUT-TO-OUT OF BAR)

Computer File Information	
Creation Date:	07/31/2019
Last Modified Date:	07/31/2019
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Drawing File Name:	
AutoCAD Version:	2018 Scale: AS NOTED Units: English

Index of Revisions		
Date:	Comments:	Initials:

WELD COUNTY

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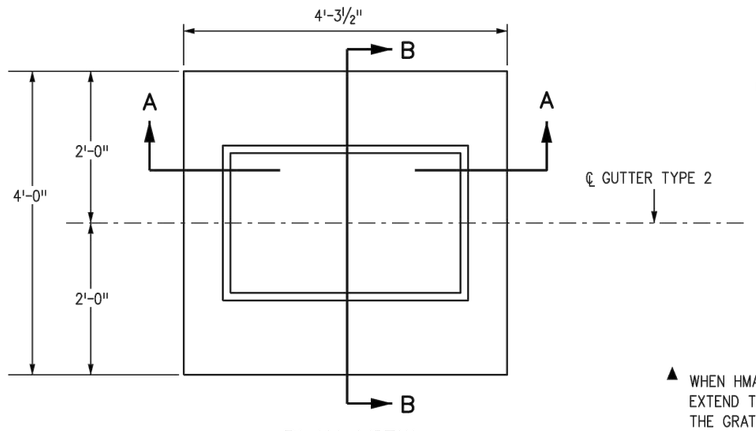
CURB INLET TYPE R

Designer: CDOT		Project No./Code
Detailer: CDOT		
Sheet Subset:	Sheet Subset: 2 of 2	Sheet Number of

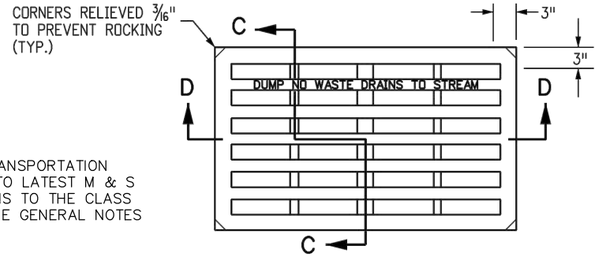


PLAN VIEW

TYPE 13 INLET FOR GUTTER TYPE 2

Know what's below. Call before you dig.

REFERENCE:
COLORADO DEPARTMENT OF TRANSPORTATION STANDARD M-604-13. REFER TO LATEST M & S STANDARDS, WITH MODIFICATIONS TO THE CLASS OF CONCRETE AS SHOWN IN THE GENERAL NOTES ON THIS DETAIL.

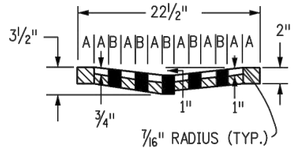


NO. 13 GRATE

GENERAL NOTES

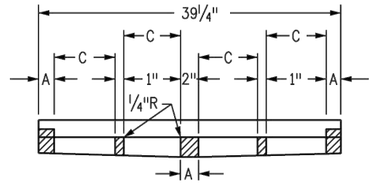
1. CONCRETE SHALL BE CLASS D. INLET MAY BE CAST-IN-PLACE OR PRECAST.
2. CAST-IN-PLACE CONCRETE WALLS SHALL BE FORMED ON BOTH SIDES.
3. EXPOSED CONCRETE CORNERS SHALL BE CHAMFERED ¾ OF A INCH.
4. REINFORCING BARS SHALL BE DEFORMED #4 AND SHALL HAVE A 2 INCH MINIMUM CLEARANCE. ALL REINFORCING BARS SHALL BE GRADE 60 AND EPOXY COATED.
5. STEPS SHALL BE PROVIDED WHEN INLET DIMENSION "H" IS EQUAL TO OR GREATER THAN 3 FEET-6 INCHES AND SHALL CONFORM TO AASHTO M 199.
6. ALL GRATES AND FRAMES SHALL BE GRAY OR DUCTILE CAST IRON IN ACCORDANCE WITH SUBSECTION 712.06. GRATES AND FRAMES SHALL BE DESIGNED TO WITHSTAND HS 20 LOADING.
7. STATION POINT IS AT THE CENTER OF THE INLET.
8. GRATE SHALL HAVE "DUMP NO WASTE DRAINS TO STREAM" MESSAGE CAST ON SURFACE.

▲ WHEN HMA MATERIAL IS TO EXTEND TO THE EDGE OF THE GRATING FRAME, CONCRETE MAY BE DEPRESSED.

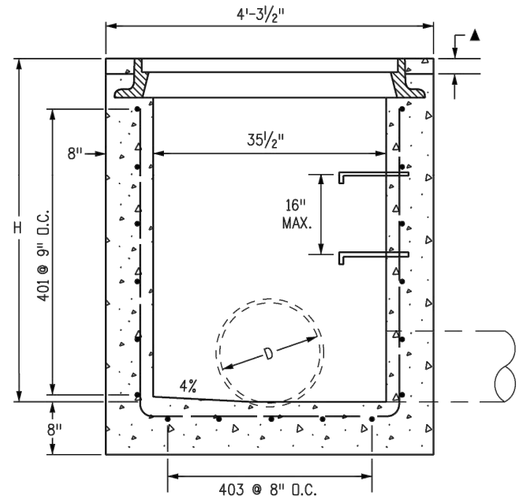


SECTION C-C

A = 1¾"
B = 1 11/16"
C = 7 15/16"

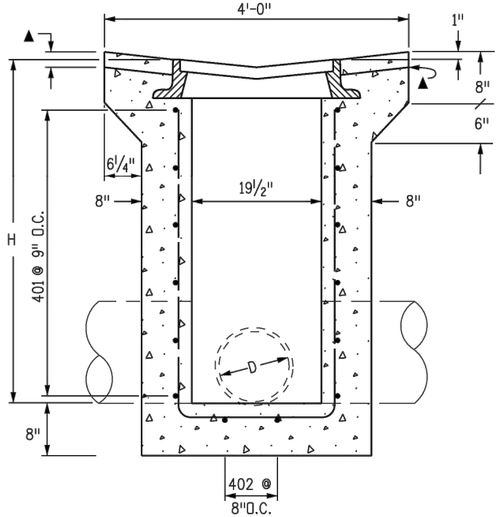


SECTION D-D



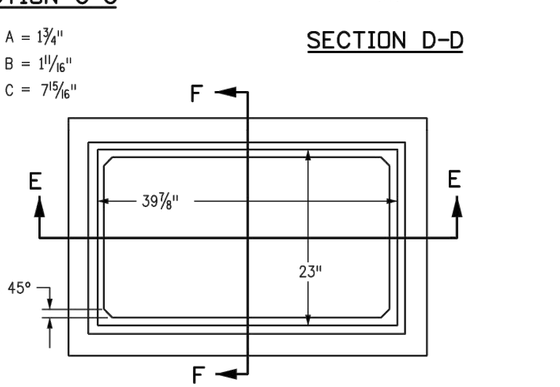
SECTION A-A

D MAX = 30 IN. FOR H > 4 FT.



SECTION B-B

D MAX = 18 IN. FOR ALL H

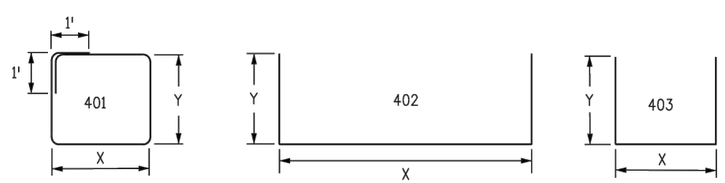


NO. 13 GRATING & FRAMES

H	CONCRETE	REINFORCING STEEL	NO. OF 401 BARS REQ'D.	MAXIMUM PIPE I.D.	
				SEC. A-A	SEC. B-B
	CU. YDS.	θ LB.		IN.	IN.
3'-0"	1.3	72	4	18	18
3'-6"	1.5	76	4	24	18
4'-0"	1.6	90	5	30	18
4'-6"	1.8	104	6	30	18
5'-0"	1.9	109	6	30	18
5'-6"	2.1	122	7	30	18
6'-0"	2.2	136	8	30	18
6'-6"	2.4	141	8	30	18
7'-0"	2.5	154	9	30	18
7'-6"	2.7	168	10	30	18
8'-0"	2.8	173	10	30	18
8'-6"	3.0	187	11	30	18
9'-0"	3.1	200	12	30	18
9'-6"	3.3	205	12	30	18
10'-0"	3.4	219	13	30	18

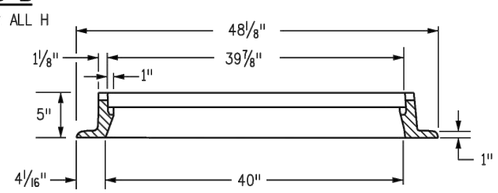
θ INCLUDES 1% FOR OVERRUN.
NOTE: CONCRETE QUANTITIES INCLUDE VOLUME OCCUPIED BY PIPE.

QUANTITIES FOR ONE INLET



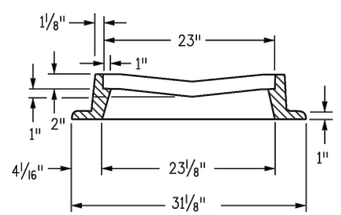
BENDING DIAGRAMS

ALL DIMENSIONS ARE OUT-TO-OUT OF BAR.



SECTION E-E

APPROXIMATE WEIGHT = 590 LBS.



SECTION F-F

MARK	NO. REQ'D.	DIMENSIONS		LENGTH
		X	Y	
401	4	3'-6"	2'-2"	13'-4"
402	2	3'-4½"	* 2'-6½"	8'-5½"
403	5	2'-½"	* 2'-7"	7'-2½"

* ADD 6 IN. TO THIS DIMENSION FOR EACH 6 IN. INCREASE OF "H" OVER 3 FT.-0 IN.

BAR LIST FOR H = 3 FT.-0 IN.

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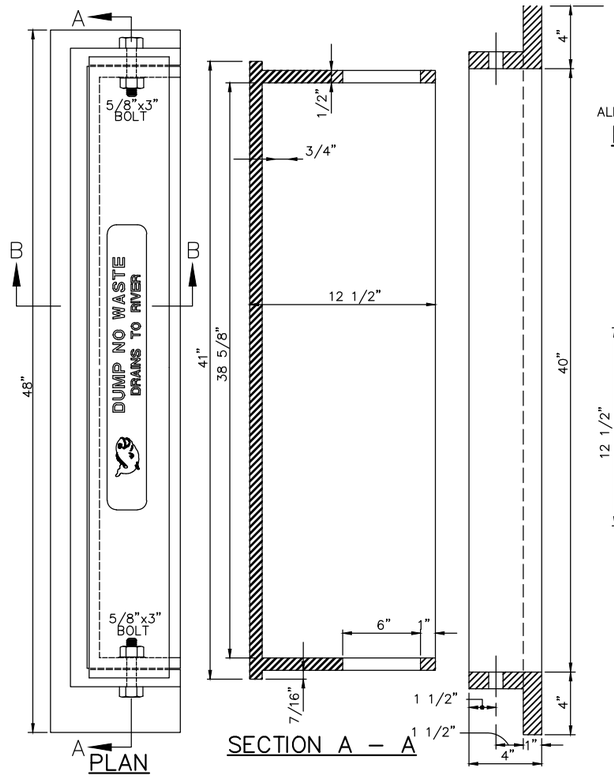
CONCRETE INLET
TYPE 13

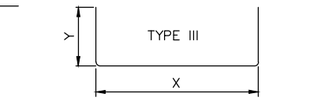
Designer: CDOT	
Detailer: CDOT	
Sheet Subset:	Sheet Subset: 1 of 1

Project No./Code	
Sheet Number	of



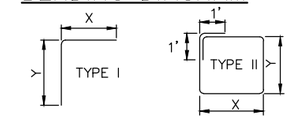
PLAN

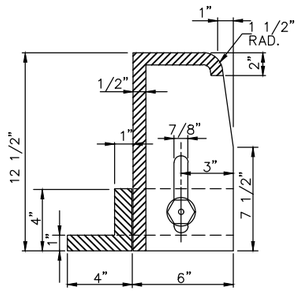
SECTION A – A



ALL DIMENSIONS ARE OUT-TO-OUT BAR

BENDING DIAGRAM





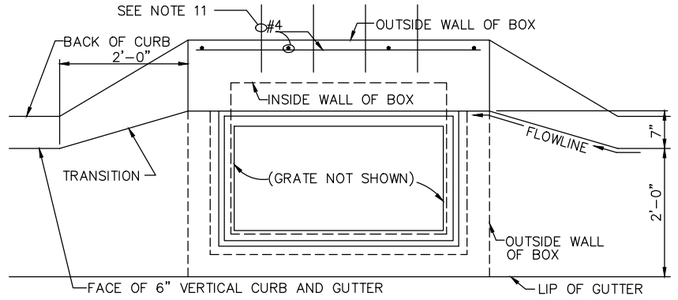
SECTION B – B

BAR LIST FOR H=3'-0"

MARK	TYPE	NO. REQ'D	TYPE 3 INLET DIMENSIONS X	Y	LENGTH
401	I	4	1'-0"	1'-0"	2'-0"
402	II	3	3'-7 1/4"	2'-10 1/2"	14'-11 1/2"
403	III	2	3'-5 3/4"	*2'-0 1/2"	7'-6 3/4"
404	III	4	2'-9"	*2'-1"	6'-11"

MARK	TYPE	NO. REQ'D	TYPE 3 DOUBLE INLET DIMENSIONS X	Y	LENGTH
401	I	7	1'-0"	1'-0"	2'-0"
402	II	3	7'-2 1/2"	2'-10 1/2"	22'-2"
403	III	2	7'-1"	*2'-0 1/2"	11'-2"
404	III	8	2'-9"	*2'-1"	6'-11"

*ADD 6" TO THIS DIMENSION FOR EACH 6" INCREASE OF "H" OVER 3'-0"

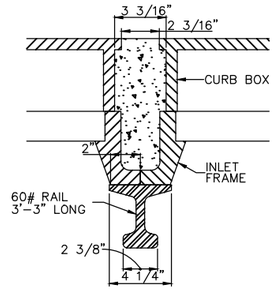


DEETER NO. 2502-A SINGLE, CURB INLET FRAME, GRATE, CURB & PARTIAL FRAME

PLAN OF TYPE 3 INLET FOR VERTICAL FACE CURB, GUTTER & SIDEWALK

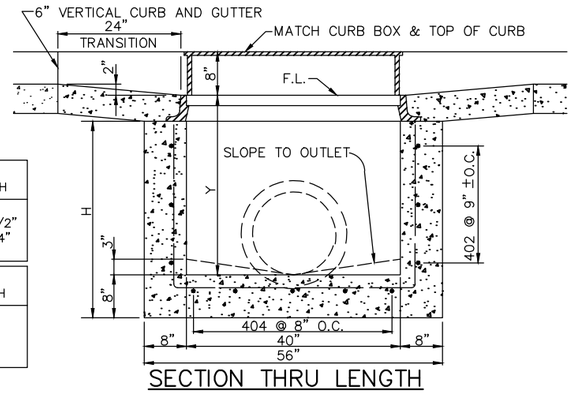
H	NO. OF 402 BARS REQ'D.
3'-0"	3
3'-6"	4
4'-0"	4
4'-6"	5
5'-0"	6
5'-6"	6
6'-0"	7
6'-6"	8
7'-0"	8
7'-6"	9
8'-0"	10
8'-6"	10
9'-0"	11
9'-6"	12
10'-0"	12

BAR QUANTITIES

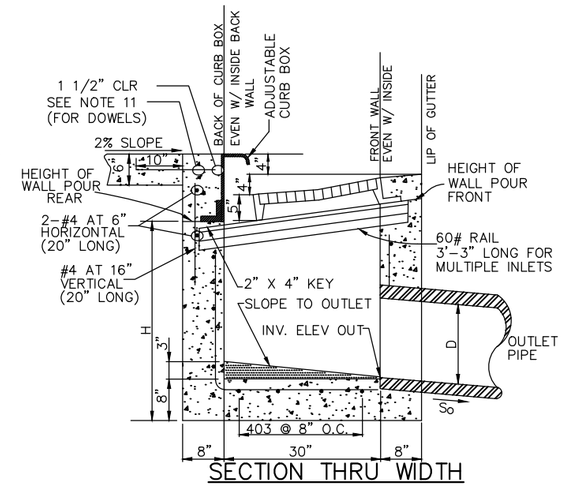


SECTION

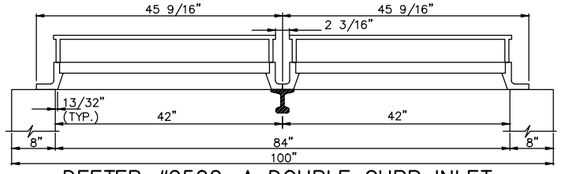
CENTER OF MULTIPLE INLETS



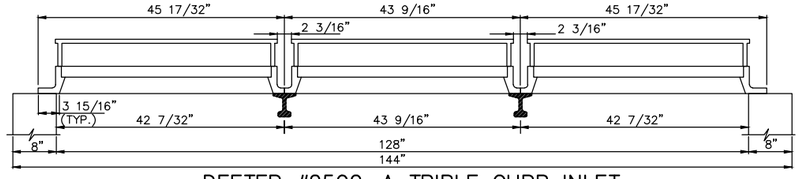
SECTION THRU LENGTH



SECTION THRU WIDTH



DEETER #2502-A DOUBLE CURB INLET



DEETER #2502-A TRIPLE CURB INLET

# OF INLETS	STD. DEPTH (Y)	MIN ø (D)	MIN. SLOPE S_o
SINGLE	3'-6"	18"	1.00%
DOUBLE	4'-0"	18"	1.80%
TRIPLE	4'-6"	21"	1.80%

FRAME AND GRATE

FRAME AND GRATE SHALL BE A DEETER 2502-A OR EQUAL

GENERAL NOTES:

1. ALL WORK SHALL BE DONE IN ACCORDANCE WITH THE WELD COUNTY ENGINEERING AND CONSTRUCTION CRITERIA.
2. CONCRETE SHALL BE CLASS D. INLET MAY BE CAST-IN-PLACE OR PRECAST.
3. ALL CONCRETE SHALL BE FORMED ON BOTH SIDES.
4. ALL EXPOSED CONCRETE CORNERS SHALL BE CHAMFERED 3/4".
5. ALL GRATINGS, FRAMES, RINGS AND COVERS SHALL BE CAST IRON.
6. REINFORCING BARS SHALL BE DEFORMED, GRADE 60, PER ASTM A615, AND SHALL HAVE A 2" MINIMUM CLEARANCE.
7. BARS MAY BE BENT OR CUT AT CULVERT ENTRANCES.
8. ALL CULVERTS SHALL BE SMOOTHLY GROUTED INTO THE WALLS OF THE BOX.
9. FOR INLETS WHERE H IS LESS THAN 3'-0", REINFORCING IS STILL REQUIRED AS DIRECTED BY THE ENGINEER. INLET FRAMES SHOWN ARE FOR SINGLE INLETS. ONLY DOUBLE INLETS REQUIRE FRAMES WITH CLIPPED FLANGES WHERE THE TWO FRAMES ABUT.
10. INLET STRUCTURES SHALL NOT BE CONSTRUCTED UNTIL THE CURB AND GUTTER HAS BEEN INSTALLED, OR CONTRACTOR STAKES THE CURB & GUTTER FOR 100' ON EACH SIDE OF INLET. CONTRACTOR MUST ALSO STAKE INLET BOX CORNERS.
11. ADD (4) #4 REBARS-16 INCHES LONG (MIN) EQUALLY SPACED AND 6" AT MID-DEPTH INTO THE TYPE 3 INLET CONCRETE & 10" AT MID-DEPTH INTO EACH SIDEWALK SECTION ADJACENT TO THE INLET (TYP L=5'). 4 ADDITIONAL BARS ARE REQUIRED FOR EACH 5' OF LENGTH ADDED FOR DOUBLE OR TRIPLE INLET.
12. ALL GRATES AND FRAMES SHALL BE GRAY OR DUCTILE CAST IRON CONFORMING TO CDOT STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION-712.06. GRATES AND FRAMES SHALL BE DESIGNED TO WITHSTAND HS-20 LOADING.
13. MINIMUM CURB OPENING AREA = 150 SQ. IN.
14. MINIMUM REBAR SPLICE LENGTH SHALL BE 10".

REFERENCE:

CITY OF GREELEY STORMWATER DETAIL 7-4A, JUNE 2008

Know what's below. Call before you dig.

Computer File Information	
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Last Modified Date:	JUNE 2008
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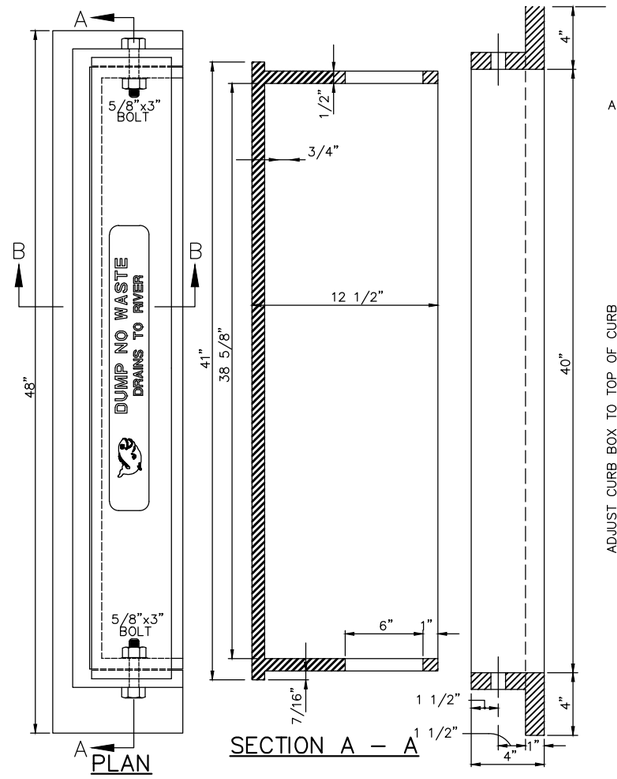
No Revisions:	
Revised:	
Void:	

COMBINATION INLET TYPE 3 (FOR VERTICAL FACE CURB)

Designer: Cit□of Greele□		Project No./Code
Detailer: Cit□of Greele□		
Sheet Subset:	Sheet Subset: 1 of 2	Sheet Number of

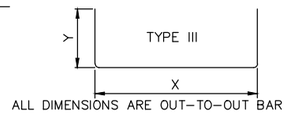


PLAN

SECTION A – A

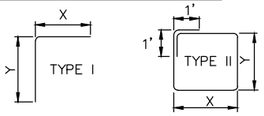
GENERAL NOTES:

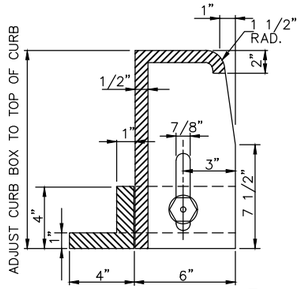
1. ALL WORK SHALL BE DONE IN ACCORDANCE WITH THE WELD COUNTY ENGINEERING AND CONSTRUCTION CRITERIA.
2. CONCRETE SHALL MEET OR EXCEED METROPOLITAN GOVERNMENT ENGINEERING COUNCIL (MGPEC) SPECIFICATIONS, ITEM 11, PORTLAND CEMENT CONCRETE PAVEMENT; SECTION 11.2, MATERIALS. CDOT CLASS D 4,500 PSI CDOT SPEC 601.
3. ALL CONCRETE SHALL BE FORMED ON BOTH SIDES.
4. ALL EXPOSED CONCRETE CORNERS SHALL BE CHAMFERED 3/4".
5. ALL GRATINGS, FRAMES, RINGS AND COVERS SHALL BE CAST IRON.
6. REINFORCING BARS SHALL BE DEFORMED, GRADE 60, PER ASTM A615, AND SHALL HAVE A 2" MINIMUM CLEARANCE.
7. BARS MAY BE BENT OR CUT AT CULVERT ENTRANCES.
8. ALL CULVERTS SHALL BE SMOOTHLY GROUTED INTO THE WALLS OF THE BOX.
9. FOR INLETS WHERE H IS LESS THAN 3'–0", REINFORCING IS STILL REQUIRED AS DIRECTED BY THE ENGINEER. INLET FRAMES SHOWN ARE FOR SINGLE INLETS. ONLY DOUBLE INLETS REQUIRE FRAMES WITH CLIPPED FLANGES WHERE THE TWO FRAMES ABUT.
10. INLET STRUCTURES SHALL NOT BE CONSTRUCTED UNTIL THE CURB AND GUTTER HAS BEEN INSTALLED, OR CONTRACTOR STAKES THE CURB & GUTTER FOR 100' ON EACH SIDE OF INLET. CONTRACTOR MUST ALSO STAKE INLET BOX CORNERS.
11. ADD (4) #4 REBARS–16 INCHES LONG (MIN) EQUALLY SPACED AND 6" AT MID–DEPTH INTO THE TYPE 3 INLET CONCRETE & 10" AT MID–DEPTH INTO EACH SIDEWALK SECTION ADJACENT TO THE INLET (TYP L=5'). 4 ADDITIONAL BARS ARE REQUIRED FOR EACH 5' OF LENGTH ADDED FOR DOUBLE OR TRIPLE INLET.
12. ALL GRATES AND FRAMES SHALL BE GRAY OR DUCTILE CAST IRON CONFORMING TO CDOT STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE CONSTRUCTION–712.06. GRATES AND FRAMES SHALL BE DESIGNED TO WITHSTAND HS–20 LOADING.
13. MINIMUM CURB OPENING AREA = 150 SQ. IN.
14. MINIMUM REBAR SPLICE LENGTH SHALL BE 10".



ALL DIMENSIONS ARE OUT–TO–OUT BAR

BENDING DIAGRAM





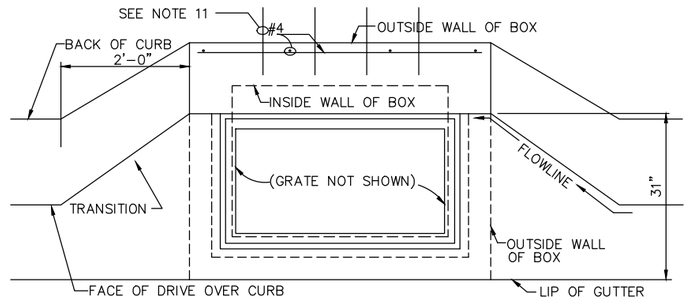
SECTION B – B

BAR LIST FOR H=3'–0"

MARK	TYPE	NO. REQ'D	TYPE 3 INLET DIMENSIONS X	Y	LENGTH
401	I	4	1'–0"	1'–0"	2'–0"
402	II	3	3'–7 1/4"	2'–10 1/2"	14'–11 1/2"
403	III	2	3'–5 3/4"	*2'–0 1/2"	7'–6 3/4"
404	III	4	2'–9"	*2'–1"	6'–11"

MARK	TYPE	NO. REQ'D	TYPE 3 DOUBLE INLET DIMENSIONS X	Y	LENGTH
401	I	7	1'–0"	1'–0"	2'–0"
402	II	3	7'–2 1/2"	2'–10 1/2"	22'–2"
403	III	2	7'–1"	*2'–0 1/2"	11'–2"
404	III	8	2'–9"	*2'–1"	6'–11"

*ADD 6" TO THIS DIMENSION FOR EACH 6" INCREASE OF "H" OVER 3'–0"

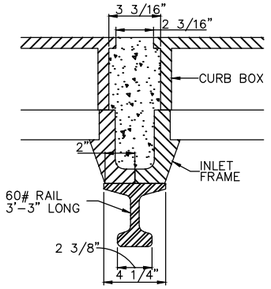


DEETER NO. 2502–A SINGLE, CURB INLET FRAME, GRATE, CURB & PARTIAL FRAME

PLAN OF TYPE 3 INLET/DRIVE OVER CURB, GUTTER & SIDEWALK

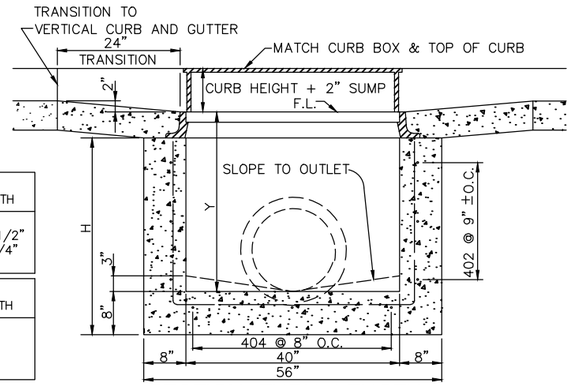
H	NO. OF 402 BARS REQ'D.
3'–0"	3
3'–6"	4
4'–0"	4
4'–6"	5
5'–0"	6
5'–6"	6
6'–0"	7
6'–6"	8
7'–0"	8
7'–6"	9
8'–0"	10
8'–6"	10
9'–0"	11
9'–6"	12
10'–0"	12

BAR QUANTITIES

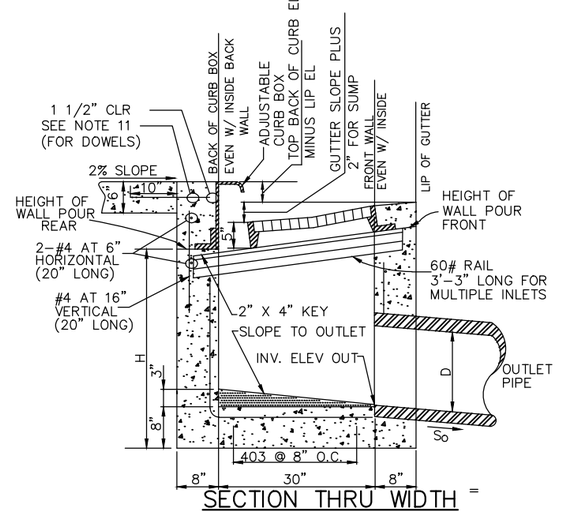


SECTION

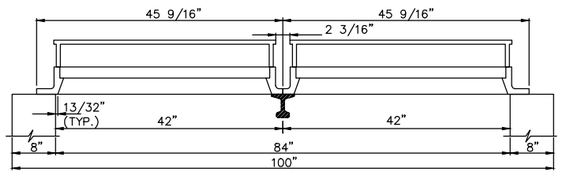
CENTER OF MULTIPLE INLETS



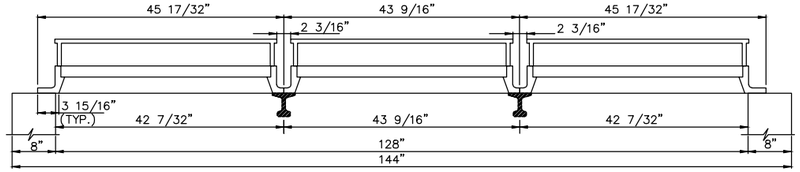
SECTION THRU LENGTH



SECTION THRU WIDTH



DEETER #2502–A DOUBLE CURB INLET



DEETER #2502–A TRIPLE CURB INLET

# OF INLETS	STD. DEPTH (Y)	MIN ø (D)	MIN. SLOPE S_o
SINGLE	3'–6"	18"	1.00%
DOUBLE	4'–0"	18"	1.80%
TRIPLE	4'–6"	21"	1.80%

FRAME AND GRATE

FRAME AND GRATE SHALL BE A DEETER 2502–A OR EQUAL

REFERENCE:

CITY OF GREELEY STORMWATER DETAIL 7–4A, JUNE 2008

Know what's below. Call before you dig.

Computer File Information	
Creation Date:	JUNE 2008
Last Modified Date:	JUNE 2008
Full Path:	
Drawing File Name:	
AutoCAD Version: 2018	Scale: AS NOTED Units: English

Index of Revisions		
Date:	Comments:	Initials:

WELD COUNTY

PUBLIC WORKS DEPARTMENT
1111 H. STREET
P.O. BOX 758
GREELEY, CO. 80632-0758
PHONE: (970) 356-4000
FAX: (970) 304-6497

As Constructed

No Revisions:

Revised:

Void:

COMBINATION INLET TYPE 3 (FOR DRIVE OVER CURB)

Designer: Cit□of Greele□

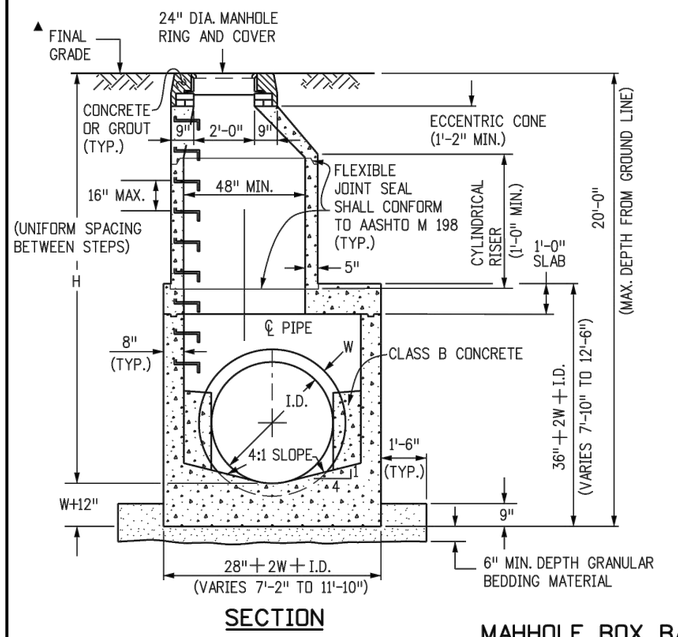
Detailer: Cit□of Greele□

Sheet Subset:

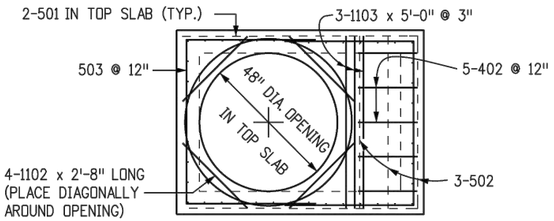
Sheet Subset: 2 of 2

Project No./Code

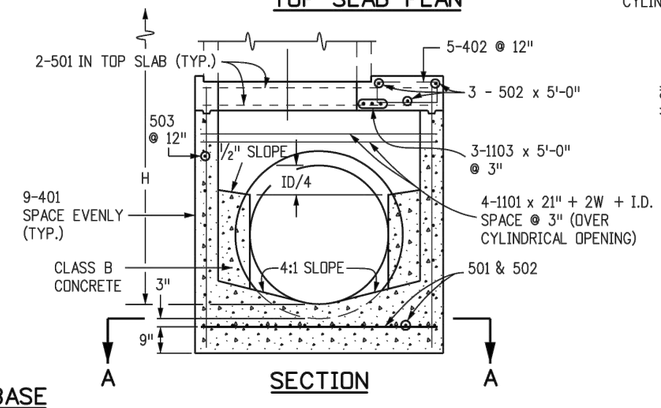
Sheet Number of



SECTION

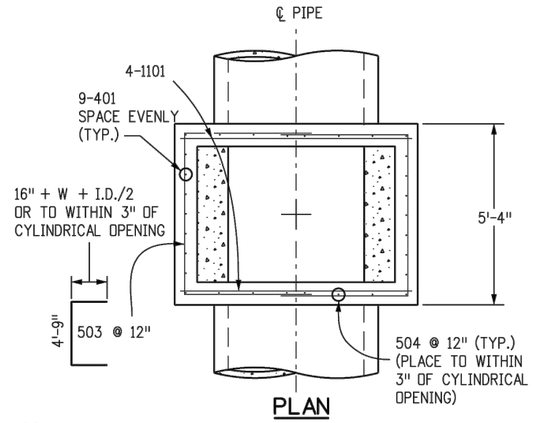


TOP SLAB PLAN

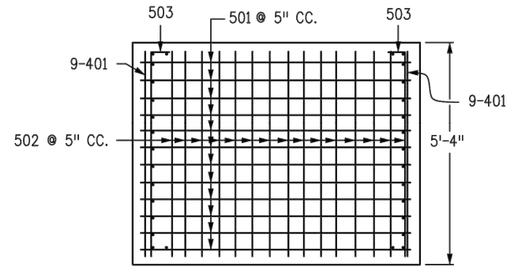


SECTION

MAHHOLE BOX BASE



PLAN



SECTION A-A
(STEEL IN BOTTOM OF BASE)

GENERAL NOTES

1. SINCE ALL PIPE ENTRIES INTO THE BASE ARE VARIABLE, THE DIMENSIONS SHOWN ARE TYPICAL. ACTUAL DIMENSIONS AND QUANTITIES FOR CONCRETE AND REINFORCEMENT SHALL BE AS REQUIRED IN THE WORK.
2. THE PRECAST FLAT TOP MAY BE USED ON ANY MANHOLE. THE ECCENTRIC CONE MAY BE USED WHEN THE MANHOLE "H" HEIGHT IS AT LEAST 8 FT.
3. THE MANHOLE RING FRAME SHALL BE SET IN A BED OF GROUT. THE FRAME SHALL BE SURROUNDED WITH A CEMENT GROUT IN UNPAVED AREA, OR A CONCRETE COLLAR IN PAVED AREA. SEE DETAILS ON SHEETS 2 AND 3.
4. DESIGN OF BOX BASE IS BASED ON STRAIGHT RUNS OF PIPE OR CHANGE IN DIRECTION OF LESS THAN 45°. SPECIAL DESIGN IS REQUIRED FOR 45° OR GREATER.
5. PRECAST MANHOLES AND REINFORCEMENT SHALL CONFORM TO AASHTO M 199 (ASTM C 478).
6. CAST-IN-PLACE MANHOLES SHALL BE CLASS B CONCRETE.
7. STEPS SHALL BE REQUIRED WHEN THE MANHOLE DEPTH EXCEEDS 3 FT.-6 IN. AND SHALL CONFORM TO AASHTO M 199.
8. ALL REINFORCING STEEL SHALL BE GRADE 60 AND EPOXY COATED. VERTICAL STEEL SHALL BE PLACED AT CENTERLINE OF WALL. ALL BARS SHALL HAVE A 2 IN. MINIMUM CLEARANCE.
9. ALL PIPE ENTRIES INTO THE BASE OF MANHOLE SHALL BE CONNECTED BY OPEN CHANNELIZATION ADJUSTED FOR PIPE SIZE, SHAPE, SLOPE, AND DIRECTION OF FLOW. DETAILS SHOWN ARE TYPICAL FOR INSTALLATIONS WITH ALL INVERTS OF SAME RELATIVE ELEVATION. FOR EXCESSIVE ELEVATION DIFFERENCE BETWEEN INVERTS, SPECIAL BASE/CHANNEL DETAILS WILL BE SHOWN ON THE PLANS.
10. FLOW CHANNELS AND INVERTS SHALL BE FORMED BY SHAPING WITH CLASS B CONCRETE OR APPROVED GROUT.
11. STUB-OUTS SHALL EXTEND 2 FT. MINIMUM BEYOND OUTSIDE WALL SURFACE OF MANHOLE AND BE SATISFACTORILY PLUGGED.
12. THE SLOPE OF THE MANHOLE COVER SHALL MATCH THE ROADWAY PROFILE AND CROSS SLOPE.

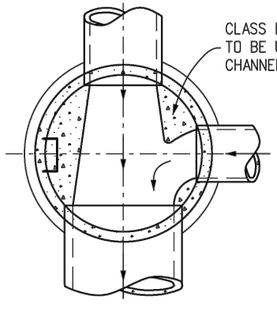
▲ WHEN FINAL GRADE IS PAVEMENT SURFACE, RECESS MANHOLE RING AND COVER 1/4" MIN. TO 1/2" MAX.

REFERENCE:
COLORADO DEPARTMENT OF TRANSPORTATION STANDARD M-604-20 (SHEET 1 OF 3) REFER TO THE LATEST M & S STANDARDS.

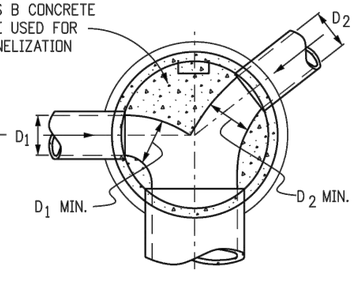
MARK	SIZE	TYPE	WT. #/FT.	BARS	I.D. 54"	60"	66"	72"	84"	96"	FORMULAS
401	4	I	0.668	NO. REQ'D.	18	18	18	18	18	18	401
				LENGTH	8'-1"	8'-8"	9'-3"	9'-10"	11'-0"	12'-2"	BAR LENGTH = 32" + 2W + I.D.
				WEIGHT *	97.2	104.2	111.2	118.2	132.3	146.3	
402	4	III	0.668	NO. REQ'D.	5	5	5	5	5	5	402
				LENGTH	5'-5"	6'-0"	6'-7"	7'-2"	8'-4"	9'-6"	BAR LENGTH = I.D. + 2W
				WEIGHT *	18.1	20.0	22.0	23.9	27.8	31.7	
501	5	I	1.043	NO. REQ'D.	17	17	17	17	17	17	501
				LENGTH	7'-5"	8'-0"	8'-7"	9'-2"	10'-4"	11'-6"	BAR LENGTH = 24" + I.D. + 2W
				WEIGHT *	131.5	141.8	152.2	162.5	183.2	203.9	
502	5	I	1.043	NO. REQ'D.	22	23	25	26	29	32	502
				LENGTH	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	NUMBER BARS REQ'D. = 3 + ((24+I.D.+2W)/@ 5" +1)
				WEIGHT *	114.7	119.9	130.4	135.6	151.2	166.9	
503	5	II	1.043	NO. REQ'D.	16	16	18	18	20	24	503
				LENGTH	12'-10"	13'-5"	14'-0"	14'-7"	15'-9"	16'-11"	NUMBER BARS REQ'D. = 2((13+I.D.+2W)/@ 12" +1)
				WEIGHT *	214.2	223.9	262.8	273.8	328.5	423.5	BAR LENGTH = 4'-9"+2(16+W+I.D./2)
504	5	I	1.043	NO. REQ'D.	12	14	14	16	18	20	504
				LENGTH	8'-1"	8'-8"	9'-3"	9'-10"	11'-0"	12'-2"	NUMBER BARS REQ'D. = 2((2W+I.D.-4)/@ 12" +1)
				WEIGHT *	101.2	126.6	135.1	164.1	206.5	253.8	BAR LENGTH = 32"+2W+I.D.
1101	11	I	5.313	NO. REQ'D.	4	4	4	4	4	4	1101
				LENGTH	7'-2"	7'-9"	8'-4"	8'-11"	10'-1"	11'-3"	BAR LENGTH = 21" + I.D. + 2W
				WEIGHT *	152.3	164.7	177.1	189.5	214.3	239.1	
1102	11	I	5.313	NO. REQ'D.	4	4	4	4	4	4	BENDING
				LENGTH	2'-8"	2'-8"	2'-8"	2'-8"	2'-8"	2'-8"	TYPE I STRAIGHT
				WEIGHT *	56.7	56.7	56.7	56.7	56.7	56.7	
1103	11	I	5.313	NO. REQ'D.	3	3	3	3	3	3	TYPE II 4'-9", 16"+W+I.D./2
				LENGTH	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	5'-0"	
				WEIGHT *	79.7	79.7	79.7	79.7	79.7	79.7	TYPE III 12", 12", 7", I.D.+2W-38"
* REINFORCING STEEL TOTAL					965.6	1,037.5	1,127.2	1,204.0	1,380.2	1,601.6	
CONCRETE - CUBIC YARDS - TOTAL					6.0	6.6	7.3	8.0	9.5	11.1	

NOTE: QUANTITIES ARE BASED ON SAME SIZE PIPE ENTRANCE TO AND EXIT FROM, BASE AND A 4 FT. MANHOLE ENTRANCE INTO TOP SLAB OF BASE.

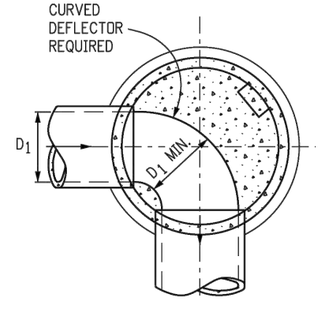
QUANTITIES FOR CONCRETE MANHOLE BOX BASE



THROUGH PIPE ONE LATERAL



ANGLED LATERALS

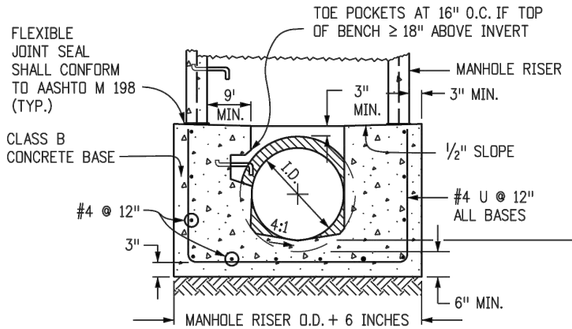


SHARP ANGLE

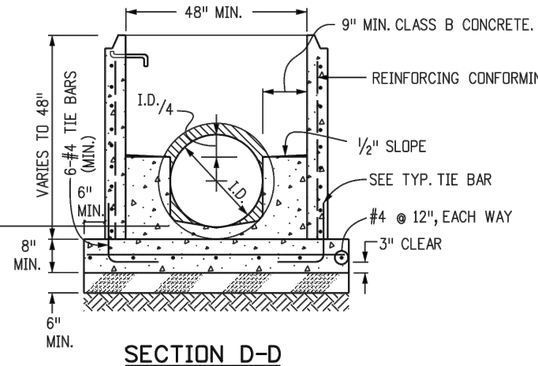
TYPICAL CHANNELIZATION DETAILS

811 Know what's below. Call before you dig.

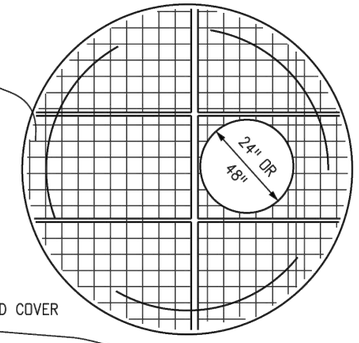
Computer File Information		Index of Revisions			WELD COUNTY	As Constructed	MANHOLES	Project No./Code
Creation Date: 07/31/2019		Date:	Comments:	Initials:	PUBLIC WORKS DEPARTMENT 1111 H. STREET P.O. BOX 758 GREELEY, CO. 80632-0758 PHONE: (970) 356-4000 FAX: (970) 304-6497	No Revisions:		
Last Modified Date: 07/31/2019						Revised:	Designer: CDOT	
Full Path:							Detailer: CDOT	
Drawing File Name:						Void:	Sheet Subset:	Sheet Subset: 1 of 3
AutoCAD Version: 2018 Scale: AS NOTED Units: English								Sheet Number of

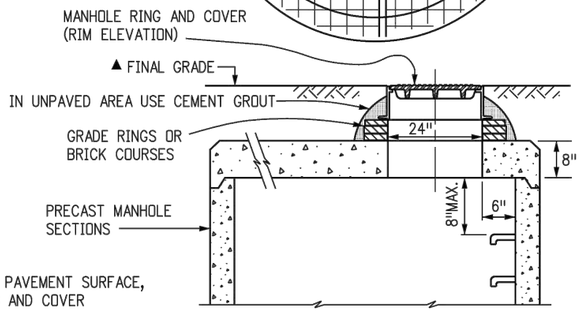


SECTION B-B



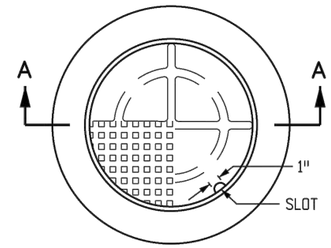
SECTION D-D

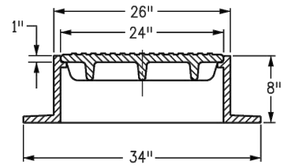




FLAT TOP SECTION DETAIL

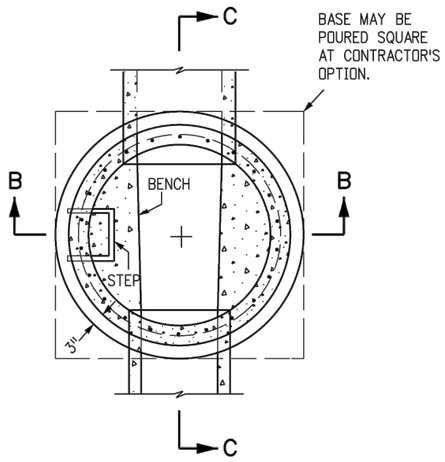
▲ WHEN FINAL GRADE IS PAVEMENT SURFACE, RECESS MANHOLE RING AND COVER ¼" MIN. TO ½" MAX.



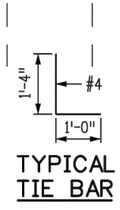


TOTAL WEIGHT: APPROXIMATELY 400 LBS. SHALL BE GRAY OR DUCTILE CAST IRON IN ACCORDANCE WITH SUBSECTION 712.06.

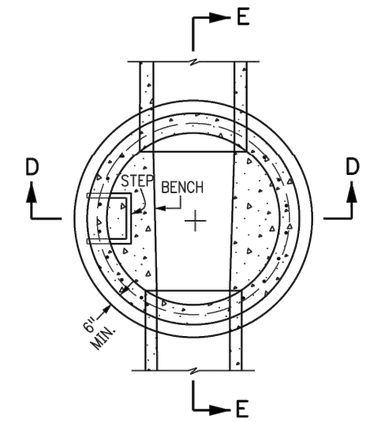
SECTION A-A
MANHOLE RING AND COVER



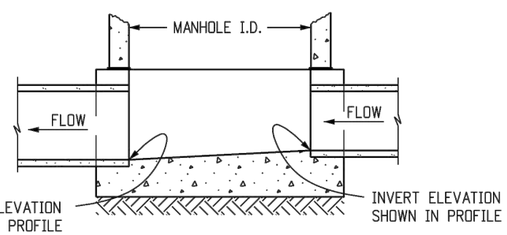
PLAN



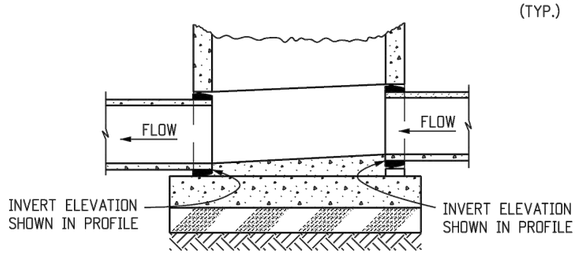
TYPICAL TIE BAR



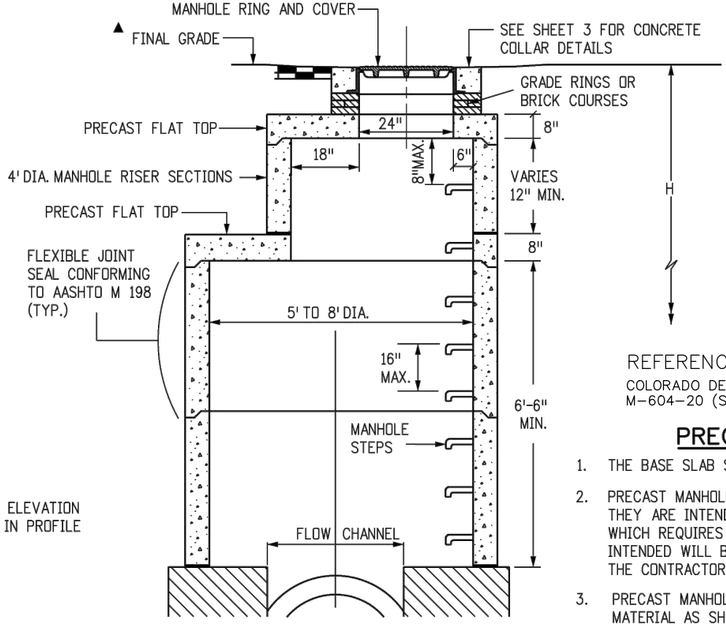
PLAN



SECTION C-C
CAST-IN-PLACE SLAB BASE



SECTION E-E
PRECAST SLAB BASE



MANHOLE RISER DETAIL

Know what's below. Call before you dig.

LEGEND

- SUITABLE SUBGRADE
- GRANULAR BEDDING MATERIAL
- CONCRETE

REFERENCE:
COLORADO DEPARTMENT OF TRANSPORTATION STANDARD M-604-20 (SHEET 2 OF 3) REFER TO THE LATEST M & S STANDARDS.

PRECAST MANHOLE BASES NOTES:

1. THE BASE SLAB SHALL BE POURED MONOLITHICALLY WITH BOTTOM RISER SECTION.
2. PRECAST MANHOLE BASES SHALL FIT THE CONDITIONS AND LOCATIONS FOR WHICH THEY ARE INTENDED WITHOUT ANY FIELD MODIFICATIONS. ANY MANHOLE BASE WHICH REQUIRES FIELD CUTTING OR MODIFICATION IN ORDER TO FIT THE LOCATIONS INTENDED WILL BE REJECTED BY THE ENGINEER AND REMOVED AND REPLACED BY THE CONTRACTOR AT NO COST TO THE DEPARTMENT.
3. PRECAST MANHOLE BASES SHALL BE BEDDED ON AN APPROVED GRANULAR BEDDING MATERIAL AS SHOWN ABOVE.

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Last Modified Date:	07/31/2019
Full Path:	
Drawing File Name:	
AutoCAD Version:	2018 Scale: AS NOTED Units: English

Index of Revisions		
Date:	Comments:	Initials:

WELD COUNTY

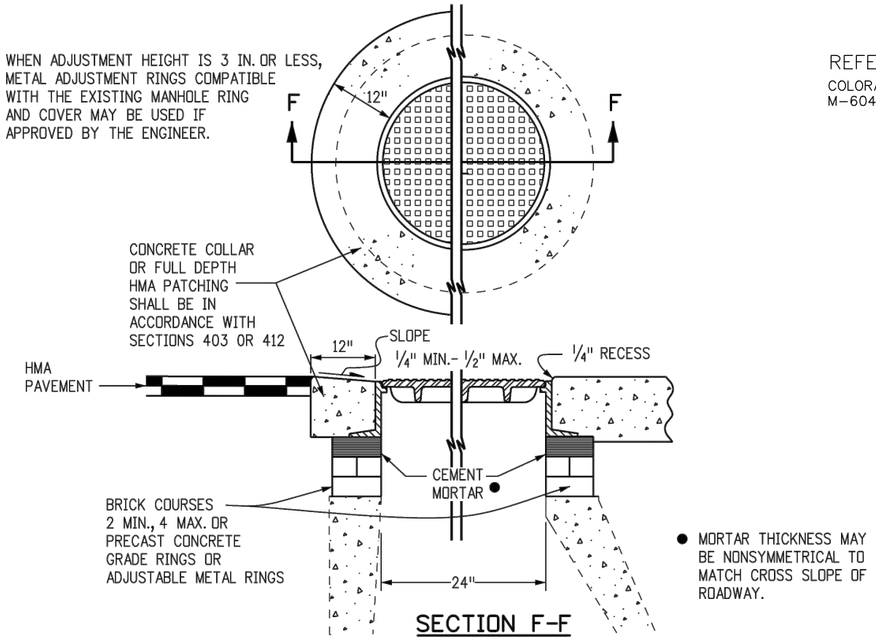
PUBLIC WORKS DEPARTMENT
1111 H. STREET
P.O. BOX 758
GREELEY, CO. 80632-0758
PHONE: (970) 356-4000
FAX: (970) 304-6497

As Constructed	
No Revisions:	
Revised:	
Void:	

MANHOLES

Designer: CDOT		
Detailer: CDOT		
Sheet Subset:	Sheet Subset: 2 of 3	

Project No./Code	
Sheet Number	of

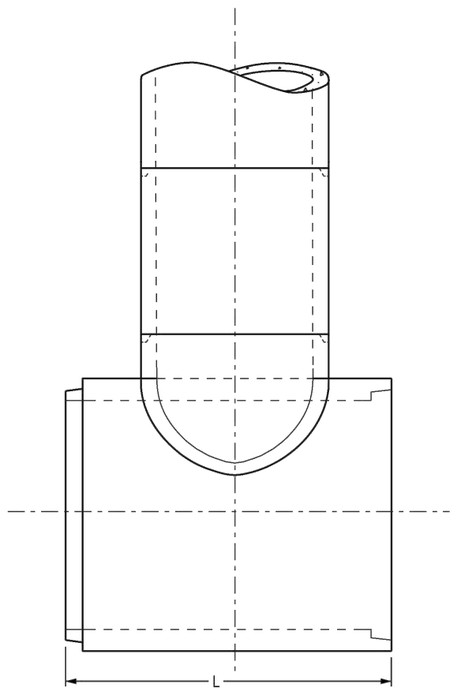


REFERENCE:

COLORADO DEPARTMENT OF TRANSPORTATION STANDARD
M-604-20 (SHEET 3 OF 3) REFER TO THE LATEST M & S STANDARDS.

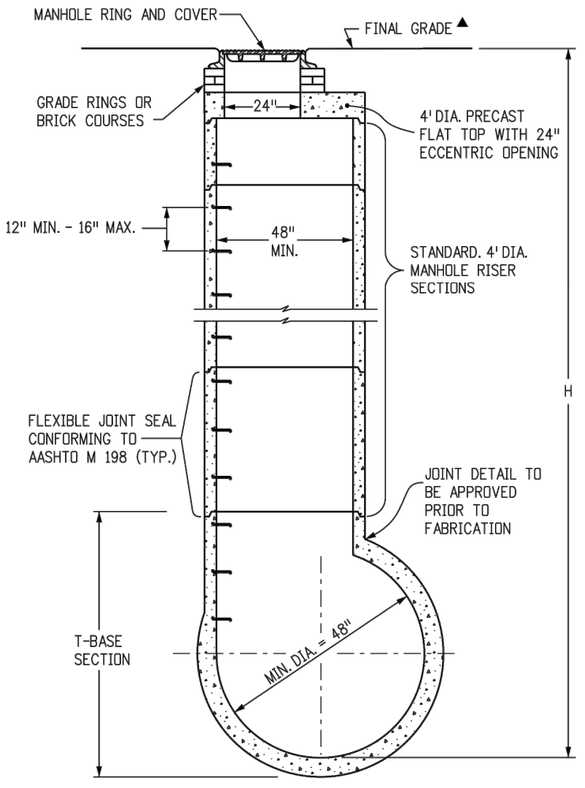
T-BASE MANHOLES NOTES

1. THE T-BASE SECTION SHALL BE SHOP-FABRICATED FOR DELIVERY TO THE CONSTRUCTION SITE AS A COMPLETE UNIT.
2. THESE DETAILS SHOW ONLY THE CONCEPTUAL AND STANDARD DIMENSIONAL REQUIREMENTS FOR TYPE T-BASE MANHOLES. THE CONTRACTOR SHALL FURNISH DETAILED SHOP DRAWINGS FOR APPROVAL PRIOR TO FABRICATION. THE DETAILS SHOWN HEREIN APPLY ONLY TO 48 IN. AND GREATER DIAMETER PIPES.
3. EXCEPT FOR CLASS OF PIPE, SPECIFICATIONS FOR THE MANHOLE SHALL BE THE SAME AS THOSE REQUIRED FOR THE ADJOINING PIPE.
4. THE T-BASE SECTION SHALL MAINTAIN ITS INTERNAL SHAPE AND FLOW AREA. GROUTING OR FILLING SHALL BE APPLIED SO AS TO NOT DISTURB THE NORMAL FLOW OR REDUCE THE AREA.



CIRCULAR RIGID PIPE
(LONGITUDINAL SECTION)

▲ WHEN FINAL GRADE IS PAVEMENT SURFACE, RECESS MANHOLE RING AND COVER 1/4" MIN. TO 1/2" MAX.



CIRCULAR RIGID PIPE
(TRANSVERSE SECTION)

MANHOLE T-BASE

Know what's below. Call before you dig.

Computer File Information		Index of Revisions			WELD COUNTY	As Constructed	MANHOLES	Project No./Code
Creation Date: 07/31/2019		Date:	Comments:	Initials:	PUBLIC WORKS DEPARTMENT 1111 H. STREET P.O. BOX 758 GREELEY, CO. 80632-0758 PHONE: (970) 356-4000 FAX: (970) 304-6497	No Revisions:		
Last Modified Date: 07/31/2019						Revised:	Designer: CDOT	
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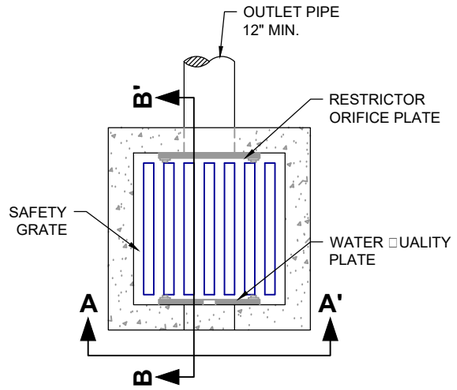
Drawing File Name:						Void:	Sheet Subset:	Sheet Subset: 3 of 3
AutoCAD Version: 2018 Scale: AS NOTED Units: English								Sheet Number of

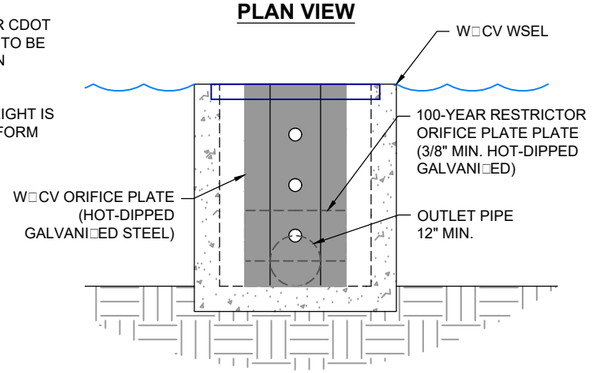
OUTLET RE□UIREMENTS

- W□CV SHALL BE RELEASED OVER 40 HOURS
- OUTLET WORKS SHOULD BE SI□ED AND STRUCTURALLY DESIGNED TO RELEASE AT NO MORE THAN THE 1-HOUR, 5-YEAR HISTORIC RELEASE RATE IN URBANI□ING AREAS AND THE 1-HOUR, 10-YEAR HISTORIC RELEASE RATE IN NON-URBANI□ING AREAS.
- OPENINGS IN THE SAFETY GRATE SHALL ALLOW ENOUGH FLOW TO PASS THE 5-YEAR OR 10-YEAR HISTORIC FLOW (DEPENDENT ON URBANI□ATION CLASSIFICATION), USING A 50□ CLOGGING FACTOR.
- STEEL FOR GRATES AND GRATE INSTALLATION HARDWARE SHALL BE GALVANI□ED AND CONSTRUCTED IN ACCORDANCE WITH CDOT SECTION 712.06.
- CONCRETE SHALL BE CDOT CLASS D, 4500 PSI IN 28 DAYS, PER CDOT SPECIFICATION SECTION 601.
- REINFORCEMENT BARS SHALL BE PER CDOT SPECIFICATIONS. SPACING AND SI□E TO BE DETERMINED BY CONSULTING DESIGN ENGINEER.
- STEPS SHALL BE PROVIDED WHEN HEIGHT IS GREATER THAN 3□6" AND SHALL CONFORM TO AASHTO M 199.

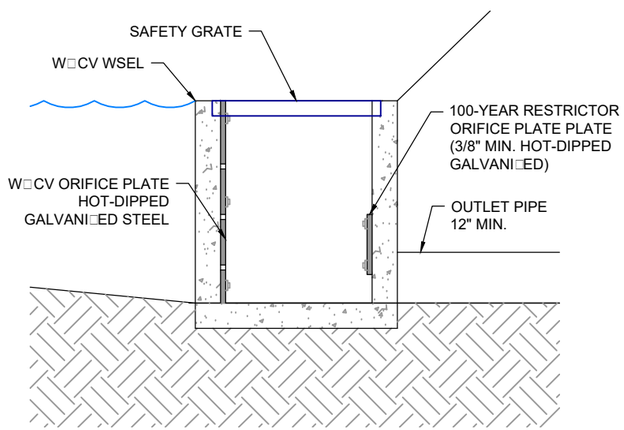
OUTLET STRUCTURE



PLAN VIEW

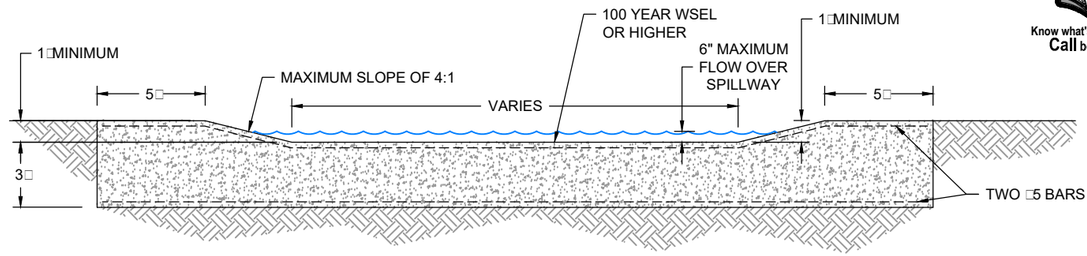


SECTION A-A'

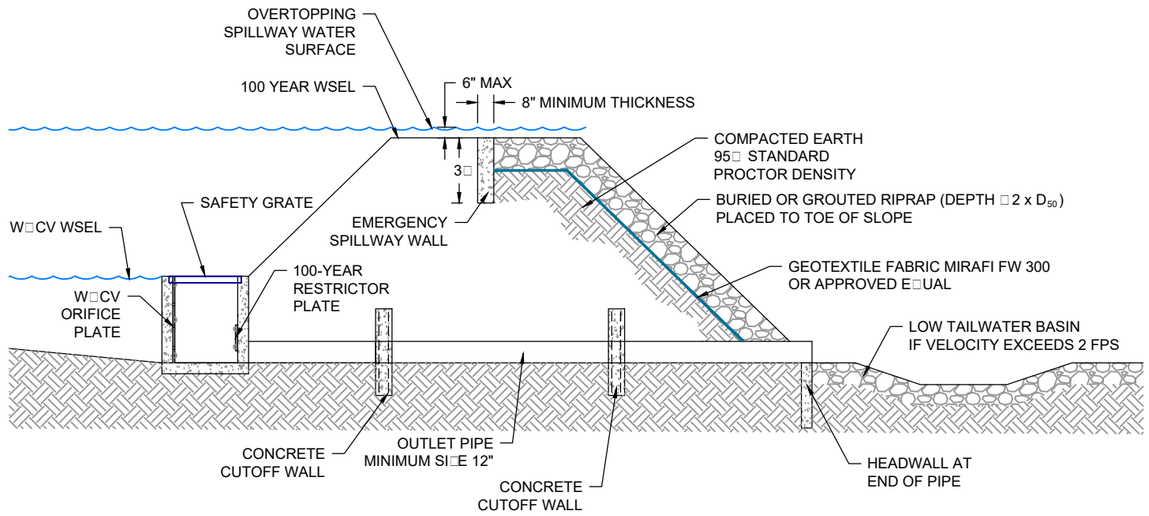


SECTION B-B'

EMERGENCY SPILLWAY



FRONT VIEW



SIDE VIEW

EMERGENCY SPILLWAY RE□UIREMENTS

- EACH DETENTION POND SHALL CONTAIN AN EMERGENCY SPILLWAY CAPABLE OF CONVEYING THE PEAK 100-YEAR STORM AT A DEPTH OF SIX (6) INCHES OR LESS. BURIED OR GROUTED RIPRAP SHALL BE PLACED FORM THE EMERGENCY SPILLWAY DOWNHILL TO THE EMBANKMENT TOE OF SLOPE AND COVERED WITH SIX (6) INCHES OF TOPSOIL, IF BURIED. THE RIPRAP MUST BE SI□ED AT THE TIME OF FINAL ENGINEERING DESIGN. GROUTING OF THE RIPRAP MAY BE RE□UIRED.
- IN ORDER TO PREVENT DAMAGE TO PUBLICLY-OWNED INFRASTRUCTURE (ROADS, ROADSIDE DITCHES), A CONCRETE CUTOFF WALL EIGHT (8) INCHES THICK, THREE (3) FEET DEEP, AND EXTENDING A MINIMUM OF FIVE (5) FEET INTO THE EMBANKMENT ON EACH SIDE OF THE SPILLWAY OPENING IS RE□UIRED ON ALL DETENTION PONDS. THE EMERGENCY SPILLWAY ELEVATION MUST BE TIED BACK INTO THE TOP OF THE EMBANKMENT USING A MAXIMUM SLOPE OF 4:1.
- CONCRETE SHALL BE CDOT CLASS D, 4500 PSI IN 28 DAYS, PER CDOT SPECIFICATION SECTION 601.

811 Know what's below. Call before you dig.

Computer File Information		Index of Revisions			WELD COUNTY	As Constructed	OUTLET AND SPILLWAY DETAILS		Project No./Code
Creation Date:		Date:	Comments:	Initials:	PUBLIC WORKS DEPARTMENT 1111 H. STREET P.O. BOX 758 GREELEY, CO. 80632-0758 PHONE: (970) 356-4000 FAX: (970) 304-6497	No Revisions:	Designer:		
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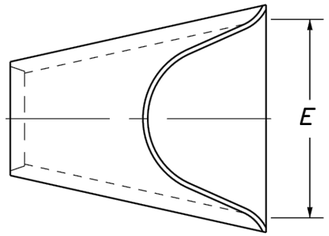
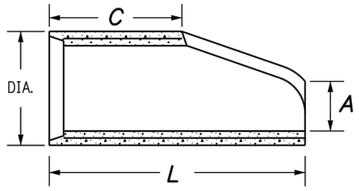


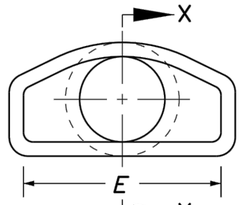
PLAN

PIPE I.D.	DIMENSIONS			
	A	C	L	E
	IN.			
18	10	48	78	36
24	10	48	78	48
30	14	36	96	60
36	18	36	96	72
42	24	36	96	78
48	28	24	96	84
54	30	36	96	90
60	36	36	96	96
72	34	20	96	108

REINFORCED CONCRETE CIRCULAR PIPE



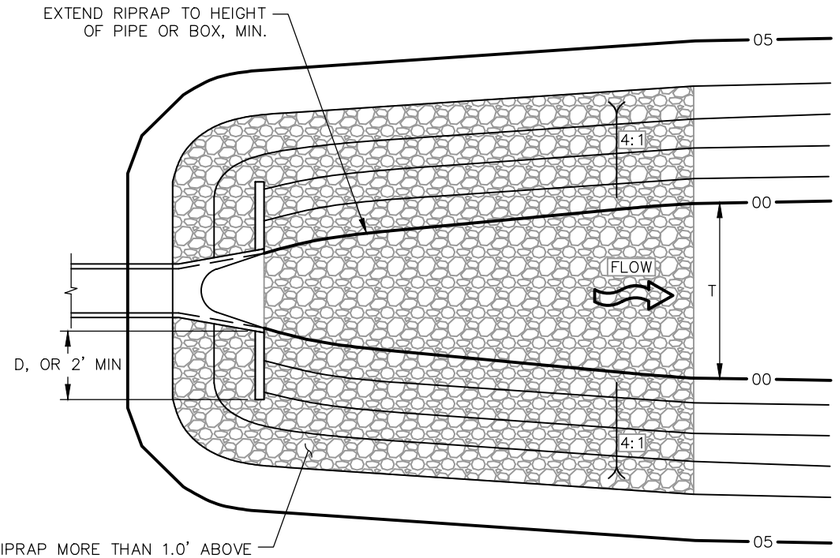
SECTION X-X



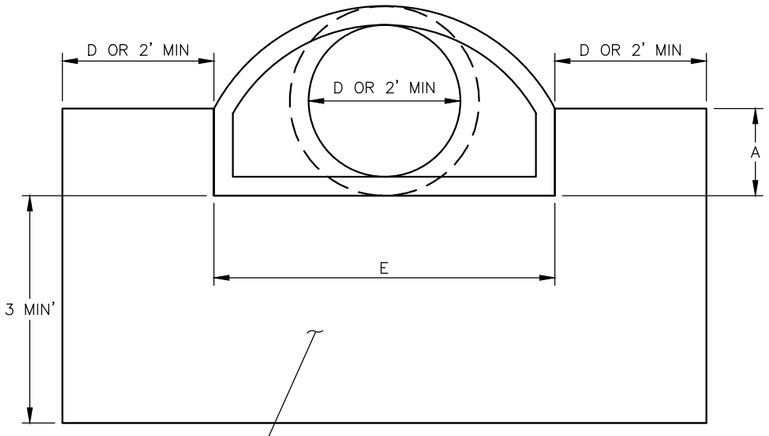
END VIEW

END SECTION FOR REINFORCED CONCRETE CIRCULAR PIPE

COLORADO DEPARTMENT OF TRANSPORTATION STANDARD M-603-10. REFER TO LATEST M&S STANDARDS. REFER TO M-603-10 FOR ELLIPTICAL PIPES.

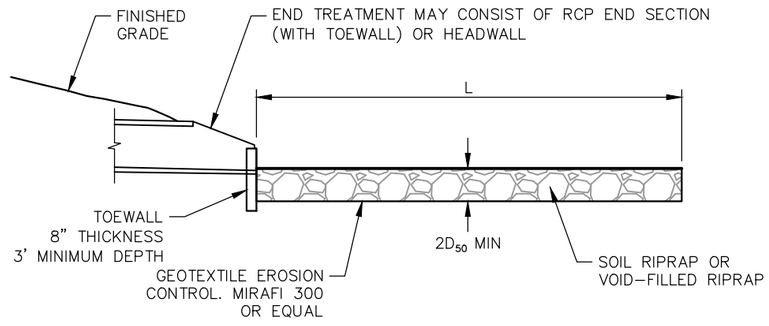


PLAN
NTS



NOTE:
TOEWALL SHALL BE 4,500 PSI CLASS D CONCRETE WITH 8-INCH THICKNESS. TOEWALL REINFORCEMENT SHALL BE DESIGNED BY THE ENGINEER OR CONTRACTOR FOR APPROVAL BY THE COUNTY.

TOEWALL
NTS



PROFILE
NTS

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WELD COUNTY

PUBLIC WORKS DEPARTMENT
1111 H. STREET
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RIPRAP APRON DETAIL

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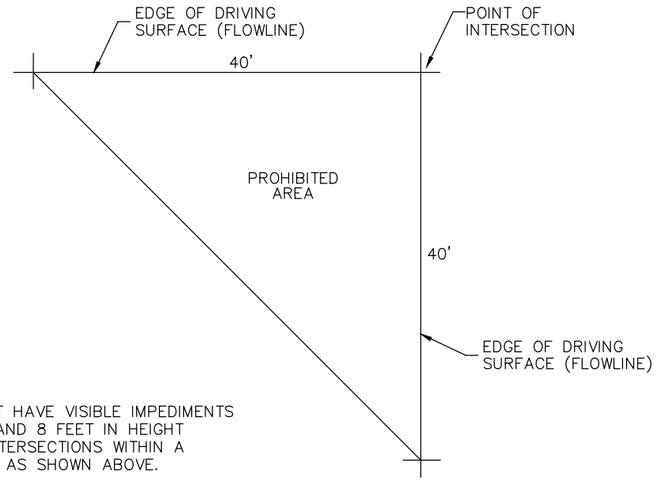


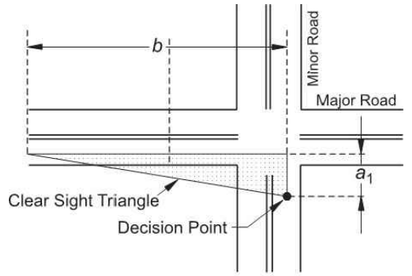
NOTE:

1. ROADS SHALL NOT HAVE VISIBLE IMPEDIMENTS BETWEEN 3 FEET AND 8 FEET IN HEIGHT AT SUBDIVISION INTERSECTIONS WITHIN A TRIANGULAR AREA AS SHOWN ABOVE.

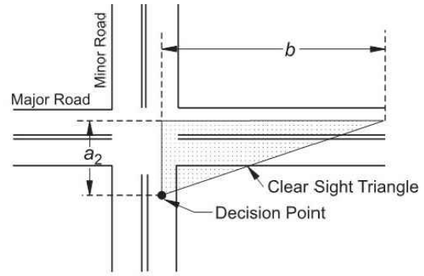
SUBDIVISION ROADS SIGHT DISTANCE

NOTES:

1. DISTANCE a_2 IS EQUAL TO DISTANCE a_1 PLUS THE WIDTH OF THE LANE(S) DEPARTING FROM THE INTERSECTION ON THE MAJOR ROAD TO THE RIGHT.
2. DISTANCE a_2 ALSO SHOULD INCLUDE THE WIDTH OF ANY MEDIAN PRESENT ON THE MAJOR ROAD.
3. THE APPROPRIATE MEASUREMENT OF DISTANCE a_1 AND DISTANCE a_2 FOR DEPARTURE SIGHT TRIANGLES DEPENDS ON THE PLACEMENT OF ANY MARKED STOP LINE THAT MAY BE PRESENT AND, THUS, MAY VARY WITH SITE-SPECIFIC CONDITIONS. IN WELD COUNTY, THE TYPICAL DISTANCE BEHIND THE TRAVELED WAY TO THE STOP BAR IS 14 FEET.
4. ADDITIONAL INFORMATION REGARDING SIGHT DISTANCE FOR INTERSECTIONS AND CASES OTHER THAN THE STOP CONTROL CONDITION CAN BE FOUND IN AASHTO'S A POLICY ON GEOMETRIC DESIGN OF HIGHWAYS AND STREETS.

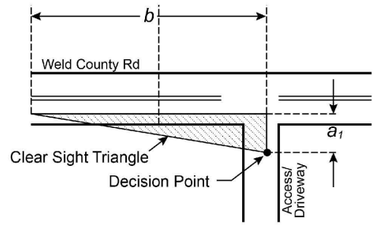


Departure Sight Triangle for Viewing Traffic Approaching the Minor Road from the Left

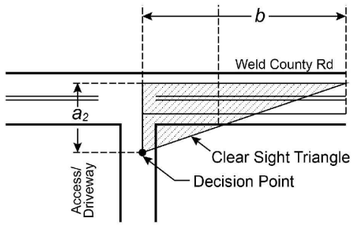


Departure Sight Triangle for Viewing Traffic Approaching the Minor Road from the Right

DEPARTURE SIGHT TRIANGLES INTERSECTION (STOP CONTROL)



Departure Sight Triangle for Viewing Traffic Approaching the Access/Driveway from the Left



Departure Sight Triangle for Viewing Traffic Approaching the Access/Driveway from the Right

DEPARTURE SIGHT TRIANGLES AT ACCESS (STOP CONTROL)

Access Sight Distance $b = 1.47 * V_{major} * t_g$

V_{major} = Design Speed of major road (MPH)

t_g = time gap needed for vehicle entering major road (sec)

t_g = 7.5 Car, 9.5 Single-Unit Truck, 11.5 Combo-Unit Truck

Adjust t_g for crossing more than 2 lanes:

+0.5/extra lane for cars
+0.7/extra lane for trucks

Also adjust t_g for starting grade of the vehicle if it exceeds 3%

+0.2 sec/percent grade for cars and trucks (only for starting uphill)

Computer File Information		Index of Revisions			WELD COUNTY	As Constructed	SIGHT TRIANGLES		Project No./Code
Creation Date:		Date:	Comments:	Initials:	PUBLIC WORKS DEPARTMENT 1111 H. STREET P.O. BOX 758 GREELEY, CO. 80632-0758 PHONE: (970) 356-4000 FAX: (970) 304-6497	No Revisions:			
Last Modified Date: 11/12/2020						Revised:	Designer:		
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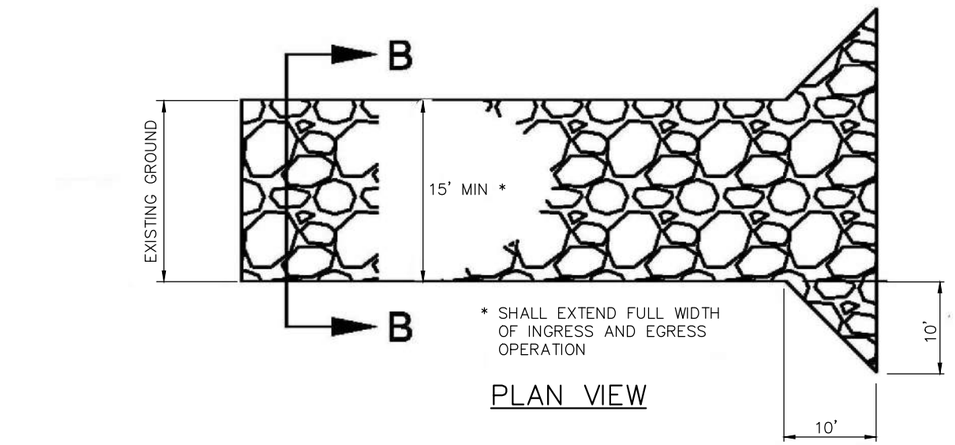
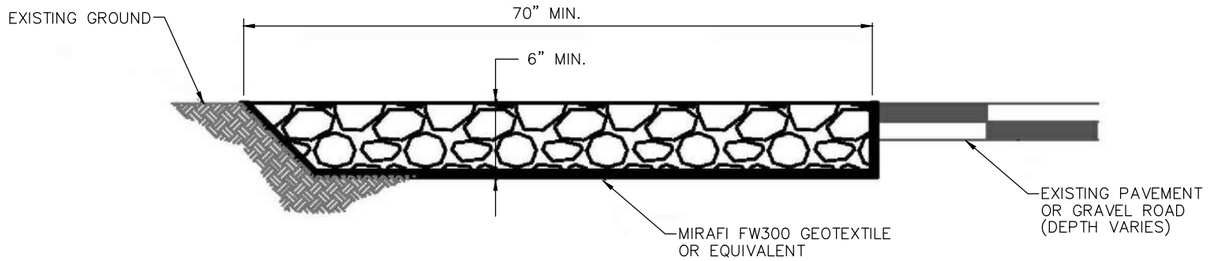


PLAN VIEW



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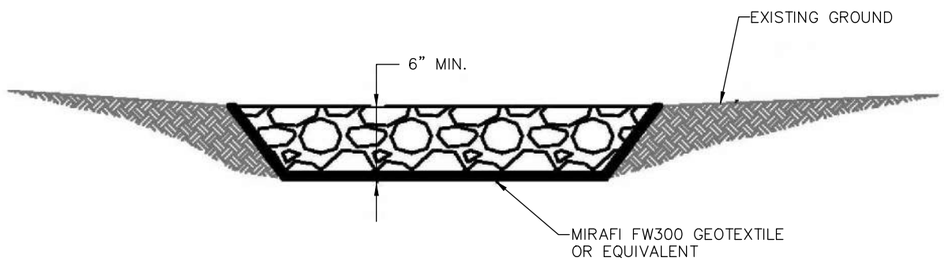

SECTION B–B

NOTES:

1. AGGREGATE SHALL CONFORM TO CDOT SPECIFICATIONS, SUBSECTION 208.02 (I)

2. THE CONTRACTOR SHALL PROTECT CURB AND GUTTER, EDGE OF PAVEMENT, OR EDGE OF GRAVEL ROAD THAT CROSSES OR IS ADAJACENT TO THE ENTRANCE FROM DAMAGE, WHILE NOT BLOCKING FLOW OF WATER. IN THE CASE THERE IS AN EXISTING DITCH, A CULVERT IS REQUIRED. PROTECTION OF THE ADJACENT ROADWAY MATERIALS MENTIONED ABOVE SHALL BE INCLUDED IN THE COST OF THE WORK AND NOT PAID FOR SEPARATELY.

3. ALL MATERIALS AND LABOR TO COMPLETE THE VEHICLE TRACKING PAD SHALL BE INCLUDED IN THE COST OF THE WORK AND NOT PAID FOR SEPARATELY.

4. THE PAY ITEM NUMBER FOR VEHICLE TRACKING PAD (EACH) IS CDOT STANDARD SPECIFICATION 208–00070.

REFERENCE:
COLORADO DEPARTMENT OF TRANSPORTATION STANDARD M–208–1, WITH MODIFICATIONS.

Computer File Information		Index of Revisions			WELD COUNTY	As Constructed	VEHICLE TRACKING PAD (TEMPORARY ACCESS)		Project No./Code
Creation Date:		Date:	Comments:	Initials:	PUBLIC WORKS DEPARTMENT 1111 H. STREET P.O. BOX 758 GREELEY, CO. 80632-0758 PHONE: (970) 356-4000 FAX: (970) 304-6497	No Revisions:			
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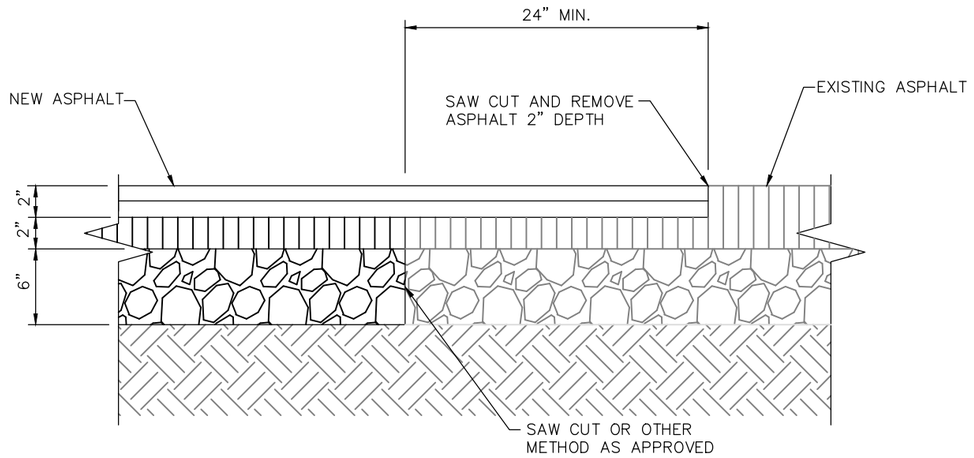

SAW CUT ASPHALT OR "T-JOINT" DETAIL

NOTES:

1. PAINT THE EDGE WITH DILUTED EMULSIFIED ASPHALT (SLOW SETTING) PRIOR TO PAVING OPERATION. APPLY TACK (CSS-1h) TO THE MILLED OR SAW-CUT EDGE PRIOR TO PAVING OPERATIONS.

2. RATE OF APPLICATION SHALL BE AS DETERMINED BY THE ENGINEER AT THE TIME OF APPLICATION. CSS-1h SHALL BE APPLIED AT 0.10 GAL/SY. A DIFFERENT APPLICATION RATE SHALL BE APPROVED BY WELD COUNTY.

Computer File Information		Index of Revisions			WELD COUNTY	As Constructed	SAW CUT ASPHALT OR "T-JOINT" DETAIL		Project No./Code
Creation Date:		Date:	Comments:	Initials:	PUBLIC WORKS DEPARTMENT 1111 H. STREET P.O. BOX 758 GREELEY, CO. 80632-0758 PHONE: (970) 356-4000 FAX: (970) 304-6497	No Revisions:			
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