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## 12.0 DRAINAGE

This Section 12 includes the requirements for the drainage Work for the Region 2 Bridge Bundle Design Build Project (Project). This Work shall be completed in accordance with the Contract Documents.

The National Environmental Policy Act (NEPA) approval documents and Preliminary Hydraulics Report Package (PHRP) are included in the Reference Documents. These documents provide information regarding design flows, hydraulic conveyance structure sizing, preliminary scour analysis, and a conceptual layout of the proposed drainage for informational purposes.

For the overall system capacity, drainage will fully accommodate the Basic Configuration and AREs that are incorporated into the Project representing the ultimate build-out of the Project. Basic Configuration improvements shall be designed and constructed to limit reconstruction of future improvements. The Project consists of the Basic Configuration and the AREs as identified in Book 2, Section 1.

The Contractor shall design and construct a complete drainage system to intercept and remove surface runoff from the Project; maintain surface, channel, and conduit flow through the ROW; and convey flows crossing the highways. The drainage system shall be designed and constructed to manage subsurface flows to avoid saturation of Subgrade Materials that support the Roadway and its associated Structures. Since the project lies outside of CDOT's Municipal Separate Storm Sewer System (MS4) boundary, permanent water quality (PWQ) control measures (CM) are not required. The Contractor shall design and construct the drainage facilities to limit drainage-related hazards within and outside the ROW, while minimizing future operation and maintenance costs, public inconvenience, flood damages, and water quality impacts during construction.

Where applicable, the Contractor shall evaluate all existing cross drains, storm drains, and drainage facilities to remain within the Project for condition and performance, and shall provide recommendations on adequacy to CDOT for Acceptance. All drainage facilities shall be clean prior to Final Acceptance.

The Contractor shall design drainage facilities to be compatible with existing drainage systems on adjacent properties and shall preserve existing drainage patterns or discharges. Wherever possible, the Contractor shall design drainage facilities to be compatible with proposed drainage systems on adjacent properties. All existing and proposed drainage facilities shall be designed and constructed to be commensurate with Colorado Drainage Law documented in the Mile High Flood District (MHFD) *Urban Storm Drainage Criteria Manual*. The Contractor shall obtain approval from affected Local Agencies for any proposed -on-site drainage improvements that connect to or impact existing storm drains upstream or downstream of the Project. If existing drainage patterns or discharges must be changed or they increase above pre-project peak flow rates due to the design of the Project, the Contractor shall design and construct a solution that does not adversely impact CDOT or property owners outside the CDOT ROW or Easement areas. Where drainage patterns or discharges are changed from existing, the Contractor shall secure necessary approvals, permits, and additional Easements from Local Agencies and affected Stakeholders.

### 12.1 Administrative Requirements

#### 12.1.1 Standards

The Contractor shall design and construct the Project in accordance with the requirements of the standards in the documents listed in Table 12-1 and those referenced in Book 3. The Contractor shall use the latest adopted edition at the time of the Proposal Due Date.

**Table 12-1 Standards for Drainage**

<b>Author or Agency</b>	<b>Title</b>
CDOT	<i>Standard Specifications for Road and Bridge Construction (CDOT Standard Specifications)</i>
CDOT	<i>Standard Plans, M&amp;S Standards</i>
CDOT	<i>Drainage Design Manual (DDM)</i>
CDOT	<i>Erosion Control and Stormwater Quality Guide</i>
CDOT	<i>Design Bulletin Pipe Material Selection Policy</i>
CDOT	<i>Bridge Design Manual, Section 16—Hydraulics and Drainage</i>
Mile High Flood District (MHFD)	<i>Urban Storm Drainage Criteria Manual, Volumes I, II, and III (USDCM)</i>
Federal Emergency Management Agency (FEMA)	<i>National Flood Insurance Program Regulations (44 Code of Federal Regulations [CFR] Parts 59-80)</i>
Colorado Water Conservation Board (CWCB)	<i>Rules and Regulations for Regulatory Flood Plains in Colorado</i>
CWCB	<i>Floodplain and Stormwater Criteria Manual</i>
Otero County	<i>Resolution #2008-006 – Culverts, Road Access, Drainage &amp; Cattle Guards</i>
Las Animas County	<i>Las Animas County Land Use Regulations</i>
Park County	<i>Park County Land Use Regulations Article VII</i>
Fremont County	<i>Subdivision Regulations of Fremont County, Colorado</i>
Teller County	<i>Teller County Roadway Design and Construction Standards, Appendix G – Drainage Criteria</i>
El Paso County	<i>Drainage Criteria Manual of El Paso, Colorado</i>

**12.1.2 Design Guidelines**

Where the above standards do not address a certain design criterion or element, the design guidelines listed in Table 12-2 shall be used.

**Table 12-2 Design Guidelines for Drainage**

<b>Author or Agency</b>	<b>Title</b>
American Association of State Highway and Transportation Officials (AASHTO)	<i>A Policy on Geometric Design of Highways and Streets</i>

CDOT	<i>Erosion Control and Stormwater Quality Guide</i>
Federal Highway Administration (FHWA)	<i>Hydraulic Design Series (HDS) No. 4, Introduction to Highway Hydraulics</i>
FHWA	<i>HDS No. 5, Hydraulic Design of Highway Culverts</i>
FHWA	<i>Hydraulic Engineering Circular (HEC) No. 12, Drainage of Highway Pavements</i>
FHWA	<i>HEC-14, Design of Energy Dissipators for Culverts and</i>
FHWA	<i>HEC-15, Design of Roadside Channels with Flexible Linings</i>
FHWA	<i>HEC-18, Evaluating Scour at Bridges</i>
FHWA	<i>HEC-20, Stream Stability at Highway Structures</i>
FHWA	<i>HEC-21, Design of Bridge Deck Drainage</i>
FHWA	<i>HEC-22, Urban Drainage Design Manual</i>
FHWA	<i>HEC-23, Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance-Third Edition</i>

**12.1.3 Coordination with Other Agencies and Disciplines**

The Contractor shall coordinate all drainage related issues with affected regulatory agencies. The Contractor shall include CDOT in all contacts with appropriate regulatory agencies.

The implementation of the conceptual drainage plan, as described in the NEPA approval documents and PHRP, is dependent upon Agreements between CDOT and Third Parties. The Agreements between the third parties and CDOT have not been executed. The Contractor shall be responsible for coordinating Third Party Agreements for the Project per Book 2 Section 6 – Third Party Agreements.

**12.1.4 Permits**

The Contractor shall be cognizant of and adhere to the requirements of the various environmental and stormwater permits that are necessary for construction and operation of the Project. The Contractor shall follow the requirements of the latest CDOT Stormwater Management Plan (SWMP) template and appropriate specifications. The Contractor shall be required to obtain all permits, unless otherwise indicated. The listing herein is not all-inclusive and it shall be the responsibility of the Contractor to determine all of the permits required to perform the Work. Because CDOT is the landowner, CDOT is partially liable for any Contractor negligence. Fines may be incurred upon the Project for permit non-compliance by CDOT or other regulatory agencies. Any non-compliance fines will be passed onto the Contractor. The Contractor shall refer to Book 2 Section 5 - Environmental Requirements for additional requirements. If conflicts exist between requirements of Book 2 Section 5 – Environmental Requirements and this Section 12, the more stringent shall apply.

**12.1.4.1 Colorado Discharge Permit System – Stormwater Construction Permit (CDPS-SCP)**

Implementation of the permit requirements (i.e., SWMP, SWMP Site Map, and SPCC Plan) shall be a first construction item. Construction cannot begin until these items have been Accepted by CDOT. CDOT will review the Contractor's stormwater management activities throughout the duration of the Project for verification of compliance with the CDPS-SCP and Consent Order. The Contractor shall comply with the requirements in Book 2 Section 5 – Environmental and CDOT Standard Specifications, Sections 101, 107 and 208.

#### 12.1.4.1.1 Temporary Drainage

The Contractor shall be responsible for temporary drainage of each structure segment during construction to provide adequate drainage for each phase or stage of construction. The Contractor shall be responsible for the design and construction of temporary drainage of the Site for the duration of the Project. Temporary drainage shall comply with Project clear zone requirements. Temporary drainage shall be designed to avoid hydroplaning and icing for each phase or stage of construction.

The minimum size for temporary storm drains and cross drains shall be 12 inches. The minimum size of temporary underdrains shall be 4 inches. The Contractor shall be responsible for selection of material type for temporary drainage features. For any major drainage crossings, temporary pipe sizes shall be designed per the CDOT DDM.

The Contractor shall submit temporary drainage plans to CDOT for Acceptance in accordance with this Section.

Temporary drainage features shall be constructed in accordance with the Accepted temporary drainage plans for each phase or stage of construction. The Contractor shall continuously maintain temporary drainage features until removal. All temporary drainage features shall be removed when they are no longer required.

#### 12.1.4.2 Construction Dewatering Permit

Refer to Book 2, Section 5 – Environmental.

#### 12.1.4.3 U.S. Army Corps of Engineers Section 404 Permit

Refer to Book 2, Section 5 – Environmental.

#### 12.1.4.4 Other Regulations and Requirements

##### 12.1.4.4.1 Floodplain Regulations

The Contractor shall comply with all Local, State, and Federal Requirements associated with potential impacts to regulated floodplains. Regulated floodplains include the most recent flood hazard areas delineated on FEMA Flood Insurance Rate Maps (FIRM) (or Digital FIRMs [DFIRM]) or shown by more recent studies, local or regional master plans, or local floodplain maps. The Contractor shall obtain floodplain development permits (FDP), floodplain use permits (FPUP), no-rise certifications, and map revisions for impacts to floodplains crossing the Project. The Contractor shall obtain Approval for, and provide all technical analysis and supporting documentation for, necessary work in regulated floodplains as further described in this Section. The PHRP provide information regarding potential impacts to floodplains and anticipated regulatory processes for obtaining permits, no-rise certifications, and/or map revisions, as necessary.

##### 12.1.4.4.2 Senate Bill 40 Requirements

Refer to Book 2, Section 5 – Environmental, for additional requirements.

## 12.2 Design Requirements

### 12.2.1 Submittals

All submittals shall be prepared, Reviewed, and submitted in accordance with the requirements set forth in Book 2, Section 3.

### 12.2.2 Drainage Design Software

The following software (most recent or compatible versions) shall be used in performing drainage design calculations.

1. FHWA, HY-8
2. FHWA, Hydraulic Toolbox
3. Bentley, InRoads Storm and Sanitary
4. Bentley, FlowMaster
5. Bentley, CulvertMaster
6. Bentley, StormCAD
7. MHFD, MHFD-Detention v4.03
8. MHFD, MHFD-Culvert v4.00
9. MHFD, UD-Inlet v4.06
10. MHFD, UD Rational 2.00
11. MHFD, UD-BMP v3.07
12. Environmental Systems Research Institute (ESRI), Arc-Geographic Information System (GIS)
13. US Army Corps of Engineers, HEC- HMS
14. EPA Stormwater Management Model (SWMM)
15. Aquaveo LLC, Surface-Water Modeling System (SMS)
16. US Bureau of Reclamation (USBR), SRH-2D
17. US Army Corp of Engineers, HEC-RAS

All software used must be capable of creating summary tables for all individual input values and all individual output values (including all hydraulic losses) and summary tables of the accumulated results of the analyses at key locations in the system.

No software or spreadsheets created by the Contractor may be used without Acceptance by CDOT. The Contractor shall demonstrate the proposed alternative provides analyses and

results more adequately than the aforementioned software. Alternative software shall also provide results of comparable accuracy and reliability prior to CDOT Acceptance. CDOT is under no obligation to consider alternatives to Accepted software and spreadsheets.

### 12.2.3 Data Collection

The Contractor shall identify all drainage related issues using available data, including, but not limited to, requirements imposed by Local, State, and Federal Regulations and official documents concerning the Project.

The Contractor shall obtain all relevant storm drainage improvement plans, drainage planning studies, and drainage reports for the Project area from CDOT, FEMA, all Local Agencies, and appropriate ditch companies.

The Contractor shall obtain any existing and known projected future land uses from all Local Agencies, as necessary, to design facilities to be compatible with drainage systems, existing or proposed, on adjacent properties.

The Contractor shall perform detailed mapping and surveys, as required, to verify locations of existing drainage features necessary for the proposed drainage design. The Contractor shall further verify or identify boundaries, flow patterns, and land uses of drainage basins based on field observations.

### 12.2.4 Surface Hydrology

The Contractor shall perform hydrologic analyses for all on Site drainage basins and for all local off-site drainage areas immediately adjacent to the Project that contribute runoff to on-site drainage basins. Local, on-site drainage basins shall include those that manage runoff generated from the Project improvements. Local, off-site drainage basins shall include those contributing flow onto the Project where flow rates are not quantified by published documents. The analyses shall be based on known projected future land uses.

Preliminary hydrology was performed for the project and is included in the Reference Documents.

The Contractor shall perform hydrologic analyses for any locations where published design flow rates are not available or where changes in off Site drainage patterns or increased discharges are proposed as a result of the design of the Project.

#### 12.2.4.1 Design Frequencies

For all CDOT owned facilities, the design storm frequency shall comply with *Table 7.2, Table of Design Frequencies*, in the CDOT *Drainage Design Manual (DDM)* for rural areas. The design storm frequency for all cross drains shall be determined through the CDOT DDM and Approved by CDOT. The design storm frequency for all other roadways affected by the Project shall comply with the affected Local Agency's criteria.

#### 12.2.4.2 Precipitation

Precipitation data for all drainage analyses shall be obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, *Precipitation Frequency Atlas of the Western United States, Volume III, Colorado*.

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### 12.2.4.3 Hydrologic Methods

The Contractor shall perform the necessary hydrologic analyses using the following methods:

1. Areas less than 90 acres shall be evaluated using the Rational Method as described in the UDFCD *USDCM*. The minimum time of concentration shall be 10 minutes.
2. Areas greater than 90 acres shall be evaluated using methods described in the CDOT *DDM*.

### 12.2.5 Hydraulic Structures

#### 12.2.5.1 Roadways

Roadway component geometric configurations shall be designed to provide adequate drainage and minimize hydroplaning and icing. Roadway component geometric configurations shall be in accordance with the requirements of Book 2, Section 13.

##### 12.2.5.1.1 Roadway Profile

Longitudinal grades shall be in accordance with the requirements of Book 2, Section 13. Where there is curb and gutter or Guardrail Type 9 Single Sloped Barrier and the minimum profile grades cannot be maintained, flanking inlets shall be constructed, as required in the CDOT *DDM*.

##### 12.2.5.1.2 Allowable Flow Spreads

The Contractor shall design all Roadway storm drain systems including gutters, inlets, inlet spacing, catch basins, laterals, and trunk lines, using Section 13 of the CDOT *DDM*.

All other Roadways outside of CDOT ROW shall comply with the Local Agency's criteria.

##### 12.2.5.1.3 Edge Treatment

In areas where the Roadway pavement discharges runoff to Guardrail Type 9 Single Sloped Barrier or Type 3 W Beam Guardrail with curb, inlets, Type 3 Embankment Protectors or Type 5 Embankment Protectors shall be used to manage flow from the curb section, down the Roadway embankment and protect the embankment from erosion. Erosion protection shall be constructed at the outfalls.

##### 12.2.5.1.4 Roadside Ditches, Open Channels, and Slope Protection

For Roadside ditches along all existing and proposed Roadways, the design water surface profile shall have a minimum of 1 foot of freeboard, measured from the bottom of the Base Course to the water surface elevation, for the 10-year storm frequency peak discharge and shall not exceed edge of pavement for the 100-year storm frequency peak discharge. The Contractor is not responsible for analyzing or improving existing Roadside ditches that are not impacted or improved as part of this Project.

For infill sections and median ditches, the water surface profile elevation shall not exceed the edge of pavement for the 100-year storm frequency peak discharge.

All open channels within the Project shall be designed to capture and convey the 100-year

design flow, except at structure H-13-N, and designed in accordance with Chapter 8 of the CDOT *DDM*. Capacity shall be determined using Manning's Equation or backwater analysis at culverts, inlets, and other hydraulic structures.

All outside roadside ditch inverts shall be set at least 1 foot lower than the intersection of the ditch side slope with the bottom of the roadway pavement section to avoid routine exposure of the pavement section to routine ditch flows. Stabilized subgrade shall not be considered part of the roadway pavement section relative to this requirement.

All proposed Roadside ditches, swales, or other areas of concentrated flow shall be evaluated to determine the channel hydraulic shear stresses for 10-year design flows. Where hydraulic shear stresses are found to exceed the maximum allowable shear stresses, a Turf Reinforcement Mat (TRM) or riprap armoring shall be designed and placed to protect against the design shear stresses in the proposed ditch or channel facility. The maximum permissible shear stresses for a TRM Class 3 (CDOT *Standard Special Provision 216*) must meet or exceed the criteria identified in the CDOT *Erosion Control and Stormwater Quality Guide* or FHWA *Design of Roadside Channels with Flexible Linings, HEC-15*. Where slopes exceed the maximum allowable gradient of 5 percent or where the maximum allowable shear stress of 3.1 pounds per square foot is exceeded, embedded riprap armoring or other permanent erosion control treatment shall be designed and placed to protect against the design shear stresses in the proposed ditch/ channel facility.

Flexible channel linings shall be designed in accordance with FHWA *Design of Roadside Channels with Flexible Linings, HEC-15*. Riprap channel lining shall be designed in accordance with FHWA *Bridge Scour and Stream Instability Countermeasures, HEC-23, or the USDCM*.

All abandoned concrete diversion Structures in Roadside ditches and open channels shall be removed and disposed of off-site.

#### 12.2.5.2 Cross Drains

Cross drains shall be defined as pipes or culverts that convey water from one side of the Highway to the other. All cross drains shall be designed for the 100-year frequency peak discharge for the Project with no inundation of the Highway paved Shoulders or adjacent properties and no inadvertent detention or retention.

Hydraulic design of cross drains shall be based on the procedures included in FHWA HDS-5, *Hydraulic Design of Highway Culverts*. Hydraulic design data shall be listed on the final design and RFC Documents for each cross drain, including drainage area, peak discharges, allowable headwater elevation, and design headwater elevation.

The minimum allowable pipe size for cross drains shall be 36 inches in diameter. Flared end sections with toe walls or headwalls with beveled edges and wingwalls shall be provided for all cross drain pipe ends, regardless of size. Concrete aprons with a toe wall shall be installed at the ends of box culverts with the necessary scour protection. To reduce culvert sizes, improved inlets may be used. Improved inlets shall be designed based on FHWA HDS-5, *Hydraulic Design of Highway Culverts*.

All cross drain pipe Material shall comply with Section 624 – Drainage Pipe in the CDOT *Standard Specifications*.

Allowable headwater elevation for the 100-year frequency peak discharge shall be designed



as described in Chapter 9.2.2 of the CDOT *DDM*. In addition, allowable headwater elevation shall be limited by the minimum of the following:

1. Non-damaging to upstream or adjacent property.
2. Below outside edge of Roadway Shoulder elevation.
3. Headwater to depth ratio requirements shall be as shown in the CDOT *DDM*, Table 9.3.
4. No overflow to another drainage basin is allowed.

The use of sag pipes or inverted siphons shall not be allowed.

Cross drains shall be continuous and straight. Bends or turns will not be permitted.

Cross drains that are connected directly to off-site existing drainage systems shall have a manhole constructed inside and adjacent to CDOT ROW, to join the CDOT cross drain to the existing drainage system. Manholes shall be constructed of the appropriate size and type, according to the CDOT *DDM*.

All stormwater runoff, either from off-site or on-site areas, shall drain freely to an existing cross drainage or storm drain system.

#### 12.2.5.3 Storm Drains

Storm drains shall be defined as a network of pipes that connect inlets, manholes, and other drainage features to an outfall. Cross drains and side drains connected to the storm drainage system are considered part of the storm drain system for the purpose of determining the hydraulic performance of storm drains. Runoff generated from within the limits of the Project and/or draining onto the Project from off Site areas shall be collected and conveyed in a drainage system designed for the design frequencies included herein. The drainage system shall be designed to not worsen the existing conditions for properties outside the CDOT ROW or Easement. Ponding shall not be permitted within the Project.

Hydraulic analyses and plans for storm drains that are connected to existing storm drain systems upstream or downstream of the Project must be coordinated with affected Local Agencies. The hydraulic analyses shall identify the impacts to the existing storm drain systems caused by the connections and proposed combined peak design discharges for the overall systems. The Contractor shall obtain acceptance of the proposed design by Local Agencies affected by connections to their storm drain systems and for runoff leaving the Project.

The minimum allowable pipe diameter for storm drain systems shall be 18 inches.

All storm drain pipe Material shall comply with Section 624 – Drainage Pipe in the CDOT *Standard Specifications*.

The use of sag pipes or inverted siphons will not be allowed.

Storm drains shall not decrease in size in the downstream direction. From upstream to downstream, pipe diameters shall remain constant or increase. All bends and turns shall occur within a manhole or inlet.

The maximum allowable pipe diameter within Mechanically Stabilized Earth (MSE) strap zones shall be 30-inch outside diameter.

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#### 12.2.5.3.1 Hydraulic Design of Storm Drains

Storm drain system design shall be performed using hydraulic gradient analysis to account for all friction losses and minor losses. Friction losses shall be calculated using Manning's Equation. Minor losses at junctions, manholes, bends, and other appurtenances shall be calculated based on design procedures in FHWA *HEC-22, Urban Drainage Design Manual*.

Storm drains under the Highway shall be designed with the Hydraulic Grade Line (HGL) at or below the crown of pipe for the 10-year frequency peak discharge. The Energy Grade Line (EGL) shall be at or below the surface of pavement and inlet grates where the pipe is required to convey the 100-year frequency peak discharge. Local Agency criteria shall be followed for storm drain system design outside of CDOT ROW. The hydraulic and energy gradient for the minor (10-year) and major (100-year) design peak discharges shall be plotted for all storm drains in each storm drain profile.

The flow velocity of storm drains shall not be less than 3 feet per second for the 10-year frequency peak discharge and shall not be greater than 22 feet per second for the 100-year frequency peak discharge. This minimum storm drain flow velocity requirement may be waived, at CDOT's sole discretion, in locations where tailwater controls the flow and no alternative solution is evident.

#### 12.2.5.3.2 Storm Drain Alignment and Profile

Storm drain alignments shall be straight between Structures. Profiles of all storm drains shall be straight grades between Structures.

The Contractor shall comply with Local Agency criteria for storm drains outside CDOT ROW.

#### 12.2.5.4 Inlets

Inlets are required at locations to collect runoff within the design controls specified in this Section 12. In addition, there are locations where inlets may be necessary with little regard to contributing drainage area. These locations shall be designated on the plans prior to computations regarding discharge, water spread, inlet capacity, or bypass. Examples of such locations can be found in Chapter 13.4.2 of the CDOT *DDM*:

1. CDOT *M&S Standard Plans* inlets shall be used on all CDOT Roadways.
2. The following criteria apply to inlets:
  - A. Type C and Type D inlets shall not be allowed within the Roadway pavement limits unless used in conjunction with embankment protectors.
  - B. Vane grate inlets shall be used in the Shoulders of the Highway and shall not extend into adjacent travel lanes.
  - C. Close mesh grates shall be used for Type C and D inlets near pedestrian areas; concrete aprons shall be installed on Type C and D inlets.
  - D. Type 13 or Type C inlets shall be used in conjunction with valley pans.
  - E. Pursuant to the CDOT Design Guide, placement of drainage inlet grates should be avoided within a bicycle facility regardless of whether that facility is a bike lane, shoulder, or shared lane. If this is not possible, drainage inlet grates should

be replaced with bicycle-safe grates that maintain the required hydraulic capacity for the inlet. A bicycle-safe grate should have, at a minimum, bars perpendicular to the travel direction at a 4 inch center-to-center spacing.

3. Inlet hydraulic efficiency and spacing shall be determined based on design procedures in FHWA *HEC-22, Urban Drainage Design Manual*; 100 percent of the bypass flow shall be added to the next downstream inlet.
4. For a continuous storm drain system, maximum inlet spacing shall be designed based on allowable flow spread or the manhole spacing criteria, whichever is less.
5. The sag vertical curve or sump area on a Roadway requires an inlet at the lowest point and flanking inlets on each side of the lowest inlet to provide relief from debris clogging. Inlets shall be located such that the design criteria for spread are maintained.
6. Inlets are required 10 feet upstream from the point where the street cross slope begins to super-elevate toward the opposite side to minimize cross street flow. Bypass flow across the Highway shall be limited to 0.1 cubic foot per second (cfs) or less for the 10-year design frequency. Sump inlets shall not be placed at the zero point of the superelevation transition.
7. Trench drains will not be allowed in the traveled way or transverse to traffic flow on the Highway.
8. Inlets and inlet aprons shall not be located in the travel lanes of the Highway or CDOT Roadways.
9. A clogging factor of 50 percent shall be used for sizing single-unit inlet grates. A clogging factor of 10 percent shall be used for sizing single-unit curb opening inlets. For multiple-unit inlets, the clogging factor may be reduced as recommended in the UDFCD *USDCM, Volume I*, Chapter 7, Section 3.

#### 12.2.5.5 Maintenance Access Structures

Maintenance access Structures shall be incorporated into the storm drain system to provide access for inspection, cleaning, and other maintenance activities. Maintenance access shall be constructed at all junctions, changes in pipe size, drops, and grade changes. Maintenance access shall be provided at any change in horizontal alignment greater than 2 degrees. Maintenance access shall not be located in travel lanes of the Highway. Inlets should be used for maintenance access where permitted by pipe sizes according to the CDOT *DDM*.

A lateral that is less than half the size (inside diameter) of the trunkline, and no more than 75 feet long may be connected to the trunkline with a prefabricated pipe wye or tee connection. Larger laterals shall be connected to the trunkline with a maintenance access Structure.

The spacing of maintenance access Structures shall be in accordance with the criteria identified in the CDOT *DDM*. The spacing of maintenance access Structures outside of CDOT ROW shall be in accordance with Local Agency criteria. For storm drain diameters of 60 inches or greater, maintenance access Structures shall be located considering Site conditions that provide for staging of large-scale maintenance activities.

Maintenance access and junction Structure floors shall be shaped to fit the pipe inverts to

minimize hydraulic losses within the Structure.

Maintenance access Structures, junction Structures, and vaults in Roadside areas shall be designed to extend a maximum of 2 inches above the finished grade all around the Structure.

#### 12.2.5.6 Water Quality Control Measures

Not required for the Project.

#### 12.2.5.7 Off Site Drainage Systems

The Contractor shall assess the impacts of the increase in peak flows on the downstream system and provide the assessment as part of the drainage report to CDOT for Review and Acceptance. The report shall provide information regarding the source and amount of flows discharged off Site and the characteristics of the off Site system receiving the increase in peak flow. The report shall include options for mitigating the increase in peak flows to the off Site system. The report also shall include a record of communications with the owner of the off Site system and their stated position regarding the proposed design to address potential impacts due to the increase in peak flows.

The Contractor shall take immediate temporary action to mitigate potential impacts due to the increased peak flows while awaiting Acceptance for proposal to provide permanent mitigation of potential impacts.

The Contractor shall mitigate the increase in anticipated peak flow rates, if necessary, based on the Local Agency direction and as Approved by CDOT.

#### 12.2.5.8 Bridge Deck Drainage

See Book 2, Section 15 – Structures, for more information on Bridge deck drainage.

#### 12.2.5.9 Stormwater Pumping Stations

The use of stormwater pumping stations shall not be permitted.

#### 12.2.5.10 Drain Outfalls

Cross Drain and storm drain outfalls shall be designed such that the outlet elevation matches the receiving drainageway flowline. Outfalls shall be oriented in a downstream direction and designed to minimize existing habitat disturbances during construction.

Permanent erosion protection shall be provided at all outfalls and along the drainage flowlines where needed. Energy dissipaters shall be designed in accordance with FHWA *HDS-5, Hydraulic Design of Highway Culverts*, or UDFCD *USDCM, Design of Low Tailwater Riprap Basins for Storm Sewer Pipe Outlets*.

All drain outfalls require either a headwall or flared end section regardless of pipe size. All drain outfalls with a pipe diameter (or an equivalent diameter) of 36 inches or larger shall require toe walls. End sections or headwalls shall be used for drains 48 inches and smaller. A headwall shall be used for any drain 54 inches and larger. Saddle headwalls shall not be used. Concrete pipe joint fasteners for end sections shall be installed so that a minimum of

15 linear feet of the outlet end of the pipe are mechanically locked together.

The effect of tailwater in the receiving drainageway on the hydraulics of the outfall shall be evaluated. The design frequency of the tailwater of the receiving drainageway shall be based on the comparison of design discharge frequencies for coincidental occurrence included in FHWA HEC-22, *Urban Drainage Design Manual*.

Grouted boulder rundowns must extend down to bedrock or to at least 2 feet below the ultimate scour depth in the channel in the receiving water, whichever is less.

### 12.2.6 Scour and Erosion Control

~~Existing scour, rill, or channel erosion, slope failures, and areas with poor vegetative cover within the Project limits and areas caused by the Work shall be identified and corrected by the Contractor. Existing scour, rill, or channel erosion, slope failures, and areas with poor vegetative cover within the Project limits caused by the Work shall be identified and corrected by the Contractor.~~

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Bridges over drainageways shall be designed in accordance with the CDOT *DDM* and the CDOT *Bridge Design Manual*. Scour analyses shall be completed for all existing and proposed Bridges based on the procedures in the FHWA HEC-18, *Evaluating Scour at Bridges*, and HEC-20, *Stream Stability at Highway Structures*. Scour countermeasures shall be designed in accordance with the FHWA HEC-23, *Bridge Scour and Stream Instability Countermeasures: Experience, Selection, and Design Guidance-Third Edition*.

Outlet protection for culverts shall be designed in accordance with the standards of the *USDCM*, Chapter 9, Section 3 or FHWA HDS-5, *Hydraulic Design of Highway Culverts* or UDFCD *USDCM Design of Low Tailwater Riprap Basins for Storm Sewer Pipe Outlets*.

The following minimum criteria apply to riprap layer thickness:

1. Thickness shall not be less than the spherical diameter of the D100 stone or less than 2.0 times the spherical diameter of the D50 stone, whichever results in the greater thickness.
2. Thickness shall not be less than 12 inches for practical placement.
3. The thickness determined by the criteria above, shall be increased by 50 percent where the riprap is placed underwater to provide for uncertainties associated with this type of placement.
4. Stones greater than the D100 spherical diameter shall not be used.
5. Minimum D50 shall not be less than 9 inches.
6. Geotextile (Drainage) (Class 1) shall be used under all riprap per CDOT M&S Standards.

### 12.2.7 Subsurface Drainage Systems

Where needed, subsurface drainage systems (e.g., underdrains, edge drains) shall be designed in accordance with the CDOT *DDM*. Subsurface drainage systems shall not be discharged to the stormwater systems, with the exception of open channel conveyances.

Groundwater may be encountered during construction of this Project. If groundwater is day-lighted to the ground surface via storm drains (point source), a Subterranean Permit from CDPHE shall be required.

Upon completion of the Project, the permit shall be transferred to CDOT. The Contractor shall be responsible for obtaining the permit. Refer to Book 2, Section 5.

If underdrains are found to exist in certain locations, the Contractor shall preserve the capacities and functionality of all existing groundwater drains encountered during construction or replace drains if impacted by construction. Geotechnical investigations conducted for the Project are provided in the Reference Documents.

If the Contractor encounters wells or springs within the Project limits, the Contractor shall protect the flow quantity, water quality, access, and availability of the wells and springs during and after construction.

### 12.2.8 Irrigation Facilities

All irrigation ditches, canals, and laterals crossing the Project shall be protected and preserved in place, or reconstructed as needed to accommodate the Project, and the Contractor shall ensure all facilities are maintained so that normal ditch operations are uninterrupted. The Contractor shall coordinate with the appropriate owners to identify and mitigate any potential disturbance to the irrigation facilities or operations. All irrigation facilities impacted by the Project shall be cleaned prior to Final Acceptance.

The Contractor shall limit stormwater discharges to irrigation ditches to be equal to or less than pre- Project discharges.

See Table 12-3 for a summary of irrigation facilities affected by the Project.

**Table 12-3 Irrigation Summary Table**

Location	Irrigation Type	Irrigation Ditch Name	Irrigation Owner
US 350 (MP 69.817)	Canal	Otero Ditch	Otero Ditch Company
SH 239 (MP 1.74)	Canal	Picketwire Ditch	Picketwire Ditch Company

### 12.2.9 Floodplains

The Project will impact several FEMA and/or locally regulated floodplains (1-percent and 0.2-percent annual chance) associated with at least seven flooding sources. Several other flooding sources do not have a FEMA/local regulated floodplain. The floodplains and the anticipated regulatory requirements are discussed in more detail in the PHRP. The Contractor shall comply with all local, State, and federal regulations associated with the proposed modifications located in regulated floodplains. Receiving Approval of required floodplain permits, no-rise certifications, and map revisions will require close coordination with CDOT and the local agencies to comply with local agencies' permit applications and submittal requirements. Local agencies affected or potentially affected by the proposed changes to a regulatory floodplain shall be notified and

approve of the proposed changes.

The Contractor shall obtain Floodplain Development Permits and/or other similar permits from the appropriate local agencies for any Work associated with the Project that is within or will impact regulated floodplains prior to any grading and/or construction within the limits of the regulated floodplains. The Contractor shall provide all additional surveying, analyses, recertification, and mapping required to document proposed and constructed changes to the regulated floodplains.

Where applicable and required by local and/or FEMA regulations, the Contractor shall obtain Approval of Conditional Letter of Map Revisions (CLOMRs) and/or no-rise certifications prior to commencing work within the regulated floodplains. Upon completion of construction in the floodplains, the Contractor shall obtain As-Built data reflecting all changes located in the floodplain. The Contractor shall utilize the As-Built data to compile and submit Letter of Map Revisions (LOMRs) and no-rise recertification for local review and acceptance. After local acceptance, CLOMRs (if required) and LOMRs shall be submitted to FEMA for final review and Approval. The Contractor shall be responsible for the schedule, all local agency and FEMA submittal/review fees associated with the permit applications, and flood map revision requests.

The anticipated primary and adjacent jurisdiction local review agencies for the floodplain permitting, no-rise certification, and FEMA map revisions and their respective administrative contacts are shown in Table 12-4.

**Table 12-4 Anticipated Local Agency Floodplain Jurisdiction Contacts for the Project**

Structures in Zone A Floodplains	Flooding Source	Local Jurisdiction	Contact	
			Name	Telephone
G-12-C	Middle Fork South Platte River	Park County	Jenny Gannon	(719) 836-4292
H-13-N	Middle Fork South Platte River			
J-14-C	Louis Gulch			
M-21-I	Unnamed	Otero County	Lex Nichols	(719)383-3038
M-21-B	Lone Tree Arroyo			
M-21-C	Hoe Ranch Arroyo			
N-21-F	Sheep Canyon Arroyo			
I-17-X	Upper Fountain Creek	El Paso County	Keith Curtis	(719)327-2898

**12.2.10 Project and Area-Specific Drainage Requirements and/or Information**

**12.2.10.1 Structures in Non-Regulatory Floodplains**

The Contractor shall model the existing 100-year floodwater surface for all structures. The proposed structures must limit the allowable maximum rise of backwater to less than 1-foot and shall not cause increased flood damage to properties insurable to under the National Flood Insurance Program (NFIP). The existing and proposed elevations of the 100-year floodwater surface shall be documented in the sealed Final Hydraulics Reports for CDOT Acceptance.

The Contractor shall verify decreed flows with the irrigation canal companies.

The Twin Creek is directly downstream of structures I-15-AO and I-15-T. Impacts to the hydraulic conditions of the structures due to tailwater conditions from Twin Creek flows must be included in the hydraulic design of these structures.

#### 12.2.10.2 Structures in Regulatory Floodplains

The Contractor shall model the existing 100-year Base Flood Elevations (BFE) for all structures. The proposed structures must limit the change in BFE to less than +/- 0.5 feet per CWCB Rules and Regulations and shall not cause increased flood damage to properties insurable to under the National Flood Insurance Program (NFIP). The Contractor shall coordinate with Floodplain Administrators and complete the CLOMR/LOMR process if necessary. The existing and proposed elevations of the 100-year BFE shall be documented in the sealed Final Hydraulic Reports for CDOT Acceptance.

It has been determined that at segment H-13-N that passage of the 100-year flow cannot be achieved within the scope of this Project. The structure shall be replaced in-kind and not change the floodplain base elevation. The Contractor shall obtain a no-rise certification from the floodplain administrator prior to commencing work. Variances to the DDM requirements shall be documented in the sealed Final Hydraulics Report for CDOT Acceptance. The Contractor shall assist CDOT in development of a Safety Plan for the Roadway and structure overtopping that includes signage, maintenance response requirements, etc. The Safety Plan will be reviewed by FHWA.

#### 12.2.10.3 Structures used for Cattle Crossings

Structures listed as known cattle crossings in Book 2, Section 15 – Structures, shall meet the requirements for stock passes in the CDOT *DDM*.

### 12.3 Construction Requirements

The Contractor shall map all new and existing (remaining) outfalls for inclusion into CDOT's GIS system.

The Contractor shall resolve all conflicts between Utilities and proposed drainage improvements in accordance with Book 2, Section 7 – Utilities.

#### 12.3.1 Pipe Material Selection Policy

The Contractor shall comply with the CDOT *Design Bulletin Pipe Material Selection Policy*, except where required pipe Materials are specified herein. The most current version, as signed by the CDOT Chief Engineer at the time of the Proposal Due Date, shall be utilized.

Clarifications of the CDOT *Pipe Material Selection Policy* are as follows:

1. The Contractor shall sample soil and water.



2. References to "Project Manager" in the Guide shall be the Contractor.
3. The Contractor shall provide a sampling schedule for pipe selection to CDOT for review 30 Days after issuance of the First Notice to Proceed (NTP1).
4. Pipe material selection report shall be submitted as part of the Drainage Reports.
5. Storm Drains that are both parallel to and within the strap zone of retaining walls shall be solid wall plastic conduit.

## 12.4 Deliverables

### 12.4.1 Drainage Reports

#### 12.4.1.1 Final Hydraulics Reports

The Contractor shall prepare a Final Hydraulics Report for each proposed structure. The purpose of the Final Hydraulics Reports is to document hydrology and hydraulic analysis and design for each structure. The Final Hydraulics Reports shall be prepared by the Contractor and submitted to CDOT for Acceptance prior to RFC.

#### 12.4.1.2 Documentation Procedure

Hydraulics Reports shall follow the documentation procedure in Chapter 4 of the CDOT *DDM* and shall include the following:

1. Basic design data, design assumptions, hydrologic and hydraulic methodologies, assumptions, model inputs and outputs, detailed calculations, computations and computer printouts, relevant design criteria, circumstances influencing design, discussion of all drainage issues and drainage facilities, appropriate maps, figures, and plans.
2. Rationale for sizing and selection of all drainage elements, including, but not limited to, catch basins, storm drain systems, cross drains, ditches, swales, detention/infiltration facilities, and pipe Materials selection.
3. Hydraulic data sheets with a summary of hydraulic design information for each storm drain and cross drain.
4. A delineation of contributing basins, existing drainage patterns for both Highway and cross- drainage flows, drainage parameters, discharge characteristics, and other information necessary for the design of the drainage system; all drainage reports shall include documentation of tributary flows from areas outside of each construction segment, as defined by the Contractor.
5. Documentation that the proposed runoff will be controlled and treated in accordance with this Section 12 and all drainage Permits.
6. Documentation of existing drainage discharge rates, outfall locations, and pond release rates.
7. Documentation of the impact of proposed drainage designs on existing drainage facilities.

In addition to the documentation procedure in Chapter 4 of the CDOT *DDM*, the Contractor shall follow the report outline below. The section and subsection headings shall be maintained at a

minimum. If a section or subsection is not used, the reason it is not applicable to the Project shall be specified. New sections or additional subsections shall be added as necessary to fully document the drainage design.

### 12.4.1.3 Hydraulics Report Outline

The Hydraulics Reports shall use the report outline below as guidance. The report outline shall also address the documentation requirements set forth in Chapter 4 of CDOT's *DDM*. New sections or additional subsections shall be added as necessary to fully document the design:

1. TABLE OF CONTENTS
2. INTRODUCTION
  - A. Location of Improvements
  - B. Description of Improvements
  - C. Discussion of Drainage Investigation
3. CROSS DRAINAGE, DRAINAGEWAY, AND IRRIGATION DITCH CROSSINGS
  - A. Location and General Discussion
  - B. Hydrology and Design Flow Development
    - i. Information Sources
  - C. Agency Coordination (i.e., FEMA, Local Agencies)
  - D. Description of Structural Design (i.e., for non-CDOT standard concrete box culverts)
  - E. Hydraulic Design
  - F. Irrigation Ditch Crossings
  - G. Drainageways and Floodplains
  - H. Scour Analysis
  - I. Bank Stabilization
4. ROADWAY DRAINAGE SYSTEMS
  - A. General Discussion
  - B. Design Coordination
    - i. Adjacent Segments
    - ii. Agency Coordination
  - C. Drainage Basin Delineations and Characterization
    - i. Existing Basins
    - ii. Proposed Basins
  - D. Hydrology and Design Flow Development
  - E. Pavement, Median and Roadside Drainage
    - i. Inlet/Catch Basin Spacing Design
    - ii. Storm Drain Design
    - iii. Roadside Ditch and Channel Design
    - iv. Erosion Control Design

5. PERMANENT BEST MANAGEMENT PRACTICES

- A. Assumptions and Methodologies
  - i. Allowable Release Rate Discussion
- B. Hydrology and Hydraulics
  - i. Storage and Outlet Design Documentation

6. REFERENCES

7. APPENDICES

- A. Hydrologic Analysis
  - i. On Site Hydrology
  - ii. Off Site Hydrology
  - iii. Precipitation Data
  - iv. Soil Survey
  - v. Land Use
  - vi. FEMA Maps
- B. Hydraulic Analysis
  - i. Spread width, Inlet and Storm Drain Calculations
  - ii. Roadside Ditch and Channel Calculations
  - iii. Hydraulic Grade Line Calculations
  
  - iv. Drain Outfalls, Scour and Erosion Control Calculations
  - v. Sub-Drainage Systems
- C. Basin Maps
  - i. Existing and Proposed On-Site Basin Maps
  - ii. Off-Site Basin Maps (full size 22-inch by 34-inch sheets)
- D. Floodplain Development Permits and Map Revision Documentation
- E. Maintenance Exhibit

The Contractor shall submit to CDOT the Final Hydraulics Reports for Acceptance. All Hydraulics Reports shall be signed and sealed. The Contractor also shall submit to CDOT an electronic copy of all signed and sealed drainage reports in a format compatible with Adobe .PDF. All hydraulics reports shall include electronic copies of all computer analysis input and output files in the native file format.

#### 12.4.2 Water Quality Reports

Not required for the Project.

#### 12.4.3 Drainage Design Plans

The Contractor shall prepare plans for all drainage-related facilities for the Project in a format that follows the documentation procedure in the CDOT *DDM* Chapter 4, the CDOT *CADD Manual*, and the CDOT *Drafting Manual*.

The Contractor shall submit all applicable plans with each hydraulics report. The Contractor shall include the following for all drainage plan deliverables:

1. PLAN VIEW
  - A. Provide the location of all existing and proposed storm drains. Provide a label for each proposed storm drain location. The Contractor shall establish a labeling

system that is specific to each proposed storm drain system and provide a table to summarize all pertinent information. The table shall include, at a minimum, the drain line and sheet number where the profile can be found.

- B. Provide the location of all existing and proposed inlets, maintenance access Structures, end sections, and outlet protection. Provide a label for each proposed inlet, manhole, end section, outlet structure, and outlet protection. Include a table that summarizes all pertinent information. The table shall include, at a minimum, the label identification (ID), station and offset, item, length, pay depth, and notes.
- C. Provide all existing and proposed grading.
- D. Provide all Utility locations and Relocations.
- E. Provide location of ROW lines.

## 2. PROFILES

- A. Provide profiles for all proposed storm drains. Include the label ID from plan view sheets, station and offset, invert elevations, rim elevations, structure depth, slopes, sizes, Material, Utility crossings, existing and proposed finished grade lines, the design flow for the 10-year and 100-year event, and the calculated HGL and EGL for the 10-year and 100-year event.
- B. Provide profiles for all proposed cross drains. Include the label ID from plan view sheets, station and offset, invert elevations, slopes, sizes, material, utility crossings, and existing and proposed finished grade lines. Provide the drainage area of contributing basin, 50 and 100 year design discharge, tailwater, and headwater elevation on all applicable profile sheets for cross drains.

## 3. DRAINAGE DETAILS

- A. Include details for all non-standard CDOT items.

### 12.4.4 Drainage As-Constructed Documents

The Contractor shall provide accurate as-constructed survey of the constructed drainage systems for the Project per the requirements of Book 2, Section 9.

The Contractor shall submit As-Constructed Documents to CDOT for Acceptance per the requirements of Book 2, Section 3.

Clearly label and locate all items of Work with station, offset, coordinates, and elevation information based on surveys of what was actually built in the field. Provide summaries of all As-Constructed drains with the following hydraulic information, at a minimum: pipe/culvert size, invert elevations and slope.

### 12.4.5 Floodplain Design and Permitting Reports

The Contractor shall provide analyses and reports documenting the design and impacts of all Project-related improvements and changes located in the 1-percent (100 year) and 0.2-

percent annual chance (500-year) floodplain and the Project's compliance with Federal, State, and local floodplain management regulations. The Contractor shall provide a combined hydraulic design and floodplain permitting report. A separate report shall be provided for each flood hazard area identified along the Project.

#### **12.4.5.1 Floodplain Improvements Report**

##### **12.4.5.1.1 Certification of No-Rise in the Base Flood Elevation**

All proposed work in regulated flood fringe or floodways is considered floodplain development work and must be preceded by an approved local agency permit, commonly referred to as a Floodplain Development Permit (FDP) or Floodplain Use Permit (FPUP). Each permit request must be supported by certifiable evidence from a Professional Engineer licensed to practice in the State of Colorado. All proposed floodway activities must be certified to cause no-rise in the base flood elevation (BFE) shown on the current effective work map, or in the most recent study or work map provided by local agencies, State agencies, or FEMA for a given watershed. If no-rise cannot be proven by hydrologic and hydraulic analysis in accordance with standard engineering practices, then a CLOMR must be prepared to quantify impacts to upstream and downstream BFEs for review, comment, revision, and ultimate Approval by the governing local agency or agencies and FEMA.

##### **12.4.5.1.2 Conditional Letter of Map Revision (CLOMR)**

The Contractor shall prepare a CLOMR Report and submit it to CDOT for Acceptance concurrent with the Preliminary (60% Level) Plan Package. The CLOMR shall document the proposed project's hydraulic design, floodplain impacts, and compliance with all applicable floodplain regulations, as discussed in this Section.

##### **12.4.5.1.3 Interim Hydraulic Design and Floodplain Permitting**

If changes are made to design conditions approved with the CLOMR, the Contractor shall provide an addendum to the CLOMR that documents the changes and their compliance with Federal, State, and local floodplain management regulations.

##### **12.4.5.1.4 Letter of Map Revision (LOMR)**

The Contractor shall prepare a LOMR Report and submit it to CDOT for Acceptance prior to Notice of Final Acceptance. The Contractor shall include a summary index that documents all physical Project changes and their floodplain impacts from the CLOMR Report to the LOMR Report. The LOMR shall document the As-Built Project's hydraulic analyses, floodplain impacts, and compliance with floodplain regulations, as discussed in this Section. Survey information will be required and must be sealed by a Professional Land Surveyor licensed to practice in the State of Colorado as certifiable material supporting all LOMR analyses. Any violations of or inconsistencies with local, State, or Federal floodplain standards will require analytical revisions and/or on-the-ground mitigation after construction at the Contractor's expense.

##### **12.4.5.1.5 Floodplain Improvements Report Content**

The hydraulic design portions of the reports shall provide the documentation supporting the applicable parts of the analyses documented in Chapters 10 and 17 of the CDOT DDM and other design criteria and guidelines for road and bridge design in riverine environments. The floodplain permitting portions of the reports shall provide the documentation supporting compliance with Federal, State, and local floodplain regulations, as discussed in this Section.

In general, the Floodplain Improvements Report shall describe the following:

1. Project Description
2. Background Information
3. Topography, Aerial Photos, and Mapping Sources/Information
4. Hydrology
5. Hydraulics
6. Modeling Results
7. Regulatory Compliance
8. References

#### 12.4.5.2 Floodplain Improvements Report Outline

The Floodplain Improvements Reports shall follow the report outline below. New sections or additional subsections shall be added as necessary to fully document the hydraulic design and the floodplain permitting compliance.

##### TABLE OF CONTENTS

- I. INTRODUCTION
  - 1.1 Background
    - 1.1.1 Definitions of Project Reach, Study Limits, and Model Limits
  - 1.2 Previous Studies
    - 1.2.1 Effective Condition
    - 1.2.2 Best Available
  - 1.3 Topographic Mapping and Vertical Datum Considerations
    - 1.3.1 Effective Condition
    - 1.3.2 Corrected/Existing/Pre-Project
    - 1.3.3 Revised/Post-Project Condition
  - 1.4 Purpose of Study
- II. HYDROLOGY
  - 2.1 Effective Regulatory
  - 2.2 Previous Flooding History Other/Local/Best Available Hydrology
  - 2.3 Other/Local/Best Available Hydrology
  - 2.4 Discharge Probability (in support of construction crossings and low flow channel designs)
- III. EFFECTIVE CONDITION
  - 3.1. Published Effective Condition
  - 3.2 Duplicate Effective Condition
- IV. CORRECTED EFFECTIVE CONDITION (or EXISTING CONDITION if no CORRECTED)
  - 4.1 Model Development
  - 4.2 Floodplain Results
  - 4.2 Floodway Results

V. DESIGN CRITERIA AND DISCUSSION

- 5.1 Local Criteria
  - 5.1.1 City/County
- 5.2 State Criteria and Guidelines
  - 5.2.1 Colorado drainage law
  - 5.2.2 CWCB
  - 5.2.3 CDOT
- 5.3 Federal/National Criteria and Guidelines
  - 5.3.1 FEMA
  - 5.3.2 FHWA and ASSHTO
- 5.4 Selected Bridge Design Criteria and Parameters

VI. PRELIMINARY DESIGN SUMMARY/HYDRAULIC EVALUATION FINAL DESIGN ALTERNATIVES

VII. HYDRAULIC DESIGN OF SELECTED BRIDGE OPTION (POST-PROJECT)

VIII. SCOUR EVALUATIONS

IX. SCOUR MITIGATION

X. REVISED CONDITION HYDRAULIC EVALUATION AND FLOODPLAIN PERMITTING

- 10.1 Floodplain Results and Comparisons
- 10.2 Floodway Results and Comparisons
- 10.3 Compliance with Local, State, and Federal Regulations
  - 10.3.1 Local—Codes/Ordinances, Local Permits/Applications
  - 10.3.2 State—CWCB Rules and Regulations
  - 10.3.3 Federal—NFIP Regulations (44 CFR), Endangered Species Act (ESA, for CLOMRs Only), No-Rise Certification, draft MT-2 Forms, Property Owner Notifications

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Appendix 2.0 Pre-Project Hydraulics

- Appendix 2.1 Input Data
- Appendix 2.2 Hydraulic Comparison Tables (Effective Condition, Duplicate Effective Condition, Corrected Effective Condition, and Existing Condition)
- Appendix 2.3 Hydraulic Work Maps

Appendix 3.0 Hydraulic Design Criteria

- Appendix 3.1 Local—City/Town/County of ....

Appendix 3.2 State of Colorado Criteria and Guidelines

Appendix 3.2.1 CWCB

Appendix 3.2.2 CDOT

Appendix 3.3 Federal/National Criteria and Guidelines

Appendix 3.3.1 FEMA

Appendix 3.3.2 FHWA and AASHTO

Appendix 4.0 Hydraulic Analyses of Proposed Project

Appendix 4.1 Alternative Evaluations (if applicable)

Appendix 4.2 Selected Configuration of Improvements (Post-Project, Revised Condition)

Appendix 4.2.1 Hydraulic Comparison Tables

Appendix 4.2.2 Hydraulic Work Maps

Appendix 5.0 Scour Evaluations

Appendix 5.1 Geotechnical and Hydraulic Inputs

Appendix 5.1.1 Geotechnical Report (Hardcopy Excerpts—Complete Copy on Disk)

Appendix 5.1.2 Hydraulic Inputs

Appendix 5.2 Scour Calculations

Appendix 5.2.1 General Scour-Aggradation/Degradation, Long-Term, and Contraction

Appendix 5.2.2 Local Scour-Piers, Abutments

Appendix 5.2.3 Scour Profile Plot

Appendix 6.0 Scour Mitigation

Appendix 6.1 Riprap Calculations

Appendix 6.2 Sample Riprap Design Details

Appendix 6.3 Riprap Configuration

Appendix 7.0 Design Drawings - Hydraulic Excerpts

Appendix 8.0 Floodplain Permitting

Appendix 8.1 MT-2 Forms (including ESA Compliance, Annotated Firm Panel(s))

Appendix 8.2 Certifications of Compliance with Floodplain and Floodway Regulations

Appendix 8.3 Property Owner Notification(s)

Appendix 8.4 City/County Floodplain Development Applications/Permits

Appendix 8.5 Correspondence/Meeting Minutes

Appendix 9.0 HEC-RAS Models (Report and Hydraulic Models)

Appendix 9.1 HEC-RAS Model/Project/Plan Summary Descriptions

Appendix 9.2 HEC-RAS Design Model

Appendix 10.0 Disk (Report and Hydraulic Models)



**12.5 Deliverables**

At a minimum, the Contractor shall submit the following to CDOT (and all applicable review agencies) for Review, Acceptance, or Approval:

**Table 12-5 Deliverables**

<b>Deliverable</b>	<b>Review, Acceptance, or Approval</b>	<b>Schedule</b>
Temporary Drainage Plans	Acceptance	Within 14 Days prior to the implementation of each TCP
Sampling Schedule for Pipe Selection	Review	30 Days after issuance of NTP1
Final Hydraulics Report	Acceptance	Prior to RFC
Revised Final Hydraulics Report (as required)	Acceptance	Prior to Project Final Acceptance
Floodplain Improvements Report – West Fork South Platte River (Structure G-12-C)	Acceptance	As part of the Final RFC Documents submittal
Floodplain Improvements Report – West Fork South Platte River (Structure H-13-N)	Acceptance	As part of the Final RFC Documents submittal
Floodplain Improvements Report – Louis Gulch (Structure J-14-C)	Acceptance	As part of the Final RFC Documents submittal
Floodplain Improvements Report – Lone Tree Arroyo (Structure M-21-B)	Acceptance	As part of the Final RFC Documents submittal
Floodplain Improvements Report – Hoe Ranch Arroyo (Structure M-21-C)	Acceptance	As part of the Final RFC Documents submittal
Floodplain Improvements Report – Sheep Canyon Arroyo (Structure N-21-F)	Acceptance	As part of the Final RFC Documents submittal
Floodplain Improvements Report – Fountain Creek (Structure I-17-X)	Acceptance	As part of the Final RFC Documents submittal
Floodplain Improvements Report – Unnamed Wash (Structure M-21-I)	Acceptance	As part of the Final RFC Documents submittal
FEMA Approved CLOMR (as required)	Acceptance	Prior to RFC Documents
FEMA Approved LOMR (as required)	Acceptance	Prior to Final Acceptance
Drainage As-Constructed Documents	Acceptance	Per the requirements of Book 2, Section
Temporary Drainage As-Constructed Documents	Acceptance	To be maintained during the duration of the Project