

## 4 DRAINAGE ANALYSIS & DESIGN ASSESSMENT

As mentioned in the foreword, this project is composed of two separate segments, Connection and 302 North, that each started as individual projects and were combined into a single project. Below is a general description of the drainage design for each segment. Appendix A and Appendix B contain all the design calculations for the Connection and 302 North segments, respectively.

### 4.1 302 North

In general, roadside ditches are proposed to capture and convey runoff to cross culverts under US 550. At the start of the 302 North project the roadside ditches were designed to convey flows to specific locations for water quality treatment. These water quality facilities have since been removed with the change in permanent water quality needs for the project. However, the roadside ditches have not been revised. The final drainage design shall take into consideration maintaining the historical drainage patterns and adjust the proposed drainage design to avoid adverse impacts to adjacent property owners.

### 4.2 Connection

Initial drainage design for the Connection project included proposed drainage swales to capture and convey offsite drainage to culverts that carried flows under US 550. Additionally, the design included separate onsite ditches to MS4 PWQ facilities for treatment of onsite impervious areas. Since the change in PWQ requirements some of these ponds have been eliminated while others are still being shown in the design.

#### **Farmington Hill**

The existing US 550 roadway between CR 220 and the existing at-grade intersection with US 160 is commonly referred to as Farmington Hill. This portion of roadway will be abandoned as a part of this project. The existing culverts under the roadway that convey flows into Wilson Gulch must remain in-place in order to maintain existing flow patterns.

#### **Existing US 160/550 Intersection**

With the abandonment of US 550 at US 160, the existing signal will be removed, US 160 will be restriped, and a new median will be installed on US 160. The existing inlets on US 160 are anticipated to be removed and replaced as needed to meet allowable street capacity. The proposed inlets shall maintain conveyance of runoff to Wilson Gulch.

### 4.3 Ditch Design

Typical drainage and ditch cross sections have been included in **Appendix B** to illustrate the required additional width beyond the shoulder necessary to accommodate the proposed ditches. Ditch geometry shall be in accordance with the requirements in Book 2, Sections 12 and 13 of the RFP to meet clear zone, freeboard, and subsurface drainage requirements. Generally, outside ditches will be 3-feet deep with 6:1 foreslopes and 4:1 backslopes and median ditches will have 6:1 side slopes.

Ditches have generally been sized to convey the maximum flowrate reached within a given swale section and may therefore be oversized near the upper ends of a basin. In final design, the swales should be refined to more closely reflect the necessary capacity at any point along the flow route. In addition to geometric refinements, shear stresses should be evaluated at critical ditch locations to determine the appropriate soil retention measures necessary to stabilize the ditches prior to the establishment of

vegetation. Offsite drainage basins that intersect fill slopes such that storm flows will be concentrated within the “valley” section adjacent to the fill, also require further design.

#### 4.4 Storm Drainage Facilities

The realignment and widening of US 550 requires new culverts to meet the criteria set forth in the *CDOT’s Drainage Design Manual*. Cross culverts are sized to a minimum of 36 inches with all other drainage pipe sized to a minimum diameter of 18 inches. New drainage structures convey flows under both the southbound and northbound lanes of the proposed highway, under the frontage road where present, and collect and convey flows from within the depressed median areas. The proposed storm drainage for both the Connection Segment and the 302 North segment and MS4 systems for the Connection Segment meet all applicable CDOT criteria for roadway spread width, storm sewer capacity, and cross culvert headwater limits. Drainage plans showing the proposed preliminary storm drainage for both segments and MS4 infrastructure for the Connection Segment are included in **Appendix B**. The 50-year flow rates for all proposed drainage pipes can be adequately conveyed by the sizes proposed in the plans without exceeding CDOT headwater or HGL criteria. Supporting documentation related to the storm sewer and cross culvert hydraulic designs are included in **Appendix B**.

The outfalls for culverts and storm drain system outlets require standard CDOT Pipe Outlet Paving per M-601-12 to protect against erosion. Near the bridge abutments or where flows from pipe outlets are conveyed into drainage swales; the intent is to extend the application of the M-601-12 detail as far as necessary to adequately cover the area of protection required. Additional detailing will be needed during final design to more fully establish the limits and the specific protection required in each of these areas.

#### 4.5 Irrigation

##### **Ditches and Culverts**

Irrigation ditches cross through the proposed alignment multiple times. Without known flows, all irrigation ditch culverts crossing US 550 have been sized to be 36” pipe. To reduce the impacts to existing irrigation ditches, roadside swales have been replicated in similar locations and pipes have been aligned to tie in upstream and downstream to the ditches as closely to historic paths as possible. If the irrigation crossing culvert slopes exceed 5% due to the steep terrain of the areas, a manhole has been added to the line where the difference in elevation results in a pipe velocity exceeding 16 fps, elevation difference exceeds 20 feet, and/or the culvert layout requires a bend. All irrigation pipes include a riprap pad designed according to CDOT M-601-12 in the M&S Standard July 2012 edition.

##### **Stock Pond**

The relocated US 550 alignment results in impact to an existing, privately-owned and maintained stock pond, near Station 991+50 RT, on the Marie J Webb Ranch parcel. To maintain the existing drainage pattern, which hydraulically links 3 irrigation ponds in series, a new irrigation pond of the same approximate size and volume is required. The proposed pond will remain outside CDOT’s right of way and will be owned and maintained by the property owner. The outfall for the pond is an overflow swale flowing south to an irrigation culvert at 986+20. This will maintain the existing flow path and outfall under US 550 through the proposed pipe, which reconnects it to the existing flow path.

### **Piccoli Pond**

The existing pond on the Piccoli property near Station 986+00 will be filled in at the request of the landowner. Currently, this pond receives irrigation overflow from the series of three stock ponds located on the east side of US 550 on the Webb property. Rather than outflow directly into the pond before outfalling down the edge of the mesa, the flows will now outfall into a small swale, carried under an access road in a culvert and then outfall over the side of the mesa in a location similar to the existing location. Riprap protection has been included in the design at this location to protect the slope.

## **4.6 Wildlife Crossings**

### **Small Mammal Crossings**

Small mammal crossing are spaced approximately every 750 ft along the US 550 corridor. They are designed to be an average of 48 inches in diameter with 1 foot of native material filled above the invert. The crossings are not assumed or designed to convey flows from storm events. The small mammal crossings require minor grading at pipe entrances as well as minor ditch rerouting to reduce the likelihood of flows entering the culvert. Small mammal crossings will need to extend outside of specified roadway clear zone (30 foot) due to the height of the culvert exposed exceeding 2 ft.

The 3 vertical foot protrusion introduces the pipe ends as hazards to vehicular traffic. If it is not feasible to extend small mammal crossings outside of clear zone to remove the hazard, the option to reduce the culvert size to 36 inches with the same 1 foot of native material remains. This option would reduce the vertical protrusion to 2 foot vertical which reduces the hazards within the confines of the clear zone. Use of traversable end sections is not recommended because it deters small mammals from using the designated mammal crossings and results in animals using pipes designated for drainage instead. Slopes of the small mammal crossings are assumed not to exceed 10%.

### **Large Animal Crossings**

The US 550 corridor experiences high accident rates between motor vehicles and animals. The introduction of wildlife crossings and wildlife exclusion fencing can greatly reduce the number of serious accidents expected and multiple crossings are included in this project. A wildlife underpass is proposed at approximately Station 910+00 on the south end of the project, with the final location to be determined later in conjunction with CDOT and Colorado Parks and Wildlife. An additional large mammal crossing is proposed at Station 958+00.

In addition, there are 2 bridge structures to be constructed over Gulch A and Gulch B and will serve as small mammal and large animal crossings. Storm events will also be conveyed under the bridges. The bridges are larger than needed to carry the expected tributary flows because the alignment and natural topography are controlling the length and height rather than the expected water surface. Therefore, it is expected that the large animals will be able to cross under the bridges above the flows from frequent storm events. Proposed large mammal crossing locations are shown in **Table 4-1**.

**Table 4-1: Large Mammal Crossings**

Station	Type of Structure	Size
Approx. 910 + 00	Underpass	13' Clearance
968 + 00	Underpass	13' Clearance
1017+00	Bridge	480' Span
1031+00	Bridge	240' Span

In total, there will be four (4) large mammal crossings: two (2) underpasses and two (2) bridges doubling as large mammal underpasses along US 550.

## 4.7 Water Quality and MS4 Treated Areas

As discussed in the Forward and Design Methodology Section, the requirement for providing permanent water quality was lifted after substantial completion of the 30% level design.

### **302 North**

Permanent water quality facilities that could easily be removed from the 302 North segment were removed, but there may still be some ditches associated with previously located water quality features. Designers should re-evaluate the system under the new requirements.

### **Connection**

Permanent Water Quality features in the Connection segment were more robust and not as easily modified, therefore the design still shows many of the features originally anticipated. In addition, CDOT still sees potential value in including some water quality features on the project. The design features show where they may best fit into the design. The remainder of this section discusses the PWQ facilities initially included in the project and should be considered as project background and reference only.

To meet the MS4 Priority Development Project water quality criteria, four (4) Extended Detention Basins (EDBs) were originally proposed for permanent water quality BMPs.

The requirement to treat 90% of the new impervious area allows portions of runoff from US 550 to bypass a treatment pond. Large offsite drainage areas and some of these bypassed areas are combined in roadside swales. This reduces the number and size of the required treatment ponds. Four EDBs have been sized and contoured into the proposed design. They capture 13.36 acres of impervious area. The required area to be captured and treated is 12.35 acres. *Note that due to ease of re-design efforts, the EDB shown in the center of the roundabout (STA 1039+00) was removed and only three (3) EDB's remain in the design plans.* See **Appendix C – Summary of Roadway Basins and Treatment**.

The location of the proposed EDBs with information regarding the tributary area, percent impervious and the WQCV, and 100-Year flow rate are available in **Table 4-2**.

**Table 4-2: Proposed Permanent Extended Detention Basins**

<b>Station</b>	<b>Type of BMP</b>	<b>Total Tributary Area (Acres)</b>	<b>Impervious Area (Area)</b>	<b>Water Quality Capture Volume (Acre-feet)</b>	<b>100-Year Flow Rate (CFS)</b>
960+00	EDB	3.89	1.30	0.064	9.08
981+00	EDB	4.14	4.14	0.161	30.0
1007+00	EDB	19.03	5.13	0.146	60.5
1039+00	EDB	5.79	2.79	0.223	22.3
<b>TOTAL TREATED IMPERVIOUS AREA</b>		13.36			

The required area to treat is calculated as 90% of the new impervious area. The existing pavement area of US 550, frontage road, CR 220 and the associated driveways equals 7.21 acres. This amount subtracted from the new pavement area within the project limits (20.65 acres) is a total new impervious area of 13.44 acres. The required 90% of this new impervious area is 12.35 acres. The proposed design treats 13.36 acres of impervious area.

The four (4) water quality BMPs shown above detain the WQCV and provide for 20% additional volume to allow for sedimentation within the pond between maintenance intervals. The water quality depths in each pond vary depending on the  $\frac{1}{2}$ " runoff volume tributary to the pond. A two-stage outlet structure (Water Quality/100-year) in each pond is designed to release the WQCV over a 40-hour period and impound the 100-year tributary runoff volume with one foot of freeboard. The proposed ponds provide only the minimum features needed to determine right-of-way needs, and do not reflect maintenance access roads, sediment forebays, or micropools at this time. Access roads to the ponds have been considered, and although not shown on the grading plans, can be easily achievable within the proposed right-of-way limits.

## 5 CONCLUSION

### **Storm Drainage Facility**

CDOT's drainage criterion is met with this drainage design using roadside swales, cross culverts, and storm drain systems to convey flows across US 550, CR 220 and the frontage roads. The existing topography allows for sufficient pipe cover on pipe alignments but requires the use of manholes or inlets to make up grade for drops.

### **Irrigation**

Impacted irrigation ditch systems crossing and adjacent to the highway are to be replaced as needed based on agreements with the irrigation company and landowners. Refer to Book 2 Sections 8 and 12 for detailed information on irrigation.

### **Wildlife Crossings**

For the proposed US 550 alignments small mammal crossings are approximately 750 ft apart. The design has two large wildlife underpasses and two bridges that also function as large animal crossings. All wildlife crossings must have a natural substrate surface on the bottom to promote animal use.

### **Water Quality**

Water quality is not required for this project, however it is modeled in the design of the Connection segment due to requirements at the time of design of this segment which have been since been lifted. The Connection segment followed the SFEIS which stipulated that the project adhere to the CDOT's MS4 Discharge Permit requirement of treating 90% of the new impervious area.

## 6 REFERENCES

- CDOT. (2005). *CDOT Roadside Design Guide*. Denver: Colorado Department of Transportation.
- CDOT; FHWA. (2005). *US 550 Corridor Improvements from State Line North to County Road 220 Environmental Assessment. Report Number NH 5501-011 12979*. US Department of Transportation and Colorado Department of Transportation.
- CDOT; FHWA. (2006). *Final Environmental Impact Statement / Final Section 4(f) Evaluation for US Highway 160 from Durango to Bayfield, La Plata County, Colorado. Report Number FC-NH(CX) 160-2(048)*. US Department of Transportation and Colorado Department of Transportation.
- CDOT; FHWA. (2012). *US 550 South Connection to US 160 Supplemental Final Environmental Impact Statement / Section 4(f) Evaluation to the US Highway 160 from Durango to Bayfield EIS. Report Number FC-NH(CX)162-2(048)*. US Department of Transportation and Colorado Department of Transportation.
- Colorado Department of Transportation. (2004). *Drainage Design Manual*. Colorado.
- Colorado Department of Transportation. (2004). *New Development and Redevelopment Stormwater Management Program*. Colorado.
- FHWA. (2008). *Wildlife Vehicle Collision Reduction Study*.
- FHWA. (2011). *Wildlife Crossing Structure Handbook Design and Evaluation in North America*. Lakewood, Colorado.
- La Plata County, Colorado. (1998). *Code of La Plata County Colorado*. Colorado.
- Urban Drainage and Flood Control District. (2008). *Urban Storm Drainage Criteria Manual (Vol. 1 & 2)*. Denver, Colorado.
- Urban Drainage and Flood Control District. (2010). *Urban Storm Drainage Criteria Manual (Vol. 3)*. Denver, Colorado: Water Resources Publications, LLC.
- URS. (2005). *Preliminary Drainage Report US 160 - Sections 1-2: US 550 and Interchange CDOT Project # FC-NH(CX)160-2(048)*. Colorado Springs, Colorado.

