SHOOKS RUN

DRAINAGE BASIN PLANNING STUDY

TECHNICAL APPENDIX VOLUME III - IMPROVEMENT ALTERNATIVES ANALYSIS

prepared for
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Department of Planning & Development
City Engineering Division

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**SOFT-LINED ALTERNATIVE**

Sta. 0+25 to Sta. 9+75 - New open Channel between Fountain Creek Confluence and Las Vegas Street

- **Equal West**: 25 ft
- **12% Pipe**: 200 ft
- **Biased**: 18 ft
- **Landscape Channel**: 50 ft

**LEVEE BED'D ALONG WEST BANK**

- **B_{100} = 6910 cfs**
- **S_{ex} = 0.479**
- **d = 10^{-1} \Rightarrow V = (1.41 \times 10^{-3})^{1/3} \times (0.004)^{1/2} = 6.33 \text{ fps} \Rightarrow Q = (6.33)(100) = 693 CFS**
- **Freeboard = 10^{-1} + (0.005)(10)^{1/8}; 118\Rightarrow Use \text{ 2' D = 10+2 = 12'}**
- **F = \frac{1.5}{10} = 0.15 \Rightarrow Subcritical**

Sta. 9+75 to Sta. 10+80 - Replace bridge and drainage at Las Vegas Street

- **S = 12\times10^{-1} \text{ RCF}**
- **G_{100} = 6910 \text{ cfs}**
- **C = 70\text{'}**
- **S_{ex} = 0.750**
- **A + H = 116 - 67.7 = 48.3**
- **Inlet Control \Rightarrow \frac{6.40}{60} = 0.105 \Rightarrow H_{in} = 0.105**
- **Outlet Control \Rightarrow h = 3\text{'}**
- **d_c = 7.5\text{'}**
- **H_{o} = \frac{10+2+5}{2} = 9\text{'}**
- **L_{c} = \frac{(70)(0.40)}{10} = 0.5\text{'}**
- **H_{in} = 3+9-0.5 = 11\text{'}5\text{'}**
Station 10+00 to 11+40 - New Concrete Transition Channel Between Las Vegas Sheet and Atchison, Topeka & Santa Fe Railroad

Station 14+20 to 11+45 - Existing Culvert for Atchison, Topeka & Santa Fe Railroad

**Station 10+00 to 11+40 - New Concrete Transition Channel Between Las Vegas Sheet and Atchison, Topeka & Santa Fe Railroad**

- **Area:** 6910 cfs
- **Discharge:** 1050 cfs
- **Channel:** 5.5' x 6.44'

**Station 11+45 to 14+20 - Existing Culvert for Atchison, Topeka & Santa Fe Railroad**

- **Cross Section:** 20' x 14.5'
- **Area:** 6910 cfs
- **Discharge:** 1300 cfs
- **Culvert:** 15.4' x 1.8'

**Discharge Calculation**

- **Area:** 6910 cfs
- **Discharge:** 1050 cfs
- **Channel:** 5.5' x 6.44'

**Actual Discharge:**

\[ Q = \frac{4.91 \times 10^4 \times 0.010 \times 5.5 \times 6.44}{12} = 7455 \text{ cfs} \]

**Freeboard:**

\[ h_f = 1.0 + 0.025 \times (15.7) \times 11.5 \times 0.010 = 1.8 \text{ ft} \]

**Flood Stage:**

\[ F = \frac{13.7}{1.025 \times 1.010} = 0.71 \text{ ft} \]

**Subcritical:**

**Station 14+20 to 11+45 - Existing Culvert for Atchison, Topeka & Santa Fe Railroad**

- **Cross Section:** 20' x 14.5'
- **Area:** 6910 cfs
- **Discharge:** 1300 cfs

**Culvert Calculation**

- **Cross Section:** 20' x 14.5'
- **Discharge:** 1300 cfs
- **Culvert:** 15.4' x 1.8'

**Inlet Control:**

\[ H = 3 + 11.5 \times 0.6 = 13.9 \text{ ft} \]

**Outlet Control:**

\[ H = 3 + 11.5 \times 0.6 = 13.9 \text{ ft} \]
0_{90} = 6910 cfs
S_p = 0.597 ft
S_{pr} = 0.597 ft

D = 11\text{'} = \frac{11}{60} \text{ ft}
0.0095 = \frac{3}{4} \times 0.6\text{ ft/s} = \frac{9}{60} \times 0.6\text{ ft/s} = 0.14\text{ ft/s} = 817\text{ ft/s}

F_c = \frac{4.3}{182.2 \times 0.5} = 0.21 => Subcritical

St. 11+65 to St. 15+60 - Newgate Channel Between A.T. & S. & D.B. & N. Railroad and abandoned railroad

Inlet Control \Rightarrow \frac{Q}{L} = \frac{6910}{11+65} \times \text{Perf} = 6910 \times \frac{11}{60} = 1151.64 \text{ ft/s}

Outlet Control \Rightarrow H = 2.3 \text{ ft} \quad H_0 = 13.5 \text{ ft} \quad L_s = (60/0.00) = 0.4 \text{ ft}

\bar{W} = 2.2 + 13.5 - 0.4 = 15.0 \text{ ft}
Sta 16+20 to Sta 24+400 - Remove undesirable vegetation and debris from floodplain, Schuylkill abandoned railroad and Fountain Boulevard.

Existing Channel with riprapped banks and landscaped levee banks.

$Q_{100} = 6910 \text{ cfs}$ to $6440 \text{ cfs}$, $S_p = 0.7$, $Q_{50} = 1040 \text{ cfs}$

$d = 11$ and $0.35^4 \Rightarrow 0.038 \times 100 \Rightarrow 0.19 \Rightarrow 10.14$ fps $\Rightarrow Q = (10.14)(6900) = 70000 \text{ cfs}$

Actual $d = 18.5^\circ$ to $15^\circ$ $\Rightarrow H_e = 0.15$ and $6.5^\circ$ $\Rightarrow A = 1255 \text{ ft}^2$ $\Rightarrow \frac{6.5}{125} = 0.05$ fps

Floodplain = $1.0 + 0.025(150)(150)\% = 1.4 ^\circ$ $\Rightarrow V = 2.0 \text{ fps}$ $\Rightarrow D_{min} = 15 + 2 = 17.0$

$F = \frac{627}{520.58} = 0.28 \Rightarrow \text{ Subcritical}$

Sta 24+400 to Sta 25+500 - Replace curbed at Fountain Boulevard.

$4 - 12^\circ x 10 \text{ RCB}$

$Q_{100} = 6910 \text{ cfs}$, $L = 150$, $S_p = 0.7$, $A_{100} = 30.3 - 10.3 = 20.0$

Inlet Control $\Rightarrow Q/4 = \frac{6910}{40} = 145$ $\Rightarrow H/15 = 40$ $\Rightarrow H = (1.8)(15) = 15.0$

Outlet Control $\Rightarrow H = 4.16$, $H_0 = 1.5$, $L_2 = (150)(0.003) = 1.1$

$H = 4.16 + 1.5 - 1.1 = 18.5$
Sta 25+50 to Sta 48+65 - Remove undesirable vegetation and debris from floodplain and reduce slope of West overbank between Fountain Boulevard and Costilla Street.

Drawn by:

Date: November 6, 1992

Sta 48+65 to Sta 50+65 - Replace culvert at Costilla Street.

Outlet Control: 11.5' H_0 = 12.5' L_s = 200' x 0.6% = 12.0'  H_W = 7.0' + 12.5' - 1.2 = 18.3'
Station 55+30 to Station 71+55 - New open channel between Costilla Street and El Paso Street

Landscape Channel w/ Beaded Retaining Walls and Soil Bottom

2 - 3' Hog Structures and Replace 2 Sanitary Sewer Crossings

Station 71+55 to Station 72+80 - Replace Culvert at El Paso Street

5 - 14" x 10' RCC

Station 55+30 to 60+05 CFS
L = 125' S_p = 1.03% AHW = 65 - 53.2 = 11.8'

Outlet Control
H = 2.0' H_o = 10.0' L_s = (125)(0.01) = 1.3

HW = 2.0 + 10.0 - 1.3 = 10.7
Station 72+40 to Station 76+80 - New open channel between E1 Paso Street and Pikes Peak Avenue.

Channel Design:

\[ Q_{100} = 6705 \text{ cfs} \]
\[ S_{BP} = 0.4\% \]
\[ d = 4.8' \Rightarrow v = 1.99 \left( \frac{1.175}{1.15} \right) \left( 0.004 \right)^{1/2} = 6.3 \text{ fps} \Rightarrow Q = (6.3)(115) = 6956 \text{ cfs} \]

Actual \[ d = 10.7' \Rightarrow (Est'd/Est'd/Area) \Rightarrow A = 1347 \text{ sf} \]
\[ v = \frac{6956}{1347} = 5.14 \text{ fps} \]

Flowboard:
\[ Q = 1.03 \times (0.025)(6.0)(10.0)^{1/2} = 1.33 \Rightarrow \text{Use 2.0} \]
\[ D = 0.17 + 2.0 = 2.17' \]
\[ F = \frac{5.0}{17.0(2.0)} = 0.27 \Rightarrow \text{Subcritical} \]

Station 76+80 to Station 85+60 - Replace culverts at Pikes Peak Avenue / E1 Paso Street and at Kiowa Street.

Pikes Peak Avenue / E1 Paso Avenue

\[ S = 14 \times 10^{-6} \text{ B.C.} \]
\[ Q_{100} = 6705 \text{ cfs} \]
\[ L = 650' \Rightarrow S_{BP} = 1.0\% \text{ A.H.W.} = 76.0 - 61.2 = 14.8' \]

Initial Control:
\[ B/b = 6.95 \]
\[ H_y = 10.5' \text{ H.W.} = (1.15)(10.5) = 11.0' \text{ Switch Control:} \]
\[ H_y = 10.7' \text{ H.W.} = 2.7 + 10.7 - 6.5' = 6.9' \]
Known Street

4 - 14'x10' RCC

Q_{100} = 5060 cfs  \ L = 150'  \ S_e = 0.3\%  \ A = 76.0 + 0.42 + 13.0'

Outlet Control \Rightarrow \ Q/b = \frac{5060}{50} = 90  \  \ H_s = 1.0,  \  \ H_s = (1.0)(1) = 1.0'

Outlet Control \Rightarrow \ h = 1.8',  \  \ h_o = 1.8',  \  \ L_s = (150)(0.003) = 0.5'

\Delta H = 1.8 + 1.0 - 0.5 = 11.8'

Start 85+60 to 89+75 - New open channel between Known Street and Byron Street

\text{Landscape Channel with Boulder Retaining Walls and Soil Bottom by 1-2' Drop Structure}

Q_{100} = 5060 cfs  \  \ S_e = 0.9\%  \  \ S_{no} = 0.5\%  \  \ d = 7.0'

\Rightarrow \frac{1.44}{1.0016} \times 0.005 \times 0.005 \times 6.24 \Rightarrow Q = (6.6)(850) = 5270 cfs

F \text{freeboard} = 1.0 + 0.025(0.02)(15) = 0.5 \Rightarrow \text{Use 2.0'}  \  \ D_{min} = 9.0 + 2.0 = 11.0'

F = \frac{2}{1.58} = 0.86 \Rightarrow \text{Satisfactory}
Sta. 89+45 to Sta. 94+50 - Replace Culvert at Bigou Street

4 - 14' x 10' R.C.B.

$Q_{100} = 5060 \text{ cfs} \quad L = 455' \quad \alpha = 0.6^\circ \quad H_{iw} = 82.0 - 69.8 = 12.2'$

Inlet Control $\Rightarrow 0.4 = \frac{5060}{524} = 90.0$  $H_{iw} = 1.0$  $H_{iw}(1.0)(100.0) = 10.0$'

Outlet Control $\Rightarrow 2.1^\circ + 9.0' \quad L_0 = 4(552)(0.008) = 2.7'$

$H_{iw} = 2.1 + 9.0 - 2.7 = 8.4'$

Sta. 94+50 to Sta. 98+10 - New open channel between Bigou Street and Platte Avenue

- Landscaped Channel
- Bounded by retaining walls and spill point
- Bottom is r.c. drop structure

$Q_{100} = 5060 \text{ cfs} \quad \alpha_{ex} = 0.9^\circ \quad \alpha_{f} = 0.3^\circ \quad d = 0.5'$

$Q = \frac{(144)(50.0)(0.025)(0.008)}{1} = 6.0 \text{ fps} \quad Q = (1.0)(865) = 865 \text{ cfs}$

$F = \frac{6.0}{(865)(8.8)} = 0.36 \Rightarrow Subcritical$
Sta. 98+00 to Sta. 106+30 - Replace culvert at Platte Avenue/School Athletic Field and bridge at Boudin Street

4-12' x 10' RCB

Q_{in} = 5020 cfs  \quad L = 495'  \quad S_{ex} = 0.150' \quad AH_{in} = 9.5 - 7.5 = 2' 10''

Outlet Control \Rightarrow Q_{out} = \frac{5020}{9} = 560 cfs  \quad H_{w} = 4.0  \quad L_{so} = (4.0)(0.005) = 3.5'

4H = 3.4 + 8.5 - 3.5 = 8.4'

Sta. 106+30 to Sta. 112+35 - New open channel between Boudin Street and 1st Van St

\begin{align*}
Q_{in} &= 5020 cfs  \quad S_{ex} = 0.150' \\
d &= 8' = (1.499 \times 850)^{1/6}(0.009)^{1/2} = 7.0' \quad Q = (7.0)(850) = 5950 cfs
\end{align*}

Fsection = (0.0025)(7.0)(8.0)^{1/2} / 4' > Use 4' \quad D_{in} = 8.0 + 4.0 = 10.0'

F = \frac{7.0}{4.0} = 0.44 \Rightarrow Subcritical
Sta. 112+35 to Sta. 113+40 - Replace Culvert at St. Vrain Street

4 - 10' x 10' RCB

Q_{100} = 4935 cfs \quad L = 105' \quad S_e = 0.4\% \quad AHW = 60.0 - 85.0 = 25.0'

Inlet Control => Q/6 = \frac{4935}{6} = 822.5 \quad H_L/D = 1.8 \quad H_W = (1.3)(10.0) = 13.0'

Outlet Control => H = 3.2' \quad H_0 = 8' \quad L_S = (105)(0.004) = 0.4'

H_W = 3.3 + 8.0 - 0.4 = 10.9'

Sta. 113+40 to Sta. 114+76 - New open channel between St. Vrain Street and Willamette Street

Tw = 236'

Q_{100} = 4935 cfs \quad S_e = 0.7\%

D = 6' \quad V = \sqrt{\frac{Q}{0.058}(\frac{S_e}{10})(10.0)} = 6.01 fps \quad Q = (6.01)(8.1) = 4940 cfs

Actual D = 10.1 + 10.9 = 21.0' \quad H_W = 13.0' \quad V = \frac{4935}{2100} = 2.34 fps

Freeboard = 1.0 + (0.02)(4.1)(10)^{1/2} = 2.8' \quad D = 10 + 2 = 12'

F = \frac{4.1 \times 2(10)}{0.02 \times 2(10)} = 0.23 \quad Subcritical

Sta. 117+25 to Sta. 119+50 - Replace Culvert at Willamette Street

8'-10" x 10' RCB

Q_{100} = 4875 cfs  \  L = 205'  \  S_p = 0.190  \  AHW = 12.0 - 9.14 = 28.1'

Inlet Control: Q/l = \frac{4875}{80} = \frac{609.4}{163}  \  d_{th} = 11.7  \  H_0 = (1.7)(10) = 17.0'

Outlet Control: \# = 6.3  \  H_0 = 10'  \  L = (205)(0.001) = 0.3'

H_0 = 6.3 + 10 - 0.3 = 16.0'

Sta. 119+50 to Sta. 125+15 - New open channel between Willamette Street and Cache La Poudre Street

Landscaped Channel with Pedestrian Bridge at Sta. 128+40

Q_{100} = 4875 cfs  \  S_{ex} = 0.790  \  S_{pro} = 0.590  \  d = 10  

\frac{10}{\frac{10}{15}} = 10  

Q = (610)(850) = 5610 cfs  

F = \frac{610}{1500} = 0.407  \Rightarrow \text{Sufficient}
Sta. 13+515 to Sta. 13+705 - Replace Culvert at Cache la Poudre Sheet

3 - 10' x 10' RCA

Q_100 = 4305 cfs  L = 190'  S_70 = 0.270  AHW = 260 - 0.95 = 165'

Outlet Control => dh = \frac{4.350}{30} = 144  Hw/D = 1.5  HW = (1.5)(10) = 15.0'

Outlet Control => h = 5.0  H_0 = 10'  L_{(0.002)} = 0.4'  H_w = 5.0 + 10 - 0.4 = 14.6'

Sta. 13+705 to Sta. 15+245 - New open channel between Cache la Poudre Sheet and Uintah Sheet

L = 21/5

\frac{d}{S_{(0.5)}} = (1.894) \frac{7.95}{154} \frac{1.005}{0.005} = 6.2 fps  \Rightarrow Q = (6.2)(783) = 4855 cfs

Depth = \frac{1.2 + 0.025}{(1.3)(9.5)} = 1.3  \Rightarrow dh = 0.3'

\frac{Q}{(1.2)(9.5)} = 0.35 \Rightarrow Subcritical
Sta. 52+45 to Sta. 53+55 - Replace Culvert at Viuwah Street

$\text{CUB} = 14' \times 10'\text{ CUB}$

$Q_{100} = 3940\text{ cfs}$

$\theta = 110^\circ \quad \frac{A_{w}}{A_{o}} = 1.2970 \quad \Delta H_{W} = 50.0 - 28.1 = 21.9'$

Inlet Control $\Rightarrow \theta = 14^\circ \quad A_{w}/A_{o} = 1.5 \quad H_{W} = (15)(10)/15 = 15.0'$

Outlet Control $\Rightarrow H_{b} = 4.4' \quad H_{b} = 9.5' \quad L_{s} = (10)(0.02) = 1.3'$

$H_{W} = 4.4 + 9.5 - 1.3 = 12.6'$

Sta. 53+55 to Sta. 57+55 - New open channel between Viuwah Street and San Miguel Street

$T_{W} = 2.10'$

$Q_{100} = 3940\text{ cfs}$

$S_{ex} = 1.15$,

$S_{pro} = 0.580$,

$d = 9.5' \Rightarrow \frac{u}{(0.050)(164)}(0.005)^{0.5} = 6.1\text{ fps} \Rightarrow Q = (6.1)(735) = 448.5\text{ cfs}$

Actual $d = 5.0' + 1.0' = 6.0'$

$A = 0.055\text{ ft}^{2} \Rightarrow \frac{3940}{3940} = 3.19$ fps

$F = 0.75 + (0.0025)(1.0)(11.5)^{0.5}/2 = 1.3 \Rightarrow V_{ave} = 1.3$,

$D_{min} = 11.5 + 2 = 13.5'$

$F = \frac{3.7}{13.5(11.5)^{0.5}} = 0.19 \Rightarrow S_{subcritical}$
Sta. /57.55 to Sta. /58+40 - Replace Culvert at San Miguel Street

2 - 14' x 10' RCC

Q[0] = 3940 ft³/s \( L = 85' \) \( \text{SS} = 0.6\% \) \( \Delta H = 52.5 - 33.1 = 19.4' \)

Inlet Control \( \Rightarrow \frac{Q}{b} = \frac{3940}{28} = 141 \) \( \text{hw} = 1.5 \) \( \text{hw} = \frac{L}{(S(0.006))} = 15.0' \)

Outlet Control \( \Rightarrow H = 4.2' \) \( h_o = 11.5' \) \( L_o = (85)(0.006) = 0.5' \)

\( \text{hw} = 4.2 + 11.5 - 0.5 = 15.2' \)

Sta. /58+40 to Sta. /67+36 - Open Channel between San Miguel Street and Pedestrian Bridge

New

\( \text{Flow} = \frac{6}{2} = 2' \) \( \text{Deep Structures} \)

\( Q[0] = 3940 \text{ ft}³/\text{s} \) \( \text{SS} = 1.0\% \) \( \text{SS} = 0.5\% \)

\( L = 9.5' \) \( \Rightarrow u = \frac{1.04[(0.75)(0.05)]^{0.5}}{0.1 \text{ fps}} \Rightarrow \alpha = (w)(0.75) = 4485 \text{ ft/s} \)

\( \text{Flow} = \frac{1.04(0.05)(0.75)}{3' > 0.35 \Rightarrow \text{Use } D_{min} = 4.5' \quad \text{Cutoff} = 9.5' = 11.0' \)

\( f = \frac{1}{(5(2)(9.5))} = 0.35 \Rightarrow \text{Subcritical} \)
Sta. 167+35 - Replace Pedestrian Bridge

Sta. 167+35 to Sta. 126+25 - New open channel between Pedestrian Bridge and Patty Jewett Golf Course South Boundary

\[ \text{Discharge} = \frac{3.88 \times 5 \text{cfs} \times 0.05 \times 0.05 \times 5.8}{1.0} = 0.58 \text{cfs} \]

\[ c = 9 \Rightarrow u = \frac{(4.49)(0.10)(5.8)}{0.005} = 5.8 \text{fps} \]

\[ Q_{50} = (5.8)(0.70) = 3.88 \text{cfs} \]

\[ \text{Freeboard} = 1.0 + 0.025(5.8)(0.10) = 1.3 \Rightarrow \text{Use } 2' \text{ Freeboard} \]

\[ F = \frac{5.8}{0.327(0.9)} = 0.34 \Rightarrow \text{Subcritical} \]
Sta 126+25 to Sta 189+05 - New Open Channel between Path, Jewett, Golf Course, South Boundary, and Espanola Street.

**TW = 380'**

- **D = 23'**
- **Ex = 10%**
- **Ex = 6'**
- **Spd = 0.85**

**Q**

**Q_{100} = 3665 cfs**

**Q_{10} = 616 cfs**

**Q_{100} = 0.149 (0.008) (550)^{0.6} = 616 cfs**

**Q = (616)(550) = 36300 cfs**

**Freeboard = 1.0 + (0.025)(6/10)^{0.5} = 1.4**

**F = \frac{6}{550} = 0.01**

**Subcritical**

**Sta 189+05 to Sta 190+85 - Replace Culvert at Espanola Street**

**W = 12' X 10' RC**

**Q_{100} = 3555 cfs**

**Q_{10} = 1390 cfs**

**AHW = 0.5 - 7.2 = 12.7'**

**Inlet Control**

**Q_{10} = \frac{3555}{20} = 99**

**HW/D = 1.05**

**HW = (1.05)(10) = 10.5'**

**Outlet Control**

**Q_{10} = 7.0**

**L_{c} = 10'**

**L_{o} = (180)(0.01) = 2.3'**

**HW = 2.0 + 10 - 2.3 = 9.7'**
Sta 190+85 to Sta 198+45 - New Open Channel between Esparza Street and End of Existing Channel lining

Lined Channel
Lined channel
Lined channel with Green Retaining Walls and Soil Bottom

\[ Q_{100} = 3400 \text{ cfs} \]
\[ Q_{100} = 1.4D + 2 + \text{Dup} \]
\[ Q_{100} = 1.5D + 2 \]

\[ d = 6' \Rightarrow \frac{V}{A} = \frac{64}{144}(500)^{0.6}(0.015)^{0.2} = 6.9 + \text{ps} \Rightarrow Q = (6.9)(500) = 3450 \text{ cfs} \]

F = \frac{10 + (0.025)(6.9)(6)}{5.5} = 1.3 \Rightarrow \text{Use } 2' \quad D_{min} = 6' + 2' = 8' \]

\[ F = \frac{6.9}{5.5} = 0.127 \Rightarrow \text{Subcritical} \]
Sta. 198+45 to Sta. 216+40 - New Open Channel between End of Existing Channel Liming and Paseo Road

\[ Q_{100} = 110 \text{ cfs} \]
\[ s_{fo} = 1.090 \pm \]

\[ d = 4' \Rightarrow \frac{V}{(1.4)} = \frac{(0.08)(140)(0.09)^{2}}{(0.4)(0.010)^{2} - 5.424} \Rightarrow Q = (5.16)(210) = 1100 \text{ cfs} \]

\[ F = \frac{5.2}{1(4)(0.4)} = 0.46 \Rightarrow \text{Subcritical} \]

Sta. 240+40 to Sta. 241+45 - Replace Culvert at Paseo Road

\[ Q_{100} = 110 \text{ cfs} \]
\[ L = 55' \quad s_{fo} = 0.790 \quad \text{ATW} = 12.3 - 05.9 = 614' \]

Inlet Control \( Q_{1} = \frac{110}{55} = 2.7 \quad \text{ATW} = 11.1 \quad \text{ATU} = (11.1)(5) = 55' \)

Outlet Control \( H = 4.2' \quad H_{0} = 4' \quad L_{S} = (55)(0.005) = 0.4' \)

\[ \text{ATW} = 11.2 + 4 - 0.4 = 4.8' \]
Sta 216+95 to Sta 218+30 - New Open Channel between Paseo Road and Jefferson Street

\[ Q_{in} = 110 \text{ cfs} \]
\[ Q_{out} = 0.175 \text{ cfs} \]
\[ Q = 5.5 \text{ cfs} \]
\[ Q_{free} = 110 \]
\[ Q_{f} = 0.43 \]

Sta 218+30 to Sta 219+10 - Replace Culvert at Jefferson Street

\[ Q_{in} = 110 \text{ cfs} \]
\[ Q_{out} = 0.175 \text{ cfs} \]
\[ Q = 5.5 \text{ cfs} \]
\[ Q_{f} = 0.43 \]
Sta 219+10 to Sta 222+50 - New Open Channel Between Jefferson Street and Madison Street

L = 15'  B = 10'  T10 = 78'

Q = 1110 cfs
D = 6.5 ft

Sta 223+20 to Sta 223+30 - Replace Culvert at Madison Street

3-10' x 5' PCB

L = 80'  C = 1.25

Outlet Control: H = 12'  T0 = 4.5'  L0 = (80)(0.012) = 1.0'  H1 = 1.2 + 4.5 - 1.0 = 4.7'
Station 223+30 to Station 226+25 - New Open Channel Between Madison Street and Monroe Street

**Landscaped Channel w/Fauldner Retaining Walls and Soil Bottom**

**Station 226+25 to 227+05 - Replace Culvert at Monroe Street**

- $Q_{100} = 1110 \text{ cfs}$
- $S_{500} = 1.2 \text{ ft}$
- $d = 4.5' \Rightarrow v = (\frac{1.44}{0.65})^{1/2}(0.012)^{1/2} = 6.84 \text{ fps} \Rightarrow Q = (6.84)(184) = 1250 \text{ cfs}$
- $F = \frac{6.8}{\sqrt{2.34}} = 0.56 \Rightarrow S_{vertical}$

- $3 = 10' \times 5' \text{ RCB}$
- $Q_{100} = 1110 \text{ cfs}$
- $L = 80'$
- $p_{o_2} = 1/2 \text{ psig}$
- $A_{HW} = 23.6 \times 141 = 408'$
- $Inlet \ Control \Rightarrow Q/b = \frac{110}{36} = 3.07$
- $H/w = 1/1$
- $H/w = (1.1)(5) = 5.5'$
- $Outlet \ Control \Rightarrow H = 1/2$
- $h_b = 4/5'$
- $L_2 = 80(0.012) = 1/10$
- $H/w = 1/2 + 4.5 - 1/10 = 4.5'$
Sta. 227+00 to Sta. 229+70 - New Open Channel between Monroe Street and Jackson Street

\[ Q_{100} = 1100 \, cfs \quad \text{and} \quad S_{pp}=1.2 \% \]

\[ d = 4.5' = h = (4.5' \times 0.25)' = 1.125' \quad \text{and} \quad b = 30' \]

Bed Grade:

\[ \frac{Q}{b} = \frac{1250}{30} = 41.67 \text{ cfs/ft} \]

Flow:

\[ Q = \frac{6.8}{11.32} = 0.6 \text{ cfs/ft} \]

Subcritical

Sta. 224+70 to Sta. 234+15 - Replace Culvert at Jackson Street/Lasalle Street

\[ Q_{100} = 1100 \, cfs \quad \text{and} \quad L = 445' \quad \text{and} \quad S_{pp}=1.2 \% \quad \text{and} \quad HLU = 313' - 250' = 63' \]

Inlet Control:

\[ Q/b = \frac{1100}{30} = 37 \quad \text{and} \quad H/b = 1 \quad \text{and} \quad \text{HLU} = (1.15) (15) = 53' \]

Outlet Control:

\[ H = 1' \quad H_o = 4.5' \quad L_{o} = (445')(0.012) = 5.3' \]

\[ H_W = 1.9 + 4.5 = 6.4' \]

\[ H_W = 1' \]
Sta. 234+15 to Sta. 235+40 - New Open Channel between LaSalle Street and Pedestrian Path

\[ T = 78^\circ \]

Landscape Channel w/ Boulders Retaining Walls and Soil Bottom, and 1'/3' Drop Structure

\[ b = 30' \]

**D[100] = 1070 cfs**\[ S = 0.68% \]

\[ d = 4.5' \rightarrow w = (1.49 \times 1.86) = 6.8 \text{ fps} \rightarrow Q = (6.8 \times 1.86) = 12.50 \text{ cfs} \]

Freeboard = \[ \frac{1}{3} + (0.029 \times 6.8) \times \frac{1}{3} \rightarrow \text{Use } 2' \]

\[ D_{min} = 4.5 + 2 = 6.5' \]

\[ F = \frac{6.8}{0.25 \times 6.5} = 0.5 \rightarrow \text{Sedimented} \]

Sta. 235+40 to Sta. 235+40 - Replace Culvert at Pedestrian Path

\[ 5' = 10' \times 5' \text{ BEC} \]

\[ Q_{100} = 1070 \text{ cfs} \]

\[ L = 50' \]

\[ S_{ho} = 2.2\% \]

\[ AH = 35.6 - 28.6 = 6.8' \]

Inlet Control \[ \frac{Q}{b} = \frac{1070}{50} = 3.6 \]

\[ H/D = 1/11 \]

\[ HW = (1/11) (6.8) = 0.6' \]

Outlet Control \[ H = 1/11 \]

\[ H_0 = 4.5' \]

\[ L_S = (50' / 0.022) = 1/1' \]

\[ HW = 1/11 + 4.5 - 1/1' = 4.5' \]
Sta. 235+90 to Sta. 236+20 - New Open Channel between Pedestrian Path and C.R.I.P. Railroad

Sta. 236+20 to Sta. 236+75 - Replace Culvert at C.R.I.P. Railroad

\[ Q_{100} = 1070 \text{ cfs} \leq 0.25 \times 1.2 \times 100 \]

\[ d = 5.0' \Rightarrow \frac{V}{0.05 \times 5.0} = 6.8 \times 10^{-4} \Rightarrow Q = (6.8) \times (1.64) = 11.5 \text{ cfs} \]

F = \frac{1}{(0.025)(6.8)(5.0)^{1/3}} = 0.13 \Rightarrow Use 2'

Outlet Control \Rightarrow H = 3.0', H_o = 5.0' \Rightarrow L_o = (55)(0.025) = 1.4'

Outlet Control \Rightarrow H = 3.0' + 5.0' - 1.2 = 6.8'
Templeton Gap Road at Van Buren Channel - Replace Culvert

2-11'x6' RCB

\[ Q_{100} = 1440 \text{ cfs} \]
\[ L = 100' \]
\[ S_{ex} = 0.690 \]
\[ H_W = 40.1 - 50.3 = 9.8' \]

**Inlet Control**
\[ Q = 1440 \]
\[ $C_2 = 0.66 = 0.6' \]
\[ H_W/D = 1.5 \]
\[ H_W = (1.5)(0.6) = 9.1' \]

**Outlet Control**
\[ H = 2.6' \]
\[ D = 5.1' \]
\[ H_0 = 6 + \frac{5.1}{2} = 5.6' \]
\[ L_s = (100)(0.006) = 0.6' \]
\[ H_W = 2.6 + 5.6 - 0.6 = 7.6' \]
B. STRUCTURAL FULL IMPROVEMENT
ALTERNATIVE HYDRAULIC CALCULATIONS
Sta. 0+815 to Sta. 9+775 - New open channel between Fountain Creek Confluence and Las Vegas Street

Concrete Channel w/ Concrete Berming along East Bank

\[ Q_{100} = 6,910 \text{ cfs} \]

\[ Q = 2,412 \text{ cfs} \]

\[ F = \frac{0.12}{\sqrt{2h}} = 1.5 \Rightarrow \text{Super-Critical} \]

Sta. 9+775 to Sta. 10+80 - Replace bridge and dissipator at Las Vegas Street

\[ Q_{100} = 6,910 \text{ cfs} \]

Outlet Control \( d_c = 7.5' \)

\[ L_o = (0.005) \cdot 0.5' = 0.5' \]

\[ H_o = 10 + 2.5' = 9' \]

\[ H_p = 3 + 4 = 7' \]

\[ h = 3.5 - 0.5 = 3' \]

\[ d = 4' \]

\[ f = 0.05 \]
Ste. 10+80 to Ste. 11+20 - New Concrete Transition Channel between Las Vegas St. and ATSF & D.R.G.W. Railroad

Vertical Walled Concrete Transition Channel

Q100 = 1690.0 cfs \quad P^e = 1.090

d = 5.5' and b = 44' \implies V = \frac{(5.5)^2 \times 44}{2} = 666.5 \text{ cubic ft}

Actual Flow = \frac{1.03}{1.66} \times \text{Existing Area} = \frac{1.03}{1.66} \times 464.4 = 250.6 \text{ cfs}

Freeboard = 1.03 \times (0.025) (15.7)(11.5) = 18.7 \implies Use 2'

F = \frac{18.7}{(16.5)(0.5)} = 0.71 \implies Subtraction

Ste. 11+20 to 11+65 - Existing Culvert for ATSF & D.R.G.W. Railroad

Double 20" x 11.5" Conc. Arch (18.3' x 11.5') PER (End)

Q100 = 6910.0 cfs \quad \phi = 0.95 \quad \phi \times \phi = 1.300 \quad \text{HSL} = 23.0 - 98.0 = 24.51

Inlet Control \implies Q = \frac{(0.6)(6910.0)}{18.3(1.5)} = 185 \quad \text{HWD} = 1.1 \quad \text{HSL} / (1.1)(1.5) = 16.9

Outlet Control \implies H = 5' \quad H_0 = 4.5' \quad L_0 = 0.5(0.04) = 0.1

\text{HWD} = 3 + 11.5 - 0.6 = 13.9'
Station 11+05 to Station 14+60 - New Open Channel Between A.T., S.F. & P.R.R. W. Railroad and abandoned railroad

Concrete Channel with Concrete Retaining Walls

\[ Q_{100} = 49.10 \text{ cfs} \]
\[ Q_{10} = 0.11\text{ cfs} \]

**Design Details:**

- **d = 55 ft**
- **\( Q = 12,300 \text{ cfs} \)**
- **Actual \( Q = 13,500 \text{ cfs} \)**
- **F = 0.44**

**Inlet Control:**
- \( L = 18.8 \) ft

**Outlet Control:**
- \( H = 2.1 \) ft

**Summary:**
- **11+05 to 14+60 - Existing Culvert for abandoned railroad**
- **Double 20' x 12.9' Stone Masonry Arch (18.8' x 16.8' RCS Equal)**
- **Q\(_{100}\) = 49.10 cfs**
- **Q\(_{10}\) = 0.11 cfs**
- **Q\(_{f}\) = H x B = 38.8 cfs**
Sta. 14+20 to Sta. 24+40 - Remove undesirble vegetation and debris from floodplain between abandoned railroad and Fountain Boulevard.

- Peak Property
- Existing Channel with irregular banks and landscaped over banks
- Freeboard: \[ F = \frac{2L}{30} \] or \[ F = 0.28 \] => Subcritical

Sta. 24+40 to Sta. 25+50 - Replace culvert at Fountain Boulevard

- \[ Q_{100} = 64.10 \text{ cfs} \] to \[ 69.49 \text{ cfs} \] \[ S_e = 0.09 \text{ ft/m} \]
- \( d = 11'\) and \( b = 30' \) \[ Q = 64.10 \times 1.09 = 70.00 \text{ cfs} \] \[ V = 0.10 \times 11' = 1.10 \text{ ft} \]
- Actual \( d = 18' \) to 15' (Eq. 2) / Existing: HEC 2020, 2 instant 26' - 20' \[ A = 115.5 \times 1.5' = 173.3 \text{ cfs} \]
- Freeboard: \[ F = \frac{2L}{30} = 0.15' \]

Outlet Control: \[ H = 4.16' \]

\[ H_W = 4.16 + 15' = 19.16' \]
Sta. 25+50 to Sta. 48+65 - Remove undesirable vegetation and debris from floodplain and reduce slope of west overbank between Fountain Boulevard and Costilla Street.

Concrete retaining walls and landscaped west overbank.

Existing channel with riprapped banks and landscaped east overbank.

\[ Q_{100} = 6840 \text{ cfs} \] to \[ 6820 \text{ cfs} \]  
\[ C_{90} = 0.870 \]

\[ d = 10^\circ \] and \[ b = 20^\circ \]  
\[ e = \frac{1.4}{1.0} \times \frac{0.825}{0.45} = 0.109 \text{ fps} \]  
\[ Q_{100} = 1.09 (6820)^{0.625} = 8550 \text{ cfs} \]

Actual \[ d = 18.5^\circ \] to \[ 16.5^\circ \]  
\[ e = 0.825 \] 
\[ b = 20^\circ \]  
\[ Q_{100} = 8540 \text{ cfs} \]  
\[ F = \frac{1.75}{0.232(1.25)} = 0.38 \text{ => Subcritical} \]

Sta. 48+65 to Sta. 50+65 - Replace culvert at Costilla Street.

4 - 10' x 10' RCCB

\[ Q_{100} = 6820 \text{ cfs} \]  
\[ L = 200' \]  
\[ S_{90} = 0.690 \]  
\[ A_{100} = 50.1 - 29.9 = 20.2' \]

Total Cost = 20.2'  
\[ H_{w1} = 1.8 \]  
\[ H_{w2} = 118' (10.0') = 18.0' \]

Outlet Cost = \[ h = 7.0' \]  
\[ H_0 = 12.5' \]  
\[ L_{95} = (200)(0.006) = 1.2' \]

\[ H_{w1} = 7.0 + 12.5 - 1.2 = 18.3' \]
December 1, 1992

Sta. 50+65 to Sta. 74+55 - New open channel between Costella Street and El Paso Street

\[ Q_{0.01} = 6820 \rightarrow 4705 \text{ cfs}, \quad \Delta F = 0.8 \% \]

\[ d = 5.5'' \Rightarrow V = \left( \frac{L}{0.05} \right)^{\frac{1.875}{61}} \left( 0.008 \right)^{\frac{1}{6}} = 28.0 \text{ fps} \Rightarrow Q = (28.0)(275) = 7700 \text{ cfs} \]

Friction: \[ h_f = 1.0 + (0.015)(28.0)(50) \Rightarrow 2.1 \Rightarrow d_{ec} = 5.5'' \Rightarrow D_{min} = 5.5 + 5.5 = 11.0'' \]

\[ T = \frac{28.0}{\sqrt{128}(5.5)} \approx 2.10 \Rightarrow \text{supercritical} \]

Sta. 74+55 to Sta. 78+10 - Replace Culvert at El Paso Street

5 - 14' x 10' KCB

\[ Q_{100} = 6705 \text{ cfs}, \quad L = 125', \quad c_{eq} = 10.0 \% \]

Inlet Control: \[ \frac{Q}{b} = \frac{6705}{9} = 746 \Rightarrow HW = 10.05 \text{ ft} \]

Outlet Control: \[ H_0 = 5.5'', \quad L_{eq} = (125)(0.01) = 1.3' \]

\[ HW = 20 + 5.5'' - 1.3'' = 24.2' \]
Sta 72+80 to Sta 76+80 — New open channel between El Paso Street and Pikes Peak Avenue

Concrete Channel w/ Concrete Retaining Walls

\[ Q_{000} = 6705 \text{ cfs}, \quad S_e = 0.47\% \]

\[ d = 5' \Rightarrow V = \left( \frac{255}{12} \right) \left( \frac{255}{12} \right) \left( \frac{0.004}{19.4} \right) = 19.4 \text{ fps} \Rightarrow Q = (19.4)(6705) = 6705 \text{ cfs} \]

\[ h_{(c+1)} = (1.0 + 0.025)(4.1)/(0.5)^{1/2} = 5' \Rightarrow Use 5' \]

\[ D\text{min} = 10.5 + 2 = 12.5' \]

Conduit: \( \frac{7.1}{9(528)(105)} = 0.04 \Rightarrow S_{subcritical} \)

Sta 76+80 to Sta 85+60 — Replace culvert at Pikes Peak Avenue / El Paso Street and at Knorr Street

Dikes Peak Avenue / El Paso Avenue

\[ S = 14 \times 10^3 \text{ cfs} \]

\[ Q_{000} = 6705 \text{ cfs}, \quad L = 650', \quad S_e = 1.0\% \]

\[ AH = 76.0 - 61.2 = 14.8' \]

Inlet Control: \( A = \frac{6705}{70} = 96 \quad Huy & = 1.05 \quad HU = (1.05)(10) = 10.5' \]

Outlet Control: \( H = 2.7 \quad H_b = 10.5' \quad L_s = (650)(0.01) = 6.5' \]

\[ HU = 2.7 + 10.5 - 6.5 = 6.7' \]
Known Sheet

4 - 14' x 10' RC

Q_{100} = 5060 cfs

L = 50'

S_{100} = 0.35'

H_{in} = 3.0

H_{out} = 0.0

Outlet Control

Q = 5060

H_{out} = 0.0

H_{in} = 3.0

H = 1.8

Given:

L_{up} = 150

P_{c} = 0.5

H_{up} = 1.8

P_{c} = 0.5

Project:

Station 65+00 to 69+95 - New open channel between Known Street and Bijou Street

Concrete Channel w/ Concrete Retaining Walls

Calculation:

Q_{100} = 5060 cfs

S_{100} = 0.35'

d = 4.5

\( d = 4.5 = \sqrt{\frac{0.5}{0.01} \left( \frac{225}{d} \right)^{0.5} \left( 0.001 \right)^{0.5} \Rightarrow \frac{225}{d} \Rightarrow d = 425 \Rightarrow v = \frac{225}{425} = 0.53 \text{ fps} \)

Actual d = 8.5 ft

Est'd. d = 11.9 ft

Actual d = 8.5 ft

Est'd. d = 11.9 ft

Freeboard = \( 1.0 + (0.025)(11.9)(8.5) \Rightarrow 0.0 \Rightarrow \) Use 2.0

D = 8.5 - 2.0 = 6.5

f = \frac{1}{1120(6.5)} = 0.72 \Rightarrow Subcritical
Sta 89+45 to Sta 94+50 - Replace culvert at Bijou Street

4 - 14' x 10' RCB

\[ Q_{100} = 50,000 \text{ cfs} \]
\[ L = 450' \]
\[ S_{ex} = 0.69\% \]
\[ H/W = 82.0 \]
\[ B/W = 90 \]
\[ H/W = 10.0 \]
\[ H/W = 10.0 \]

Outlet Control
\[ z_0 = (450' \times 0.001) = 2.7' \]
\[ H/W = 2.1 + 8.5 - 2.7 = 7.9' \]

Sta 94+50 to Sta 98+10 - New open channel between Bijou Street and Platte Avenue

\[ Q_{100} = 50,000 \text{ cfs} \]
\[ S_{ex} = 0.99\% \]
\[ d = 4.5' \]
\[ v = (1.4) \frac{225}{54} \frac{0.001}{2} = 26.5 \text{ fps} \]
\[ Q = (26.5)(225) = 6030 \text{ cfs} \]

Actual d = 8 + \frac{1}{2}(100 \times \text{HEC} - 2) \Rightarrow d = 4.00 \text{ ft} \Rightarrow v = \frac{50,000}{240} = 12.7 \text{ fps} \]

Floodboard = 10 + (0.025) \frac{12.7}{6} = 10.1' \Rightarrow Use 2' \]

\[ d_{max} = 8 + 2 = 10' \]

\[ f = \frac{1.17}{(0.12)(8)} = 0.79 \text{ Subcritical} \]
Sta. 98+00 to Sta. 100+30 - Replace Culvert at Platte Avenue/School Athletic Field and Bridge at Boulder Street

4 - 12'-10" RCB

\[ Q_{100} = 5000 \, \text{cfs} \quad L = 695' \quad S_{0x} = 0.15 \, \text{ft} \quad HYD = 9.15' - 7.65' = 1.5' \]

Outlet Control: \( Q = 6 \, \text{ft}^3/\text{s} \)

Outlet Control: \( H_0 = 2.9' \quad L_{S_0} = (695)(0.005) = 3.5' \)

Outlet Control: \( H = 3.4' + 8.5' = 7.9' \)

Sta. 104+20 to Sta. 112+35 - New open channel between Boulder Street and St. Vrain Street

Outlet Control: \( Q = 6 \, \text{ft}^3/\text{s} \)

Outlet Control: \( S_{x0} = 0.15 \, \text{ft} \)

Outlet Control: \( d = 10' = \frac{10}{60} \, \text{fps} \)

Outlet Control: \( d = 10' = \frac{10}{60} \, \text{fps} \)

Outlet Control: \( D_{min} = 1.5' + (0.005)(2.5')(0.005) = 1.5' \)

Outlet Control: \( D_{min} = 1.5' + (0.005)(2.5')(0.005) = 1.5' \)

Outlet Control: \( D_{min} = 1.5' + (0.005)(2.5')(0.005) = 1.5' \)

Outlet Control: \( \frac{2.65}{\sqrt{32.2}(4.5)} = 2.20 \Rightarrow Supercritical \)
Sta. 118+35 to Sta. 118+40 - Replace Culvert at Sth Main Street

4 x 10' x 10' RCC

Q_{no} = 4935 cfs  \quad L = 105'  \quad S = 0.7\%  \quad H_{W} = 0.0'  \quad H_{D} = 0.0'  \quad H_{w} = 0.0'  \quad H_{w} = 0.0'

Outlet Control \Rightarrow H = 3.3'  \quad H_{o} = 4.5'  \quad L_{o} = (105X0.004) = 0.4'

H_{w} = 3.3 + 4.5 - 0.4 = 7.4'

Sta. 118+40 to Sta. 117+75 - New open channel between Sth Main Street and Willamette Street

Concrete Channel w/ Concrete Retaining Walls

Q_{no} = 4935 cfs  \quad S_{en} = 0.7\%

d = \sqrt{(4.9^4 \times 225/65) / (0.00) / 245.6} = 0.43\% \Rightarrow d = 5"  \quad (0.02) x (4.9)/12 = 0.04\%  \Rightarrow (225/65) x 245.6 = 6515 cfs

Actual d = 12"  \Rightarrow 2.75\% [Est. d / (4.9 + 14.5 - 2)] \Rightarrow d = 2.75\% \Rightarrow 3.18\% \Rightarrow 0.02 x 4.9 / 12 = 0.01\%  \Rightarrow 225 x 65 / 12 = 14.6 cfs

F = \frac{(4.9)}{[225 / (4.9)]} = 20.94 \Rightarrow Subcut en
Sta. 117+75 to Sta 119+80 - Replace Culvert at Willamette Sheet

3-10'x10' RCB

Q_{100} = 4875 cfs  \quad L = 205'  \quad \theta = 0.190  \quad H_1 = 12.0 - 91.9 = 20.1'

Inlet Control \Rightarrow Q / b = \frac{4875}{10} = 487.5  \quad H_1 = 1.7  \quad H_2 = (1.7)(10) = 17.0'

Outlet Control \Rightarrow H_2 = 16.3  \quad H_1 = 20.3 - \theta_L = 20.3(0.001) = 0.2'

H_2 = 16.3 + 0.3 = 16.6'

Sta. 119+80 to Sta 135+15 - New open channel between Willamette Sheet and Cache La Poudre Sheet

Concrete Channel w/ Concrete Retaining Walls and Replace Pedestrian Ramps at Sta 128+170

$Q_{100} = 4875 \text{ cfs}$  \quad $\theta = 0.170$

$d = \omega \Rightarrow \omega = \sqrt{\frac{Q}{0.054((10)'^2)(0.16)}} = 2.10' \quad \Rightarrow Q = \frac{2.10(20)}{2.0} = 54.0 \text{ cfs}$

Freeboard = $3.0 + (0.025)(20)' = 2.2' \Rightarrow Use 3'  \quad D_{min} = 6 + 3 = 9''$

$F = \frac{24.0}{\sqrt{152(7)}} = 1.87' \Rightarrow Sufficient$
Sta 185+15 to Sta 187+05 - Replace Culvert at Cache la Poudre Sheet

3-10'x10' RCB

\( Q_{100} = 4205 \text{ cfs} \quad L=190' \quad S_{D}=0.70' \quad AHW=260-0.95=250.5' \)

Inlet Control \( \Rightarrow Q/6=4205/80=52.5\) \( \quad HW/D=1.5 \quad HW(15/10,0)=15.0' \)

Outlet Control \( \Rightarrow h=5.0 \quad H_b=6.0 \quad L_{50}=(190)(0.002)=0.4' \)

\( HW=5.0+6-0.4=10.6' \)

Sta 187+05 to Sta 187+45 - New open channel between Cache la Poudre Sheet and Uintah Sheet

Concrete Channel w/ Concrete Retaining Walls

\( Q_{100} = 4805.4\text{ cfs} \quad S_{D}=0.70' \)

\( d=5.5' \Rightarrow v=\sqrt{\frac{1.44}{(0.025)(5.5)^{0.6}}} = 24.9\text{ fps} \Rightarrow Q=(24.9)(193)=4805.4\text{ cfs} \)

\( F_{R Channel} = 0.0 + (0.025)(24.9)(5.5)^{0.5} = 25' \Rightarrow V_{c}=3' \quad D_{min} = 5.5 + 3 = 8.5' \)

\( F = \frac{15(6.25)(5.5)}{18} = 0.8 \Rightarrow Separation \)
Sta. 52+45 to Sta. 53+55 - Replace Curb at Utah Street

2 - 14' x 10' RC B.

Q_{100} = 3940 cfs
\theta = 110^\circ \quad \delta_p = 120^\circ
A_{TH} = 50.0 - 28.1 = 21.9'

Inlet Control \Rightarrow Q/6 = \frac{2940}{288} = 10.2
\frac{A_{TH}}{B_a} = 0.5
\frac{A_{TH}}{(15)(10)} = 15.0

Outlet Control \Rightarrow H_0 = 4.4
H_0 = 5.5
L_{G0} = (110)(0.02) = 13

H_{TH} = 4.4 + 5.5 - 13 = 6.9

Sta. 53+55 to Sta. 57+55 - New open channel between Utah Street and San Miguel Street

Concrete Channel W/ Concrete Retaining Walls

\theta = 110^\circ \quad c_{TH} = 11.170

d = 5' \Rightarrow \frac{d}{a} = \frac{1.40}{a}\frac{150}{400}(0.01)\frac{1}{2} = 29.0 \text{ fps} \Rightarrow d = 29.0(1.50) = 43.50 \text{ cfs}

\text{Channel:} d = 12' + 11.5 = 23.5, \theta = 5\text{ ft} \Rightarrow d = 11.6', a = 4055, f = \frac{29.0}{4055} = 9.7 \text{ fps}

Re-calculation: \frac{1.0 + (0.025)(9.7)(11.6)}{11.6} = 1.5 \Rightarrow \text{Use } 2' \text{ concrete } D_{TH} = 11.542 = 13.5'

F = \frac{9.7}{\sqrt{32.2(11.5)}} = 0.50 \Rightarrow \text{Subcritical}


**Sta. 156+55 to Sta. 158+40 - Replace Culvert at San Miguel Street**

\[ Z = 14' \times 10' \text{ PCB} \]

\[ Q_{100} = 3940 \quad L = 85' \quad S_{d} = 0.06 \% \quad H_{w} = 52.1 - 33.1 = 19.0' \]

**Inlet Control**

\[ B/f_0 = \frac{3940}{2D} = 141 \quad h_{w}/D = 1.5 \quad H_{w} = (1.5)(0.1) = 15.0' \]

**Outlet Control**

\[ H = 4.2' \quad h_0 = 11.5' \quad L_{0} = (0.006)(11.5)(0.5) = 0.5' \]

\[ h_{w} = 4.2 + 11.5 - 0.5 = 15.2' \]

---

**Sta. 158+40 to Sta. 167+35 - Open Channel between San Miguel Street and Pedestrian Bridge**

**Twins 116'**

**Concrete Channel w/ Concrete Retaining Walls**

\[ Q_{100} = 3940 \text{ cfs} \quad S_{d} = 1.090 \%

\[ d = 5' \Rightarrow \frac{4.44}{(0.06)(50)^{0.5}(0.010)} = 27.1 \text{ fps} \Rightarrow Q = (27.1)(50) = 1355 \text{ cfs} \]

**Actual d = 7.5'**

\[ \frac{4.44}{(0.06)(50)^{0.5}(0.010)} = 225 \text{ sf} \quad \Rightarrow w = \frac{3940}{225} = 17.5 \text{ fps} \]

**Froude = 1.0 + (0.025)(7.5)/(7.5)^{0.5} = 1.9 \Rightarrow Use 2'**

\[ D_{max} = 7.5 + 2 = 9.5' \]

\[ F = \frac{17.5}{\sqrt{128}(7.5)} = 1.1 \Rightarrow \\text{Super Critical} \]
Sta. 167+35 - Replace Pedestrian Bridge

Sta. 167+35 to Sta. 176+25 - New open channel between Pedestrian Bridge and Betty Jewell Golf Course South Boundary

Concrete Channel w/ Concrete Retaining Walls

\[
Q_{100} = 3665 \text{ cfs} \quad S_{F} = 1.0 \%
\]
\[
d = \frac{Q_{100}}{1000} \left( \frac{1.44}{0.01} \right) \left( \frac{0.001}{40} \right) = 272.7 \text{ ft} \Rightarrow 272.7 \times 50 = 1350 \text{ cfs}
\]
\[
\text{Freeboard} = 1.0 + 0.025\left( \frac{272.7}{5} \right) = 2.2 \Rightarrow \text{ Use } 3 \text{ ft}, \quad \text{Min} = 5.5 - 8 \text{ ft}
\]
\[
E = \frac{23.7}{1000 \times (5)} = 0.118 \Rightarrow \text{ SuperCritical}
\]
Sta 171+25 to Sta 189+05 - New Open Channel between Patty Jewett Golf Course South Boundary and Espanola Street

Concrete Channel w/ Concrete Retaining Walls and Replace 4 Golf Cart Bridges

\[ Q_{100} = 3665 \text{ cfs} \quad S_e = 1.070 + 0.6 \text{ Ev. Dwp} \quad S_p = 0.870 + \]
\[ Q = \frac{S_e}{S_p} \Rightarrow Q = \frac{1.070}{0.870} \approx 1.22 \text{ cfs} \]

Freeboard = 1.0 + (0.025 \times 24.7) = 2.11' => Use 3'

Dam: 5 + 3 = 8'

Sta 189+05 to Sta 190+85 - Replace Culvert at Espanola Street

3 - 12' x 10' RC (2)

\[ Q_{100} = 3555 \text{ cfs} \quad L = 180' \quad S_e = 1.390 \quad AHW = 85.5 - 72.8 = 12.7' \]

Inlet Control \( \Rightarrow Q_i = 3555 \div 10 = 355.5 \text{ cfs} \)

Outlet Control \( \Rightarrow H_i = 2.0' \quad H_o = (180 \times 0.03) = 5.4' \),

\[ AHW = 2.0 + 5' - 2.3 = 4.7' \]
Sta. 190+85 to Sta. 198+45 - Open Channel between Esperola Street and End of Existing Channel Lining

Concrete Channel and Replace 4 Golf Cart Bridges

\[ Q_{100} = 3.4 \text{ cfs} \sim \text{Sec} = 1.49 \text{ ft} + 3 \text{ ft Drop} \sim \text{Spd} = 1.06 \text{ ft/s} \]

\[ d = 3.5 \text{ ft} \Rightarrow \text{V} = \frac{(1.49)(1.75)^{0.5}}{28.1 \text{ fps} \Rightarrow Q = (28.1)(100) = 3654 \text{ cfs} \]

Froude Number \[ = \frac{1.0 + (0.025)(28.1)(3.5)^{0.5}}{2.1} = 0.825 \Rightarrow \text{Normal} \]

\[ F = \frac{28.1}{(3.5)^{0.5}} = 2.05 \Rightarrow \text{Super Critical} \]
Sta. 198+95 to Sta. 216+40 - New Open Channel between End of Existing Channel, Lining and Paved Road

Concrete Channel and Replace 2 Golf Cart Bridges

\[
\begin{align*}
Q_{100} & = 1110 \text{ cfs} \\
S_{FL} & = 1.09 \text{ ft} \\
d & = 2' \Rightarrow V = \left( \frac{1.44}{0.018} \right)^{1/3} \left( 0.01 \right)^{1/2} = 0.01 \text{ ft} \\
Q & = \frac{V}{B} = \frac{190}{20} = 11.30 \text{ cfs} \\
\text{Freeboard} & = \frac{1.0 + (0.025)}{166} (2)^{1/5} = 0.5' \\
f & = \frac{1.6}{1750 \times 2} = 0.07 \Rightarrow \text{Supercritical} \\
\end{align*}
\]

Sta. 216+40 to Sta. 224+75 - Replace Culvert at Paved Road

3 - 10' x 5' RC B

\[
\begin{align*}
Q_{200} & = 1110 \text{ cfs} \\
L & = 8.5' \\
S_{FL} & = 0.19 \text{ ft} \\
\text{Inlet Control} & \Rightarrow \frac{Q}{V} = \frac{1110}{590} = 1.9 \\
\text{Outlet Control} & \Rightarrow H = 1.2' \\
\text{Inlet} & \Rightarrow \frac{1}{2} + 0.4 + 2.8' \\
\text{Outlet} & \Rightarrow \frac{1}{2} + 0.4 + 2.8' \\
\end{align*}
\]
### Sta. 214+95 to Sta. 218+30 - New Culvert Channel between Paico Road and Jefferson Sheet

- **Concrete Channel**
- **L = 3.0**

#### Water Calculation

- **Q_{req} = 1110 cfs**
- **P_{req} = 0.75 m**
- **d = 2.5**

#### Actual Calculation

- **d = 5.5** (Est = D / 2 + 0.6)
- **A = 150** (Est) **s**
- **F = 4.7**

- **F = 0.58**
- **Super C ==**

### Sta. 218+30 to Sta. 219+10 - Replace Culvert at Jefferson Sheet

- **S = 0.5**

#### Water Calculation

- **Q_{req} = 1110 cfs**
- **P_{req} = 0.75 m**
- **H_{inlet} = 14.0**
- **S = 0.5**

#### Inlet Control

- **Q_{inlet} = 0.6**
- **H_{inlet} = 11.0**
- **H_{inlet} = 0.5**

#### Outlet Control

- **H_{outlet} = 5.5**
- **L_{outlet} = 0.10**
- **L_{outlet} = 0.10**
- **H_{outlet} = 5.5**
Sta. 219.10 to Sta. 222.50 - New Open Channel between Jefferson Street and Madison Street

Conduit Channel

\[ b = 30 \]

\[ Q_{100} = 1100 \text{ cfs} \quad s_{p} = 1.2\% \]

\[ d = 2^\circ \Rightarrow V = \frac{1}{2} \times 241.25 \times 2.0012 \times 18 \times 3600 = 0.18.31/60 = 1100 \text{ cfs} \]

Actual \( d = 2^\circ \times (\text{Est.mit} + \text{Exist.HEC-2}) \Rightarrow h = 925.6^\circ \Rightarrow v = \frac{1100}{925.6} = 12.0 \times 3600 \]

Freeboard = \( 1.0 + (0.025 \times 12.0) / 3.25^\circ = 1.4 > V \leq 2.0 \) 

\( b_{100} = 3^\circ + 2 \times 8 \]

\[ F = \frac{1}{12.5} \Rightarrow \text{Supercritical} \]

Sta. 222.50 to Sta. 225.50 - Replace Culvert at Madison Street

\[ 3 - 10' \times 5' \text{ PCB} \]

\[ Q_{100} = 1100 \text{ cfs} \quad L = 80' \quad s_{p} = 1.2\% \quad \text{AHWS} = 20.0 - 12.4 = 7.6' \]

Inlet Control \( \Rightarrow d/L = \frac{120}{80} = 1.5 \quad \text{AHWD} = 1.1 \quad \text{HW} = (1.1)(5) = 5.5' \]

Outlet Control \( \Rightarrow H = 1.2' \quad H_b = 3' \quad L_S = 80(0.012) = 0.9' \)

\[ \text{HW} = 1.2 + 3 - 1.0 = 3.2' \]
Sta. 223+20 to Sta. 226+25 - New Open Channel between Madison Street and Monroe Street

Concrete Channel

L = 30'

Q_{100} = 1110 cfs

C_{p} = 1.25%

d = 2'

D = 0.4V^{0.35} + 0.02V^{0.5} = 0.34 + 0.02V^{0.5} = 0.34 + 0.02 \times 10 = 0.34 + 0.2 = 0.54 ft

v = \frac{18.3}{0.54} \times (1.00 + 0.025) = \frac{33.6}{0.54} fpm

Actual d = 3 + 0.25 = 3.25 ft

Freeboard = \frac{10 + 0.25}{18.3} = 0.6\% 

D = 2.5 = \frac{125 \text{ ft}}{125} = \text{supercritical}

Sta. 226+25 to 227+05 - Replace Culvert at Monroe Street

Q_{100} = 1110 cfs

C_{p} = 1.25%

Inlet Control: Q/I = \frac{1110}{30} = 37 \text{ ft}^3/\text{sec}

Outlet Control: H = 1.21 ft

\text{HW} = \frac{1.2 + 3}{1.0} = 3.2
Sta 224+05 to Sta 224+20 - New Open Channel between Nanao Street and Jackson Street

Sta 224+20 to Sta 234+155 - Replace Culvert at Jackson Street/LaSalle Street
Stai 234+15 to Stai 235+40 - New Open Channel between La Salle Street and Pedestrian Path

**Concrete Channel**

\[ b = 3.0 \]

\[ Q_{in} = 1070 \text{ cfs} \]

\[ Q_{out} = 1.2 \text{ cfs} \]

\[ d = 2 \Rightarrow \frac{b}{d} = \frac{2}{1} = 2 \]

\[ A = 0.04 \times 1.5 \times 0.1 = 0.06 \]

\[ \frac{Q}{A} = 18.3 \text{ cfs/m} \]

**Actual Flow:**

\[ Q = 105.6 \text{ cfs} \]

**Freeboard:**

\[ h = 0.02 \times \left( \frac{1.5}{102.5} \right) = 0.002 \]

**Downstream:**

\[ 3.5 + 2 = 5.5 \]

**Stai 235+40 to Stai 235+40 - Replace Culvert at Pedestrian Path**

\[ S = 10' \times 5' = 50' \]

\[ Q_{in} = 1070 \text{ cfs} \]

\[ L = 50' \]

\[ h = 2.0 \]

**Inlet Control:**

\[ Q = 0.6 \times 10^{10} = 3.6 \]

\[ H = 0.01 \]

\[ H_w = 1.1 \times 5' = 5.5' \]

**Outlet Control:**

\[ h = 1.1 \]

\[ h_0 = 3.5' \]

\[ Q = 50 \times 0.022 = 1.1 \]

\[ H_w = 1.1 + 3.5 - 1.1 = 3.5' \]
Sta. 235+40 to Sta 236+20 - New Open Channel between Pedestrian Path and C.I.R.P. Railroad

Concise Channel

\[ Q = \frac{1070 \text{ cfs}}{1.29} \]

Actual \( Q = \frac{5.73}{1.2} = 100 \text{ cfs} \)

Outlet Control  \( Q = \frac{1070}{16} = 67 \text{ cfs} \)

Outlet Control => \( H = 3.0' \)  \( h_0 = 5.0' \)  \( L_0 = \frac{550 \times 0.002}{1.2} = 1.2' \)

**Sta. 236+20 to Sta. 236+75 - Replace Culvert at C.I.R.P. Railroad**

2 - 9' x 5' P.C.B.

\[ Q_{100} = 1070 \text{ cfs} \]

Outlet Control  \( Q = \frac{1070}{16} = 67 \text{ cfs} \)

Outlet Control => \( H = 3.0' \)  \( h_0 = 5.0' \)  \( L_0 = \frac{550 \times 0.002}{1.2} = 1.2' \)

**Sta. 236+75 to Sta. 237+20**
Templeton Gap Road at Van Buren Channel - Replace Culvert

2 - 11' x 6' PCB

Q\text{100} = 1460 cfs

\frac{Q}{A} = \frac{1460}{11 \times 6} = 22.56

\frac{L}{A} = \frac{100}{11 \times 6} = 1.83

\frac{W}{D} = \frac{40.1}{0.26} = 154.3

\frac{W}{D} = \frac{154.3}{2.6} = 9.10

\text{Inlet Control} \Rightarrow H = 2.6 \text{ ft} \quad D_c = 5.1 \text{ ft} \quad H_o = \frac{6+5.1}{2} = 5.6

L_c = (100)(0.006) = 0.6

\text{Outlet Control} \Rightarrow H = 2.6 \text{ ft} + 5.1 - 0.6 = 7.1
C. SOFT-LINED FULL IMPROVEMENT
WITH COMPLETE SHOOKS RUN DIVERSION
AT THE VAN BUREN CHANNEL
ALTERNATIVE HYDRAULIC CALCULATIONS
**SOFT-LINED ALTERNATIVE w/DIVERSION (VAN BUREN CHANNEL)**

**Sta. 0+25 to Sta. 9+75 - New open channel between Fountain Creek Confluence and Las Vegas Street**

- $Q = 6750$ cfs, $S_0 = 0.49\%$
- $d = 10' = y = (1.44 \times 10^3)^1/120' = 0.0036 = 6.13$ fps
- $Q = (1.03 \times 105) = 6615$ cfs

**Freeboard:** $10 + (0.0036 \times 10) = 1.13' 
$Use 2' $D_{min} = 10 + 2 = 12' (Meet exist. east bank)$

**$F = \frac{0.5}{\sqrt{3.22(10)}} = 0.35 \Rightarrow Subvertical$**

**Sta. 9+75 to Sta. 10+80 - Replace bridge and dissipator at Las Vegas Street**

- $S_{in} = 6750$ cfs, $S_{in} = 0.75\%$
- $A + W = 116'-17.7 = 18.9'$
- Inlet control: $D_0 = 8.1$ in
- Outlet control: $Q = 2.7$, $d_0 = 7.4'$, $h_0 = 12.4'/2 = 6.2'$
- $LS = (70)(0.00) = 0.5'$
- $HW = 2 + 87 = 0.5 = 10.9'$
Sta. 10+50 to Sta. 11+20 - New Concrete Transition Channel between Las Vegas Sheet and ATSF & D.R.G.M. Railroad

Vertical Walled Concrete Transition Channel

$Q_{1050} = 6750 \text{ cfs} \quad S_{ex} = 1.050$

d = 5.5' and $6.44' \Rightarrow d = (5.5^2 + 6.44^2)^{1/2} = 8.44' \Rightarrow Q = (8.44')^2 = 71.95 \text{ cfs}$

Actual $d = 8.44' \Rightarrow \frac{d}{8.44'} = 0.952$ (Stockwell & Eucleids) $\Rightarrow d = 11.8' \Rightarrow d = 11.8'$

$F = \frac{13.3}{\sqrt{(0.952)(0.5)}} = 0.65$ $\Rightarrow$ Subcritical

Sta. 11+20 to 11+65 - Existing Channel for ATSF & D.R.G.W. Railroad

Double $20' \times 4.5' \text{ Conc. Arch (18.7') x 15.4' RCB Eqv.}$

$Q_{1165} = 6750 \text{ cfs} \quad L = 45' \quad S_{ex} = 1.050 \quad A H W = 23.2' - 98.7' = 24.5'$

Inlet Control $\Rightarrow \frac{Q}{6} = \frac{6750}{6} = 1125' \Rightarrow H = 0.20'(180')$ $\Rightarrow H = 0.20'(180') = 36.2'$

Outlet Control $\Rightarrow H = 2.8' \quad H_0 = 11.5' \quad L = (45')(0.013) = 0.6' \Rightarrow H = 2.8' + 11.5' = 14.3'$
Sta. 1465 to Sta. 1546 - New Fork Channel between A.T.&S.F. & B.R.I.W. Paehl's and abandoned railroad

\[ TW = 215 + \frac{1}{3} \]

Landscaped Channel w/ Boulder, Retaining Walls and Sediment w/ 1-3' Drop Structure

- \( Q_{100} = 0.750 \text{ cfs} \)
- \( S_{xy} = 1/2 \% \)
- \( S_{ppro} = 0.5 \% \)
- \( d = 11' \Rightarrow V = \frac{0.49}{0.050} \times \frac{0.025}{0.025} = 0.5 \text{ fps} \Rightarrow Q = (6.21 \times 0.5) = 3.1 \text{ cfs} \)
- Actual \( d = 12' \times 0.975 \) (Exist HEC-C) \( \Rightarrow d = 13' \Rightarrow A = 1425 \text{ sf} \) \( \Rightarrow V = \frac{0.750}{4} = 4.7 \text{ fps} \)
- Freeboard \( = 0.05 \times 1.3 \times 4.7 = 0.5 \text{ sf} \) \( D_{min} = 13 + 0.0 = 13' \)
- \( f_7 = \frac{1.7}{87.7(18)} = 0.123 \Rightarrow Subscriptal \)

Sta. 1546 to 1620 - Existing culvert for abandoned railroad

Double 20' x 11.9' Stone Masonry Arch (18.8' x 16.8' RCE Eqv)

- \( Q_{100} = 0.750 \text{ cfs} \)
- \( L = 60' \) \( S_{xy} = 0.7 \% \) \( \Rightarrow H_W = 43.8 - 0.8 = 40.0' \)
- Inlet Control \( \Rightarrow G_{in} = 0.180 \)
- Outlet Control \( \Rightarrow H_{out} = 13' \) \( D_{min} = (60/0.20) = 0.4' \)
- \( H_W = 21.1 + 13.0 - 0.4 = 14.7' \)
Sta. 24+00 to Sta. 25+50 - Replace Cutbank at Fountain Boulevard

\[ A_0 = 14 \times 10 \text{ RCBO} \]

\[ Q_{100} = 0.790 \text{ cfs} \]

\[ L = 150 \text{ ft} \]

\[ S_{00} = 0.790 \text{ ft/m} \]

\[ A_{THW} = 50.3 - 10.3 = 20.0 \text{ ft}^2 \]

\[ H_{INLET} = 0.84 \text{ ft} \]

\[ H_{OUTLET} = 1.1 \text{ ft} \]

\[ H_{W} = 5.2 + 14.11 = 19.1 \text{ ft} \]
St, 25+50 to St, 48+65 - Remove undesirable vegetation and debris from floodplain and reduce slope of West embankment between Fountain Boulevard and Costilla Street.

0.770 cfs to 0.65 cfs  \( \Delta E = 0.18 \%
\)

\[ d = 10.5^\prime \quad b = 50^\prime \quad Q = \frac{0.770}{0.65} \times \left( \frac{0.008}{0.009} \right) \times 10^3 \quad \Rightarrow \quad Q = 10.16 \times 0.65 \times 10^3 \quad \Rightarrow \quad 6780 \text{ cfs}
\]

Actual \( d = 18.1^\prime \quad b = 30^\prime \) (inlet HECE) \( \Rightarrow \quad d = 12.5^\prime \quad b = 30^\prime \) \( \Rightarrow \quad b = 8846 \times 0.65 \quad \Rightarrow \quad b = 5654 \text{ cfs}
\]

Fire demand \( 50+0 \text{ cfs} \times 0.75 \times 0.5 = 1.4 \Rightarrow \quad \text{design} \quad 12.5+2.0 = 14.5^\prime
\]

\[ F = \frac{872.22 \times 0.65}{650} = 0.37 \Rightarrow \text{Subcritical}
\]

St, 48+65 to St, 50+65 - Replace culvert at Costilla Street.

\[ 4 = 10 \times 10^\prime \text{ ECE}
\]

\[ Q_{max} = 6785 \text{ cfs} \quad L = 200' \quad \Delta S_{eq} = 0.6 \%
\]

Inlet Control \( \Rightarrow Q = \frac{6785}{30} = 1.17 \quad \text{h} \quad H_{in} = 1.15 \quad H_{wa} = (1.15)(10.0) = 17.5
\]

Outlet Control \( \Rightarrow H = 10.5' \quad H_0 = 52.5' \quad L_{eq} = (200) \times 0.006 = 1.2
\]

\[ H_{wa} = 6.5 + 12.5 - 1.2 = 17.8
\]
Stan 501+65 to Stan 71+55 - New Open Channel between Costilla Street and El Paso Street

\[ Q_{in} = 650 \text{ cfs} \quad \text{to} \quad 6550 \text{ cfs} \]
\[ L = 125' \quad C_{eq} = 1.05' \quad A + H = 65 - 53.3 = 11.8' \]

Outlet Control \( Q = \frac{6550}{65} = 101 \quad H_{out} = 10.0' \quad H_{up} = (10.0)(10.0) = 100.0' \)

Outlet Control \( H = 2.0' \quad H_0 = 10.0' \quad C_{eq} = (125(10.0)) = 1.3' \)

\[ H_{out} = 2.0 + 10.0 - 1.3 = 10.7' \]
Sta 72+80 to Sta 76+80 - New open channel between El Paso Street and Pikes Peak Avenue
TWO: 245' +

Landscaped channel by Boulder Retaining Walls and Soil Bottom

Sta 76+80 to Sta 85+160 - Replace culverts at Pikes Peak Avenue / El Paso Street and at Kiowa Street

**Design Criteria**

**Discharge (Q)**
- Q = 6550 cfs

**Floodplain (B)**
- B = 200 ft

**Slope (S)**
- S = 0.005

**Cross Sectional Area (A)**
- A = 12,000 sq ft

**Width (W)**
- W = 50 ft

**Erosion Control (E)**
- E = 0.7

**Flow深度 (H)**
- H = 2.8 ft

**Floodplain (B)**
- B = 200 ft

**Soil Depth (S)**
- S = 0.5 ft

**High Water (HW)**
- HW = 28' +10.7" - 0.5" = 28' +10.2"
Known Street

\[ Q_{100} = 4120 \text{ cfs} \]

\[ L = 150' \quad S_e = 0.35' \quad A_{HW} = 760 - 62.4 = 13.6' \]

Inlet Control

\[ Q/b = \frac{4120}{14} = 294 \quad H_{WD} = 10.5' \quad H_{HW} = 110(10)/10 = 10.5' \]

Outlet Control

\[ H_0 = 10.5' \quad L_5 = 150(0.003) = 0.5' \]

\[ H_{WO} = 10.5 + 10.5 - 0.5 = 11.5' \]

Sta. 85+60 to Sta. 89+95 - New open channel between Known Street and Bijou Street

TW: 180'

Landscaped Channel
w/ Founder, Retaining Walls and Soil Bottom
w/ 1-2' Drop Structure

\[ Q_{100} = 4120 \text{ cfs} \]

\[ S_p = 0.97' \quad P = 0.5' \]

\[ d = 9.0' \quad v = \left( \frac{1.494 \times 10^3}{108} \right)^{1/2} \times 6.76 \text{ fps} \]

\[ Q = (6.76)(610) = 4085 \text{ cfs} \]

Freeboard

\[ + = \frac{6.76(0.025)(9.0)}{1.3} = 2.0' \]

\[ D_{min} = 9.0 + 2.0 = 11.0' \]

\[ + = \frac{(32.2)(9.0)}{11.0} = 0.39 \quad \text{Sedimental} \]
Sta. 89+45 to Sta. 94+50 - Replace culvert at Byou Street

- $Q_{100} = 4100 \text{ cfs}$
- $C = 450''$
- $S_{ex} = 0.16\%$
- $H_w = 82.0 - 49.8 = 12.2''$

**Inlet Control**

- $Q/4 = 1025 \div 4 = 256.25$
- $H_w = 4.05$
- $H_w = (1.02)(100) = 10.2''$

**Outlet Control**

- $S_{ex} = 9.1'$
- $L_S = (450)(0.006) = 2.7'$
- $H_w = 2.6 + 9.0 - 2.7 = 8.9''$

Sta. 94+50 to Sta. 98+10 - New open channel between Byou Street and Platte Avenue

- $C_{avea} = 170$ ft
- $B = 10$ ft

- $Q_{ave} = 4120 \text{ cfs}$
- $S_{ex} = 0.4 \%$
- $S_{pro} = 0.5 \%$

- $d = 8.5'$
- $d = (0)(0.025)(0.5)(8.5)^{1/3} = 0.5$ ft
- $Q = (0.5)(0.65) = 428 \text{ cfs}$

- $F_{ave} = 1.0 + (0.025)(8.5)(8.5)^{1/3} = 1.0
- $D_{ave} = 8.5 + 2.0 = 10.5'$

- $E = \frac{0.5}{10.2} = 0.039$ => Subcritical
Sta. 78+10 to Sta. 106+30 - Replace Culvert at Plateau Avenue/School Athletic Field and Bridge at Boulder Street

4 - 10'x10' RCC

Q_{100} = 4080 cfs \quad L = 695' \quad S_{EX} = 0.15\% \quad ATT = 915 - 765 = 150'

Outlet Control => H = 3.6' \quad H_0 = 8.5' \quad L = (9.5)(0.005) = 3.5'

4W = 3.6 + 8.5 - 3 = 8.6'

Sta. 106+30 to Sta. 112+85 - New open channel between Boulder Street and St. Vrain Street

L = 50'

Q_{100} = 4080 cfs \quad S_{EX} = 0.9\%

d = 7.5' - 0.04(0.65/125)^{1/4}(0.009)^{1/2} = 7.04' \quad Q = (7.04)(600) = 4200 cfs

F = \frac{1.04}{\sqrt{(2.5)(7.5)}} = 0.45 \Rightarrow Subcritical
Sta. 112+35 to Sta. 113+40 - Replace Culvert at St. Vrain Street

$V = 11 \times 10^5 \text{ KCB}$

- $Q_{100} = 3990 \text{ cfs}$
- $L = 105'$
- $S = 0.4\%$
- $A_{HW} = 0.010 - 0.650 = 15.0'$

Outlet Control $\Rightarrow H = 3.4'$
- $H_0 = 7.5'$
- $L_x = (105)(0.004) = 0.4'$
- $H_W = 3.4 + 2.5 - 0.4 = 10.5'$

Sta. 113+40 to Sta. 117+50 - New Open Channel between St. Vrain Street and Willamette Street

- $Q_{100} = 3990 \text{ cfs}$
- $S_{EX} = 0.75\%$
- $d = 8'$
- $w = (1.0 + 0.65)(10.00)^{0.01} = 0.5 \text{ fps}$
- $Q = (0.5)(10) = 49.5 \text{ cfs}$

Actual $d = 12.5 + 0.10 = 12.6'$
- $d = 10 \Rightarrow 700 \text{ sf}$
- $w = 3990 \text{ cfs} = 4.4 \text{ fps}$

Freeboard $= 1.0 + 0.02(4.4)(10)^{0.01} = 1.2 \Rightarrow 0.2 \text{ ft} \Rightarrow D_z = 10 + 2 = 12$

$F = \frac{64}{(44)(2)(10)} = 0.25 \Rightarrow 0.25 \text{ ft}$
Sta 117+25 to Sta 119+80 - Replace Culvert at Willamette Street

- 2' x 10' RCC

Q = 3920 cfs
L = 205'
S = 0.190
AHw = 12.0
9.9 = 20.1

Inlet Control ⇒ Q = \( \frac{3920 \times 168}{24} \) = 274.8 cfs

HW = 6.9
HW = (1.5)(10) = 17.0

Outlet Control ⇒ \( h = \frac{Q}{2} \)

= 10

\( H_b = 10' \)

\( LS_p = (205)(0.001) = 0.3' \)

HW = 6.2 + 10 - 0.3 = 15.9'

Sta 119+80 to Sta 135+15 - New open channel between Willamette Street and Cache La Poudre Street

Landscaped channel
W/ Boulder Retaining Walls and Silt
Bottom w/ 1'5'
Diag Structure
and Replace Pedestrian Bridge at Sta 128+70

Q = 3920 cfs
S_ex = 0.790
S_pes = 0.596

\( d = 10 \) ⇒ \( V = 1.44 \times \left( \frac{0.596}{10} \right)^{1/3} = 6.3 \text{ fps} \)

⇒ Q = (6.3)(10) = 63 cfs

Freeboard ⇒ 10 + (0.025)(6.3)(10) = 15'3"

⇒ Use 15'

\( D_{min} = 10.4 + 12' \)

F = \( \frac{6.3}{15'3} \) = 0.35 ⇒ Suckerhead
Sta. 185+05 to Sta. 187+05 - Replace Culvert at Cache la Poudre Sheet

\[ Q_{00} = 3345 \text{ cfs} \quad L = 190' \quad \theta_{0} = 0.290 \quad AH_{W} = 260.0 - 0.915 = 16.5' \]

Inlet Control \( \Rightarrow Q/I = 3345 / 234 = 14.3 \)

Outlet Control \( \Rightarrow h = 4.5 \quad h' = 7.1' \)

\[ H_{W} = 4.5 + 10 - 0.4 \times 14.5' \]

Sta. 187+05 to Sta. 189+45 - New open channel between Cache la Poudre Sheet and Uintah Street

\[ Q_{00} = 3345 \text{ cfs} \quad \theta_{0} = 0.790 \quad \theta_{40} = 0.570 \]

\[ d = 9.5' \quad \phi = (9.5/1200)(598)^{0.5} = 0.008 \text{坡度} \quad \Rightarrow Q = (6.0)(598) = 3590 \text{ cfs} \]


downstream = 10 + 10.02(4.0)(9.5)^{0.5} = 13.5 \Rightarrow D_{min} = 9.5 + 2 = 11.5' \]

\[ F = (432.8)(9.5) \times 0.34 = \text{subcritical} \]
Sta 152+45 to Sta 153+55 - Replace Culvert at Vinutah Street

\[ Z = 10' \times 10' \text{ ECB} \]

\[ Q_{100} = 2480 \text{ cfs} \]
\[ L = 110' \quad \theta = 12'90'' \quad AHW = 50'0'' - 28'1'' = 21'9'' \]

**Inlet Control**

\[ \frac{Q}{6} = \frac{2480}{20} = 124 \quad \frac{H}{D} = \frac{1.65}{4.1} = 0.395 \quad \frac{H}{D} = \frac{1.53}{10} = 0.153 \]

**Outlet Control**

\[ H = 4.9' \quad h_p = 9.5' \quad L_g = 110(0.025) = 1.1' \]

\[ H_W = 4.9 + 9.5 - 1.1 = 13'1'' \]

Sta 153+55 to Sta 157+55 - New open channel between Vinutah Street and San Miguel Street

**TW = 120'**

\[ Q_{100} = 2480 \text{ cfs} \quad s_p = 1.1\% \quad s_p = 0.1\% \]

\[ d = 9.5'' \Rightarrow \Delta z = (0.065)(9.5^2 / 16)(0.005)^2 = 5.9 \text{ fps} \]

\[ Q = 0.64(0.05) = 2480 \text{ cfs} \]

**Actual \( A = 15.5' \times 12' + 12' \) (Excavated from earth) \Rightarrow d = 12' \Rightarrow A = 810 \text{ ft}^2 \Rightarrow \frac{2480}{810} = 3.7 \text{ fps} \]

**Freeboard: \( h = 10 + (0.025)(12) = 12' \Rightarrow Use \text{ Tracer} \)

**\( D_{max} = 12' + 2' = 14' \)**

\[ F = \frac{3.7}{14240(12)} = 0.19 \Rightarrow \text{ Subcritical} \]
Stn.15+55 to Stn.158+40 - Replace Culvert at San Miguel Street

2 x 10' x 10' RCC

Q_{100} = 2980 ft³/s  L = 85'  \Delta h_{100} = 0.060'  \Delta h_{14} = 19.14'

Inlet Control  Q/\Delta h = 2980/44 = 68.14

Outlet Control  H = 4.7'  L_{o} = 50

HW = 4.7 + 12 - 0.5 = 16.2'

Stn.158+40 to Stn.167+35 - New channel between San Miguel Street and Pedestrian Bridge

New channel will be landscaped channel w/boulder riprap, retaining walls and soil riprap w/2'-2' drop structures

Q_{100} = 2980 cfs  \Delta h_{0} = 1.090'  S_{pro} = -0.59'

b = 9.5'  \Rightarrow w = (1/144) \frac{2980^{1/3}}{(0.005)^{1/2}} = 5.45 ft  \Rightarrow D_{min} = 9.5 + 2 = 11.5'

F = \frac{5.4}{W_{50}^{2}(9.5)} = 0.34 \Rightarrow Subcritical
Station 167435 - Replace Pedestrian Bridge

Station 167435 to 1716425 - New open channel between Pedestrian Bridge and Patty Jewett Golf Course South Boundary

\[
Q_{req} = 2980 \text{ cfs} \quad S_{Fr} = 0.90 \% \quad S_{PRO} = 0.5 \% \\
d = 9.5 \Rightarrow V = \left(1.44 \left(\frac{225}{32} \right) \left(0.005\right)^2\right) = 5.9 \text{ fps} \Rightarrow Q = 6.59 (5.9)(505) = 2980 \text{ cfs} \\
F_e = 1.0 + 2(0.025)(5.9)^{0.5} \	\Rightarrow 0.34 \Rightarrow \text{ Subcritical} \\
P = \frac{5.9}{(62.4)(1.5)} = 0.34 \Rightarrow \text{ Subcritical}
\]
Station 17+025 to Station 189+05 - New Open Channel between Patty Jewett Golf Course South Boundary and Esponola Street

Station 189+05 to Station 190+85 - Replace Culvert at Esponola Street

\[ B_{100^0} = 2640 \text{ cfs} \]
\[ B_{70^0} = 1020 \text{ cfs} \]
\[ B_{Ex} = 1020 + 6^0 \text{ Ex.Dip} \]
\[ B_{Pro} = 0.89 \text{ cfs} \]
\[ d = 10^0 \Rightarrow V = \left( \frac{1}{0.085} \right) \left( \frac{450}{130} \right)^{0.72} \left( 0.006 \right) ^{0.5} = 611 \text{ fps} \]
\[ B_{Pro} = 0.89 \text{ cfs} \]
\[ Q = \left( 400 \times 450 \right) = 1740 \text{ cfs} \]
\[ F = \frac{1}{0.52 \times (10)} = 0.18 \Rightarrow Subcritical \]

Station 189+05 to Station 190+85

\[ Q_{100} = 2580 \text{ cfs} \]
\[ L = 180^0 \]
\[ Q_{10} = 1390 \text{ cfs} \]
\[ A_{inlet} = 85.5 - 22.8 = 12.7^0 \]
\[ A_{Outlet} = 210^0 \]
\[ H_I = 10^0 \]
\[ U_D = \left( 180 \times 0.03 \right) = 2.5^0 \]
\[ H_I = 2.0 + 10 - 2.8 = 9.2^0 \]
Sta. 190+85 to Sta. 198+45 - New Open Channel between Esperola Street and End of Existing Channel Lining

Sta. 216+40 to Sta. 216+15 - Existing Culvert at Paseo Road

Sta. 216+45 to Sta. 218+30 - New Open Channel between Paseo Road and Jefferson Street

Sta. 218+30 to Sta. 219+10 - Existing Culvert at Jefferson Street

\[ Q_{100} = 2400 \, \text{cfs} \]
\[ S_{100} = 1/143 + 8' \, \text{at Dup} \]
\[ \Delta = 0.5 \, \text{ft} \]
\[ d = 6' \]
\[ V = \frac{Q}{b} \left( \frac{1}{2} - \frac{1}{2} \right) \]
\[ V = \frac{Q}{b} \left( \frac{1}{2} - \frac{1}{2} \right) \]
\[ \Delta = 0.5 \, \text{ft} \]
\[ \text{Freeboard} = (0.30)(0.5)(6) = 0.9 \, \text{ft} \]
\[ F = \frac{1}{\sqrt{V_0}} = 0.47 \Rightarrow \text{Subcritical} \]
Sta 2.19+10 to Sta 2.22+50 - Exist Open Channel between Jefferson Street and Madison Street

\[ Q_{10} = 130 \text{ cfs} \Rightarrow \text{Routine Maintenance Only} \]

Sta 2.22+50 to Sta 2.23+30 - Exist Culvert at Madison Street

\[ Q_{10} = 130 \text{ cfs} \Rightarrow \text{Routine Maintenance Only} \]

Sta 2.23+30 to Sta 2.24+25 - Exist Open Channel between Madison Street and Monroe Street

\[ Q_{10} = 130 \text{ cfs} \Rightarrow \text{Routine Maintenance Only} \]

Sta 2.24+25 to Sta 2.25+05 - Exist Culvert at Monroe Street

\[ Q_{10} = 130 \text{ cfs} \Rightarrow \text{Routine Maintenance Only} \]

Sta 2.25+05 to Sta 2.29+30 - Exist Open Channel between Monroe Street and Jackson Street

\[ Q_{10} = 130 \text{ cfs} \Rightarrow \text{Routine Maintenance Only} \]

Sta 2.29+30 to Sta 2.34+15 - Exist Culvert at Jackson Street/LaSalle Street

\[ Q_{10} = 130 \text{ cfs} \Rightarrow \text{Routine Maintenance Only} \]
Sta 234+45 to Sta 235+40 - Exist Open Channel between LaSalle Street and Pedestrian Path
=> Routine Maintenance Only

Sta 235+40 to Sta 235+90 - Exist Culvert at Pedestrian Path
=> Routine Maintenance Only

Sta 235+10 to Sta 236+20 - Exist Open Channel between Pedestrian Path and C.R.I.P. Railroad
=> Routine Maintenance Only

Sta 236+20 to Sta 236+75 - Remove Exist Culvert at C.R.I.P. Railroad
=> Q100 = 0

Temple Gap Road at Van Buren Channel - Replace Culvert
13' x 6' PVC

Q100 = 25.30 cfs
L = 100’
\( S_e \approx 0.16 \%
H_{W1} = 9.1 - 30.3 = 9.1’

Inlet Control
\( Q_0 = \frac{25.30}{39} = 0.65 \)

Outlet Control
\( H = 2.5’
D_c = 5.1
H_o = \frac{5.1 + 2.5}{2} = 4.5’

L_{o2} = (162)(0.006) = 0.6’
H_W = 2.5 + 5.6 - 0.6 = 7.5’
Access between El Paso Sheet 2 and Monument Creek = 5000 LF

\[ \text{Sheet 2} = 20' \]

En. Concrete-lined Channel

\[ \text{Sep. 1.5' H (1931 Cost Plans)} \]

\[ \begin{align*}
\text{Dep} &= 5' \\
\text{V}_{\text{Dep}} &= \left( \frac{1}{4} \text{Dep} \right) (\text{width})^2 (0.010) = 250 \text{ cfs} \\
\text{C}_{\text{Dep}} &= (250.2 \times 5) = 814 \text{ cfs} \\
\text{Dep} &= 7' \\
\text{V}_{\text{Dep}} &= \left( \frac{1}{4} \text{Dep} \right) (\text{width})^2 (0.010) = 376.4 \text{ cfs} \\
\text{C}_{\text{Dep}} &= (294.6 \times 7) = 2085 \text{ cfs}
\end{align*} \]

\[ Q_{\text{Dep}} + T_{\text{Dep}} = 2600 \text{ cfs} \]

\[ \frac{A}{n} = \frac{2530}{2.36} = 1245 \text{ cfs}/(sq. ft) \]

\[ E_b = 2.12 + 1.7 = 3.8 \text{ ft} \]

\[ E = 3-0.03 \text{ sq} = 3070 \text{ cfs} \]

(Permits from aesthetic is offset by higher density of added grass N.E. Of Tributary)

New Vertical-Walled Concrete Channel, 6' + 70' Long, Foundation Crossing and I Sanitary Sewer Crossing

\[ b = 20' \]

\[ Q_{\text{Dep}} = 2800 \text{ cfs} \]

\[ \text{Sep} = 1.0' \]

\[ d = 5.5' \\
\text{V} = \left( \frac{1}{4} \text{Dep} \right) (\text{width})^2 (0.010) = 280 \text{ cfs} \]

\[ \text{C}_{\text{Dep}} = (280.2 \times 5) = 880 \text{ cfs} \]

\[ E_{\text{Dep}} = 1.0 + 0.025 \times 280 \times (4.5) = 2.12 \]

\[ d_{\text{Res}} = \text{Use 2.75' } \]

\[ b_{\text{Res}} = 5.5' + 2.75' = 8.0' \]

\[ i = \frac{0.04 (5.5 + 1.0)}{20} = 0.1 \text{ = Super oven} \]
D. SOFT-LINED FULL IMPROVEMENT WITH DETENTION PONDING ALONG THE CHANNEL ALTERNATIVE HYDRAULIC CALCULATIONS
SOFT-LINED ALTERNATIVE W/DETENTION

Sta. 0+25 to Sta. 9+75 - New Open Channel between Fountain Creek Continue and Las Vegas Street

Levee Repl'd Along West Bank

Landscaped Channel w/ Boulders Between Walls and Soil Bottom

\[ D_{100} = 4,725 \text{ cfs} \quad S_{0x} = 0.490 \]

\[ d = 9.5 \Rightarrow \nu = \left[ \frac{144 \times 830^{0.62}}{0.069} \right]^{0.6} = 6.7 \text{ fps} \Rightarrow Q = (5.2)(830) = 4,330 \text{ cfs} \]

Freeboard \( = 1/0 + (0.08)(5/11)/2 \times 1/13 \Rightarrow \text{Use } 2' \quad D = 9.5 + 2 = 11.5' \)

\[ F = \frac{57}{122} = 0.33 \Rightarrow \text{Subcritical} \]

Sta. 9+75 to Sta. 10+80 - Exist. Bridge and dissipation at Las Vegas Street

Existing 40' x 10' Bridge

\[ G_{10} = 4,725 \text{ cfs} \quad L = 70' \quad S_{0x} = 0.750 \quad H_{116} = 1.69 \rightarrow 7.7 = 13.4' \]

Inlet Control \( \Rightarrow Q = 4,725 \text{ cfs} \quad H_{116} = 1.2 \quad H_{116} = (1.69)(10) = 12' \)

Outlet Control \( \Rightarrow h = 2.9 \quad d_{c} = 7.5' \quad h_{0} = \frac{10 + 2}{2} \)

\[ L_{0} = (70)(0.005) = 0.35' \quad H_{116} = 2.9 + 9 = 0.5 = 11.4' \]
Sh. 10+80 to Sh. 11+20 - Existing Concrete Transition Channel between Las Vegas Street and A.T.&S.F. & D.R.G.W. Railroad

<table>
<thead>
<tr>
<th>Sh. 10+80</th>
<th>Sh. 11+20</th>
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<tr>
<td>10+80</td>
<td>11+20</td>
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Vertical Walled Concrete Transition Channel

\[ c = 4.5 \text{ in} \times 40 \text{ in} = 1.5 \text{ ft} \times 180 \text{ in} \]

\[ Q_{1} = 4725 \text{ cfs} \]

\[ s_{e} = 1.0350 \]

\[ c = 4.5 \text{ in} \times 40 \text{ in} = 1.5 \text{ ft} \times 180 \text{ in} \]

\[ Q_{2} = 1568 \text{ cfs} \]

Actual \( c = 12.3 \text{ in} \times 115.5 \text{ in} = 1.0 \text{ ft} \times 96.25 \text{ in} \)

\[ c_{a} = 11.5 \text{ in} \times 115.5 \text{ in} = 0.94 \text{ ft} \times 96.25 \text{ in} \]

\[ A = 0.5064 \text{ ft}^{2} \]

\[ V = 9.3 \text{ fps} \]

Freedom \( = 1.0 + 0.025(9.3)(115.5) = 11.5 \Rightarrow \text{ Use } 2' \text{ Dia} \]

\[ D_{a} = 11.5 + 2.0 = 13.5 \Rightarrow \text{ Use } 14' \text{ Dia} \]

\[ F_{a} = \frac{9.3}{\sqrt{322.8}} = 0.48 \Rightarrow \text{ Subcritical} \]

Sh. 11+20 to 11+65 - Existing Culvert for A.T.&S.F. & D.R.G.W. Railroad

Double 20' x 16'5" Box Arch (18.5" x 15.4") RCC Equivalent

\[ D_{a} = 4725 \text{ cfs} \]

\[ L = 45 \text{ in} \]

\[ s_{e} = 1.350 \]

\[ AHW = 23.2 - 98.7 = 24.5' \]

Inlet Control \( = 0.5 \text{ ft} / 0.5 \text{ ft} = 1.26 \)

\[ H_{w} = 0.9 \]

\[ H_{w} = (0.5)(15.4) = 13.9' \]

Outlet Control \( = 4.5 \text{ in} \)

\[ H_{0} = 11.5 \]

\[ L_{0} = (4.5)(0.025) = 0.1 \text{ ft} \]

\[ H_{w} = 14' + 11.5 - 0.1 = 18.3' \]
Station 11+60 to Station 15+60 - Nonporous Channel between A.T.&S.F. & D.R.L.N.W. Railroad and abandoned railroad

**TW = 165 ft**

**Typical Section**

- **d = 11.5 ft** = \( \frac{1.49 \sqrt{0.75}}{1.005} \) (0.001) \( \frac{0.0015}{1.4} \) \( s = 0.05 \% \)
- **Q = (6.4)(7.5) = 49.0** ft³/s

**Freeboard:**

- **F = \( \frac{6.4}{(6.2)(11.5)} \) = 0.84** => Subcritical

**Station 15+60 to 16+30 - Existing Culvert for abandoned railroad**

- **Double 20' x 12.9' Stone Masonry Arch (18.8' x 6.3' R.C.E. Equiv.)**
- **Q = 425** ft³/s
- **L = 60'**
- **\( s = 0.77 \% \)**
- **\( \frac{E_{out}}{E_{in}} = 0.8 \) => \( H_{out} = 0.8 \times H_{in} = 0.8 \times 12.4 = 10.0 \)**

**Outlet Control**

- **\( H_{0} = 11' \)**
- **\( L_{0} = (60)(0.001) = 0.4 \)**
- **\( H = 1.1 + 11' - 0.4 = 11.7 \)**
Sta. 6+20 to Sta. 24+100 – Remove undesirable vegetation and debris from floodplain between abandoned railroad and Fountain Boulevard.

Existing Channel with riprap lower banks and landscaped upper banks.

\[ Q_{eq} = 4725 \text{ cfs} \times 0.75 \] 
\[ d_{avg} = 9.5 \text{ ft} \] 
\[ b = 30 \text{ ft} \] 
\[ F = \frac{d_{avg}}{b} = 0.316 \] 
\[ F = 0.153 \] 

Firebreak = 104 + 0.05(9.5)(19.5) \[ \approx 1.6 \] 
\[ D = 9.5 + 1.6 = 11.1 \text{ ft} \]

Sta. 24+100 to Sta. 25+50 – existing cutback at Fountain Boulevard

**Excavation**: 30' X 9.5' cutback and 20' X 10.5' MEPH (Double 18' X 9.5' RCB Eqiv)

\[ Q_{eq} = 4725 \text{ cfs} \] 
\[ L = 150 \text{ ft} \] 
\[ q_{eq} = 0.75 \] 
\[ AH \equiv 30 - 10 = 20 \text{ ft} \]

Outlet Control \[ D_{base} = \frac{Q_{eq}}{b} = 131 \]
\[ H_{inj} = 11 \text{ ft} \] 
\[ H_{out} = 11.4 \text{ ft} \]

\[ H = 4.5 \text{ ft} \] 
\[ H_{inj} = 9.5 \text{ ft} \] 
\[ L_{base} = (150)(0.05) = 7.5 \text{ ft} \] 
\[ H_{out} = 4.5 + 9.5 - 11 = 2.9 \text{ ft} \]
Sta. 25+50 to Sta. 48+05 - Remove undesirable vegetation and debris from floodplain and reduce slope of west overbank between Fountain Boulevard and Costilla Street.

Existing Channel with Riprap, Crown Level, and landscaped west overbank.

Outlet Control: $H_o = 10'$ $L_o = 125'$ $Q_{ave} = 515$ cfs

$Q_{ave} = 515$ cfs to 4600 cfs $S_{avg} = 0.86$

$d = 9'$ and $b = 30'$

$V = (4.89 \times 5.13) \times 0.083 \times 977 = 10' \text{ ft}$

$A = (1.1 \times 5.13) \times 977 = 4975$ cfs

$F = \frac{7.7}{(1.32 \times 10)} = 0.43$ Subcritical

Sta. 48+05 to Sta. 50+65 - Replace current at Costilla Street.

Outlet Control: $H_o = 10'$ $L_o = 125'$ $Q_{ave} = 515$ cfs

$Q_{ave} = 4600$ cfs $L = 200'$ $S_{avg} = 0.690$ $A_{ave} = 50.1 - 24.9 = 25.2'$
STA. 50 + 65 TO STA. 71 + 55 - NEW OPEN CHANNEL BETWEEN COSTILLA STREET AND EL PASO STREET

Two 230'- 95° West
135° East

Landscape Channel
W/ Paved Retaining Walls and Soil
Bottom w/ 2'-8" Hog Structures
and Replace 2 Sanitary Sewer Closings

Q_{0} = 4600 cfs to 440 cfs
\Delta F = \frac{0.149}{(0.030) 1.24} \frac{Q_{0}}{(0.085)^{1/3}} \text{fps} = 0.56 ft
\Delta F = 0.56 ft

F = \frac{Q_{0}}{(0.030)(1.24) 6.7} \text{fps} = 45.20 cfs

Freeboard = 1.0 + (0.015)(6.7)(0.95) = 1.3' USE 2.0'

D_{min} = 9.5 + 2.0 = 11.5'

STA. 71 + 55 TO STA. 72 + 00 - REPLACE DRAINAGE AT EL PASO STREET

4 - 12 X 10' RC

Q_{10} = 440 cfs
L = 125'
S_{p} = 1.0'

\text{Inlet Control} \Rightarrow Q_{10} = \frac{440}{40} = 94' \text{ fps}

H_{1} = 1.05' \text{ H}_{0}(105)/100 = 105'

\text{Outlet Control} \Rightarrow H_{0} = 1.0'

L_{p} = (125)(0.01) = 1.8'

H_{p} = 1.9 + 9.5 - 1.3 = 10.1'
Sta 72+480 to Sta 76+80 - New open channel between El Paso Street and Pikes Peak Avenue.

Sta 76+80 to Sta 85+60 - Replace culverts at Pikes Peak Avenue / El Paso Street and at Kiewit Street.

**Sta 72+480 to Sta 76+80** - New open channel between El Paso Street and Pikes Peak Avenue.

- **Q_{100} = 4440 cfs**
- **Q_{ex} = 0.496 ft**
- **d = 9.5 ft**
- **b = 50 ft**

**Total Flow:**

- **E_1 = 8.75**
- **E_2 = 5.1**
- **E_3 = 1.9**
- **E_4 = 1.3**
- **E_5 = 2.0**

**F = 0.28**

**Sta 76+80 to Sta 85+60** - Replace culverts at Pikes Peak Avenue / El Paso Street and at Kiewit Street.

- **Q_{100} = 4440 cfs**
- **L = 650 ft**
- **A_{100} = 76.0 - 6.1 = 14.8 ft**

**Inlet Control:**

- **B / b = 4.42 / 7.2 = 0.62**

**Outlet Control:**

- **H_{o} = 10.5 ft**
- **L_{S} = 6.5**
- **H_{W} = 2.7 + 10.5 - 6.5 = 7.7 ft**
Known Sheet

3 - 10' x 8' RCP (Equivalent w/3-120' RCP used in TR-20 Analysis)

Q_{in}=90.35 cfs  L=150'  S_{in}=0.3%  H_{in}=80.0-62.1=17.9'

Inlet Control => Q/b = 90.35/30 = 3.01  H_{in}/D=2.05  H_{in}=L_{in}(B)=14.9'

Outlet Control => H_{o}=L_{o}(B)  H_{o}=10.5'  L_{o}=L_{in}(0.03)=15.6'

H_{w}=L_{w}+10.5-0.5 = 15.0' in TR-20 Analysis = OK (Could be adjusted in Prelim Design)

Sta 85+60 to Sta 98+10 - New detention pond between Kiowa Sheet and Platte Avenue and between Corona Sheet and El Paso Street.
Sta. 78+00 to Sta. 106+30 - Replace Culvert at Platte Avenue / School Athletic Field and use existing bridge at Boulder Street.

\[ C = 14' \times 10' \text{ RCB} \]

\[ Q_{100} = 2590 \text{ cfs} \quad L = 695' \quad S_{EX} = 0.150 \quad \text{ATVH} = 9.5' - 7.5' = 2.0' \]

Outlet Control \( \Rightarrow Q/L = \frac{2590}{2.0} = 1295 \quad \text{HyD} = 1.0 \quad \text{Hw} = (1.0)(1.0) = 1.0' \)

Outlet Control \( \Rightarrow H = 5.8' \quad H_0 = 2.0' \quad L_s = (0.5)(0.005) = 3.5' \)

\[ H_w = 5.8 + 2.0 - 3.5 = 4.3' \]

Sta. 106+30 to Sta. 118+35 - New open channel between Boulder Street and St. Vrain Street.

- \[ Q_{100} = 2590 \text{ cfs} \quad S_{EX} = 0.150 \]
- \[ d = 7.5' = \frac{1}{2} \left( \frac{1.5 + 0.5}{2} \right) = 0.875' \quad \text{fps} \quad Q = (400)(0.875) = 350 \text{ cfs} \]
- \[ Elev(\text{top}) = 10 + (0.025)(2.0)(7.5) = 12.5' \quad \text{Use} \ 2' \]
- \[ D = 7.5 + 2.0 = 9.5' \]
- \[ F = \frac{12.5}{350} = 0.043 \Rightarrow \text{Subcritical} \]
Sta. 112+35 to Sta. 113+40 - Replace Culvert at St. Vrain Street

2 - 12' x 10' ECB

Q_{100} = 2400 cfs
L = 105
S_f = 0.1%
A_{HW} = 0.1
H_{AV} = 0.05
-85.0 = 15.0

Outlet Control ⇒ Q = \frac{2400}{4} = 600
H_{AV} = 105
H_{AV}/100 = 10.5

Sta. 113+40 to Sta. 117+25 - New Open Channel between St. Vrain Street and Willamette Street

Q_{100} = 2400 cfs
S_{100} = 0.177%

d = B' ⇒ d = \frac{(1.44)\times(0.003)}{(0.11)}(0.003) = 0.733 ft
D = 8 + 2 = 10'

Freeboard = 1.0 + (0.025)(6.0) = 1.3 ⇒ 8 + 2 = 10'

\frac{60}{30+2x0} = 0.37 ⇒ Subcritical
Station 117+25 to 119+80 - Existing Culvert at Willamette Street

- 20' x 10' Concrete Arch (12' x 8')
- Flow Equivalent: Provide Culvert at original elev.

- $Q_{100} = 2245$ cfs
- $C = 205'$
- $S_e = 0.190$
- $AH = 12.0 - 93.9 = 18.1$
- $\Delta YD = 0.5$
- $HW = (1.55)(12.0) = 18.8'$

Outlet Control

Outlet Control

Outlet Control

- $Hw = 4.4 + 8 - 0.3 = 12.1'$

Station 119+80 to 135+15 - New open channel between Willamette Street and Cache La Poudre Street

- $Q_{100} = 2245$ cfs
- $S_e = 0.790$
- $d = 5' = \frac{V^2}{q} = \frac{1.44 \times 400}{110} = 5.17$ USD
- $\Delta YB = 10 + 0.035 \times 57 = 1.3$
- $\Delta YB = 0.025 \times 57 = 1.3$
- $D_{min} = 8 + 2 = 10$
- $F = \frac{5.72}{10(2.18)} = 0.36$ (Sculptural)
Station 1354+50 to Station 1372+05 - Existing Culvert at Cache La Poudre Street

- 20' x 10' Concrete Arch w/ Upper 5' Blocked by Lower Casing & Utilities. 6' x 6' R.C. Equivalent.
- $Q_{100} = 395$ cfs  $L = 190$'  $S_0 = 0.250$  $AHW = 260 - 12.2 = 13.8''$
- Inlet Control $\Rightarrow Q/L = 195$  $D = 1.75$  $H = (1.9)(5) + 10 = 10.2''$
- Outlet Control $\Rightarrow h = 3.5''  \ h_D = 8''  \ L_5 = (190)(0.002) = 0.4''$
- $HW = 35'' + 8'' - 0.4'' = 41.1''$

Station 1374+50 to Station 152+45 - New Open Channel between Cache La Poudre Street and Uintah Street

- Landscaped Channel w/ Brick & Retaining Walls, Soil Bottom
- $Q_{100} = 395$ cfs  $S_{exit} = 0.750$
- $d = 7.5'' \Rightarrow \frac{Q_{100}}{7.5^2} = 6.14 \Rightarrow \frac{Q_{exit}}{7.5^2} = 5.64$  $\Rightarrow Q_{exit} = (6.14)(7.5) = 45.3$ cfs
- Freeboard = $1 + (0.020)(0)(7.5) = 1.3'' \Rightarrow D_{min} = 7.5 + 1.3 = 8.8''$
- $F = \sqrt{\frac{5}{(2)(7.5)}} = 0.36 \Rightarrow Subcritical$
Sta. 152+45 to Sta. 153+55 - Existing Culvert at Viutah Street

- 20'x10' Conc. Arch (17.8'x8.9') REC Eqn = Provide Conc. Inlet at o.g. (elev.)
- Q
  = 795 cfs
- C = 110
- S
  = 0.25
- 12.90
- THW = 50.0
- 28.4 = 21.6
- Inlet Control = 0/6 = \frac{795}{120} = 6.6
- THW/d = 0.7
- THW = (0.7)(19.9) = 13.9
- Outlet Control = H = 0.5
- H_o = 7.5
- L_s = 110
- 0.012 = 1.3
- THW = 0.5 + 7.5 - 1.3 = 6.7

Sta. 153+55 to Sta. 157+55 - New open channel between Viutah Street and San Miguel Street

- T.W. = 140°
- L' = 20°
- S
  = 1.15°
- Q
  = 795 cfs
- S
  = 0.25
- T.W. = 0.03
- 120
- S = 1.15
- 0.03
- 120
- Q = \frac{795}{120} = 6.6
- (Q = \frac{795}{120} = 6.6)
- B = 0 cfs
- Actual d = \frac{d_0}{1.15} = \frac{1.15}{1.15} = 1
- (End from Final HEC-2) = d = 6.7
- A = 20c + 10c = 302.6
- 0.03
- 120
- \frac{795}{120} = 6.6
- \frac{3.9}{1.15} = 3.9
- THW = 0.012(19.9) = 0.12
- Use 2
- D_{min} = 6.7 + 2 = 8.7
- F = \frac{3.9}{1.032(0.12)} = 0.12
- \Rightarrow S_{min} = 1.5
Sta. 158+55 to Sta. 158+40 - Exisit Culvert at San Miguel Street:

- 20'x10' Conc Arch (17.8'x8.4') B.C.R. Equwi - Double Conc Inv at original elev.
- $Q_{1000} = 795$ cfs $L = 86'$ $S = 0.6\%$ $A_{w} = 52.5 - 34.6 = 17.9'$
- Inlet Control $Q = 795$ $T_{D} = 4.5'\text{ }$ $h_{w} = 0.7\text{ }$ $h_{w} = (0.7)(5.9) = 4.1'$
- Outlet Control $H_0 = 0.5'\text{ }$ $h_{0} = 4.0'$ $C_{1} = 50.0$ $h_{w} = (0.5)(0.5) = 0.5'$
- $h_{w} = 0.5 + 0.7 - 0.5 = 0.7'$

Sta. 158+40 to Sta. 167+35 - New Channel between San Miguel Street and Pedestrian Bridge:

- Open Channel between San Miguel Street and Pedestrian Bridge

- $Q_{1000} = 795$ cfs $S_{e} = 1.00\%$
- $d = l \Rightarrow \frac{1.141 l^{0.62}}{D} \Rightarrow 0.010 l^{0.62} = 51. f_{ps} \Rightarrow 0.5(51)(10) = 815$ cfs
- $F = 0.010 + 0.025 x 51.1 \Rightarrow C_{1} = 11.2 \Rightarrow use D_{min} = 6' + 2' = 8'$
- $F = \frac{5.1}{11.2(l)^{0.62}} = 0.37 \Rightarrow Subvertical$
Sta. 16+735 - Replace Pedestrian Bridge

Sta. 16+735 to Sta. 16+825 - New open channel between Pedestrian Bridge and Pretty Jewel Golf Course South Boundary

\[ Q_{100} = 110 \, \text{cfs} \quad \text{Eq} \, 1/100 \]

\[ d = \frac{\sqrt{v - (0.050)(\frac{40}{24})(0.010)^{1/2}}}{4.2} = 4.12 \, \text{fps} \quad \Rightarrow Q = (4.12)(40) = 170 \, \text{cfs} \]

Freeboard = \frac{1.0 + (0.025)(4.2)(2)^{1/2}}{1.1} \Rightarrow Use 2' \quad D_{\text{min}} = 2 + 2 = 4' \]

\[ F = \frac{4.12}{(0.25)(2)} = 0.14 \Rightarrow Subcritical \]
Sta 181+05 to Sta 184+05 - New detention pond on Patty jewett golf course between south boundary and espanola street.

- Sta 184+05 to Sta 190+85 - Replace culvert at espanola street.

<table>
<thead>
<tr>
<th>3 = 12' x 18' PCB</th>
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<tbody>
<tr>
<td>Q100 = 3555 CFS</td>
</tr>
<tr>
<td>L = 180'</td>
</tr>
<tr>
<td>S = 1.390</td>
</tr>
<tr>
<td>HW = 85.5 - 72.8 = 12.7'</td>
</tr>
</tbody>
</table>

Inlet Control = \( \frac{Q}{4} = \frac{3555}{20} = 177.7 \)  \( HW = 105\)  \( HW = (105)(10) = 1050\)  
Outlet Control = \( H = 2.0\)  \( \Delta h = 10\)  \( L_{0} = (180)(0.013) = 2.3' \)  
\( HW = 2.0 + 10 - 2.3 = 9.7' \)
Sta. 198+45 to Sta. 216+40 - New Open Channel between End of Existing Channel/Lining and Paseo Road

$Q_{100} = 1100 \text{ cfs}$

$S_{100} = 1.09\%$

$d = 4' \Rightarrow \frac{d}{L} = \frac{1}{1.44} = \frac{1}{2.67} \Rightarrow \phi = 5.2^\circ$

$Q(5.2)^{7/8} = 1090\text{ cfs}$

$F = \frac{5.2}{1720(0.4)} = 0.046 \Rightarrow \text{Subcritical}$

Sta. 216+40 to Sta. 216+55 - Replace Culvert at Paseo Road

$3 - 10' X 5' = RCB$

$Q_{100} = 1100 \text{ cfs}$

$L = 55' \Rightarrow S_{100} = 0.79\%$

$\text{AHW} = 12.3 - 0.59 = 6.4'$

Inlet Control: $Q/\sqrt{h} = \frac{1100}{30} = 37$

$\text{HW} = 1.1 \Rightarrow h = 0.5\text{'}$

Outlet Control: $H = 1.2\text{'}$

$H_2 = 4\text{'}$

$L_{sp} = (0.55)(0.007) = 0.04$

$\text{HW} = 1.2 + 4 - 0.4 = 4.8'$