FINAL DRAINAGE AND EROSION CONTROL STUDY
FOR
BURNS RANCH AT QUAIL RIDGE
FIRST FILING
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EROSION CONTROL STUDY
FOR
BURNS RANCH AT QUAIL RIDGE
FIRST FILING

August 2, 1991

Prepared for:
Burns Farms Inc.
2837 Overland Trail
Fort Collins, Colorado 80526

Prepared by:
RBD, Inc. Engineering Consultants
2900 South College Avenue
Fort Collins, Colorado 80525
(303) 226-4955

RBD Job No. 394-003
August 2, 1991

Ms. Susan Hayes  
City of Fort Collins  
Utility Services Stormwater  
235 Mathews  
Fort Collins, Co. 80522

RE: Final Drainage and Erosion Control Study for Burns Ranch at Quail Ridge First Filing  
RBD Job No. 394-003

Dear Susan:

We are pleased to resubmit to you, for your review and approval, this Final Drainage and Erosion Control Study for Burns Ranch at Quail Ridge First Filing. All computations within this report have been completed in compliance with the city of Fort Collins Storm Drainage Design Criteria.

Thank you for your time and consideration of this submittal. Please call if you have any questions.

Respectfully,

RBD Inc. Engineering Consultants

Kevin W. Gingery, P.E.  
Project Engineer

CC: Mr. Rex Burns - Burns Ranches Inc.
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FINAL DRAINAGE AND EROSION
CONTROL STUDY FOR
BURNS RANCH AT QUAIL RIDGE
FIRST FILING

I. GENERAL LOCATION AND DESCRIPTION

A. Location

The Burns Ranch at Quail Ridge Subdivision is located southwest of Overland Trail and Skimmerhorn Street and is bounded on the west by Dixon Reservoir and on the east by the Quail Hollow Subdivision, in southwest Fort Collins, Colorado. The site is shown on the Vicinity Map in the Appendix. More particularly, the site is described as Burns Ranch at Quail Ridge, First Filing, and is situated in the Northeast 1/4 of Section 29, Township 7 North, Range 69 West of the 6th P.M., City of Fort Collins, Larimer County, Colorado.

B. Description of Property

The First Filing of Burns Ranch at Quail Ridge contains 17.05 acres more or less. Currently three residential dwelling units exist within the First Filing. Two of the dwelling units are to remain and the third will be removed. The property is being proposed as a foothills residential development with large open spaces within the City of Fort Collins Foothills Zoning District (RF Zone). The majority of the property contains natural Colorado grasses. Topography at the site is generally sloping from west to east at approximately 9%. An existing farmers irrigation lateral, owned by the Dixon Irrigation Co., traverses the subject site in a northwest to southeast direction.

II. DRAINAGE BASINS AND SUB-BASINS

A. Major Basin Description

No major drainageway exists in the First Filing of Burns Ranch at Quail Ridge. The Burns Ranch property does drain into Spring Creek per the Spring Creek Major Drainageway Plan by Gingery Associates, Inc. dated August 1980. The City of Fort Collins is planning a regional detention pond on the southwest corner of Drake Road and Taft Hill Road in the future.
B. **Sub-Basin Description**

Historic drainage patterns on the subject site are easterly across the site towards Spring Creek, or westerly into Dixon Reservoir. Historic drainage flows from Burns Ranch cross the Quail Hollow Subdivision on the way to Spring Creek. The northeast portion of the First Filing of Burns Ranch at Quail Ridge has historically drained into what is now called Quail Hollow Filing No. 3. The majority of the First Filing of Burns Ranch at Quail Ridge drains to the south of Filing 4 of Quail Hollow and onto Spring Creek. The natural drainage path from Burns Ranch at Quail Ridge First Filing to Spring Creek has been interrupted with the construction of Quail Hollow Filing No. 4. No off-site flows are currently draining onto or across the subject site.

III. **DRAINAGE DESIGN CRITERIA**

A. **Regulations**

The City of Fort Collins Storm Drainage Design Criteria is being used for the subject site.

B. **Development Criteria Reference and Constraints**

A preliminary drainage report was previously completed for the subject site. The Preliminary Drainage Report for Burns Ranch at Quail Ridge developed the design criteria for the subject site. With the development of Filing No. 5 of Quail Hollow during the summer of 1991, a detention pond is under construction. The City of Fort Collins is planning a regional detention pond on the southwest corner of Drake Road and Taft Hill Road in the future. Until the regional detention pond is constructed, the City of Fort Collins has required that temporary detention ponds be constructed within the upstream developments in order to protect the downstream property owners.

The detention pond in Filing No. 5 of Quail Hollow will have adequate outlets and detention to reduce developed flows to historic conditions as drainage waters leave the site and enter Spring Creek. Per the City of Fort Collins Storm Drainage Criteria, a temporary detention pond has been designed in Filing No. 5 of Quail Hollow and is currently under construction. Per the report titled Final Drainage Study For The Quail Hollow Fifth Filing it states "The proposed drainage concepts adequately provide the detention of developed on-site flows from the Quail Hollow Subdivision Filings 4 through 7 and the proposed Burns Ranch at Quail Ridge
Subdivision".

C. Hydrological Criteria

The rational method was used to determine runoff peak flows from the site. The 2 and 100 year rainfall criteria, which was obtained from the City of Fort Collins, is the criteria which was utilized. This criteria is included in the Appendix.

D. Hydraulic Criteria

All calculations within this report have been prepared in accordance with the City of Fort Collins Drainage Criteria.

E. Variances from Criteria

For the subject site, several variances are being requested. The variances are as follows:

1. Skimmerhorn Street between Overland Trail and Alumbaugh Ct. traverses through 250 foot and 200 foot vertical curves, cuts of up to 12.5 feet, contains sidewalk only on the southeast side, will contain limited trees, only contains one residential lot on the southeast side, will contain no parking signs, and therefore we have assumed that the theoretical street flow is equal to the allowable street flow. Thus the need for a storm sewer system does not become necessary until a point immediately west of Overland Trail.

2. In reference to the discussion under number 1 above, a special 45 foot CDOH type R curb inlet is proposed on the north side of Skimmerhorn Street immediately west of Overland Trail. Additionally a 15 foot CDOH type R curb inlet is proposed on the south side of Skimmerhorn Street immediately west of Overland Trail. Due to the lengths of the inlets, their location, and the items mentioned under number 1 above, we have assumed no clogging of the inlets will occur for the inlet and storm sewer analysis.

3. As storm water runoff (not collected by the inlets discussed in number 2 above) traverses through Filing No. 3 of Quail Hollow, the detention pond in Filing No. 3 will rise approximately 2.4 inches and the freeboard will decrease from 12 inches to 9.6 inches. The pond will still function as intended and we have therefore assumed that a freeboard of
9.6 inches will be sufficient. In addition Skimmerhorn Street and Zendt Drive in Quail Hollow Filing No. 3 will adequately transmit storm water runoff (not collected by the inlets discussed in number 2 above) to the Filing No. 3 detention pond. We have assumed that Skimmerhorn Street and Zendt Drive in Quail Hollow Filing No. 3 may be used to transmit storm water runoff from Burns Ranch First Filing to the Quail Hollow Filing No. 3 detention pond.

4. A temporary drainage swale has been designed from the outlet of the storm sewer system on Skimmerhorn Street to the Quail Hollow Filing No. 5 detention pond. The segment along Overland Trail has been designed with a freeboard of less that 1.0 feet, but with a capacity of at least 1.8 times the design flow. Therefore we have assumed that a freeboard of less than 1.0 feet will be acceptable along Overland Trail in the temporary swale.

IV. DRAINAGE FACILITY DESIGN

A. General Concept

As development occurs within the First Filing of Burns Ranch at Quail Ridge, all on-site fully developed flows will flow easterly and eventually into the detention pond in the Fifth Filing of the Quail Hollow subdivision. Included in the back pocket of this report is the Burns Ranch at Quail Ridge First Filing drainage plan and grading plan.

B. Specific Details

The existing farmers irrigation lateral traverses the subject site in a northwest to southeast direction. The Burns Ranch property is underlain by sandy silt on top of siltstone, claystone and sandstone, and due to the slope of the site, groundwater is not anticipated to be a problem in the development of the site. If for some unforeseen reason ground water is encountered during construction, a Colorado Department of Health Construction Dewatering Permit would be required. The Spillway outlet for Dixon Reservoir is not located in the proximity of the Burns Ranch property.

During the course of preparing the proposed drainage plan for the First Filing of Burns Ranch at Quail Ridge, various drainage problems arose. The portion of the irrigation canal crossing Skimmerhorn Street has caused grading problems with the site. Due to the existing
ground slope of approximately 9%, the irrigation lateral and the location of the access off of Overland Trail for Skimmerhorn Street, the initial portion of Skimmerhorn Street is designed with a 200 foot and a 250 foot vertical curve and a maximum street slope of 12.68%. The
existing irrigation canal is proposed to be piped under Skimmerhorn Street in a 14" by 23" elliptical pipe. If for some unforeseen reason the elliptical pipe becomes plugged, the irrigation canal will overtop at Skimmerhorn Street and irrigation waters will travel down Skimmerhorn Street and be collected by the storm sewer system immediately west of Overland Trail.

On sheet 11 of 63 in the appendix is the Vicinity Map from the Quail Hollow Filing No. 3 approved drainage report. As you can see, a portion of Burns Ranch First Filing was included in Offsite Basin A of the Filing No. 3 report.

The Filing No. 3 development was designed to pass the historic flow from Offsite Basin A through the subdivision via an existing 33" RCP and into the Filing No. 3 detention pond. Because the Offsite Basin A was at an historic level, the detention pond was set to pass the offsite flows through undetained and exit by an overflow weir into Quail Hollow Filing No. 4.

Per the Burns Ranch First Filing Utility Plans, the future west PCR of the Skimmerhorn Street/Overland Trail intersection is at station 0+45.34. The beginning of the proposed 200 foot vertical curve is at station 0+91.00. The resultant is a length of 45.66 feet of Skimmerhorn Street at a centerline street slope of 3%.

Utilizing the new Urban Drainage & Flood Control District hydraulic computer programs UDBUILD and UDTOOL, the street flows were analyzed and the proposed inlets were designed. In summary, a 45 foot Type "R" inlet is proposed on the north side of Skimmerhorn Street at Overland Trail and a 15 foot Type "R" inlet is proposed on the south side of Skimmerhorn Street at Overland Trail. These inlets are proposed to do the following:

<table>
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<th>INLET</th>
<th>2 yr Flow Collected</th>
<th>2 yr Flow Not Collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>45'</td>
<td>8.94 cfs</td>
<td>0.26 cfs</td>
</tr>
<tr>
<td>15'</td>
<td>1.24 cfs</td>
<td>0.06 cfs</td>
</tr>
</tbody>
</table>
INLET  100 YR FLOW COLLECTED  100 YR FLOW NOT COLLECTED

45'  18.50 cfs  16.40 cfs
15'  2.96 cfs  1.84 cfs

During the 2 year storm event, 0.32 cfs of storm water runoff from Burns Ranch First Filing is being proposed to pass across overland Trail and into Quail Hollow Filing No. 3. During the 100 year storm event, 18.24 cfs of storm water runoff from Burns Ranch First Filing is being proposed to pass across Overland Trail and into Quail Hollow Filing No. 3. The remainder of the storm water runoff is proposed to be redirected southerly along Overland Trail and eventually into the Quail Hollow Filing No. 5 detention pond.

An off-site analysis was done to analyze carry over flows from Burns Ranch First Filing as the flows pass through Quail Hollow Filing Numbers 3, 4 and 5. A conservative approach was done in the analysis, because no credit was given to the Offsite Basin A as discussed above. Thus in the analysis, the 18.2 cfs (100 year flow carry over from Burns Ranch) was directly added onto the entire Offsite Basin A historic flow, thus resulting in a higher flow value than could occur. In summary, the analysis in the appendix indicated (using the conservative approach) the downstream streets can safely convey the Burns Ranch First Filing carry over flows to their destination. Further more, the detention pond in Filing No. 3, the swale in Filing No. 4 and the ponding upstream of Yorkshire St. in Filing No. 4 will all experience a rise of between 1 and 2 inches (conservative) due to the carry over flows from Burns Ranch First Filing. All of the calculations demonstrate that the carry over flows can safely reach the Quail Hollow Filing No. 5 detention pond and not impact any downstream existing developments.

Runoff from basins 1 and 4 of the First Filing of Burns Ranch at Quail Hollow are proposed to remain as open space in their natural historic flow patterns. Basin 1 does contain the rear of four of the proposed residential lots where storm water runoff is expected to be insignificant. Basin 1 naturally sheet flows easterly into the Quail Hollow Subdivision and towards Spring Creek. Basin 4 naturally sheet flows westerly into the Dixon Reservoir.

With the development of Filing No. 7 of the Quail Hollow subdivision, will come the completion of the western 1/2 of Overland Trail from Skimmerhorn Street south to the southern boundary of the Quail Hollow Subdivision. As
Filing No. 7 is developed, culverts will be constructed under Tiflin Ct. and Brendan Ct. (immediately west of Overland Trail south of Skimmerhorn St.), to transmit developed runoff from the Burns Ranch property to the detention pond in Filing No. 5 of Quail Hollow. The temporary swale along the western side of Overland Trail will be replaced with culverts and a permanent swale as Filing No. 7 of Quail Hollow is developed. The temporary swale has been sized for the developed runoff from Burns Ranch First Filing and historic runoff from the remainder of Burns Ranch and Quail Hollow Filing No. 7.

V. EROSION CONTROL

A. General Concept

The First Filing of Burns Ranch at Quail Ridge lies within the High Rainfall Erodibility Zone and the Moderate Wind Erodibility Zone per the City of Fort Collins zone maps. Due to the existing site slopes of 9% and the proposed street slope of 12.68%, the potential exists for severe erosion problems after the first filing improvements are completed and the ground is bare. It is anticipated that the first filing improvements will be completed during the fall of 1991. Thus the new improvements will be subjected to both wind and rainfall erosion as well as snowmelt erosion before new vegetation has taken hold or the new residential lots are developed.

Per the City of Fort Collins Erosion Control Reference Manual for Construction Sites and the related calculations in the appendix, the erosion control performance standard for the subject site is 84.5%. From the calculations in the appendix, the effectiveness of the proposed erosion control plan is 83.7%. Therefore the erosion control plan as specifically detailed below, most nearly meets the City of Fort Collins requirements.

B. Specific Details

Basin 1 consists mainly of native vegetation consisting of well established grasses. This area is being planned for open space and therefore the existing vegetation should be maintained. A natural drainage ditch traverses through basin 1 and the drainage ditch will be retained. The rear half of four of the estate residential lots lies within basin 1 and minor runoff from the lawn is anticipated to sheet flow into the existing native grasses within the open space. The native grasses will detain any sediment leaving the rear half of the residential lot.
Basin 2 is planned for the development of 3 estate residential lots and a portion of Skimmerhorn Street. Once Skimmerhorn Street has been rough cut and prior to construction of the pavement structure, straw bale erosion barriers should be installed on alternating sides of the street. The bales should be perpendicular to the sides extending to the road centerline at 150 foot intervals (a maximum distance of 75 feet between the barriers along the road). After the overlot grading has been completed, all disturbed areas should have a temporary vegetation seed applied into the ground. Once the seed has been applied, a hay or straw mulch should be applied over the seed at a rate of 2 tons/acre (minimum) and the mulch should be adequately anchored, tacked, or crimped into the soil. The mulch will reduce both wind and rainfall erosion per the City of Fort Collins criteria.

Basin 3 is planned for the development of 6 estate residential lots, the continued use of two homes on two estate residential lots, a portion of Skimmerhorn Street, and Alumbaugh Court. Once the streets have been rough cut, prior to construction of the pavement structure, straw bale barriers should be installed on alternating sides of the streets. The barriers should be installed perpendicular to the sides of the road extending to the road centerline at 150 foot intervals (a maximum distance of 75 feet between the barriers along the road). The existing vegetation (established grasses) on the two residential lots currently occupied and the open space, should be maintained. After the overlot grading has been completed, all disturbed areas should have the soil roughened to control wind and rainfall erosion. Once the soil is roughened, a temporary vegetation seed should be applied into the ground. Per the City of Fort Collins effectiveness calculations, no mulch is required in Basin 3 unless desired by the owner. Because moderate wind erodibility soils exist, a perimeter barrier should be placed on the disturbed ground in a northeast to southwest direction at a maximum spacing of 200 feet between the barriers.

Basin 4 consists mainly of native vegetation consisting of well established grasses. This area is being planned for open space and therefore the existing vegetation should be maintained.

Basin 5 consists mainly of the entrance road, Skimmerhorn Street, to the development. The entrance road traverses through extensive cut areas. Once the road has been rough cut in and prior to construction of the pavement structure, straw bale barriers should be installed on...
alternating sides of the road. The barriers should be perpendicular to the sides extending to the road centerline, at 150 foot intervals (a maximum distance of 75 feet between the barriers along the road). After the curb inlets have been installed, the inlets should be filtered with a combination of concrete blocks, 1/2" wire screen and coarse gravel (3/4") in order to trap sediment. Once the road has been constructed, the slopes and all other disturbed areas should have a perennial dry land grass seed applied into the ground. After the seed is applied, a hay or straw mulch should be applied over the seed at a rate of 2 tons/acre (minimum) and the mulch should be adequately anchored, tacked, or crimped into the soil. The mulch should reduce both wind and rainfall erosion per the City of Fort Collins criteria. A recommended seed mix for the Burns Ranch vegetation has been provided on the Drainage and Erosion Control Plan.

VI. CONCLUSIONS

A. Compliance with Standards

All computations within this report have been completed in compliance with the City of Fort Collins Storm Drainage Design Criteria and the Erosion control Reference Manual for Construction Sites.

B. Drainage Concept

The proposed drainage concepts adequately provide the detention of developed on-site flows from the First Filing of Burns Ranch at Quail Ridge. By utilizing the detention pond in Filing No. 5 of Quail Hollow, all developed storm water runoff from the subject site will be controlled in order to eliminate off-site downstream damage from the 2 year and 100 year storm events.

The proposed storm sewer system will adequately remove nuisance and snowmelt flows from Skimmerhorn Street and the majority of the 2 year storm runoff and a portion of the 100 year storm runoff. The proposed street systems will adequately transport storm water runoff to the discharge locations. The excess runoff from the entrance portion of the subject site will be conveyed to the Quail Hollow Filing No. 3 detention pond by Skimmerhorn Street and Zendt Drive streets, and from there through Quail Hollow Filing No. 4 to the detention pond in Filing No. 5 of Quail Hollow.

The First Filing of Burns Ranch at Quail Ridge design is dependent on offsite development within Quail Hollow
Filing No. 5 in order to detain developed runoff and release the runoff at historic conditions. Also, the design depends on offsite development within Quail Hollow future Filings 6 & 7 in order to transmit storm water runoff through the Quail Hollow site to the detention pond. For this report it has been assumed that Burns Farms Inc. will coordinate their drainage needs with d. Jensen Enterprises in order to minimize the impacts to the Quail Hollow Subdivision.

The proposed drainage concepts presented in this report and shown on the drainage plan are in compliance with the City of Fort Collins drainage criteria.

C. Erosion Control Concept

The proposed erosion control concepts adequately provide for the control of wind and rainfall erosion from the First Filing of Burns Ranch at Quail Ridge. Through the construction of the proposed erosion control concepts, the City of Fort Collins performance standards will be met. The proposed erosion control concepts presented in this report and shown on the erosion control plan are in compliance with the City of Fort Collins erosion control criteria.

REFERENCES


PHASE 1 HYDROLOGY
BASIN HYDROLOGY & Tc Calculations

**Historic - Developed Condition**

- \( A = 3.66 \text{ ac} \)
- \( C = 20\% \)
- \( b = 236\) 
- \( S = 517.3\% \)

**2yr Storm**

\[ T_c = 1.87(0.61 - 0.20)(236) \]
\[ T_c = 10.7 \text{ min} \]

**100yr Storm**

\[ T_c = 1.87(0.61 - 0.20)(236) + 0.5 \]
\[ T_c = 14.3 \text{ min} \]

Shower than expected because flows from lots 2, 3, 4 will be caught by the irrigation ditch.

(Note: The composite C for dev. condition at the rear of 4 lots is 0.22 and the Tc is 10.7; 0.5 min. less than the Historic Flow - Developed flow.)

**OKAY!**

**Basin 2**

**Historic Condition**

- \( A = 0.58 \text{ ac} \)
- \( D = 180\) 
- \( C = 20\% \)

**2yr Storm**

\[ T_c = 1.87(0.61 - 0.20)(236) \]
\[ T_c = 8.3 \text{ min} \]

**100yr Storm**

\[ T_c = 1.87(0.61 - 0.20)(236) + 0.5 \]
\[ T_c = 10.5 \text{ min} \]

**Developed Condition**

Determine a composite "C" 0.51 acres (electric radial)
0.07 acres (open space)

\[ C = 0.07(2) + 0.51(45) = 0.42 \]
\[ 0.58 \]

**2yr Storm**

- \( A = 0.58 \text{ ac} \)
- \( D = 140\) 
- \( D = 36.4\% \)

\[ T_c = 1.87(1.11 - 0.25)(36.4) + T_c \]
\[ T_c = 4.8 \text{ min} \]

**100yr Storm**

\[ T_c = 1.87(1.11 - 0.25)(36.4) + T_c \]
\[ T_c = 7.3 \text{ min} \]
HISTORIC CONDITION:

\[ A = 1.68 \text{ HC} \]

\[ C = 0.20 \]

20-Year Storm:

\[ Tc = 1.87 \times (11 - 2(1)) \times 30^{1/2} \]

\[ Tc = 17.5 \text{ min} \]

100-Year Storm:

\[ Tc = 1.87 \times (11 - 2(1)) \times 45^{1/2} \]

\[ Tc = 16.5 \text{ min} \]

DEVELOPED CONDITION:

DESIGN: 1. Composite C

\[ C = 0.53 \text{ HC} \]

\[ C = 0.53 \times (50) = 0.44 \]

2-Year Storm:

\[ A = 1.68 \times C \]

\[ D = 360 \times \sqrt{130 \times 0.128} \times \text{initial} \]

\[ V = 6.54 \text{ fps} \]

\[ Tc = 1.87 \times (11 - 2(1)) \times 130^{1/2} \times 300 \]

\[ Tc = 6.5 \text{ min} \]

100-Year Storm:

\[ Tc = 1.87 \times (11 - 2(1)) \times 130^{1/2} + 230 \]

\[ Tc = 5.5 \text{ min} \]


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<th>Length ft.</th>
<th>Inlet Time min.</th>
<th>Flow Time min.</th>
<th>Time of Concentration</th>
<th>Significant Intensity</th>
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Figure 5-1

TYPICAL FORM FOR STORM DRAINAGE SYSTEM PRELIMINARY DESIGN DATA
(From: Wright-McLaughlin Engineers, 1969)
### STORM DRAINAGE SYSTEM PRELIMINARY DESIGN DATA

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### TYPICAL FORM FOR STORM DRAINAGE SYSTEM PRELIMINARY DESIGN DATA

(From: Wright-McLaughlin Engineers, 1969)
DETENTION
GIVEN

BURNS RANCH DEVELOPMENT
REQUIREMENTS TO OBTAIN THE
DIFFERENCE BETWEEN HEIRLOOM & DRYLAND
FILINGS.

FIND

DETECTION SOLUTION

SOLUTION

FOR THE REPORT TITLED

"FINAL DRAINAGE STUDY
FOR THE "QUAIL HOLLOW"
FIFTH FILING" DATED
MARCH 29, 1971, BY
RED, INC.

PAGE 8, SECTION "B. DRAINAGE CONCEPT"

STATES THE PROPOSED DRAINAGE CONCEPTS
ADEQUATELY PROVIDE THE DETENTION OF DEVELOPED
ON-SITE FLOWS FROM THE QUAIL HOLLOW SUBDIVISION
FILINGS 4 THROUGH 7 AND THE PROPOSED BURNS
RANCH AT QUAIL RIDGE SUBDIVISION.

S. DUE TO EXTENSIVE CALCULATIONS WITH
THE ABOVE REF. REPORT, FOR THIS
REPORT, DETENTION HAS BEEN PROVIDED
DOWNSTREAM IN "QUAIL HOLLOW" FILINGS.
DESIGN OF INLETS,
STORM SEWER AND
SWALES
VICINITY AND OFFSITE BASIN MAP

Hughes Stadium
Gravel Pit

Dixon

Reservoir

Dixon

Quail Hock, Filing No. 3, Drainage Report

Burns Ranch Phase One
OFFSITE BASIN "A"

High Canyon Dam

OVERLAND TRAIL

Drake Road

5120

5140

5773

5400

5600

20

For additional information or an official copy, please contact City of Fort Collins Utilities 700 Wood Street Fort Collins, CO 80524 USA
GIVEN FROM THE UD&FCO NEW STREET INFLOW COMPUTER OUTPUTS ON PREVIOUS PAGES, THE CARRYOVER FLOW CROSSING OVERLAND TRAIL AT SKIMMERHORN ST. IS

\[ \text{NORTH SIDE} = 16.4 \, \text{cfs} \quad (100 \, \text{yr storm event}) \]
\[ \text{SOUTH SIDE} = 1.08 \, \text{cfs} \quad (100 \, \text{yr storm event}) \]
\[ \text{TOTAL} = 18.2 \, \text{cfs} \quad \text{AT} \quad \frac{1}{V} = 13.5 \, \text{minutes} \]

The total 100 yr runoff at Overland Trail 4

skimmerhorn st. from burns ranch phase 1 is 39.7 cfs

\[ \frac{21.5}{39.7} = 54.2\% \text{ of 100 yr runoff picked up by} \]

Total flows from skimmerhorn street

- 45' type "K" inlet on the north side of skimmerhorn st. and
- 15' type "K" inlet on the south side of skimmerhorn st.

FIND ANALYZE OFFSITE IMPLICATIONS OF TAKING 18.2 cfs

through quail hollow filings. 3'4' to get into

the quail hollow filing 5 detention pond.

SOLUTION

STEP 1)

ANALYZE FLOW CROSSING OVERLAND TRAIL TO FIND DEPTH

ASSUME FLOW CONTINUES ACROSS OVERLAND TRAIL IN THE 36' WIDE (R-E) CONFIGURATION OF THE FLOW ON SKIMMERHORN ST. AS "FLOWS" FROM BOTH SIDES OF SKIMMERHORN (COMBINE W/S OF OVERLAND TRAIL) SHOW ON PLANS.

ASSUME THE FLOW VELOCITY ON SKIMMERHORN ST

(from computer output) of 10.0 fps CONTINUES ACROSS OVERLAND TRAIL

USE THE MANNINGS EQUATION

\[ Q = VA \]
\[ A = \frac{Q}{V} = \frac{18.2 \, \text{cfs}}{10.0 \, \text{fps}} = 1.82 \, \text{SF} \]

\[ H = 36' \text{ wide by } x' \text{ deep} \]

\[ 36 \times 1.82 = 0.0506 \, \text{ft} \]

\[ x = 0.61 \, \text{inches deep over overland trail} \]

ANS

For city of fort collins & allowable cross street flow = 6''

0.61 < 6'' (OK)
**STEP 2**  ANALYZE FLOW DOWN SKIMMERHORN ST. BETWEEN OVERLAND TRAIL AND BENDT DRIVE

PER QUAIC HOLLOW A.U.D. 3RD FILING GRADING PLAN AND DRAINAGE PLAN, APPROXIMATELY 14 ACRES OF THE SUBDIVISION WERE BUILT DRAINING ONTO SKIMMERHORN ST. THEREFORE, FIND Q100 AT Tc = 13.5 min.

\[ Q_{100} = 165 \text{ cfs (Burns Ranch) } \]

Street Slope = 2.2% (Average) 1.7% (Overland Trail and Bendt St.)

From the Street flow Nonograph page 29/37 (enclosed) for 6" depth, 1.7% slope.

Also, Q100 = 165 cfs represents both gutters, but the majority of the flow (92.4 portion of 5.5) will be in the northern gutter.

**STEP 3**  ANALYZE FLOW DOWN BENDT ST. TO LOW POINT S.E. OF SKIMMERHORN ST.

PER QUAIC HOLLOW A.U.D. 3RD FILING DRAINAGE PLAN, BASINS A3 & A4 DRAIN DOWN BENDT DRIVE. THEREFORE, FIND Q100 AT SKIMMERHORN ST. AND BENDT DRIVE.

DUE TO BURNS RANCH FLOW SPLIT, USE Tc = 13.5 min. AT THE INTERSECTION OF SKIMMERHORN ST. & BENDT ST.

Determine Q100 AT Tc = 13.5 min. FOR BASINS A3 & A4.

Conervative: Assuming all flows will peak at the same time.

Not available FROM 3RD FILING DRAINAGE PLAN & WHERE C = 0.50

BASIN A3 \( C_{100} = 0.63, A = 9.244 \text{ ft}^2 \)

BASIN A4 \( C_{100} = 0.63, A = 24.25 \text{ ft}^2 \)

**TOTAL FLOW ON BENDT ST. = 46.3 cfs + 23.7 cfs = 70.0 cfs \( \sqrt{\text{ During a 100 yr. storm event,}} \)**

**STREETSLOPE ON BENDT ST. = 1.0% to 2.2%**

(Cont'd on next page)
STEP 3 CONT.

Once again, 6" depth for both gutters. It appears that A3+18.2 will be in the southern gutter. A3+18.2 = 54.91 cfs

½(114) = 57 cfs

57 cfs > 54.9 cfs
Okay!!

STEP 4

ANALYZE IMPACT TO QUAIL HOLLOW FILING NO.3 DETENTION POND.

ASSUME POND FULL AT TIME OF BURNS RANCH FLOW ARRIVAL. PER THE FILING 3 DRAINAGE PLAN, THE MAX. 100 YR. STORM WATER ELEV. IN THE POND IS 5'125'.

PER THE FILING 3 GRADING PLAN, THE TOP OF POND BERM ELEV. = 5'126'.

Therefore, 1 FT. OF FREE BOARD EXISTS.

FROM QUAIL HOLLOW FILING 5 DRAINAGE REPORT PAGE 12/91 (ENCLOSED) IS THE FILING 3 DETENTION POND EMERGENCY WEIR OVERFLOW RATING CURVE.

DETERMINE RISE IN DETENTION POND TO PASS Q100 = 18.2 cfs FROM BURNS RANCH, SEE ENCLOSED RATING CURVE.

FROM THE ENCLOSED POND WEIR RATING CURVE, IN ORDER TO PASS 18.2 cfs (Q100) FROM BURNS RANCH INTO QUAIL HOLLOW FILING 4, THE POND LEVEL WILL RISE 0.2 ft = 2.4 inches.

AND THE FREE BOARD WILL DECREASE FROM 12 INCHES TO 9.6 INCHES, THE POND WILL STILL FUNCTION OK, SEEK VARIANCE FROM CITY STORMWATER DEPARTMENT.
ANALYZE IMPACT TO QUAIL HOLLOW FILING NO.4 TO PASS Q_{100} = 18.2 cfs FROM BURNS RANCH. FROM THE QUAIL HOLLOW FILING NO.4 DRAINAGE PLAN, SECTION A-A IS SHOWN BELOW:

\[ \lambda = \frac{1}{2} (2.0)' = 1 \]
\[ P = 16.50 \]
\[ \frac{Q}{P} = \frac{1.486}{16} (0.97)(0.0115) \]
\[ Q = 71.38 cfs \]
\[ V = 4.46 fps \]
\[ Q = 71.29 cfs \]
\[ F = 0.79 \]
\[ \text{Find depth for } Q_{100} = 71.39 + 18.2 = 89.59 cfs \]
\[ \lambda = \frac{1}{2} (2.0)'(2.72)' = 3.2 \]
\[ A = \frac{1}{2} (2.18)(0.40) = 1.90 \]
\[ V = 4.73 fps \]
\[ Q = 89.84 cfs \]
\[ F = 0.80 \]

\[ \text{To pass } Q_{100} = 18.2 cfs \text{ (Burns Ranch) through Quail Hollow Filing No. 4 to Yorkshire St. will increase the depth of the grass lined channel by } \frac{0.18}{4} = 2.16 \text{ inches. The grass lined channel will safely convey a } Q_{100} = 18.2 cfs \text{ (increase from Burns Ranch) from Quail Hollow Filing 3 to Yorkshire St.)} \]

\[ \text{HNS} \]
STEP 6. ANALYZE IMPACT TO YORKSHIRE ST.  
48" RCP CROSSING IN Qual Hollow FILING NO. 4,  
(FROM THE Qual Hollow FILING 4  
DRainAGE REPORT CALCULATION SHEET 6)  
THE EX. 48" RCP WAS DESIGNED TO  
PASS 73.5 CFS AT A HW/D = 1.1  
THE INV. OF THE U/S END OF THE EX.  
48" RCP IS 14.0.  

DETERMINE INCREASE IN U/S HEADWATER  
DEPTH TO PASS AN ADDITIONAL 18.2 CFS  
FROM BURNS RANCH, NOTE 8 FOR CALCULATIONS  
THE 73.5 CFS + 18.2 CFS IS DIRECTLY ADDED.  
TOGETHER WHICH ASSUMES ALL THE WATER  
ARRIVES AT YORKSHIRE ST. AT THE SAME  
TIME; THIS IS A CONSERVATIVE ASSUMPTION.  

73.5 CFS + 18.2 CFS = 91.7 CFS  
FROM CHART 1 (ENCLOSED) HEADWATER DEPTH FOR  
CONC. PIPE CULVERTS (UN)  
INLET CONTROL  
HW/D = 1.14  
HW = 1.14(4)  
HW = 4.56 FT (PROPOSED)  
HW = 1.11(4)  
HW = 4.40 FT (EXISTING)  

INCREASE IN HEADWATER DEPTH = 0.16 FT = 1.92 INCHES  

TO PASS AN ADDITIONAL Q100=18.2 CFS (BURNS RANCH)  
THROUGH THE EX. 48" RCP UNDER YORKSHIRE ST.  
IN FILING NO. 4, OF Qual Hollow, THE HEADWATER  
DEPTH, U/S OF YORKSHIRE ST., WILL INCREASE  
BY 0.16 FT = 1.92 INCHES. THE EX. 48" RCP WILL  
SAFELY CONVEY A Q100= 18.2 CFS (INCREASE FROM  
BURNS RANCH) UNDER YORKSHIRE ST.  

R3D INC.
Engineering Consultants

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For additional information or an official copy, please contact City of Fort Collins Utilities 700 Wood Street Fort Collins, CO 80524 USA
STEP 7  ANALYZE IMPACT TO W/S END OF QUAIL HOLLOW FILING 5 DETENTION POND FOR INCREASE OF \( q_{100} = 18.2 \) CFS FROM BURNS RANCH.

FROM THE QUAIL HOLLOW FILING NO. 5 DRAINAGE REPORT PAGE 38/60 (ENCLOSED) A CROSS SECTION WAS TAKEN BETWEEN LOTS 43/44 ACROSS TO LOT 39 OF FILING NO. 5.

FROM THE ENCLOSED CHANNEL RATING SHEET, THE INCREASE OF \( q_{100} = 18.2 \) CFS FROM BURNS RANCH CAUSES A RISE IN THE SWALE WATER SURFACE ELEVATION OF 0.11 ft = 1.32 inches. THE SWALE THROUGH QUAIL HOLLOW FILING NO. 5 WILL SAFELY CONVEY A \( q_{100} = 18.2 \) CFS (INCREASE FROM BURNS RANCH) INTO THE QUAIL HOLLOW FILING NO. 5 DETENTION POND.
**III STREET HYDRAULICS FOR THE GIVEN FLOW AND SPREAD:**

**INITIAL STORM**

**GIVEN STREET AND GUTTER GEOMETRIES:**

- **LONGITUDINAL SLOPE (%):** 8.50 (AVERAGE SLOPE BETWEEN STA 0+50 AND STA 5+00 ON SKIMMERHORN ST.)
- **CROSS SLOPE (%):** 2.00 (TO ACCOUNT FOR ROLLED CURB)
- **DEPRESSION AT GUTTER (inch):** 1.32
- **GUTTER WIDTH (feet):** 2.00
- **CURB HEIGHT (inch):** 4.68
- **STREET MANNING ROUGHNESS N:** 0.016

**STREET HYDRAULICS FOR THE GIVEN FLOW:**

- **FOR THE GIVEN DESIGN FLOW (cfs):** 8.60
- **FLOW CARRIED BY GUTTER (cfs):** 4.88
- **FLOW CARRIED BY STREET (cfs):** 3.71
- **WATER SPREAD ON STREET (ft):** 9.91
- **GUTTER FLOW DEPTH (ft):** 0.31
- **FLOW AREA (ft²):** 2.07
- **AVERAGE FLOW VELOCITY (fps):** 7.87

**Q = 1.4^{2/3}(1.54^{2/3})(0.22^{2/3})(0.085^{1/2})**

**Q = 11.81 cfs**

**III STREET HYDRAULICS FOR THE GIVEN SPREAD:**

- **THE GIVEN MAX SPREAD ON STREET (ft):** 14.00
- **STREET CAPACITY AT GIVEN SPREAD (cfs):** 19.30 (ONE SIDE OF STREET)
- **GUTTER FLOW DEPTH AT GIVEN SPREAD (ft):** 0.39

**THE STREET CAPACITY IS DOMINATED BY THE CURB HEIGHT**

**A = \sqrt[2]{(14 \times 3.9)} = 2.73**

**Q = V \times A = 7.87 \times 2.73 = 21.5 cfs**

---

**NOTE:** SKIMMERHORN ST. BETWEEN OVERLAND TRAIL AND ALUMBAUGH CT. WILL BE CLOSED TO PARKING, PER UNFD. AN EMPIRICAL REDUCTION OF THE THEORETICAL ALLOWABLE RATE OF FLOW IS TO ACCOUNT FOR PRACTICAL FIELD CONDITIONS (PARKED CARS). THEREFORE, FOR THIS ANALYSIS, THE THEORETICAL FLOW = ALLOWABLE FLOW ON SKIMMERHORN ST. BETWEEN STA 0+50 AND STA 5+00.

SKIMMERHORN STREET BETWEEN OVERLAND TRAIL AND ALUMBAUGH ST. TRAVERSE THROUGH A 250' (400' VERTICAL CURVES, UP TO 12.5' OF CURT) CONTAINS NO SIDEWALK ON THE NW SIDE, WITH LIMITED TREES, AND ONLY CONTAINS ONE RESIDENTIAL LOT ON THE SE SIDE. THIS IN ADDITION TO NO PARKED CARS IS THE REASON WE HAVE ASSUMED THE THEORETICAL FLOW = ALLOWABLE FLOW.
**STREET DRAINAGE INLET DESIGN: DEVELOPED BY CU-DENVER**

UD STREET NETWORK: DESIGN MENU: STREET FLOW: RESULTS

---

*** STREET HYDRAULICS FOR THE GIVEN FLOW AND SPREAD:  

**MAJOR STORM**

**GIVEN STREET AND GUTTER GEOMETRIES:**

- **LONGITUDINAL SLOPE (%)** = 8.50
- **CROSS SLOPE (%)** = 2.00
- **DEPRESSION AT GUTTER (inch)** = 1.32
- **GUTTER WIDTH (feet)** = 2.00
- **CURB HEIGHT (inch)** = 5.16
- **STREET MANNING ROUGHNESS N** = 0.016

**STREET HYDRAULICS FOR THE GIVEN FLOW:**

- **FOR THE GIVEN DESIGN FLOW (cfs)** = 26.79
- **FLOW CARRIED BY GUTTER (cfs)** = 9.80
- **FLOW CARRIED BY STREET (cfs)** = 17.25
- **WATER SPREAD ON STREET (ft)** = 16.06
- **GUTTER FLOW DEPTH (ft)** = 0.43
- **FLOW AREA (ft^2)** = 2.67
- **AVERAGE FLOW VELOCITY (fps)** = 10.06

\[
Q = 26.79 \times 10.06 = 268.6 \text{ cfs}
\]

---

*** STREET HYDRAULICS FOR THE GIVEN SPREAD:***

- **THE GIVEN MAX SPREAD (ft)** = 16.00
- **STREET CAPACITY AT GIVEN SPREAD (cfs)** = 26.79
- **GUTTER FLOW DEPTH AT GIVEN SPREAD (ft)** = 0.43

The street capacity is dominated by the curb height.

**NOTE** 

Skimmerhorn St. between Overland Trail and Alumbaugh Ct. will be posted no parking, per UDO. EDM; AN EMPIRICAL REDUCTION OF THE
THEORETICAL ALLOWABLE RATE OF FLOW IS TO ACCOUNT FOR PRACTICAL FIELD CONDITIONS (PARKED CARS). THEREFORE FOR THIS ANALYSIS, THE THEORETICAL
FLOW = ALLOWABLE FLOW ON SKIMMERHORN ST. BETWEEN 0+50 0+500.

---

Theoretical Flow = 34.61 cfs

---

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For additional information or an official copy, please contact City of Fort Collins Utilities 700 Wood Street Fort Collins, CO 80524 USA
UDINLET--STREET INLET DESIGN
DEVELOPED BY
JAMES C.Y. GUO, PHD, P.E.
CIVIL ENGINEERING DEPARTMENT
UNIVERSITY OF COLORADO AT DENVER

EXECUTED ON 07-11-1991 AT TIME 08:35:01

*** PROJECT TITLE: INLET DESIGN

*** DETERMINATION OF STREET DESIGN FLOW:

STREET ID NUMBER : 1.00
LOCAL BASIN FLOW (cfs) = 1.30 (2YR DEV. D.D.P.S BASINS 2YR OFS)
TIME OF CONCENTRATION (min) = 0.00
CARRYOVER FLOW (cfs) = 0.00
TIME OF CONCENTRATION (min) = 0.00
CARRYOVER FLOW LENGTH (ft) = 0.00
CARRYOVER FLOW SLOPE (%) = 0.00
CARRYOVER FLOW SCS TYPE =
DESIGN STREET FLOW (cfs) = 1.30
TIME OF CONCENTRATION (min) = 0.00

NOTE: TIME OF CONCENTRATION=0 MEANS IT IS NOT GIVEN. AS A RESULT, THE STREET DESIGN FLOW IS THE SUM OF GIVEN FLOWS.

*** CURB OPENING INLET HYDRAULICS AND SIZING:

INLET ID NUMBER: 1

INLET HYDRAULICS: ON A GRADE.

GIVEN INLET DESIGN INFORMATION:

GIVEN CURB OPENING LENGTH (ft) = 15.00
REQUIRED CURB OPENING LENGTH (ft) = 18.24
EFFICIENCY OF CURB OPENING = 0.96

Q = \frac{1.4426 \times 0.27 \times 0.08 \times 0.95^{\frac{3}{8}}}{0.16}
Q = 1.35 \text{ cfs}

STREET GEOMETRIES:

STREET LONGITUDINAL SLOPE (%) = 8.50 (AVE. SLOPE BETWEEN STA 0+50 + STA 5+00 ON SKIMMERHORN ST.)
STREET CROSS SLOPE (%) = 2.00
STREET MANNING N = 0.016
GUTTER DEPRESSION (inch) = 1.32
GUTTER WIDTH (ft) = 2.00 (TO ACCOUNT FOR ROLLED CURB)

STREET FLOW HYDRAULICS:

WATER SPREAD ON STREET (ft) = \textcolor{red}{3.20}
GUTTER FLOW DEPTH (ft) = 0.17
FLOW VELOCITY ON STREET (fps) = 6.09
FLOW AREA ON STREET (sq ft) = 0.21
INLET CLOGGING AREAL RATIO (%) = 0.00

\textcolor{red}{(ASSUME NO CLOGGING DUE TO SIZE & LOCATION, SEE NOTE ON NEXT PAGE)}
**INLET INTERCEPTION CAPACITY:**

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<th>Description</th>
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<tr>
<td>IDEAL INTERCEPTION CAPACITY</td>
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<tr>
<td>ACTUAL FLOW INTERCEPTED</td>
<td>1.24</td>
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<tr>
<td>CARRY-OVER FLOW</td>
<td>0.06</td>
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THE TIME OF CONCENTRATION OF CARRYOVER FLOW = 0 MINUTES.

**NOTES:**

SKIMMERHORN STREET BETWEEN OVERLAND TRAIL AND ALUMBAUGH CT. TRAVERSES THROUGH A 250'-9" 200' VERTICAL CURVES, UP TO 12.5' OF CUT, WILL CONTAIN LIMITED TREES, AND ONLY CONTAINS ONE RESIDENTIAL LOT ON THE SE SIDE, THIS IN ADDITION TO NO PARKED CARS IS THE REASON WE HAVE ASSUMED NO INLET CLOGGING WILL OCCUR.

*Added*
UDINLET--STREET INLET DESIGN
DEVELOPED BY
JAMES C.Y. GUO, PHD, P.E.
civil engineering department
university of colorado at denver

EXECUTED ON 07-10-1991 AT TIME 10:21:13

*** PROJECT TITLE: INLET DESIGN

*** DETERMINATION OF STREET DESIGN FLOW:

STREET ID NUMBER : 1.00
LOCAL BASIN FLOW (cfs) = 9.20 (2yr dev, 20.5 ft basin 34 1/2 of 5)
TIME OF CONCENTRATION (min) = 0.00
CARRYOVER FLOW (cfs) = 0.00
TIME OF CONCENTRATION (min) = 0.00
CARRYOVER FLOW LENGTH (ft) = 0.00
CARRYOVER FLOW SLOPE (%) = 0.00
CARRYOVER FLOW SCS TYPE =
DESIGN STREET FLOW (cfs) = 9.20
TIME OF CONCENTRATION (min) = 0.00

NOTE: TIME OF CONCENTRATION=0 MEANS IT IS NOT GIVEN. AS A RESULT, THE STREET DESIGN FLOW IS THE SUM OF GIVEN FLOWS.

*** CURB OPENING INLET HYDRAULICS AND SIZING:

INLET ID NUMBER: 1
INLET HYDRAULICS: ON A GRADE.

GIVEN INLET DESIGN INFORMATION:

GIVEN CURB OPENING LENGTH (ft) = 45.00
REQUIRED CURB OPENING LENGTH (ft) = 52.14
EFFICIENCY OF CURB OPENING = 0.97
\[ Q = \frac{1.456}{0.012} \left(1.59 0.15 0.95\right)^{1/2} \]
\[ Q = 12.08 \text{ cfs} \]

STREET GEOMETRIES:

STREET LONGITUDINAL SLOPE (%) = 8.50
STREET CROSS SLOPE (%) = 2.00
STREET MANNING N = 0.016
GUTTER DEPRESSION (inch) = 1.32
GUTTER WIDTH (ft) = 2.00

STREET FLOW HYDRAULICS:

WATER SPREAD ON STREET (ft) = 10.19
GUTTER FLOW DEPTH (ft) = 0.31
FLOW VELOCITY ON STREET (fps) = 7.97
FLOW AREA ON STREET (sq ft) = 1.15
INLET CLOGGING AREAL RATIO (%) = 0.00

\[ \lambda = \frac{1}{2} \times (10.19 \times 0.31) = 1.58 \]
INLET INTERCEPTION CAPACITY:

DESIGN FLOW FOR CURB OPENING (cfs) = 9.20
IDEAL INTERCEPTED CAPACITY (cfs) = 8.94
ACTUAL FLOW INTERCEPTED (cfs) = 8.94
CARRY-OVER FLOW (cfs) = 0.26 (ACROSS OVERLAND TRAIL)

THE TIME OF CONCENTRATION OF CARRYOVER FLOW = 0 MINUTES.

NOTES:
SKIMMERHORN STREET BETWEEN OVERLAND TRAIL AND ALUMBAUGH CT. TRAVELS SE'S THROUGH A 250' 9.200' VERTICAL CURVE'S, UP TO 12.5' OF CUT, WILL CONTAIN LIMITED TREES, AND ONLY CONTAINS ONE RESIDENTIAL LOT ON THE SE SIDE. THIS IN ADDITION TO NO PARKED CARS IS THE REASON WE HAVE ASSUMED NO INLET CLOGGING WILL OCCUR.
Major Storm for South Skinnerhorn Street

\[ S_x = 0.02 \text{ FT/FT} \]

\[ T = 10 \text{ FT} \]

\[ S = 0.03 \text{ FT/FT} \]

\[ L_c = 11.8 \text{ FT} \]

\[ L_c = 34 \text{ FT} \]

\[ Q/I = 0.65 \]

\[ Q / l = 1 \]

**Figure 5-5**

**Standard Curb-Opening Inlet Chart**

**Reference:** Carl Izzard, Flood Hazard News, UD and FCD, June 1977

MAY 1984

5-13

DESIGN CRITERIA
UDINLET--STREET INLET DESIGN
DEVELOPED BY
JAMES C.Y. GUO, PHD, P.E.
CIVIL ENGINEERING DEPARTMENT
UNIVERSITY OF COLORADO AT DENVER

EXECUTED ON 07-10-1991 AT TIME 10:40:37

*** PROJECT TITLE: INLET DESIGN

*** DETERMINATION OF STREET DESIGN FLOW:

STREET ID NUMBER : 1.00
LOCAL BASIN FLOW (cfs) = 4.80 ✓ (100 YR DEV. 2 D.P.S BASINS 2½% OFS)
TIME OF CONCENTRATION(min) = 0.00
CARRYOVER FLOW (cfs) = 0.00
TIME OF CONCENTRATION(min) = 0.00
CARRYOVER FLOW LENGTH (ft) = 0.00
CARRYOVER FLOW SLOPE (%) = 0.00
CARRYOVER FLOW SCS TYPE =
DESIGN STREET FLOW (cfs) = 4.80 ✓
TIME OF CONCENTRATION (min) = 0.00

NOTE: TIME OF CONCENTRATION=0 MEANS IT IS NOT GIVEN. AS A RESULT,
THE STREET DESIGN FLOW IS THE SUM OF GIVEN FLOWS.

*** CURB OPENING INLET HYDRAULICS AND SIZING:

INLET ID NUMBER: 1

INLET HYDRAULICS: ON A GRADE.

GIVEN INLET DESIGN INFORMATION:

GIVEN CURB OPENING LENGTH (ft) =
REQUIRED CURB OPENING LENGTH(ft) =
EFFICIENCY OF CURB OPENING =

STREET GEOMETRIES:

STREET LONGITUDINAL SLOPE (%) = 8.50 ✓ (AVE. SLOPE BETWEEN STR 0-500 ON SKIMMERHORN ST.)
STREET CROSS SLOPE (%) = 2.00 ✓ (STR 5400 ON SKIMMERHORN ST.)
STREET MANNING N = 0.016
GUTTER DEPRESSION (inch) = 1.32
GUTTER WIDTH (ft) = 2.00 ✓ (TO ACCOUNT FOR ROLLED CURB)

STREET FLOW HYDRAULICS:

WATER SPREAD ON STREET (ft) = 7.53 ✓
GUTTER FLOW DEPTH (ft) = 0.26 ✓
FLOW VELOCITY ON STREET (fps) = 7.09 ✓
FLOW AREA ON STREET (sq ft) = 0.68 ✓
INLET CLOGGING AREAL RATIO (%) =

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INLET INTERCEPTION CAPACITY:

DESIGN FLOW FOR CURB OPENING (cfs) = 4.80
IDEAL INTERCEPTION CAPACITY (cfs) = 2.96 
ACTUAL FLOW INTERCEPTED (cfs) = \text{2.96} 
CARRY-OVER FLOW (cfs) = \text{1.84} \hspace{1cm} \text{(ACROSS OVERLAND TRAIL)}

THE TIME OF CONCENTRATION OF CARRYOVER FLOW = 0 \hspace{1cm} \text{MINUTES.}
UDINLET--STREET INLET DESIGN
DEVELOPED BY
JAMES C.Y. GUO, PHD, P.E.
CIVIL ENGINEERING DEPARTMENT
UNIVERSITY OF COLORADO AT DENVER

EXECUTED ON 07-10-1991 AT TIME 13:00:17

*** PROJECT TITLE: INLET DESIGN

*** DETERMINATION OF STREET DESIGN FLOW:

STREET ID NUMBER : 1.00
LOCAL BASIN FLOW (cfs) = 26.79
TIME OF CONCENTRATION (min) = 0.00
CARRYOVER FLOW (cfs) = 0.00
TIME OF CONCENTRATION (min) = 0.00
CARRYOVER FLOW LENGTH (ft) = 0.00
CARRYOVER FLOW SLOPE (%) = 0.00
CARRYOVER FLOW SCS TYPE =
DESIGN STREET FLOW (cfs) = 26.79
TIME OF CONCENTRATION (min) = 0.00

NOTE: TIME OF CONCENTRATION=0 MEANS IT IS NOT GIVEN. AS A RESULT, THE STREET DESIGN FLOW IS THE SUM OF GIVEN FLOWS.

*** CURB OPENING INLET HYDRAULICS AND SIZING:

INLET ID NUMBER: 1

INLET HYDRAULICS: ON A GRADE.

GIVEN INLET DESIGN INFORMATION:

GIVEN CURB OPENING LENGTH (ft) = 45.00
REQUIRED CURB OPENING LENGTH (ft) = 93.97
EFFICIENCY OF CURB OPENING = $\frac{45.00}{93.97} = 0.47$

STREET GEOMETRIES:

STREET LONGITUDINAL SLOPE (%) = 8.50 (AVE. SLOPE BETWEEN STA 0+50 AND STA 5+00 ON SKIMMERHORN ST.)
STREET CROSS SLOPE (%) = 2.00 (FOR INLET 5400 ON SKIMMERHORN ST.)
STREET MANNING N = 0.016
GUTTER DEPRESSION (inch) = 1.32
GUTTER WIDTH (ft) = 2.00 (TO ACCOUNT FOR ROLLED CURB)

STREET FLOW HYDRAULICS:

WATER SPREAD ON STREET (ft) = 16.00 (TO CROWN OF STREET)
GUTTER FLOW DEPTH (ft) = 0.43
FLOW VELOCITY ON STREET (fps) = 10.03 (A = 1/2(16)(0.43) = 3.44)
FLOW AREA ON STREET (sq ft) = 2.67
INLET CLOGGING AREAL RATIO (%) = 0.00 (ASSUME NO CLOGGING DUE TO SIZE 4 LOCATION AS DISCUSSED ON INITIAL STORM DESIGN SHEETS

26.79 cfs
INLET INTERCEPTION CAPACITY:

DESIGN FLOW FOR CURB OPENING (cfs) = 26.79
IDEAL INTERCEPTION CAPACITY (cfs) = 18.50
ACTUAL FLOW INTERCEPTED (cfs) = 18.50
CARRY-OVER FLOW (cfs) = 8.29

THE TIME OF CONCENTRATION OF CARRYOVER FLOW = 0 MINUTES.

DET. TOTAL FLOW ACROSS OVERLAND TRAIL FROM OUTPUT ON THIS RUN:

TOTAL FLOW = 34.9 cfs (D.R.S North Side of Street)
ACTUAL FLOW INTERCEPTED = 18.5 cfs

ACTUALLY CROSSES OVERLAND TRAIL DURING A 100 YEAR STORM EVENT.)
A.) Size Storm Sewer Between Inlet #1442

\[ Q_2 = 8.91 \text{ cfs} \]

\[ P_m = 18.50 \text{ cfs} \]

Use Manning's Eq. to determine the min. slope required to pass 18.50 cfs.

\[ \frac{V}{A} = \frac{19.5}{3.14} = 6.0 \text{ fps} \]

\[ n = 0.013 \]

\[ Q = 0.02 \text{ fps} \]

\[ Q_2 = 18.93 \text{ cfs} \]

\[ \text{Slope} \]

Determine Headwater required for inlet control

From Chart 1, \( Q = 18.5 \text{ cfs} \) \( \Rightarrow \) HWD = 1.4

\( 24'' \text{ RCP} \)

\[ H = 2.8' \]

\[ \text{OKAY!} \]

Use 24'' RCP w/min slope of 0.709% and min. HWD = 2.8'

B.) Size Storm Sewer Between Inlet #1 and Outlet Saree

\[ Q = 10.18 \text{ cfs} \]

\[ Q_m = 21.46 \text{ cfs} \]

Use Manning's Eq. to determine the min. slope required to pass 21.46 cfs.

\[ \frac{V}{A} = \frac{7.02}{3.14} = 2.22 \text{ fps} \]

\[ n = 0.013 \]

\[ Q = 22.05 \text{ cfs} > 21.46 \text{ cfs} \] (OK)

Determine Headwater required for inlet control

From Chart 1, \( Q = 21.5 \text{ cfs} \) \( \Rightarrow \) HWD = 1.65

\[ H = 1.65'(2) \]

\[ \text{OKAY!} \]

Use 24'' pipe w/min slope of 0.95% and min. HWD = 3.3'

C.) Size Swale to Design Pt. 6 (Swale is temporary due to uncompleted work of overland trench)

\[ Q_{100} = 2.146 \text{ cfs} \]

in out of 24'' pipe = 37.01

\[ \text{GRD ELEV. at D/P. 6} = 36.00 \]

\[ \text{Assume Swale is 20' deep} \]

\[ 36.00 - 2 = 34.00 \]

\[ \text{Length} = 425' \]

\[ S = \frac{320'}{425'} = 0.762 \% \]

Use Manning's equation for swale, w/4' side slopes

\[ c = 2.6 \]

\[ n = 0.035 \]

\[ Q = 56.49 \text{ cfs} = 2.63 \text{ Q}_0 \]

\[ F = 0.62 < 1.0 \text{ (OK)} \]

Provide \( V \) sump from 24'' pipe to D/P. 6. Use 41' side slopes, swale slope = 0.762%, min. total depth = 2.0'.
REPORT OF STORM SEWER SYSTEM DESIGN

USING UDSEWER-MODEL VERSION 3
DEVELOPED
BY
JAMES C.Y. GUO, PHD, PE
DEPARTMENT OF CIVIL ENGINEERING, UNIVERSITY OF COLORADO AT DENVER
IN COOPERATION WITH
URBAN DRAINAGE AND FLOOD CONTROL DISTRICT
DENVER, COLORADO

EXECUTED BY DENVER UD AND FCD POOL FUND STUDY - DENVER METRO AREA
ON DATA 07-30-1991 AT TIME 20:45:14

PROJECT TITLE:
BURNS RANCH FIRST FILING STORM SEWER ANALYSIS

RETURN PERIOD OF FLOOD IS 100 YEARS

SUMMARY OF HYDRAULICS AT MANHOLES

<table>
<thead>
<tr>
<th>MANHOLE</th>
<th>CNTRIBUTING</th>
<th>RAINFALL</th>
<th>RAINFALL</th>
<th>DESIGN</th>
<th>GROUND</th>
<th>WATER</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td></td>
<td>ID NUMBER</td>
<td>AREA</td>
<td>DURATION</td>
<td>INTENSITY</td>
<td>PEAK FLOW</td>
<td>ELEVATION</td>
<td>ELEVATION</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>MINUTES</td>
<td>INCH/HR</td>
<td>CFS</td>
<td>FEET</td>
<td>FEET</td>
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<tr>
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<td>N/A</td>
<td>N/A</td>
<td>21.46</td>
<td>5143.50</td>
<td>5139.04</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>75.00</td>
<td>N/A</td>
<td>N/A</td>
<td>21.46</td>
<td>5141.68</td>
<td>5138.04</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>112.50</td>
<td>N/A</td>
<td>N/A</td>
<td>18.50</td>
<td>5141.56</td>
<td>5140.50</td>
<td>OK</td>
<td></td>
</tr>
<tr>
<td>112.60</td>
<td>N/A</td>
<td>N/A</td>
<td>18.50</td>
<td>5141.56</td>
<td>5140.76</td>
<td>OK</td>
<td></td>
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</table>

OK MEANS WATER ELEVATION IS LOWER THAN GROUND ELEVATION
### SUMMARY OF SEWER HYDRAULICS

**NOTE:** THE GIVEN FLOW DEPTH-TO-SEWER SIZE RATIO = 0

<table>
<thead>
<tr>
<th>SEWER ID NUMBER</th>
<th>MANHOLE NUMBER</th>
<th>SEWER SHAPE</th>
<th>REQUIRED (HIGH) DIA (IN)</th>
<th>SUGGESTED (HIGH) DIA (IN)</th>
<th>EXISTING WIDTH (FT)</th>
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<tbody>
<tr>
<td>1.00</td>
<td>75.00</td>
<td>ROUND</td>
<td>23.76</td>
<td>24.00</td>
<td>0.00</td>
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<td>2.00</td>
<td>112.50</td>
<td>ROUND</td>
<td>23.80</td>
<td>24.00</td>
<td>0.00</td>
</tr>
<tr>
<td>3.00</td>
<td>112.60</td>
<td>ROUND</td>
<td>23.80</td>
<td>24.00</td>
<td>0.00</td>
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</table>

DIMENSION UNITS FOR ROUND AND ARCH SEWER ARE IN INCHES
DIMENSION UNITS FOR BOX SEWER ARE IN FEET
REQUIRED DIAMETER = COMPUTED; SUGGESTED DIAMETER = COMMERCIAL
FOR A NEW SEWER, FLOW IS ANALYZED BY THE SUGGESTED SEWER SIZE; OTHERWISE, EXISTING SIZE IS USED

<table>
<thead>
<tr>
<th>SEWER ID NUMBER</th>
<th>DESIGN Q (CFS)</th>
<th>P-FULL Q (CFS)</th>
<th>DEPTH (Y FEET)</th>
<th>CTRC DEPTH (Y FEET)</th>
<th>VELOCITY (IN FPS)</th>
<th>FROUDE NUMBER</th>
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<tbody>
<tr>
<td>1.00</td>
<td>21.46</td>
<td>22.11</td>
<td>1.59</td>
<td>1.65</td>
<td>8.02</td>
<td>1.10 V-OK</td>
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<tr>
<td>2.00</td>
<td>18.50</td>
<td>18.98</td>
<td>1.60</td>
<td>1.55</td>
<td>6.88</td>
<td>0.94 V-OK</td>
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<tr>
<td>3.00</td>
<td>18.50</td>
<td>18.98</td>
<td>1.60</td>
<td>1.55</td>
<td>6.88</td>
<td>0.94 V-OK</td>
</tr>
</tbody>
</table>

FROUDE NUMBER = 0 INDICATES THAT A PRESSURIZED FLOW OCCURS

<table>
<thead>
<tr>
<th>SEWER ID NUMBER</th>
<th>SLOPE (FT)</th>
<th>INVERT ELEVATION (FT)</th>
<th>BURIED DEPTH (FT)</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td>1.00</td>
<td>0.95</td>
<td>5137.75</td>
<td>5137.04</td>
<td>4.46</td>
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<td>1.50</td>
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<tr>
<td>3.00</td>
<td>0.70</td>
<td>5138.06</td>
<td>5138.06</td>
<td>1.50</td>
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OK MEANS BURIED DEPTH IS GREATER THAN REQUIRED SOIL COVER OF 1 FEET
### SUMMARY OF HYDRAULIC GRADIENT LINE ALONG SEWERS

<table>
<thead>
<tr>
<th>SEWER</th>
<th>SEWER SURCHARGED</th>
<th>CROWN ELEVATION</th>
<th>WATER ELEVATION</th>
<th>FLOW</th>
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<tbody>
<tr>
<td>ID NO.</td>
<td>LENGTH</td>
<td>LENGTH</td>
<td>UPSTREAM</td>
<td>DNSTREAM</td>
</tr>
<tr>
<td></td>
<td>FEET</td>
<td>FEET</td>
<td>FEET</td>
<td>FEET</td>
</tr>
<tr>
<td>1.00</td>
<td>75.00</td>
<td>0.26</td>
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<tr>
<td>2.00</td>
<td>37.50</td>
<td>37.50</td>
<td>5140.06</td>
<td>5139.80</td>
</tr>
<tr>
<td>3.00</td>
<td>0.10</td>
<td>0.00</td>
<td>5140.06</td>
<td>5140.06</td>
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</tbody>
</table>

PRSS'ED=PRESSURED FLOW; JUMP=POSSIBLE HYDRAULIC JUMP; SUBCR=SUBLITICAL FLOW

### SUMMARY OF ENERGY GRADIENT LINE ALONG SEWERS

<table>
<thead>
<tr>
<th>SEWER</th>
<th>UPSTREAM MANHOLE</th>
<th>FRICTION</th>
<th>DOWNSTREAM MANHOLE</th>
</tr>
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<tbody>
<tr>
<td>ID NO.</td>
<td>MANHOLE</td>
<td>ENERGY</td>
<td>WATER</td>
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<tr>
<td>ID NO.</td>
<td>ELEV FT</td>
<td>ELEV FT</td>
<td>FT</td>
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<tr>
<td>1.00</td>
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<td>5140.40</td>
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<td>2.00</td>
<td>112.50</td>
<td>5141.24</td>
<td>5140.50</td>
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<tr>
<td>3.00</td>
<td>112.60</td>
<td>5141.49</td>
<td>5140.76</td>
</tr>
</tbody>
</table>

BEND LOSS =BEND K* VHEAD IN SEWER.
MAINLINE LOSS= OUTFLOW VHEAD-JCT LOSS K*INFLOW VHEAD
JUNCTURE LOSS= 0 IF THE ABOVE DIFFERENCE IS LESS THAN ZERO
FRICTION LOSS=0 MEANS IT IS NEGLIGIBLE OR POSSIBLE ERROR DUE TO JUMP.
FRICTION LOSS INCLUDES DROP AT MANHOLE.
D. Size Temporary Swale from D.P. 6 South to Blue Leaf Drive

\[ Q_{100} = 21.5 \text{ cfs (April)} + 6.4 \text{ cfs (June)} + 23.0 \text{ cfs (Historic Basis A-2 from Preliminary Report Burns Ranch)} + 7.4 \text{ cfs (Historic Basis A-3 from Preliminary Report Burns Ranch)} \]

\[ Q_{100} = 58.3 \text{ cfs} \]

Available slope & use 2' deep

\[ \text{INV 0/15} = 26.00 - 2 = 24.00 \rightarrow \]

\[ \text{INV 0/15} = 20.00 - 2 = 18.00 \]

\[ \text{Length} = 1160' \]

\[ S = \frac{24' - 18'}{1160'} = 0.052 \]

\[ n = 0.035 \]

\[ w = 2.0' \]

\[ A = 2005' \]

\[ d = 2.0' \]

\[ V = 5.26 \text{ fps} \]

\[ Q = 155.1 \text{ cfs} \]

\[ Q = 61.77 \text{ cfs} > 58.3 \text{ cfs} \]

Erosion & sink check arms will control erosion.

Provide Swale from D.P. 6 South to Blue Leaf Drive w/ 4:1 side slopes.

\[ A = 0.24 + 20.6' = 13.4' \]

\[ Q = 1.948 \left( \frac{13.4'}{0.035} \right)^{0.52} \left( 0.0138 \right)^{0.5} \]

\[ Q = 61.77 \text{ cfs} \]

Size Temporary Swale from Blue Leaf Drive to Detention Pond

Use, \( Q_{100} = 58.3 \text{ cfs} \) (from Part D)

Available slope = \( \frac{5112 - 5112}{230} = 0.95 \% \)

Use Manning equation for swale w/ 4:1 side slopes

\[ n = 0.035 \]

\[ w = 2.5' \]

\[ d = 2.0' \]

\[ V = 5.21 \text{ fps} \]

\[ Q = 213.76 \text{ cfs} \]

\[ F = 0.77 > 0.80 \]

\[ Q = 213.76 \text{ cfs} > 58.3 \text{ cfs} \]

Provide Swale from Blue Leaf Drive to Detention Pond w/ 4:1 side slopes

\[ w = 12.5' \]

\[ A = 0.71 \text{ cfs} > 0.71 \text{ min} \]

Total depth = 2.0'
FILING NO. 3 DETENTION POND EMERGENCY WEIR OVERFLOW

WEIR COEF.
3.000

<table>
<thead>
<tr>
<th>STA</th>
<th>ELEV</th>
</tr>
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<tbody>
<tr>
<td>0.0</td>
<td>5126.00</td>
</tr>
<tr>
<td>8.0</td>
<td>5124.00</td>
</tr>
<tr>
<td>23.0</td>
<td>5124.00</td>
</tr>
<tr>
<td>31.0</td>
<td>5126.00</td>
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</table>

ELEVATION (feet)          DISCHARGE (cfs)
--------------------------------------------
5124.0                     0.0
5124.2                     4.2
5124.4                     12.3
5124.8                     23.3
5124.8                     37.1
5125.0                     53.6 EXISTING MAX. POND ELEV.
5125.2                     72.7
5125.4                     94.4
5125.6                     118.8
5125.8                     145.8

Program uses \[ Q = CNH^{3/2} \] Equation

\[ \text{At ELEV. 5125} \Rightarrow Q = 53.6 \text{ cfs} \]
\[ Q_0 = 53.6 \text{ cfs} + 18.2 \text{ cfs (Burns Ranch)} \]
\[ Q_{100} = 71.8 \text{ cfs} \approx 72.7 \text{ cfs at ELEV 5125.2} \]

**Proposed Maximum Pond ELEV. = 5125.2**
RBD INC. ENGINEERING CONSULTANTS
CHANNEL RATING INFORMATION

SWALE FROM YORKSHIRE ST. TO POND # 1

<table>
<thead>
<tr>
<th>STA</th>
<th>ELEV</th>
</tr>
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<tbody>
<tr>
<td>0.00</td>
<td>5114.10</td>
</tr>
<tr>
<td>4.00</td>
<td>5114.00</td>
</tr>
<tr>
<td>11.00</td>
<td>5112.25</td>
</tr>
<tr>
<td>54.00</td>
<td>5112.25</td>
</tr>
<tr>
<td>61.00</td>
<td>5114.00</td>
</tr>
<tr>
<td>66.00</td>
<td>5114.20</td>
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'CROSS SECTION TAKEN FROM THE BACK REAR LOT CORNER OF LOTS 434-44 ACROSS TO THE CENTER OF LOT 39 D/S OF YORKSHIRE ST. STA 0.00 IS 42-44 CORNER. SECTION EXTENDS FROM REAR LOT LINE TO REAR LOT LINE.'

<table>
<thead>
<tr>
<th>'N' VALUE</th>
<th>SLOPE (ft/ft)</th>
</tr>
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<tbody>
<tr>
<td>0.035</td>
<td>0.0032</td>
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<table>
<thead>
<tr>
<th>ELEVATION (feet)</th>
<th>AREA (sq ft)</th>
<th>VELOCITY (fps)</th>
<th>DISCHARGE (cfs)</th>
<th>FROUDE NO.</th>
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<td>4.3</td>
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<td>17.9</td>
<td>1.3</td>
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<td>2.7</td>
<td>167.47</td>
<td>0.43</td>
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<tr>
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<td>68.1</td>
<td>2.8</td>
<td>190.16</td>
<td>0.44</td>
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<tr>
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<td>73.6</td>
<td>2.9</td>
<td>214.11</td>
<td>0.44</td>
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<tr>
<td>5113.85</td>
<td>79.1</td>
<td>3.0</td>
<td>239.30</td>
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<tr>
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<td>84.8</td>
<td>3.1</td>
<td>265.72</td>
<td>0.45</td>
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<tr>
<td>5114.05</td>
<td>90.5</td>
<td>3.1</td>
<td>284.26</td>
<td>0.45</td>
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</tbody>
</table>

At design point 8, Q_{100} = 73.5 cfs
Freeboard = 1.0 ft.

Calculations are based on the Mannings equation Q = 
\frac{1.486}{T} R^{\frac{2}{3}} S^{\frac{1}{2}} A

PROPOSED 73.5 cfs + 18.2 cfs (Burns Ranch) = 91.7 cfs
FOR A TOTAL Q_{100} = 91.7 cfs, THE PROPOSED WSEL = 5113.16
EXISTING WSEL = 5113.05
DIFFERENCE = 0.11 ft = 1.32 inches
IRRIGATION CANAL

CROSSING
**RBD INC. ENGINEERING CONSULTANTS**  
**CHANNEL RATING INFORMATION**

**CROSS SECTION OF IRRIGATION CANAL NORTH SIDE**

Assume side slopes of 4:1 and then find p with respect to the given area.

\[
\begin{align*}
\lambda &= \sqrt[3]{\frac{q^2}{g}} = 0.6 \\
\rho &= 4.123(0.6) + 0.6 \\
\rho &= 2.46 \\

'N' VALUE & SLOPE (ft/ft) \\
0.035 & 0.0012
\end{align*}
\]

<table>
<thead>
<tr>
<th>ELEVATION (feet)</th>
<th>AREA (sq ft)</th>
<th>VELOCITY (fps)</th>
<th>DISCHARGE (cfs)</th>
<th>FROUDE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5175.80</td>
<td>0.6</td>
<td>0.5</td>
<td>0.30</td>
<td>0.19</td>
</tr>
<tr>
<td>5176.00</td>
<td>1.4</td>
<td>0.7</td>
<td>0.99</td>
<td>0.21</td>
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<tr>
<td>5176.20</td>
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<td>0.9</td>
<td>2.03</td>
<td>0.22</td>
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<tr>
<td>5176.40</td>
<td>3.4</td>
<td>1.0</td>
<td>3.45</td>
<td>0.23</td>
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<tr>
<td>5176.60</td>
<td>4.6</td>
<td>1.1</td>
<td>5.25</td>
<td>0.23</td>
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<tr>
<td>5176.80</td>
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<td>1.2</td>
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<td>7.5</td>
<td>1.3</td>
<td>10.11</td>
<td>0.24</td>
</tr>
<tr>
<td>5177.20</td>
<td>9.1</td>
<td>1.4</td>
<td>13.23</td>
<td>0.25</td>
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<td>30.82</td>
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<td>5178.20</td>
<td>19.4</td>
<td>1.9</td>
<td>36.62</td>
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</tbody>
</table>

On 7/10/91 a depth of flow was measured in the field to be 12" deep, the discharge at a flow depth of 12" = 5.25 cfs.
<table>
<thead>
<tr>
<th>ELEVATION (feet)</th>
<th>AREA (sq. ft)</th>
<th>VELOCITY (fps)</th>
<th>DISCHARGE (cfs)</th>
<th>Froude No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5175.50</td>
<td>0.06</td>
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<td>5175.90</td>
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<td>1.50</td>
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<td>5176.70</td>
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<td>5177.0</td>
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<td>0.57</td>
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<tr>
<td>5177.30</td>
<td>0.035</td>
<td>0.13</td>
<td>0.13</td>
<td>0.26</td>
</tr>
</tbody>
</table>

FLOW RATE: 0.25 cfs

**Comments:**
- Cross section of irrigation canal.
- Channel rating information.
### TABLE 6-5E

**DISCHARGE OF 9" PARSHALL FLUME**

**FORMULAS:**
- CFS = 3.07 H^{1.53}
- GS = CFS \times 7.481
- MGD = CFS \times 0.6463

<table>
<thead>
<tr>
<th>HEAD FT.</th>
<th>CFS</th>
<th>GS</th>
<th>MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>0.007</td>
<td>0.020</td>
<td>0.017</td>
</tr>
<tr>
<td>0.02</td>
<td>0.017</td>
<td>0.035</td>
<td>0.030</td>
</tr>
<tr>
<td>0.03</td>
<td>0.023</td>
<td>0.046</td>
<td>0.044</td>
</tr>
<tr>
<td>0.04</td>
<td>0.033</td>
<td>0.059</td>
<td>0.056</td>
</tr>
<tr>
<td>0.05</td>
<td>0.043</td>
<td>0.070</td>
<td>0.069</td>
</tr>
<tr>
<td>0.06</td>
<td>0.054</td>
<td>0.082</td>
<td>0.081</td>
</tr>
<tr>
<td>0.07</td>
<td>0.064</td>
<td>0.093</td>
<td>0.092</td>
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<tr>
<td>0.08</td>
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<tr>
<td>0.09</td>
<td>0.090</td>
<td>0.115</td>
<td>0.114</td>
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<tr>
<td>0.10</td>
<td>0.104</td>
<td>0.126</td>
<td>0.124</td>
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<tr>
<td>0.11</td>
<td>0.117</td>
<td>0.138</td>
<td>0.136</td>
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<tr>
<td>0.12</td>
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<td>0.146</td>
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<td>0.160</td>
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<tr>
<td>0.14</td>
<td>0.161</td>
<td>0.174</td>
<td>0.172</td>
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<td>0.15</td>
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<td>0.184</td>
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<td>0.210</td>
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<td>0.18</td>
<td>0.218</td>
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<tr>
<td>0.19</td>
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<td>0.270</td>
<td>0.267</td>
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<tr>
<td>0.23</td>
<td>0.283</td>
<td>0.282</td>
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<tr>
<td>0.24</td>
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<td>0.294</td>
<td>0.291</td>
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<tr>
<td>0.25</td>
<td>0.308</td>
<td>0.306</td>
<td>0.303</td>
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</table>

**DISCHARGE OF 9" PARSHALL FLUME**

**TABLE 6-5E CONTINUED**

<table>
<thead>
<tr>
<th>HEAD FT.</th>
<th>CFS</th>
<th>GS</th>
<th>MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.26</td>
<td>0.322</td>
<td>0.320</td>
<td>0.317</td>
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<tr>
<td>0.27</td>
<td>0.335</td>
<td>0.333</td>
<td>0.330</td>
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<tr>
<td>0.28</td>
<td>0.348</td>
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<tr>
<td>0.29</td>
<td>0.360</td>
<td>0.358</td>
<td>0.355</td>
</tr>
<tr>
<td>0.30</td>
<td>0.373</td>
<td>0.371</td>
<td>0.368</td>
</tr>
<tr>
<td>0.31</td>
<td>0.386</td>
<td>0.384</td>
<td>0.381</td>
</tr>
<tr>
<td>0.32</td>
<td>0.400</td>
<td>0.397</td>
<td>0.394</td>
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<tr>
<td>0.33</td>
<td>0.413</td>
<td>0.410</td>
<td>0.407</td>
</tr>
<tr>
<td>0.34</td>
<td>0.426</td>
<td>0.423</td>
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<td>0.35</td>
<td>0.439</td>
<td>0.436</td>
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<td>0.36</td>
<td>0.452</td>
<td>0.449</td>
<td>0.446</td>
</tr>
<tr>
<td>0.37</td>
<td>0.465</td>
<td>0.462</td>
<td>0.459</td>
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<td>0.38</td>
<td>0.478</td>
<td>0.475</td>
<td>0.472</td>
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<td>0.491</td>
<td>0.488</td>
<td>0.485</td>
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<tr>
<td>0.40</td>
<td>0.504</td>
<td>0.501</td>
<td>0.498</td>
</tr>
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<td>0.517</td>
<td>0.514</td>
<td>0.511</td>
</tr>
<tr>
<td>0.42</td>
<td>0.530</td>
<td>0.527</td>
<td>0.524</td>
</tr>
<tr>
<td>0.43</td>
<td>0.543</td>
<td>0.539</td>
<td>0.536</td>
</tr>
<tr>
<td>0.44</td>
<td>0.556</td>
<td>0.552</td>
<td>0.549</td>
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<tr>
<td>0.45</td>
<td>0.569</td>
<td>0.565</td>
<td>0.562</td>
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<tr>
<td>0.46</td>
<td>0.582</td>
<td>0.578</td>
<td>0.575</td>
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<tr>
<td>0.47</td>
<td>0.595</td>
<td>0.591</td>
<td>0.588</td>
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<tr>
<td>0.48</td>
<td>0.608</td>
<td>0.604</td>
<td>0.601</td>
</tr>
<tr>
<td>0.49</td>
<td>0.621</td>
<td>0.617</td>
<td>0.614</td>
</tr>
<tr>
<td>0.50</td>
<td>0.634</td>
<td>0.629</td>
<td>0.626</td>
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</table>

**DISCHARGE OF 9" PARSHALL FLUME**

**TABLE 6-5E CONTINUED**

<table>
<thead>
<tr>
<th>HEAD FT.</th>
<th>CFS</th>
<th>GS</th>
<th>MGD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.51</td>
<td>0.647</td>
<td>0.642</td>
<td>0.639</td>
</tr>
<tr>
<td>0.52</td>
<td>0.660</td>
<td>0.655</td>
<td>0.652</td>
</tr>
<tr>
<td>0.53</td>
<td>0.673</td>
<td>0.668</td>
<td>0.665</td>
</tr>
<tr>
<td>0.54</td>
<td>0.686</td>
<td>0.681</td>
<td>0.678</td>
</tr>
<tr>
<td>0.55</td>
<td>0.700</td>
<td>0.695</td>
<td>0.692</td>
</tr>
<tr>
<td>0.56</td>
<td>0.713</td>
<td>0.708</td>
<td>0.705</td>
</tr>
<tr>
<td>0.57</td>
<td>0.726</td>
<td>0.721</td>
<td>0.718</td>
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<td>0.58</td>
<td>0.739</td>
<td>0.734</td>
<td>0.731</td>
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<tr>
<td>0.59</td>
<td>0.752</td>
<td>0.747</td>
<td>0.744</td>
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<tr>
<td>0.60</td>
<td>0.765</td>
<td>0.760</td>
<td>0.757</td>
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</table>

This unofficial copy was downloaded on Jul-11-2019 from the City of Fort Collins Public Records Website: http://citydocs.fcgov.com

For additional information or an official copy, please contact City of Fort Collins Utilities 700 Wood Street Fort Collins, CO 80524 USA
Given: 24" Rdn. Pipe out of inlet #1
\[ s = 0.95\% \]
\[ Q = 21.5\,\text{cfs} \]

Find: The required riprap at the outlet of the 24" Pipe

Solution: Use Urban Drainage & Flood Control Criteria:
Velocity at pipe outlet = 8.0 fps

Tailwater depth = unknown

Step 1: Determine the required type of riprap for erosion protection
\[ Q_{0.5} = \frac{21.5}{0.5} = 3.8 < 6 \quad \text{(ok to use design charts)} \]
\[ V_t = 0.40 \quad \text{(Tailwater depth unknown)} \]
\[ Q_{0.5} = \frac{21.5}{0.5} = 7.60 \checkmark \]

From Fig. 5-17, use Type L = CLASS 6 RIPRIP

Step 2: Determine the expansion factor (L/tanθ)
\[ \frac{Q}{Q_{0.5}} = 3.8 \quad \text{From Fig. 5-9, } L/\tan\theta = 3.8 \]

Step 3: Determine the length of riprap protection
\[ A_e = \frac{Q}{A_e} \quad \text{(ideal, } V = 5.0 \,\text{fps}) \]
\[ A_e = \frac{21.5}{5} = 4.3 \checkmark \]
\[ V_t = 0.40 \quad V_e = 1.4(0.3) = 0.80 \checkmark \]

Step 4: Check, if maximum or minimum limit governs
\[ L \text{ cannot be less than 30.} \]
\[ L \text{ does not need to exceed 100.} \]
\[ L = 12.8 \checkmark \]

Step 5: Determine riprap depth
\[ \text{max. depth} = 2d_{50} \quad \text{because Fig. 5-7 yielded Class 6 riprap, use } d_{50} = 6'' \]
\[ d_{50} = 1.5'' \checkmark \]

Step 6: Determine bedding

& Use 12" Thick layer of Type II COOK Class II Bedding Material

Step 7: Determine riprap width
\[ 3(2) = 6 \checkmark \]

& Use 6'5" df. width of riprap
EROSION CONTROL
## EFFECTIVENESS CALCULATIONS

### PROJECT: BURNS RANCH PHASE I

<table>
<thead>
<tr>
<th>Erosion Control Method</th>
<th>C-Factor Value</th>
<th>P-Factor Value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROADS &amp; CURB</td>
<td>0.01</td>
<td>1.00</td>
<td>Paved &amp; Constructed</td>
</tr>
<tr>
<td>GRAVEL FILTERS</td>
<td>1.00</td>
<td>0.80</td>
<td>AT INLETS</td>
</tr>
<tr>
<td>ESTAB GRASS</td>
<td>0.11</td>
<td>1.00</td>
<td>EXISTING CONDITION</td>
</tr>
<tr>
<td>MULCH WITH SEED</td>
<td>0.06</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>TEMPORARY VEGETATION</td>
<td>0.45</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>ROUGHENED GROUND</td>
<td>1.00</td>
<td>0.90</td>
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</table>

### MAJOR BASIN PS SUB AREAS (Ac)

<table>
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<tr>
<th>BASIN</th>
<th>PS (%)</th>
<th>SUB</th>
<th>AREA (Ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>64.5</td>
<td>2</td>
<td>0.58</td>
<td></td>
</tr>
</tbody>
</table>

### CALCULATIONS

- **ROADS & CURB**: 0.2 AC + (GRAVEL FILTERS)
  - TEMPORARY VEGETATION: 0.38 AC
  - ROUGHENED GROUND: 0.39 AC
  - **NET C FACTOR**: 0.2(0.01)+0.38(0.45) = 0.30
  - **NET P FACTOR**: 0.90 x 0.80 = 0.72
  - **EFF**: (1-CXP) x 100 = (1-(0.2 x 0.72)) x 100 = 78.4%

- **ROADS & CURB**: 0.2 AC + (GRAVEL FILTERS)
  - MULCH: 0.38 AC
  - **NET C FACTOR**: 0.2(0.01)+0.38(0.06) = 0.04
  - **NET P FACTOR**: 0.80
  - **EFF**: (1-CXP) x 100 = (1-(0.04 x 0.80)) x 100 = 96.8%

- **ROADS & CURB**: 0.6 AC + (GRAVEL FILTERS)
  - TEMPORARY VEGETATION: 0.72 AC
  - ROUGHENED GROUND: 0.72 AC
  - **NET C FACTOR**: 0.6(0.01)+0.72(0.38)+0.72(0.01) = 0.72
  - **NET P FACTOR**: 0.80
  - **EFF**: (1-CXP) x 100 = (1-(0.08 x 0.80)) x 100 = 80.6%

- **ROADS & CURB**: 0.6 AC + (GRAVEL FILTERS)
  - MULCH: 0.72 AC
  - **NET C FACTOR**: 0.6(0.01)+0.72(0.06)+0.72(0.01) = 0.60
  - **NET P FACTOR**: 0.80
  - **EFF**: (1-CXP) x 100 = (1-(0.10 x 0.80)) x 100 = 90.6%

- **ROADS & CURB**: 0.53 AC + (GRAVEL FILTERS)
  - MULCH: 0.15 AC (deco to 4:1 slopes)
  - **NET C FACTOR**: 0.53(0.01)+0.15(0.80) = 0.48
  - **NET P FACTOR**: 0.80
  - **EFF**: (1-CXP) x 100 = (1-(0.04 x 0.80)) x 100 = 96.8%

**TOTAL**: 11.86% (CONT. ON NEXT PAGE)
EFFECTIVENESS CALCULATIONS

PROJECT: BURNS RANCH PHASE 1

COMPLETED BY: KWG

DATE: 4/9/1

<table>
<thead>
<tr>
<th>Erosion Control Method</th>
<th>C-Factor Value</th>
<th>P-Factor Value</th>
<th>Comment</th>
</tr>
</thead>
</table>

MAJOR BASIN | PS | SUB BASIN | AREA (Ac) | CALCULATIONS |

<table>
<thead>
<tr>
<th>EFFNET =</th>
<th>SUM(EFFI x ASI) / SUMASI</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRAIL1</td>
<td>EZIET 11.228</td>
</tr>
<tr>
<td>EFFNET</td>
<td>78.4(0.55) + 80.6(9.62) + 96.8(1.68)</td>
</tr>
<tr>
<td>EFFNET</td>
<td>82.8 &lt; 84.5 (NO GOOD)</td>
</tr>
</tbody>
</table>

| EFFNET | 96.8(0.58) + 80.6(9.62) + 96.8(1.68) | 11.88 |
| EFFNET | 83.7 < 84.5 (OK) |

| EFFNET | 78.4(0.58) + 93.6(9.62) + 96.8(1.68) | 11.88 |
| EFFNET | 93.3 > 84.5 (OK) |

CONCLUSION

USE TRAIL 2 RESULTS

EFFNET = 83.7

HDI/SF-R-1989
CONSTRUCTION SEQUENCE

PROJECT: **BURNS RANCH FIRST FILING**

SEQUENCE FOR 1991 ONLY COMPLETED BY: **KWG** DATE: **10/91**

Indicate by use of a bar line or symbols when erosion control measures will be installed. Major modifications to an approved schedule may require submitting a new schedule for approval by the City Engineer.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>MONTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>6</td>
</tr>
<tr>
<td>1992</td>
<td>8</td>
</tr>
</tbody>
</table>

**OVERLOT GRADING**

- Wind Erosion Control
  - Soil Roughing
  - Perimeter Barrier
  - Additional Barriers
  - Vegetative Methods *EXISTING*
  - Soil Sealant
  - Other

**RAINFALL EROSION CONTROL**

**STRUCTURAL:**
- Sediment Trap/Basin
- Inlet Filters
- Straw Barriers
- Silt Fence Barriers
- Sand Bags
- Bare Soil Preparation
- Contour Furrows
- Terracing
- Asphalt/Concrete Paving
- Other

**VEGETATIVE:**
- Permanent Seed Planting
- Mulching/Sealant
- Temporary Seed Planting
- Sod Installation
- Nettings/Mats/Blankets
- Other

**STRUCTURES:** INSTALLED BY __________________________ MAINTAINED BY __________________________

**VEGETATION/MULCHING CONTRACTOR** __________________________

**DATE SUBMITTED** __________________________ APPROVED BY CITY OF FORT COLLINS ON __________________________

HDI/SF-C: 1989
CONSTRUCTION SEQUENCE

PROJECT: **BURNS RANCH FIRST FILING**

SEQUENCE FOR 1991 ONLY  COMPLETED BY: **KWN**  DATE: **4/91**

Indicate by use of a bar line or symbols when erosion control measures will be installed. Major modifications to an approved schedule may require submitting a new schedule for approval by the City Engineer.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>MONTH</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>S</td>
</tr>
</tbody>
</table>

OVERLOT GRADING

WIND EROSION CONTROL
- Soil Roughing
- Perimeter Barrier
- Additional Barriers
- Vegetative Methods **existing**
- Soil Sealant
- Other

RAINFALL EROSION CONTROL

STRUCTURAL:
- Sediment Trap/Basin
- Inlet Filters
- Straw Barriers
- Silt Fence Barriers
- Sand Bags
- Bare Soil Preparation
- Contour Furrows
- Terracing
- Asphalt/Concrete Paving
- Other

VEGETATIVE:
- Permanent Seed Planting
- Mulching/Sealant
- Temporary Seed Planting
- Sod Installation
- Nettings/Mats/Blankets
- Other

STRUCTURES: **INSTALLED BY**  MAINTAINED BY

VEGETATION/MULCHING CONTRACTOR

DATE SUBMITTED  **APPROVED BY CITY OF FORT COLLINS ON**

HDI/SF-C:1989
CHARTS, TABLES
AND FIGURES
FIGURE 3-2. ESTIMATE OF AVERAGE FLOW VELOCITY FOR USE WITH THE RATIONAL FORMULA.

*MOST FREQUENTLY OCCURRING “UNDEVELOPED” LAND SURFACES IN THE DENVER REGION.

Figure 4-2
REDUCTION FACTOR FOR ALLOWABLE GUTTER CAPACITY
Apply reduction factor for applicable slope to the theoretical gutter capacity to obtain allowable gutter capacity.
(From: U.S. Dept. of Commerce, Bureau of Public Roads, 1965)
**MANNINGS EQUATION**

\[ Q = c/n A R^{2/3} S^{1/2} \]

- \( Q \): Discharge
- \( c \): Chezy Coefficient = 1.486
- \( n \): Roughness factor
- \( A \): Area
- \( R \): Hydraulic Radius = Area/WP
- \( WP \): Netted Perimeter
- \( S \): Slope

Let \( X = c/n A R^{2/3} \)

then \( Q = X S^{1/2} \)

**Minor storm**

(one side of road only)
- Area = 2.63 ft²
- Mannings "n" = 0.016
- Wetted Perimeter = 16.65 ft.
- Hydraulic = 0.16 ft.
- \( X = 91.99 \)

**Major storm**

(both sides of road)
- Area = 42.52 ft²
- Mannings "n" (composite)

\[ (37.47ft)(0.016) + (24.25ft)(0.025) \]

\[ = 0.026 \]

\[ 47.42 \]

- Wetted Perimeter = 94.96
- Hydraulic radius = 0.45
- \( X = 1427.08 \)

To find "Q", multiply "X" by the square root of the slope and then by the reduction factor, Fig. 4.2 P. 4-4, of Fort Collins, specs.
<table>
<thead>
<tr>
<th>Minor Storm</th>
<th>Major Storm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope (%)</td>
<td>V (fps)</td>
</tr>
<tr>
<td>0.40</td>
<td>1.4</td>
</tr>
<tr>
<td>0.50</td>
<td>1.7</td>
</tr>
<tr>
<td>0.60</td>
<td>2.0</td>
</tr>
<tr>
<td>0.70</td>
<td>2.1</td>
</tr>
<tr>
<td>0.80</td>
<td>2.3</td>
</tr>
<tr>
<td>0.90</td>
<td>2.4</td>
</tr>
<tr>
<td>1.00</td>
<td>2.6</td>
</tr>
<tr>
<td>1.10</td>
<td>2.7</td>
</tr>
<tr>
<td>1.20</td>
<td>2.8</td>
</tr>
<tr>
<td>1.30</td>
<td>2.9</td>
</tr>
<tr>
<td>1.40</td>
<td>3.0</td>
</tr>
<tr>
<td>1.50</td>
<td>3.1</td>
</tr>
<tr>
<td>1.60</td>
<td>3.2</td>
</tr>
<tr>
<td>1.70</td>
<td>3.3</td>
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<tr>
<td>1.80</td>
<td>3.4</td>
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<td>2.00</td>
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<td>4.5</td>
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<td>3.75</td>
<td>4.6</td>
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<td>4.00</td>
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<td>4.25</td>
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<td>4.75</td>
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<td>5.00</td>
<td>4.8</td>
</tr>
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<td>5.25</td>
<td>4.9</td>
</tr>
<tr>
<td>5.50</td>
<td>4.9</td>
</tr>
<tr>
<td>5.75</td>
<td>4.9</td>
</tr>
<tr>
<td>6.00</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Minor: \( n = 0.016 \) \( A = 5.26 \text{ ft}^2 \) \( R = 0.16 \) \( C = 143.89 \)

Major: \( n = 0.026 \) \( A = 42.47 \text{ ft}^2 \) \( R = 0.45 \) \( C = 1,425.02 \)

\[
Q = \frac{1.48 AR^{2/3} S^{1/2}}{n} \\
V = Q/A \\
Q = C S^{1/2} [RF]
\]
Figure 5-2

NOMOGRAPh FOR CAPACITY OF CURB OPENING INLETS IN SUMPS, DEPRESSION DEPTH 2"
Adapted from Bureau of Public Roads Nomograph

MAY 1984

DESIGN CRITERIA
$S_x (T-2) = d_w$

**Given:**
- $S_x = 0.02 \text{ ft/ft}$
- $T = 10 \text{ ft}$
- $S = 0.03 \text{ ft/ft}$

**Find:**
- $Q_i/Q = 1$
- $Q_i = 0.65$
- $Q_i/Q = 1$

**Figure 5-5**

Standard Curb-Opening Inlet Chart

CHART 1

EXAMPLE

D=42 inches (3.5 feet)

Q=120 cfs

HW

\( \frac{R}{D} \)

HW in feet

(1) 2.5 8.8
(2) 2.1 7.4
(3) 2.2 7.7

D in feet

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 2.63
BUREAU OF PUBLIC ROADS JAN. 1963
REVISED MAY 1964

181

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CHART 1

EXAMPLE

D = 42 inches (3.5 feet)
Q = 120 cfs

<table>
<thead>
<tr>
<th>HW</th>
<th>HW</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>(1)</td>
<td>2.5</td>
</tr>
<tr>
<td>(2)</td>
<td>2.1</td>
</tr>
<tr>
<td>(3)</td>
<td>2.2</td>
</tr>
</tbody>
</table>

*D in feet

DIA. OF CULVERT (D) IN INCHES

DISCHARGE (Q) IN CFS

HEADWATER DEPTH IN DIAMETERS (HW / D)

HEADWATER DEPT FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

HEADWATER SCALES 283
REvised MAY 1964

BUREAU OF PUBLIC ROADS JAN. 1963

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CHART 29

EXAMPLE
Size: 76" x 48"
Q = 300 cfs

HW = * HW
0
(feet)

(1) 2.8 1.2
(2) 2.2 6.8
(3) 2.3 9.2

* D in feet

To use scale (2) or (3)
draw a straight line
through known values
of size and discharge
to intersect scale (1).
From point on scale (1)
project horizontally to
solution on either scale
(2) or (3).

HEADWATER DEPTH IN TERMS OF RISE (HW/D)

SCALE

ENTRANCE TYPE

(1) Square edge with
headwall

(2) Groove end with
headwall

(3) Groove end
projecting

HEADWATER DEPTH FOR

OVAL CONCRETE PIPE CULVERTS
LONG AXIS HORIZONTAL
WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963
Use \( D_0 \) instead of \( D \) whenever flow is supercritical in the barrel.

** Use Type L for a distance of 3D downstream.

**FIGURE 5-7. RIPRAP EROSION PROTECTION AT CIRCULAR CONDUIT OUTLET.**

11-15-82

URBAN DRAINAGE & FLOOD CONTROL DISTRICT
FIGURE 5-9. EXPANSION FACTOR FOR CIRCULAR CONDUITS
<table>
<thead>
<tr>
<th>FLOW LENGTH (FT)</th>
<th>SLOPE (%)</th>
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<tbody>
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<td>70.9</td>
</tr>
<tr>
<td>1.0</td>
<td>74.6</td>
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<tr>
<td>1.5</td>
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<td>78.4</td>
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<td>79.5</td>
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<td>80.3</td>
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<td>81.1</td>
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<tr>
<td>4.0</td>
<td>81.6</td>
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<td>82.1</td>
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<td>84.9</td>
</tr>
<tr>
<td>100</td>
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<td>1000</td>
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<td>83.6</td>
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<td>1400</td>
<td>83.9</td>
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<td>1500</td>
<td>84.0</td>
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<td>84.8</td>
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<td>4200</td>
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<td>4300</td>
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<td>84.8</td>
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<tr>
<td>4900</td>
<td>84.8</td>
</tr>
<tr>
<td>5000</td>
<td>84.8</td>
</tr>
</tbody>
</table>
Table 5.2  C-Factors and P-Factors for Evaluating EFF Values.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>C-Factor</th>
<th>P-Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>BARE SOIL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Packed and smooth</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Freshly disked.</td>
<td>1.00</td>
<td>0.90</td>
</tr>
<tr>
<td>Rough irregular surface</td>
<td>1.00</td>
<td>0.90</td>
</tr>
<tr>
<td>SEDIMENT BASIN/TRAP</td>
<td>1.00</td>
<td>0.50(1)</td>
</tr>
<tr>
<td>STRAW BALE BARRIER, GRAVEL FILTER, SAND BAG.</td>
<td>1.00</td>
<td>0.80</td>
</tr>
<tr>
<td>SILT FENCE BARRIER</td>
<td>1.00</td>
<td>0.50</td>
</tr>
<tr>
<td>ASPHALT/CONCRETE PAVEMENT</td>
<td>0.01</td>
<td>1.00</td>
</tr>
<tr>
<td>ESTABLISHED DRY LAND (NATIVE) GRASS.</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>SOD GRASS</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>TEMPORARY VEGETATION/COVER CROPS</td>
<td>0.45(2)</td>
<td>1.00</td>
</tr>
<tr>
<td>HYDRAULIC MULCH @ 2 TONS/ACRE</td>
<td>0.10(3)</td>
<td>1.00</td>
</tr>
<tr>
<td>SOIL SEALANT</td>
<td>0.01-0.60(4)</td>
<td>1.00</td>
</tr>
<tr>
<td>EROSION CONTROL MATS/BLANKETS</td>
<td>0.10</td>
<td>1.00</td>
</tr>
</tbody>
</table>

HAY OR STRAW DRY MULCH
After planting grass seed, apply mulch at a rate of 2 tons/acre (minimum) and adequately anchor, tack or crimp material into the soil.

<table>
<thead>
<tr>
<th>Slope (%)</th>
<th>Maximum Length (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 5</td>
<td>400</td>
</tr>
<tr>
<td>6 to 10</td>
<td>200</td>
</tr>
<tr>
<td>11 to 15</td>
<td>150</td>
</tr>
<tr>
<td>16 to 20</td>
<td>100</td>
</tr>
<tr>
<td>21 to 25</td>
<td>75</td>
</tr>
<tr>
<td>25 to 33</td>
<td>50</td>
</tr>
<tr>
<td>&gt; 33</td>
<td>35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Slope (%)</th>
<th>Maximum Length (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 to 5</td>
<td>400</td>
</tr>
<tr>
<td>6 to 10</td>
<td>200</td>
</tr>
<tr>
<td>11 to 15</td>
<td>150</td>
</tr>
<tr>
<td>16 to 20</td>
<td>100</td>
</tr>
<tr>
<td>21 to 25</td>
<td>75</td>
</tr>
<tr>
<td>25 to 33</td>
<td>50</td>
</tr>
<tr>
<td>&gt; 33</td>
<td>35</td>
</tr>
</tbody>
</table>

Maximum Length (feet) = 0.06 + 0.02 S

NOTE: Use of other C-Factor or P-Factor values reported in this table must be substantiated by documentation.

(1) Must be constructed as the first step in overlot grading.
(2) Assumes planting by dates identified in Table 7.4, thus dry or hydraulic mulches are not required.
(3) Hydraulic mulches shall be used only between March 15 and May 15 unless irrigated.
(4) Value used must be substantiated by documentation.
ESTABLISHED GRASS AND C-FACTORS

FORT COLLINS, COLORADO

![Graph showing the relationship between established grass ground cover (%) and c-factor.]

FIGURE 5.1
STREETS

DRAINAGE CRITERIA MANUAL

6. STORM DRAINAGE DESIGN CRITERIA FOR URBAN STREETS

The following sections present specific design requirements for storm drainage on urban type streets. The methods employed to meet these requirements are at the designer's option, so long as they are in compliance with criteria in other parts of this Manual.

6.1 Street Capacity for Initial Storms

Determination of street carrying capacity for the initial storm shall be based upon two considerations:

A. Pavement encroachment for computed theoretical flow conditions.
B. An empirical reduction of the theoretical allowable rate of flow to account for practical field conditions. (6)

6.1.1 Pavement Encroachment. The pavement encroachment for the initial storm shall be limited as set forth in the following Table.

TABLE 6-1
ALLOWABLE USE OF STREETS FOR INITIAL STORM RUNOFF
IN TERMS OF PAVEMENT ENCROACHMENT

<table>
<thead>
<tr>
<th>Street Classification</th>
<th>Maximum Encroachment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local</td>
<td>No curb over-topping.* Flow may spread to crown of street.</td>
</tr>
<tr>
<td>Collector</td>
<td>No curb over-topping  Flow spread must leave at least one lane free of water.</td>
</tr>
<tr>
<td>Arterial</td>
<td>No curb over-topping.* Flow spread must leave at least one lane free of water in each direction.</td>
</tr>
<tr>
<td>Freeway</td>
<td>No encroachment is allowed on any traffic lane.</td>
</tr>
</tbody>
</table>

*Where no curbing exists, encroachment shall not extend over property lines.

The storm sewer system should commence at the point where the maximum encroachment is reached, and should be designed on the basis of the initial storm. Development of the major drainage system is encouraged so that the initial runoff is removed from the streets, thus making the point at

11-15-68