REVISED
FINAL DRAINAGE REPORT

BAILEY'S RUN SUBDIVISION

945 E. PABOR AVENUE

FRUITA, CO

PREPARED FOR:

RUBY CANYON 190, LLC
945 E. Pabor Avenue
Fruita, CO 81521

September 2004

SHARPER
Engineering Services, Inc.
1950 Hwy 6 & 50 - Fruita, CO 81521
Ph: (970) 858-9671 - Fax: (970) 858-0221

CERTIFICATION

I hereby certify that this Revised Final Drainage Report for **Bailey's Run** subdivision was prepared by me or under my direct supervision. The report was prepared in accordance with the Stormwater Management Manual, adopted by the City of Grand Junction in May 1996.

Steven E. Sharpe
Registered Professional Engineer
State of Colorado #29547

REVISED FINAL DRAINAGE REPORT
BAILEY'S RUN

(Revisions appear in *italics*)

I. GENERAL LOCATION AND DESCRIPTION

SITE LOCATION

The proposed Bailey's Run Subdivision is located at 945 East Pabor Avenue in the City of Fruita and is a replat of Lot 5, Ryan's Minor Subdivision. A Vicinity Map is included in Appendix A that shows the project limits in relation to the area. Lots 1-4, Ryan's Minor Subdivision, border this site on the north, Sycamore Subdivision borders this site on the east, Sycamore Street right-of-way and single-family parcels border the site on the west, and East Pabor Avenue borders the site on the south. The surrounding zoning consists of City of Fruita - Community Residential. Access to the site will be obtained from East Pabor Avenue. Refer to the Final Plat for proposed street layouts.

SITE AND MAJOR BASIN DESCRIPTION

The 2.01-acre parcel that makes up Bailey's Run currently consists of an existing single-family residence, a detached garage and two small storage sheds. The balance of the site consists of bare ground, a few mature trees and patches of weed growth. Historically, only about one-fourth of the site was utilized for residential purposes with the other three-fourths of the site left vacant. There are no signs of farming or cultivating operations in the recent past. In researching the soils type at this location, information was obtained from the Mesa County Soils Map web site. The soil type on this parcel, as shown on the geologic map in Appendix A, was found to be entirely Sagers Silty Clay Loam (Bc) as described also in Appendix A. This soil type can be generally categorized as hydrologic soil type "B", having moderate infiltration rates when thoroughly wetted.

II. EXISTING DRAINAGE CONDITIONS

MAJOR BASIN

The existing major drainage basin is delineated by Little Salt Wash on the north and west, Adobe Creek on the east, and U.S. Interstate 70 on the south. The general direction of drainage within the basin is from northeast to southwest.

In researching the floodplain hazard for the area, reference was made to the Flood Insurance Rate Map for Mesa County as produced by the Federal Emergency Management Agency (FEMA), revised July 1992. This site has been designated as within "Zone X", which are areas determined to be outside the 500-year flood plain.

SITE

The site drainage basin is shown on the Historic Drainage Map in Appendix B, which illustrates the basin draining from south to north then east to west at slopes ranging from 0.8 – 1.5% in disked furrows. Drainage exiting from the west side of the property discharges into the Sycamore Street right-of-way drain ditch at a rate of 0.6 cfs for the 2-year and 2.7 cfs for the 100-year storm event (see Appendix C for historic basin computations). This roadside drain is an open earthen ditch that transports drainage northward to Columbine Avenue where it enters a 12" pipe that connects to the Sycamore Drain, a Grand Junction Drainage District tiled line. This 12" pipe will be inundated in a 100-year storm event, however since the ditch feeding the 12" pipe is open, detention of stormwater accumulations is available until the peak discharge passes and the pipe is able to drain upstream accumulations.

Historically, and due to the natural topography, approximately 0.5 acres of drainage is introduced to this site from the north (Ryan's Minor Subdivision). The Encanto Ditch and grading of the east adjacent lots prevents drainage from being introduced from the east. This site slopes away from the north sidewalk along East Pabor Avenue and therefore no runoff is introduced from the south. No runoff is introduced from the west due to the natural topography of the land sloping to the west. Drainage from this site ultimately discharges into Little Salt Wash to the north.

III. PROPOSED DRAINAGE CONDITIONS

CHANGES IN DRAINAGE PATTERNS

No change in drainage patterns is proposed for the lands adjacent to and surrounding Bailey's Run. A Major Basin Drainage Map is included in Appendix B that illustrates the existing drainage basin. Proposed drainage patterns within the site will be modified to accommodate development and to better control surface flows. A Developed Drainage Map is also included in Appendix B illustrating the site grading along with the Tc flow paths.

The developed drainage basin area is 2.09 acres. This area includes a strip of land west of the Encanto Ditch (0.04 acres) and from the north sidewalk along East Pabor to the south property line. Runoff within Bailey's Run will be conveyed in street curb and gutter sections to the end of Ryans Court. From here, drainage will enter a *12" concrete pipe* and discharge into the Sycamore Street right-of-way ditch. This drain ditch will be better defined as shown on the Grading and Drainage Plan. Drainage will then proceed northward along the same route as under historic conditions.

Developed discharge rates are 0.9 cfs for the 2-year and 3.9 cfs for the 100-year storm (Appendix C). The net increase in runoff from historic conditions is 1.2 cfs for the 100-year storm. *Developed drainage from this site will be detained in the Sycamore Street roadside ditch, south of the 12" PVC pipe under Columbine Avenue, which offers a detention volume capacity of approximately 1,900 c.f. At a calculated release rate through the existing 12" pipe of approximately one-half the pipe's capacity, only 1,180 c.f. of storage is required. The release rate through the 12" pipe is figured strictly on Manning's formula and does not account for head pressure above the pipe, thus making the calculations more conservative.* Historic and developed runoff rates (Appendix C) are illustrated in tabular form in Section V of this report.

MAINTENANCE ISSUES

A Homeowners Association will be formed for this development to be responsible for maintaining the drainage ditch along the east side of Sycamore Street to insure proper performance of the ditch and to avoid potential impacts to adjacent areas.

IV. DESIGN CRITERIA & APPROACH

GENERAL CONSIDERATIONS

To our knowledge there has been no master plan completed for this area to determine if large-scale drainage improvements are required for the local region. Since the location of the proposed site discharge is very near the natural discharge point under existing conditions, adjacent lands should be unaffected by drainage improvements to this site.

HYDROLOGY

Calculations are based on 2-year & 100-year rainfall events and precipitation based on Intensity-Duration-Frequency (IDF), Table A-1a, City of Grand Junction Stormwater Management Manual, May 1996. Runoff calculations were performed using the Rational Method, for historic and developed release rates. Parameter selection and design procedures were based on using a composite runoff coefficient, the largest time of concentration (T_c) obtained for the drainage basin, and the basin area obtained by use of a computer.

HYDRAULICS

Hydraulic calculations were accomplished by AutoDesk software, Haestad Methods hydrology software, and Manning's equation. Parameter selection was determined by the various surfaces utilized, and the corresponding coefficients from the City of Grand Junction SWMM manual, May 1996.

V. RESULTS AND CONCLUSIONS

RUNOFF RATES

Historic and developed runoff rates for Bailey's Run are tabulated below:

	2-Year Storm	100-Year Storm
Historic Release Rate	0.6 cfs	2.7 cfs
Developed Release Rate	0.9 cfs	3.9 cfs

Calculated "Average" Release Rate @ 12" Pipe Under Columbine = ***2.0 cfs***

Calculations to support the above runoff rates are included in:
Appendix C and E – Storm Runoff Calculations & Modified Rational Method.

CONCLUSIONS

In developing this area into Bailey's Run Subdivision, it is nearly impossible not to increase the amount of runoff. However, with proper design and construction of the proposed drainage system little, if any, impacts to downstream facilities are anticipated. The general concept of the drainage plan is to follow historic patterns of flow toward the west central region of the site, then north to a 12" culvert under Columbine Avenue. *At this location (south side of Columbine Avenue), detention storage of upstream drainage accumulations is available in the amount of 1,917 cubic feet. The calculated volume necessary to detain upstream flows equals 1,182 cubic feet. As mentioned previously, the release rate through the existing 12" pipe under Columbine Avenue was figured at 57% of the pipe's capacity, based strictly on Manning's formula. The volume of detention required was figured conservatively and the volume available should not be challenged. The route of surface runoff if it overtops this detention facility will be to the west, to and within the Sycamore Street right-of-way.*

This Drainage Report has been prepared to address site-specific drainage concerns in accordance with the requirements of the City of Fruita. The appendices of this report include criteria, exhibits and calculations used in the design and analysis of this project. Finish floor elevations were established to prevent the intrusion of stormwater runoff to any of the proposed building structures and to comply with City of Fruita and Mesa County Standards.

VI. REFERENCES

1. Stormwater Management Manual, City of Grand Junction and County of Mesa, Colorado, Adopted May 1996.

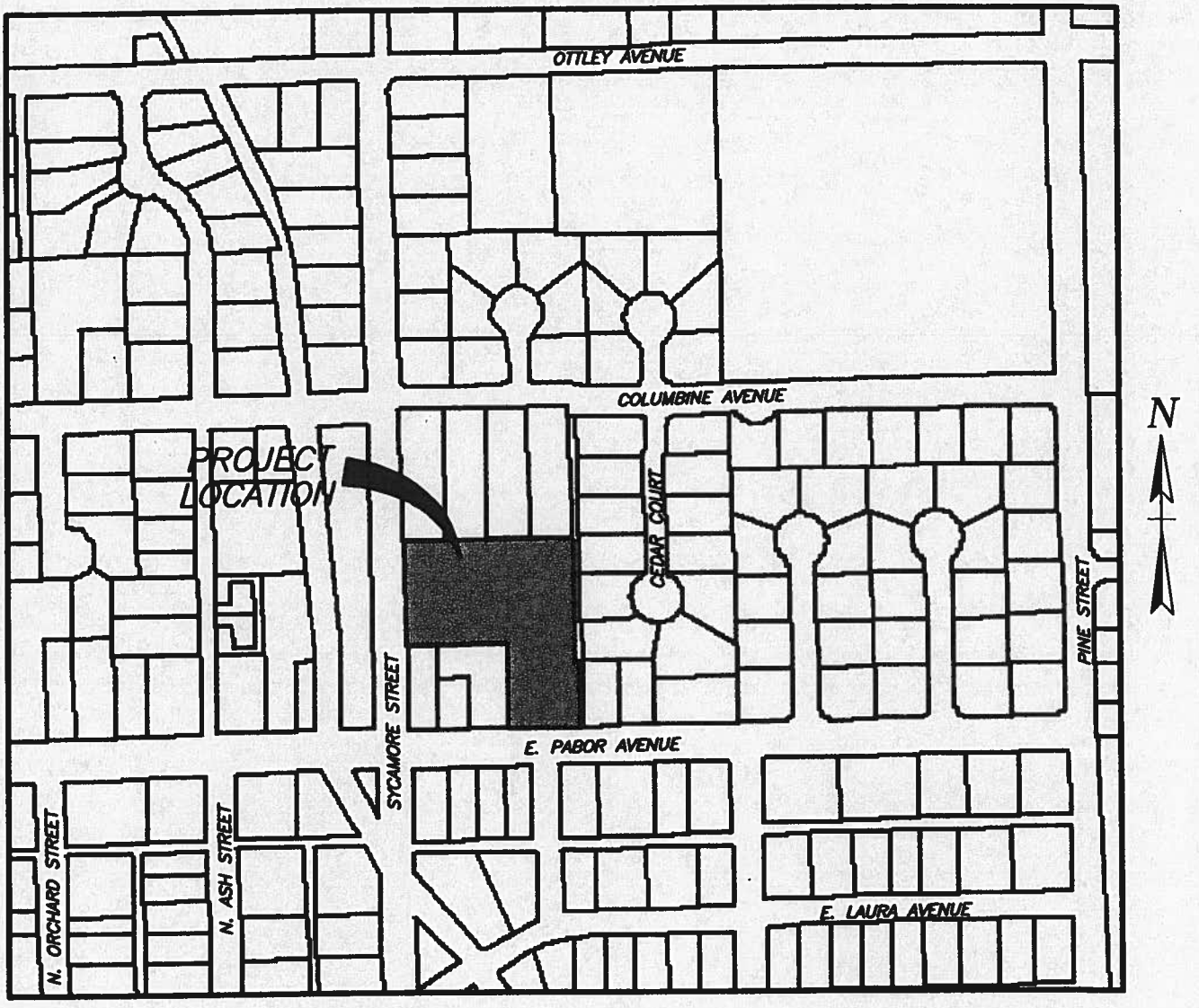
2. Flood Insurance Rate Map, National Flood Insurance Program, Federal Emergency Management Agency, Mesa County, Revised July 1992.

3. Soil Survey, Grand Junction Area, Colorado, U.S. Department of Agriculture, Soil Conservation Service, 1955 and updated in 1997.

4. Autodesk Land Desktop 3 Civil/Survey Design 2001, Civil Engineering Software, Autodesk, Inc., San Rafael, CA.

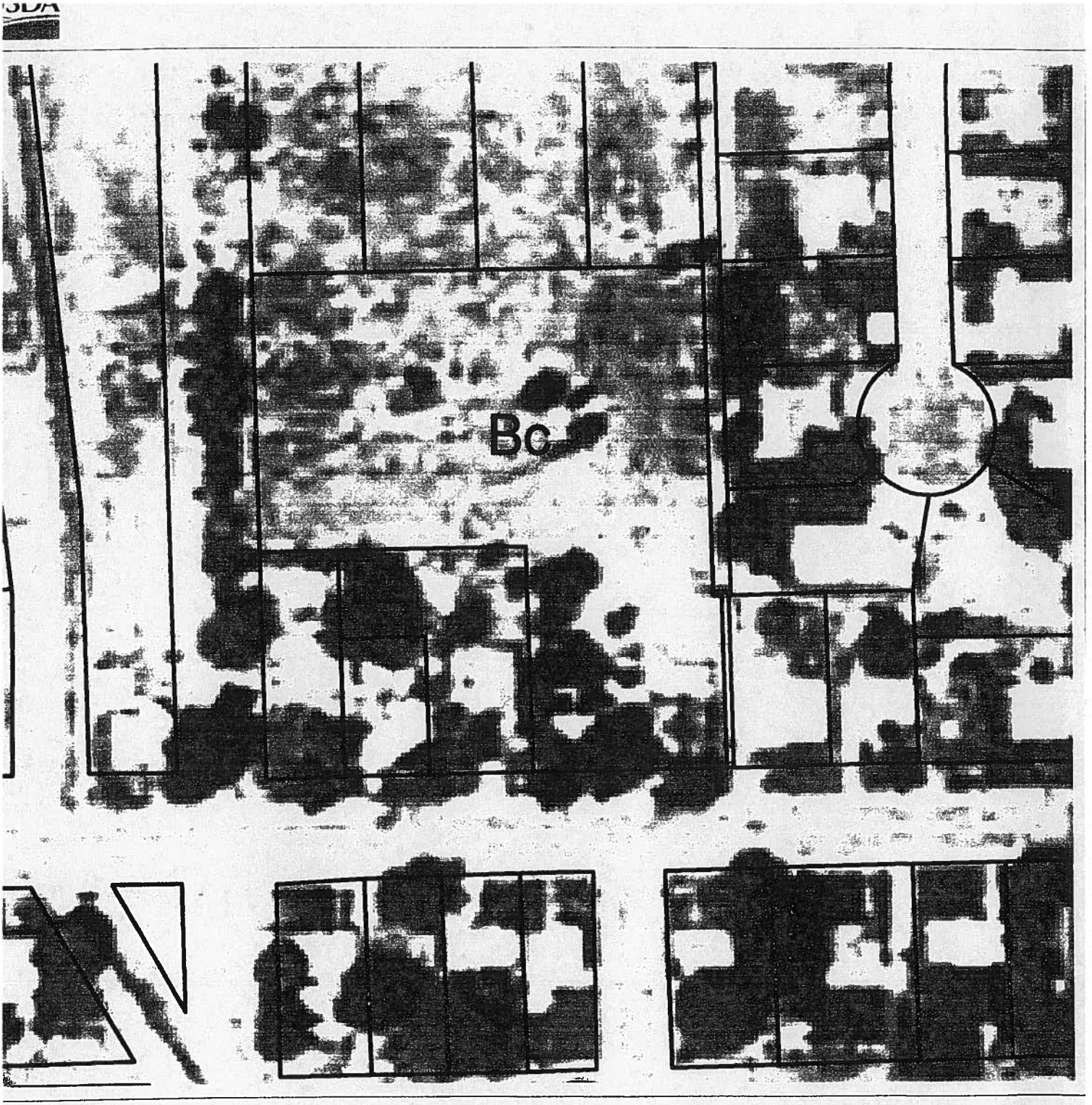
5. Flowmaster Professional Edition, Version 5.13, Haestad Methods Hydrology Software, Haestad Methods, Waterbury, CT.

APPENDIX A



VICINITY MAP

NTS



Legend

- Mesasoils.shp
- county parcel03

200 0 200 Feet

Mapunit Component Descriptions

Soil Survey Area: **CO680 Mesa County Area, Colorado**

Mapunit Symbol **Bc** SAGERS SILTY CLAY LOAM, 0 TO 2 PERCENT SLOPES

Component Name ***SAGERS*** ***Comp % -*** ***90***

THE SAGERS FAMILY CONSISTS OF VERY DEEP, WELL DRAINED SOILS FORMED IN ALLUVIUM FROM SHALE ON TERRACES AND BASIN FLOORS. TYPICALLY, THE SURFACE LAYER IS SILTY CLAY LOAM ABOUT 12 INCHES THICK. THE UNDERLYING MATERIAL IS SILTY CLAY LOAM TO A DEPTH OF 60 INCHES OR MORE.

Component Name ***Other soils*** ***Comp % -*** ***5***

Component Name ***SAGERS, WET*** ***Comp % -*** ***5***

Prime Farmland

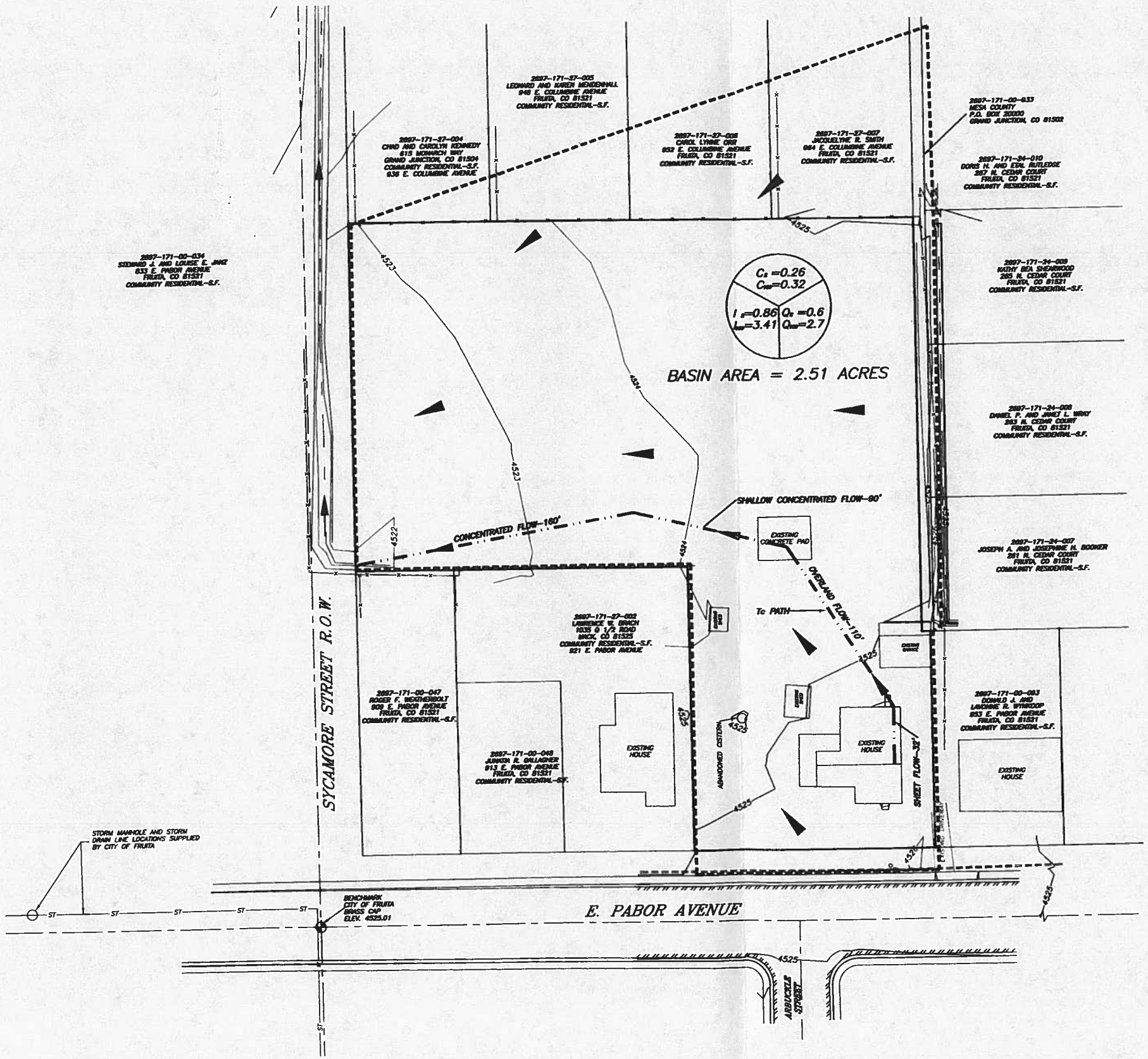
CO680 - Mesa County Area, Colorado

Map Unit Symbol	Map Unit Name	Prime Classification
Bc	SAGERS SILTY CLAY LOAM, 0 TO 2 PERCENT SLOPES	Prime farmland if irrigated

APPENDIX B

BAILEY'S RUN SUBDIVISION

HISTORIC DRAINAGE MAP



LEGEND

- HISTORIC FLOW DIRECTION
- OFF-SITE FLOW DIRECTION
- BASIN BOUNDARY
- FLOWPATH (Tc)

CONTOURS SHOWN ARE EXISTING

BENCH MARK:
NE 1/16 CORNER
SECTION 17
T. 1N., R. 2W., UTE P.M.
N 69869.54
E 45941.11
ELEVATION=4525.01
NAVD88

BY:
REVISION:
NO:
DATE:

HISTORIC DRAINAGE MAP

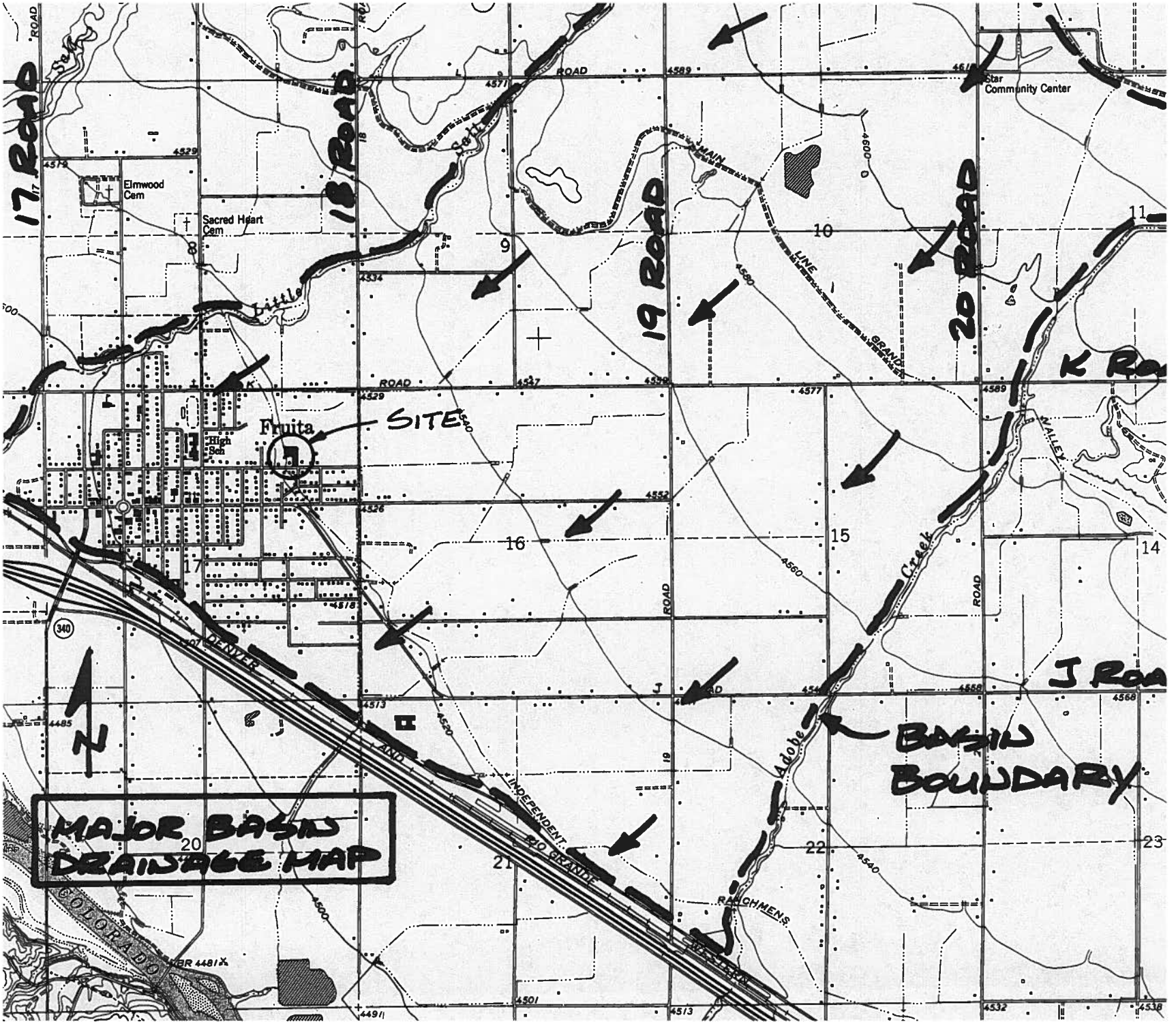
BAILEY'S RUN SUBDIVISION
LOTS, RYANS MINOR SUBDIVISION
RUBY CANYON 190, LLC

PROJECT NO.:
FILE NAME: BAILEY-devdrainage
DATE: 6-23-2004
DRAWN: RLC
CHK'D: SES

SHARPER
Engineering Services, Inc.
1950 HIGHWAY 6 & 50
FRUITA, COLORADO 81521
P.O. BOX 550
(970) 858-9671

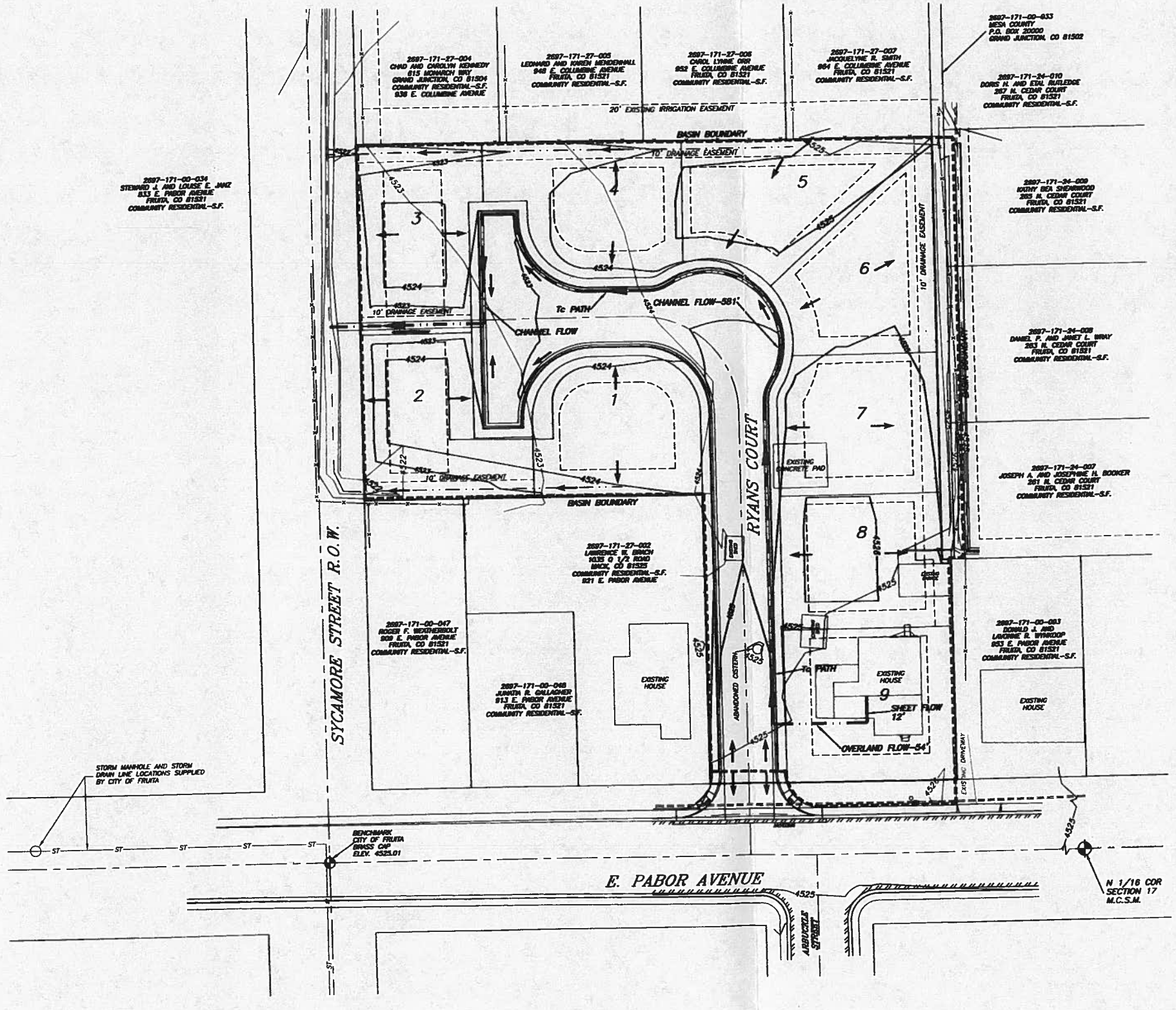
COLORADO REGISTERED
STEVEN E. SHARPER
29547
PROFESSIONAL ENGINEER

SHEET 1 OF 1


17 Road
18 Road
19 ROAD
20 ROAD
Elmwood Cem
Sacred Heart Cem
Fruita
SITE
High Sch
Star Community Center
MAIN LINE
GRAND
Little Salt Creek
Salt Creek
Adobe Creek
DENVER AND RIO GRANDE
INDEPENDENT
RIO GRANDE
RANCHMENS
COLORADO
RIVER
ROAD
K ROAD
J ROAD
VALLEY
BASIN BOUNDARY
MAJOR BASIN DRAINAGE MAP
N

BAILEY'S RUN SUBDIVISION

DEVELOPED DRAINAGE MAP



N

0 15 30 60

SCALE: 1" = 30'
CONTOUR INTERVAL = 1 FOOT

C_a =0.61
C_{100}=0.66

I_a =0.72 Q_a =0.9
I_{100}=2.85 Q_{100}=3.9

BASIN AREA = 2.09 ACRES

LEGEND

- PROPOSED DRAINAGE FLOW
- OFF-SITE FLOW DIRECTION
- BASIN BOUNDARY
- Tc FLOWPATH/DIRECTION
- Tc DESIGN CAPACITY POINT*

*SEE APPENDIX "C" AND "D" FOR SUPPORTING CALCULATIONS.

BENCH MARK:
NE 1/16 CORNER
SECTION 17
T. 1N., R. 2W., UTE P.M.
N 69868.54
E 45941.11
ELEVATION=4525.01
NAVD88

BY:	REVISION:	NO.	DATE:

DEVELOPED DRAINAGE MAP

BAILEY'S RUN SUBDIVISION
LOTS, RYANS MINOR SUBDIVISION
RUBY CANYON 190, LLC

PROJECT NO.:

FILE NAME: BAILEY-devdrainage

DATE: 6-28-2004

DRAWN: RLC

CHK'D: SES

SHARPER
Engineering Services, Inc.
1950 HIGHWAY 6 & 50 P.O. BOX 350
FRUITA, COLORADO 81521 (970) 858-9671

COLORADO REGISTERED
STEVEN E. SHARPER
29547
PROFESSIONAL ENGINEER

SHEET 1 OF 1

APPENDIX C

BAILEY'S RUN SUBDIVISION

HISTORIC CONDITIONS

Total drain Basin area, A_T = 2.51 acres

The historic basin includes about 0.42 acres of off-site drainage from the north, 0.04 acres of off-site drainage from the west side of the Encanto Ditch, and 0.04 acres from the north side of E. Pabor Avenue sidewalk (2.01 + 0.42 + 0.04 + 0.04 = 2.51). The historic drainage patterns within the site are from south to north, then east to west.

Soil type: (B_c), Sagers silty clay loam

Hydrologic soil type "B", Land slope 0 - 2%

Basin Description	**A_T = 2.51 Ac.**	**C_2**	**C_{100}**
Roofs and Buildings	0.17	0.93	0.95
Graveled Areas	0.16	0.64	0.72
Landscape/Lawns	0.27	0.18	0.24
Bare Ground/Weeds	1.91	0.18	0.24

Composite "C" determination:

Cc_2 = (0.17)(0.93) + 0.16(0.64) + (0.27 + 1.91)(0.18) / 2.51 = **0.26**

Cc_{100} = (0.17)(0.95) + 0.16(0.72) + (0.27 + 1.91)(0.24) / 2.51 = **0.32**

INTENSITY: Table "A-1a" (SWMM) @ T_c = 12 min, I_2 = 0.86 in/hr, I_{100} = 3.41 in/hr

(See next sheet for time of concentration determination.)

PEAK DISCHARGE: Q = CiA

Q_2 = 0.26(0.86)(2.51) = 0.6 cfs **Q_{100} = 0.32(3.41)(2.51) = 2.7 cfs**

Reference: Stormwater Management Manual (SWMM) Adopted May 1996

STORM RUNOFF CALCULATIONS (cont.)

BAILEY'S RUN SUBDIVISION

HISTORIC CONDITIONS – TOTAL BASIN

TIME OF CONCENTRATION DETERMINATION:

Sheet flow:

C = 0.94 (ave.), L = 32 ft., S = 25%, sheet flow from Lot 9 roof
Fig. E-2 (SWMM), $T_o = 1.8\ (1.1 - 0.94)(32)^{0.5} / (25)^{0.33}$

T = 0.6 min.

Overland flow:

C = 0.68 (ave.), L = 110 ft., S = 1.45%, flow across gravel to field
Fig. E-2 (SWMM), $T_o = 1.8\ (1.1 - 0.68)(110)^{0.5} / (1.45)^{0.33}$

T = 7.0 min.

Shallow concentrated flow:

L = 90 ft., S = 0.8%, flow across bare field to furrows
Fig. E-3 (SWMM), V = 0.9 fps

T = L/V = 90 ft./0.9 fps = 100 sec. T = 1.7 min.

Channel flow:

Flow in parabolic disked furrows: width = 0.5 ft, depth = 0.25 ft.
Flow area = 0.084 sf, wet perimeter = 0.834 ft, $r_H = 0.084/0.834 = 0.10$ ft.
Manning's n = 0.025 (excav. earth channel), s = 0.0113, L = 160 ft.

$$V = \frac{1.49}{n} (r_H)^{0.67} (s)^{0.5} = \frac{1.49}{0.025} (0.10)^{0.67} (0.0113)^{0.5} = 1.4 \text{ fps}$$

T = L/V = 160 ft./1.4 fps = 114 sec. T = 1.9 min.

Total T_c = 11.2 min.

BAILEY'S RUN SUBDIVISION

DEVELOPED CONDITIONS

Total drain Basin area, A_T = 2.09 acres

The total developed drain basin includes 0.04 acres of off-site drainage from the west side of the Encanto Ditch and 0.04 acres from the north side of E. Pabor Avenue sidewalk (2.01 + 0.04 + 0.04 = 2.09). Off-site drainage from the north will be intercepted by a drainage swale along the north boundary. The developed drainage patterns are from south to north, then east to west.

Soil type: (B_c), Sagers silty clay loam

Hydrologic soil type "B", Land slope 0 - 2%

Basin Description	A_T = 2.09 Ac.	C_2	C_{100}
Buildings, concrete	0.52	0.93	0.95
Streets, sidewalks	0.40	0.93	0.95
Graveled Areas	0.46	0.64	0.72
Landscape, lawns	0.71	0.18	0.24

Composite "C" determination:

Cc_2 = (0.52 + 0.40)(0.93) + 0.46(0.64) + (0.71)(0.18) / 2.09 = **0.61**

Cc_{100} = (0.52 + 0.40)(0.95) + 0.46(0.72) + (0.71)(0.24) / 2.09 = **0.66**

INTENSITY: Table "A-1a" (SWMM) @ T_c = 18 min, I_2 = 0.72 in/hr, I_{100} = 2.85 in/hr

(See next sheet for time of concentration determination.)

PEAK DISCHARGE: Q = CiA

Q_2 = 0.61(0.72)(2.09) = 0.9 cfs **Q_{100} = 0.66(2.85)(2.09) = 3.9 cfs**

Reference: Stormwater Management Manual (SWMM) Adopted May 1996

BAILEY'S RUN SUBDIVISION

DEVELOPED CONDITIONS

TIME OF CONCENTRATION DETERMINATION:

Sheet flow:

C = 0.94 (ave.), L = 12 ft., S = 25%, sheet flow from roof, Lot 9
Fig. E-2 (SWMM), $T_o = 1.8\ (1.1 - 0.94)(12)^{0.5} / (25)^{0.33}$

T = 0.3 min.

Overland flow:

C = 0.21 (ave.), L = 54 ft., S = 1.2%, flow across lawn, Lot 9
Fig. E-2 (SWMM), $T_o = 1.8\ (1.1 - 0.21)(54)^{0.5} / (1.2)^{0.33}$

T = 11.1 min.

Channel flow:

Flow in **Ryan's Court to bulb-out**, depth = 0.25 ft
(see following worksheets and cross-sections for velocity determination)
s = 0.55%, L = 185 ft., V = 1.35 fps

T = L/V = 185 ft./1.35 fps = 137 sec.

T = 2.3 min.

Channel flow:

Flow in **Ryans Court, bulb-out to Lot 4**, depth = 0.31 ft
(see following worksheets and cross-sections for velocity determination)
s = 0.55%, L = 136 ft., V = 1.59 fps

T = L/V = 136 ft./1.59 fps = 86 sec.

T = 1.4 min.

BAILEY'S RUN SUBDIVISION

DEVELOPED CONDITIONS

TIME OF CONCENTRATION DETERMINATION:

Channel flow:

Flow in **Ryans Court, Lot 4 to v-pan**, depth = 0.34 ft
(see following worksheets and cross-sections for velocity determination)
s = 0.55%, L = 183 ft., V = 1.75 fps

T = L/V = 183 ft./1.75 fps = 105 sec.

T = 1.7 min.

Channel flow:

Flow in **4' V-pan to Sycamore Street ROW**, depth = 0.36 ft
(see following worksheets and cross-sections for velocity determination)
s = 0.50%, L = 77 ft., V = 3.35 fps

T = L/V = 77 ft./3.35 fps = 23 sec.

T = 0.4 min.

Total T_c = 17.2 min.

APPENDIX D

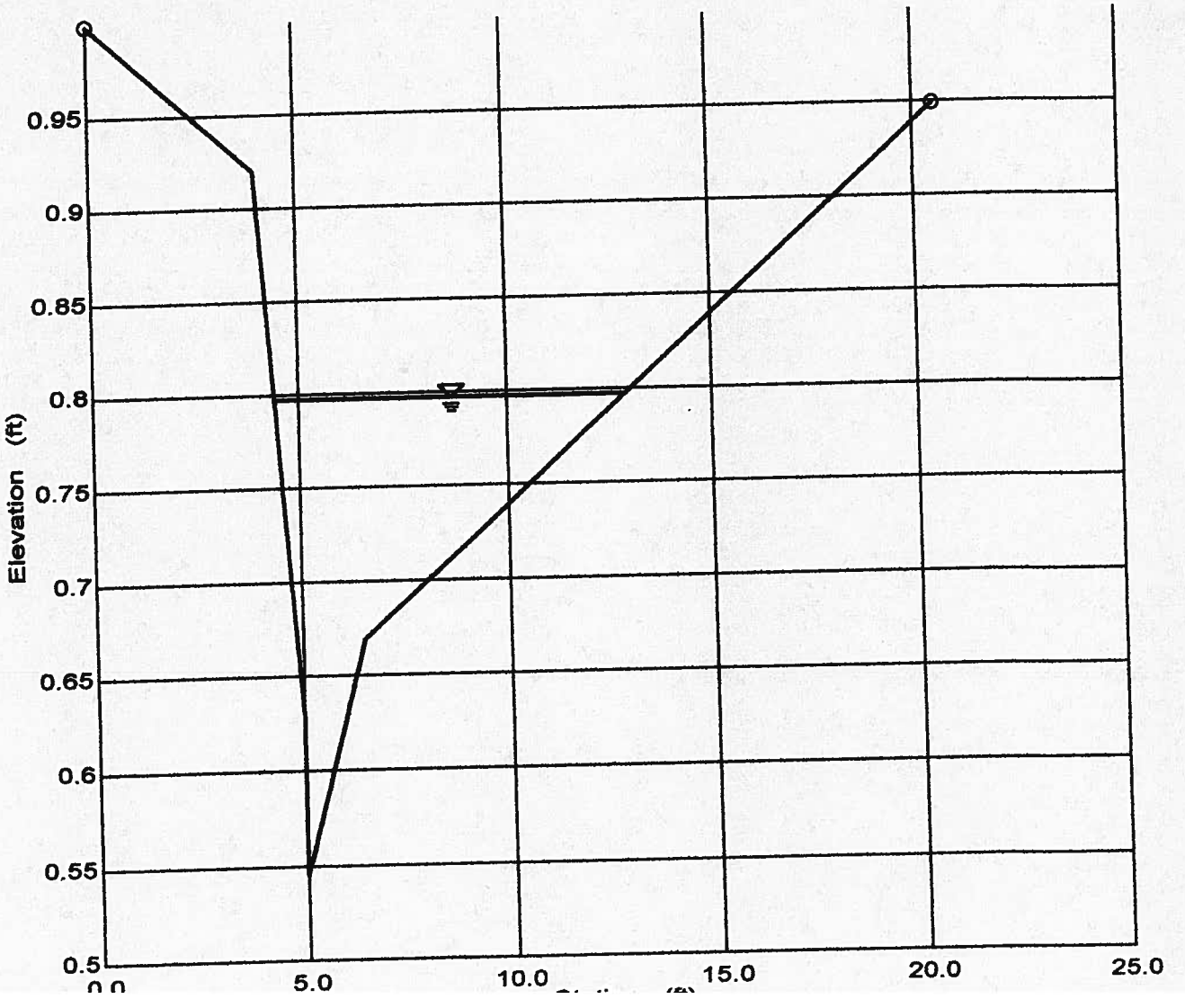
Project Description	
Project File	c:\haestad\fmw\gutter.fm2
Worksheet	Capacity of Gutter Flow - Mountable Curb
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Input Data				
Channel Slope	0.005500 ft/ft			
Elevation range: 0.55 ft to 1.00 ft.				
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	1.00	0.00	20.50	0.016
4.00	0.92			
5.00	0.63			
5.00	0.55			
6.50	0.67			
20.50	0.95			
Discharge	1.00 cfs			

Results		
Wtd. Mannings Coefficient	0.016	
Water Surface Elevation	0.80	ft
Flow Area	0.74	ft²
Wetted Perimeter	8.58	ft
Top Width	8.47	ft
Height	0.25	ft
Critical Depth	0.78	ft
Critical Slope	0.008794	ft/ft
Velocity	1.35	ft/s
Velocity Head	0.03	ft
Specific Energy	0.83	ft
Froude Number	0.80	
Flow is subcritical.		

Project Description	
Project File	c:\haestad\fmw\gutter.fm2
Worksheet	Capacity of Gutter Flow - Mountable Curb
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Section Data		
Wtd. Mannings Coefficient	0.016	
Channel Slope	0.005500	ft/ft
Water Surface Elevation	0.80	ft
Discharge	1.00	cfs



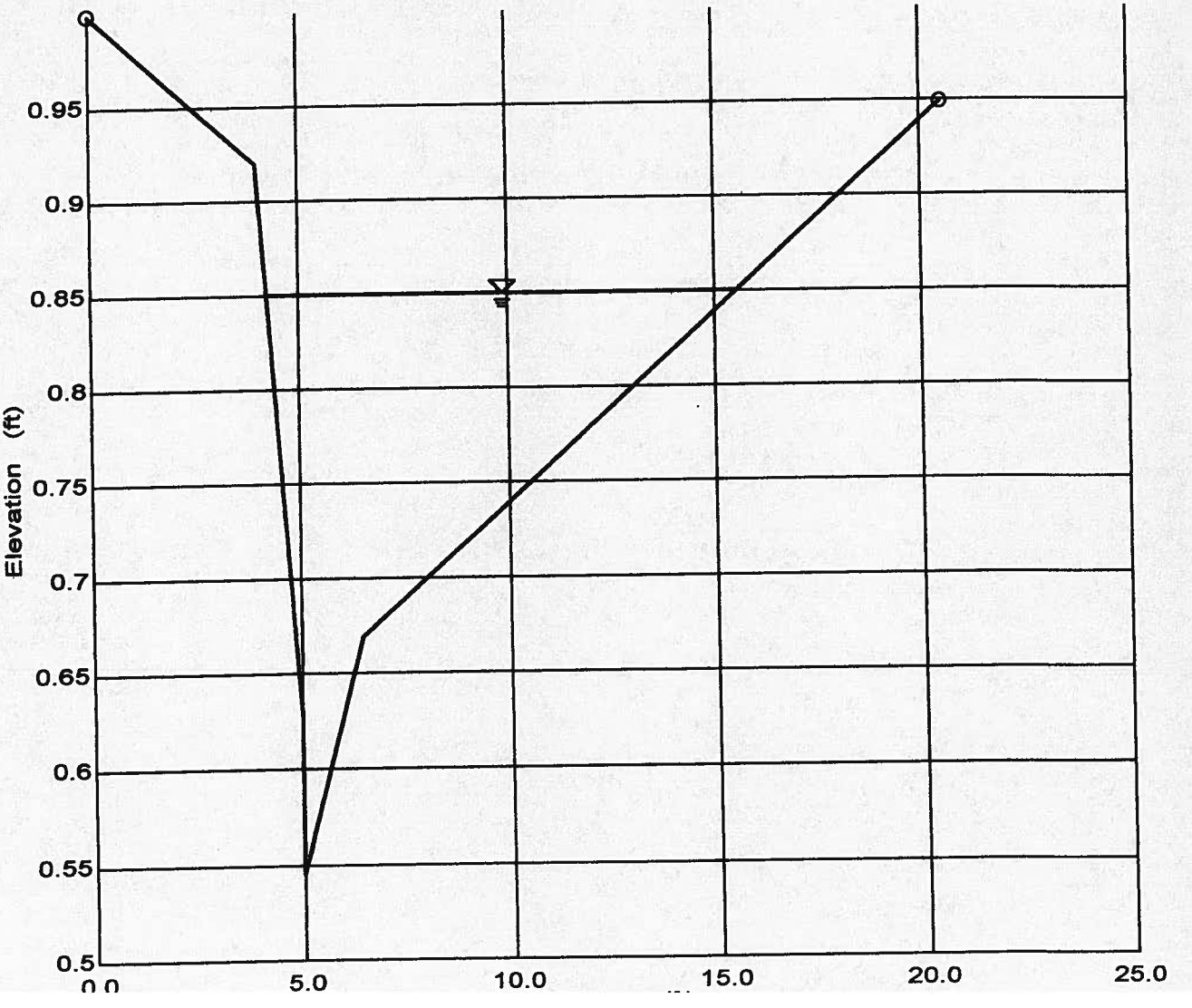
Project Description	
Project File	c:\haestad\fmw\gutter.fm2
Worksheet	Capacity of Gutter Flow - Mountable Curb
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Input Data				
Channel Slope	0.005500 ft/ft			
Elevation range: 0.55 ft to 1.00 ft.				
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	1.00	0.00	20.50	0.016
4.00	0.92			
5.00	0.63			
5.00	0.55			
6.50	0.67			
20.50	0.95			
Discharge	2.00 cfs			

Results		
Wtd. Mannings Coefficient	0.016	
Water Surface Elevation	0.85	ft
Flow Area	1.26	ft²
Wetted Perimeter	11.40	ft
Top Width	11.27	ft
Height	0.31	ft
Critical Depth	0.83	ft
Critical Slope	0.008042	ft/ft
Velocity	1.59	ft/s
Velocity Head	0.04	ft
Specific Energy	0.89	ft
Froude Number	0.84	
Flow is subcritical.		

Project Description	
Project File	c:\haestad\fmw\gutter.fm2
Worksheet	Capacity of Gutter Flow - Mountable Curb
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Section Data		
Wtd. Mannings Coefficient	0.016	
Channel Slope	0.005500	ft/ft
Water Surface Elevation	0.85	ft
Discharge	2.00	cfs



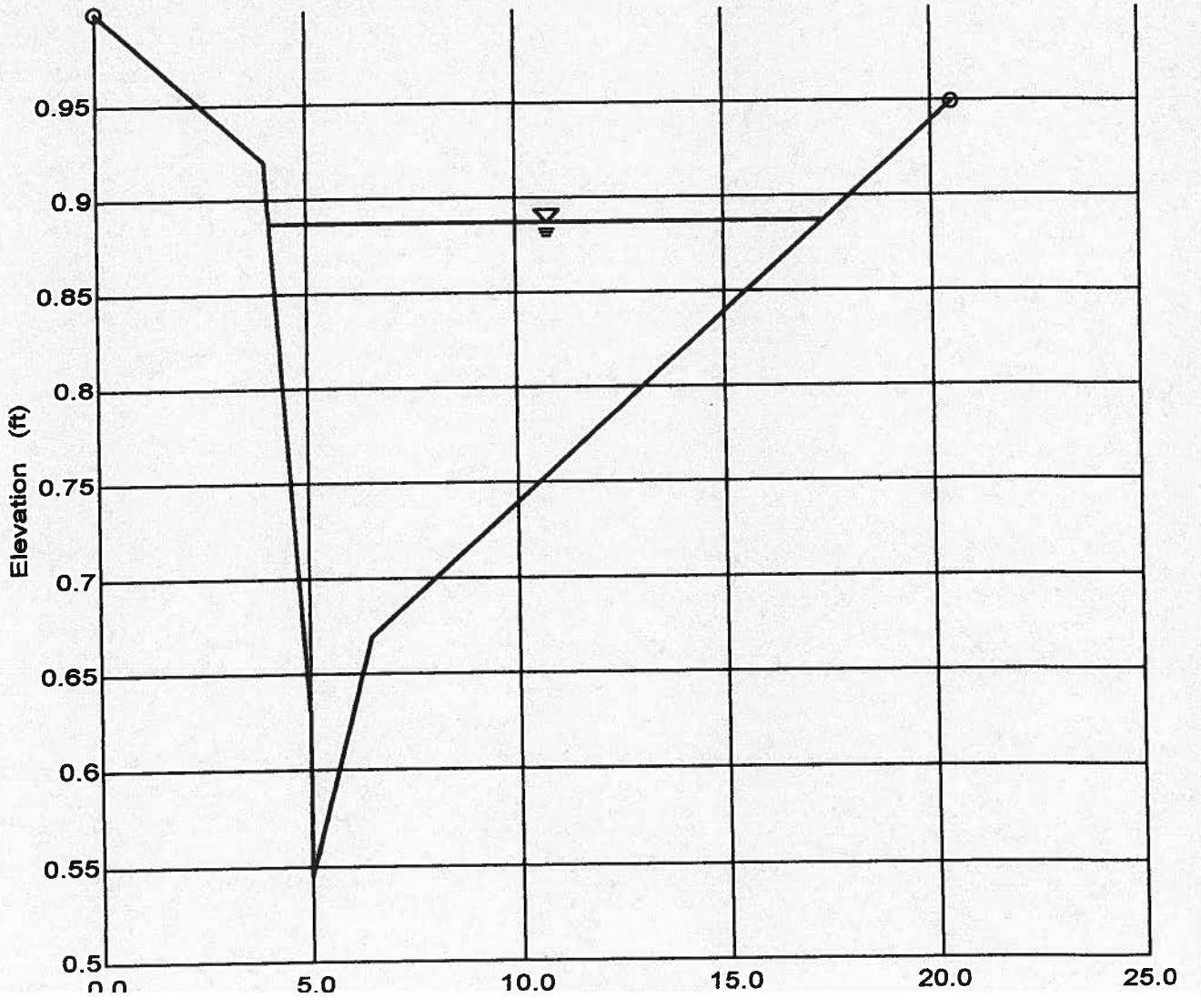
Project Description	
Project File	c:\haestad\fmw\gutter.fm2
Worksheet	Capacity of Gutter Flow - Mountable Curb
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Input Data				
Channel Slope	0.005500 ft/ft			
Elevation range: 0.55 ft to 1.00 ft.				
Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	1.00	0.00	20.50	0.016
4.00	0.92			
5.00	0.63			
5.00	0.55			
6.50	0.67			
20.50	0.95			
Discharge	3.00 cfs			

Results		
Wtd. Mannings Coefficient	0.016	
Water Surface Elevation	0.89	ft
Flow Area	1.71	ft^2
Wetted Perimeter	13.38	ft
Top Width	13.25	ft
Height	0.34	ft
Critical Depth	0.87	ft
Critical Slope	0.007625	ft/ft
Velocity	1.75	ft/s
Velocity Head	0.05	ft
Specific Energy	0.93	ft
Froude Number	0.86	
Flow is subcritical.		

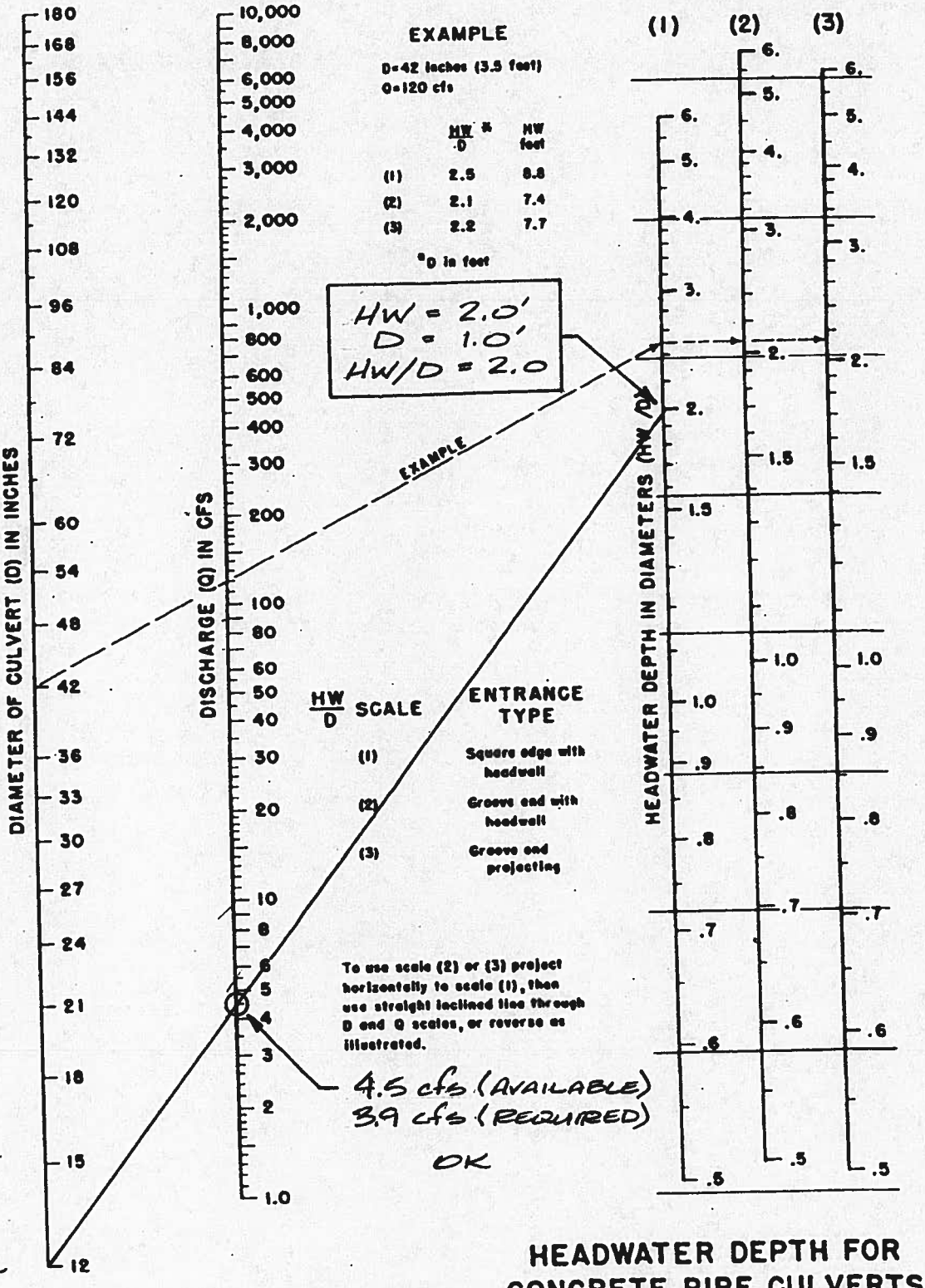
Project Description	
Project File	c:\haestad\fmw\gutter.fm2
Worksheet	Capacity of Gutter Flow - Mountable Curb
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Section Data		
Wtd. Mannings Coefficient	0.016	
Channel Slope	0.005500	ft/ft
Water Surface Elevation	0.89	ft
Discharge	3.00	cfs



MIN. REQUIRED DISCHARGE = 3.7 CFS)

CHART 1



12" RCP CULVERT

HEADWATER SCALES 2&3
REVISED MAY 1964

HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

APPENDIX E

RATIONAL METHOD

(Per Appendix "N", Stormwater Management Manual, SWMM)

MODIFIED RATIONAL METHOD EQUATIONS

100-Yr Storm Event: $Td_{100} = ((1972.9C_dA / Qr - (Qr^2Tc_d/209.9C_dA))^{0.5} - 18.8$

$Id_{100} = 104.94 / Td_{100} + 18.80$

Volume Equations: $Qd = C_dA(Id)$

$K = Tc_h / Tc_d$

$V = 60((Td(Qd - Qr) - QrTc_d + (KQrTc_d/2) + (Qr^2Tc_d/2Qd))$

FROM THE RATIONAL METHOD CALCULATIONS:

100-Year Storm Event Results:

$Cd_{100} = 0.66$
A = 2.09 acres
Q_{100h} = 2.7 cfs (historic release rate < 12" pipe capacity of 3.5 cfs)
$Qr = 0.75Q_{max}$ (Figure N-2a, page N-8 SWMM, Orifice only)
$Qr = 0.75(2.7) = 2.03$ cfs (average release rate)
$Tc_h = 11.2$ min.
$Tc_d = 17.2$ min.

$Td_{100} = ((1972.9x0.66x2.09 / 2.03 - (2.03)^2x17.2/209.9x0.66x2.09))^{0.5} - 18.8$
$Td_{100} = 20.2$ min.

$Id_{100} = 104.94 /(20.2 + 18.8)$
$Id_{100} = 2.69$

DETENTION VOLUME REQUIRED (100-YR STORM):

100-Year Storm Event:

$Qd = C_dA(Id)$
$Qd = 0.66(2.09)(2.69) = 3.7$ cfs
$K = Tc_h / Tc_d = 11.2/17.2 = 0.65$

$V_{100} = 60((20.2(3.7 - 2.03) - 2.03(17.2) + ((0.65(2.03)(17.2))/2 + ((2.03)^2(17.2))/2(3.7))$
$V_{100} = 60(33.7 - 34.9 + 11.3 + 9.6)$

DETENTION VOLUME AVAILABLE PER GRADING AND DRAINAGE PLAN

BAILEY'S RUN

(East side of Sycamore Street R.O.W. @ 12" pipe under Columbine Avenue)

TRUE ELEVATION (PER PLAN)	AVERAGE END VOLUME (CF)
4522.00	1,917
4521.40	720
4521.00	352
4520.00	2.8
4519.80	0.03
4519.75	0

REQUIRED VOLUME: 1,182 C.F.*
AVAILABLE VOLUME: 1,917 C.F.

(BASED ON 100-YEAR STORAGE)

***Refer to previous page for Detention Volume Required.**

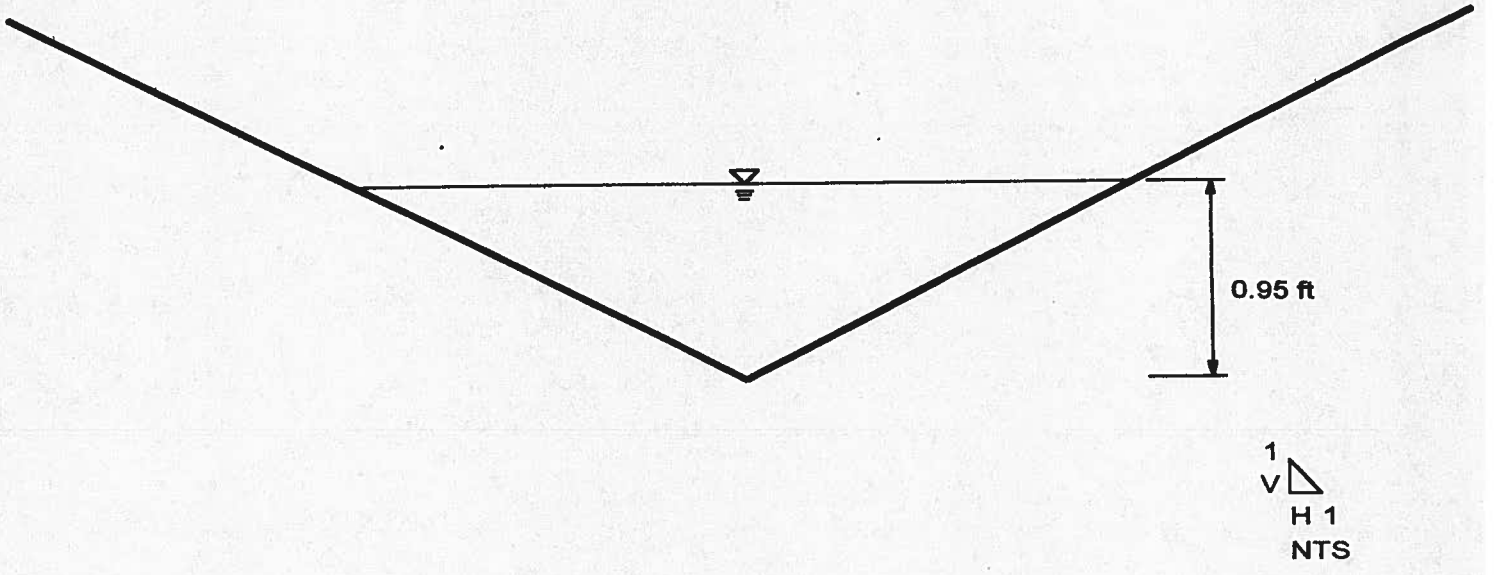
Project Description	
Project File	c:\haestad\fmw\gutter.fm2
Worksheet	Detention Pond V-Pan
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Input Data		
Mannings Coefficient	0.025	
Channel Slope	0.006800	ft/ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V
Discharge	5.00	cfs

Results		
Depth	0.95	ft
Flow Area	1.81	ft^2
Wetted Perimeter	4.25	ft
Top Width	3.80	ft
Critical Depth	0.83	ft
Critical Slope	0.014181	ft/ft
Velocity	2.77	ft/s
Velocity Head	0.12	ft
Specific Energy	1.07	ft
Froude Number	0.71	
Flow is subcritical.		

Project Description	
Project File	c:\haestad\fmw\gutter.fm2
Worksheet	Detention Pond V-Pan
Flow Element	Triangular Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.025	
Channel Slope	0.006800	ft/ft
Depth	0.95	ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V
Discharge	5.00	cfs



Project Description	
Project File	c:\haestad\fmw\baileys.fm2
Worksheet	12" PVC Drain Pipe Under Columbine Ave
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.010	
Channel Slope	0.005000	ft/ft
Depth	1.00	ft
Diameter	12.00	in

Results		
Discharge	3.27	cfs
Flow Area	0.79	ft^2
Wetted Perimeter	3.14	ft
Top Width	0.3e-7	ft
Critical Depth	0.77	ft
Percent Full	100.00	
Critical Slope	0.005589	ft/ft
Velocity	4.17	ft/s
Velocity Head	0.27	ft
Specific Energy	1.27	ft
Froude Number	0.14e-3	
Maximum Discharge	3.52	cfs
Full Flow Capacity	3.27	cfs
Full Flow Slope	0.005000	ft/ft
Flow is subcritical.		

APPENDIX F

STORM RUNOFF CALCULATIONS TO DETER...

REAR LOT DRAINAGE PIPE

(For rear of lot drainage – Lots 4, 5, 6, 7 & 8)

BAILEY'S RUN SUBDIVISION

DEVELOPED CONDITIONS

Total drain Basin area, A_T = 0.46 acres

The total developed drain basin includes the back approximately half of Lots 4, 5, 6, 7 and 8. The basin description includes the entire garage roof area and half of the house roof area draining to the back of the above lots.

Soil type: (B_c), Sagers silty clay loam

Hydrologic soil type "B", Land slope 0 - 2%

Basin Description	A_T = 0.46 Ac.	C_{100}
House roofs	0.10	0.95
Garage roofs	0.06	0.95
Patio area	0.01	0.95
Landscape, lawns	0.29	0.24

Composite "C" determination:

Cc_{100} = (0.10 + 0.06 + 0.01)(0.95) + 0.29(0.24) / 0.46 = **0.50**

INTENSITY: Table A-1a, (SWMM) @ T_c = 9 min, I_{100} = 3.78 in/hr

(See next sheet for time of concentration determination.)

PEAK DISCHARGE: Q = CiA

Q_{100} = 0.50(3.78)(0.46) = 0.87 cfs

Reference: Stormwater Management Manual (SWMM) Adopted May 1996 by the City of Grand Junction and Mesa County.

REAR LOT DRAINAGE PIPE (Cont.)

BAILEY'S RUN SUBDIVISION

DEVELOPED CONDITIONS

TIME OF CONCENTRATION DETERMINATION:

Sheet flow:

C = 0.95, L = 18 ft., S = 25%, sheet flow from roof, Lot 8
Fig. E-2 (SWMM), $T_o = 1.8\ (1.1 - 0.95)(18)^{0.5} / (25)^{0.33}$

T = 0.4 min.

Overland flow:

C = 0.24, L = 12 ft., S = 5%, flow from house to side swale
Fig. E-2 (SWMM), $T_o = 1.8\ (1.1 - 0.24)(12)^{0.5} / (5)^{0.33}$

T = 3.2 min.

Channel flow:

Flow in side yard grass swale
S = 2.0%, L = 100 ft., V = 1.0 fps

T = L/V = 100 ft./1.0 fps = 100 sec.

T = 1.7 min.

Channel flow:

Flow in 6" drain pipe to NW corner of lot 4
Assume average flow in pipe to be half full in overall length
S = 0.4%, L = 440 ft., V = 2.35 fps

T = L/V = 440 ft./2.35 fps = 187 sec.

T = 3.1 min.

Total T_c = 8.4 min.

Project Description	
Project File	c:\haestad\fmw\baileys.fm2
Worksheet	Rear Lot Drainage Pipe Sizing
Flow Element	Circular Channel
Method	Manning's Formula
Solve For	Discharge

Input Data		
Mannings Coefficient	0.010	
Channel Slope	0.004000	ft/ft
Depth	0.67	ft
Diameter	8.00	in

Results		
Discharge	0.99	cfs
Flow Area	0.35	ft²
Wetted Perimeter	2.09	ft
Top Width	0.00	ft
Critical Depth	0.47	ft
Percent Full	100.00	
Critical Slope	0.005512	ft/ft
Velocity	2.85	ft/s
Velocity Head	0.13	ft
Specific Energy	FULL	ft
Froude Number	FULL	
Maximum Discharge	1.07	cfs
Full Flow Capacity	0.99	cfs
Full Flow Slope	0.004000	ft/ft