

DRAINAGE REPORT OUTLINE EXAMPLE

The following example is inserted as a guide and may not contain all of the necessary detail for some submittals.

FINAL DRAINAGE STUDY
FOR
CLARK'S ADDITION
TOWN OF BENNETT
ADAMS COUNTY, COLORADO

MAY, 1995



BY:

Powers Elevation Co., Inc.

13900 E. HARVARD AVE., SUITE 113

P.O. BOX 440889

AURORA, COLORADO 80044

(303)321-2217

FINAL DRAINAGE STUDY
FOR
CLARK'S ADDITION
TOWN OF BENNETT
ADAMS COUNTY, COLORADO
MAY, 1995

THE PLANS ARE REVIEWED FOR CONCEPT ONLY, AND THE REVIEW DOES NOT IMPLY RESPONSIBILITY BY THE REVIEWING DEPARTMENT, THE TOWN ENGINEER, CITY ENGINEER, OR THE TOWN OF BENNETT FOR ACCURACY AND CORRECTNESS OF CALCULATIONS. THE REVIEW DOES NOT IMPLY THAT QUANTITIES OF ITEMS INDICATED ON THE PLAN(S) ARE THE FINAL QUANTITIES REQUIRED. THE REVIEW SHALL NOT BE CONSTRUED FOR ANY REASON AS ACCEPTANCE OF FINAL RESPONSIBILITY BY THE TOWN OR REVIEWING DEPARTMENTS FOR ADDITIONAL ITEMS AND ADDITIONAL QUANTITIES OF ITEMS SHOWN THAT MAY BE REQUIRED DURING THE CONSTRUCTION PHASE.

ALL WORK SHALL BE CONSTRUCTED IN ACCORDANCE WITH
THE TOWN OF BENNETT
STANDARD SPECIFICATIONS

APPROVED FOR ONE YEAR FROM THIS DATE:

TOWN ENGINEER _____

DATE _____

OR:

DESIGNATED TOWN REPRESENTATIVE _____

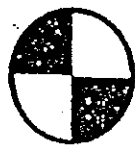
DATE _____

DATE _____

OWNER OR REPRESENTATIVE

GREG MOLER
QUALITY CONSTRUCTION
830 SHARIS COURT
BENNETT, COLORADO 80102
(303)644-3544

BY:



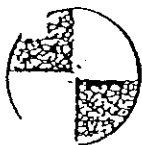
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CLARKS ADDITION TO THE TOWN OF BENNETT

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May, 1995

I. INTRODUCTION

This report was prepared for Mr. Greg Moler dba Quality Construction owner/developer of Clark's Addition to the Town of Bennett, Colorado.

II. Location

This DRAINAGE REPORT is submitted for the CLARK'S ADDITION TO THE TOWN OF BENNETT herein after referred as to "site", located in the in part of the northwest quarter of Section 27, Township 3 South, Range 63 West of the Sixth principal meridian, Town of Bennett, Colorado. This report is submitted as a courtesy to the Town of Bennett to document.

DESCRIPTION OF PROPERTY

The site is bounded by First Street on the west, proposed Truman Avenue on the north, Third Street on the east and Roosevelt on the south.

The site consists of approximately 8.1 acres. Its primary use will be of single family housing units. Development will consists of 24 single family lots. Bordered to the South and East by existing single family housing subdivisions. To the North and West is vacant Lands parcels. There exist one residential building and barn in lot 6 Block 1 of Clark's Addition to the Town of Bennett. The site has natural grasslands, with a sandy clay underlain. There are no irrigation ditches or canals within 300 feet of the subject site.

III. Intent

The purpose of this study is to identify the major drainage flows that will impact the site and to design the necessary structures for handling the storm runoff in compliance with the pertaining Town of Bennett Regulations.

In conjunction with the final drainage analysis within this report, grading outlines, the general location and type of hydraulic structures, will be indicated, To that purpose the following outline was adhered to.

First, it was investigated as to what extent the subject property is impacted by the 100-year flood plain as delineated by FEMA (Federal Emergency Management Agency). Visual representations of their maps are provided to that purpose within this report.

Subsequently, an existing swale was improved and structures designed to collect and convey the developed peak flows towards the general location of a detention area indicated on the drainage and grading map enclosed within the back of this report. From this location the 10-year and 100-year runoff will be released at allowable rates or less.

U.S. Geological survey quadrangle sheets, topographical field data and the Storm Drainage Master Plan as prepared by McCarty Engineering Consultants, Inc., of Longmont, Colorado were utilized to determine the size and other physical characteristics of the surrounding area and the subject addition. This data was significantly augmented with a detailed field inspection.

IV. Criteria

The peak runoff quantities were calculated using the latest revisions of the Rational Method as per the Denver Regional Council of Government's Urban Storm Drainage Criteria Manual and the latest revisions thereof, and the Town of Bennett requirements, Where conflicting data were encountered, the more stringent requirements were adhered to.

The following Rational Formula was used to compute the storm runoff values:

Q	=	CIA
Q	=	Peak runoff rate in cubic feet per second
C	=	Runoff coefficient
I	=	Storm intensity in inches per hour
A	=	Drainage tributary area in acres

In compliance with current good engineering standards, minimum concentration times of 10 minutes, undeveloped, and 5 minutes, developed, will be adhered to. Where desirable, composite or weighted "C" values were derived from the data contained within this report.

No detention area will be designed to restrict the combined 10-year and 100-year discharge from the subject Clarks addition to the Town of Bennett as waived by the Town of Bennett.

V. Discussion

According to the Federal Emergency Management Agency (FEMA) data enclosed, the subject property is outside the Kiowa Creek 100-year flood plain and no further analysis proved necessary.

First Street

Flows from drainage basin TP (Trupp Park), are conveyed towards the north by means of existing culverts and ditches along the west side of First Street and do not impact the subject site. Along the east side of First Street, flows from drainage basin 1 are accumulating within the bounding curb and gutter section and thence conveyed towards design point 1 in the amount of Q10 = 3.4 cfs and Q100 = 6.3 cfs.

These flows continue north by means of an existing cross-pan at the intersection with Roosevelt, and are thence conveyed towards design point 4 in the accumulating amount of Q10 = 4.4 cfs and Q100 = 8.3 cfs. These flow magnitudes are well within the capacity of the proposed ditch section A - A and the associated 18" dia. CMP driveway underpass culverts.

Second Street

By far the largest impact on the subject site are the accumulated flows at design point 2 in the amount of Q10 = 29.7 cfs and Q100 = 60.0 cfs.

These flows are generated from drainage basin 2, which is one of the major drainage collectors within the Town of Bennett. Since the calculated 10-year flow far exceeds the combined carrying capacity of the proposed Second Street curb and gutter, a low area will be created on the north side of the intersection with Roosevelt, and 24 l.f. (12 l.f. on each side), of type "R" storm sewer inlets constructed with an associated 27" dia. main collector line discharging towards the north at design point 5. A modest high point in Second Street, approximately 25' north of the Roosevelt intersection, will be set at an elevation equal to or slightly above the top of curb elevation of the proposed storm inlet. This will insure full interception of the 10-year storm flows while at the same time providing alleviation of the 100-year storm event and an associated overflow escape. Typical street section B - B is well capable of conveying the 100-year storm without building line infringement or excessive street flow depth that would prevent emergency vehicle access.

Third Street

Flows from drainage basin 3 collect towards design point 3 in the amount of Q10 = 8.5 cfs and Q100 = 18.0 cfs, and thence towards design point 5 in the amount of Q10 = 11.3 cfs and Q100 = 23.1 cfs. Both design point flows are well within the conveying capacity of a 6-inch curb at approximately 0.5% Grading on the west side of Third Street (and on the south of Truman and the north of Roosevelt), shall be as per typical street section B - B

On-site sub-basins B and C have been analysed as part of drainage basins 2 and 3. Sub-basin D will require a storm sewer outfall towards design point 5 if currently existing interior grades are largely maintained. This outfall can be deleted when the area is filled in such a manner that it subsequently drains towards the bounding streets.

Truman Avenue

The historic flow was to the northeast, this street was not previously graded or developed. The south half of the Proposed Truman Street will be developed during this construction. The South gutter will carry the drainage from First Street East to Third Street, picking up the drainage from both east and west gutters of Second Street and continuing onto Third Street where the flows will then head in a Northerly direction along an existing natural drainage, as shown on the Town of Bennett Storm Drainage Master Plan as prepared by McCarty Engineering Consultants, Inc. of Longmont, Colorado.

VI. Conclusion

The suggested outline insures that there will be no change in the impact of the major storm on both the upstream and downstream side of the property while the site itself remains compatible with historical conditions. And will elevate the Third Street Drainage by opening up both East and West Gutters.

Surfacing, topsoiling, seeding, and fertilizing will be applied within ten days of completion of any newly-exposed slope. Eventual stock piles, susceptible to weather action, will be covered with protective blankets, Rip-rap lining shall consist of natural stone of the minimum sizes indicated and shall have a weight of not less than 185 pounds per cubic foot.

In conclusion it is recommended that, when and where applicable, the erosion control procedures outlined in the pertaining Appendix section of this report will be strictly adhered to.

This report is for review and approval only. Final design and subsequent construction shall be in accordance with the guidelines provided herein.

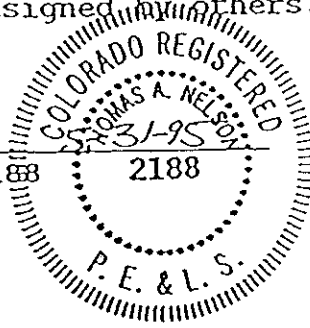
Prepared by: _____

Tom Nelson, P.E. & L.S. 2188
Vice President



This report (plan) for the drainage design of Clarks Addition to the Town of Bennett was prepared under my direct supervision, in accordance with the provisions of the Town of Bennett Drainage Design and Technical Criteria Manuals, for the owners thereof. I understand that the Town of Bennett does not and will not assume liability for drainage facilities designed by others.

Tom Nelson
Tom Nelson PE & LS 2188



_____ hereby certifies that the drainage facilities for Clarks addition to the Town of Bennett, shall be constructed according to the design presented in this report. I understand that the Town of Bennett does not and will not assume liability for the drainage facilities designed and/or certified by my engineer and that the Town of Bennett reviews drainage plans pursuant to Colorado Revised Statutes, Title 30, Article 28, but cannot, on behalf of Clarks Addition to the Town of Bennett, guarantee that final drainage design review will absolve _____ and or their successors and /or assigns of future liability for improper design, I further understand that approval of the Final Plat does not imply approval of my engineer's drainage design.

Glen Leyshon dba Buffalo Inc.

Glen Leyshon

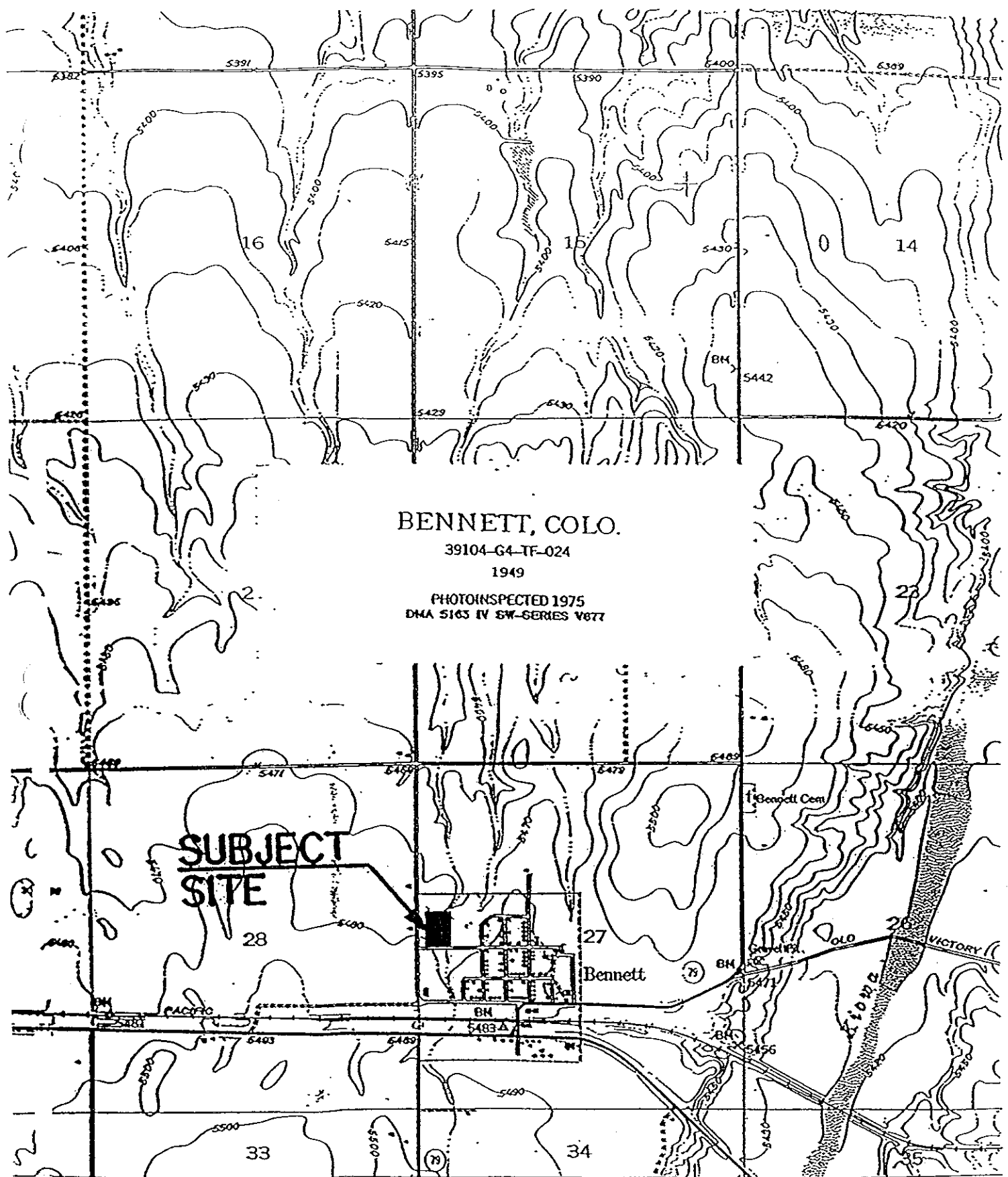
Date:

BIBLIOGRAPHY

1. Town of Bennett Drainage Regulations and Technical Criteria Manual.
2. Denver Regional Council of Government's Drainage Manual
3. Adams County Storm Drainage Manual

APPENDICES

VICINITY MAP



BENNETT, COLO.

39104-G4-TF-024

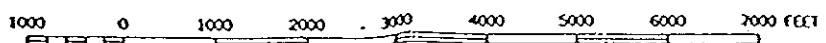
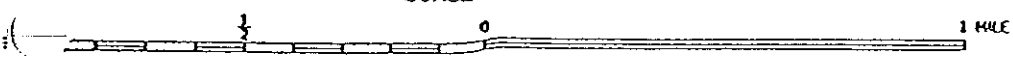
1949

PHOTOINSPECTED 1975
DMA 5163 IV SW-SERIES V877

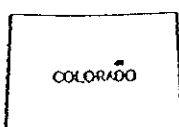
**SUBJECT
SITE**

0.8 ML TO INTERSTATE 70 AND U.S. 36-40-287
STRASBURG NW 1/4
5163 III NW

SCALE 1:24000



CONTOUR INTERVAL 10 FEET



100-YEAR FLOOD PLAIN MAP

NATIONAL FLOOD INSURANCE PROGRAM

FIRM
FLOOD INSURANCE RATE MAP
ADAMS COUNTY,
COLORADO AND
INCORPORATED AREAS

PANEL 450 OF 875
(SEE MAP INDEX FOR PANELS NOT PRINTED)

CONTAINS: COMMUNITY	NUMBER	PANEL	SUFFIX
ADAMS COUNTY, UNINCORPORATED AREAS	06000	040	0
BOHETE TOWN OF	06000	040	0

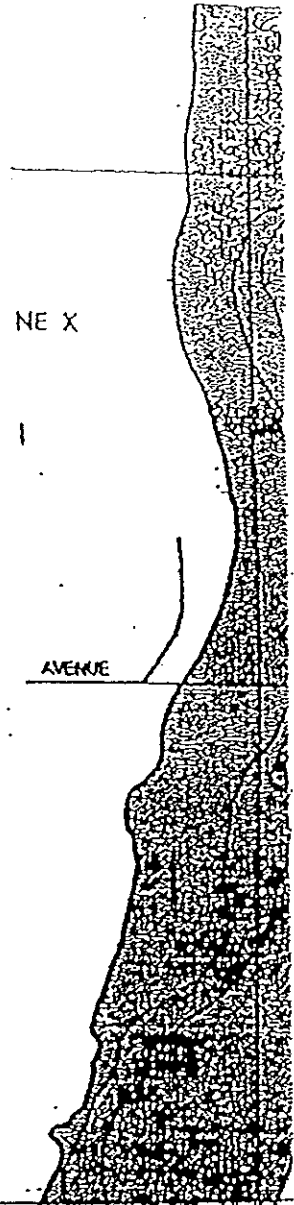
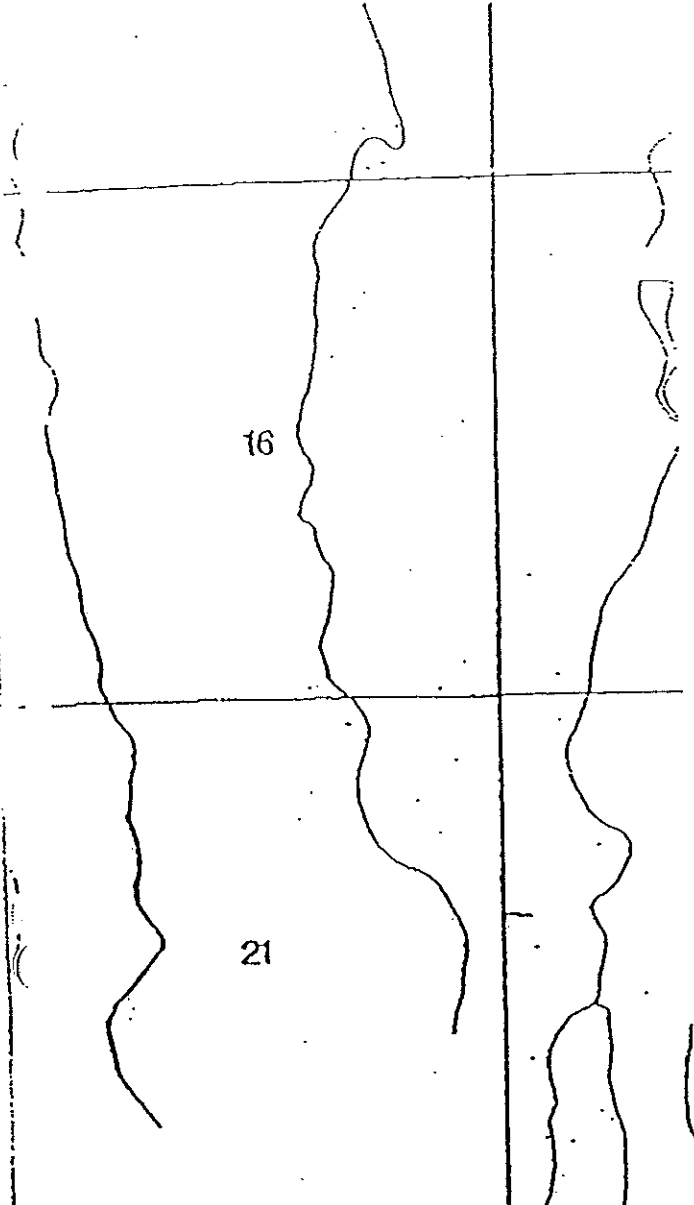
MAP NUMBER
0600100450 0

EFFECTIVE DATE:

PRELIMINARY
MICHAEL BAIGER, JR., INC.

SEP 30 1993

Federal Emergency Management Agency



SUBJECT SITE

TOWN OF BENNETT
060003

ZONE X

PALMER AVENUE

VICTORY

PROVOST ROAD

TOWN OF BENNETT
060003

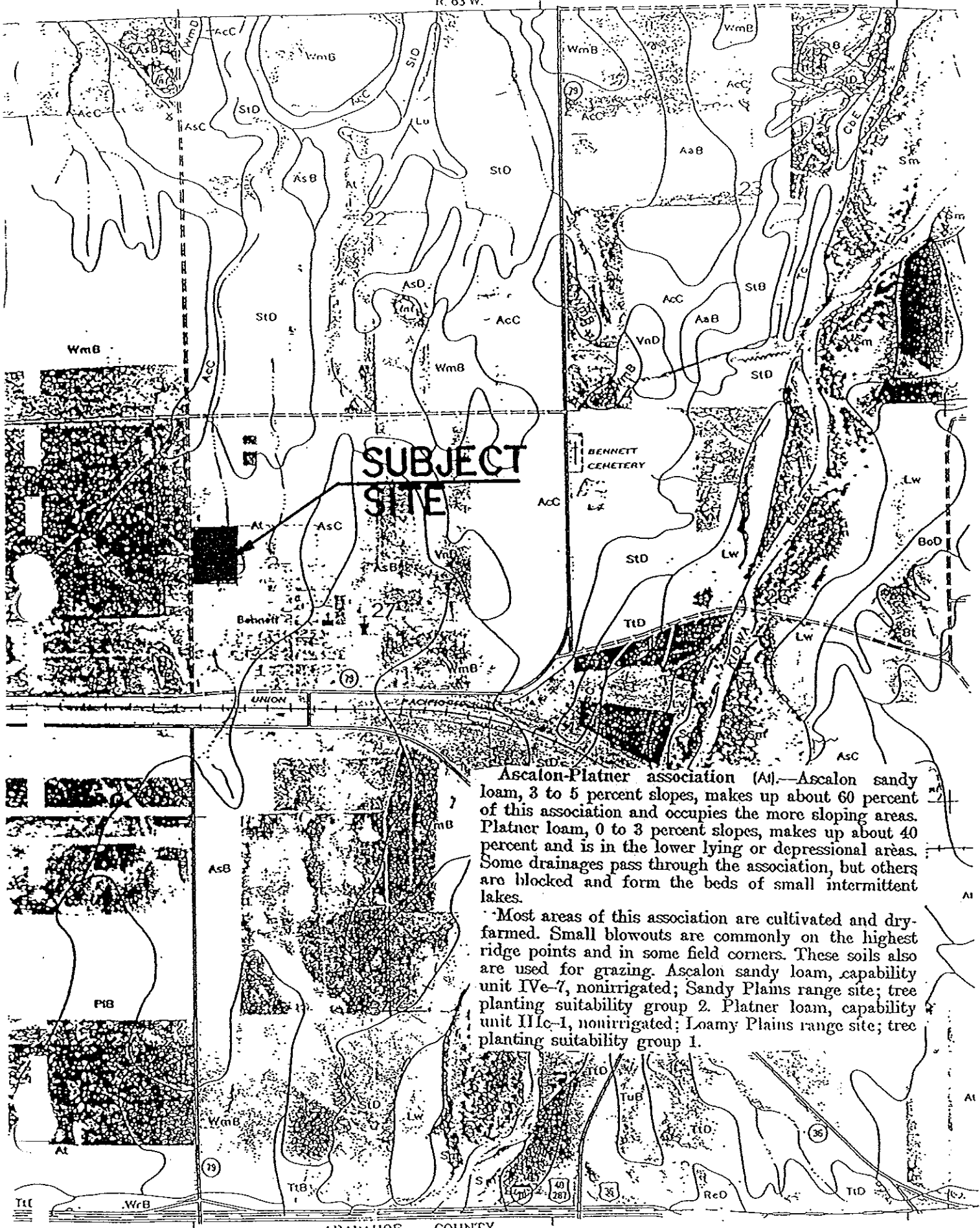
ADAMS COUNTY
UNINCORPORATED AREAS
060001

UNION

JOINS PANEL 0726

SOILS MAP

R. 63 W.



SUBJECT SITE

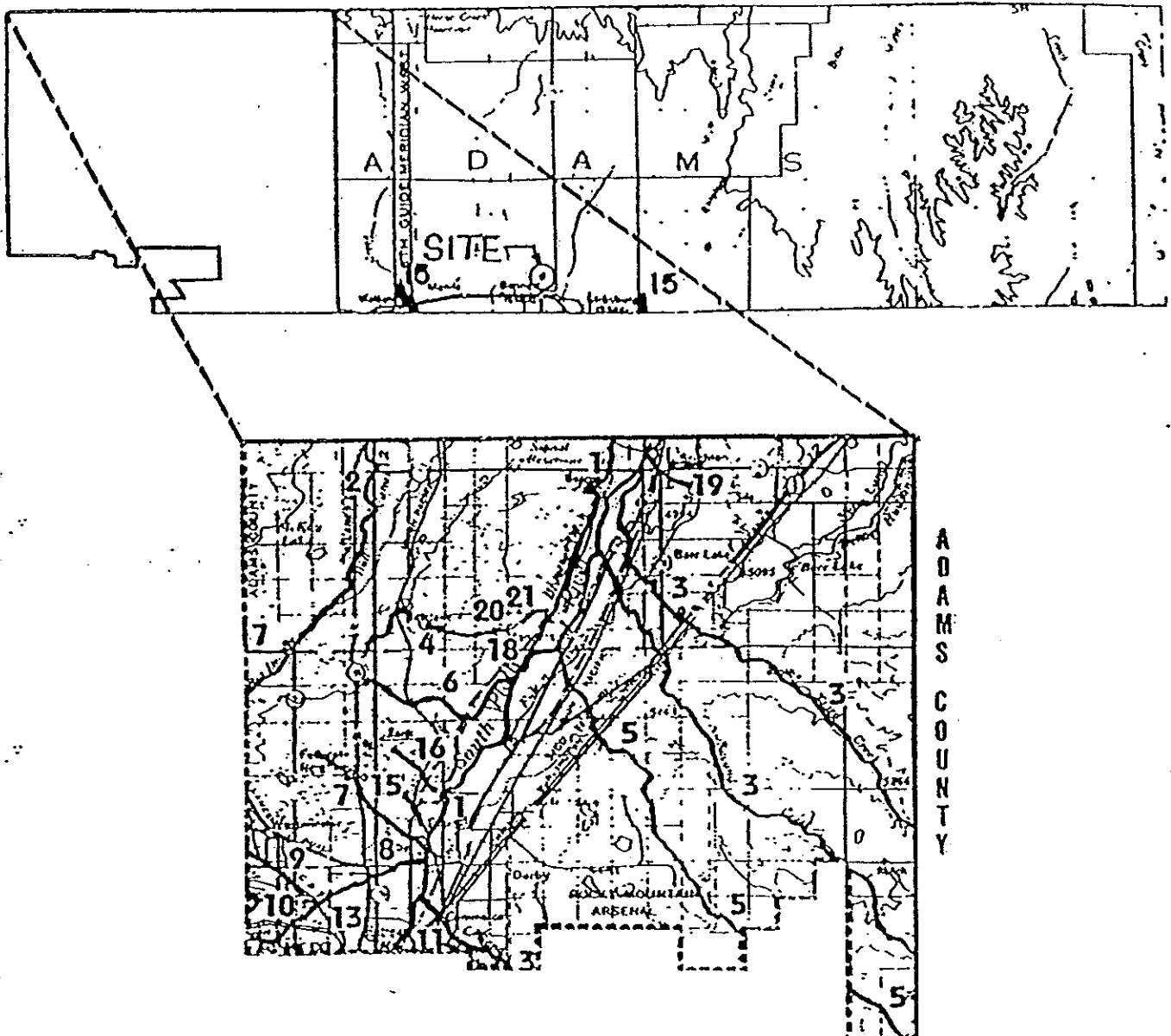
Ascalon-Platner association (A1).—Ascalon sandy loam, 3 to 5 percent slopes, makes up about 60 percent of this association and occupies the more sloping areas. Platner loam, 0 to 3 percent slopes, makes up about 40 percent and is in the lower lying or depressional areas. Some drainages pass through the association, but others are blocked and form the beds of small intermittent lakes.

Most areas of this association are cultivated and dry-farmed. Small blowouts are commonly on the highest ridge points and in some field corners. These soils also are used for grazing. Ascalon sandy loam, capability unit IVe-7, nonirrigated; Sandy Plains range site; tree planting suitability group 2. Platner loam, capability unit IIIc-1, nonirrigated; Loamy Plains range site; tree planting suitability group 1.

ONSITE & OFFSITE

BASIN ANALYSIS

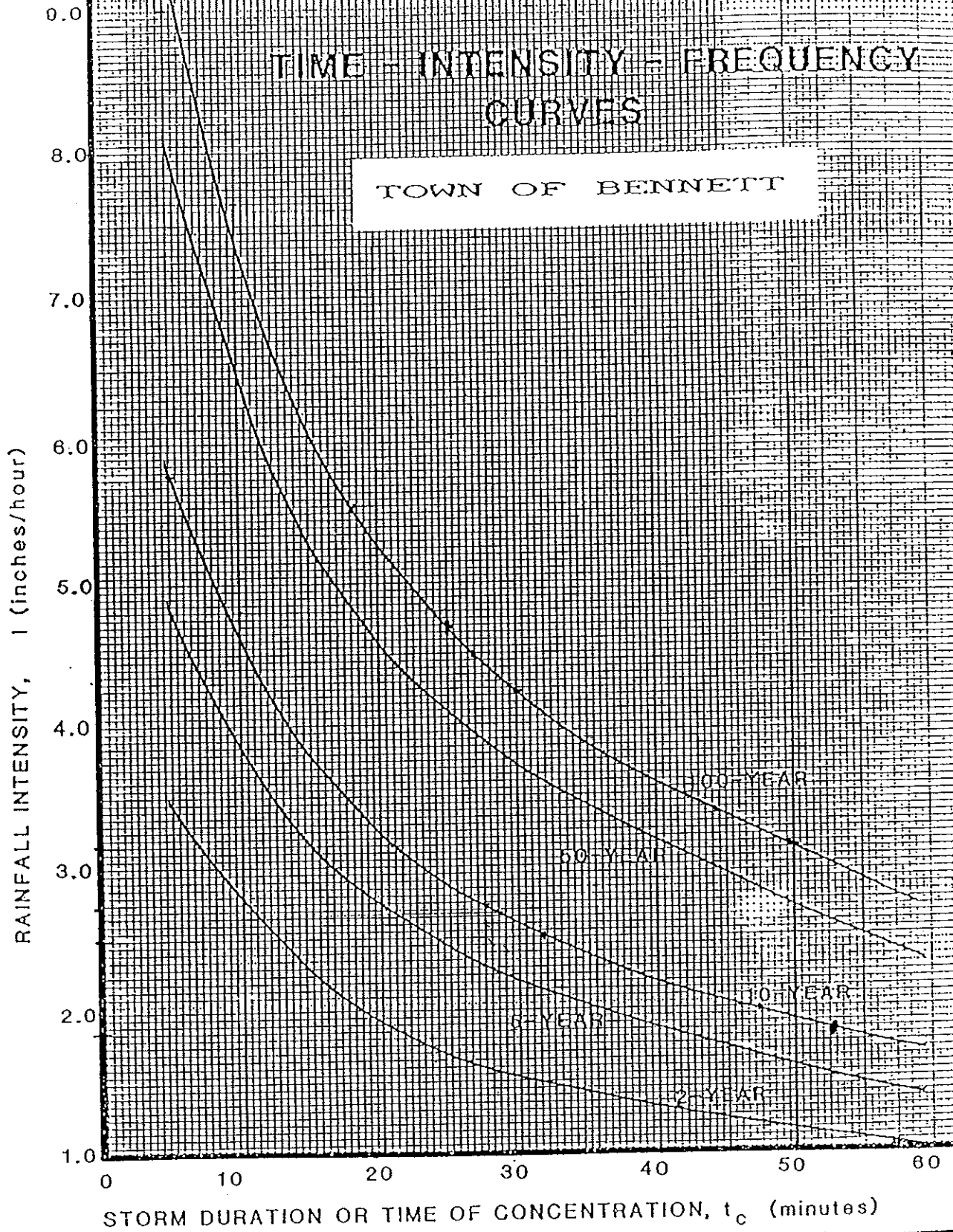
FLOODPLAIN INFORMATION FOR ADAMS COUNTY



REFER TO TABLE 201 FOR REPORTS CORRESPONDING TO
THE NUMBERS ON THIS FIGURE

Date: FEB 1989
Rev:

REFERENCE:



Date:
Rev:

REFERENCE:

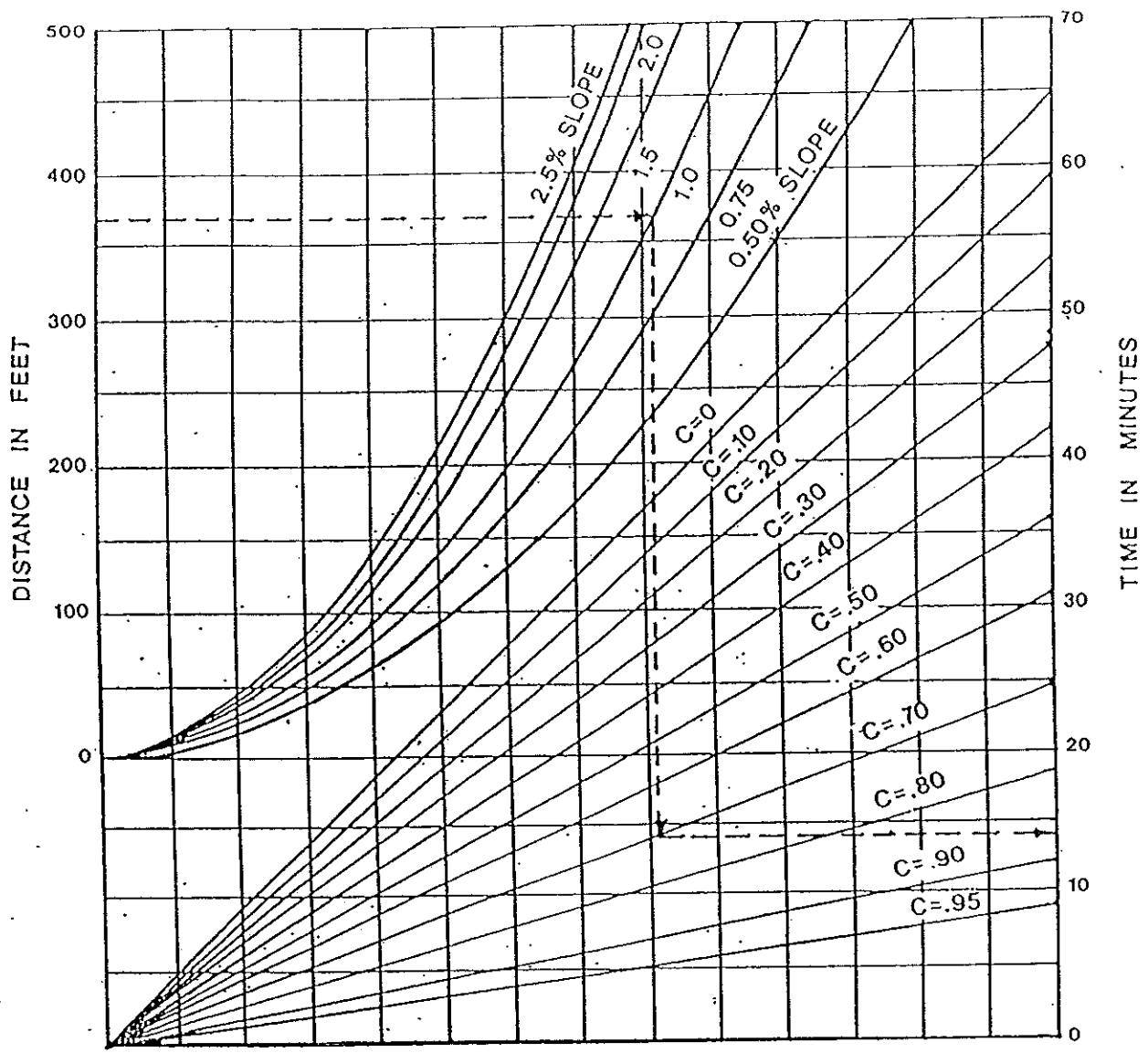
DRAINAGE CRITERIA MANUAL

RECOMMENDED RUNOFF COEFFICIENTS AND PERCENT IMPERVIOUS

LAND USE OR SURFACE CHARACTERISTICS	PERCENT IMPERVIOUS	FREQUENCY			
		2	5	10	100
<u>Business:</u>					
Commercial Areas	95	.87	.87	.88	.89
Neighborhood Areas	70	.60	.65	.70	.80
<u>Residential:</u>					
Single-Family	*	.40	.45	.50	.60
Multi-Unit (detached)	50	.45	.50	.60	.70
Multi-Unit (attached)	70	.60	.65	.70	.80
1/2 Acre Lot or Larger	*	.30	.35	.40	.60
Apartments	70	.65	.70	.70	.80
<u>Industrial:</u>					
Light Areas	80	.71	.72	.76	.82
Heavy Acres	90	.80	.80	.85	.90
<u>Parks, Cemeteries:</u>	7	.10	.10	.35	.60
<u>Playgrounds:</u>	13	.15	.25	.35	.65
<u>Schools:</u>	50	.45	.50	.60	.70
<u>Railroad Yard Areas</u>	40	.40	.45	.50	.60
<u>Undeveloped Areas:</u>					
Historic Flow Analysis-	2	(See "Lawns")			
Greenbelts, Agricultural					
Offsite Flow Analysis (when land use not defined)	45	.43	.47	.55	.65
<u>Streets:</u>					
Paved	100	.87	.88	.90	.93
Gravel	13	.15	.25	.35	.65
<u>Drive and Walks:</u>	96	.87	.87	.88	.89
<u>Roofs:</u>	90	.80	.85	.90	.90
<u>Lawns, Sandy Soil</u>	0	.00	.01	.05	.20
<u>Lawns, Clayey Soil</u>	0	.05	.10	.20	.40

NOTE: These Rational Formula coefficients may not be valid for large basins.

*See Figure 2-1 for percent impervious.

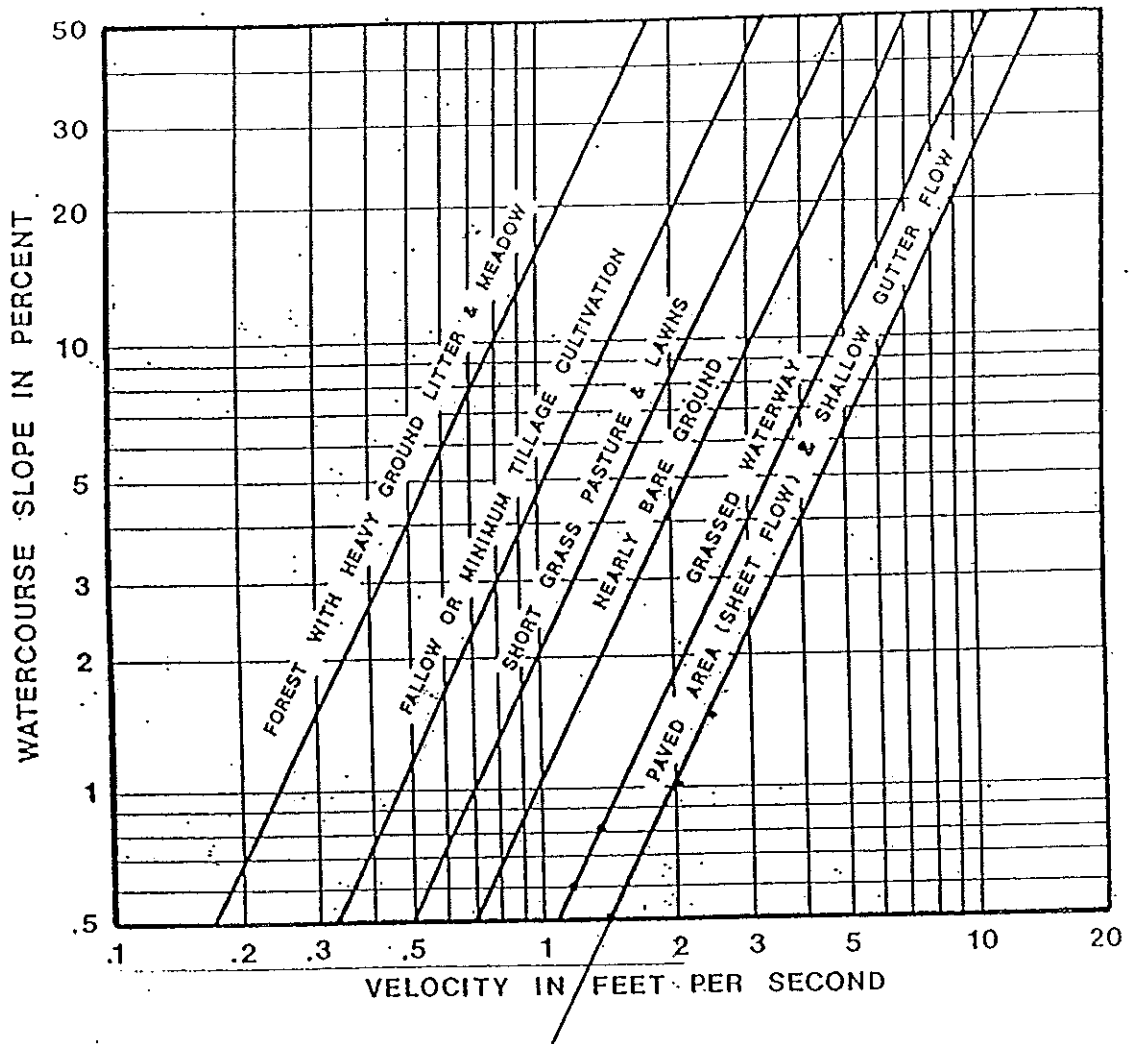


$$T_c = \frac{1.8 (1.1 - C)\sqrt{D}}{\sqrt[3]{S}}$$

OVERLAND TIME OF FLOW CURVES

NOTE:

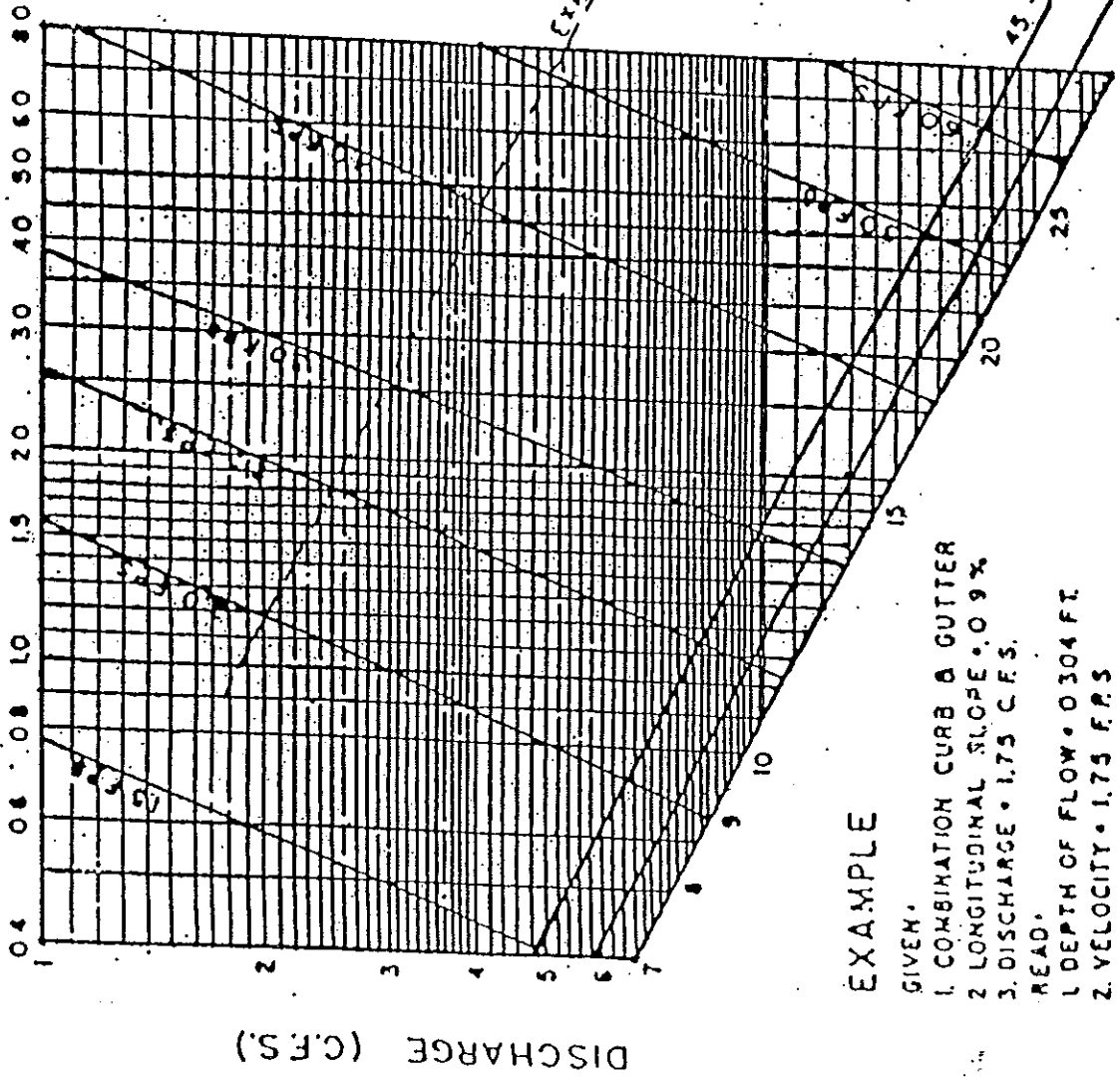
- Minimum T_c undeveloped = 10 minutes
- Minimum T_c developed = 5 minutes



ESTIMATE OF AVERAGE FLOW VELOCITY FOR
USE WITH THE RATIONAL FORMULA.

REFERENCE: "Urban Hydrology For Small Watersheds" Technical
Release No. 55, USDA, SCS Jan. 1975.

LONGITUDINAL CURB SLOPE (PERCENT)



EXAMPLE

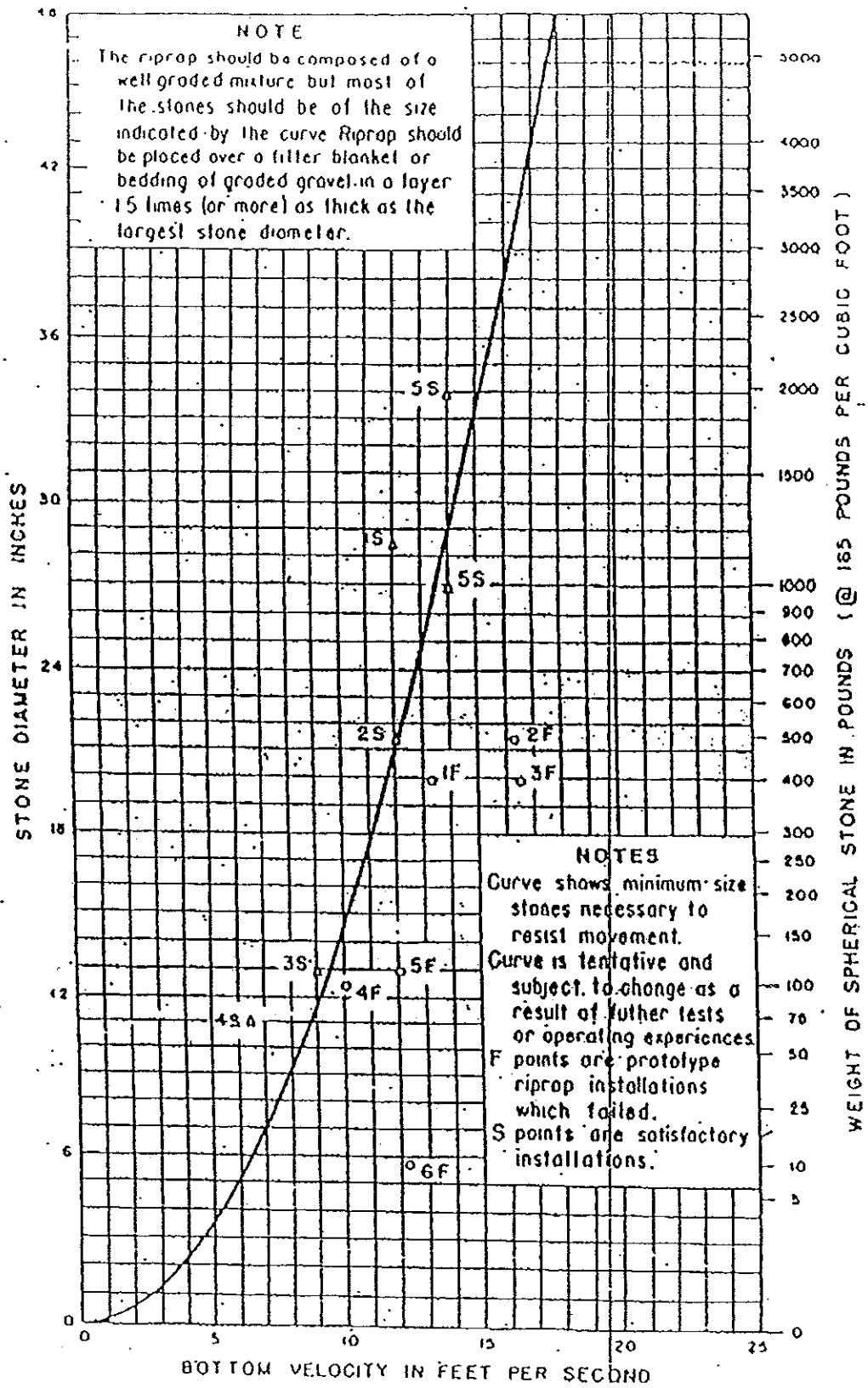
GIVEN:

1. COMBINATION CURB & GUTTER
2. LONGITUDINAL SLOPE = 0.9%
3. DISCHARGE = 1.75 C.F.S.

READ:

1. DEPTH OF FLOW = 0.304 FT.
2. VELOCITY = 1.75 F.P.S.

CURB CAPACITY NOMOGRAPH



RIPRAP SIZING

EXISTING + PROP.

SUBDIVISION: CLARK ADDITION DESIGN STORM 10 YR. RECURRENCE INTERVAL
 LOCATION DWY OF BENNETT COMPUTED BY: _____ DATE: 6/95 PAGE 1 OF _____

Street	Design Point	Area Desig. (acres)	A	C	CA (acres)	Σ CA (acres)	I ¹	T _c (min.)	i (in/hr)	Q (cfs)	Slope (%)	Long. L (feet)	VEL. V (fps)	Δt (min.)	Remarks
157.	1	1	2.00	0.64	1.28			28.6	6.5	1.1	2%	50	1.2	9.8	OVERLAND CHARS ECHTER
												1350		18.8	
			C _w = (0.69 x 0.90) + (1.31 x 0.50)		2.00									28.6	
157	4	14A	2.77	0.63	1.75			31.6	6.5	1.1	1.5	450	2.5	28.6	DITEN
														3.0	
			C _w = (0.82 x 0.90) + (1.85 x 0.50)		2.77									31.6	

Storm drainage system design

EXIST. + PROP.

SUBDIVISION: CLARK ADDITION DESIGN STORM 10 YR. RECURRENCE INTERVAL
 LOCATION TOWN OF BENNETT COMPUTED BY: _____ DATE: 6/95 PAGE 2 OF _____

Street	Design Point	Area Desig. (acres)	A (acres)	C	CA (acres)	Σ CA (acres)	I ₁	T _c (min.)	I (in/hr)	Q (cfs)	Slope (%)	Leng. L (feet)	VEL. V (fps)	Δt (min.)	Remarks
2ND	2	2	1.69	0.50	11.85			47.3	1.0	1.0	1.0	100	1.5	17.5	OVERLAND CURB & GUTTER
									0.5	4.0	0.5	410	1.4	4.6	GRASSED SWALE
									0.6	13.5	0.6	1350	1.2	18.8	SWALE (POOR)
									0.5	200	0.5	200	1.5	2.2	CURB & GUTTER
														47.3	
TRUMAN	5	2+B	2.1	0.50	16.65			52.7	1.0	8.0	1.0	645	2.0	47.3	CURB & GUTTER
									1.0	30.0	1.0	645	2.0	5.4	
														52.7	

Storm drainage system design

EXIST. + PROP.

SUBDIVISION: CLARK ADDITION DESIGN STORM 10 YR. RECURRENCE INTERVAL
 LOCATION TOWN OF BENNETT COMPUTED BY: _____ DATE: 6/95 PAGE 3 OF _____

Street	Design Point	Area Desig. (acres)	A	C	CA (acres)	Σ CA (acres)	t ₁	t ₀	T _c (min.)	i (in/hr)	Q (cfs)	Slope (%)	Length L (feet)	VEL. V (fps)	Δt (min.)	Remarks
3RD	3	3	5.12	0.50	1.2	1.2			20.6	1.5	8.5	2.0	100	2.6	13.9	OVERLAMP
													1050		6.7	CHRB & CUTTER
															20.6	
TRUMAN	5	3+C	8.19	0.50	11.0	11.0			27.5	1.5	11.3	0.5	620	1.5	28.6	CHRB & CUTTER
															27.5	
TRUMAN	5	D	2.61	0.50	3.5	3.5			*5.0	1.5	1.1					

Storm drainage system design
 * MIN. T_c. DEV. = 5 MINUTES

EXIST. & PROP.

SUBDIVISION: CLARK ADDITION DESIGN STORM 10 YR. RECURRENCE INTERVAL
 LOCATION TOWN OF BENNETT COMPUTED BY: _____ DATE: 8/95 PAGE 4 OF _____

Street	Design Point	Area Desig. (acres)	A	C	CA (acres)	Σ CA (acres)	I ₁	I ₀	T _c (min.)	I (in/hr)	Q (cfs)	Slope (%)	Long. L (feet)	VEL. V (fps)	Δt (min.)	Remarks
TRUMAN	5	273 +37 CUD	44.13	50		590.25			* 52.7	1.85	40.8					* LONGEST TC

Storm drainage system design

EXIST. + PROP.

SUBDIVISION: CLARK ADDITION DESIGN STORM 100 YR. RECURRENCE INTERVAL
 LOCATION TOWN OF BENNETT COMPUTED BY: _____ DATE: 6/95 PAGE 7 OF _____

Street	Design Point	Area (acres)	C	CA (acres)	Σ CA (acres)	i ₁	t ₀	T _c (min.)	i (in/hr)	Q (cfs)	Slope (%)	Leng. L (feet)	VEL. V (fps)	Δt (min.)	Remarks
3 RD	3	5.42	60	3.25				18.1	5.4	8.0	2.6	100	2.6	11.4	OVERLAND CURB & GUTTER
														18.1	
TRUMAN	5	8.19	60		46.4			25.0	11.7	30	0.5	620	1.5	18.1	CHRB & GUTTER
														25.0	
TRUMAN	5	7.61	60	1.69				* 5.0	6.6	15					

Storm drainage system design
 * MIN. T_c DEV. = 5 MINUTES.

EXIST. & PROP.

SUBDIVISION: CLARK ADDITION

DESIGN STORM: 100 YR. RECURRENCE INTERVAL

LOCATION TOWN OF BENNETT COMPUTED BY:

DATE: 6/95 PAGE 8 OF 8

Street	Design Point	Area Desig. (acres)	A	C	CA (acres)	Σ CA (acres)	ti	to	Tc (min.)	i (in/hr)	Q (cfs)	Slope (%)	Long. L (feet)	VEL. V (fps)	Δt (min.)	Remarks
TRUMAN	5	2+3 +B+ E+D	51.11	90		81.11			* 49.6	1.2	82.6					* LONGEST TC

Storm drainage system design

1 ST street at design points 1 & 4

$$Q_{10} = 3.4 \text{ cfs (4.4 cfs)}$$

$$Q_{100} = 6.3 \text{ cfs (8.3 cfs)}$$

Capacity section A - A is ok

2 ND street at design point 2

$$Q_{10} = 29.7 \text{ cfs}$$

$$Q_{100} = 60.0 \text{ cfs}$$

see nomograph (@1%)

$$\text{Curb capacity 4"} = 7.6 \times 2 = 15.2 \text{ cfs}$$

$$\text{Curb capacity 6"} = 9.0 \times 2 = 18.0 \text{ cfs}$$

STORM INLETS WILL BE REQUIRED

$$\text{Inlet interception rate (sump)} = 1.2 \text{ cfs / lf}$$

$$\text{Required: } 29.7/1.2 = 24 \text{ l.f. (12 l.f. on each side)}$$

Associated storm sewer pipe: 27" dia. (@ 1% approx.)

3 RD street at design points 3 & 5

$$Q_{10} = 8.5 \text{ cfs (11.3 cfs)}$$

$$Q_{100} = 18.0 \text{ cfs (23.1 cfs)}$$

see nomograph (0.5%)

$$\text{Curb capacity 4"} = 5.4 \times 2 = 10.8 \text{ cfs}$$

$$\text{Curb capacity 6"} = 6.8 \times 2 = 13.6 \text{ cfs}$$

Use 6" curb

TRUMAN at design point 5

Discharge from basin "D"

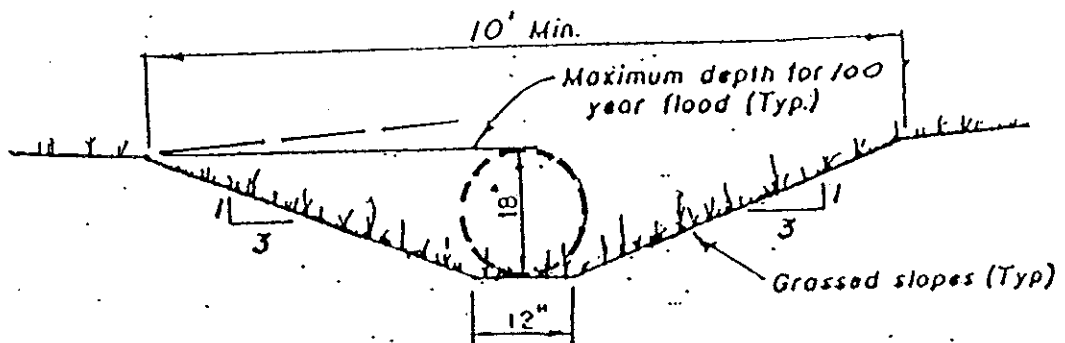
Q100 = 15.0 cfs ----- Use a 21" dia. @ 1% (min.)

TRUMAN at design point 5

Design apron for 82.6 cfs

SECTION A - A

no scale



Area = 8.25 sq.ft.

W.P. = 10.487 l.f.

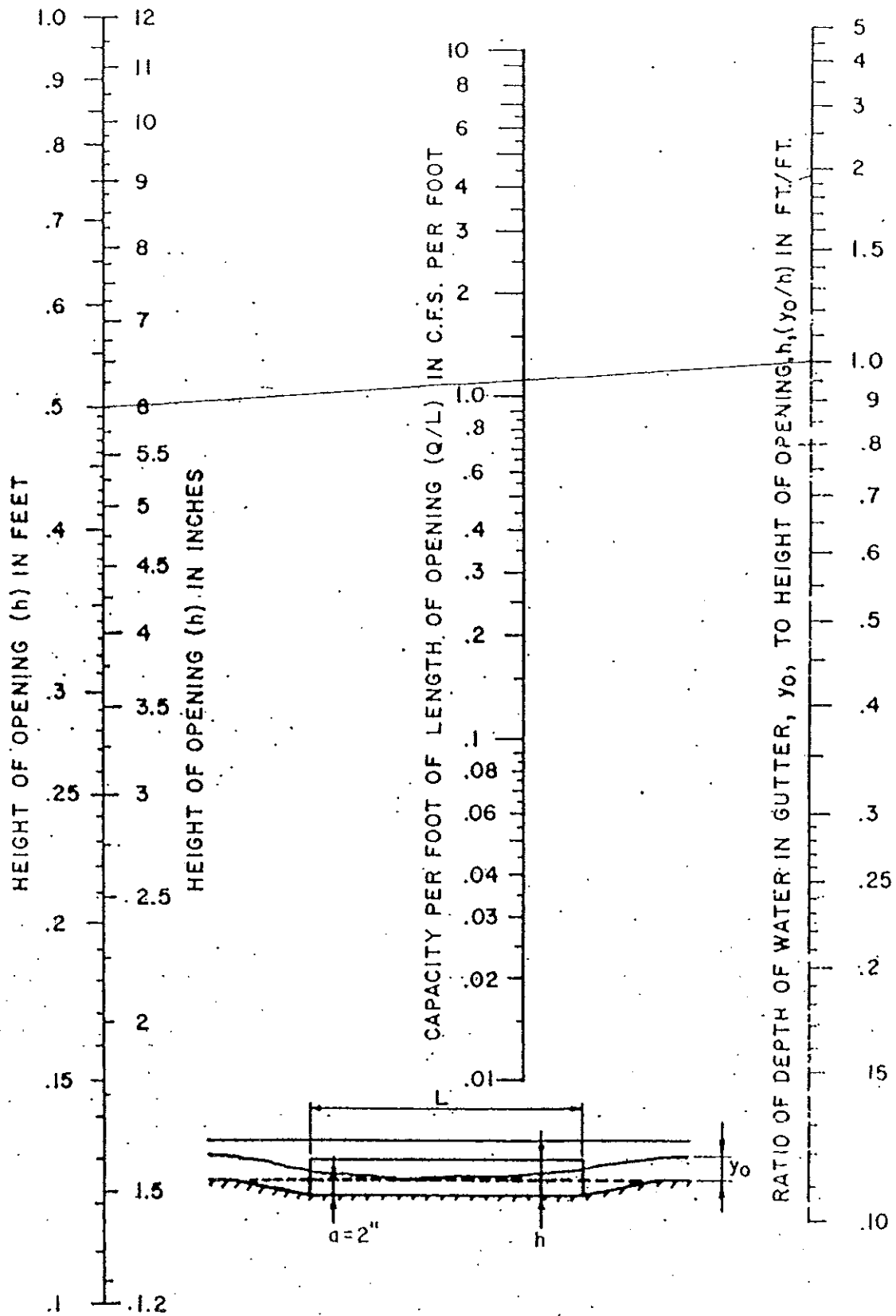
R = 0.787

S = 0.015 (1.5% approx.)

n = 0.035 (grassed)

$$V = \frac{1.49}{0.035} \times (0.787)^{2/3} \times (0.015)^{1/2} = 4.4 \text{ fps (ok)}$$

$$Q = 8.25 \times 4.4 = 36.3 \text{ cfs} > 8.3 \text{ cfs (Q100) ok}$$



NOMOGRAPH FOR CAPACITY OF CURB OPENING INLETS IN SUMPS, DEPRESSION DEPTH 2"

EXISTING + PROP.

SUBDIVISION: CLARK ADDITION DESIGN STORM 100 YR. RECURRENCE INTERVAL
 LOCATION TOWN OF BENNETT COMPUTED BY: _____ DATE: 6/95 PAGE 2 OF _____

Street	Design Point	Area A (acres)	C	CA (acres)	ΣCA (acres)	I_1	I_0	T_c (min.)	I (in/hr)	Q (cfs)	Slope (%)	Length L (feet)	VEL. V (fps)	Δt (min.)	Remarks
1ST.	1	2.00	0.1	1.17				269	1.5	6.3	2%	50	1.2	8.1	OVERLAND CURB & GUTTER
	CW	$(0.69 \times 0.93) + 2.00$				(1.31×0.60)		$= 0.71$						269	
1ST	4	1+A 2.77	0.1	1.69				299	1.5	8.3	1.5	450	2.5	26.9	DITCH
	CW	$(0.92 \times 0.93) + 2.77$				(1.85×0.60)		$= 0.71$						29.9	

Storm drainage system design

EXIST. + PROP.

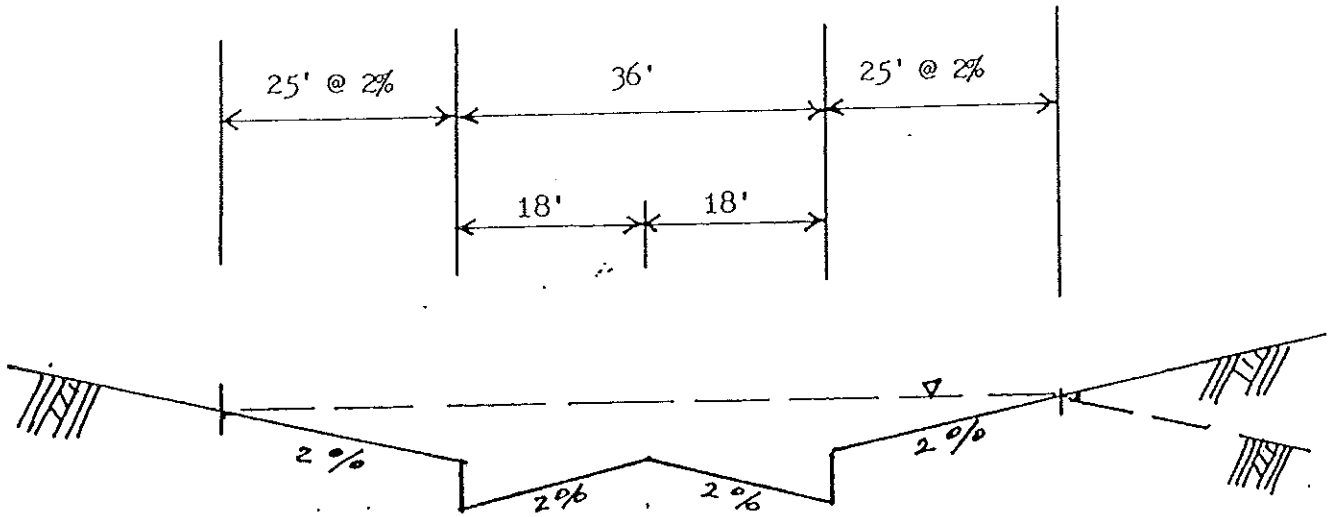
SUBDIVISION: CLARK ADDITION DESIGN STORM 100 YR. RECURRENCE INTERVAL
 LOCATION TOWN OF BENNETT COMPUTED BY: 6/95 DATE: 6/95 PAGE 6 OF 6

Street	Design Point	Area Desig. (acres)	A	C	CA (acres)	Σ CA (acres)	i ₁	t ₀	T _c (min.)	i (in/hr)	Q (cfs)	Slope (%)	Long. L (feet)	VEL. V (fps)	Δt (min.)	Remarks
RND	2	2	1.9	0.6	1.14				44.2	1.2	60.0	1.0	100	1.5	14.4	OVERLAND CURB & GUTTER
												0.5	410	1.4	4.6	CURB & GUTTER
												0.8	350	1.2	4.2	GRASSED SWALE
												0.6	1350	1.5	18.8	SWALE (POOL)
												0.5	200	1.5	2.2	CURB & GUTTER
															44.2	
TRUMAN	5	2.48	3.2	0.6	1.96	19.96			49.6	1.2	60.0	1.0	645	2.0	44.2	CURB & GUTTER
															5.4	
															49.6	

Storm drainage system design

SECTION B - B

no scale



Area = 42.02 sq.ft.
 W.P. = 87.017 l.f.
 R = 0.483
 S = 0.01 (1% approx.)
 n = 0.024 (conc. & grassed)

$$V = \frac{1.49}{0.024} \times (0.483)^{2/3} \times (0.01)^{1/2} = 3.8 \text{ fps} \quad \text{ok}$$

$$Q = 42.02 \times 3.8 = 160 \text{ cfs} > 60.0 \text{ cfs (Q100)} \quad \text{ok}$$

DETENTION

NO PONDING REQUIRED

NOTE: THE TOWN OF BENNETT HAS WAIVED PONDING ON
THE CLARKS ADDITION TO THE TOWN OF BENNETT.

EXAMPLES FROM OTHER REPORTS

EXAMPLE I

Impervious %

Basins A-1 + 2 + 3 (estimates)

		<u>impervious %</u>
Roofs, conc. & asphalt	= 1.11 Ac.	90
Gravel	= 0.12 Ac.	13
Grassed & Landscaping	= 3.62 Ac.	0
	<hr/>	
	4.85	

$$I = \frac{(1.11 \times 90) + (0.12 \times 13) + (3.62 \times 0)}{4.85} = 21.0$$

DETENTION (100YR.)

Basins A-1 + 2 + 3 = 4.85 Acres

Composite "I" = 21% (impervious)

Detention Volume Required: $(V) = KA$ $A = \text{Area in Acres}$

$$K_{100} = \frac{(1.78I - 0.002I^2 - 3.56)}{1000} = \frac{1.78(21) - 0.002(21)^2 - 3.56}{1000}$$

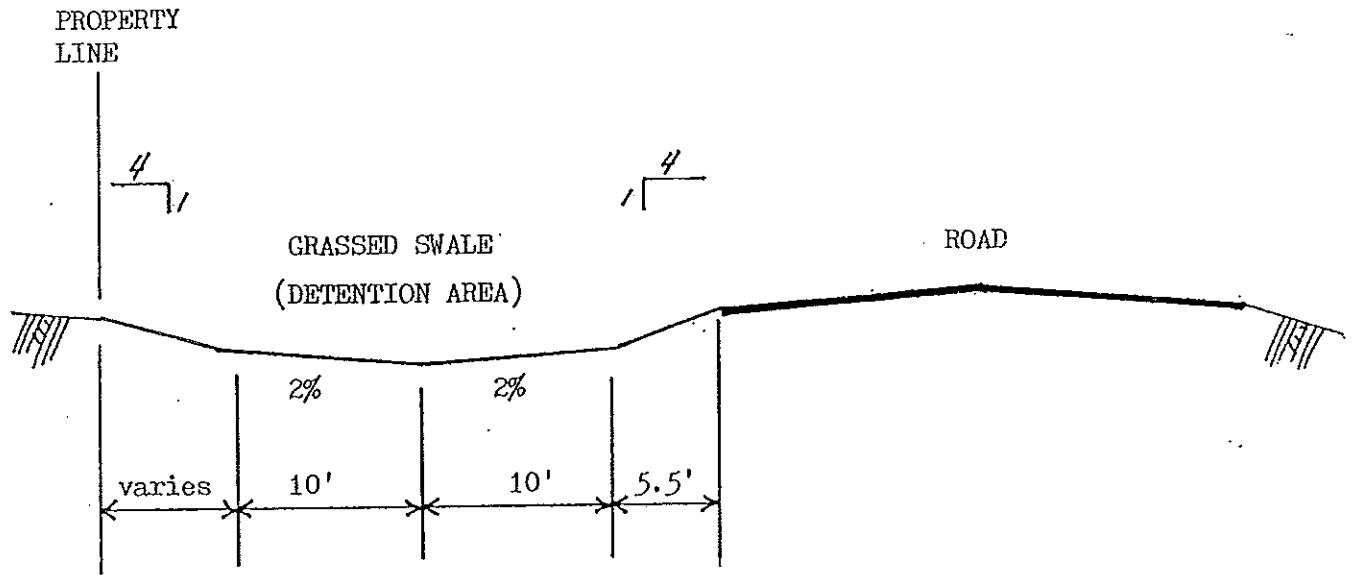
= 0.0329 acre-feet

$$K \times A = 0.0329 \times 4.85 = 0.160 \text{ acre-feet} = \underline{6,959 \text{ cu.ft}}$$

DETENTION (10YR.)

$$K_{10} = \frac{0.95I - 1.90}{1000} = \frac{(0.95 \times 21) - 1.90}{1000} = 0.01805 \text{ acre-feet}$$

$$K \times A = 0.01805 \times 4.85 = 0.0875 \text{ acre-feet} = \underline{3,813 \text{ cu.ft.}}$$



SECTION "C - C"

no scale

PONDING VOLUME

ELEVATION	SQ. FT.	STORAGE (CU. FT)	Σ STORAGE (CU. FT.)
22.69	0	0	0
23.00	840	87	87
23.50	3,300	1,035	1,122
24.00	6,400	2,425	3,547
24.40	9,950	3,270	6,817

6,817 ≈ 6,959

The required 100-year detention volume of 6,959 cu.ft. is reached at
elev. 24.40
H = 1.71'

The required 10-year detention volume of 3,813 cu.ft. is reached at
elev. 24.08
H = 1.31'

RESTRICTION

100 - YR.

Headwater Depth = 1.71'

Allowable Discharge = 5.03 c.f.s. (Net Q100)

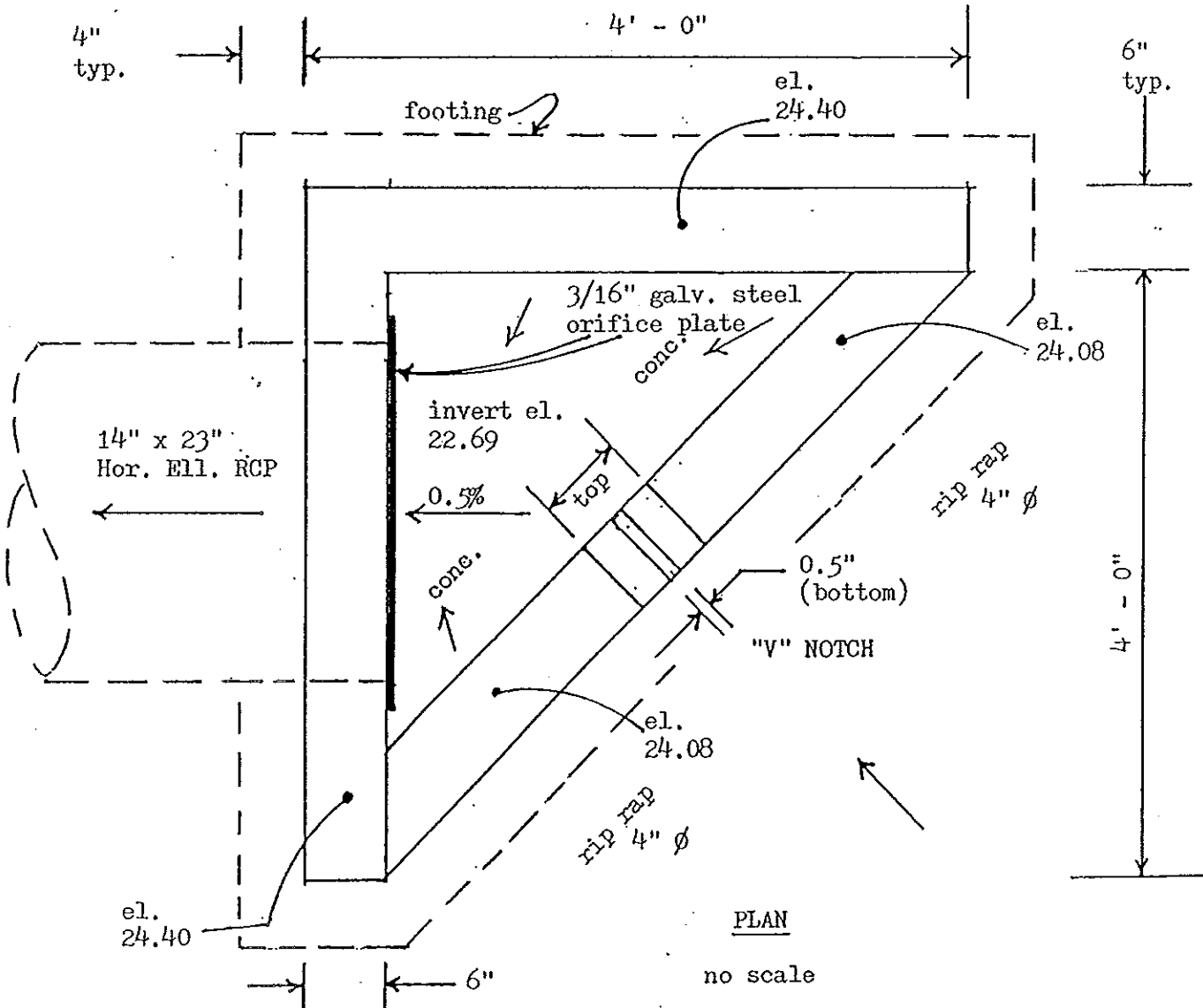
C = 0.65

$$Q = CA (2gh)^{1/2}$$

$$Q = 0.65A (2 \times 32.2 \times 1.71)^{1/2} = 5.03$$

$$A = 0.7374 \text{ sq.ft. } (= 106.19 \text{ sq.in.})$$

Use a 14" x 23" Hor. Elliptical R.C.P @ 0.5% with 10.3" x 10.3" restriction opening as shown.



CONCRETE OUTFLOW CONTROL STRUCTURE

"V" NOTCH WEIR

10 - YR.

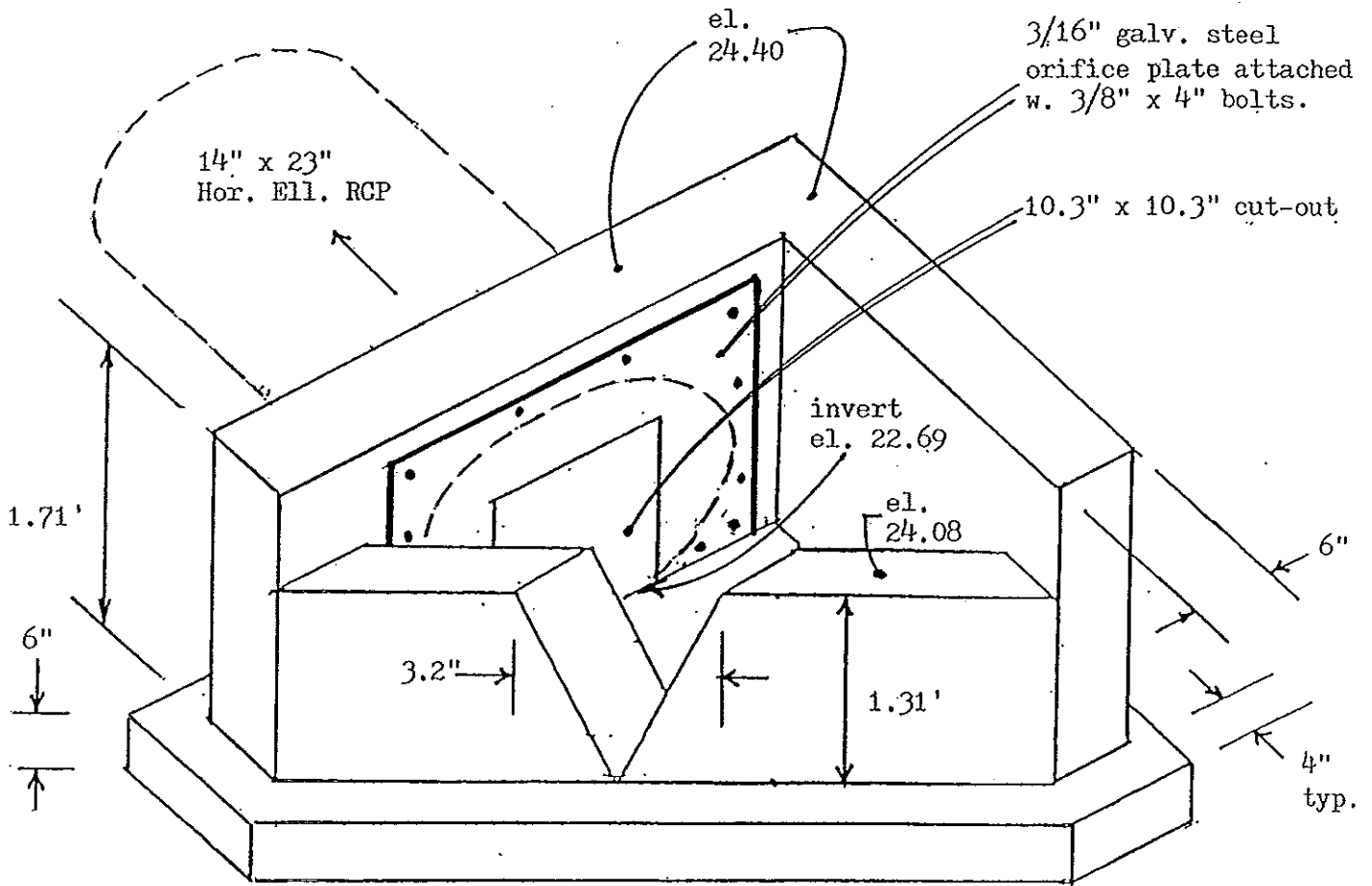
$d = 1.31'$

Allowable Release = 0.5 cfs. (Net Q10)

$$*L = \dot{Q} / 1.25H^{3/2}$$

$$= 0.5 / 1.25 (1.31)^{3/2}$$

$$= 0.267 \text{ ft. } (3.2'')$$



* FROM KINGS HANDBOOK - $Q = C1 \tan \frac{\theta}{4} H^{5/2}$
 $C1 = 2.5$

TRIANGULAR WEIR

EXAMPLE II

ALLOWABLE RELEASE RATES

Area A+B (subject area) consists of approx. 10% soils group "A" and 90% soils group "B"

$$10\text{yr.} = \frac{(90 \times 0.23) + (10 \times 0.13)}{100} = 0.22$$

$$100\text{ yr.} = \frac{(90 \times 0.85) + (10 \times 0.50)}{100} = 0.82$$

TABLE 3-2
ALLOWABLE RELEASE RATES FOR DETENTION PONDS - CFS/ACRE

CONTROL FREQUENCY	SOIL GROUP.		
	10% A	90%B	C & D
2-year	0.02	0.04	0.06
5-year	0.07	0.13	0.17
10-year	<u>0.13</u>	<u>0.23</u>	0.30
25-year	0.24	0.41	0.52
100-year	<u>0.50</u>	<u>0.85</u>	1.00

5-1-84

Total subject area (A+B) = 30.3 acres

Allowable release rate =

10 yr. = 30.3 x 0.22 = 6.7 c.f.s.

100 yr. = 30.3 x 0.82 = 24.8 c.f.s.

ALLOWABLE RELEASE RATES ADJUSTMENTS

Q100

Allowable release total subject area =	24.8 c.f.s.
Excess 100 year release from D.P. 4 at same Tc = 20.5 (dev.) - 10.3 (undev.) =	10.2 c.f.s.
	<hr/>
Net allowable release from D.P. 1 =	14.6 c.f.s.

Q10

Allowable release total subject area =	6.7 c.f.s.
Excess 10 year release from D.P. 4 at same Tc = 8.6 (dev.) - 2.8 (undev.) =	5.8 c.f.s.
	<hr/>
Net allowable release from D.P. 1 =	0.9 c.f.s.

Impervious %

Subject Area

Impervious %

Large Lots ($2\frac{1}{2}$ Ac. average) = 28.85 Ac.

5

Asphalt & Conc. (60' ROW) = 1.45 Ac.

100

30.3 Ac.

$$I = \frac{(28.85 \times 5) + (1.45 \times 100)}{30.3} = 9.55$$

DETENTION (100YR.)

Basin "A" = 30.3 Acres

Composite "I" = 9.55% (impervious)

Detention Volume Required: (V) = KA A = Area in Acres

$$K_{100} = \frac{(1.78I - 0.002I^2 - 3.56)}{1000} = \frac{1.78(9.55) - 0.002(9.55)^2 - 3.56}{1000} =$$

0.01326 acre-feet

$$K \times A = 0.01326 \times 30.3 = 0.402 \text{ acre-feet} = \underline{\underline{17,501 \text{ cu.ft.}}}$$

DETENTION (10YR.)

$$K_{10} = \frac{0.95I - 1.90}{1000} = \frac{(0.95 \times 9.55) - 1.90}{1000} = 0.0072 \text{ acre-feet}$$

$$K \times A = 0.0072 \times 30.3 = 0.217 \text{ acre-feet} = \underline{\underline{9,467 \text{ cu.ft.}}}$$

POND FOR AREA
OF PROPOSED DEVELOPMENT

DESIGN POINT

1

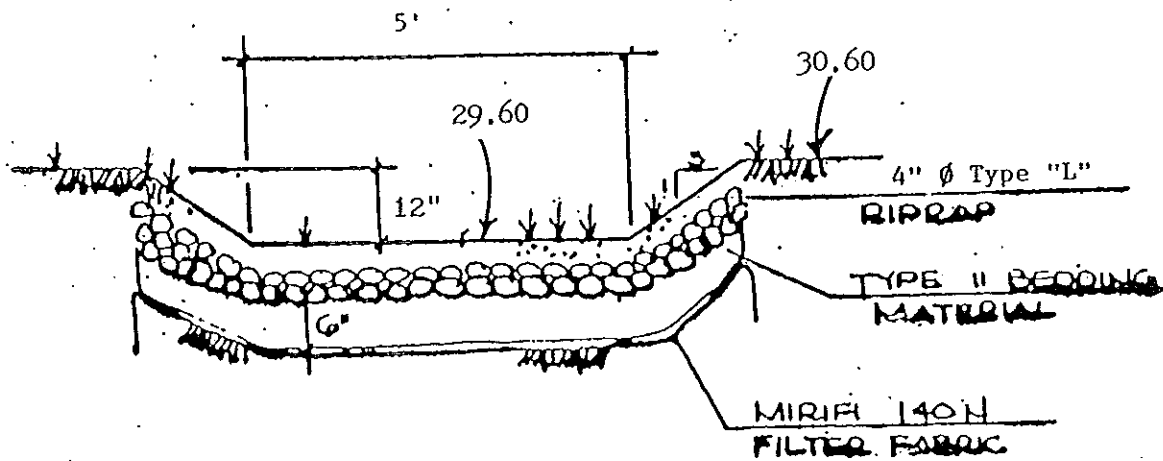
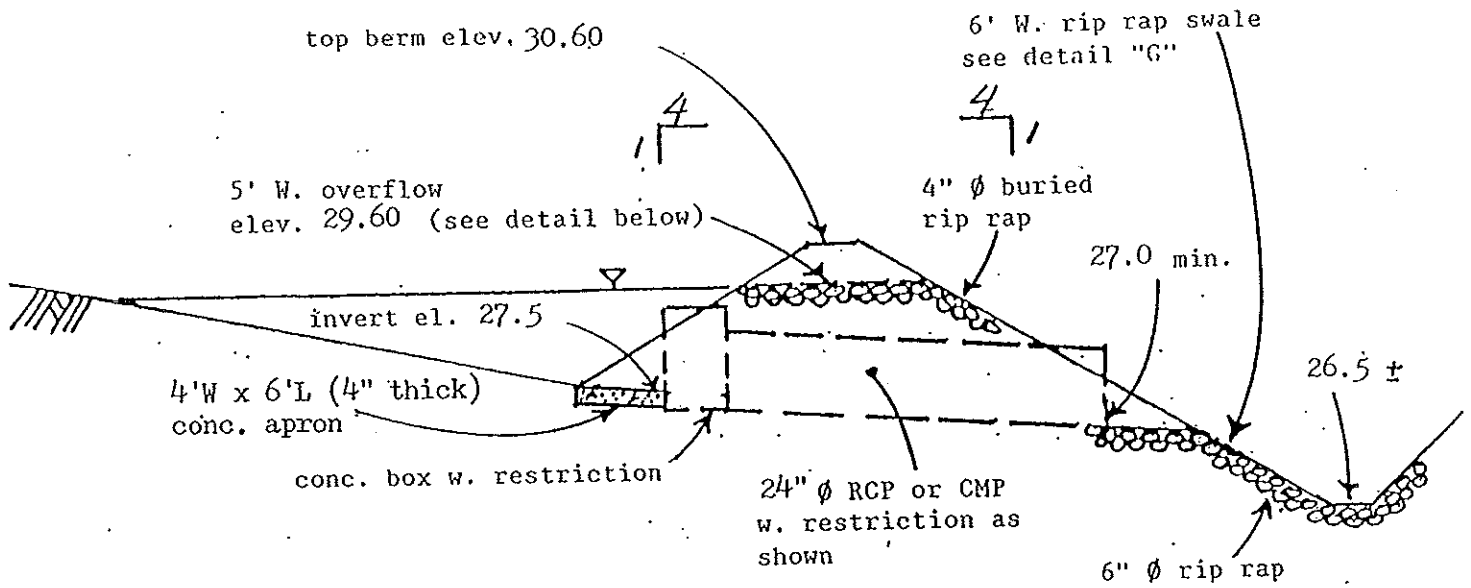
ELEVATION	SQ. FT.	STORAGE	Σ STORAGE
27.5	0	0	0
28.0	7,350	1,838	1,838
29.0	10,460	8,905	10,743
30.0	12,225	11,343	22,086

Q100 - The required detention volume of 17,501 cu. ft. is reached at elev. 29.60 H = 2.1'

Q10 - The required detention volume of 9,467 cu. ft. is reached at elev. 28.86 H = 1.36'

SECTION "A - A"

no scale



EMERGENCY OVERFLOW

RESTRICTION

10-YR.

Headwater Depth = 1.36'

Allowable Discharge = 0.9 c.f.s.

C = 0.65

$$Q = CA(2gh)^{\frac{1}{2}}$$

$$Q = 0.65A (2 \times 32.2 \times 1.36)^{\frac{1}{2}} = 0.9$$

$$A = 0.148 \text{ sq. ft.} = 21.3 \text{ sq. in.}$$

Use a 6" ϕ Opening (= 28.3 sq.in.)

100-YR.

Headwater Depth = 2.10'

Allowable Discharge = 14.6 c.f.s.

C = 0.65

$$Q = 0.65A (2 \times 32.2 \times 2.10)^{\frac{1}{2}} = 14.6$$

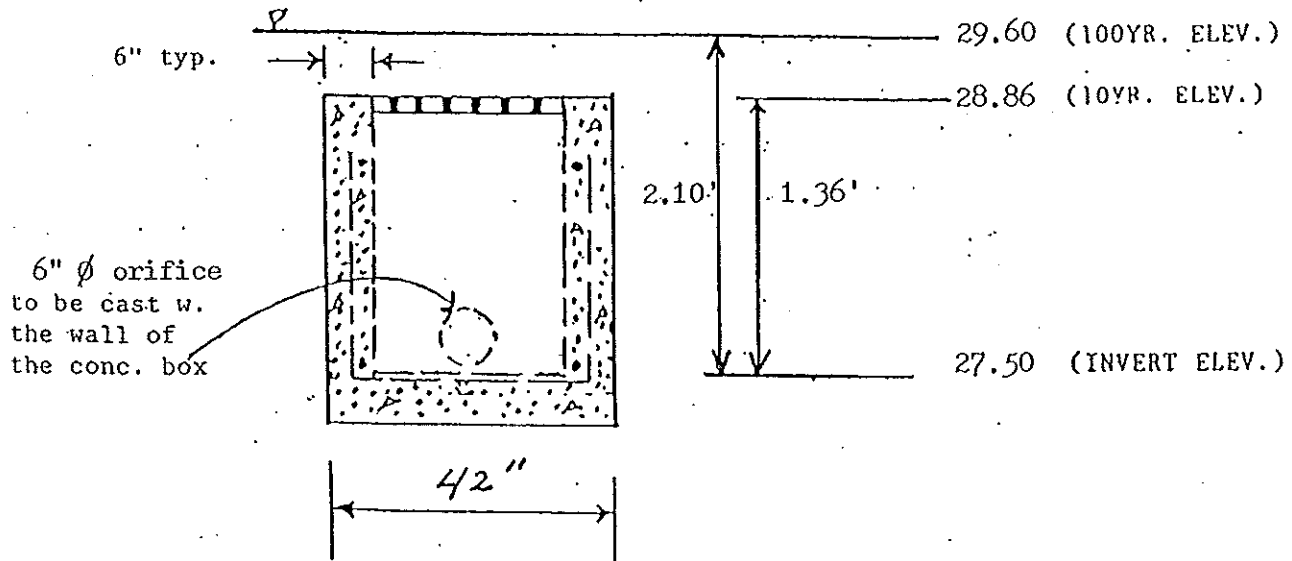
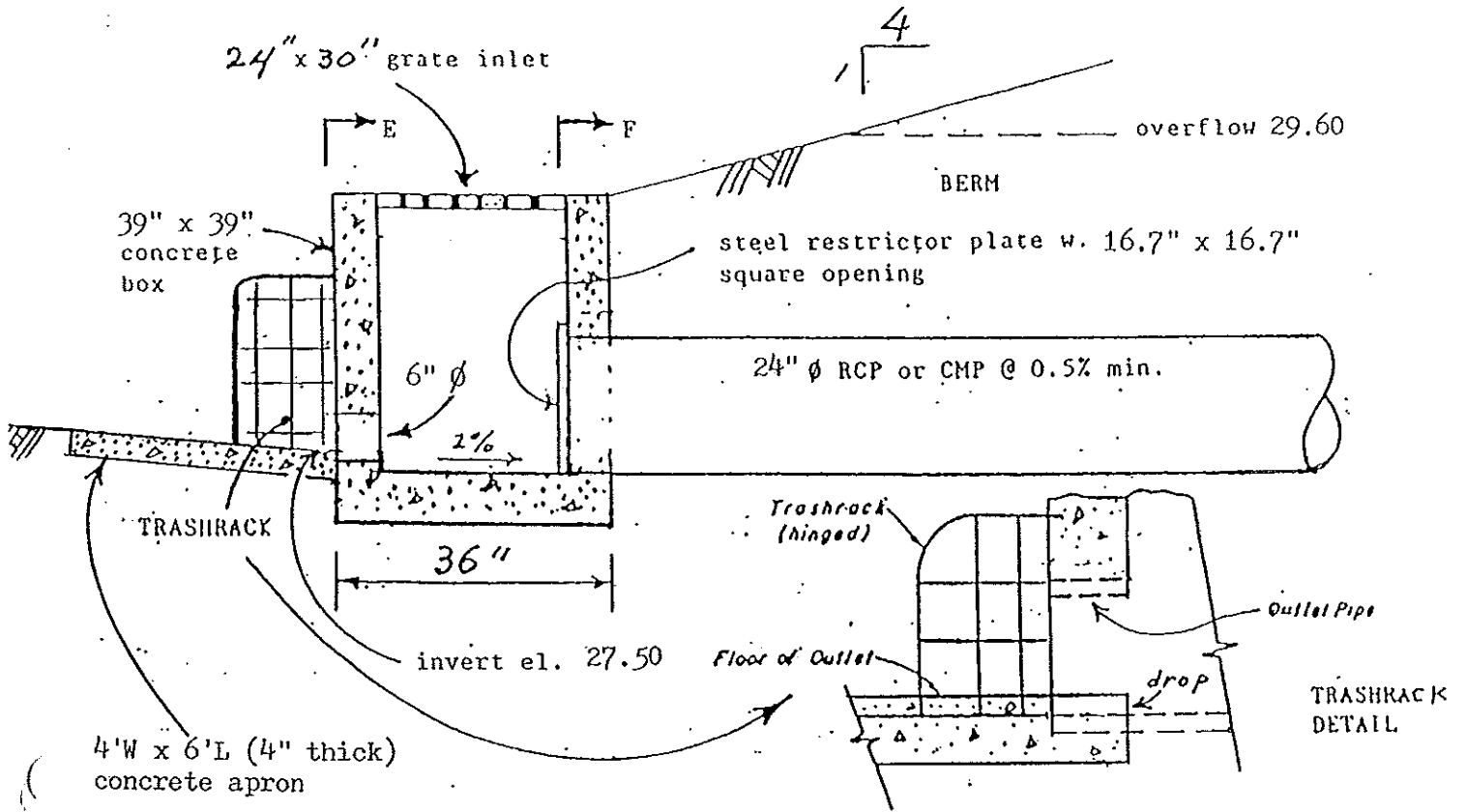
$$A = 1.931 \text{ sq. ft.} = 278.1 \text{ sq. in.}$$

(16.7" x 16.7")

Use a 24" ϕ RCP or CMP @ 0.5% min. with restriction as shown
(next page)

RESTRICTION DETAIL

AS PER TYPE 2 OUTLET CONFIGURATION

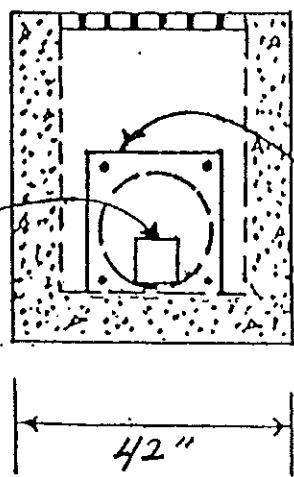


SECTION "E"

▽ 29.60 (100YR. ELEV.)

28.86 (10YR. ELEV.)

16.7" x 16.7"
opening cut
in steel
restrictor plate



20" x 20" x ³/₁₆" galv. steel
orifice plate attached w.
4 - ³/₈" x 4" bolts

SECTION "F"

EROSION CONTROL

**EROSION CONTROL
DURING CONSTRUCTION**

EROSION CONTROL DURING CONSTRUCTION

The techniques for minimizing erosion and sedimentation rely on a few simple principles, as outlined briefly below. They are the basis for the erosion control solutions presented later.

Shield soil from rainfall and runoff. Numerous mulches, blankets, and nettings are available to protect soil from raindrop impact and runoff. Chemical soil binders also provide similar protection.

Reduce soil exposure time. The interval between earthwork commencement and slope revegetation should be minimized, unless special grading of a slope is required to achieve a special effect.

Control runoff water. Whenever possible, natural or clear water runoff should be kept separated from project runoff and carried through the project uncontaminated. Normally, the volume of water from natural drainage is too great to allow mixing with project runoff in a contaminated water collection system.

Slowing runoff velocity will reduce its erosive force. Increased surface roughness or checks can be used for this purpose. Early construction of drainage structures maintains natural cross-drainage and simplifies the separation of natural and construction runoff.

Trap sediment. Sediment-laden water can be filtered using silt fences or erosion bales. Temporary or permanent basins can be used to trap sediment for removal at a later time. Retention time is based on the soil conditions and characteristics.

INTERCEPTING DITCH OR BARRIER

DESCRIPTION: When snowmelt runoff and groundwater springs are foreseen as potential erosion problems, an intercepting ditch or barrier may be constructed above future cut slopes to divert surface runoff to temporary or permanent cross culverts. Unless severe slope stability problems exist, interception of the natural drainage is to be used as a temporary measure until permanent ground covers (grasses) are established. If ditching is not practical, a temporary barrier of erosion bales with an entrenched plastic lining is a viable alternative which will not permanently disturb the natural watershed.

DESIGN: Intercepting ditches or barriers are to be used from cut-fill transition areas to the top of the cut slope behind the slope stakes. Intercepting ditches or barriers are to conform to STANDARD M-203-C (Ditches).

CONSTRUCTION: Type 1. Hand dug or trenched ditch with soil retention blanket or rock lining.
Type 2. Barrier of erosion bales with entrenched plastic lining secured with rocks or logs.

MAINTENANCE: Periodic inspection of ditch or barrier for sediment accumulation and/or breaks in the system, which may need handwork and repair. When vegetative cover is established, ditches are to be filled and seeded.

EROSION BALES

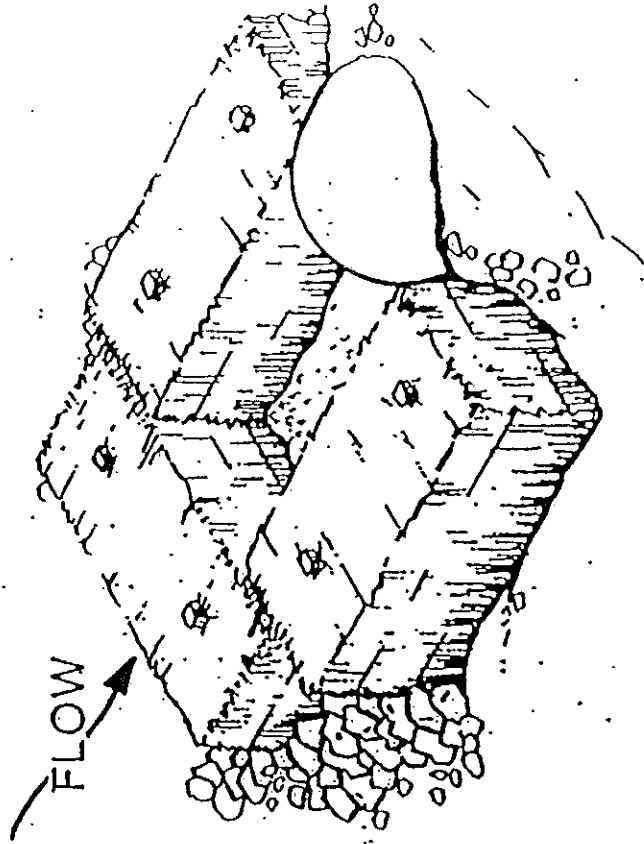
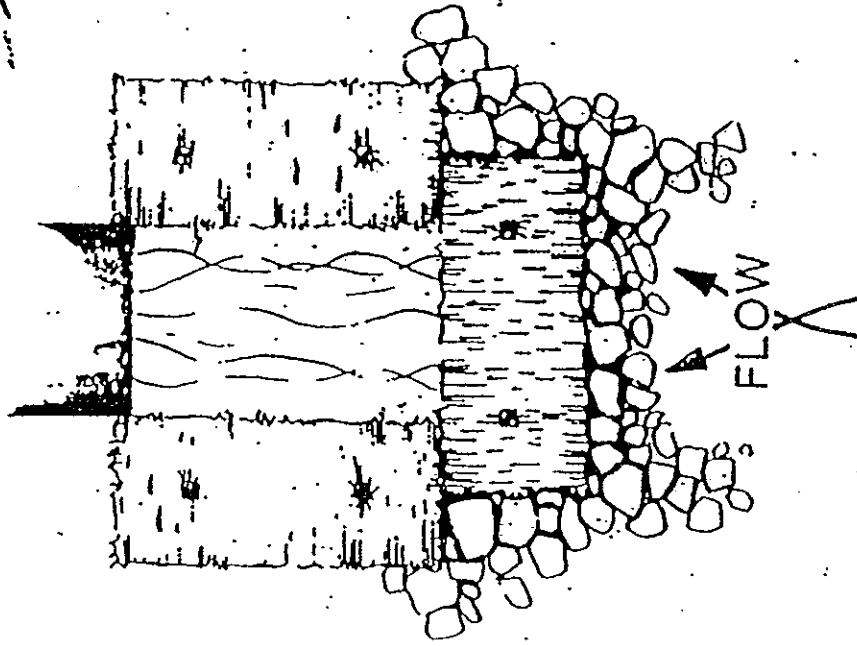
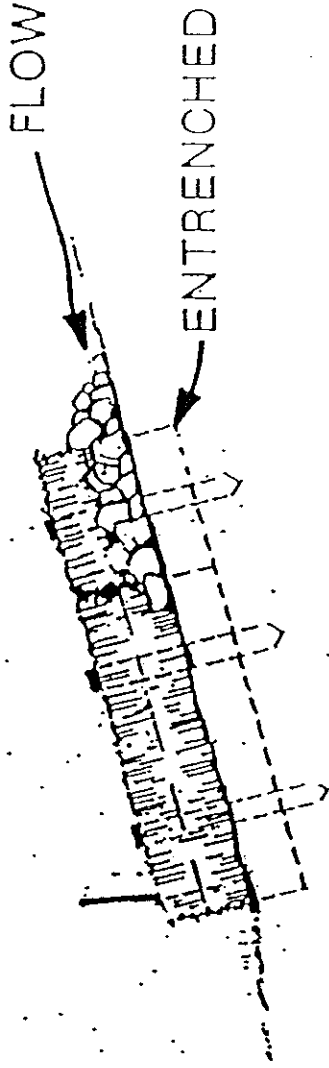
USAGE: Erosion bales are used as filters along the toe of fill; as erosion checks in ditches; and as diversions at unfinished drop inlets, culvert inlets and outlets. Erosion bales placed below new fill slopes protect streams or adjacent property from erosion until vegetation is established. When used as erosion checks in roadway ditches, bales reduce flow velocity thereby reducing erosion. Bales are often placed as a filter around drop inlets and culvert inlets and outlets to trap construction sediment until the project is completed.

CONSTRUCTION: The main consideration in placing erosion bales is to obtain tight joints. Erosion bales will not filter sediment out of the water if the water is allowed to flow between, around, or under the bales.

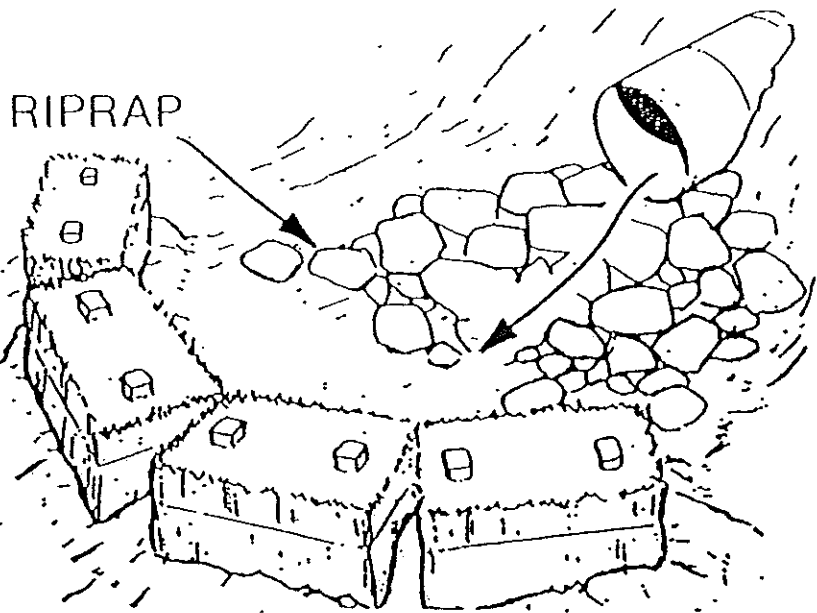
The erosion bales should be entrenched six inches and anchored with 2" X 2"X4" stakes or #4 reinforcing bars.

MAINTENANCE: Since erosion bales deteriorate quickly, they may require replacement during construction. When vegetation is established, the accumulated sediment may be spread, seeded, and then mulched with the erosion bales. Where not visually obtrusive, erosion bales may remain in place to decompose with grass seed spread on the sediment that has collected behind the barrier, i.e. where a steep fill is directly adjacent to a stream.

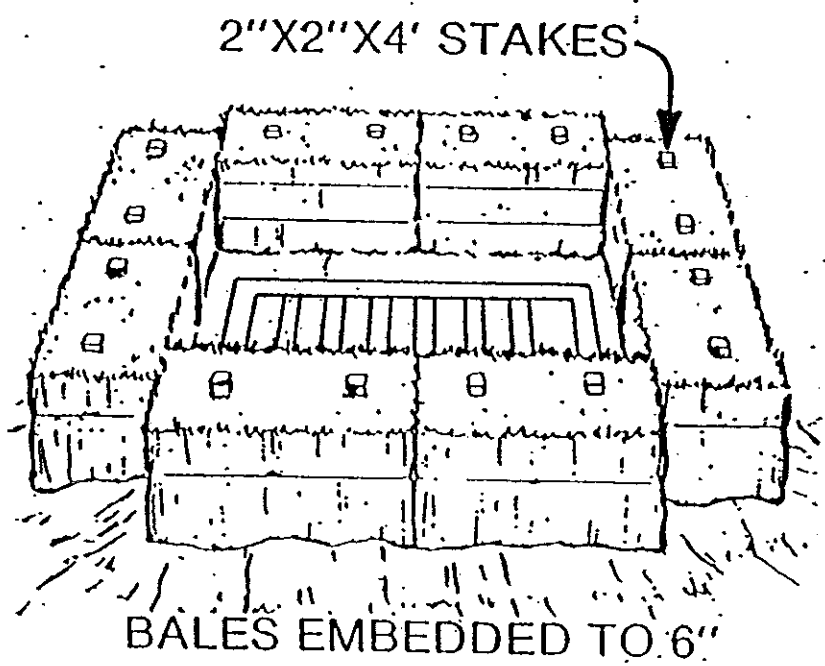
CULVERT INLET TRAP



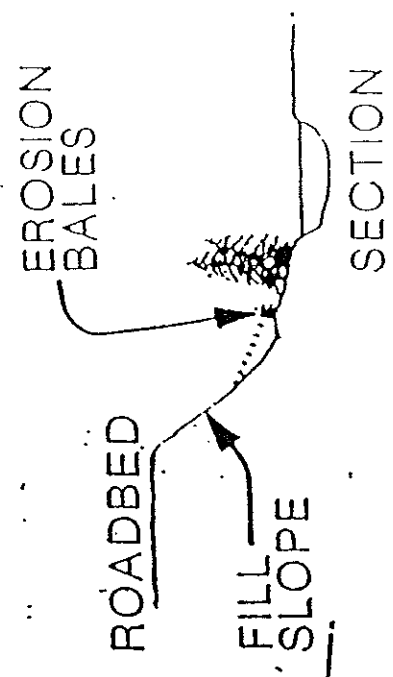
DETAIL EB - 1



Erosion Bales Trap Sediment At Culvert Inlets And Prevent Erosion At Culvert Outlets Until Vegetation Is Established



SEDIMENT COLLECTION BARRIER



EROSION
BALES

SECTION

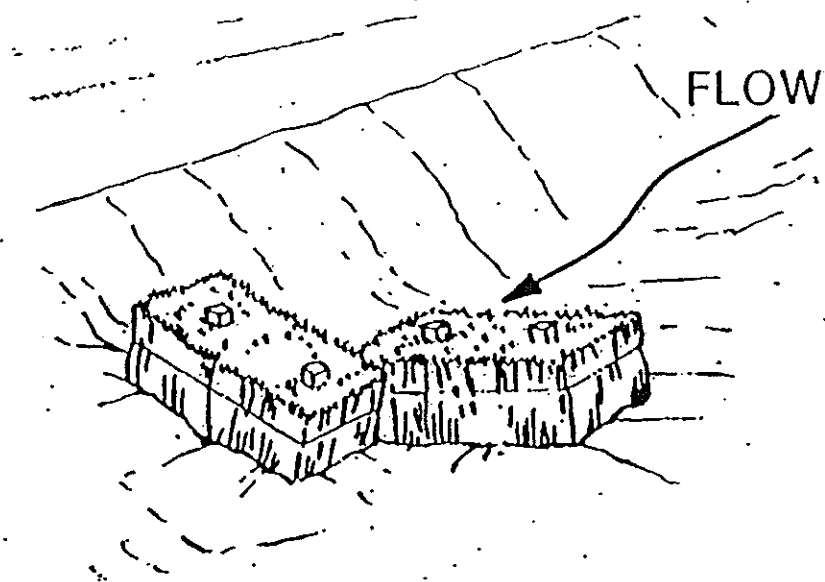
ROADBED

FILL
SLOPE

FILL SLOPE
RUNOFF

STREAM
OR ROADWAY

DETAIL EB - 3



Erosion Bale Check Dams Used In Roadside Ditches To Trap Sediment

DETAIL CD - 2

EROSION CONTROL AFTER CONSTRUCTION

SLOPE TREATMENT

INTRODUCTION: All the text to this point has dealt with temporary (short-term) erosion control problems and solutions. However, this chapter serves as a transition between short-term and long-term (permanent) erosion control techniques. Since landscaping applications such as mulching, and soil retention blankets are considered temporary erosion control in aiding the long-term establishment of grass stands, some seeding recommendations are thus included as a part of the text.

In order to adequately protect slopes from erosion, exposed slopes should have minimum acreage requirements before revegetation efforts and landscape applications are implemented. This insures that erosion potentials are checked as construction activities progress. For example, not more than three acres of newly exposed slope shall be permitted before topsoiling, seeding, mulching, fertilizing, and soil retention blanket are applied to the slopes. These applications shall be completed within ten days of completion of any section of newly exposed slope. Landscape watering shall be provided to establish healthy grass stands, except when fall plantings do not require seed germination until spring.

Soil Preparation: After nutrient-rich topsoil is graded on the slope to the specified depth, rubble and other debris are then removed. If slopes are wet, allow topsoil to dry before soil preparation. The slope seedbed is best prepared by discing or scarifying the topsoil parallel to the contours of the slope. This provides an excellent habitat for seed germination and vigorous growth. Hand raking, special chaining, and various other types of equipment are available for soil preparation of a slope.

Seeding: Soil types, elevation, and precipitation are the major site determinates for the seed selection design. A combination of grass species native to the area and other historically successful dryland species are recommended as seed mixtures.

The seeding operation is accomplished by either hand broadcasting, drilling, or hydraulic spraying. For slopes 3:1 or flatter, drill seeding is the best known method since the soil will act as a protective layer until germination occurs. Hand broadcasting or hydraulic seeding is effective on steeper slopes, which are inaccessible to drill seeding equipment. Hydraulic seeding equipment is applicable for cut or fill slopes which do not exceed 200 feet in height. Hand raking seeds into the topsoil for hydraulically-seeded areas will benefit the overall grass stand coverage.

Proper seeding techniques are important in establishing long-term erosion control of slopes through healthy grass stands. Questionable situations may be direct to the staff or district landscape architects to assist revegetation efforts.

Mulching: This operation adds needed biomass and seedbed protection to disturbed slopes before vegetation becomes established. Normally, hay or straw is spread at a rate of two tons per acre. Native hay is preferred since it provides additional grass seed. Hay and straw mulch is crimped into the soil by mechanical (or hand) methods. Chemical tackifiers have been effective in holding mulch to steep slopes where crimping machines are not accessible. Hydraulic application of mulch fiber, or hydromulch, may be used at a rate of one ton per acre. This method is commonly used on steep, inaccessible slopes, but may also be used on flatter slopes that have been drill seeded. Special tackifiers are recommended to help adhere the application to the slope. Normally hydromulch is not used on dry sites.

Mulch Netting and Soil Retention Blanket: Mulch netting may be used to hold hay or straw mulch on steep slopes.

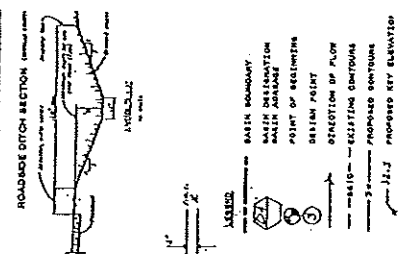
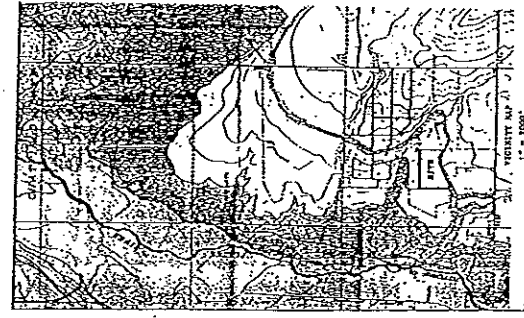
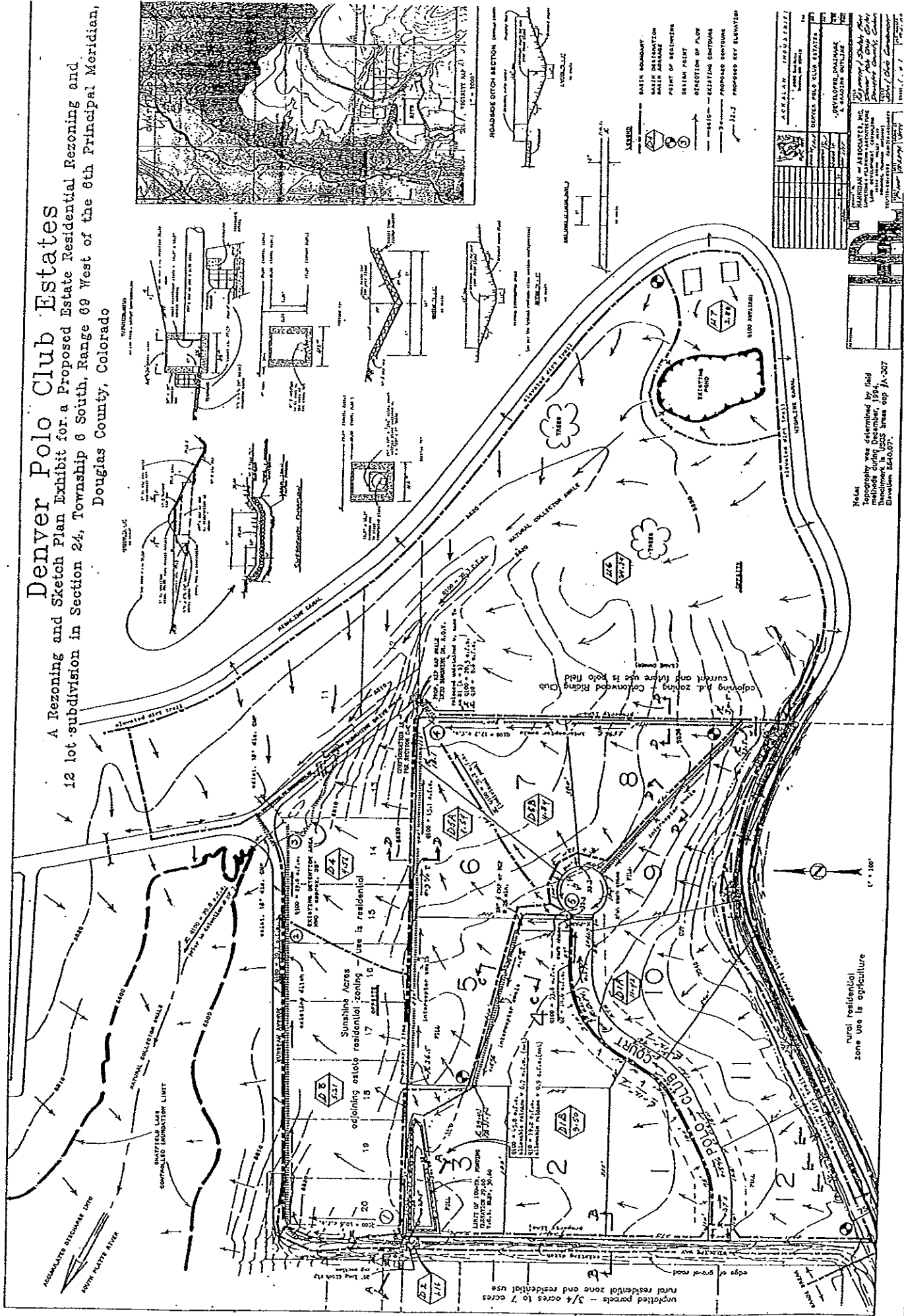
Soil retention blankets are quite effective in controlling erosion on steep slopes and in ditches. Blankets are especially advantageous on high altitude projects where growing seasons are very short and soil erosion potential is high.

The basic objective of mulch netting is to provide a stable seedbed for one or two growing seasons, then biodegrade as vegetal matter builds up to produce a healthy cover crop.

ACCEPTABLE MAP FORMATS FROM OTHER STUDIES
(ACTUAL SIZE: 24" x 36")

Denver Polo Club Estates

A Rezoning and Sketch Plan Exhibit for a Proposed Estate Residential Rezoning and 12 lot subdivision in Section 24, Township 6 South, Range 69 West of the 6th Principal Meridian, Douglas County, Colorado



NO.	DESCRIPTION	DATE	BY	CHECKED BY
1	PRELIMINARY PLAN	10/15/27	J. H. ...	J. H. ...
2	REVISED PLAN	11/15/27	J. H. ...	J. H. ...
3	FINAL PLAN	12/15/27	J. H. ...	J. H. ...

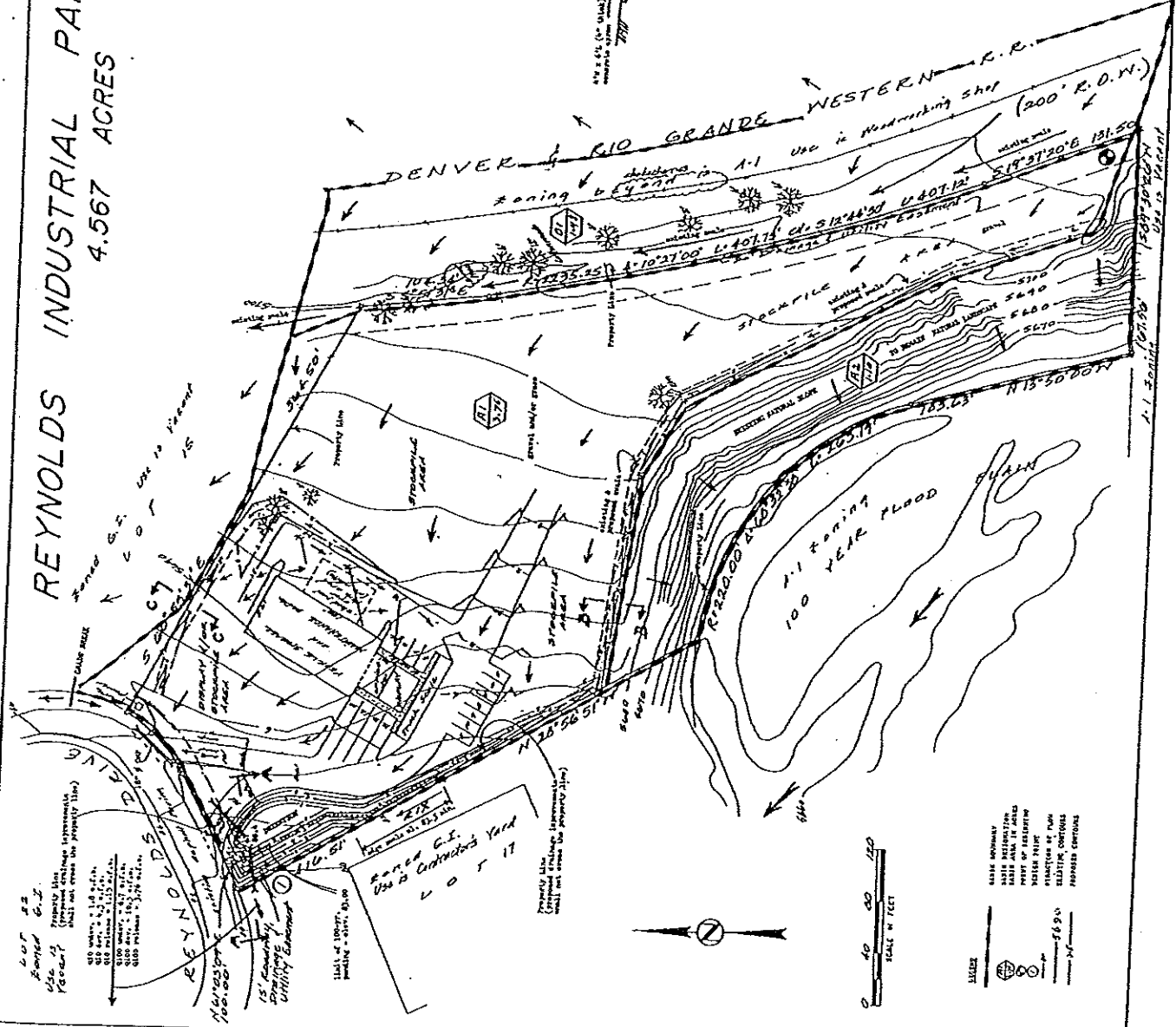
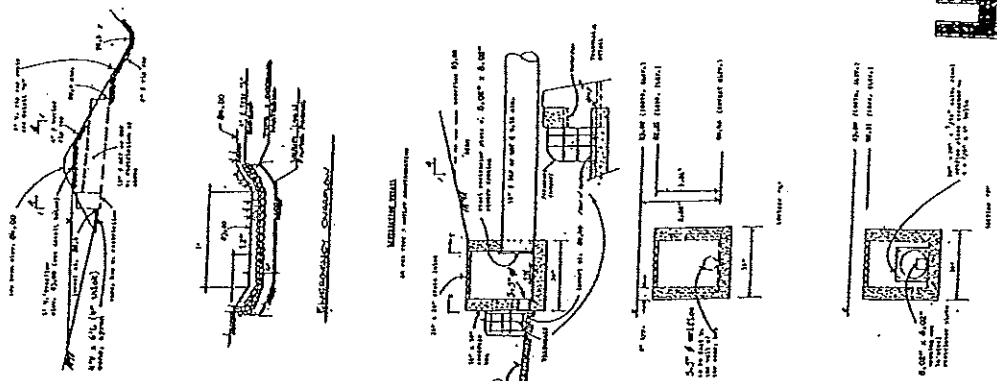
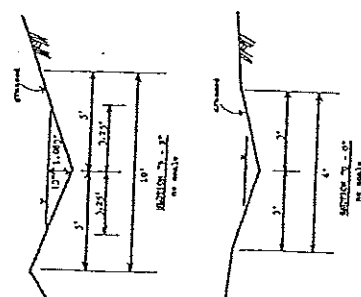
Note: Topography was determined by field methods during December, 1924. Benchmark in USGS brass cap 1A-387. Elevation 5450.07'.

rural residential zone use is agriculture

unimproved parcels - 3/4 acres to 7 acres rural residential zone and residential use

REYNOLDS INDUSTRIAL PARK - LOT 16

4.567 ACRES



ACKSLAN INDUSTRIES 321 S. 9th DENVER, CO 80210	
LOT 16, REYNOLDS INDUSTRIAL PARK DENVER, CO 80210	
PLANS, BUILDING PERMIT AND EASING OUTLINE PREPARED BY: [Signature] DATE: 8/7/74	

LOT 16
 Zoned G.I.
 Use A1
 (Proposed drainage system
 shall not cross the property line)

40' water, 2' 1/2' depth
 80' water, 2' 1/2' depth
 120' water, 2' 1/2' depth
 160' water, 2' 1/2' depth
 200' water, 2' 1/2' depth

15' concrete
 Utility Substation

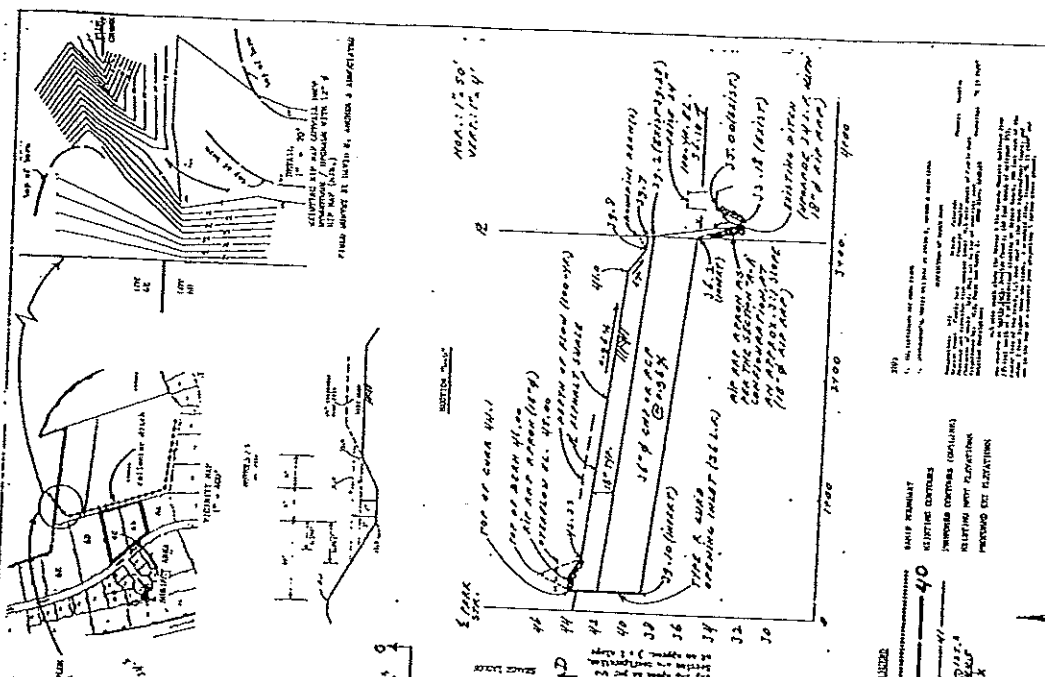
114' x 100' x 10' 6" high
 building - 40' x 10'

Zoned G.I.
 Use B
 Contaminated Yard
 LOT 17

(Proposed drainage system
 shall not cross the property line)

SLOPE
 BASIC INFORMATION
 THIS INFORMATION
 IS FOR THE AREA
 SHOWN ON THIS
 PLAN AND DOES NOT
 CONSTITUTE A
 GUARANTEE OF THE
 ACCURACY OF THE
 INFORMATION
 PRESENTED

8/7/74

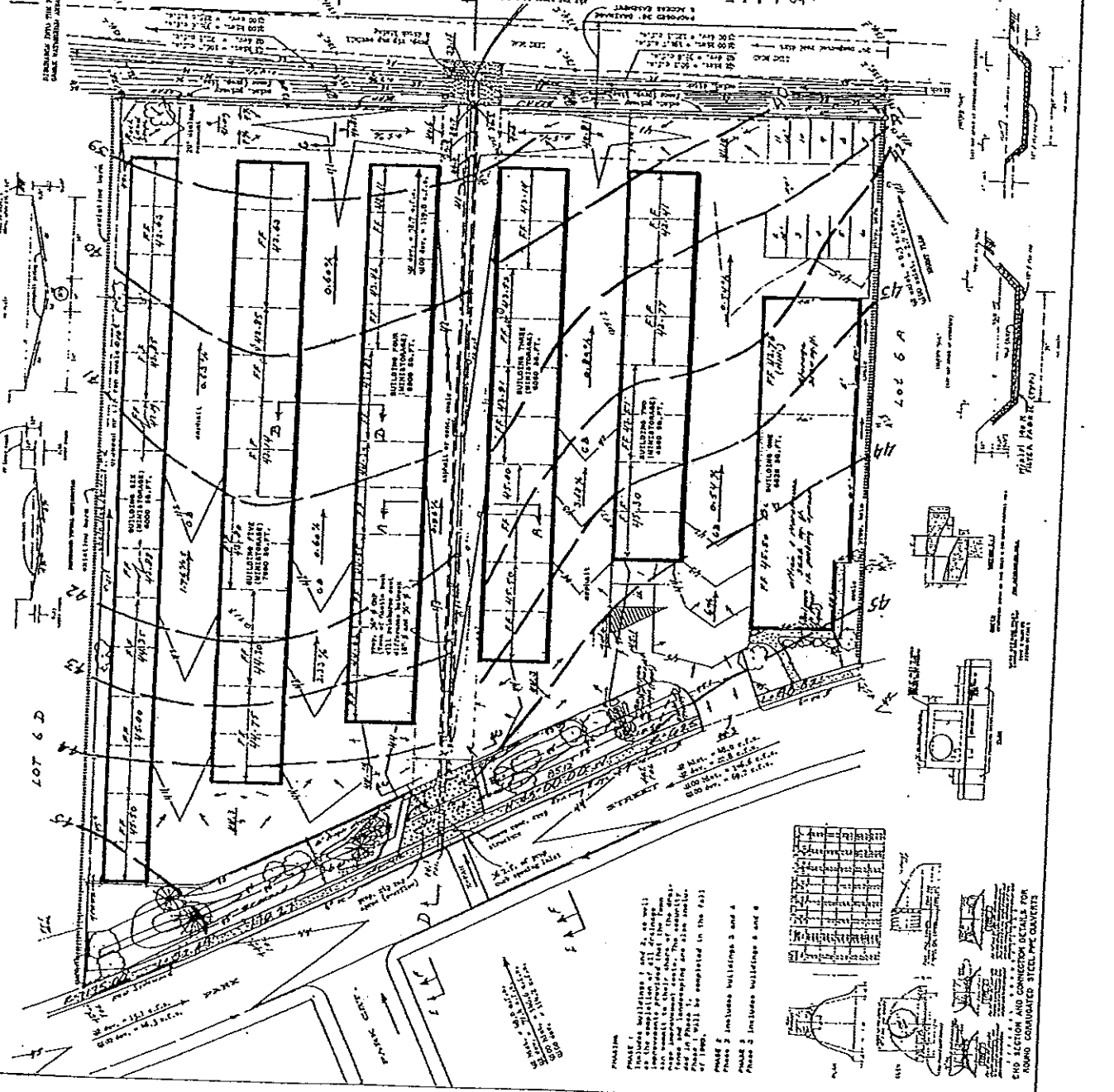


ACKLIAN INDUSTRIES
 3088 Box Road
 Denver, CO 80210
 714 - 3641

VILLAGE NORTH ANCHER - LOTS 6A & 6D
 WHITE MOUNTAIN & BEAVER CREEK

PROJECT NO. 1111
 DATE: 11/23/83

DAVID E. ANCHER & ASSOCIATES
 ARCHITECTS
 1600 S. WASHINGTON ST., SUITE 200
 DENVER, CO 80210
 733-2828



- PHASE 1**
 Includes buildings 1 and 2, as well as improvements to all existing structures. All improvements shall be completed in the fall of 1983.
- PHASE 2**
 Includes buildings 3 and 4.
- PHASE 3**
 Includes buildings 5 and 6.

