

SCANNED

A CULVERT DESIGN STUDY
FOR
GENEVA COMPANY

FOR
ACCESS TO PT. LOT 18
DUES SUBDIVISION

UNION TOWNSHIP
BUTLER COUNTY, OHIO

A

CULVERT DESIGN STUDY

FOR

GENEVA INVESTMENT CO.

1/20/94

SUBMITTED BY :

DAN E. ANTENEN
OHIO REG. ENGR. #21804

Dan E. Antenen

1/20/94

GENEVA ACCESS CULVERT STUDY

EXHIBIT A — PROPERTY LOCATION

EXHIBIT B — GENEVA ACCESS CULVERT LOCATION

EXHIBIT C — DRAINAGE AREA

C-1 — Location

C-2 — Sub-area divisions

C-3 — Location of major tributary points
and significant culverts

C-4 — Elevations & sizes of ex'g culverts

EXHIBIT D — TOTAL DISCHARGE BY TAB. HYDROGRAPH METH

(Computer Sheets) — Sub-area selection and summary —
— T_c & T_t thru sub-area computation —
— Sub-area contrib'n & total dischg at outlet

EXHIBIT E — CULVERT SELECTION FOR SITE "C"

E-1 — Comparison of existing culvert capacities

E-2 — Estimates of stream high water flow slope
and allowable head losses.

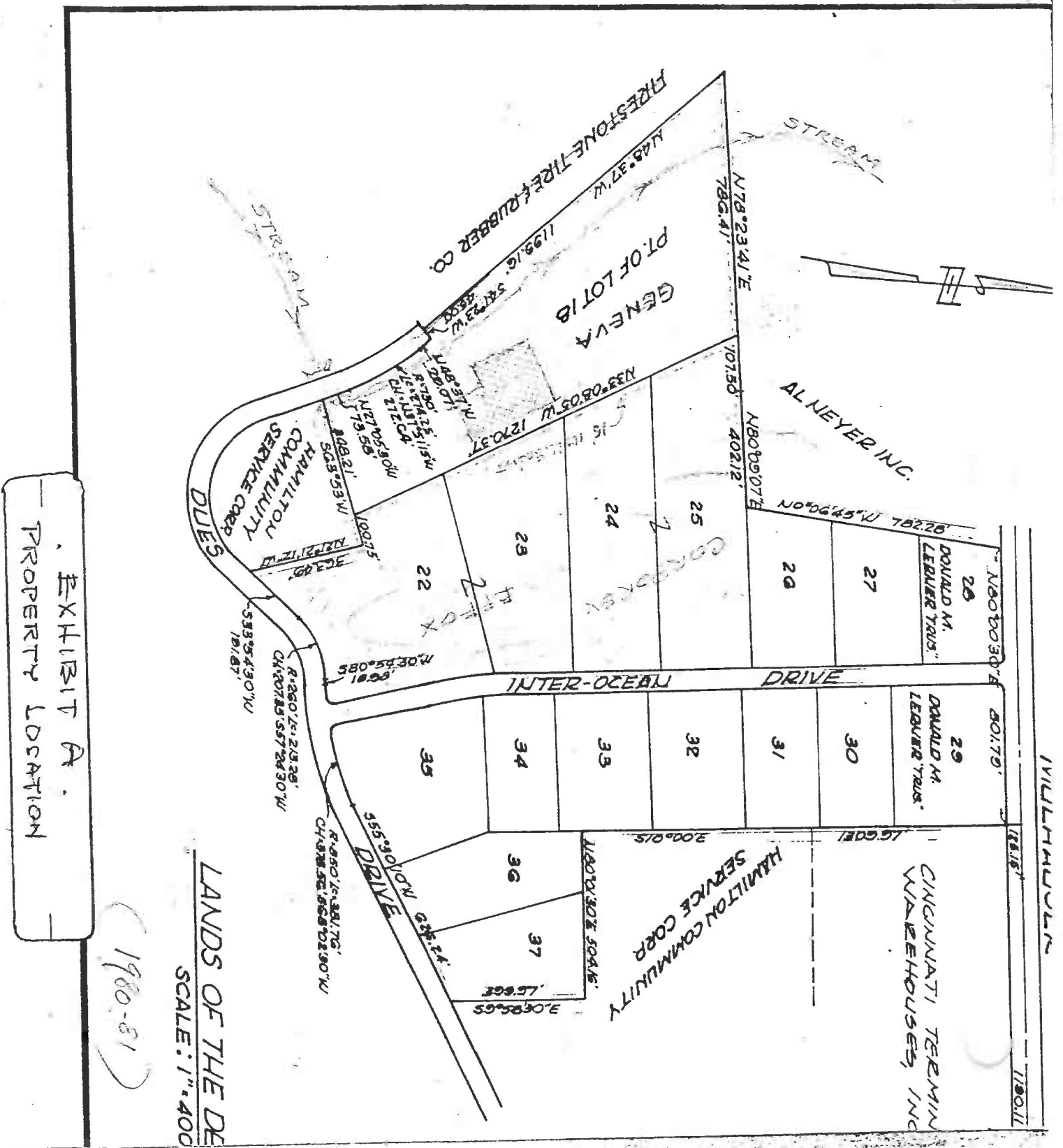
E-3 — Flows moderated by ex'g conditions

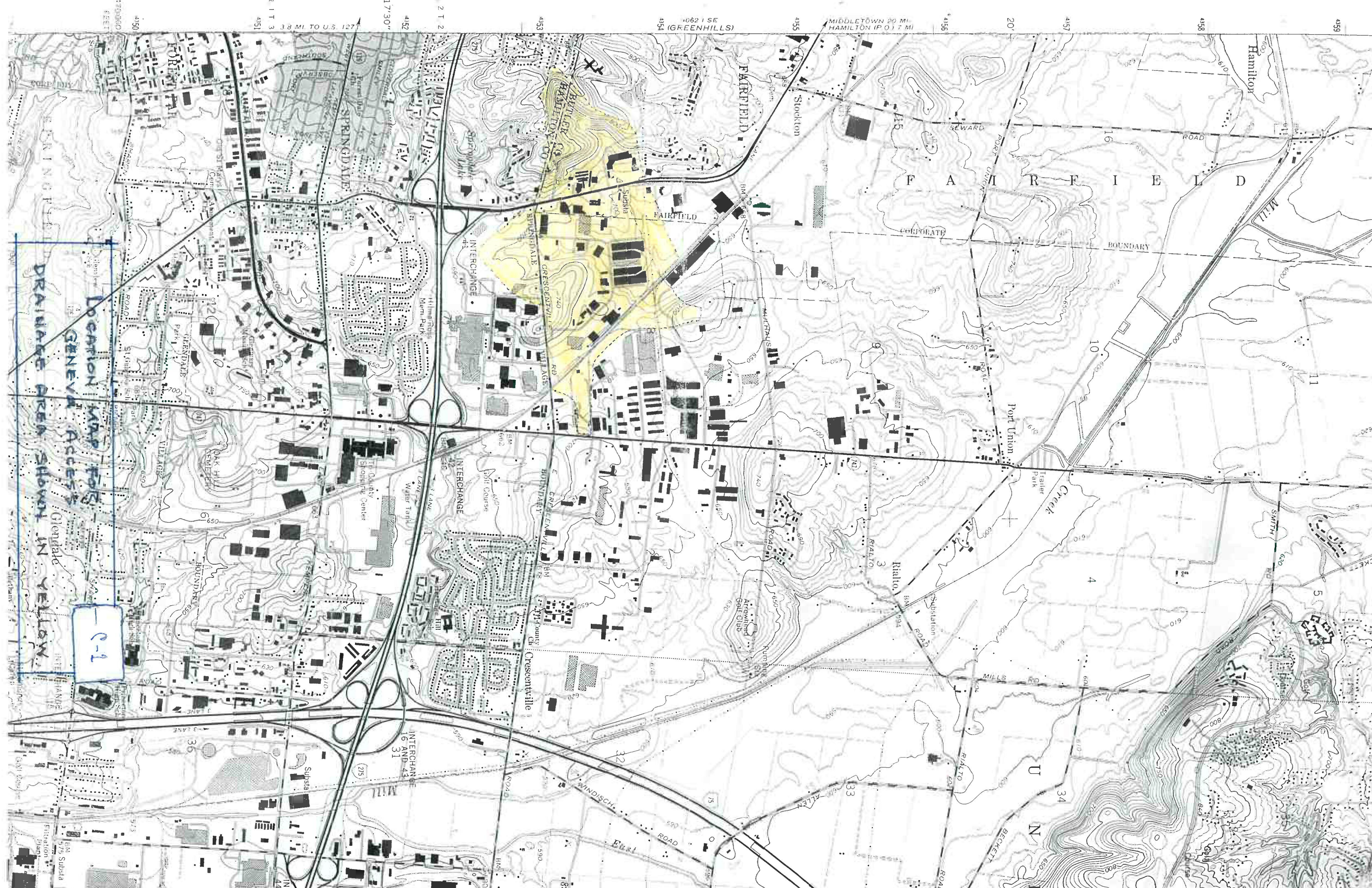
E-4 — Selection of proposed Geneva Access culvert.

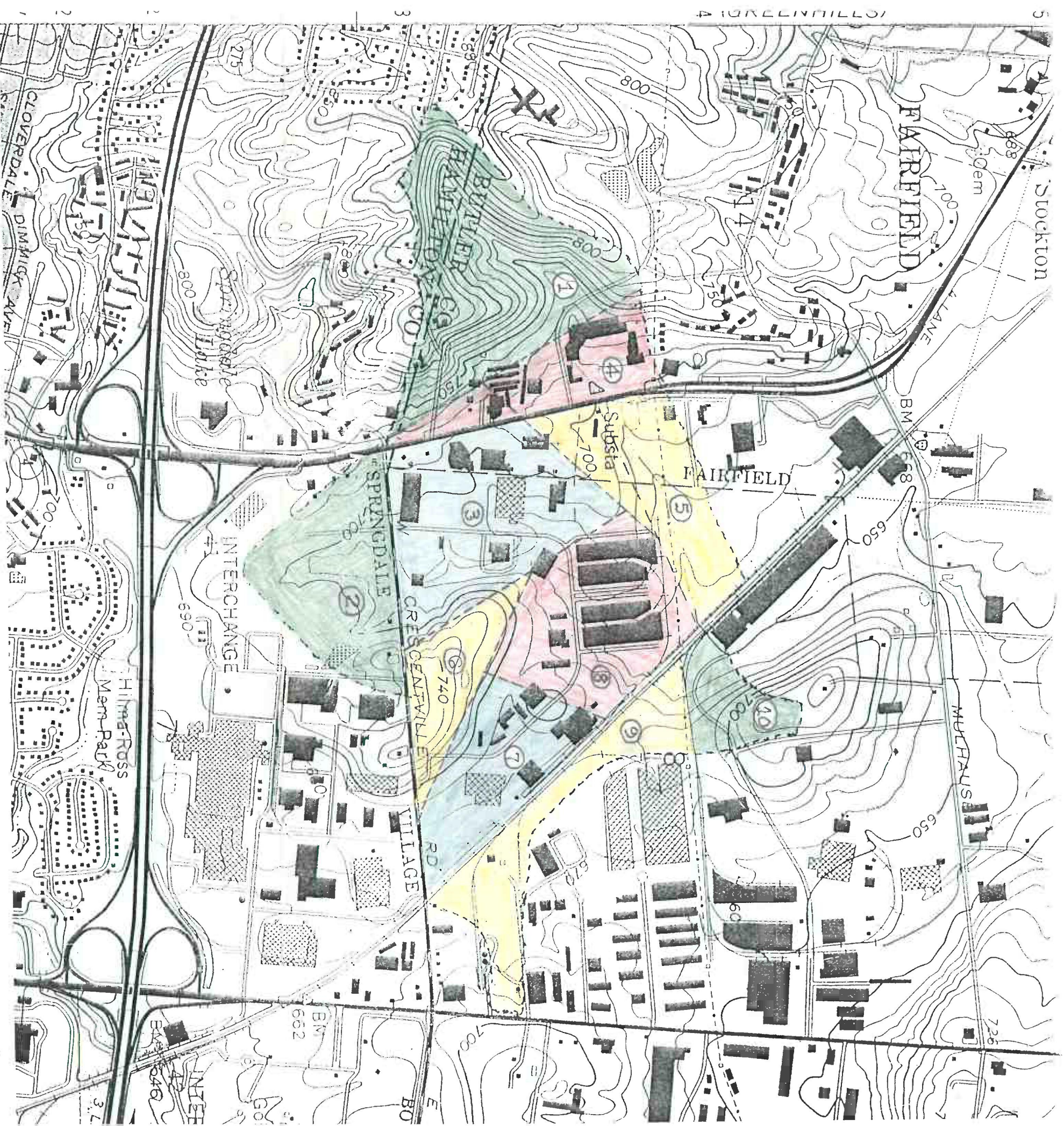
EXHIBIT () (SPECIFICATION SHEET) not provided

() (CONSTRUCTION DETAILS) not provided

C/O DAN E. ANTENEN
GENEVA COMPANY IS 1391 NEW LONDON RD
HAMILTON, OH, 45013
tel. 868-1288







APPROX. SCALE 1"=1000'

ENLARGEMENT OF U.S.G.S, 1987 PHOTO REVISION
OF 1984 SURFACE FEATURES
GLENDALE, OHIO QUADRANGLE

N ←

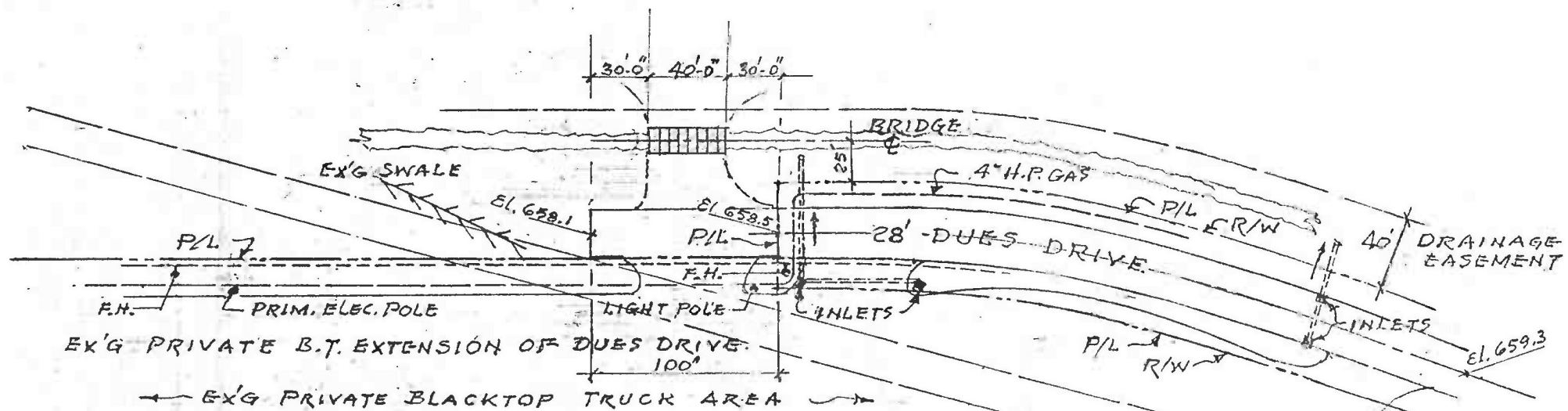


EXHIBIT B.
GENEVA ACCESS CULVERT LOCATION

GENEVA ACCESS CULVERT LOCATION,

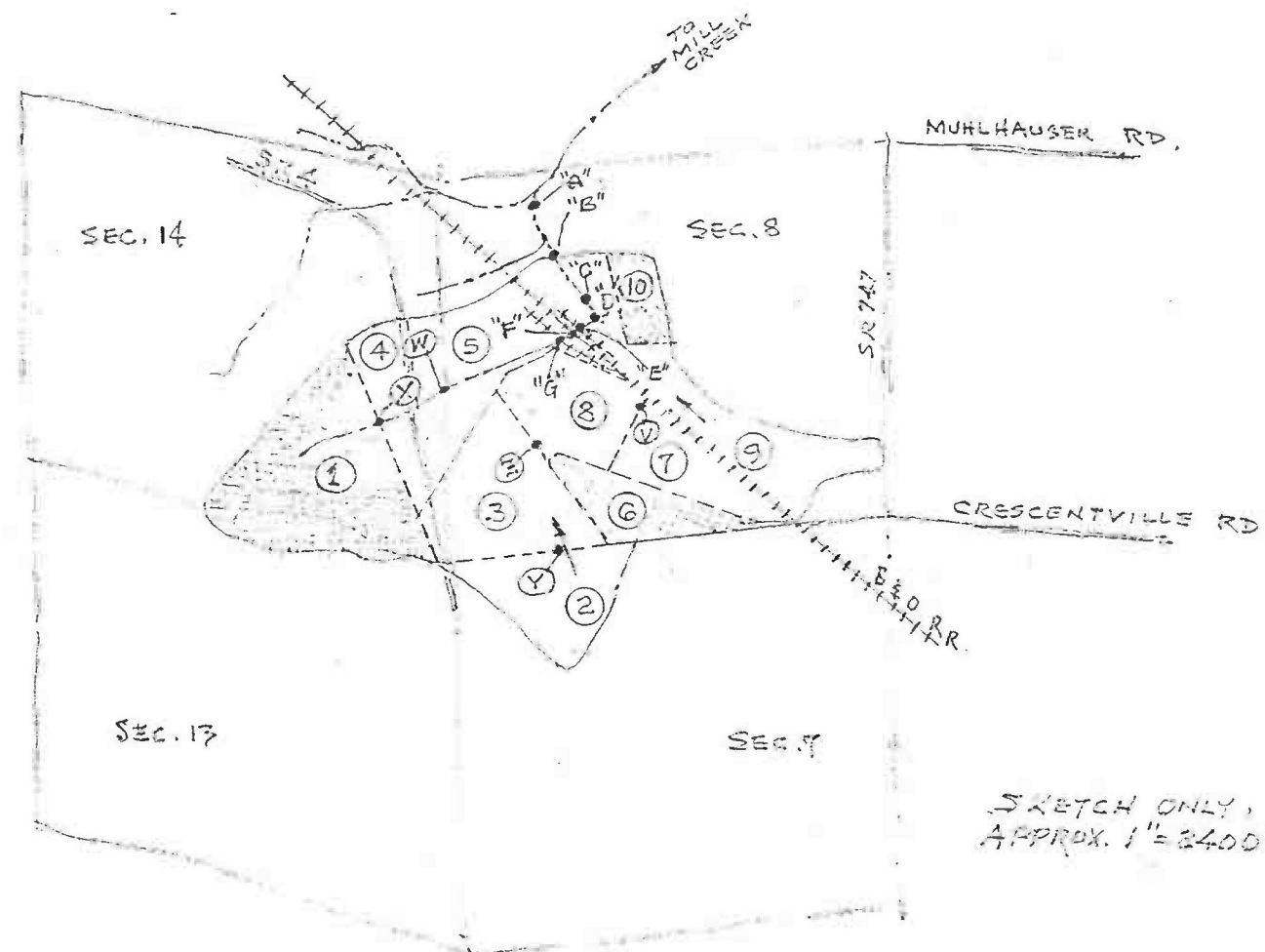
1" = 80'

1/20/94

SITE "C" FLOW

OTHER SITES INCLUDED FOR COMPARISON PURPOSES ONLY.

SEE SURVEY PLOT.



TAKEN FROM USGS GLENDALE OHIO QUADRANGLE MAP,
1984 PHOTOS 1987 REVISION

LEGEND:

① THRU ⑩ = SUB-AREAS FOR TR-55
TABULAR HYDROGRAPH METHOD.

⑪ THRU ⑫ = MAJOR TRIBUTARY POINTS.

"A" THRU "G" = SIGNIFICANT CULVERT LOCATIONS

NOTE: "C" IS LOCATION OF GENEVA ACCESS CULVERT,
AS PROPOSED.

GENEVA ACCESS DRAINAGE AREA.

C-3

1/20/94



PLOTTED FROM SURVEY NOTES OF 11/28/93 AND 12/22/93
 (CORRECTIONS) (REVOLUTIONS)

Site : GENEVA ACCESS User: DAN Date: 01-15-94
County : Butler State: OH Checked: Date:
Subtitle: Culvert Study
Subarea : 1

COVER DESCRIPTION		Hydrologic Soil Group			
		A	B	C	D
		Sq miles (CN)			
OTHER AGRICULTURAL LANDS					
Woods	good	-	.13(55)	-	-
Total Area (by Hydrologic Soil Group)		.13			
		=====			

SUBAREA: 1 TOTAL DRAINAGE AREA: .13 Sq miles WEIGHTED CURVE NUMBER: 55

EXHIBIT D
BATCH OF COMPUTER SHEETS

1 : GENEVA ACCESS User: DAN Date: 01-15-94
County : Butler State: OH Checked: Date:
Subtitle: Culvert Study
Subarea : 2

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Sq miles (CN)			

OTHER AGRICULTURAL LANDS				
Brush - brush, weed, grass mix good	-	.07[48]	-	-

Total Area (by Hydrologic Soil Group) .07
=====

SUBAREA: 2 TOTAL DRAINAGE AREA: .07 Sq miles WEIGHTED CURVE NUMBER: 48

: GENEVA ACCESS User: DAN Date: 01-15-94
 County : Butler State: OH Checked: Date:
 Subtitle: Culvert Study
 Subarea : 3

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Sq miles {CN}			

FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns, parks etc.)				
Good condition; grass cover > 75%	-	.09{61}	-	-
Impervious Areas				
Paved parking lots, roofs, driveways	-	.03{98}	-	-
Total Area (by Hydrologic Soil Group)		.12		
		====		

SUBAREA: 3 TOTAL DRAINAGE AREA: .12 Sq miles WEIGHTED CURVE NUMBER: 70

Project : GENEVA ACCESS User: DAN Date: 01-15-94
County : Butler State: OH Checked: Date:
Subtitle: Culvert Study
Subarea : 4

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Sq miles (CN)			

FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Urban Districts	Avg % imperv			
Commercial & business	85	-	.04(92)	-

Total Area (by Hydrologic Soil Group) .04
=====

SUBAREA: 4 TOTAL DRAINAGE AREA: .04 Sq miles WEIGHTED CURVE NUMBER:92

Project : GENEVA ACCESS User: DAN Date: 01-15-94
County : Butler State: OH Checked: Date:
Subtitle: Culvert Study
Subarea : 5

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Sq miles (CN)			

OTHER AGRICULTURAL LANDS				
Brush - Brush, weed, grass mix good	-	.07(48)	-	-

Total Area (by Hydrologic Soil Group) .07
=====

SUBAREA: 5 TOTAL DRAINAGE AREA: .07 Sq miles WEIGHTED CURVE NUMBER:48

Location : GENEVA ACCESS User: DAN Date: 01-15-94
County : Butler State: OR Checked: Date:
Subsite: Culvert Study
Subarea : 6

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Sq miles (CN)			

OTHER AGRICULTURAL LANDS				
Brush - brush, weed, grass mix good	-	.04(48)	-	-

Total Area (by Hydrologic Soil Group) .04
=====

SUBAREA: 6 TOTAL DRAINAGE AREA: .04 Sq miles WEIGHTED CURVE NUMBER:48

Project : GENEVA ACCESS User: DAN Date: 01-15-94
County : Butler State: OH Checked: Date:
Subtitle: Culvert Study
Subarea : 7

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Sq miles (CN)			

FULLY DEVELOPED URBAN AREAS (Veg. Estab.)				
Open space (Lawns, parks etc.)				
Good condition; grass cover > 75%	-	.02(61)	-	-
Impervious Areas				
Paved parking lots, roofs, driveways	-	.02(98)	-	-
OTHER AGRICULTURAL LANDS				
Brush - brush, weed, grass mix good	-	.02(48)	-	-
Total Area (by Hydrologic Soil Group)		.06		
		====		

Subarea: 7 TOTAL DRAINAGE AREA: .06 Sq miles WEIGHTED CURVE NUMBER:69

Project : GENEVA ACCESS User: DAN Date: 01-15-94
County : Butler State: OH Checked: Date:
Subtitle: Culvert Study
Subarea : 8

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Sq miles (CN)			

FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Urban Districts	Avg % imperv			
Industrial	72	-	.09(88)	-

Total Area (by Hydrologic Soil Group) .09
=====

SUBAREA: 8 TOTAL DRAINAGE AREA: .09 Sq miles WEIGHTED CURVE NUMBER:88

Site : GENEVA ACCESS User: DAN Date: 01-15-94
County : Butler State: OH Checked: Date:
Subtitle: Culvert Study
Subarea : 9

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
	Sq miles (CN)			

FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (lawns, parks etc.)				
Good condition; grass cover > 75%	-	.015(61)	-	-
OTHER AGRICULTURAL LANDS				
Brush - brush, weed, grass mix good	-	.955(48)	-	-
Total Area (by Hydrologic Soil Group)		.07		
		====		

SUBAREA: 9 TOTAL DRAINAGE AREA: .07 Sq miles WEIGHTED CURVE NUMBER: 51

Project : GENEVA ACCESS User: DAN Date: 01-15-94
County : Butler State: OH Checked: Date:
Subtitle: Culvert Study
Subarea : 10

COVER DESCRIPTION	Hydrologic Soil Group			
	A	B	C	D
		Sq miles	(CN)	
FULLY DEVELOPED URBAN AREAS (Veg Estab.)				
Open space (Lawns, parks etc.)				
Fair condition; grass cover 50% to 75%	-	.005(69)	-	-
Streets and roads				
Paved; curbs and storm sewers	-	.005(98)	-	-
OTHER AGRICULTURAL LANDS				
Brush - brush, weed, grass mix fair	-	.02(56)	-	-
Total Area (by Hydrologic Soil Group)		.03		
		====		

Subarea: 10 TOTAL DRAINAGE AREA: .03 Sq miles WEIGHTED CURVE NUMBER: 65

User DANr >>>> Identification Data <<<< Date 01-15-94

Project GENEVA ACCESS County Butler State OH

Subtitle Culvert Study

>>>> Subarea Selection and Summary <<<<

Area Units (Acres,SqMi,Percent) S	Subareas	Accum. Sq miles	Weighted CN
Select appropriate Area	# 1 1zzzzz	0.130	55
Units (A,S, or P above).	# 2 2zzzzz	0.070	48
Then place cursor on line	# 3 3zzzzz	0.120	70
for desired subarea. Key	# 4 4zzzzz	0.040	92
in name, if blank, and	# 5 5zzzzz	0.070	48
press PgDn to bring up	# 6 6zzzzz	0.040	48
first land use-CN screen.	# 7 7zzzzz	0.060	69
Use PgUp and PgDn to	# 8 8zzzzz	0.090	88
loop through the land uses	# 9 9zzzzz	0.070	51
and F8 to return here.	#10 10zzzz z	0.030	65

0.62
0.72

Project : GENEVA ACCESS User: DAN Date: 01-15-94
 County : Butler State: OH Checked: Date:
 Subtitle: Culvert Study

----- Subarea #1 - 1 -----

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	2.88	300	.10	i					0.931
Shallow Concent'd		1000	.10	u					0.054
Open Channel		1000	.04			.06 48	24		0.047
									Time of Concentration = 0.93*
									=====

----- Subarea #2 - 2 -----

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	2.88	300	.017	f					0.644
Shallow Concent'd		1100	.014	u					0.160
									Time of Concentration = 0.80*
									=====

----- Subarea #3 - 3 -----

Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
Sheet	2.88	300	.04	e					0.297
Shallow Concent'd		300	.033	u					0.028
Shallow Concent'd		300	.033	p					0.023
Open Channel		1000	.025			.08 2	1		0.059
									Time of Concentration = 0.41*
									=====
Open Channel		1000	.025			.08 2	1		0.059
									Travel Time = 0.06*
									=====

* - Generated for use by TABULAR method

City : GENEVA ADDRESS User: DAN Date: 01-15-94
County : Butler State: OH Checked: Date: _____
Subtitle: Culvert Study

----- Subarea #4 - 4 -----
Flow Type 2 year Length Slope Surface n Area Wp Velocity Time
rain (ft) (ft/ft) code (sq/ft) (ft) (ft/sec) (hr)

Sheet 2.88 300 .05 e 0.272
Open Channel 600 .05 .08 2 1 0.025
Time of Concentration = 0.30*
=====

Open Channel 600 .05 .08 2 1 0.025
Travel Time = 0.03*
=====

----- Subarea #5 - 5 -----
Flow Type 2 year Length Slope Surface n Area Wp Velocity Time
rain (ft) (ft/ft) code (sq/ft) (ft) (ft/sec) (hr)

Sheet 2.88 300 .033 f 0.494
Shallow Concent'd 300 .033 u 0.028
Open Channel 1300 .014 .08 2 1 0.183
Time of Concentration = 0.71*
=====

Open Channel 1300 .014 .08 2 1 0.183
Travel Time = 0.18*
=====

----- Subarea #6 - 6 -----
Flow Type 2 year Length Slope Surface n Area Wp Velocity Time
rain (ft) (ft/ft) code (sq/ft) (ft) (ft/sec) (hr)

Sheet 2.88 200 .067 j 0.169
Shallow Concent'd 200 .10 u 0.011
Time of Concentration = 0.28*
=====

----- Subarea #7 - 7 -----
Flow Type 2 year Length Slope Surface n Area Wp Velocity Time
rain (ft) (ft/ft) code (sq/ft) (ft) (ft/sec) (hr)

Sheet 2.88 300 .04 i 0.458
Shallow Concent'd 300 .033 p 0.023
Open Channel 1400 .02 .08 2 1 0.093
Time of Concentration = 0.57*
=====

Open Channel 1400 .02 .08 2 1 0.093
Travel Time = 0.09*
=====

TR-55 Tc and TE THRU SUBAREA COMPUTATION VERSION 1.11

CT : GENEVA ACCESS User: DAN Date: 01-15-94
 County : Butler State: OH Checked: Date:
 Subtitle: Culvert Study

----- Subarea #8 - 8 -----

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
-----------	----------------	----------------	------------------	-----------------	---	-----------------	------------	----------------------	--------------

Sheet	2.88	200	.05	f					0.303
Shallow Concent'd		1000	.05	p					0.061
Open Channel		1500	.02		.08 2	1			0.100

Time of Concentration = 0.46*

=====

Open Channel		1500	.02		.08 2	1			0.100
--------------	--	------	-----	--	-------	---	--	--	-------

Travel Time = 0.10*

=====

----- Subarea #9 - 9 -----

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
-----------	----------------	----------------	------------------	-----------------	---	-----------------	------------	----------------------	--------------

Sheet	2.88	300	.033	e					0.321
Shallow Concent'd		800	.005	u					0.195
Open Channel		2700	.0083		.08 2	1			1.465

Time of Concentration = 1.98*

=====

----- Subarea #10 - 10 -----

Flow Type	2 year rain	Length (ft)	Slope (ft/ft)	Surface code	n	Area (sq/ft)	Wp (ft)	Velocity (ft/sec)	Time (hr)
-----------	----------------	----------------	------------------	-----------------	---	-----------------	------------	----------------------	--------------

Sheet	2.88	300	.1	i					0.831
Shallow Concent'd		800	.075	p					0.040
Open Channel		600	.0083		.08 2	1			0.062

Time of Concentration = 0.93*

=====

Open Channel		600	.0083		.08 2	1			0.062
--------------	--	-----	-------	--	-------	---	--	--	-------

Travel Time = 0.06*

=====

--- Sheet Flow Surface Codes ---

A Smooth Surface	F Grass, Dense	--- Shallow Concentrated ---
B Pallow (No Res.)	G Grass, Bermuda	--- Surface Codes ---
C Cultivated < 20 % Res.	H Woods, Light	P Paved
D Cultivated > 20 % Res.	I Woods, Dense	U Unpaved
E Grass-Range, Short		

User DANA >>>> Identification Data <<<< Date 01-15-94

Project GENEVA ACCESS County Butler State OH

Subtitle Culvert Study

>>>> Subarea Selection and Summary<<<<

	Subareas	Tc	Tt thru Subarea
Place cursor on line for	# 1 1	0.93	
desired subarea. Key in	# 2 2zzzzz	0.80	
name, if blank, and press	# 3 3zzzzz	0.41	0.06
PgDn to bring up Tc data	# 4 4zzzzz	0.30	0.03
entry screen. Use PgUp	# 5 5zzzzz	0.71	0.18
and PgDn to toggle between	# 6 6zzzzz	0.28	
Tc and Tt entry screens	# 7 7zzzzz	0.57	0.09
or F8 to return here.	# 8 8zzzzz	0.46	0.10
	# 9 9zzzzz	1.98	
	#10 10zzzz z	0.93	0.06

F1Help F2Print F3Load F4Save F5DOS F6Zero

EXHIBIT D
BATCH OF COMPUTER SHEETS

GENEVA ACCESS
Culvert Study

Butler, OH

DAN 01-15-94

>>>> Subarea Data <<<<

Subarea Name	Drainage Area (sq mi)	Runoff Curve Number	Time of Concen- tration (hrs)	Travel Thru Subarea (hrs)	Downstream Subarea Name	24-Hour Rain (in)
1zzzzz	.13zz *	55 *	.93z *	zzzz	4zzzzz	4.8z
2zzzzz	.07zz *	48 *	.8zz *	zzzz	3zzzzz	4.8z
3zzzzz	.12zz *	70 *	.41z *	.06z *	8zzzzz	4.8z
4zzzzz	.04zz *	92 *	.3zz *	.03z *	5zzzzz	4.8z
5zzzzz	.07zz *	48 *	.71z *	.18z *	zzzzzz	4.8z
6zzzzz	.04zz *	48 *	.28z *	zzzz	7zzzzz	4.8z
7zzzzz	.06zz *	69 *	.57z *	.09z *	8zzzzz	4.8z
8zzzzz	.09zz *	88 *	.46z *	.1zz *	zzzzzz	4.8z
9zzzzz	.07zz *	51 *	1.98 *	zzzz	zzzzzz	4.8z
10zzzz	.03zz *	65 *	.93z *	.06z *	zzzzzz	4.8z z

F1Help F2Print F3Load F4Save F5DOS F6Zero F7Compute F9RCN F10TCTT

User: DAN >>>> Identification Data <<<< Date 01-19-94

Project: GENEVA ACCESS County: Butler State: OH

Subtitle: Culvert Study at Access to Property

>>>> Basic Watershed Data <<<<

Rainfall-Type (I, IA, II, III) II

Rainfall Frequency 25yr years

If constant rainfall over entire watershed, 24-Hour Rain: 4.8 in.

(If rainfall varies by subarea enter on next screen.)

Interpolate hydrograph tables based on Ia/F ratio? Y

(Enter Y for yes and N for no)

F1Help F2Print F3Load F4Save F5DOS F6Zero F7Compute F9RCN F10TOT

SUBAREA CONTRIBUTIONS AND TOTAL DISCHARGE (CFS) AT OUTLET

Subarea	Time									
	11.9	12.0	12.1	12.2	12.3	12.4	12.5	12.6	12.7	12.8
1	0	0	0	0	1	2	5	9	14	19
2	0	0	0	0	0	1	2	3	5	6
3	9	16	32	60	92	112	106	88	67	51
4	8	13	24	45	74	91	84	66	48	35
5	0	0	0	0	1	3	5	7	8	8
6	0	0	0	1	3	5	6	6	5	4
7	3	5	9	17	30	41	48	46	40	32
8	18	29	53	96	146	166	159	126	93	71
9	0	0	0	0	0	0	1	1	2	2
10	1	1	1	2	3	5	8	11	13	14
TOTAL	39	64	119	221	350	426	424	363	295	242

Esc exit compute process
t i m e s p
l a t e r

y e a r l i e r
D i s p l a y

TOTAL DISCHARGE TO "C"
IS BY WAY OF "E" & "F"

GENEVA ACCESS

Comparison of Existing Culverts

"G", "E", "D", "B", "A"

1/20/94

Assume all flowing full, both ends submerged, $H = \Delta$ surface elevations, ft.

Culvert calcs.
Sht. 1 of 4

$$v = \sqrt{\frac{H}{\frac{(1+K_e)}{2g} + \frac{n^2 L}{2.21 R^{4/3}}}}$$

K_e = Entry loss coeff.

n = roughness coeff.

L = Length of culvert, ft.

$R = \frac{A_p}{P} = \frac{\text{flow cross-section}}{\text{wetted perimeter}}$, ft.

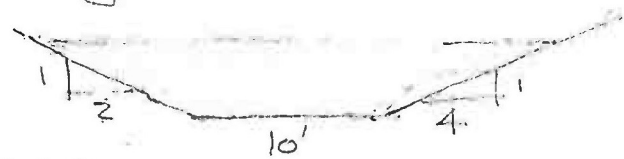
Flow $Q = Av = \text{Area} \times \text{Vel.} = \text{cfs.}$

wetted perimeter, ft.

Culvert	H	A	P	R	1+K _e	$\frac{1+K_e}{2g}$	n	L	$R^{4/3}$	$\frac{n^2 L}{2.21 R^{4/3}}$	n^2	v	Q	REMARKS
"G"	1.5	2(12.6)	2(12.6)	1.0	1.50	0.023	.024	40	1.	0.010	45.5	6.75	170.	See Sht. 3
"E"	1.5	2(29.4)	2(22.4)	1.31	1.50	0.023	.013	20	1.43	0.001	62.5	7.91	465.	clogged 25% now
"D"	1.5	2(29.4)	2(22.4)	1.31	1.50	0.023	.013	40	1.43	0.002	60.0	7.75	455.	clogged 25% now
"B"	1.5	32.4	25.4	1.28	1.50	0.023	.025	10	1.39	0.002	60.0	7.75	251.	debris @ 1' over soffit
"A"	1.5	76.8	36.8	2.09	1.50	0.023	.013	60	2.67	0.002	60.0	7.75	595.	now almost clean'
add'l areas contribution $\frac{100.4}{495}$														

GENEVA ACCESS.

What general water surface slope would accommodate a flow of 426 cfs in an earthen channel of the following approx. configuration?



$$V = \frac{(1.49) R^{2/3} S^{1/2}}{n}$$

$$\sqrt{S} = \frac{nV}{(1.49) R^{2/3}}$$

Trial Depth	A	p.	R.	n	V	$R^{2/3}$	$\sqrt{S}$	S
5'	125	41.8	3.0	0.05	3.4	2.08	.0549	0.003
5'				0.04			.0439	0.002
5'				0.03			.0329	0.001
4.5'	106	38.6	2.75	0.05	4.02	1.96	.0688	0.005
4.5'				0.04			.0550	0.003
4.5'				0.03			.0413	0.002

Comment

The general slope of the stream bed was determined by survey (see Exhibit) to be approx - 0.0042. If stream flow demand is - 0.0020

Balance avail.

for head losses = 0.0022

Length of waterway = 2100 ft.

Head avail. for

5 culverts = 4.62 ft.

Avg. available

per culvert = 0.92

Say 1 ft.

Since pipe flow velocities are $\sim \sqrt{H}$, capacities

calculated on Sht. 1 can be reworked by $\sqrt{\frac{1}{1.5}} = \sqrt{.67} = 0.82 \times \text{calc. values}$

("G" head is not involved) "E" $\approx$ "D" $\approx$ 460 cfs.

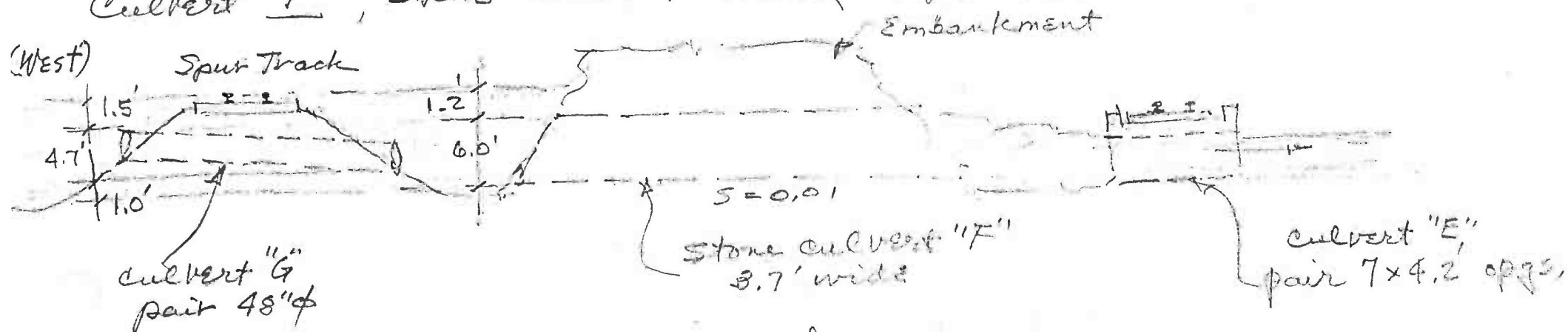
$\times 0.82$

377 cfs. probable exemplary culvert flow.

E-2

Culvert "F", STONE CULVERT UNDER B & O RR.

1/20/94
Culvert calcs.
Sht. 3 of 4



Washout of ballast and ties indicates that in recent hydrologic time the spur track was topped. Since the track is nearly level, culvert capacity at moment of topping was as per calc. on Sht. E-1 = 170 cfs.

Flow thru "F":

Practically pipe flow, but reduce to $H_{above\ of\ g} = (1 + K_e) \frac{V^2}{2g}$

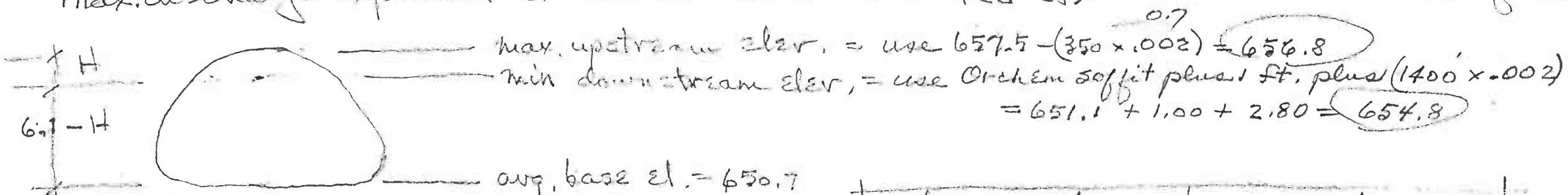
$$\text{If } K_e = 0.5, \\ V = 6.5 \sqrt{H}$$

H	n	A	Q
1.2	7.1	22.2	158 cfs
2.2	9.6		214
3.2	11.6		258
4.2	13.3		296

Range of max. expectations based on ponding upstream of B & O (C & O) RR Culvert

See TABULAR HYDROGRAPH EXHIBITS
 Max. discharge expected at culvert location = 426 cfs.

1/20/94
 Culvert Calc.
 Sht. 4 of 4



not flowing full except just inside entry, entrance shape to reduce $K_e = 0.3$
 Rough estimate, $V = \sqrt{\frac{2gH}{1 + K_e}} = \sqrt{\frac{(64.4)(2)}{1.3}} = \sqrt{99} = 9.95 \text{ fps}$, a little high, $\Delta H = 2'$

Reducing vel. to a lesser value;
 if $H = 1.5$ $V = \sqrt{\frac{1.5}{2}} \times 9.95 = 8.6 \text{ fps}$.

Area req'd = $\frac{426}{8.6} = 49.5 \text{ ft}^2$ @ 4.6' of flow

Armed 10'-8" x 6'-11" - 5' x 1' - Pipe Arch should about meet this req't (equiv $\phi = 9'-0" \phi$)
 Have possibility of setting access road elev. w/ 27' of cover?

Barely OK -

650.7
7.0 rise
2.25 cover
659.95 ± El.
road surface

Max. grade up to arch from intersection = 4%:
 $.04 \times 40' = 1.60'$

658.3
 659.9

Put culvert pipe on a slope of 0.0042