

PROFESSIONAL
ENGINEERING
CONSULTANTS
PROFESSIONAL ASSOCIATION

DRAINAGE PLAN
AND
SUPPORTING CALCULATIONS

FOR
NORTHBOROUGH 3RD ADDITION
TO WICHITA, SEDGWICK COUNTY, KANSAS

PREPARED BY
PROFESSIONAL ENGINEERING CONSULTANTS, P.A.
ENGINEERS
WICHITA, KANSAS

JUNE 20, 1986



Date June 18, 1986 Page 1 of 16

Project Northborough 3rd Addition

Item Drainage Plan

STORM SEWER SYSTEM 100

Determine Areas:

Node Plan Units Area SF Area Acres

104 723 115,680 2.7

103 2233 357,280 8.2

102 937 149,920 3.4

101 Manhole

100 Outlet

206 717 114,720 2.6

205 2230 356,800 8.2

204 Manhole

203 1550 248,000 5.7

202 979 156,640 3.6

201 Manhole

200 Outlet

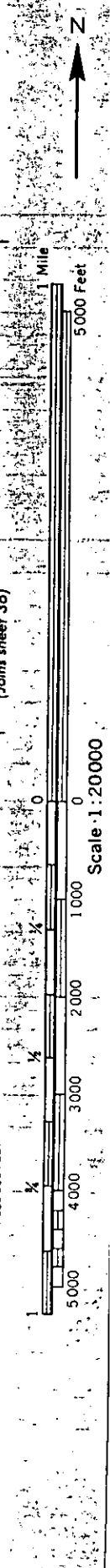
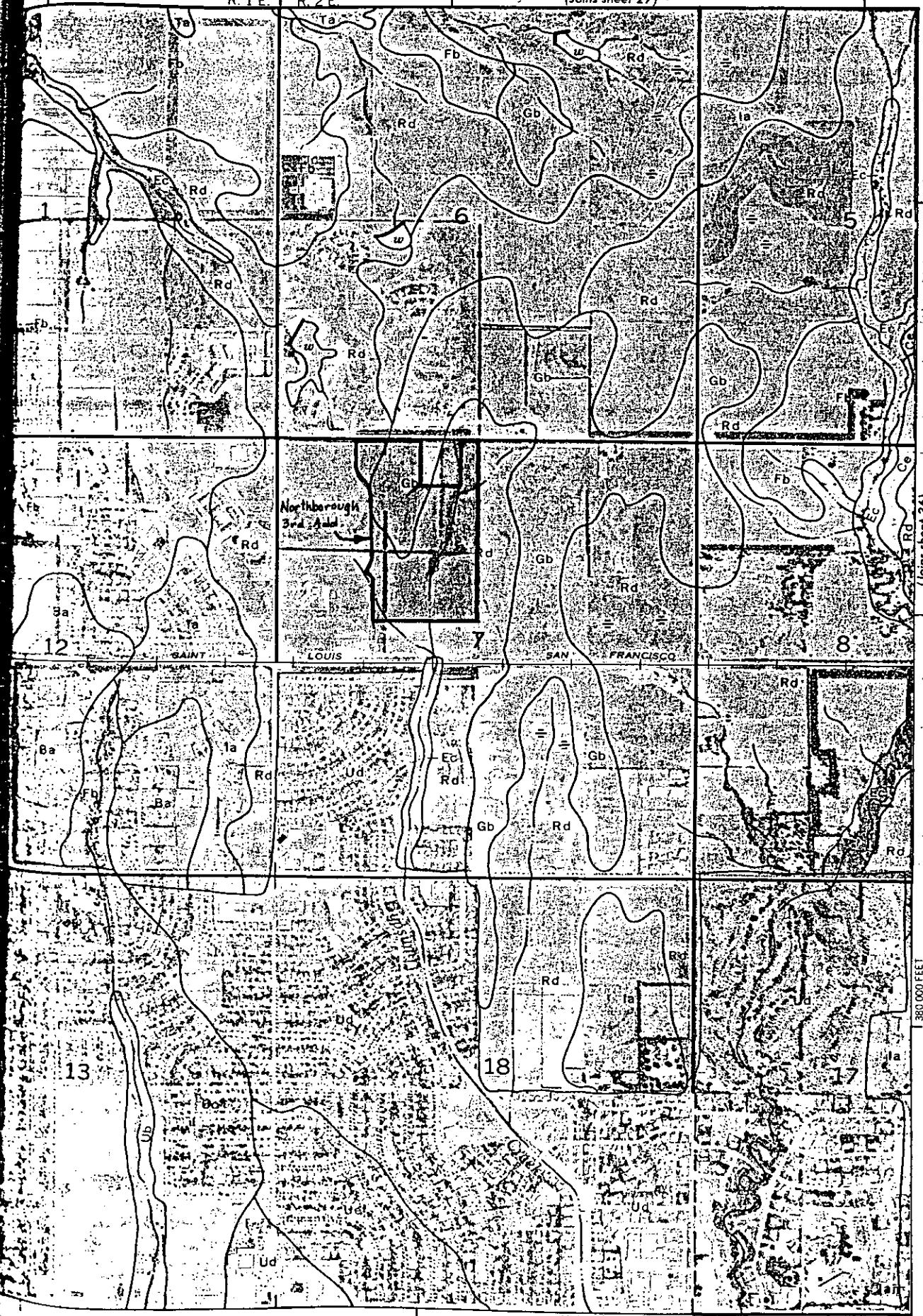
Use Rational Method For All Sub-Basins

From page 2, soil type = D

R. 1 E.

R. 2 E.

(Joins sheet 27)



Soil Types Gb D
Rd D

Northborough 3rd Alld.
Drainage Plan

(Joins sheet 43)

2 JOINS SHEET



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Project Northborough 3rd Addition

Item Drainage Plan.

Determine Runoff Coefficients For Each Sub-Basin
(2-year)

<u>Node</u>	<u>Land Use</u>	<u>%</u>	<u>C</u>	<u>Composite C</u>
104	Offices / Clinics	77	0.68	
	Street R-O-W	23	0.87	0.72
103	Offices / Clinics	85	0.68	
	Street R-O-W	15	0.87	0.71
102	Unknown off site	88	0.52	
	Street R-O-W	12	0.87	0.56
101, 100	Manhole & Outlet			
203	Offices / Clinics	86	0.68	
	Street R-O-W	14	0.87	0.71
205	Financial Institutions	28	0.68	
	Offices / Clinics	61	0.68	
	Street R-O-W	11	0.87	0.70
206	Multi-Family (Apt)	65	0.70	
	Street R-O-W	35	0.87	0.76
204	- (Manhole) -			
202	Multi-Family (Apt)	76	0.70	
	Street R-O-W	24	0.87	0.74
201, 200	Manhole & Outlet			



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Project Northborough 3rd Addition

Item Drainage Plan.

Determine Runoff Coefficients For Each Sub-Basin (100-year)

Node	Land Use	%	c	Composite c
104	Offices / Clinics	77	0.80	0.83
	Street R.O.W	23	0.93	
103	Offices / Clinics	85	0.80	0.82
	Street R.O.W	15	0.93	
102	Unknown off site	88	0.68	0.71
	Street R.O.W	12	0.93	
101, 100	Manhole & Outlet			
203	Offices / Clinics	86	0.80	0.82
	Street R.O.W	14	0.93	
205	Financial Institutions	28	0.80	0.81
	Offices / Clinics	61	0.80	
	Street R.O.W	11	0.93	
206	Multi-Family (Apt)	65	0.86	0.88
	Street R.O.W	35	0.93	
204	— (Manhole) —			
202	Multi-Family (Apt)	76	0.86	0.88
	Street R.O.W	24	0.93	
201, 200	Manhole & Outlet			



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Project Northborough 3rd Addition

Item Drainage Plan

Assume $t_c = 15$ minutes for each sub-basin.

$I_2 = 3.83$ $I_{100} = 7.37$

Node	C_u	I_2	A	Q_2
104	0.72	3.83	2.7	7.4
103	0.71	3.83	8.2	22.3
1102	0.56	3.83	3.4	7.3
101 & 100	Manhole & outlet			
203	0.71	3.83	5.7	15.5
205	0.70	3.83	8.2	22.0
206	0.76	3.83	2.6	7.6
204	Manhole			
202	0.74	3.83	3.6	10.2
201, 200	Manhole & outlet			



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Project Northborough 3rd Addition

Item Drainage Plan

Node	$C_{100} *$	$I_{100} *$	A	=	Q_{100}
104	0.83	7.37	2.7		16.5
103	0.82	7.37	8.2		49.6
102	0.71	7.37	3.4		17.8
101, 100	Manhole + Outlet				
203	0.82	7.37	5.7		34.4
205	0.81	7.37	8.2		49.0
206	0.88	7.37	2.6		16.9
204	Manhole				
202	0.88	7.37	3.6		23.3
201, 200	Manhole + Outlet				



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Project Northborough 3rd Addition

Item Drainage Plan.

Defermine

Node	Q_2	Inlet Condition	$Q \neq$ approach	L	L_T^*	E^{**}	$Q_{int.}$	Q_{bypass}	to
104	7.4	On grade	7.4	5'	28'	32%	2.4	5.0	Node 203
103	22.3	Sump	22.3	10'		100%	22.3	0.0	-
102	7.3	On grade	7.3	10'	28'	55%	4.0	3.3	Node 202
101, 100	Manhole +	Outlet							
203	15.5	Sump	$15.5 + 5.0 = 20.5$	10'		100%	20.5	0.0	-
205	22.0	Sump	22.0	10'		100%	22.0	0.0	-
206	7.6	Sump	7.6	5'		100%	7.6	0.0	-
204	-	Manhole	-	-		-	-	-	-
202	10.2	Sump	$10.2 + 3.3 = 13.5$	10'		100%	13.5	0.0	-
201, 200	Manhole +	Outlet							

* approach $Q = Q_2 + Q_{bypass}$ from other nodes
 (this Q used in 5 form sewer program)

* see page 16

** see page 15

April 15, 1986

ATTACHMENT A
DRAINAGE CRITERIA MANUAL

CITY OF WICHITA, KANSAS

RAINFALL INTENSITY TABLE FOR SEDGWICK COUNTY, KANSAS

The following tabulation contains rainfall intensity in inches per hour as derived from ESSA Weather Bureau Technical Paper 40 Modified to NWS Hydro-35, 1977 During First Hour

DURATION IN MINUTES	RETURN PERIODS OF						
	1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
5	4.18	5.57	6.53	7.41	8.52	9.48	10.32
6	3.99	5.32	6.25	7.09	8.16	9.09	9.89
7	3.81	5.09	5.99	6.81	7.84	8.74	9.50
8	3.66	4.89	5.75	6.55	7.55	8.42	9.15
9	3.52	4.70	5.54	6.31	7.28	8.13	8.83
10	3.39	4.52	5.34	6.09	7.04	7.86	8.54
11	3.27	4.36	5.16	5.89	6.81	7.61	8.27
12	3.18	4.21	4.99	5.71	6.60	7.38	8.02
13	3.05	4.08	4.84	5.53	6.41	7.17	7.79
14	2.96	3.95	4.69	5.37	6.23	6.97	7.57
15	2.87	3.83	4.56	5.22	6.06	6.78	7.37
16	2.78	3.72	4.43	5.08	5.90	6.60	7.18
17	2.71	3.61	4.31	4.95	5.75	6.44	7.00
18	2.63	3.51	4.20	4.83	5.61	6.29	6.84
19	2.56	3.42	4.10	4.71	5.47	6.14	6.68
20	2.50	3.33	4.00	4.60	5.35	6.00	6.53
21	2.44	3.25	3.90	4.50	5.23	5.87	6.39
22	2.38	3.17	3.81	4.40	5.12	5.75	6.26
23	2.32	3.10	3.73	4.31	5.01	5.63	6.13
24	2.27	3.03	3.65	4.22	4.91	5.52	6.01
25	2.22	2.96	3.57	4.13	4.81	5.41	5.90
26	2.20	2.90	3.50	4.05	4.72	5.31	5.79
27	2.16	2.84	3.43	3.98	4.63	5.21	5.69
28	2.14	2.78	3.37	3.90	4.55	5.12	5.59
29	2.11	2.72	3.30	3.83	4.47	5.03	5.49
30	2.08	2.67	3.24	3.76	4.39	4.94	5.40
31	2.05	2.62	3.19	3.70	4.32	4.86	5.32
32	2.02	2.57	3.10	3.63	4.25	4.79	5.22
33	1.99	2.52	3.05	3.57	4.18	4.71	5.14
34	1.96	2.48	3.01	3.51	4.11	4.63	5.07
35	1.93	2.44	2.98	3.46	4.05	4.56	5.00
36	1.91	2.39	2.93	3.41	3.99	4.50	4.93
37	1.89	2.35	2.88	3.36	3.93	4.43	4.86
38	1.87	2.32	2.84	3.31	3.87	4.37	4.79
39	1.85	2.28	2.80	3.26	3.82	4.31	4.73
40	1.83	2.24	2.76	3.22	3.76	4.25	4.66
41	1.81	2.21	2.72	3.17	3.71	4.19	4.60
42	1.79	2.18	2.68	3.13	3.66	4.13	4.54
43	1.77	2.14	2.64	3.09	3.61	4.08	4.49
44	1.75	2.11	2.61	3.05	3.57	4.03	4.43
45	1.73	2.08	2.57	3.01	3.52	3.98	4.38

ATTACHMENT A CONTINUED
Page 2

<u>DURATION IN MINUTES</u>	<u>RETURN PERIODS OF</u>						
	<u>1-YR</u>	<u>2-YR</u>	<u>5-YR</u>	<u>10-YR</u>	<u>25-YR</u>	<u>50-YR</u>	<u>100-YR</u>
46	1.70	2.05	2.54	2.97	3.48	3.93	4.33
47	1.67	2.02	2.50	2.93	3.44	3.88	4.28
48	1.66	2.00	2.47	2.90	3.39	3.84	4.23
49	1.64	1.97	2.44	2.86	3.35	3.79	4.18
50	1.61	1.95	2.41	2.83	3.32	3.75	4.13
51	1.59	1.92	2.38	2.79	3.28	3.71	4.09
52	1.56	1.89	2.35	2.76	3.24	3.67	4.05
53	1.54	1.86	2.33	2.73	3.20	3.63	4.00
54	1.52	1.84	2.30	2.70	3.17	3.59	3.96
55	1.50	1.81	2.27	2.67	3.14	3.55	3.92
56	1.47	1.79	2.25	2.64	3.10	3.51	3.88
57	1.45	1.76	2.22	2.61	3.07	3.48	3.84
58	1.43	1.74	2.20	2.59	3.04	3.44	3.81
59	1.42	1.72	2.18	2.56	3.01	3.41	3.77
60	1.40	1.69	2.15	2.53	2.98	3.37	3.73
61	1.38	1.67	2.13	2.51	2.95	3.34	3.70
62	1.36	1.65	2.11	2.48	2.92	3.31	3.67
63	1.34	1.63	2.09	2.46	2.89	3.28	3.63
64	1.33	1.61	2.07	2.44	2.86	3.25	3.60
65	1.31	1.59	2.05	2.41	2.84	3.22	3.57
66	1.30	1.57	2.03	2.39	2.81	3.19	3.54
67	1.28	1.56	2.01	2.37	2.79	3.16	3.51
68	1.26	1.54	1.99	2.35	2.76	3.13	3.48
69	1.25	1.52	1.97	2.33	2.74	3.10	3.45
70	1.24	1.50	1.95	2.31	2.71	3.08	3.42
71	1.22	1.49	1.93	2.28	2.69	3.05	3.39
72	1.21	1.47	1.92	2.26	2.67	3.02	3.36
73	1.20	1.46	1.90	2.25	2.64	3.00	3.34
74	1.18	1.44	1.88	2.23	2.63	2.98	3.31
75	1.17	1.43	1.86	2.21	2.61	2.95	3.29
76	1.16	1.41	1.85	2.19	2.58	2.93	3.26
77	1.15	1.40	1.83	2.17	2.55	2.90	3.24
78	1.13	1.38	1.82	2.15	2.53	2.88	3.22
79	1.12	1.37	1.80	2.14	2.50	2.86	3.19
80	1.11	1.36	1.79	2.12	2.48	2.84	3.16
81	1.10	1.34	1.77	2.10	2.46	2.82	3.13
82	1.09	1.33	1.76	2.08	2.43	2.79	3.10
83	1.08	1.32	1.74	2.06	2.41	2.76	3.07
84	1.07	1.31	1.73	2.04	2.39	2.74	3.04
85	1.06	1.30	1.72	2.02	2.37	2.71	3.01
86	1.05	1.28	1.70	2.00	2.34	2.69	2.99
87	1.04	1.27	1.69	1.99	2.32	2.66	2.96
88	1.03	1.26	1.68	1.97	2.30	2.64	2.93
89	1.02	1.25	1.68	1.95	2.28	2.62	2.91
90	1.01	1.24	1.66	1.93	2.26	2.59	2.88

ATTACHMENT A CONTINUED
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<u>DURATION IN MINUTES</u>	<u>RETURN PERIODS OF</u>						
	<u>1-YR</u>	<u>2-YR</u>	<u>5-YR</u>	<u>10-YR</u>	<u>25-YR</u>	<u>50-YR</u>	<u>100-YR</u>
91	1.00	1.23	1.65	1.92	2.24	2.57	2.86
92	1.00	1.22	1.63	1.90	2.22	2.55	2.83
93	0.99	1.21	1.62	1.89	2.20	2.53	2.81
94	0.98	1.20	1.61	1.87	2.19	2.51	2.79
95	0.97	1.19	1.59	1.85	2.17	2.49	2.76
96	0.96	1.18	1.58	1.84	2.15	2.46	2.74
97	0.96	1.17	1.57	1.82	2.13	2.44	2.72
98	0.95	1.16	1.56	1.81	2.12	2.42	2.70
99	0.94	1.15	1.54	1.80	2.10	2.41	2.67
100	0.93	1.14	1.53	1.78	2.08	2.39	2.65
101	0.93	1.13	1.52	1.77	2.07	2.39	2.65
102	0.92	1.13	1.51	1.75	2.05	2.35	2.61
103	0.91	1.12	1.50	1.74	2.04	2.33	2.59
104	0.90	1.11	1.49	1.73	2.02	2.31	2.57
105	0.90	1.10	1.47	1.72	2.01	2.30	2.55
106	0.89	1.09	1.46	1.70	1.99	2.28	2.54
107	0.88	1.09	1.45	1.69	1.98	2.26	2.52
108	0.88	1.08	1.44	1.68	1.96	2.25	2.50
109	0.87	1.07	1.43	1.67	1.95	2.23	2.48
110	0.87	1.06	1.42	1.65	1.93	2.21	2.46
111	0.86	1.06	1.41	1.64	1.92	2.20	2.45
112	0.85	1.05	1.40	1.63	1.91	2.18	2.43
113	0.85	1.04	1.39	1.62	1.89	2.17	2.41
114	0.84	1.03	1.38	1.61	1.88	2.15	2.40
115	0.84	1.03	1.37	1.60	1.87	2.14	2.38
116	0.83	1.02	1.36	1.59	1.86	2.12	2.36
117	0.82	1.01	1.36	1.58	1.84	2.11	2.35
118	0.82	1.01	1.35	1.57	1.83	2.09	2.33
119	0.81	1.00	1.34	1.56	1.82	2.08	2.32
120	0.81	0.99	1.33	1.55	1.81	2.07	2.30

<u>DURATION IN HOURS</u>	<u>RETURN PERIODS OF</u>						
	<u>1-YR</u>	<u>2-YR</u>	<u>5-YR</u>	<u>10-YR</u>	<u>25-YR</u>	<u>50-YR</u>	<u>100-YR</u>
2	0.81	0.99	1.33	1.55	1.81	2.07	2.30
3	0.59	0.72	0.97	1.13	1.32	1.51	1.68
4	0.47	0.58	0.78	0.91	1.06	1.21	1.35
5	0.40	0.49	0.66	0.77	0.89	1.02	1.14
6	0.35	0.42	0.57	0.67	0.78	0.89	0.99
8	0.28	0.34	0.46	0.53	0.62	0.71	0.79
10	0.23	0.29	0.39	0.45	0.52	0.60	0.67
12	0.20	0.25	0.33	0.39	0.45	0.52	0.58
18	0.15	0.18	0.24	0.28	0.33	0.38	0.42
24	0.12	0.15	0.20	0.23	0.27	0.31	0.34

ATTACHMENT D

DRAINAGE CRITERIA

CITY OF WICHITA, KANSAS

RECOMMENDED RUNOFF COEFFICIENTS FOR RATIONAL METHOD AND PERCENT IMPERVIOUS FOR UNIT HYDROGRAPH METHOD

Land Use or Surface Characteristics	Percent Impervious	Frequency			
		2	5	10	100
1. Business:					
Downtown Areas	95	0.84	0.85	0.87	0.91
Neighborhood Areas	70	0.68	0.69	0.73	0.80
2. Residential:					
<u>Single Family (Soil Group D)</u>					
1/8 Acre	50	0.57	0.61	0.66	0.79
1/4 Acre	38	0.50	0.54	0.62	0.76
1/3 Acre	30	0.46	0.50	0.59	0.73
1/2 Acre	25	0.42	0.48	0.56	0.72
3/4 Acre	22	0.42	0.46	0.55	0.71
1 Acre	20	0.41	0.45	0.54	0.71
<u>Multi-Family (Soil Group D)</u>					
Multi-Unit (detached)	60	0.62	0.66	0.72	0.82
Multi-Unit (attached)	65	0.64	0.68	0.73	0.83
Apartments	75	0.70	0.73	0.79	0.86
<u>Single Family (Soil Group C)</u>					
1/8 Acre	50	0.55	0.58	0.64	0.73
1/4 Acre	38	0.48	0.51	0.57	0.68
1/3 Acre	30	0.43	0.46	0.53	0.65
1/2 Acre	25	0.40	0.43	0.50	0.63
3/4 Acre	22	0.39	0.42	0.49	0.62
1 Acre	20	0.37	0.40	0.48	0.61
<u>Multi-Family (Soil Group C)</u>					
Multi-Unit (detached)	60	0.60	0.63	0.69	0.77
Multi-Unit (attached)	65	0.63	0.66	0.71	0.79
Apartments	75	0.68	0.72	0.77	0.83
<u>Single-Family (Soil Group B)</u>					
1/8 Acre	50	0.52	0.54	0.59	0.67
1/4 Acre	38	0.44	0.46	0.52	0.61
1/3 Acre	30	0.39	0.41	0.47	0.57
1/2 Acre	25	0.36	0.38	0.44	0.54
3/4 Acre	22	0.34	0.36	0.42	0.52
1 Acre	20	0.33	0.35	0.40	0.51
<u>Multi-Family (Soil Group B)</u>					
Multi-Unit (detached)	60	0.58	0.60	0.65	0.72
Multi-Unit (attached)	65	0.61	0.64	0.68	0.75
Apartments	75	0.67	0.70	0.74	0.80

Land Use or Surface Characteristics	Percent Impervious	Frequency			
		<u>2</u>	<u>5</u>	<u>10</u>	<u>100</u>
<u>Single Family (Soil Group A)</u>					
1/8 Acre	50	0.47	0.50	0.54	0.60
1/4 Acre	38	0.39	0.41	0.45	0.52
1/3 Acre	30	0.33	0.35	0.39	0.47
1/2 Acre	25	0.30	0.31	0.35	0.44
3/4 Acre	22	0.28	0.29	0.33	0.42
1 Acre	20	0.26	0.28	0.32	0.40
<u>Multi-Family (Soil Group A)</u>					
Multi-Unit (detached)	60	0.55	0.57	0.61	0.67
Multi-Unit (attached)	65	0.58	0.60	0.64	0.70
Apartments	75	0.65	0.68	0.72	0.77
3. Industrial:					
Light Areas	70	0.68	0.69	0.73	0.80
Heavy Areas	80	0.74	0.76	0.79	0.84
4. Playgrounds:					
	15	0.33	0.35	0.42	0.55
5. Schools:					
	40	0.49	0.51	0.56	0.66
6. Railroad Yard Areas:					
	30	0.43	0.45	0.50	0.62
7. Undeveloped Urban Areas: Offsite Flow Analysis (when land use not defined)					
	45	0.52	0.54	0.59	0.68
8. Streets:					
Paved	99	0.87	0.88	0.90	0.93
Gravel	00	0.24	0.26	0.33	0.48
9. Drive, Parking Lots and Walks:					
	96	0.87	0.87	0.88	0.89
10. Roofs:					
	90	0.80	0.85	0.90	0.93
11. Urban Lawn Areas (See Note No. 1 below):					
<u>Soil Group A</u>					
Slope less than 1%	00	0.08	0.09	0.13	0.23
Slope 1% to 4%	00	0.12	0.13	0.17	0.27
Slope more than 4%	00	0.16	0.17	0.21	0.31
<u>Soil Group B</u>					
Slope less than 1%	00	0.16	0.18	0.24	0.37
Slope 1% to 4%	00	0.20	0.22	0.28	0.41
Slope more than 4%	00	0.24	0.26	0.32	0.45
<u>Soil Group C</u>					
Slope less than 1%	00	0.24	0.27	0.35	0.51
Slope 1% to 4%	00	0.26	0.29	0.37	0.53
Slope more than 4%	00	0.28	0.31	0.39	0.55

Land Use or Surface Characteristics	Percent Impervious	Frequency			
		<u>2</u>	<u>5</u>	<u>10</u>	<u>100</u>
<u>Soil Group D</u>					
Slope less than 1%	00	0.28	0.33	0.43	0.63
Slope 1% to 4%	00	0.30	0.35	0.45	0.65
Slope more than 4%	00	0.32	0.37	0.47	0.67

Note No. 1: Coefficients shown in the above table are for pervious open space areas with thick turf which includes pervious areas in parks and cemeteries. Coefficients shown above must be increased 0.02 for use with agricultural pasture areas. Coefficients shown above must be reduced by 0.04 for use with agricultural cultivated areas. Group A soils are well-drained, coarse textured sands with high infiltration rates. Group B soils are moderately well-drained, moderately coarse textured soils with moderate infiltration rates. Group C soils are moderately poor-drained, moderately fine textured soils with slow infiltration rates. Group D soils are poor-drained, fine textured soils with very slow infiltration rates.

GENERAL NOTE: These Rational Formula Coefficients may not be valid for basins 320 acres or larger.

EXHIBIT NO. 1

SOIL LEGEND

<u>SYMBOL</u>	<u>HYDROLOGIC GROUP</u>	<u>NAME</u>
Aa	B	Albion-Shellabarger sandy loams, 1 to 4 percent slopes
Ab	B	Albion and Shellabarger sandy loams, 7 to 15 percent slopes
Ba	C	Blanket silt loam, 0 to 1 percent slopes
Bb	C	Blanket silt loam, 1 to 3 percent slopes
Ca	B	Canadian fine sandy loam
Cb	B	Canadian-Waldeck fine sandy loams
Cc	D	Carwile fine sandy loam
Cd	B	Clark-Ost clay loams, 1 to 4 percent slopes
Ce	C	Clime silty clay, 3 to 6 percent slopes
Ea	B	Elandco silt loam
Eb	B	Elandco silt loam, occasionally flooded
Ec	B	Elandco silt loam, frequently flooded
Fa	B	Farnum loam, 0 to 1 percent slopes
Fb	B	Farnum loam, 1 to 3 percent slopes
Fc	B	Farnum loam, sandy substratum, 0 to 1 percent slopes
Ga	D	Goessel silty clay, 0 to 1 percent slopes
Gb	D	Goessel silty clay, 1 to 2 percent slopes
Ia	D	Irwin silty clay loam, 1 to 3 percent slopes
Ib	D	Irwin silty clay loam, 3 to 6 percent slopes
Ic	D	Irwin silty clay loam, 2 to 6 percent slopes, eroded
La	C	Lesho loam
Lb	A	Lincoln soils
Ma	B	Milan loam, 1 to 3 percent slopes
Mb	B	Milan form, 3 to 6 percent slopes
Mc	B	Milan clay loam, 2 to 6 percent slopes, eroded
Na	B	Naron fine sandy loam
Oc	D	Owens clay loam, 1 to 3 percent slopes
Od	D	Owens-Rock outcrop complex, 3 to 10 percent slopes
Pa		Pits
Pb	D	Plevna fine sandy loam
Pc	A	Pratt loamy fine sand, undulating
Pd	A	Pratt-Tivoli complex, rolling
Ra	D	Renfrow silty clay loam, 1 to 3 percent slopes
Rb	D	Renfrow silty clay loam, 3 to 6 percent slopes
Rc	D	Renfrow-Owens clay loams, 1 to 4 percent slopes
Rd	D	Rosehill silty clay, 1 to 3 percent slopes
Sa	B	Shellabarger sandy loam, 1 to 3 percent slopes
Sb	B	Shellabarger sandy loam, 3 to 6 percent slopes
Sc	B	Shellabarger sandy loam, 3 to 6 percent slopes, eroded
Ta	D	Tabler silty clay loam
Tb	D	Tabler-Drummond complex
Ua	B	Urban land-Canadian complex
Ub	B	Urban land-Elandco complex
Uc	B	Urban land-Farnum complex, 0 to 3 percent slopes
Ud	D	Urban land-Irwin complex, 1 to 3 percent slopes
Ue	D	Urban land-Tabler complex
Va	B	Vanoss silt loam, 0 to 1 percent slopes
Vb	B	Vanoss silt loam, 1 to 3 percent slopes
Vc	B	Vanoss silt loam, 3 to 6 percent slopes
Vd	B	Vanoss silt loam, 3 to 6 percent slopes, eroded
Ve	D	Vernon sandy loam, 1 to 3 percent slopes
Vf	D	Vernon sandy loam, 3 to 6 percent slopes
Wa	C	Waldeck sandy loam
Wb	D	Waurika silt loam

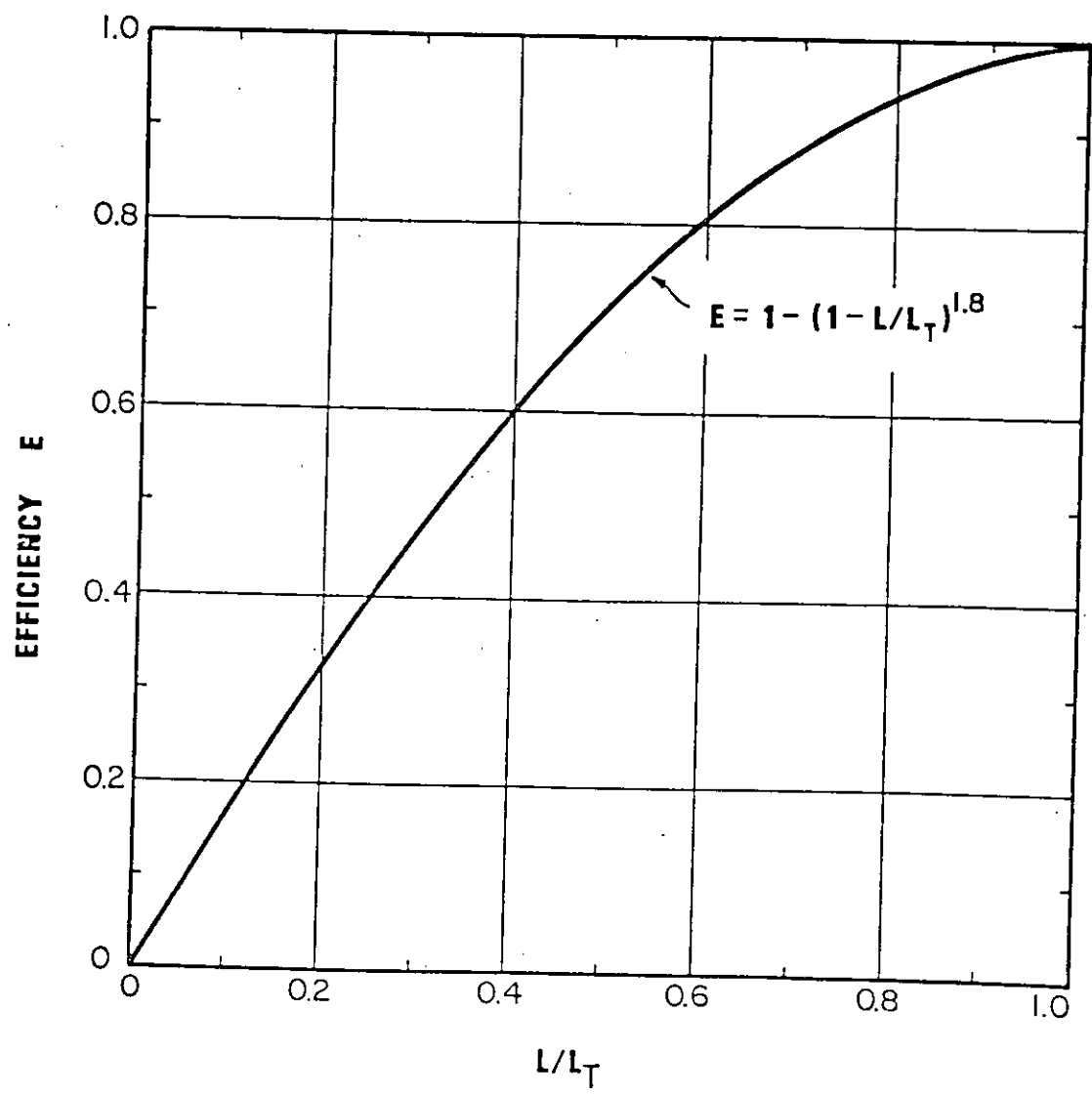


CHART 10. Curb-opening and slotted drain inlet interception efficiency.

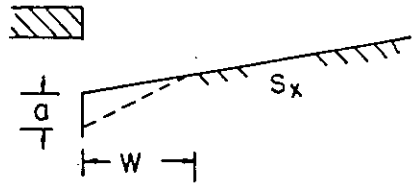
FROM HES-10, DRAINAGE OF HIGHWAY PAVEMENTS, FHWA, Mar. 1954

Northborough 3rd Addition
Drainage Plan.

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$S_x = 3/8" / ft = 0.03125$

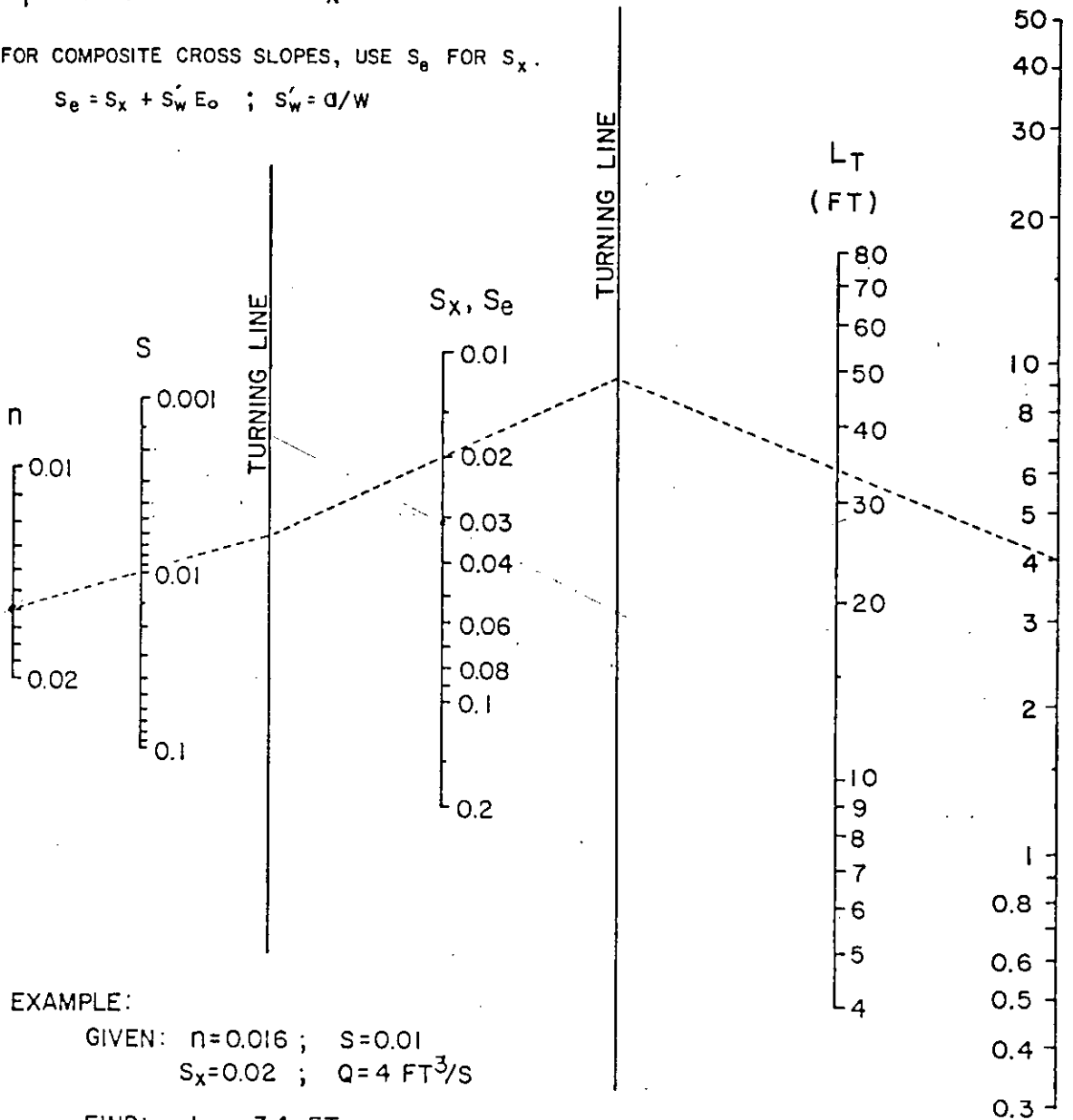
$n = 0.016$



$L_T = 0.6Q^{0.42} S^{0.3} (1/nS_x)^{0.6}$

FOR COMPOSITE CROSS SLOPES, USE S_e FOR S_x .

$S_e = S_x + S'_w E_o$; $S'_w = d/W$



EXAMPLE:

GIVEN: $n = 0.016$; $S = 0.01$
 $S_x = 0.02$; $Q = 4 \text{ FT}^3/\text{S}$

FIND: $L_T = 34 \text{ FT}$

CHART 9. Curb-opening and slotted drain inlet length for total interception.

FROM: HSP-12, DRAINAGE OF HIGHWAY PAVEMENTS, FEDERAL, MAR. 1954.

100 j, 197.0000 100 3 5 4

110 t,northborough third addition

120 t,drainage plan

130 t,storm-sewer-system-no 100 2-year-storm

140 i, 104 0.72 2.70 0.00 0.00 7.40 15.00 204.70

150 i, 103 0.71 8.20 0.00 0.00 22.30 15.00 204.70

160 i, 102 0.56 3.40 0.00 0.00 7.30 15.00 204.70

170 m, 101 201.00

180 m, 100 197.00

190 p, 103 102 80.00 24 0.013 65.00 0.00

200 p, 104 102 40.00 19 0.013 135.00 0.00

210 p, 102 101 580.00 36 0.013 55.00 0.00

220 p, 101 100 450.00 36 0.013 0.00 0.00

230 e

Date: 06-23-1986
Time: 10:34:45

Input File: nobo100

northborough-third addition
drainage plan
storm sewer system no 100 2 year storm

Storm Frequency = 2-Year

* * * H Y D R O L O G Y * * *

Tributary Area		Hydrology Summation				Conduit Data											
Node to Node	C Area (Ac)	Slope (%)	Length (Ft)	TC (0)	I (0)	Q (0)	TC (Min)	I (In/Hr)	Q (CFS)	TC (Min)	I (In/Hr)	Q (CFS)	Conduit Size	Velocity (Ft/Sec)	Length (Ft)	IT (Min)	TT+TC (Min)
103 102	0.71	8.20	0.00	0.0	15.00	4.06	22.30	15.00	4.06	22.30	22.30	22.30	24"	7.10	80.00	0.19	15.19
104 102	0.72	2.70	0.00	0.0	15.00	4.06	7.40	15.00	4.06	7.40	7.40	7.40	18"	4.19	40.00	0.16	15.16
102 101	0.56	3.40	0.00	0.0	15.00	4.06	7.30	15.19	4.06	7.26	36.96	36.96	36"	5.23	590.00	1.68	17.07
101 100	0.00	0.00	0.00	0.0	0.00	0.00	0.00	17.07	3.86	0.00	36.96	36.96	36"	5.23	450.00	1.43	18.50

Node	Hyd-Slope (Ft/Ft)	Friction (Ft)	Bend (Ft)	Transition (Ft)	Manhole (Ft)	Deflection (Ft)	Junction (Ft)	Total (Ft)	Hyd-GI	Elevation	Desired Diff.
104	0.00476	0.1985	0.0000	0.0000	0.0000	0.0000	0.0000	0.1985	201.2639	204.7000	3.44
103	0.00772	0.7774	0.0000	0.0000	0.0000	0.0000	0.0000	0.7774	201.8398	204.7000	2.86
102	0.00307	1.8116	0.0000	0.0716	0.0000	0.2047	0.3786	2.5265	201.0624	204.7000	3.64
101	0.00307	1.3817	0.0000	0.0000	0.0212	0.1175	0.0154	1.5359	198.5339	201.0000	2.46
100	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	197.0000	197.0000	0.00

100 J, 197,000 200 3 7 6
 110 t,northborough third addition
 120 t,drainage plan

130 t,storm sewer system no 200 2-year storm

140 i,	206	0.76	2.60	0.00	0.00	7.50	15.00	203.10
150 i,	205	0.70	8.20	0.00	0.00	22.00	15.00	203.10
160 s,	204	202.20						
170 i,	203	0.71	5.70	0.00	0.00	20.50	15.00	201.00
180 i,	202	0.74	3.60	0.00	0.00	13.50	15.00	201.00
190 s,	201	200.00						
200 s,	200	197.00						
210 P,	206	205	40.00	18 0.013	50.00	0.00		
220 P,	205	204	360.00	36-0.013	40.00	0.00		
230 P,	204	202	150.00	36 0.013	60.00	0.00		
240 P,	203	202	40.00	24 0.013	0.00	0.00		
250 P,	202	201	350.00	42-0.013	45.00	0.00		
260 P,	201	200	70.00	42 0.013	0.00	0.00		
270 e								

Date: 06-23-1986
Time: 11:00:53

Input Files nobo200

northborough-third-addition
drainage plan
storm sewer system no 200 2 year storm

Storm-Frequency = 2-Year

H-Y-D-R-O-L-O-G-Y

Tributary Area		Hydrology Summation				Conduit Data											
Node to	C Area (Ac)	Slope (%)	Length (Ft)	TC (Min)	I (In/hr)	Q (CFS)	TC (Min)	Sum Q (CFS)	Size (In)	Velocity (Ft/Sec)	Length (Ft)	IT+TC (Min)					
206	205	0.76	2.60	0.00	0.0	15.00	4.06	7.60	7.60	4.06	7.60	7.60	18"	4.30	40.00	0.16	15.16
205	204	0.70	8.20	0.00	0.0	15.00	4.06	22.00	29.52	4.06	22.00	29.52	36"	4.18	300.00	1.52	16.52
204	202	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	3.91	0.00	29.52	36"	4.16	150.00	0.60	17.11
203	202	0.71	5.70	0.00	0.0	15.00	4.06	20.50	20.50	4.06	20.50	20.50	24"	6.53	40.00	0.10	15.10
202	201	0.74	3.60	0.00	0.0	15.00	4.06	13.50	17.11	3.86	12.82	61.87	42"	6.43	350.00	0.91	18.02
201	200	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	3.78	0.00	61.87	42"	6.43	70.00	0.18	18.20



Date June 20, 1986 Page 7 of 18

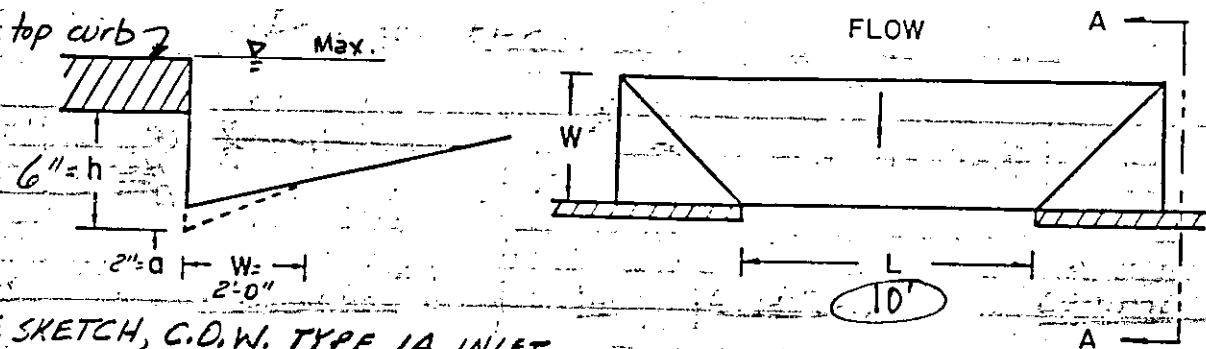
Project Northborough 3rd Addition

Item Drainage Plan

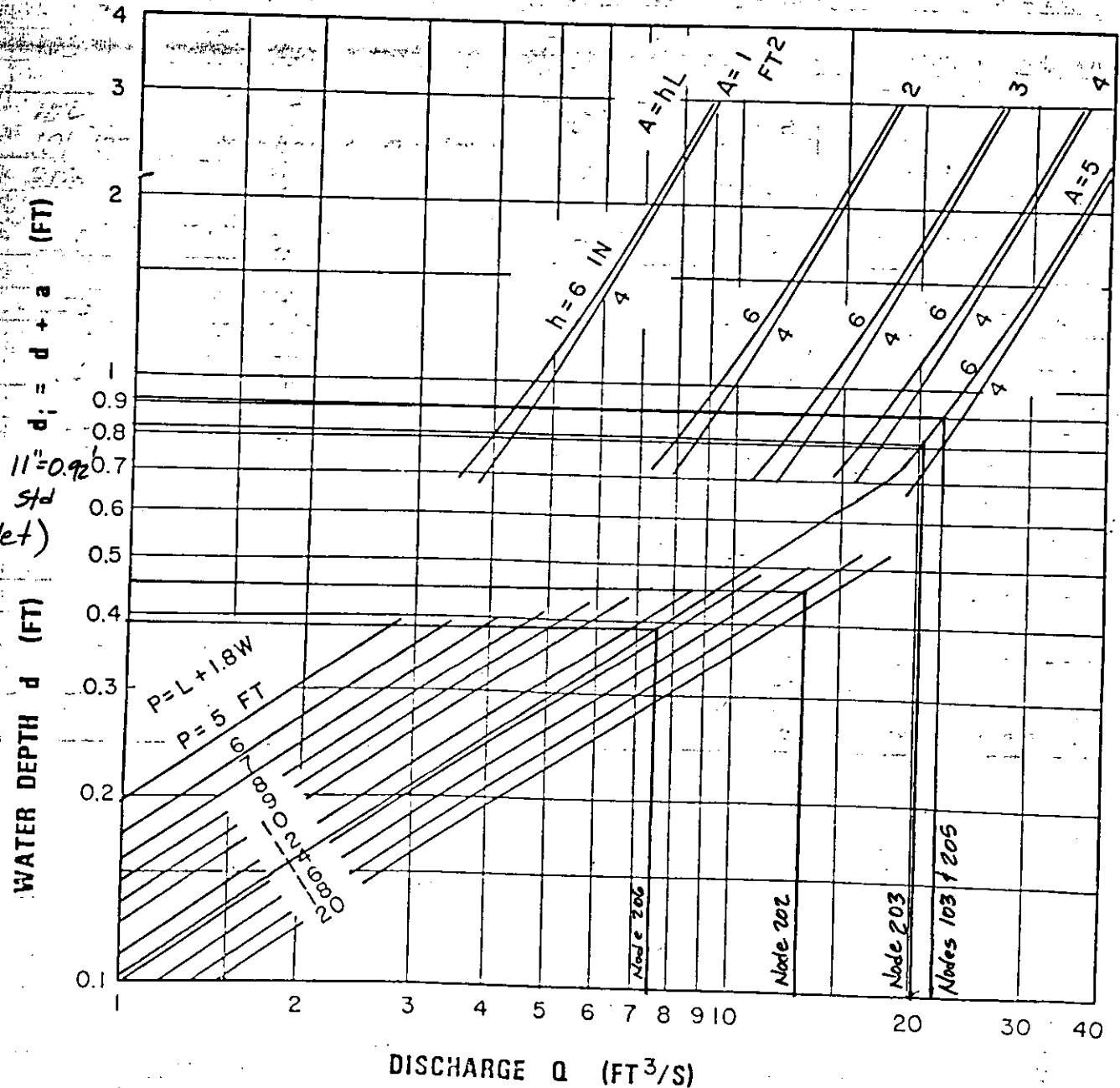
Inlet Sizes

<u>Node</u>	<u>Approach [†]</u>	<u>L</u>	<u>Inlet Condition</u>	<u>Comment</u>
104	7.4	5'	On grade	OK
103	22.3	10'	Sump	OK
102	7.3	10'	On grade	OK
101, 100	Manhole + Outlet			
203	20.5	10'	Sump	OK
205	22.0	10'	Sump	OK
206	7.6	5'	Sump	OK
204	Manhole			
202	15.5	10'	Sump	OK
201, 200	Manhole + Outlet			

[†] From page 7, Hydrology (= $Q_2 + Q_{\text{bypassed from other nodes}}$)



DEF. SKETCH, C.D.W. TYPE 1A INLET



$d_i \text{ max} = 11" = 0.92$
(per COW std
Type 1A Inlet)

CHART 12. Depressed curb-opening inlet capacity in sump locations.

FROM: HEC-12, DRAINAGE OF HIGHWAY PAVEMENTS, FHWA, MAR, 1974



Date June 20, 1986 Page 9 of 18

Project Northborough 3rd Addition

Item Drainage Plan

Check street Flow - 2yr.

Node	Q_2 approach	Flow Distribution	Street Slope	d^*	Comment
104	7.4	100% From N	0.78%	0.38	OK
103	22.3	40% From N = 8.9 cfs 60% From S = 13.4 cfs	0.78% 0.50%	0.42 0.51	OK OK
102	7.3	100% From S	0.50%	0.42	OK
101, 100	-	-	-	-	MH & Outlet
203	20.5	50% From SW = 10.3 50% From NE = 10.2	0.59% 0.52%	0.45 0.48	OK OK
205	22.0	95% From N = 20.9 cfs 5% From S = 1.1 cfs	0.96% 0.32%	0.55 0.22	OK OK
206	7.6	90% From N = 6.8 cfs 10% From S = 0.8 cfs	0.96% 0.32%	0.36 0.20	OK OK
204	-	-	-	-	Manhole
202	15.5	60% From SW = 9.3 cfs 40% From NE = 6.2 cfs	0.59% 0.52%	0.44 0.39	OK OK
201, 200	-	-	-	-	Manhole & Outlet

* see nomograph, page 7

X-slope = $\frac{1}{8}$ ft = 0.03125

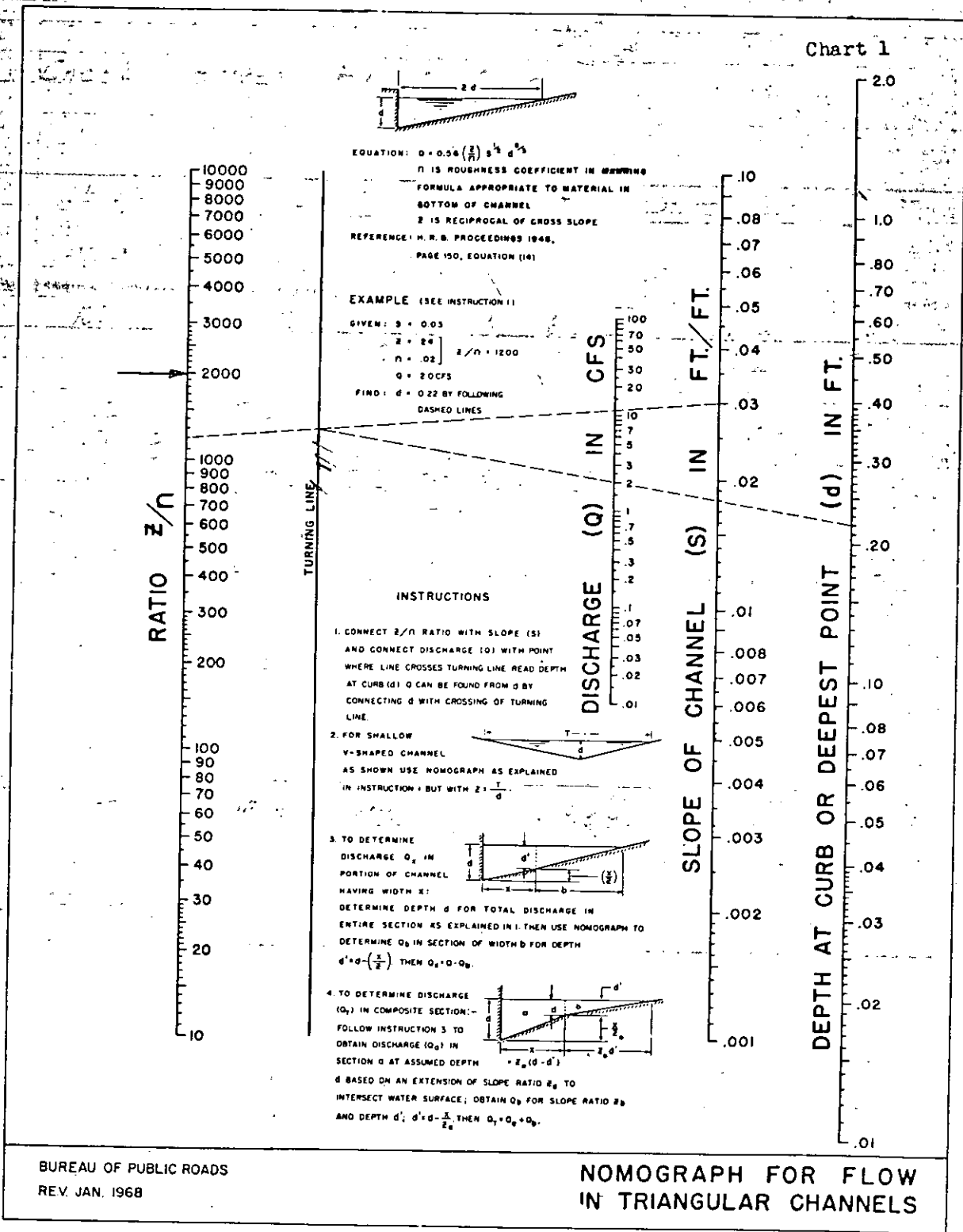
$Z = \frac{1}{0.03125} = 32$

$n = 0.016$

$\frac{Z}{n} = \frac{32}{0.016} = 2000$

Northborough 3rd Addition
Drainage Plan

10/18



100 j, 197.0000 100 3 5 4

110 t.northborough third addition

120 t.drainase plan

130 t.storm sewer system no 100 100 year storm

140 i, 104	0.83	2.70	0.00	0.00	16.50	15.00	204.70
150 i, 103	0.82	8.20	0.00	0.00	49.60	15.00	204.70
160 i, 102	0.71	3.40	0.00	0.00	17.80	15.00	204.70
170 m, 101	201.00						
180 m, 100	197.00						
190 P, 103 102	80.00	24	0.013	65.00	0.00		
200 P, 104 102	40.00	16	0.013	135.00	0.00		
210 P, 102 101	590.00	36	0.013	55.00	0.00		
220 P, 101 100	450.00	36	0.013	0.00	0.00		
230 e							

Date: 06-23-1986
 Time: 13:12:12

Input File: 100nb100

northborough third addition
 drainage Plan
 storm sewer system no 100 100 year storm

Storm Frequency = 100-Year

*** HYDROLOGY ***

Tributary Area		Hydrology Summation				Conduit Data										
Node	C	Area (Ac)	Slope (%)	Length (Ft)	TC (0)	I (0)	Q (0)	TC (Min)	I (Min)	Q (CFS)	Sum Q (CFS)	Size	Velocity (Ft/Sec)	Length (Ft)	TT (Min)	TT+TC (Min)
103	102	0.82	0.00	0.0	15.00	8.97	49.60	15.00	8.97	49.60	49.60	24"	15.79	80.00	0.08	15.08
104	102	0.03	2.70	0.00	0.0	15.00	8.97	16.50	15.00	8.97	16.50	18"	9.34	40.00	0.07	15.07
102	101	0.71	3.40	0.00	0.0	15.00	8.97	17.80	15.08	8.95	17.76	36"	11.86	590.00	0.83	15.91
101	100	0.00	0.00	0.0	0.00	0.00	0.00	15.91	8.77	0.00	88.86	36"	11.86	450.00	0.63	16.55

Date: 06-23-1986
Time: 13:12:12

Input File: 100mb100

northborough third addition
drainage Plan
storm sewer system no 100 100 year storm

Storm Frequency = 100-Year

*** HYDRAULICS ***

Node	Hyd-Slope (Ft/Ft)	Friction (Ft)	Bend (Ft)	Transition (Ft)	Manhole (Ft)	Deflection (Ft)	Junction (Ft)	Total (Ft)	Hyd-GI Elevation	Desired Elevation (Ft)	Diff.
104	0.02467	0.9869	0.0000	0.0000	0.0000	0.0000	0.0000	0.9869	218.9798	204.7000	-14.28
103	0.04807	3.8457	0.0000	0.0000	0.0000	0.0000	0.0000	3.8457	221.8385	204.7000	-17.14
102	0.01581	9.3258	0.0000	0.3371	0.0000	1.3076	2.1140	13.0864	217.9728	204.7000	-13.29
101	0.01581	7.1129	0.0000	0.0000	0.1093	0.4051	0.0792	7.7084	204.9084	201.0000	-3.91
100	0.00000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	197.0000	197.0000	0.00

100 j, 197,000 200 3 7 6

110 t, northborough third addition

120 t, drainage plan

130 t, storm sewer system no 200 100 year storm

140 i, 206	0.88	2.60	0.00	0.00	16.90	15.00	203.10
150 i, 205	0.81	8.20	0.00	0.00	49.00	15.00	203.10
160 m, 204	202.20						
170 i, 203	0.82	5.70	0.00	0.00	34.40	15.00	201.00
180 i, 202	0.88	3.60	0.00	0.00	23.30	15.00	201.00
190 m, 201	200.00						
200 m, 200	177.00						
210 p, 206 205	40.00	18	0.013	90.00	0.00		
220 p, 205 204	380.00	36	0.013	40.00	0.00		
230 p, 204 202	150.00	36	0.013	80.00	0.00		
240 p, 203 202	40.00	24	0.013	0.00	0.00		
250 p, 202 201	350.00	42	0.013	45.00	0.00		
260 p, 201 200	70.00	42	0.013	0.00	0.00		
270 e							

Date: 06-23-1986
Time: 13:12:57

Input File: 200nb100

northborough third addition

drainage plan

storm sewer system no 200 100 year storm

Storm Frequency = 100-Year

*** HYDROLOGY ***

Tributary Area		Hydrology Summation				Conduit Data							
Node to	C	Area (Ac)	Slope (%)	Length (Ft)	TC (Min)	I (In/yr)	Q (CFS)	Sum Q (CFS)	Size	Velocity (Ft/Sec)	Length (Ft)	IT (Min)	IT+TC (Min)
206	205	0.88	2.60	0.00	0.0	15.00	8.97	16.90	16.90	18"	9.56	40.00	0.07 15.07
205	204	0.01	8.20	0.00	0.0	15.00	8.97	47.00	65.82	36"	9.31	380.00	0.58 15.63
204	202	0.00	0.00	0.00	0.0	0.00	0.00	15.68	8.82	30"	9.31	150.00	0.27 15.95
203	202	0.82	5.70	0.00	0.0	15.00	8.97	34.40	34.40	24"	10.95	40.00	0.06 15.06
202	201	0.80	3.60	0.00	0.0	15.00	8.97	23.30	15.95	42"	12.70	350.00	0.46 16.41
201	200	0.00	0.00	0.00	0.0	0.00	0.00	16.41	8.66	42"	12.70	70.00	0.07 16.50

Date: 06-23-1986
Time: 13:12:57

Inout File: 200mb100

northborough third addition
drainage plan

storm sewer system no 200 100 year storm

Storm Frequency = 100-Year

*** HYDRAULICS ***

```

#####
Node   Hyd-Slope  Friction  Bend  Transition  Manhole  Deflection  Junction  Total  Hyd-GI  Desired Diff.
      (Ft/Ft)   (Ft)      (Ft)   (Ft)        (Ft)      (Ft)        (Ft)      (Ft)   (Ft)     Elevation (Ft)
#####
206    0.02588    1.0354   0.0000  0.0000     0.0000   0.0000     0.0000   1.0354  217.3612  203.1000  -14.26
205    0.00974    3.7008   0.0000  0.0147     0.0000   0.7101     3.2674   7.8730  216.3253  203.1000  -13.23
204    0.00274    1.4000   0.0000  0.0000     0.0673   0.2544     0.0480   1.8313  208.6328  202.2000   -6.43
203    0.02312    0.9247   0.0000  0.0000     0.0000   0.0000     0.0000   0.9249  207.7284  201.0000   -6.73
202    0.01476    5.1643   0.0000  0.1159     0.0000   0.5845     2.1575   8.0242  204.8015  201.0000   -5.80
201    0.01475    1.0329   0.0000  0.0000     0.1253   0.5453     0.0727   1.7773  198.7773  200.0000   1.22
200    0.00000    0.0000   0.0000  0.0000     0.0000   0.0000     0.0000   0.0000  197.0000  197.0000   0.00
#####

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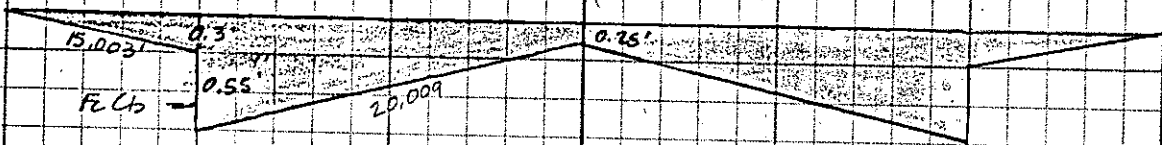


Date June 20, 1986 Page 17 of 18

Project Northborough 3rd Addition

Item Drainage Plan

100-yr. flow in R.O.W.
(Parking = T.C + 0.3')



$$n = \frac{(2 \times 15.003 \times 0.03) + (2 \times 0.55 \times 0.016) + (2 \times 20.009 \times 0.016)}{(2 \times 15.003) + (2 \times 0.55) + (2 \times 20.009)} = \frac{1.558}{71.124} = 0.022$$

$$A = 2 \times \left(\frac{1}{2} \times 15 \times 0.3 \right) + (40 \times 0.25) + 2 \times \left(\frac{1}{2} \times 20 \times 0.60 \right) = 26.5 \text{ SF}$$

$$p = (2 \times 15.003) + (2 \times 0.55) + (2 \times 20.009) = 71.124$$

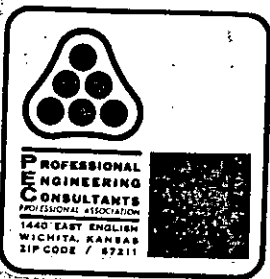
$$R = A/p = 26.5/71.124 = 0.3726$$

$$R^{2/3} = 0.517789$$

$$Q_{max} = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

$$Q_{max} = \frac{1.486}{0.022} (26.5)(0.517789) S^{1/2}$$

$$Q_{max} = 926.81 \sqrt{S}$$



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100-yr street flows

Street	Contrib. Areas	Q ₁₀₀	Q _{pipe}	Q _{street}	Street Slope	Q _{allow.}	Comment
Bramblewood (n. of Rockhill)	40% Node 103 + Node 104	36.3	0	36.3	0.78%	81.8	OK
Bramblewood (s. of Rockhill)	60% Node 103 + Node 104	47.6	0	47.6	1.15%	99.4	OK
Rockhill (w. of sump)	104, 103, 102 40% 203 50% 202	109.3	37.0	72.3	0.59%	71.2	OK*
Stratford (n. of sump)	206, 205	65.9	0	65.9	0.96%	90.8	OK
Stratford (s. of crest)	206, 205	65.9	29.5	36.4	0.52%	66.8	OK
Rockhill (e. of sump)	206, 205 60% 203 50% 202	98.2	29.5	68.7	0.52%	66.8	OK*

* USE SW GRADE = T.C + 0.4' ON ROCKHILL STREET



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CHANNEL / DETENTION POND IMPROVEMENTS

See Drainage Plan For Northborough 2nd Addition dated 5-2-83 for channel & detention pond calculations.

The storm sewer layout for Northborough 3rd Addition is slightly different due to the new street layout.

However, the differences in Q_{100} into the pond due to the new layout is minor. Therefore, the pond data as noted in the Northborough 2nd Drainage plan is still valid:

$$DWS_{100} = 198.9$$

$$\text{Static Pool} = 194.0$$

$$\text{Pond Bottom} = 189.0$$

$$\text{Outlet Pipes} = 2-36" \text{ RCP} \quad \begin{array}{l} E @ \text{ Pond} = 194.0 \\ E \text{ out} = 193.5 \end{array}$$