Flood Design Frequency Selection Chart

Design Frequency - Years					Drainage Structures
Rural Class			Urban Class		
STH/CTH (1) T1,T2,T3,T4,T5,T6	STH/CTH (2) T7	STH (3)	Urban Streets 1, 2, 3, 4, 5,	Urban Expressways & Freeways 1, 2, 3	
See Procedure 13-10-1, discussion of Major Drainage Structures					Bridges & Box Culverts
50	50	50	50	50	Underpass Storm Sewers
25	50	50	50	50	Main or Primary Channels
25	25	50	50	50	Cross Drain Pipe Culverts
25	25	25	25	25	Side Drain Pipe Culverts
25	25	25	25	25	Side Ditches and Channels
X	X	25	X	25	Median Ditches and Channels
X	X	X	10 (4) Check 25 Yr.	25	Urban Gutters, Inlets and Storm Sewers

(1) All state trunk highways with design ADT under 1500 and all county trunk highways with design ADT under 4000.

(2) All state trunk highways with design ADT of 1500-7000 and all county trunk highways with design ADT over 4000.

(3) All state trunk highways with design ADT of over 7000.

(4) See Procedure 13-25-20

FDM 13-10-1 Design Criteria

August 8, 1997

1.1 Introduction

To the highway engineer, hydrology includes the analysis of precipitation and runoff, and the determination of a flood flow rate for a given stream or channel. It also addresses the frequency of flood occurrence.

1.2 Flood Frequency

Flood frequency or recurrence interval is defined as the average interval in years between the actual occurrence of a hydrological event of a given or greater magnitude. For example, a flood frequency of 50 years means that a storm of that magnitude or greater would be expected to occur on the average of once every 50 years. It also can be stated that a 50-year flood would have a 2% chance of occurring in any one year.

Flood frequencies for various classes of highways and types of drainage structures have been selected to produce a balance between the cost of a drainage facility and the cost of potential flood damage - including risk to the traveling public. These selected frequencies are referred to as design flood frequencies or design frequencies, and are used in determining the magnitude of the design flood - which the drainage structure must accommodate with low probability of risk to the traveling public, minimum damage to the roadway, and minimum flood damage to adjacent property. By common definition, the design flood does not inundate the roadway. In many instances the design flood will not approach overtopping of the roadway, but will be limited to a maximum backwater elevation so as not to create unreasonable flood damage to either the roadway or adjacent property.

1.3 Design Frequency

The hydraulic design of drainage structures shall use the flood design frequencies given in Attachment 1.1 of this procedure. Design frequencies for bridges and box culverts are not included in this attachment, but the procedure for their sizing is discussed in the LRFD Bridge Manual Chapter 8.

1.3.1 Major Drainage Structures

84" or larger

Watercourses of sufficient magnitude to potentially produce significant flood damage (to the roadway, drainage structure, or abutting property) are most frequently crossed using a major drainage structure (a bridge, box culvert, or their replacement with large drainage conduits). Therefore when a major drainage structure is required, the process of selecting a design frequency which best produces a balance between structure costs and the cost of potential flood related damages or risks, requires a detailed analysis of each situation. It also requires that the designer be knowledgeable of FAPG Part 650A, "Location and Hydraulic Design of Encroachments on Flood Plains;" NR 116, "Wisconsin's Floodplain Management Program;" NR 320, "Bridges an Culverts in or Over Navigable Waterways;" and the "Cooperative Agreement Between the Wisconsin Department of Transportation and Department of Natural Resources" (refer to FDM 20-30-1).

Therefore, the following method should be used when designing a major drainage structure:

The hydraulic design of major drainage structures is to be addressed in terms of either a replacement structure condition, or a structure associated with a highway on new location.

Replacement structures should typically be sized to develop headwater elevations not greater than that experienced with the existing structure in place. This presumes that extensive experience at the existing structure site has indicated acceptable backwater elevations, permissible stream velocities, and adequate protection for the roadway and motorist. When this is the case, the headwater elevation for the regional flood (100 year-flood) with the existing structure in place should be computed and used as a controlling hydraulic factor in the design of the replacement structure.

Occasionally a reasonable increase in headwater depth would lead to a material savings in structure costs that would obviously outweigh backwater related impacts or risks. In these situations the acceptable headwater elevation under regional flood conditions should be determined and then used as a controlling hydraulic factor in the structure sizing. The "acceptable" headwater elevation must also take into consideration the floodplain management standards of NR 116, relevant local floodplain zoning ordinances, and the potential need for drainage easements.

Upon completion of the structure design, predicted water surface elevations shall be made available to the applicable local zoning authorities. When a structure is located on a stream that has an established water

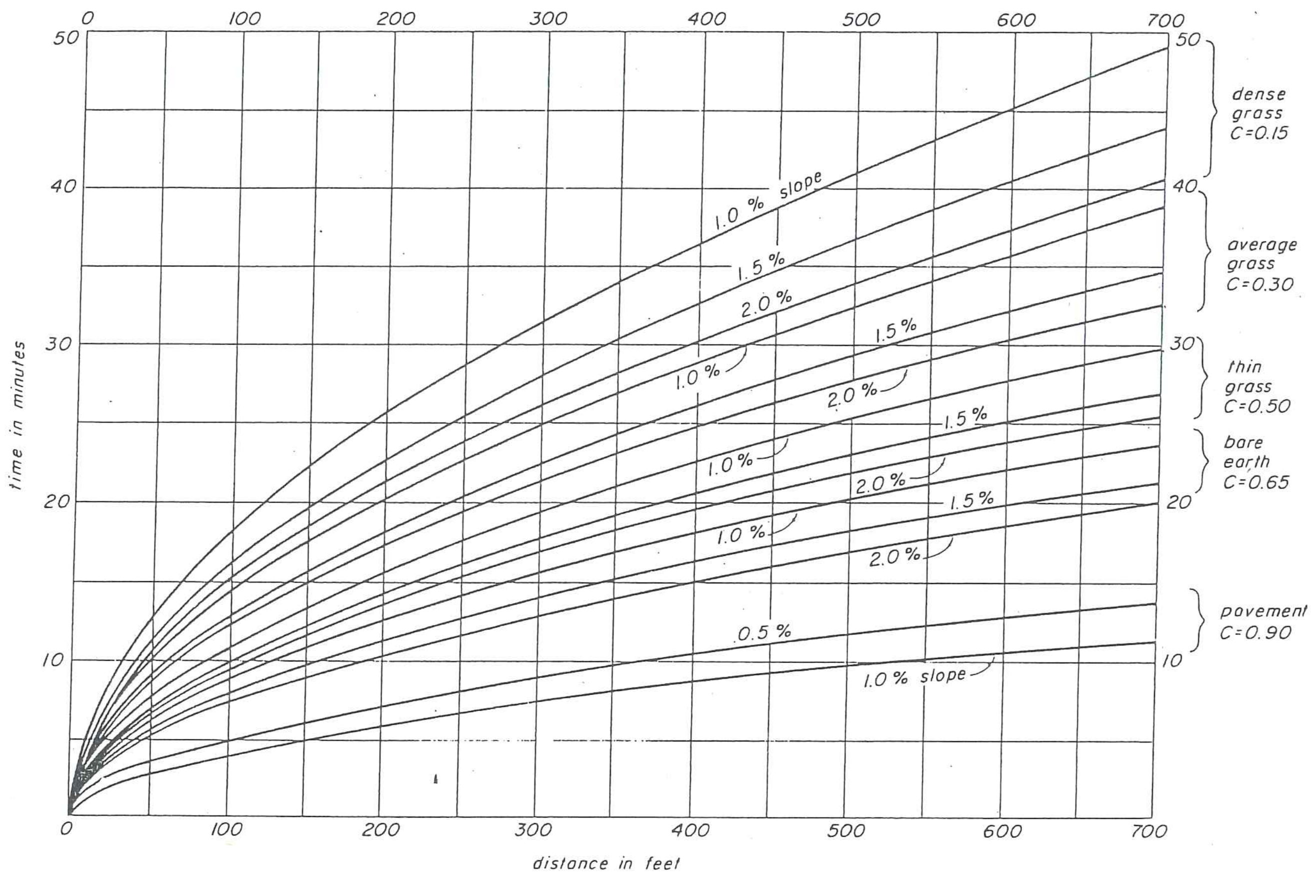

Fig. 14. Time of concentration as function of watershed characteristics.

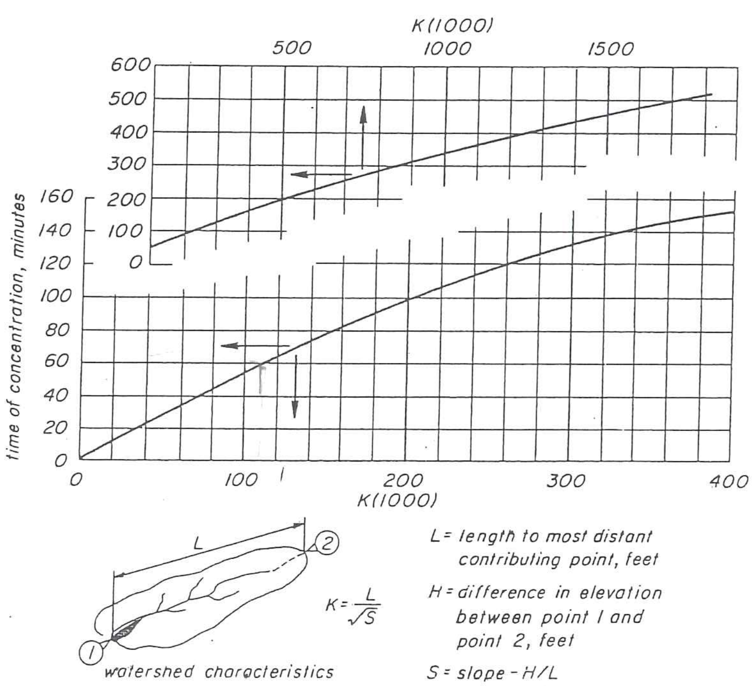

Fig. 15. Time of concentration, larger watersheds.

Not used

TIME OF CONCENTRATION OF SMALL DRAINAGE BASINS

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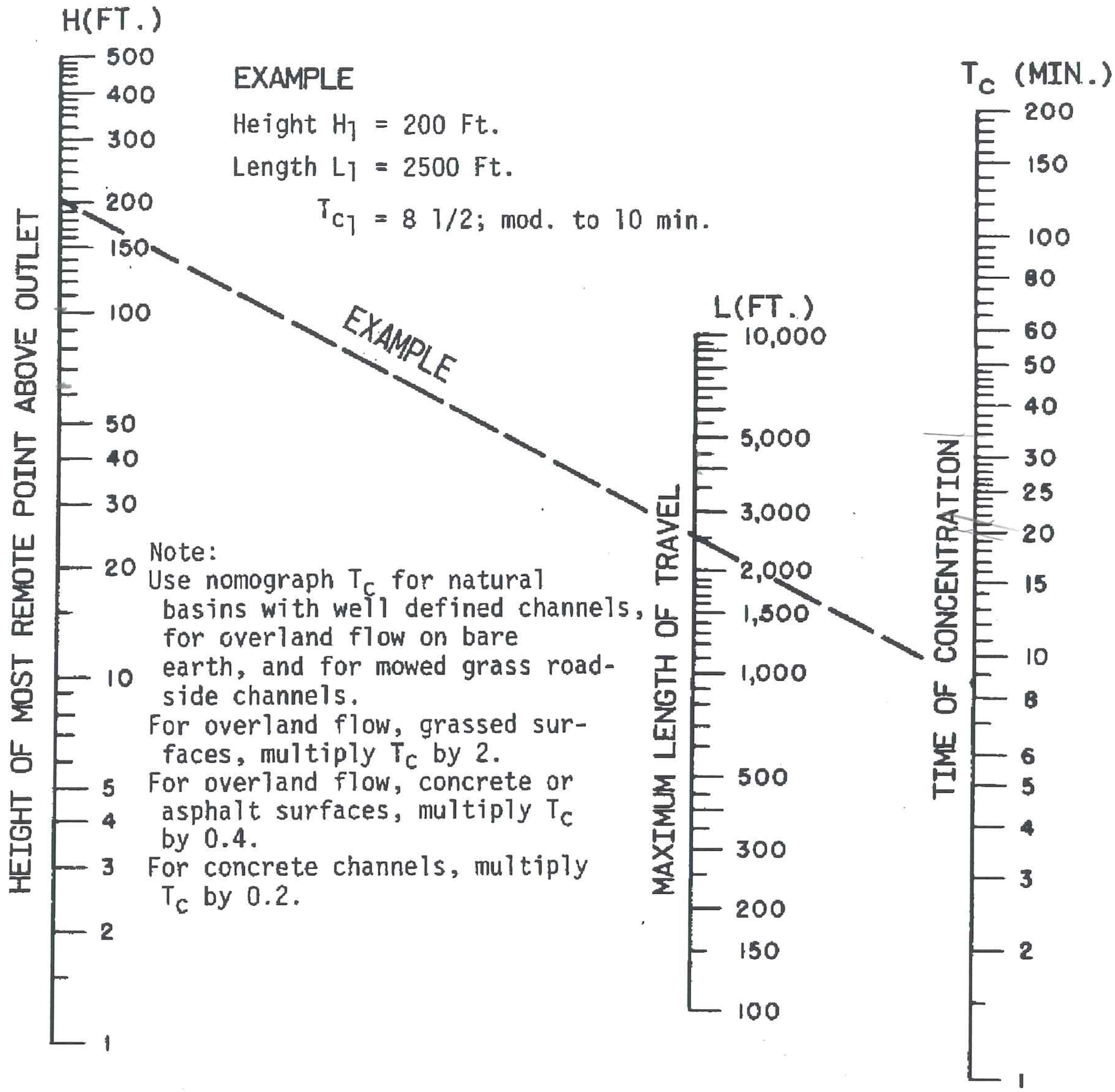
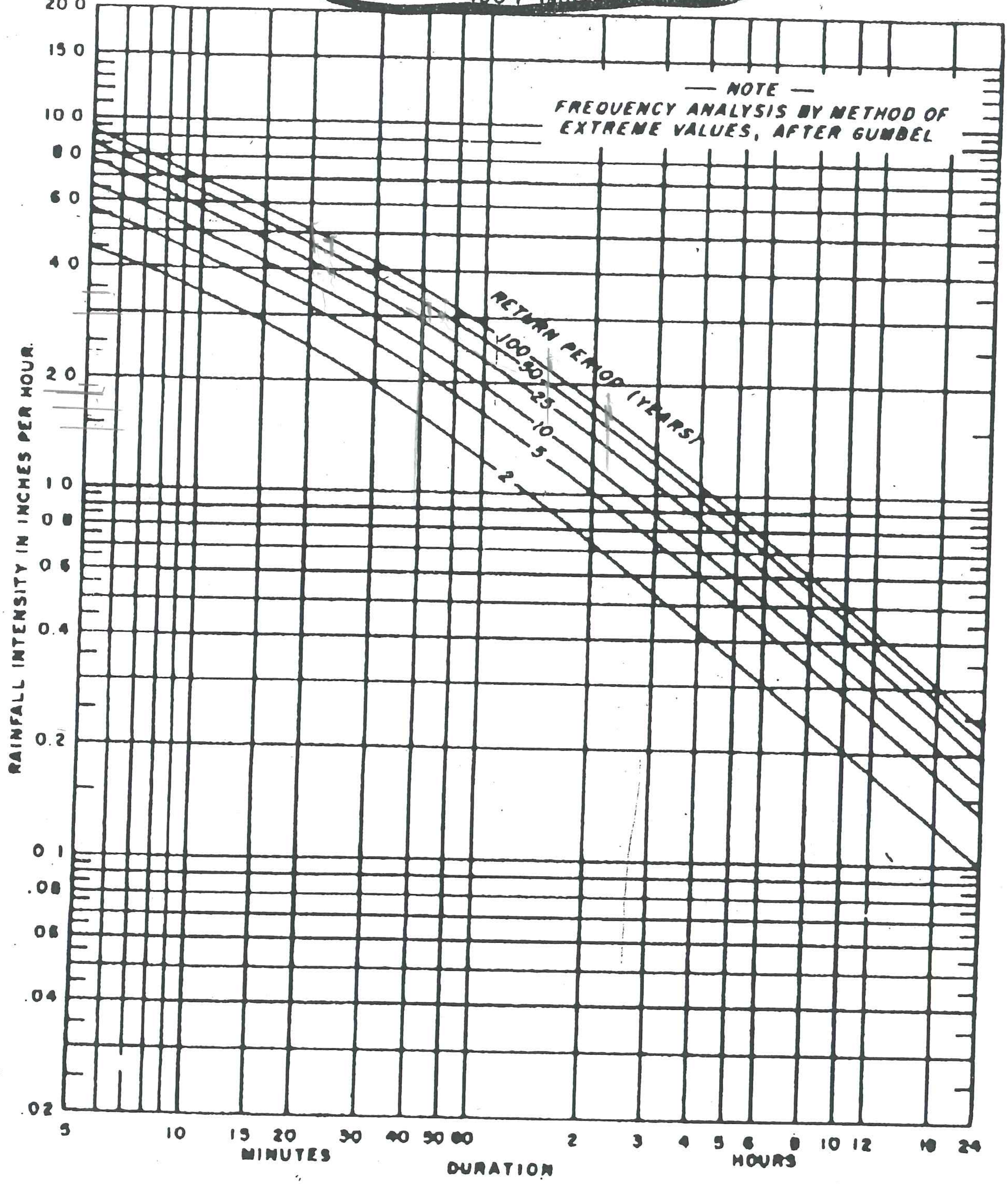


Based on study by P. Z. Kirpich,
Civil Engineering, Vol. 10, No. 6, June 1940, p.362

MINNEAPOLIS, MINNESOTA
1904-1961



RAINFALL INTENSITY

Detail A - Runoff Coefficients (C), Rational Formula

Land Use	Percent Impervious Area	Hydrologic Soil Group											
		A			B			C			D		
		Slope Range Percent			Slope Range Percent			Slope Range Percent			Slope Range Percent		
		0-2	2-6	6 & over	0-2	2-6	6 & over	0-2	2-6	6 & over	0-2	2-6	6 & over
Industrial	90	0.67 0.85	0.68 0.85	0.68 0.86	0.68 0.85	0.68 0.86	0.69 0.86	0.68 0.86	0.69 0.86	0.69 0.87	0.69 0.86	0.69 0.86	0.70 0.88
Commercial	95	0.71 0.88	0.71 0.89	0.72 0.89	0.71 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.90	0.72 0.89	0.72 0.89	0.72 0.90
High Density Residential	60	0.47 0.58	0.49 0.60	0.50 0.61	0.48 0.59	0.50 0.61	0.52 0.64	0.49 0.60	0.51 0.62	0.54 0.66	0.51 0.62	0.53 0.64	0.56 0.69
Med. Density Residential	30	0.25 0.33	0.28 0.37	0.31 0.40	0.27 0.35	0.30 0.39	0.35 0.44	0.30 0.38	0.33 0.42	0.38 0.49	0.33 0.41	0.36 0.45	0.42 0.54
Low Density Residential	15	0.14 0.22	0.19 0.26	0.22 0.29	0.17 0.24	0.21 0.28	0.26 0.34	0.20 0.28	0.25 0.32	0.31 0.40	0.24 0.31	0.28 0.35	0.35 0.46
Agriculture	5	0.08 0.14	0.13 0.18	0.16 0.22	0.11 0.16	0.15 0.21	0.21 0.28	0.14 0.20	0.19 0.25	0.26 0.34	0.18 0.24	0.23 0.29	0.31 0.41
Open Space	2	0.05 0.11	0.10 0.16	0.14 0.20	0.08 0.14	0.13 0.19	0.19 0.26	0.12 0.18	0.17 0.23	0.24 0.32	0.16 0.22	0.21 0.27	0.28 0.39
Freeways & Expressways	70	0.57 0.70	0.59 0.71	0.60 0.72	0.58 0.71	0.60 0.72	0.61 0.74	0.59 0.72	0.61 0.73	0.63 0.76	0.60 0.73	0.62 0.75	0.64 0.78

Detail B - Runoff Coefficients for Specific Land Use

Land Use	Hydrologic Soil Group											
	A			B			C			D		
	Slope Range Percent			Slope Range Percent			Slope Range Percent			Slope Range Percent		
	0-2	2-6	6 & over	0-2	2-6	6 & over	0-2	2-6	6 & over	0-2	2-6	6 & over
Row Crops	.08 .22	.16 .30	.22 .38	.12 .26	.20 .34	.27 .44	.15 .30	.24 .37	.33 .50	.19 .34	.28 .41	.38 .56
Median Stripturf	.19 .24	.20 .26	.24 .30	.19 .25	.22 .28	.26 .33	.20 .26	.23 .30	.30 .37	.20 .27	.25 .32	.30 .40
Side Slopeturf			.25 .32			.27 .34			.28 .36			.30 .38
PAVEMENT												
Asphalt	.70 - .95											
Concrete	.80 - .95											
Brick	.70 - .80											
Drives, Walks	.75 - .85											
Roofs	.75 - .95											
Gravel Roads Shoulders	.40 - .60											

NOTE: The lower C values in each range should be used with the relatively low intensities associated with 2 to 10 year design recurrence intervals whereas the higher C values should be used for intensities associated with the longer 25 to 100 year deign recurrence intervals.

from essentially 0 micrometers per second (0 inches per hour) to 0.9 micrometers per second (0.1 inches per hour). For simplicity, either case is considered impermeable for hydrologic soil group purposes. In some cases, saturated hydraulic conductivity (a quantitatively measured characteristic) data are not always readily available or obtainable. In these situations, other soil properties such as texture, compaction (bulk density), strength of soil structure, clay mineralogy, and organic matter are used to estimate water movement. Tables 7–1 and 7–2 relate saturated hydraulic conductivity to hydrologic soil group.

The four hydrologic soil groups (HSGs) are described as:

Group A—Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil. Group A soils typically have less than 10 percent clay and more than 90 percent sand or gravel and have gravel or sand textures. Some soils having loamy sand, sandy loam, loam or silt loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

The limits on the diagnostic physical characteristics of group A are as follows. The saturated hydraulic conductivity of all soil layers exceeds 40.0 micrometers per second (5.67 inches per hour). The depth to any water impermeable layer is greater than 50 centimeters [20 inches]. The depth to the water table is greater than 60 centimeters [24 inches]. Soils that are deeper than 100 centimeters [40 inches] to a water impermeable layer are in group A if the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface exceeds 10 micrometers per second (1.42 inches per hour).

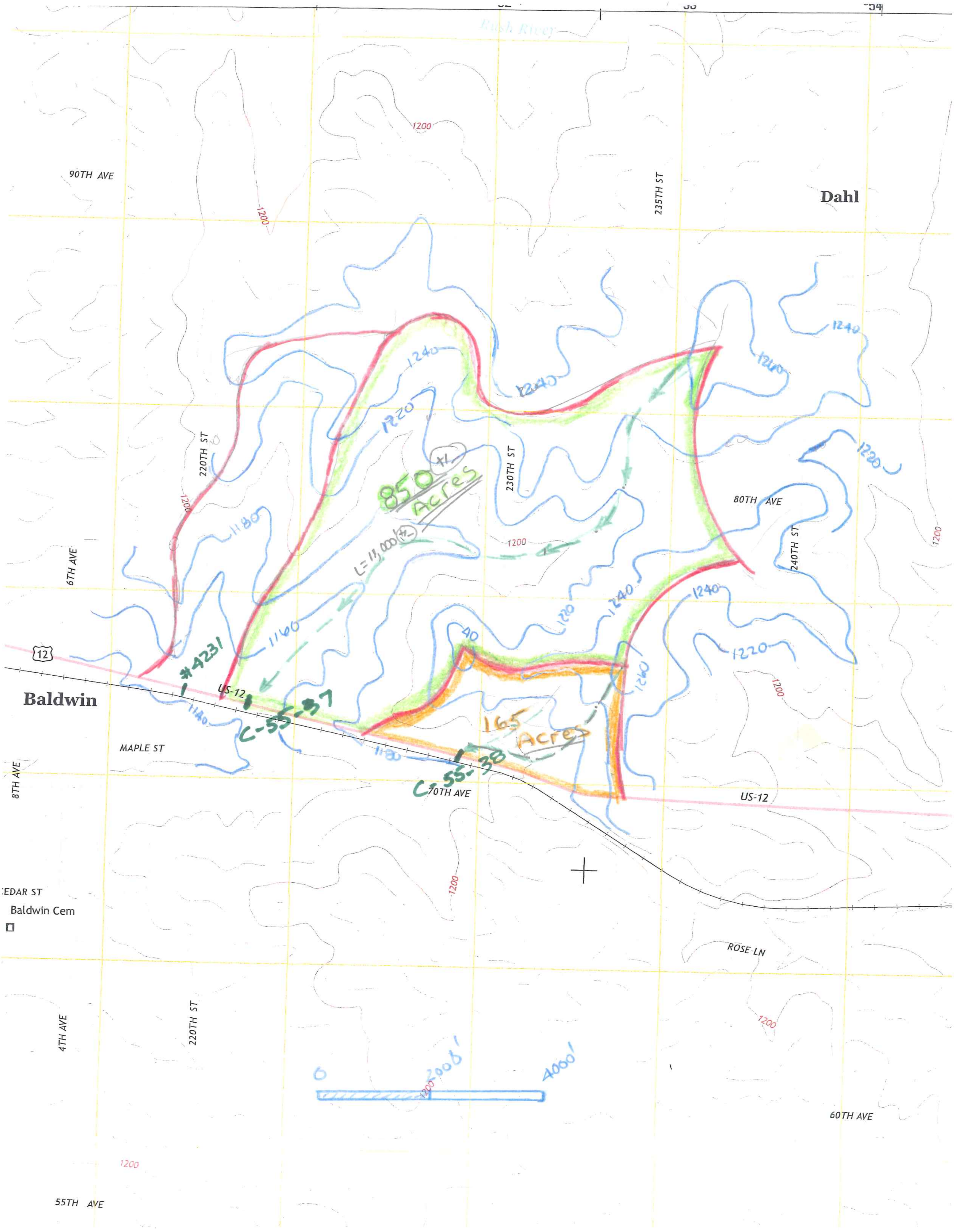
Group B—Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded. Group B soils typically have between 10 percent and 20 percent clay and 50 percent to 90 percent sand and have loamy sand or sandy loam textures. Some soils having loam, silt loam, silt, or sandy clay loam textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

The limits on the diagnostic physical characteristics of group B are as follows. The saturated hydraulic conductivity in the least transmissive layer between the surface and 50 centimeters [20 inches] ranges from 10.0 micrometers per second (1.42 inches per hour) to 40.0 micrometers per second (5.67 inches per hour). The depth to any water impermeable layer is greater than 50 centimeters [20 inches]. The depth to the water table is greater than 60 centimeters [24 inches]. Soils that are deeper than 100 centimeters [40 inches] to a water impermeable layer or water table are in group B if the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface exceeds 4.0 micrometers per second (0.57 inches per hour) but is less than 10.0 micrometers per second (1.42 inches per hour).

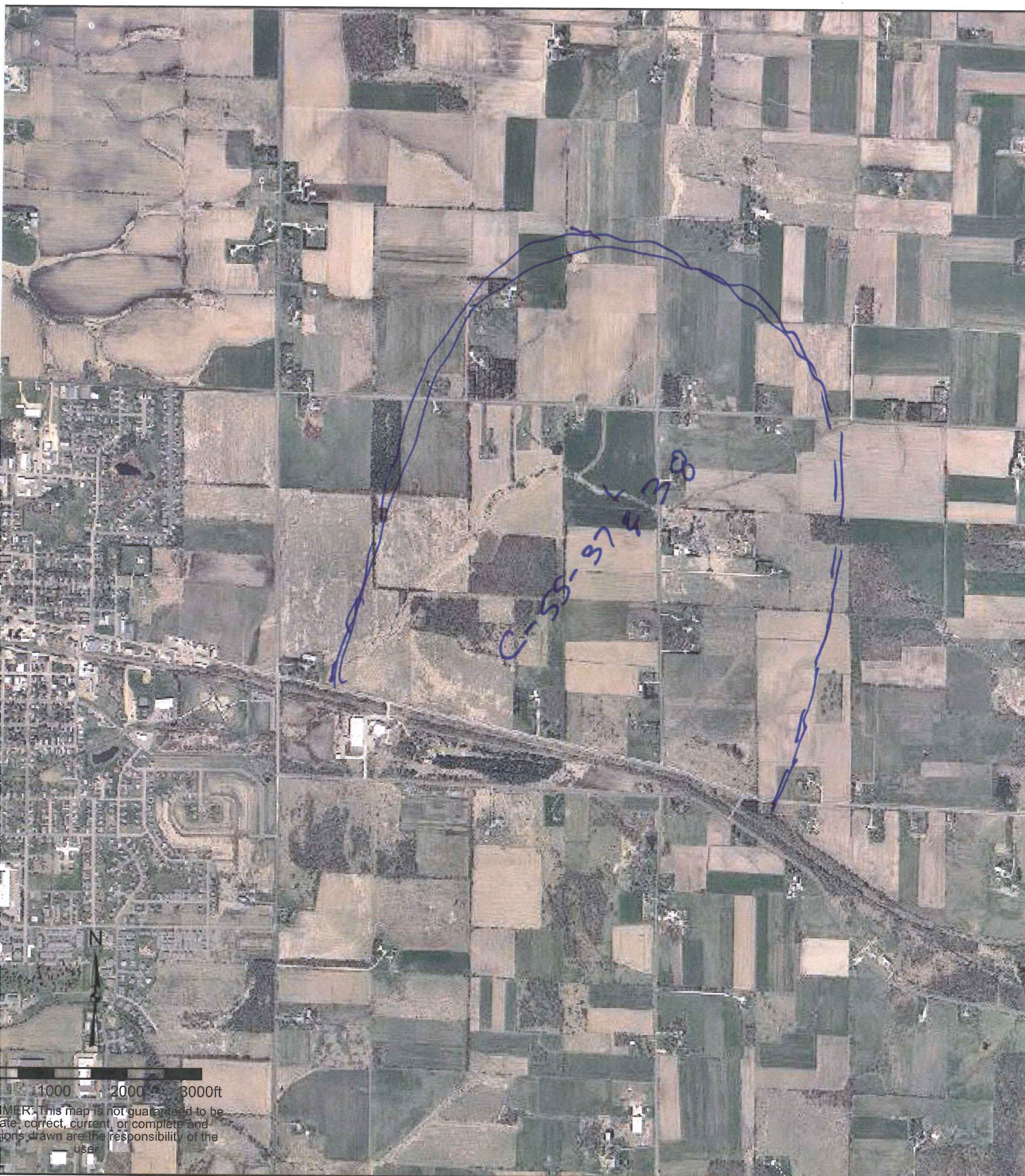
Group C—Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted. Group C soils typically have between 20 percent and 40 percent clay and less than 50 percent sand and have loam, silt loam, sandy clay loam, clay loam, and silty clay loam textures. Some soils having clay, silty clay, or sandy clay textures may be placed in this group if they are well aggregated, of low bulk density, or contain greater than 35 percent rock fragments.

The limits on the diagnostic physical characteristics of group C are as follows. The saturated hydraulic conductivity in the least transmissive layer between the surface and 50 centimeters [20 inches] is between 1.0 micrometers per second (0.14 inches per hour) and 10.0 micrometers per second (1.42 inches per hour). The depth to any water impermeable layer is greater than 50 centimeters [20 inches]. The depth to the water table is greater than 60 centimeters [24 inches]. Soils that are deeper than 100 centimeters [40 inches] to a restriction or water table are in group C if the saturated hydraulic conductivity of all soil layers within 100 centimeters [40 inches] of the surface exceeds 0.40 micrometers per second (0.06 inches per hour) but is less than 4.0 micrometers per second (0.57 inches per hour).

Group D—Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted. Group D soils typically have greater than 40 percent clay, less than 50 percent sand, and have clayey textures. In some areas, they also have high shrink-swell potential. All soils with a depth to a water impermeable layer less than 50 centimeters [20 inches] and all soils with a water table



Rush River
90TH AVE
235TH ST
Dahl
1200
1240
1220
1180
1160
1140
850 +/- Acres
L=11,000 (+/-)
220TH ST
230TH ST
80TH AVE
240TH ST
6TH AVE
12
#4231
Baldwin
US-12
C-55-37
165 Acres
C-55-38
MAPLE ST
8TH AVE
70TH AVE
CEDAR ST
Baldwin Cem
ROSE LN
4TH AVE
0
2000'
4000'
60TH AVE
55TH AVE



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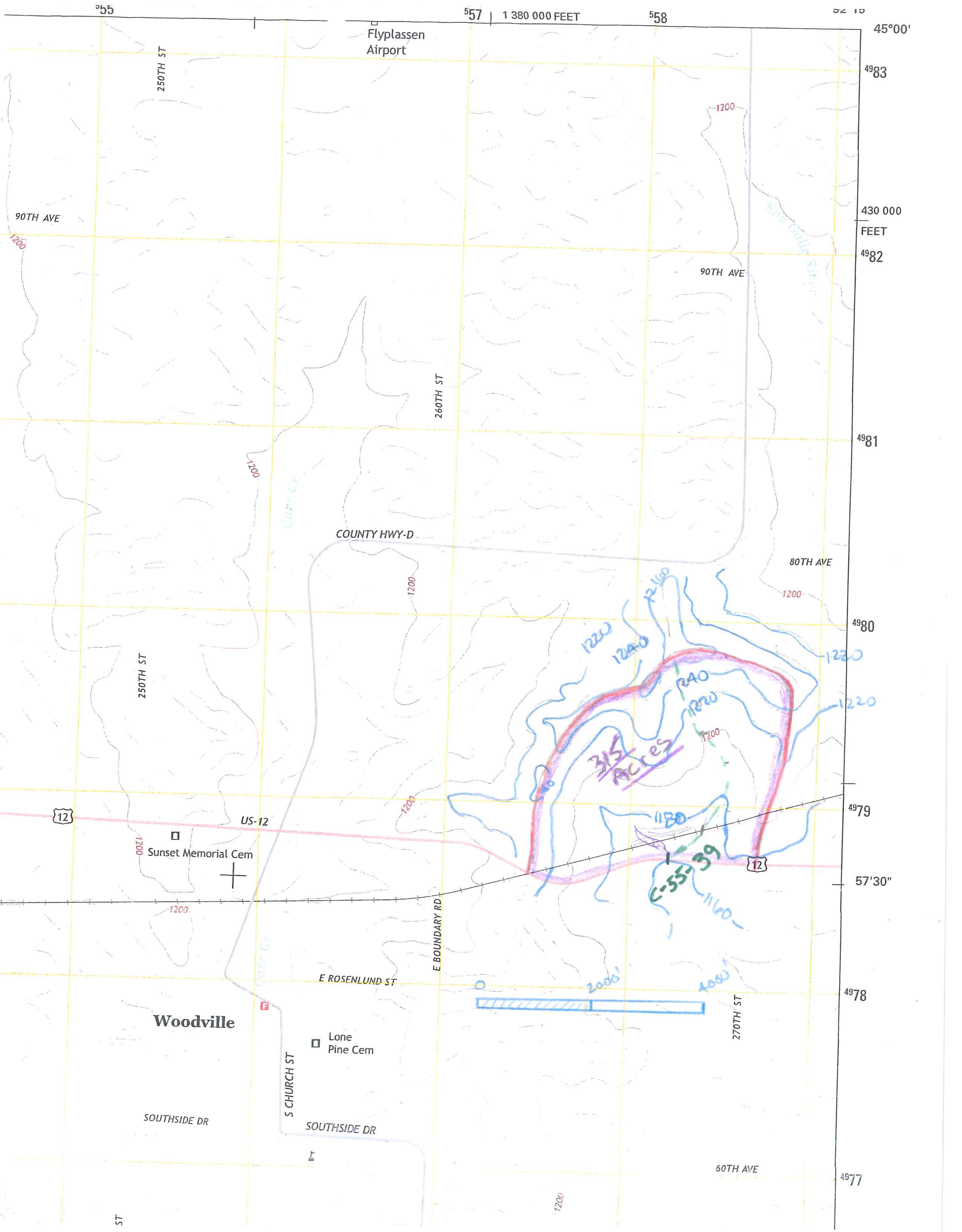

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557
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45°00'
Flyplassen Airport
250TH ST
4983
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4982
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4981
COUNTY HWY-D
80TH AVE
1200
4980
250TH ST
1220
1240
1260
1240
1220
1200
315 Acres
1180
C-55-39
1160
4979
US-12
12
Sunset Memorial Cem
57'30"
E BOUNDARY RD
E ROSENLUND ST
0
2000'
4000'
270TH ST
4978
Woodville
Lone Pine Cem
S CHURCH ST
SOUTHSIDE DR
SOUTHSIDE DR
60TH AVE
4977

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