

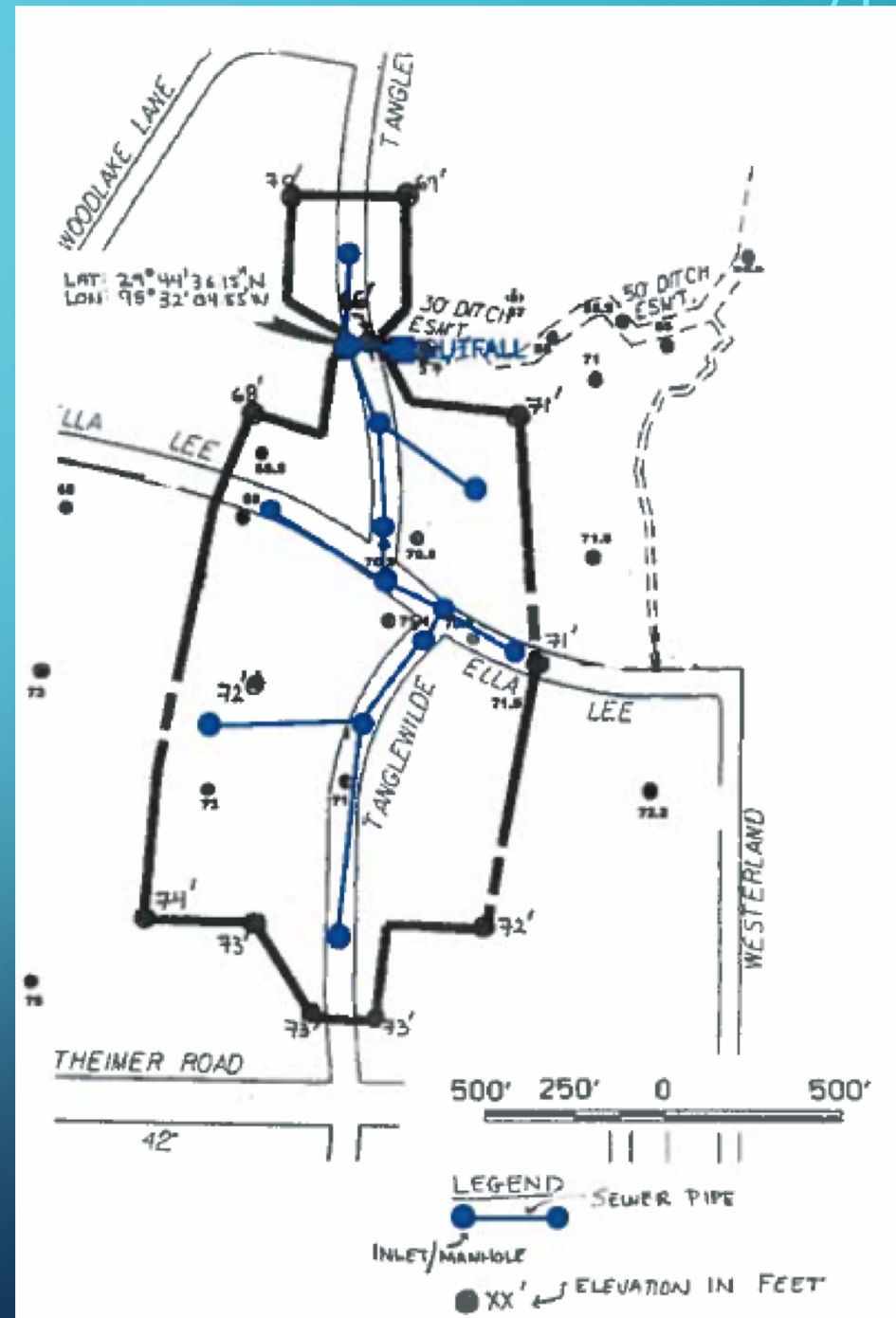


# CE 3372 WATER SYSTEMS DESIGN

LESSON 19: STORM SEWER DESIGN EXAMPLE (TANGLEWILDE STORM SEWER)

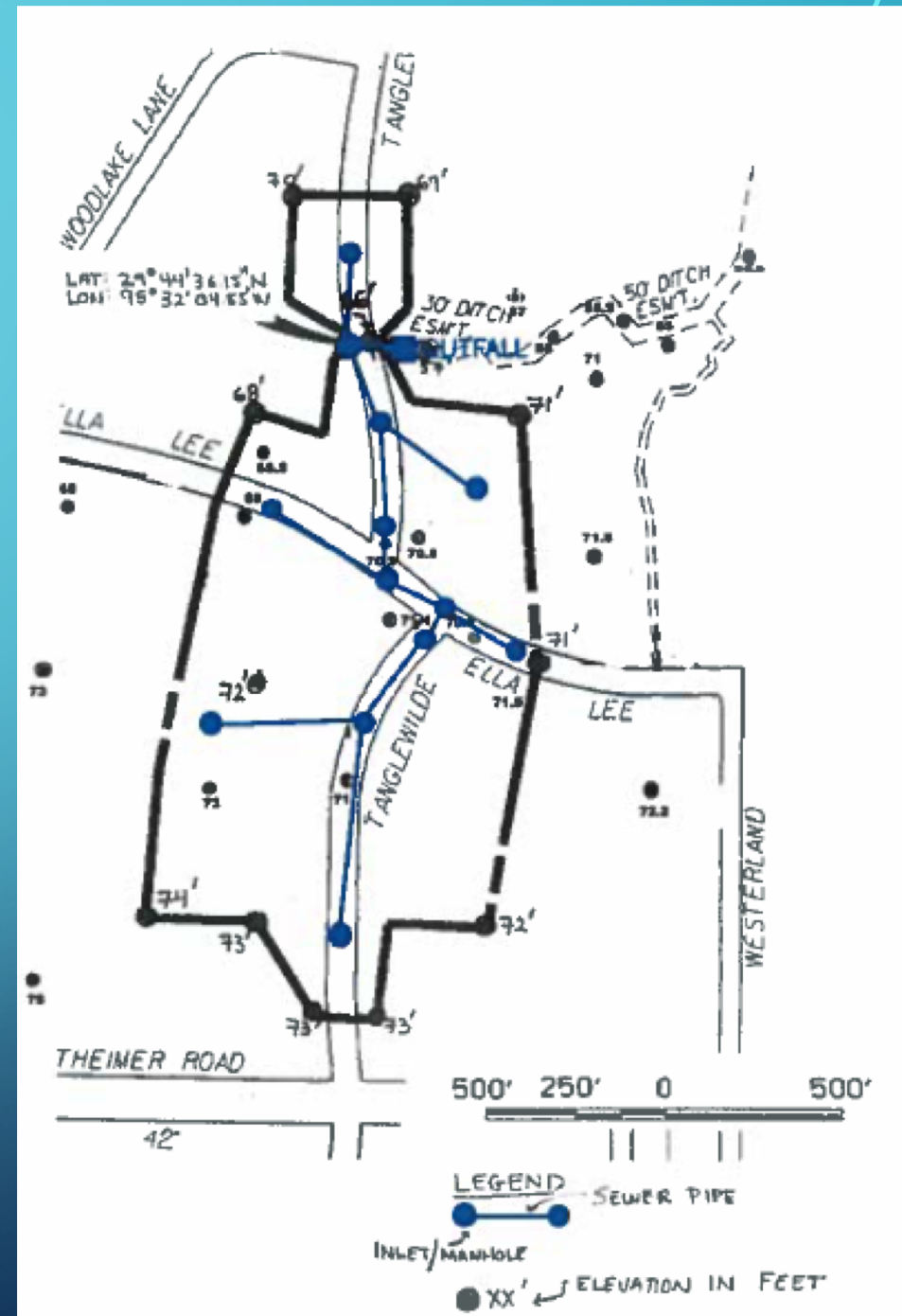
# DESIGN STORM SEWER FOR TANGLEWILDE

- Method: Rational Equation Design Method to make initial design for subsequent hydraulics analysis
- Identical study area as ES-13



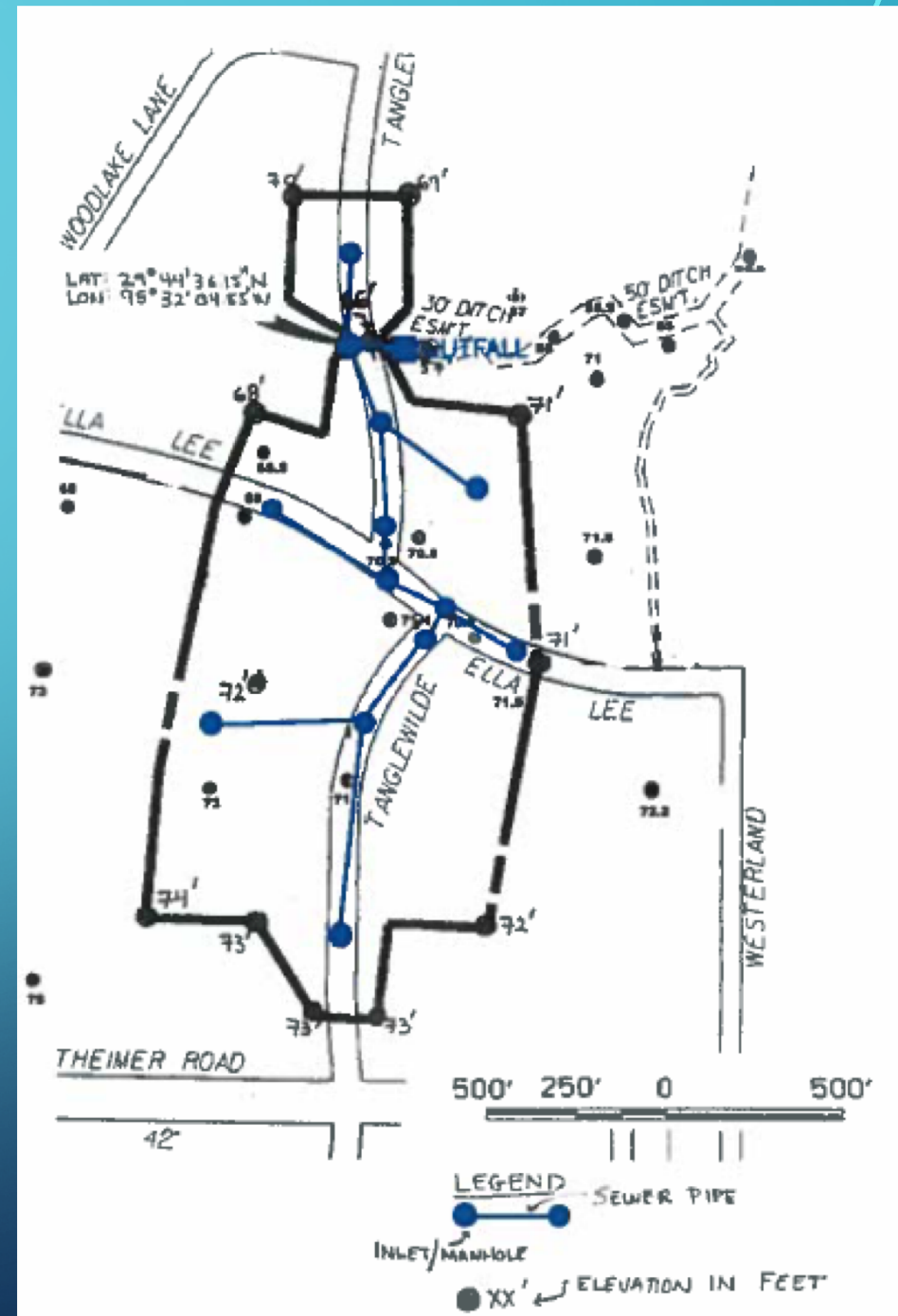
# PREPARATION STEPS

- Apply (make) topographic map principles to identify drainage pattern(s)
- Identify the individual drainage areas based on the topographic map and sewer system layout.
- Determine the area of each contributing area, in acres. (ENGAUGE, PLANIMETER, etc)
- Determine the rational runoff coefficient for each area (TABLE LOOKUP)



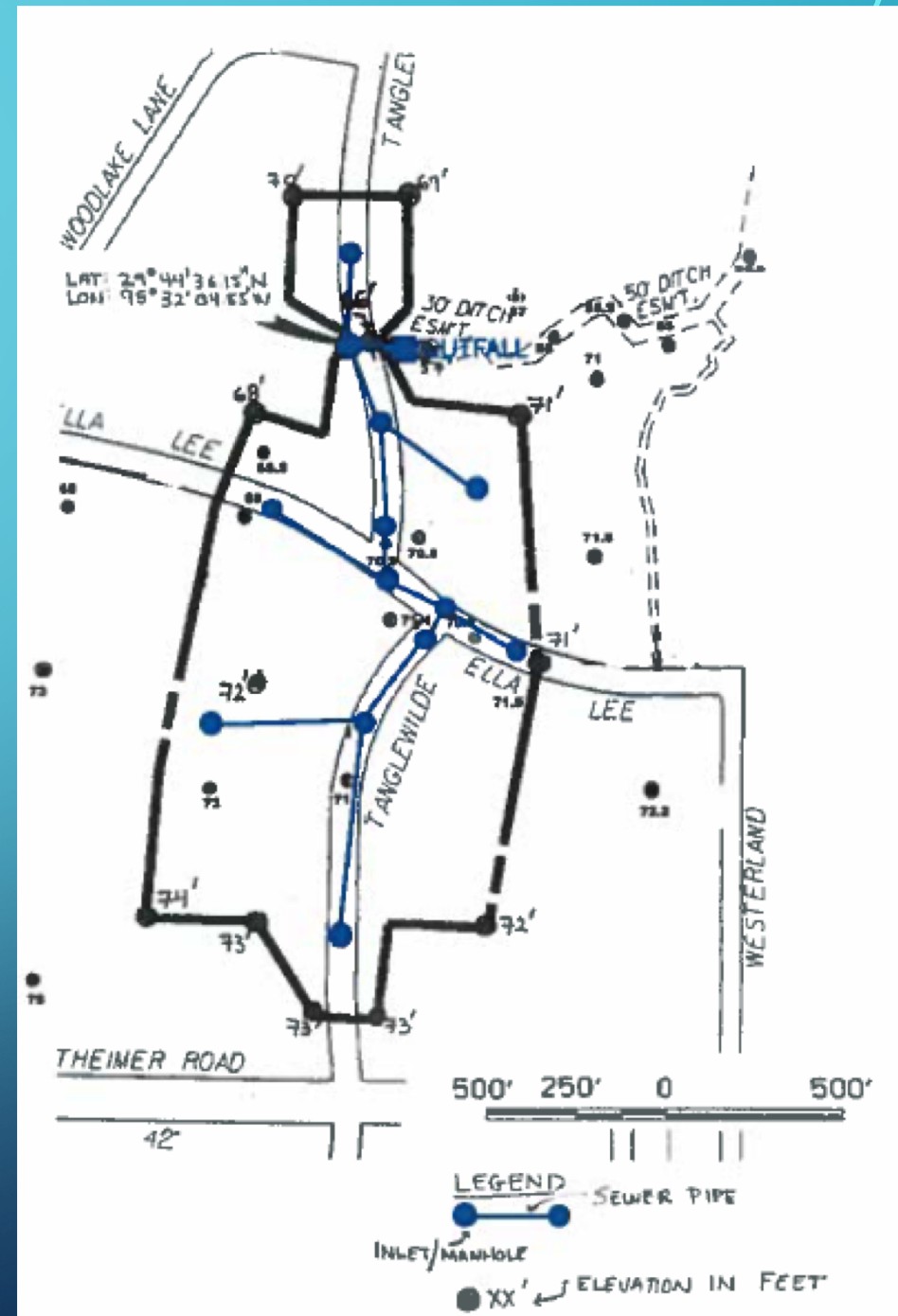
# PREPARATION STEPS

- Determine inlet time for surface portion of drainage system.
- Determine rainfall intensity equation for Harris County.



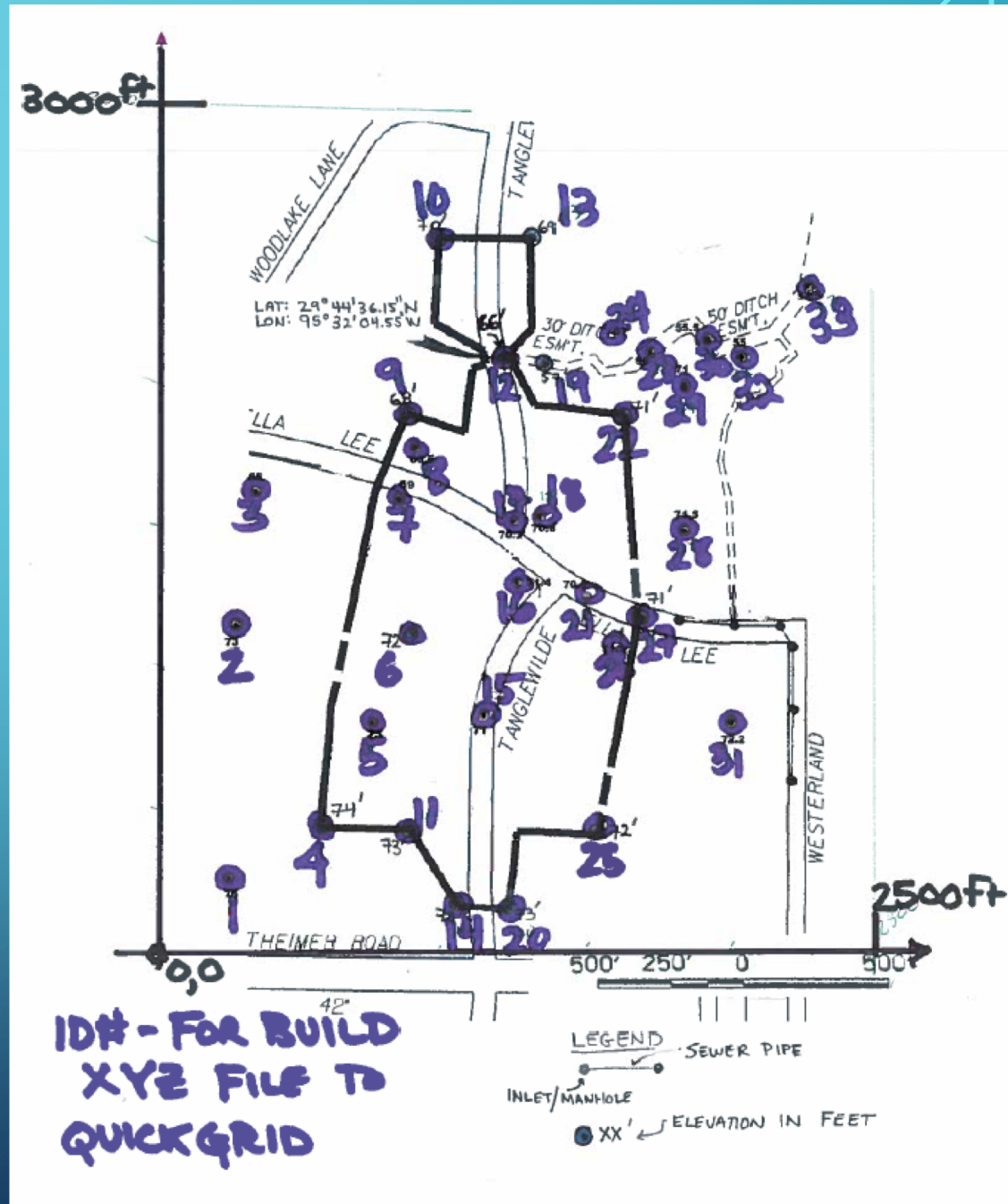
# ANALYSIS STEPS

- Apply the intensity equation to the various surface drainage areas, and the accumulating area to size the conduits.
- Check invert elevations to fit into the useable vertical drop for the location
- Size the inlets using appropriate inlet hydraulics equations.



# TOPOGRAPHIC MAP

- Locate the elevations and construct an XY coordinate system.



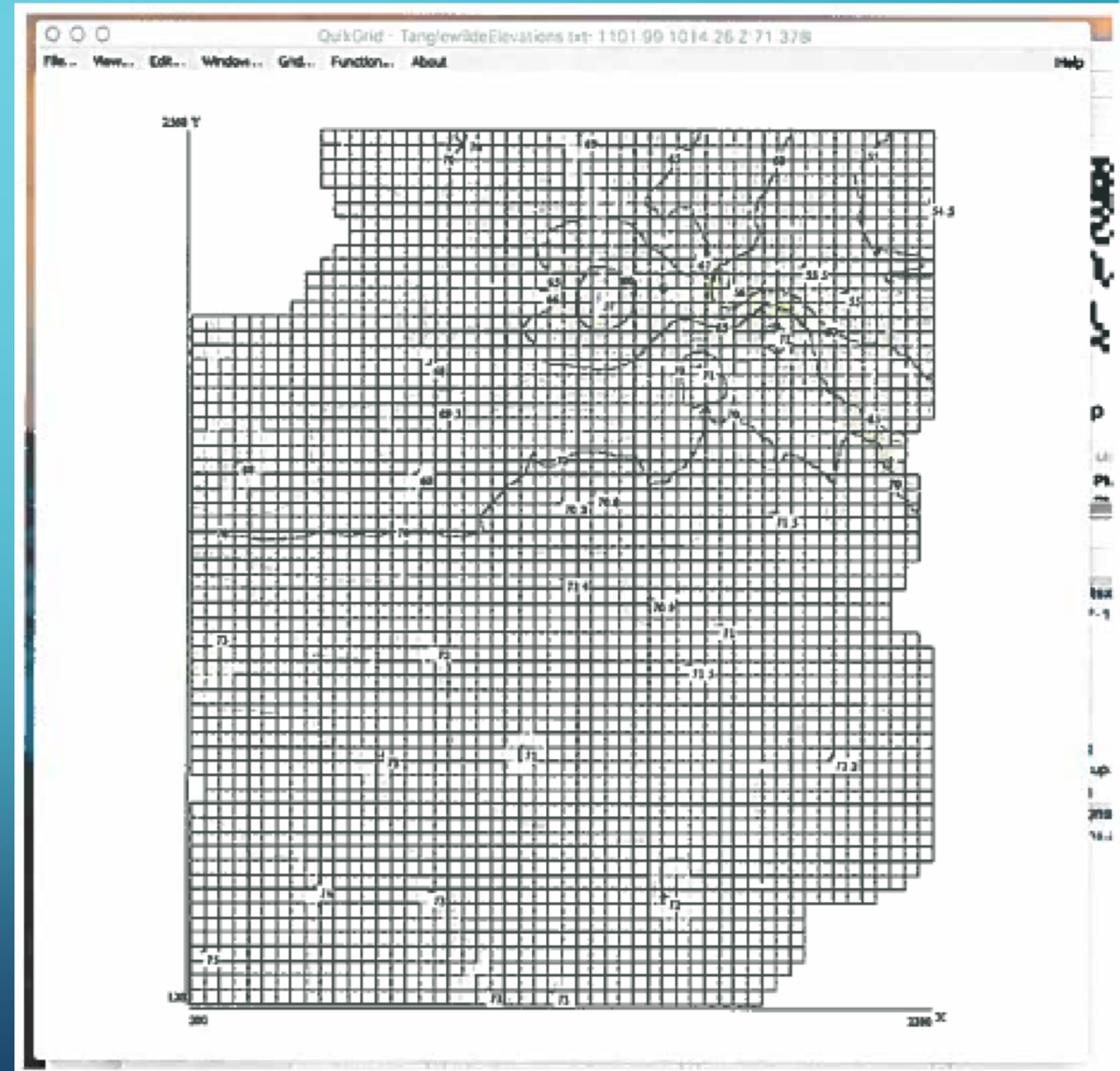
# TOPOGRAPHIC MAP

- Use the XY-coordinate system and build an XYZ input file for topographic rendering.

Tanglewilde Elevations				METHOD(S)	
ELEVATION SURVEY VALUES					
ID	X (FEET)	Y (FEET)	Z (FEET)		
1	237.484279	263.09382	75	1) Use drawing and impose axes	
2	260.879376	1158.93885	73	2) Locate X1,Y1	
3	332.144775	1633.90828	68	3) Locate X2,Y1	
4	554.122697	448.65323	74	4) Locate X1, Y2	
5	737.728288	815.072914	73	5) Use G3DATA to capture x,y each point	
6	880.998109	1119.57212	72	6) Manual enter z for each point based on collect order	
7	832.812956	1602.41018	69		
8	882.668563	1790.82685	69.5		
9	866.834237	1907.0222	68		
10	967.813595	2534.28453	70		
11	871.797496	430.252877	73		
12	1183.38082	2110.654	66		
13	1290.42541	2544.27839	69		
14	1028.15545	159.007068	73		
15	1126.33177	837.907403	71		
16	1240.80157	1310.25046	71.4		
17	1234.64451	1521.96078	70.2		
18	1328.54412	1542.51785	70.8		
19	1340.99381	2092.41894	57		
20	1218.73147	153.646749	73		
21	1484.9939	1253.19966	70.9		
22	1621.45072	1898.49764	71		
23	1706.6526	2130.76766	56		
24	1609.72694	2205.73866	67		
25	1527.34122	419.248873	72		
26	1595.18699	1067.19946	71.5		
27	1680.99234	1180.7081	71		
28	1829.31725	1490.36559	71.5		
29	1834.34173	2001.54801	71		
30	1912.21023	2177.02698	55.5		
31	1995.38308	808.61062	72.2		
32	2031.97563	2107.19589	55		
33	2266.97172	2359.96526	54.5		

# TOPOGRAPHIC MAP

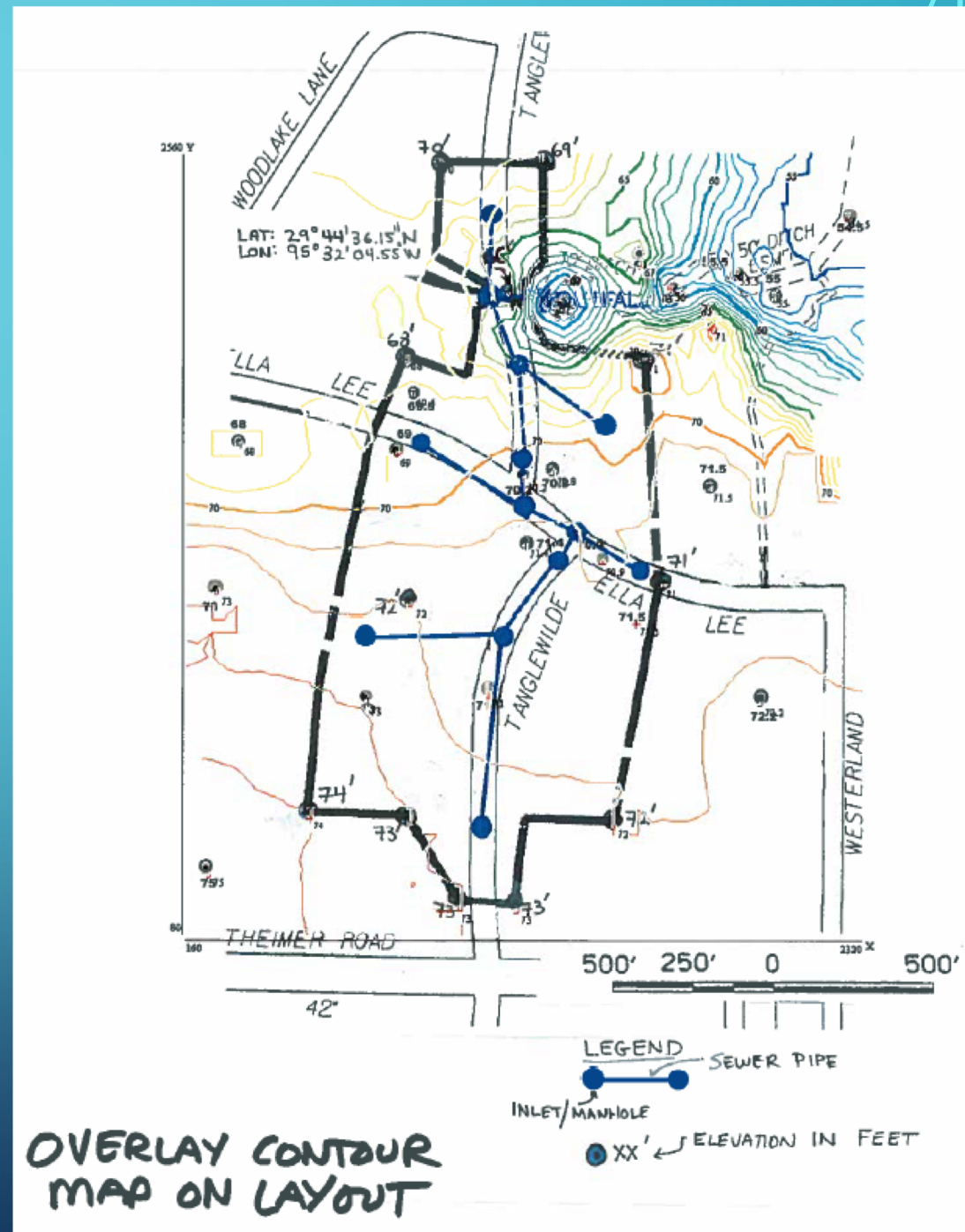
- Render a topographic map using appropriate tools
  - By-hand; Excel, R-script
  - QuickGrid, Surfer, etc.
  - Arc GIS, qGIS, etc.
- Adjust settings to build an overlay





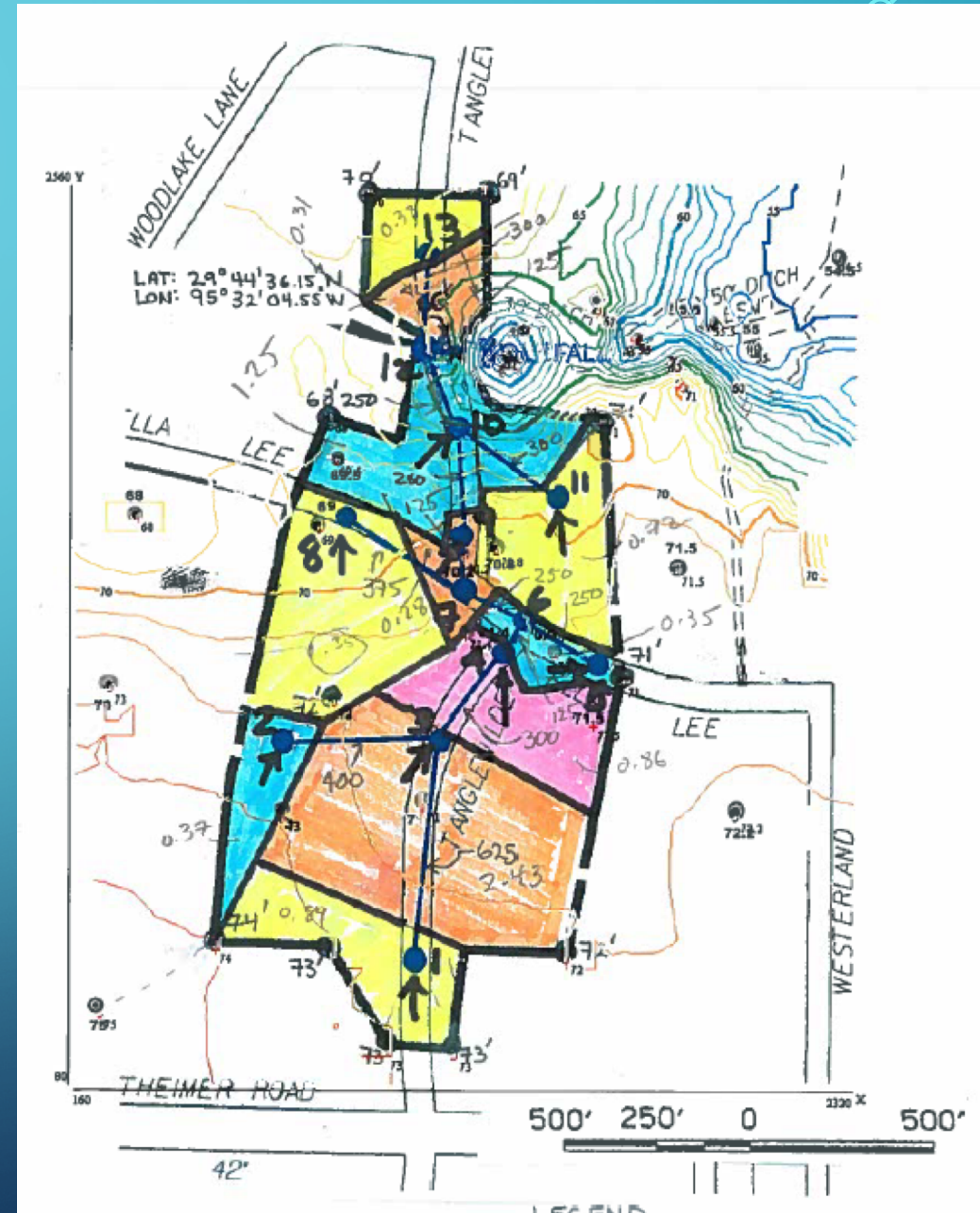
# TOPOGRAPHIC MAP

- Overlay the map – use known data locations (in XY) to reference the overlay to the sewer drawing



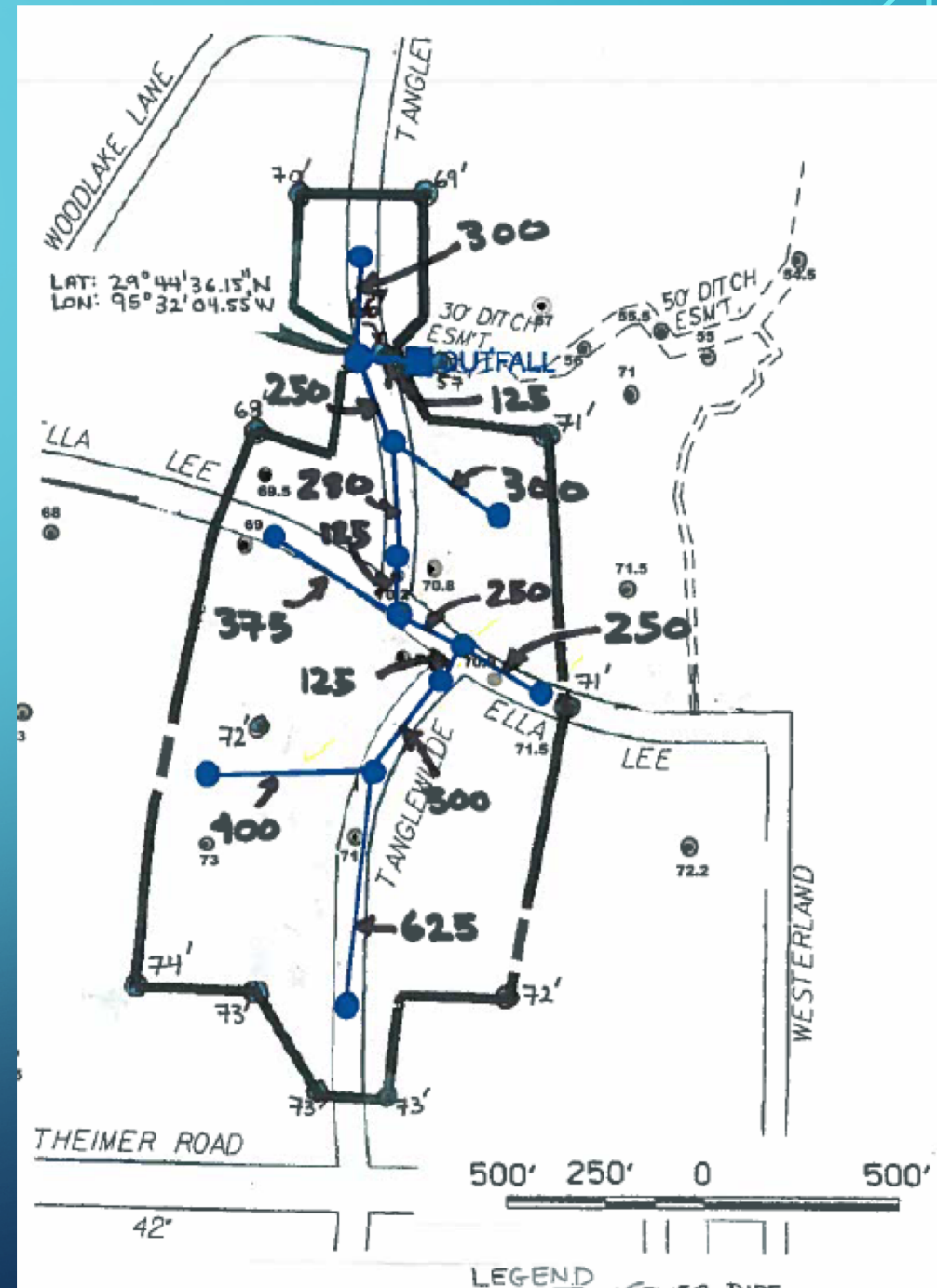
# DETERMINE DRAINAGE AREAS

- Identify the individual drainage areas using the topographic rendering and the project layout drawing.
- We will assume that drainage from outside the project area is collected elsewhere
  - The figure to the right is intended as a guide to the method – the areas listed are not topographically justified; that is left as an exercise!



# DETERMINE PIPE DISTANCES

- Identify the pipes to be sized in the drainage network
- Measure the pipe lengths



# TABULATE PREPARATORY RESULTS

## NODE-ARC DATA FROM ACROBAT

Node	Area (sq.in)	Area (sq. ft.)	Area (acres)	Overland Flow Distance (feet)	NRCS Upland Velocity (ft/sec)	Average Slope				
1	0.890	152920.962	3.511	391.051		Drop	2	feet		
2	0.370	63573.883	1.459	252.139		Distance	625	feet		
3	2.430	417525.773	9.585	646.162		Slope	0.0032	Dimensionless		
4	0.860	147766.323	3.392	384.404		Slope	0.32	% Slope		
5	0.350	60137.457	1.381	245.229						
6	0.000	0.000	0.000	0.000						
7	0.000	0.000	0.000	0.000						
8	1.350	231958.763	5.325	481.621						
9	0.280	48109.966	1.104	219.340						
10	1.250	214776.632	4.931	463.440						
11	0.720	123711.340	2.840	351.726						
12	0.310	53264.605	1.223	230.791						
13	0.380	65292.096	1.499	255.523						
14	--	--	36.250	Outfall						
Pipe	Node_1	Node_2	Length							
1	1	3	625							
2	2	3	400							
3	3	4	300							
4	4	6	125							
5	5	6	250							
6	6	7	250							
7	7	9	125							
8	8	7	375							
9	9	10	280							
10	11	10	300							
11	10	12	250							
12	13	12	300							
13	12	14	125							

USE UPLAND  
ENTER TO  
NEXT STREET

# DETERMINE INLET TIMES

- Declare a travel distance on a drainage area to an inlet
- Determine slope along that path
- Apply a Tc estimation method
- Repeat for each inlet

## NRCS Upland Method Tc Estimator

Input Values	
0.33	<= Watershed Slope (%)
Nearly Bare Ground	<= Select Watershed Surface Type (Pull Down Menu)
255	<= Path Length (ft)

Reference: NEH 630 Chapter 15

Computed Values	
0.565685425	<= Flow Velocity (ft/s)
451	<= Time (seconds)
7.5	<= Time (minutes)
0.13	<= Time (hours)

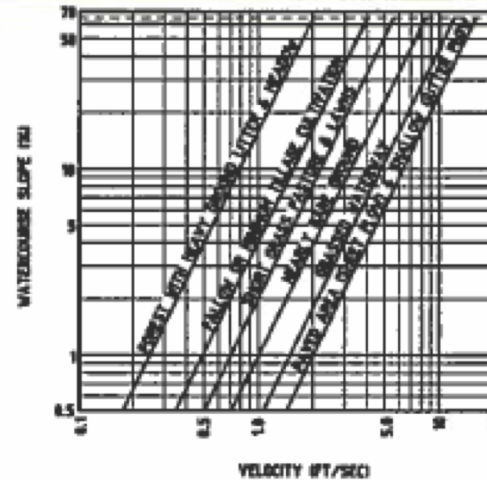
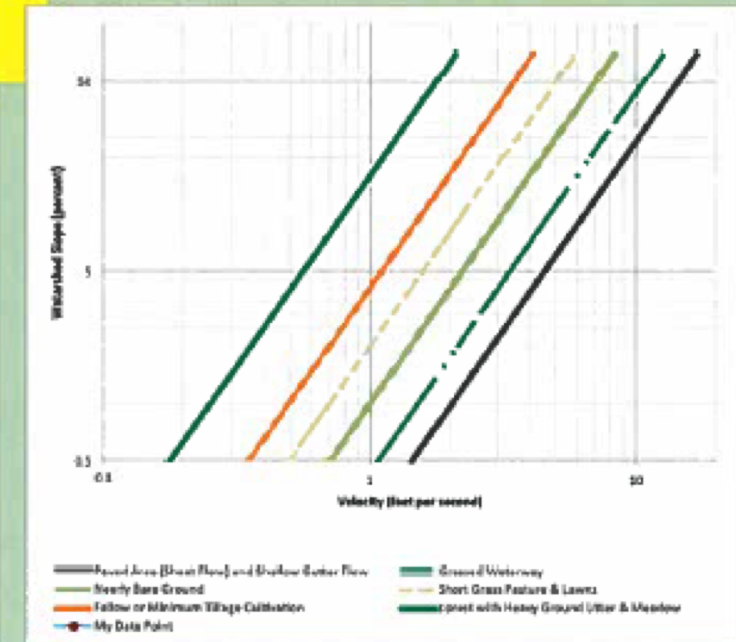


Figure 5-4. Velocities for Upland Method of Estimating Time of Concentration—English  
Adapted from the National Engineering Handbook Volume 4)



# DEVELOP AN INTENSITY EQUATION

- Locate the region on NOAA Atlas 14, Vol. 11 PFDS.
- Download the .CSV table
- Use solver to fit

$$I = \frac{B}{(T_c + D)^E}$$

hdsc.nws.noaa.gov/hdsc/pfds/pfds\_map\_cont.html?bkmrk=t

PF Data Server-PFDS/HDSC/OWP

PF Map: Cont

**Data description**  
 Data type:  Units:  Time series type:

**Select location**

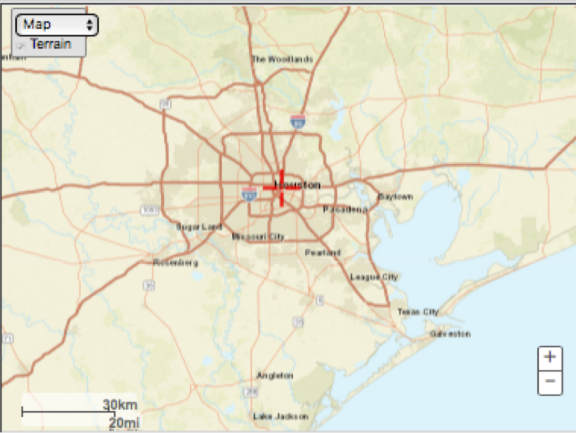
1) Manually:

a) By location (decimal degrees, use "S" for S and W): Latitude:  Longitude:

b) By station (list of TX stations):

c) By address

2) Use map (if ESRI interactive map is not loading, try adding the host: <https://js.arcgis.com/> to the firewall, or contact us at [hdsc.questions@noaa.gov](mailto:hdsc.questions@noaa.gov)):



**a) Select location**  
Move crosshair or double click

**b) Click on station icon**  
 Show stations on map

**Location information:**  
 Name: Houston, Texas, USA\*  
 Latitude: 29.7633°  
 Longitude: -95.3396°  
 Elevation: 33.12 ft\*\*

\* Source: ESRI Maps  
 \*\* Source: USGS

**POINT PRECIPITATION FREQUENCY (PF) ESTIMATES  
 WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION  
 NOAA Atlas 14, Volume 11, Version 2**

PF tabular | PF graphical | Supplementary information | Print page

**PDS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour)<sup>1</sup>**

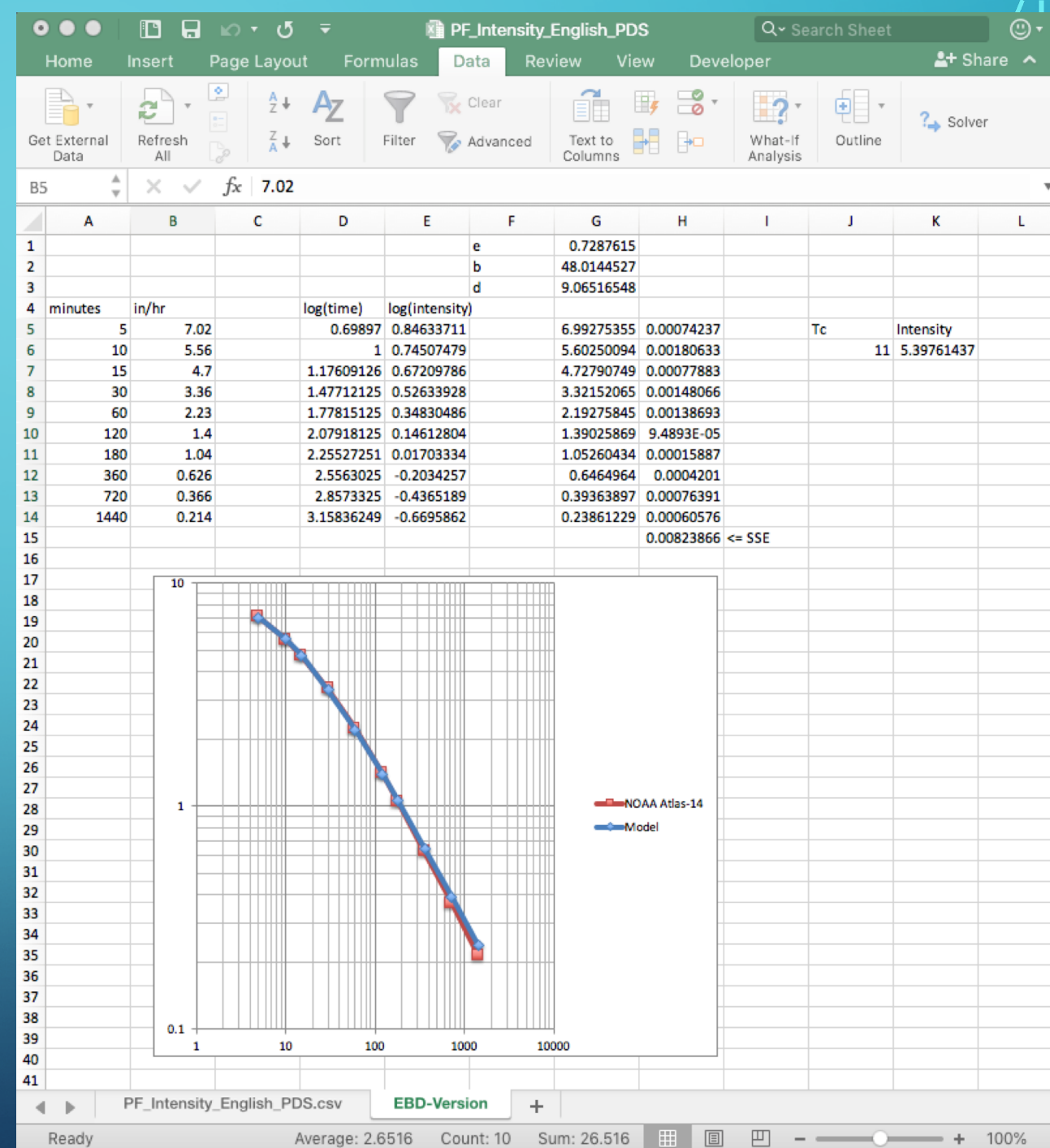
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	5.95 (4.51-7.87)	7.02 (5.35-9.16)	8.72 (6.65-11.5)	10.2 (7.63-13.5)	12.2 (8.83-16.7)	13.7 (9.70-19.3)	15.3 (10.6-22.2)	17.1 (11.5-25.4)	19.5 (12.6-30.0)	21.4 (13.5-33.8)
10-min	4.71 (3.57-6.22)	5.56 (4.24-7.25)	6.94 (5.28-9.10)	8.09 (6.07-10.8)	9.70 (7.06-13.3)	11.0 (7.77-15.5)	12.2 (8.45-17.8)	13.6 (9.11-20.2)	15.3 (9.94-23.6)	16.7 (10.5-26.3)
15-min	4.01 (3.04-5.30)	4.70 (3.59-6.14)	5.83 (4.44-7.66)	6.78 (5.09-9.03)	8.09 (5.88-11.1)	9.10 (6.44-12.8)	10.1 (7.00-14.7)	11.3 (7.58-16.8)	12.8 (8.34-19.8)	14.1 (8.92-22.3)
30-min	2.88 (2.18-3.80)	3.36 (2.57-4.39)	4.14 (3.16-5.44)	4.80 (3.60-6.39)	5.70 (4.13-7.80)	6.38 (4.50-8.98)	7.10 (4.90-10.3)	7.92 (5.33-11.8)	9.11 (5.92-14.1)	10.1 (6.39-15.9)
60-min	1.89 (1.43-2.50)	2.23 (1.70-2.91)	2.77 (2.11-3.64)	3.23 (2.42-4.31)	3.87 (2.80-5.29)	4.35 (3.07-6.12)	4.87 (3.36-7.06)	5.49 (3.69-8.18)	6.42 (4.17-9.91)	7.20 (4.56-11.4)
2-hr	1.14 (0.870-1.50)	1.40 (1.06-1.78)	1.78 (1.36-2.31)	2.13 (1.61-2.82)	2.64 (1.93-3.59)	3.05 (2.17-4.27)	3.51 (2.43-5.05)	4.06 (2.74-6.00)	4.90 (3.20-7.52)	5.63 (3.57-8.83)
3-hr	0.830 (0.635-1.08)	1.04 (0.787-1.31)	1.36 (1.04-1.75)	1.65 (1.25-2.17)	2.08 (1.53-2.83)	2.45 (1.75-3.42)	2.87 (2.00-4.12)	3.37 (2.28-4.96)	4.14 (2.71-6.33)	4.81 (3.06-7.52)
6-hr	0.480 (0.370-0.621)	0.626 (0.470-0.766)	0.830 (0.639-1.06)	1.03 (0.785-1.34)	1.33 (0.988-1.80)	1.60 (1.15-2.23)	1.91 (1.33-2.72)	2.28 (1.55-3.33)	2.84 (1.86-4.31)	3.33 (2.13-5.17)
12-hr	0.275 (0.213-0.353)	0.366 (0.275-0.441)	0.491 (0.380-0.620)	0.614 (0.472-0.795)	0.806 (0.601-1.08)	0.974 (0.706-1.35)	1.17 (0.824-1.66)	1.41 (0.959-2.04)	1.77 (1.16-2.66)	2.07 (1.33-3.20)
24-hr	0.159 (0.124-0.202)	0.214 (0.161-0.254)	0.290 (0.226-0.362)	0.365 (0.282-0.469)	0.482 (0.363-0.644)	0.587 (0.429-0.807)	0.709 (0.501-0.995)	0.850 (0.582-1.22)	1.06 (0.702-1.59)	1.25 (0.801-1.91)
2-day	0.090 (0.071-0.114)	0.124 (0.094-0.145)	0.170 (0.133-0.211)	0.216 (0.168-0.275)	0.288 (0.219-0.383)	0.354 (0.261-0.485)	0.429 (0.304-0.597)	0.510 (0.350-0.727)	0.625 (0.414-0.927)	0.719 (0.465-1.10)

# DEVELOP AN INTENSITY EQUATION

- Solver results for (2-yr ARI)

$$I = \frac{48.01}{(T_c + 9.06)^{0.73}}$$

- Use the above equation in the subsequent analysis
- Note: The exercise requests a design for 5-yr ARI, so readers will have to conduct the fitting exercise on the 5-yr column from NOAA Atlas 14!



# ANALYSIS

- Apply the intensity equation as needed