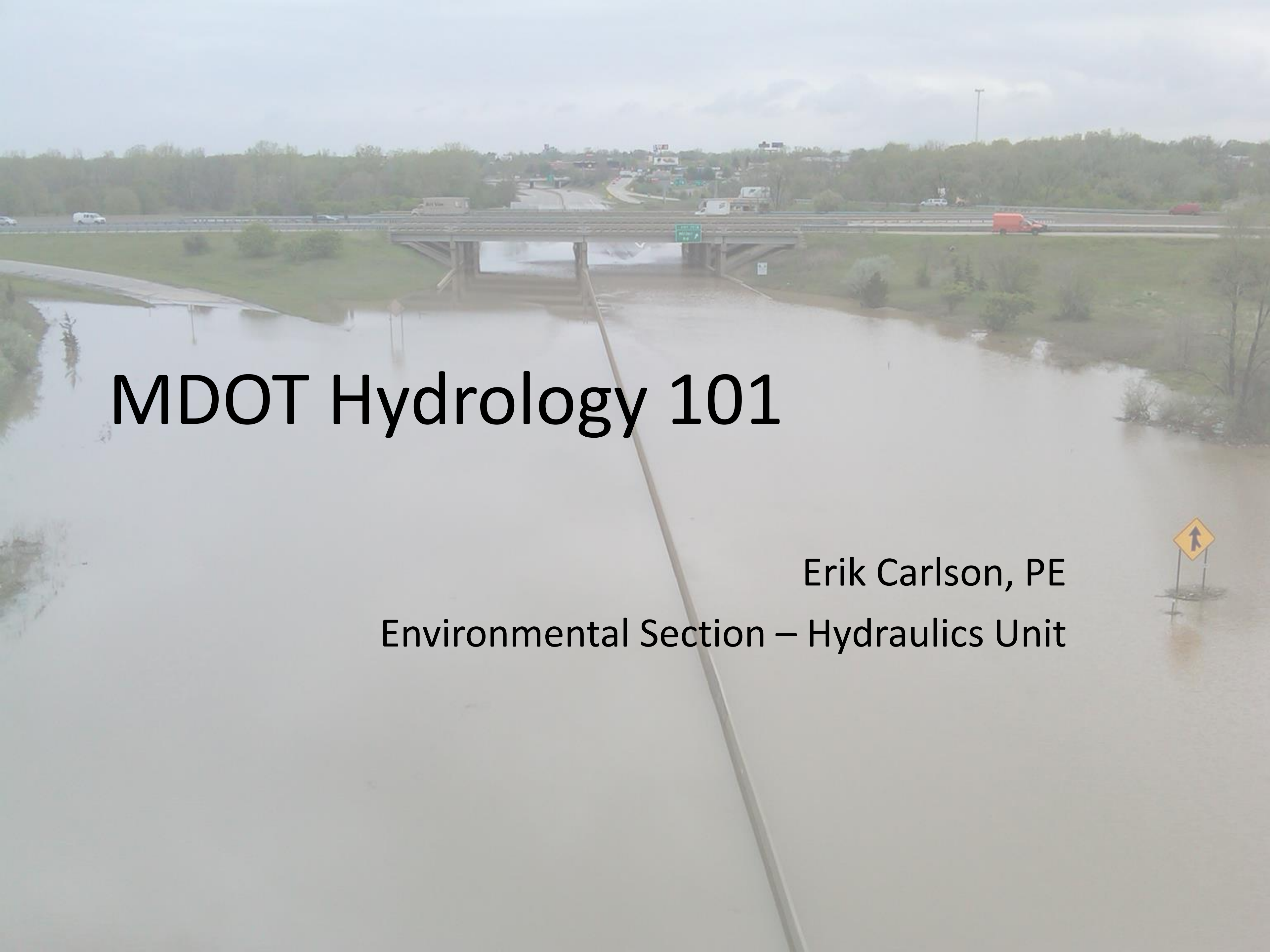


MDOT Hydrology 101

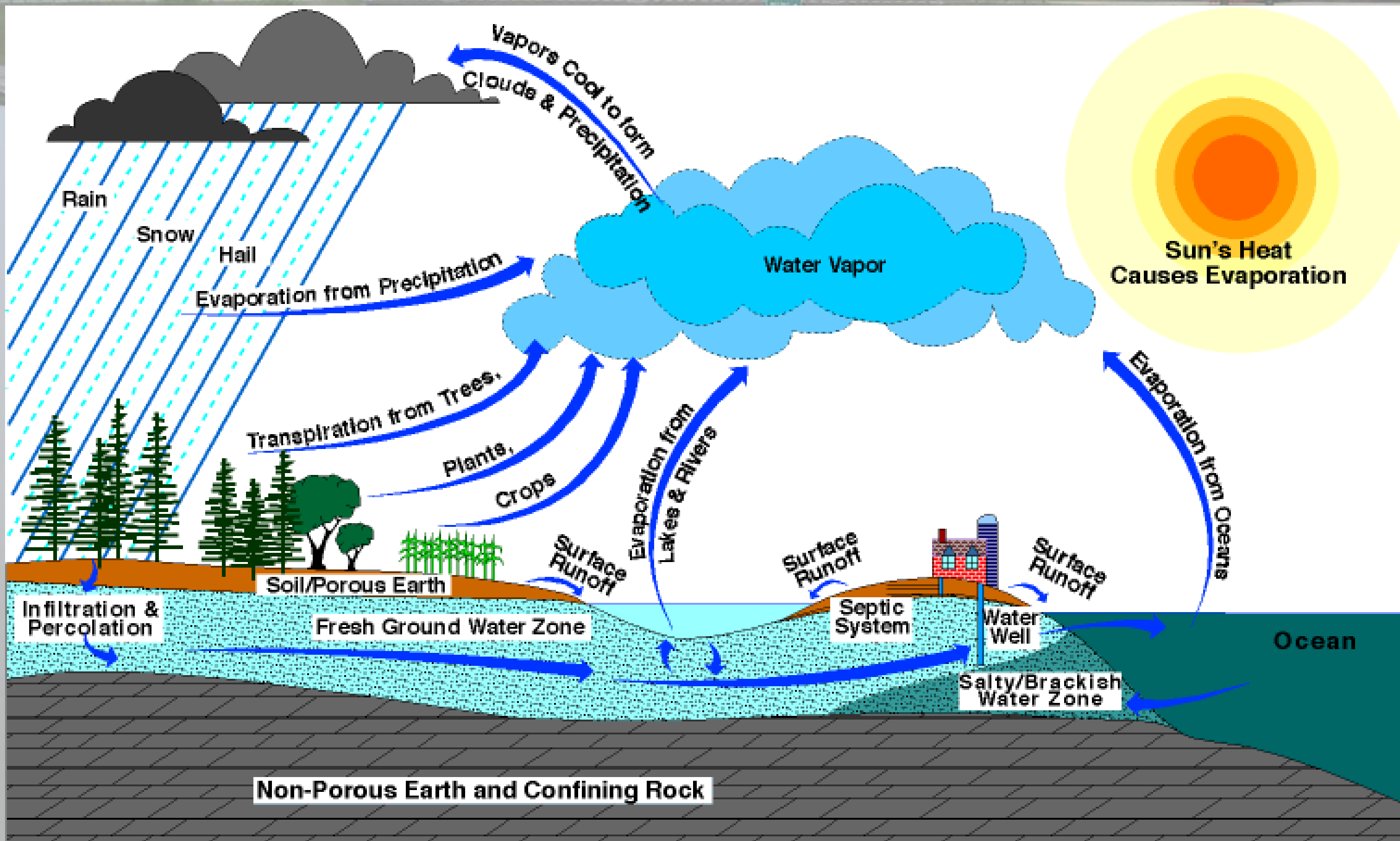
Erik Carlson, PE

Environmental Section – Hydraulics Unit

Objectives

- Define Hydrologic Cycle and Terms
- Delineate a watershed
- Develop understanding of MDOT Hydrology policy and procedures
- Define Hydrologic design methods
- Delineate and calculate the time of concentration
- Calculate curve number through soil/landuse delineations

Hydrologic Cycle



Hydrologic Cycle

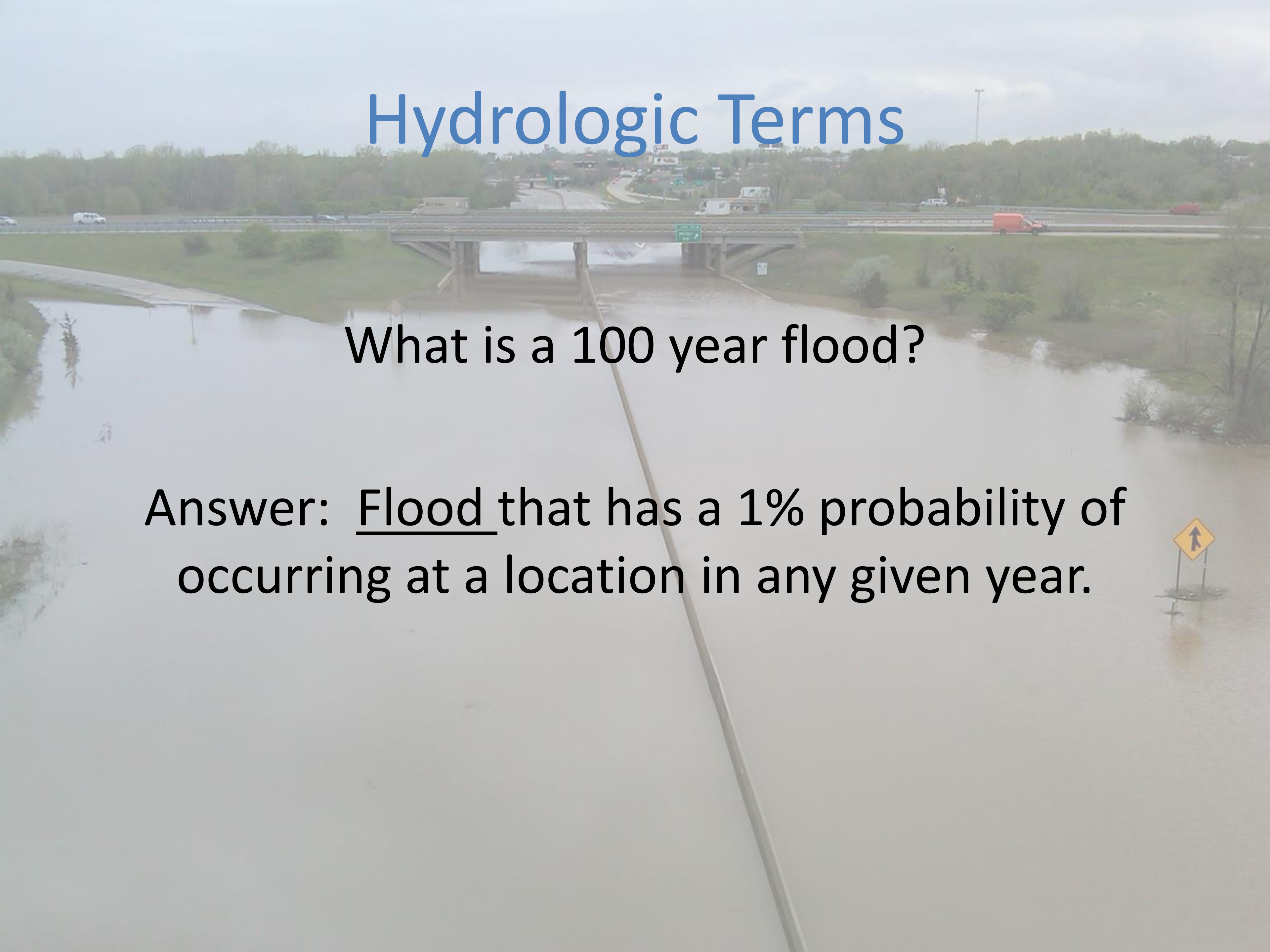
- Most design applications:
  - Precipitation
  - Infiltration
  - Storage
  - Surface runoff

Hydrologic Terms

What is a 100 year storm?

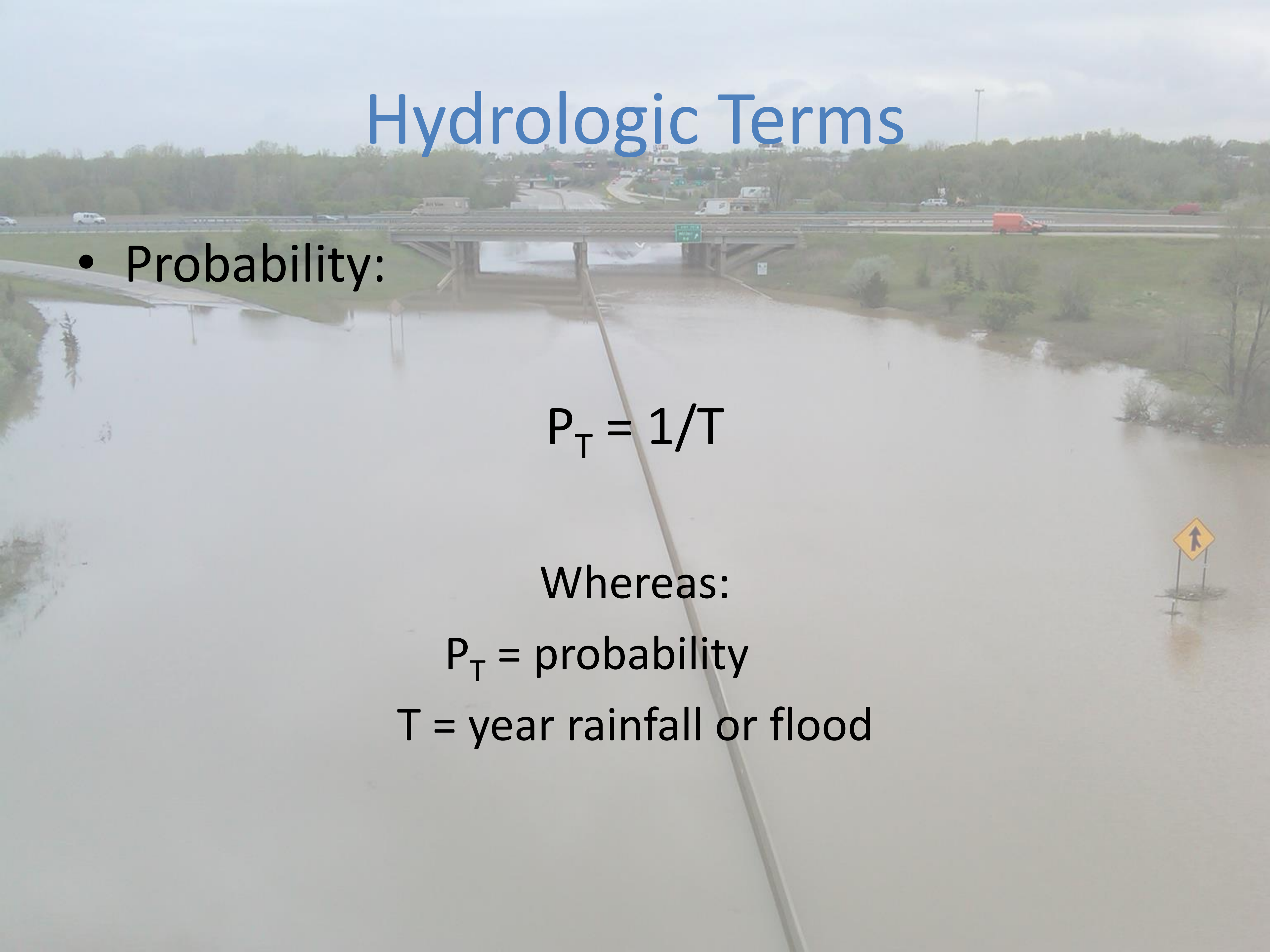
Answer: Rainfall totals that have a 1% probability of occurring at a location in any given year.

Hydrologic Terms



What is a 100 year flood?

Answer: Flood that has a 1% probability of occurring at a location in any given year.



Hydrologic Terms

- Probability:

$$P_T = 1/T$$

Whereas:

P_T = probability

T = year rainfall or flood

Hydrologic Terms

What is the probability of a 10 year storm in any given year?

Answer: 10% chance

Hydrologic Terms

- Probability of Exceedence:

$$P_T = 1 - (1 - (1 / T))^n$$

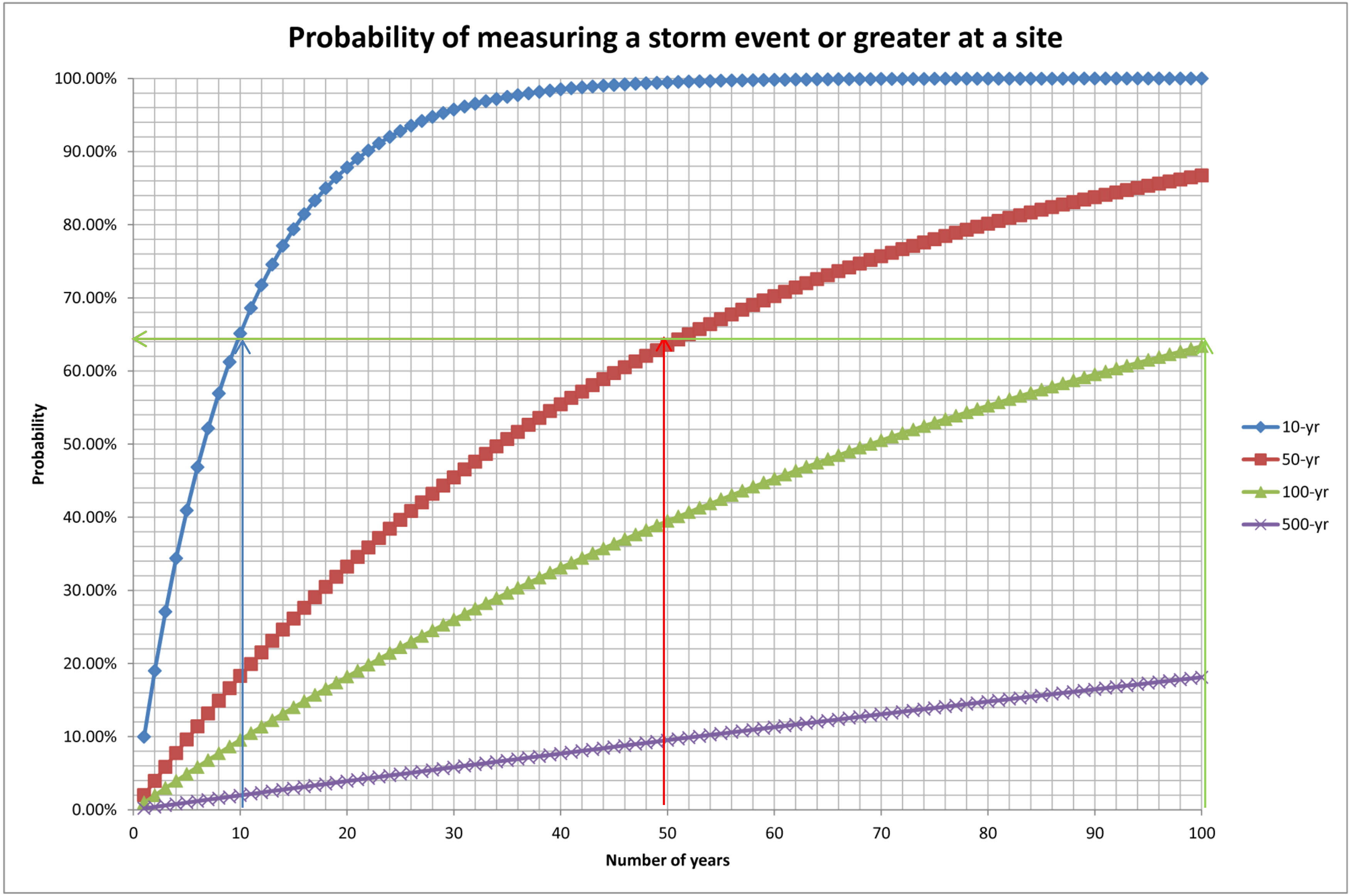
Whereas:

P_T = probability of exceedence

T = year rainfall or flood

n = number of years

Hydrologic Terms



Hydrologic Terms

- Additional notes:
  - Modeling assumes uniform rainfall across entire watershed
  - Often see high rainfall amounts over small portions of the watershed, leading to flooding of small structures but not major structures.
  - Rainfall and discharge values are determined based on limited statistical data, and are constantly evolving

Hydrologic Methods

- Spread calculations
  - 10 year (10% chance) flood
  - 50 year (2% chance) flood at sag points and depressed freeways
- Storm Sewer Pipe
  - 10 year (10% chance) flood
  - 50 year (2% chance) flood for depressed freeways
- Culverts (drainage areas less than 2 sq. miles)
  - 50 year (2% chance) flood
  - Check for harmful interference in the 100 year (1% chance) flood
- Ditches
  - 50 year (2% chance) flood
  - Check for harmful interference in the 100 year (1% chance) flood

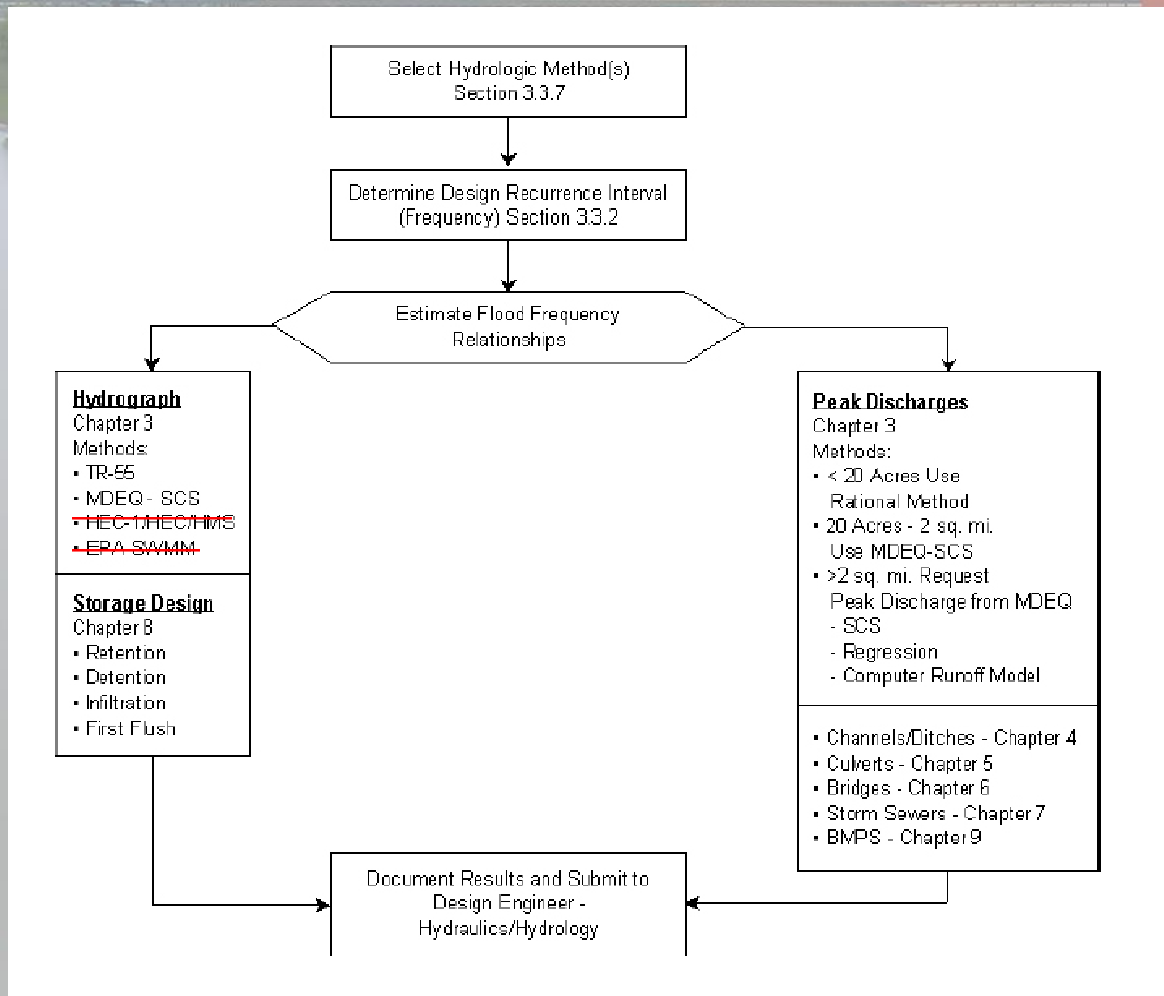
Hydrologic Methods

- Watershed delineation
  - Typically done on USGS topographic maps
  - Do not assume political or property boundaries for watershed divides
  - Things to watch for
    - Cutting valleys
    - Not choosing closest contour
    - Assuming roads as divides rather than contours
    - Boundary not perpendicular to contours

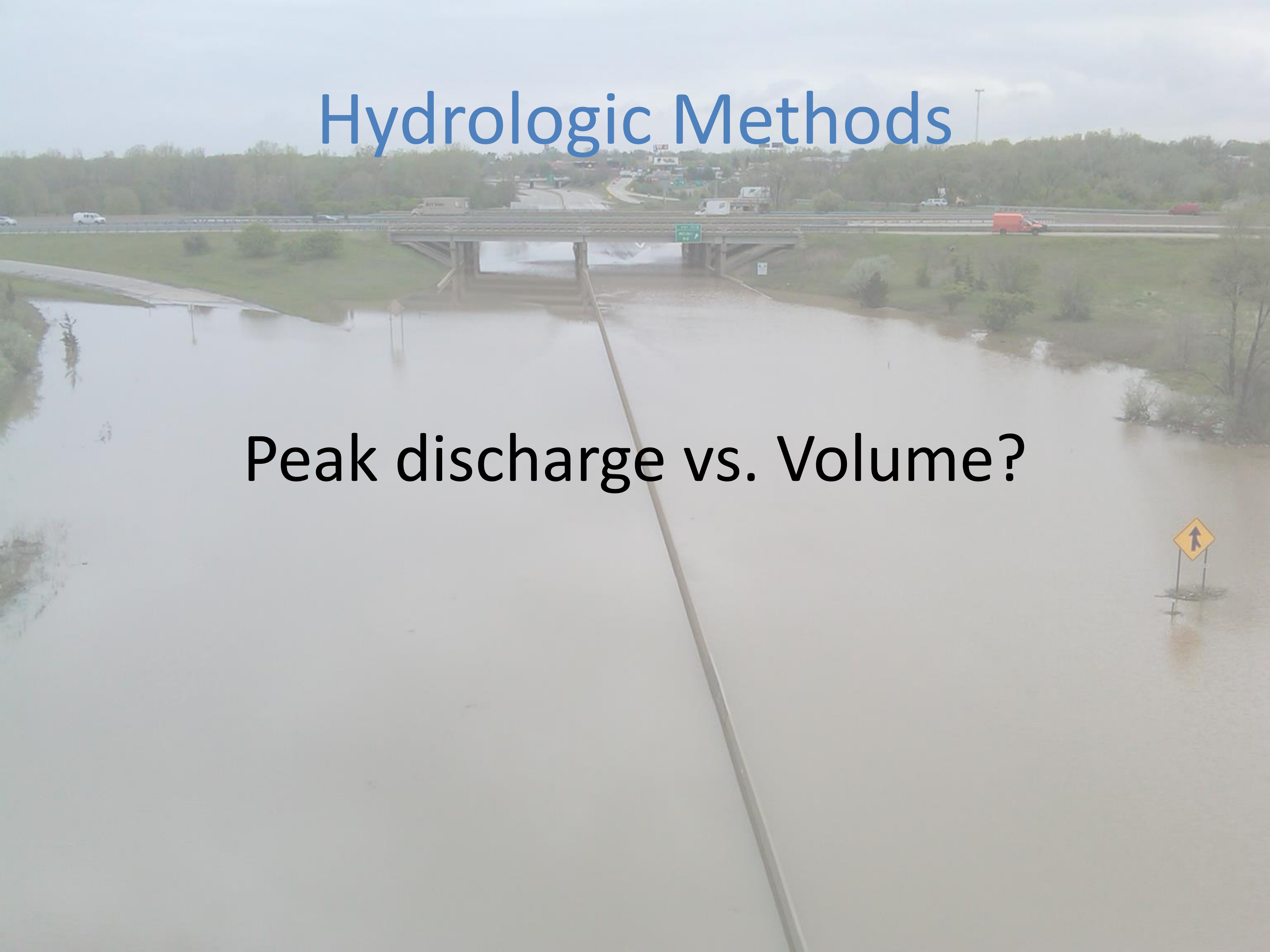
Hydrologic Methods

- Watershed delineation (cont.)
  - Assumptions
    - If not absolutely clear that a watercourse crosses a road through a filled area, assume the road is the divide.
    - Assume drainage can cross roads unless clearly shown otherwise by contours.
    - Depressions of one contour can either be assumed to contribute or not depending on size/circumstance.
    - Depressions of two contours are considered non-contributing as well as their individual contributing drainage areas.
      - To determine contributing/non-contributing
        - » Define storage potential (compute using average end areas of contours)
        - » Define runoff potential (SRO * DA)
        - » Compare the two

Hydrologic Methods



Hydrologic Methods



Peak discharge vs. Volume?

Hydrologic Methods

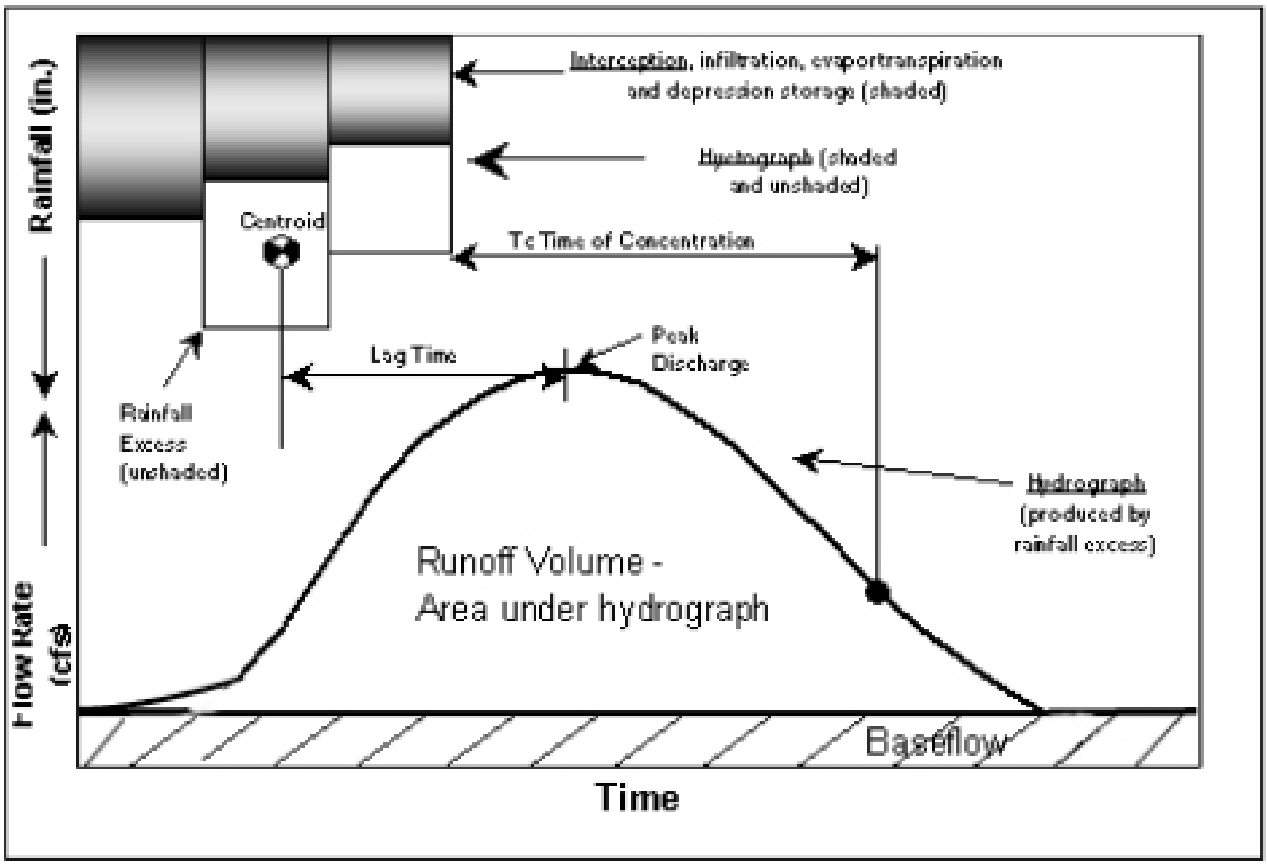


Figure 3-1 Representation of Hydrograph, Hyetograph, and Rainfall Excess

Hydrologic Methods

- Rational Method (drainage areas under 20 acres)
  - Not typically used for volume computations
- MDEQ-SCS (drainage areas over 20 acres but less than 2 sq. miles)
  - TR-55 used with MDEQ unit hydrograph when $T_c < 1$ hr
  - Typically used for volume computations
- For drainage areas greater than 2 square miles, contact Hydraulic Unit.

Hydrologic Methods

- Rational Method (drainage areas less than 20 acres):

$$Q = C\ I\ A$$ (MDOT Drainage Manual 3.1)

Whereas:

Q = peak discharge

C = Runoff coefficient

I = Rainfall Intensity, in./hr.

A = drainage area, acres

Hydrologic Methods

- Rational Method:
  - Limited to drainage areas less than 20 acres
  - C factors based on Table 3-1 in MDOT Drainage Manual
  - Rainfall intensities are defined by the time of concentration (IDF tables, Appendix 3-B, MDOT Drainage Manual)
  - The time of concentration (t_c) is often assumed, unless the flow path is well defined:
    - 15 minutes for most applications
    - 10 minutes for depressed freeways and pump station designs
  - When choosing a C factor, the designer should consider 20 years of future development
  - Use should be limited to computing peak discharge

Hydrologic Methods

Rainfall Frequency Zones

Hydrologic Methods

MDOT DRAINAGE MANUAL
RAINFALL INTENSITY – DURATION TABLE

TIME INTERVAL ON THIS SHEET = 0.1 MINUTES
Rainfall Intensity given in inches per hour.

t_c I

Time in Minutes	Zone 1			Zone 2			Zone 3			Zone 4			Zone 5		
	10 year	50 year	100 year	10 year	50 year	100 year	10 year	50 year	100 year	10 year	50 year	100 year	10 year	50 year	100 year
13.0	3.35	4.26	4.64	3.19	4.06	4.42	3.44	4.37	4.76	3.36	4.27	4.64	3.69	4.68	5.11
13.1	3.34	4.25	4.62	3.18	4.04	4.41	3.43	4.36	4.74	3.35	4.25	4.62	3.67	4.67	5.09
13.2	3.33	4.23	4.60	3.17	4.03	4.39	3.41	4.34	4.72	3.33	4.24	4.60	3.66	4.65	5.07
13.3	3.31	4.21	4.58	3.16	4.01	4.37	3.40	4.32	4.71	3.32	4.22	4.58	3.64	4.63	5.05
13.4	3.30	4.20	4.57	3.14	4.00	4.36	3.39	4.31	4.69	3.31	4.20	4.57	3.63	4.61	5.03
13.5	3.29	4.18	4.55	3.13	3.98	4.34	3.37	4.29	4.67	3.29	4.19	4.55	3.61	4.60	5.02
13.6	3.27	4.17	4.53	3.12	3.97	4.33	3.36	4.28	4.66	3.28	4.17	4.53	3.60	4.58	5.00
13.7	3.26	4.15	4.52	3.11	3.95	4.31	3.35	4.26	4.64	3.27	4.16	4.52	3.58	4.56	4.98
13.8	3.25	4.14	4.50	3.10	3.94	4.29	3.33	4.24	4.62	3.25	4.14	4.50	3.57	4.55	4.96
13.9	3.24	4.12	4.49	3.08	3.93	4.28	3.32	4.23	4.61	3.24	4.13	4.49	3.56	4.53	4.94
14.0	3.22	4.11	4.47	3.07	3.91	4.26	3.31	4.21	4.59	3.23	4.11	4.47	3.54	4.51	4.93
14.1	3.21	4.09	4.45	3.06	3.90	4.25	3.30	4.20	4.57	3.22	4.10	4.45	3.53	4.50	4.91
14.2	3.20	4.08	4.44	3.05	3.88	4.23	3.28	4.18	4.56	3.21	4.08	4.44	3.52	4.48	4.89
14.3	3.19	4.06	4.42	3.04	3.87	4.22	3.27	4.17	4.54	3.19	4.07	4.42	3.50	4.46	4.87
14.4	3.18	4.05	4.41	3.03	3.86	4.20	3.26	4.15	4.53	3.18	4.06	4.41	3.49	4.45	4.86
14.5	3.16	4.03	4.39	3.01	3.84	4.19	3.25	4.14	4.51	3.17	4.04	4.39	3.48	4.43	4.84
14.6	3.15	4.02	4.38	3.00	3.83	4.18	3.24	4.13	4.50	3.16	4.03	4.38	3.46	4.42	4.82
14.7	3.14	4.01	4.36	2.99	3.82	4.16	3.22	4.11	4.48	3.15	4.01	4.36	3.45	4.40	4.81
14.8	3.13	3.99	4.35	2.98	3.80	4.15	3.21	4.10	4.47	3.14	4.00	4.35	3.44	4.39	4.79
14.9	3.12	3.98	4.33	2.97	3.79	4.13	3.20	4.08	4.45	3.12	3.99	4.33	3.43	4.37	4.78
15.0	3.11	3.97	4.32	2.96	3.78	4.12	3.19	4.07	4.44	3.11	3.97	4.32	3.42	4.36	4.76
15.1	3.10	3.95	4.31	2.95	3.77	4.11	3.18	4.06	4.43	3.10	3.96	4.31	3.40	4.34	4.74
15.2	3.09	3.94	4.29	2.94	3.75	4.09	3.17	4.04	4.41	3.09	3.95	4.29	3.39	4.33	4.73
15.3	3.08	3.93	4.28	2.93	3.74	4.08	3.16	4.03	4.40	3.08	3.93	4.28	3.38	4.32	4.71
15.4	3.07	3.91	4.26	2.92	3.73	4.07	3.15	4.02	4.38	3.07	3.92	4.26	3.37	4.30	4.70
15.5	3.05	3.90	4.25	2.91	3.72	4.05	3.13	4.00	4.37	3.06	3.91	4.25	3.36	4.29	4.68
15.6	3.04	3.89	4.24	2.90	3.71	4.04	3.12	3.99	4.36	3.05	3.90	4.24	3.35	4.27	4.67
15.7	3.03	3.88	4.22	2.89	3.69	4.03	3.11	3.98	4.34	3.04	3.88	4.22	3.33	4.26	4.65
15.8	3.02	3.87	4.21	2.88	3.68	4.02	3.10	3.97	4.33	3.03	3.87	4.21	3.32	4.25	4.64
15.9	3.01	3.85	4.20	2.87	3.67	4.00	3.09	3.95	4.31	3.02	3.86	4.20	3.31	4.23	4.62

Hydrologic Methods

- Rational Method (cont):
  - Use a weighted C for different land uses within a watershed

$$\bar{C} = \frac{\sum CA}{A}$$

  - For storm sewer computations, the CA values for each catch basin/manhole are added, and then multiplied by the rainfall intensity:

$$Q_n = \Sigma(CA) * I$$

or

$$Q_n = ((C_1A_1) + (C_2A_2) + \ldots (C_nA_n)) * I$$

Hydrologic Methods

Sample Problem

Determine a weighted “C” for a 0.5 acre watershed with 0.4 acres of grassy area and 0.1 acres of pavement.

Hydrologic Methods

Table 3-1 Runoff Coefficients for Rational Formula

Type of Drainage Area	Runoff Coefficient, C*
Concrete or Asphalt Pavement	0.8 – 0.9
Commercial and Industrial	0.7 – 0.9
Gravel Roadways and Shoulders	0.5 – 0.7
Residential – Urban	0.5 – 0.7
Residential – Suburban	0.3 – 0.5
Undeveloped	0.1 – 0.3
Berms	0.1 – 0.3
Agricultural – Cultivated Fields	0.15 – 0.4
Agricultural – Pastures	0.1 – 0.4
Agricultural – Forested Areas	0.1 – 0.4

For flat slopes or permeable soil, lower values shall be used. For steep slopes or impermeable soil, higher values shall be used. Steep slopes are 2:1 or steeper.

From Michigan State Administrative Rules R 280.9.

Hydrologic Methods

Sample Problem

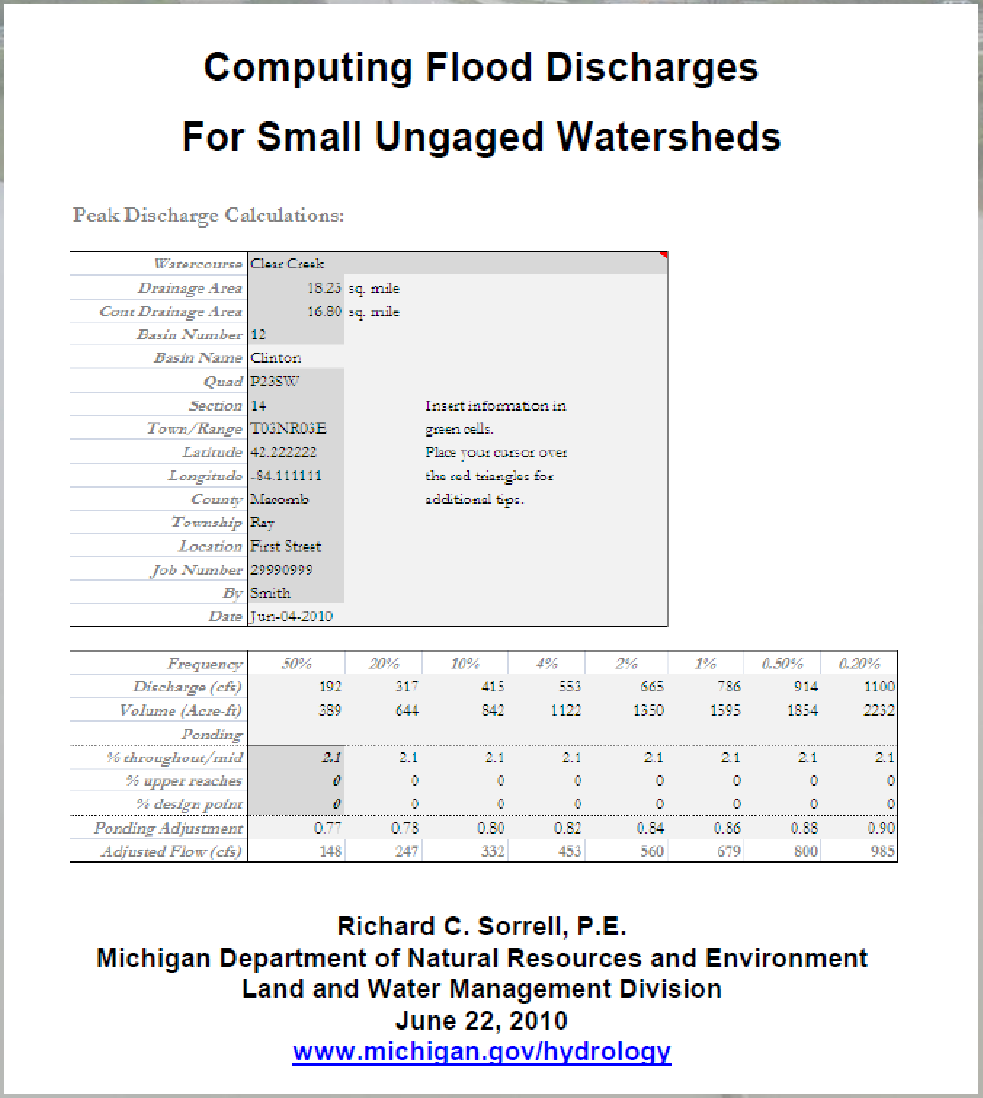
	C		A		CA
Pavement	0.9	*	0.1 acres	=	0.09 acres
Grass	0.2	*	0.4 acres	=	0.08 acres
	Σ =		0.5 acres		0.17 acres

$$\bar{C} = \frac{0.17\ \text{acres}}{0.5\ \text{acres}} = 0.34$$

Hydrologic Methods

- MDEQ-SCS Method:
  - Drainage areas greater than 20 acres but less than 2 square miles
  - "Computing Flood Discharges for Small Ungaged Watersheds," Sorrell, 2010
  - Rainfall to runoff model
    - RCN determined from soil/landuse delineations
    - Consider 20 years of future development
  - SCS Method with modified unit hydrograph
    - 28.5 percent of volume under the rising limb
    - Type II rainfall distribution
  - 24 hour design rainfall

Hydrologic Methods



Computing Flood Discharges

For Small Ungaged Watersheds

Peak Discharge Calculations:

Watercourse	Clear Creek	
Drainage Area	18.23	sq. mile
Cont Drainage Area	16.80	sq. mile
Basin Number	12	
Basin Name	Clinton	
Quad	P23SW	
Section	14	
Town/Range	T03NR03E	
Latitude	42.222222	
Longitude	-84.111111	
County	Macomb	
Township	Ray	
Location	First Street	
Job Number	29990999	
By	Smith	
Date	Jun-04-2010	

Insert information in green cells.
Place your cursor over the red triangles for additional tips.

Frequency	*50%*	*20%*	*10%*	*4%*	*2%*	*1%*	*0.50%*	*0.20%*
Discharge (cfs)	192	317	415	553	665	786	914	1100
Volume (Acre-ft)	389	644	842	1122	1350	1595	1854	2232
Ponding								
% throughout/mid	***2.1***	2.1	2.1	2.1	2.1	2.1	2.1	2.1
% upper reaches	***0***	0	0	0	0	0	0	0
% design point	***0***	0	0	0	0	0	0	0
Ponding Adjustment	0.77	0.78	0.80	0.82	0.84	0.86	0.88	0.90
Adjusted Flow (cfs)	148	247	332	453	560	679	800	985

Richard C. Sorrell, P.E.
Michigan Department of Natural Resources and Environment
Land and Water Management Division
June 22, 2010
www.michigan.gov/hydrology

Hydrologic Methods

- MDEQ-SCS Method (cont.):

$q_p' = 238.6 * T_c^{-0.82}$ (1 hr < T_c < 40 hr)

$$SRO = \frac{(P - Ia)^2}{P - Ia + S}$$

$$S = \frac{1000}{RCN} - 10$$

$I_a = 0.2 * S$

$Q = q_p' * SRO * DA * pond$

DA = drainage area (sq. miles)
RCN = Runoff curve number
Pond = watershed ponding reduction factor
P = 24 hr. rainfall (in.) found in "Computing Flood Discharges for Small Ungaged Watersheds"

Hydrologic Methods

- MDEQ-SCS Method (cont.):
  - DEQ Excel spreadsheet:

    http://www.michigan.gov/deq/0,4561,7-135-3313_3684_3724-9324--,00.html

  - If tc < 1 hr, use TR-55 with the following ordinates for unit hydrograph: 0.0, 0.5, 1.0, 0.8, 0.6, 0.4, 0.2, 0.0

Hydrologic Methods

- Runoff Curve Number (RCN)
  - Combination of soil type and landuse
  - Soil types
    - A (well-drained)
    - B
    - C
    - D (poorly drained)
  - Landuse values developed for agricultural purposes
  - Beware of drained/undrained soil types (A/D, B/D, etc.)!
  - Beware of complex soils!

Hydrologic Methods

Table 6.1 – Runoff curve numbers for hydrologic soil-cover complexes (AMC-II conditions)

Land use	Treatment or practice	Hydrologic condition	Hydrologic soil group A	B	C	D
Fallow soil	Straight row		77	86	91	94
Row crops	Straight row	Poor	72	81	88	91
		Good	67	78	85	89
	Contoured	Poor	70	79	84	88
		Good	65	75	82	86
	Contoured and terraced	Poor	66	74	80	82
		Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	Contoured and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes or rotation meadow	Straight row	Poor	66	77	85	89
		Good	58	72	81	85
	Contoured	Poor	64	75	83	85
		Good	55	69	78	83
	Contoured and terraced	Poor	63	73	80	83
		Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
		Fair	30	59	75	83
		Good	30	35	70	79
Meadow			30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	30	55	70	77
Residential	⅛ acre		77	85	90	92
	¼ acre		61	75	83	87
	1/3 acre		57	72	81	86
	½ acre		54	70	80	85
	1 acre		51	68	79	84
Open spaces (parks, golf courses, cemeteries, etc.)	Good condition: Grass cover > 75% of area		39	61	74	80
	Fair condition: Grass cover 50-75% of area		49	69	79	84
Commercial or business area (85% impervious)			89	92	94	95
Industrial district (72% impervious)			81	88	91	93
Farmsteads			59	74	82	86
Paved areas (roads, drive-ways, parking lots, roofs)			98	98	98	98
Water surfaces (lakes, ponds, reservoirs, etc.)			100	100	100	100
Swamp	At least 1/3 is open water		85	85	85	85
	Vegetated		78	78	78	78

Hydrologic Methods

- Runoff Curve Number (RCN)
  - Miller Grid Method
    - Divide watershed into individual squares, and assign numeric values correlating to a soil/landuse combination
    - Sample grid size (may have to adjust for site conditions)
      - Drainage areas less than 0.5 sq. mi. – 200’ x 200’
      - Drainage areas less than 1.0 sq. mi. – 400’ x 400’
      - Drainage areas less than 2.0 sq. mi. – 500’ x 500‘
    - Digital soil maps can be electronically printed and imported into Microstation
      - http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

USDA United States Department of Agriculture
Natural Resources Conservation Service

Web Soil Survey

The simple yet powerful way to access and use soil data.

START WSS

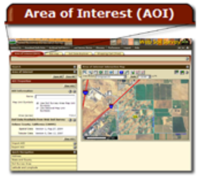
Welcome to Web Soil Survey (WSS)

Web Soil Survey (WSS) provides soil data and information produced by the National Cooperative Soil Survey. It is operated by the USDA Natural Resources Conservation Service (NRCS) and provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation's counties and anticipates having 100 percent in the near future. The site is updated and maintained online as the single authoritative source of soil survey information.

Soil surveys can be used for general farm, local, and wider area planning. Onsite investigation is needed in some cases, such as soil quality assessments and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center or your NRCS State Soil Scientist.

Four Basic Steps

1 Define.



Click to view larger image.

Use the Area of Interest tab to define your area of interest.

2 View.

Click the Soil Map tab to view or print a soil map, and detailed descriptions of the soils in your Area of Interest.

I Want To...

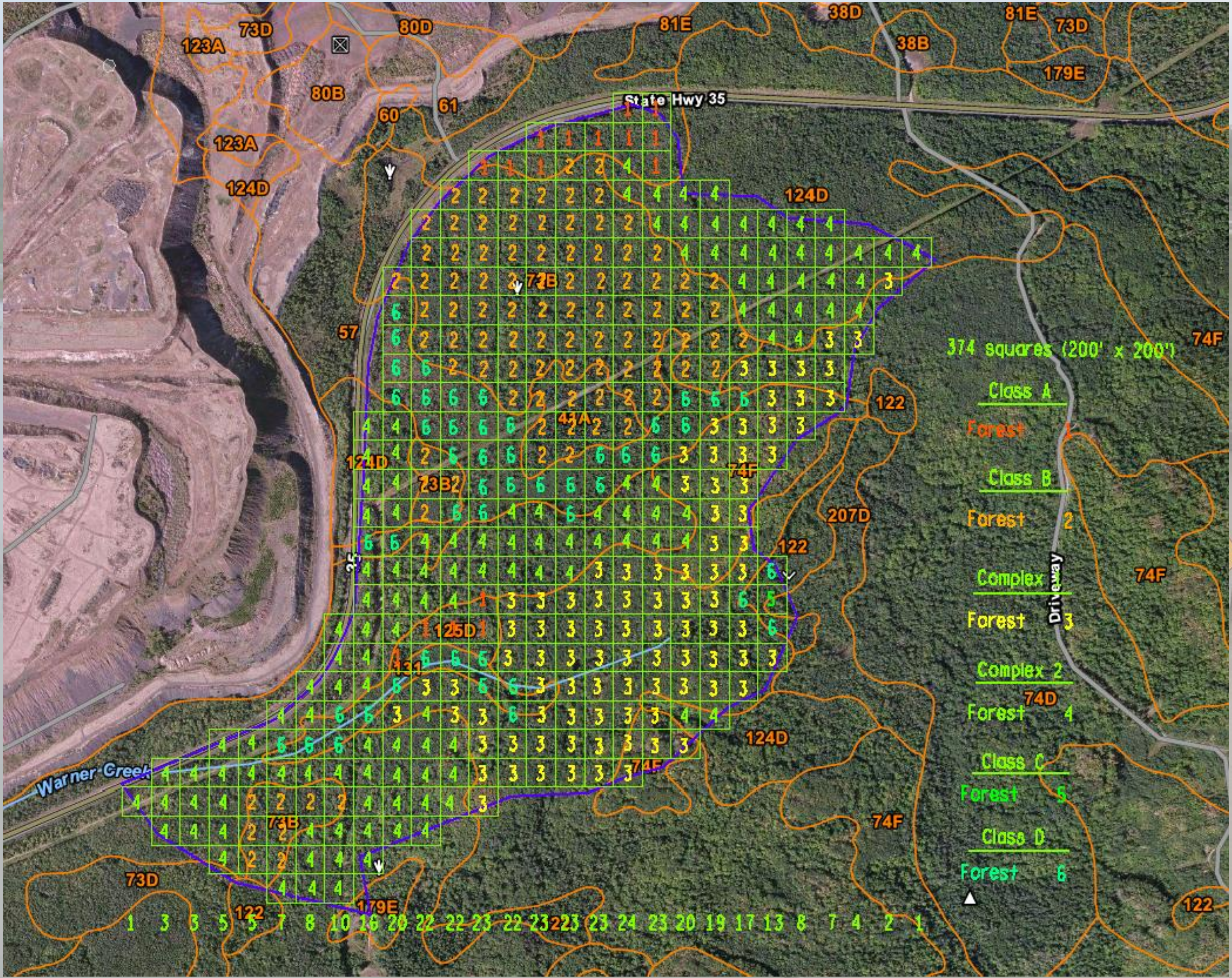
- **Start Web Soil Survey (WSS)**
- **Know the requirements for running Web Soil Survey — will Web Soil Survey work in my web browser?**
- **Know the Web Soil Survey hours of operation**
- **Find what areas of the U.S. have soil data**
- **Find information by topic**
- **Know how to hyperlink from other documents to Web Soil Survey**

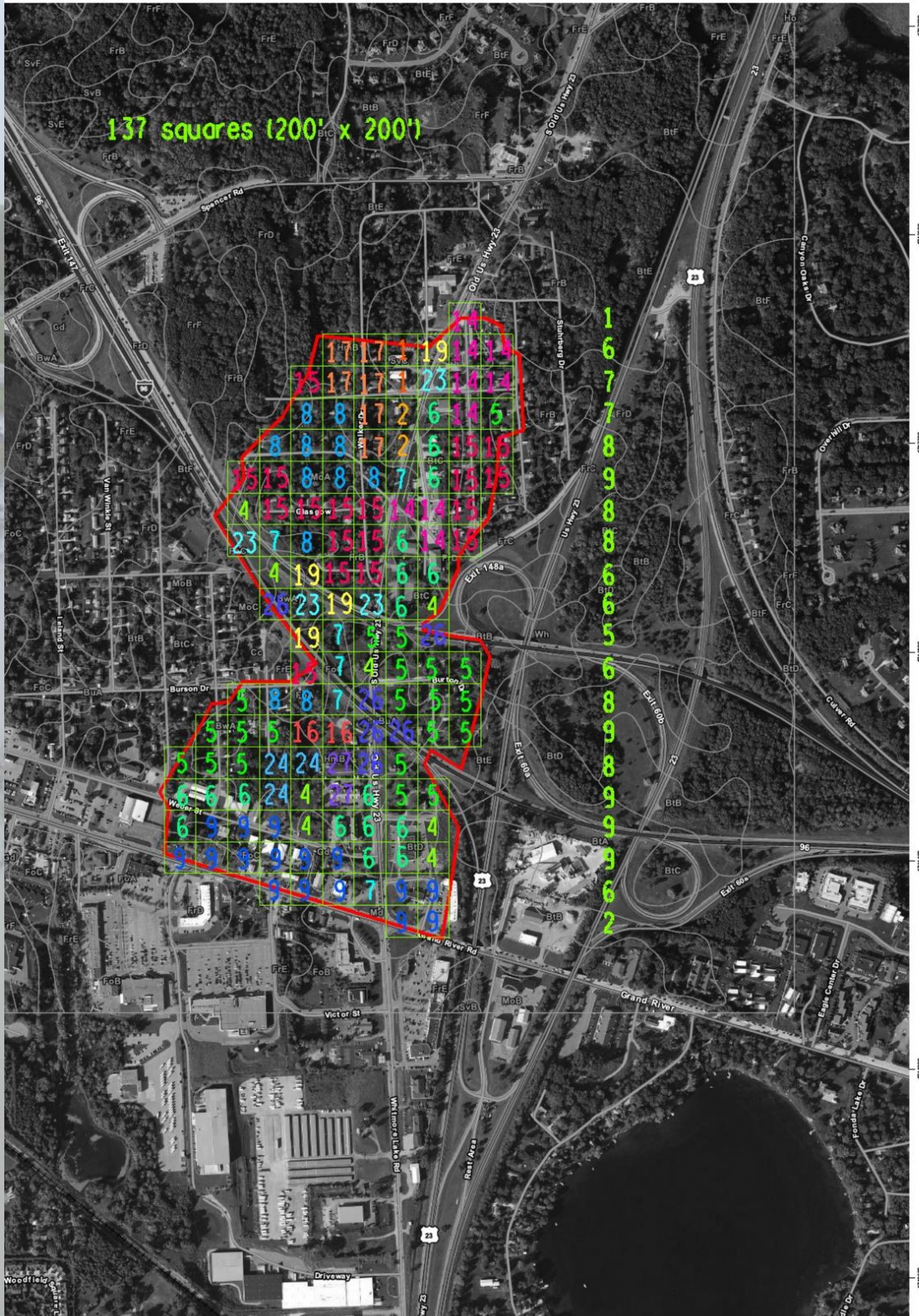
Announcements/Events

- **Web Soil Survey 3.0 has been released! View description of new features.**
- **Web Soil Survey Release History**
- **Sign up for e-mail updates via GovDelivery**

I Want Help With...

- **Getting Started With Web Soil Survey**
- **How to use Web Soil Survey**
- **How to use Web Soil Survey Online Help**
- **Known Problems and Workarounds**
- **Frequently Asked Questions**
- **Citing Web Soil Survey as a source of soils data**


State Hwy 35
Warner Creek
Driveway
374 squares (200' x 200')
Class A
Forest 1
Class B
Forest 2
Complex
Forest 3
Complex 2
Forest 4
Class C
Forest 5
Class D
Forest 6
123A
73D
80D
80B
60
61
124D
81E
38D
38B
179E
57
73B
43A
125D
131
122
207D
74F
74D
179E
1 3 3 5 5 7 8 10 16 20 22 22 23 22 23 23 23 24 23 20 19 17 13 8 7 4 2 1



Class A

Commercial	1
Res1/2	2
Paved	3
Res1	21

Class B

Open Good	4
Res1/2	5
Commercial	6
Forest	24
Paved	26

Class C

Open Good	7
Res1/2	8
Commercial	9
Paved	20
Forest	22

Class D

Swamp	10
Forest	11
Water	12
Paved	18
Res1/2	25

Complex 1

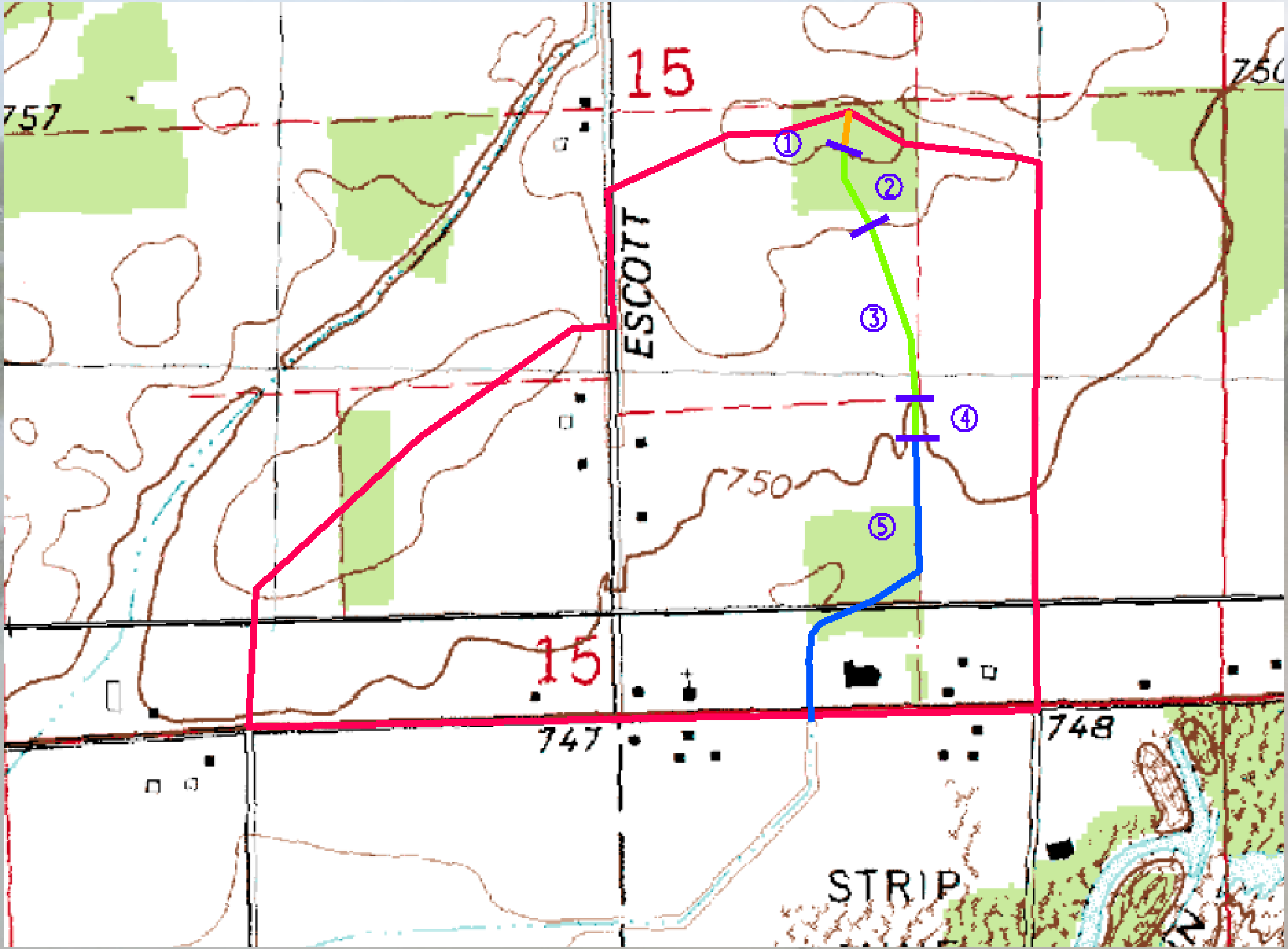
Forest	13
Commercial	14
Res1/2	15
Paved	19
Open Good	23

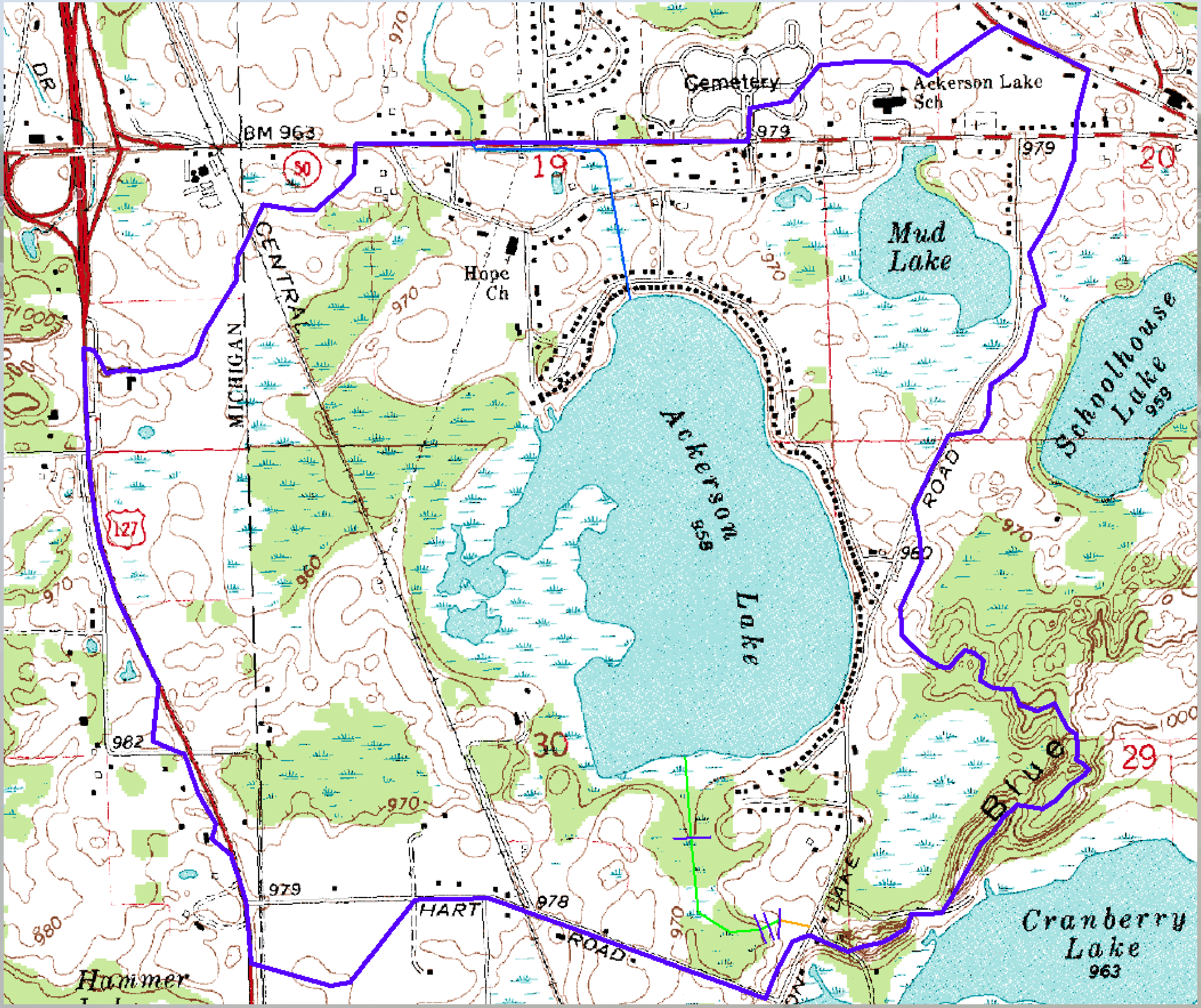
Complex 2

Forest	16
Res1/2	17
Commercial	27

Hydrologic Methods

- Time of Concentration (t_c)
  - Travel time from the hydraulically most distant point within a watershed.
  - $V = K * S^{1/2}$ (MDOT Drainage Manual, Eq. 3.2)
    - K
      - Small tributary – defined watercourses (blue lines on topographical maps) = 2.1
      - Waterway = 1.2
      - Sheet flow (limited to 300’) = 0.48
    - S is slope in %
  - $T_c = L / (3600 * V)$ (in hrs.)
    - Beware of units!
  - Establish breaks at contour lines and flow type changes
  - Gap out ponds and lakes when delineating flow paths
  - Beware of higher discharges within subwatersheds
  - Use TR-55 when $T_c < 1$ hr.


15
757
750
ESCOTT
①
②
③
④
⑤
750
15
747
748
STRIP



Cemetery
Ackerson Lake
Sch
BM 963
979
979
50
19
20
Mud
Lake
Hope
Ch
CENTRAL
MICHIGAN
970
Schoolhouse
Lake
959
Ackerson
959
Lake
ROAD
127
970
960
962
30
29
Blue
982
970
LAKE
979
HART
978
ROAD
Cranberry
Lake
963
Hammer
980
1000


VOIGT'S PHARMACY
Showboat
CARE CENTER

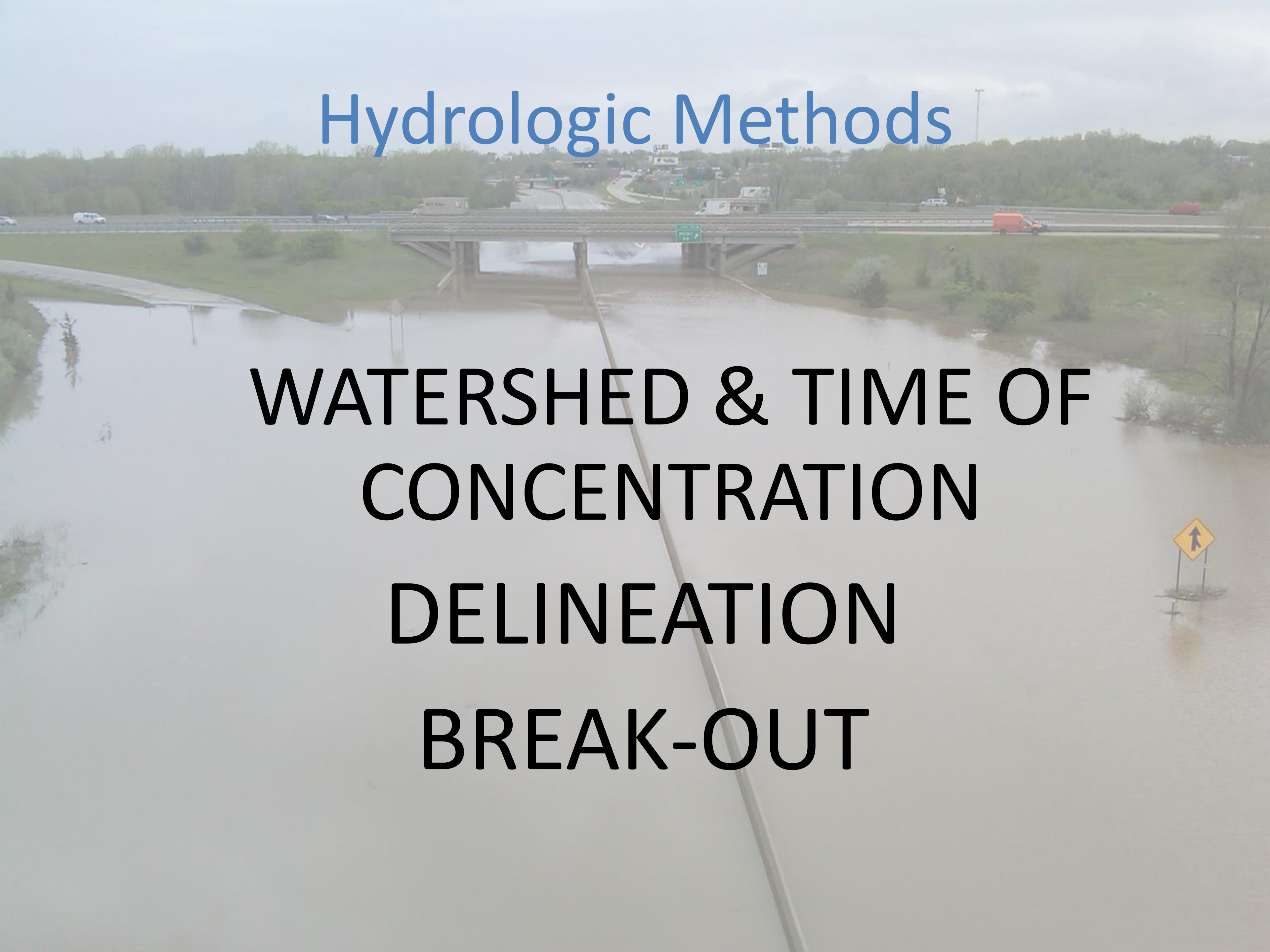
Hydrologic Methods

- Ponding factors
  - Used to account for storage within a watershed
  - Examples of ponding:
    - Depression contours
    - Swamps
    - Lakes or ponds
  - Factors based on location within watershed (upper reaches, throughout, at design point)
    - Use only <u>one</u> adjustment factor
  - Do not use ponding factor when volume or routing calculations are required

Hydrologic Methods

Table 10.1 - Adjustment factors for ponding

Percentage of ponded and swampy area	Annual Storm Probability					
	50%	20%	10%	4%	2%	1%
Ponding occurs in central parts of the watershed or is spread throughout						
0.2	0.94	0.95	0.96	0.97	0.98	0.99
0.5	0.88	0.89	0.90	0.91	0.92	0.94
1.0	0.83	0.84	0.86	0.87	0.88	0.90
2.0	0.78	0.79	0.81	0.83	0.85	0.87
2.5	0.73	0.74	0.76	0.78	0.81	0.84
3.3	0.69	0.70	0.71	0.74	0.77	0.81
5.0	0.65	0.66	0.68	0.72	0.75	0.78
6.7	0.62	0.63	0.65	0.69	0.72	0.75
10	0.58	0.59	0.61	0.65	0.68	0.71
20	0.53	0.54	0.56	0.60	0.63	0.68
Ponding occurs only in upper reaches of watershed						
0.2	0.96	0.97	0.98	0.98	0.99	0.99
0.5	0.93	0.94	0.94	0.95	0.96	0.97
1.0	0.90	0.91	0.92	0.93	0.94	0.95
2.0	0.87	0.88	0.88	0.90	0.91	0.93
2.5	0.85	0.85	0.86	0.88	0.89	0.91
3.3	0.82	0.83	0.84	0.86	0.88	0.89
5.0	0.80	0.81	0.82	0.84	0.86	0.88
6.7	0.78	0.79	0.80	0.82	0.84	0.86
10	0.77	0.77	0.78	0.80	0.82	0.84
20	0.74	0.75	0.76	0.78	0.80	0.82
Ponding occurs only in lower reaches of watershed						
0.2	0.92	0.94	0.95	0.96	0.97	0.98
0.5	0.86	0.87	0.88	0.90	0.92	0.93
1.0	0.80	0.81	0.83	0.85	0.87	0.89
2.0	0.74	0.75	0.76	0.79	0.82	0.86
2.5	0.69	0.70	0.72	0.75	0.78	0.82
3.3	0.64	0.65	0.67	0.71	0.75	0.78
5.0	0.59	0.61	0.63	0.67	0.71	0.75
6.7	0.57	0.58	0.60	0.64	0.67	0.71
10	0.53	0.54	0.56	0.60	0.63	0.68
20	0.48	0.49	0.51	0.55	0.59	0.64



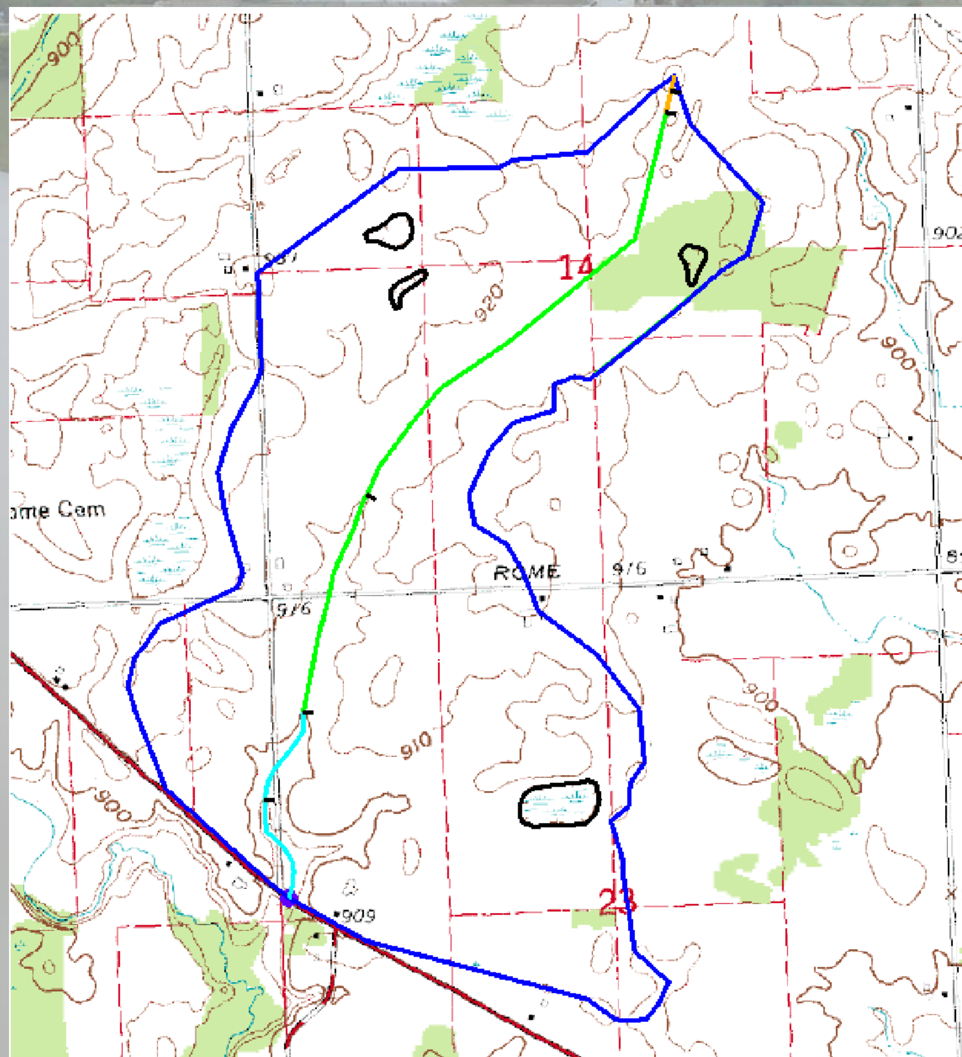
Hydrologic Methods

WATERSHED & TIME OF CONCENTRATION

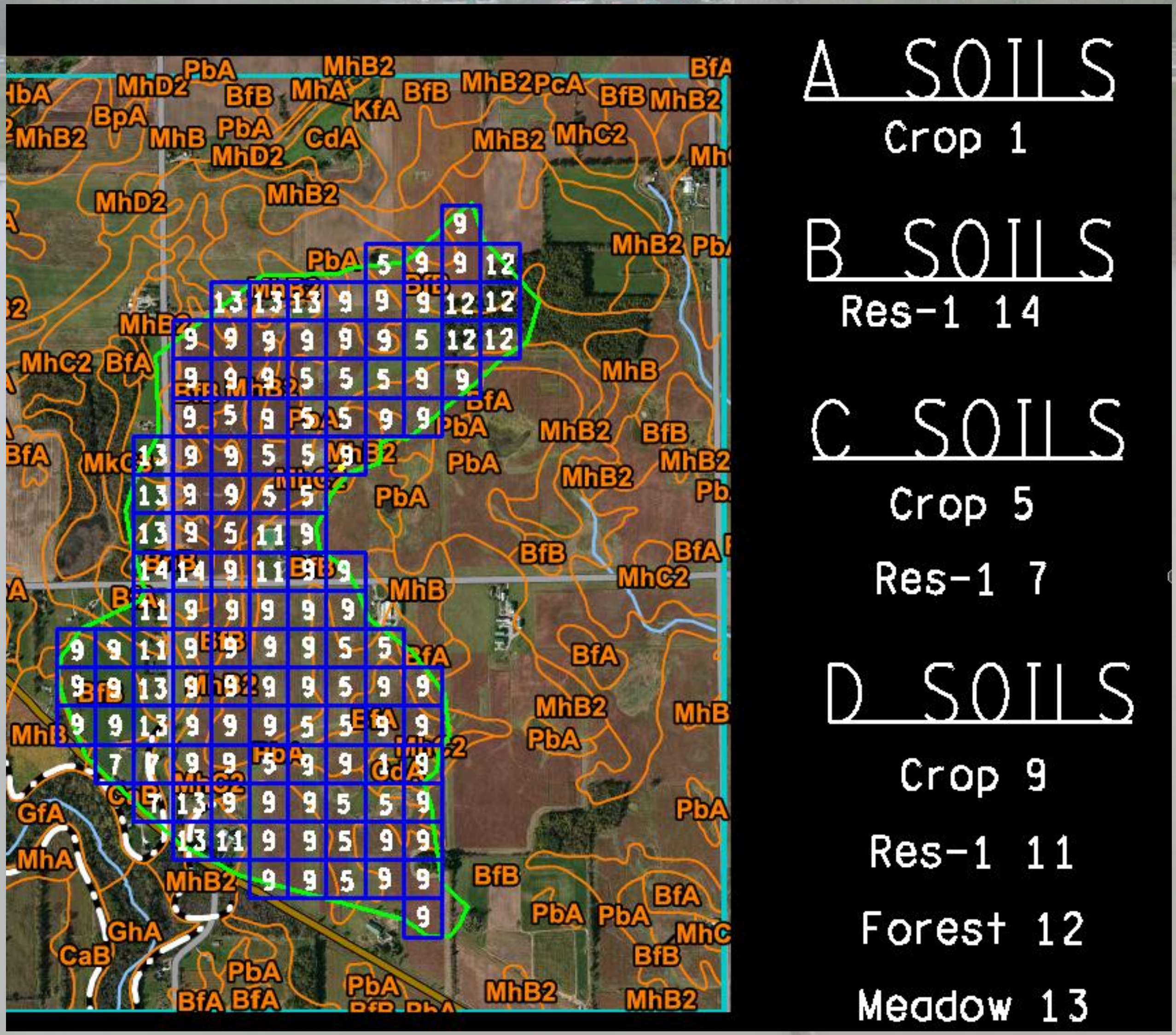
DELINEATION

BREAK-OUT

Hydrologic Methods



Hydrologic Methods



Hydrologic Methods

SCS-92 Method Discharge Calculations:

Description

Watercourse	Unnamed Trib. to Hazen Creek
Drainage Area	0.71 sq. mile
Cont Drainage Area	**0.71** sq. mile
Basin Number	0
Basin Name	
Quad	0
Section	22/23
Town/Range	T6S, R2E
Latitude	0
Longitude	0
County	Lenawee
Township	Rome
Location	0
Job Number	110627
By	J. Logsdon
Date	Jul-31-2019

Time of Concentration

Flow Type	*Length*	*U/S Elev*	*D/S Elev*	*Slope*	*Velocity*	*Tc*
	feet	*feet*	*feet*	*%*	*ft/s*	*hours*
Sm Trib	876	890.00	889.00	0.114	0.710	0.34
Sm Trib	794	900.00	890.00	1.259	2.357	0.09
Waterway	1834	910.00	900.00	0.545	0.886	0.57
Waterway	4042	919.58	910.00	0.237	0.584	1.92
Sheet Flow	178	920.00	919.58	0.236	0.233	0.21
Sheet Flow	122	920.29	920.00	0.238	0.234	0.14
Total	7846			0.399	0.835	**3.29**

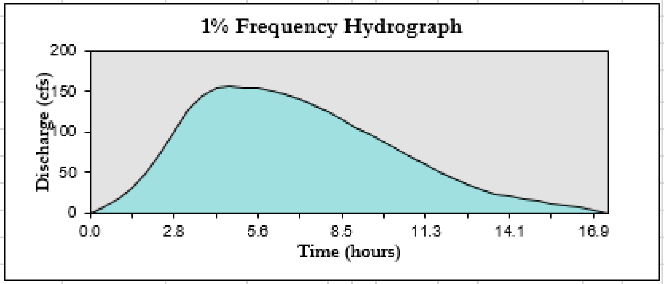
* *Portions of the Time of Concentration that were cut off to evaluate alternate travel routes.*

Curve Number

Soils Group	*%*	*Land Use Type*	*%*	*CN*
A	0.8	Crop	100	65
B	1.6	Res 1	100	68
C	21	Crop	88	84
		Res 1	12	79
D	77	Crop	79	88
		Res 1	5	84
		Forest	5	79
		Meadow	11	78

Discharge

Frequency	*10%*	*4%*	*2%*	*1%*	*0.50%*	*0.20%*
Adj Rainfall (inch)	3.13		3.98	4.36		
Avg Runoff (inch)	1.71		2.46	2.80		
Comp Curve Number	85.2		85.2	**85.2**		
Discharge (cfs)	109	136	157	179	200	231
Volume (Acre-ft)	65	81	93	106	119	137
Ponding: throughout	2	2	2	2	2	2
Ponding: upper reaches	0	0	0	0	0	0
Ponding: design point	0	0	0	0	0	0
Ponding Adjustment	0.81	0.83	0.85	0.87	0.88	0.90
Adjusted Flow (cfs)	88	**113**	133	155	**176**	208
Flow (cfs) with incr. SRO:	90		134	156		



Unit Hydrograph Peak (cfs/sq. mile-in) 89.86

Hydrologic Methods

Hydrologic Analysis Synopsis

By: Justin Logsdon
Date: October 13, 2016
Chk:
Date:

Job Location Information:

Control Section:	46061
Job Number:	110627
Trunkline:	US-223
Location:	Sec. 22/23, T6S, R2E
Watercourse:	Unnamed trib.
Tributary to:	Hazen Creek
MDEQ Hydro Basin:	29 (Lenawee)

[*]Hydrograph Synthesis:

Drainage Area:	0.71 sqmi.
[**]T_c:	3.29 hr.
Composite CN:	85.19
Percent Ponding:	2%

[†]Peak Flows:

10 year (10%):	90 cfs
50 year (2%):	135 cfs
100 year (1%):	155 cfs

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[*] MDEQ SCS, "Computing Flood Discharges for Small Ungaged Watersheds", Sorrell, June 2010. Soil info from "Soil Survey of Lenawee County, Michigan.". Landuse corroborated w/ Google Earth aerial photos (10/2016).
[†] Discharge Estimates rounded up to the nearest 5 cfs or down if <1 over.

Hydrologic Methods

Questions?