The New Drainage Manual

Partnering Conference
August 2010

David Moses
Chief Drainage Engineer
Kentucky Transportation Cabinet

David Lanham
Palmer Engineering


GOVERNMENT
If You Think the Problems We Create Are Bad,
Just Wait Until You See Our Solutions.

- Association of State Floodplain Managers National Conference
- May 15-20, 2011 - Galt House, Louisville
- http://www.kymitigation.org/ASFPM.html
- 100 Speakers, 1200 Participants

ASFPM
Flood Risk Management: The Winning Ticket
May 15–20, 2011 | Louisville, KY

KAMM
Kentucky Association of Mitigation Managers

Presentation Outline

- Manual Progress
- Manual Policy Released in July
  - Hydrology Policy
  - Temporary Drainage Structures
- New Policy Currently Under Development
  - Drainage Folder Structure
  - Software
  - Water Related Impacts
  - Bore & Jack

Manual Progress

Progress To Date

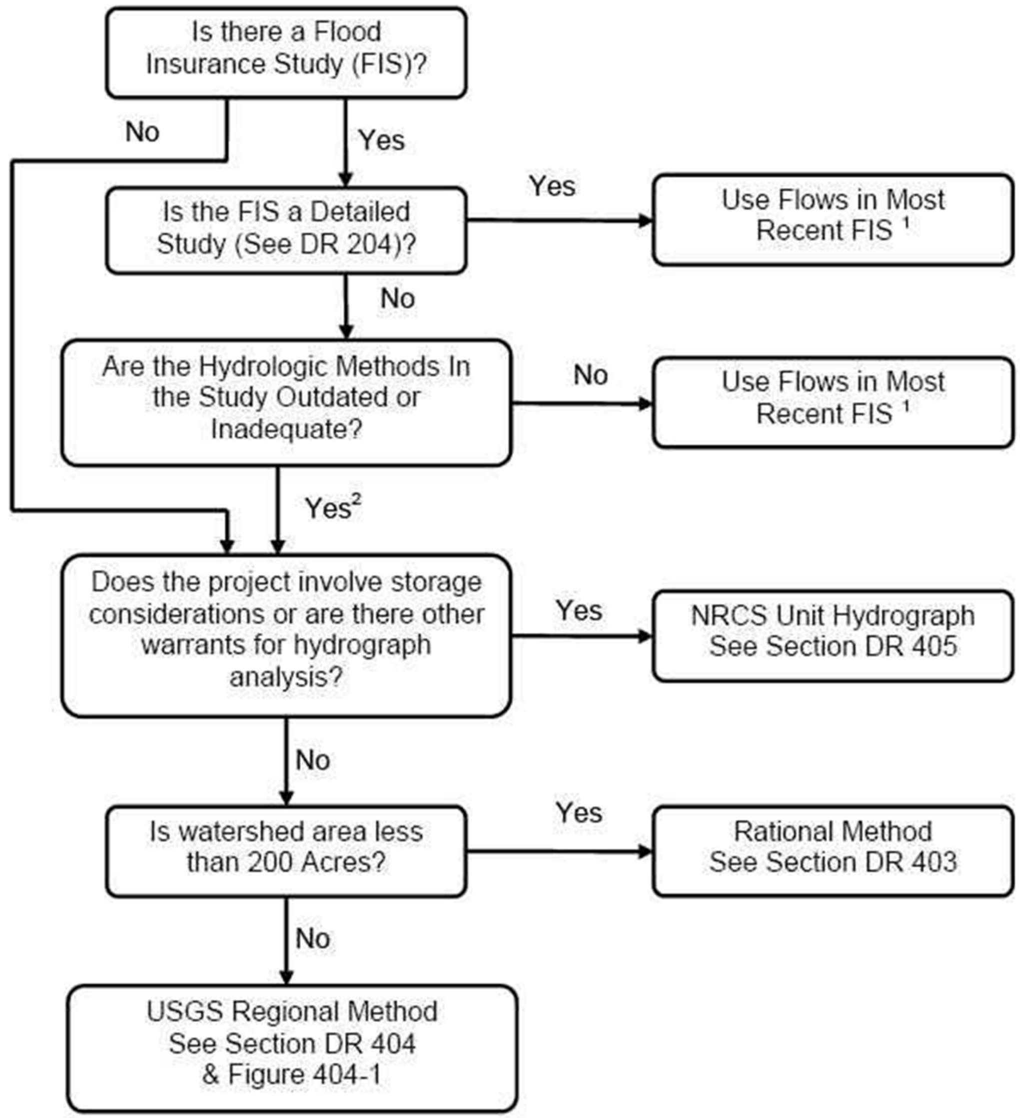
OLD MANUAL	NEW MANUAL
TABLE OF CONTENTS & TITLE	TABLE OF CONTENTS [3]
CHAPTER 1 - INTRODUCTION	DR 100 - Introduction
CHAPTER 2 - FLOODPLAIN MANAGEMENT	DR 200 - Stormwater & Floodplain Management
CHAPTER 3 - DRAINAGE FOLDERS	DR 300 - Drainage Folders
CHAPTER 4 - DISCHARGE	DR 400 - Hydrology
CHAPTER 5 - CHANNELS AND DITCHES	DR 500 - Open Channels
CHAPTER 6 - CULVERTS AND HEADWALLS	DR 600 - Culverts & Headwalls
CHAPTER 7 - INLETS AND STORM SEWERS	DR 700 - Inlets and Storm Sewers
CHAPTER 8 - BRIDGES	DR 800 - Bridges
CHAPTER 9 - DAMS AND STORAGE	DR 900 - Storage
CHAPTER 10 - EROSION CONTROL	DR 1000 - Erosion
CHAPTER 11 - RESTORATION	(Deleted)
	DR 1100 - Miscellaneous [2]
	Subject 1101 - Temporary Drainage Facilities
	Subject 1102 - Computer Applications
	Subject 1103 - Plan Requirements
	Subject 1104 - Field Data Collection
CHAPTER 12 - COMPUTER PROGRAMS	(Deleted)
APPENDIX A--DRAINAGE FORMS	(Will be inserted throughout the various chapters)
APPENDIX B--SAMPLE DRAINAGE FOLDER	
APPENDIX C--GLOSSARY	Glossary

Policy Released In July 2010

DR 400 Hydrology Changes

- Project Specific Precipitation Values
- Updated USGS Regional Method
  - Statewide
  - Jefferson County
- Adoption of NRCS Unit Hydrograph Method (When Hydrograph Analysis is Required)
- Fully Developed Watershed assumptions

Hydrologic Methods Flowchart



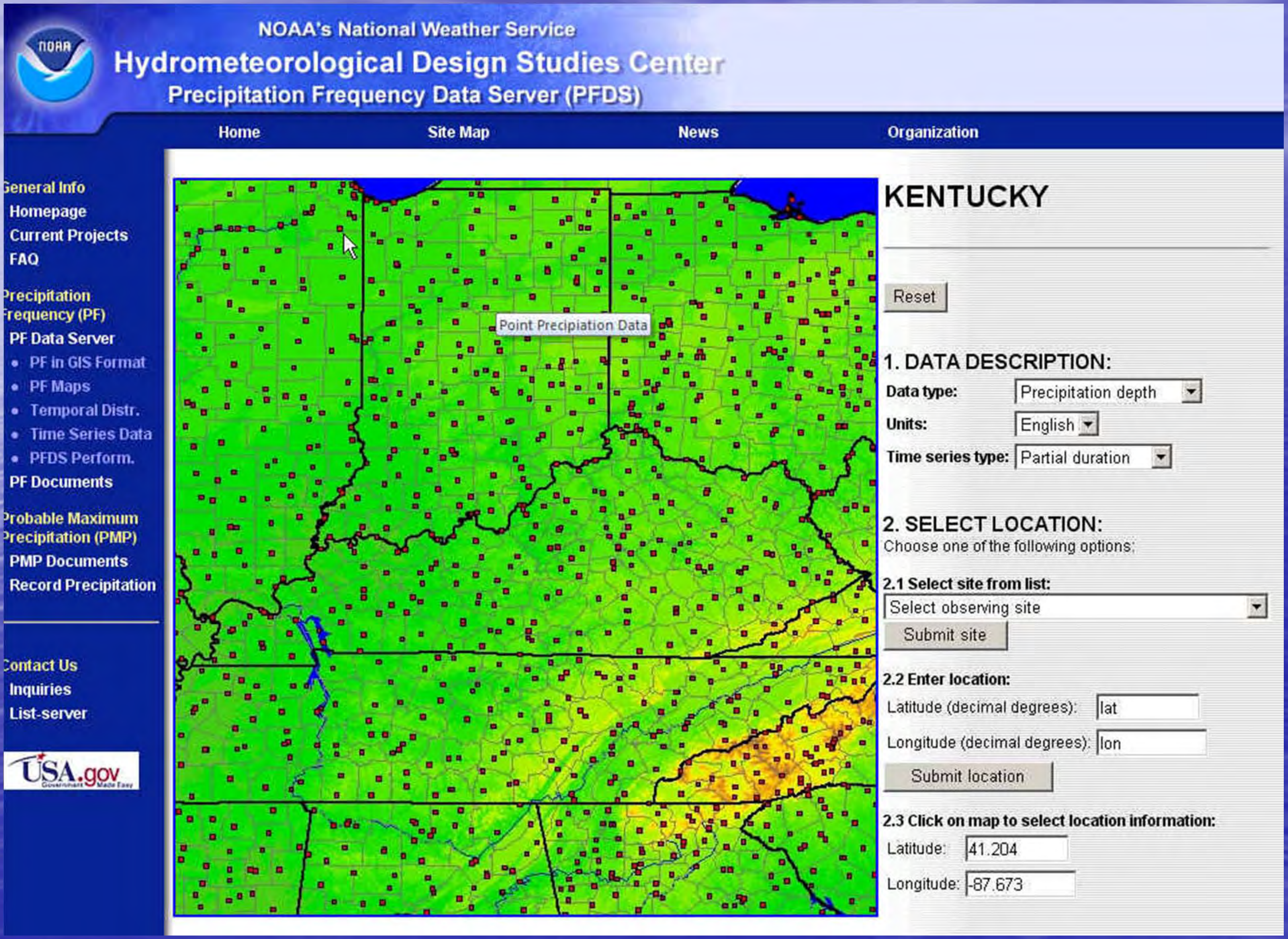
1. It is a FEMA requirement to use FIS hydrology when assessing flooding impacts in a Detailed Study Area. However, additional design and/or check storm calculations may be based on other methods.
2. It may be necessary to use the FIS flows to satisfy FEMA requirements, however additional flows can be calculated for design purposes.
3. Locally required methods may be considered when requested.

Precipitation Data

- In 2004, the National Oceanic and Atmospheric Administration released "NOAA Atlas 14 Volume 2 for the Ohio Valley Region"
- Precipitation values (depth and intensities) from this study are available in a web based application called the Precipitation Frequency Data Server.

Precipitation Frequency Data Server

http://dipper.nws.noaa.gov/hdsc/pfds/



Data Table

POINT PRECIPITATION
FREQUENCY ESTIMATES
FROM NOAA ATLAS 14

Kentucky 36.786 N 84.161 W 951 feet

from "Precipitation-Frequency Atlas of the United States" NOAA Atlas 14, Volume 2, Version 3
G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley
NOAA, National Weather Service, Silver Spring, Maryland, 2004

Extracted: Tue Aug 3 2010

Confidence Limits | Seasonality | Related Info | GIS data | Maps | Docs | Return to State Map

Precipitation Intensity Estimates (in/hr)

ARI* (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	3.90	3.11	2.59	1.78	1.11	0.66	0.47	0.29	0.18	0.11	0.06	0.04	0.03	0.02	0.01	0.01	0.01	0.01
2	4.60	3.67	3.08	2.13	1.33	0.79	0.56	0.34	0.21	0.13	0.08	0.04	0.03	0.02	0.02	0.01	0.01	0.01
5	5.41	4.33	3.65	2.59	1.66	0.98	0.70	0.42	0.25	0.16	0.09	0.05	0.04	0.03	0.02	0.02	0.01	0.01
10	6.08	4.87	4.10	2.97	1.94	1.14	0.81	0.49	0.29	0.18	0.11	0.06	0.04	0.03	0.02	0.02	0.01	0.01
25	7.01	5.59	4.72	3.50	2.33	1.38	0.98	0.58	0.35	0.21	0.13	0.07	0.05	0.04	0.02	0.02	0.02	0.01
50	7.75	6.17	5.21	3.92	2.66	1.58	1.12	0.66	0.39	0.24	0.14	0.08	0.05	0.04	0.03	0.02	0.02	0.02
100	8.52	6.77	5.70	4.37	3.01	1.81	1.27	0.75	0.44	0.26	0.16	0.09	0.06	0.05	0.03	0.02	0.02	0.02
200	9.31	7.39	6.21	4.83	3.39	2.05	1.43	0.84	0.50	0.29	0.17	0.10	0.07	0.05	0.03	0.02	0.02	0.02
500	10.40	8.23	6.90	5.49	3.94	2.41	1.68	0.98	0.57	0.33	0.20	0.11	0.07	0.05	0.03	0.03	0.02	0.02
1000	11.29	8.89	7.44	6.03	4.40	2.71	1.88	1.09	0.63	0.36	0.22	0.12	0.08	0.06	0.04	0.03	0.02	0.02

*These precipitation frequency estimates are based on a partial duration series. ARI is the Average Recurrence Interval.
Please refer to NOAA Atlas 14 Document for more information. NOTE: Formatting forces estimates near zero to appear as zero.

*** Upper bound of the 90% confidence interval**
Precipitation Intensity Estimates (in/hr)

ARI** (years)	5 min	10 min	15 min	30 min	60 min	120 min	3 hr	6 hr	12 hr	24 hr	48 hr	4 day	7 day	10 day	20 day	30 day	45 day	60 day
1	4.32	3.44	2.87	1.97	1.23	0.72	0.52	0.32	0.19	0.12	0.07	0.04	0.03	0.02	0.02	0.01	0.01	0.01
2	5.09	4.07	3.41	2.35	1.48	0.87	0.62	0.38	0.23	0.14	0.08	0.05	0.03	0.03	0.02	0.01	0.01	0.01

Rational Method

- Q = CIA
- "I" will now come from PFDS

NRCS Unit Hydrograph

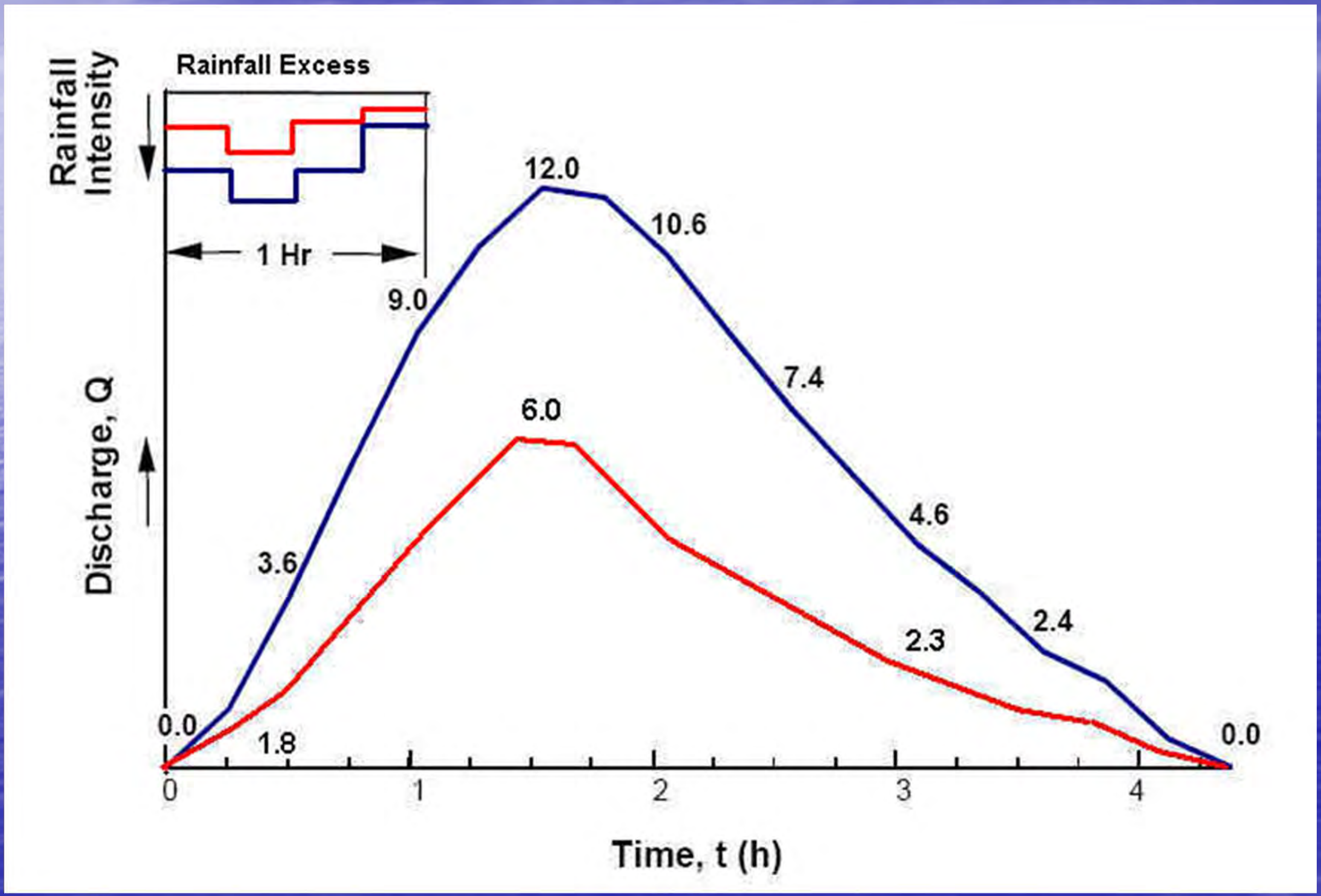
- Natural Resources Conservation Service (NRCS), formerly Soil Conservation Service (SCS) developed the method in 1972.
- Developed by analyzing a large number of natural unit hydrographs from a broad cross-section of geographic locations and hydrologic regions.

NRCS Unit Hydrograph Basic Steps

- Determine unit hydrograph characteristics
- Determine storm criteria (Rainfall Depth combined with Storm Distribution)
- Determine runoff factor (CN)
- Compute rainfall excess
- Combine rainfall excess data with unit hydrograph to determine a runoff hydrograph (Convolution)

Hydrograph Principals

Hydrograph Proportionality



Combining Hydrographs

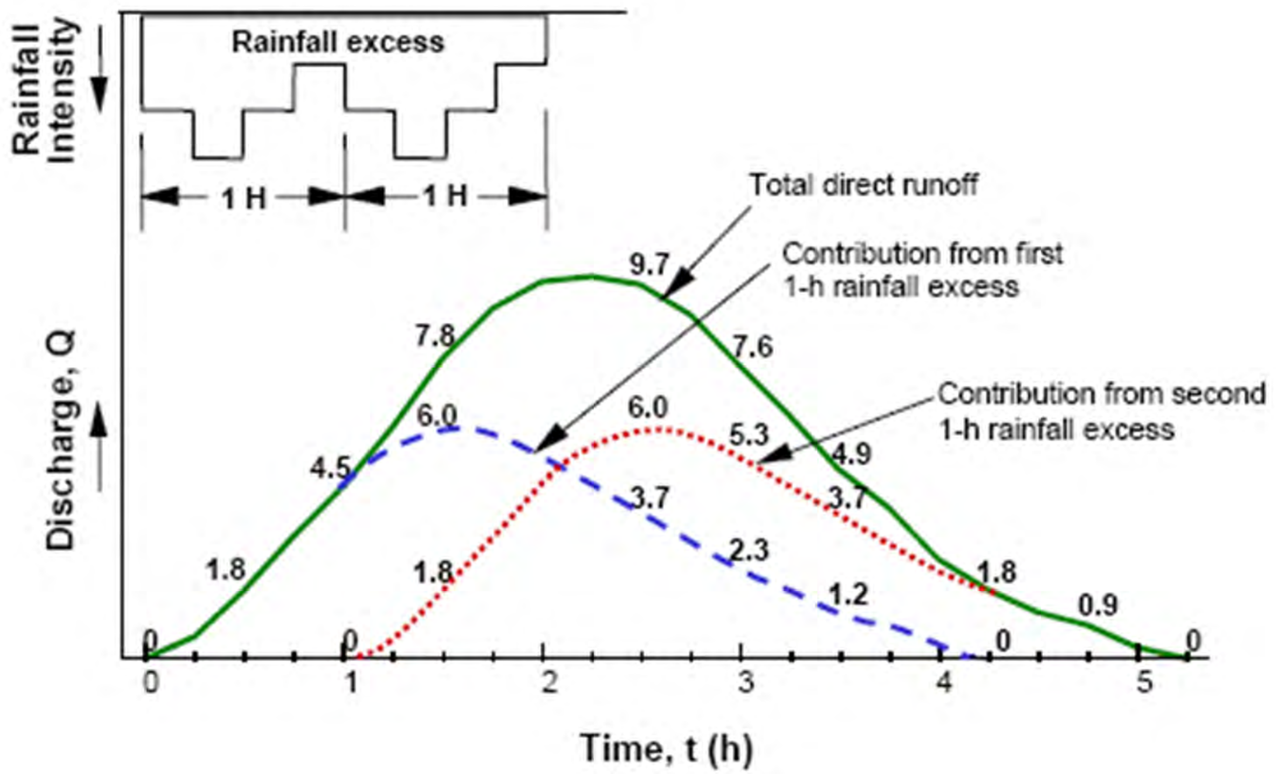


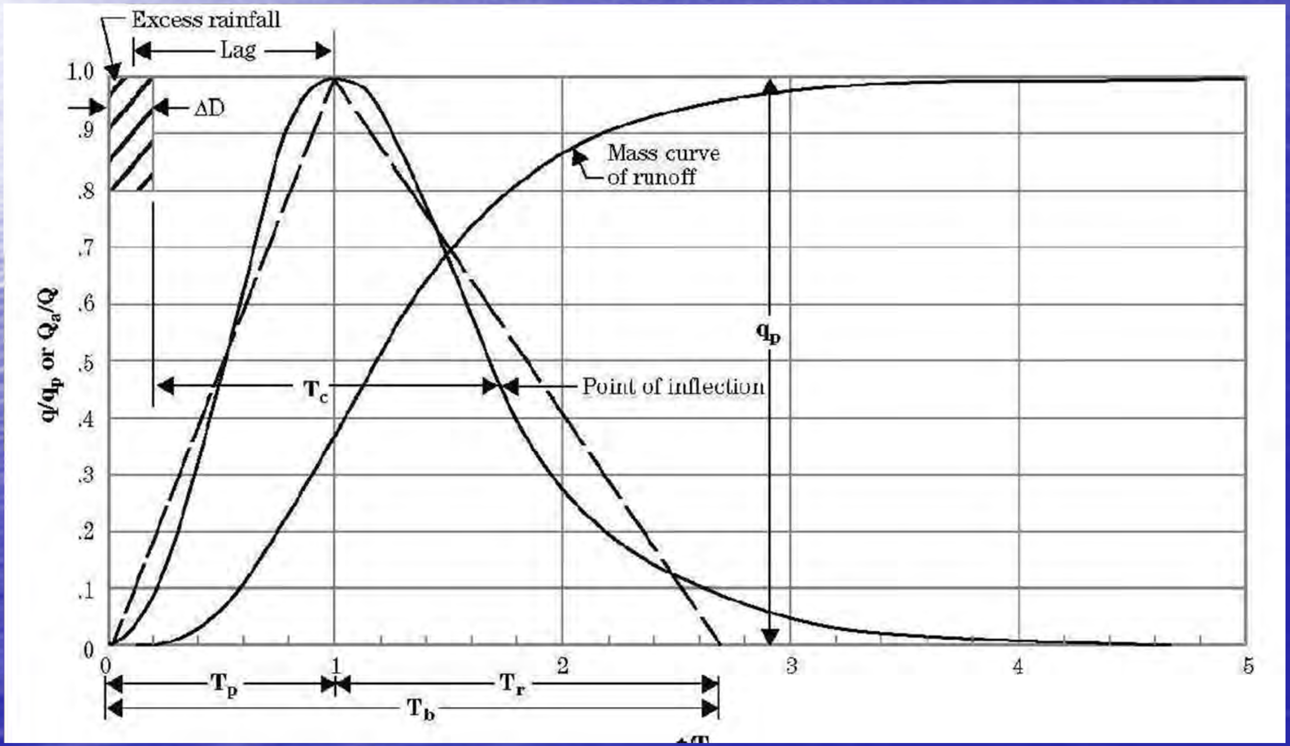
Figure 6.4. Runoff hydrograph for two successive 1-hour storms

Unit Hydrograph Characteristics

Unit Hydrograph

A hydrograph of a direct runoff resulting from one unit (1 in.) of effective rainfall generated uniformly over the watershed area during a specified period of time or duration

NRCS Dimensionless Unit Hydrograph



Time ratios (t/T_p)	Discharge ratios (q/q_p)	Mass curve ratios (Q_a/Q)
0	.000	.000
.1	.030	.001
.2	.100	.006
.3	.190	.017
.4	.310	.035
.5	.470	.065
.6	.660	.107
.7	.820	.163
.8	.930	.228
.9	.990	.300
1.0	1.000	.375
1.1	.990	.450
1.2	.930	.522
1.3	.860	.589
1.4	.780	.650
1.5	.680	.705
1.6	.560	.751
1.7	.460	.790
1.8	.390	.822
1.9	.330	.849
2.0	.280	.871
2.2	.207	.908
2.4	.147	.934
2.6	.107	.953
2.8	.077	.967
3.0	.055	.977
3.2	.040	.984
3.4	.029	.989
3.6	.021	.993
3.8	.015	.995
4.0	.011	.997
4.5	.005	.999
5.0	.000	1.000

Unit Hydrograph Shape

- The Unit hydrograph shape for a watershed depends on peak discharge (q_p) and time to peak (Tp)

$$q_p = \frac{K_p \times A \times Q}{Tp}$$

Peak Discharge of the Unit Hydrograph
Q is in Inches

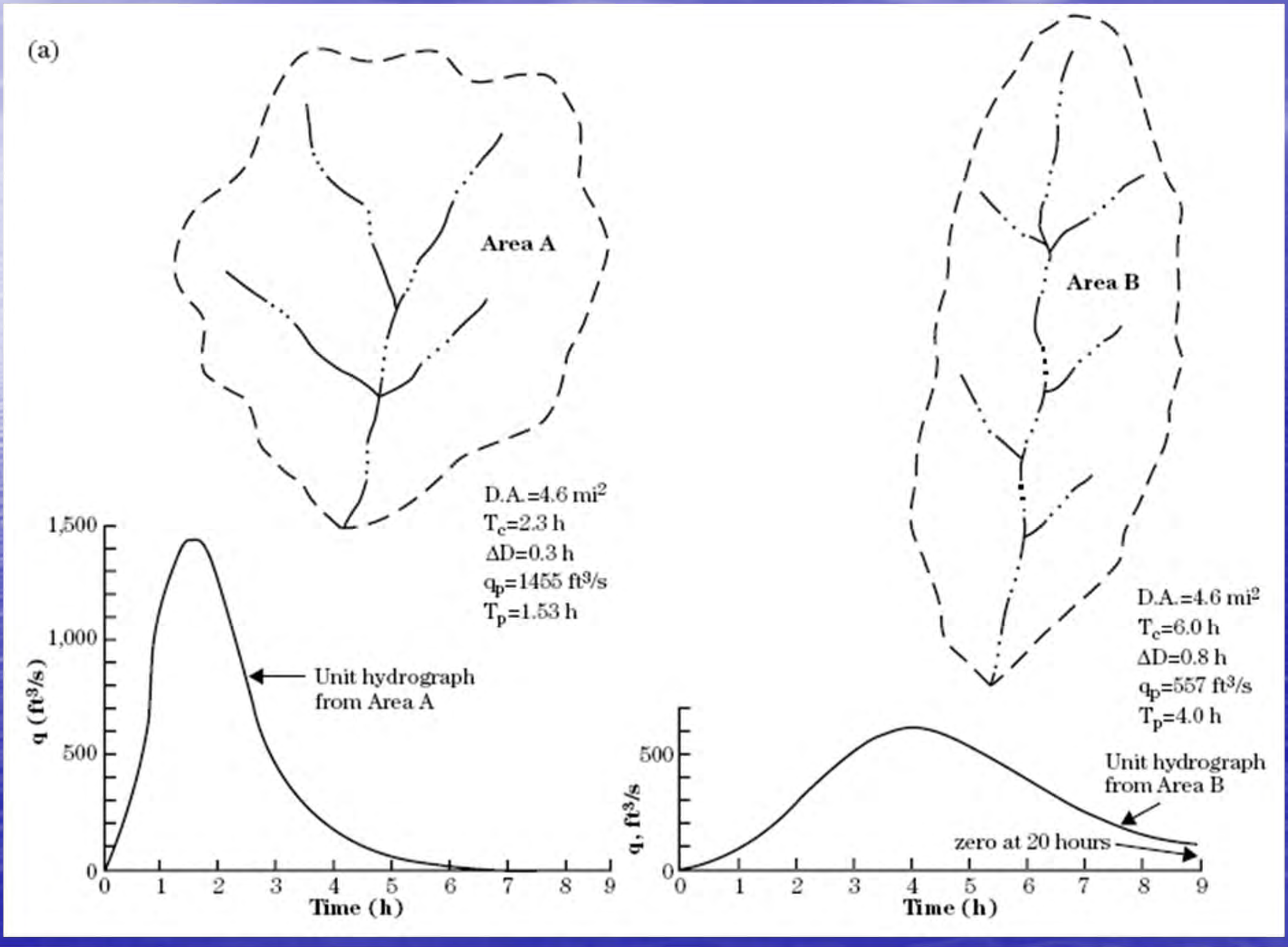
- Tp and q_p both depend largely on basin Lag (L) and duration of unit excess rainfall

Unit Hydrograph for the Watershed

- Basin Lag : L = .6 Tc
- Duration of unit excess rainfall :

  ΔD = .133 Tc
- Resulting Unit hydrograph is a ΔD – hour unit hydrograph
- AKA: a hydrograph that results from one unit (1 inch) of excess precipitation over a period of ΔD

Watershed Shape

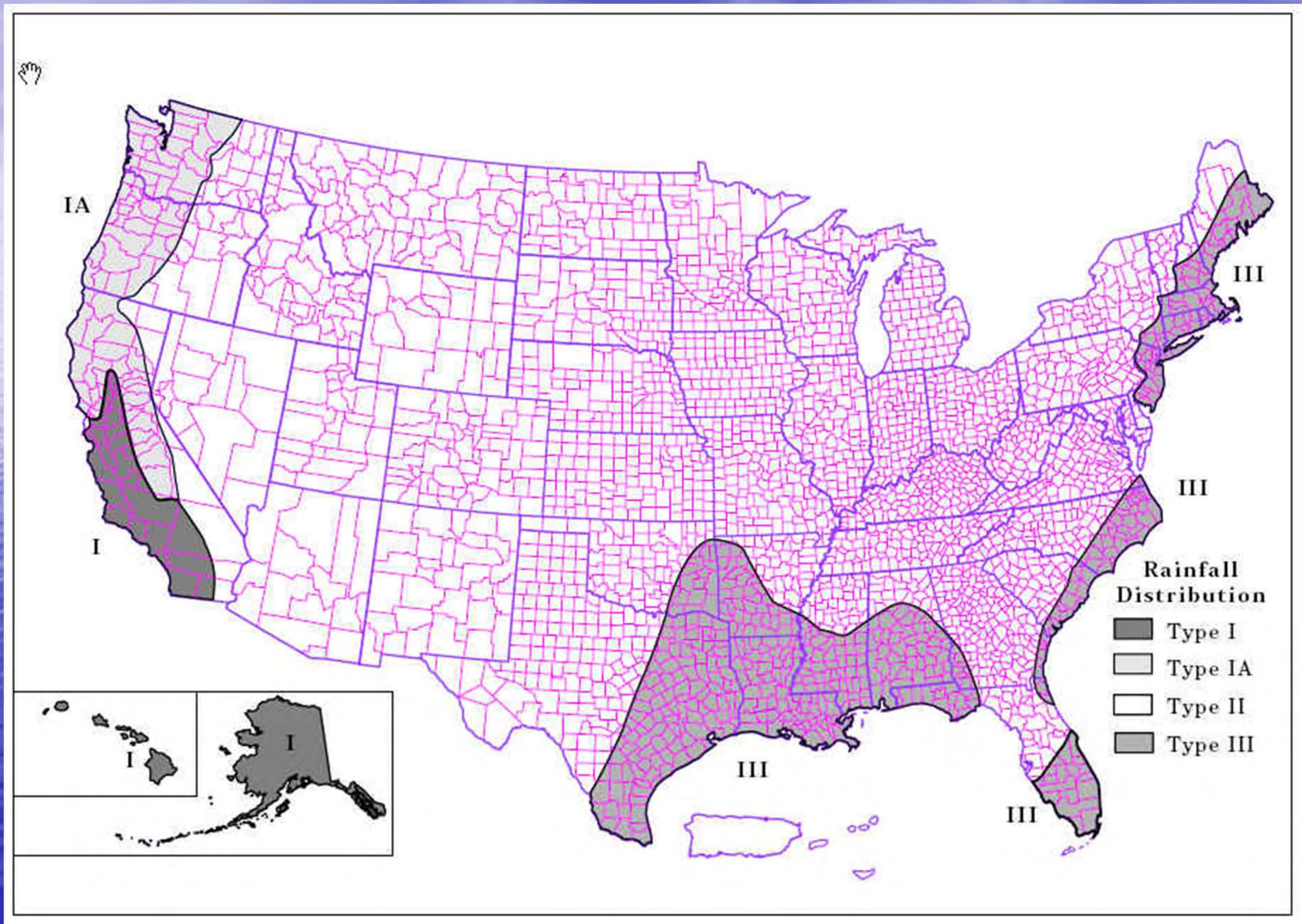


Storm Characteristics

NRCS Storm Criteria

- Acquire 24 hour storm depths for applicable return period from Precipitation Frequency Data Server
- Apply the Type II distribution to develop a rainfall hyetograph (distribution of rainfall over time)

NRCS Rainfall Distributions



NRCS Type II Distribution

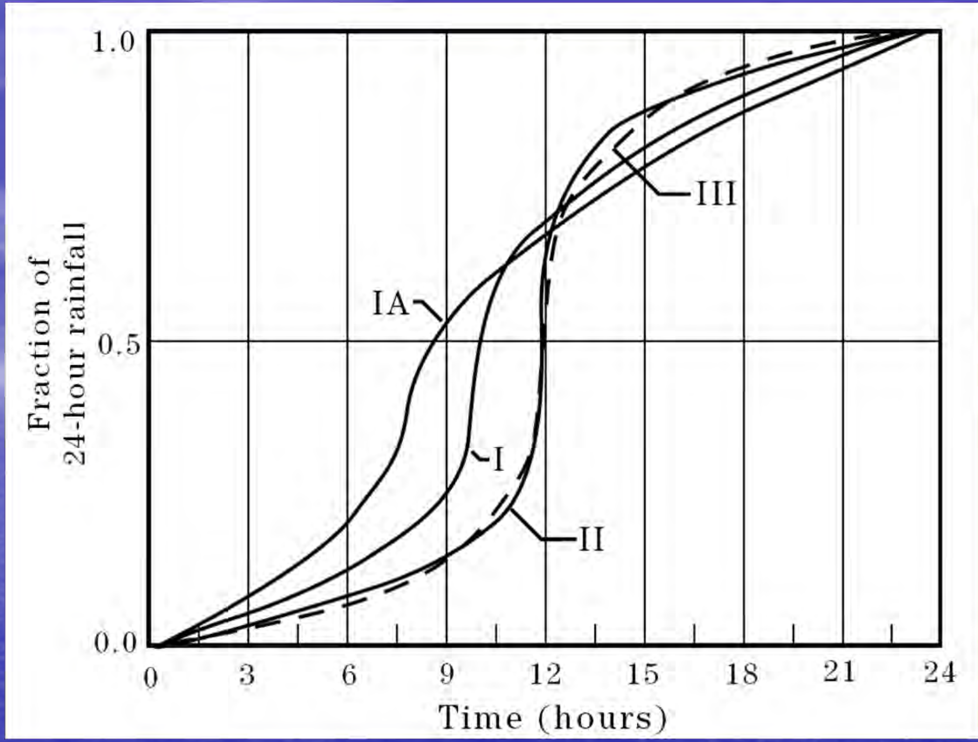


TABLE 405-1 NRCS 24-Hour Type II Rainfall Distributions			
Time, t (h)	Fraction of 24-h Rainfall	Time, t (h)	Fraction of 24-h Rainfall
0	0	11	0.235
2	0.022	11.5	0.283
4	0.048	11.75	0.393
6	0.080	12	0.663
7	0.098	12.5	0.735
8	0.120	13	0.772
8.5	0.133	13.5	0.799
9	0.147	14	0.820
9.5	0.163	16	0.880
9.75	0.172	20	0.952
10	0.181	24	1
10.5	0.204		

Runoff Factor
NRCS Curve Number (CN)

Curve Number

- An index relating to the potential of the watershed to produce runoff.
- Dependant on the hydrologic soil group (soil), the land use and treatment class (cover) and the antecedent moisture conditions.
- Higher CN values = higher runoff potential

Curve Numbers

* Table 405-2 NRCS Curve Numbers For Urban Areas				
Cover Type	**Curve Numbers For Hydrologic Soil Group**			
	A	B	C	D
Fully developed urban areas[a] (vegetation established)				
Lawns, open spaces, parks, golf courses, cemeteries, etc.				
Good condition; grass cover on 75% or more of the area	39	61	74	80
Fair condition; grass cover on 50% to 75% of the area	49	69	79	84
Poor condition; grass cover on 50% or less of the area	68	79	86	89
Paved parking lots, roofs, driveways, etc. (excl. right-of- way)	98	98	98	98
Streets and roads				
Paved with curbs and storm sewers (excl. right-of-way)	98	98	98	98
Gravel (incl. right-of-way)	76	85	89	91
Dirt (incl. right-of-way)	72	82	87	89
Paved with open ditches (incl. right-of-way)	83	89	92	93

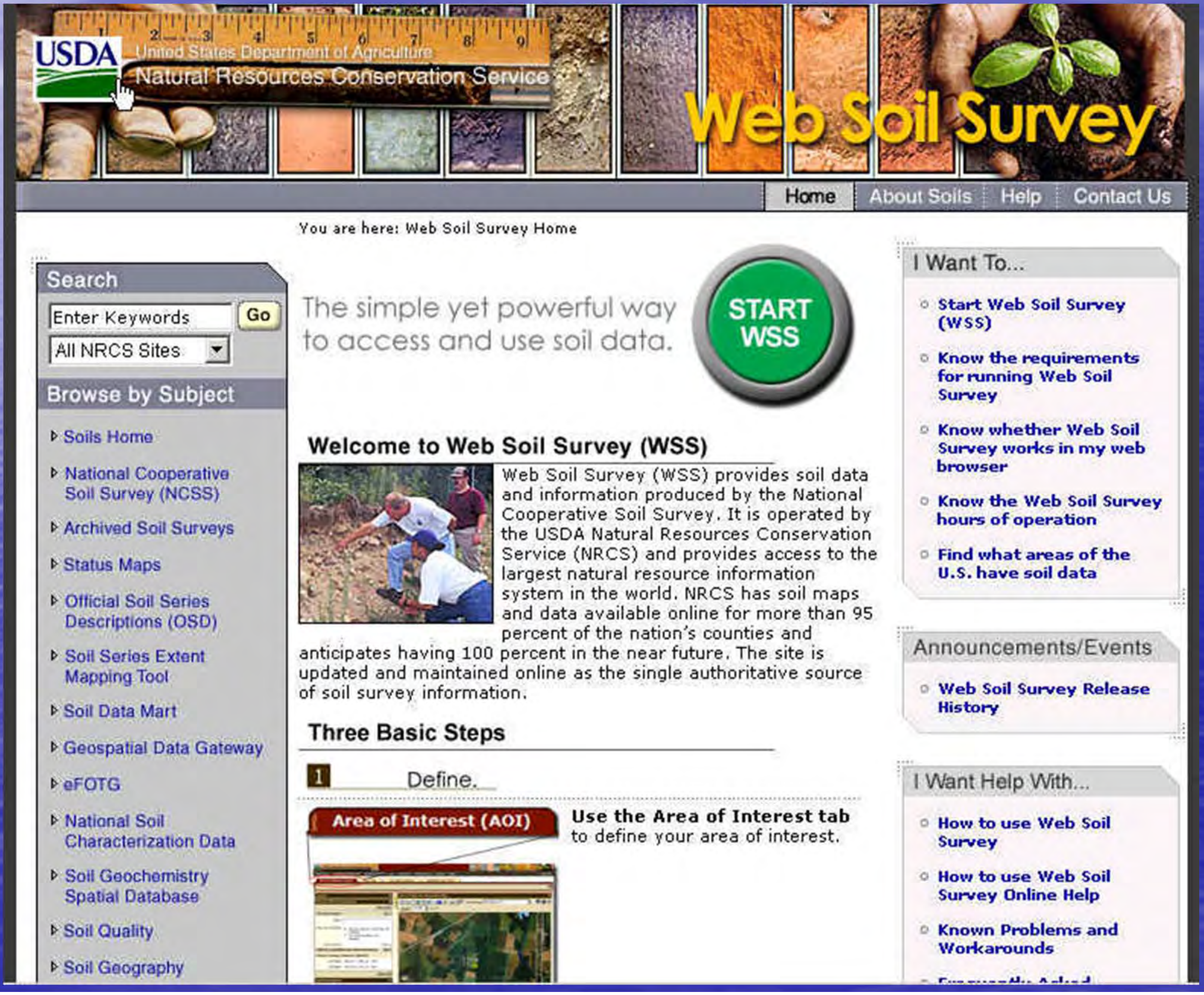
Hydrologic Soil Groups

Runoff Potential

- Group A: deep sand, deep loess; aggregated silts
- Group B: shallow loess; sandy loam
- Group C: clay loams; shallow sandy loam; soils low in organic content; soils usually high in clay
- Group D: soils that swell significantly when wet; heavy plastic clays; certain saline soils

HSG - NRCS Web Soil Survey

http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm



Rainfall Excess

Rainfall Excess

$$Q = \frac{(P - I_a)^2}{P - I_a + S}$$

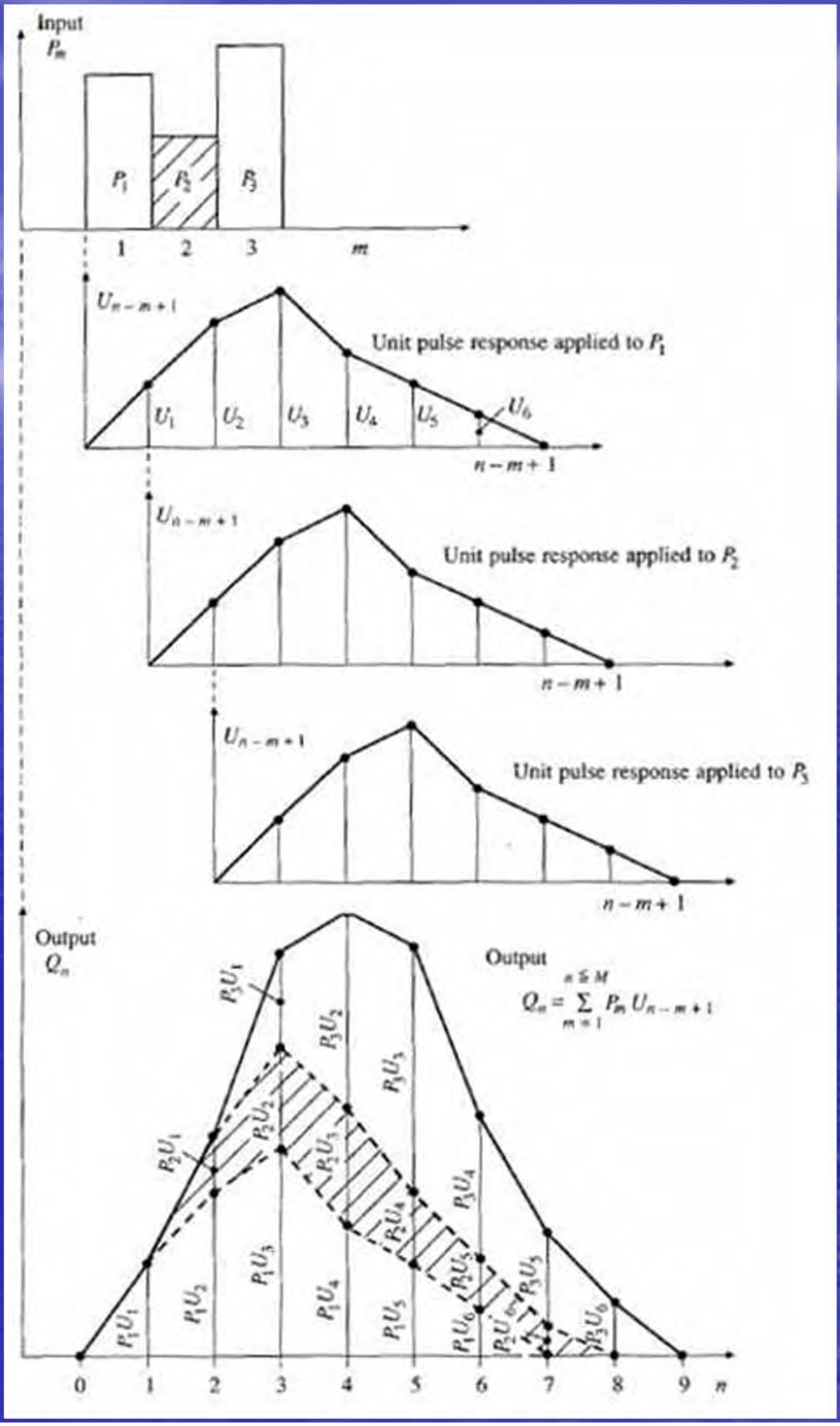
Accumulated Direct Runoff (Inches)

- Ia & S can be calculated from CN
- Rainfall excess is divided into small pulses with a duration of ΔD for each pulse
- These rainfall pulses are combined with the unit hydrograph to determine a direct runoff hydrograph

Convolution

Combining the incremental precipitation excess pulses from the design storm with the unit hydrograph to produce the direct runoff hydrograph

Convolution of Unit Hydrographs



USGS Regional Method
(Peak Flow)

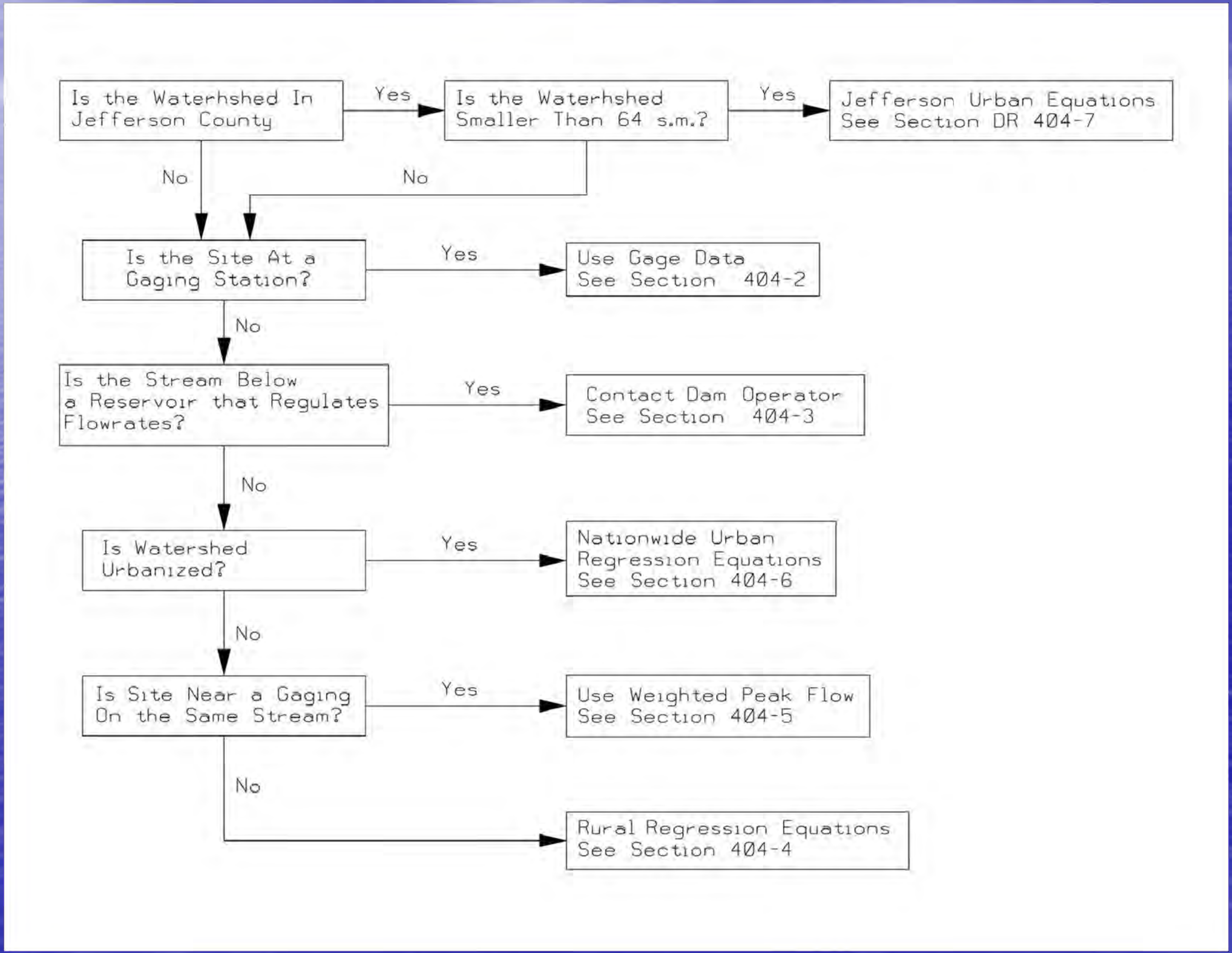
USGS Regional Method

- Peak flow estimating technique based on analysis of stream gage data
- USGS has been collecting data in Kentucky since 1907
- Flow rates obtained from a combination of stream gage data and regional regression equations

Applicable USGS Reports

- Water Resources Investigations Report 03-4180 (2003) “Estimating the Magnitude of Peak Flows for Streams in Kentucky for Selected Recurrence Intervals”
- Water-Supply Paper 2207 (1983) titled “Flood Characteristics of Urban Watersheds in the United States”
- Water Resources Investigations Report 97-4219 (1997) titled, “Estimation of Peak-Discharge Frequency of Urban Streams in Jefferson County Kentucky.”

Regional Method Review



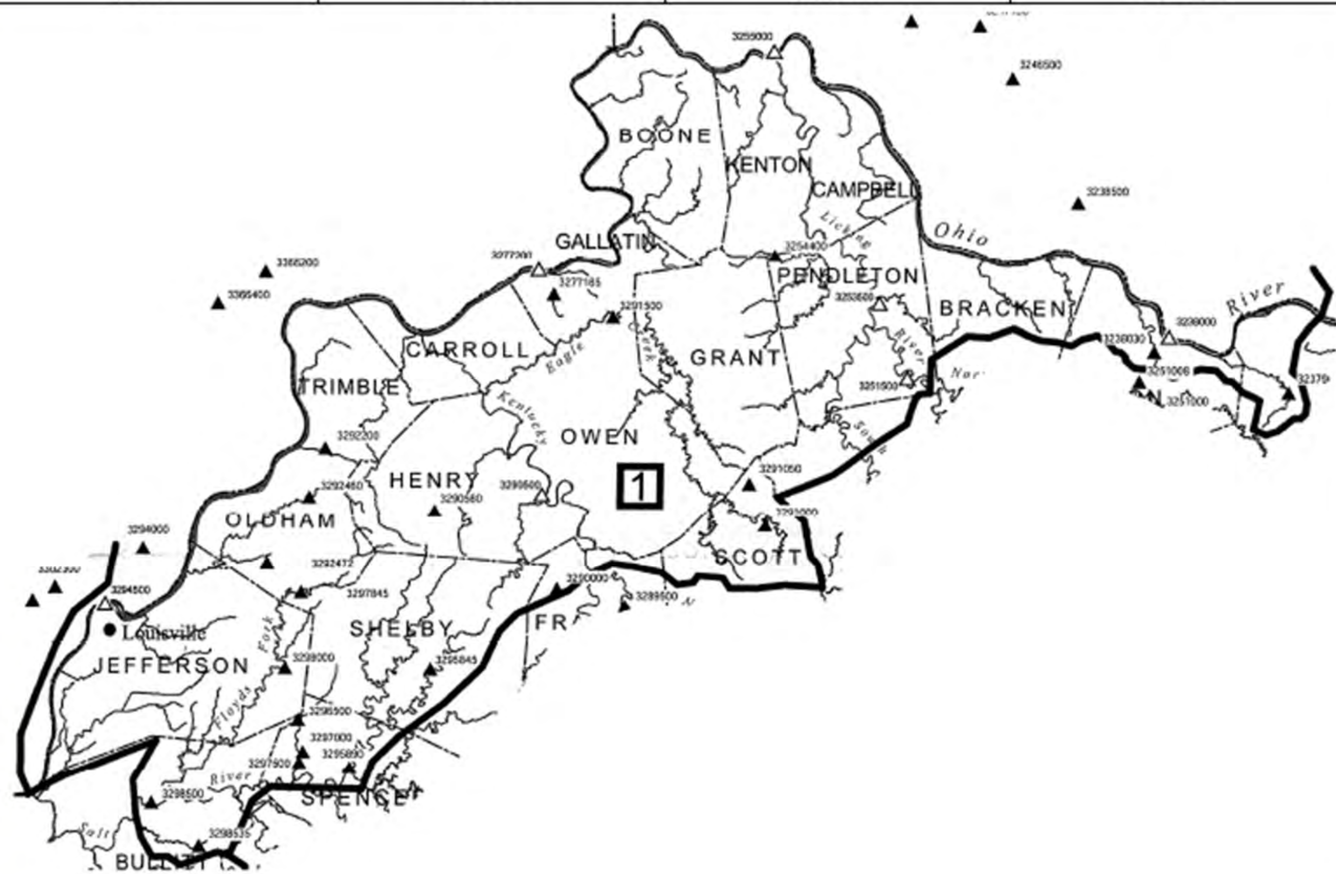
Statewide Rural Regression Equations

$$Q_R = K \times A^b \times S^c$$

- Q in cfs, A = area in acres, S = Main Channel Slope in ft/mile
- Constants K, b, c listed in tables in Drainage Manual

Regression Equation Constants for the North Region

Table 404-4, Region 1 (North) - Regression Equation Variables			
Return Period (years)	K	b	c
2	312	0.673	0
5	493	0.651	0
10	91.5	0.843	0.451
25	81.2	0.872	0.535
50	75.8	0.890	0.587
100	71.4	0.907	0.632
200	67.8	0.922	0.673
500	63.6	0.941	0.722



Site Located At A Gage

- At a gage - drainage area of the site must be within +/- 3 percent of the drainage area at the USGS stream gage
- Flow is computed as a weighted average between the gage flow and the flow resulting from the appropriate regression equation
- These weighted flows are listed in Report 03-4180 for each gage

Site Located Near a Gage

- Near A Gage – drainage area of the site ranges from 50 to 200 percent of the drainage area of a nearby USGS gage
- Flow determined by a weighting technique using the gage data and the regional equation. (Not same technique used for "At a gage")

Site Located On A Regulated Stream

- Regulated - drainage basin above the site contains more than 4.5 million ft^3 of usable reservoir storage per mi^2 drainage area
- Houston…..we have a problem
- Contact Dam Operator

Urbanized Basin

- More than 15 percent of the drainage-basin area above the site is covered by some type of commercial, industrial, or residential development
- Nationwide Urban Regression Equations

7 Parameter Urban Regression Equations

$$UQR = K \times (A^{M}) \times (S^{N}) \times ((RI2 + 3)^{O} \times (ST + 8)^{P} \times (13 - BDF)^{Q} \times (IA^{R}) \times (RQ^{S})$$

ST - Basin Storage, percentage of the drainage basin occupied by lakes, reservoirs, swamps and wetlands

BDF - Basin Development Factor

IA - Percentage of the drainage basin occupied by impervious surfaces

RQ - Rural regression equation peak flow

RI2 - Rainfall depth, in inches, for the two-hour, two-year occurrence

K, M, N, O, P, Q, R, S are constants

Basin Development Factor

- Divide Basin Into Thirds
- Each third is evaluated and assigned a code for:
  - Channel Improvements
  - Channel Linings
  - Storm Drains, Storm Sewers
  - Curb & Gutter Streets
- Ranges from 0 (no urbanization) -12 (highly urbanized)

Jefferson County Regression Equations

Table 404-15 Jefferson County Regression Equations	
Return Interval (Years)	**Jefferson County Urban Peak-discharge estimating equations**
2	$UQ2 = 442(A^{0.635})(SL^{0.128})(13 - BDF)^{-0.337}$
5	$UQ5 = 517(A^{0.589})(SL^{0.208})(13 - BDF)^{-0.268}$
10	$UQ10 = 561(A^{0.574})(SL^{0.243})(13 - BDF)^{-0.235}$
25	$UQ25 = 647(A^{0.556})(SL^{0.276})(13 - BDF)^{-0.209}$
50	$UQ50 = 703(A^{0.547})(SL^{0.295})(13 - BDF)^{-0.189}$
100	$UQ100 = 780(A^{0.538})(SL^{0.310})(13 - BDF)^{-0.181}$

DR 1101
Temporary Drainage Design

- All drainage design is based on acceptable levels of risk
- Design of temporary structures highlights this concept

Temporary Drainage Design / Risk Assessment

- Key Concept Examples
  - A diversion that is built for a construction project that will last for only 3 months has a much smaller risk of seeing a large storm than one where the diversion will remain in place for 1 year.
  - Diversions in highly populated areas with houses in close proximity to the structure should be designed to higher levels than one where no dwellings are located.
  - There is less acceptance to a temporary diversion flooding on a highly traveled route with no close detour as opposed to a route with low traffic or a close detour

Temporary Drainage Design

- As with any stream crossing, temporary structures should be design to accommodate larger floods than the “design” flood. This accomplishes two primary goals
  - Reduce damages from larger floods
  - Avoid total washout of diversion
- This is usually accomplished by ensuring that anything over the design storm overtops the structure.

Two Primary Considerations in Determining overall Risk

- Frequency that a undesired event will happen
- Impact of the event

General Procedure

- Compute the following:
  - Total Impact Rating Value
  - Percent Design Risk
  - Design Frequency
- Size so that the next highest frequency storm overtops

Impact Rating Value

Table 1101-1 Rating Selection

Factor			Impact Rating Values (IRV)		
Average Daily Traffic (ADT) (number of vehicles per day)	Urban	ADT	0–400	401–1500	> 1500
		IRV	1	2	3
	Suburban	ADT	0–750	751–1500	> 1500
		IRV	1	2	3
	Rural	ADT	0–1500	1501–3000	> 3000
		IRV	1	2	3
Loss of Life (cross-checked with roadway ADT)	Yes → IRV		15	30	45
	No → IRV		1	2	3
Property damage (cross-checked with roadway ADT)	IRV for residential, commercial, industrial areas, waste, and storm and water supply systems		10	20	30
	IRV for croplands, parking and recreational areas		5	10	15
	IRV for all others (pasture, meadow, bare soil, etc.)		1	2	3
Detour Length	Length (mi)		< 5	5–9	> 9
	IRV		1	2	3
Height above streambed	Height (ft)		< 10	10–20	> 20
	IRV		1	2	3
Drainage Area	Area (mi2)		< 1	1–65	> 65
	IRV		1	2	3
Traffic Interruptions (see instructions)			IRV for ADT multiplied by IRV for detour length.		

Percent Design Risk

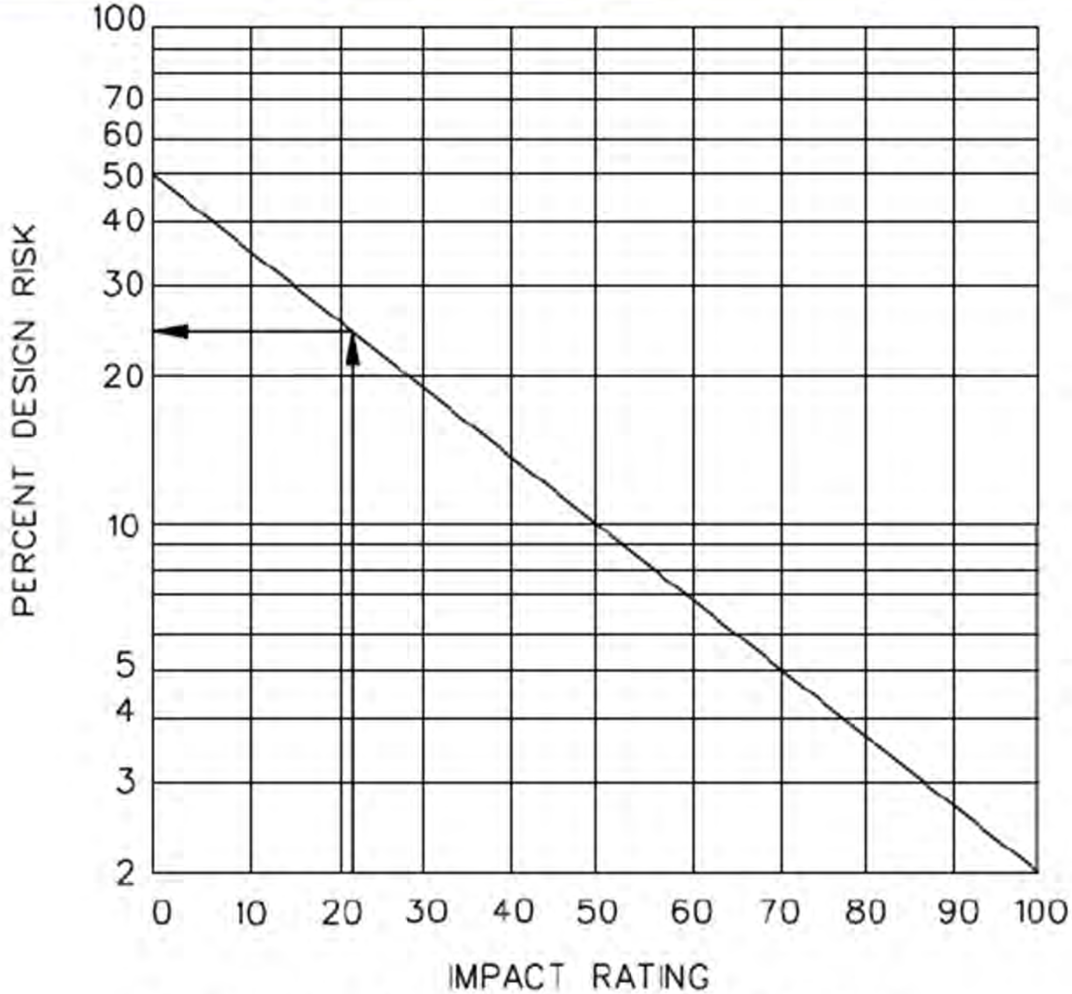


FIGURE 1101-1 DESIGN RISK VERSUS IMPACT RATING

Design Frequency

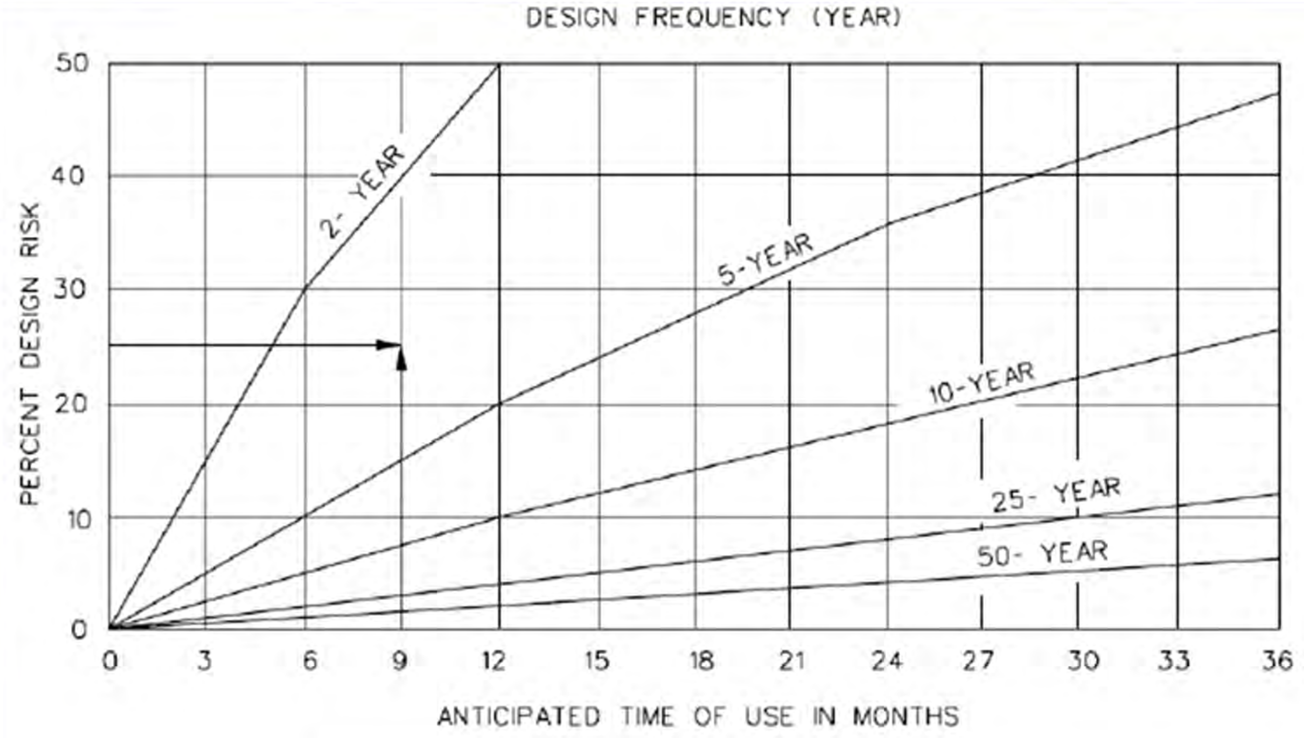


FIGURE 1101-2 RECOMMENDED DESIGN FREQUENCY

Design to overtop for next return interval.

Software Policy

- Narrowing recommended software down to a short list
- Require these to be used?
- Phase out software that is not recommended?

Drainage Folder Structure

Goals:

1. Make Drainage Folders easier to review

2. Improve summary forms

3. Improve documentation of key decisions

Goal 1: Ease of Review

- Define consistent organization for content
- Set clear content standards

Goal 1: Ease of Review (cont'd)

- Drainage Folder organized by "Sections"

Table 302-1, Sequence of Drainage Folder Components	
Section	**Description**
N/A	Drainage Folder Cover
N/A	Table of Contents
Section 1	Drainage Summary
Section 2	Meeting Reports and Correspondence
Section 3	Hydrology
Section 4	Plan Sheets
Section 5	Bridges and Culverts
Section 6	Storm Sewer Systems
Section 7	Pavement Inlet Spread Calculations
Section 8	Channel Calculations
Section 9	Other

Goal 1: Ease of Review

- Similar “Section” organization concept for Advance Situation Folders
  - Coordinate with Structural Design Manual
  - Pull information from the Drainage Folder

Goal 1: Ease of Review

- Content standards
  - Define specific content required for each Section
  - Define output specifications for software reports
    - Limit reports to that which is necessary
    - Avoid massive reports

Goal 2: Improve Summary Forms

- Improve Drainage Design Summary Form (TC 61-100)
- Create Storm Sewer Design Summary Form
- Clarify Bridge & Culvert Summary Form (TC 61-504)
- Write Detailed Instructions for Forms

Goal 2: Improve Summary Forms

- Drainage Design Summary (TC 61-100)

Kentucky Transportation Cabinet Division of Highway Design 4-06	DRAINAGE DESIGN SUMMARY TC 61-100	1 of 2
County : Scott	Route : KY 356	Item # : 7-1102.0
UPN : FD52 105 0356 002-003	FPN : BRZ 0702 259	Station : 18+25

EXISTING CONDITIONS

Stream : NO NAME	Drainage Area: 0.69 Ac		Slope (ft/ft):
OHW Elev. :	Drift :	Bed Material : Dry	D_{50} (mm) :
Abrasion Level :	pH : Medium	Resistivity :	Date Taken:

Return Interval (years)	2	5	10	25	50	100	500
Discharge (cfs)							
Flow Depth or Tailwater (ft)							
Velocity (ft/s)							

PROPOSED STRUCTURE

Type : 18" Culvert Pipe	Geometry, Skew : 45 lf @ 0° Skew	
Lt. Abut. / Inlet : S&F Wingwall	Rt. Abut./ Outlet : S&F Wingwall	
Coating :	Cover Height : ft	Low Road Elev. : 955.53
Net Opening : sf	Low Beam Elev. :	Grate Elev. :
Slope : 0.0167 ft/ft	Inlet Elev. : 951.75	Outlet Elev. : 951.00

WSEL with Structure				952.44		952.52	
WSEL without Structure							
Velocity with Structure (ft/s)				5.1		5.6	
Q over Road							

EXISTING STRUCTURE

Type : 15" RCP Culvert Pipe	Geometry, Skew :	
Lt. Abut. / Inlet :	Rt. Abut./ Outlet :	
Condition :		Low Road Elev. :
Net Opening : sf	Low Beam Elev. :	Grate Elev. :
Slope :	Inlet Elev. : 954.22	Outlet Elev. : 952.05

WSEL with Structure							
WSEL without Structure							
Velocity with Structure							
Q over Road							

Kentucky Transportation Cabinet Division of Design 2-06	DRAINAGE DESIGN SUMMARY TC 61-100	2 of 2

REMARKS and / or CONTROLS

RECORD HIGHWATER DATA

Source	1.	2.	3.
Elevation			
Date			
Location			

PROPOSED CHANNEL LINING

Location	Class	Thickness	Depth Protect	Length	Quantity
Upstream		FT	FT	LF	
Downstream	2	1.25 FT	1.0 FT	LF	4.5 TNS

PROPOSED DIVERSION

Flooding	Return Interval (yrs)	Discharge (CFS)	Elevation
Design Storm			
Overtop Storm			

Recommended Size and Type of Opening(s):

PROPOSED BOX CULVERT OR SPECIAL WINGWALL ANGLES

Normal End ☐Y ☐N | Skewed End ☐Y ☐N

Location	1	2	3	4
30 Degree	☐	☐	☐	☐
Skewed				
Special				

OTHER SITE SPECIFIC INFORMATION

DRY STRUCTURE

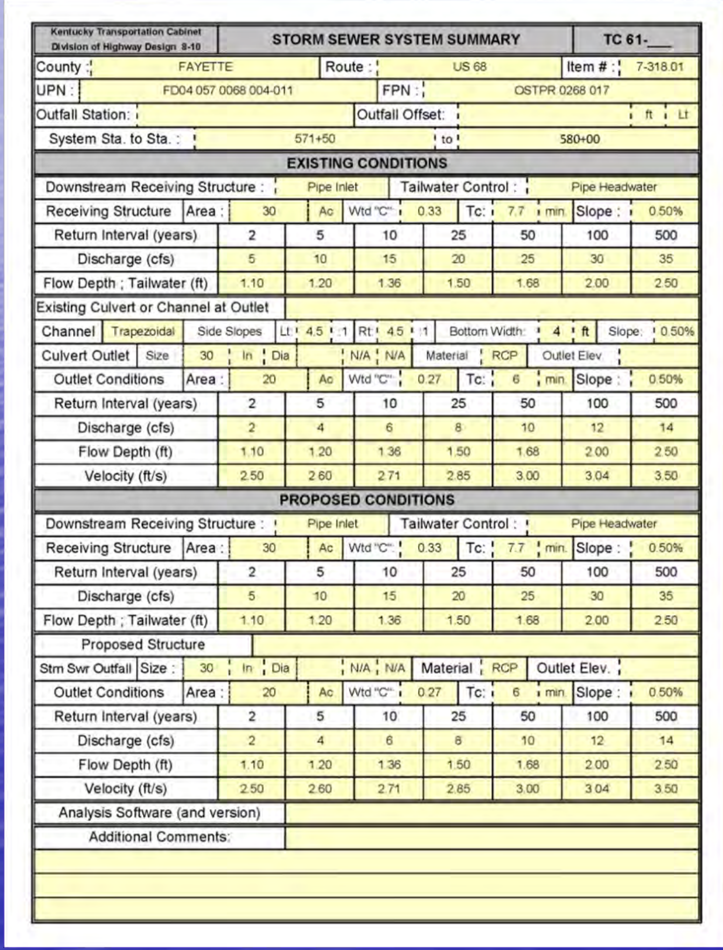
Goal 2: Improve Summary Forms

- Questionnaire Comments
  - Add Latitude / Longitude
  - Add section for bridge scour data
- Ideas/comments still being accepted

- Instructions

Goal 2: Improve Summary Forms

- Develop Storm Sewer Summary Form



Kentucky Transportation Cabinet Division of Highway Design 8-10	STORM SEWER SYSTEM SUMMARY					TC 61-___	
County :	FAYETTE	Route :	US 68		Item # :	7-318.01	
UPN :	FD04 057 0068 004-011		FPN :	OSTPR 0268 017			
Outfall Station:			Outfall Offset:			ft	Lt
System Sta. to Sta. :	571+50		to	580+00			
EXISTING CONDITIONS							
Downstream Receiving Structure :	Pipe Inlet		Tailwater Control :	Pipe Headwater			
Receiving Structure	Area : 30 Ac		Wtd "C": 0.33	Tc: 7.7 min.		Slope : 0.50%	
Return Interval (years)	2	5	10	25	50	100	500
Discharge (cfs)	5	10	15	20	25	30	35
Flow Depth ; Tailwater (ft)	1.10	1.20	1.36	1.50	1.68	2.00	2.50
Existing Culvert or Channel at Outlet							
Channel	Trapezoidal	Side Slopes	Lt: 4.5 :1	Rt: 4.5 :1	Bottom Width: 4 ft		Slope: 0.50%
Culvert Outlet	Size 30 In Dia		N/A N/A	Material RCP		Outlet Elev	
Outlet Conditions	Area : 20 Ac		Wtd "C": 0.27	Tc: 6 min.		Slope : 0.50%	
Return Interval (years)	2	5	10	25	50	100	500
Discharge (cfs)	2	4	6	8	10	12	14
Flow Depth (ft)	1.10	1.20	1.36	1.50	1.68	2.00	2.50
Velocity (ft/s)	2.50	2.60	2.71	2.85	3.00	3.04	3.50
PROPOSED CONDITIONS							
Downstream Receiving Structure :	Pipe Inlet		Tailwater Control :	Pipe Headwater			
Receiving Structure	Area : 30 Ac		Wtd "C": 0.33	Tc: 7.7 min.		Slope : 0.50%	
Return Interval (years)	2	5	10	25	50	100	500
Discharge (cfs)	5	10	15	20	25	30	35
Flow Depth ; Tailwater (ft)	1.10	1.20	1.36	1.50	1.68	2.00	2.50
Proposed Structure							
Stm Swr Outfall	Size : 30 In Dia		N/A N/A	Material RCP		Outlet Elev.	
Outlet Conditions	Area : 20 Ac		Wtd "C": 0.27	Tc: 6 min.		Slope : 0.50%	
Return Interval (years)	2	5	10	25	50	100	500
Discharge (cfs)	2	4	6	8	10	12	14
Flow Depth (ft)	1.10	1.20	1.36	1.50	1.68	2.00	2.50
Velocity (ft/s)	2.50	2.60	2.71	2.85	3.00	3.04	3.50
Analysis Software (and version)							
Additional Comments:							

- System/outfall location
- Pre- and Post-developed conditions
- Downstream conditions and controls
- Summary of results
- Software used (and version #)

Goal 2: Improve Summary Forms

- Clarify the Bridge & Culvert Summary Form (TC 61-504)
  - Name has created confusion
  - Considering changing name of form and making minor revisions
  - Detailed instructions

Goal 3: Improve Documentation

- "Drainage Executive Summaries"
  - Project-wide
  - Individual drainage structures
    - Show in remarks column of TC 61-504 for individual drainage structures

- Clearly convey information to reviewers regarding important decision processes

Results:

- Clear Expectations
- Consistent Folder Content
- Simplify Review
- Improve information transfer between various parties who use the Folders

Water Related Impacts

Current Policy

- Originated in Design Memos 19-90 and 3-91
- "Avoidance Alternatives to Water-Related Impacts“ included in DES and Conceptual Design Meeting (AKA PL&G) minutes. Discusses avoidance and may address minimization.
- "Assessment of Water-Related Impacts“ included in Final Inspection Report. Includes the “Avoidance Alternatives to Water-Related Impacts“. Addresses all three: avoidance, minimization and mitigation.

The Point

- Avoid impacts
- If you can’t avoid, Minimize.
- After you have minimized, mitigate for impacts that you could not avoid
- Became significant in early 1990’s when Section 404 permit guidelines where modified

Proposed Policy

- One document that is initiated during the conceptual design phase, and is built upon though final design
- This document will be entitled the “Water Related Impact Summary”
- First Section completed for each alternate considered
- Second Section completed for selected alternate
- Expanded to cover more impacts
- More definitive about contents

Why?

- The time to avoid and minimize is when the project is being designed
- Get designers thinking about avoiding and minimizing water related impacts early in the design process
- Will be used by DEA and Drainage Branch to identify major water related impacts
- Some impacts can cause project delays and significant permitting or mitigation costs

WATER RELATED IMPACT SUMMARY

County	Harrison	**Route No.**	US 27	**Item No.**	6-1053.00
Date	11-08-07	**Program #**	7370501D		
Federal Project No.	BRO 0272(101)				
State Project No.	FD52 049 0027 006-007				
Location Engineer	Brad Eldridge				

Section 1: Impact Checklist

Complete this section for each alternative considered at the conclusion of Phase 1 design.

FLOODPLAIN IMPACTS		
FEMA Study Type	**Yes**	**Community No.**
Detailed FEMA Study with delineated floodway*		
Detailed FEMA Study without delineated floodway*		
Approximate FEMA Study		
No FEMA Study		

* May require initiation of the map revision process if impacts to water surface elevations cannot be avoided. Potential impacts to floodplains and/or floodways shall be assessed early in the project. Refer to Sections DR 203 and DR 204 of the Drainage Manual.

SIGNIFICANT RESOURCE IMPACTS				
Are open sinkholes impacted? If so, how many sinkholes are impacted?	Yes		No	
Are wetlands impacted? If so, how many total acres are estimated? ______ acres	Yes		No	
Are any of the streams in the project area designated "Special Use Waters" impacted (e.g. Wild Rivers, Exceptional Waters, Outstanding State Resource Water, etc.)?	Yes		No	

Where possible, alignments should be developed that avoid significant resources. When it becomes impossible to avoid a significant resource, the project should be designed to minimize these impacts. Significant resource impacts are discussed in DR 202 of the drainage manual. Wetland impacts and their costs are also discussed in DR 500 of the Drainage Manual.

Projects that impact special use waters may require an individual KPDES Erosion Control Permit. Contact the Division of Environment analysis for more information.

STREAM CHANNEL IMPACTS				
Will stream relocations (channel changes) be needed? If so, how many total linear feet are estimated? ______ LF	Yes		No	
Will new culverts or culvert extensions be constructed?	Yes		No	
Will temporary stream crossings be needed?	Yes		No	
Will excess material sites that require permitting be needed?	Yes		No	
Will bridges be constructed?	Yes		No	

On highway projects that involve stream crossings such as bridge and culverts, it is often not feasible to totally avoid stream channel impacts. In these cases, design the project to minimize the impacts. Stream relocations should be avoided if possible. If stream relocations are unavoidable design to project to minimize their impacts. Stream channel impacts are discussed in DR 500 of the drainage manual.

Section 2 : Impact Discussion

Complete this section for the chosen alternate. Discuss the selected alternate's influence on each of the impacts listed above. Discuss any avoidance, minimization and/or mitigation measures included in the project.

Boring & Jacking of Pipe

Boring & Jacking of Pipe

- Railroad involvement may require specific criteria.
- We have specs that cover boring and jacking of: encasement pipes section 706, and a combination encasement-carrier pipe in special note 11E
- Be sure to include bid items and any special requirements in the contract documents

Please Wake Up and Head To Your Next Presentation

Thank You

Questions?