

Information on Speaker Notes

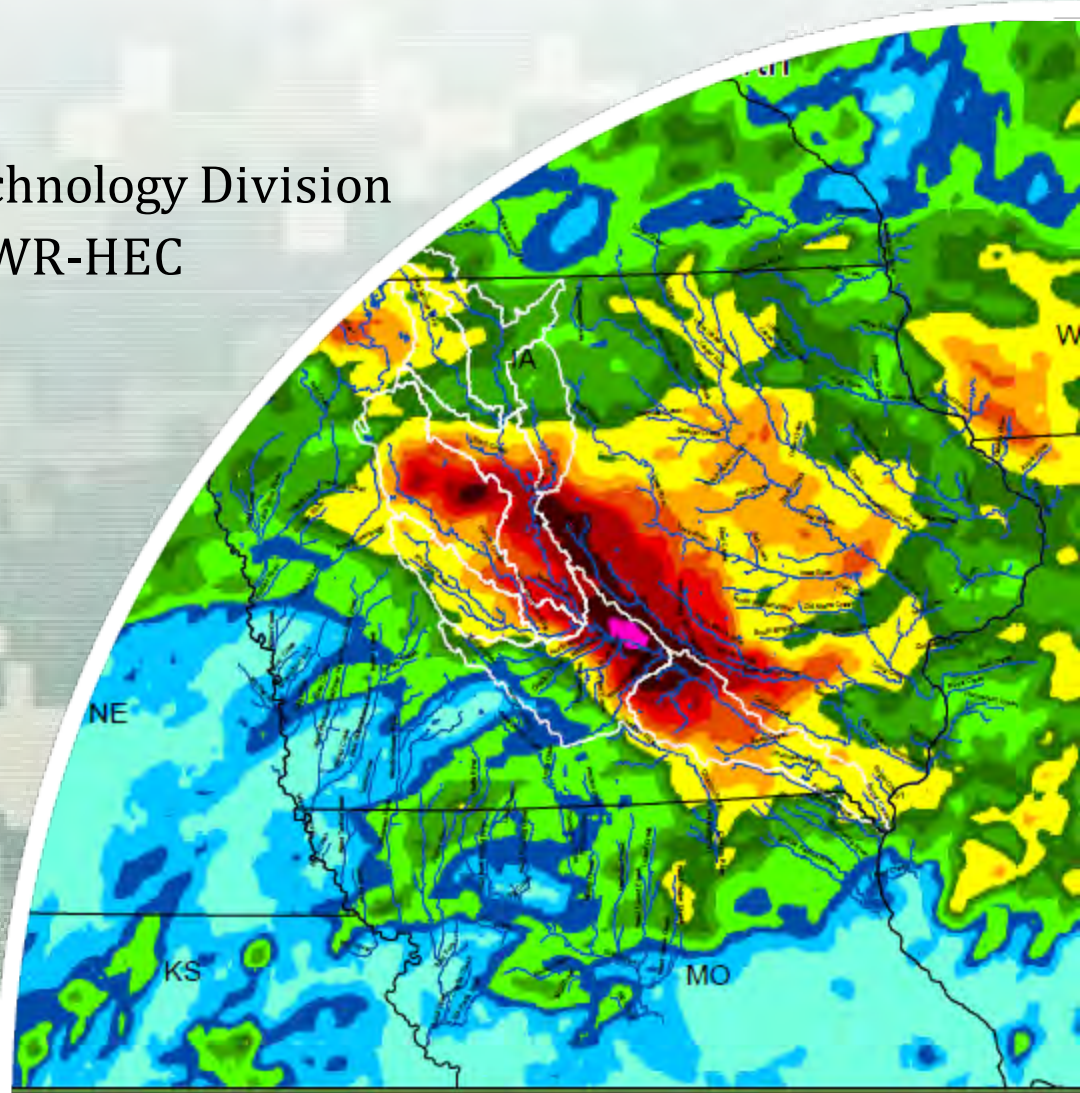
There are speaker notes on some of the slides. The notes provide more information about the content of the slide. An icon, indicating there are notes for a slide, is found in the upper left hand corner of the slide. You can activate the notes window in two ways:

- Hold the cursor over the icon and the text will appear.
- Click on the icon and a text box will open. Close with a click outside the text box. The text box can be moved around if needed by clicking (in top of box) and dragging.

USACE Extreme Storm Team and Hypothetical Storm Analysis

Matthew Fleming, P. E.

Chief, Hydrology and Hydraulics Technology Division
Hydrologic Engineering Center, CEIWR-HEC
Institute for Water Resources



US Army Corps of Engineers
BUILDING STRONG

Outline

▪ **USACE Extreme Storm Team**

- Catalog Historic Storms
- Perform Site Specific PMP and Antecedent Storm Studies
- Develop Guidance for Hypothetical Storm Analysis

▪ **HEC-MetVue and its Application to Cataloging Historic Storms and Applying Synthetics Storms**

▪ **Stochastic Hydrologic Simulations using HEC Software**

- Monte Carlo Analyses will be Available in HEC Software
- Knowledge Uncertainty and Natural Variability are Modeled in a Nested Monte Carlo Sampling Loop within HEC-WAT
- Application of HEC-WAT, HMS, and ResSim to Define Flow and Reservoir Stage Frequency Curves (Beyond Observed Records) while Including Uncertainty



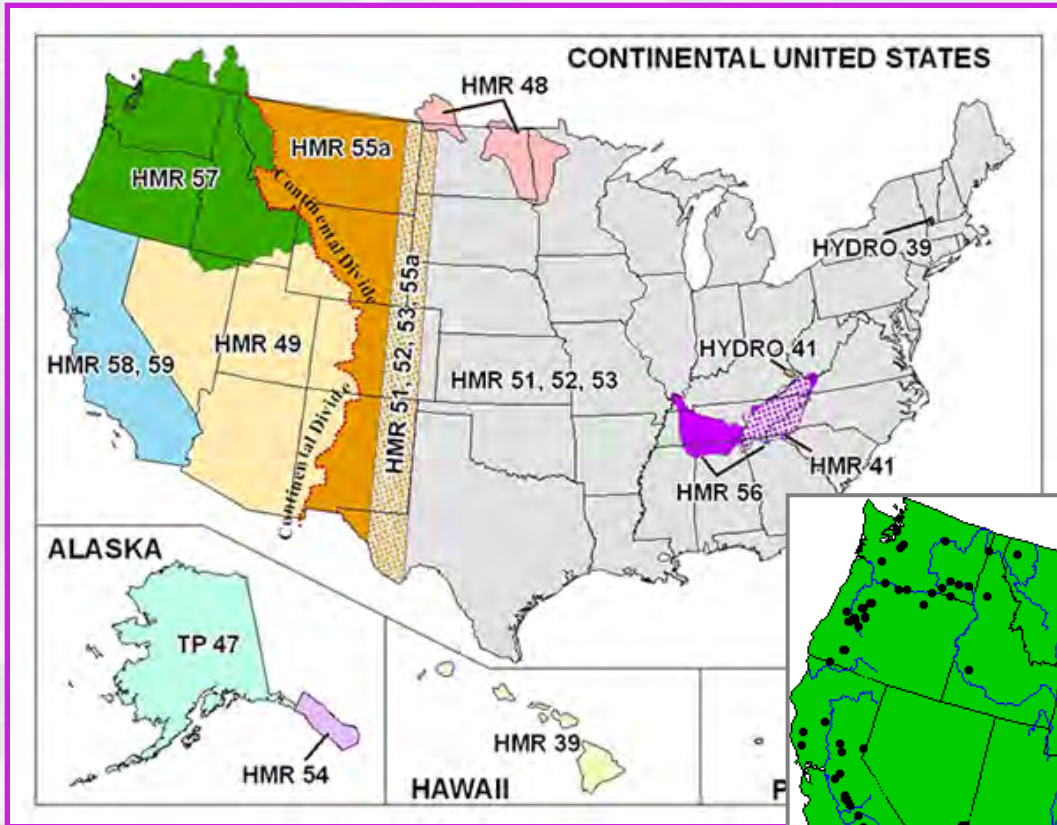


USACE Extreme Storm Data Needs

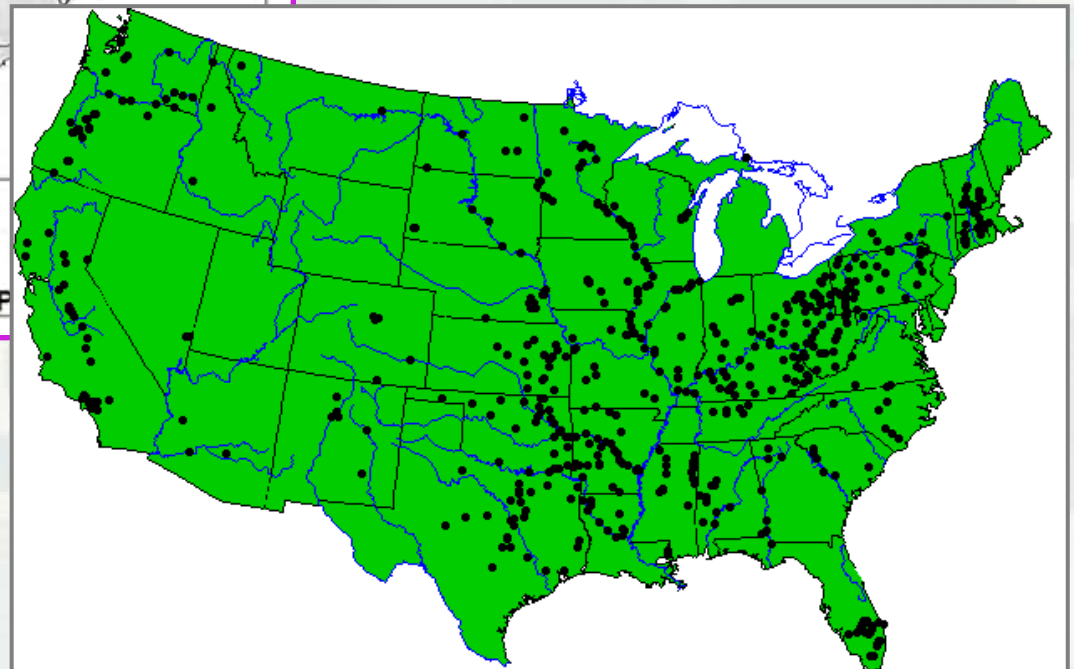
- **Dam Safety Program**
 - Site-Specific PMP and Antecedent Storm Studies
 - NOAA Hydrometeorological Reports (HMRs) updates
- **Levee Safety Program**
 - Update Standard Project Storm Criteria
 - Precipitation-Frequency (NOAA-14, TP40, NOAA II)
- **Extreme Storm Database**
 - Extreme Storm Data Archiving/Retrieval
 - Analysis of Recent Extreme Storm Events
 - Linked with HEC-HMS and HEC-MetVue
- **Computation of Areal Reduction Factors**
- **Monte Carlo Analysis for Frequency Curve Extension**
- **Atmospheric Modeling of Extreme Precipitation**



NOAA HMR Regional Coverage



Location of USACE Dams



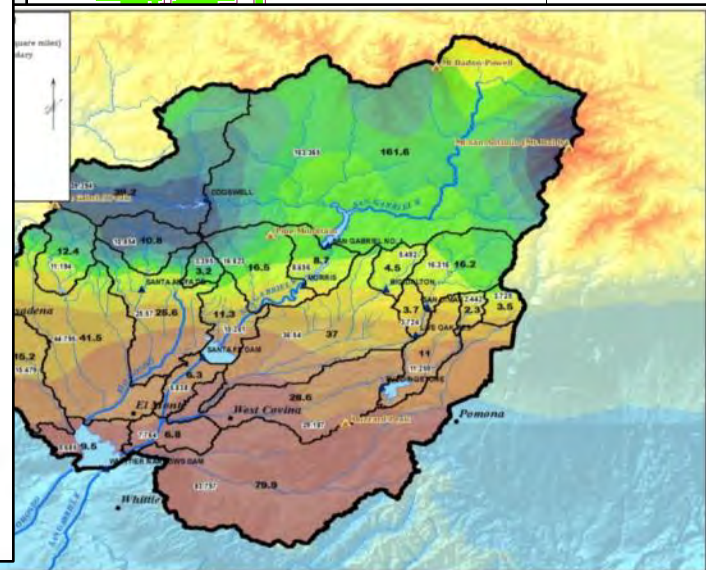
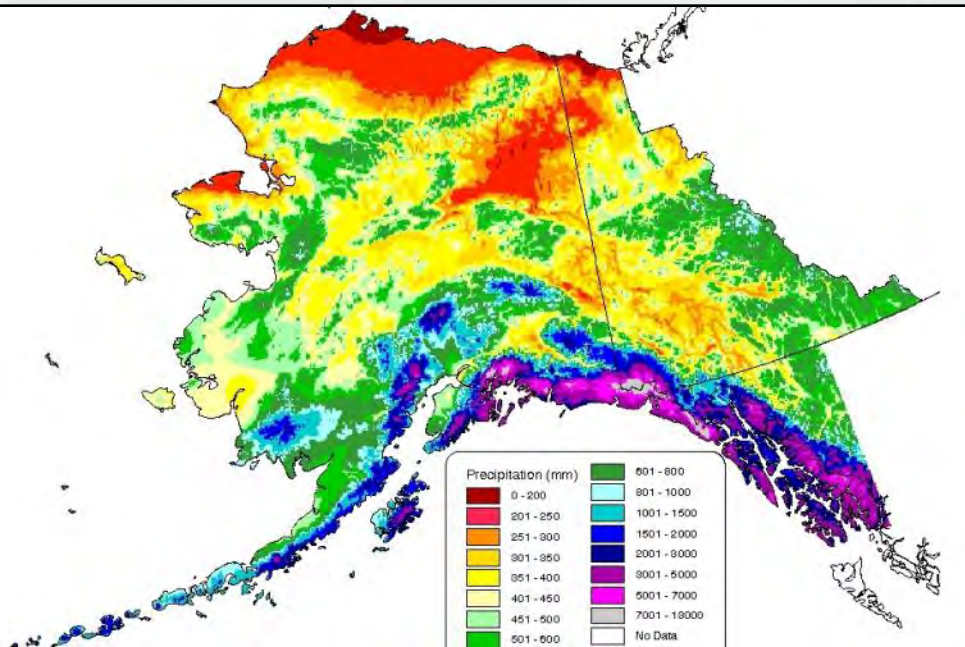
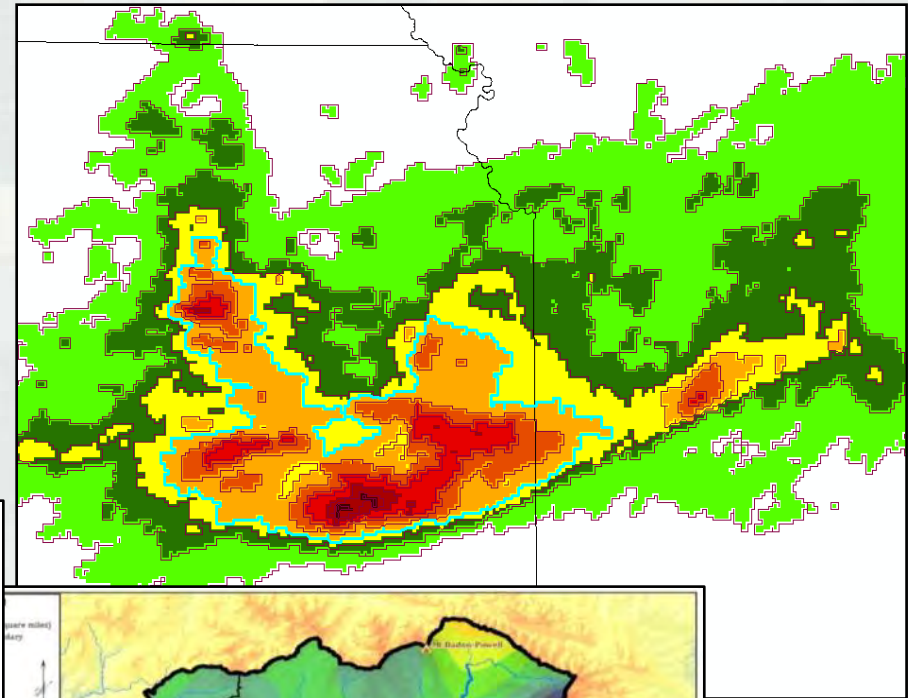
Site Specific Studies

■ Site Specific PMP Studies

- Completed: Moose Creek, Bluestone, Whittier Narrows
- In progress: Martis Creek, Ft Peck, Garrison, Kajaki

■ Antecedent Storm Studies

■ Atmospheric Modeling



Status of NOAA HMRs

HMR	Publication Date	Latest Storm Used
49	1977	Sept. 3-7, 1970
51	June 1978	June 19-23, 1972
55A	June 1988	Aug. 1-4, 1978
57	October 1994	Dec. 24-26, 1980
59	February 1999	Feb. 14-19, 1986

**6 of the Top 10 Texas Storms
Have Occurred Since
HMR 55A Publication**

Rank	Rainfall (inches)	Date	Location	Storm
1	43	7/24-25 1979	Alvin	TS Claudette
2	42	8/1-2 1978	Kerr County	TS Amelia
3	38.2	9/9-10 1921	Thrall	Unnamed
4	36	7/1-2 1932	Ingram	None
5	35	6/27-28 1954	Pandale	Alice
6	34	9/20 1967	Nueces River	Beulah
7	33	8/3 1978	Shackleford Co	TS Amelia
8	30	10/17-18 1998	San Marcos	None
9	28.8	6/9 2001	Houston	TS Allison
10	25	10/19 1984	Oden	Unnamed



Extreme Storm Catalog

WAR DEPARTMENT CORPS OF ENGINEERS, U.S. ARMY

STORM STUDIES - PERTINENT DATA SHEET



Storm of 26-29 July 1897
Assignment NA 1-7 (a)
Location North Atlantic Division
Study Prepared by New York, N. Y. District

Part I Review by Weather Bureau
Part II Approval of Engineer of Factuality
Remarks: North Atlantic Division Centers at Elizabeth

DATA AND COMPUTATIONS COMPILED PART I

Preliminary isohyetal map, in 1 sheet, scale 1:2,500,000
Precipitation data and mass curves:
Form 5001-C (Hourly precip. data).....
Form 5001-B (24-hour " " " ").....
Form 5001-D (" " " " " ").....
Misc. precip. records, meteorological data, etc.....
Form 5002 (Mass rainfall curves).....

PART II

Final isohyetal maps, in 1 sheet, scale 1:1,000,000
Data and computation sheets:
Form S-10 (Data from mass rainfall curves)..... 5
Form S-11 (Depth-area data from isohyetal map)..... 2
Form S-12 (Maximum depth-duration data)..... 5
Maximum duration-depth-area curves..... 3
Data relating to periods of maximum rainfall..... 2

MAXIMUM AVERAGE DEPTH OF RAINFALL IN INCHES

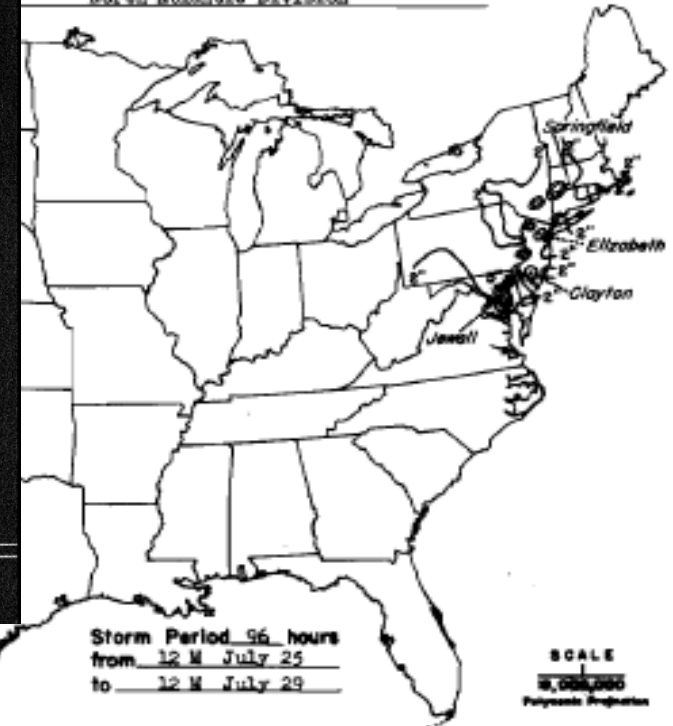
Area in Sq. Mi.	Duration of Rainfall in Hours									
	6	12	18	24	30	36	48	60	72	96
10	6.2	8.1	8.6	8.7	8.9	9.0	9.0	9.1	9.1	9.1
100	4.3	7.3	7.5	7.8	7.9	8.0	8.0	8.1	8.1	8.1
200	3.8	6.6	6.8	7.0	7.1	7.2	7.3	7.3	7.3	7.3
500	3.1	5.5	5.7	5.9	6.0	6.1	6.2	6.3	6.3	6.3
1,000	2.8	4.6	4.8	4.9	5.1	5.2	5.3	5.4	5.5	5.5
2,000	2.4	3.9	4.0	4.1	4.3	4.4	4.5	4.6	5.1	5.1
5,000	1.9	3.1	3.3	3.3	3.4	3.7	3.8	3.9	4.0	4.1
10,000	1.5	2.6	2.8	2.9	2.9	3.3	3.4	3.5	3.6	3.7
20,000	1.1	2.1	2.4	2.5	2.6	2.9	3.1	3.2	3.3	3.4
26,000	1.0	1.9	2.1	2.2	2.3	2.8	3.0	3.2	3.3	3.3

Form S-2

WAR DEPARTMENT CORPS OF ENGINEERS, U.S. ARMY

STORM STUDIES - ISOHYETAL MAP

Storm of July 26-29, 1897 Assignment NA 1-7 (a)
Study Prepared by New York, N. Y. District
North Atlantic Division



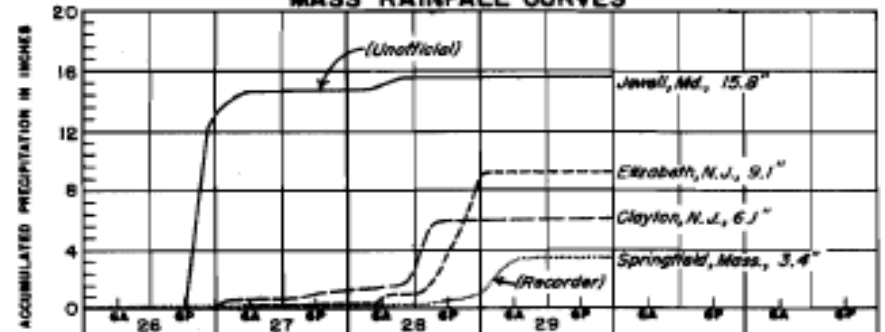
STORM RAINFALL IN THE UNITED STATES

DEPTH - AREA - DURATION DATA



CORPS OF ENGINEERS, U.S. ARMY 1945

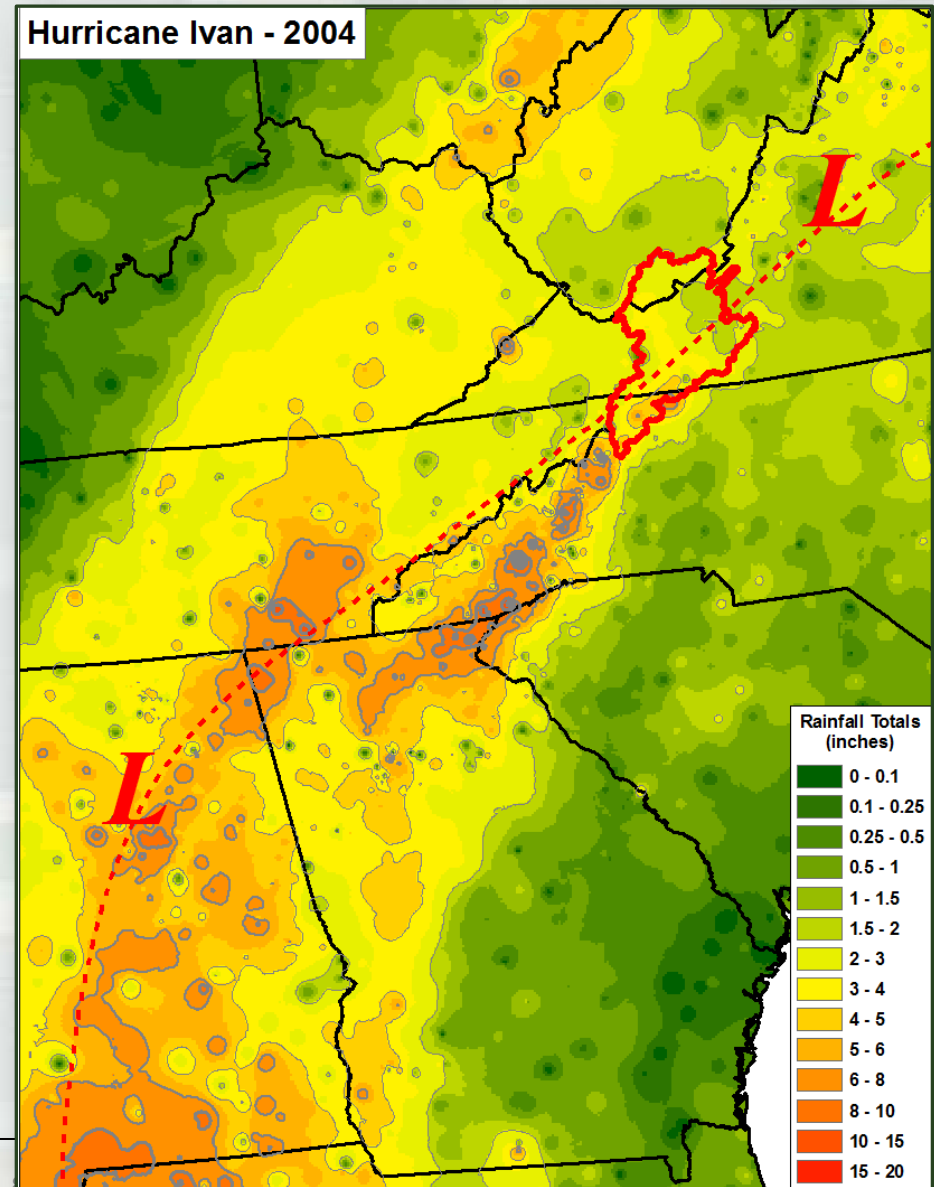
MASS RAINFALL CURVES

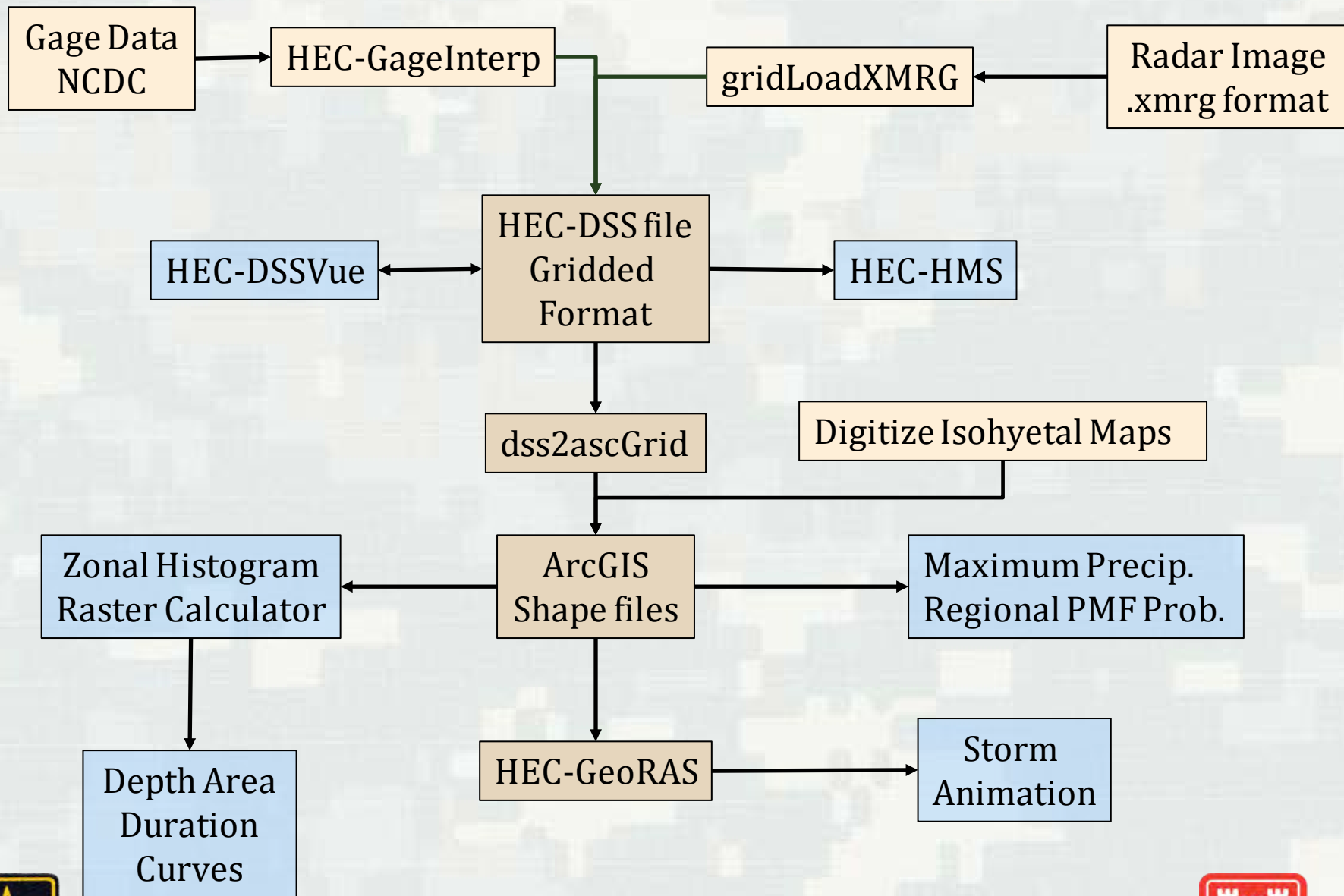


FORM S-11

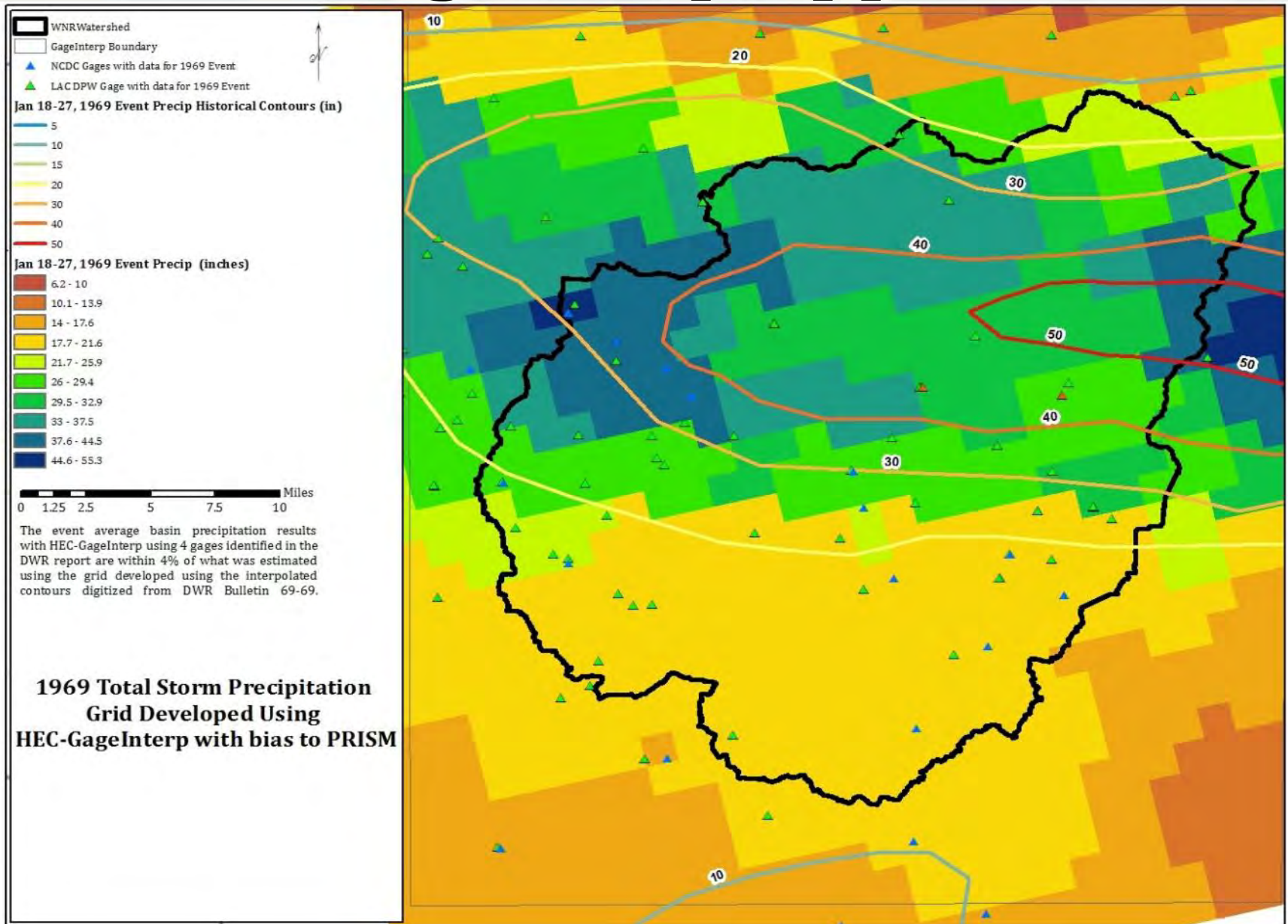
Extreme Storm Database

- Common Database shared with all federal and state agencies, academia, private consultants
- Historic and Synthetic Extreme Storms
- Depth Area Duration, Isohyetal maps, mass rainfall curves, meteorological characteristics
- Interfaced with Hydrologic Models, tools, etc





HEC-GageInterp Approach



Extreme Storm Database

US Army Corps of Engineers
Storms

Storm Search Map

Storm Search

Go Reports: 1. Primary Report Rows: 50 Actions

ID #	Assignment Number	Approximate Location of Storm Center	Division	District	Date Start	Date End	Total Rainfall (in)	Storm Duration (hrs)	Storm Area
1	GM 3-13	Ex, NM	South Pacific	FA					
2	GM 3-14	Kickerbocker, TX	Southwestern	FA					
3	GM 4-21	Eagle Pass, TX	Southwestern	FA					
4	GM 5-1	Mountain Home, TX	Southwestern	FA					
5	GM 5-10	Elkavado, TX	Southwestern	FA					
6	GM 5-10B	Mesa, NM	South Pacific	FA					
7	GM 5-10B	Abilene, TX	Southwestern	FA					
8	GM 5-17	Rogaland, NM	Southwestern	FA					
9	GM 5-10	Praineview, NM	Southwestern	FA					
10	GM 5-19	McColeum Ranch, NM	South Pacific	FA					
11	GM 5-2	Sogovia, TX	Southwestern	FA					
12	GM 5-3	Ballingen, TX	Southwestern	FA					
13	GM 5-7	Bronna, TX	Southwestern	FA					
14	MAN-6-35	Tilton, Manitoba							
15	MR 35-31	Big Thompson, CO	Northwestern	GA					
17	MR 10-1	Howard, SD	Northwestern	GA					
16	MR 10-10	Mexico, IA	Massissippi Valley	RA					
19	MR 10-12	Rapid City, SD	Northwestern	GA					
20	MR 10-13	Kirkman, IA	Northwestern	GA					
21	MR 10-14	David City, NE	Northwestern	GA					
22	MR 10-2	Council Grove, KS	Northwestern	GA					
23	MR 10-3	Scottsbluff, NE	Northwestern	GA					
24	MR 10-6	Derrison, IA	Massissippi Valley	RA					
25	MR 10-7	Manstead, NE	Northwestern	GA					
26	MR 10-8	Ritter, IA	Massissippi Valley	RA					
27	MR 1-1	Phillipsburg, MO	Southwestern	LA					
28	MR 1-10	Woodburn, IA	Massissippi Valley	RA					
29	MR 1-11	Burlington, KS	Northwestern	GA					
30	MR 1-12	Nevada, MO	Northwestern	GA					
31	MR 1-13	Newlot, KS	Southwestern	LA					
32	MR 1-14	Vilas, CO	Southwestern	LA					

Select Storm by Map or by Searching Catalog

Extreme Storm Database

US Army Corps of Engineers

Storms

Storm Search Map

Enter a location

Map Satellite

Google

Map data © 2013 Google, INEGI, MapLink Terms of Use

The map displays the United States and parts of Canada and Mexico, overlaid with a dense distribution of blue location pins. The pins are most concentrated in the central and eastern United States, particularly in the Great Plains and the Northeast. State names are labeled on the map, including California, Nevada, Idaho, Wyoming, Utah, Arizona, Colorado, New Mexico, Texas, Oklahoma, Kansas, Nebraska, Iowa, Missouri, Illinois, Indiana, Ohio, Michigan, Wisconsin, Minnesota, North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, Texas, Louisiana, Mississippi, Alabama, Georgia, Florida, Virginia, North Carolina, South Carolina, Georgia, Florida, New York, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, New Jersey, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, Maine, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland and Labrador. The map also shows the Gulf of California, Gulf of Mexico, and Gulf of St. Lawrence.



Extreme Storm Database

Obtain Storm Documents, Storm Summary, and Data

The screenshot displays the US Army Corps of Engineers Storms database interface. At the top, there is a search bar and a 'Storms' tab. Below this is a table listing various storm assignments. A map of New Mexico is shown, with a red pin indicating the location of the selected storm. To the right of the map is a 'Storm Summary' panel with the following details:

Storm Summary	
Id	6
Date Start	15-Sep-1919
Date End	17-Sep-1919
Approximate Location of Storm Center	Meek, NM
Assignment Number	GM 5-15B
Total Rainfall (in)	9.8
Storm Duration (hr)	54
Storm Area (mi ²)	75000
Max Average Depth of Rainfall (in)	4.4
24-hr, 100 mi ² Rainfall (in)	6.4
Storm Dewpoint	72
In-Place Moisture Adjustment	1.4
Max Dewpoint	79
Ref Location	400 ESE
Hnr	5155A
Elevation	6700
Latitude	33.41
Longitude	-105.11
Last Dmi Timestamp	24-OCT-13 01:28:27.000000 PM - 04:00
District	Albuquerque
Division	South Pacific

Below the summary is a 'Document Checklist' section.





Planned Extreme Storm Database Enhancements

- **Lat/Long Search Box or by Location/Radius**
- **Field for Storm Type (ie, synoptic, convective)**
- **Access by non-Corps (read-only, edit, add rights)**
 - Field to ID who entered/edited data
- **DAD Tables**
 - Search & Interpolate any area or duration
 - Plot DAD Curves
- **Show Reference Location on Map**
- **Extract Dew Points from Map**
- **Extract PMP from Map**
 - Compute % PMP





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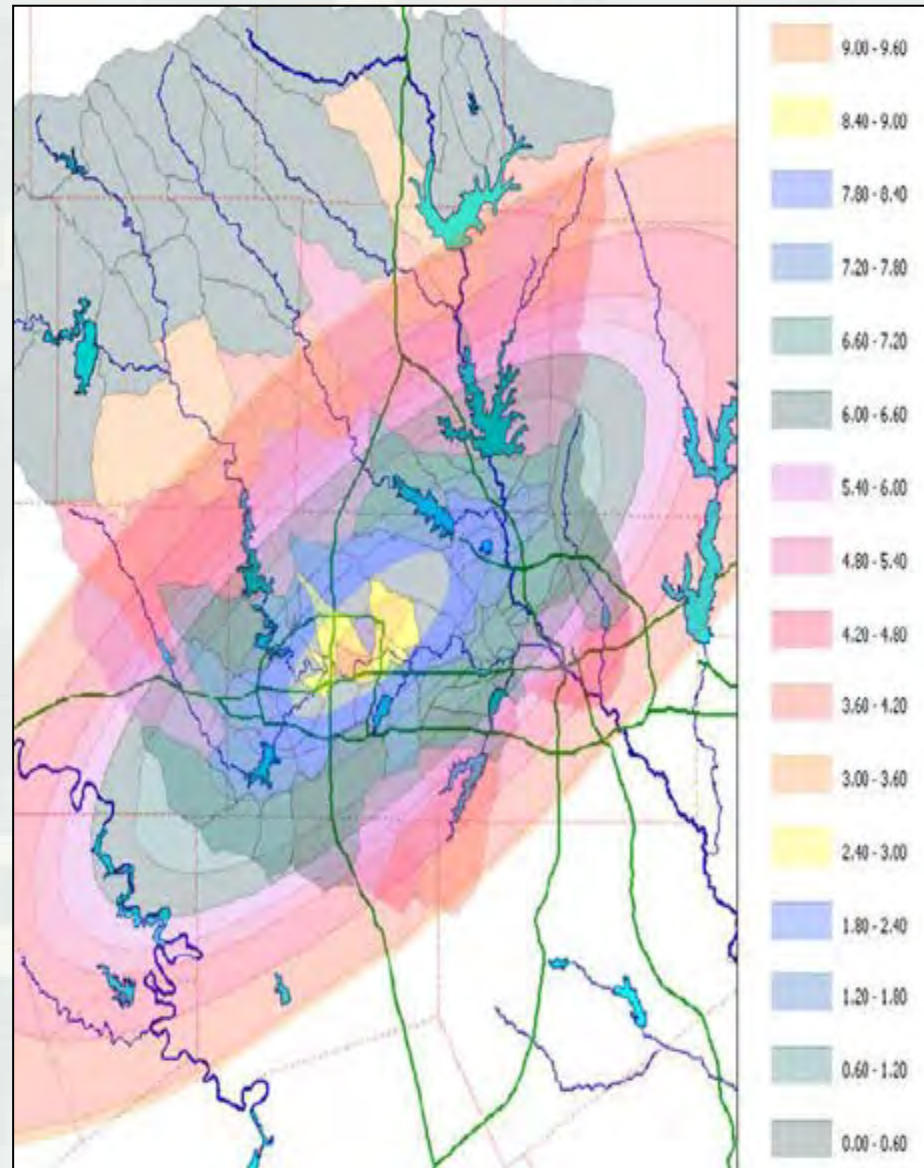
▪ Stochastic Hydrologic Simulations using HEC Software

- Monte Carlo Analyses will be Available in HEC Software
- Knowledge Uncertainty and Natural Variability are Modeled in a Nested Monte Carlo Sampling Loop within HEC-WAT
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HEC-MetVue

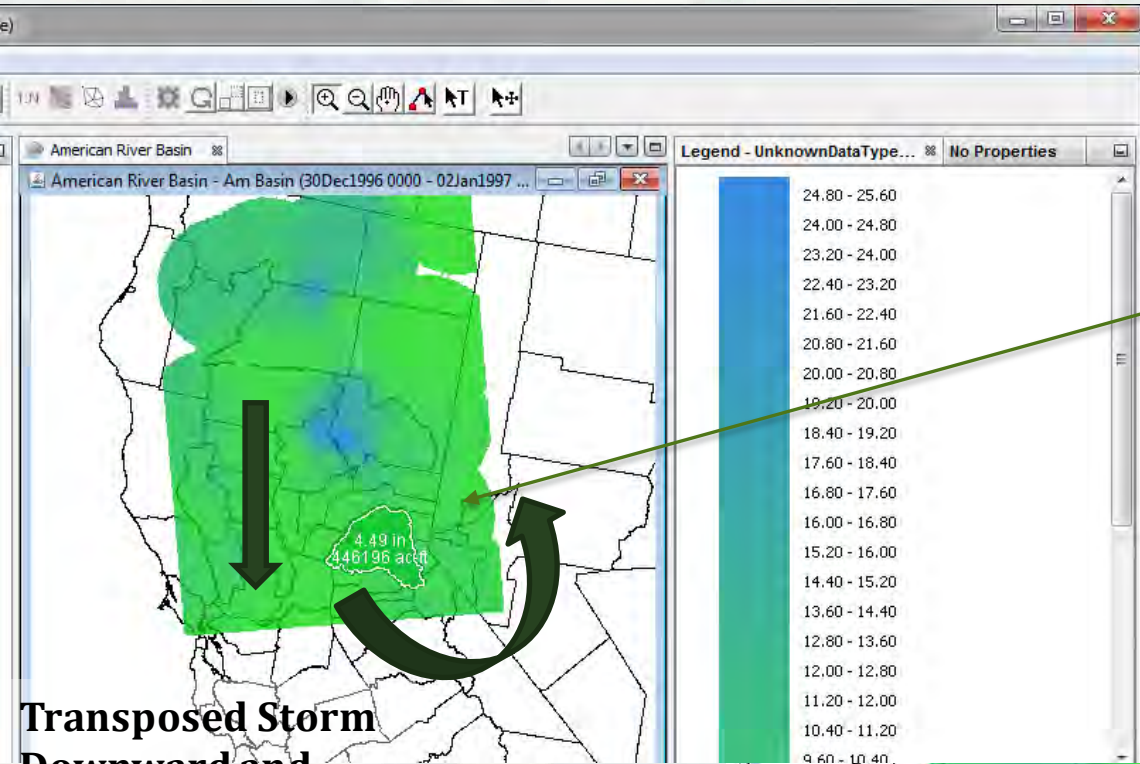
- **GIS-Based Meteorologic Model / Visualization Tool**
 - Accepts shapefiles in any coordinate system
- **Inputs**
 - QPE, QPF (XMRG, NetCDF)
 - Gage Data (ASCII, DSS)
- **Outputs**
 - Hyetographs/ Gridded Precipitation (HRAP,SHG)
- **Analyze Historic Storms**
 - Compute DAD
 - Translate, Rotate, Maximize
 - Calibrate QPE to gage data or PRISM data
 - Aggregate/Segregate Storms
- **Develop Design Storms**
 - Hypothetical Frequency Based
 - PMP (HMR51/52, HMR55A, HMR58/59)
- **Linkage with HEC-HMS/Extreme Storm Database**
- **Future work : Sample storm characteristics such as movement, centroid location, and orientation**



HEC-MetVue

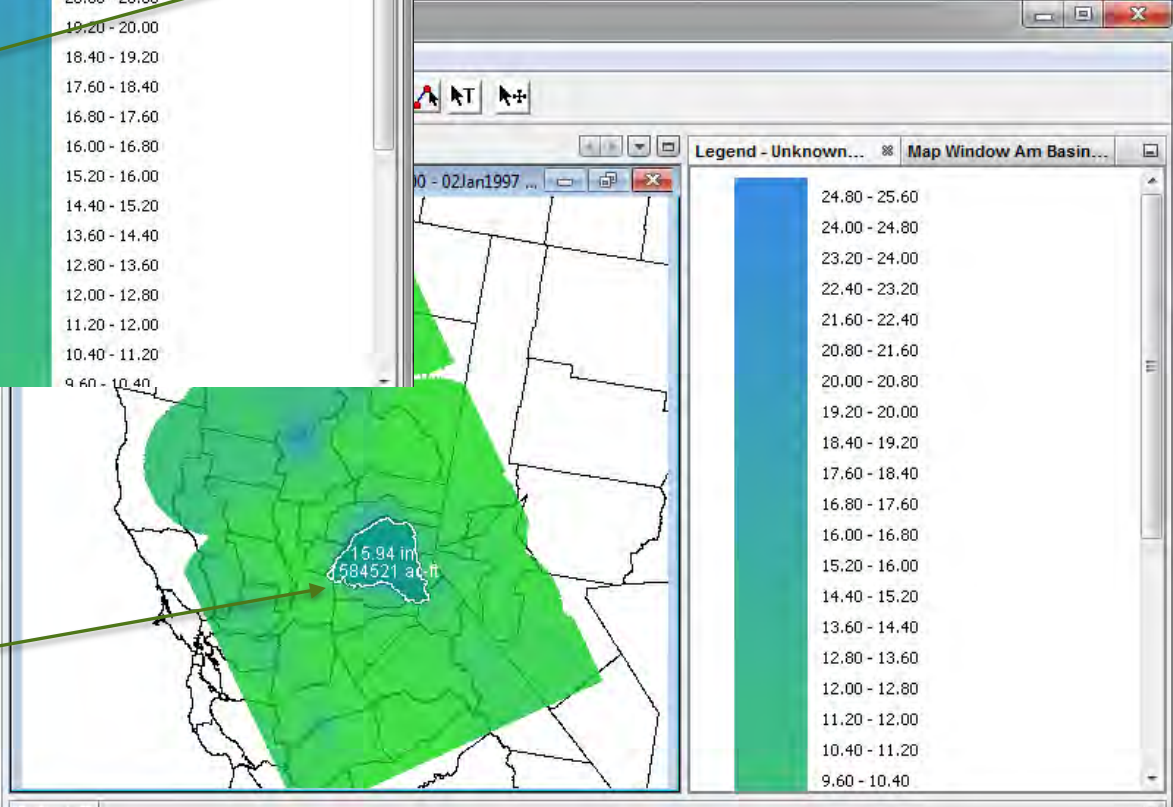
Dynamically updates basin average precipitation with transposed, reoriented storm

Basin
Precipitation
= 4.49 inches



Transposed Storm
Downward and
Rotated
20 Degrees

Basin
Precipitation =
15.94 inches



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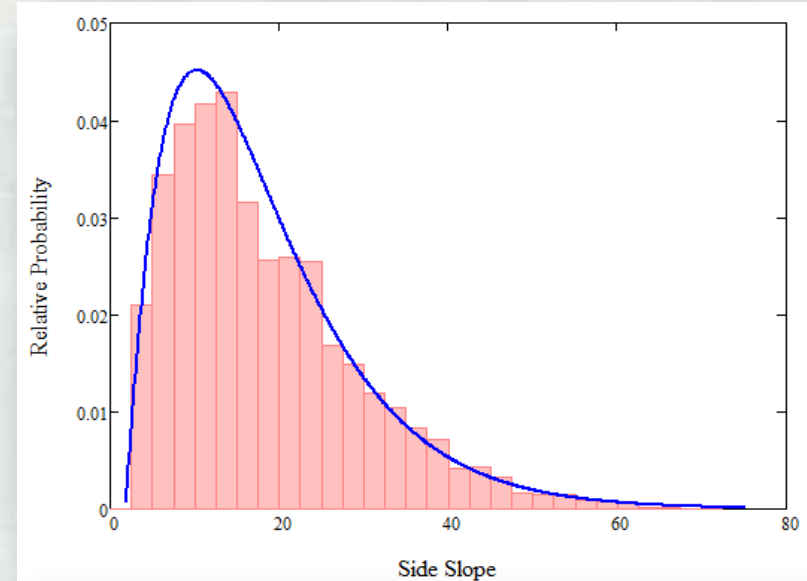
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Monte Carlo Capabilities in HEC Software

- **Monte Carlo sampling capabilities are being added to HEC Software:**
 - HEC-HMS - Loss Rate, Transform, Baseflow, and Routing
 - HEC-ResSim – Initial conditions, Rules (like maximum releases), and input TS
 - HEC-RAS – Manning’s n-values and dam breach parameters
 - HEC-FIA – Stage-damage information and structure elevations
- **User defines parameters for uncertainty distributions (Beta, Exponential, Gamma, Log-Normal, Normal, Triangular, Uniform, Weibull)**
- **Independent and Dependent Parameter Sampling**
- **When used within a HEC-WAT Monte Carlo simulation, HEC-WAT helps to manages sampling of model data/parameters**



Uncertainty Analysis Parameter 3

Name: 1994

Element: Mahoning

Parameter: Kinematic Wave - Side Slope

*Method: Simple Distribution

Distribution: Gamma

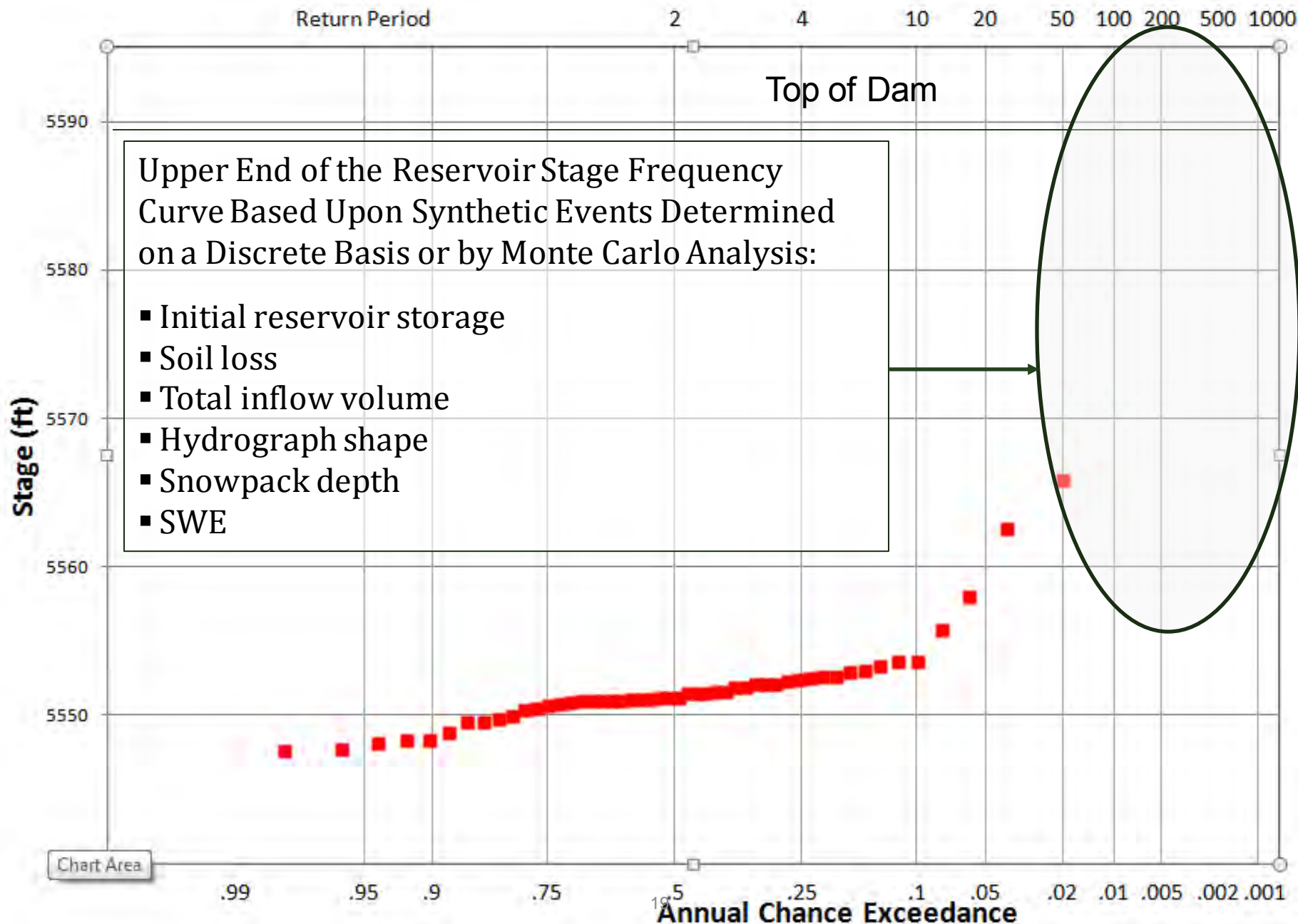
*Shift: 1.83

*Shape: 2.06

*Scale: 7.95



Extension of Frequency Curve



HEC-WAT

The screenshot displays the HEC-WAT software interface. The main window shows a map of a river system with various simulation parameters and a list of alternatives. The interface includes a menu bar (File, Edit, View, Maps, Compute, Results, Tools, Window, Help), a toolbar with various icons, and a main map area showing a river network with blue and orange lines. The map is overlaid with a green background. The river is labeled 'Deschutes River'. The interface also shows a list of alternatives on the left, including 'Without Project Conditions', 'BaseConditions', and 'Analysis Periods'. The 'BaseConditions-Event1948' alternative is selected. The 'Analysis Periods' list includes 'ECC Base', 'VECC2Flood', 'URC Adj', 'CalledUpon', 'ECC Comp', 'VCompICF', 'Reach1', 'Reach5', 'Reach9', 'Reach17', 'Reach24', 'Reach28', 'Reach29', 'R01_PHASE2a', 'R02_PHASE2a_CCP', 'R03_PHASE2a_CCP', 'R04_PHASE2a_CCP', 'R05_PHASE2a', and 'R06_PHASE2a_CCP'. The 'Messages' window at the bottom shows the following text: 'Loading Analysis Periods Event1902', 'Loading Analysis Periods Event1974', 'Loading Analysis Periods Event1972', 'Stream Alignment added to Simulation: BaseConditions-Event1948', 'BaseConditions-Event1948 added to Simulation: BaseConditions-Event1948', and 'Loading Alternatives Without Project Conditions'. The status bar at the bottom shows 'Coordinates: -6586100 east, 9699792 north', '20', and '326M of 398M'.

An overarching interface that allows project teams to perform water resources studies in a comprehensive, systems-based approach by building, editing and running models commonly applied by multi-disciplinary teams and save and display data and results in a coordinated fashion.

HEC-WAT for the Columbia River Watershed



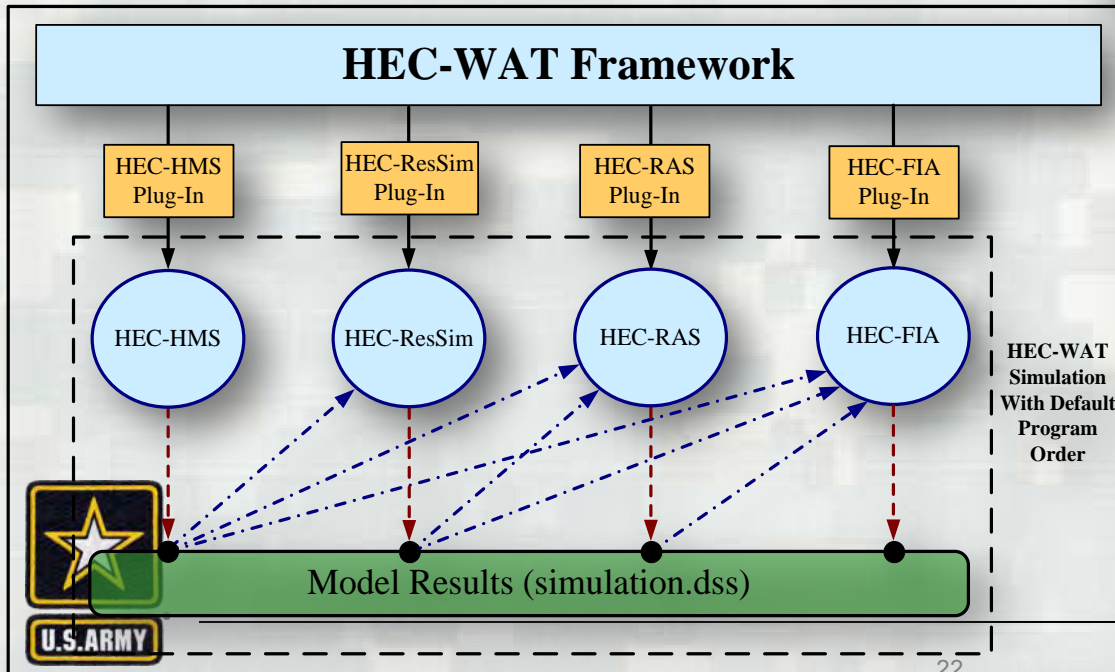
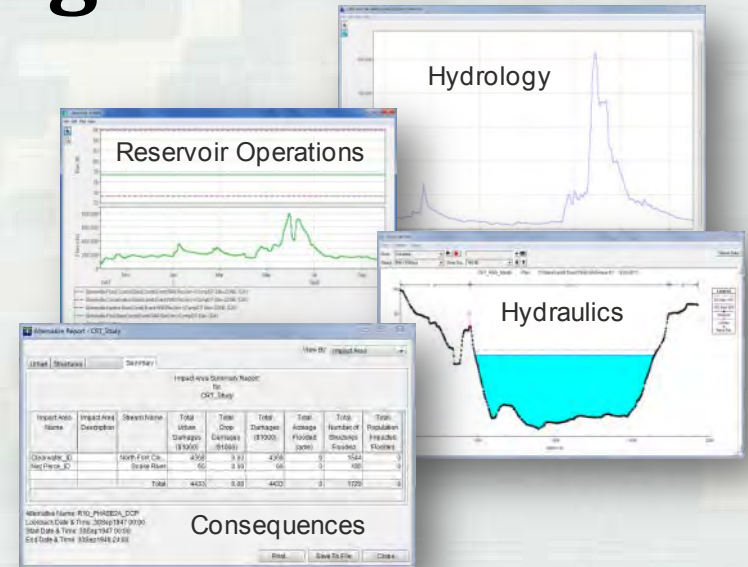
- 258,000 sq. miles
- 2 countries
- 7 states
- 1,214 miles
- 125 tributaries
- Approximately 176,000 structures
- 65 projects
- 100 fragility curve locations
- 43 consequence areas
- 128 levee systems; 449 miles



HEC-WAT - Linking Models

- The initial set of models and tools to be used during the analytical process in HEC-WAT are:

- Hydrology (HEC-HMS)
- Reservoir Operations (HEC-ResSim)
- Hydraulics (HEC-RAS)
- Consequences (HEC-FIA)



- Communication between software is provided through a "plug-in."
- Data is shared through a common DSS file.

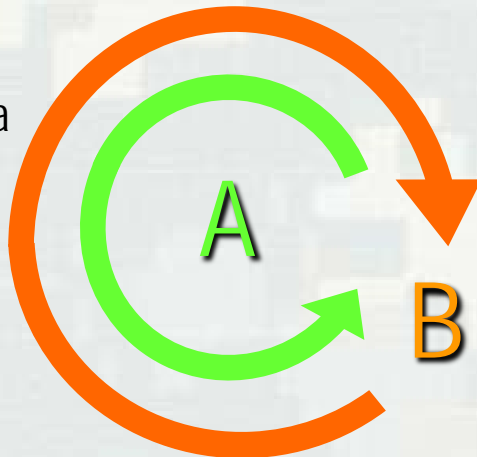


Nested Sampling Approach for Monte Carlo Simulations

Nested Monte Carlo:

- A. Sample instances of **natural variability** as flood *events*, with enough events to capture the distribution of damage
- B. Sample instances of **knowledge uncertainties** in model parameters to get their impact on the damage distribution

1 outer loop B = a realization

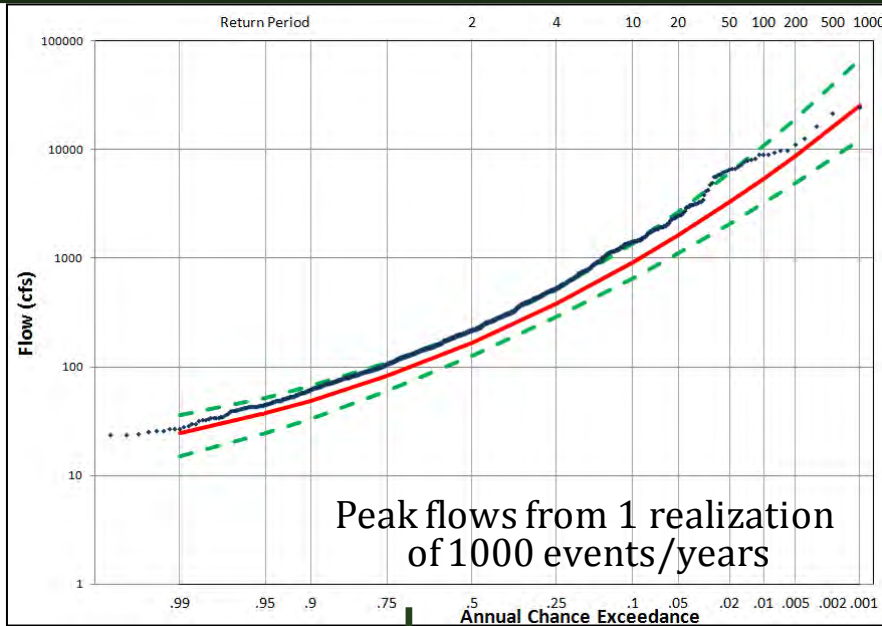


inner loop A varies natural variabilities, computes EAD

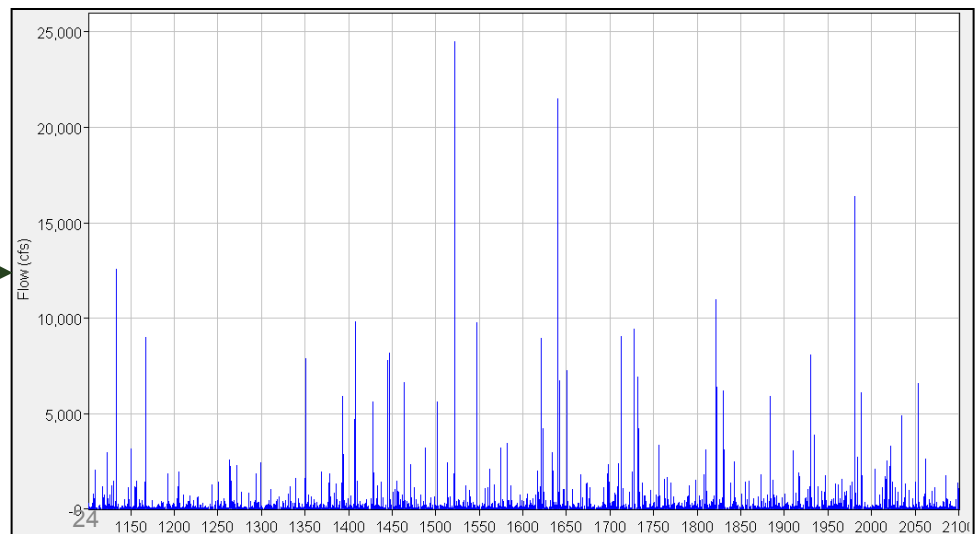
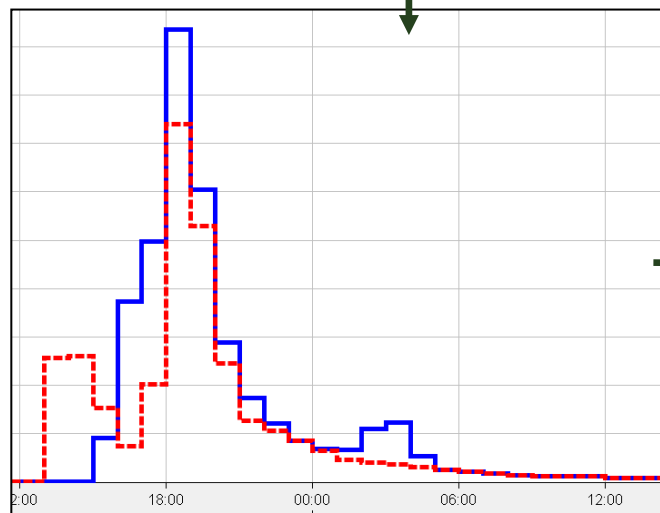
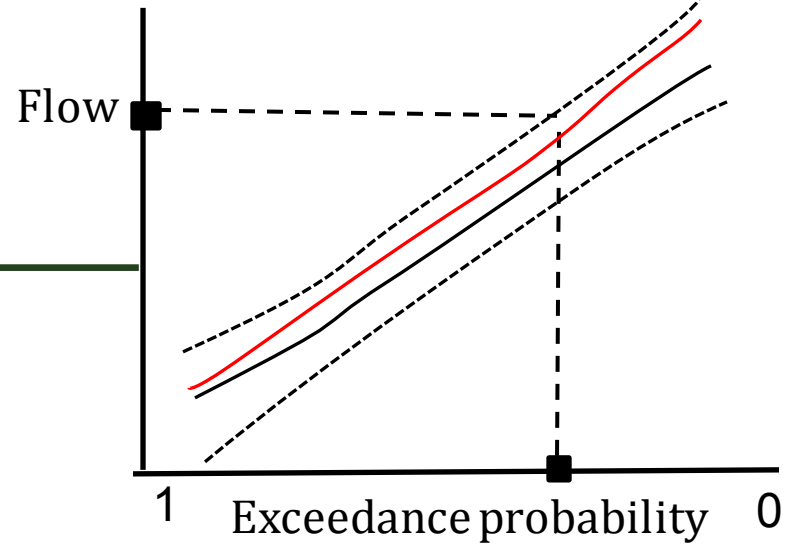
outer loop B varies knowledge uncertainty, computes EAD distribution



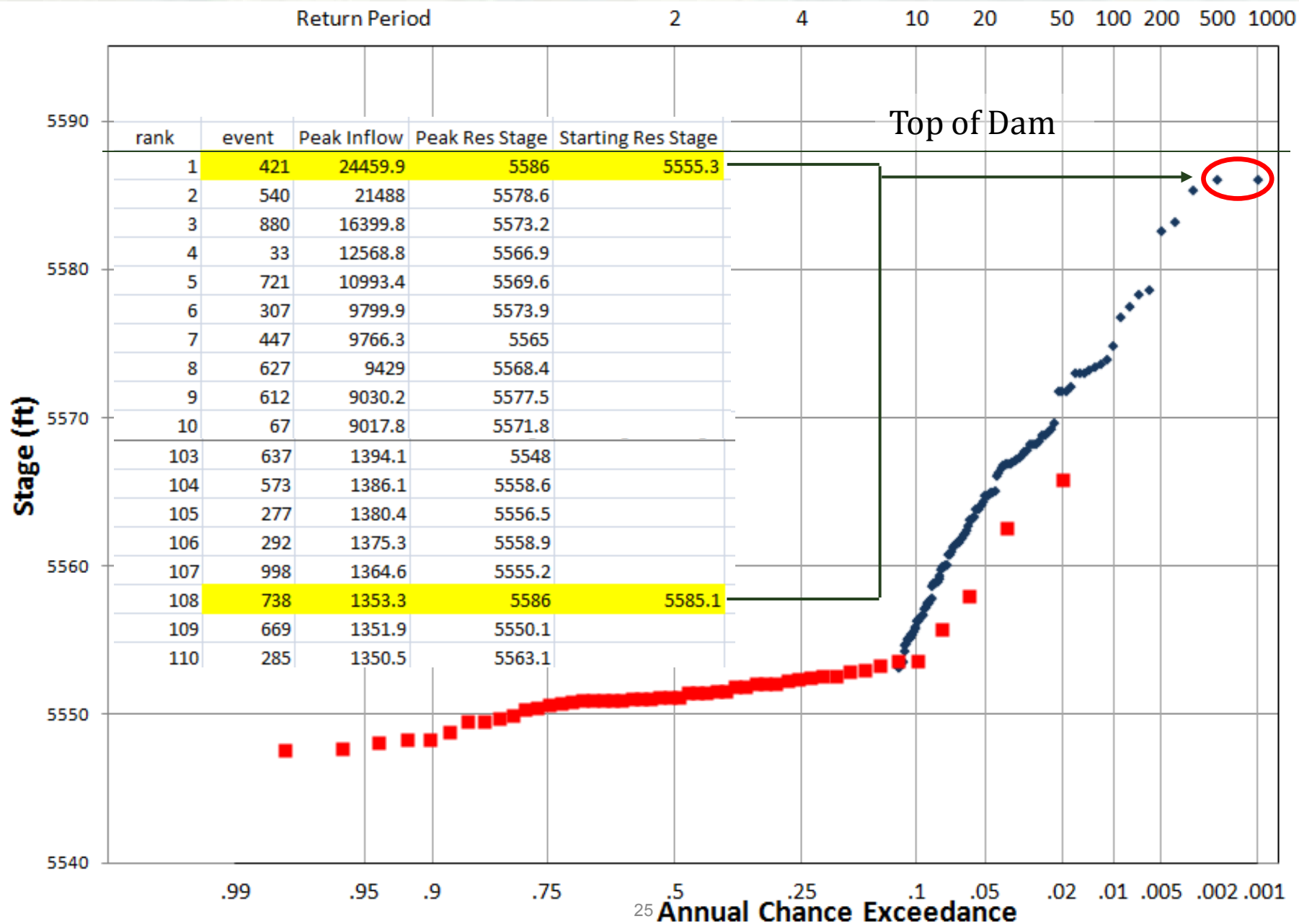
Nested Sampling Approach for Monte Carlo Simulations



HS

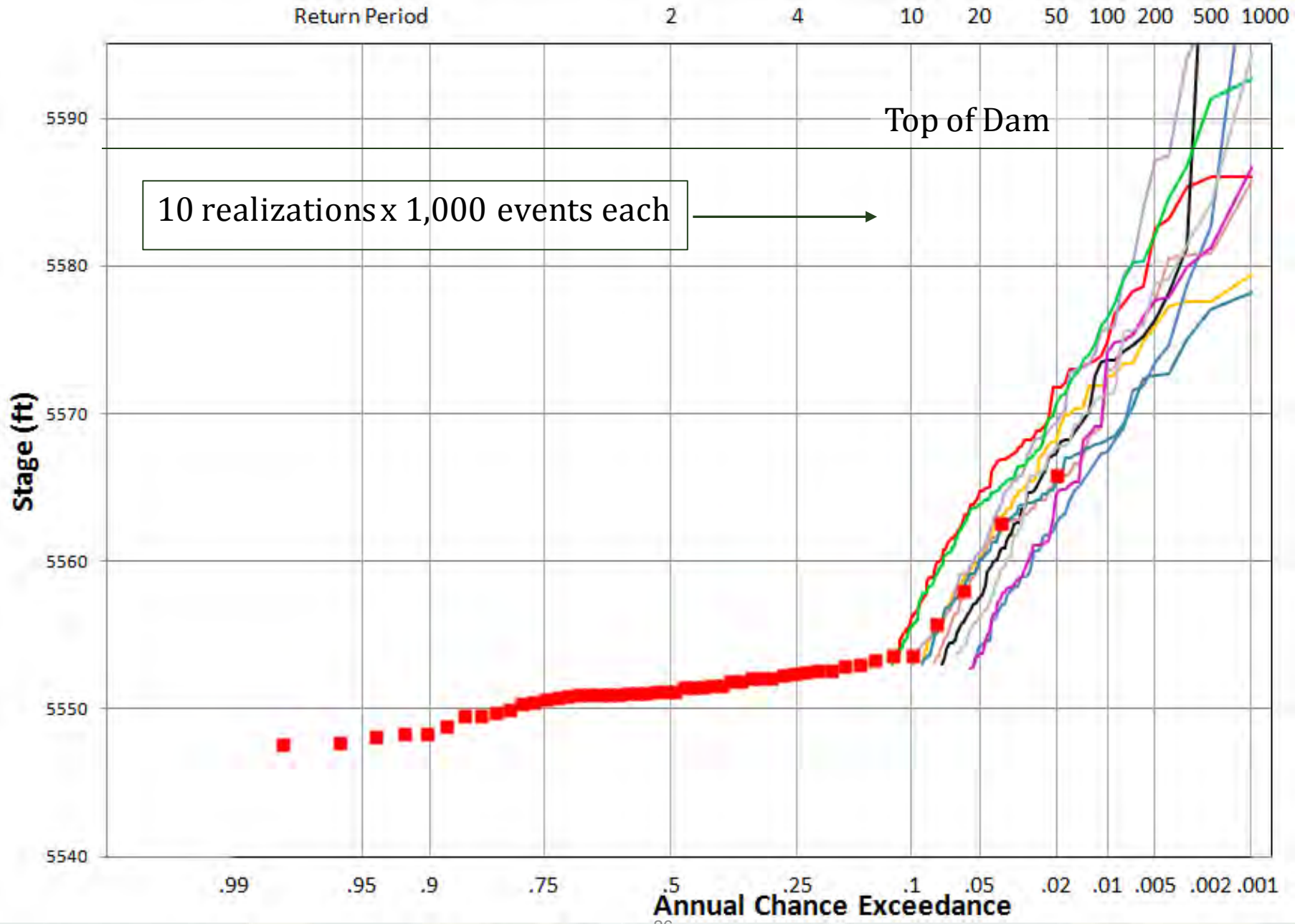


Peak Reservoir Stage from 1 Realization







Peak Reservoir Stage from 10 Realizations



The Hydrologic Sampler

- Generate the boundary conditions for the first model in the compute sequence (initially, this has been flow)
- Two methods for generating flow data:
 - Sampling from a frequency curve (and applying a shape)
 - Sampling historic events
-  Sample precipitation depth
-  Sample hyetograph shapes
- Future: Incorporating HEC-MetVue to sample storm characteristics, such as storm centroid, depth-area-duration, angle of orientation, and pass either a grid or hyetographs to HEC-HMS.

Hydrologic Sampling Editor

Name: June Events

Description:

Data to be Sampled: Flow Sampling

Sampling Method: Correlated Peak Frequency Curves

Local Flow Locations | Cross Correlation Matrix | Shape Sets | Shape Summary

Event Sampling | Headwater Flow Locations

Location: Cherry_Creek_IN

Peak Flow Frequency Curve

Distribution Type: Log Pearson type III

Log Pearson type III

Mean (of log): 2.282

St. dev (of log): 0.507

Skew (of Log): 0.763

Peak Flow Frequency Curve

Return Period

Flow (cfs)

Exceed. Prob.

Pop-up Plot

Uncertainty

Equiv. years of record: 54

User defined Uncertainty:

Exceedance ...	St. Dev. (of Lo...

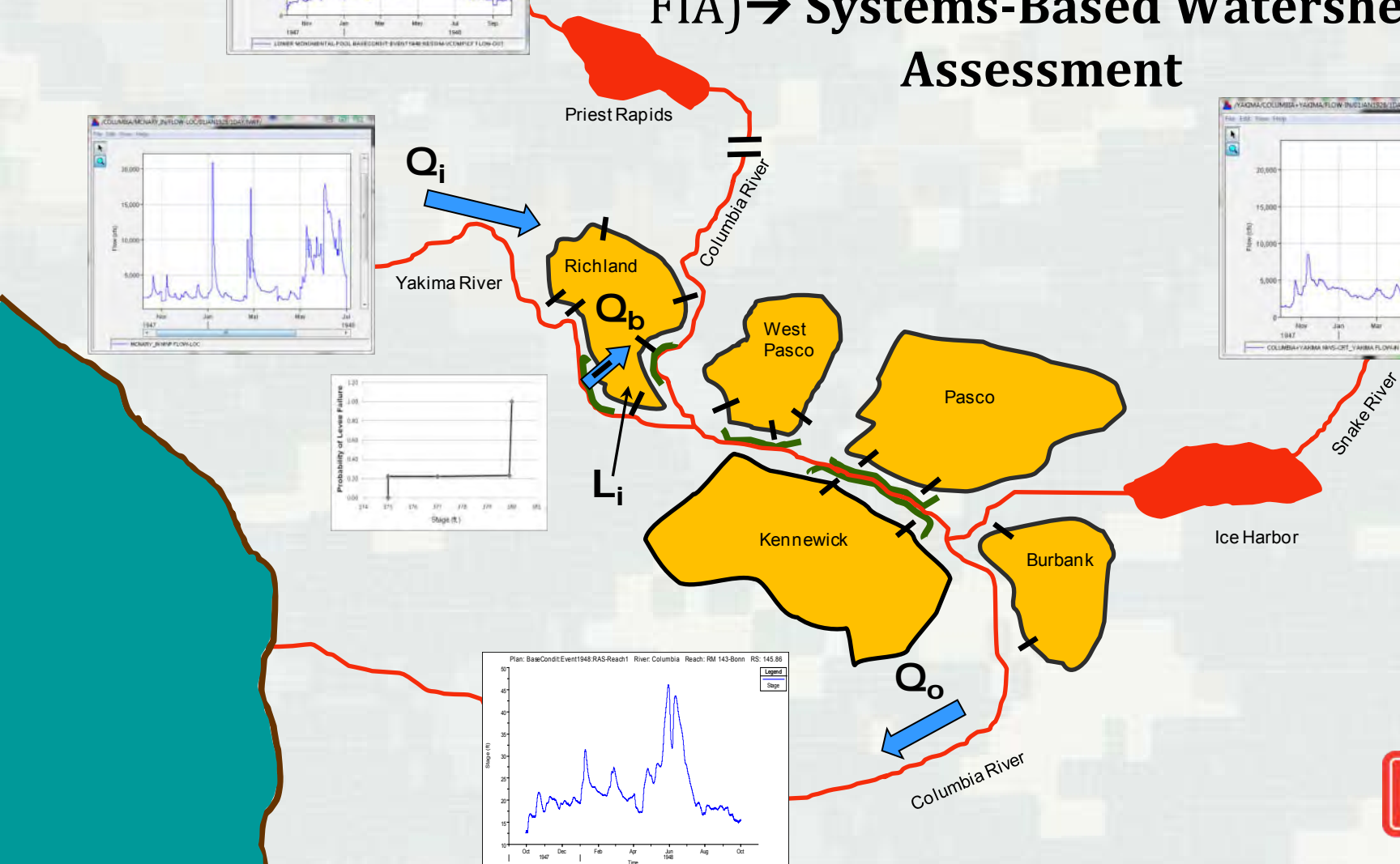
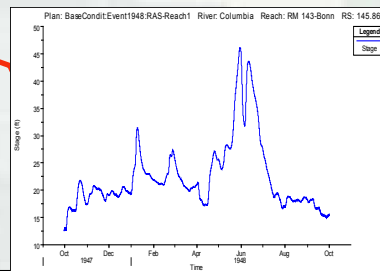
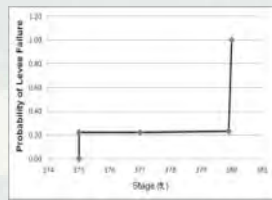
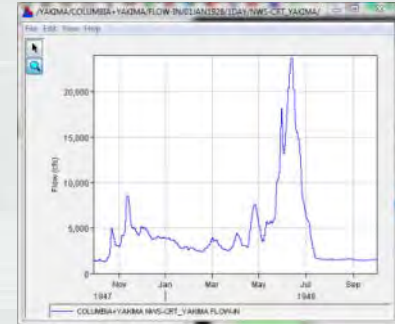
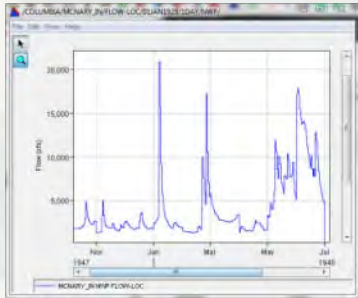
Duration

Duration of maximum average flow: Peak 1

Data Check OK Cancel Apply



Flow Volume Sampling → Hydrographs → Integrated Routing through HEC-WAT (HEC-HMS, HEC-ResSim, HEC-RAS, HEC-FIA) → Systems-Based Watershed Assessment



Distributed Computing

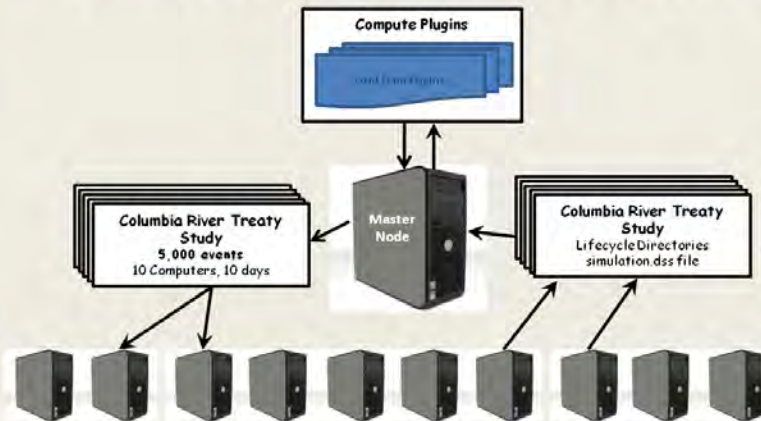
Testing Model Setup



Columbia River Treaty Study
100 lifecycles: 5,000 events
86.8 days

Compute can be run standalone on a single PC to test and calibrate the models and the linkages between models.

Local Network Compute



Compute can be distributed on computers on the local area network. One realization to each computer.



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Time Window Modifications

Order of Time Window Modifications

- 1) Simulation Window (defined by the hydrograph shapes)
- 2) Time Window Modification (with in the simulation)
- 3) Time Window Modification Alternative (simple model)
- 4) Scripting Option with Time Window Modification Alternative

FIA	R17_E19ZZ	Simulation Window	Edit...
TIMEWINDOWMODIFIER	time_mod_R09	Simulation Window	(+183D), (-78D)
Fragility Curve	Reach9_Fragility...	Simulation Window	Edit...
RAS	R09_1977	time_mod_R09	Edit...
FIA	R09_E19ZZ	Simulation Window	Edit...
TIMEWINDOWMODIFIER	time_mod_R05	Simulation Window	(+183D), (-78D)
Fragility Curve	Reach5_Fragility...	Simulation Window	Edit...
RAS	R05_1977	time_mod_R05	Edit...
FIA	R05_E19ZZ	Simulation Window	Edit...
TIMEWINDOWMODIFIER	time_mod_R01_...	Simulation Window	(+183D), (-78D)
Fragility Curve	Reach1_Fragility...	Simulation Window	Edit...
RAS	R01_1977	time_mod_R01_...	Edit...
FIA	R01_E19ZZ	Simulation Window	Edit...

Time Window Modifier Editor

Start: Relative, End: Relative

Days: 183, Days: -78

Hours: 0, Hours: 0

OK Cancel



Skip Models in the Compute Sequence

- Model simulations can be skipped (might not be necessary to simulate smaller magnitude events).
- Multiple locations can be selected
 - Interface assists in defining skip logic
 - Select the models to be skipped in the compute sequence

Model Skip Rules Editor

Simulation: CC-FRA_Full_withFragility

Description:

Model Alternative: time_mod_R01_CC

Row	Condition	Rule
1	IF	
2	{	
3	AND	MAX(TIMEWINDOW(MODEL,MODEL,ResSim:P2NoBiOp[Columbia+Cowlitfz - Flow]))<400000.0
4	AND	MAX(TIMEWINDOW(MODEL,MODEL,ResSim:P2NoBiOp[Columbia+Washougal - Flow]))<40000
5	AND	MAX(TIMEWINDOW(MODEL,MODEL,ResSim:P2NoBiOp[Bonneville_OUT - Flow]))<459922.0
6	AND	MAX(TIMEWINDOW(MODEL,MODEL,ResSim:P2NoBiOp[Columbia+Kalama - Flow]))<408593.0
7	AND	MAX(TIMEWINDOW(MODEL,MODEL,ResSim:P2NoBiOp[Columbia+Lewis - Flow]))<400000.0
8	AND	MAX(TIMEWINDOW(MODEL,MODEL,ResSim:P2NoBiOp[Columbia+Willamette - Flow]))<400000
9	SKIP	TimeWindowModifier:time_mod_R01_CC;Fragility Curve:Reach1_FragilityCurvesCC;RAS.R01_1977;FIA:R01_E19ZZ
10	END	
11		

Available Actions

Else If Else And Or (selection) Select List of Models to Skip Comment Delete

Select Models to Skip

Select to Skip	Model
<input checked="" type="checkbox"/>	time_mod_R01_CC
<input checked="" type="checkbox"/>	Reach1_FragilityCurvesCC
<input checked="" type="checkbox"/>	R01_1977
<input checked="" type="checkbox"/>	R01_E19ZZ



HEC-WAT Output

The screenshot displays the HEC-WAT software interface with several windows open:

- HEC-WAT - CRT_Study:** The main application window showing project settings and simulation parameters.
- ECC_AOP25.LIS:** A text window showing simulation control data:
 - 1) SECOND WORST YEAR OF STREAMFLOWS (REQD) : 1931
 - 2) BEGINNING YEAR OF VECC CALCULATION (REQD) : 1913
 - 3) ENDING YEAR OF VECC CALCULATION (REQD) : 1998
 - NOTE: The High, Medium, and low MAF values must be different and cannot be zero. If they are then default values will be used for all three.
 - 4) SPECIFY HIGH THE DALLES MAF TO USE : 110
 - 5) SPECIFY MEDIUM THE DALLES MAF TO USE : 95
- Bonneville, 642AM:** A graph showing Elevation (ft) vs. Time (1947-1948) and Flow (cfs) vs. Time (1947-1948).
- Simulations BaseConditions-Event1948:** A map showing the river network with simulation points and flow directions.
- Cross Section:** A graph showing the cross-section of the river channel with elevation and stationing.
- Aggregated Structure Damage Report for Untitled - R01_PHASE2a:** A table summarizing impact areas and damages.

Aggregated Structure Damage Report for Untitled - R01_PHASE2a

View By: **Impact Area**

Impact Area Summary Report for ColumbiaRiverTreaty								
Impact Area	Impact Area Description	Stream Name	Total Urban Damages (\$1000)	Total Crop Damages (\$1000)	Total Damages (\$1000)	Total Acreage Flooded (acre)	Total Number of Structures Flooded	Total Population Impacted
Clackamas_OR		Clackamas Riv...	2,564.23	0.00	2,564.23	0.00	12	0
Clark_WA		Lewis River	3,134.18	0.00	3,134.18	0.00	67	0
Clatsop_OR		Youngs	155.45	0.00	155.45	0.00	31	0
Columbia_OR		Columbia River	725.69	0.00	725.69	0.00	83	0
Cowlitz_WA		Lewis River	1,561.27	0.00	1,561.27	0.00	62	0
Multnomah_OR		Columbia River	5,848.02	0.00	5,848.02	0.00	124	0
Pacific_WA		Deer	0.00	0.00	0.00	0.00	50	0
Skamania_WA		Lewis River	660.77	0.00	660.77	0.00	13	0
Unassigned			118.14	0.00	118.14	0.00	35	0
Wahkiakum_WA		Columbia River	2.22	0.00	2.22	0.00	12	0
Total			14,769.99	0.00	14,769.99	0.00	489	0

