HEC-MetVue Implementation

Date: 19 January 2017

Audience: Advisory Committee on Water Information's Subcommittee on Hydrology (SOH)

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USACE Hydrologic Hazards Team

What is HEC-MetVue?

- Precipitation viewing and analysis tool
- Precipitation processing for real-time forecasting
- Storm translation and rotation
- Storm analysis
- Design storms
  - HMR's for PMP
  - SPF
  - Standard frequency (100-yr, 50-yr…)
- Stand alone or integrated with CWMS

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History of MetVue

- Region prone to tropical storm systems
- Wet cycle in late 1980's
- Surcharge releases at USACE projects with tainter gates
- Need for a tool to visualize and process precipitation for real-time numerical hydrologic modeling

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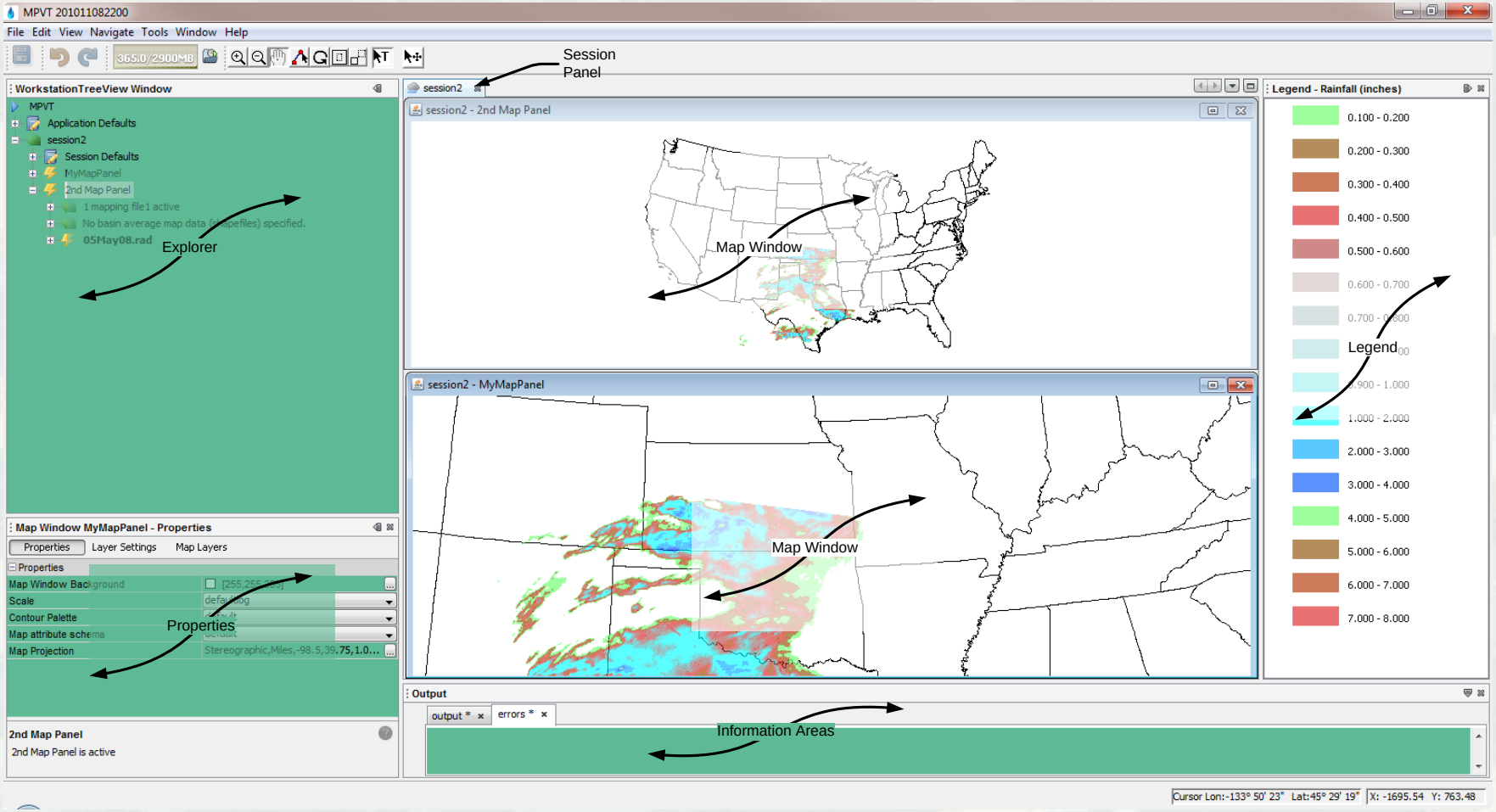
HEC-METVUE
Meteorologic Visualization Utility Engine



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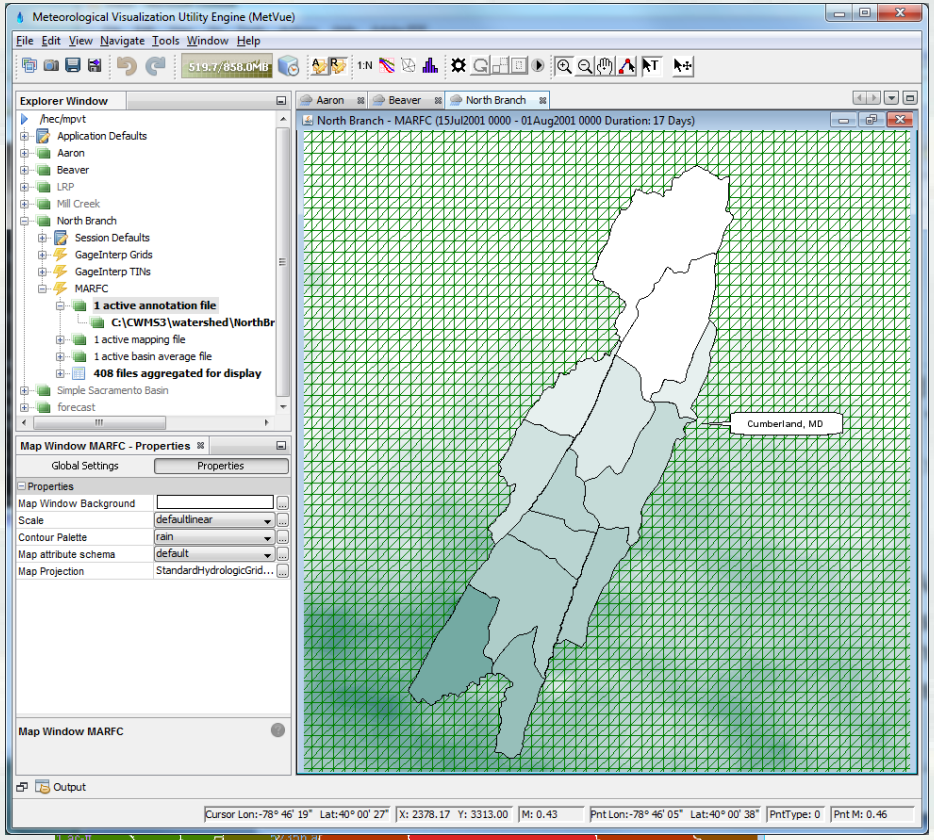
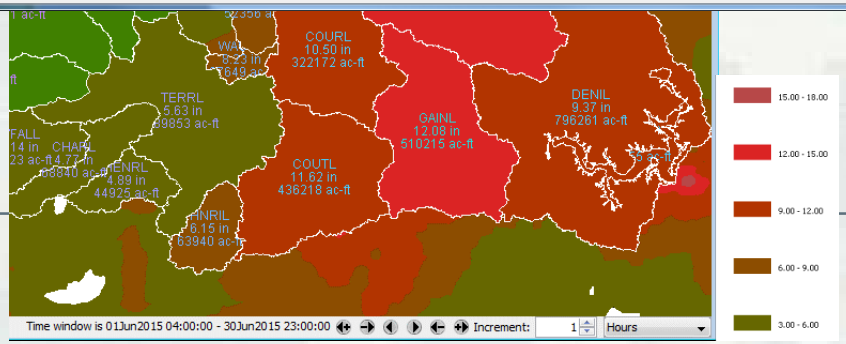
HEC-MetVue
TINs, Grids, and Time Series





- Creates and Manages Meterologic TINs
  - From point sources
  - From grids
- Produces
  - Grids (HRAP or SHG)
  - Event totals or averages
  - Time series (e.g. MAP hyetographs)

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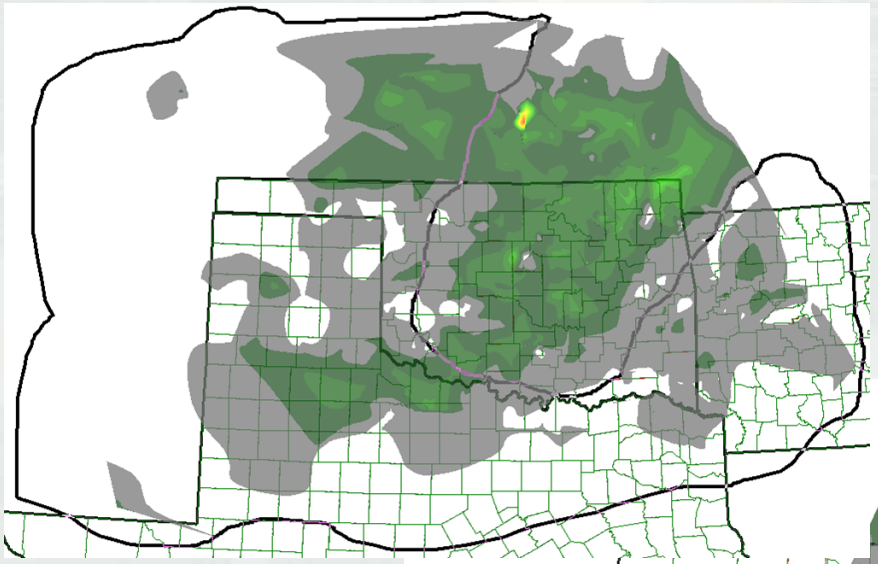
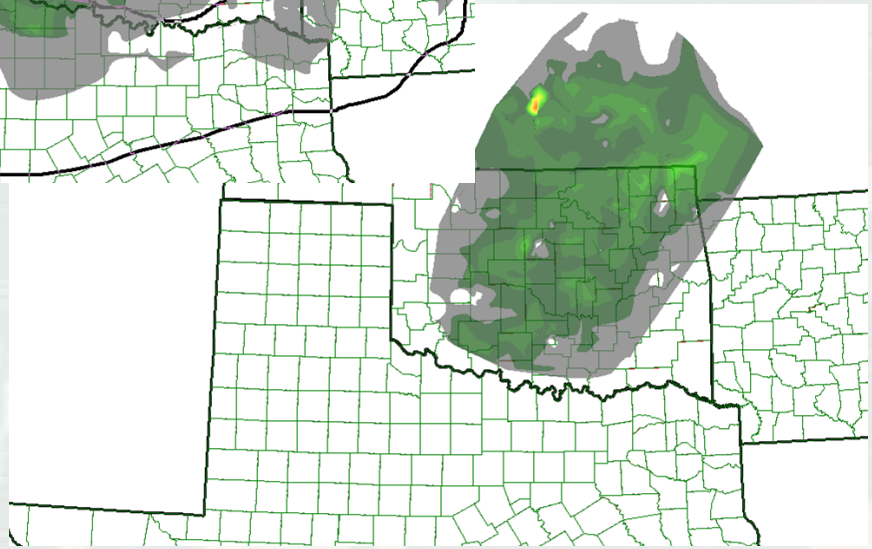
HEC-METVUE

Analysis and Manipulation

- Refine Storms
  - o Trim & Correct
- Translate Storms
  - o Spatially
  - o Temporally
- Rotate Storms
- Scale Storms
  - o Factor & Resize
- Animate Storms





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HEC-MetVue I/O Providers

- TIN
- NEXRAD
- NEXRAD_GRIB
- XMRG
- NetCDF
- SHG
- ASCII_GRID
- PRISM
- HRRR
- GageInterp

HEC-MetVue Input Providers

Selection Interface

- DSS
  - SHG
  - HRAP
- TIN (legacy format)
- GageInterp

Drag & Drop Selections

- NEXRAD
- NEXRAD_GRIB
- XMRG
- NetCDF
- ASCII_GRID
- PRISM
- HRRR
- HDF5 (under development)

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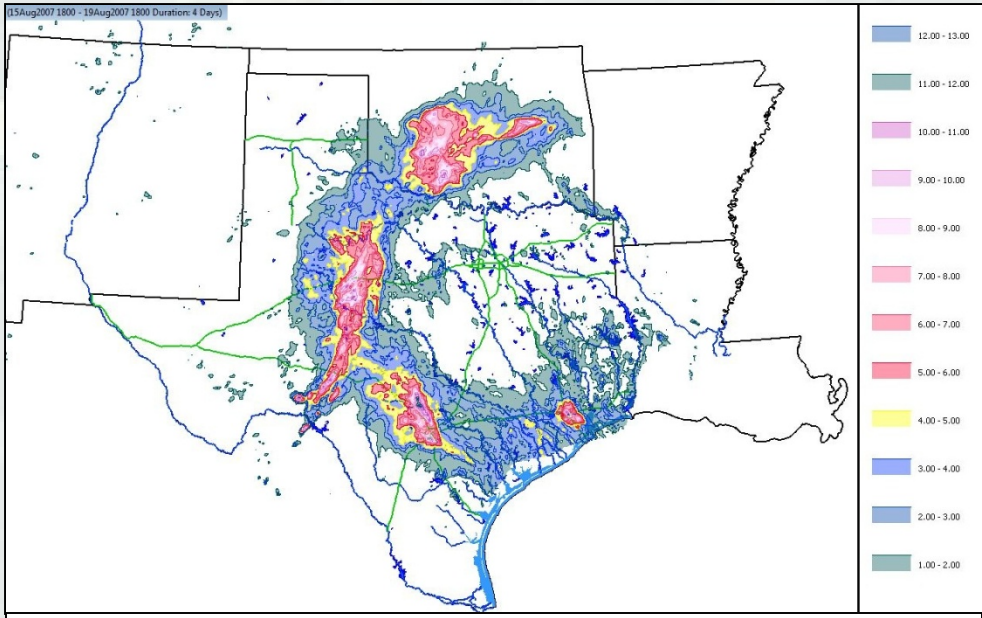
HEC-MetVue Output Providers

- DSS
- Native TIN
- ASCII_GRID
- HDF5 (under development)

HEC-MetVue Background/Needs

- Real-Time Forecasting
  - Incorporate rainfall data
  - Adjust for NWS QPF
- Emergency Management
  - Better visualize threats
  - Improved communications
- PMP Storm Development
  - Analysis of Extreme Storms
  - Improve DSMS process
- Project Planning



August 2007 – Tropical Storm Erin

Oklahoma Rainfall Totals

- 12.81” @ Eakly
- 11.03” @ Geary
- 9.30” @ Fort Cobb
- 9.11” @ Watonga

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HEC-MetVue
Real-time & Planning Applications

- CWMS Real-time Decision Support
  - Weather Monitoring and Assessment
  - Batch Processing of Event Data and Report Generation
  - Radar Image Calibration
  - Scenario Development for Forecast Modeling
- Dam Safety Studies
  - Depth-Area-Duration
  - PMP Development
  - Strom Construction and Analysis
  - Hypothetical Storm Design

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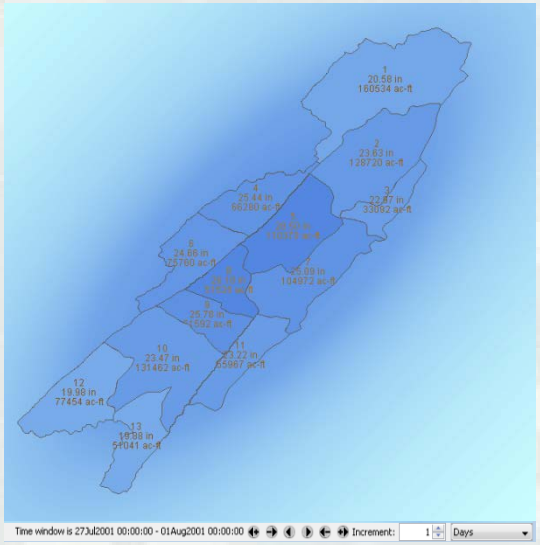
HEC-MetVue in CWMS

Automated Processing

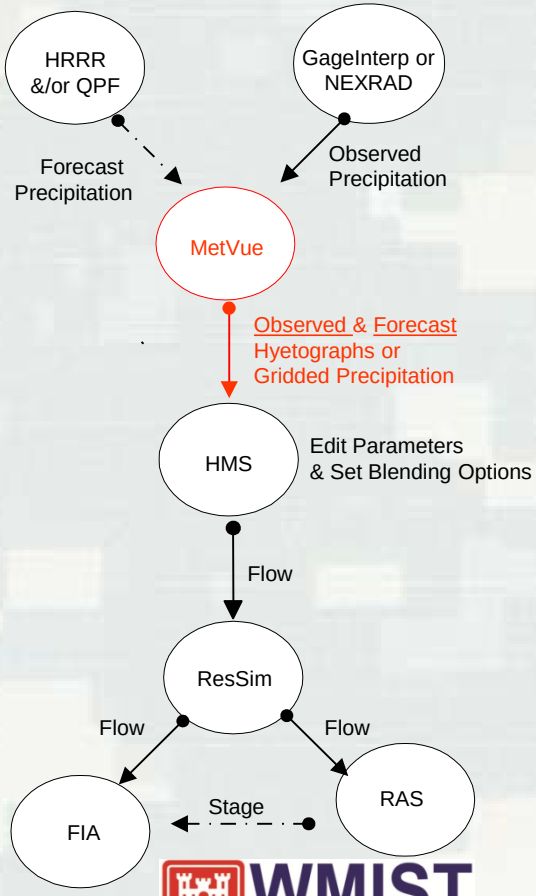
- Data Acquisition & Processing
- Calibration
- Report Generation

Visualization & Interactive Analysis

- Calibration
- Storm Totals
- Animation



Modeling & Forecast Scenarios



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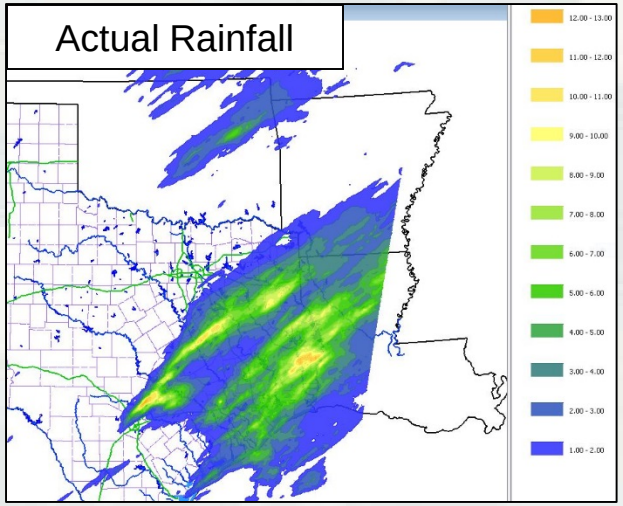
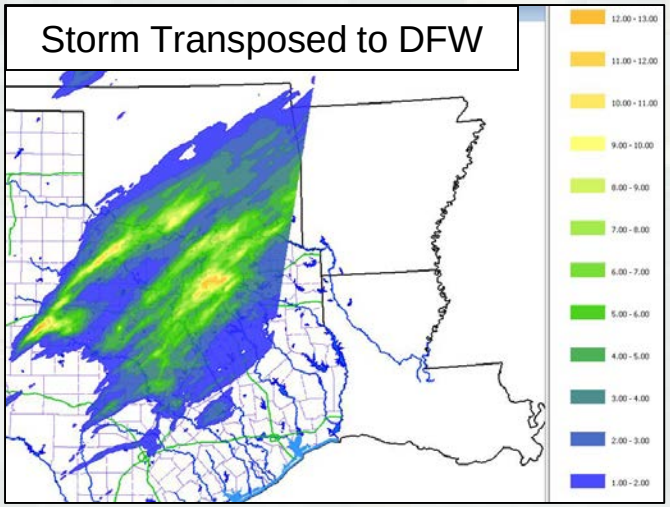
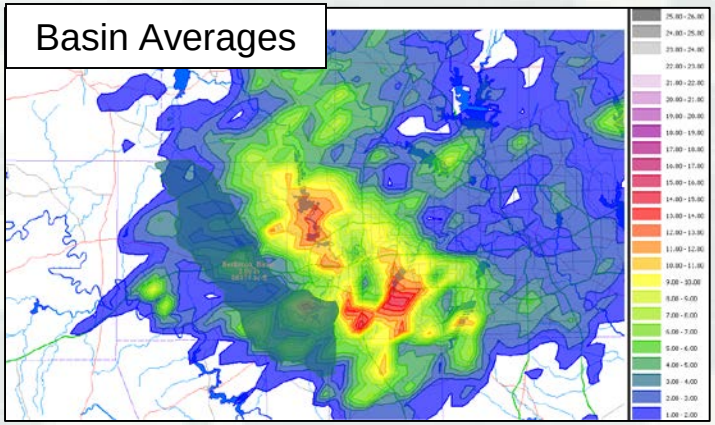
HEC-MetVue Real-Time Applications







- Ingest Radar/Forecast Data
- Analyze In-Place or Transpose
  - Ability to rotate storm or maximize
  - Provides a variety of storm options
- Compute Basin Average Rainfall
- Output Data to Hydrology Model

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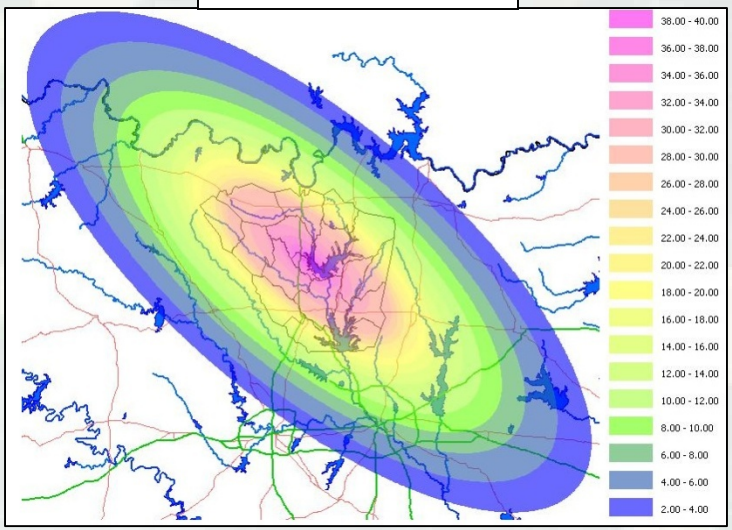
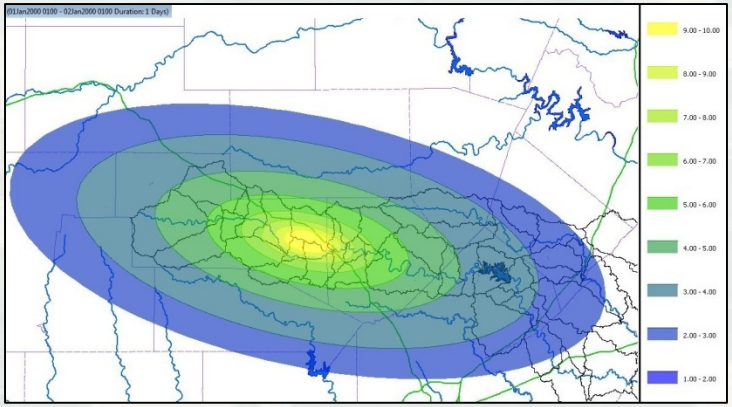
HEC-MetVue PMP/Planning Applications

- Analysis of Extreme Storms
  - Use of radar and point rainfall data
  - Combination of recent and historical storms
- Transposition to Additional Basins
  - Provides greater confidence in results
  - Simplifies process for end-users
- Development of Project Design Storm
  - Adheres to accepted NWS/WMO standards
  - Incorporates HMR procedures (52, 55A, etc.)
- Use in PMP/PMF Studies
  - Ability to conduct studies more efficiently
  - Interconnectivity with Hydrology models
- Assisting the Planning Process

Basin Averages





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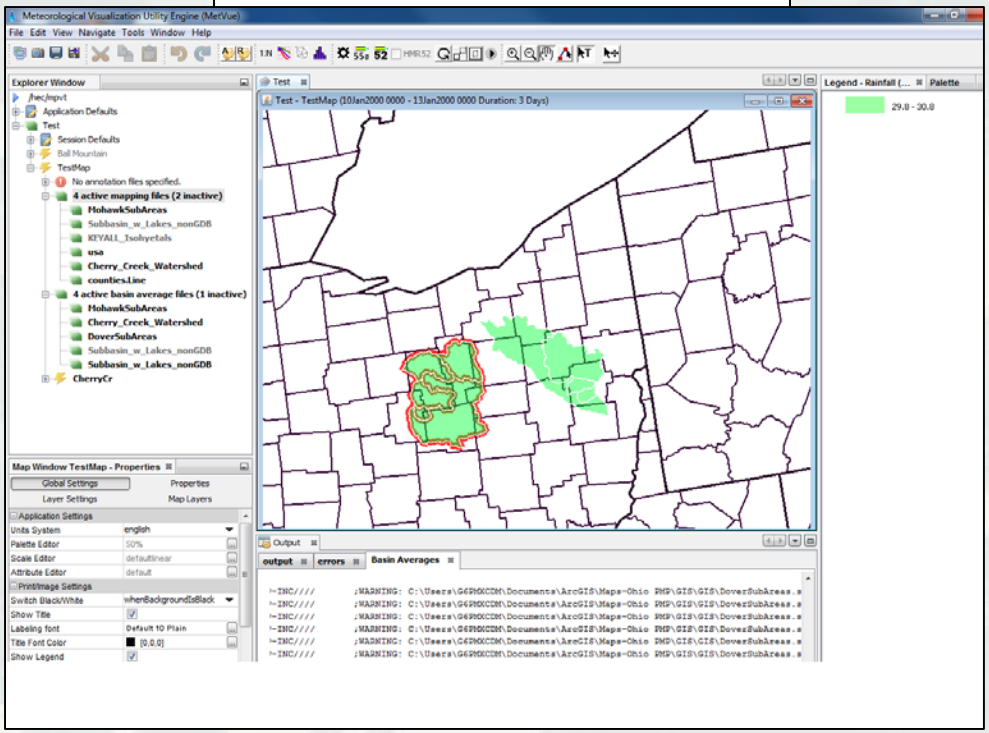
HEC-MetVue Overall Uses/Advantages

- Real-Time Forecasting
  - Increased decision time
  - Coordination with NWS
- Emergency Management
  - More clearly identify threats
  - Increased warning times
- PMP Storm Development
  - Decreased study time
  - Decreased overall costs
- Project Planning
  - Visualization of impacts

Muskingum Basin, Eastern Ohio



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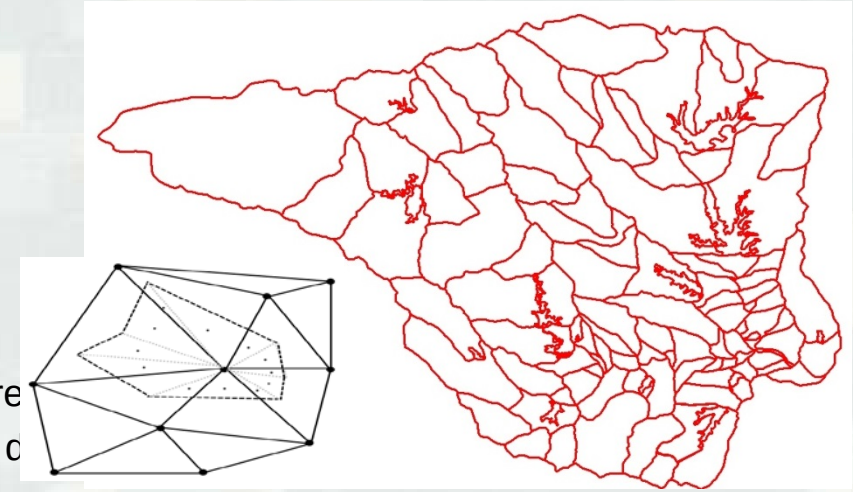
HEC-MetVue Inputs

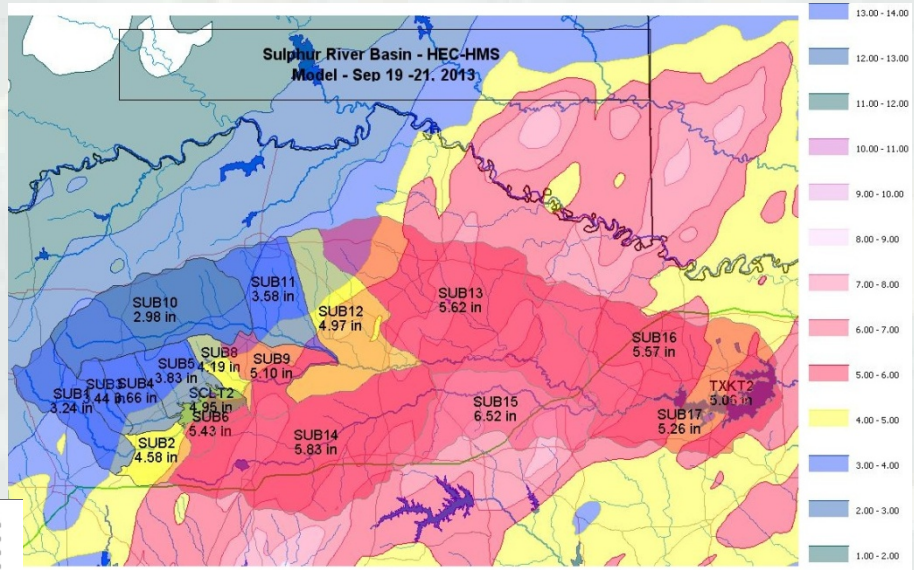
- General
  - Supports drag and drop
  - Loading through file selection menu
- Precipitation
  - Gage and gridded data
    - Adjustment and/or deletion of gages on-the-fly
    - QPE's and QPF's (XMRG and NETCDF)
    - Any grid system (HRAP & SHG)
  - Creates surfaces using TIN technology
  - Mixed time steps - aggregation and de-aggre
  - Calibration editing and mass adjustments – c
  - Batch processing

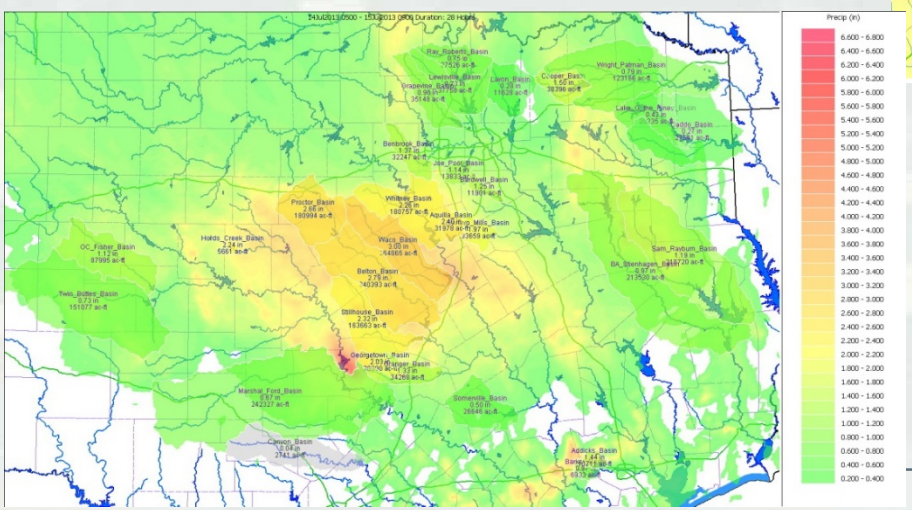


- Shape files
  - Supports shape files of multiple coordinate systems/projections simultaneously. e.g. mixed use of Albers, UTM, long/lat shape files supported

Forecasting - CWMS

- Lumped modeling
  - Hyetographs to DSS
- Grid models
  - SHG specification, grids to DSS





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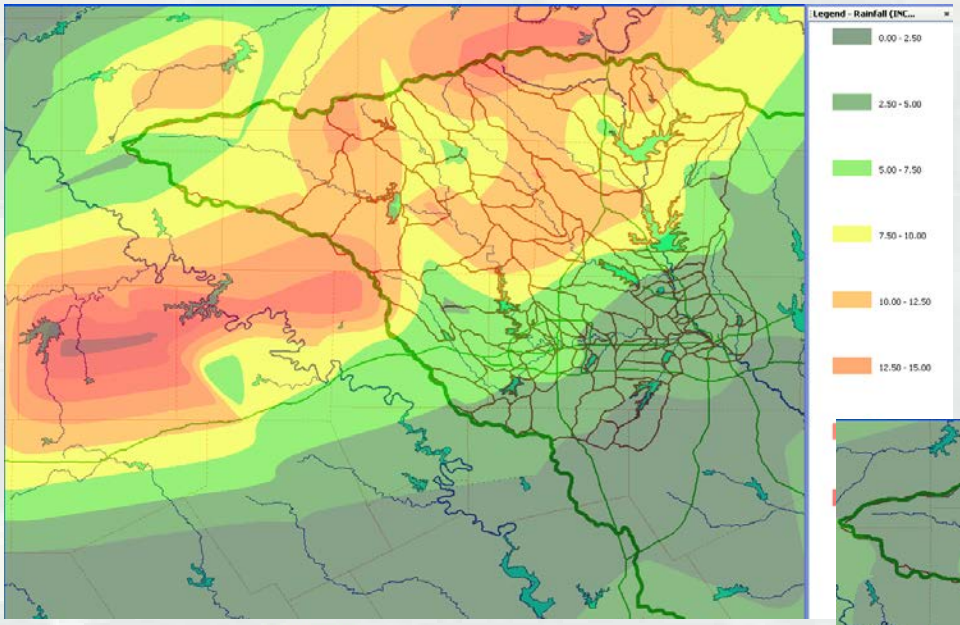
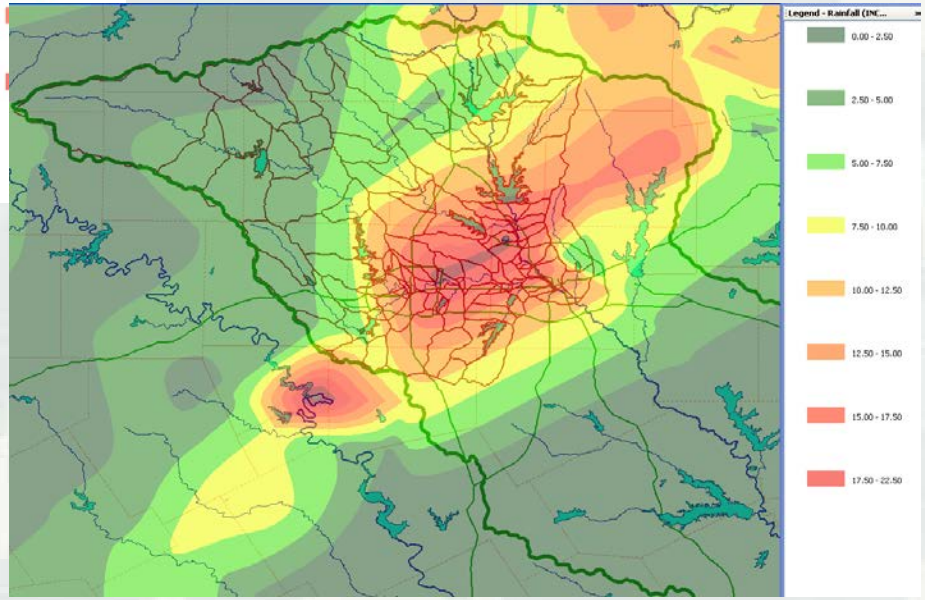
Transposition and Rotation of Storms





- Tropical storm Clyde, 1981
- SPF level event
- Used for evaluation of Dallas federal levees

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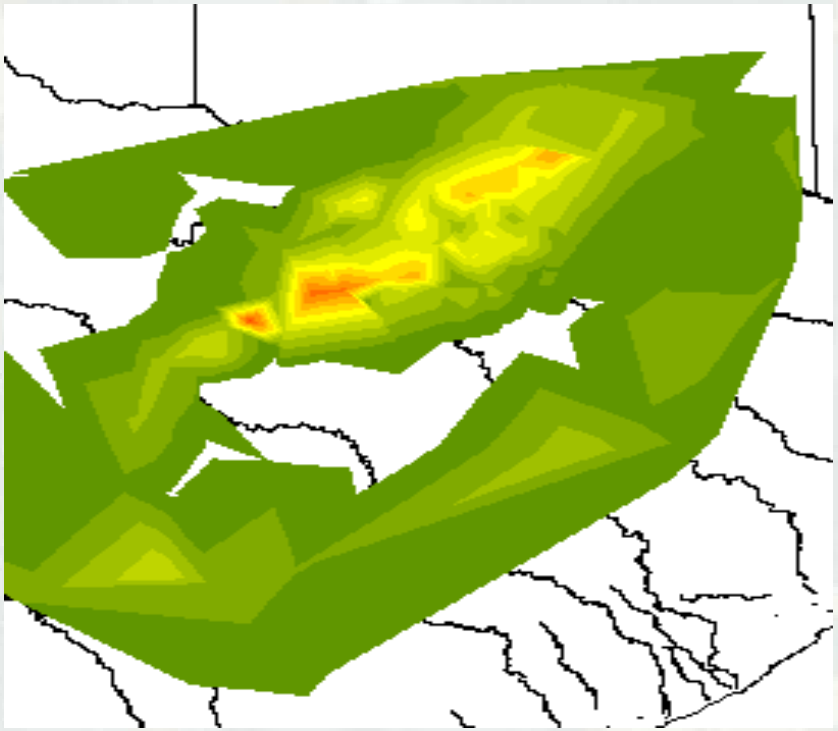
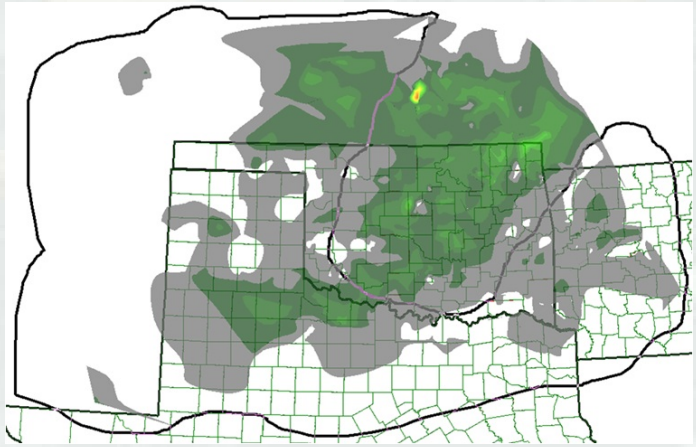
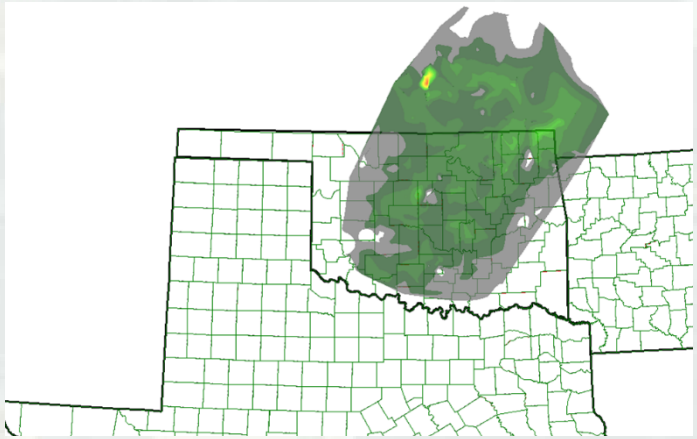
Storm Construction and Refinement







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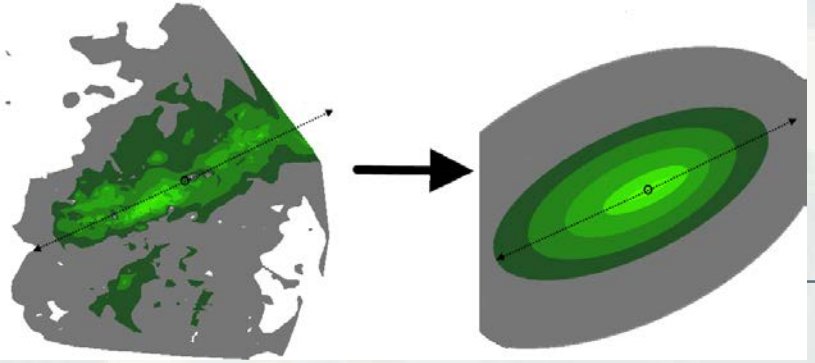
Storm Analysis Parameters

- Storm description
- Storm location/region
- Storm significance (peak runoff or volume)
- Storm type (convective, tropical, etc.)
- Storm shape
- Storm orientation if applicable
- Movement direction/velocity
- depth-area-duration (DAD)data

- Temporal data
  - Hyetographs/mass curves
- Weighted maximum and minimum moment of inertia
- Storm event statistics
- Environmental information such as solar radiation, wind speed, wind direction, temperature, relative humidity, atmospheric pressure, etc. as available

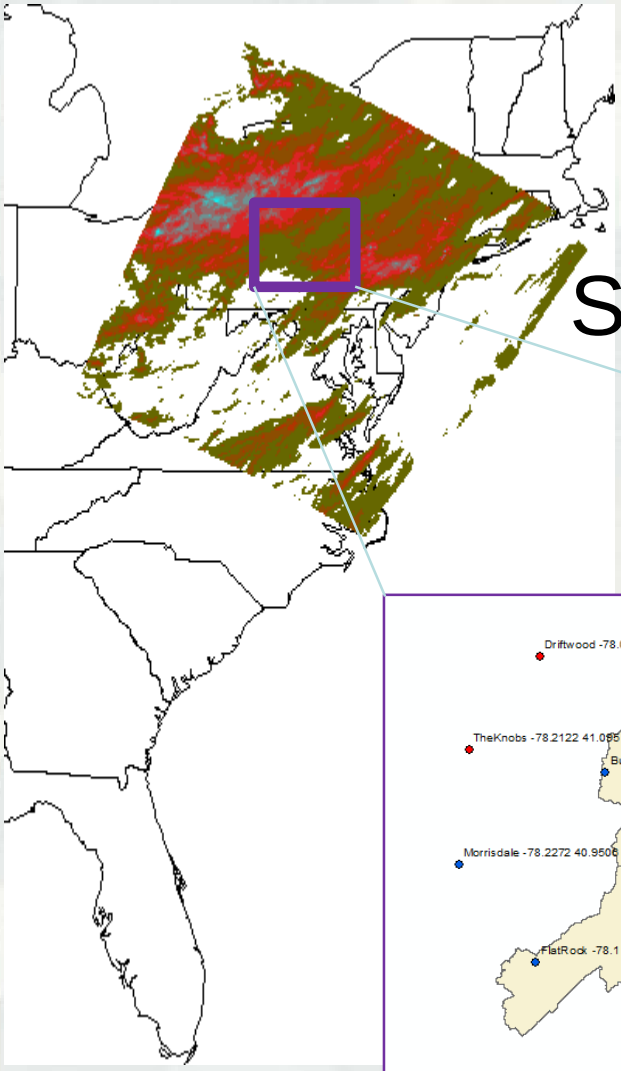


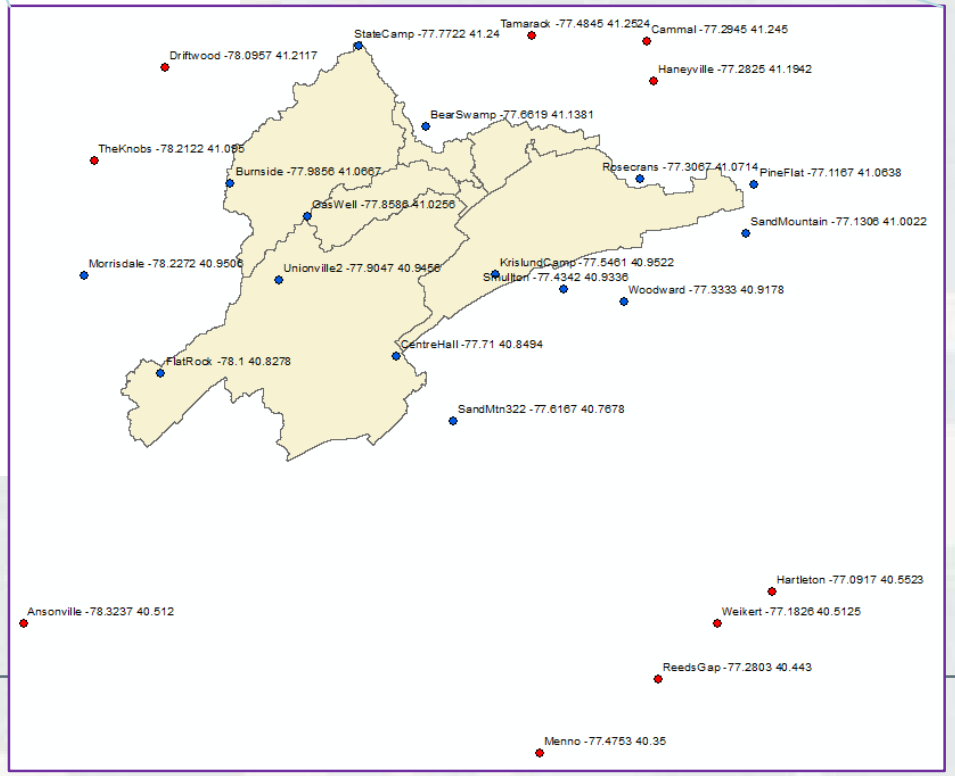
HEC-MetVue Computation Tools

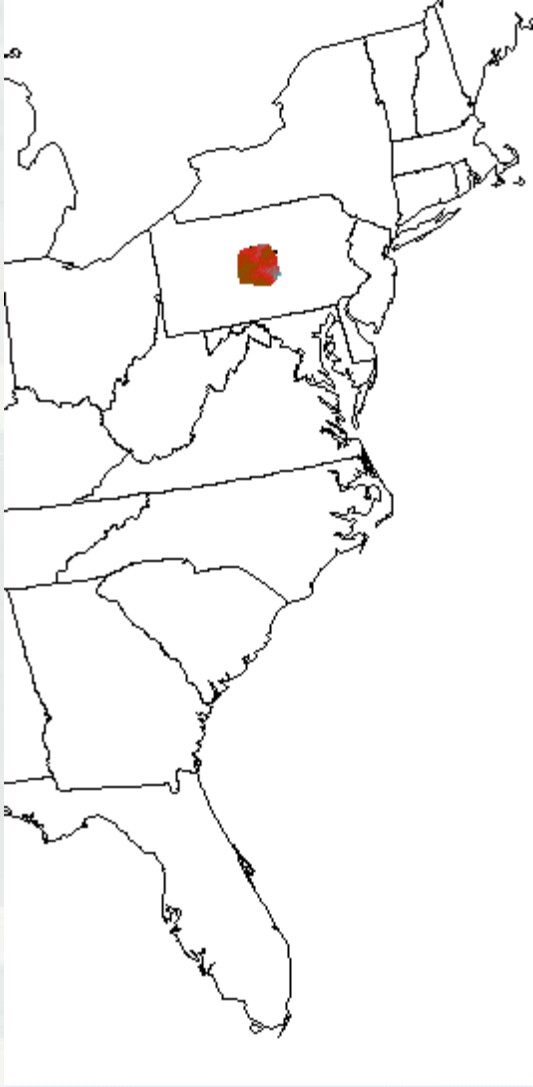
Depth-Area-Duration Computation Tool

Hyetograph/TIN Surface Generation Tool

Hyetograph/TIN Surface Generation







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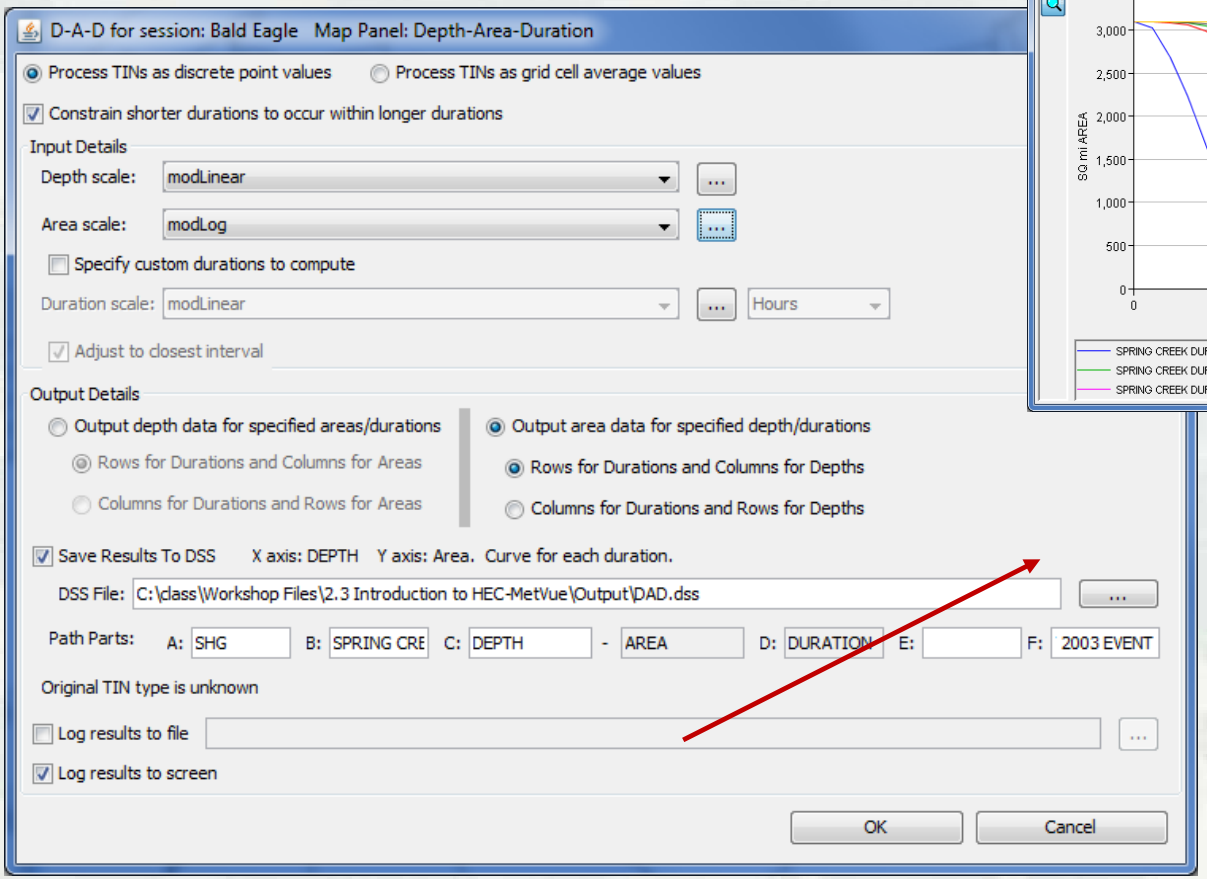
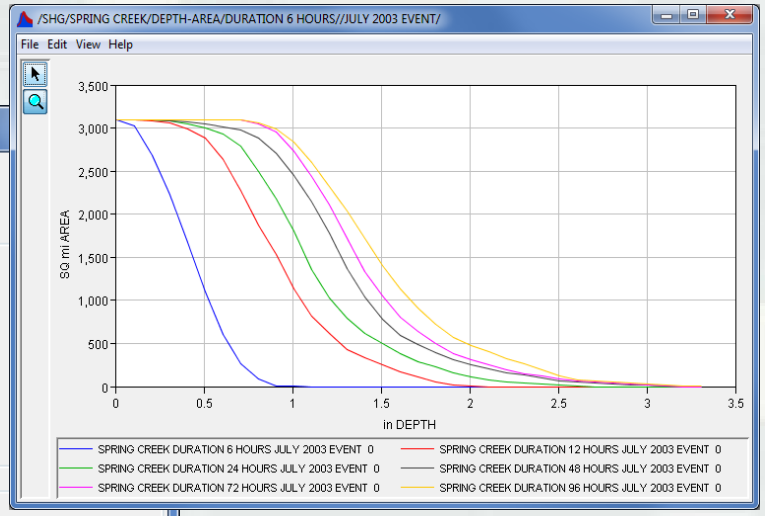
Depth-Area-Duration Analysis Tool





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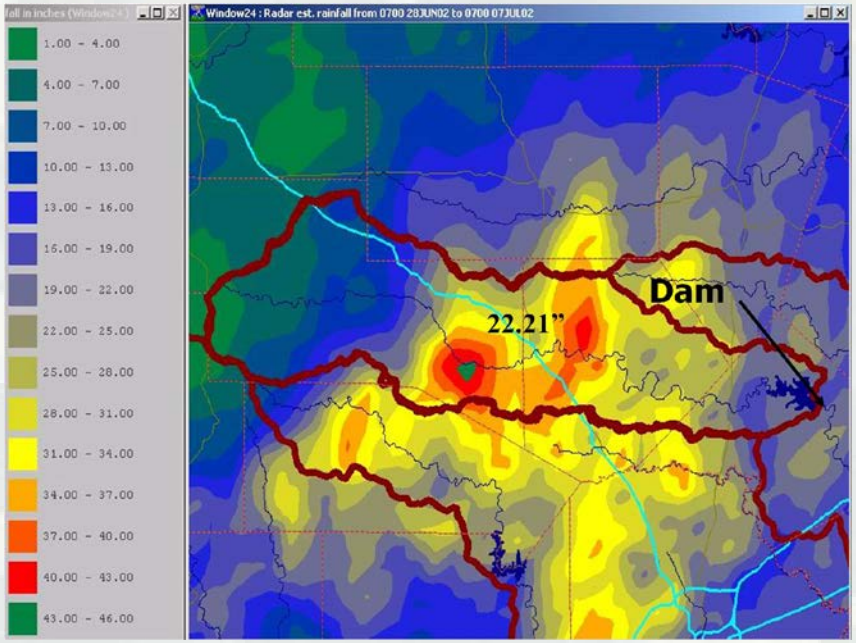
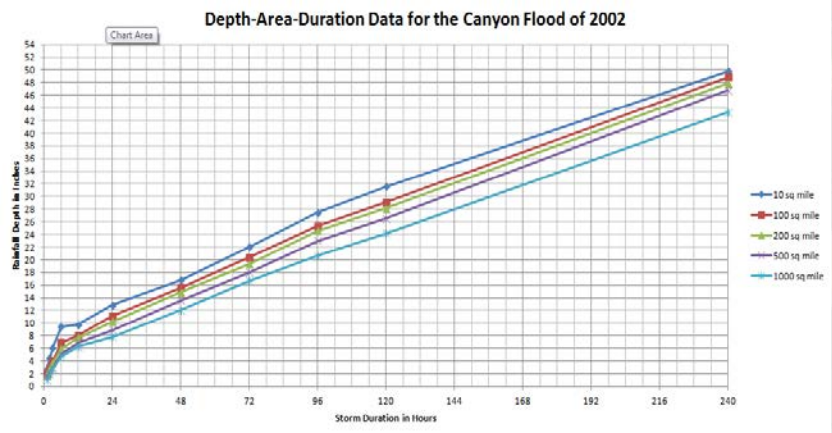
Storm Analysis

Canyon Dam Watershed, 28 June – 7 July 2002



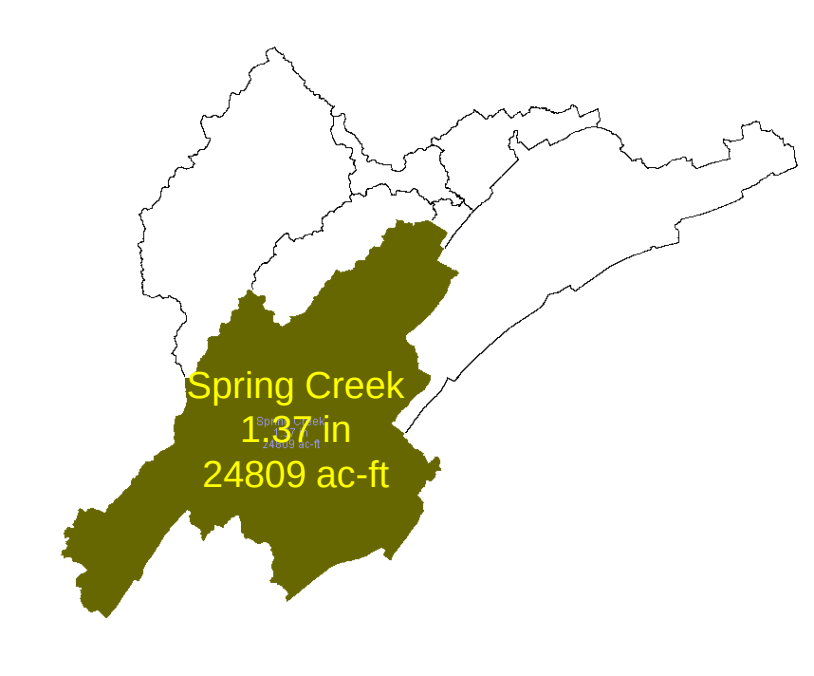


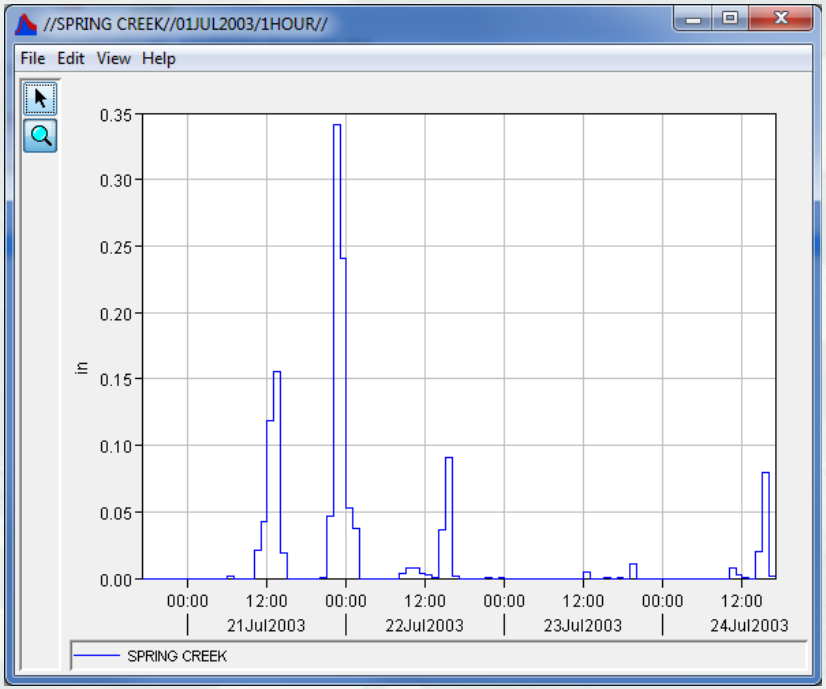
HEC-MetVue Output Tools

- Save Basin Average Hyetographs
- Save Aggregate TIN
- Save Modified TIN as a new projected TIN

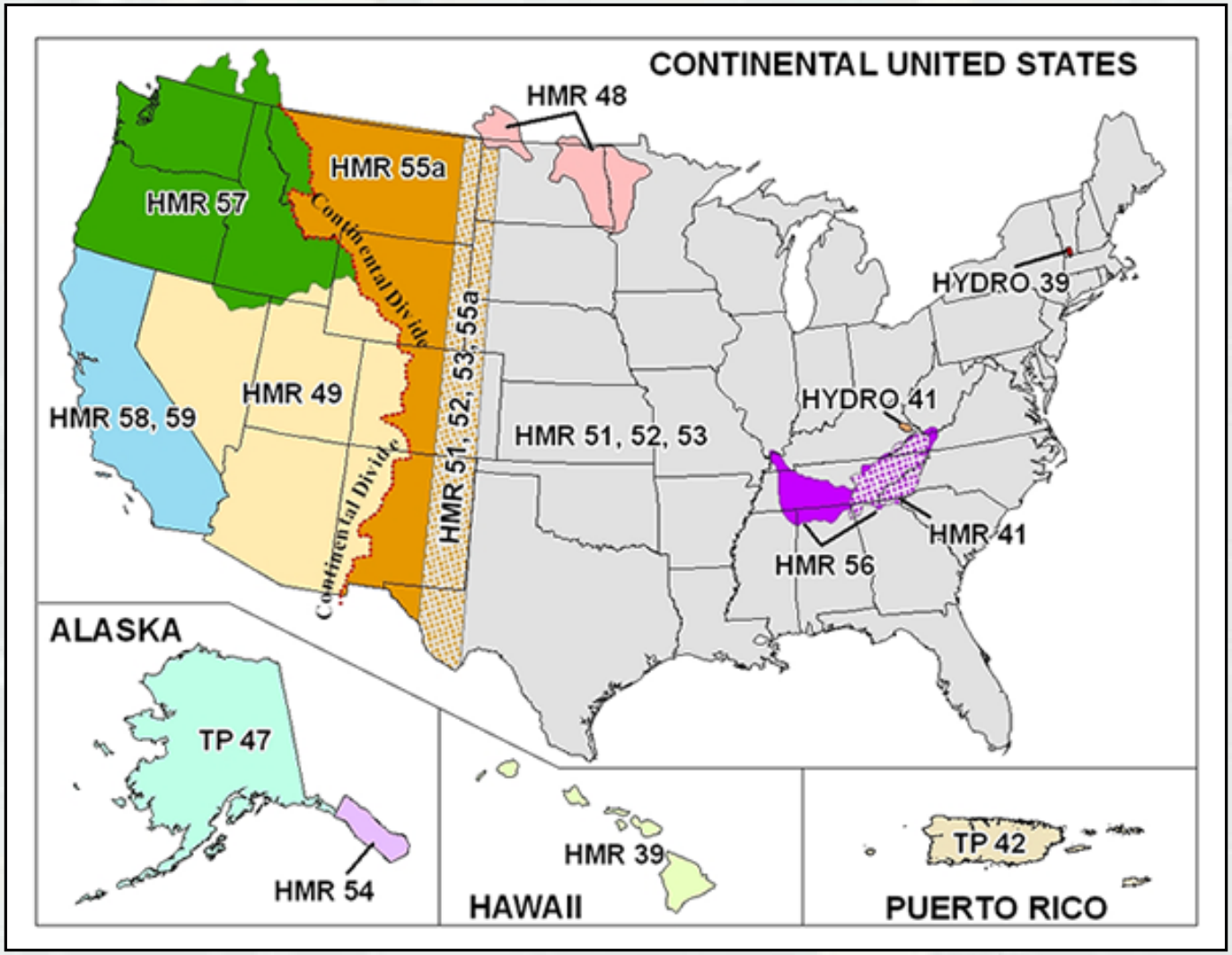
Save Hyetograph

- 96 aggregated (Hourly) TINs
- 21July2003 – 25July2003



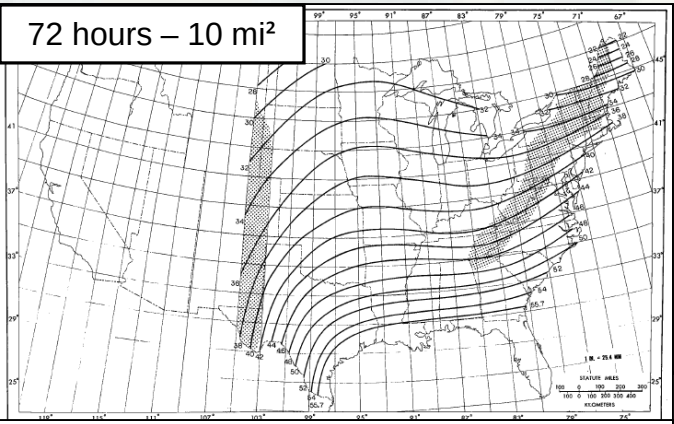


HMR Map Coverage

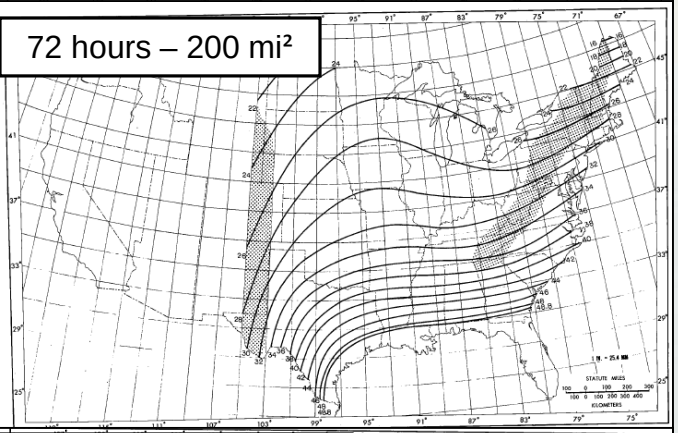


HMR 51 Procedures

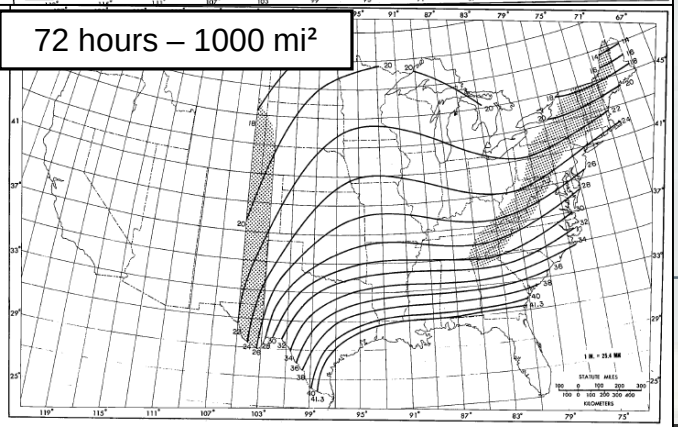
72 hours – 10 mi²



72 hours – 200 mi²



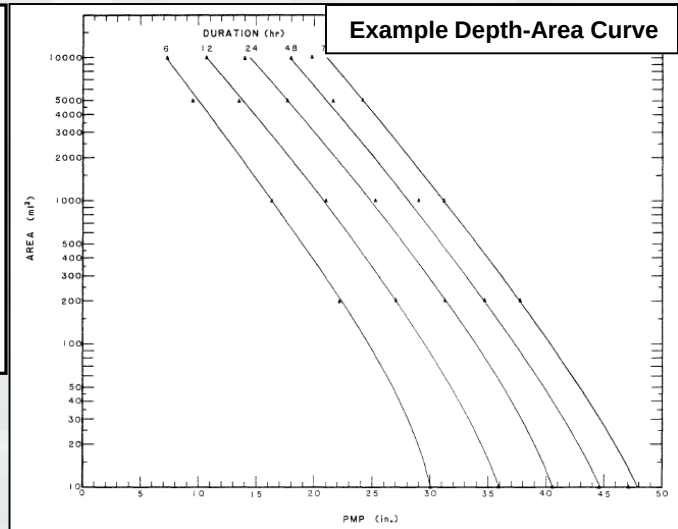
72 hours – 1000 mi²



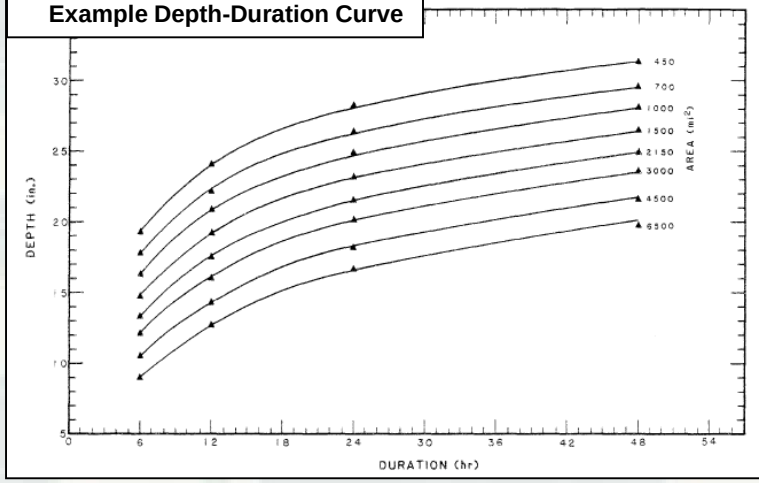
Generalized PMP Steps

1. Select geographic location
2. Determine average PMP depths
   a) 6, 12, 24, 48, and 72 hours
   b) 10 mi² through 20,000 mi²
3. Plot the PMP depths (D-A Curves)
4. Determine PMP depth for basin size (each duration)
5. Plot PMP depths (D-D Curve)

Example Depth-Area Curve



Example Depth-Duration Curve



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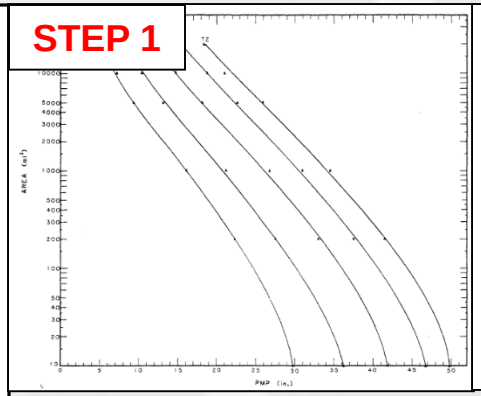
HMR 52 Procedures

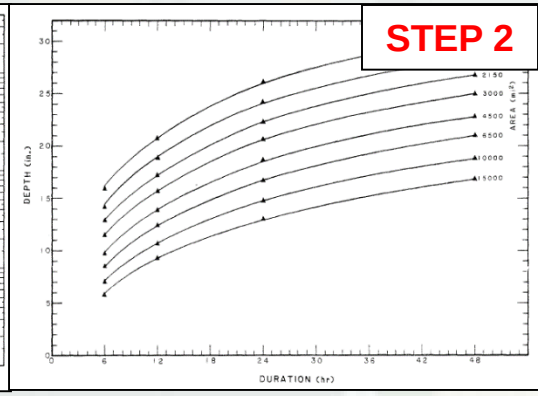
Site Specific PMP Steps

1. Plot D-A-D Curves for basin being studied
2. Obtain depths for durations at isohyetal area sizes and plot
3. Determine 6-hour increments through 18 hours (smooth?)
4. Place isohyetal pattern over basin and orient (reduction?)
5. Determine isohyetal pattern size for maximum PMP volume
6. Extend selected pattern size to 72 hours (use Step #2 plot)
7. Multiply by orientation factor (if necessary)
8. *Multiply by appropriate table to obtain isohyet values
9. *Obtain incremental volumes (average depth) from Step #5

STEP 1



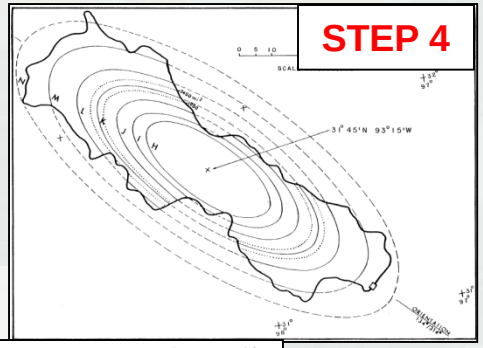
STEP 2



STEP 3

Area (mi²)	6-hr periods 1	2	3
1000	16.1	4.6	3.0
1500	14.4	4.5	2.9
2150	12.9	4.3	2.8
3000	11.5	4.2	2.8
4500	9.8	4.1	2.6
6500	8.5	3.9	2.4
10000	7.1	3.5	2.4
15000	5.9	3.4	2.0

STEP 4



STEPS 6-7

	6-hr periods 1	2	3	4	5	6	7	8				
Adj. PMP (in.)	11.50	3.83	2.50	2.06	1.34	1.08	0.90	0.81	0.72	0.72	0.63	0.63

Isohyet	Storm area (mi²) size 450	560	700	850	1000	1200	1500	1800	2150	2600	3000	3800
A	132	136	140	145	149	155	162	169	176	184	191	203
B	124	128	132	136	140	145	152	158	165	172	179	189
C	116	120	124	128	131	136	142	147	154	160	166	176
D	108	111	115	119	122	126	132	137	142	148	154	163
E	101	104	107	110	113	116	122	126	131	137	142	150
F	93	95	98	101	104	107	112	117	122	127	132	140
G	86*	89	92	94	97	100	105	108	113	118	122	130
H	63	72	84*	87	89	92	96	99	103	108	112	119
I	50	56	63	72	82*	85	88	91	95	99	102	108
J	38	43	48	54	60	68	80*	83	86	89	92	98
K	30	33	36	40	44	49	56	64	77*	80	83	89
L	23	25	27	30	32	35	41	46	52	62	74*	79
M	15	16	18	19	21	23	26	29	33	38	44	56
N	8	9	10	11	12	14	16	18	20	22	25	31
O	3	3	4	4	5	6	7	8	9	11	13	15
P	0	0	0	0	0	0	0	1	2	3	4	6
Q								0	0			

STEP 8

STEP 5

Drainage: Leon River, TX — Area: 3,660 mi² — Date: ____ — Increment: 1.2

Area size	Iso.	Nomo.	Amt. 5.99	Avg. depth	ΔA	ΔV
10000/1	A	262	15.69	15.69	10	156.9
	B	243	14.56	15.12	15	226.8
	C	227	13.60	14.08	25	352.0
	D	209	12.52	13.06	50	653.0
	E	194	11.62	12.07	75	905.2
	F	178	10.66	11.14	125	1392.5
	G	166	9.94	10.30	150	1545.0
	H	152	9.10	9.52	250	2380.0
	I	140	8.39	8.74	271	2368.5
	J	128	7.67	8.03	393	3155.8
	K	117	7.01	7.34	488	3581.9
	L	107	6.41	6.71	582	3905.2
(.60 X)	M	93	5.57	6.07	737	4475.6
(.75 X)	N	82	4.91	5.40	489	2640.6
					Sum =	27737.0

Area size	Iso.	Nomo.	Amt. 5.93	Avg. depth	ΔA	ΔV
15000/1	A	290	14.30	14.30	10	143.0
	B	271	13.36	13.83	15	207.4
	C	253	12.47	12.92	25	323.0
	D	232	11.44	11.96	50	598.0
	E	214	10.55	11.00	75	825.0
	F	196	9.66	10.10	125	1262.5
	G	183	9.02	9.34	150	1401.0
	H	168	8.28	8.65	250	2162.5
	I	156	7.69	7.98	271	2162.6
	J	143	7.05	7.37	393	2896.4
	K	131	6.46	6.76	488	3298.9
	L	120	5.92	6.19	582	3602.6
(.60 X)	M	106	5.22	5.64	737	4156.7
(.75 X)	N	94	4.63	5.07	489	2479.2
					Sum =	23519.8

Area size	Iso.	Nomo.	Amt. 4.42	Avg. depth	ΔA	ΔV
1000/2	A	116	5.13	5.13	10	51.3
	B	112	4.95	5.04	15	75.6
	C	108.5	4.80	4.88	25	121.9
	D	105	4.64	4.72	50	236.0
	E	103	4.55	4.60	75	345.0
	F	101	4.46	4.51	125	563.8
	G	99	4.38	4.42	150	663.0
	H	97	4.29	4.34	250	1085.0
					271	1131.8
					393	1485.5
					488	1498.2
					582	1466.6
					737	1488.7
					489	743.3
					Sum =	10975.7

Area size	Iso.	Nomo.	Amt. 4.12	Avg. depth	ΔA	ΔV
1500/2	A	117	4.82	4.82	10	48.2
	B	113	4.66	4.74	15	71.1
	C	110	4.53	4.60	25	114.9
	D	107	4.41	4.47	50	223.5
	E	105	4.33	4.37	75	327.8
	F	103	4.24	4.29	125	535.8
	G	100.5	4.14	4.19	150	628.5
	H	99	4.08	4.11	250	1027.5
	I	97	4.00	4.04	271	1094.8
	J	95.5	3.93	3.97	393	1560.2
	K	75.5	3.11	3.52	488	1717.8
	L	605	2.49	2.80	582	1629.6
(.60 X)	M	45	1.85	2.53	737	1863.5
(.75 X)	N	31	1.28	1.71	489	836.2
					Sum =	11459.2

STEP 9

	6-hr periods 1	2	3	4	5	6	7	8	9	10	11	12
Avg. PMP (in.)	8.59	3.24	2.18	1.78	1.16	0.93	0.78	0.70	0.62	0.62	0.54	0.54

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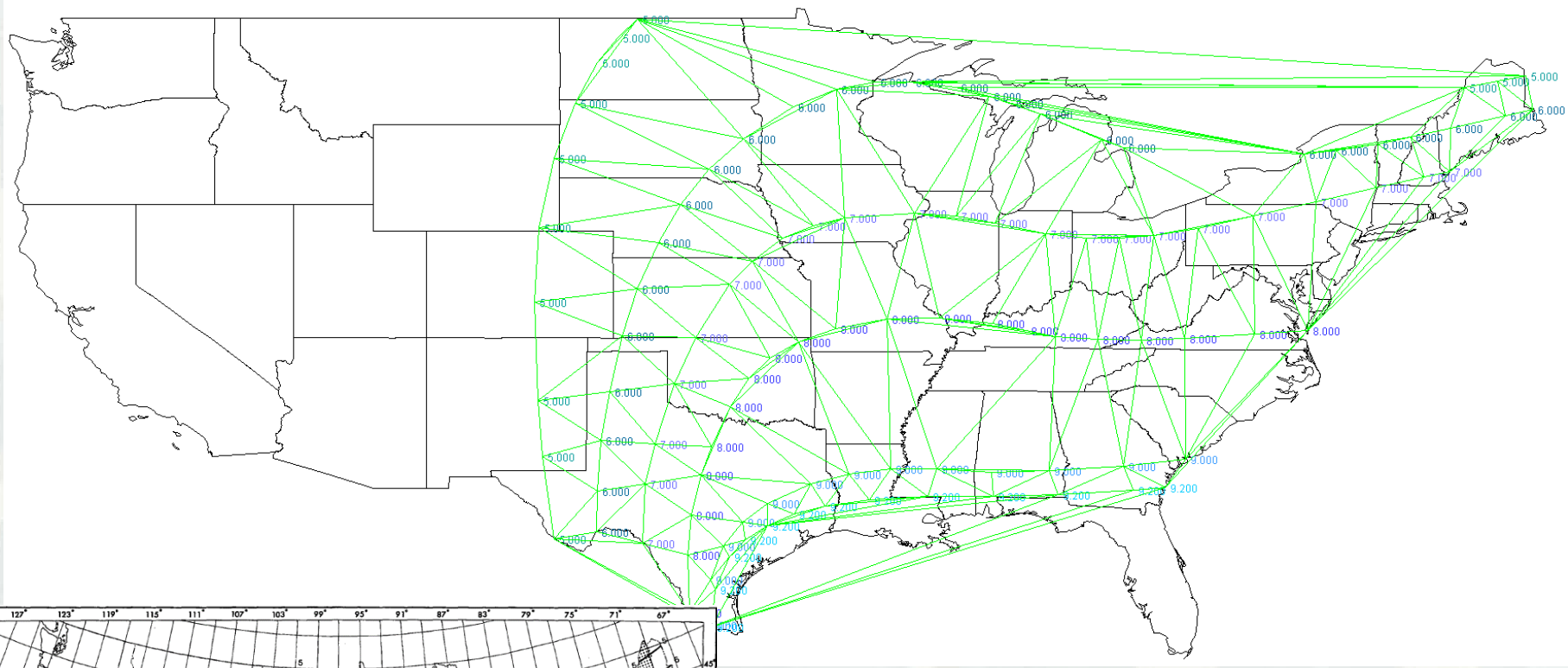
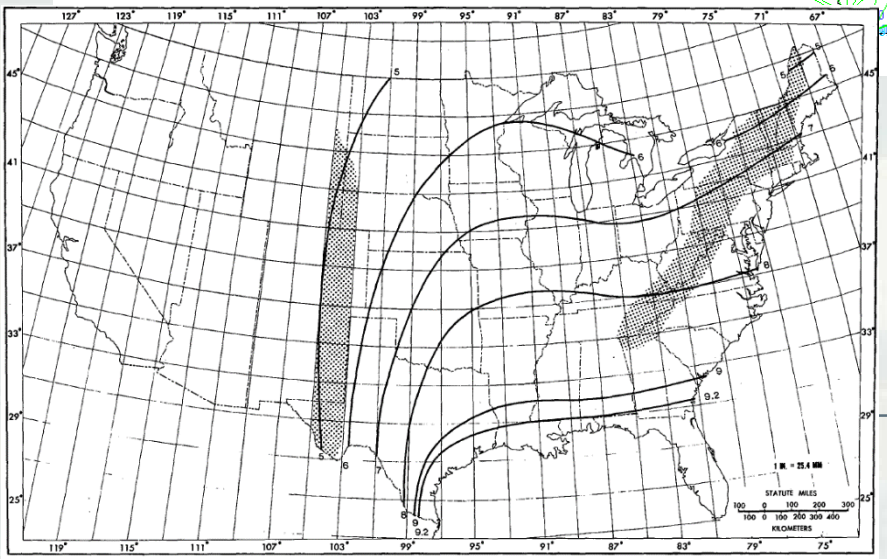
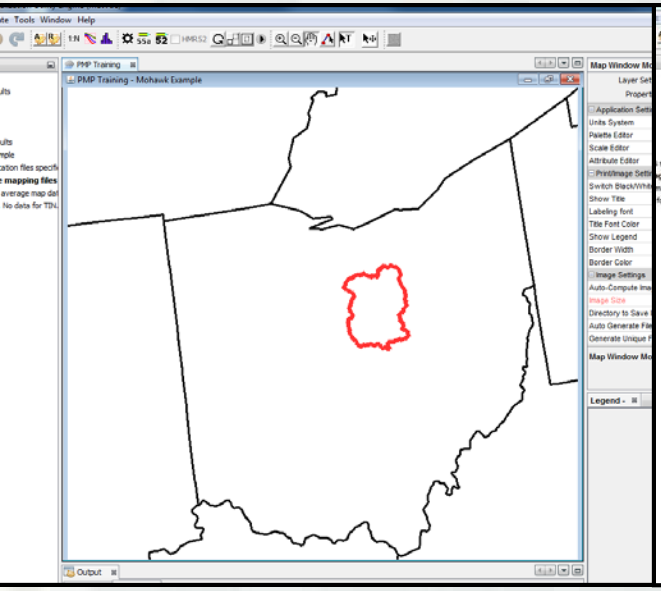
*Can use ArcGIS for these steps

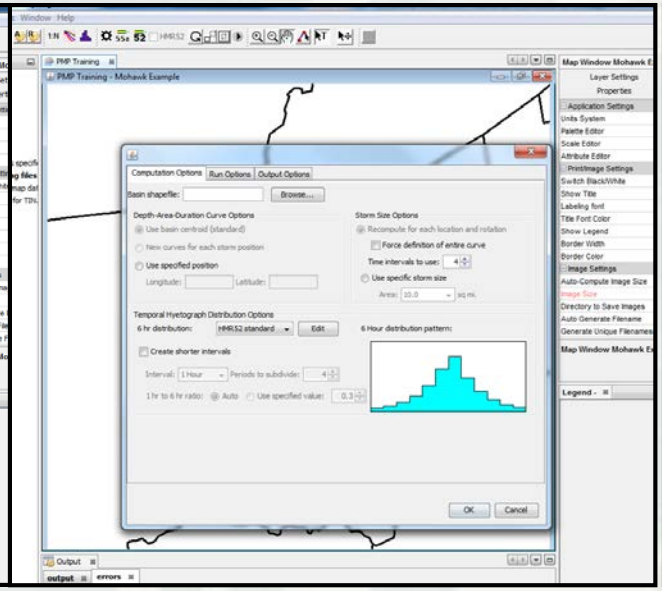
HEC-MetVue (HMR 51 TINs)

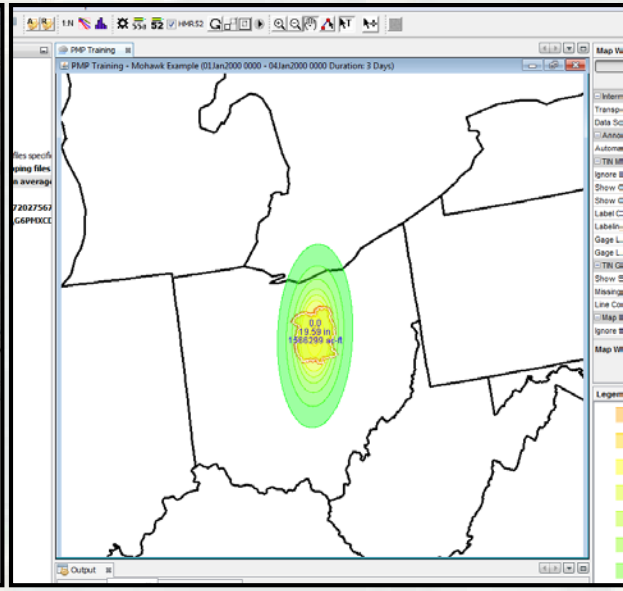




HEC-MetVue (HMR 52 Plug-In)







1. Open HEC-MetVue
2. Establish New Session
3. Add Map Panel
4. Load Basin Shapefile

1. Select HMR 52 Plug-In
2. Choose Basin Shapefile
3. Define Temporal Pattern
4. Specify Output File

1. Compute HMR 52 Results
2. Rotate/Translate, if needed
3. Note the different depths
4. Handoff input to HEC-HMS

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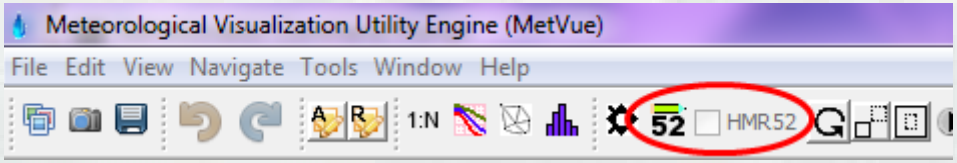
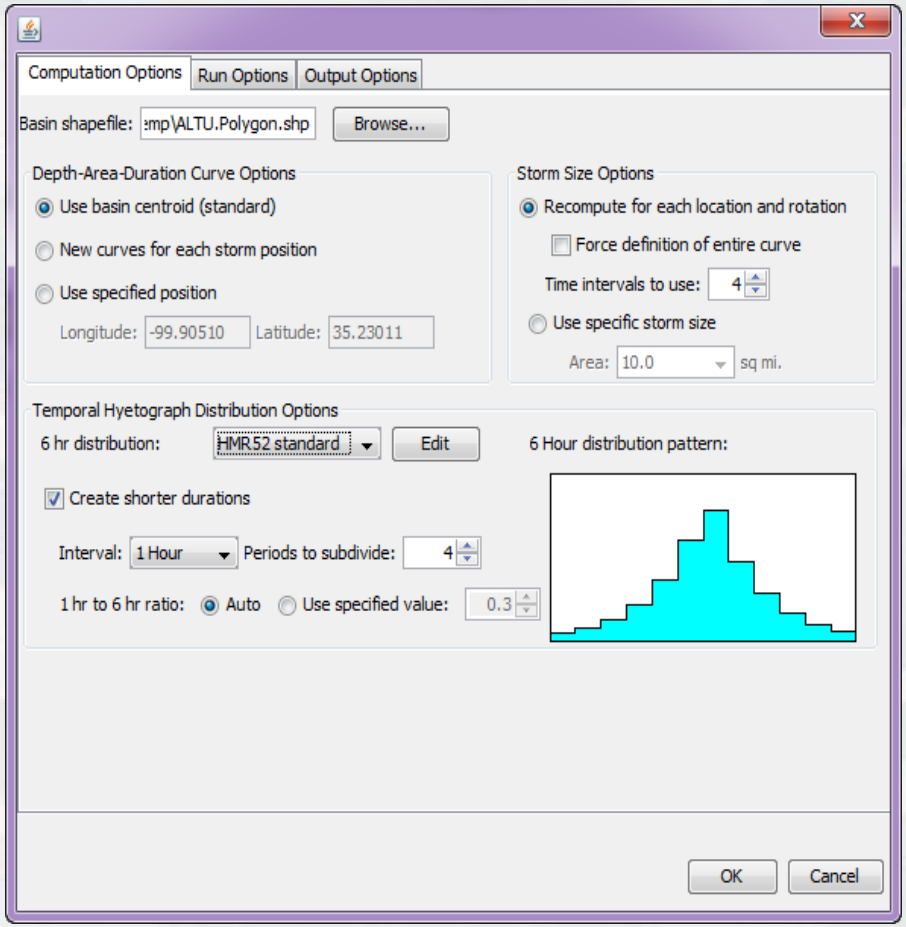
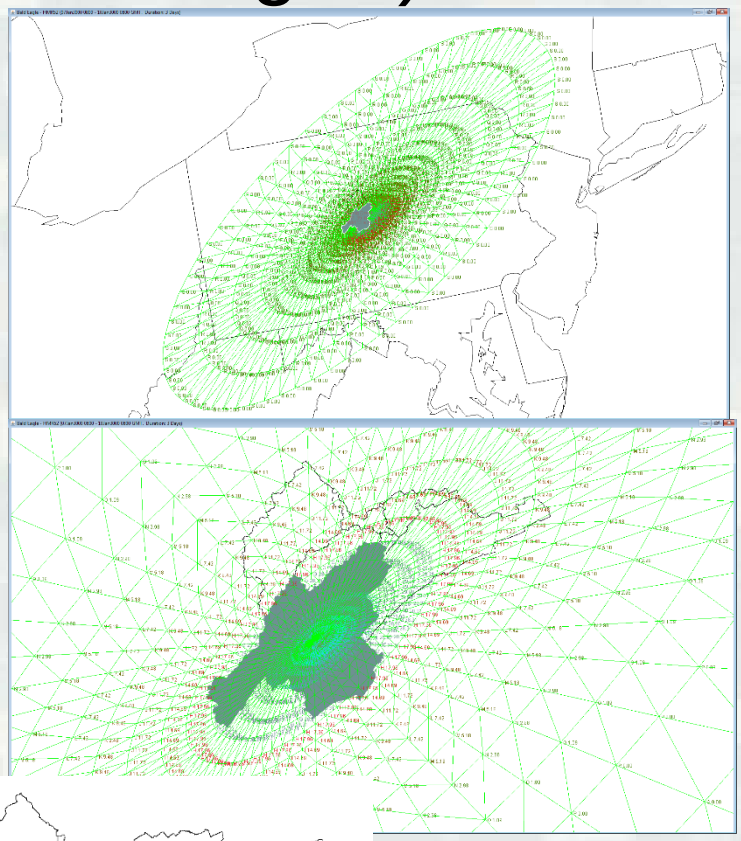
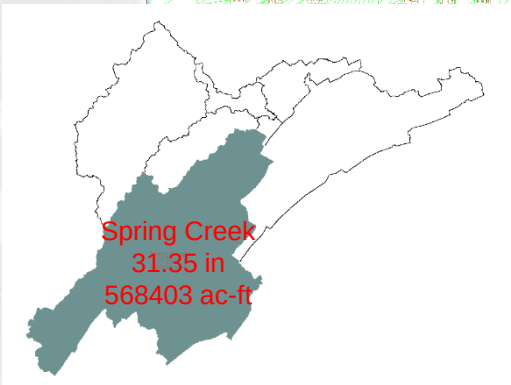
HEC-MetVue (HMR 52 Plug-In)









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HMR52 Hyetograph Output

Hyetograph Output Options

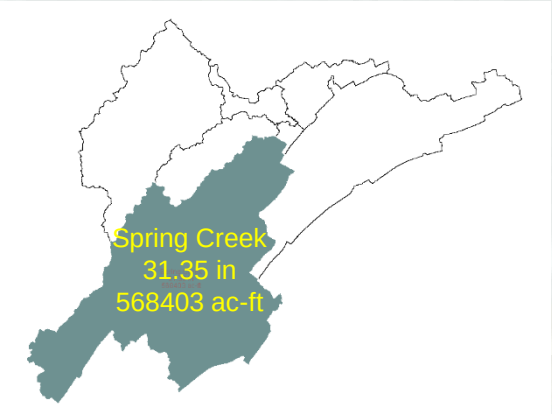
☑ Set hyetograph ordinals to 0.0 prior to start of storm for 3 Days

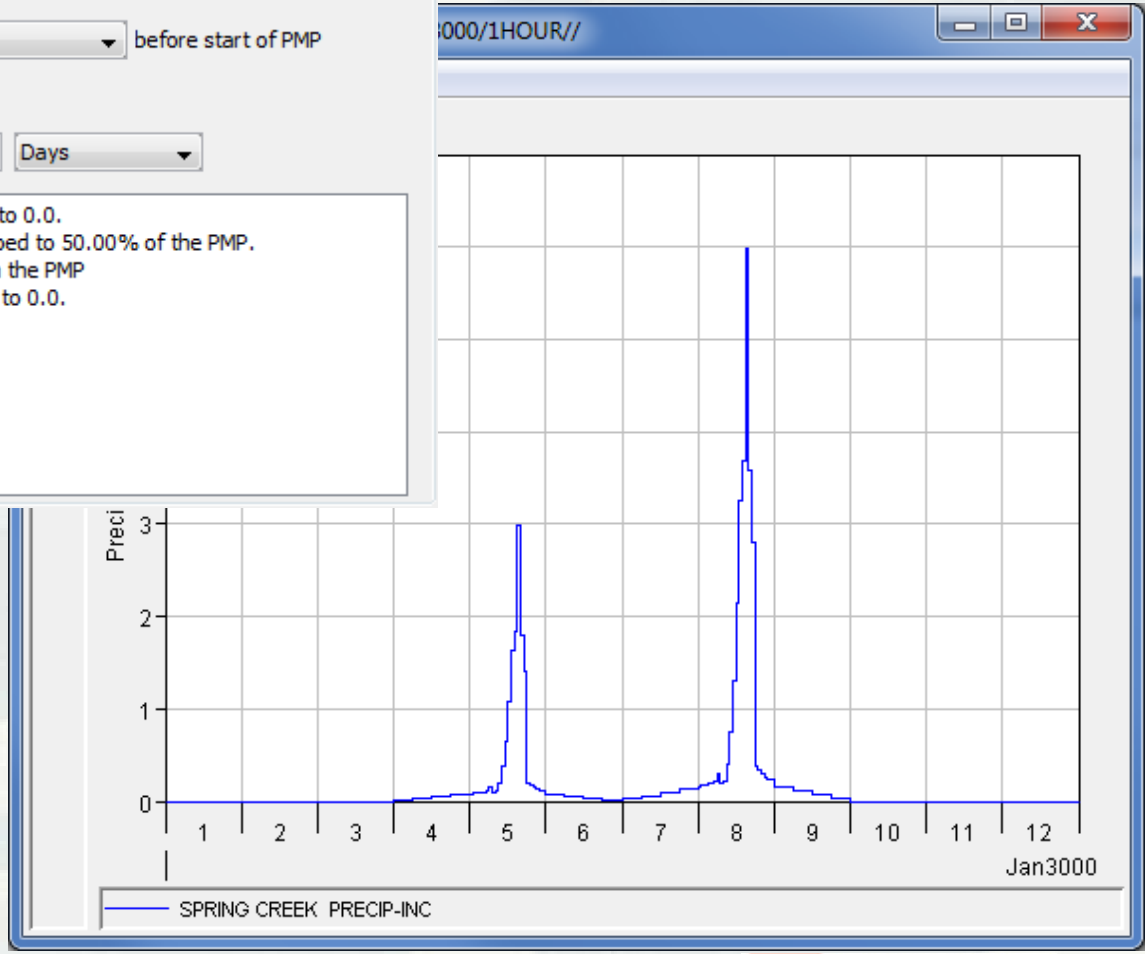
☑ Apply ratio of 0.5 of the PMP starting 3 Days before start of PMP

Start date of PMP: 07Jan3000 0000

☑ Set hyetograph ordinals to 0.0 following end of storm for 3 Days

Hyetograph ordinals from 01Jan3000 0000 up to 04Jan3000 0000 will be set to 0.0.
Hyetograph ordinals from 04Jan3000 0000 up to 07Jan3000 0000 will be ratioed to 50.00% of the PMP.
Hyetograph ordinals from 07Jan3000 0000 up to 10Jan3000 0000 will contain the PMP
Hyetograph ordinals after 10Jan3000 0000 up to 13Jan3000 0000 will be set to 0.0.





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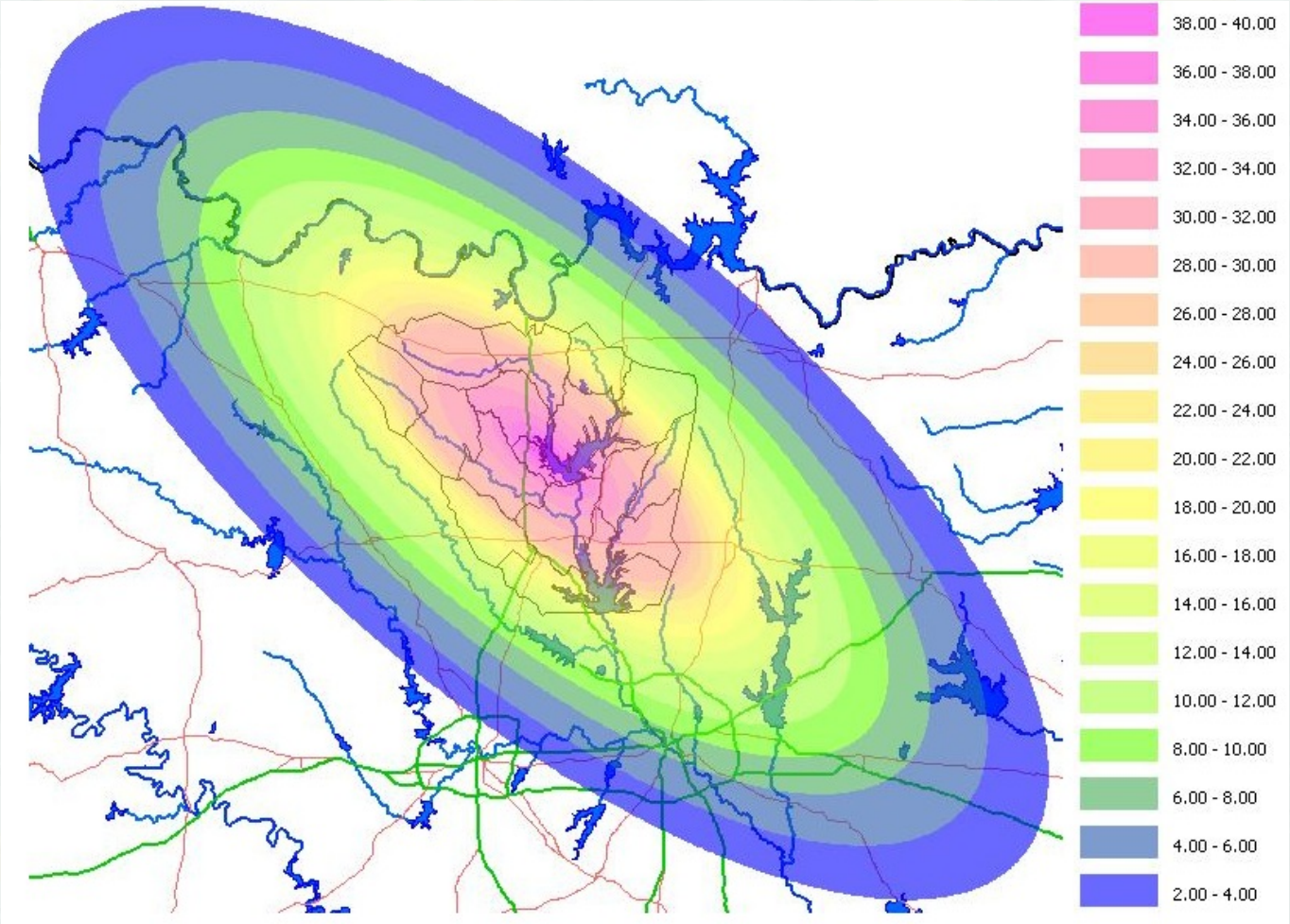
Design Storms – HMR's

HMR52 for Lewisville Reservoir



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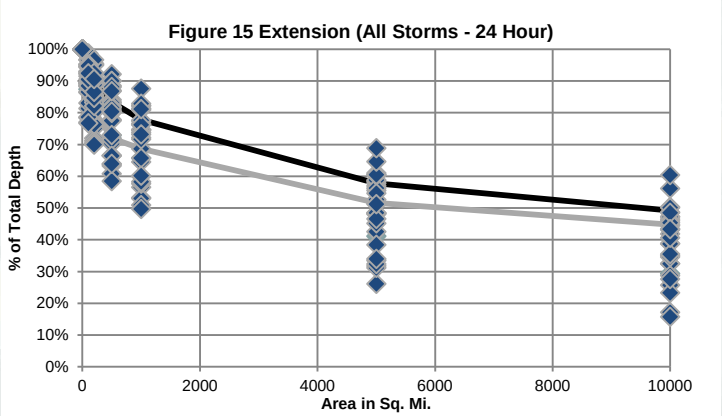
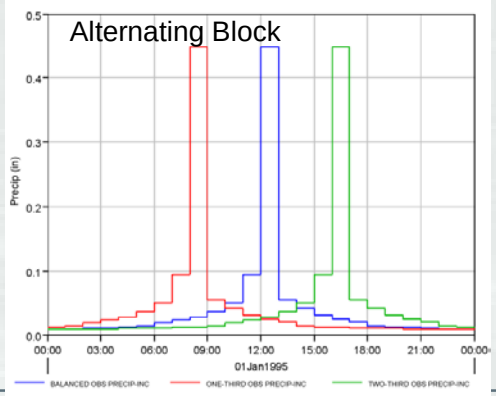
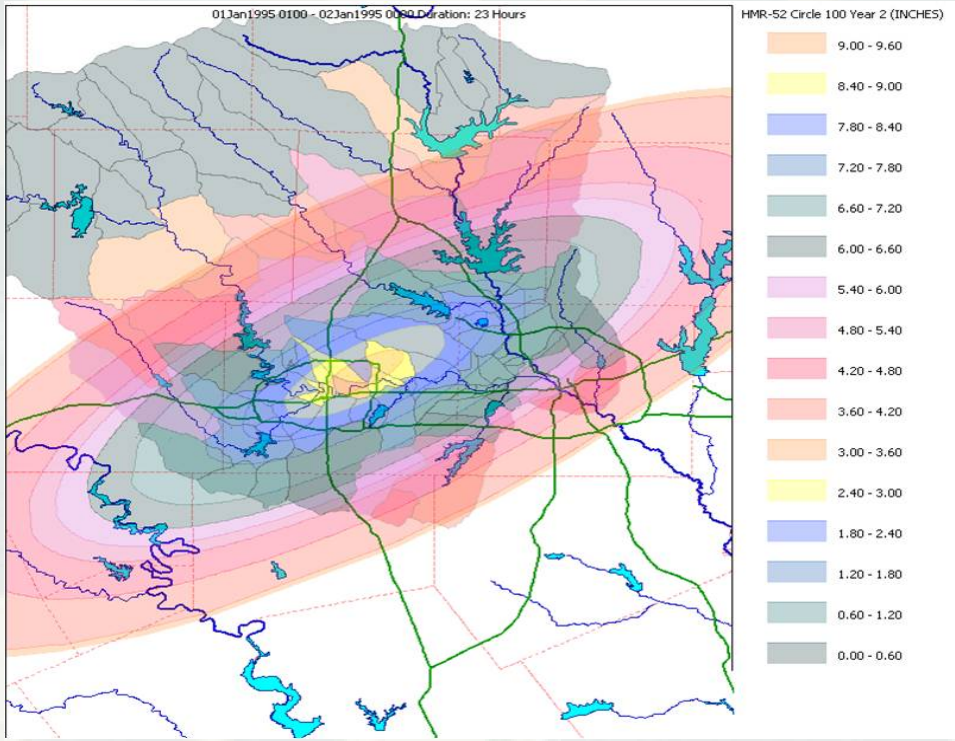
Design Storms

Standard Frequency – 100-yr at Dallas, TX

- NOAA statistical rainfall







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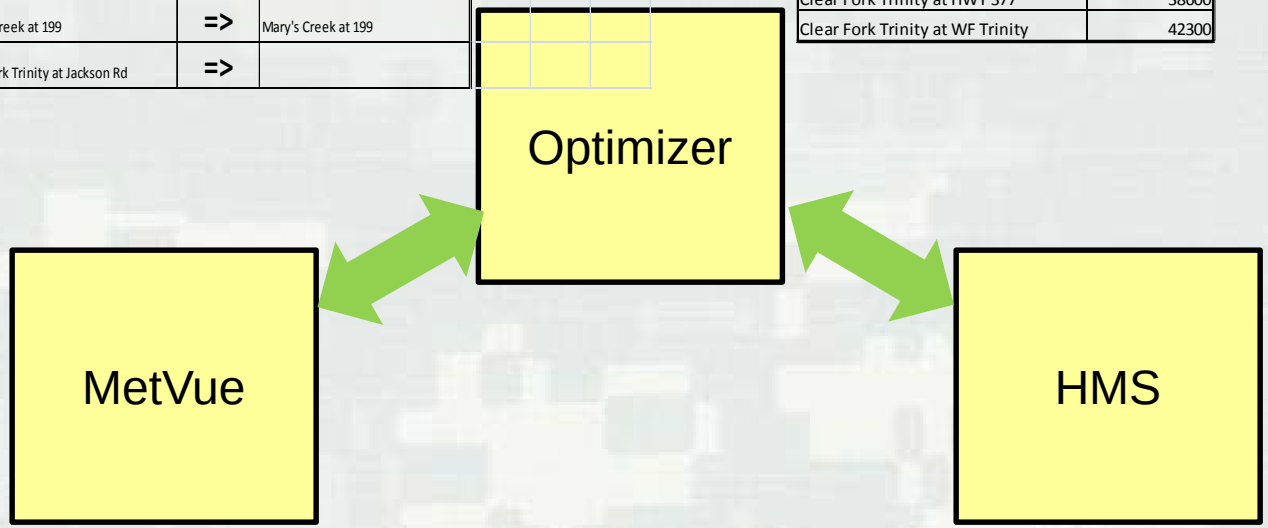
Future Enhancements

- Storm centering optimizer

Available Discharge Points		Selected Discharge Points
Mary's Creek at Sycamor Sch Rd	=>	Mary's Creek at Sycamor Sch Rd
Mary's Creek at Weber Rd	=>	
Mary's Creek at Hemphill	=>	
Mary's Creek at 199	=>	Mary's Creek at 199
Clear Fork Trinity at Jackson Rd	=>	

Discharge Location	Maximum
Mary's Creek at Sycamor Sch Rd	2800
Mary's Creek at HWY 199	14200
Clear Fork Trinity at Conf. Mary's Ck	27400
Clear Fork Trinity at HWY 377	38600
Clear Fork Trinity at WF Trinity	42300



- Storm ensembles

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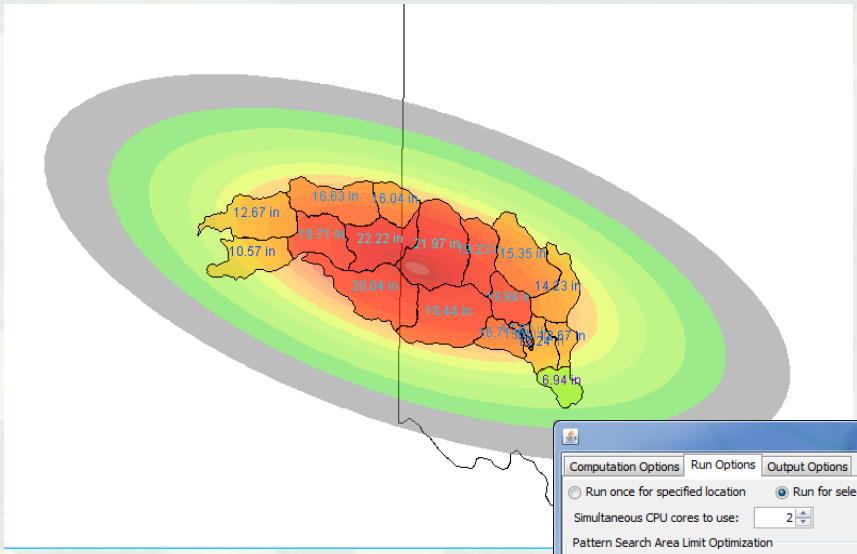
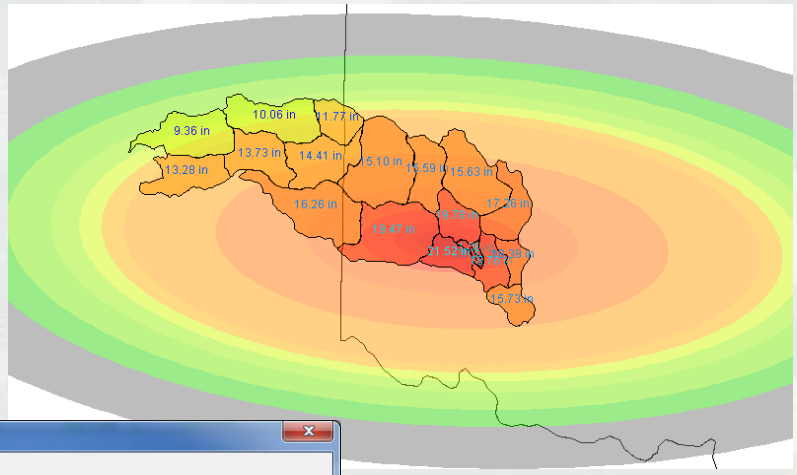
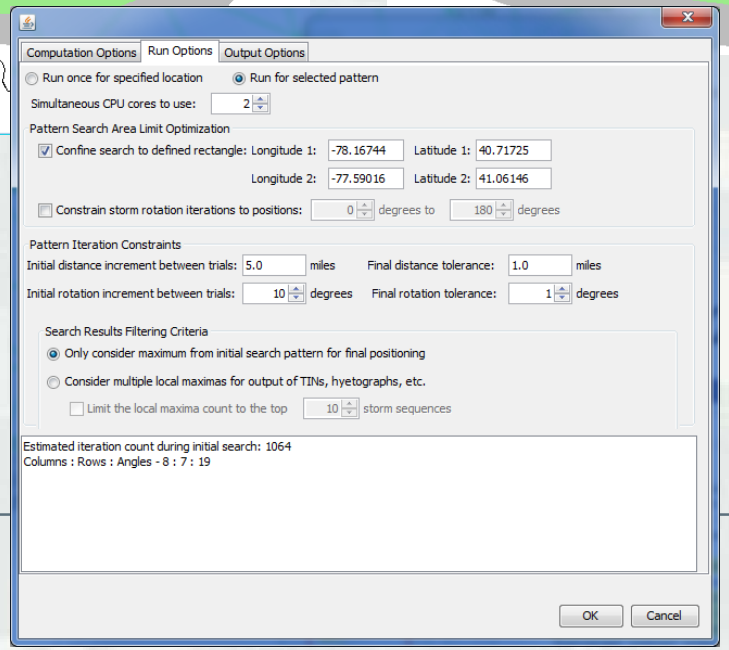
HEC-MetVue (HMR 52 Optimization)

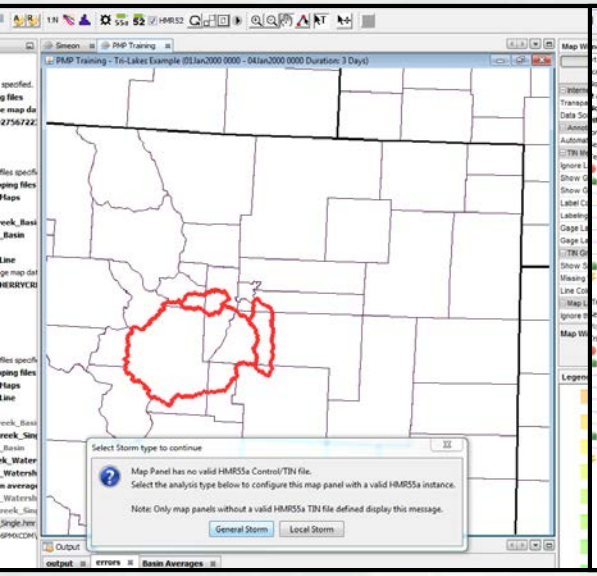
- Basin Centroid
- Specified Position and Rotation

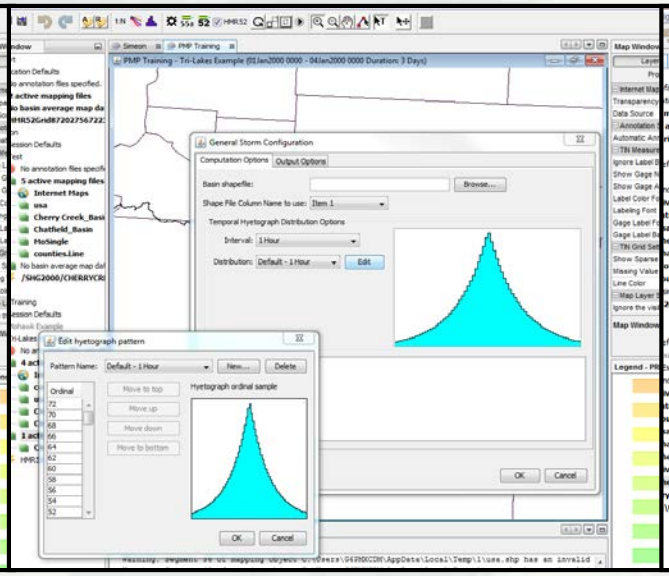


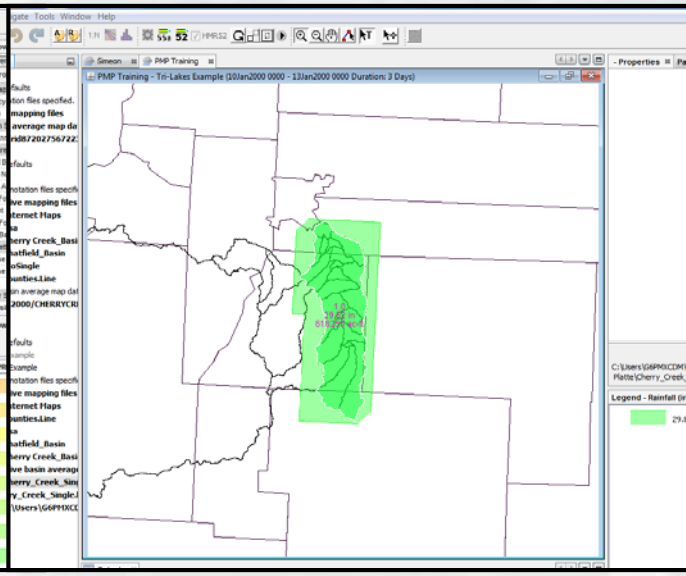




HEC-MetVue (HMR 55A Plug-In)







1. Open HEC-MetVue
2. Establish New Session
3. Add Map Panel
4. Load Basin Shapefile
5. Select HMR 55A Plug-In
6. Select General or Local

1. Choose Basin Shapefile
2. Define Temporal Pattern
3. Remember Output File

1. Compute HMR 55A Results
2. No translation/rotations
3. HMR 55A already spatially

Notes:

- Top result is basin name (change default)
- Middle number is basin average depth
- Bottom number is volume equivalent
- Much easier to adjust temporally
- Much more difficult to adjust spatially

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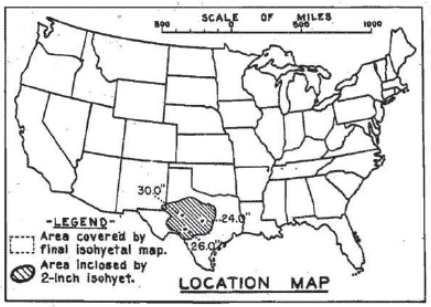
HEC-MetVue Historical Storm Analysis

WAR DEPARTMENT — CORPS OF ENGINEERS, U.S. ARMY

STORM STUDIES – PERTINENT DATA SHEET



Storm of 19-25 July 1938
Assignment GM 5-10
Location Texas
Study Prepared by:
Southwestern Division
Gal eston District Office

Part I Reviewed by H. M. Sec. of Weather Bureau, 10/31/45
Part II Approved by Office, Chief of Engineers for Distribution of Factual Data, 9/30/46
Remarks: Centers near
Eldorado, Texas
Rocksprings, Texas
San Saba, Texas

DATA AND COMPUTATIONS COMPILED

PART I

Preliminary isohyetal map, in 1 sheet, scale 1 : 1,000,000

Precipitation data and mass curves:	(Number of Sheets)
Form 5001-C (Hourly precip. data)	23
Form 5001-B (24-hour " ")	32
Form 5001-D (" " " ")	15
Misc. precip. records, meteorological data, etc.	32
Form 5002 (Mass rainfall curves)	78

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)	10
Form S-11 (Depth-area data from isohyetal map)	4
Form S-12 (Maximum depth-duration data)	17
Maximum duration-depth-area curves	1
Data relating to periods of maximum rainfall	3

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	144
10	11.5	13.4	13.4	15.9	16.0	16.0	18.0	20.0	22.6	27.8	30.0
100	9.4	10.0	10.5	12.5	13.3	13.4	15.1	16.9	19.1	22.9	25.2
200	8.4	9.0	9.5	11.2	12.3	12.6	14.3	16.5	18.8	22.2	24.3
500	7.0	7.5	8.1	9.3	11.0	11.4	13.1	15.5	18.1	20.9	23.1
1,000	6.0	6.5	6.9	7.9	10.0	10.5	11.9	14.6	17.1	19.6	21.9
2,000	5.0	5.5	5.9	6.7	9.0	9.6	10.7	13.5	15.3	17.8	20.6
5,000	3.7	4.4	4.7	5.4	7.6	8.2	8.9	11.6	12.7	15.0	18.2
10,000	2.9	3.6	3.8	4.4	6.6	7.0	7.5	9.9	10.5	12.3	15.4
20,000	2.2	2.8	3.0	3.4	5.1	5.5	5.9	7.8	8.2	9.7	12.0
50,000	1.3	1.7	1.8	2.1	3.1	3.3	3.7	4.8	5.0	6.2	7.4
68,000	1.0	1.3	1.4	1.6	2.3	2.6	2.9	3.7	3.9	4.9	6.1

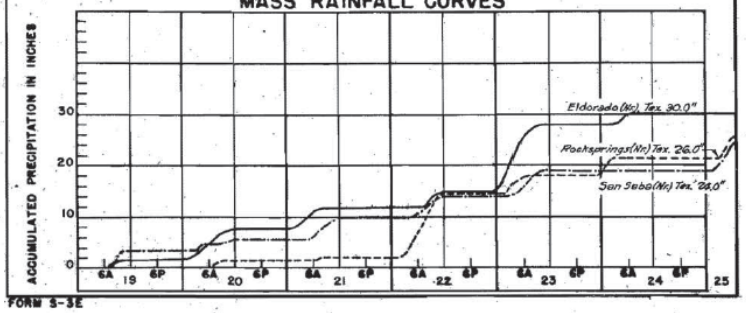
Form S-2

WAR DEPARTMENT — CORPS OF ENGINEERS, U. S. ARMY

STORM STUDIES – ISOHYETAL MAP

Storm of July 19 – 25, 1938 Assignment GM 5-10
Study Prepared by: Galveston, Texas District
Southwestern Division

MASS RAINFALL CURVES



FORM S-3E

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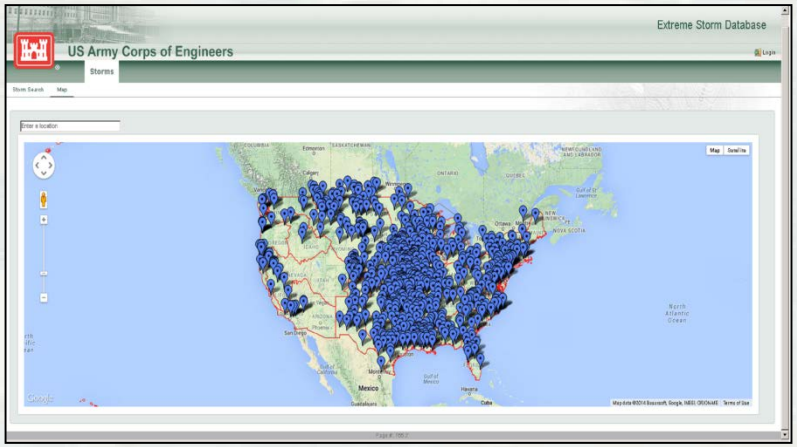
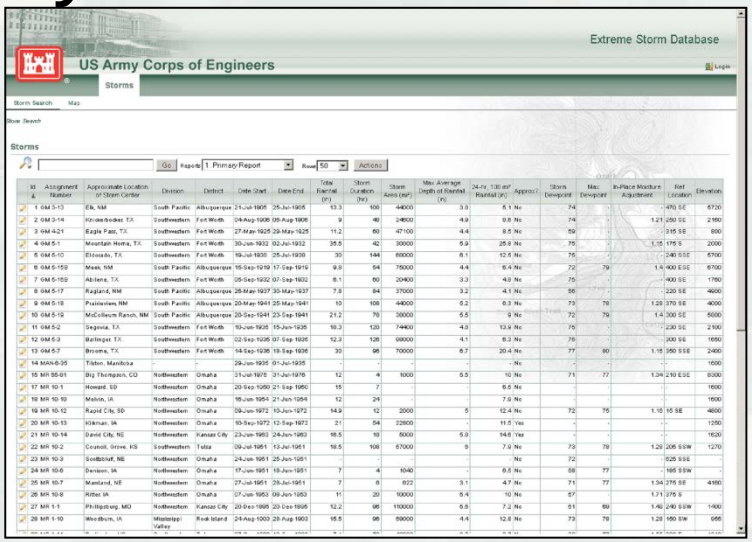
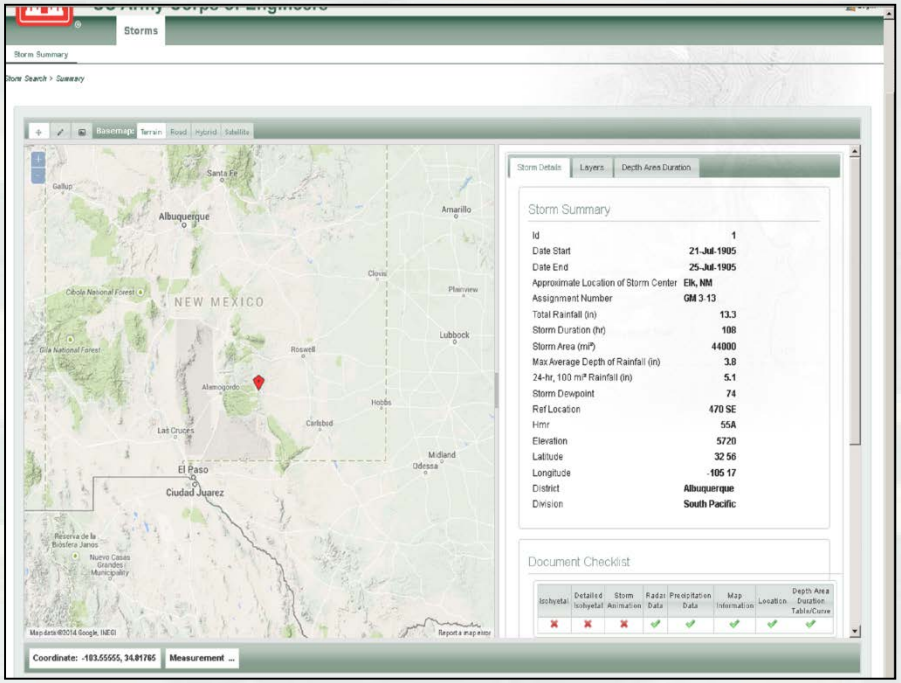
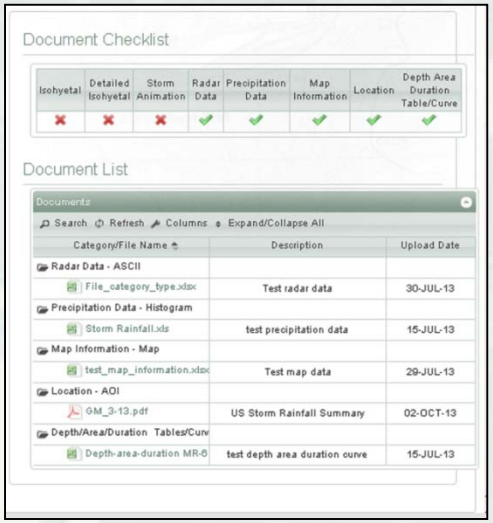
HEC-MetVue: Storm Analysis & Database









USACE Extreme Storm Database

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HEC-MetVue Development

Ongoing

- File Management
- Time Zone Management
- CWMS Forecast Integration Design
- Documentation Update
- **Official Release Version**

Future

- Interface Enhancements
- CWMS Enhancements
- Extreme Storms Database
- MetVue-HMS Data Exchange
- HEC-WAT/FRA Uncertainty
- …

WMIST
WATER MANAGEMENT IMPLEMENTATION SUPPORT TEAM

Questions?

Chuck McWilliams

Meteorologist, Hydrological Eng. Branch
Hydrology

U.S. Army Corps of Engineers
Omaha District (NWO)
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Suite 9000, NWO-ED-HE
Omaha, NE 68102

(402) 995-2319 TEL
charles.d.mcwilliams@usace.army.mil

WMIST COP Site: https://cops.usace.army.mil/sites/HHC/CoPs/WM/WMIST/default.aspx