Extreme Precipitation Estimates for State Regulators - Past, Present, and Future

TASK #1 - Probable Maximum Precipitation - Texas Example

ASDSO Soapbox Session
September 12, 2017
ASDSO 2017 - San Antonio, TX

Colorado Water Conservation Board
Colorado Division of Water Resources

CO-NM REPS
Colorado-New Mexico Regional Extreme Precipitation Study

New-Mexico Office of the State Engineer

Texas Statewide Probable Maximum Precipitation (PMP) Development

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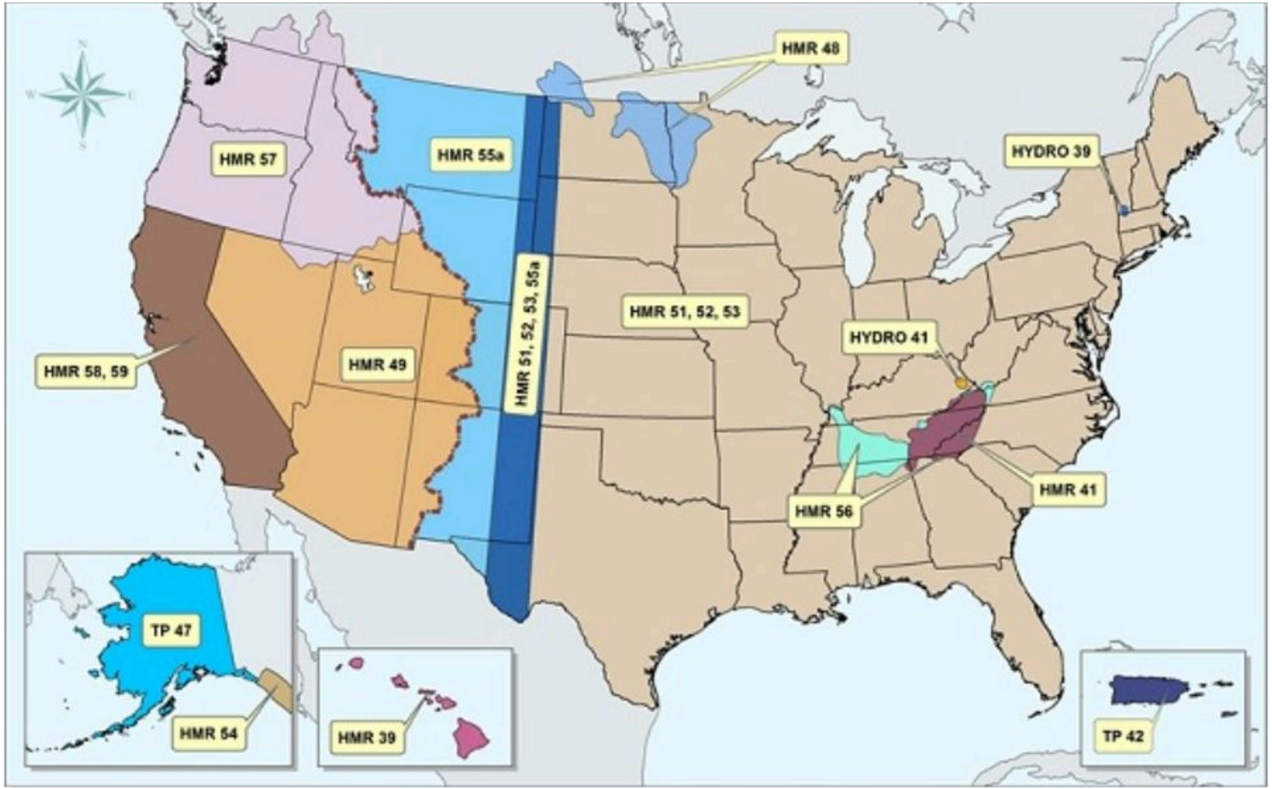
Probable Maximum Precipitation

Definition: The *theoretically* greatest depth of precipitation for a given duration that is *physically possible* over a given storm area at a particular *geographic location* at a certain time of year (HMR 59, 1999)

Probable Maximum Precipitation - History



Probable Maximum Precipitation - History

- Storm Based Approach-Deterministic
  - Maximize storms
  - Transposition storms
- Combine into PMP design storm
  - By storm type
  - By area size
  - By duration
- Subjective decisions involved

Probable Maximum Precipitation - History

- HMRs have become out-of-date
  - Based on outdated methods and techniques
  - Better understanding of meteorology
  - Storm datasets not updated
    - More than 40 years missing from HMR 51
- Effect of topography not accurate
  - Subjective
  - Lack of empirical data-unknowns

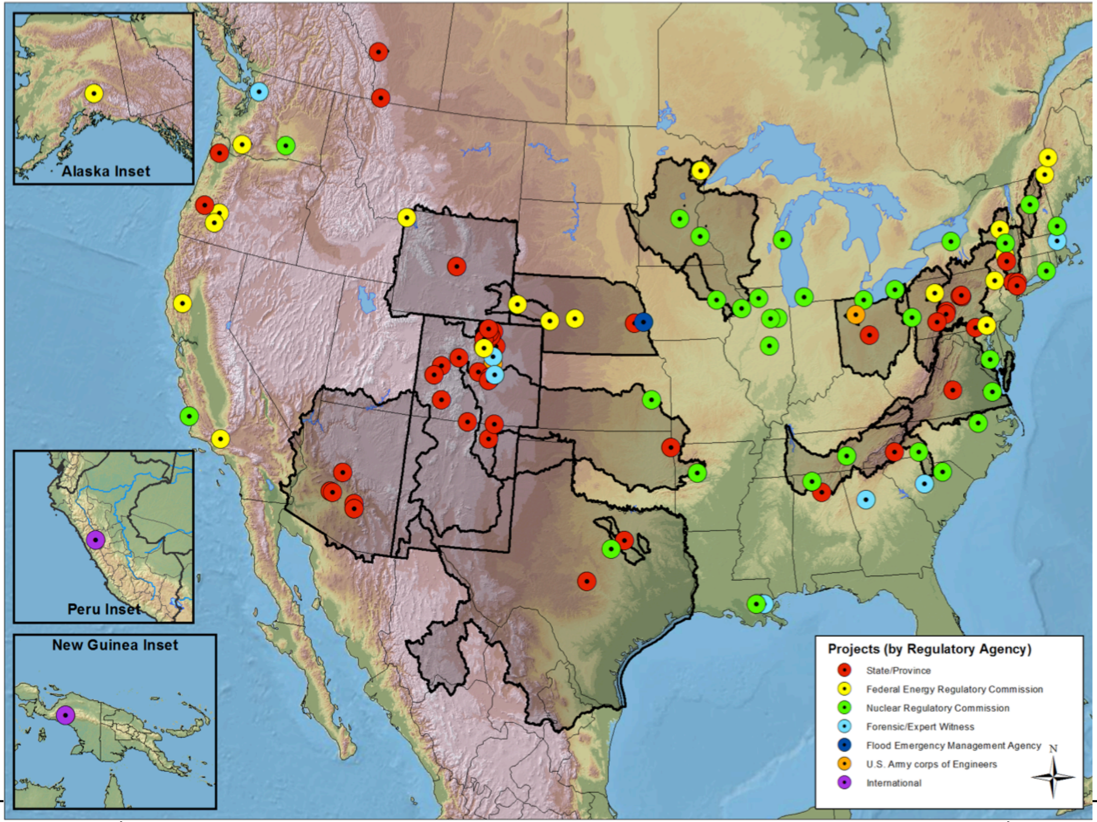
PMP– Texas CEQ Perspective

- HMR 51 too conservative, not credible with elected officials
- No funding initially
- Obtain approval from management
- Management approved project with funds
- Used FEMA grant funds over 2 years

Important Elements – Texas CEQ Perspective

- Peer Review Team (Contracts with 2 of team)
- 4 meetings with all members
- Storm data from around the state, including data from 2016
- Protection of the data
- How do we allow the public to use the PMP tool while hosting the data?
- Do we have the expertise to provide the tool?
- How quickly can we provide to the public?

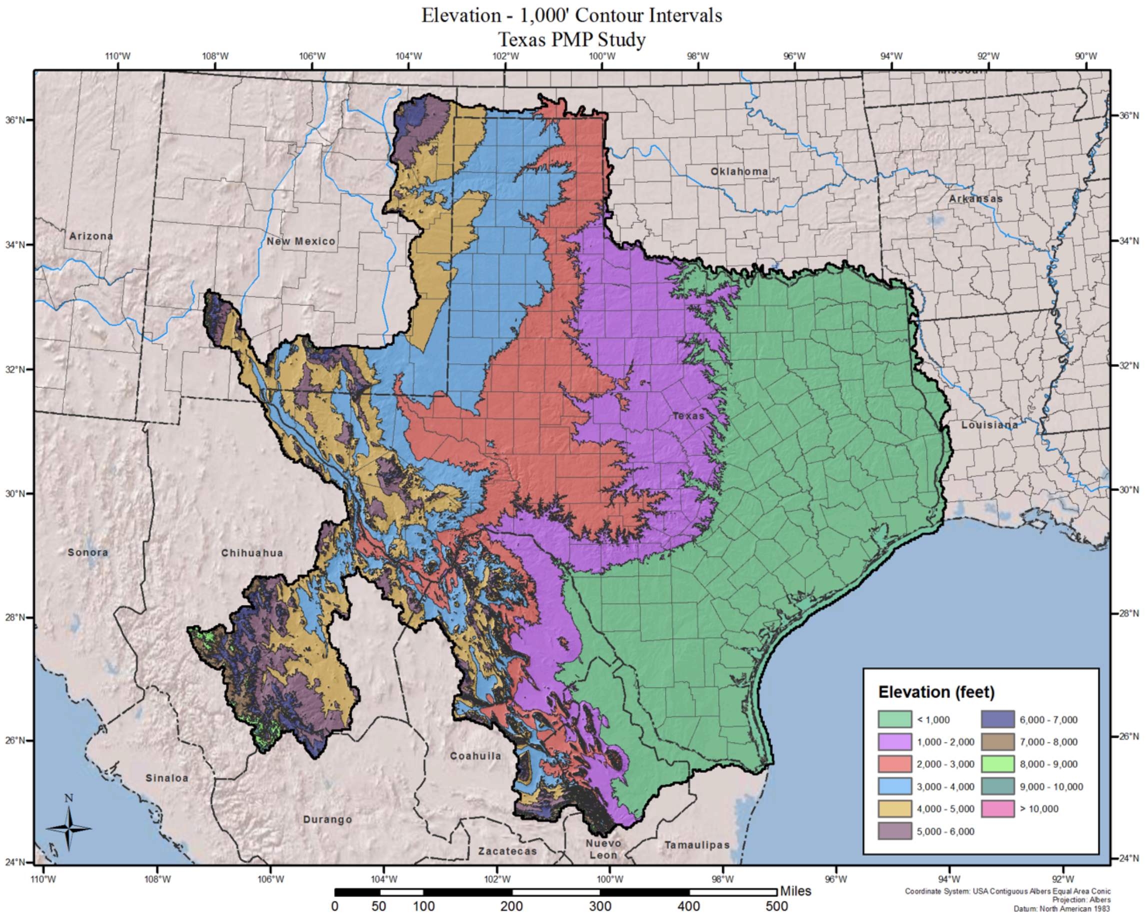
AWA Probable Maximum Precipitation Studies



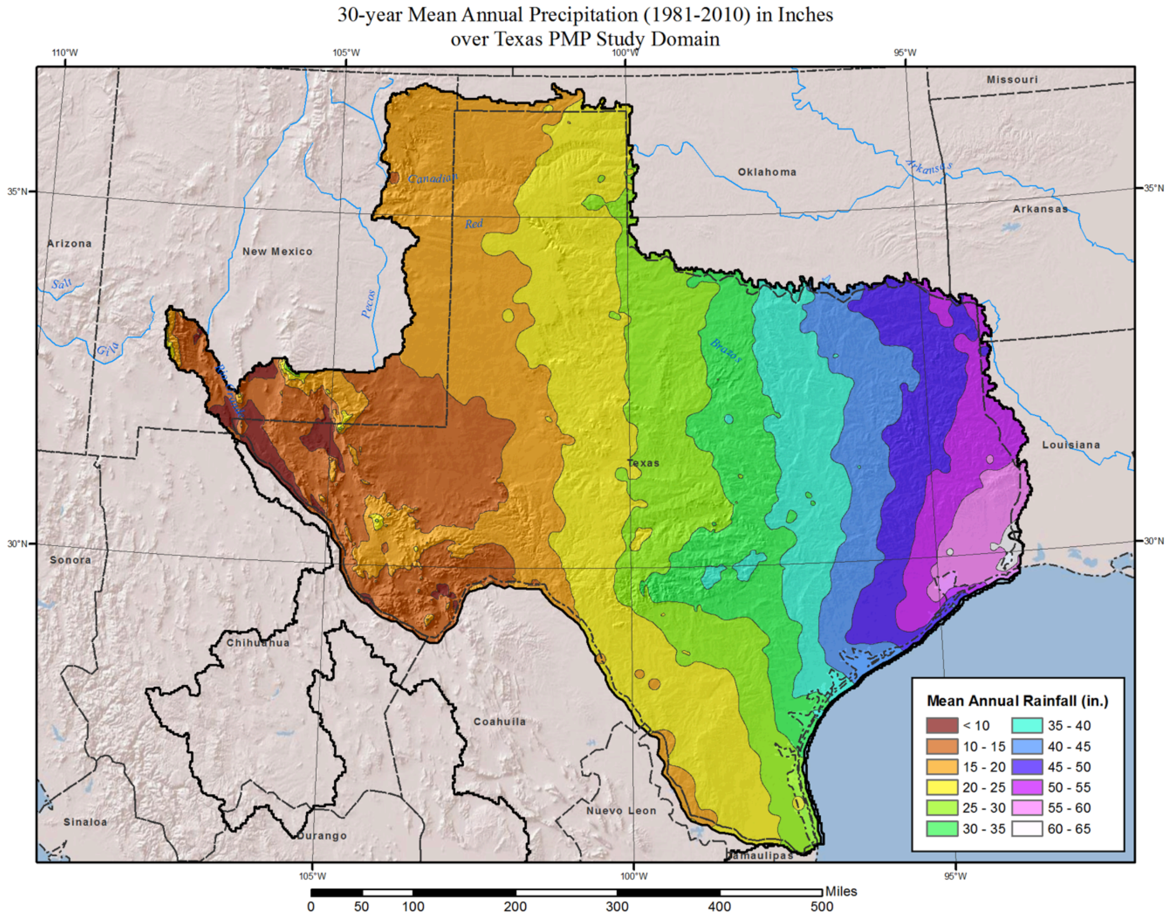
Probable Maximum Precipitation - Today

- Update the storm database
  - Produce Depth-Area-Duration (DAD) analyses for all major storm events
- Use updated dew point analyses to maximize storms
  - Storm representative & maximum dew points
- Use of state-of-the-science procedures and tools
  - Extreme Rainfall, GIS, Precip Frequency, Geographic Transposition Factor
- Provide gridded PMP values
  - All locations considered in this study, all durations/area sizes as required
  - Utilize PMP Evaluation Tool to produce PMP on a gridded basis (~2.5sqmi grid)
- Provide continuity of PMP values across the region in space and time while taking into considerations differences in topography and climate

Texas Topography



Texas Mean Annual Precipitation



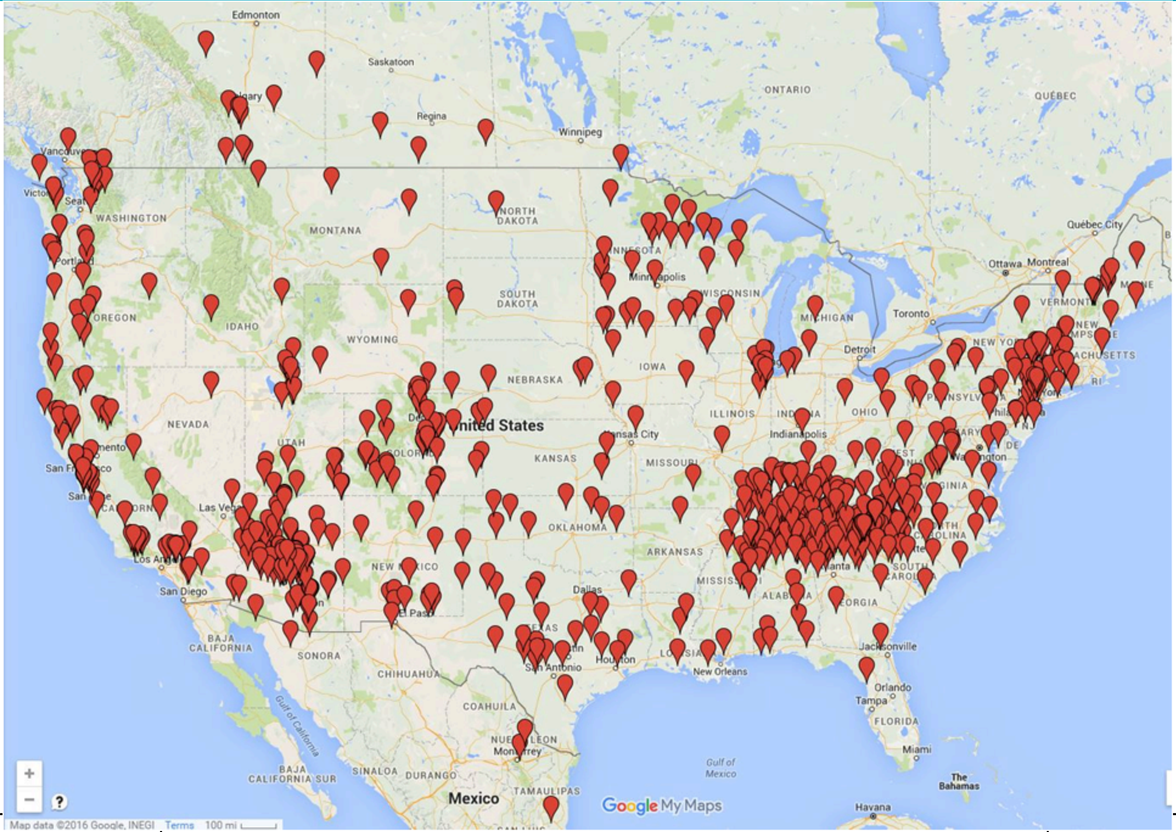
Probable Maximum Precipitation – Goals

- Ensure consistency with other studies
- Already have a very good idea of important storms
- Three storm types of concern-how to define each
  - General (synoptic)
  - Local (thunderstorms)
  - Remnant Tropical
- Let the data talk to use

Probable Maximum Precipitation – Storm List

- Storm Search and Storm List
  - Complete a storm search to identify the most significant storms that could have occurred over the region where storms are transpositionable
  - Identify storms used in HMRs and other PMP studies
  - Identify the most significant flood events that have occurred in region
  - Identify extreme rainfall-producing storm types and seasons
  - Use SPAS to analyze
- Storm must have similar meteorology/topography to be considered transpositionable

Probable Maximum Precipitation – Storm Search



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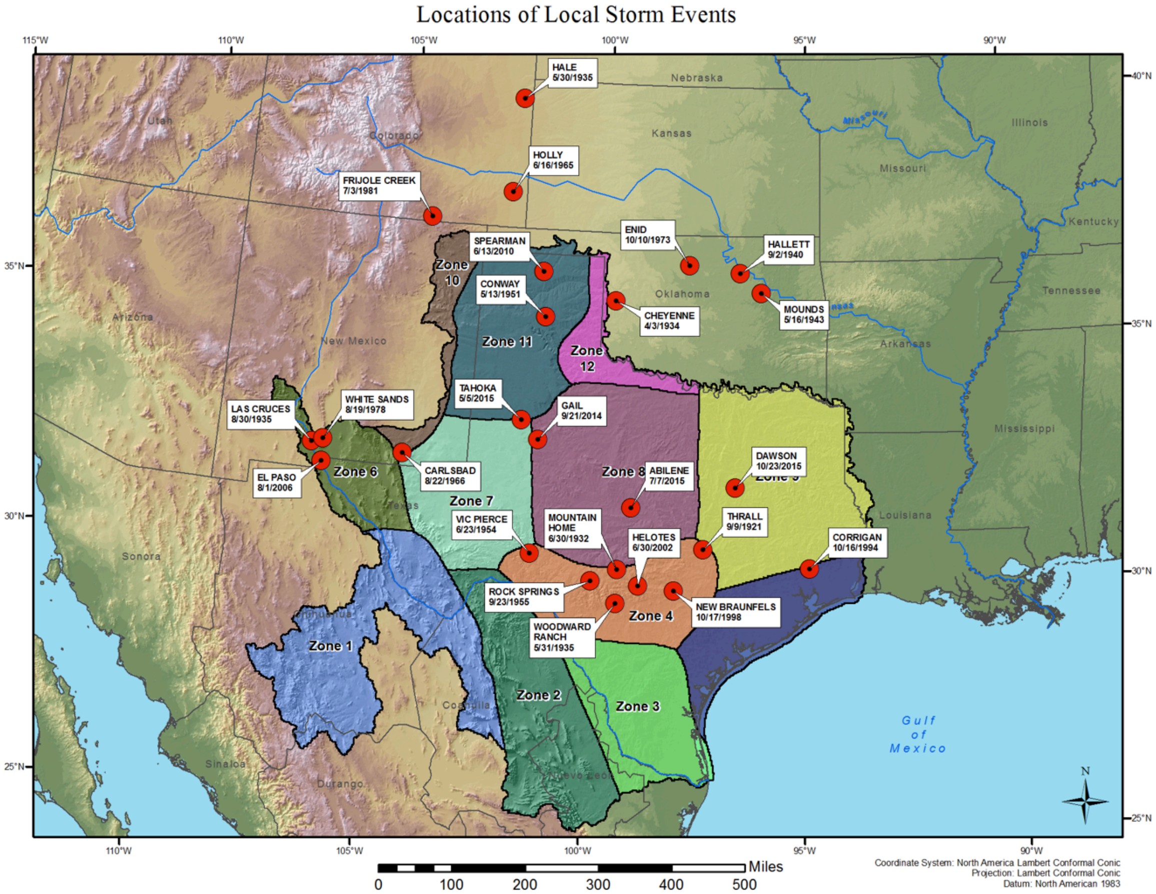
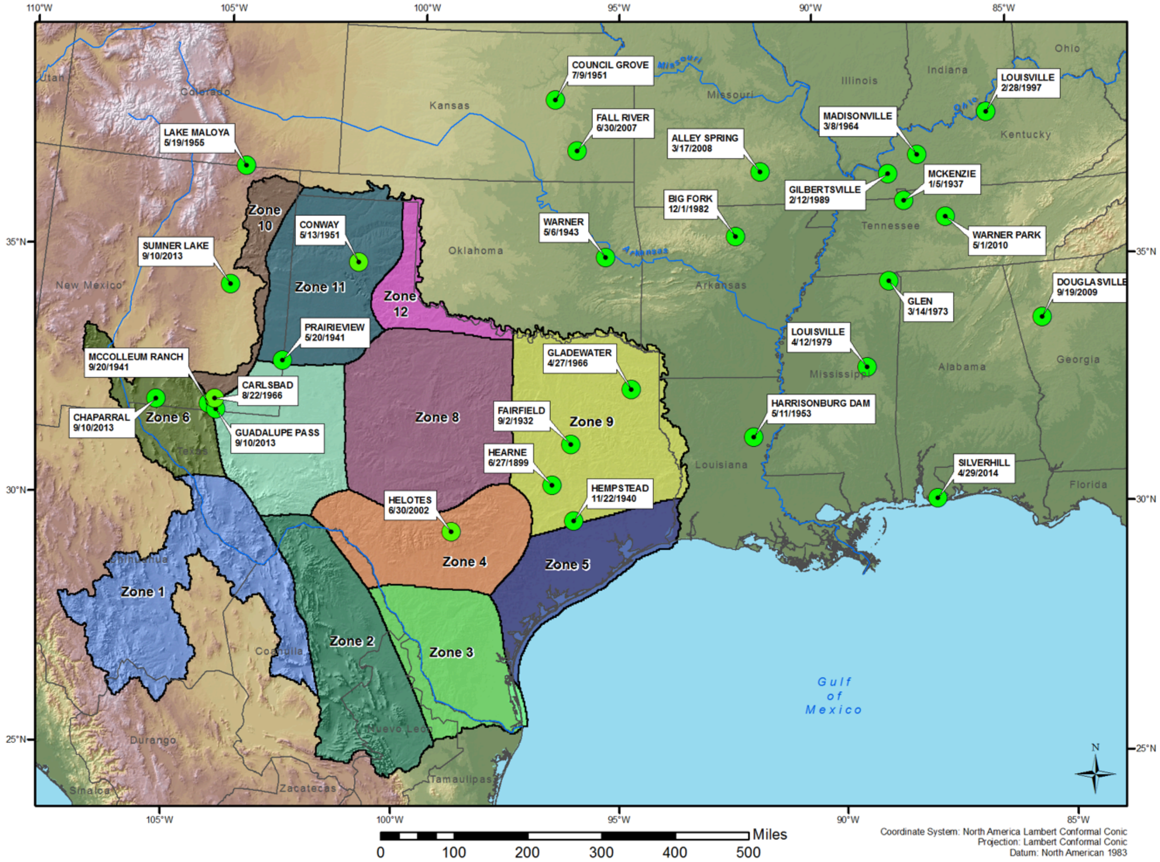
Local storm locations

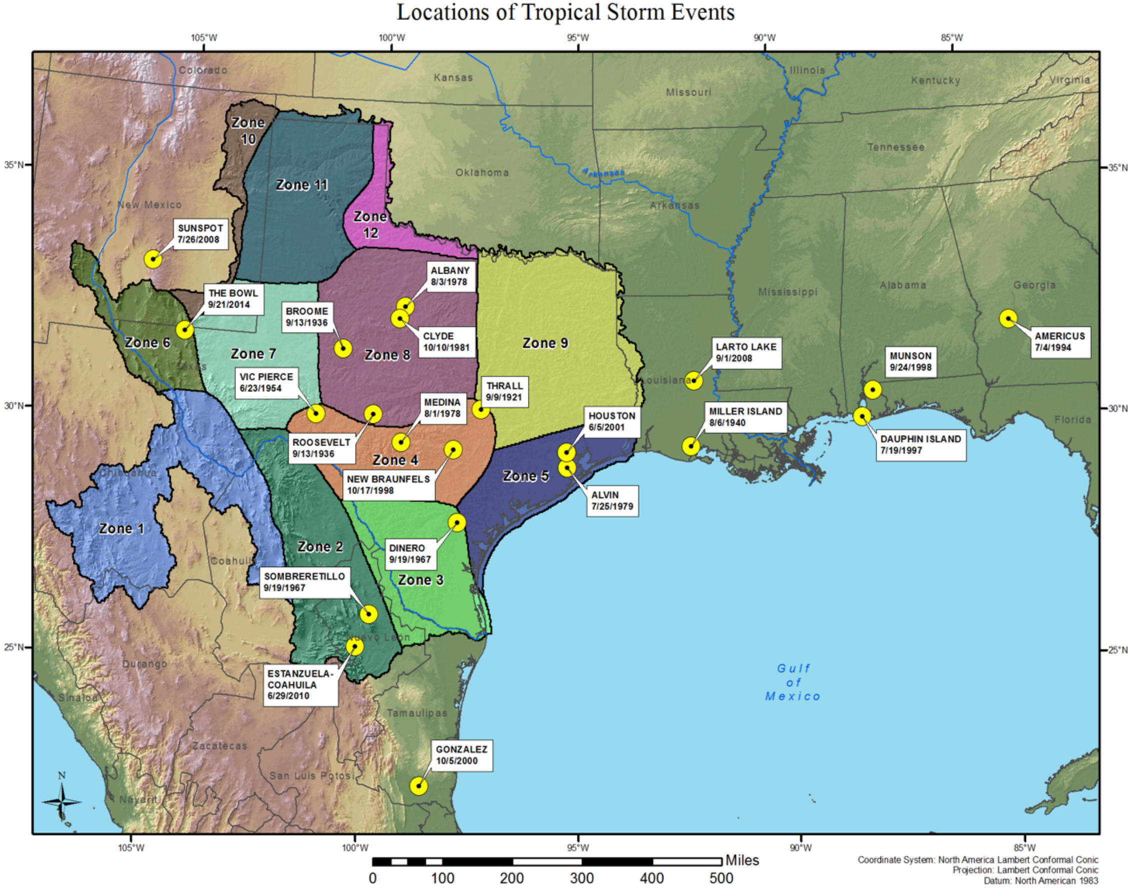


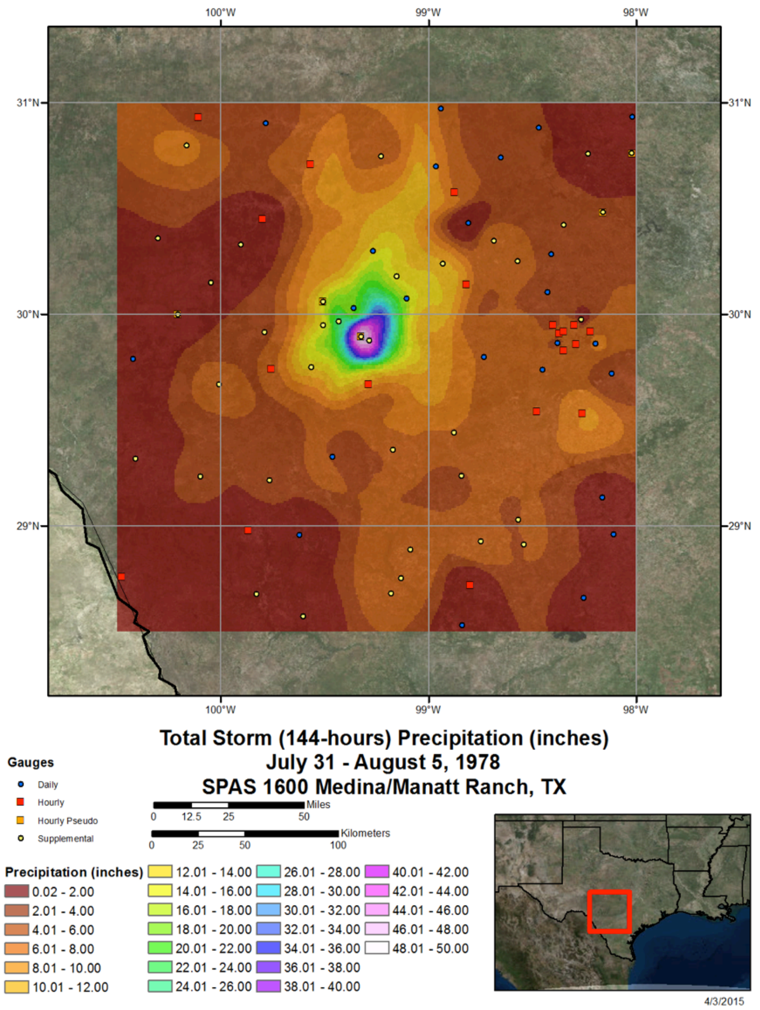
General storm locations

Locations of General Storm Events

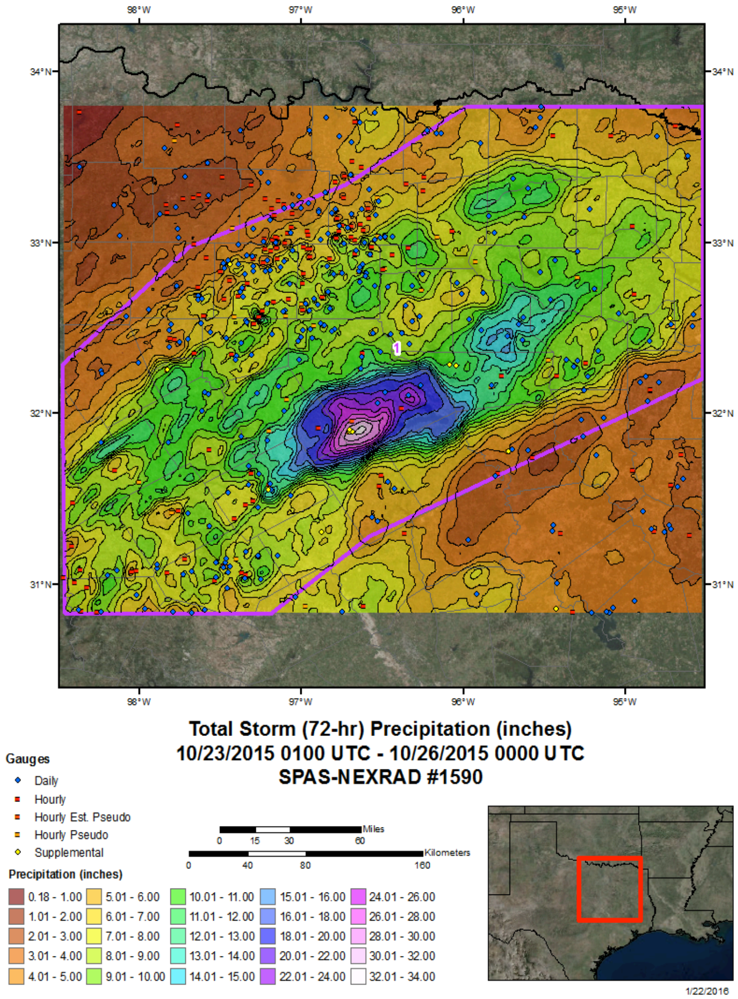


Tropical storm locations



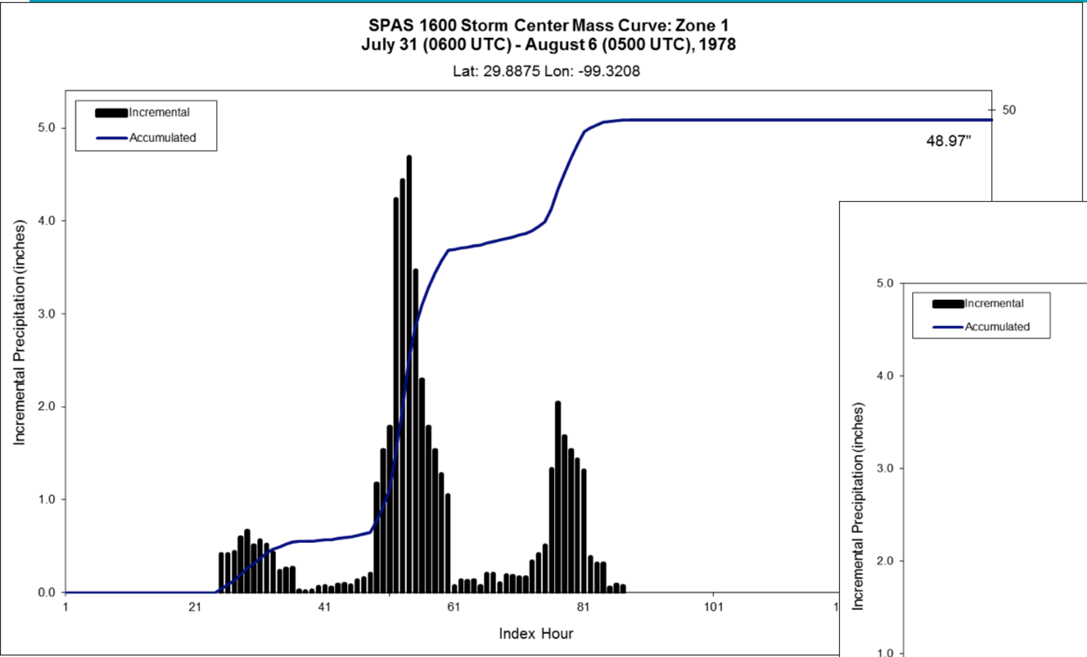


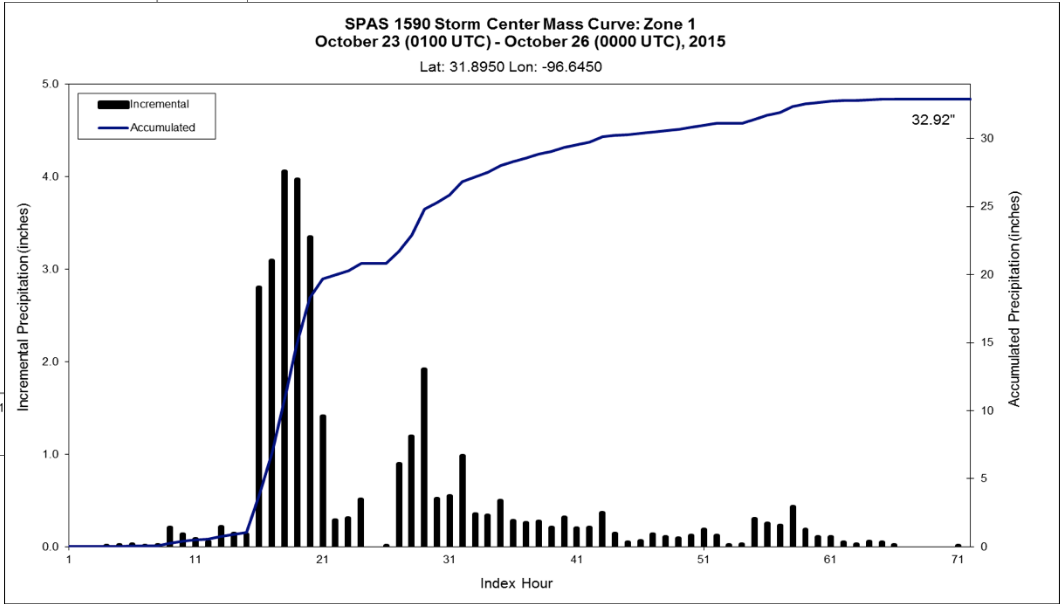
100°W
99°W
98°W
31°N
30°N
29°N
Total Storm (144-hours) Precipitation (inches)
July 31 - August 5, 1978
SPAS 1600 Medina/Manatt Ranch, TX
Gauges
Daily
Hourly
Hourly Pseudo
Supplemental
Miles
0 12.5 25 50
Kilometers
0 25 50 100
Precipitation (inches)
0.02 - 2.00
2.01 - 4.00
4.01 - 6.00
6.01 - 8.00
8.01 - 10.00
10.01 - 12.00
12.01 - 14.00
14.01 - 16.00
16.01 - 18.00
18.01 - 20.00
20.01 - 22.00
22.01 - 24.00
24.01 - 26.00
26.01 - 28.00
28.01 - 30.00
30.01 - 32.00
32.01 - 34.00
34.01 - 36.00
36.01 - 38.00
38.01 - 40.00
40.01 - 42.00
42.01 - 44.00
44.01 - 46.00
46.01 - 48.00
48.01 - 50.00
4/3/2015



98°W
97°W
96°W
95°W
34°N
33°N
32°N
31°N
1
Total Storm (72-hr) Precipitation (inches)
10/23/2015 0100 UTC - 10/26/2015 0000 UTC
SPAS-NEXRAD #1590
Gauges
Daily
Hourly
Hourly Est. Pseudo
Hourly Pseudo
Supplemental
Miles
0 15 30 60
Kilometers
0 40 80 160
Precipitation (inches)
0.18 - 1.00
1.01 - 2.00
2.01 - 3.00
3.01 - 4.00
4.01 - 5.00
5.01 - 6.00
6.01 - 7.00
7.01 - 8.00
8.01 - 9.00
9.01 - 10.00
10.01 - 11.00
11.01 - 12.00
12.01 - 13.00
13.01 - 14.00
14.01 - 15.00
15.01 - 16.00
16.01 - 18.00
18.01 - 20.00
20.01 - 22.00
22.01 - 24.00
24.01 - 26.00
26.01 - 28.00
28.01 - 30.00
30.01 - 32.00
32.01 - 34.00
1/22/2016

Probable Maximum Precipitation - Major Tasks

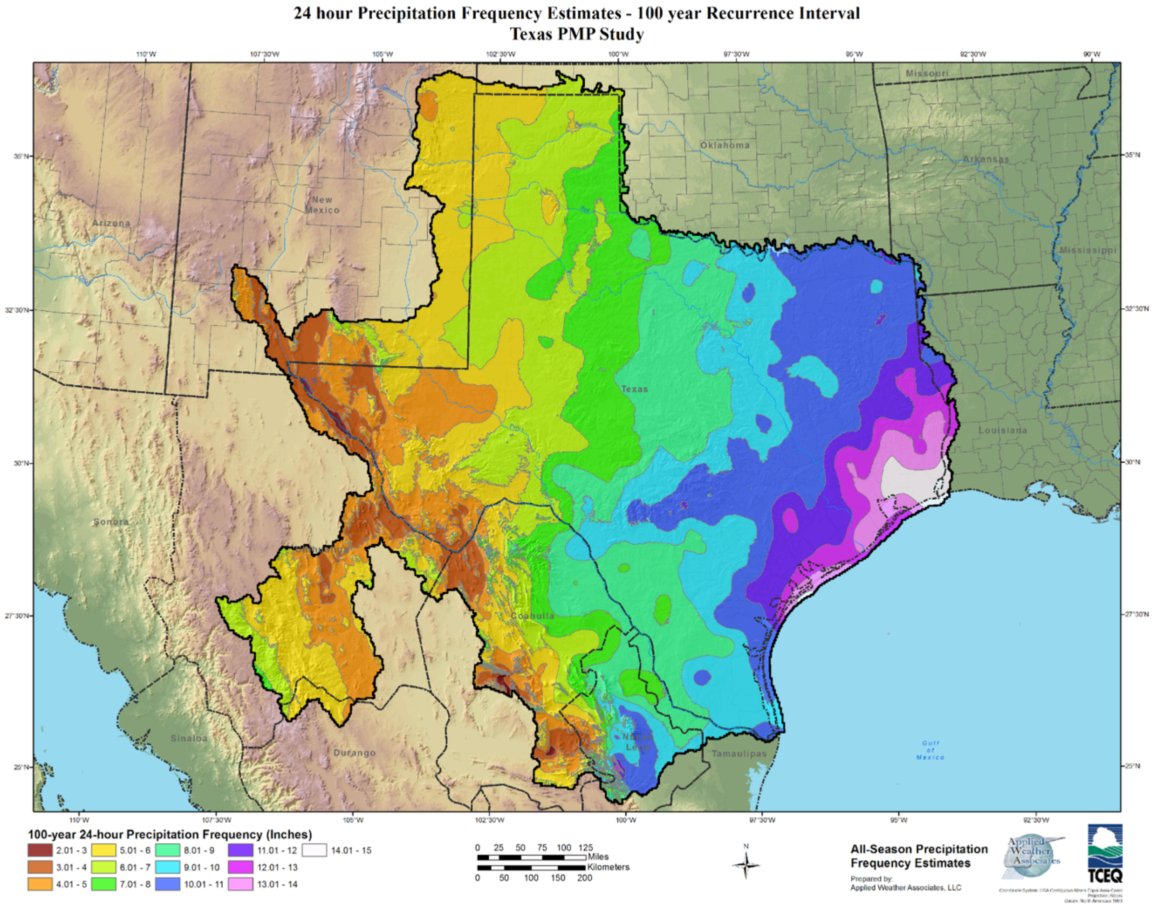




Probable Maximum Precipitation – DAD Table

Storm 1600 - July 31 (0600 UTC) - August 6 (0500 UTC), 1978															
MAXIMUM AVERAGE DEPTH OF PRECIPITATION (INCHES)															
Area (mi^2)	Duration (hours)														
	1	2	3	4	5	6	12	18	24	36	48	72	96	120	Total
0.3	4.67	9.10	13.31	16.77	19.06	20.83	29.15	29.96	30.91	42.39	43.51	48.82	48.82	48.97	48.97
1	4.63	9.02	13.20	16.62	18.90	20.66	28.90	29.70	30.65	42.04	43.16	48.43	48.43	48.43	48.43
10	4.53	8.81	12.90	16.26	18.45	20.19	28.24	29.06	29.95	41.06	42.17	47.34	47.34	47.34	47.34
25	4.41	8.58	12.57	15.83	17.99	19.67	27.51	28.30	29.19	40.03	41.12	46.16	46.16	46.16	46.16
50	4.24	8.26	12.09	15.23	17.30	18.93	26.47	27.25	28.12	38.52	39.59	44.52	44.54	44.54	44.54
100	3.92	7.64	11.19	14.08	15.99	17.52	24.48	25.24	26.11	35.65	36.72	41.54	41.58	41.58	41.58
150	3.63	7.04	10.33	12.97	14.70	16.16	22.53	23.38	24.25	32.85	34.04	38.80	38.86	38.86	38.86
200	3.40	6.52	9.57	12.00	13.56	14.97	20.76	21.73	22.54	30.36	31.65	36.45	36.56	36.56	36.56
300	3.03	5.71	8.40	10.48	11.76	13.05	17.90	19.16	19.91	26.30	27.95	32.67	32.85	32.85	32.85
400	2.78	5.10	7.53	9.33	10.52	11.63	15.91	17.28	18.11	23.50	25.38	29.93	30.12	30.12	30.12
500	2.59	4.65	6.87	8.44	9.56	10.54	14.34	15.87	16.74	21.54	23.79	27.81	28.04	28.04	28.04
1,000	2.03	3.42	5.04	6.02	6.85	7.58	10.35	11.91	12.74	16.59	18.95	21.59	21.79	21.79	21.79
2,000	1.39	2.30	3.45	4.04	4.69	5.20	7.46	8.78	9.66	12.55	14.65	16.35	16.51	16.51	16.51
5,000	0.70	1.20	1.65	2.05	2.38	2.73	4.57	5.74	6.33	8.34	9.82	10.87	10.97	10.97	10.97
10,000	0.46	0.82	1.08	1.35	1.65	1.85	2.76	3.44	4.52	6.21	6.80	7.71	7.71	7.71	7.71
20,000	0.27	0.50	0.67	0.84	1.01	1.14	1.74	2.21	2.84	4.01	4.41	5.11	5.14	5.14	5.14
25,872	0.22	0.40	0.54	0.67	0.82	0.92	1.39	1.77	2.37	3.38	3.75	4.38	4.42	4.42	4.42

Texas 24-hr 100-yr Precip Frequency



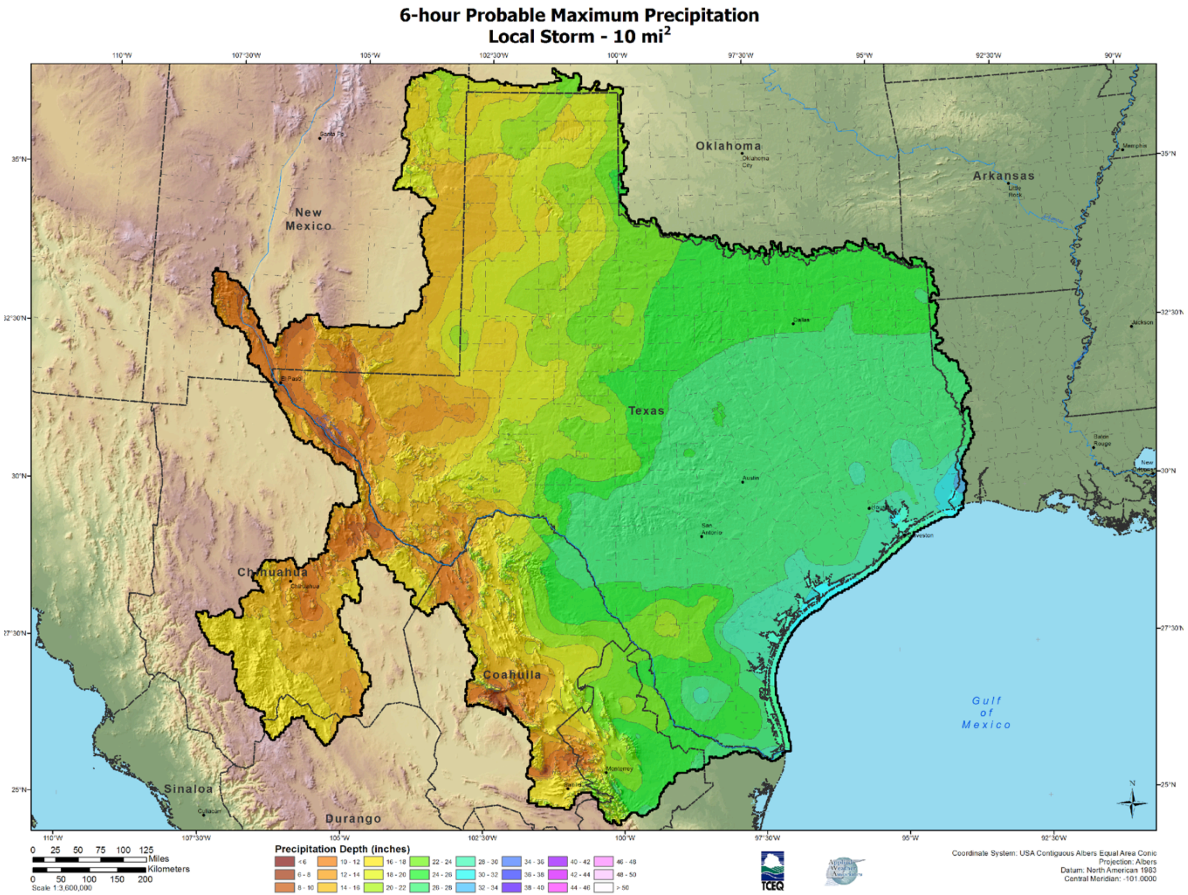
Probable Maximum Precipitation - Major Tasks

- Each storm adjusted and specific transposition limits applied
  - In-place maximization
  - Differences in moisture
  - Difference in topography and all other precipitation producing processes

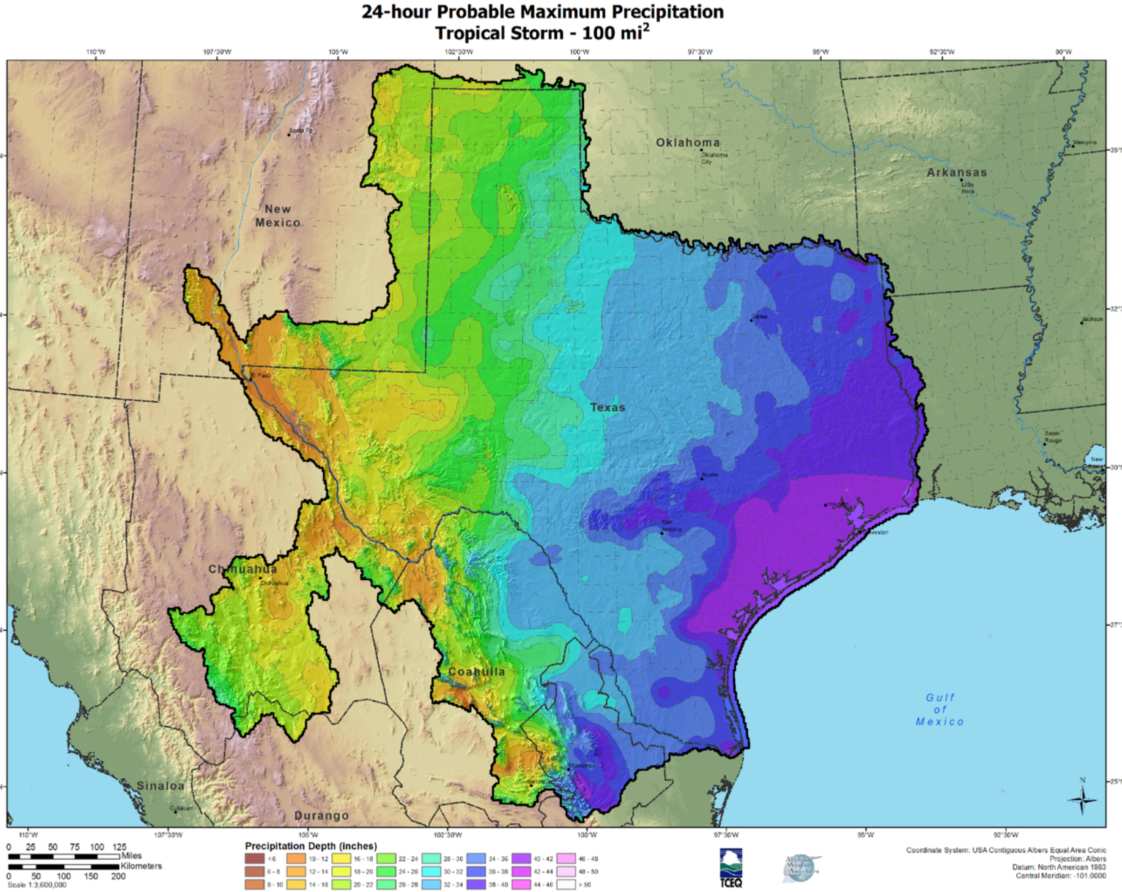
IPMF x MTF x GTF = Total Adjustment Factor

  - Derived for each grid for each storm
  - Greatest depth at each grid by storm type by duration becomes PMP for that grid

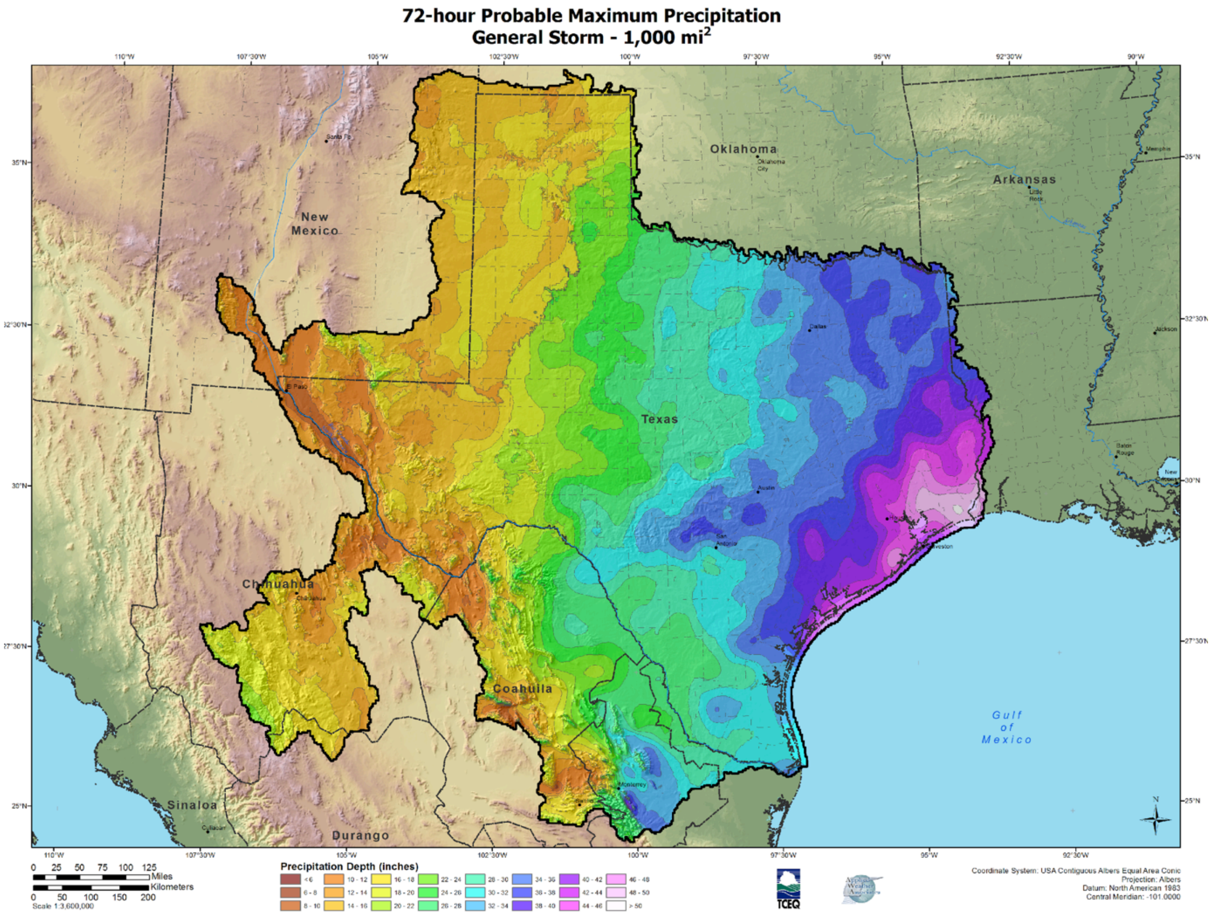
Texas Local Storm PMP 6-hour 10-square mile



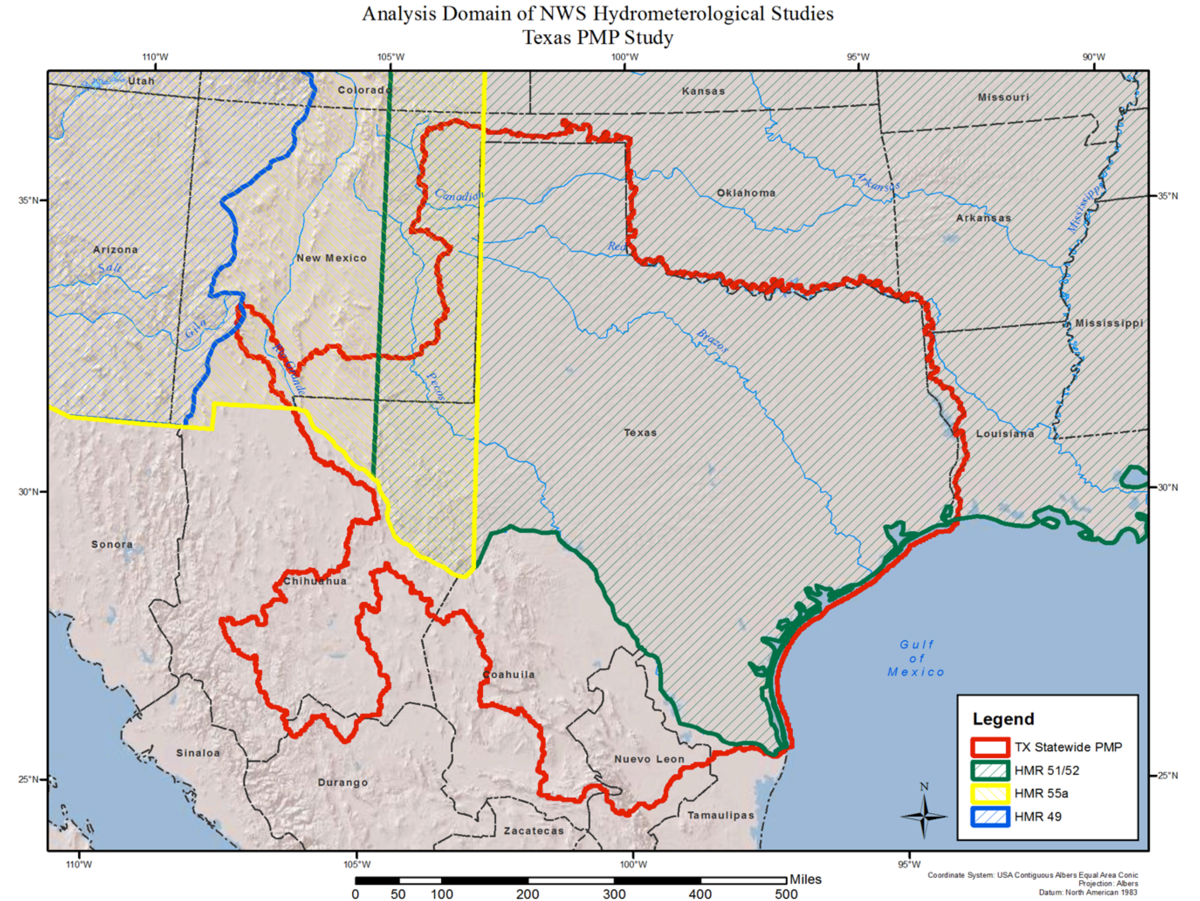
Texas Tropical Storm PMP 24-hour 100-sq mile



Texas General Storm PMP 72-hour 1000-sq mile



Coverage of HMRs over Texas PMP Domain



Texas PMP Compared to HMR 51 Values

Average PMP Percent Change from HMR 51 (by transposition zone)										
Duration	Area	Zone 3	Zone 4	Zone 5	Zone 7	Zone 8	Zone 9	Zone 10	Zone 11	Zone 12
6-hour	10-sqmi	-18%	-10%	-11%	-31%	-16%	-15%	-28%	-28%	-20%
6-hour	200-sqmi	-14%	-8%	-3%	-30%	-15%	-11%	-31%	-27%	-19%
6-hour	1,000-sqmi	-13%	-7%	-11%	-35%	-20%	-12%	-37%	-33%	-23%
6-hour	5,000-sqmi	-10%	-5%	3%	-39%	-15%	-2%	-51%	-47%	-20%
6-hour	10,000-sqmi	-18%	-14%	-3%	-40%	-23%	-7%	-47%	-42%	-27%
6-hour	20,000-sqmi	-19%	-11%	-7%	-38%	-25%	-9%	-49%	-38%	-30%
12-hour	10-sqmi	-9%	-4%	-3%	-34%	-18%	-7%	-37%	-33%	-21%
12-hour	200-sqmi	-9%	-2%	-5%	-26%	-10%	-5%	-29%	-24%	-11%
12-hour	1,000-sqmi	-18%	-10%	-10%	-25%	-14%	-8%	-25%	-21%	-13%
12-hour	5,000-sqmi	-4%	0%	9%	-29%	-12%	9%	-41%	-34%	-16%
12-hour	10,000-sqmi	-4%	2%	11%	-35%	-10%	11%	-44%	-37%	-16%
12-hour	20,000-sqmi	-7%	0%	7%	-28%	-11%	5%	-43%	-33%	-15%
24-hour	10-sqmi	-9%	-3%	-4%	-33%	-15%	-4%	-33%	-27%	-15%
24-hour	200-sqmi	-10%	-2%	-8%	-18%	-2%	-4%	-15%	-10%	2%
24-hour	1,000-sqmi	-10%	-3%	-16%	-10%	4%	-7%	-3%	2%	13%
24-hour	5,000-sqmi	-13%	-3%	-2%	-17%	-7%	2%	-12%	-8%	-1%
24-hour	10,000-sqmi	-4%	8%	8%	-17%	2%	12%	-29%	-20%	3%
24-hour	20,000-sqmi	7%	18%	21%	-9%	11%	21%	-36%	-14%	12%
48-hour	10-sqmi	-8%	-5%	-9%	-23%	-5%	-8%	-22%	-16%	-3%
48-hour	200-sqmi	4%	10%	-4%	-5%	15%	6%	-3%	4%	19%
48-hour	1,000-sqmi	-1%	6%	-4%	-2%	13%	2%	1%	8%	21%
48-hour	5,000-sqmi	-12%	-5%	4%	-15%	-4%	4%	-10%	-7%	1%
48-hour	10,000-sqmi	-9%	1%	4%	-22%	-5%	7%	-21%	-19%	-6%
48-hour	20,000-sqmi	-2%	8%	12%	-16%	2%	14%	-30%	-18%	1%
72-hour	10-sqmi	-14%	-9%	-15%	-25%	-10%	-13%	-25%	-19%	-8%
72-hour	200-sqmi	-6%	0%	-9%	-10%	5%	-3%	-6%	-1%	12%
72-hour	1,000-sqmi	-10%	-4%	-1%	-10%	2%	0%	-4%	1%	11%
72-hour	10,000-sqmi	-20%	-8%	4%	-22%	-9%	3%	-18%	-14%	-6%
72-hour	10,000-sqmi	-23%	-11%	-1%	-27%	-11%	-1%	-29%	-25%	-9%
72-hour	20,000-sqmi	-20%	-10%	-4%	-25%	-13%	-4%	-34%	-23%	-12%

Texas PMP Compared to HMR 55A Values

Percent Change from HMR 55A PMP							
Point	Latitude	Longitude	Zone	1-hour 1-mi^2	6-hour 10-mi^2	24-hour 10-mi^2	72-hour 10-mi^2
1	29.50°	-104.00°	1	-54.2%	-41.0%	-44.1%	-38.0%
2	29.50°	-103.25°	1	-53.0%	-38.6%	-40.1%	-33.8%
3	30.50°	-104.50°	1	-54.9%	-41.4%	-40.9%	-35.0%
4	30.50°	-103.25°	7	-51.2%	-31.1%	-33.1%	-26.3%
5	31.50°	-105.75°	6	-42.6%	-20.0%	-17.1%	-8.9%
6	31.50°	-104.50°	6	-53.3%	-38.9%	-36.9%	-30.3%
7	31.50°	-103.25°	7	-65.3%	-44.4%	-46.0%	-37.8%
8	32.50°	-107.00°	6	-38.9%	-25.0%	-28.2%	-22.1%
9	32.50°	-105.75°	6	-51.7%	-31.1%	-27.9%	-21.3%
10	32.50°	-104.50°	10	-53.9%	-38.6%	-34.6%	-27.4%
11	32.50°	-103.25°	7	-51.9%	-21.4%	-19.7%	-10.8%
12	33.25°	-107.50°	6	-38.2%	-25.7%	-29.8%	-24.3%
13	33.75°	-103.25°	11	-52.3%	-37.1%	-31.0%	-22.6%
14	35.00°	-104.00°	10	-52.8%	-27.5%	-35.1%	-26.7%
15	35.00°	-103.25°	11	-53.8%	-39.0%	-34.7%	-24.7%
16	36.25°	-104.00°	10	-45.1%	-33.9%	-38.7%	-31.2%
17	36.25°	-103.25°	10	-33.1%	-22.0%	-30.4%	-21.6%

Implementation– Texas CEQ Perspective

- Identified GeoProcessing Service as the ideal solution
- Agency had never implemented a GeoProcessing Service so there was no assistance or resources to help
- Required server access and permissions
- Dam Safety Program has a person with extensive GIS experience and a willingness to learn coding
- We became the “guinea pig” for the agency for program staff to get server access with permissions to publish.
- Had to learn python & how to publish GeoProcessing Service

Implementation– Texas CEQ Perspective

- Sought assistance from Applied Weather Associates and from ESRI
- Tested all possible scenarios, especially after each change
- Had to identify the proper projections to avoid differences in the results
- Wrote user guide
- Initially set Jan. 1, 2017, for availability of PMP tool
- Took 5 months to develop and publish
- Released at a Dam Owner workshop on Jan. 25, 2017
- Set up an e-mail for questions or problems

Results– Texas CEQ Perspective

- One large dam was found to be adequate without modification, saving $1.5 million
- One dam with a small drainage area had a cost savings of $75,000 to $100,000
- A new dam had a cost savings of $140,000
- One dam had a cost savings of about $100,000, which was about half the project costs
- Another has a cost savings of $100,000, which was about 10% of the total costs

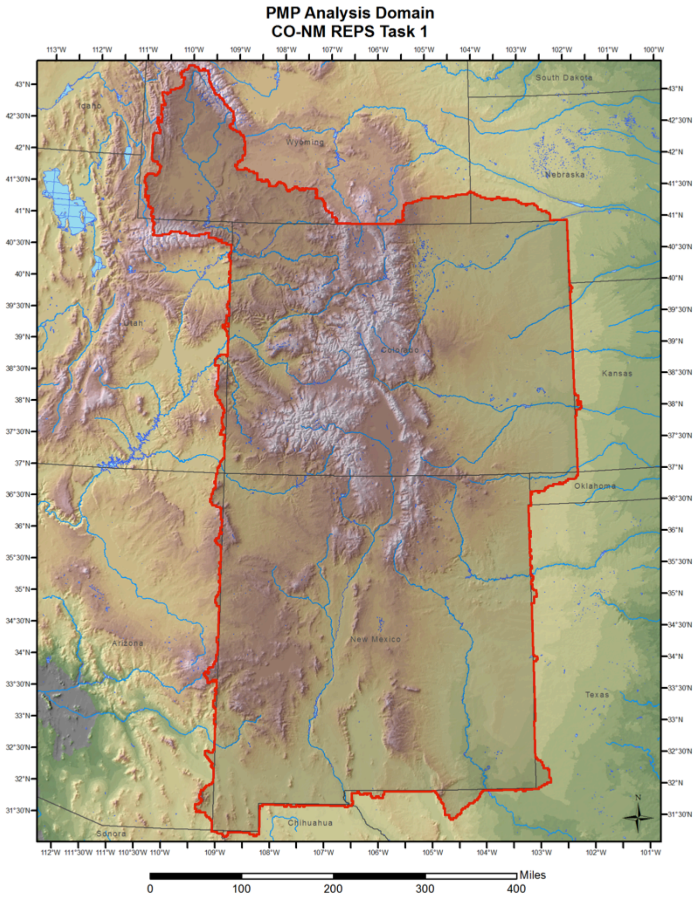
Results– Texas CEQ Perspective

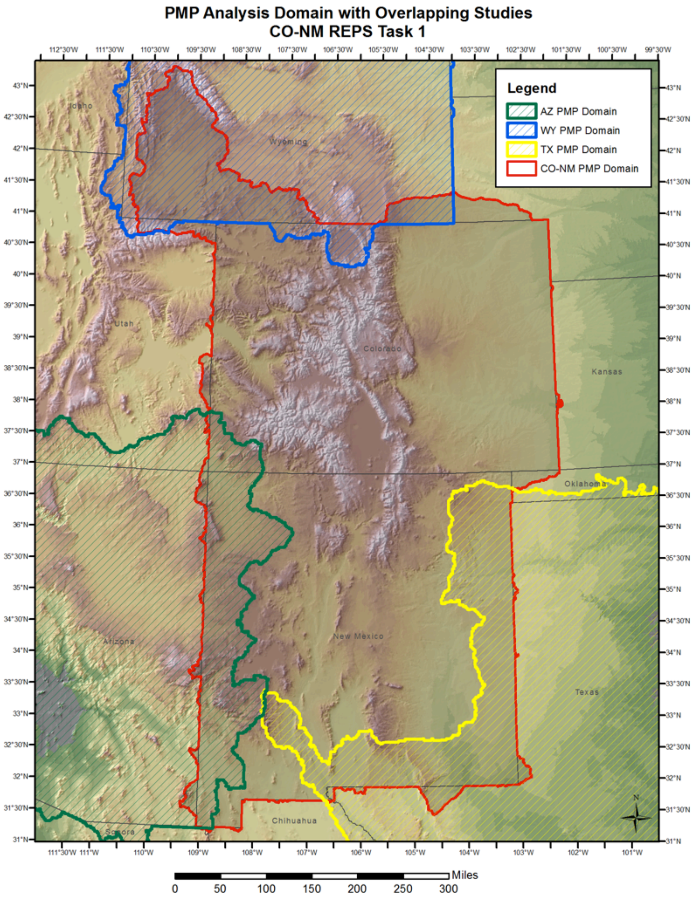
- One larger project, already approved by TCEQ, was checked and found that the PMP went up, resulting in a rise of 2 feet
- A new dam was found to have virtually no reduction in dam height, essentially no cost savings

Next Steps – Texas CEQ Perspective

- We are developing a web map to publish on our server, where individuals or companies without GIS capabilities can create a watershed and use the tool
- Should be available soon

Colorado-New Mexico PMP Domain





Colorado-New Mexico PMP

- High elevation rainfall/PMP
  - Rain vs snow
  - Lack of observed rainfall events
- Wide variety of meteorology/topography
- Unique consortium of participants/reviewers
  - Many different experiences/backgrounds/ideas
- Unique combination of tasks
  - Leverage off other tasks' work
  - Coordination between tasks

Question?