

Calculating Arizona Statewide PMP Using The PMP Evaluation Tool

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ASDO Dam Safety 2013
September 8-12, 2013 Providence, RI

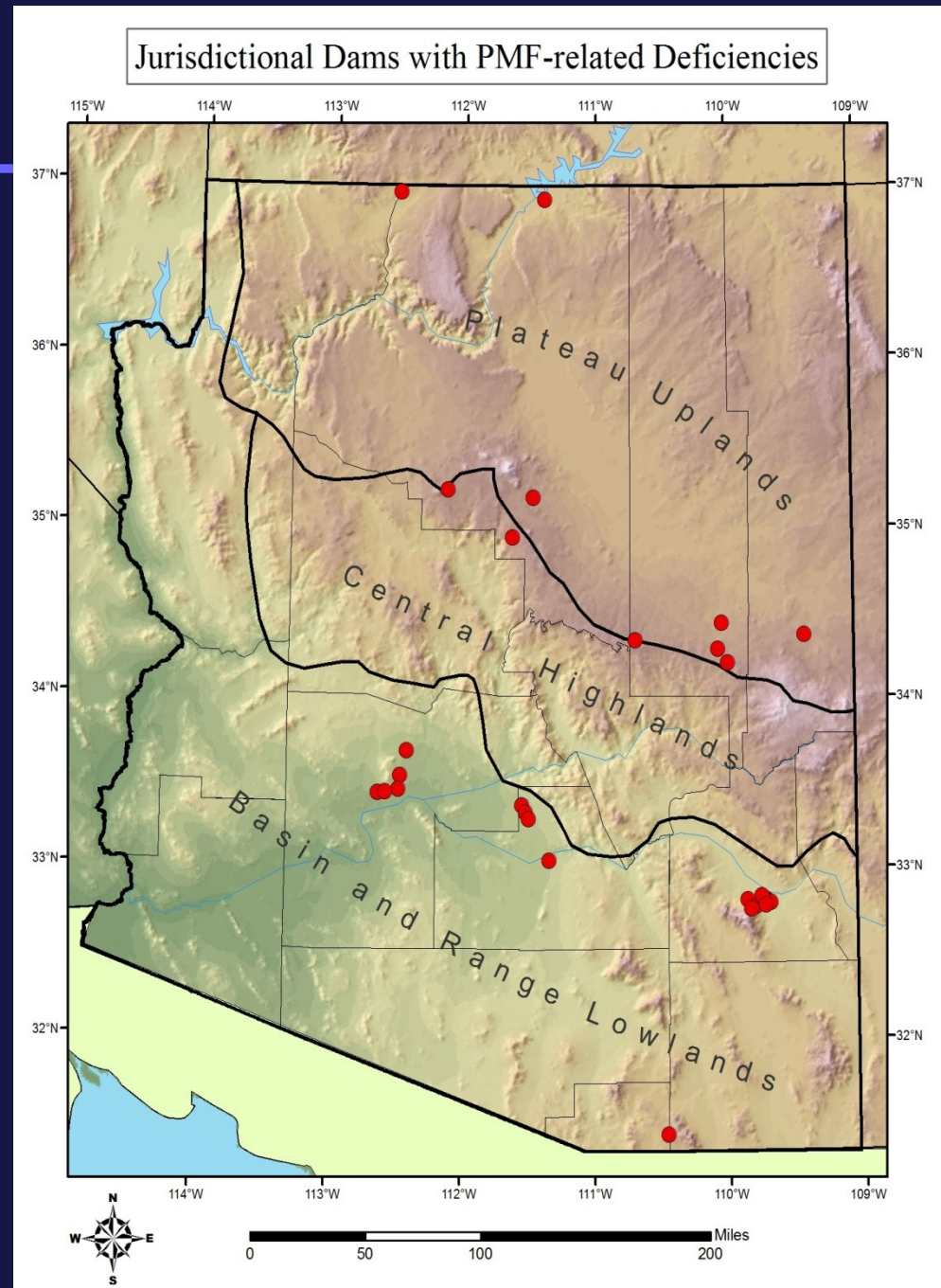


Reasons For Study-AZ

Deficient Dams:
29 state-regulated
>\$75,000,000 estimated
upgrade costs

**State-of-practice data
and understanding**

**Regulator/Owner
confidence in
results/applications**



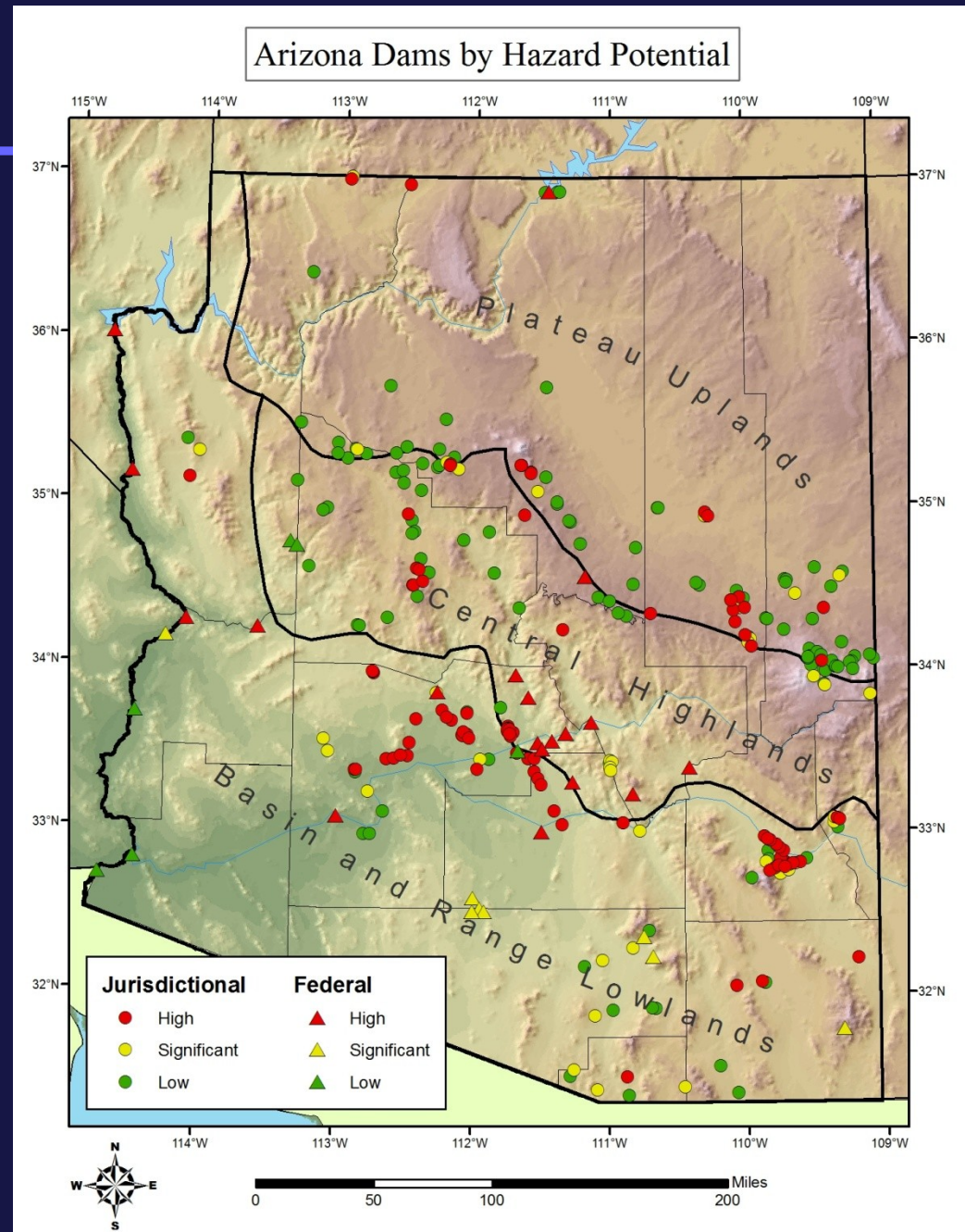
Reasons For Study

“Hazard creep”

In past 3 years:
17 dams reclassified

More than half
deficient

156 more could be
reclassified in the
future



Cooperative Efforts-AZ

- Funding/Cooperating Partners
 - Arizona Department of Water Resources
 - Arizona Game & Fish Department
 - FCD (Maricopa, Navajo)
 - NRCS
 - FEMA (NDSP State Assistance Grant)
- Working together all partners achieve desired results
- State/Users benefit at a reduced cost



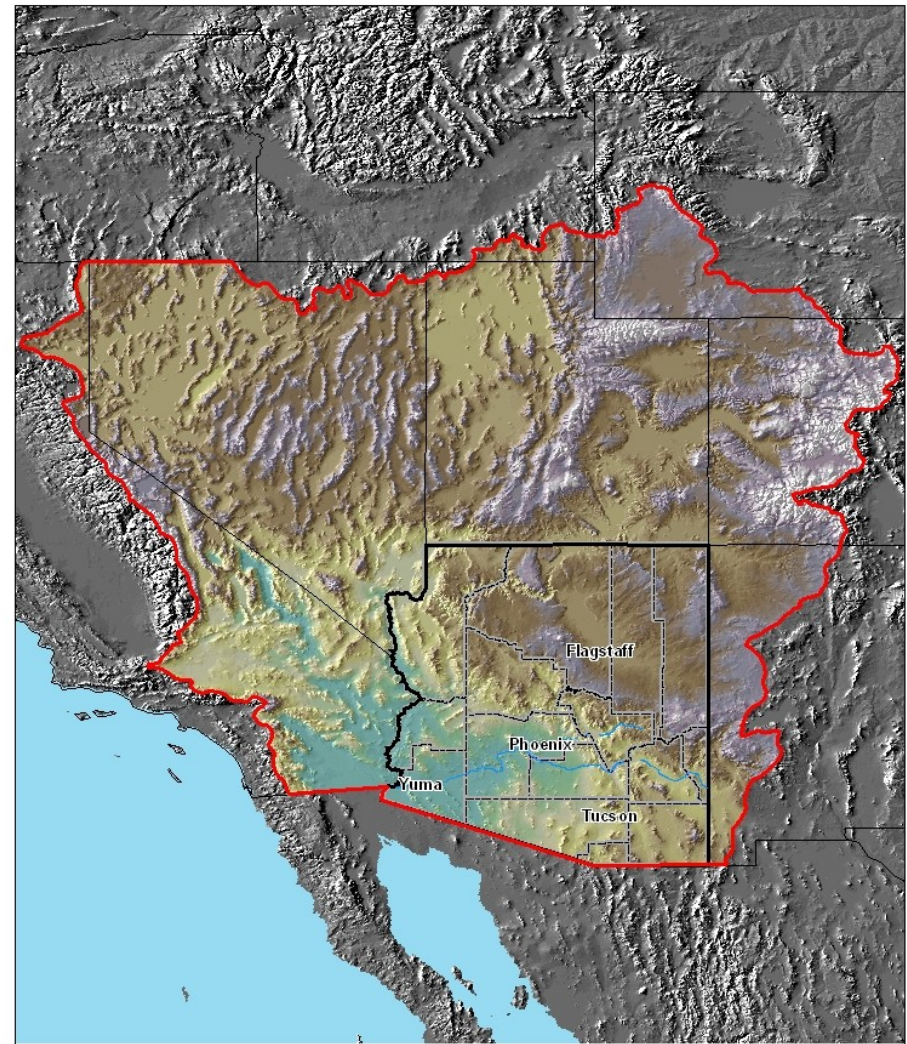
Expected Project Benefits

- Reduced Construction Costs
 - New Dams
- Reduced Rehabilitation Costs
 - Remove need for rehabilitation
 - Millions in cost savings during useful lifetime
- Reclaimed Opportunity Costs
 - Flood protection
 - Storage capacities
 - Operational availability



HMR 49 Domain

HMR 49 Boundary



Miles
0 50 100 200 300 400

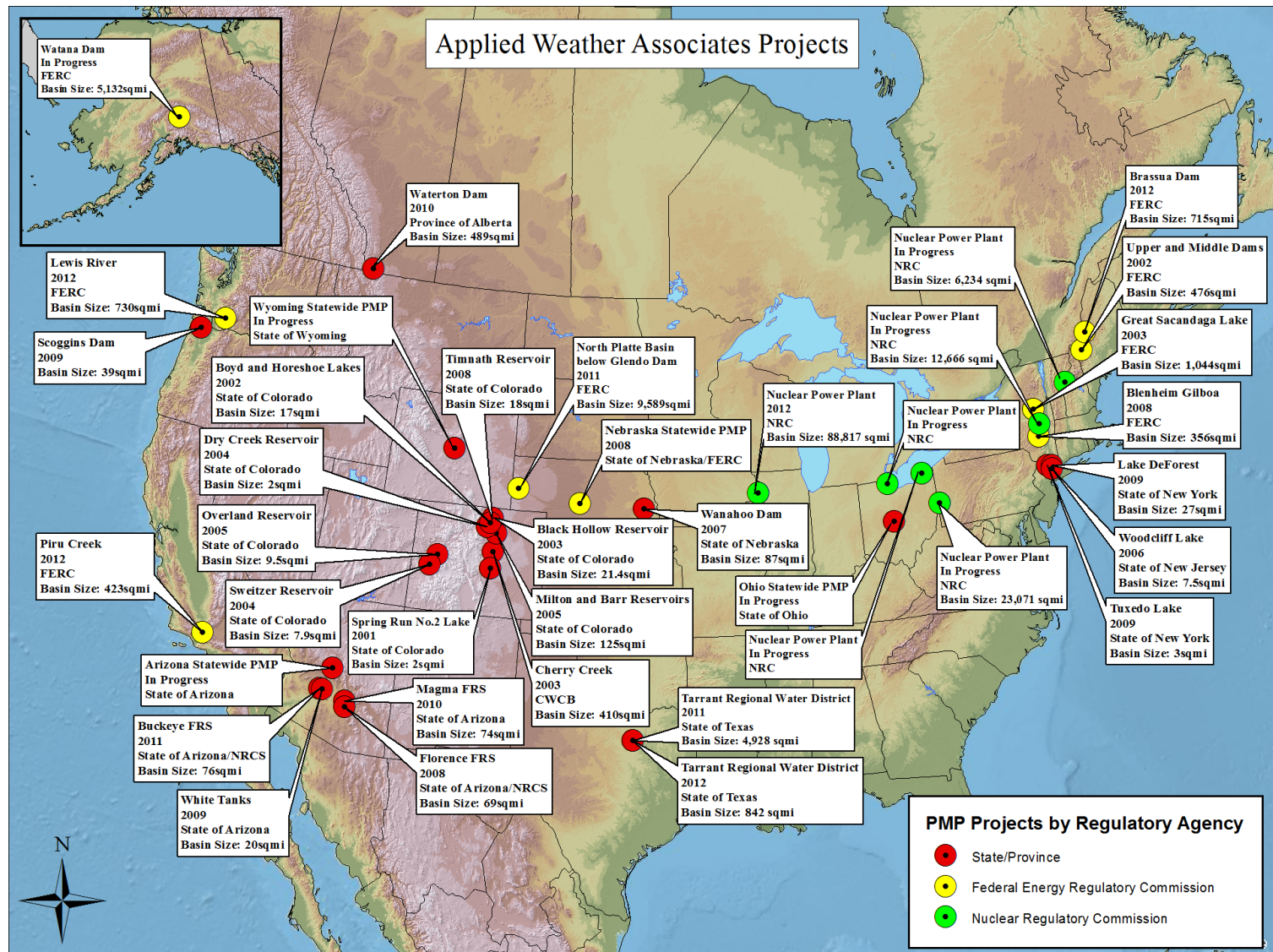


Why Does HMR 49 Need Updating?

- HMR 49
 - The oldest of the HMRs currently in use
 - Based on outdated methods and techniques no longer used
 - Few Storms used
 - No DADs



Not Our First PMP Study

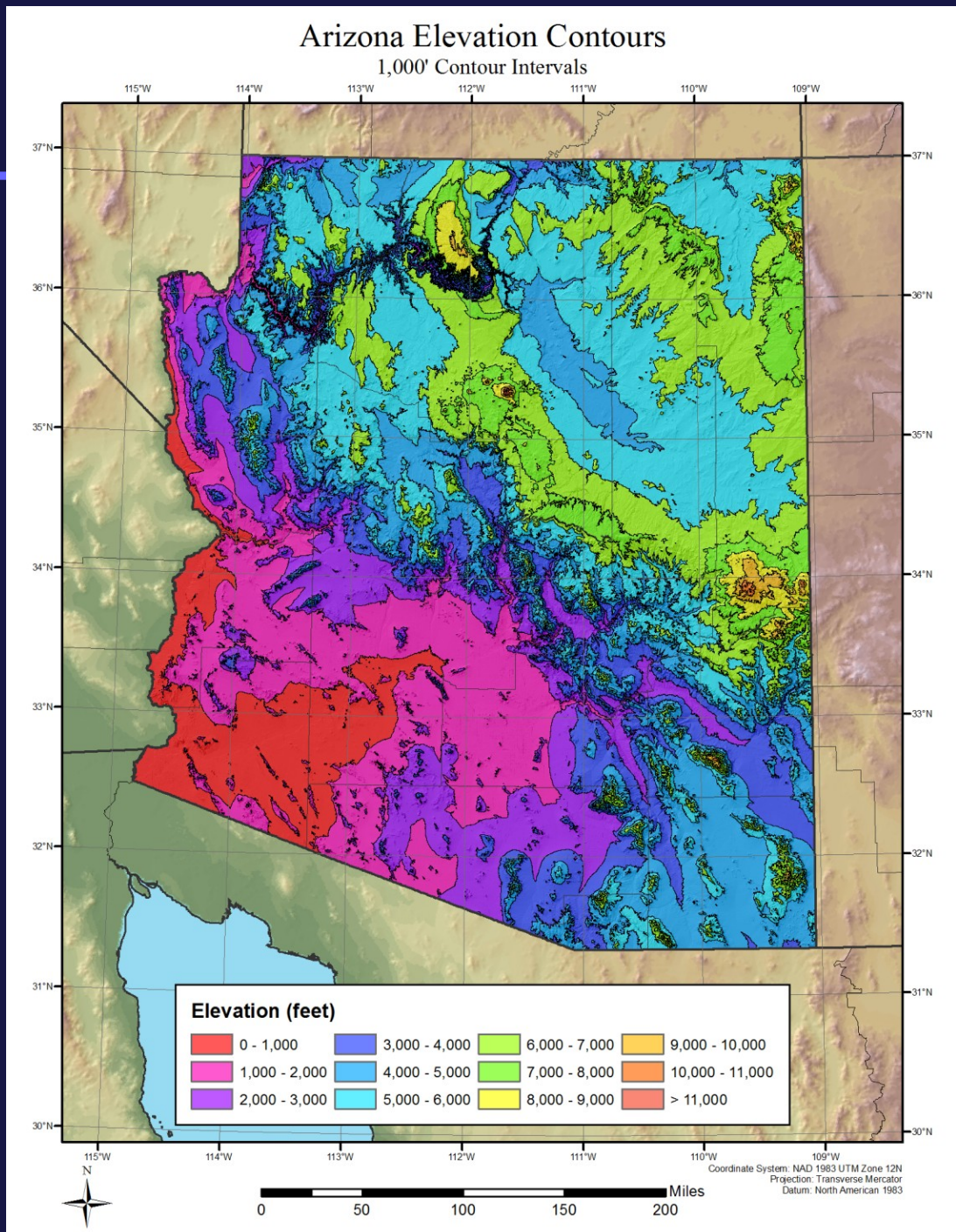


How Did We Compute PMP?

- Storm Based Approach
 - Similar to HMR/WMO procedures
 - Deterministic
- Maintain consistency with AWA PMP studies
 - Improvements in understanding
 - Expanded data base
 - Use of computer technologies
 - Use of NEXRAD weather radar
 - Better understanding of meteorology



Elevations Across Arizona, 1,000 Foot Interval



Updating PMP-What Did We Do

- Storm Search
 - Update the storm database
 - Identify the most extreme rainfall events
 - Throughout the state
 - Surrounding regions
 - Identify Storm Types
 - Local Convective
 - Remnant Tropical (Arizona only)
 - General Frontal

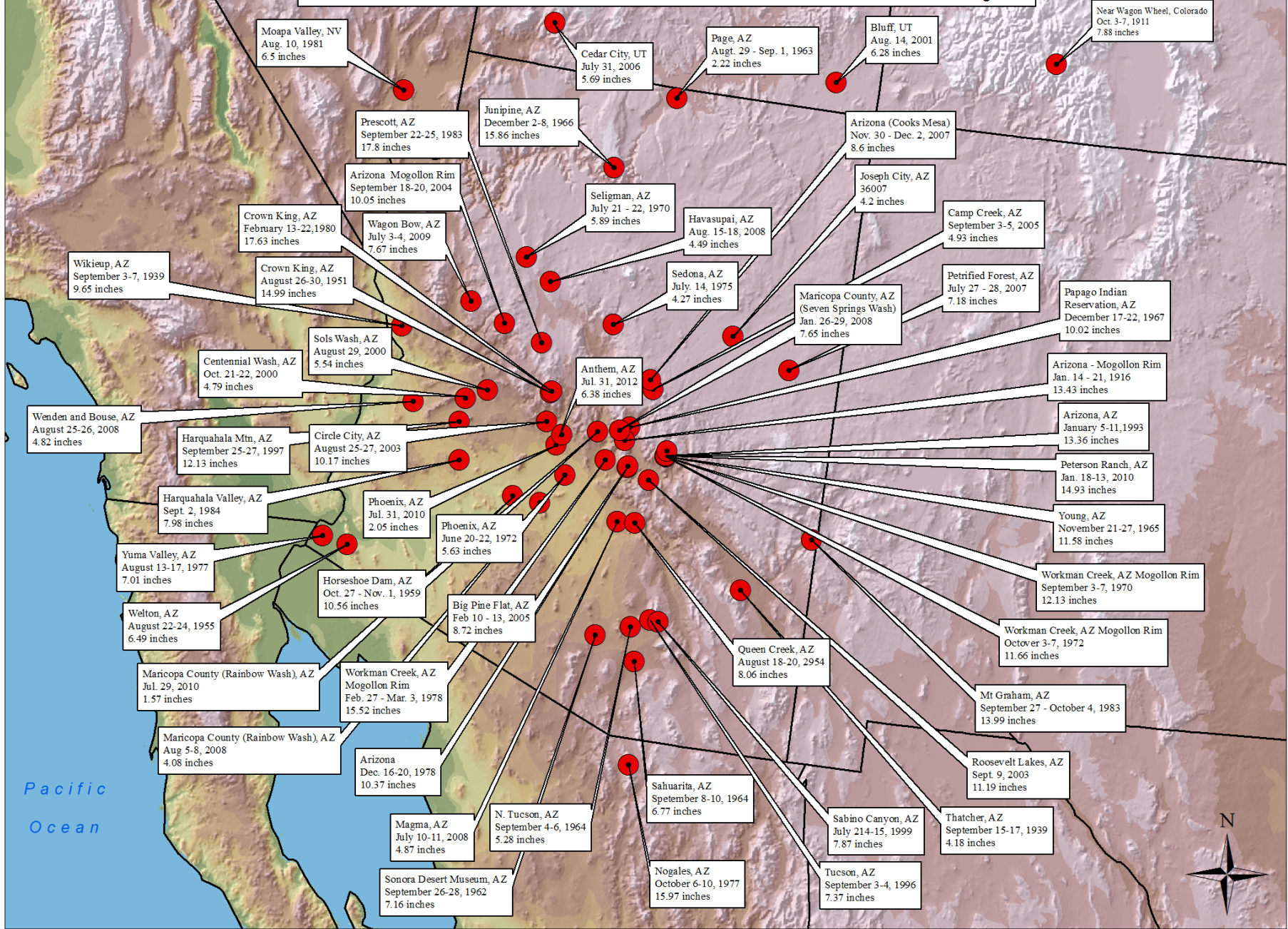


Updating PMP-Storm Search

- 1000's of storms initially captured
- Grouped by storm type
 - Local Convective, tropical, Frontal
 - Location
 - Duration
- Storms used in HMRs included
- Ensure no potential PMP storms missed
- Storms must be transpositionable
 - Meteorological and topographical similar characteristics



SPAS Storm Locations - Arizona Statewide PMP Project

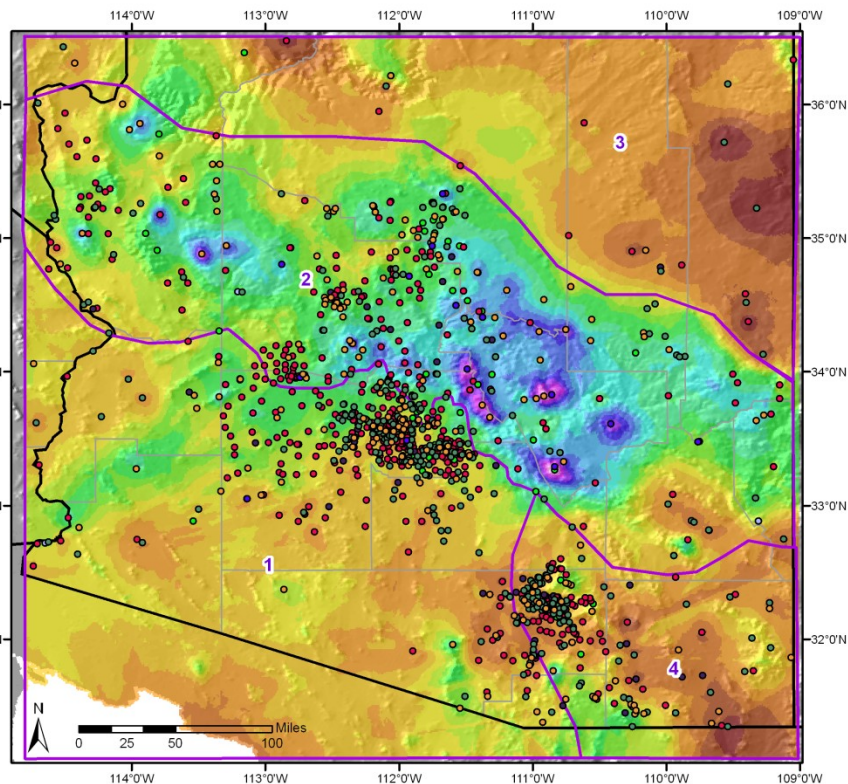


Updating PMP-Storm Analysis

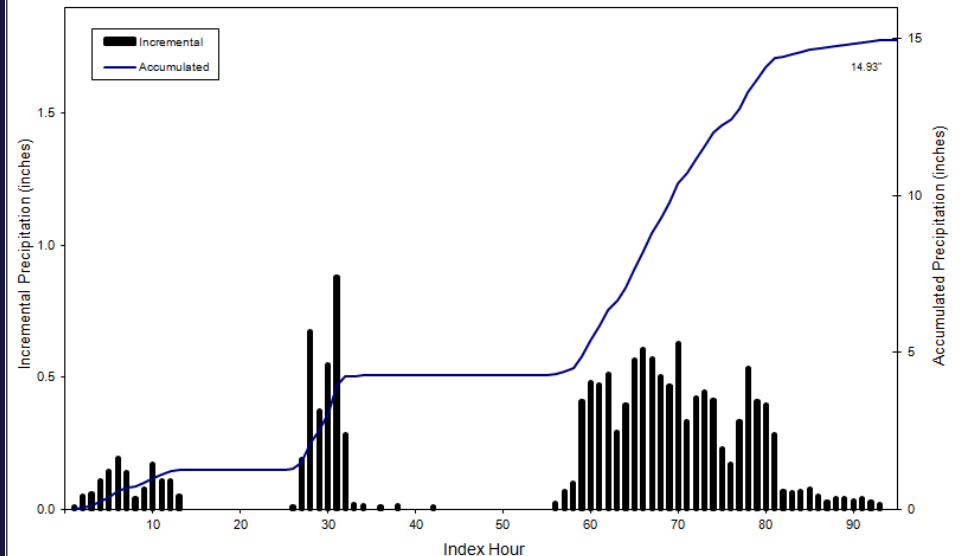
- Storm Precipitation Analysis System (SPAS)
 - Depth-Area-Duration
 - Mass Curves
 - Storm Isohyetal
 - Hourly (5-minute rainfall) at 1/3rd square mile
 - Dynamically adjusted radar and/or basemap for spatial interpolation



SPAS Storm Analysis Results



SPAS 1200 Storm Center Mass Curve: Zone 2
 January 19 (0000 UTC) to January 22 (2300 UTC), 2010
 Lat: 33.81 Lon: -110.91



Storm 1200 - January 19, 2010 (0000 UTC) - January 22, 2010 (0400 UTC)
 MAXIMUM AVERAGE DEPTH OF PRECIPITATION (INCHES)

Area (mi ²)	Duration (hours)										
	1	3	6	12	18	24	36	48	72	95	Total
0	1.15	2.33	3.8	6.03	8.09	9.98	10.6	10.99	13.66	14.93	14.93
1	1.1	2.26	3.71	5.81	7.92	9.72	10.39	10.7	13.43	14.57	14.57
10	1.04	2.09	3.64	5.75	7.56	9.1	9.94	10.27	12.95	14.52	14.52
25	0.96	2.01	3.54	5.56	7.31	8.7	9.62	9.89	12.53	13.99	13.99
50	0.88	1.97	3.39	5.38	7.02	8.46	9.33	9.51	12.16	13.44	13.44
100	0.85	1.89	3.31	5.09	6.84	8.05	8.98	9.15	11.67	12.82	12.82
150	0.82	1.83	3.21	4.86	6.57	7.95	8.79	8.9	11.34	12.44	12.44
200	0.8	1.79	3.14	4.72	6.53	7.7	8.56	8.73	11.18	12.18	12.18
300	0.73	1.72	3.02	4.58	6.26	7.57	8.36	8.52	10.89	11.79	11.79
400	0.72	1.66	2.94	4.48	6.04	7.36	8.14	8.31	10.6	11.51	11.51
500	0.71	1.61	2.87	4.4	5.76	7.1	7.97	8.12	10.29	11.28	11.28
1,000	0.62	1.34	2.34	4	5.53	6.37	7.05	7.51	8.75	10.48	10.48
2,000	0.52	1.29	2.28	3.6	4.95	5.93	6.64	6.64	8.51	9.78	9.78
5,000	0.43	1.08	1.93	2.92	4.4	5.1	5.78	5.78	7.49	8.6	8.60
10,000	0.39	0.9	1.59	2.77	3.78	4.39	5.04	5.21	6.57	7.58	7.58
20,000	0.28	0.71	1.29	2.32	2.88	3.53	4.28	4.59	5.51	6.37	6.37
40,231	0.19	0.53	1.02	1.74	2.35	2.77	3.23	3.43	4.36	4.74	4.74

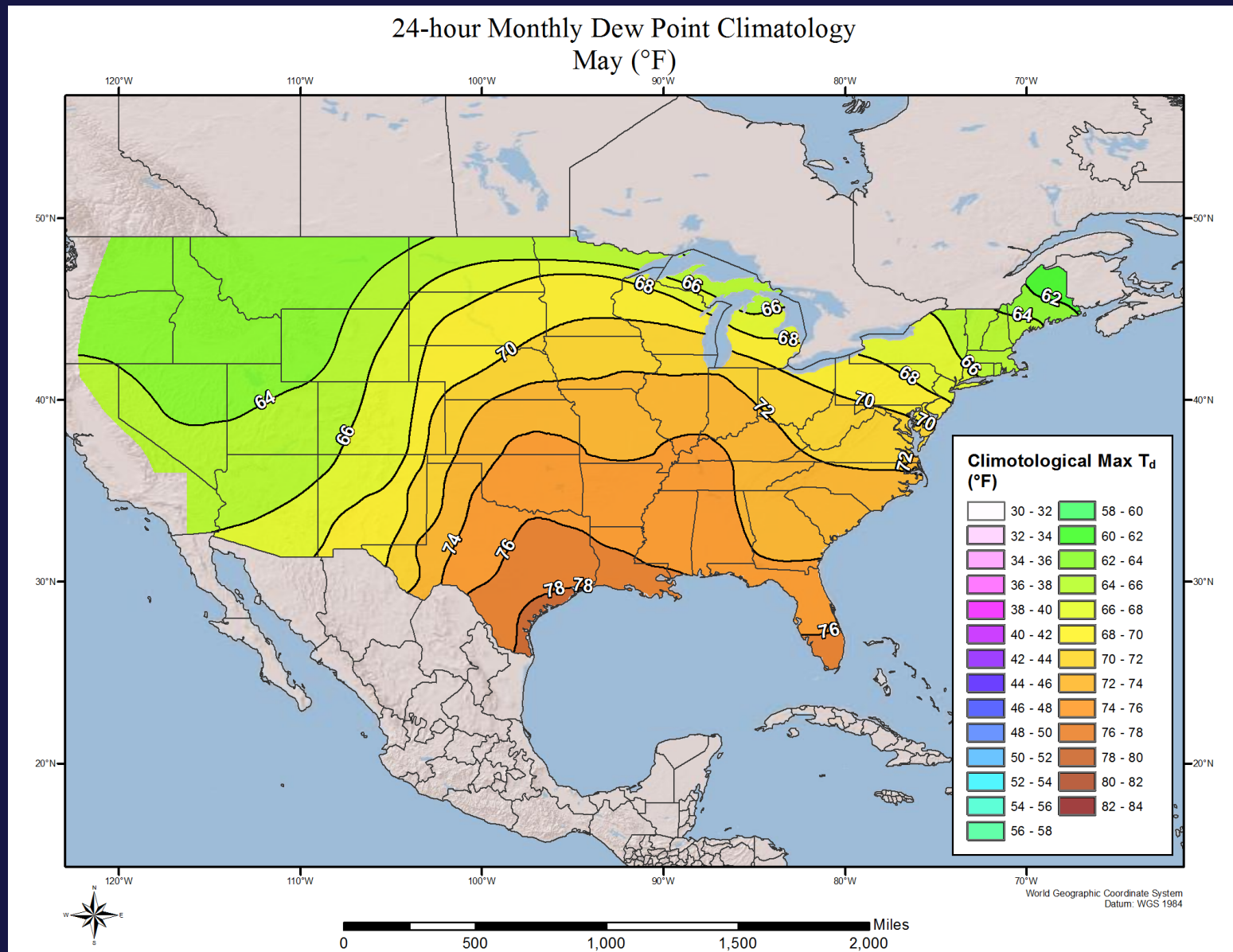


How Did We Compute PMP?

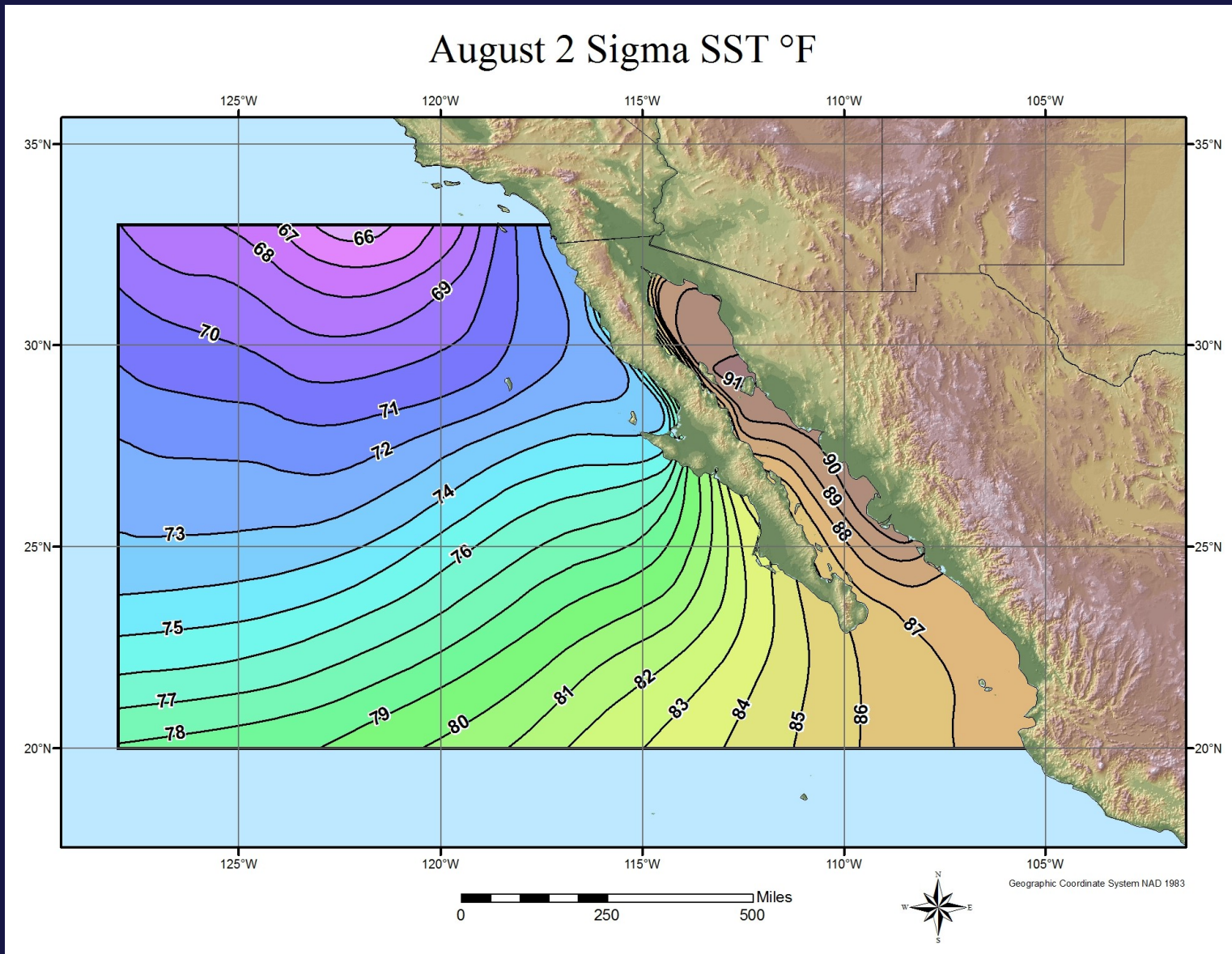
- Each storm maximized
 - Make it as big as physically possible
 - Storm rainfall = dynamics + moisture
 - Can't quantify dynamics, can quantify moisture
 - Assume most efficient storm dynamics
 - Only moisture varies
 - Use surface dew points or SST for maximization
- Determine moisture which fed the storm = fuel
- Ratio: climatological maximum moisture to actual storm moisture = in-place maximization factor



Dew Point Map, May 24-hr 100-yr



Sea Surface Temp, August +2-sigma



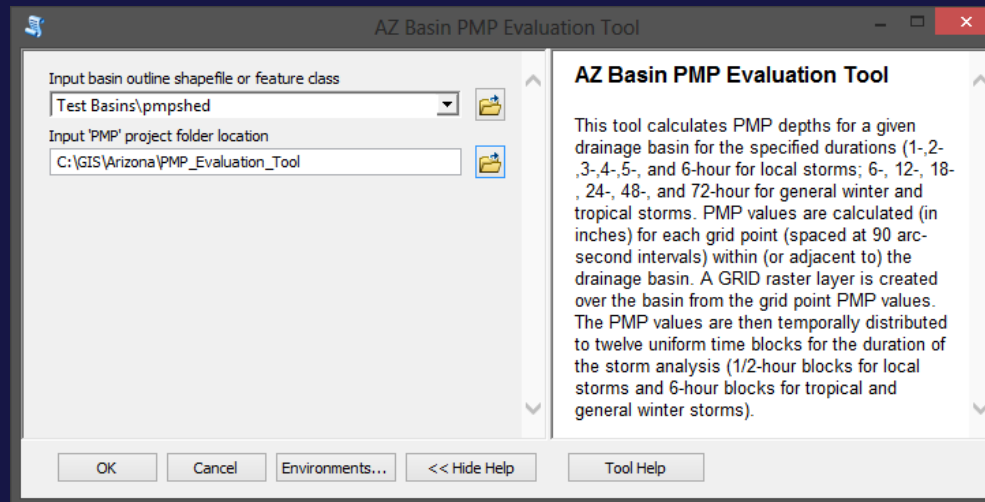
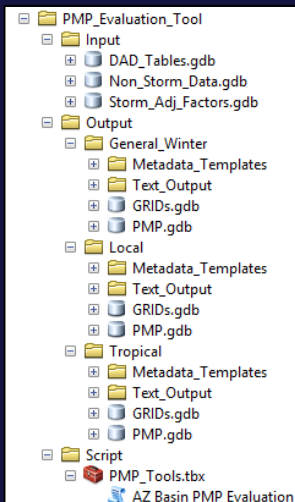
How Did We Compute PMP?

- PMP on a $\sim 2.5\text{mi}^2$ grid
 - 64,103 grid cells-that's a lot of data!
- Move maximized storms to each grid
- Account for differences in moisture and elevation
- Calculate the Orographic Transposition Factor (OTF)
 - Uses Precip Frequency-NOAA Atlas 14
 - Difference between source and target location
- OTF-Quantifiable/Reproducible
 - Replaces HMR SSM, K-Factor
 - Highly subjective
 - Not reproducible
- Results in total adjustment factor
- Apply to the DAD values



PMP Evaluation Tool (PET)

- Calculates gridded PMP for a user-defined drainage basin
- Custom Python-based scripted tool
 - Designed to be used within the ArcGIS environment
 - Flexible for future updates/enhancements
- Iterates through a storm database
 - Currently 91 maximized historical DAD tables
 - Adjusted to each grid cell
- Produces temporally distributed PMP output in both vector and raster GIS file formats for the basin spatial extent



Summary

- Storm based and reproducible
 - ✓ Ability to consider site-specific characteristics
- Higher confidence in results/data
- Significant cost savings
 - ✓ Properly sized spillways
- PMP study produces updated/reliable values
 - ✓ PMP values for any point within Arizona
 - ✓ Developed using the most current methods and data available



QUESTIONS

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Arizona Statewide PMP Study

A multi-agency study to improve understanding of public risk and reduce infrastructure costs



Presentation Outline

- Reason for the study
- Regulator Perspective
- PMP Development Process
- Storm based approach
 - 49 new storms analyzed!
 - Updated dew point/SST climatologies
 - Explicitly Address orographics
- Results/findings
 - Quantifiable/Reproducible
 - No black box



2008 Feasibility Study

- HMR 49 is overdue for updating
- HMR 49 PMP values are unreliable
- HMRS developed using similar methods have been replaced

Study Background

- Arizona kicked-off Spring 2009, Wyoming Spring 2011
- Storm Based Approach
- Deterministic, but of course there is uncertainty
- All-season PMP
 - 1-hr to 72-hr values
 - $\sim 2.5\text{-mi}^2$ grid across orographically influenced regions
- Wyoming gets cool-season PMP, rain on snow

Basin Characteristics/Geographic Location

Review Previous Work
in Regions with Similar
Meteorology/Topography

Identify PMP
Storm Type(s)

Conduct Storm
Search

Initial List of
Storms
(Long List)

Determine Magnitude
Determine Transpositionability
Run DA Estimator

Potentially Significant PMP
Storms
(Intermediate Storm List)

Identify Final Storm List for PMP
(Short Storm List)

DAD Available?

Yes

No

Calculate In-Place
Maximization
Factors

Run SPAS
Storm Analysis

Barriers to Inflow
Moisture Affecting
the Basin?

Yes

No

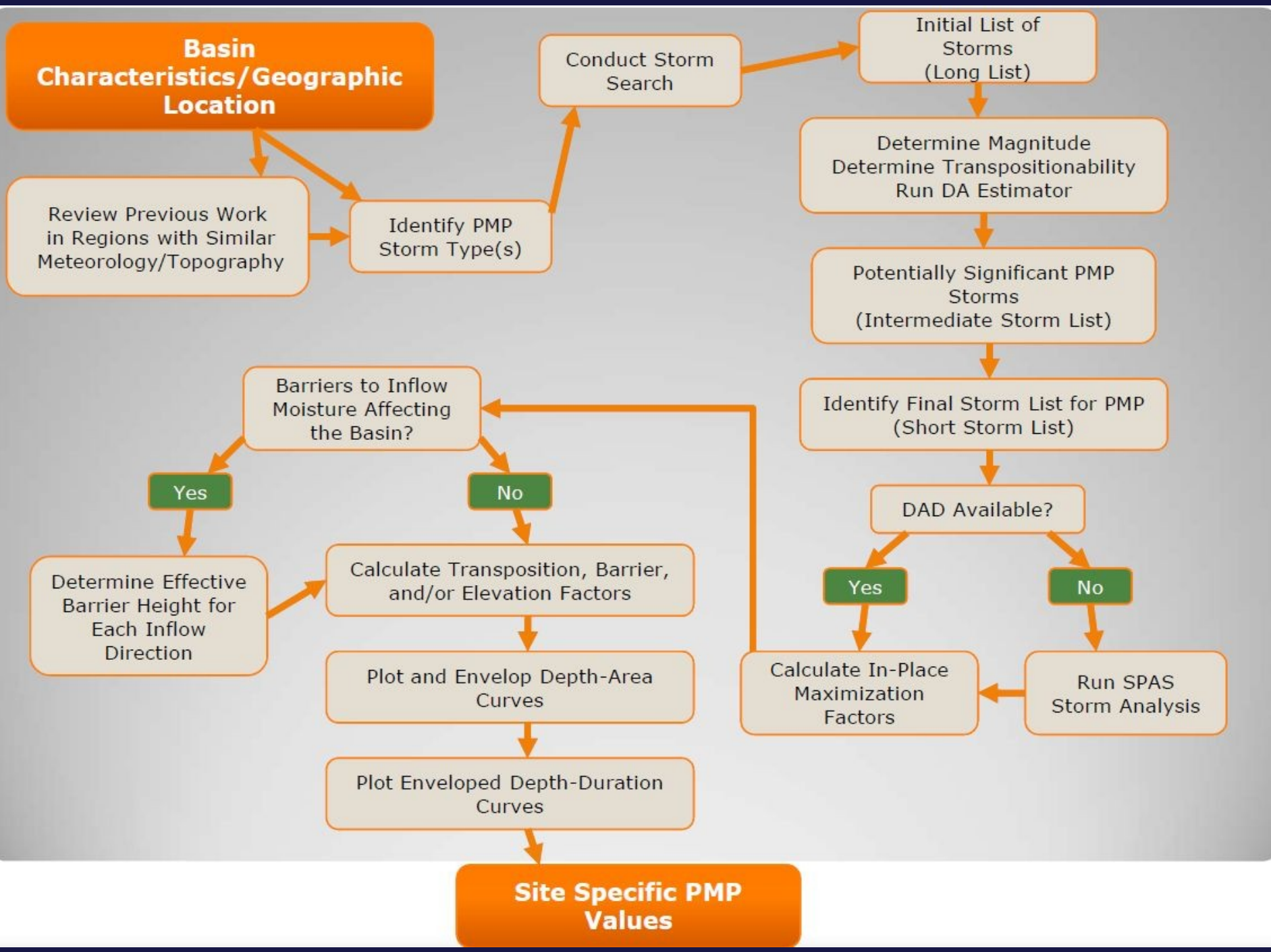
Determine Effective
Barrier Height for
Each Inflow
Direction

Calculate Transposition, Barrier,
and/or Elevation Factors

Plot and Envelop Depth-Area
Curves

Plot Enveloped Depth-Duration
Curves

Site Specific PMP
Values



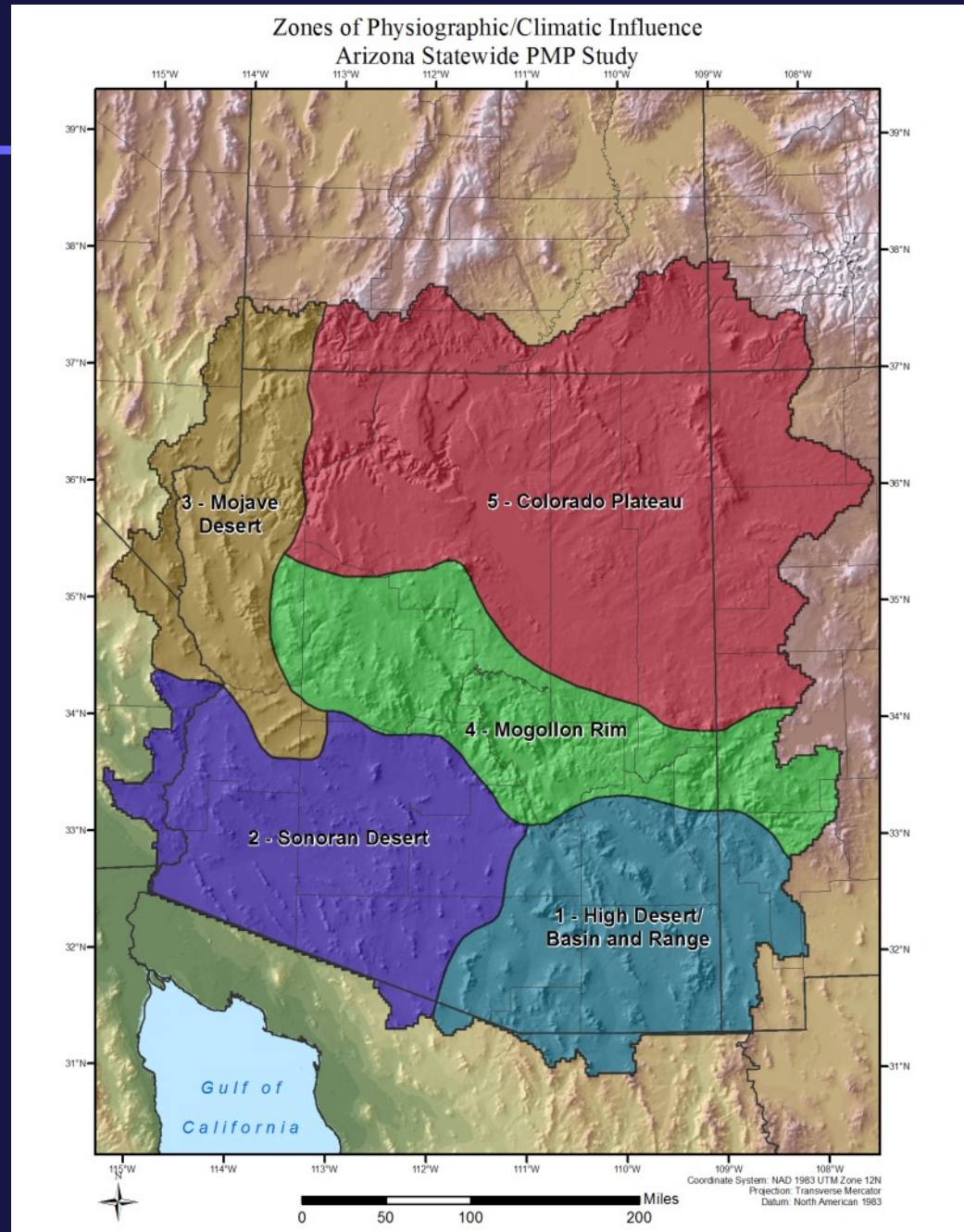
Unique Issues in Arizona

- Terrain and orographics
- How much can it rain at high elevations?
- Lack of data for large areas
- Rain on snow
- Transition between climate regions

Transposition Zones

Provide spatial transposition constraints for each storm

1. High Desert/Basin and Range
2. Sonoran Desert
3. Mojave Desert
4. Mogollon Rim
5. Colorado Plateau



Summary

- HMR 49
 - Out of date
 - Inadequate for use in deriving PMP values
- Hydrological implementation manual
 - For application of the PMP values
 - Based on state regulator's needs
- PMP study produces updated/reliable values for PMF modeling
 - PMP values for any point within Arizona
 - Developed using the most current methods and data available



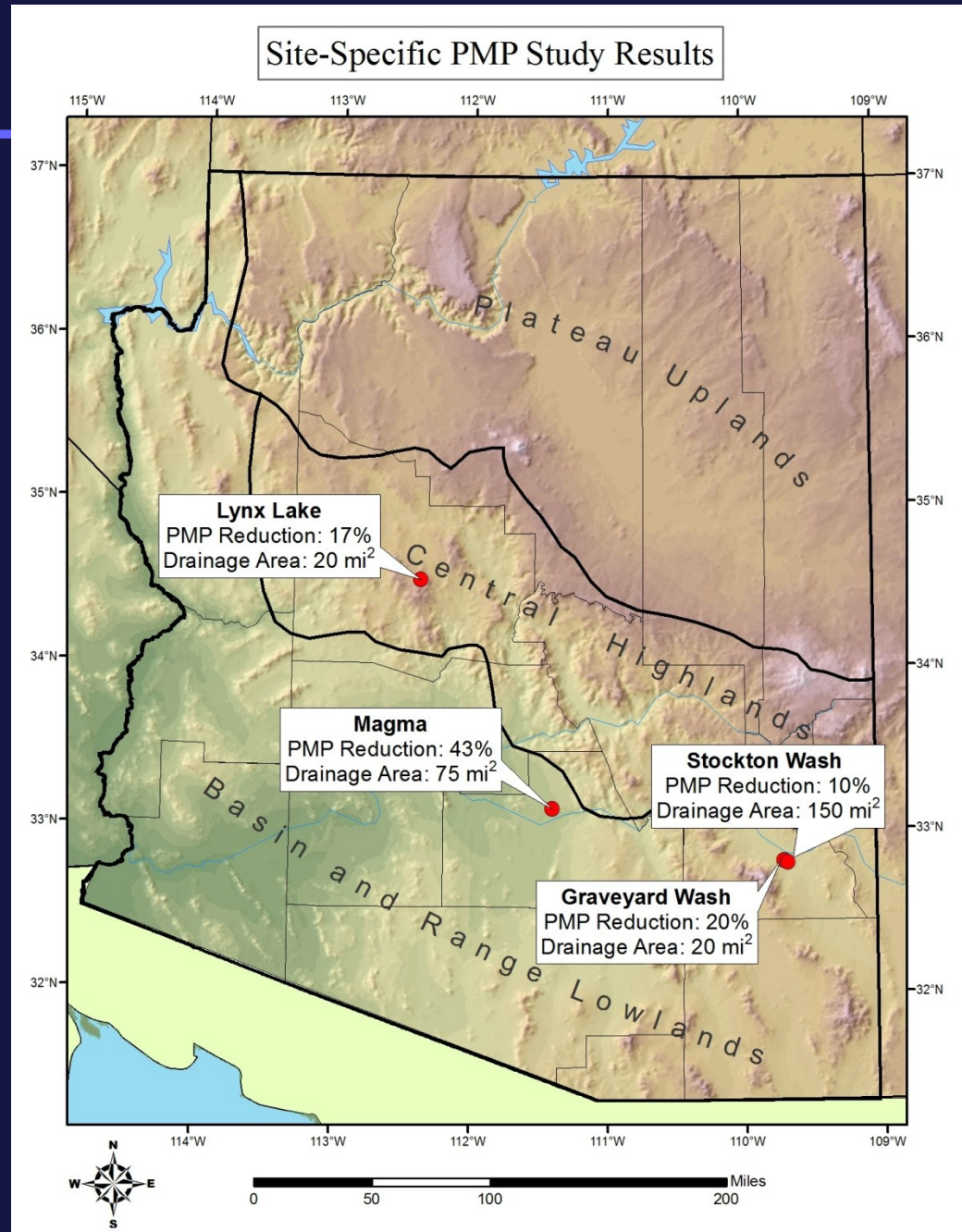
Problems with HMR 49 – overly conservative?

**1996: Lynx Lake Dam,
cost savings to AGFD**

**2008: Magma FRS,
> \$5M cost savings**

**2008: NRCS-Funded
Safford Regional PMP**

**2009: Florence Dam,
> \$5M cost savings**



Background

- HMR 49-Published in 1977
 - The oldest of the HMRs currently in use
 - Based on outdated methods and techniques
 - Subsequently been improved
 - Better understanding of meteorology
 - Updated datasets
 - Improved spatial analysis
 - Methods and techniques updated in newer HMRs
- Major issues with HMR 49
 - Lack of storm data used to develop the PMP values
 - Only a handful of storms were investigated
 - None were analyzed using individual storm Depth-Area-Duration (DAD) values
 - Covers a widely varying region
 - Climatologically/Topographically



Deliverables for Arizona

- Updated storm database
 - 51 new storm analyses using SPAS
 - 3 PMP storm types
- Enormous amount of data
- PMF hydrologic implementation parameters
 - Temporal distributions
 - Basin specific distributions
- One PMP process using state-of-the-science understanding and techniques

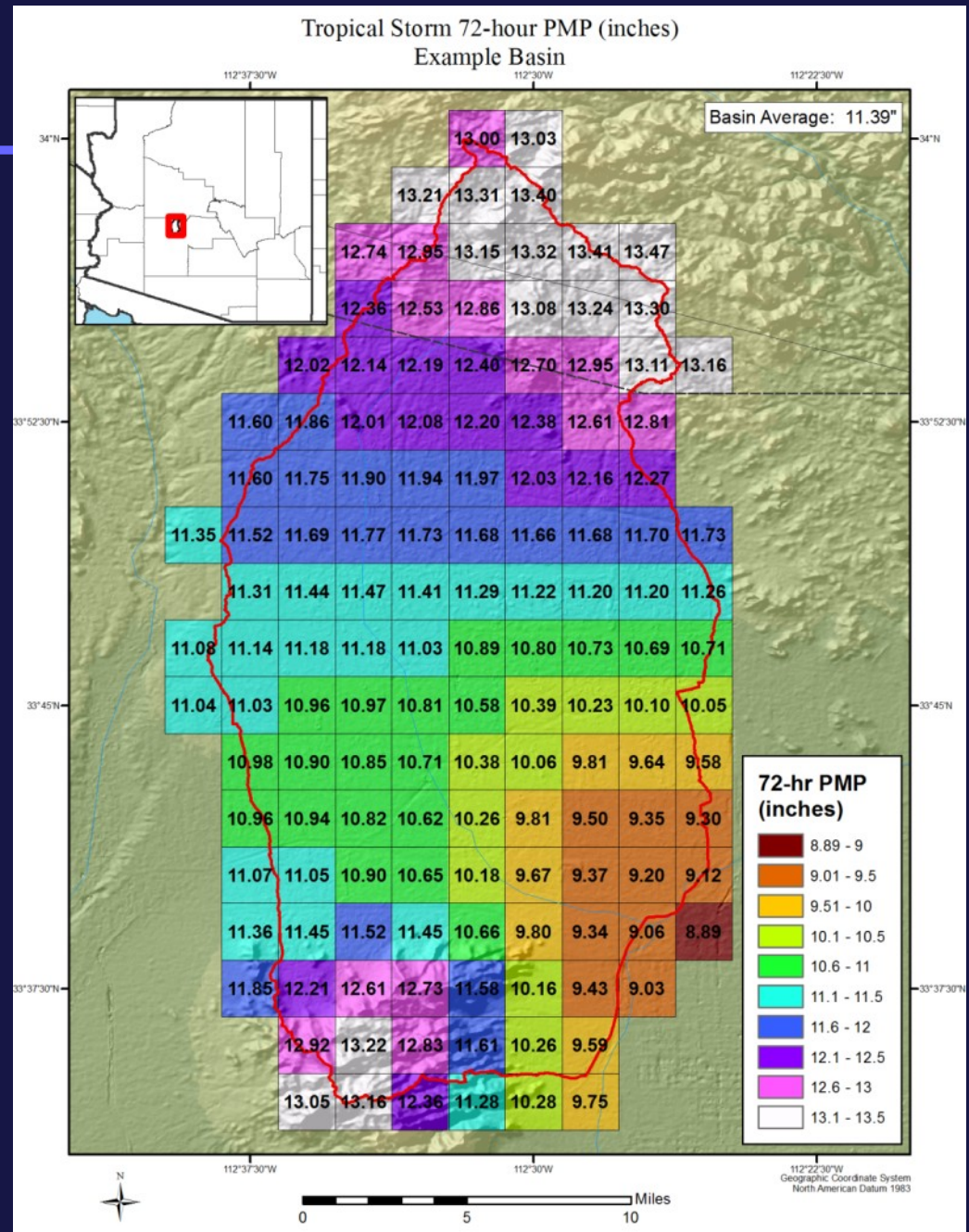


Example PMP Results

72-hour tropical storm PMP values

Provide basin, sub basin, or grid values/average

Associated with storm type temporal timing

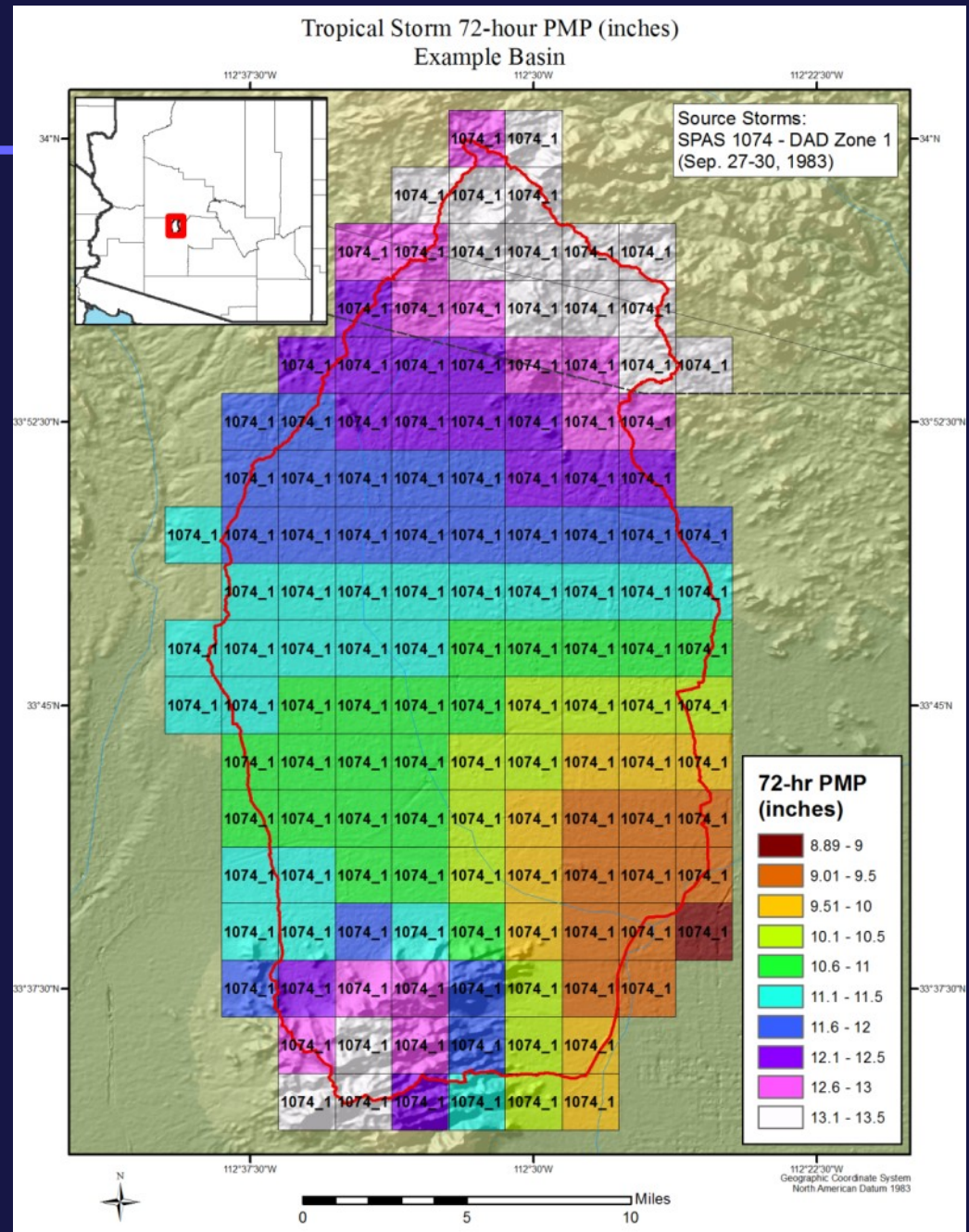


Example PMP Results

72-hour tropical storm
PMP

Source storm ID by
SPAS storm number

Allows for back
calculation and
verification



AWA Storm Search Domains

Storm Search Domains

