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Hydropower Optimization: Updating the Probable Maximum Precipitation and Flood in a Complex Basin in the Oregon Cascades

Bill Kappel, Chief Meteorologist-Applied Weather Associates

Courtney Moore, Junior Engineer-Northwest Hydraulic Consultants

Mark Reeves, P.E., G.E.-PacifiCorp Dam Safety

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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)
- **T**ypes of PMP studies:
  - Generalized (Hydrometeorological Reports)
    - Provides PMP values for a large region
  - Regional/Statewide
    - Provide PMP values over regions with varying topography
    - Individual basins are included in the regional/statewide results
    - Considers unique meteorology and topography
  - Site-Specific
    - Provides PMP values for individual drainage basins
    - Considers unique meteorology and topography
    - NRC studies performed under Appendix B program

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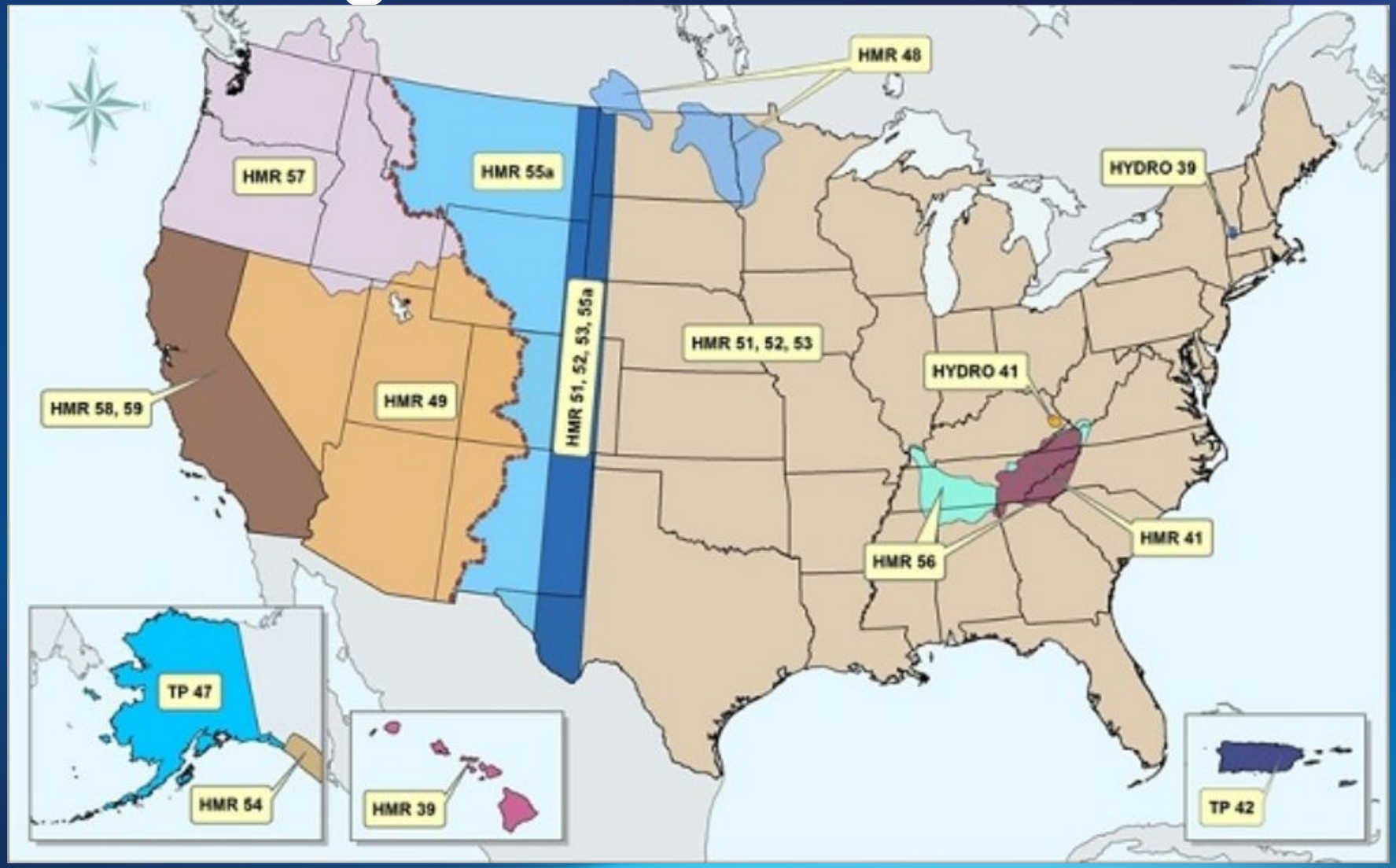
Coverage of HMRs



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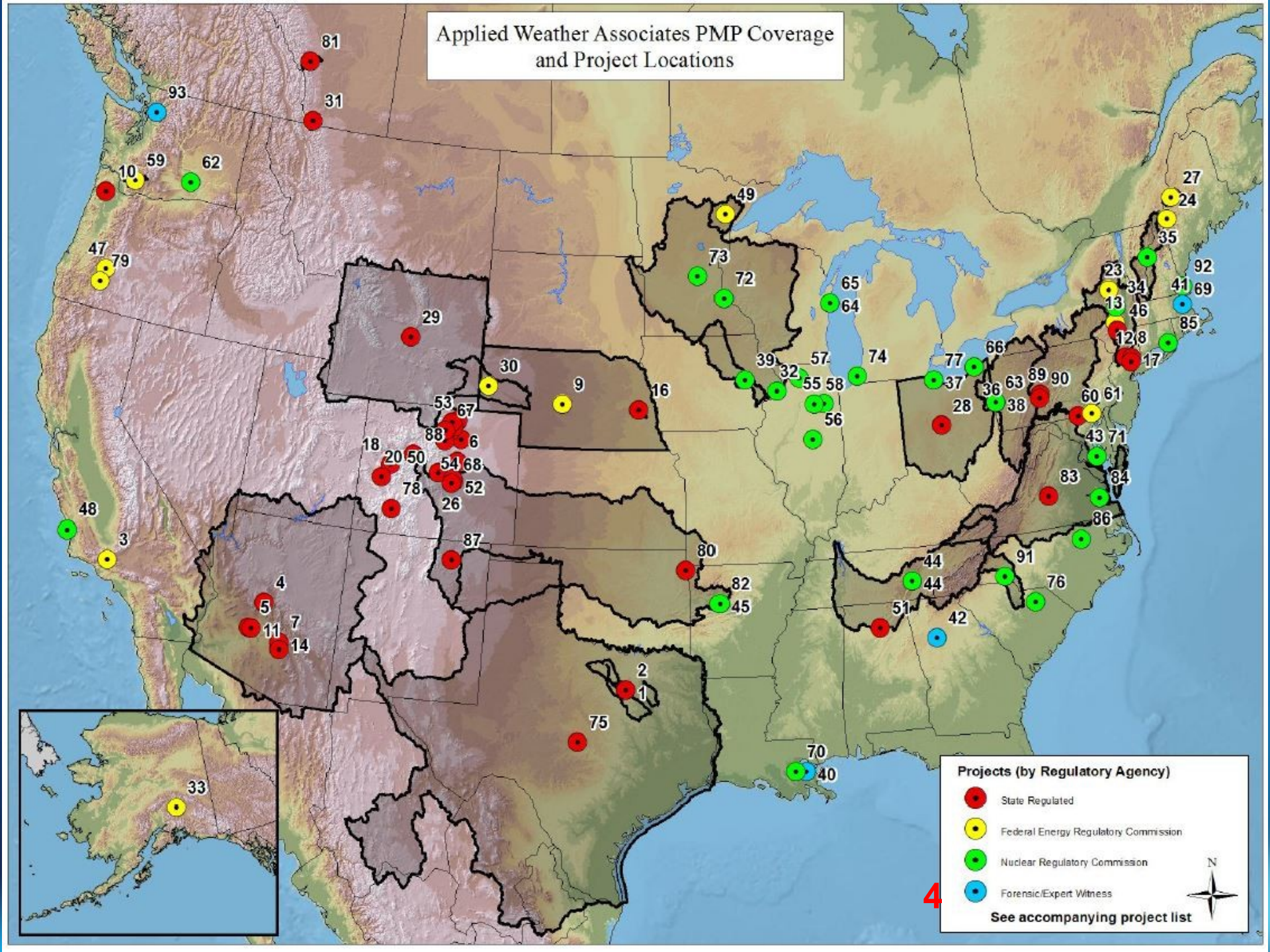
Applied Weather Associates PMP Coverage and Project Locations
Projects (by Regulatory Agency)
State Regulated
Federal Energy Regulatory Commission
Nuclear Regulatory Commission
Forensic/Expert Witness
See accompanying project list
N
4

Method for Computing PMP Values

- Observed extreme rainfall events are used
  - Storm based approach
- Identify extreme storms in regions that are considered transpositionable
  - Identify recent extreme storms since publication of the appropriate HMRs
  - Review older rainfall data records
- Identify extreme storm types
  - General storms (frontal systems) Atmospheric Rivers
  - Local storm discussed and determined as not of PMF type

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Method for Computing PMP Values

- Identify unique topography
  - Precipitation enhancement/decrease
    - -orographics
  - Effects on rainfall center location
    - -physically possible storm centering/orientation
- Review HMR/Hydro/Tech Memo procedures
  - Identify inconsistent assumptions
  - Apply new technologies and data
  - Apply new/updated methods

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Storm Search Domain

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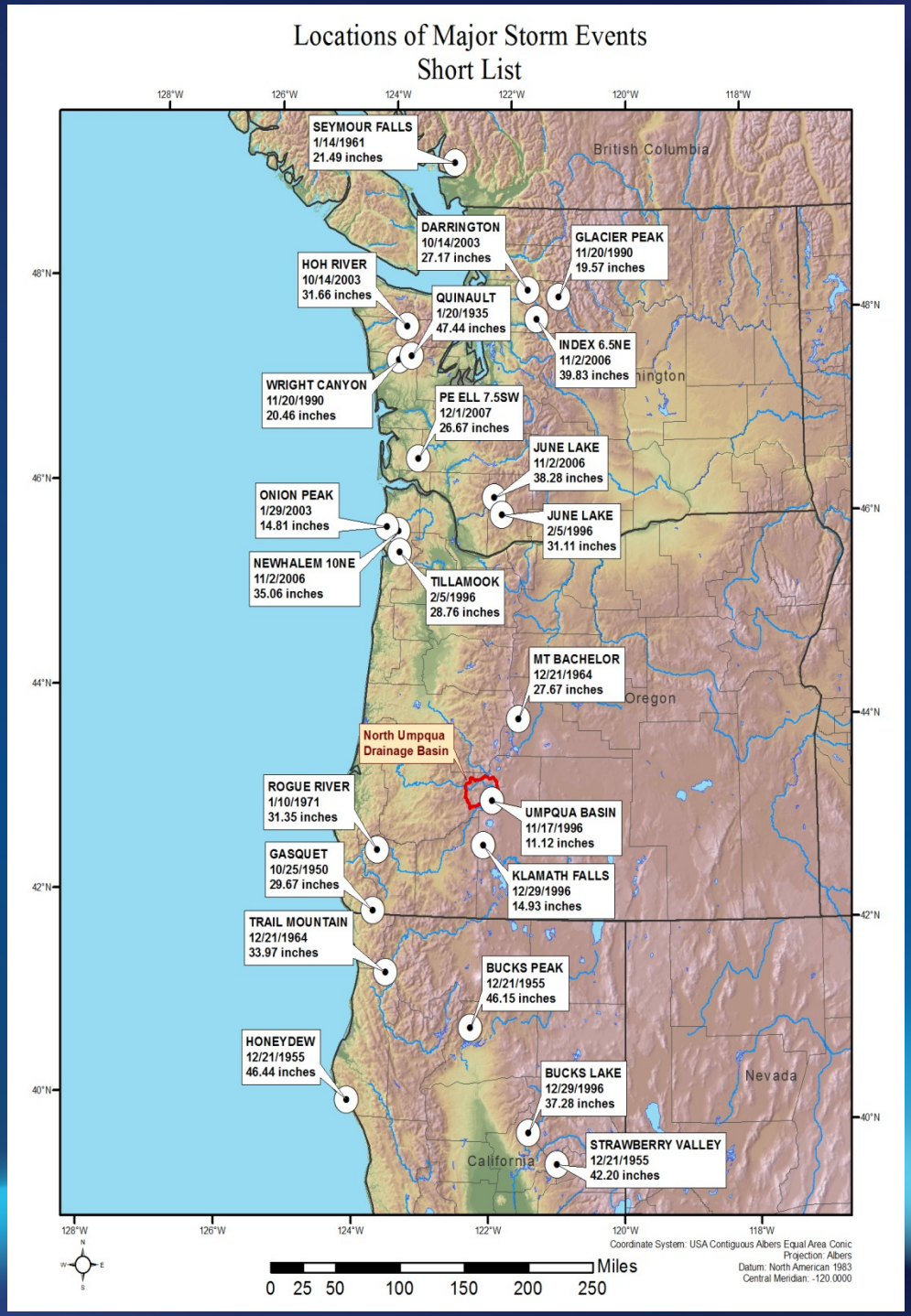
Final Storm List



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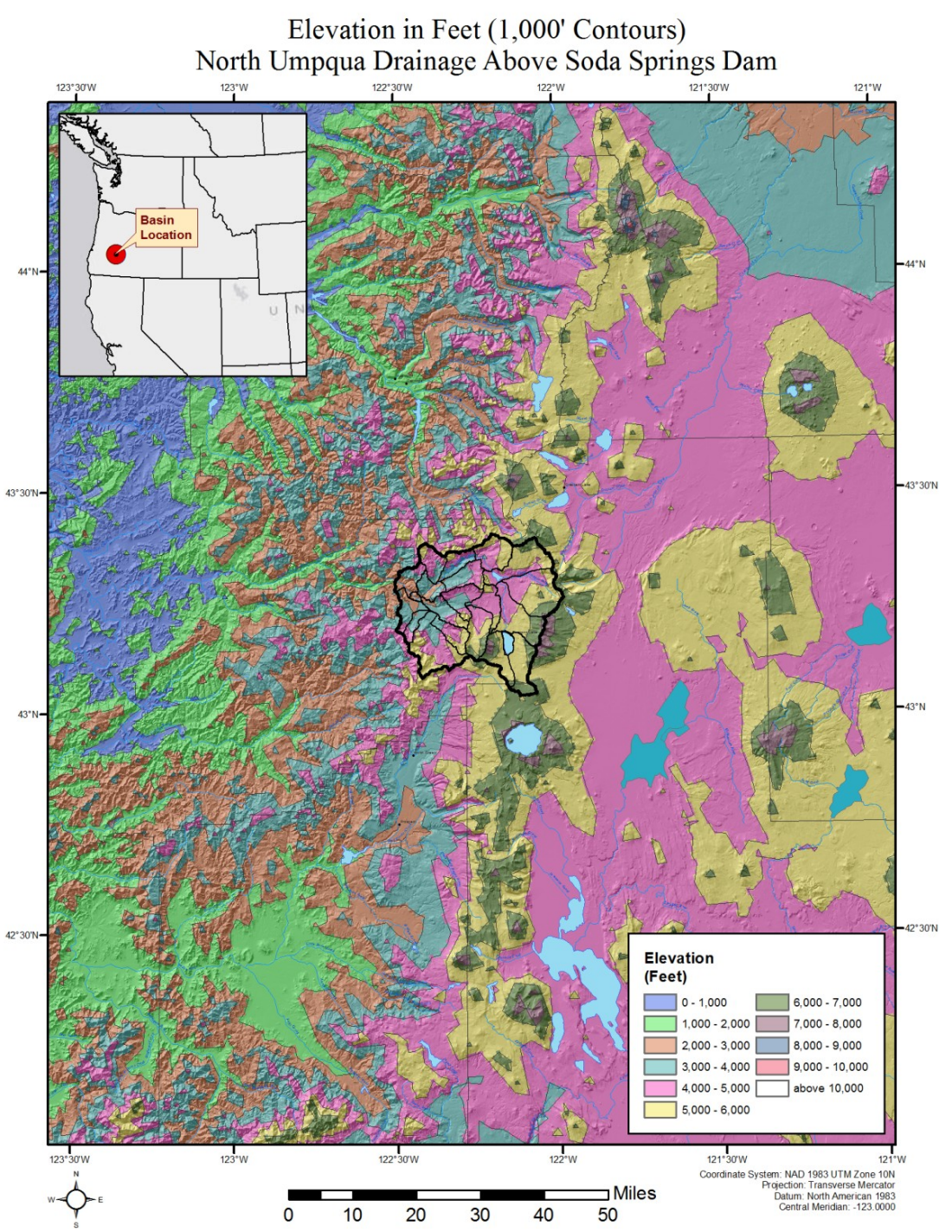
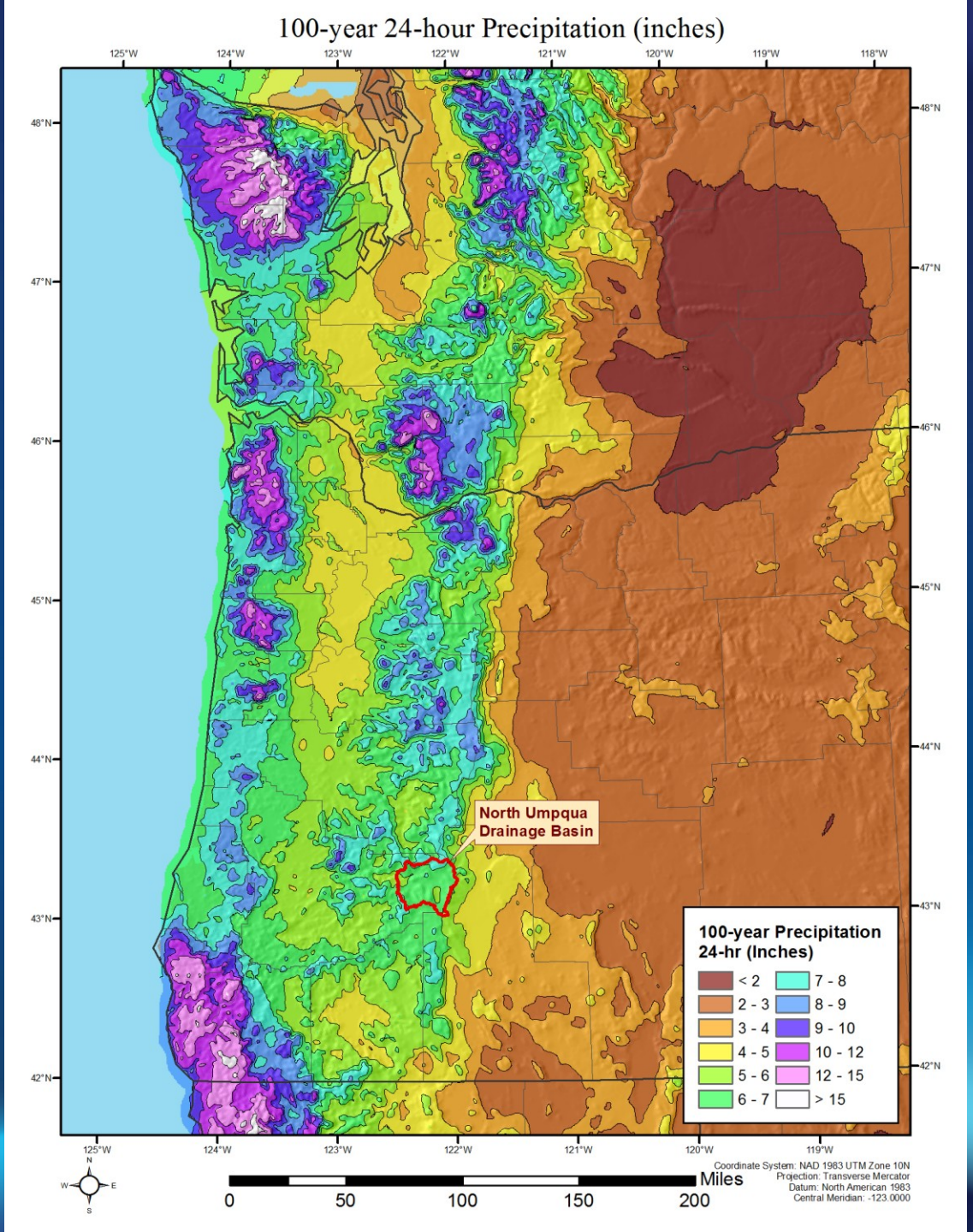
Topography Around the Basin



Precip Frequency Around the Basin



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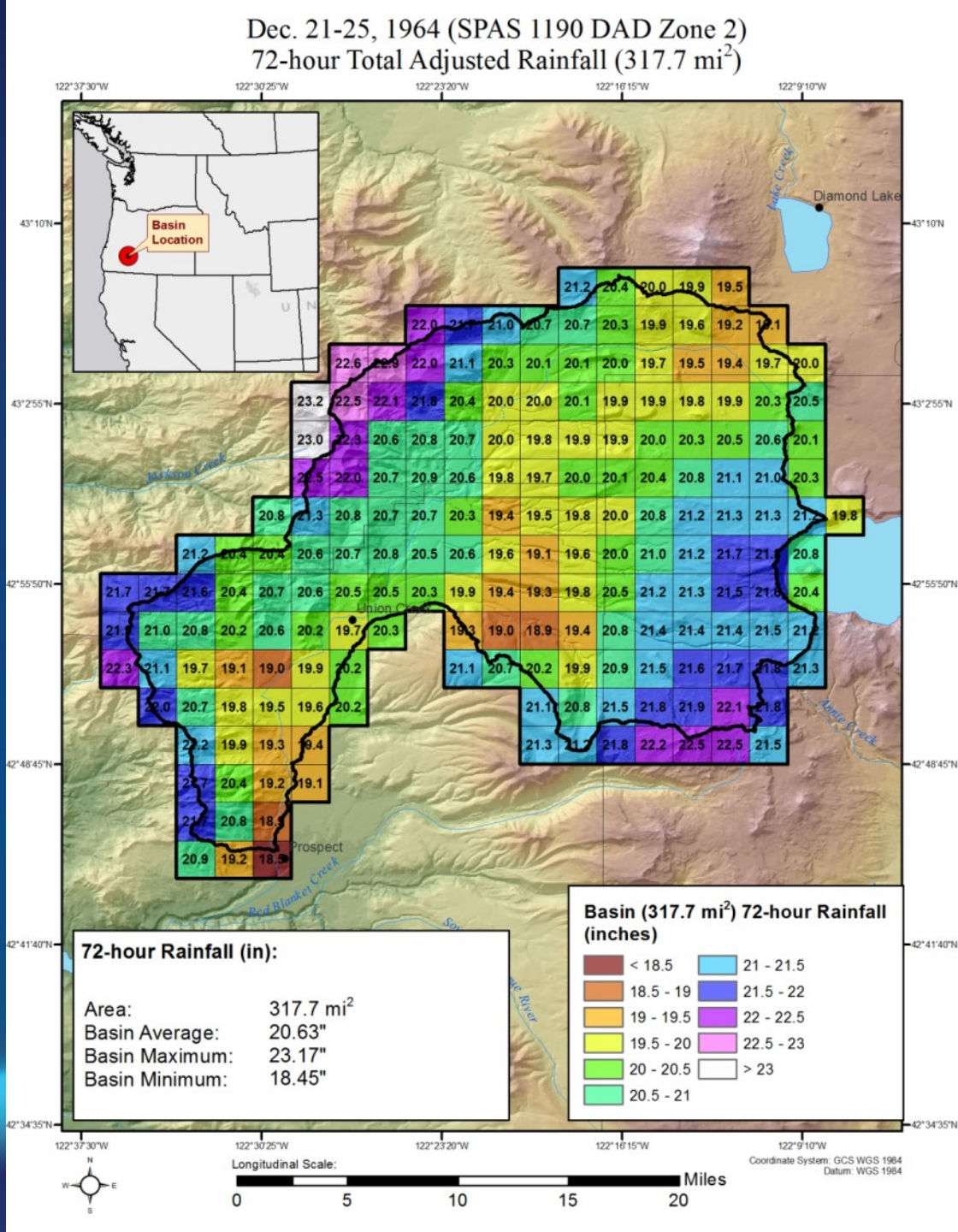
Total Adjusted Rainfall

- Product of IPMF*MTF*OTF*SPAS Rainfall at basin area size
- Follows spatial distribution of OTF (precip. climatology).
- PMP calculated as largest adjusted rainfall from all storms.



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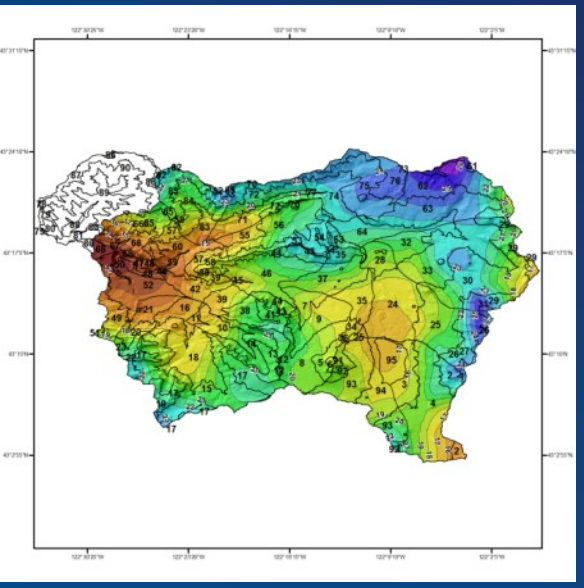
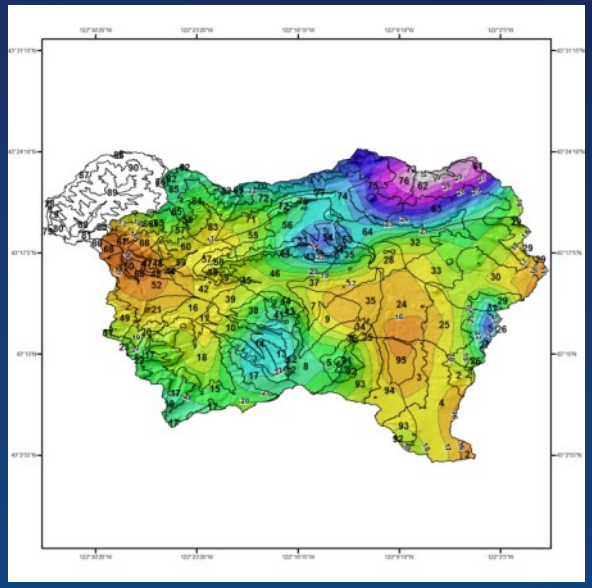
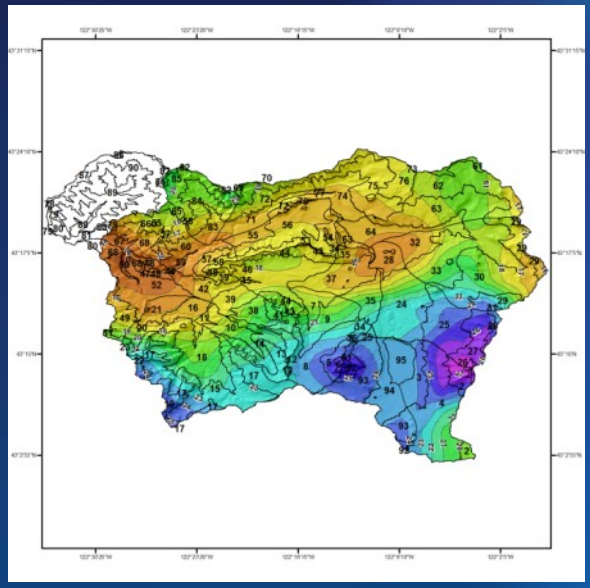
North Umpqua Spatial Distribution Examples



Dec. 1964

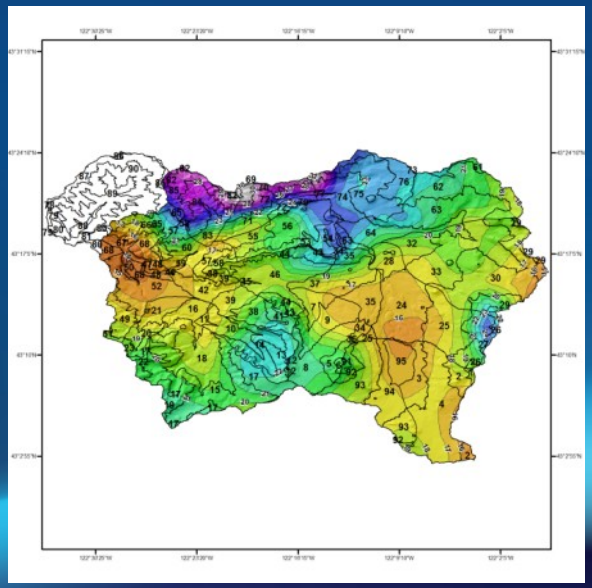


Jan. 1971

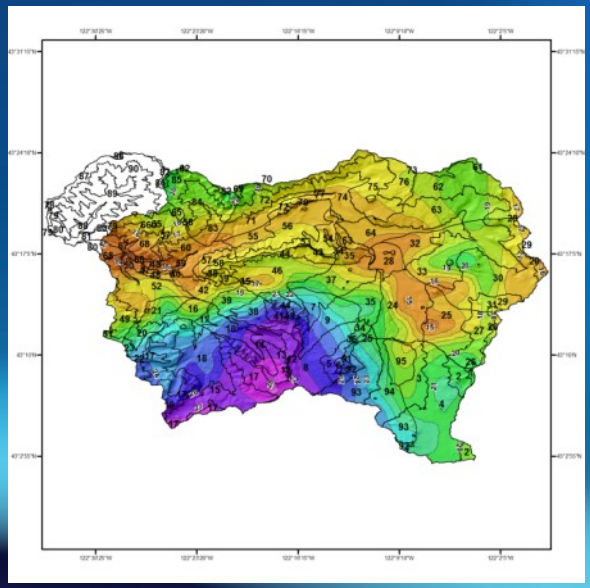


Dec ‘96-Jan ’97

Alternate scenarios are hypothetical distributions based on historical events



Jan. 1971 - Alternate



Dec ‘96-Jan ‘97 – Alternate

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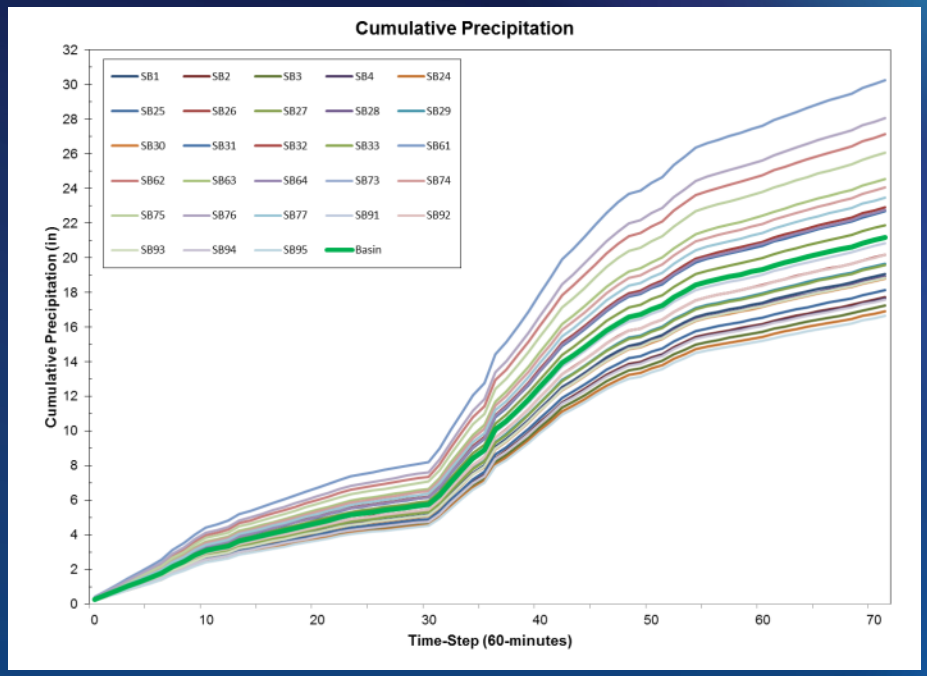
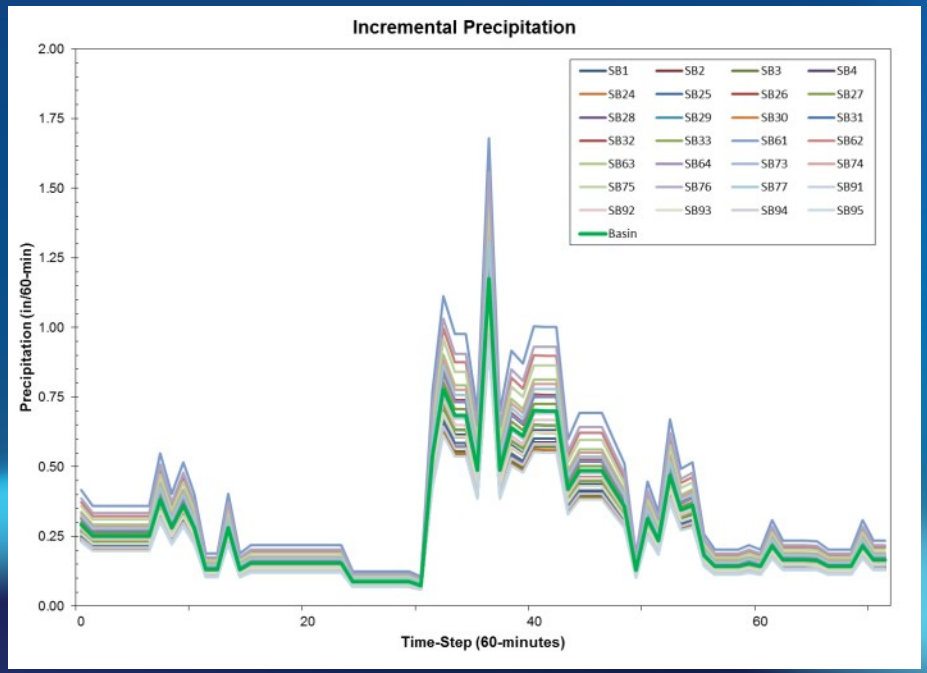
Temporal Distributions (continued…)

- Temporal distribution pattern applied to each subbasin-elev. band PMP depth.
- Temporally distributed PMP needed to be “scaled” to adhere to the depth-duration accumulations that were originally calculated
- Resulting temporal pattern does not exactly match historical pattern – but reasonably follows general timing pattern.



Temporal distribution for Lemolo #2 Dam PMP



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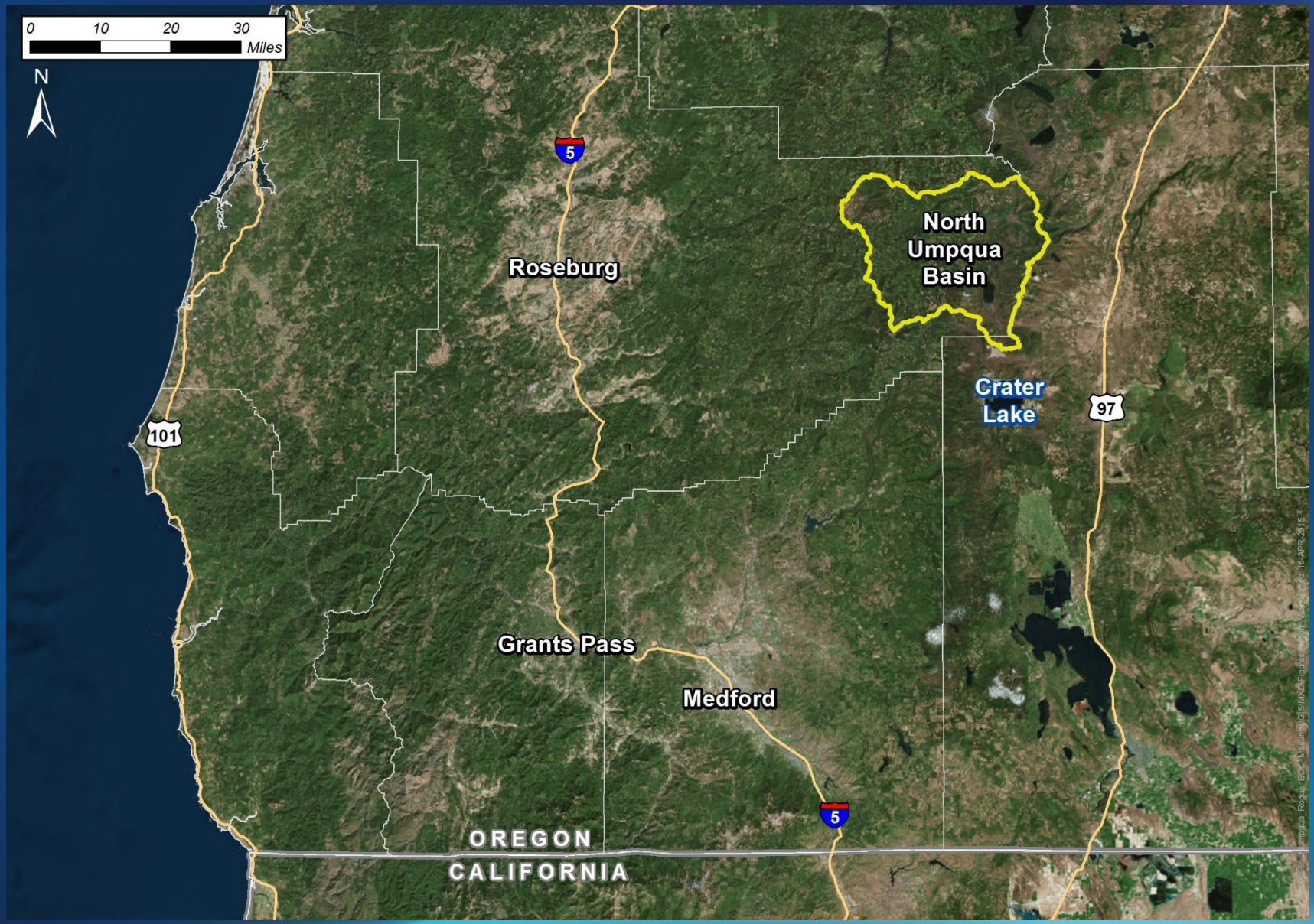
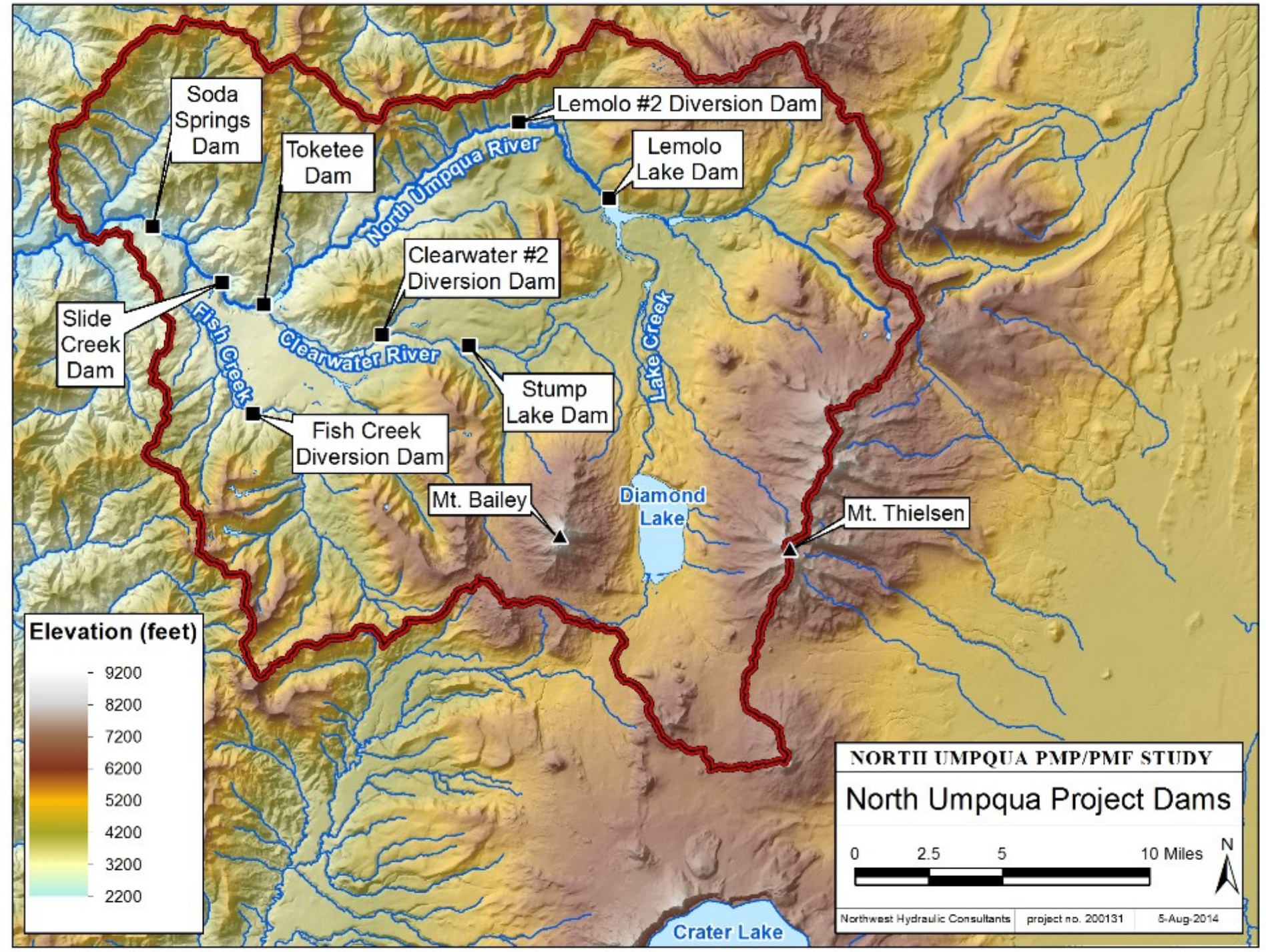
North Umpqua PMP/PMF Study

- 470 square miles.
- 8 dams (6.5 to 120 ft. in height, max. active storage 11,000 acre-ft.).
- Basin elev. range 1,600 – 9,000 ft., median elev. 5,000 ft.
- Hydrologic response of eastern half of basin heavily influenced by volcanic deposits and ash flow from the eruption of Mount Mazama (~7,700 years BP).


0 10 20 30
Miles
N
5
Roseburg
North Umpqua Basin
Crater Lake
97
101
Grants Pass
Medford
5
OREGON
CALIFORNIA

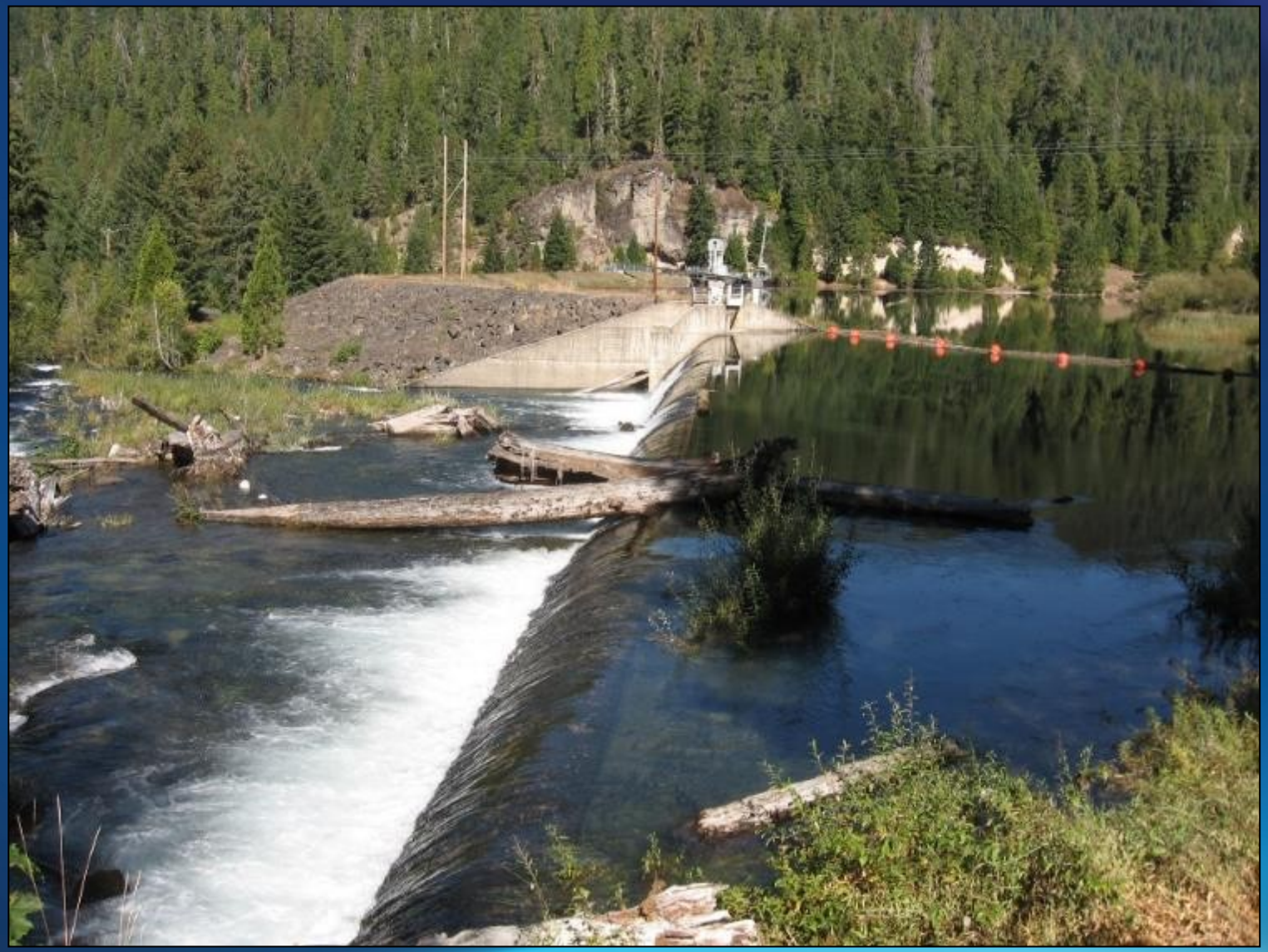

Soda Springs Dam
Toketee Dam
Lemolo #2 Diversion Dam
Lemolo Lake Dam
North Umpqua River
Clearwater #2 Diversion Dam
Slide Creek Dam
Fish Creek
Clearwater River
Lake Creek
Stump Lake Dam
Fish Creek Diversion Dam
Mt. Bailey
Diamond Lake
Mt. Thielsen
Crater Lake
Elevation (feet)
9200
8200
7200
6200
5200
4200
3200
2200
NORTH UMPQUA PMP/PMF STUDY
North Umpqua Project Dams
0
2.5
5
10 Miles
N
Northwest Hydraulic Consultants
project no. 200131
5-Aug-2014

NORTH UMPQUA DIVERSION DEVELOPMENT

View Looking East

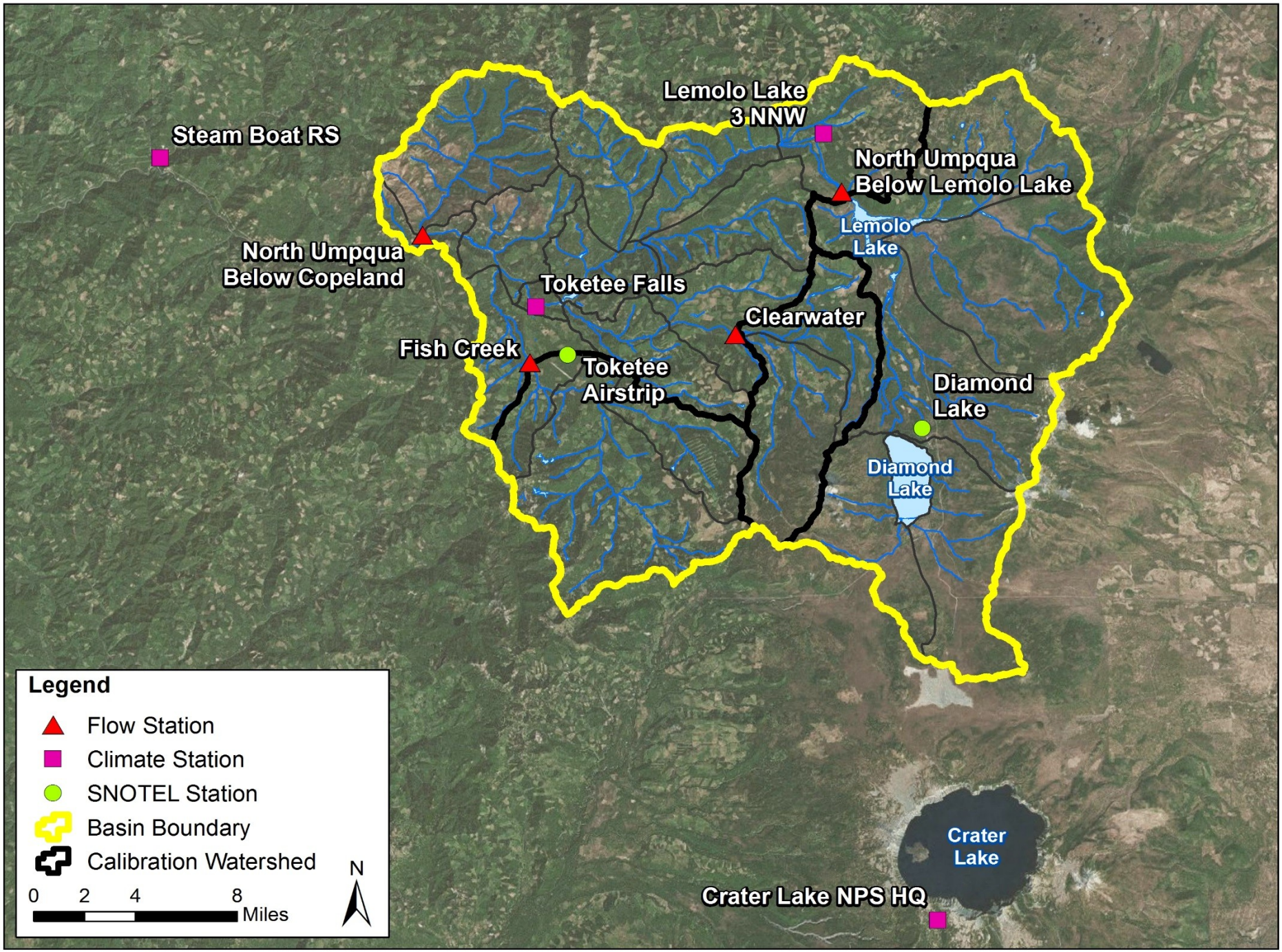
Dam Name	Dam Height above Streambed (ft)	Active Storage (acre-ft)	Drainage Area (sq mi)
LEMOLO LAKE DAM	120	11,079	173
LEMOLO #2 DIVERSION DAM	25	0	197
CLEARWATER #1 (STUMP LAKE) DAM	17	5.5	41
CLEARWATER #2 DAM	18	0	60
TOKETEE LAKE DAM	58	491	335/259
FISH CREEK DIVERSION DAM	6.5	0	62
SLIDE CREEK DAM	30	0	337
SODA SPRINGS DAM	77	216	435

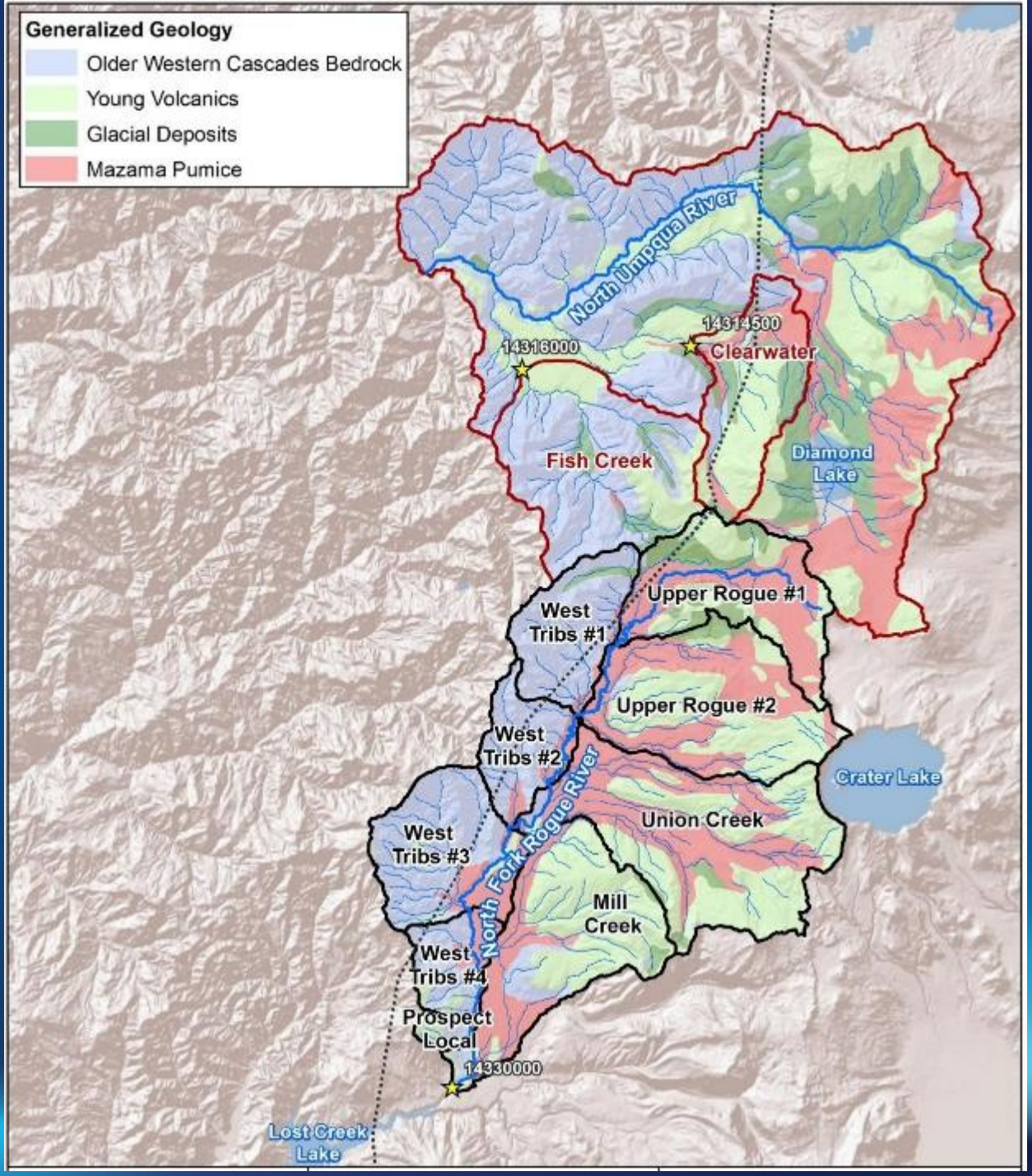
Pacific Power & Light Company

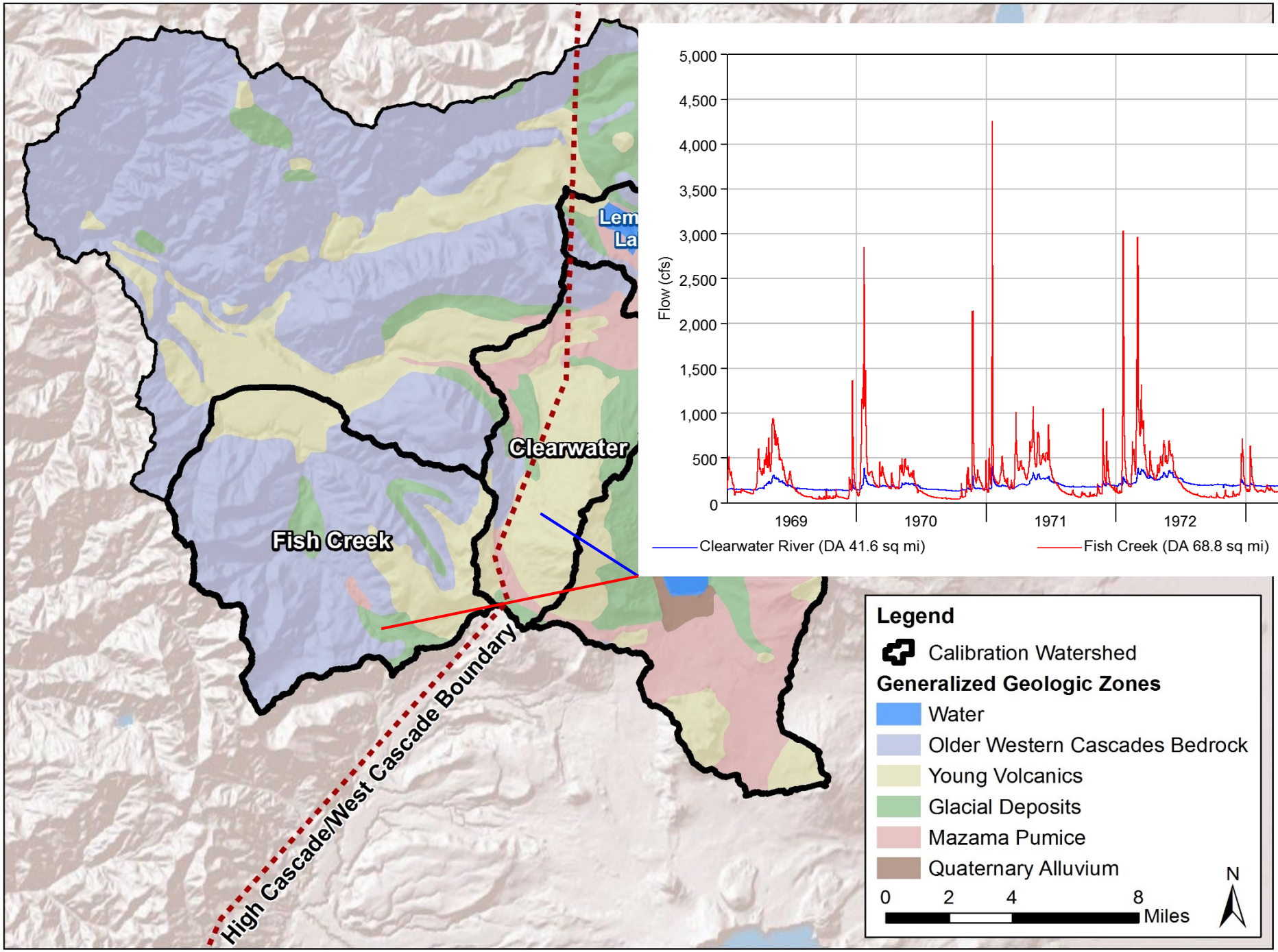


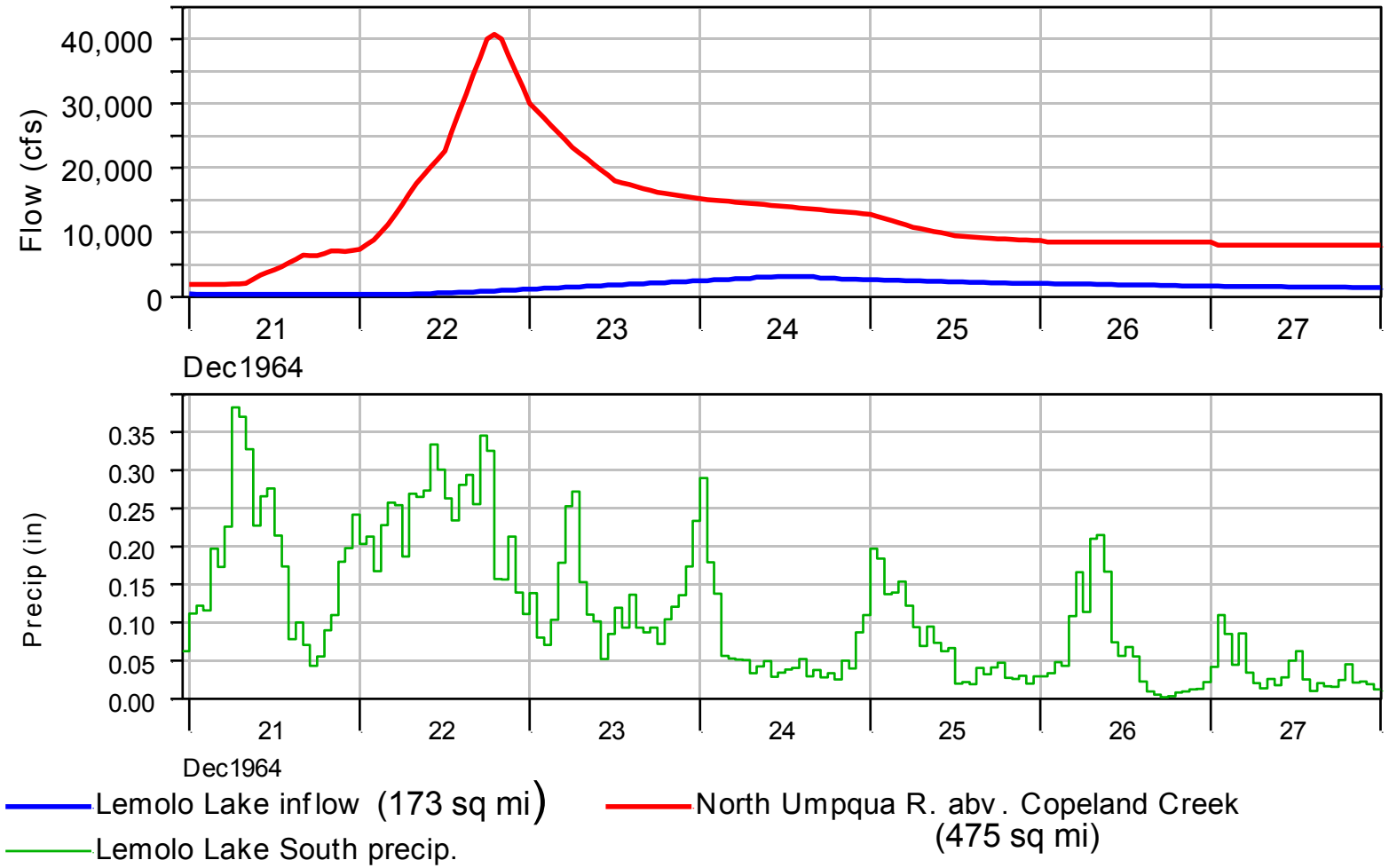
Hydrologic Modeling

- HEC-HMS model (semi-distributed, 1000 ft elevation bands).
- Calibrate snow model parameters to SNOTEL data
- Calibrate hydrologic response parameters to major floods (incl. Dec 1964)
- Data problems (as is often the case):
  - Gaged flows affected by power canal diversions
  - Difficulty estimating Lemolo Lake inflows
  - Unrepresentative gage temperature data


Steam Boat RS
Lemolo Lake
3 NNW
North Umpqua
Below Lemolo Lake
Lemolo
Lake
North Umpqua
Below Copeland
Toketee Falls
Clearwater
Fish Creek
Toketee
Airstrip
Diamond
Lake
Diamond
Lake
Crater
Lake
Crater Lake NPS HQ
Legend
Flow Station
Climate Station
SNOTEL Station
Basin Boundary
Calibration Watershed
0 2 4 8
Miles
N


Generalized Geology
Older Western Cascades Bedrock
Young Volcanics
Glacial Deposits
Mazama Pumice
North Umpqua River
14314500
Clearwater
14316000
Fish Creek
Diamond Lake
Upper Rogue #1
West Tribs #1
Upper Rogue #2
West Tribs #2
Crater Lake
North Fork Rogue River
Union Creek
West Tribs #3
Mill Creek
West Tribs #4
Prospect Local
14330000
Lost Creek Lake


Clearwater
Fish Creek
High Cascade/West Cascade Boundary
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Flow (cfs)
1969
1970
1971
1972
Clearwater River (DA 41.6 sq mi)
Fish Creek (DA 68.8 sq mi)
Legend
Calibration Watershed
Generalized Geologic Zones
Water
Older Western Cascades Bedrock
Young Volcanics
Glacial Deposits
Mazama Pumice
Quaternary Alluvium
0
2
4
8
Miles
N

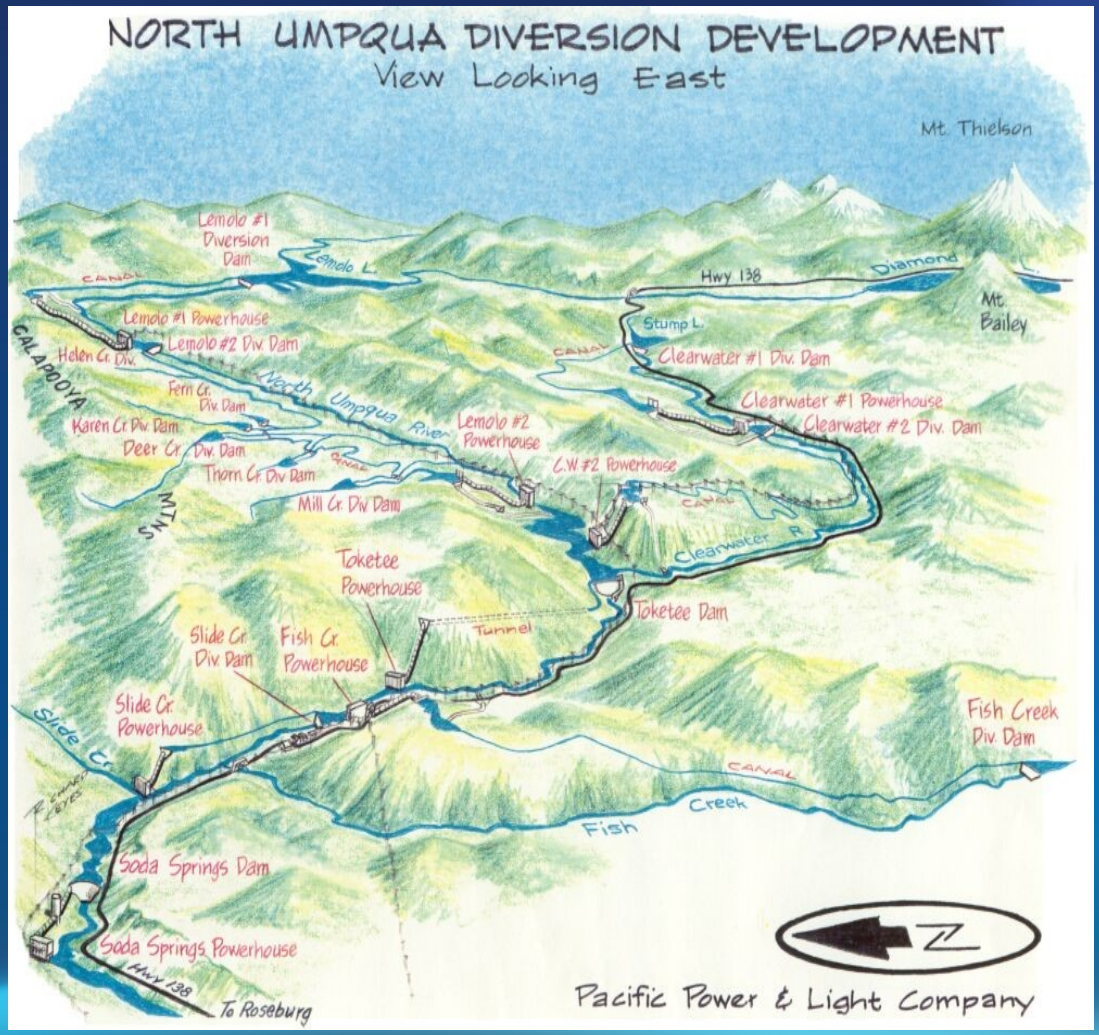

40,000
30,000
20,000
10,000
0
Flow (cfs)
21
22
23
24
25
26
27
Dec1964
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
Precip (in)
21
22
23
24
25
26
27
Dec1964
Lemolo Lake inflow (173 sq mi)
North Umpqua R. abv. Copeland Creek
(475 sq mi)
Lemolo Lake South precip.

North Umpqua Water Balance

Gage Location/Contributing Area	Area (sq mi)	Mean Annual Flow (cfs)	Mean Annual Runoff (in)	Mean Annual Precip (in)	Mean Annual Loss(Gain) (in)
Lake Creek (Diamond Lake outflow)	54.9	62.1	15.4	54.1	38.7
N Umpqua R. blw Lemolo Lake	173.0	445.0	34.9	58.7	23.8
Incremental area: Lake Creek - Lemolo Lake	118.1	382.9	44.0	60.8	16.8
Clearwater R. abv Trap Ck	41.6	184.0	60.0	57.7	-2.3
Fish Creek at Big Camas RS	68.8	233	46.0	60.2	14.2
N Umpqua R. abv Copeland Creek	470	1482	42.8	59.3	16.5

Hydrologic Impacts

- Lag times & management
- Response to storm centering
- Parameterization



Project	Drainage area (sq mi)	PMF Peak Flow (cfs)	Creager #	December 1964 Peak Flow (cfs)		Ratio PMF/ Dec 1964	100-year Peak Flow	Ratio PMF/ 100-year	Previous PMF Estimates (cfs)
LEMOLO LAKE DAM	173	15,700	9	3,160	Calc	5.0	2,600	6.0	18,850 (1972)
LEMOLO #2 DIVERSION DAM	197	19,500	11	5,440	Sim	3.6	4,870	4.0	
CLEARWATER #1 DAM	41	10,900	15	1,020	Obs	10.7	1,000	10.9	
CLEARWATER #2 DAM	60	20,300	22	4,320	Sim	4.7	3,230	6.3	
TOKETEE DAM[1]	335	66,400[1]	28	21,500[1]	Sim	3.1	15,900[1]	4.2	44,000 (n/a)
SLIDE CREEK DAM	337	67,100	29	21,600	Sim	3.1	15,900	4.2	
FISH CREEK DIVERSION DAM	62	32,000	34	12,100	Obs	2.6	9,050	3.5	
SODA SPRINGS DAM	435	107,600	40	35,600	Sim	3.0	26,500	4.1	111,000 (1968?)
NORTH FORK DAM	318	98,800	40	22,400	Obs	4.4	16,200	6.1	185,151 (1982)

Notes:

1 Clearwater Reconnect assumed blocked in current analyses

QUESTIONS?

Bill Kappel: billkappel@comcast.net

Courtney Moore: cmoore@nhcweb.com

Mark Reeves: Mark.Reeves@pacificorp.com