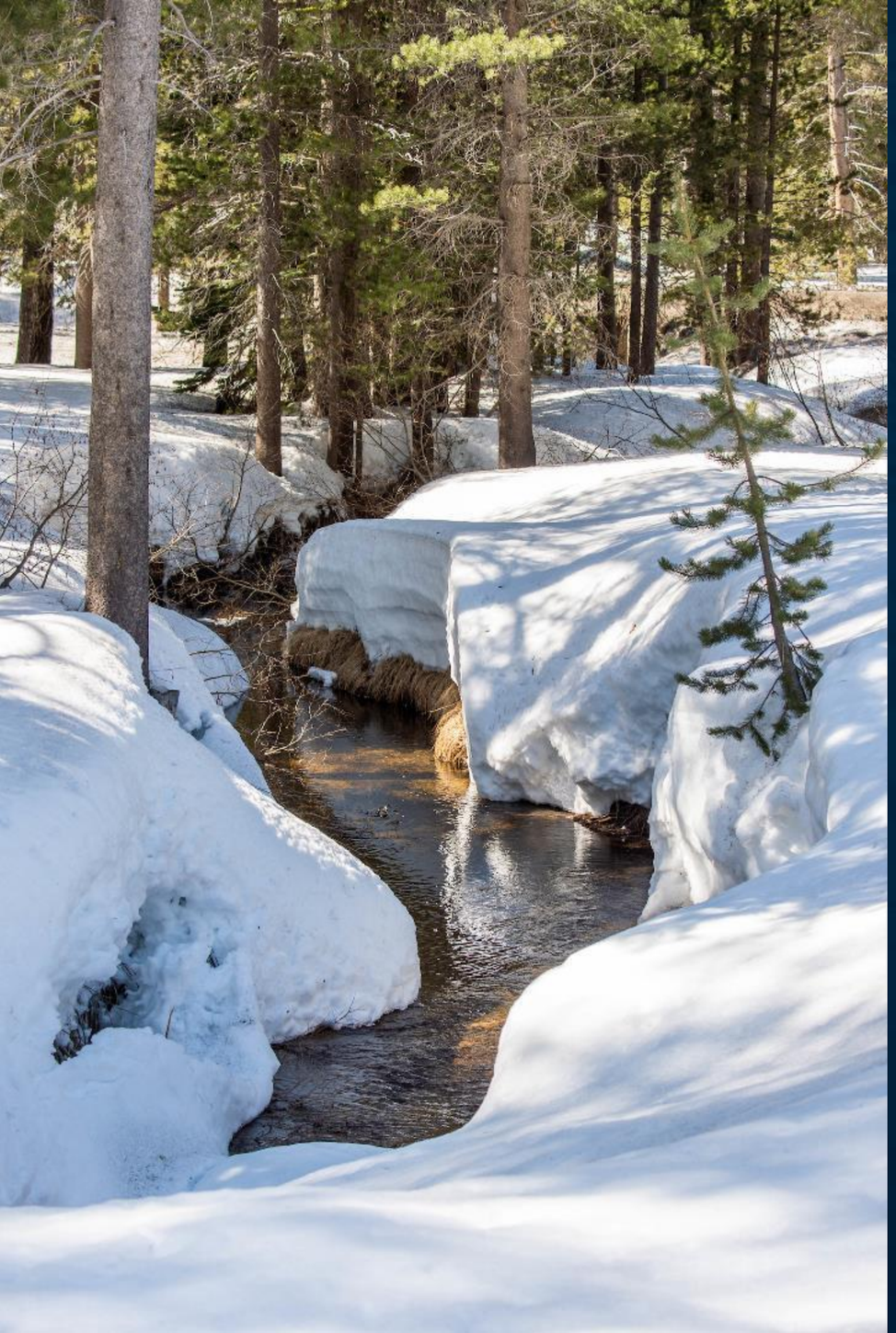


S2S Precipitation Forecasts and Snowmelt Runoff Forecasting

Western States Water Council S2S Workshop
May 19, 2022
San Diego, CA

David Rizzardo, P.E.
Manager, Hydrology Section
Division of Flood Management
California Department of Water Resources

Agenda

- Overview of CA-DWR’s Snowmelt Forecasting
- Reliance on historical conditions to predict future runoff
- Water Management/Forecasts Decision Points from a WY Climate and Weather POV
- Building Climate Resilience through better observations and forecasts

Bulletin 120: Water Conditions in California

State of California
The Natural Resources Agency

Department of
Water Resources

Water Conditions in California

Report 4 May 1, 2021

Gavin Newsom
Governor
State of California

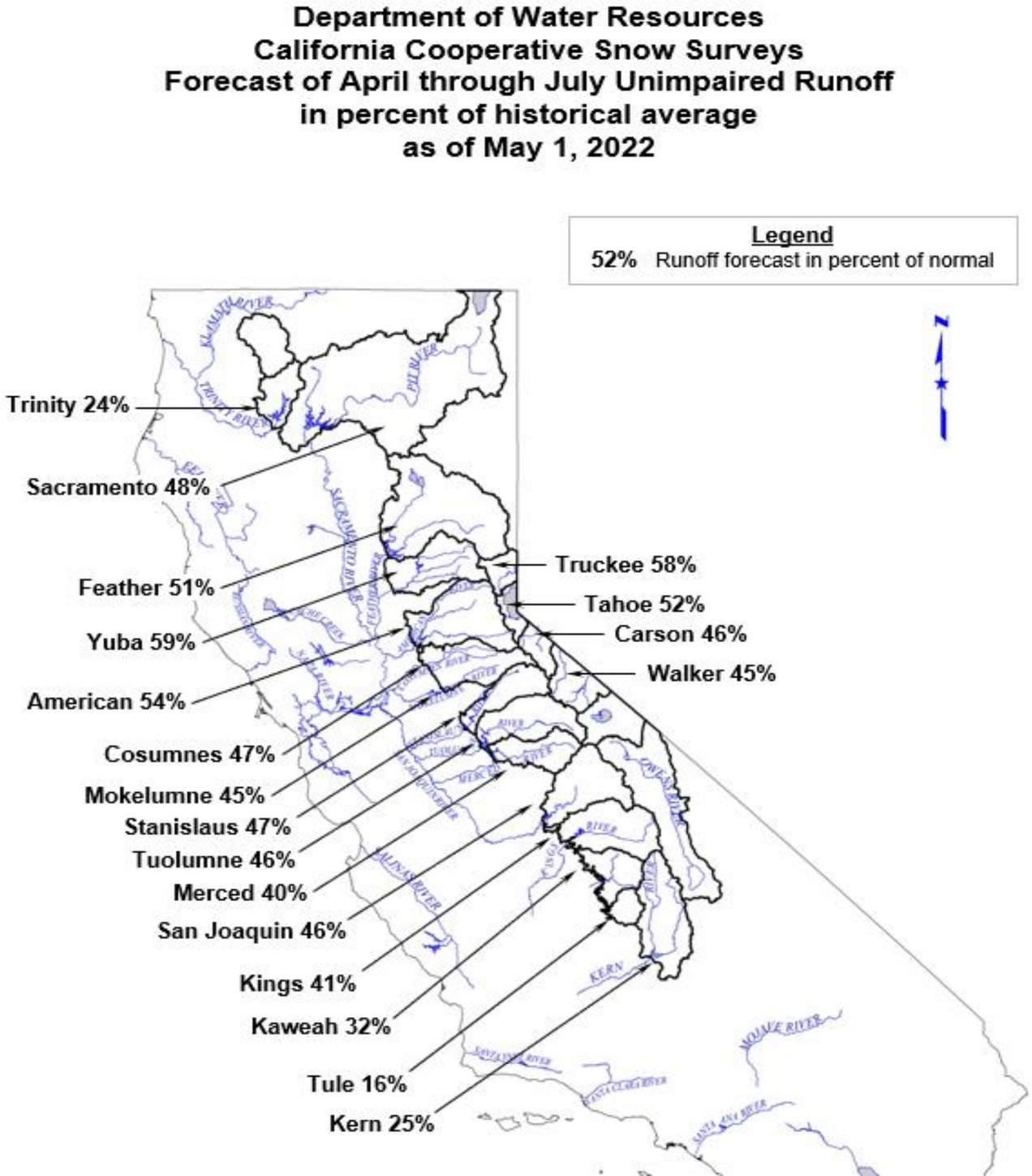
Wade Crowfoot
Secretary for Natural Resources
The Natural Resources Agency

Karla Nemeth
Director
Department of Water Resources

Salient Features of Bulletin 120

- Published as a series of monthly reports titled Bulletin 120, “Water Conditions in California” at the start of February, March, April, and May of every year
- The bulletin series includes forecasts of median unimpaired April through July runoff volume and 80 percent confidence range for 24 river basins in the State
- These are the official forecasts used by the water managers to determine a host of environmental standards governing stream fishery flow and water allocations/deliveries
- Forecast updates on major Central Valley rivers are produced on a weekly basis till mid-June or later

Basins included in the Bulletin 120



Forecasting Procedures

- Water supply forecasts for each watershed are currently based on multiple linear regression equations that relate April-July unimpaired runoff to:
  - An index of accumulated Snow (SWE) to date
  - An index of accumulated Precipitation to date
  - Observed Unimpaired Runoff at the forecast location
- For a given basin, a set of equations is used during the February to June forecast season. This is different from other agencies that use different equations for different months
- The equations are created with the assumption that April 1 remains the date of peak SWE in the Sierra Nevada

General Form of Water Supply Equation

AJRO = C1(HSNO) + C2(LSNO) + C3(OMPT) + C4(AJPT) + C5(OMRO) + C6(PYRO) + K

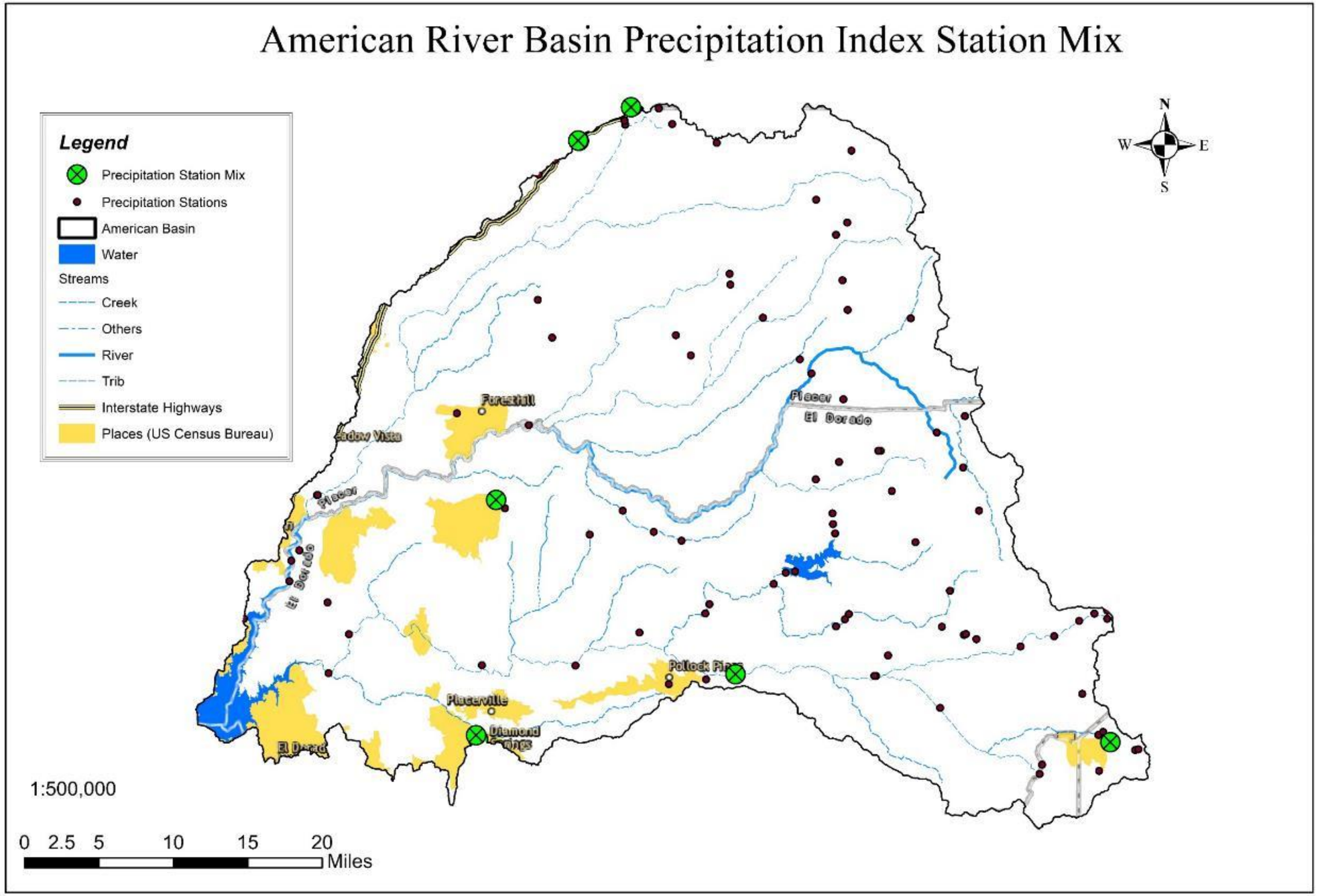
Where:

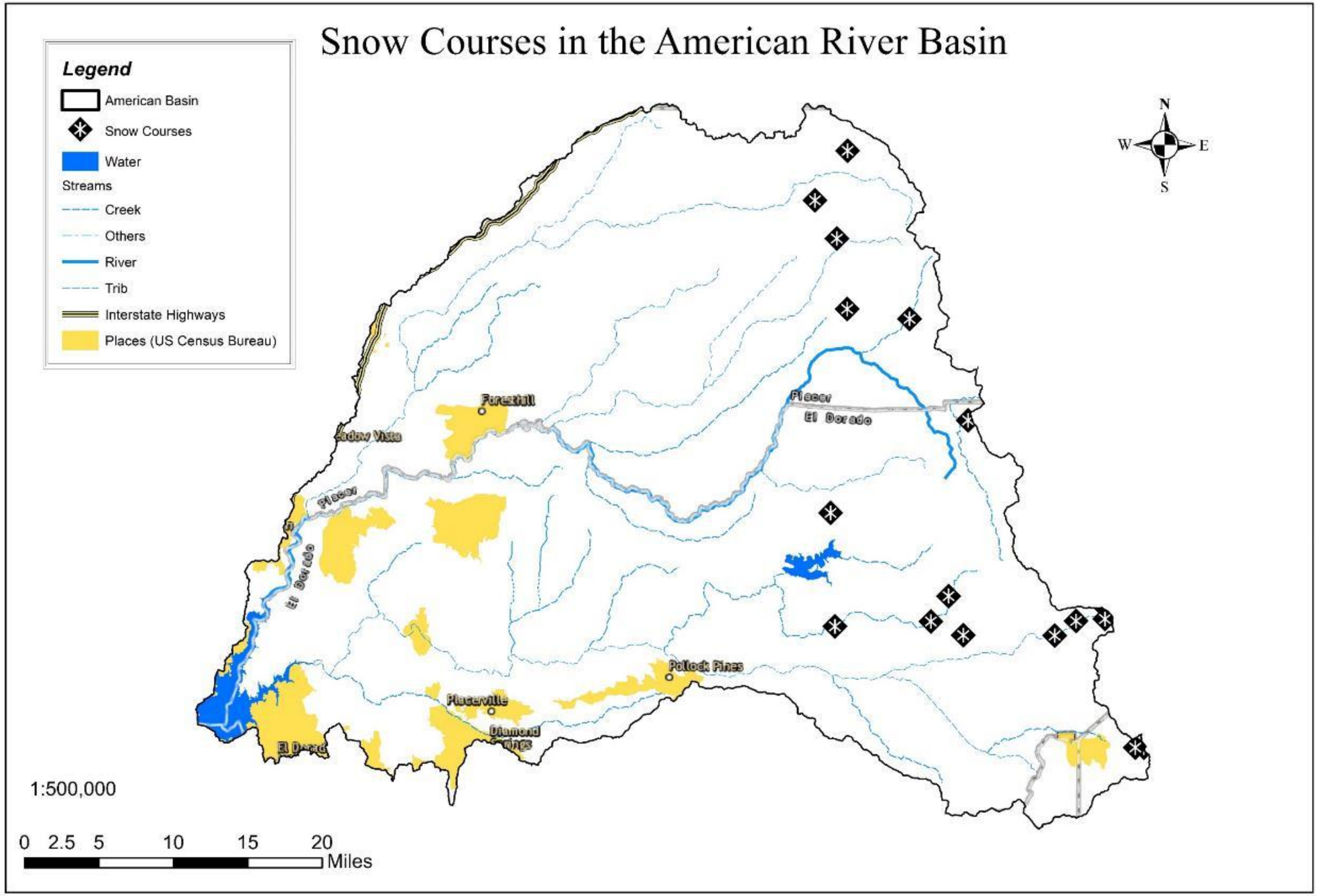
- AJRO is the April-July runoff in acre-feet
- HSNO is the high elevation April 1 snow index
- LSNO is the low elevation April 1 snow index
- OMPT is the October-March precipitation index
- AJPT is the April-June precipitation index
- OMRO is the October-March runoff
- PYRO is the previous year’s April-July runoff
- K is a constant
- C1 through C6 are fixed coefficients

Index Computation

- Seasonal averages (Oct-Mar and Apr-Jun) of precipitation are computed for each station for the period of record
- Precipitation at each station is then weighed by month, recognizing that early season storms will contribute less to Apr-Jul runoff than those later in the season
- The measured water content at each snow course is adjusted to reflect the first of the month conditions
- The adjusted snow water content is expressed as a percentage of the April 1 historical average for each snow course

American River Basin Precipitation Index Station Mix




Snow Courses in the American River Basin
Legend
American Basin
Snow Courses
Water
Streams
Creek
Others
River
Trib
Interstate Highways
Places (US Census Bureau)
N
W
E
S
Placer
El Dorado
Placerville
Pollock Pines
1:500,000
0 2.5 5 10 15 20
Miles

Calculation of April-June Precipitation Index

May 1 forecast example

Feather River inflow to Lake Oroville: Precipitation Index Computations for May 01, 2018

ID	Station Name	River Basin	Dir	Elev (ft)	Lat °N	O-M Avg	Oct		Nov		Dec		Oct-Dec		Jan		Feb		Mar		A-J Avg	Apr		May		Jun		O-J Obs	WY Avg
							Prec.	Index	Prec.	Index	Prec.	Index	Index	Adj.	Prec.	Index	Prec.	Index	Prec.	Index		Prec.	Index	Prec.	Index	Prec.	Index		
						Scale Factor	0.5		0.6		0.7				0.8		0.9		1.0			1.0		0.8		0.6			
SRR	SIERRAVILLE RS	Feath	↘	4,975'	+39.6	16.90	0.59	1.7	7.51	26.7	0.39	1.6	30.0	30.0	2.76	13.1	1.13	6.0	8.25	48.8	3.00	1.94	64.7					22.57	25.92
MNR	MINERAL	SacVl	↖	4,875'	+40.4	32.50	1.13	1.7	13.91	25.7	1.12	2.4	29.8	29.8	8.43	20.8	1.05	2.9	7.27	22.4	6.70	6.25	93.3					39.16	51.13
PRT	PORTOLA	Feath	→	4,850'	+39.8	13.30	0.38	1.4	4.84	21.8	0.48	2.5	25.8	25.8	2.95	17.7	1.17	7.9	8.89	66.8	2.70	2.46	91.1					21.17	20.68
CNY	CANYON DAM	Feath	↖	4,560'	+40.2	25.60	1.00	2.0	11.67	27.4	0.50	1.4	30.7	30.7	6.67	20.8	0.52	1.8	10.55	41.2	4.60	3.63	78.9					34.54	38.44
BCM	BRUSH CREEK	Feath	↙	3,560'	+39.7	47.00	1.28	1.4	15.25	19.5	0.97	1.4	22.3	22.3	11.50	19.6	1.34	2.6	18.69	39.8	7.90	8.14	103.0					57.17	70.08
QRD	QUINCY RADIO	Feath	⊕	3,420'	+39.9	26.70	0.58	1.1	10.14	22.8	0.84	2.2	26.1	26.1	6.19	18.5	0.90	3.0	12.88	48.2	5.00	2.96	59.2					34.49	
CBO	CARIBOU PH	Feath	⊕	2,986'	+40.1	27.50	0.79	1.4	10.31	22.5	0.89	2.3	26.2	26.2	6.23	18.1	0.27	0.9	10.46	38.0	5.00	3.93	78.6					32.88	40.67
BUP	BUCKS CREEK	Feath	←	1,760'	+39.9	45.40	0.89	1.0	16.10	21.3	2.20	3.4	25.6	25.6	8.38	14.8	1.62	3.2	17.85	39.3	8.00	8.50	106.2					55.54	
Basin Averages				5,200	+40.0	29.36	0.83	1.5	11.22	23.4	0.92	2.2	27.1	27.1	6.64	17.9	1.00	3.5	11.86	43.1	5.36	4.73	84.4					37.19	41.15
Historical Median Index (month's share of period's index)																26.0		22.0		18.0			54.0		26.0		7.0		
Oct-Mar Indices							Jan 1	93.1		93.1	Feb 1	85.0	Mar 1	66.5	Apr 1	91.6			May 1	91.6	Jun 1		Jul 1					
Apr-Jul Indices										87.0		87.0		87.0		87.0				117.4								

A B C D

$$D = \frac{B}{A} \times C \times 100$$

$$April\ Precipitation\ Index = \frac{April\ Precipitation}{April - June\ Precipitation\ Average} \times Scale\ Factor \times 100$$

$$64.7 = \frac{1.94}{3.00} \times 1.0 \times 100$$

Calculation of April-June Precipitation Index

What about May and June?

Feather River inflow to Lake Oroville: Precipitation Index Computations for May 01, 2018

ID	Station Name	River Basin	Dir	Elev (ft)	Lat °N	O-M Avg	Oct		Nov		Dec		Oct-Dec		Jan		Feb		Mar		A-J Avg	Apr		May		Jun		O-J Obs	WY Avg
							Prec.	Index	Prec.	Index	Prec.	Index	Index	Adj.	Prec.	Index	Prec.	Index	Prec.	Index		Prec.	Index	Prec.	Index	Prec.	Index		
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Apr-Jul Indices														87.0		87.0		87.0		87.0			117.4						

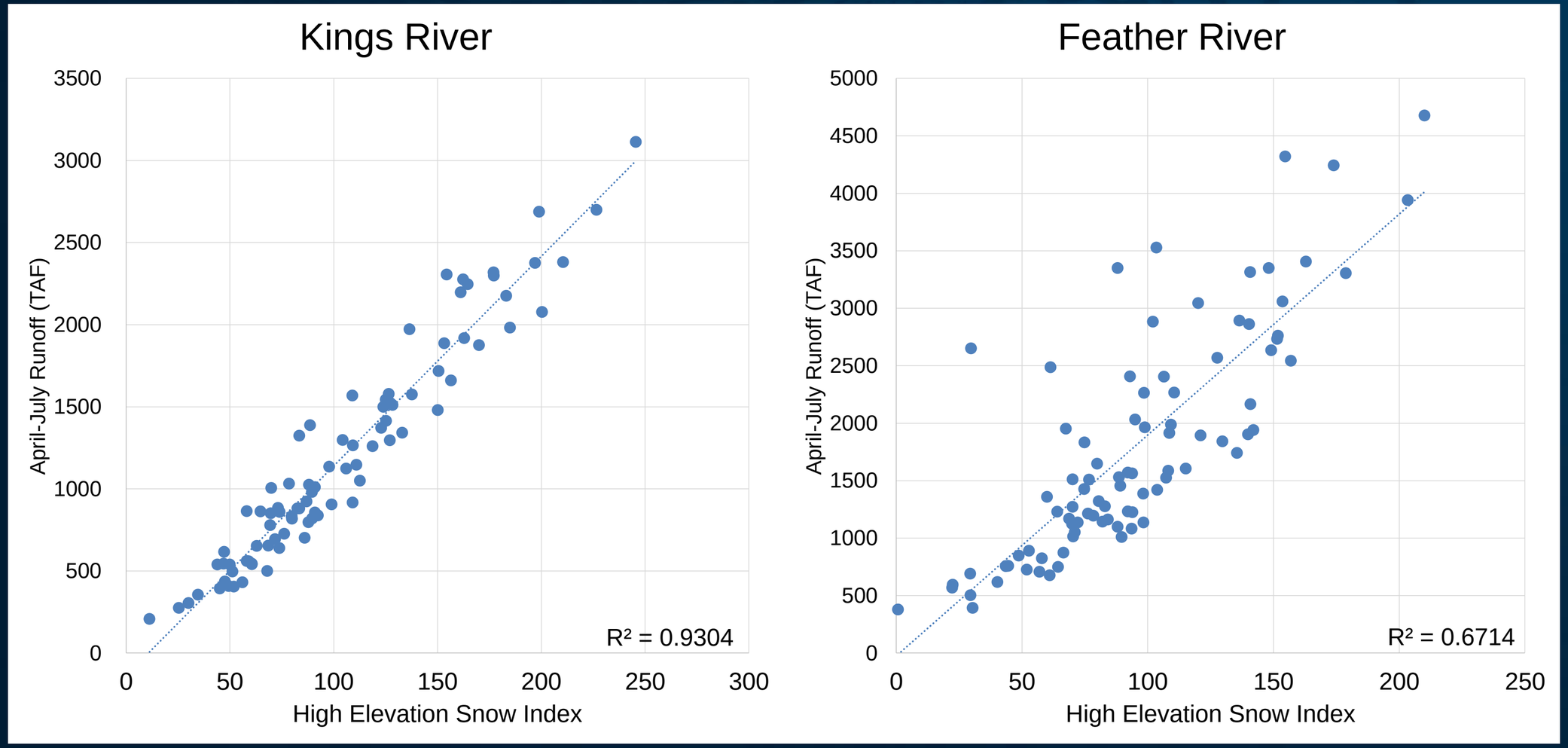
A D B C

$$D = A + B + C$$

$$April - June\ PrecipitationIndex = April\ Index + May\ Historical\ Median\ Index + June\ Historical\ Median\ Index$$

$$117.4 = 84.4 + 26.0 + 7.0$$

Historical Correlation of April-July Runoff to High Elevation Snow Index



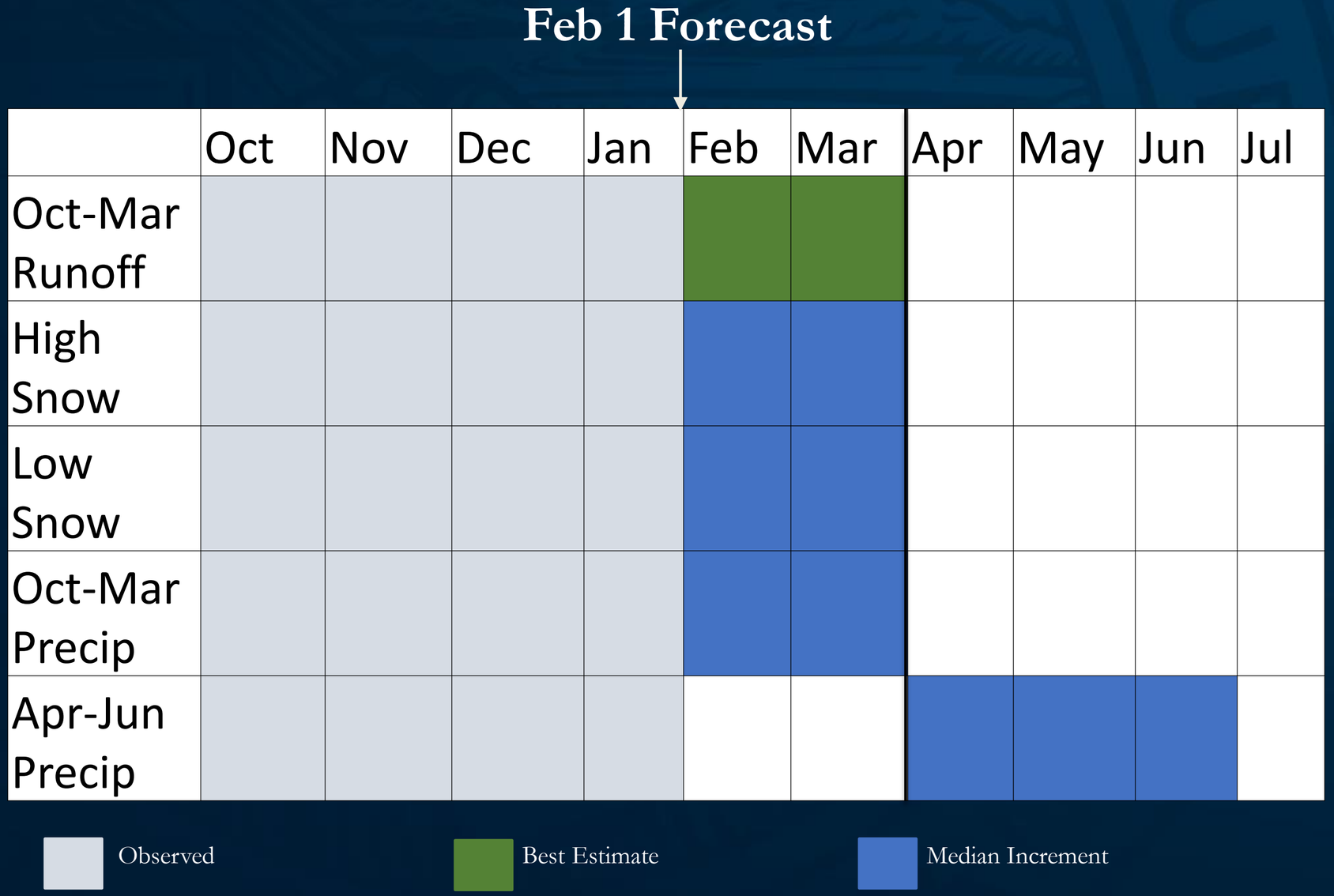
Questions: How Has Climate Change impacted these relationships?

How has greater subseasonal and seasonal variability changed these?

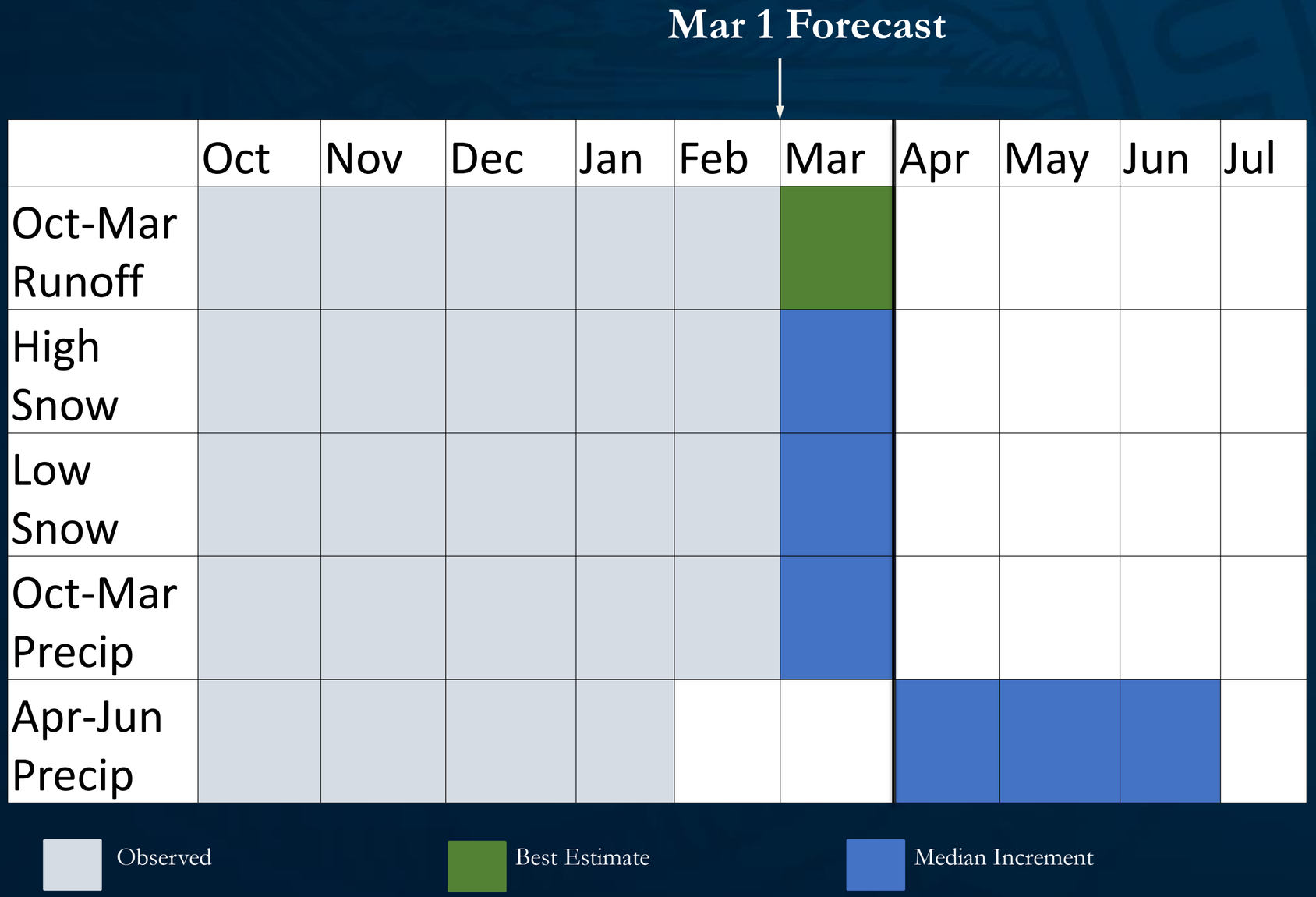
Median Condition Runoff Forecasts

Median values are used for indexed variables in the regression equations that have not yet occurred. This forces the forecasts to be based on existing conditions to date plus what would result if the subsequent hydrologic conditions are median. Because of this our forecasts are often referred to as median condition runoff forecasts

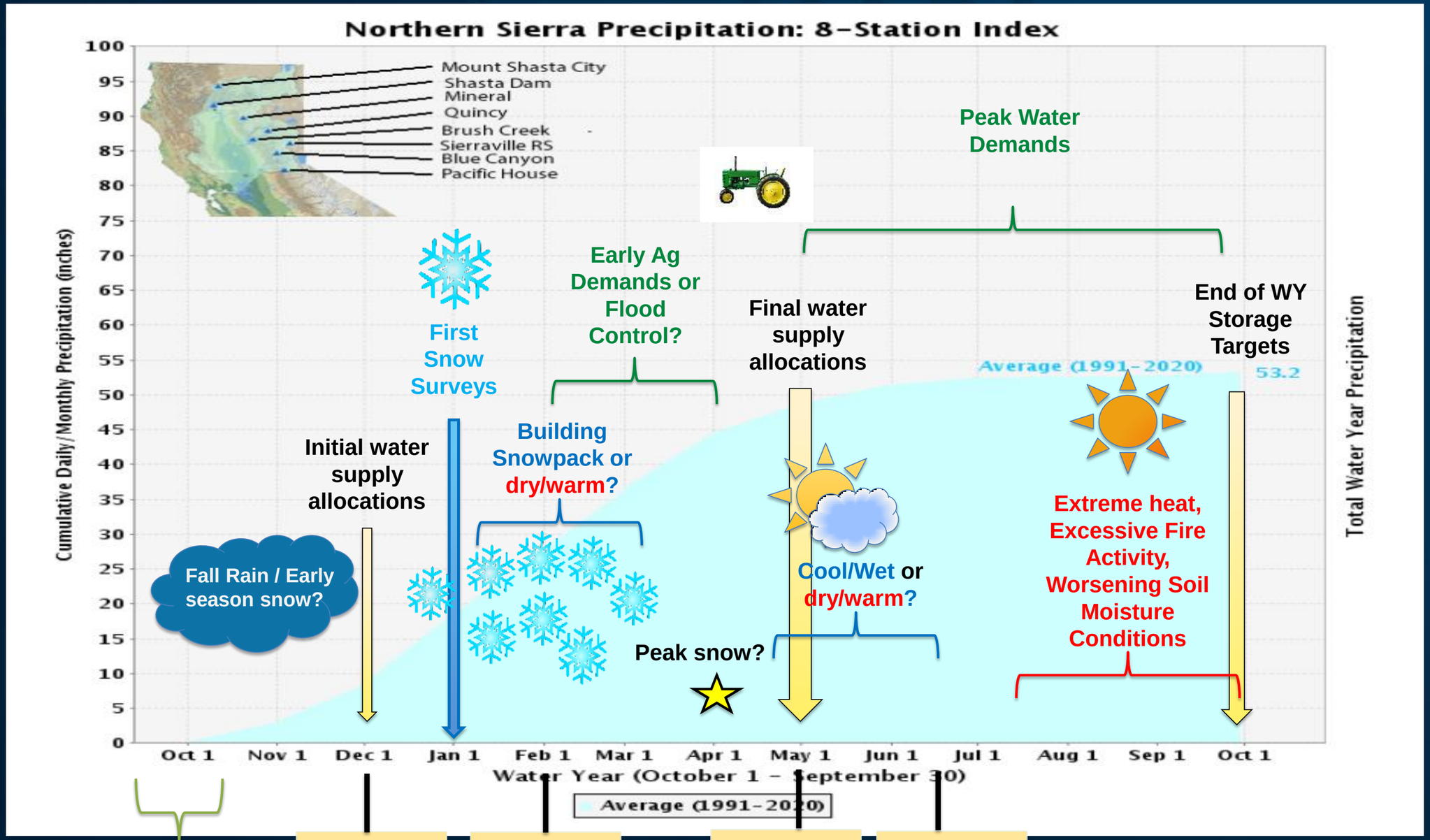
Predicting seasonal runoff using median increments



Predicting seasonal runoff using median increments

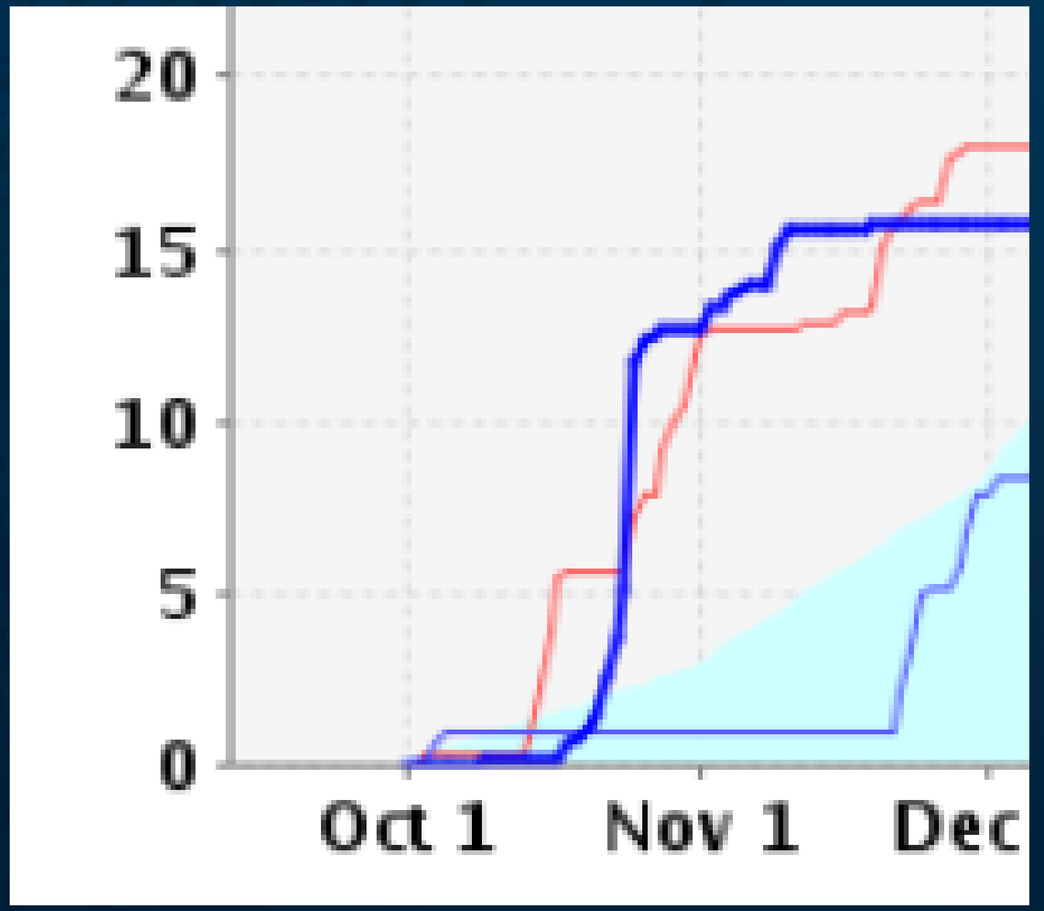


Water Management and Forecast Decision Points from a WY Climate & Weather Point of View

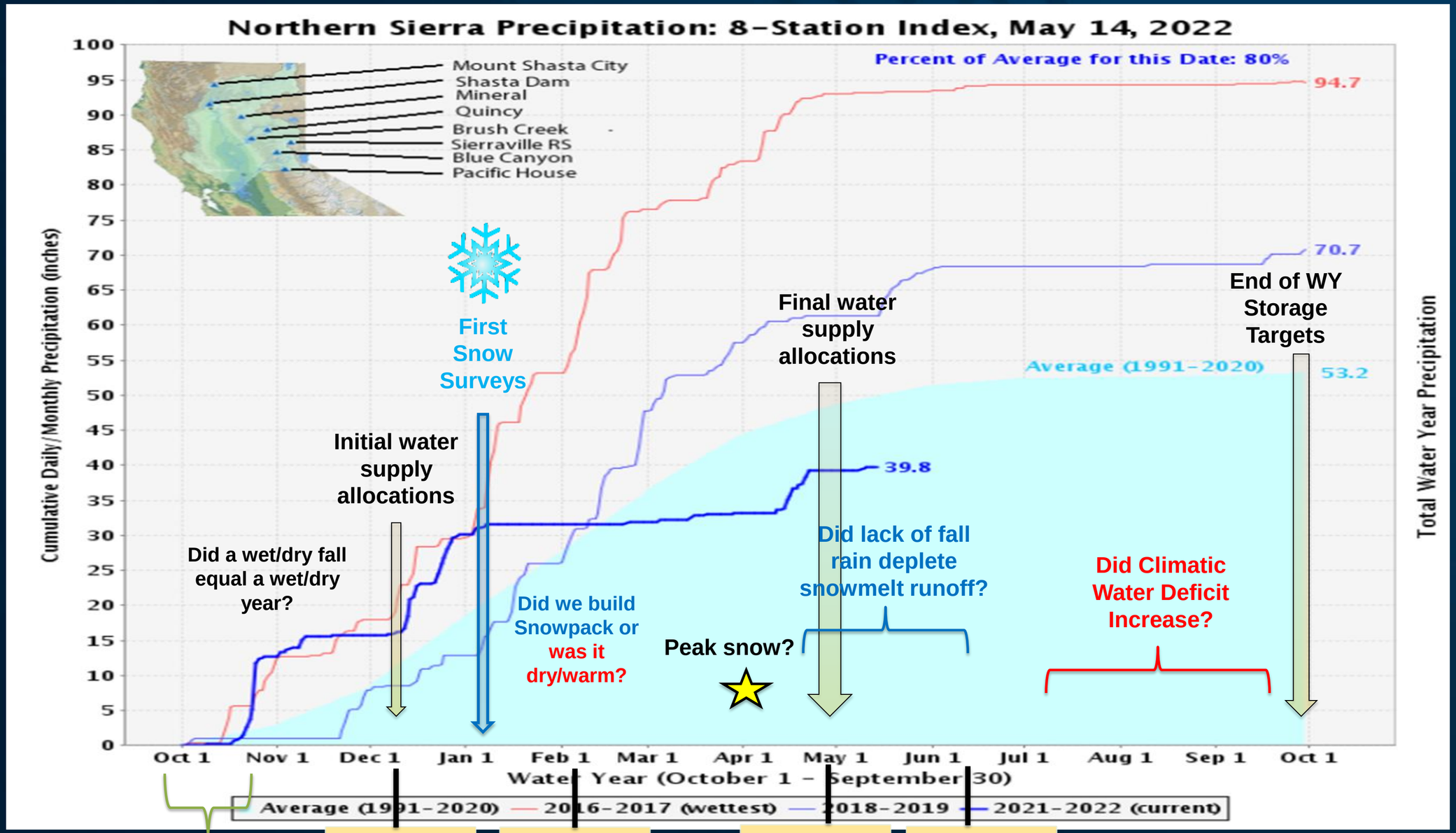


Which of these three years was
1) record setting for precipitation accumulation
2) an above average year 3)
a below average year?
Which experienced cold/wet winter conditions?
Which saw a record dry/warm winter?

A more climate resilient water management strategy depends on better observations and better forecasts to handle the timing, pace, and scale of



Water Management and Forecast Decision Points from a WY Climate & Weather Point of View



Climate Outlook F'Casts

First Water Supply Index Forecast

First B120 Forecast

Enviro / River Restoration Decisions

Final Water Supply Index Forecast

Final B120 Forecast

Fill Reservoirs, Manage Snowmelt Flood, or Low Snowmelt Runoff?

Better Observations

KINGS RIVER BASIN
APRIL 24-25, 2022 SURVEY

Survey Date: April 24-25, 2022
Survey # of Water Year 2022: 3
Report Delivery Date: April 29, 2022
Version: 0

Full basin SWE: 333 ± 20 TAF
Change in SWE since Apr 10, 2022: -25 TAF
Estimated snowline: 7800 ft

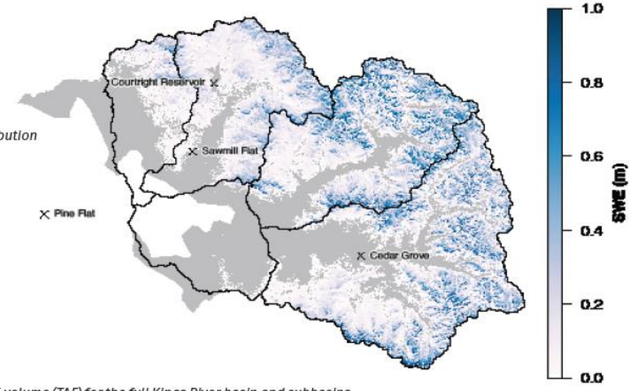


Figure 1. Spatial distribution of SWE depth (m).

Table 1. Estimated SWE volume (TAF) for the full Kings River basin and subbasins for current survey (April 24-25) and previous ASO survey (April 9-10).

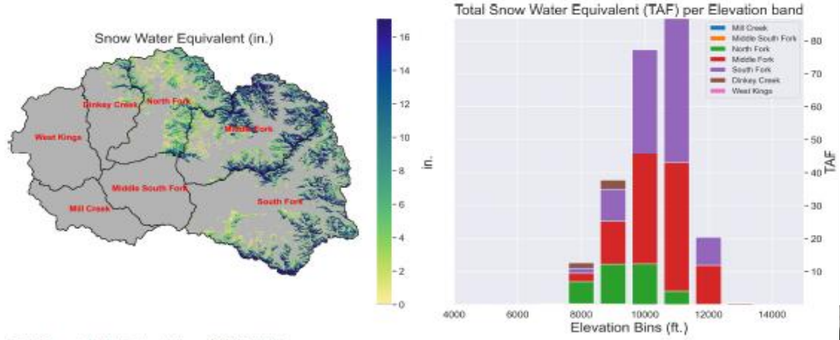


Fig.4 Snow Water Equivalent as of 2022-05-01

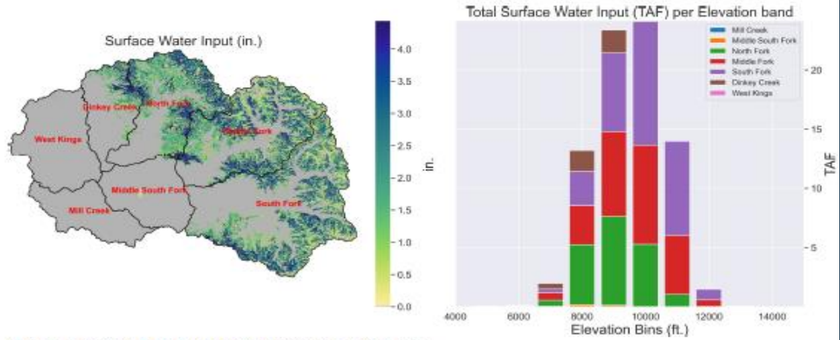


Fig.5 Accumulated Surface Water Input from 2022-04-25 to 2022-05-01

Better Forecasts

- Fall (October/November)
  - Precipitation Onset
  - Temperature Anomaly
  - Soil Moisture State with Snowpack Initiation
- Winter (December/January/February)
  - Wet/Dry
  - Notable Anomalies
- Spring (March/April/May)
  - Late-Season Bailout or Early Shutoff?
  - Peak Snowpack Timing and Magnitude
- Summer (June/July/August/September)
  - Drying Pace and Scale
  - Heat Events
  - Tropical Activity
- Multi-Year Prediction – What about next year?

Questions?

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