This is What We are Seeing

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Snow Survey Boise, Idaho

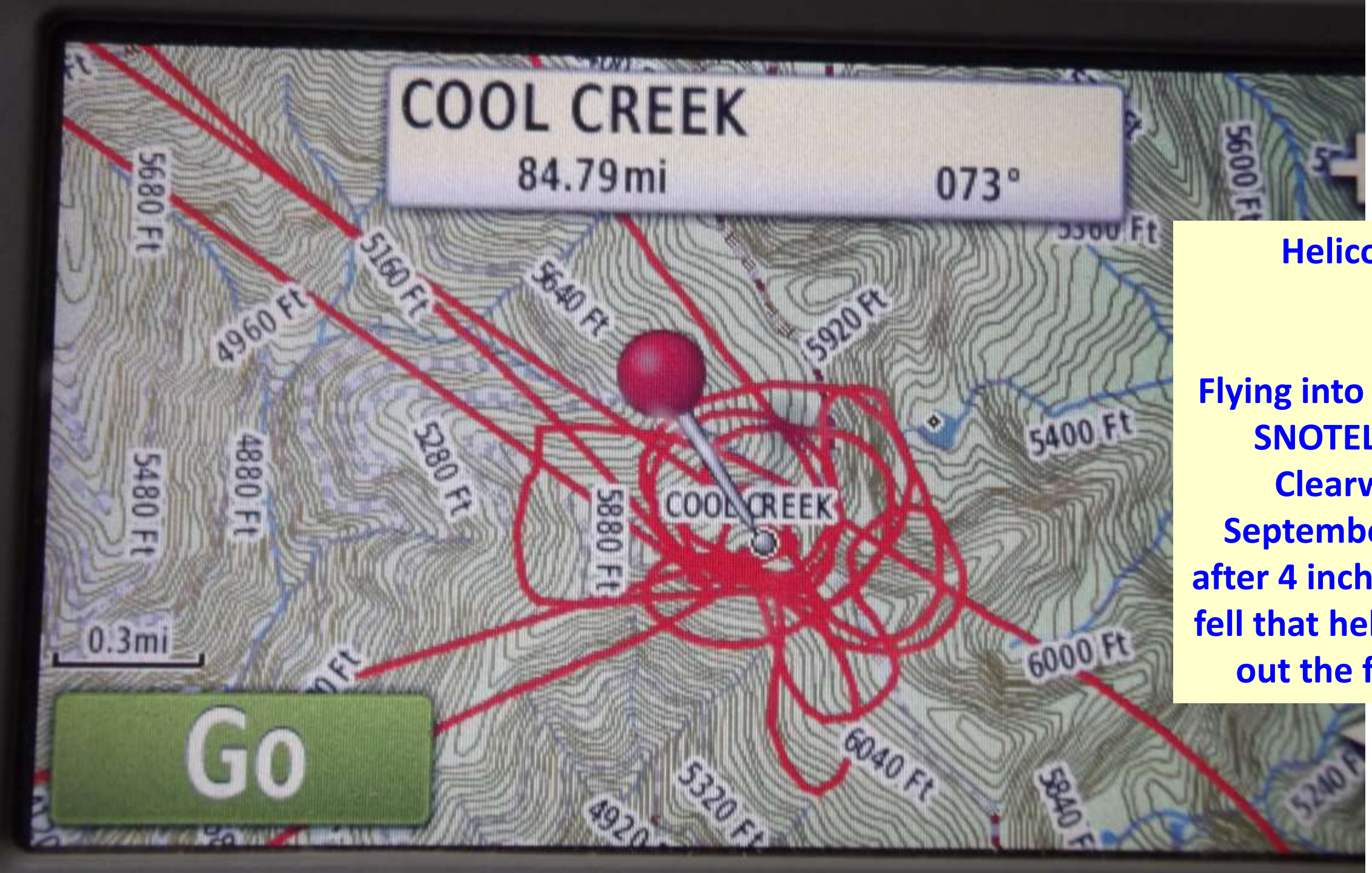
Pacific Northwest Section American Water Works Association

PNWS- AWWA Boise Conference May 4, 2016

DROUGHT & CLIMATE CHANGE - better planning or the new normal?

USDA

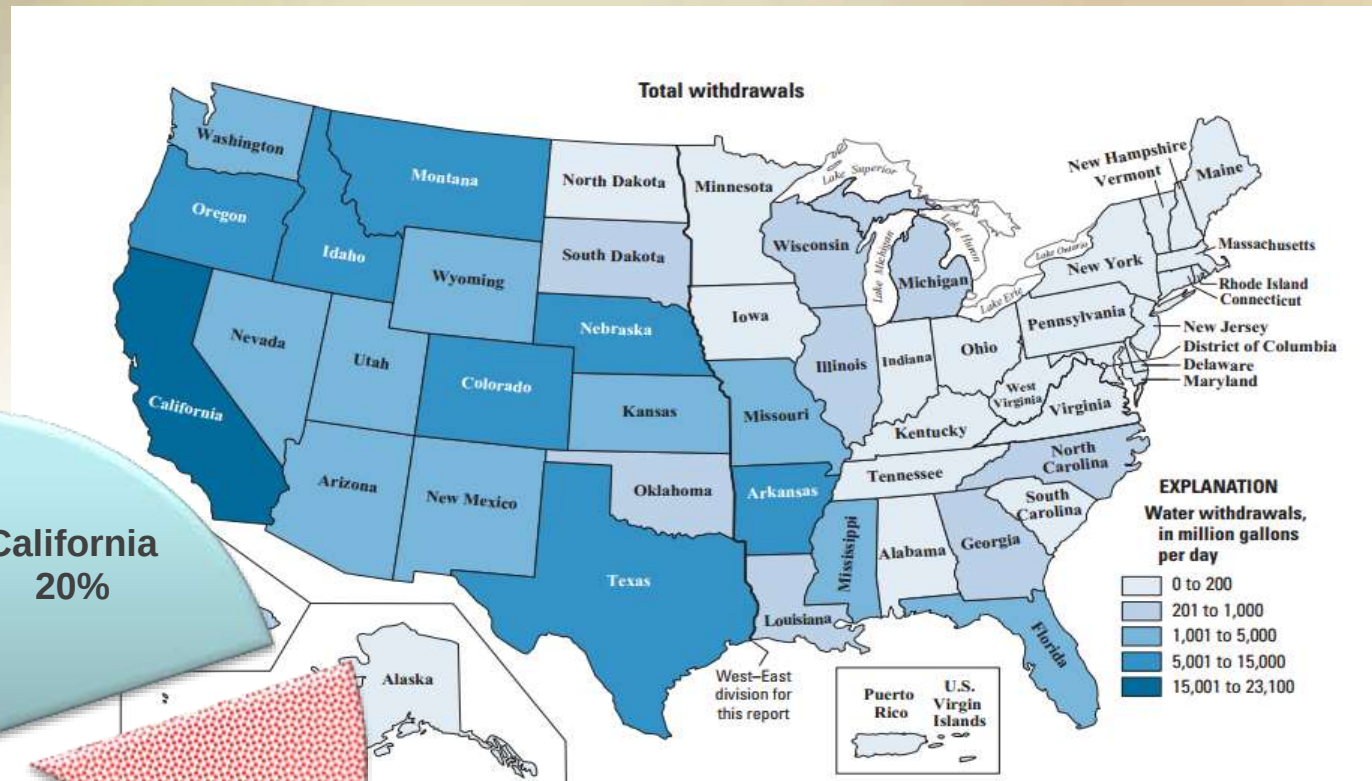
NRCS Natural Resources Conservation Service

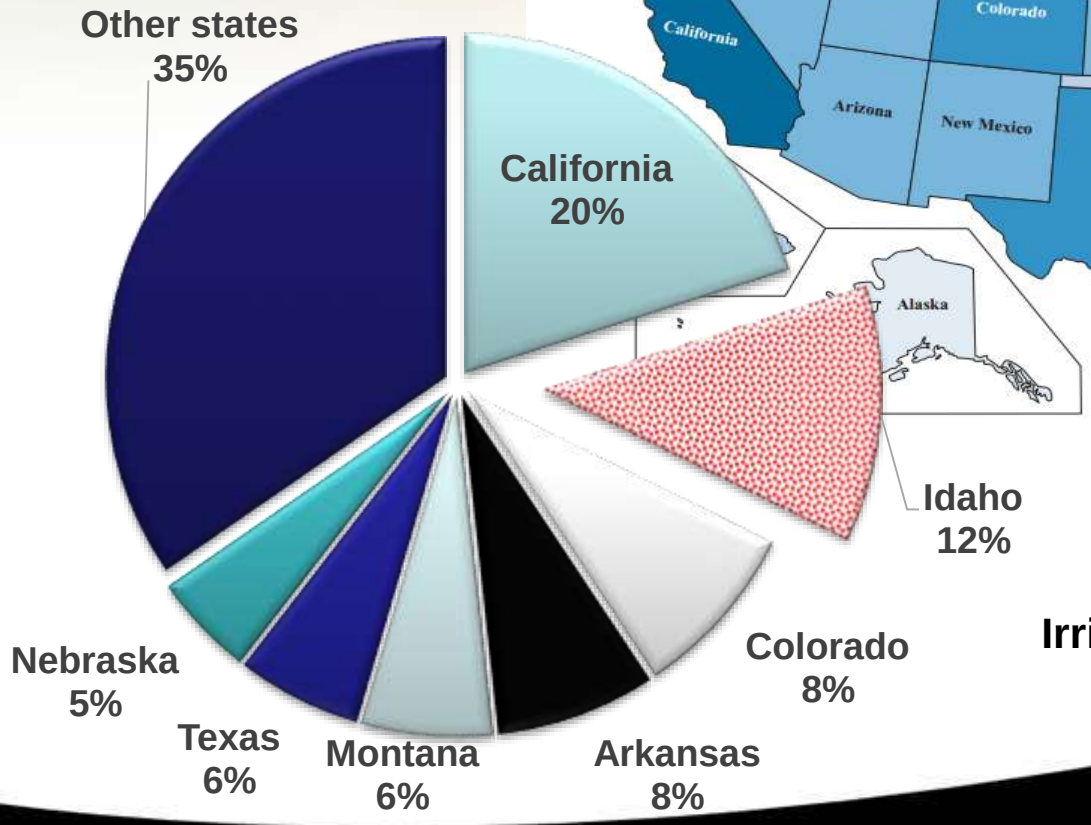


Helicopter Flight Tracker:

Flying into Cool Creek SNOTEL site in the Clearwater basin September 26, 2013 after 4 inches of snow fell that helped to put out the forest fires.

Idaho, 2nd in irrigation withdrawals

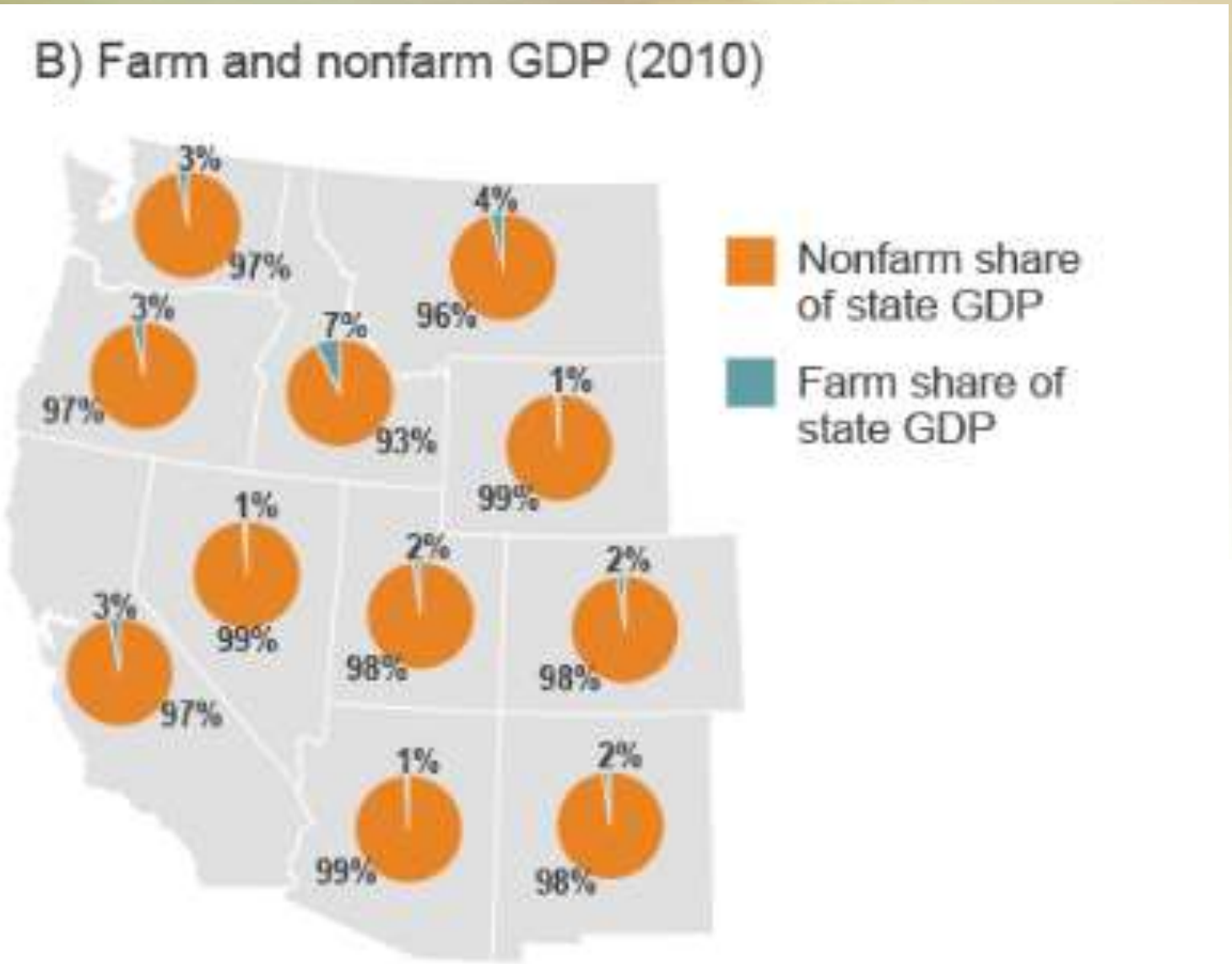




Irrigation Water Withdrawals (MGD)

Source: Estimated Use of Water In the United States in 2010, USGS Circular 1405

University of Idaho
College of Agricultural and Life Sciences



Idaho ranks 1st in farm GDP %

Water Year 2015 Summary of Climate, Hydrology & Snowpack Observations

Water year 2015 was very unique in terms of climate variability in Idaho.

November arctic cold spell

‘Snow Drought’

Two Atmospheric River events produced early runoff

A dry & warm March and April:

- **closed ski areas early**
- **produced record high early irrigation demands**

May’s rains provided some relief for southern Idaho irrigators.

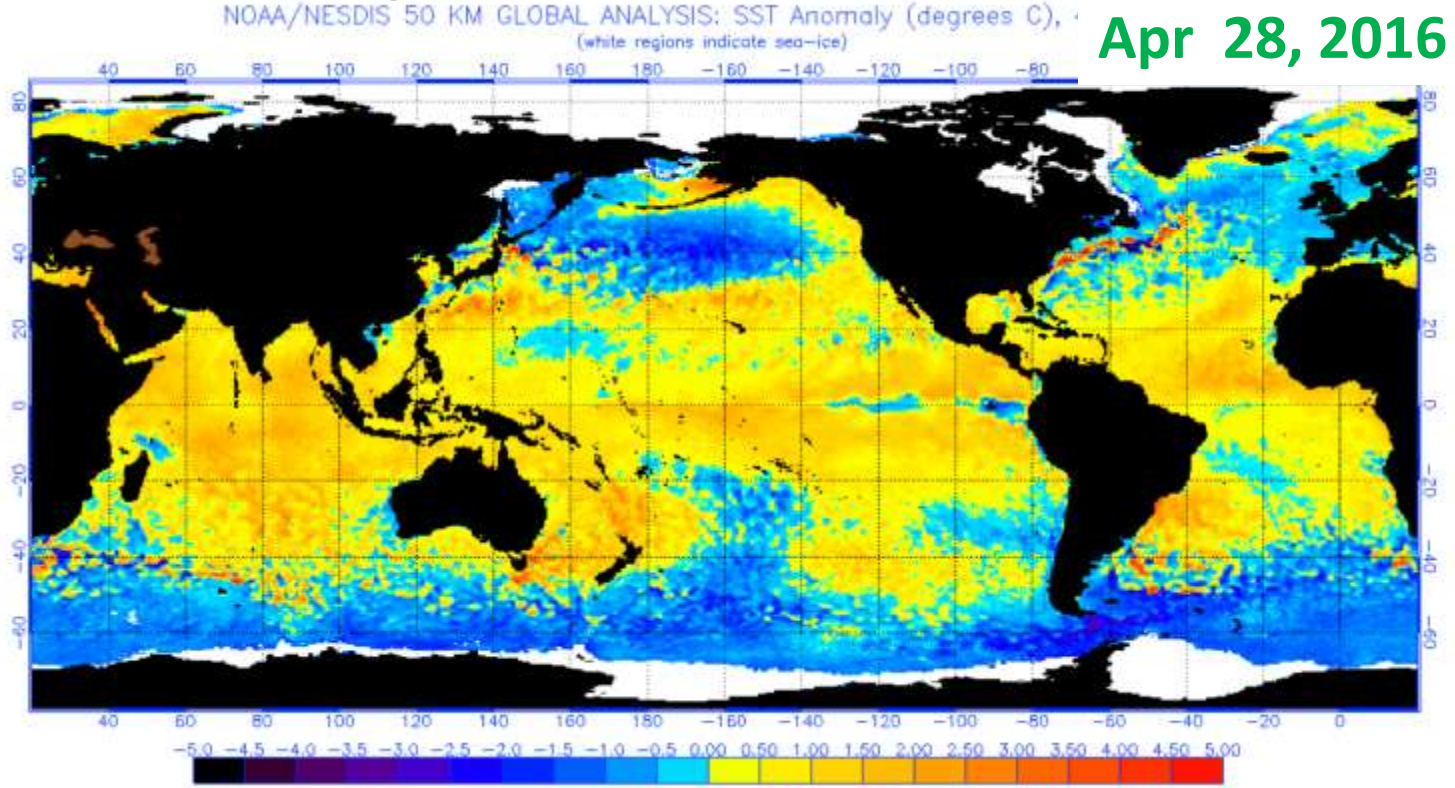
Record high June temperatures gave way to more reasonable July temperatures as the summer fire season grew in intensity.

USDA

An increase in climate variability, increases the need for better planning and to:

Summary slide

Better understand key climatological relationships in your basin OR region to provide a better understanding of what may happen when certain climatological conditions occur.



- MF Salmon River basically froze overnight & froze sap in trees

- Nov 2014 Arctic Cold Spell suddenly spilled into Idaho from Montana
- Boise went from 50s F to single digits in a few days

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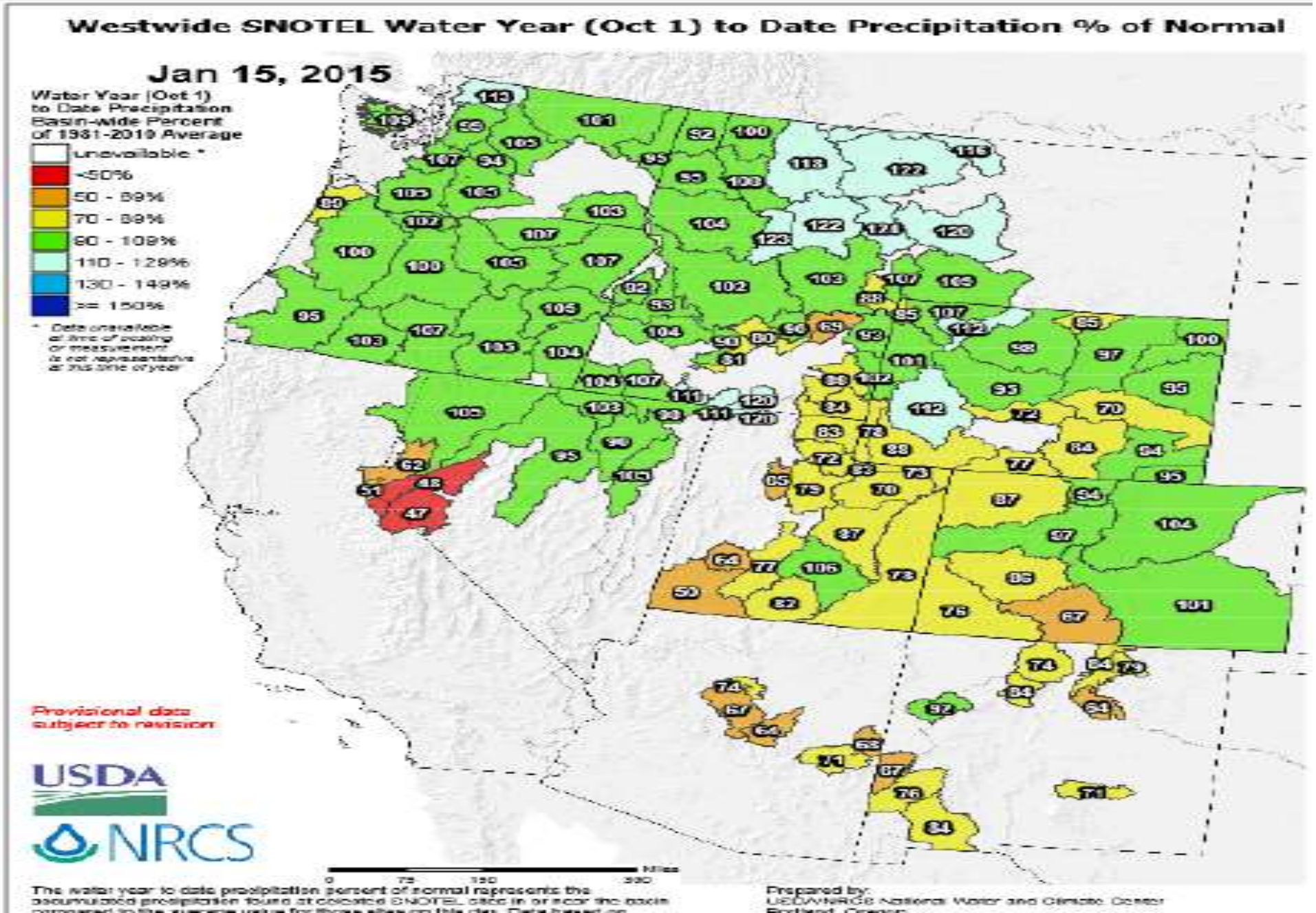
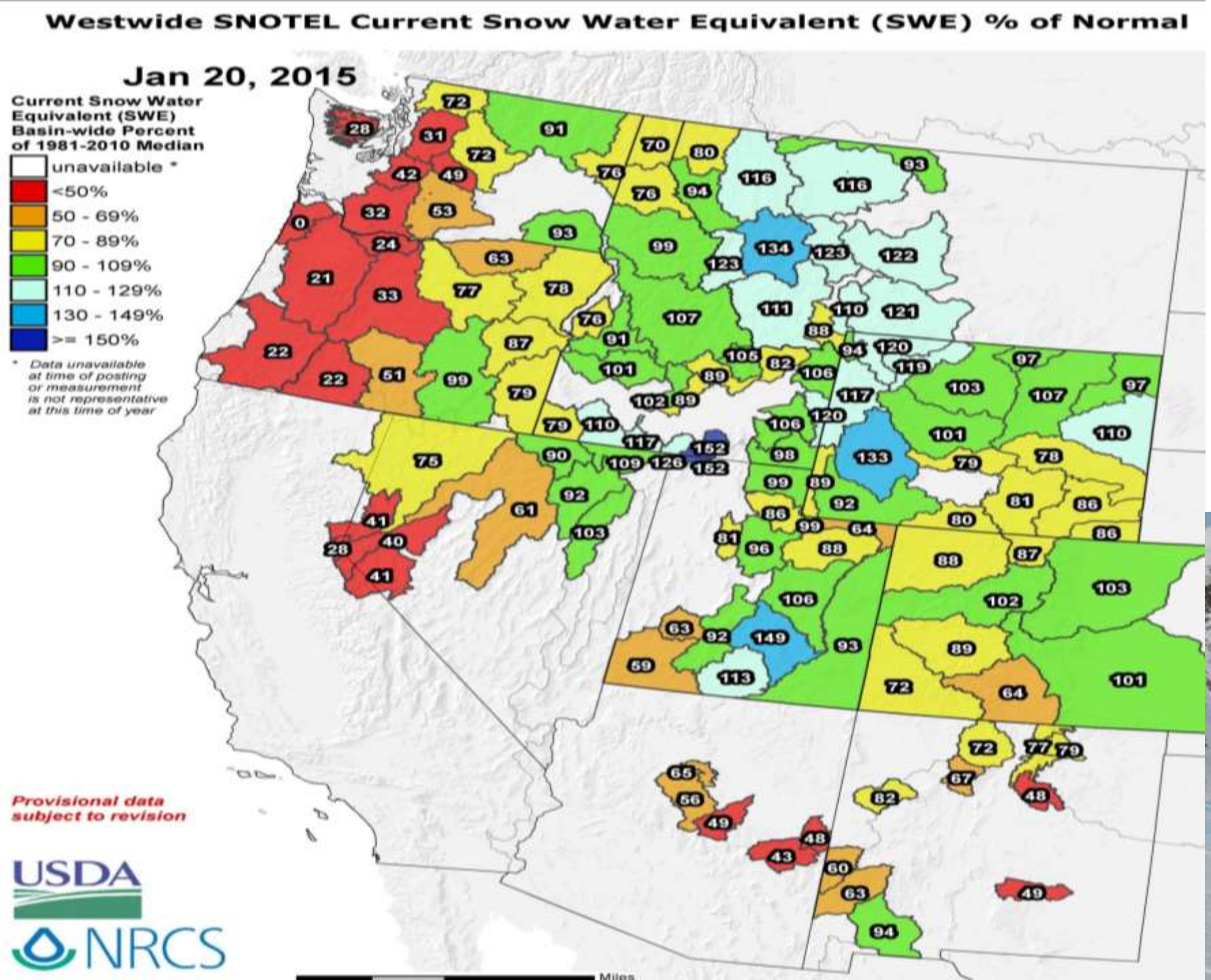
SNOTEL Mountain Precipitation Water Year to Date: Jan 15, 2015



Normal or better across Pacific NW

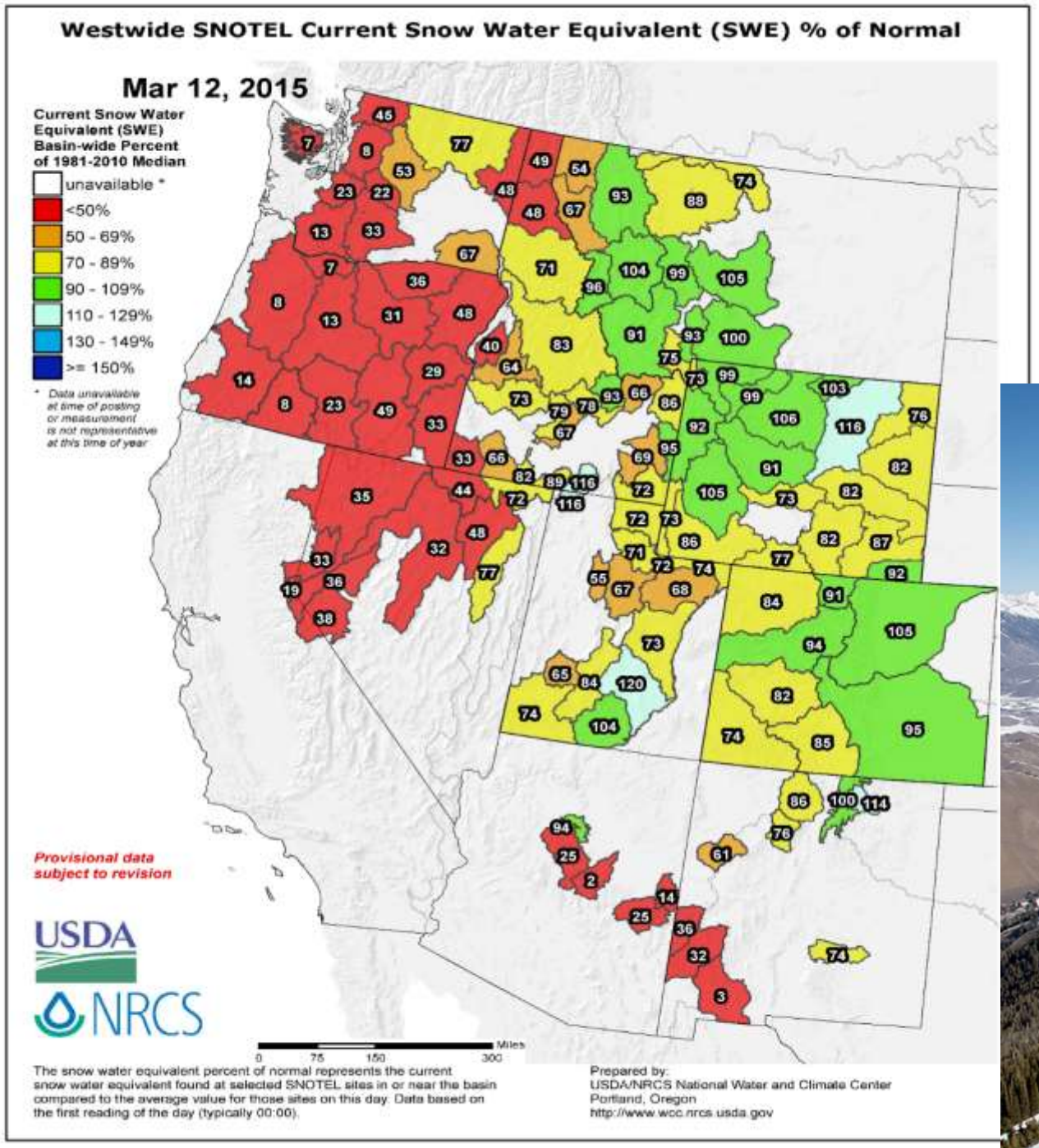
NOT a Precipitation Drought



It's a Snow Drought

Impacts on Skiing:

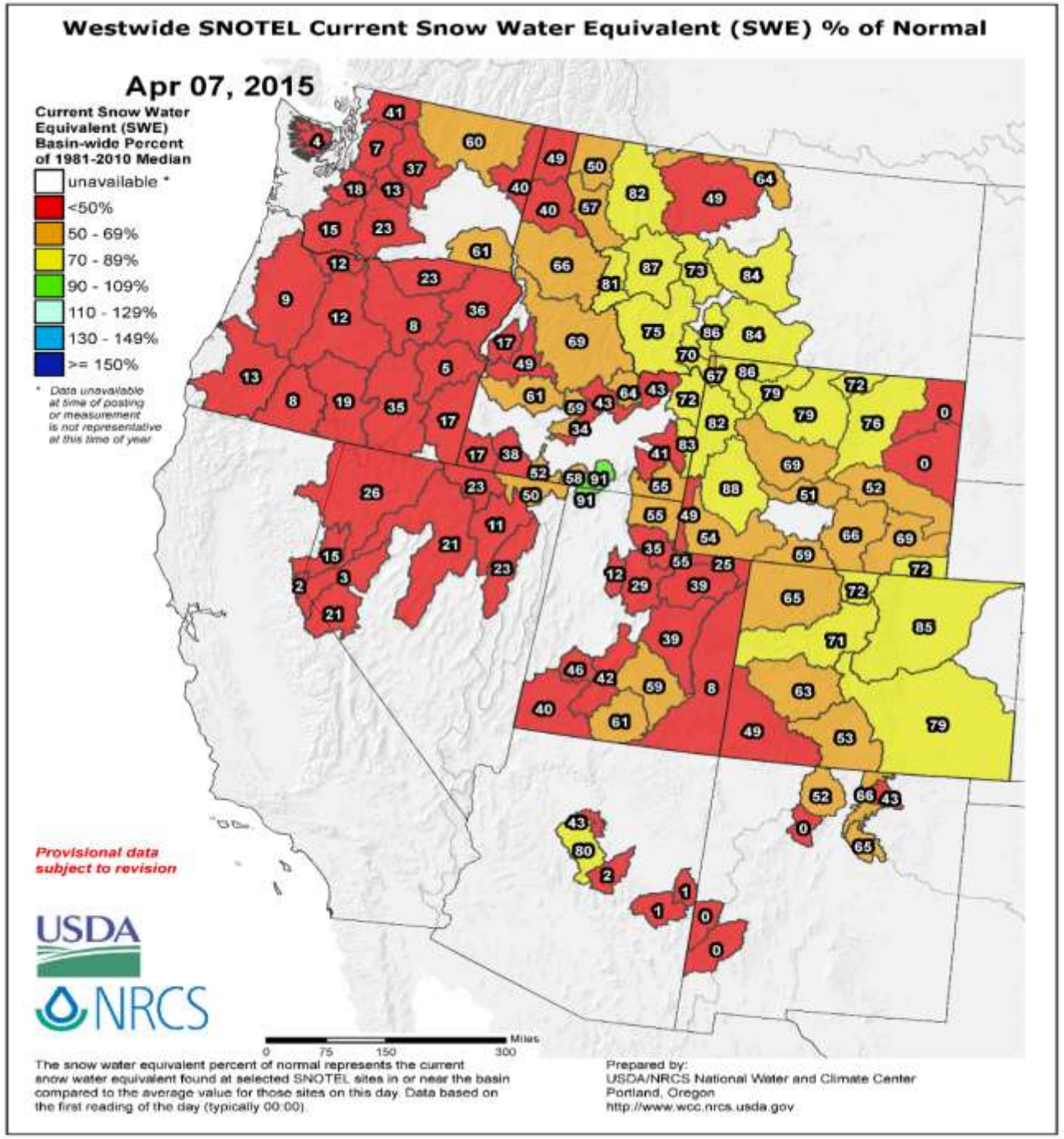
- **Moved Ski Races**
- **Skier Days Down**
- **Season Pass Sale Down**

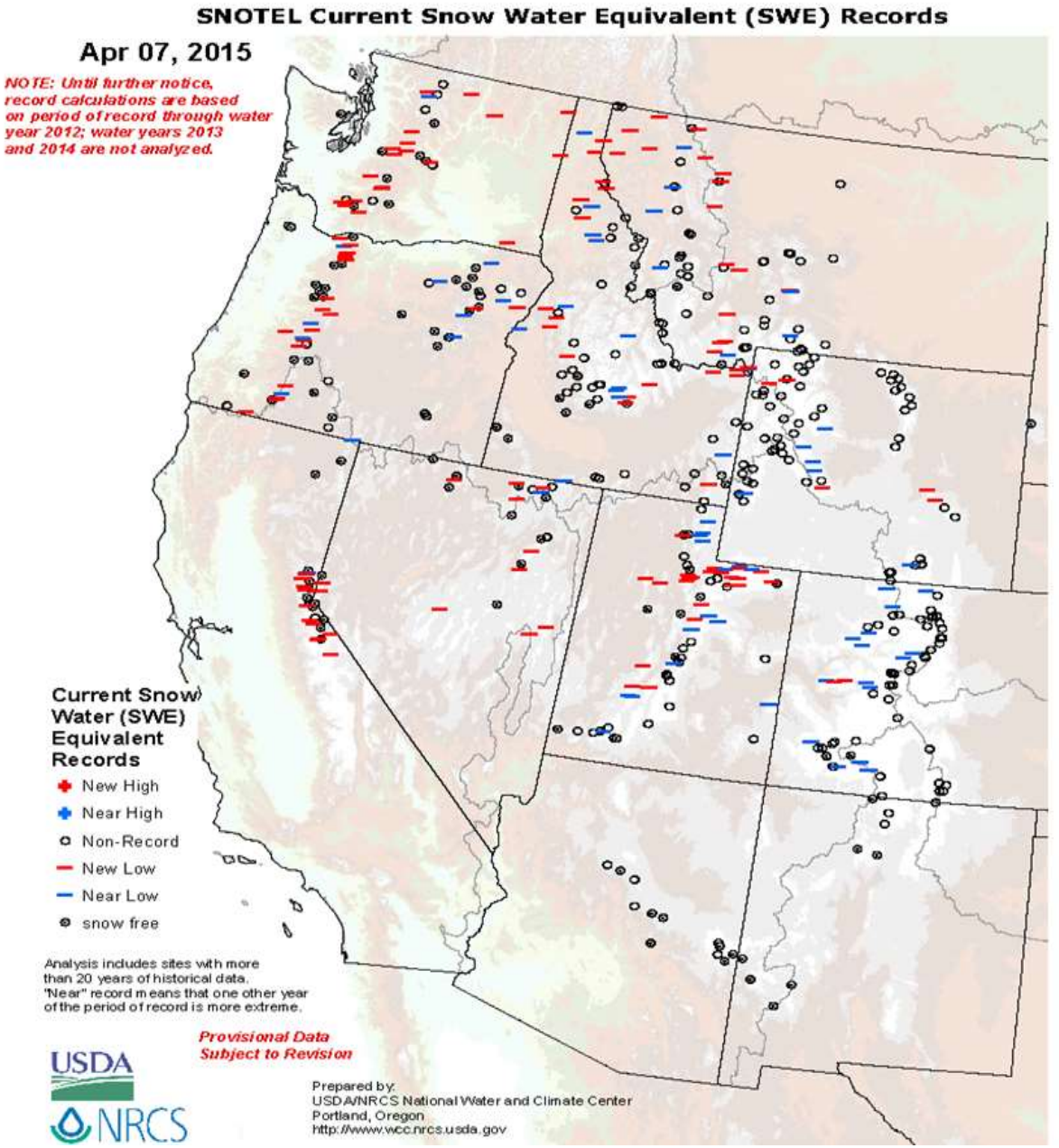


March 11, 2015 Looking east in the Big Wood Valley over Sun Valley Resort

Lack of mid – elevation snow for 2nd consecutive year

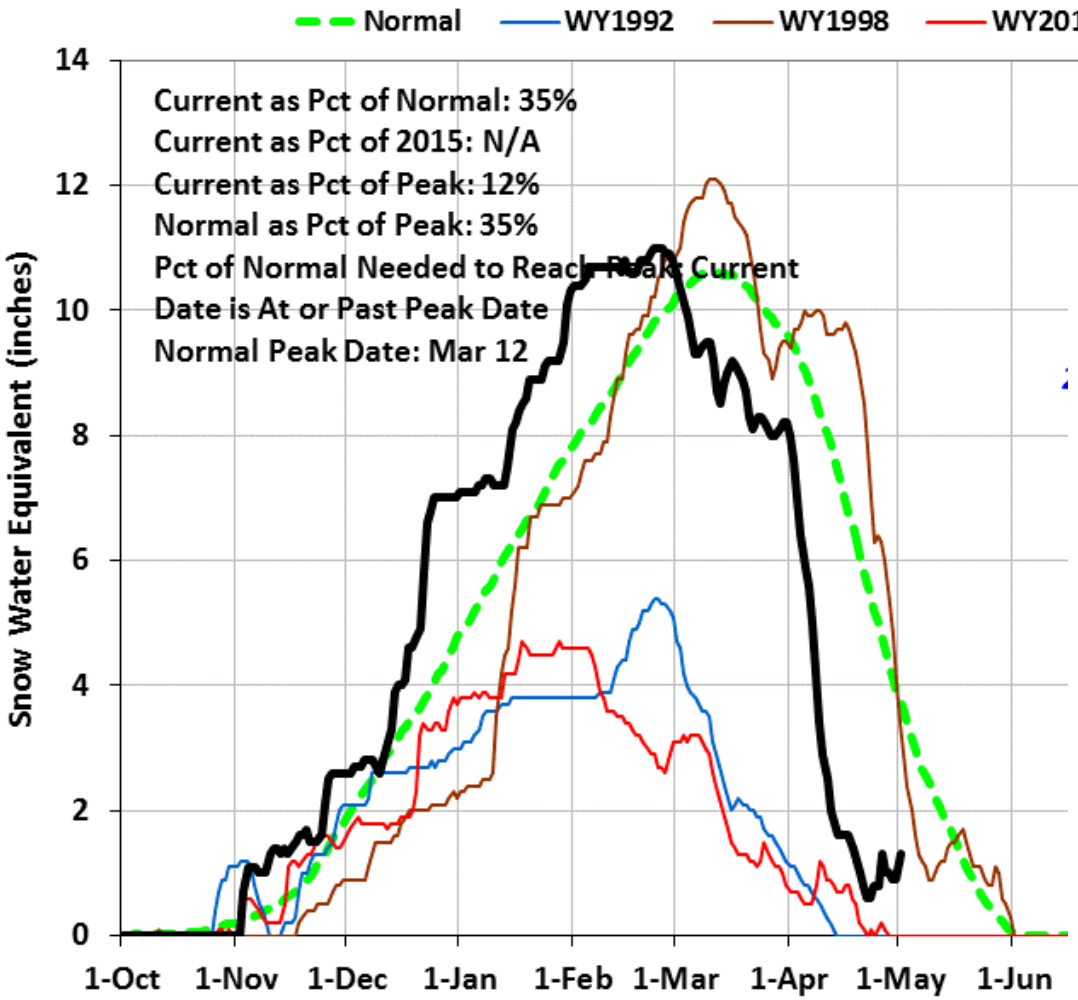
April 7, 2015 -- Record Low Snow





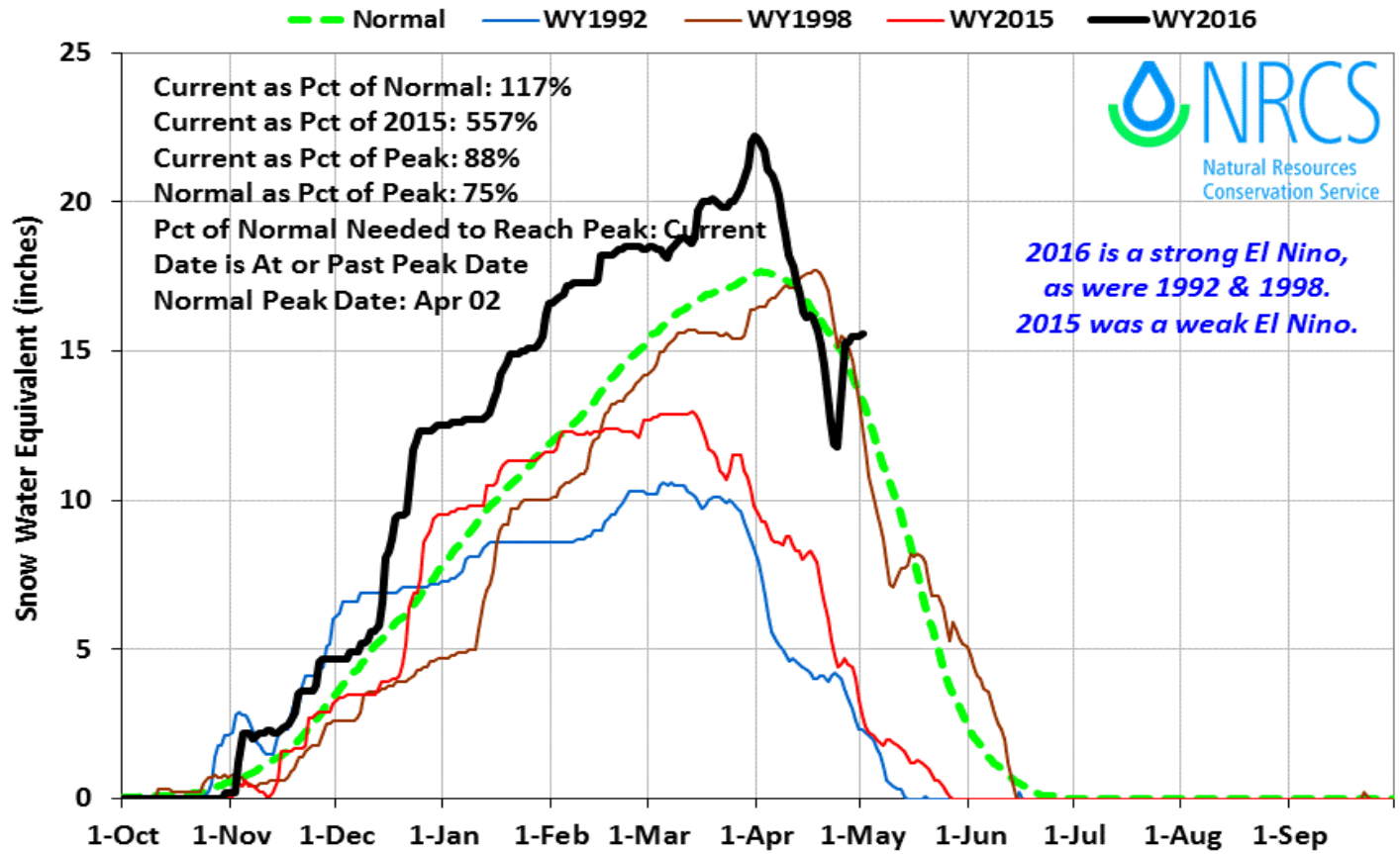
Owyhee Basin 2016 Snowpack Comparison Graph (7 sites)

Based on Provisional SNOTEL data as of May 01, 2016



Salmon Falls Basin 2016 Snowpack Comparison Graph (5 sites)

Based on Provisional SNOTEL data as of May 01, 2016

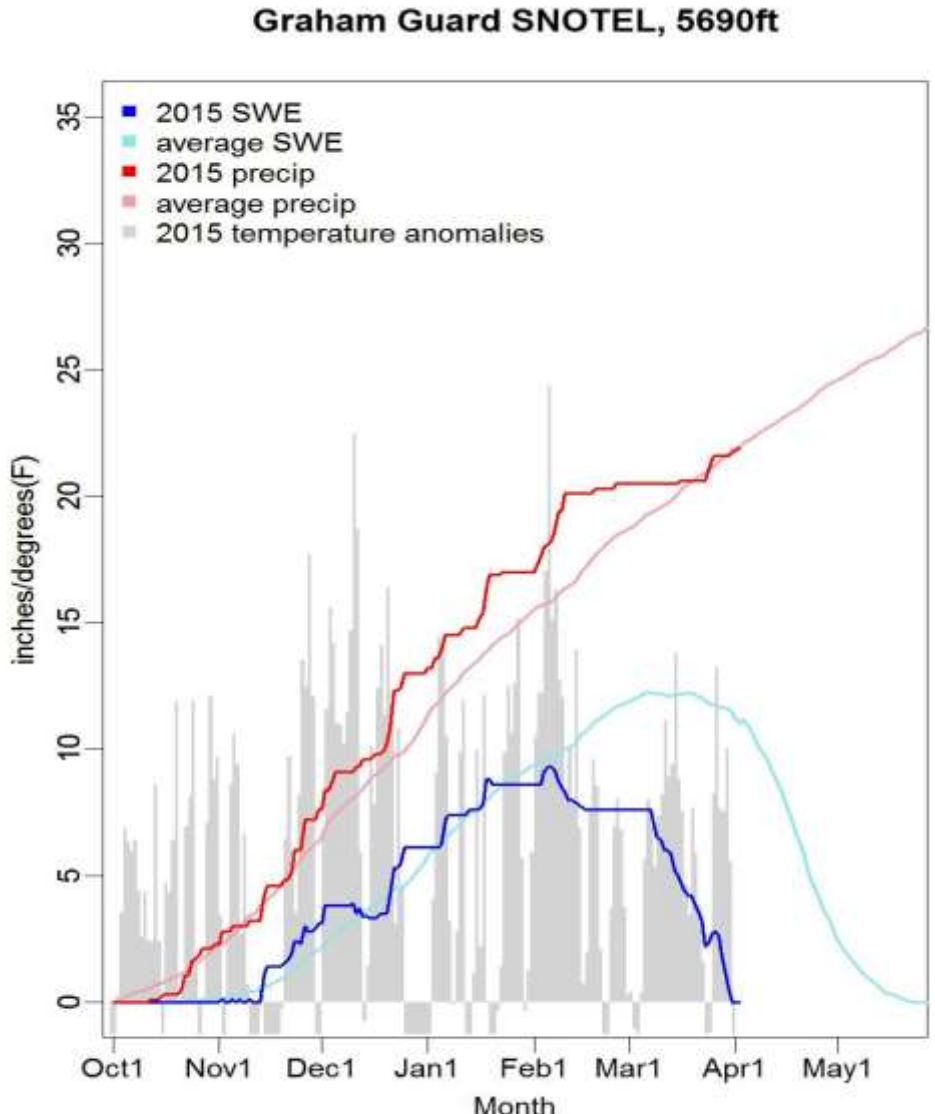


Idaho --- **Mean temperature departure & precipitation falling normal Nov 1 – Mar 31:**

Graham Guard: + 4.9 F

Normally 75% precip falls as snow

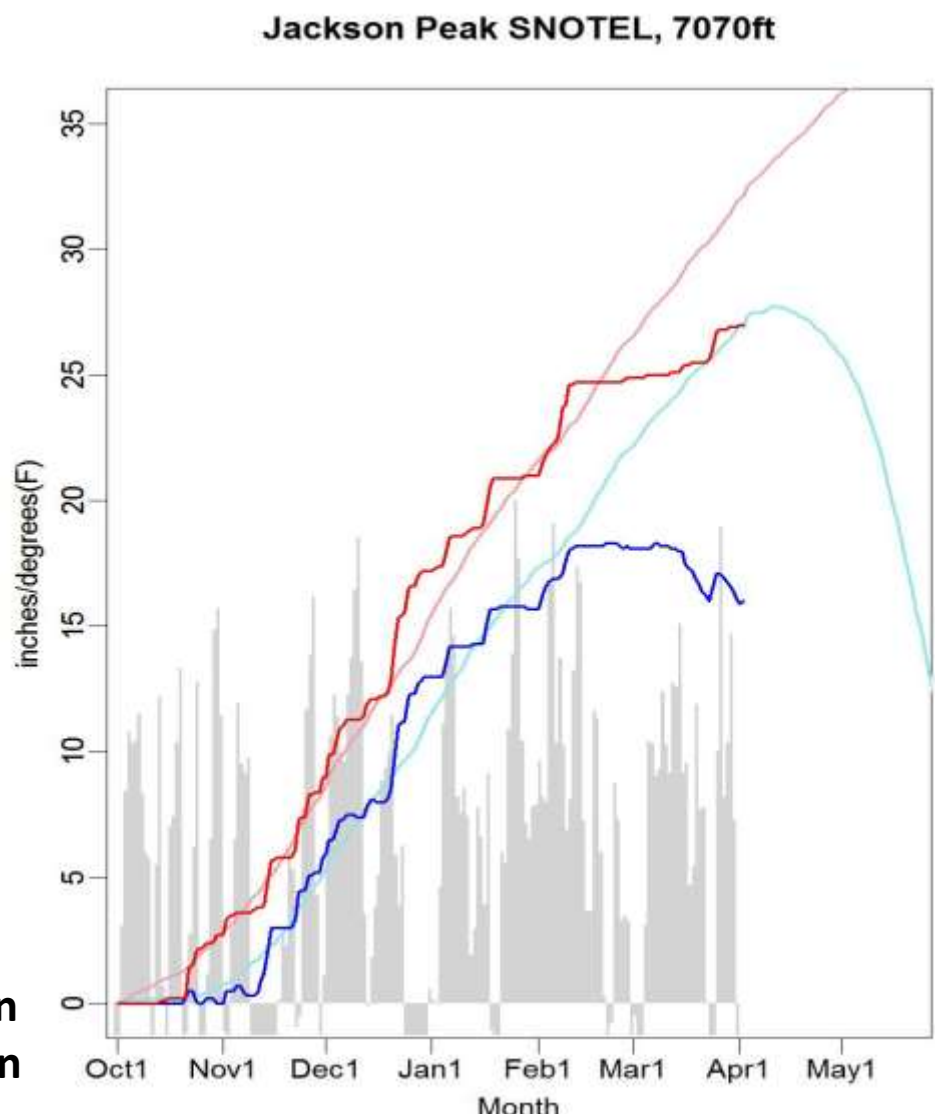
2015 60% fell as snow



Jackson Peak: + 5.1 F

Normally 92% precip falls as snow

2015 84% fell as snow



From USFS Rocky Mountain Research Station

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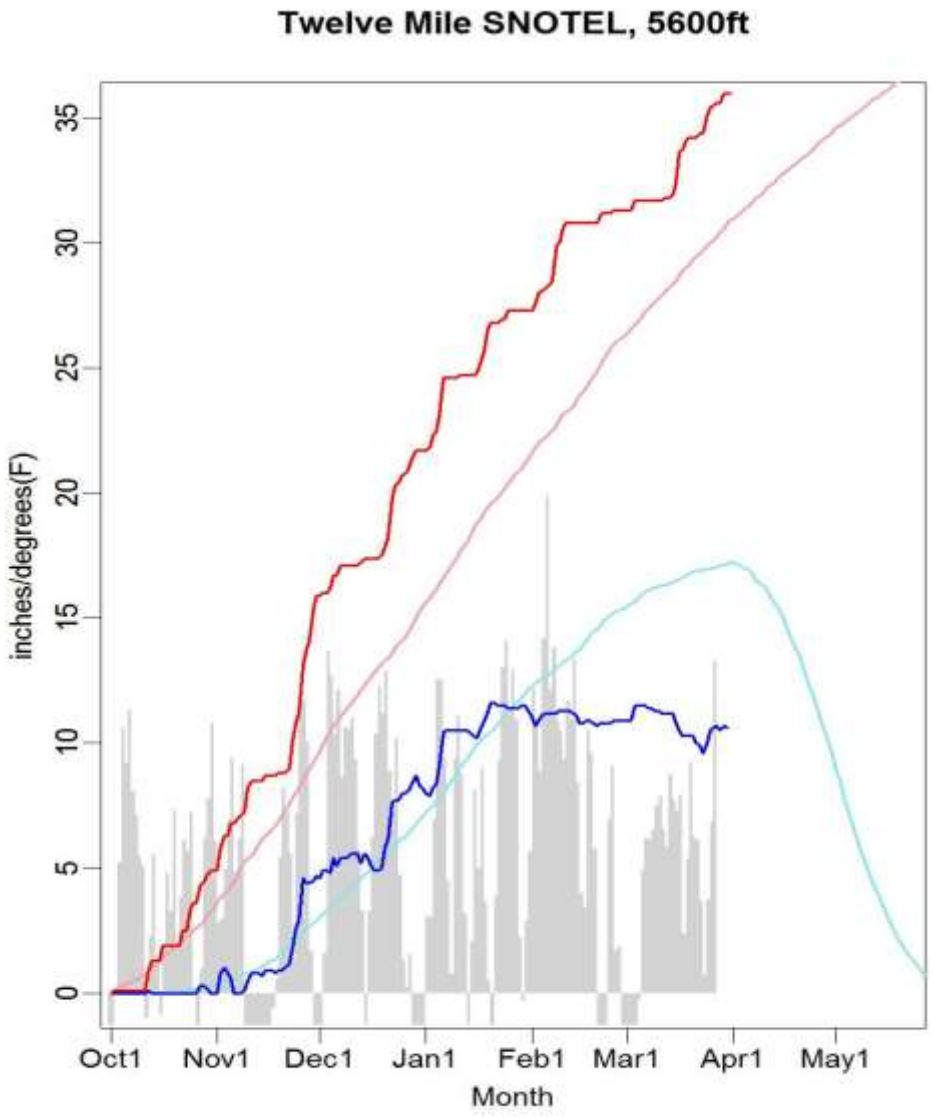
Montana --- Mean temperature departure & precipitation falling normal Nov 1 – Mar 31:

Twelve Mile: 3.8F 5600 ft

Normally 70% precip falls as snow

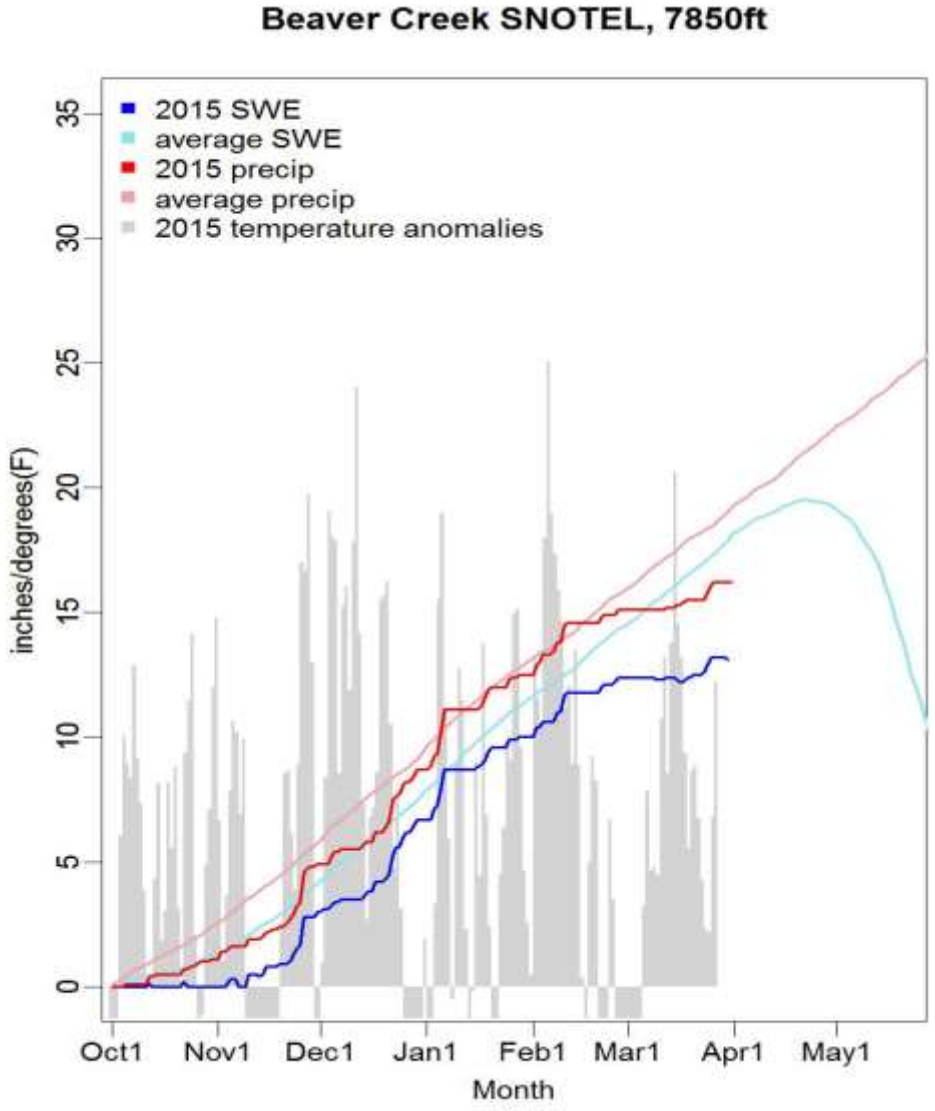
2015 60% fell as snow



Beaver Creek: 5.1F 7885 ft

Normally 97% precip falls as snow

2015 92% fell as snow



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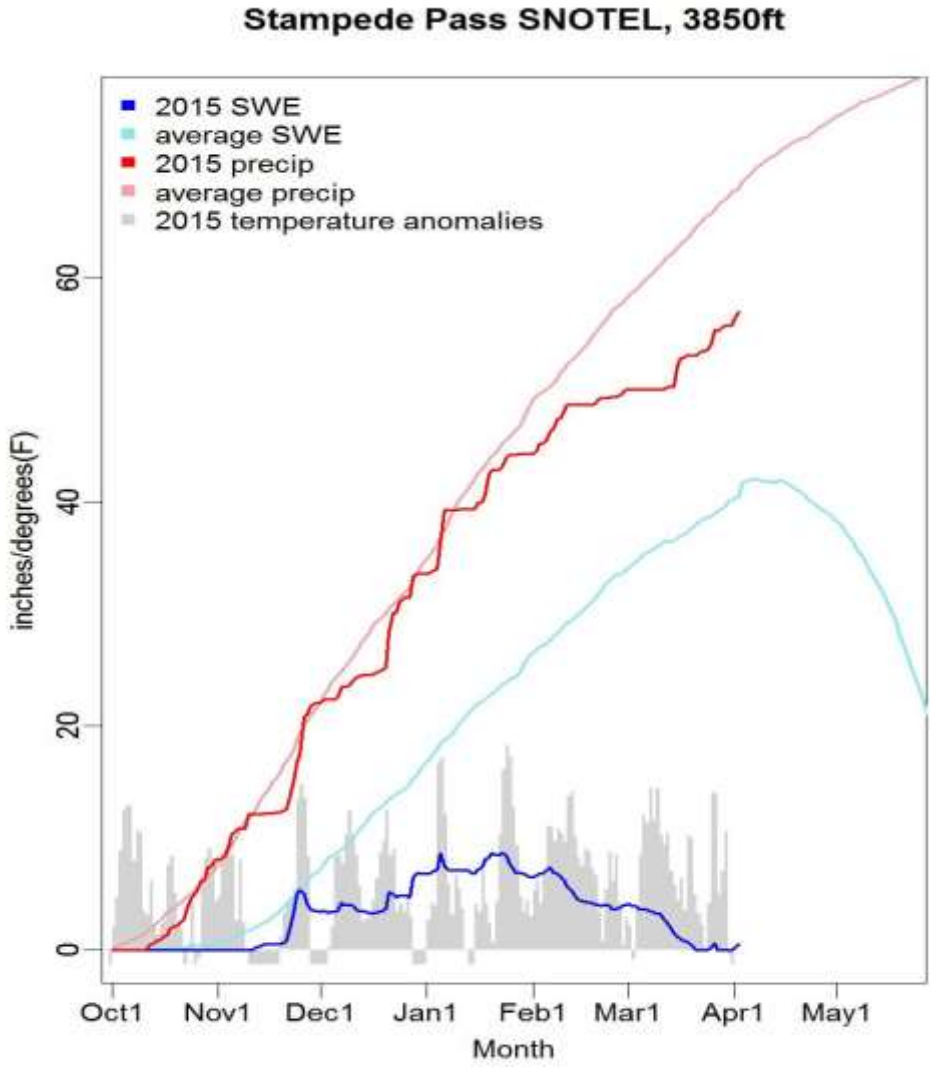
Washington --- Mean temperature departure & precipitation falling normal Nov 1 – Mar 31:

Stampede Pass: 5.0 F 3850 ft

Normally 80% precip falls as snow

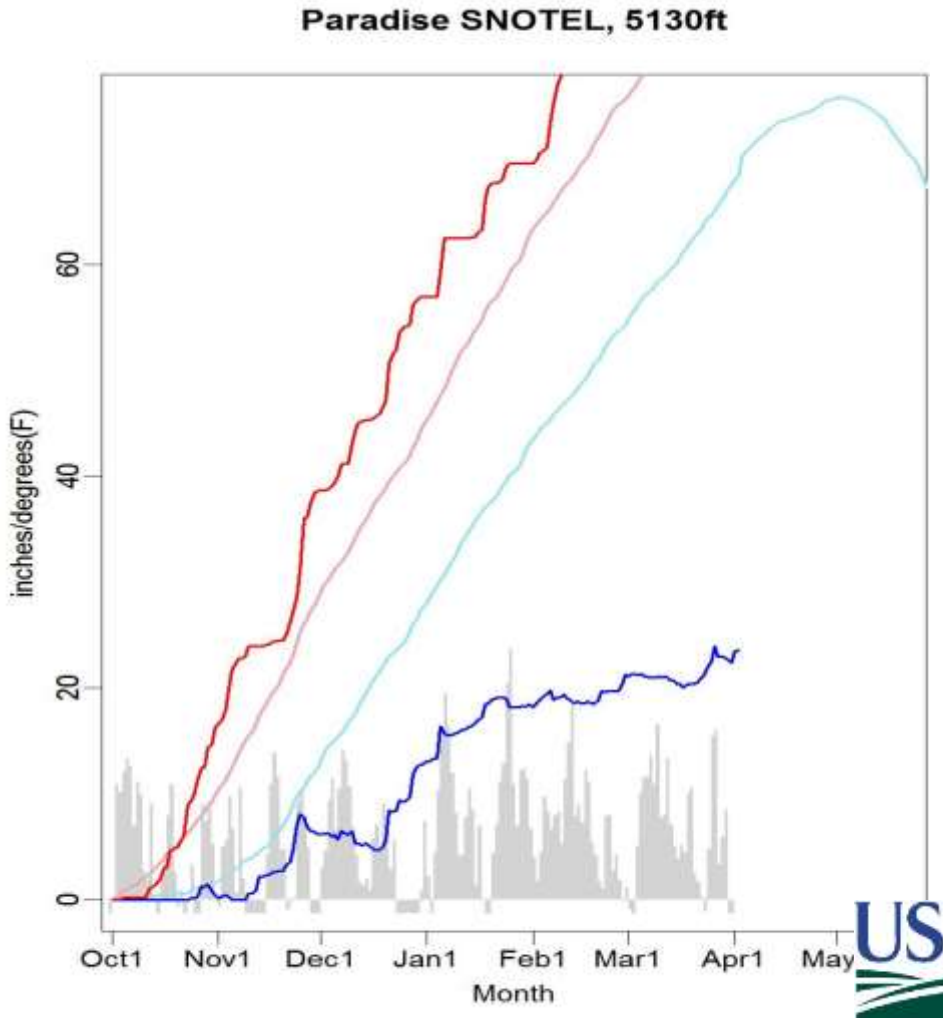
2015 34% fell as snow



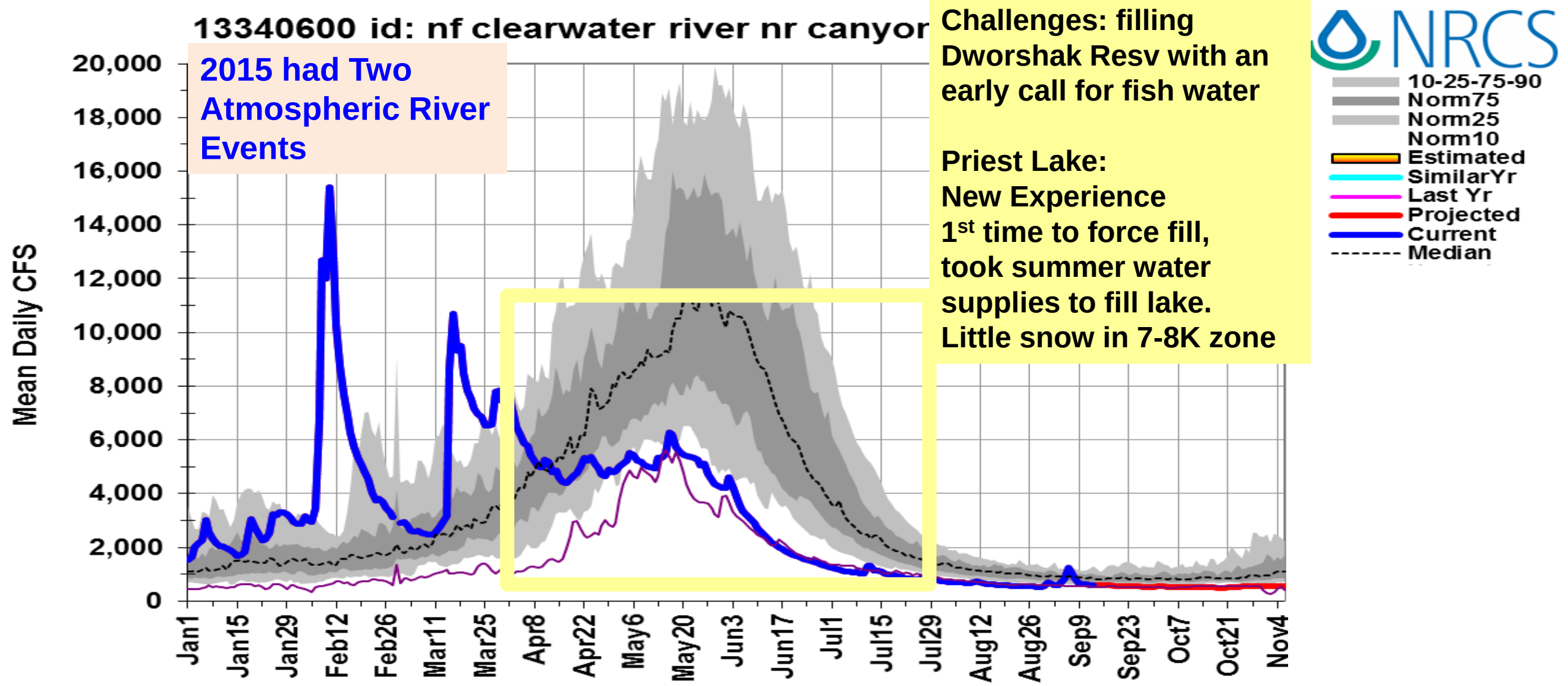
Paradise: 5.3 F 5130 ft

Normally 92% precip falls as snow

2015 46% fell as snow



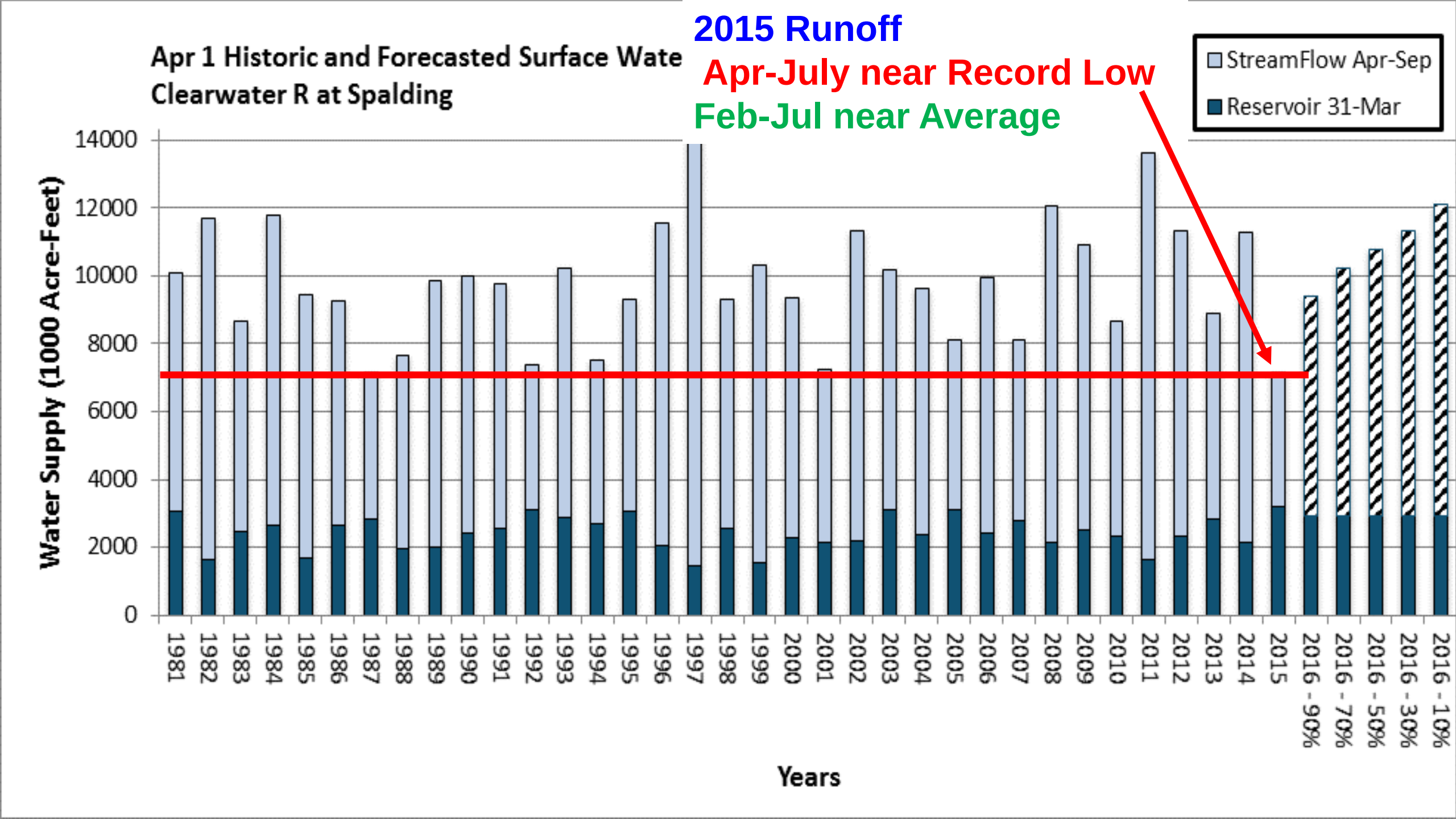
USDA

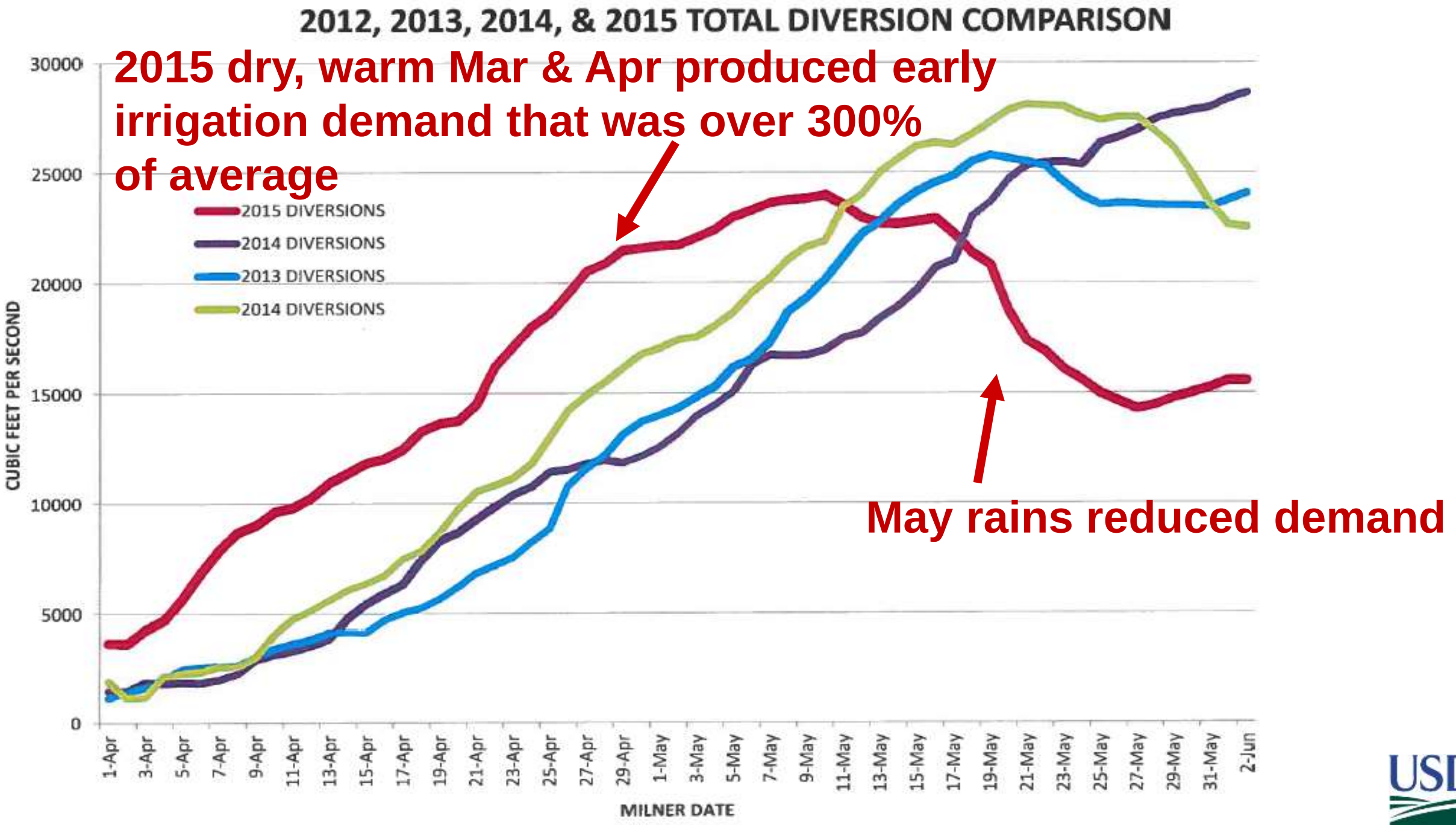


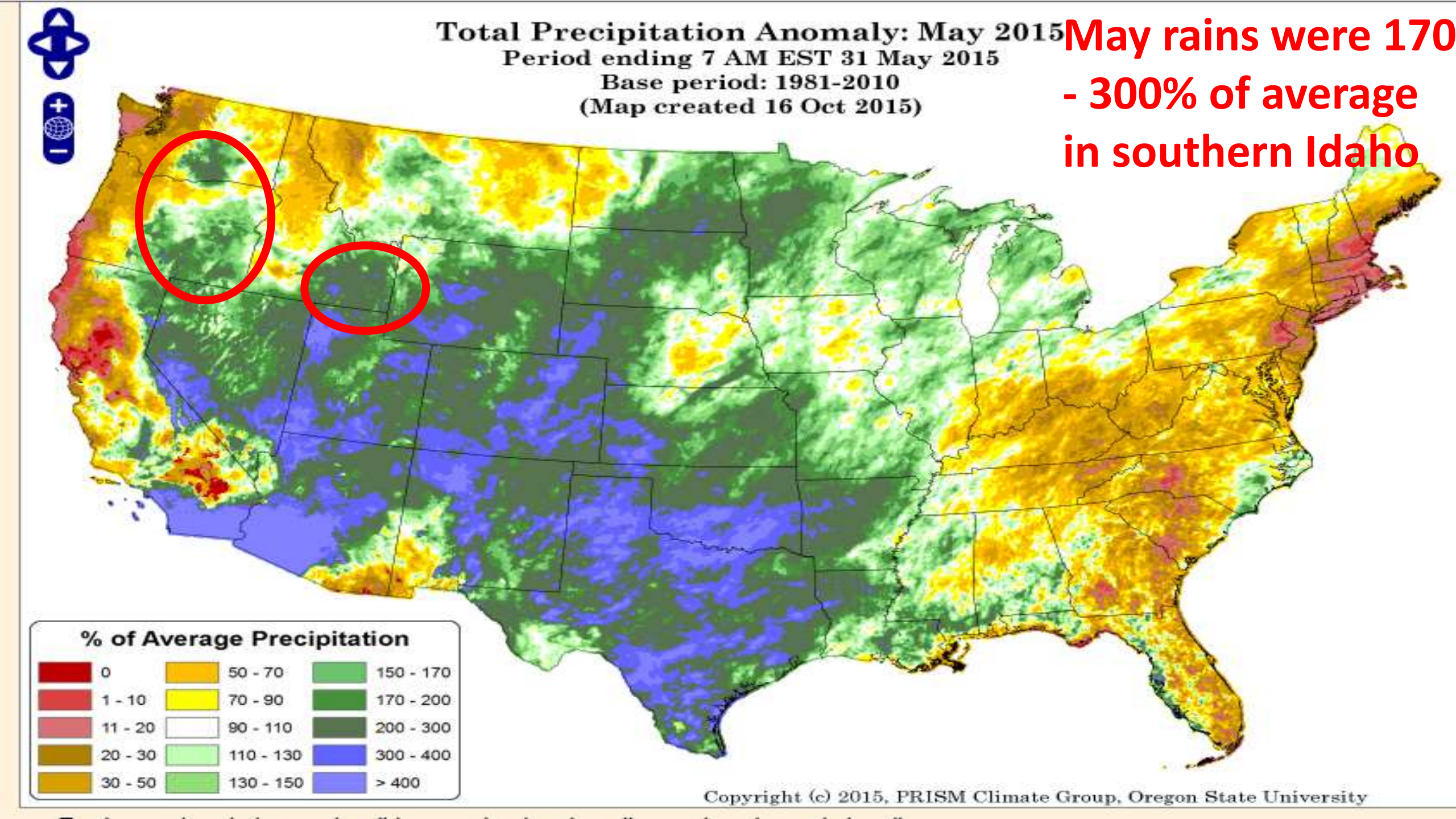
Dworshak Inflow in Thousands of Acre-Feet for Water Year 2015

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
76	169	256	266	586	569	455	429	162	41	30	17

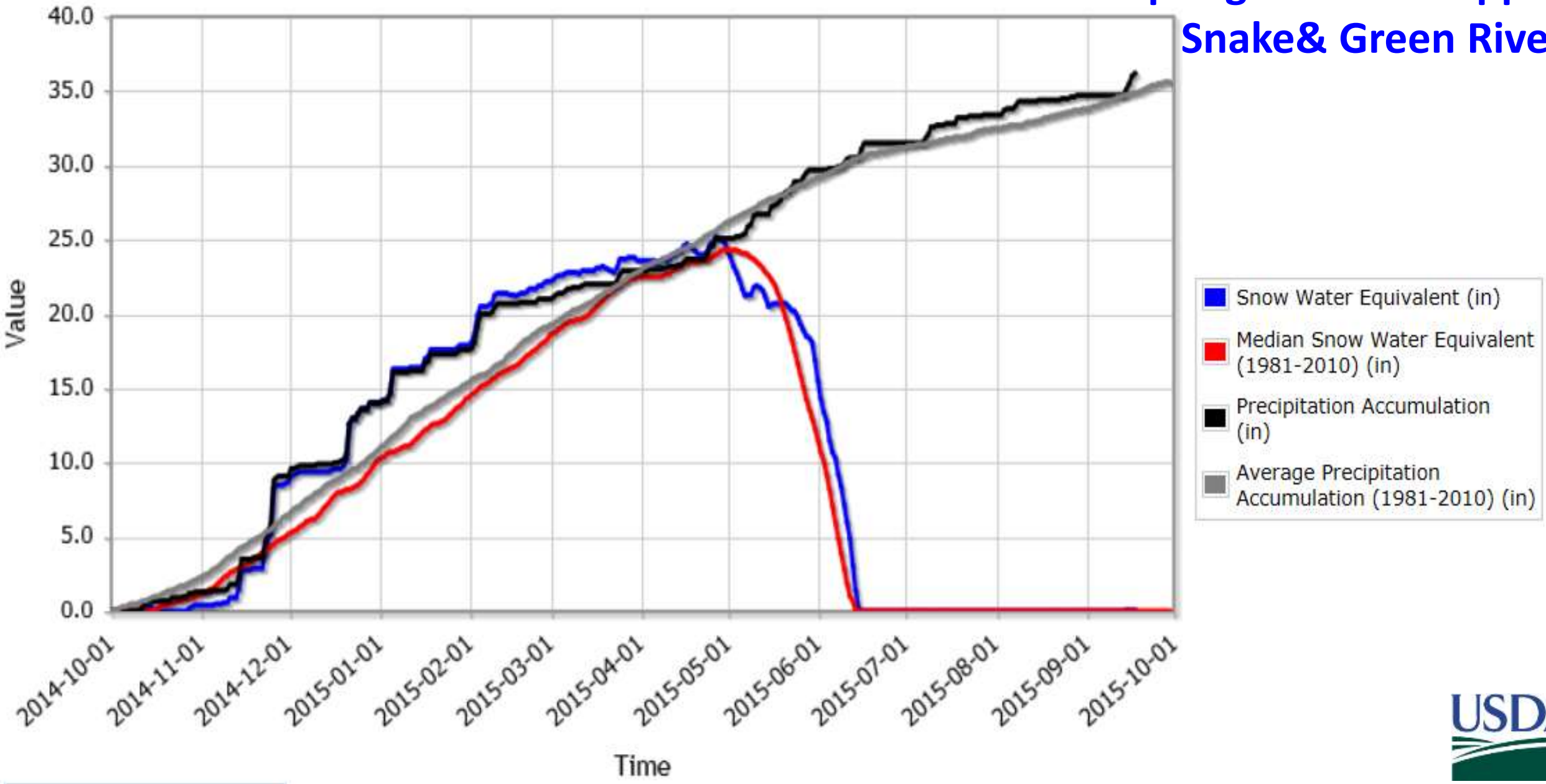
2015 monthly volumes peaked in Feb & Mar instead of May & Jun


2015 Runoff
Apr-July near Record Low
Feb-Jul near Average
Apr 1 Historic and Forecasted Surface Wate
Clearwater R at Spalding
StreamFlow Apr-Sep
Reservoir 31-Mar
Water Supply (1000 Acre-Feet)
14000
12000
10000
8000
6000
4000
2000
0
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016 - 90%
2016 - 70%
2016 - 50%
2016 - 30%
2016 - 10%
Years


2012, 2013, 2014, & 2015 TOTAL DIVERSION COMPARISON
2015 dry, warm Mar & Apr produced early irrigation demand that was over 300% of average
May rains reduced demand
2015 DIVERSIONS
2014 DIVERSIONS
2013 DIVERSIONS
2014 DIVERSIONS
CUBIC FEET PER SECOND
30000
25000
20000
15000
10000
5000
0
1-Apr
3-Apr
5-Apr
7-Apr
9-Apr
11-Apr
13-Apr
15-Apr
17-Apr
19-Apr
21-Apr
23-Apr
25-Apr
27-Apr
29-Apr
1-May
3-May
5-May
7-May
9-May
11-May
13-May
15-May
17-May
19-May
21-May
23-May
25-May
27-May
29-May
31-May
2-Jun
MILNER DATE


Total Precipitation Anomaly: May 2015
Period ending 7 AM EST 31 May 2015
Base period: 1981-2010
(Map created 16 Oct 2015)
May rains were 170 - 300% of average in southern Idaho
% of Average Precipitation
0
1 - 10
11 - 20
20 - 30
30 - 50
50 - 70
70 - 90
90 - 110
110 - 130
130 - 150
150 - 170
170 - 200
200 - 300
300 - 400
> 400
Copyright (c) 2015, PRISM Climate Group, Oregon State University

2015 Near Normal High Elevation Snow in SW WY Boosted Spring Runoff in Upper Snake& Green River



USDA

Benefits of May Rains for One Farmer in South Central Idaho

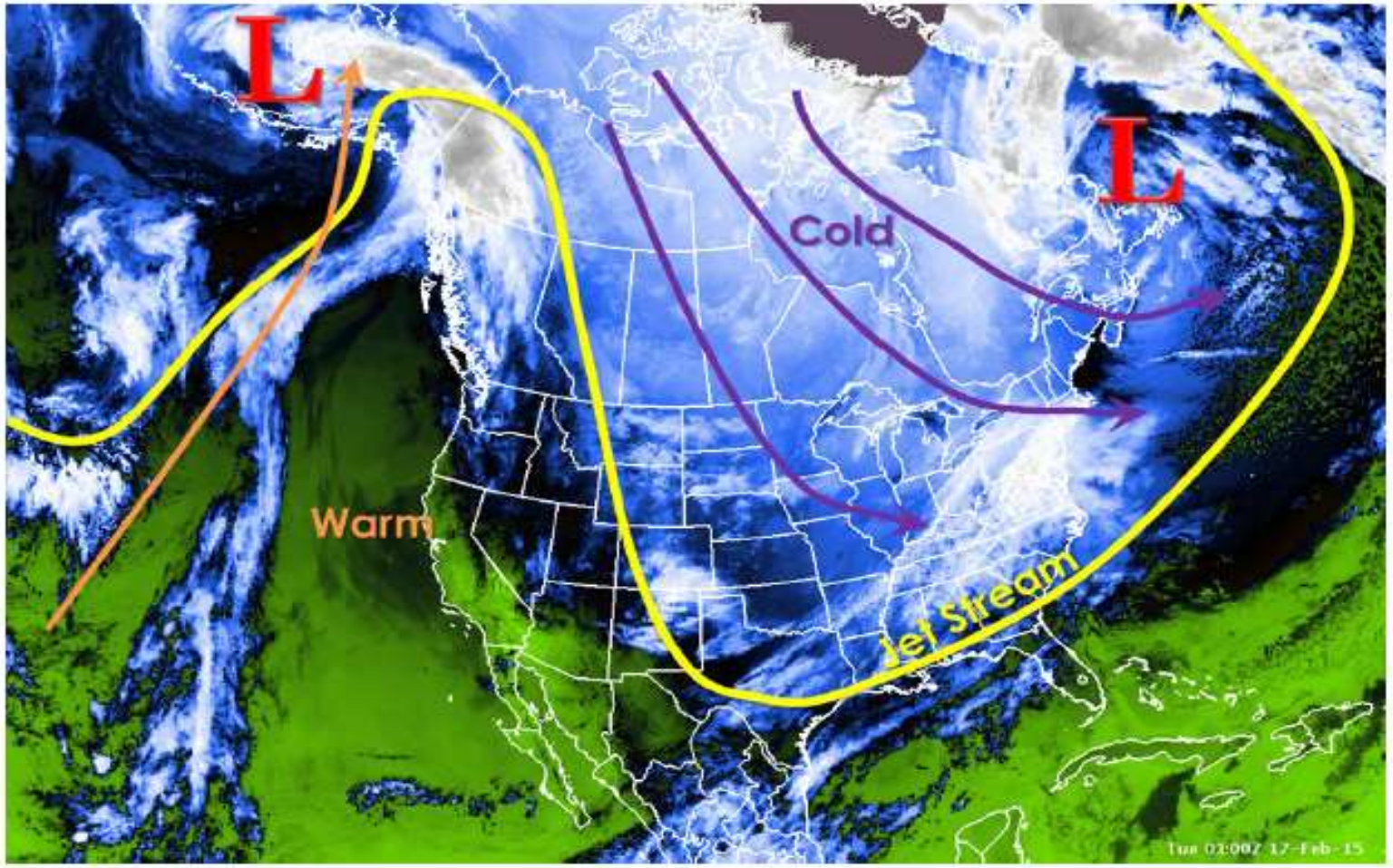
Fish Creek – Small Reservoir – Water Allotment was 12% of normal

May rains provided additional moisture for growing and cuttings of Organic Feed

Brought in $100K for One Producer

Water Allotment was kept at 12% because that's all they had in the reservoir to deliver…

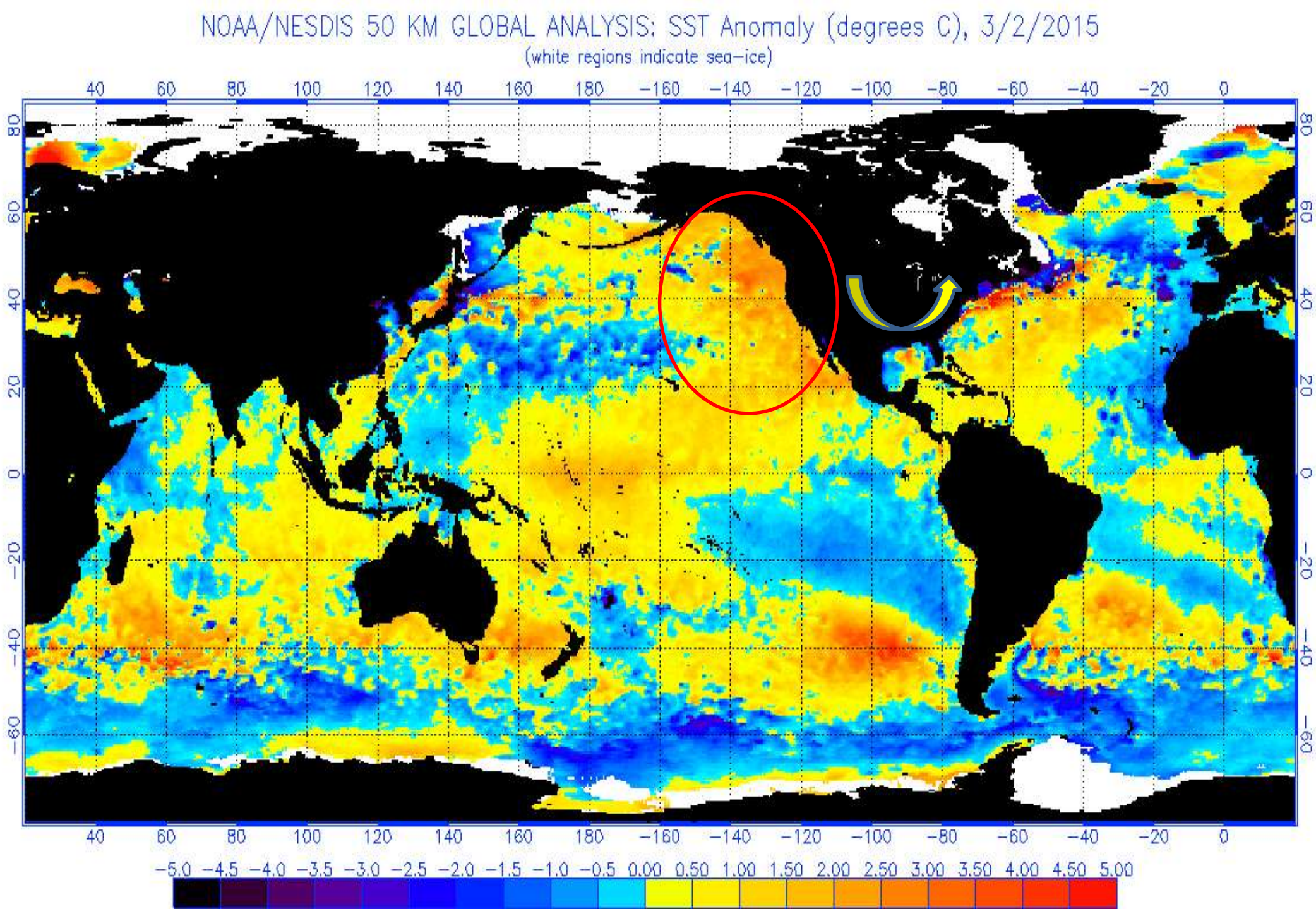
Grower in Montpelier – 2015 was best crop year ever thanks to May rain!



NWS Example of weather pattern for 2015 & most of 2014

The ridge has kept our area unseasonably warm and relatively dry through early March. A few Pacific weather systems were able to punch through, but precipitation totals for January through the first part of March were less than 50% of normal across most of southwest Idaho and southeast Oregon, and less than 25% of normal in a few areas.

USDA



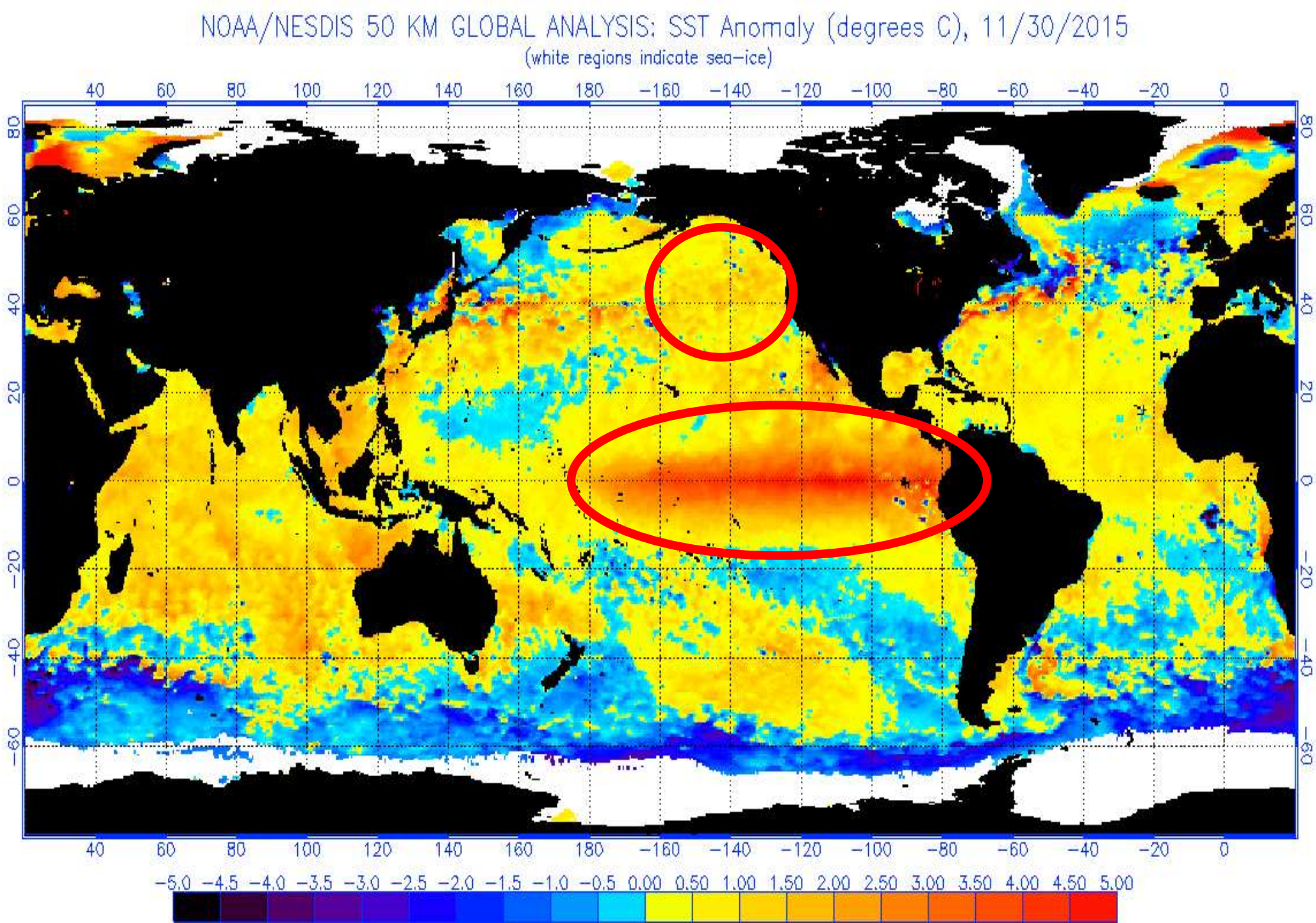
March 2, 2015

Winter 2014-15

ENSO Ocean Conditions:
– Neutral to slight El Nino

-- Warm Pacific Decadal Oscillation (PDO)

USDA



Nov 30, 2015

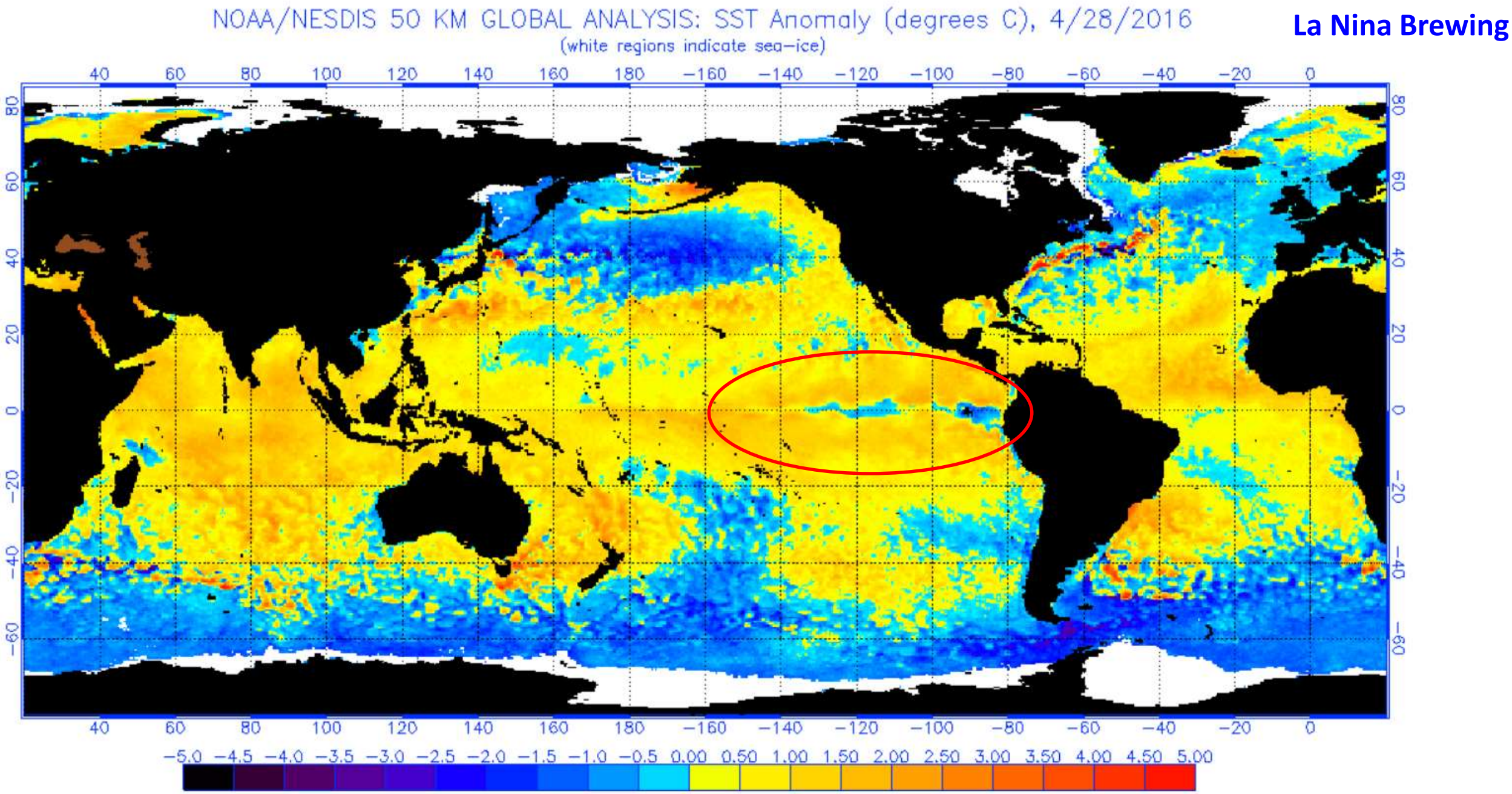
Winter 2015 - 2016

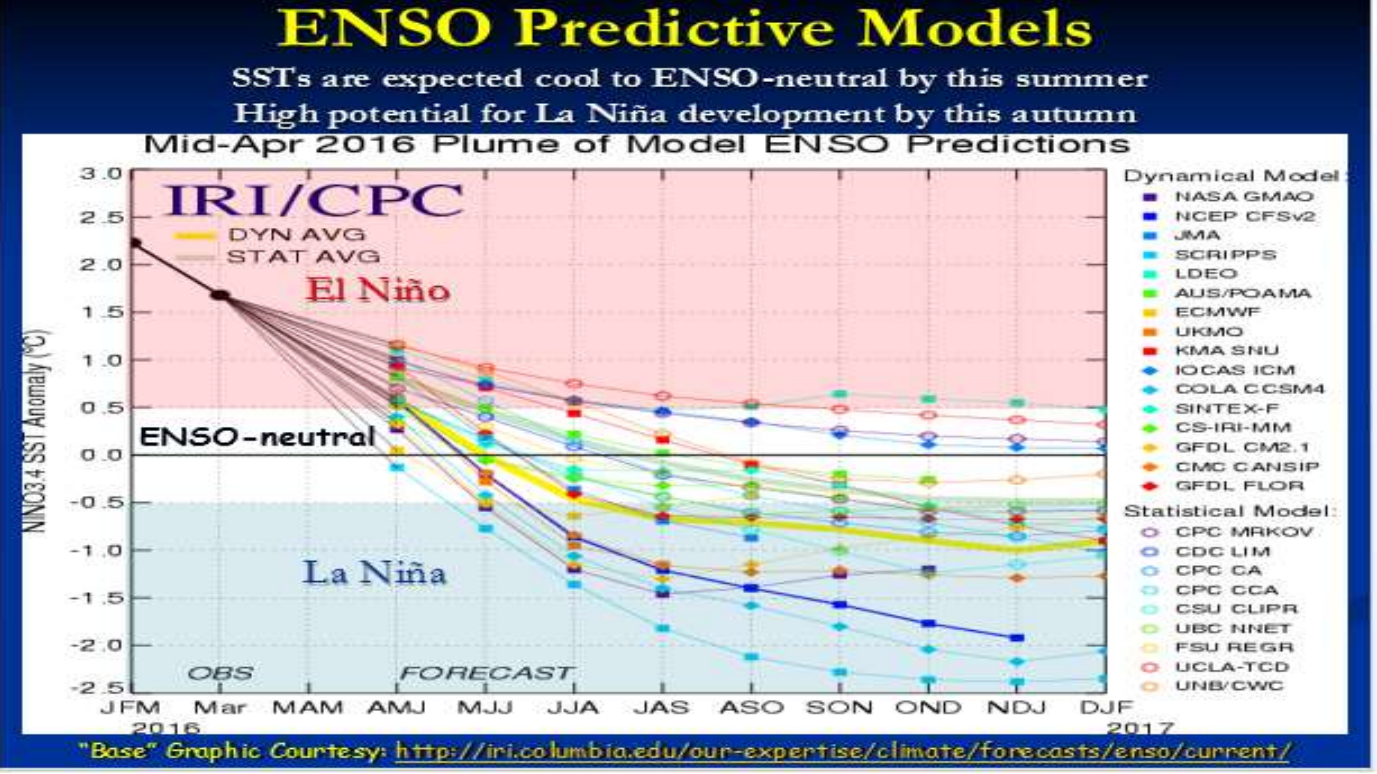
ENSO Ocean Conditions:

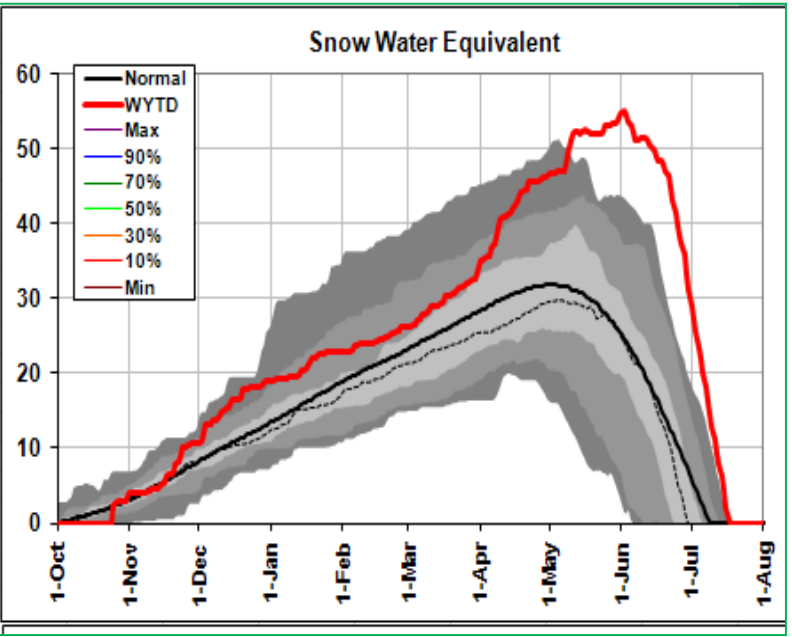
Strong El Nino

Apr 28, 2016

La Nina Brewing





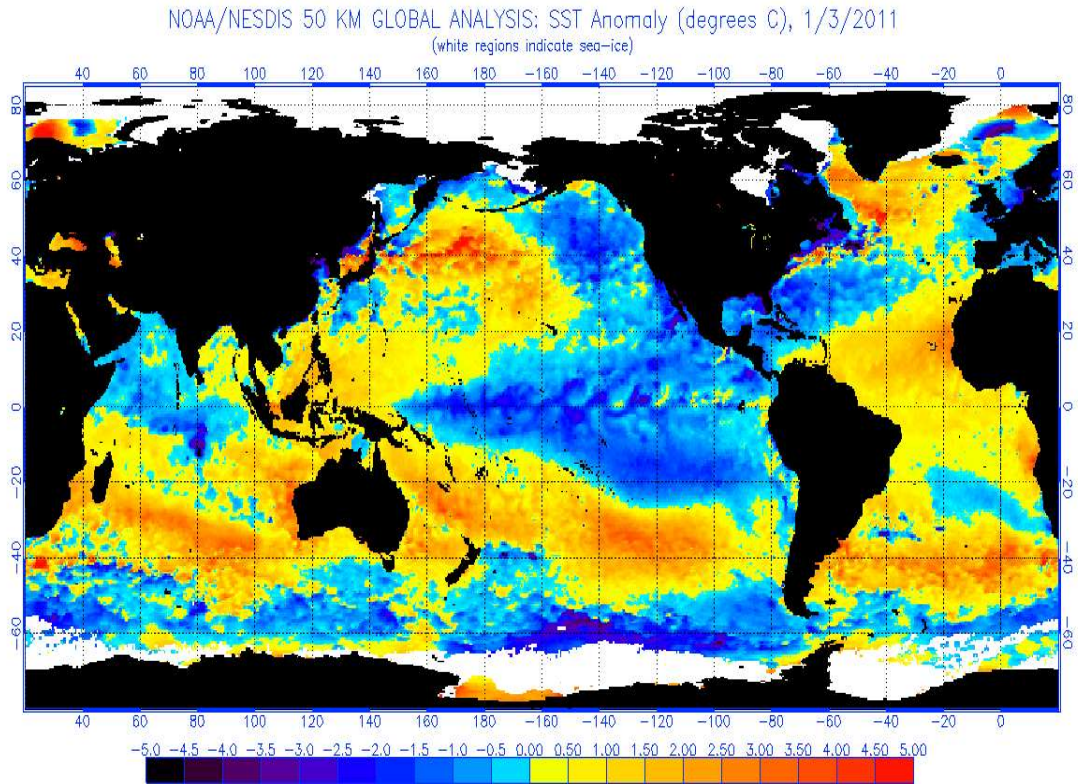


2011: Snow Water Equivalent at Two Ocean Plateau SNOTEL Site Yellowstone N.P. 9,240 feet

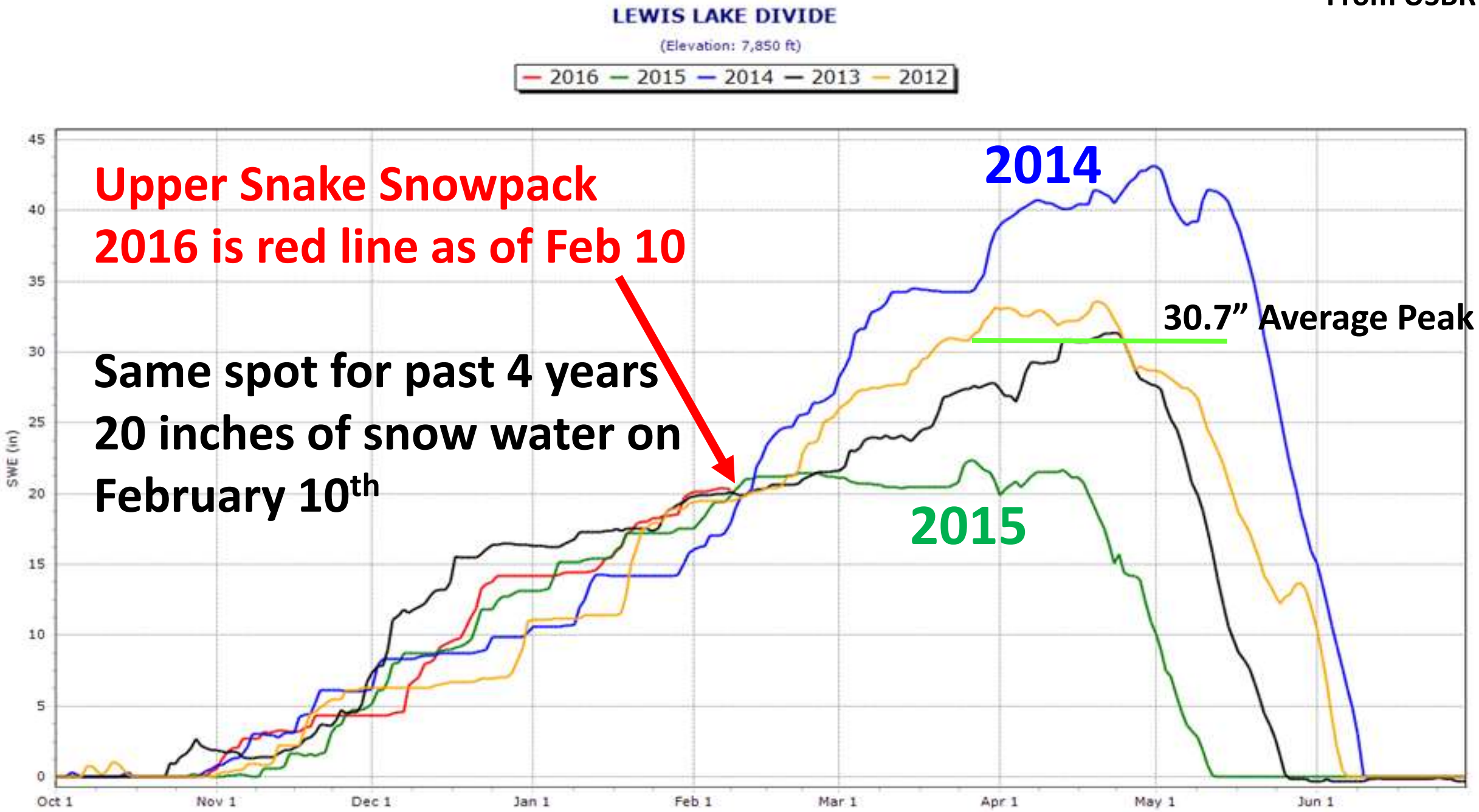
NRCS Natural Resources Conservation Service

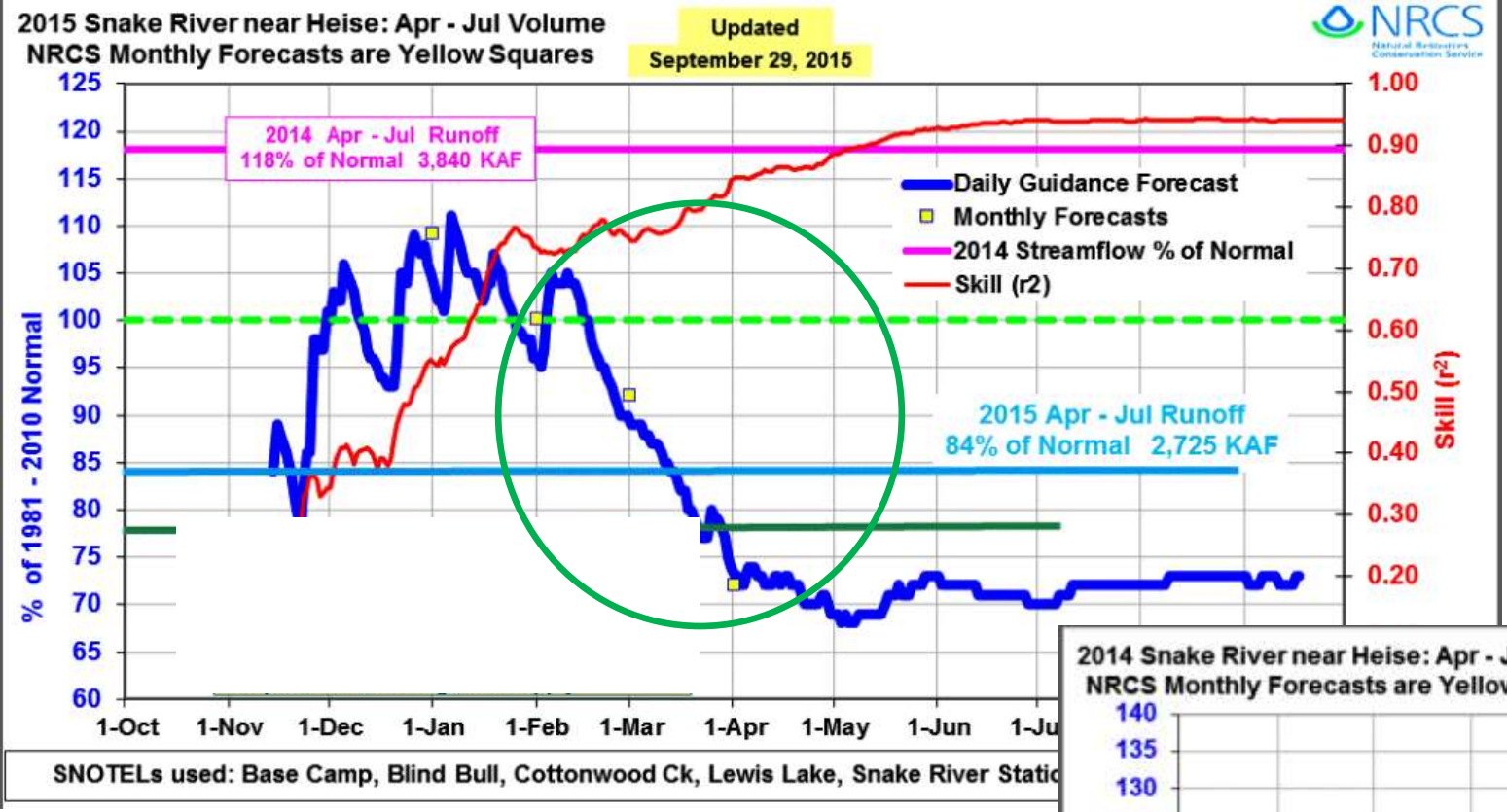
Winter 2010 - 2011

Sea Surface Temperatures Cool PDO & Strongest La Nina since 1974

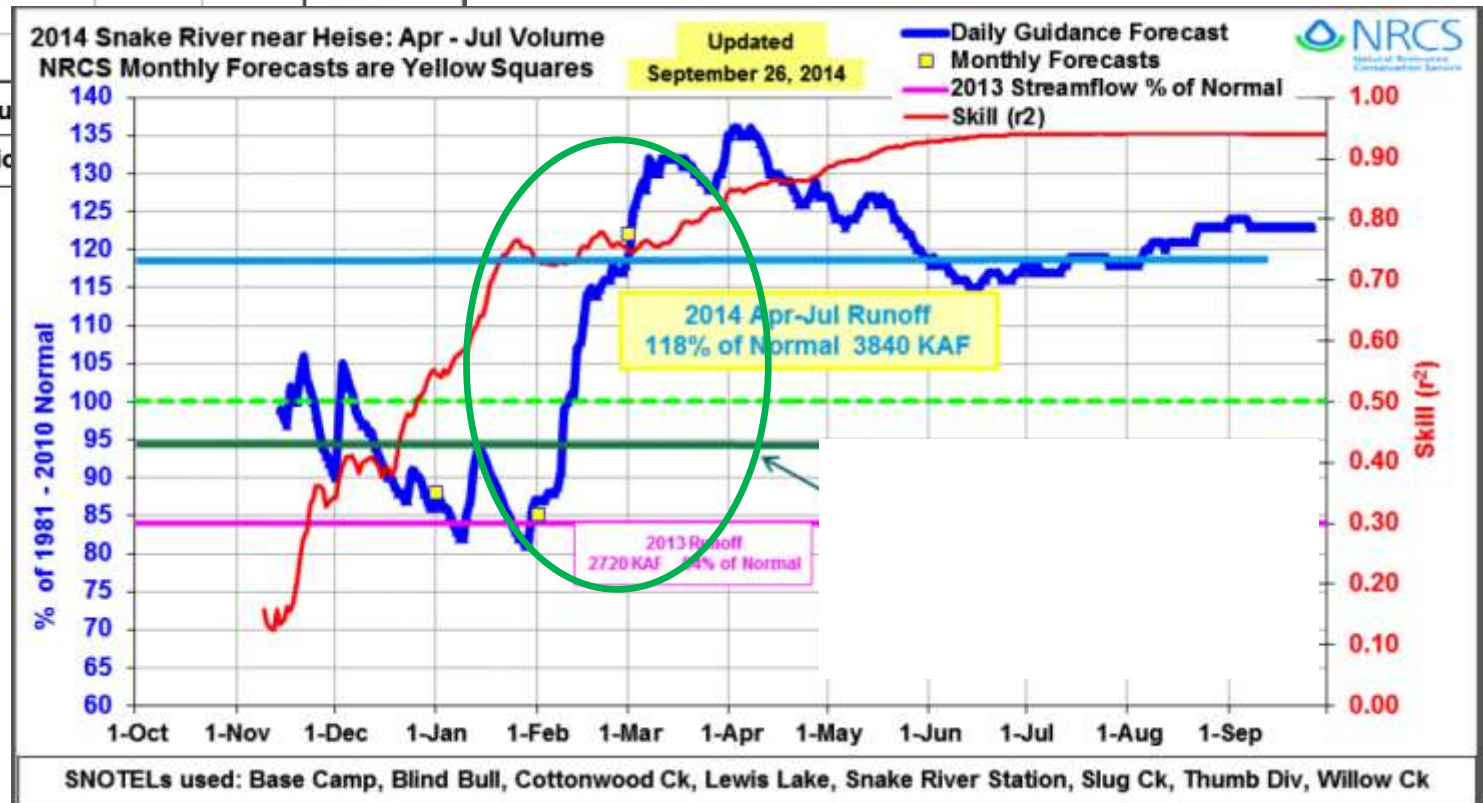


From USBR


LEWIS LAKE DIVIDE
(Elevation: 7,850 ft)
2016 2015 2014 2013 2012
Upper Snake Snowpack
2016 is red line as of Feb 10
Same spot for past 4 years
20 inches of snow water on
February 10th
2014
30.7” Average Peak
2015
SWE (in)
45
40
35
30
25
20
15
10
5
0
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
May 1
Jun 1



2015 Warm Pacific Ocean temperatures created western high pressure ridge

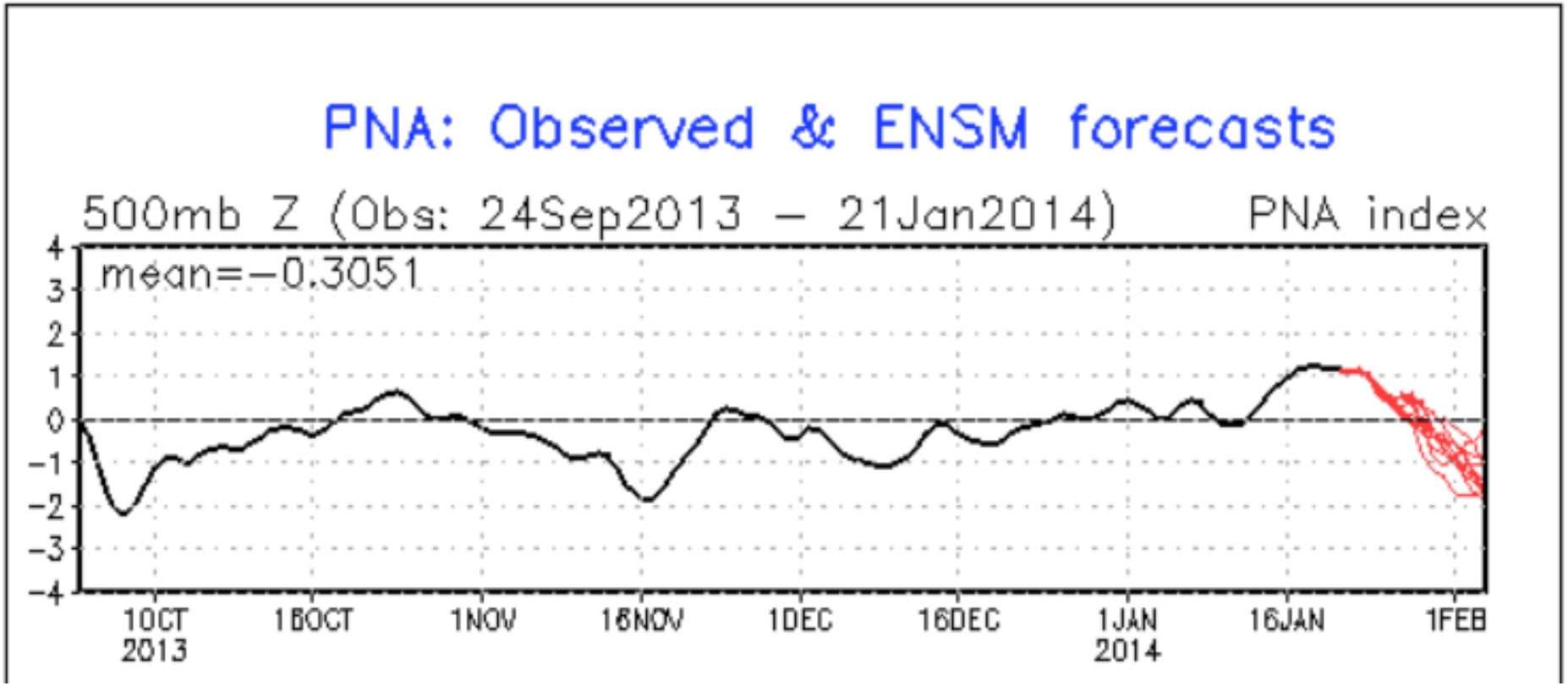


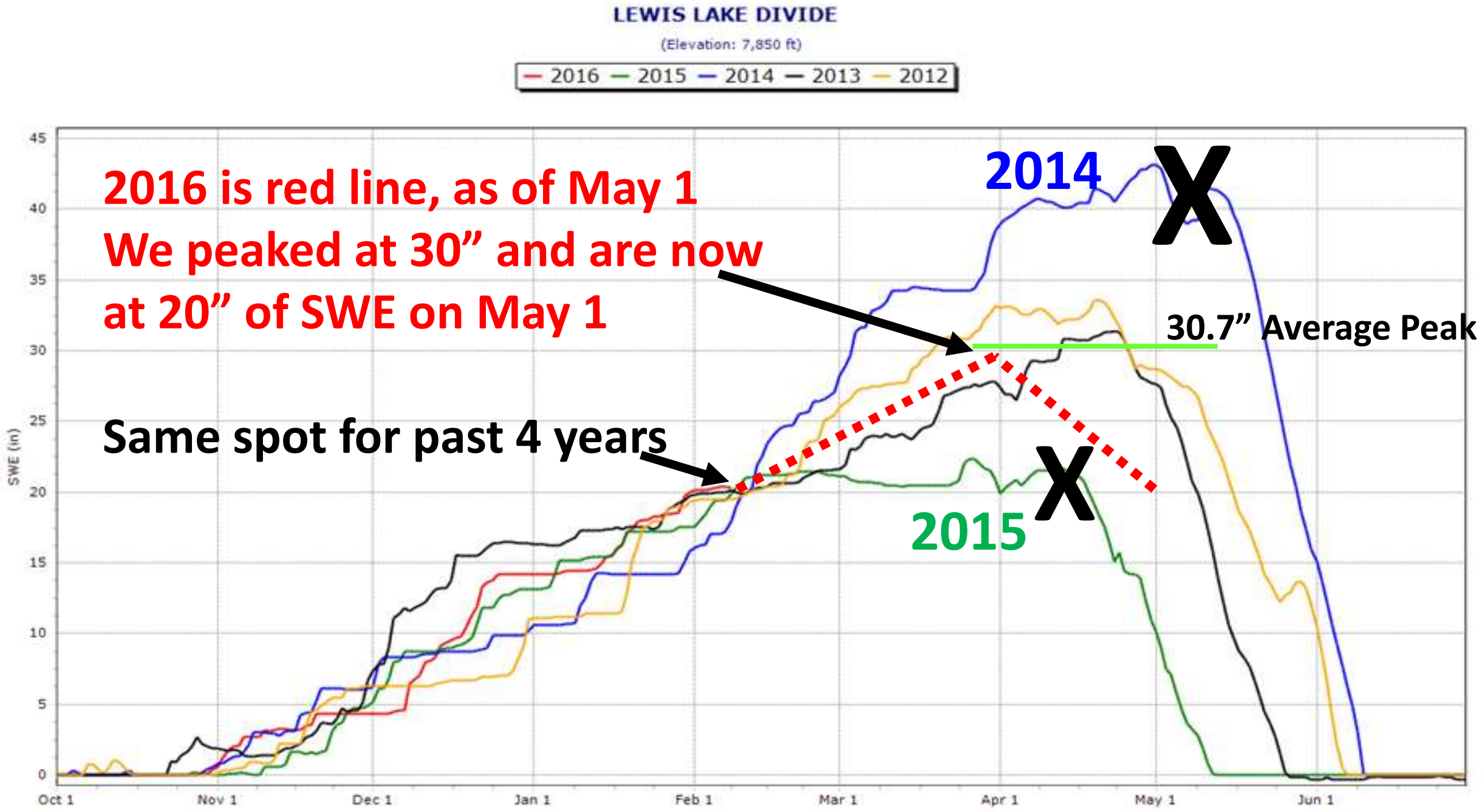
2014 PNA went negative from Feb - May impacting our weather by bringing more moisture into Idaho

From January 21, 2014 – USDA Meteorologist – Jan Curtis

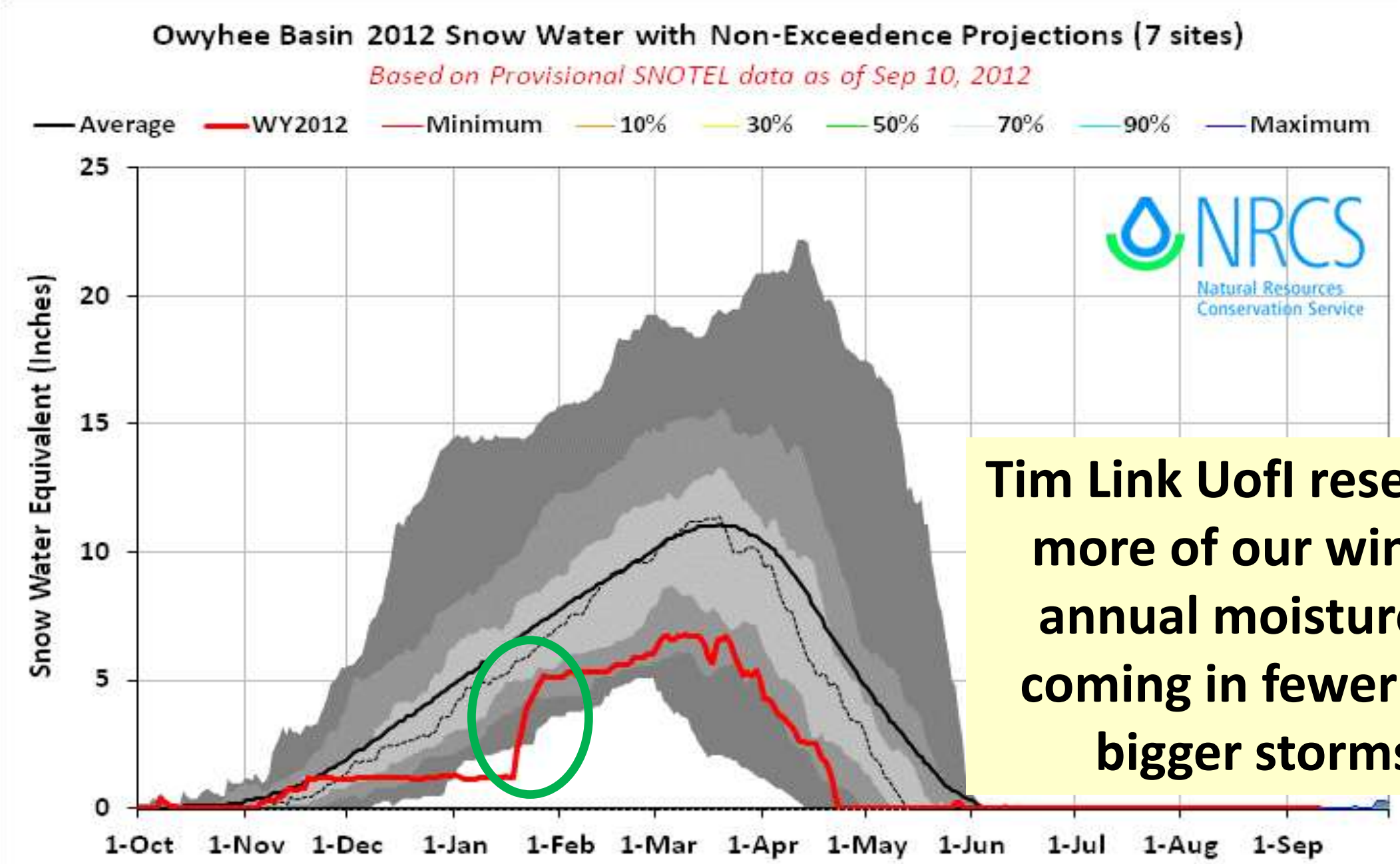
The PNA is getting interestingly negative:

<u>Pacific North American Index</u> is one parameter (index) that helps for moisture in the Pacific NW but there are others that are needed too.

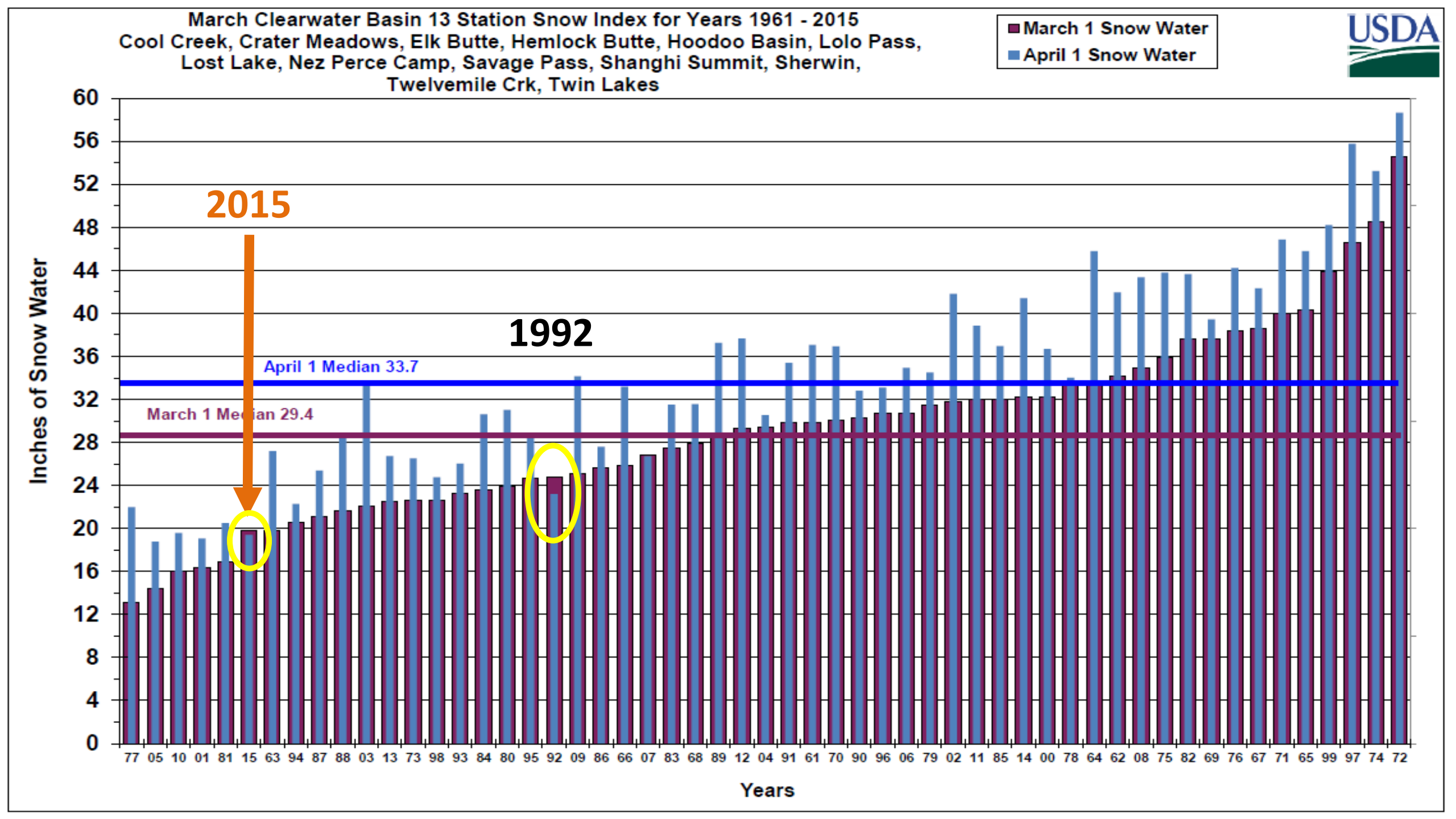


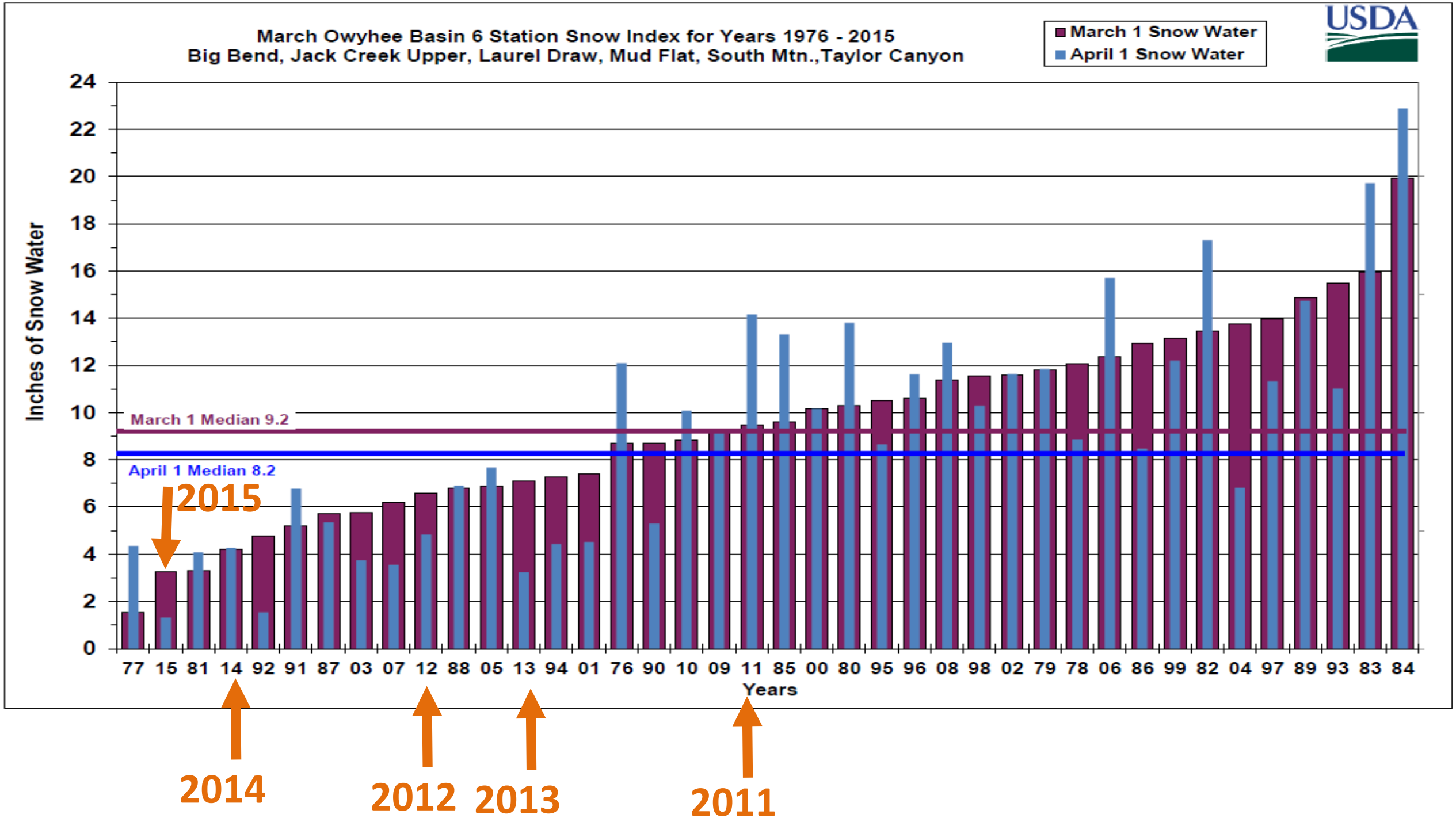

LEWIS LAKE DIVIDE
(Elevation: 7,850 ft)
2016
2015
2014
2013
2012
SWE (in)
45
40
35
30
25
20
15
10
5
0
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
May 1
Jun 1
2016 is red line, as of May 1
We peaked at 30” and are now
at 20” of SWE on May 1
Same spot for past 4 years
2014
X
30.7” Average Peak
X
2015

2012 Owyhee Basin 7 Station Snow Index at record low levels



Tim Link UofI research: more of our winter annual moisture is coming in fewer but bigger storms


March Clearwater Basin 13 Station Snow Index for Years 1961 - 2015
Cool Creek, Crater Meadows, Elk Butte, Hemlock Butte, Hoodoo Basin, Lolo Pass, Lost Lake, Nez Perce Camp, Savage Pass, Shanghi Summit, Sherwin, Twelvemile Crk, Twin Lakes
March 1 Snow Water
April 1 Snow Water
USDA
2015
1992
April 1 Median 33.7
March 1 Median 29.4
Inches of Snow Water
0
4
8
12
16
20
24
28
32
36
40
44
48
52
56
60
77 05 10 01 81 15 63 94 87 88 03 13 73 98 93 84 80 95 92 09 86 66 07 83 68 89 12 04 91 61 70 90 96 06 79 02 11 85 14 00 78 64 62 08 75 82 69 76 67 71 65 99 97 74 72
Years


March Owyhee Basin 6 Station Snow Index for Years 1976 - 2015
Big Bend, Jack Creek Upper, Laurel Draw, Mud Flat, South Mtn.,Taylor Canyon
March 1 Snow Water
April 1 Snow Water
USDA
Inches of Snow Water
0
2
4
6
8
10
12
14
16
18
20
22
24
March 1 Median 9.2
April 1 Median 8.2
2015
77 15 81 14 92 91 87 03 07 12 88 05 13 94 01 76 90 10 09 11 85 00 80 95 96 08 98 02 79 78 06 86 99 82 04 97 89 93 83 84
Years
2014
2012
2013
2011

Troy Magney paper – Spatial & Seasonal Changes in Idaho's Max Daily Prec Events: Implications for Ag

Recent Research

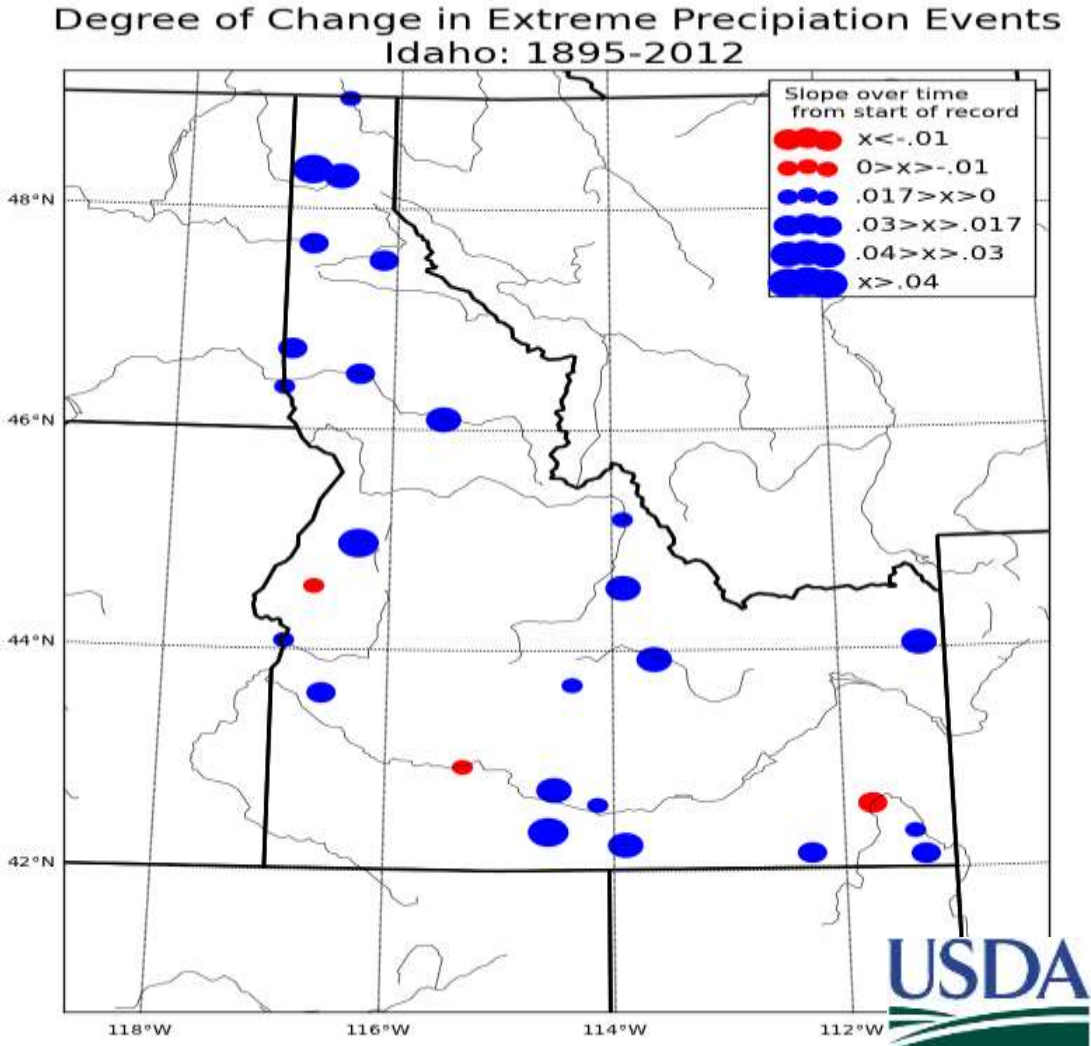
Spatial and Seasonal Changes in Idaho's Maximum Daily Precipitation Events

Troy Magney [1 2 4], John Abatzoglou [3], P. Zion Klos [4], Jan Eitel [1 2], Lee Vierling [1 2], Von Walden [3]

- **Observed warming has led to an intensification of the largest precipitation events**
  - **primarily in spring / summer**

Impacts on: Ag, design, snowmelt

Use of daily SNOTEL precipitation data in designs

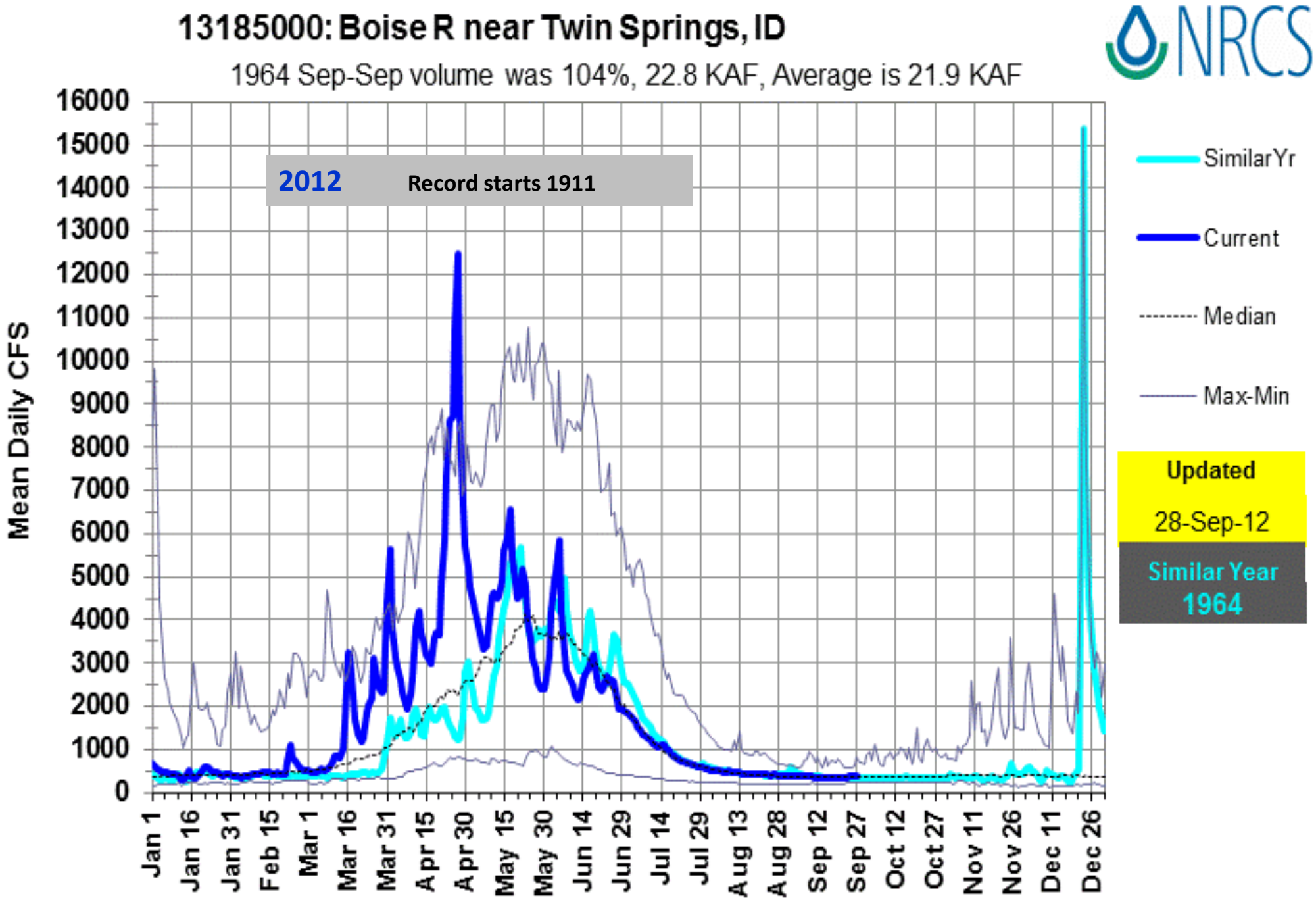


2012

Early April Record High Temperatures

Followed by 1-2 Inches of Rain

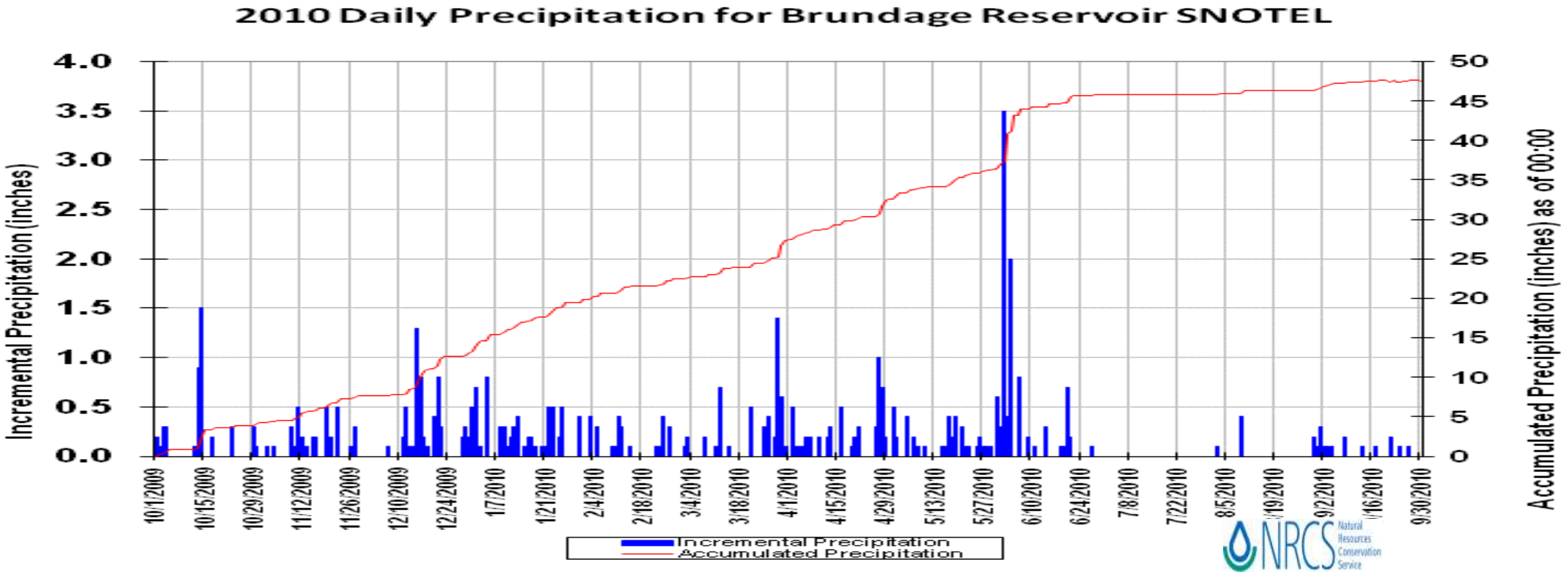
Produced 2nd Highest Peak Flow in the 100 Year Record



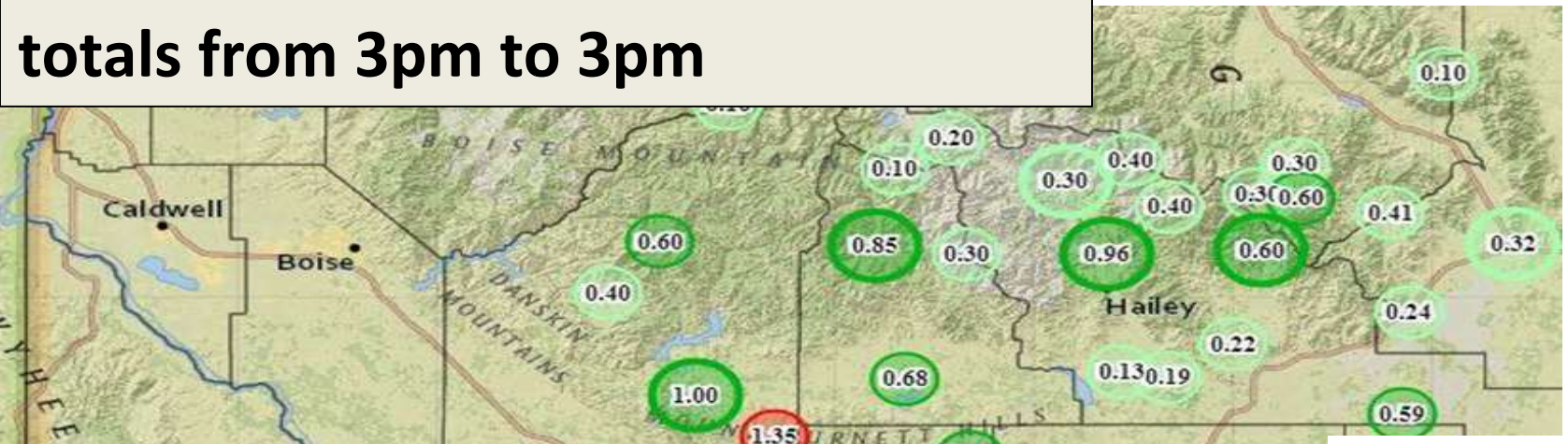
Key is Knowing Snow Line Elevation in your Basin

- **Eastern Idaho: May 2010 ~ 1.5” in 24 hours with snow on the valley floor produced flood event**

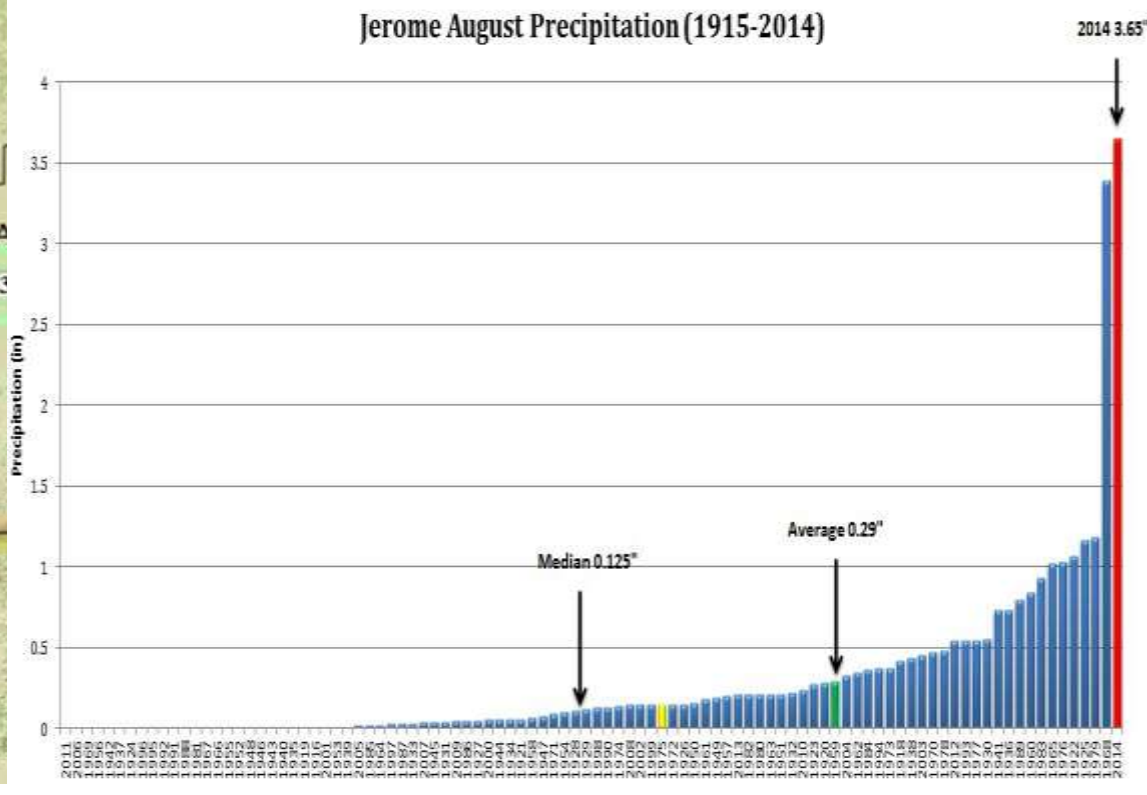
- **TWICE in Payette Basin: New Years Day 1997 & May 2010: 3.0+” in 24 hours is Key Indicator for Brundage Reservoir SNOTEL near McCall led to major flooding with snow on the ground**



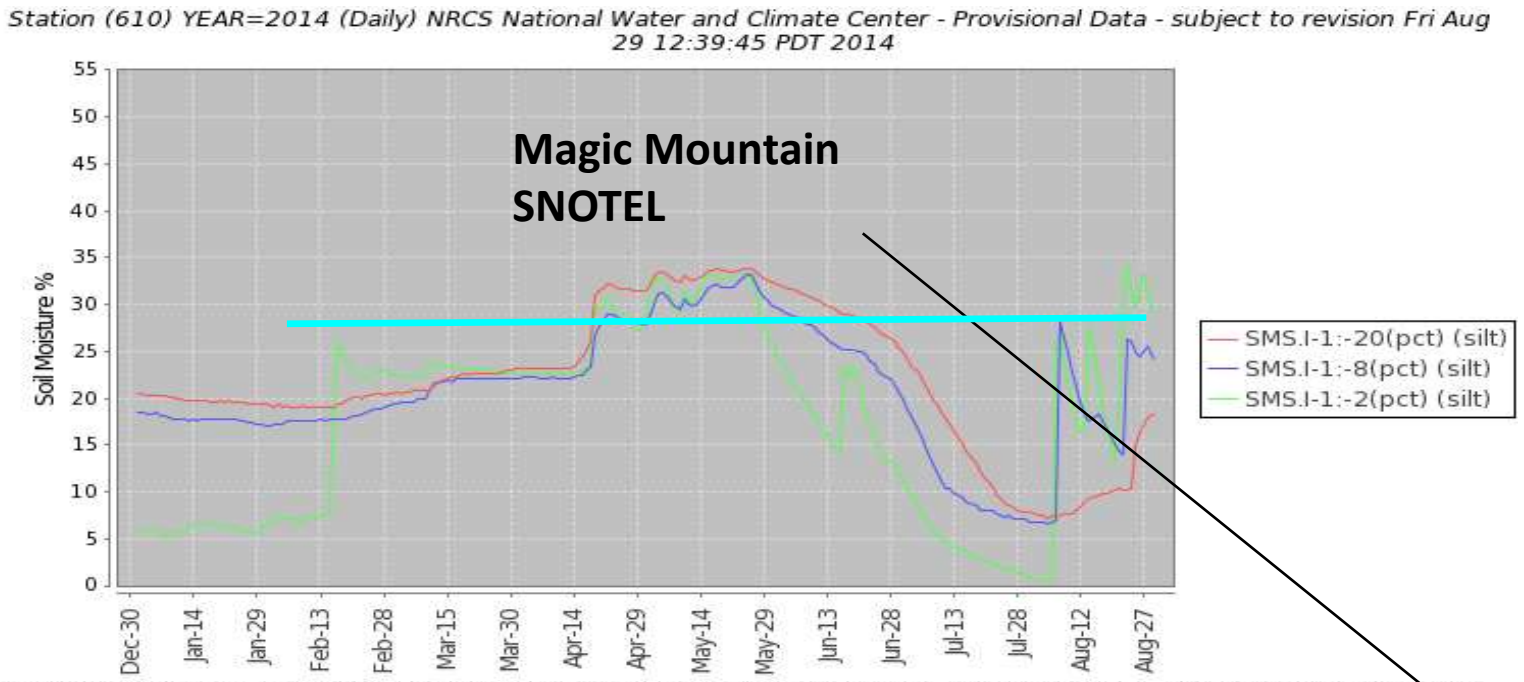
August 5 - 6, 2014 from Boise NWS: Southern Idaho 24 Hour rainfall totals from 3pm to 3pm

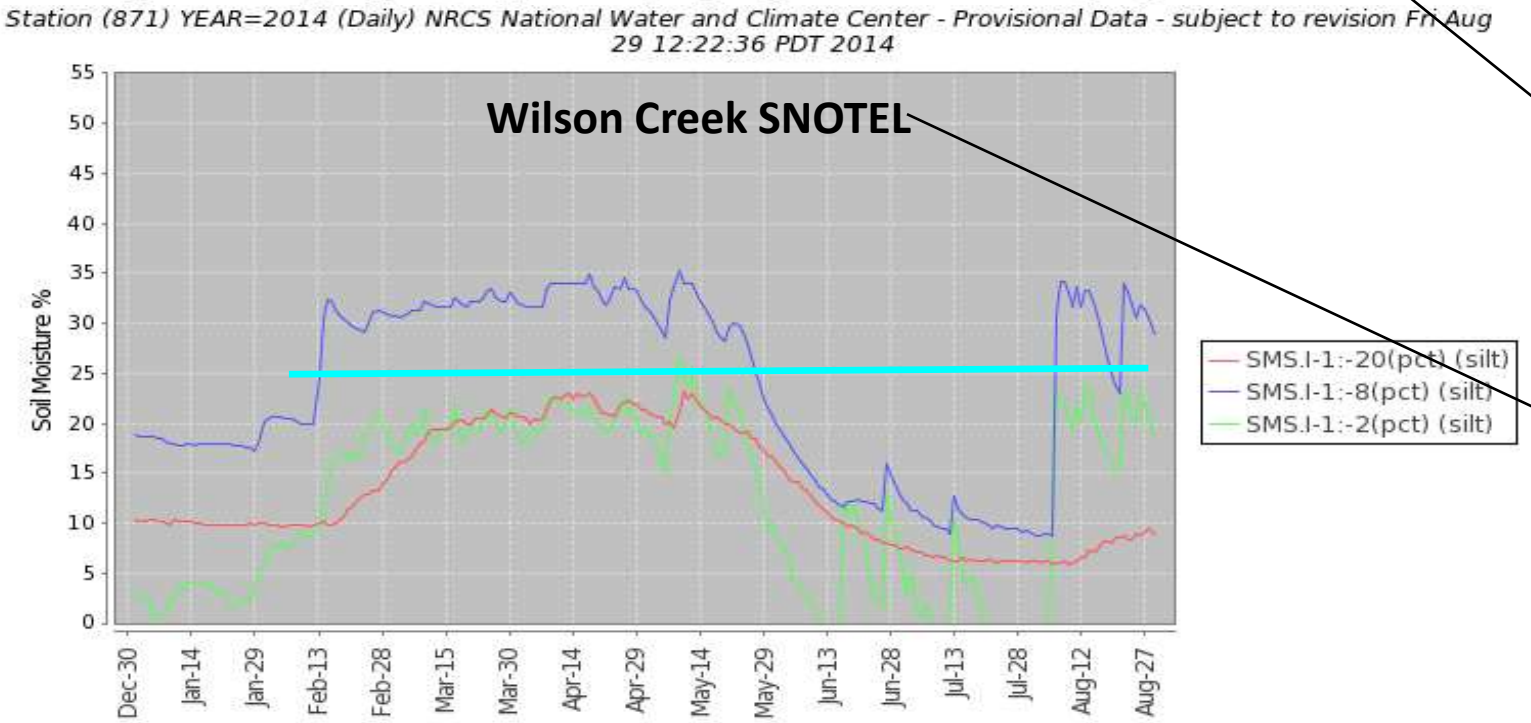


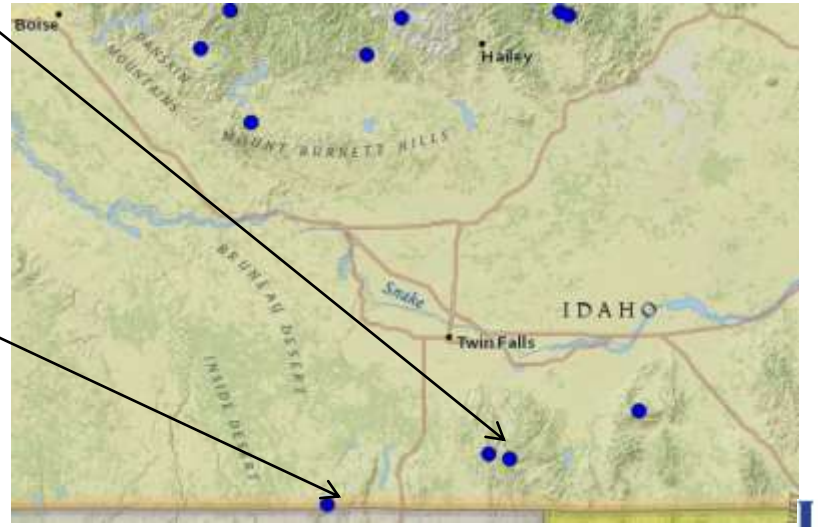
August 2014 Precipitation Event brought 5.57” to Twin Falls

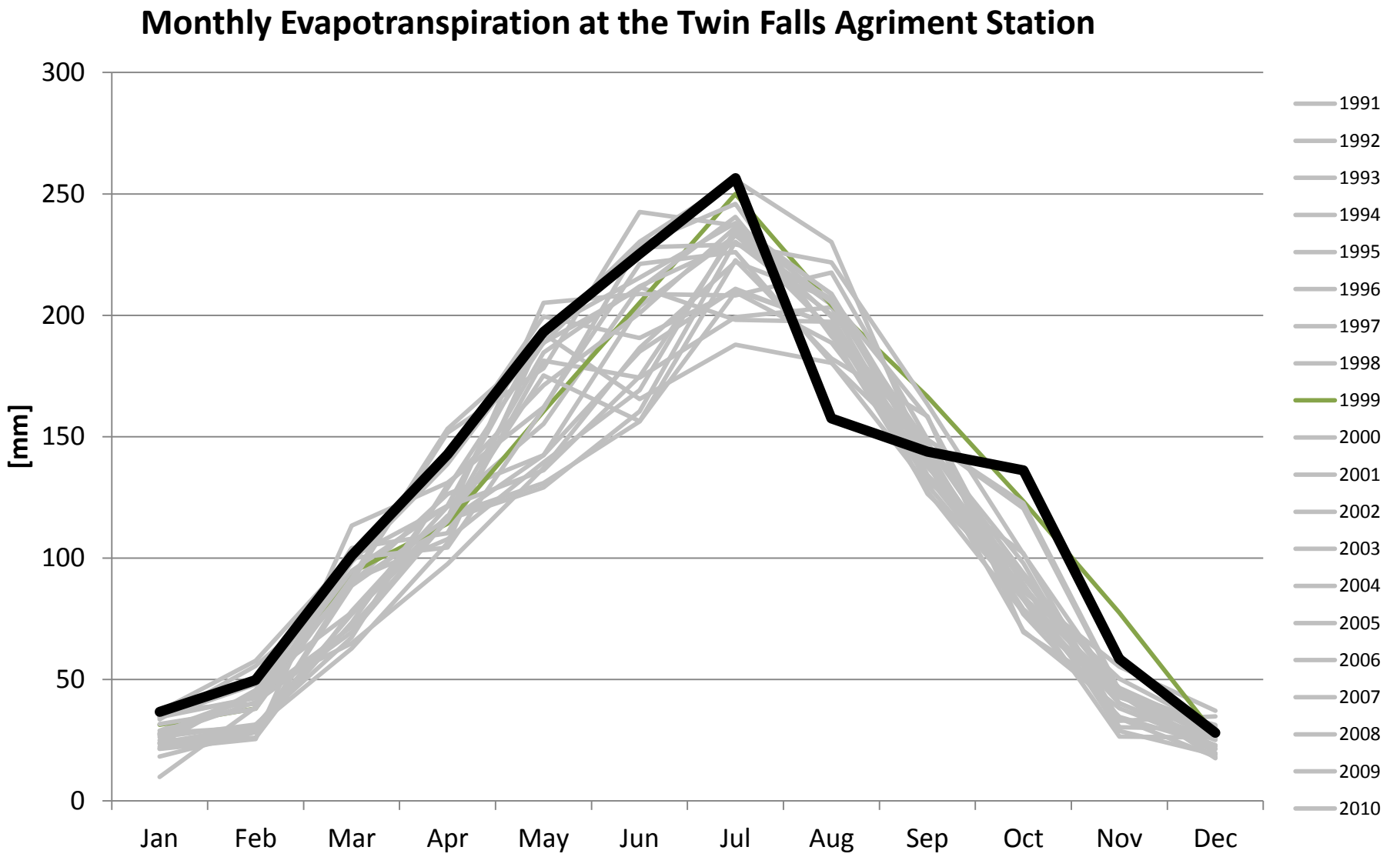


Southern Idaho:
Soil Moisture at 2 & 8 inch depths increased to similar saturations as observed during snowmelt season



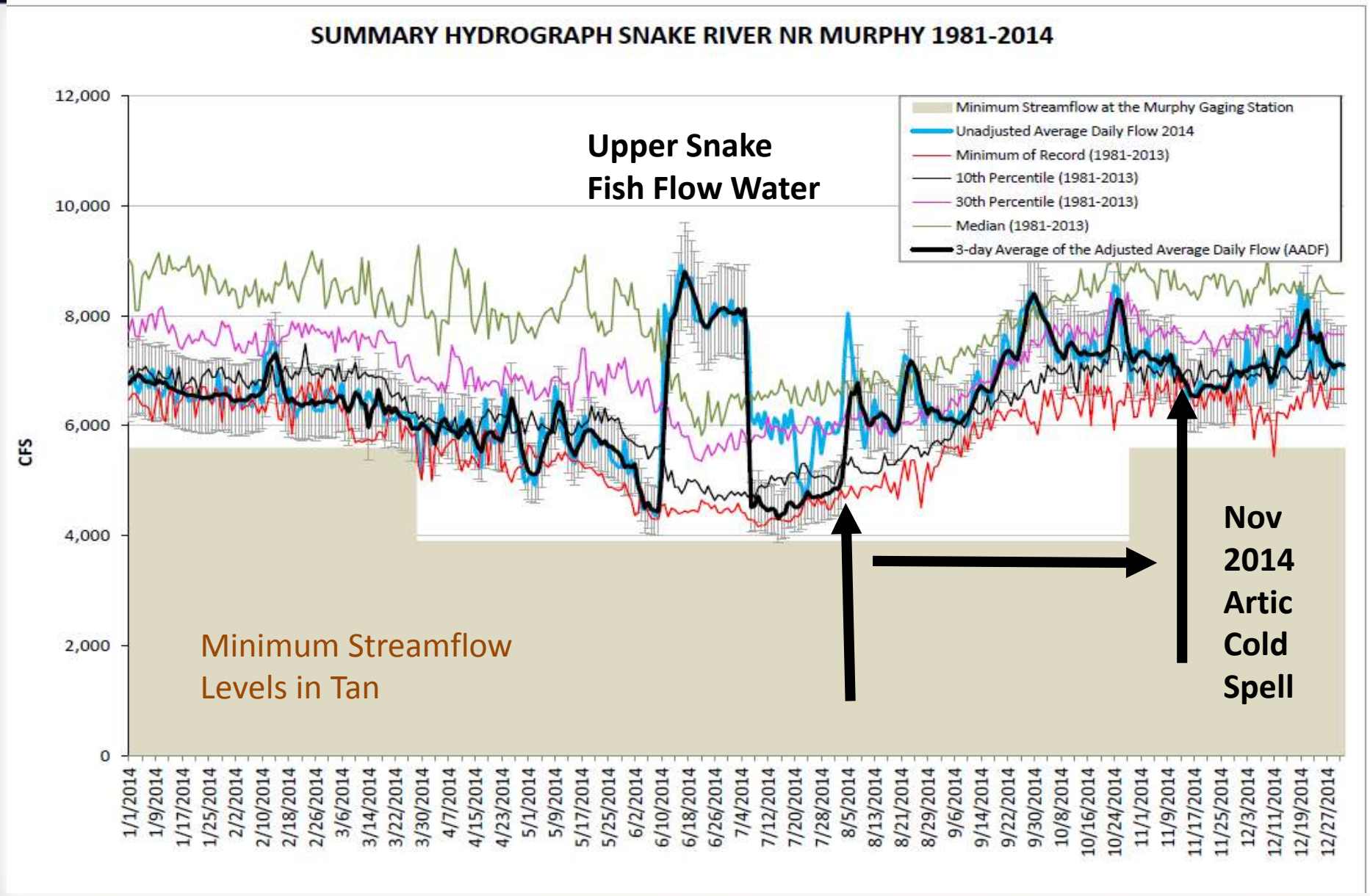






2014 ET levels decreased

Other benefits: increased reservoir carryover storage for 2015 season

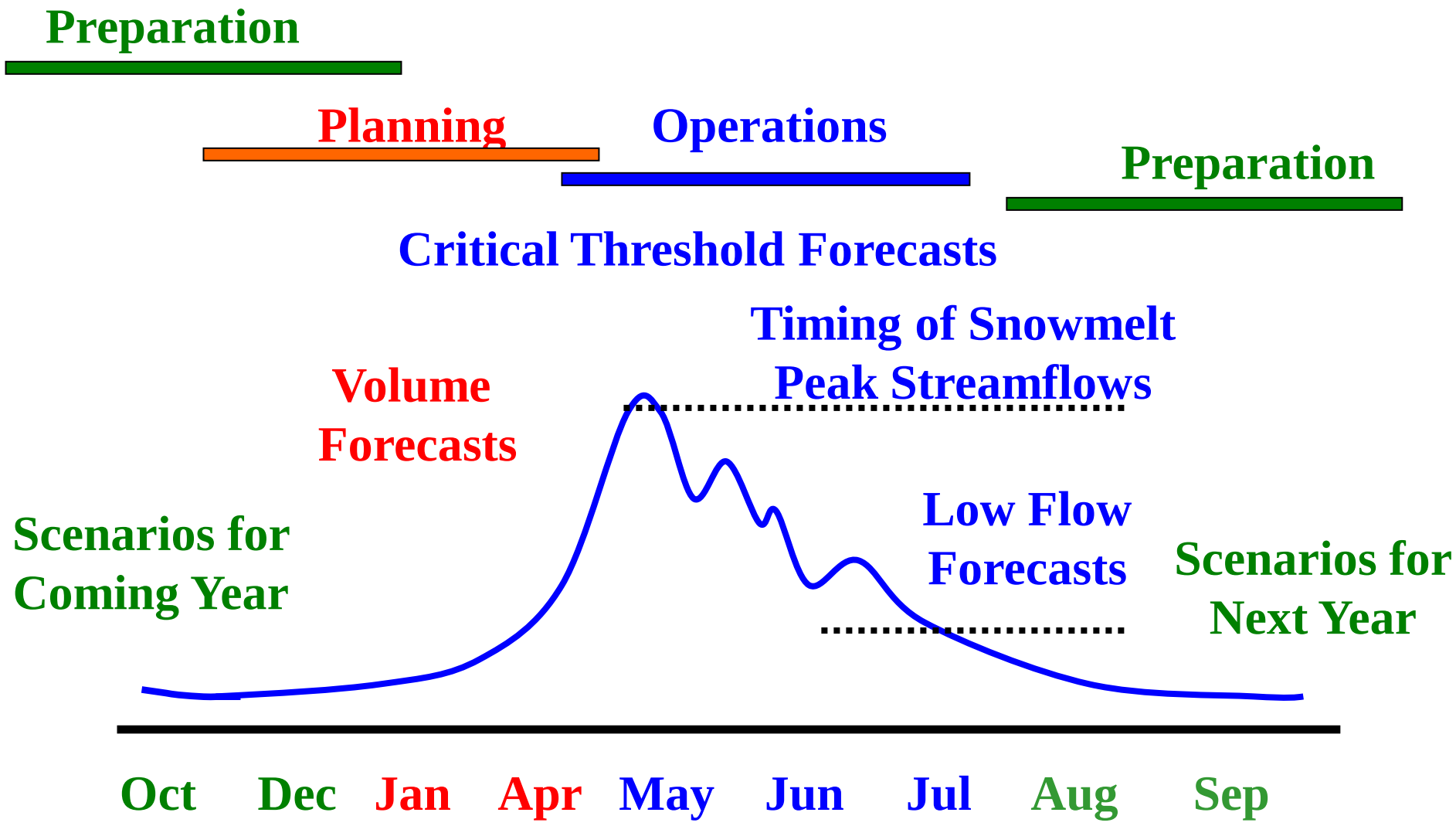


2014 Snake River flows near Murphy
3-day average flows

Increased until early November as August rains moved through the system

Water User Needs Timeline

A few slides on tools being developed to assist water users in their planning and water management decision making process



Funded through CESU grants with BSU

BOISE STATE UNIVERSITY

From Snow to Flow

1. **Estimating the timing of peak streamflow using SNOTEL ablation curves**

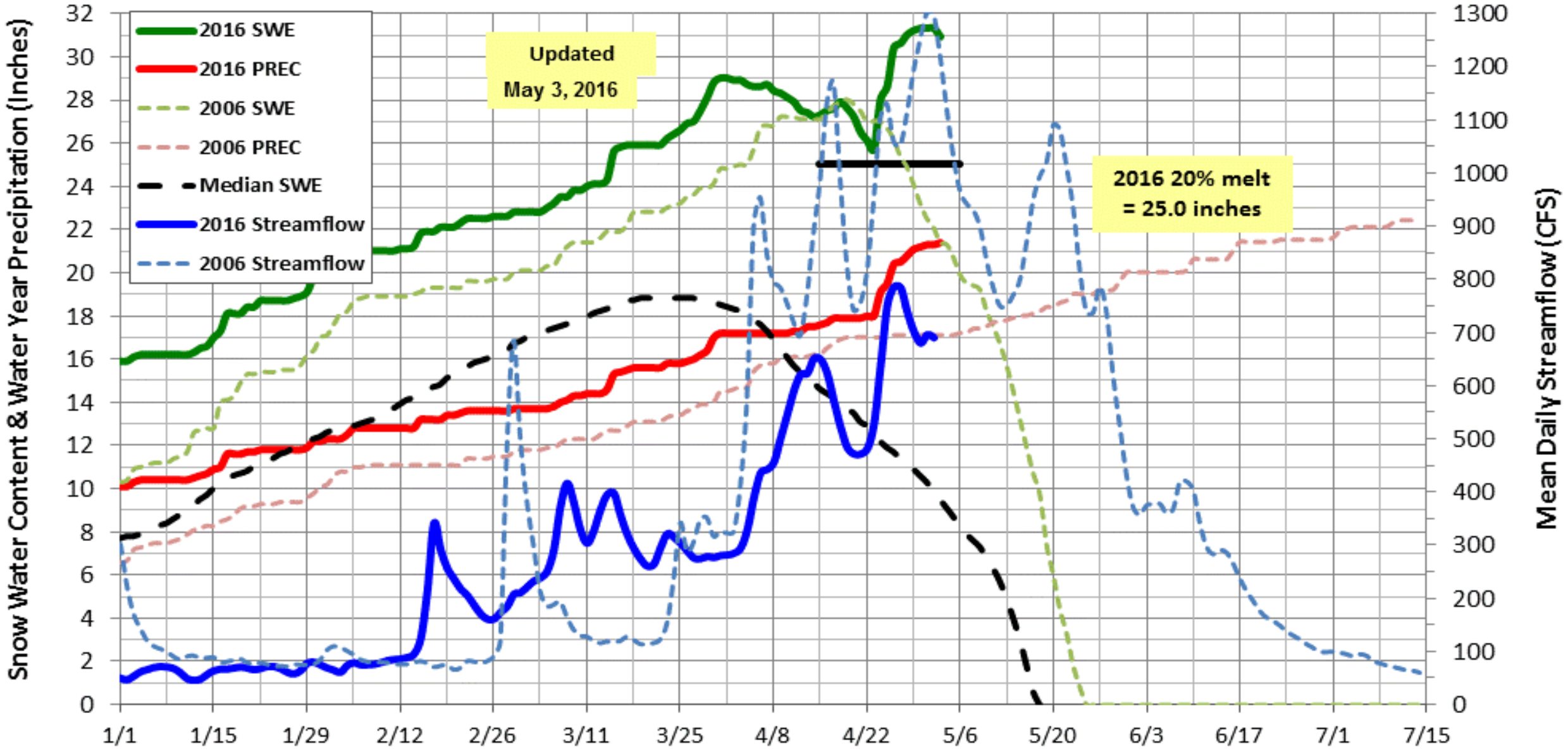
   (Kara Ferguson & Dr. Jim McNamara)

2. **Estimating critical flow magnitudes using SNOTEL data**

   (Becca Garst & Dr. Jim McNamara)

2016 & 2006 Pole Creek SNOTEL and Salmon Falls Creek near San Jacinto

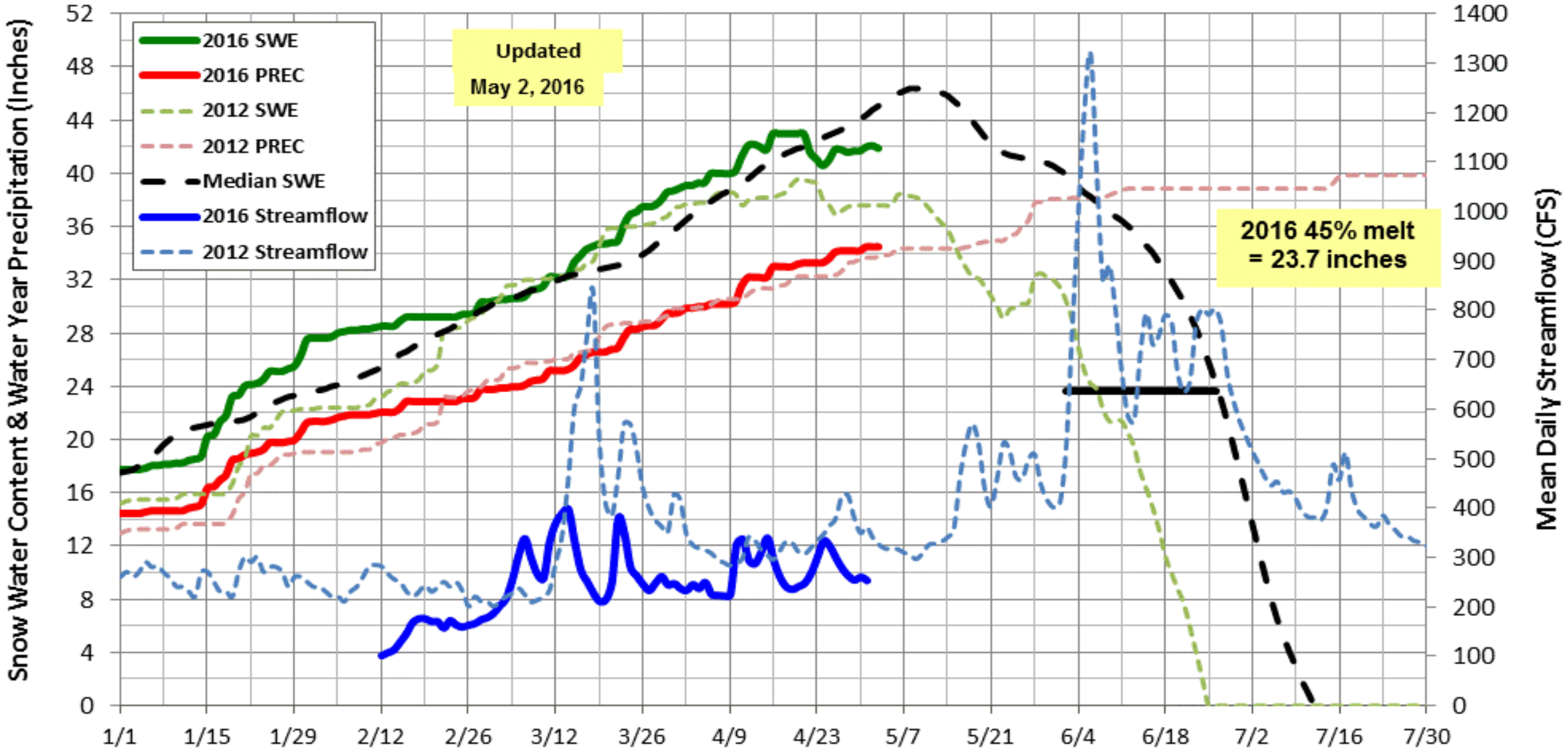
USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service



Salmon Fall Creek usually peaks or has an increase when Pole Creek SNOTEL is about 20% melted

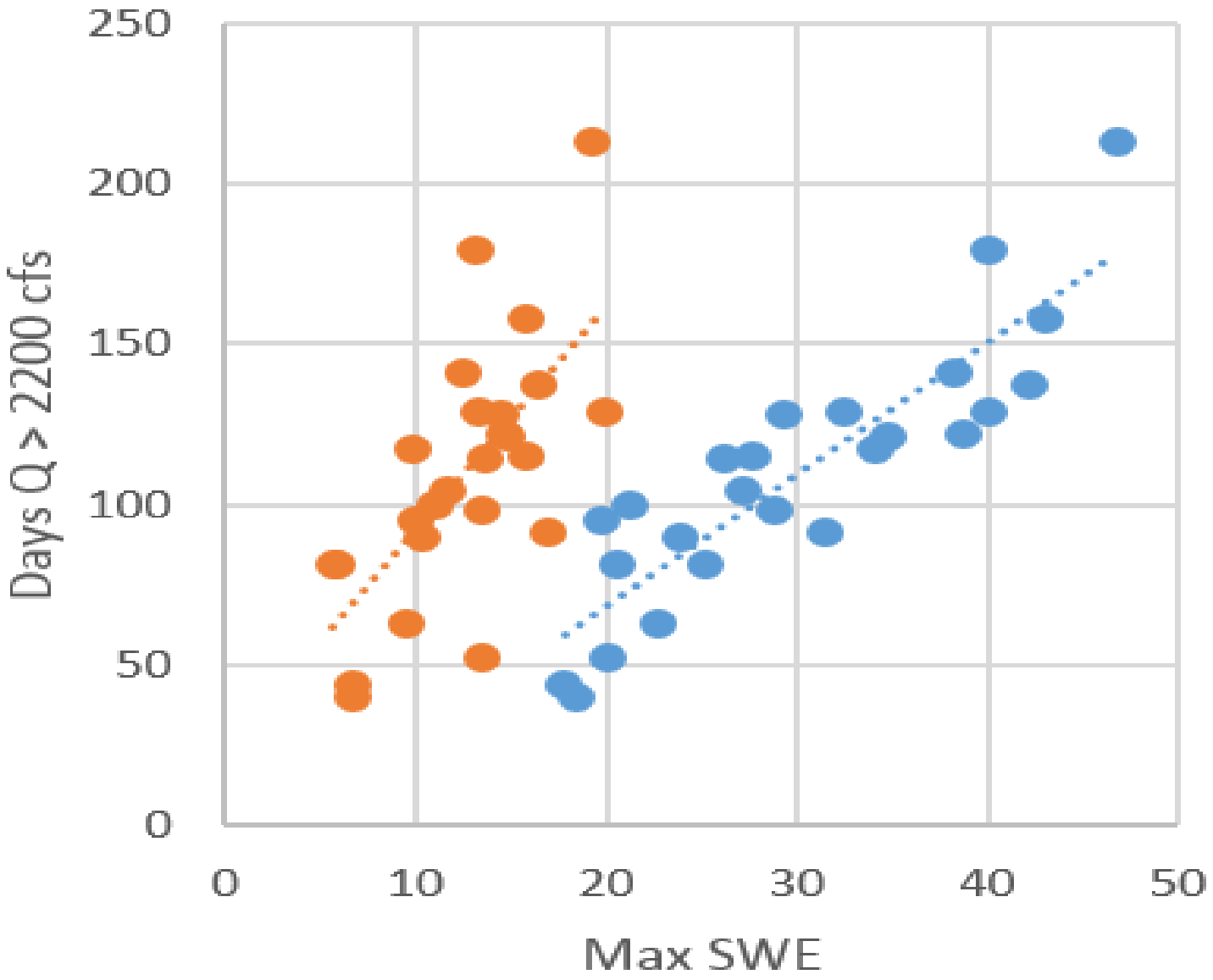
2016 & 2012 Grand Targhee SNOTEL and Teton River above Leigh Ck near Driggs

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service



Teton River has an increase or the snowmelt peak occurs when Grand Targhee SNOTEL site is about 45% melted.

Max SWE vs Days Q > 2200 cfs



Boise River Natural Flow at Lucky Peak analysis to predict Day of Allocation

Atlanta Summit Max SWE vs Days w/ Q > 6700 cfs

$y = 4.0865x - 12.964$

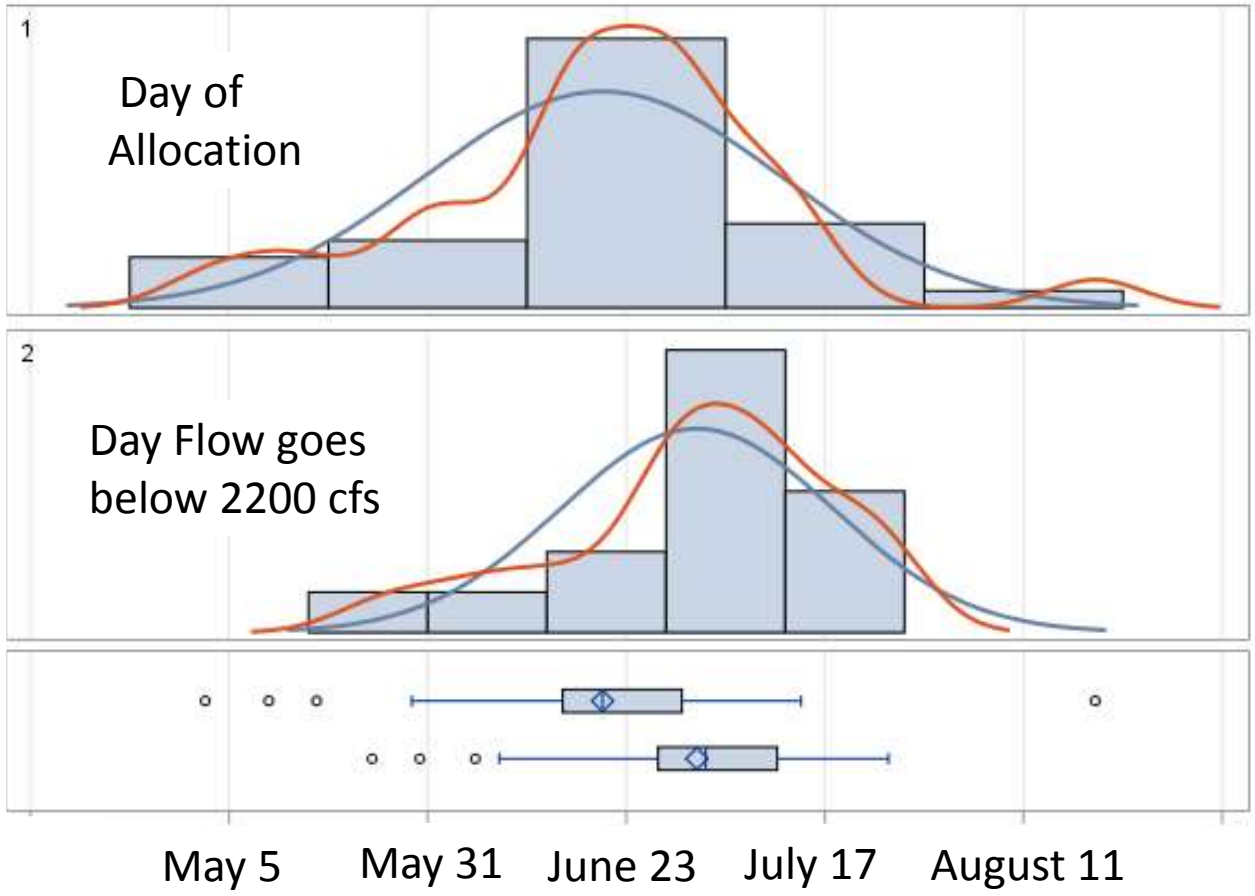
$R^2 = 0.7788$

Graham Guard Max SWE vs Days w/ Q > 6700 cfs

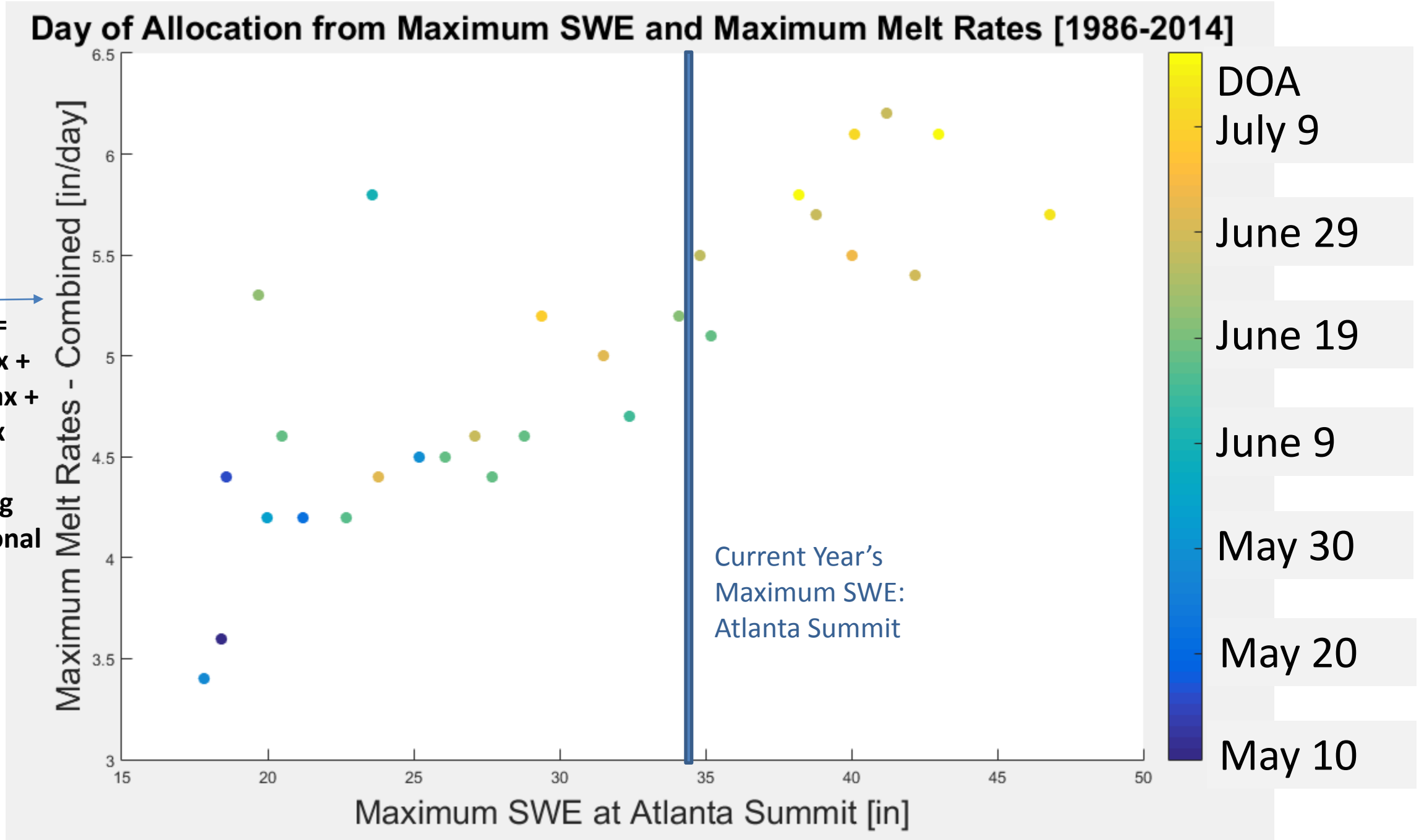
$y = 6.9675x + 22.057$

$R^2 = 0.4563$

Actual Day of Allocation (DOA) is **not** equal to when Flows at Lucky Peak go below 2200

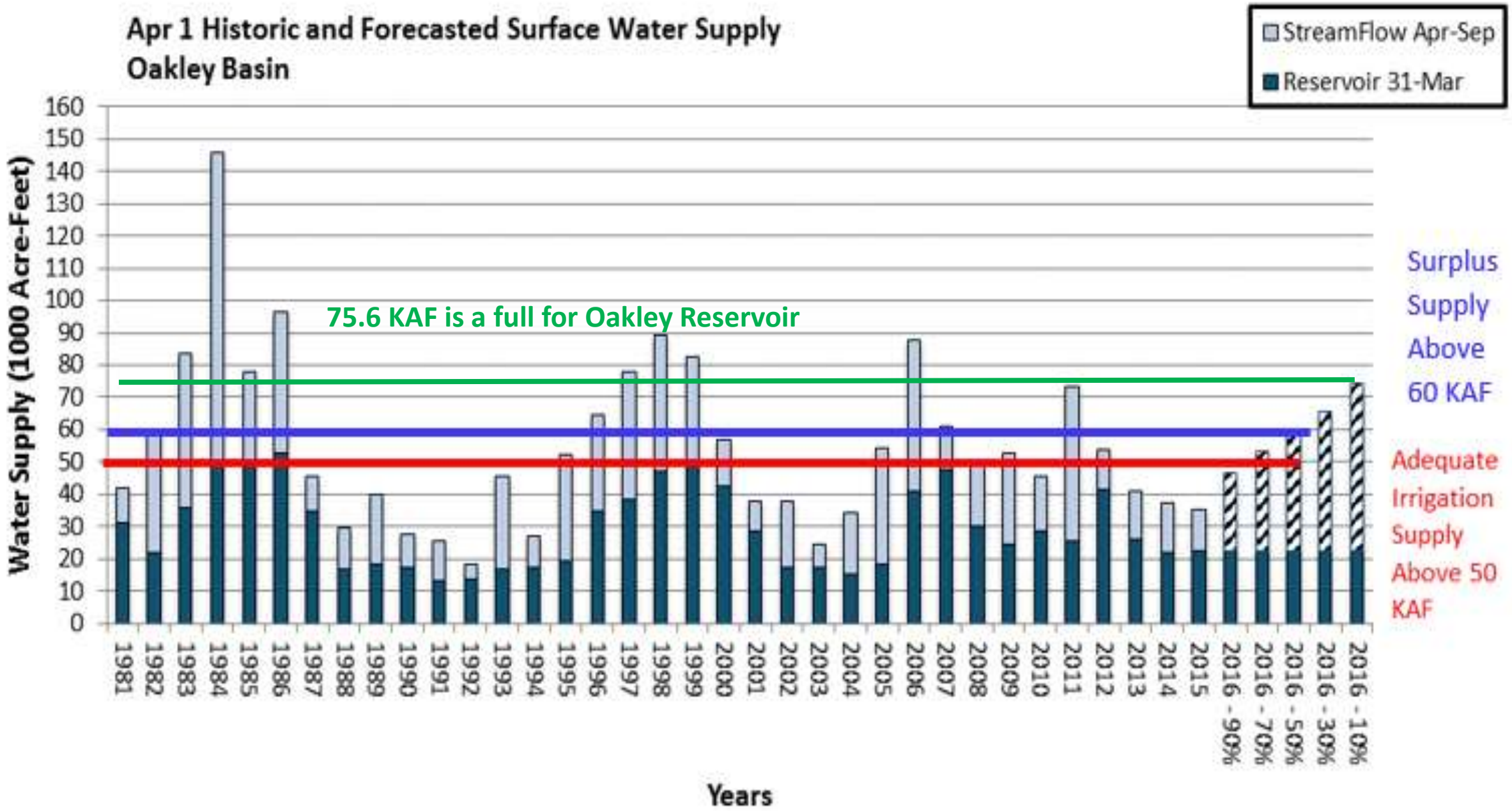


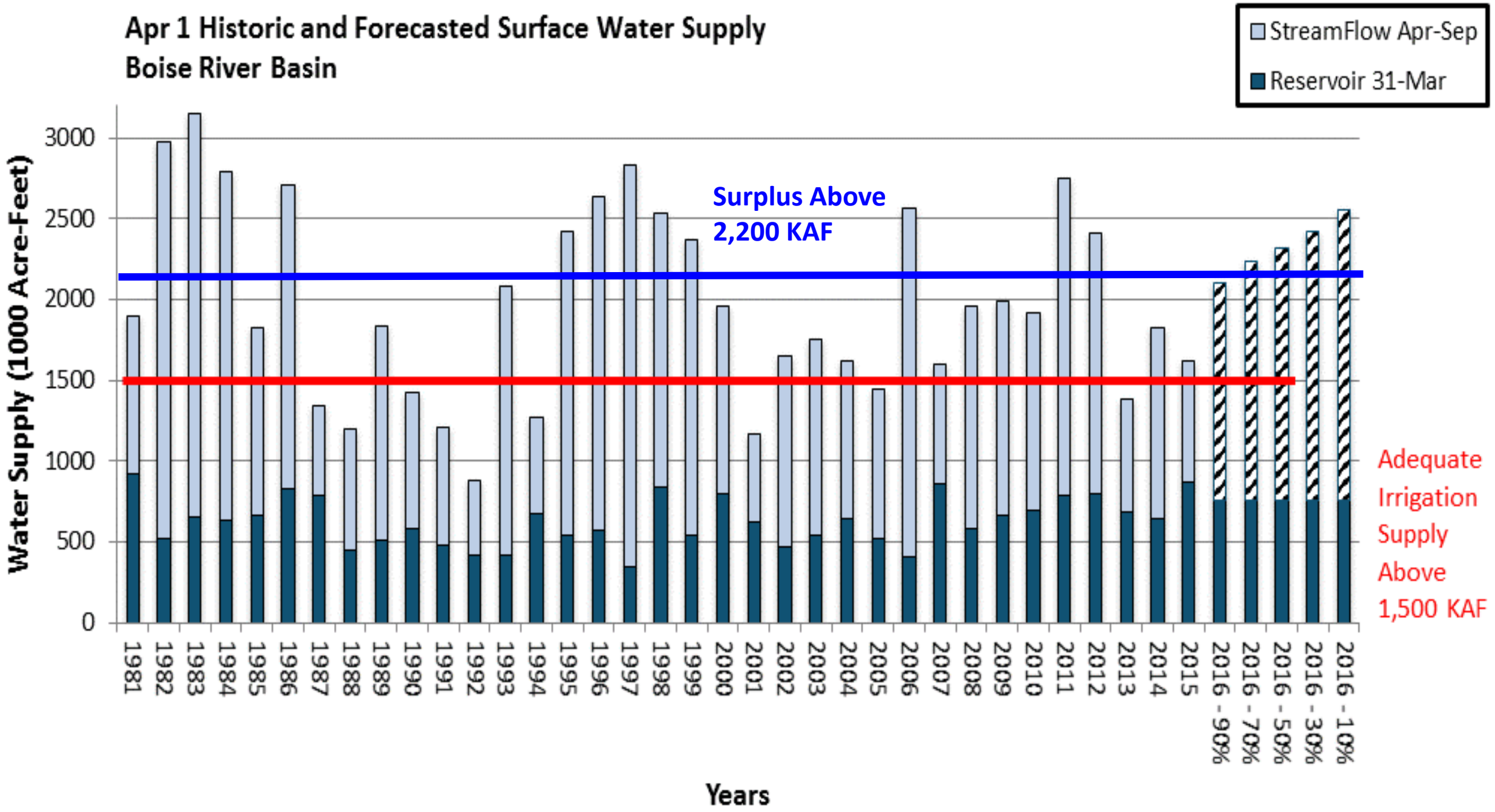
- Confidence of 98%
- DOA is about 11 days before, when Lucky Peak (QU flow) is close to 4000 cfs
- More analysis to come



Combined = Atlanta max + Graham max + Vienna max

Still working on operational here.


Apr 1 Historic and Forecasted Surface Water Supply
Oakley Basin
StreamFlow Apr-Sep
Reservoir 31-Mar
Water Supply (1000 Acre-Feet)
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
75.6 KAF is a full for Oakley Reservoir
Surplus Supply Above 60 KAF
Adequate Irrigation Supply Above 50 KAF
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016 -90%
2016 -70%
2016 -50%
2016 -30%
2016 -10%
Years


Apr 1 Historic and Forecasted Surface Water Supply
Boise River Basin
StreamFlow Apr-Sep
Reservoir 31-Mar
Water Supply (1000 Acre-Feet)
3000
2500
2000
1500
1000
500
0
Surplus Above
2,200 KAF
Adequate
Irrigation
Supply
Above
1,500 KAF
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016 - 90%
2016 - 70%
2016 - 50%
2016 - 30%
2016 - 10%
Years

Boise Basin			Based on Glenwood Gauge Data 1982 - 2014				
Year	Apr - Sep Volume [KAF]	March 31 Res Storage [KAF]	Sum Volume + Storage [KAF]	Max Q at Glenwood [cfs]	Days > 6000 cfs @ Glenwood	Max Q Unreg @ LUC [cfs]	
1983	2494.7	655.5	3150.2	9560	95	24255	
1982	2460.5	515.9	2976.4	7410	75	19020	
1997	2490.6	346.5	2837.1	7160	117	24052	
1984	2160.6	630.0	2790.6	6900	42	22541	
2011	1965.4	785.0	2750.4	7130	61	18787	
1986	1881.1	831.3	2712.4	7960	79	17992	
1996	2065.5	574.1	2639.6	6690	67	20570	
2006	2162.4	403.7	2566.1	7050	39	22066	
1998	1700.6	837.0	2537.6	8350	28	14186	
1995	1887.1	535.8	2422.9	4970	0	13350	Outlier
2012	1610.9	801.3	2412.1	8050	45	22787	
1999	1838.1	537.5	2375.6	6770	36	16445	
Surplus above 2200 KAF							
1993	1656.5	421.7	2078.2	6560	5	16339	
2009	1323.0	666.6	1989.6	6040	1	10973	Borderline Surplus
2008	1382.1	577.9	1960.0	6860	5	17201	
2000	1154.6	801.5	1956.1	3330	0	8867	Outlier
2010	1223.8	697.0	1920.8	6000	0	17686	Borderline Surplus
1989	1324.2	507.5	1831.7	6130	5	13151	
1985	1165.6	664.0	1829.6	2360	0	9842	
2014	1178.3	645.1	1823.4	1880	0	9776	
2003	1218.6	538.4	1757.0	1480	0	16023	Peak Flows below 6000 cfs
2002	1178.4	471.8	1650.2	1340	0	14216	
2004	973.5	647.1	1620.6	1320	0	7247	
2007	736.4	859.9	1596.3	1480	0	6441	
Shortages below 1500 KAF							
2005	931.1	517.2	1448.3	1230	0	13233	
1990	840.6	579.3	1419.9	875	0	7881	
2013	703.8	681.6	1385.3	1440	0	7517	
1987	561.8	784.6	1346.4	1470	0	5625	
1994	588.4	677.9	1266.3	1280	0	5573	
1991	734.4	477.5	1211.9	968	0	6308	
1988	745.6	451.3	1196.9	939	0	6234	
2001	544.9	619.5	1164.4	947	0	6209	
1992	470.8	412.3	883.1	830	0	4317	

Boise Basin:

Determination of the 2,200 KAF Surplus Level: The surplus threshold of 2200 KAF for the Boise Basin was determined based the following analysis for years 1982-2014. The Boise River at Glenwood Bridge gage was installed in 1982.

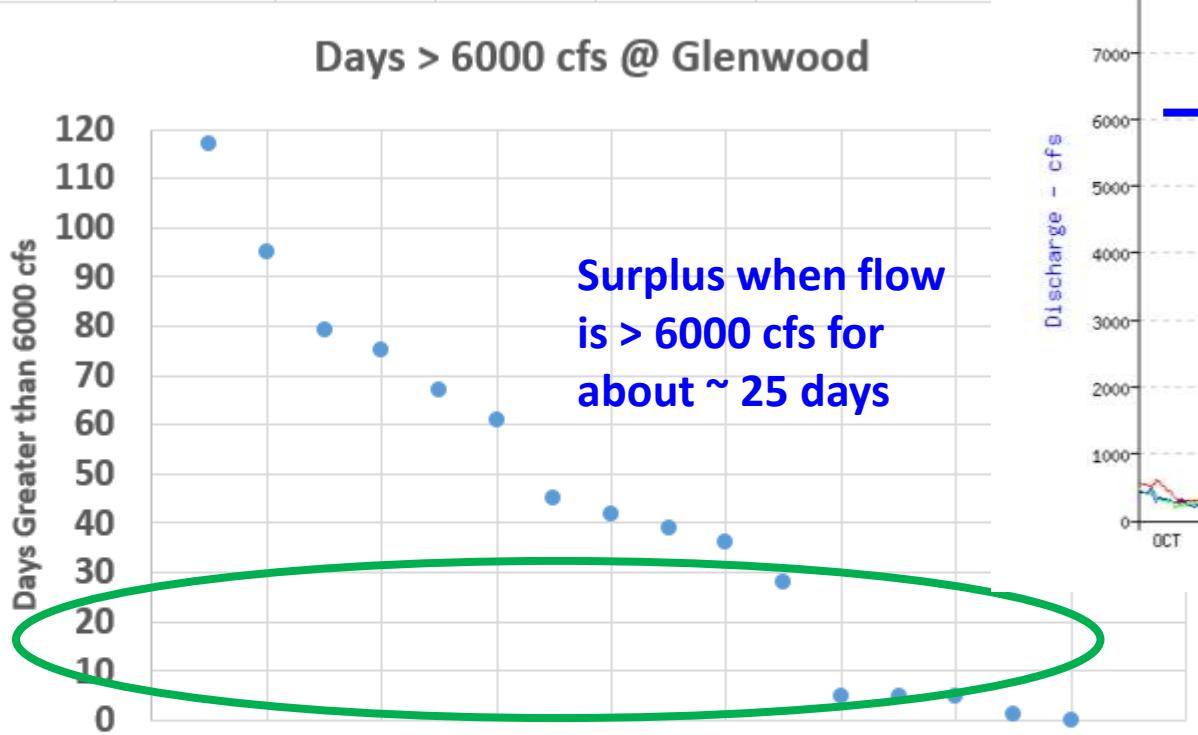
SWSI volumes greater than 2,200 KAF, which is the summation of the Mar 31 combined reservoir storage plus Apr-Sep runoff volume, was sorted high to low.

Peak flows at the Glenwood gage were determined along with the number of days above 6000 cfs. There seems to be a distinct cutoff in the maximum flow at Glenwood. **Only one year, 1995, had a maximum discharge between 3330 to 6000 cfs.**

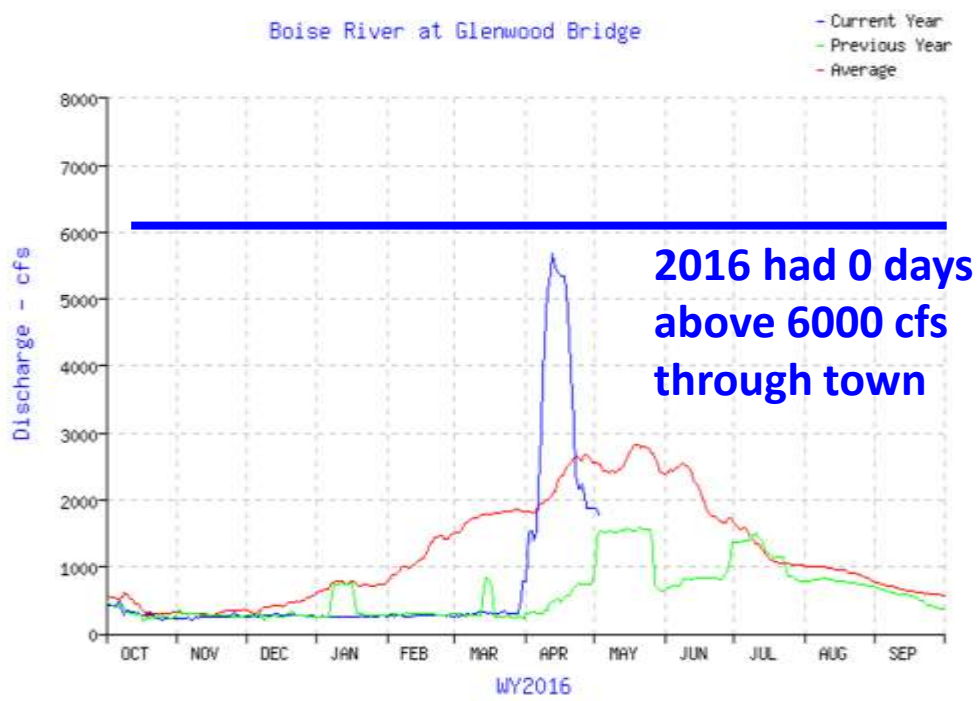
Natural inflow peaks were used as a guide but the amount released from the reservoir is primarily a function of the storage in the reservoir system. **The total volume is then compared to the Glenwood maximum flow and duration of high flows.**

A volume greater than 2,200 KAF with a flow greater 6,000 cfs passing through the Boise River at Glenwood gage for generally more than 25 days meets the surplus threshold.

Year	Days > 6000 cfs @ Glenwood
1997	**117**
1983	**95**
1986	**79**
1982	**75**
1996	**67**
2011	**61**
2012	**45**
1984	**42**
2006	**39**
1999	**36**
1998	**28**
1993	**5**
2008	**5**
1989	**5**
2009	**1**
1995	**0**
2000	0
2010	0
1985	0
2014	0
2003	0
2002	0
2004	0
2007	0
2005	0
1990	0

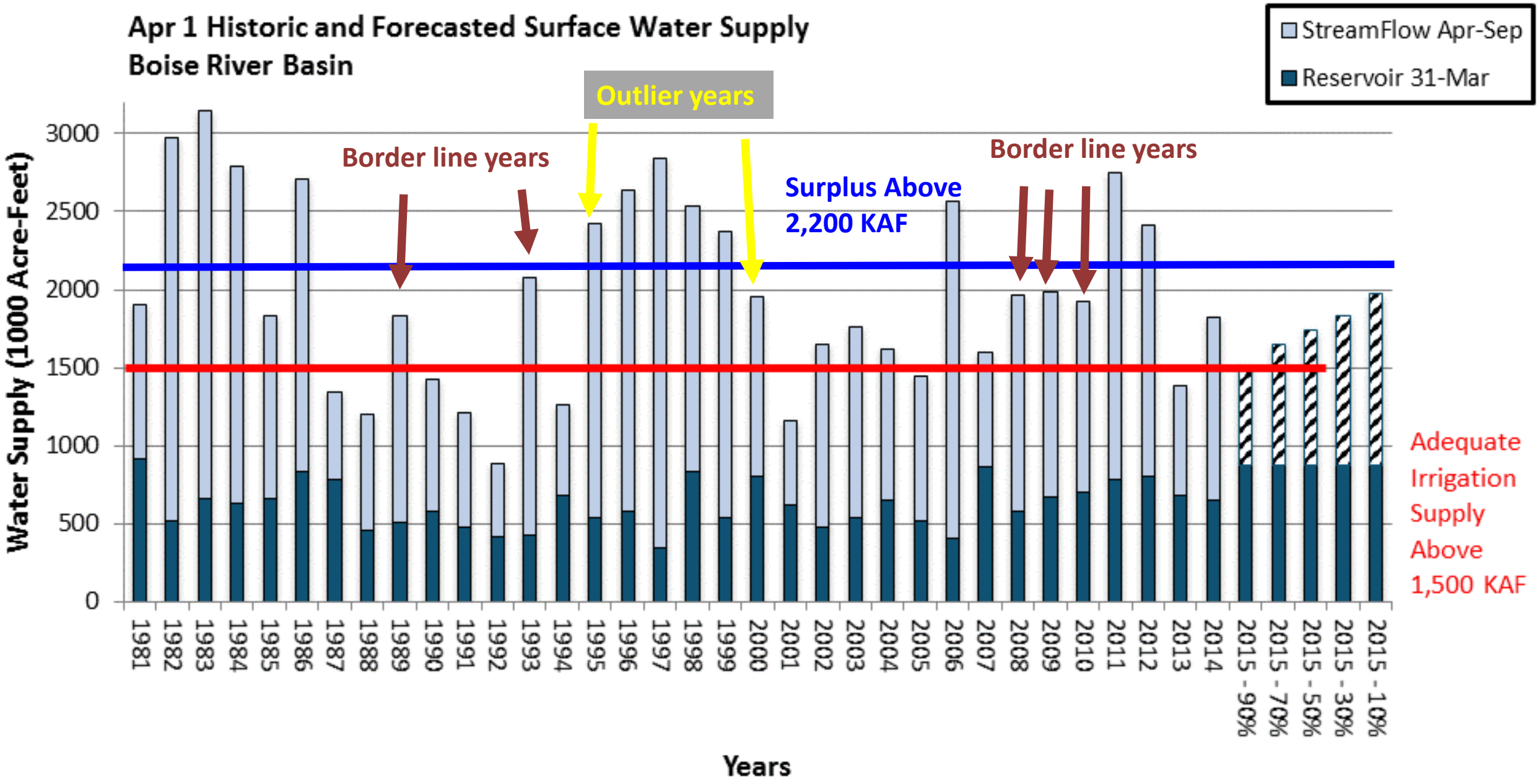


Surplus when flow is > 6000 cfs for about ~ 25 days



2016 had 0 days above 6000 cfs through town

The years with days above 6000 cfs on the Boise River at Glenwood Bridge are plotted. In the table, the years are in bold. The years in blue are surplus, and the years in green are borderline (defined above). The red years correspond to years of water supply shortage.


Apr 1 Historic and Forecasted Surface Water Supply
Boise River Basin
StreamFlow Apr-Sep
Reservoir 31-Mar
Outlier years
Border line years
Surplus Above
2,200 KAF
Border line years
Water Supply (1000 Acre-Feet)
3000
2500
2000
1500
1000
500
0
Adequate
Irrigation
Supply
Above
1,500 KAF
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015 - 90%
2015 - 70%
2015 - 50%
2015 - 30%
2015 - 10%
Years

Rain is Good
But
Snow is Better

Questions,
Comments,
Solutions
or Time for
Panel
Discussion

USDA