

NOAA's Colorado Basin River Forecast Center

Decision Support in the Cadillac Desert: *Water Supply Data and Tools in the Water Stressed and Politically Charged Colorado River Basin*

W. Paul Miller, Service Coordination Hydrologist

Arizona Hydrological Society Annual Symposium

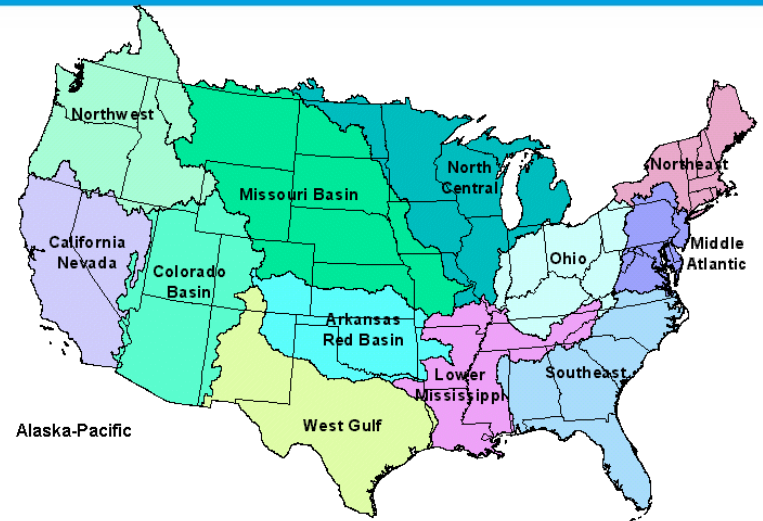
September 16, 2016

Tucson, AZ – Casino Del Sol Resort





Who Are We?



- Part of NOAA - NWS, one of 13 RFCs nationwide
- An operational field office located in Salt Lake City, UT
- Highly collaborative, reliant on partners and data
- All about decision-support!

Who We Are

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- Work with a broad and diverse set of stakeholders
 - Weather Forecast Offices and Reclamation
 - Municipal and Agricultural Water Users
 - USGS, NRCS, and many other federal agencies
 - State agencies, Academics, NGOs, Tribes
- Receive data from many of these sources



Colorado Basin River Forecast Center

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River Forecast Centers (RFCs)

- Support for WFOs
- River levels and flows
- Reservoir inflows
- Each RFC is unique

CBRFC

- Seasonal Water Supply forecasts, in addition to many other products
 - Most advanced, involved
 - Reclamation is a key stakeholder
 - www.cbrfc.noaa.gov



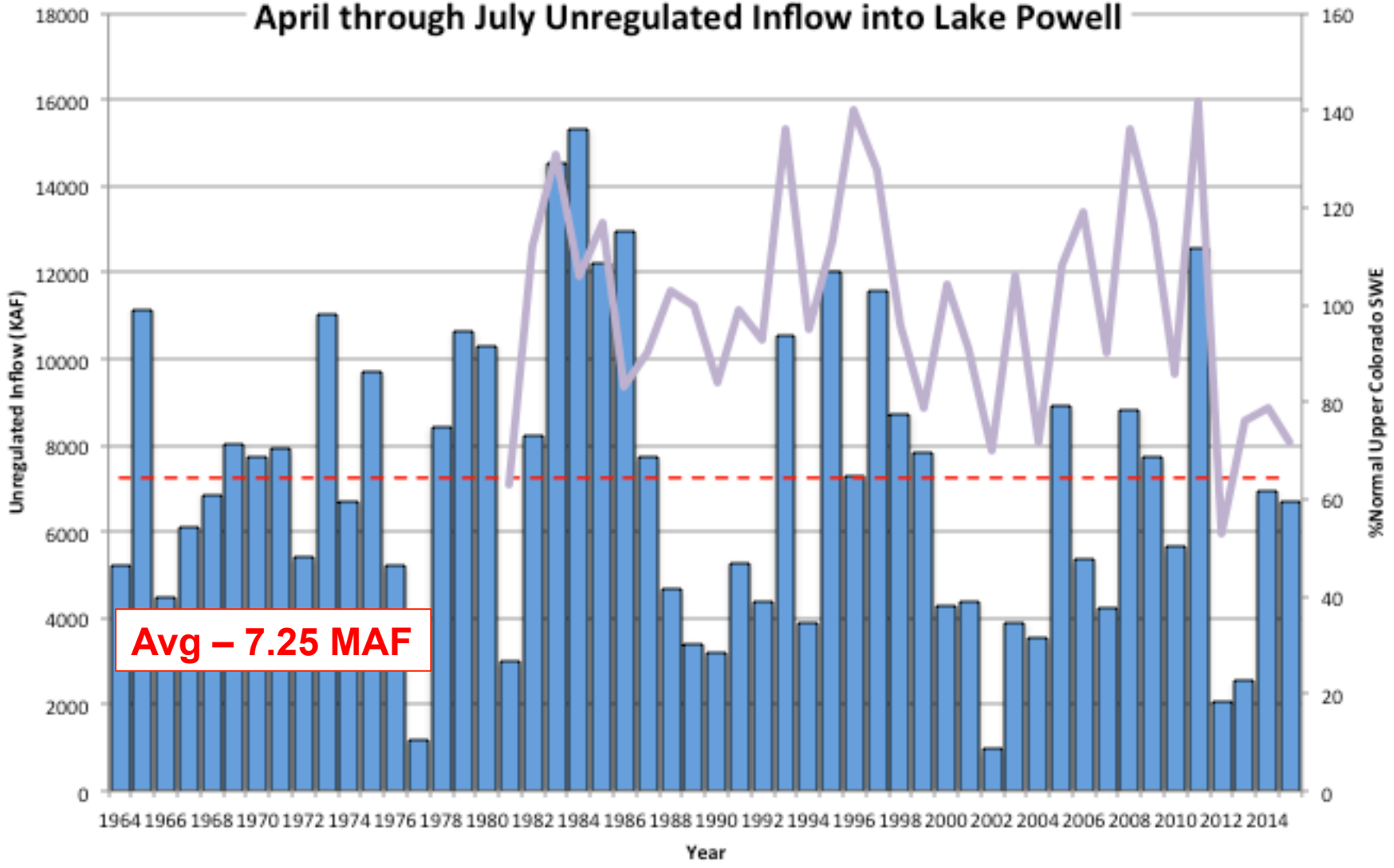
Weather Forecast Offices (WFOs)

- Everyday weather
- Extreme weather
- Warnings, watches, and advisories
- Floods, tornadoes, heat, etc...



Hydroclimatic Variability over the Colorado River Basin

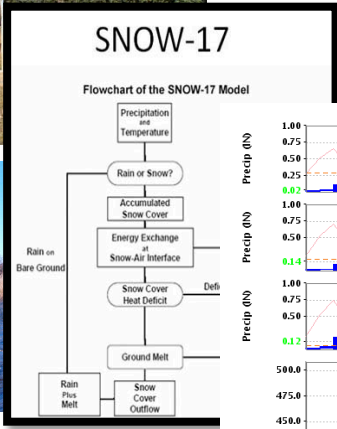
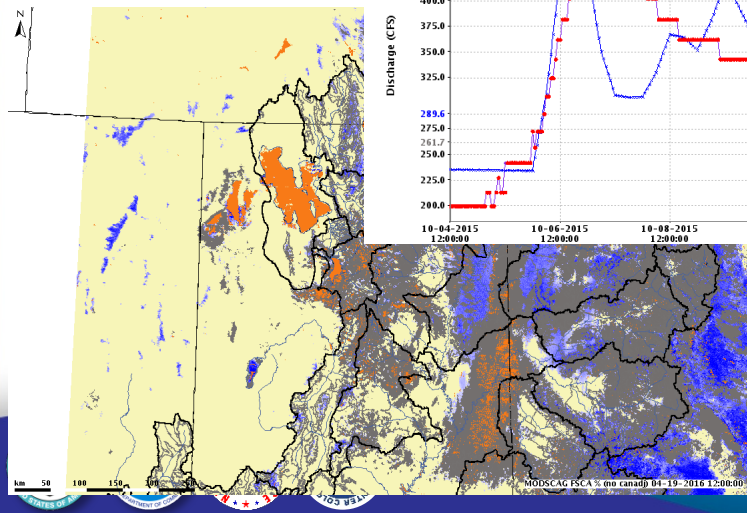
April through July Unregulated Inflow into Lake Powell



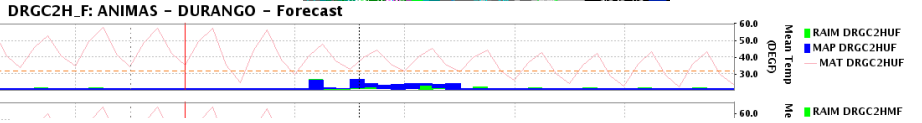
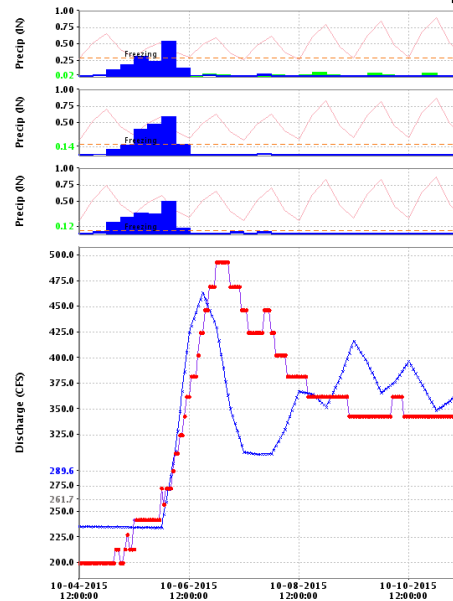
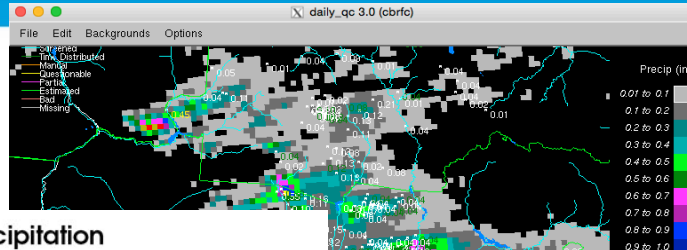
Avg - 7.25 MAF

Providing Decision Support

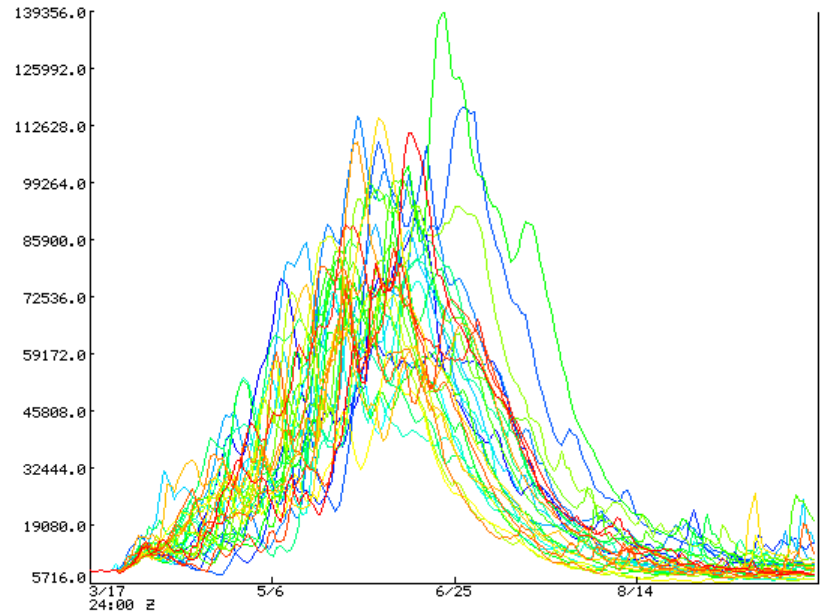
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Evapo-  Precipitation



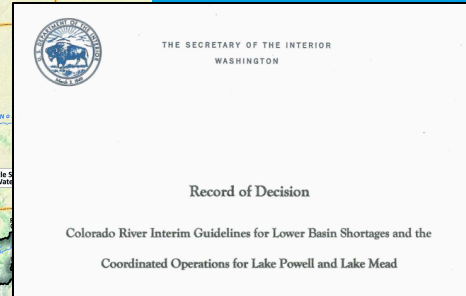
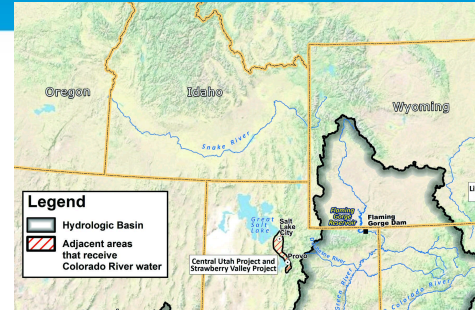
ESP Trace Ensemble of COLORADO - LAKE POWE
 Latitude: 36.9 Longitude: -111.5
 Forecast for the period 3/17/2014 24h - 10/1/2014 24h
 This is a conditional simulation based on the current conditions as of 3/17/2014



Providing Decision Support

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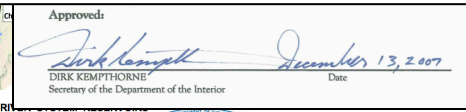
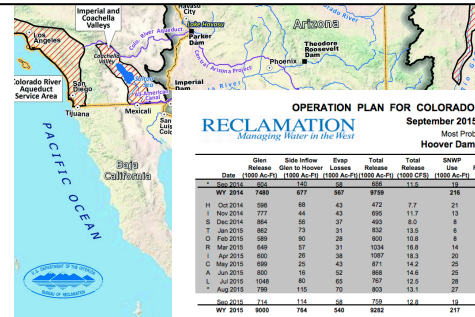
- CBRFC's water supply forecasts drive Reclamation's model that



AOP consultation process. In making these projections, the Secretary shall utilize the April 1 final forecast of the April through July runoff, currently provided by the National Weather Service's Colorado Basin River Forecast Center.

declarations

- Direct impact to State, municipal, agricultural, water and energy managers and Mexico



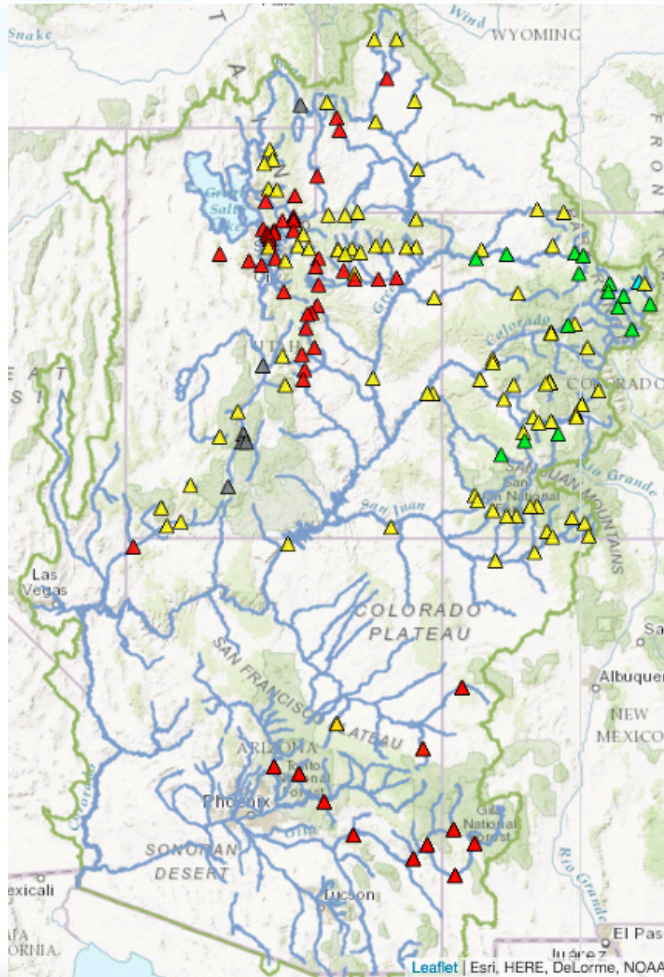
OPERATION PLAN FOR COLORADO RIVER
RECLAMATION
 September 2015 24-Month Study
 Most Probable Inflow*
 Hoover Dam - Lake Mead

Month	Gen. Release (1000 Ac-Ft)	Side Inflow (1000 Ac-Ft)	Evap. Losses (1000 Ac-Ft)	Total Release (1000 CFS)	SNWPP (1000 Ac-Ft)	Downstream (1000 Ac-Ft)	Reservoir Elev. (ft)	Bank Storage (1000 Ac-Ft)	ECM (1000 Ac-Ft)
WT 2014	7480	677	367	8789	216	9716			
1	Oct-2014	586	61	472	7.7	21	481	888	1052.78
2	Nov-2014	777	44	655	11.7	13	682	670	1033.57
3	Dec-2014	884	36	452	8.0	8	482	803	1001.78
4	Jan-2015	884	73	21	832	13.5	8	632	987
5	Feb-2015	589	90	28	600	10.8	8	580	700
6	Mar-2015	649	57	31	1026	16.8	14	1033	877
7	Apr-2015	800	26	38	1007	18.3	20	1086	646
8	May-2015	699	25	43	871	14.2	25	862	532
9	Jun-2015	800	16	52	888	14.6	25	868	624
10	Jul-2015	1048	80	65	797	12.5	28	786	841
11	Aug-2015	739	116	70	803	13.1	27	802	642
12	WT 2015	714	113	86	739	32.8	18	739	581
13	WT 2015	8000	784	540	9282	217	9283		
14	Oct-2015	800	81	42	859	9.9	24	859	640
15	Nov-2015	800	50	42	822	10.5	14	822	638
16	Dec-2015	800	96	38	812	8.3	11	812	689
17	Jan-2016	800	52	30	862	11.3	8	862	688
18	Feb-2016	600	77	28	623	10.8	7	623	672
19	Mar-2016	600	88	31	1017	16.5	15	1017	851
20	Apr-2016	600	78	38	1050	18.3	21	1050	622
21	May-2016	800	88	42	986	18.2	28	986	599
22	Jun-2016	800	23	51	824	15.5	30	824	688
23	Jul-2016	1000	67	63	874	14.2	31	874	584
24	Aug-2016	1050	127	68	778	12.7	28	778	613
25	WT 2016	8000	114	58	718	52.1	18	718	590
26	WT 2016	8000	874	537	9497	333	9497		
27	Oct-2016	600	61	41	478	7.8	20	478	628
28	Nov-2016	600	50	41	623	10.5	11	623	628
29	Dec-2016	800	96	38	852	9.0	7	852	644
30	Jan-2017	800	52	30	869	11.4	8	869	683
31	Feb-2017	600	77	27	627	11.3	7	627	687
32	Mar-2017	600	81	31	1025	16.7	15	1025	837
33	Apr-2017	800	37	37	1098	18.1	21	1098	605
34	May-2017	800	49	42	1004	18.3	30	1004	582
35	Jun-2017	1000	23	50	831	15.7	30	831	671
36	Jul-2017	1000	67	62	881	14.3	31	881	576
37	Aug-2017	1050	127	67	786	12.8	28	786	584

* Based on the Colorado River Basin Forecast Center's Most Probable Water Supply Forecast
 Model Run ID: 2266
 Processed On: 9/20/15 9:26:12AM

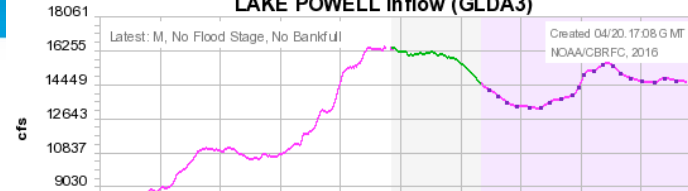


Reaching our Stakeholders

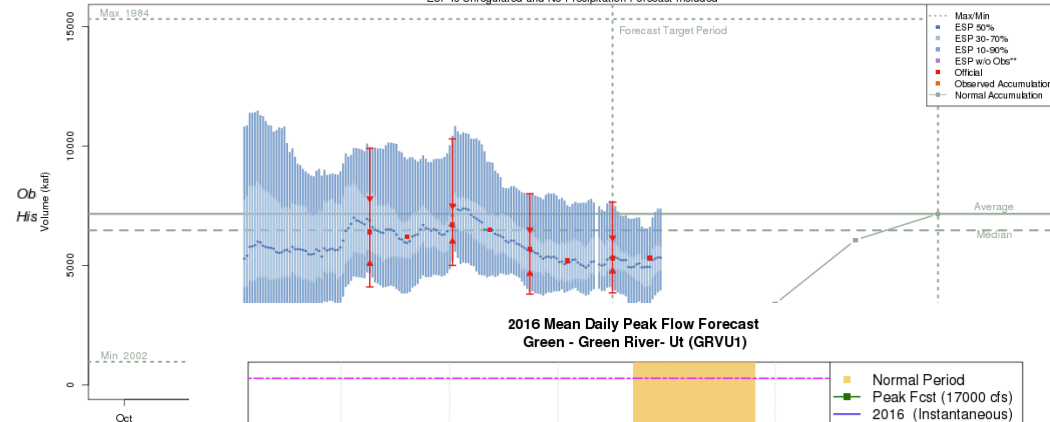


Colorado Basin River Forecast Center

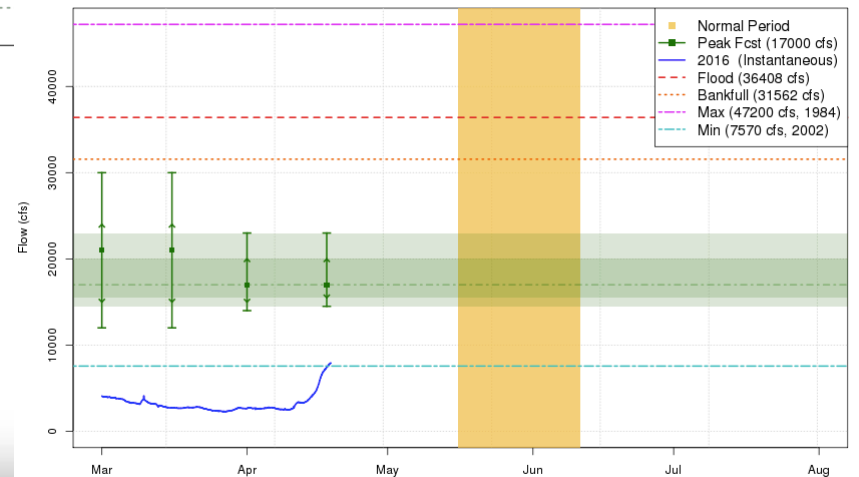
LAKE POWELL Inflow (GLDA3)



Colorado - Lake Powell- Glen Cyn Dam- At (GLDA3)
 2016-04-15 Apr-Jul Official 50% Forecast: 5300 kaf (74% of average)
 ESP is Unregulated and No Precipitation Forecast Included



2016 Mean Daily Peak Flow Forecast
 Green - Green River- Ut (GRVU1)

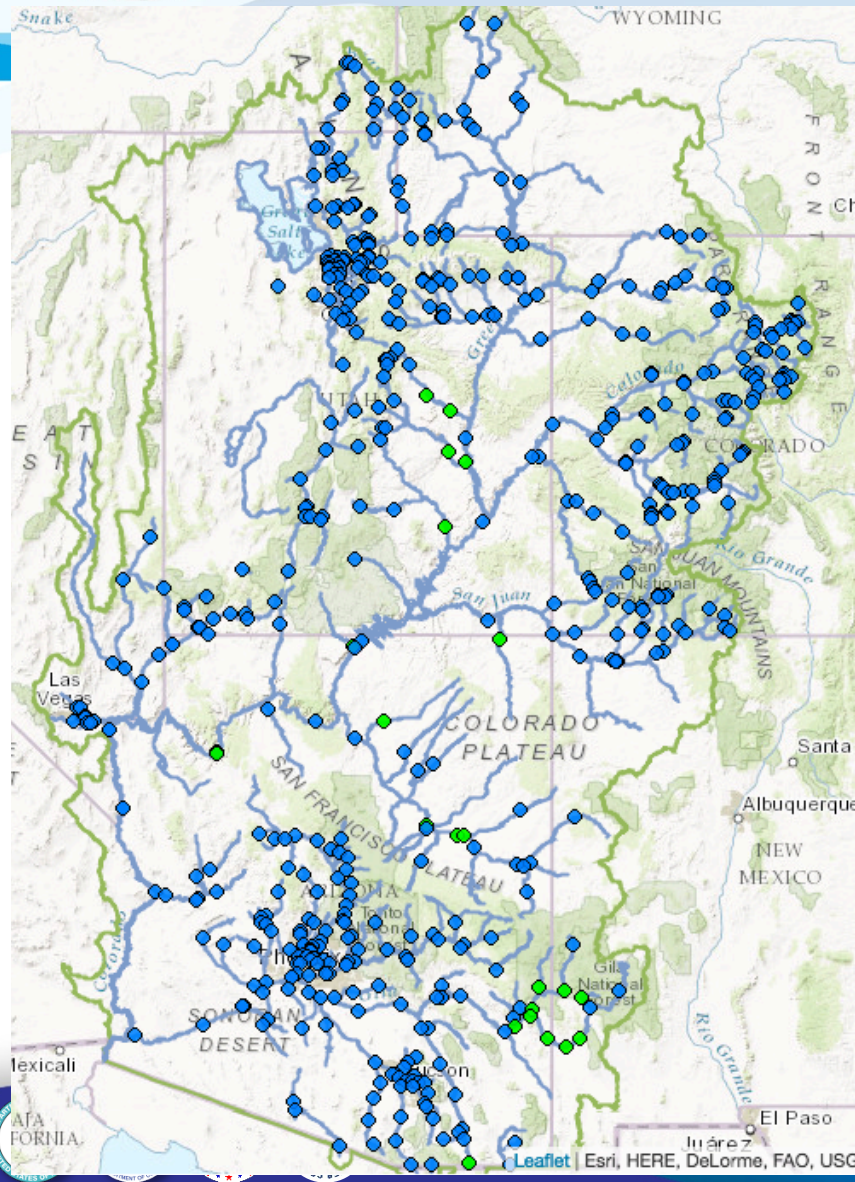


These graphics are updated approximately every two weeks between 3/1 and 5/1

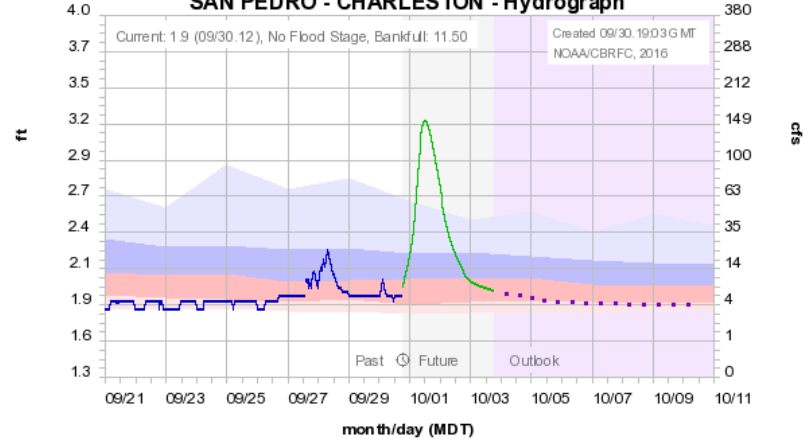
Plot Created 2016-04-18 15:23:43
 CBRFC / NWS / NOAA



Products and Services

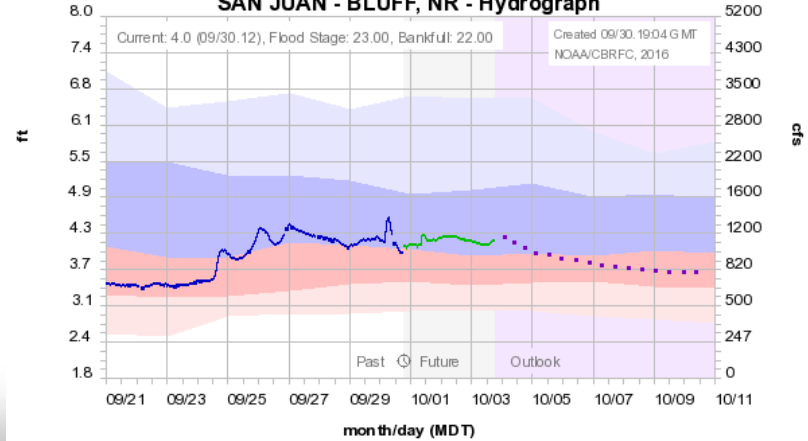


Colorado Basin River Forecast Center
SAN PEDRO - CHARLESTON - Hydrograph



Observed — Forecast (09/30 14:00) — Outlook (increasing uncertainty) —
Historical Exceedance Probability (USGS): 90-75% 75-50% 50-25% 25-10%

Colorado Basin River Forecast Center
SAN JUAN - BLUFF, NR - Hydrograph

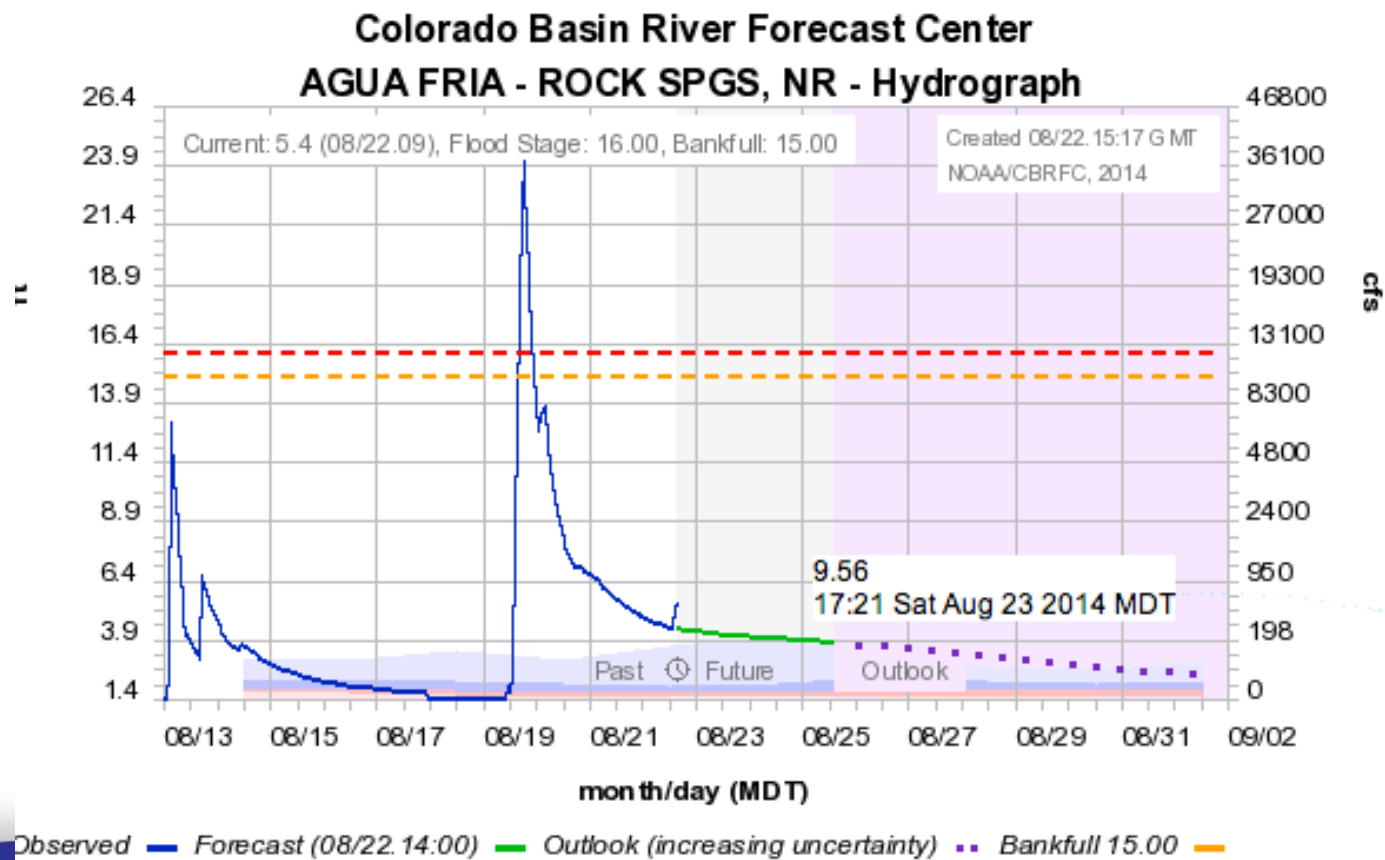


Observed — Forecast (09/30 14:00) — Outlook (increasing uncertainty) —
Historical Exceedance Probability (USGS): 90-75% 75-50% 50-25% 25-10%

Products and Services

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Support flood warning efforts by weather forecast offices



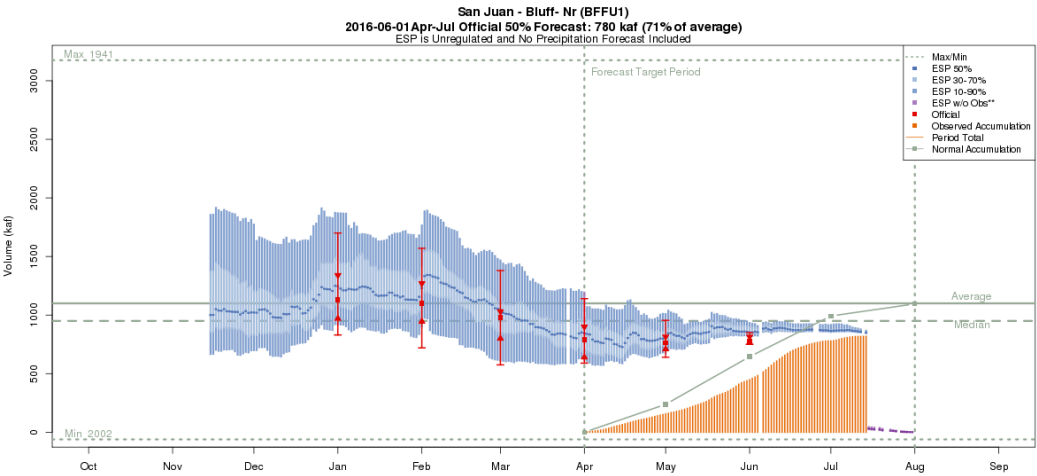
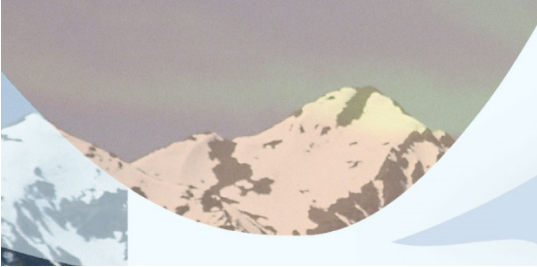
Products and Services

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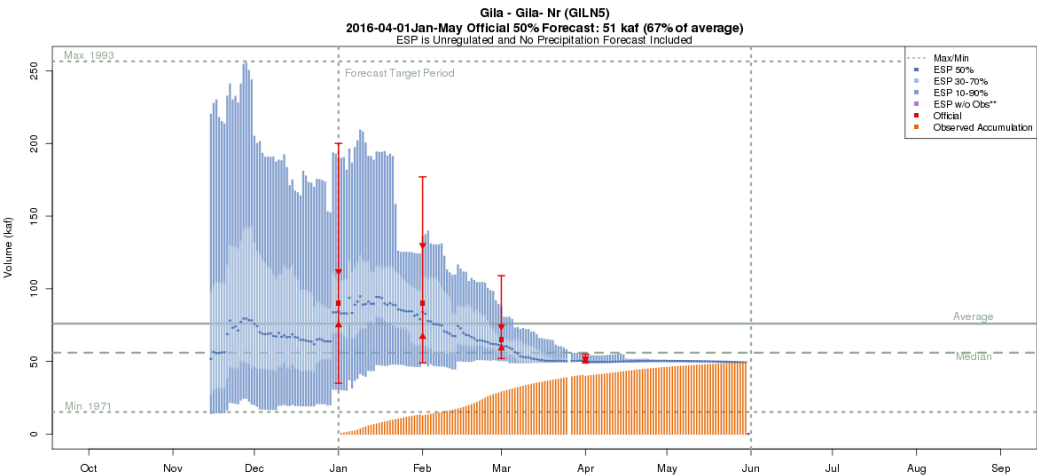
- Water Supply Forecast
 - Utilize an ensemble of future climate to generate possible streamflow futures
 - Dependent on precipitation information during the runoff season – we pay close attention to snowpack
 - Model soil moisture component is very important
- The more information we have the better!



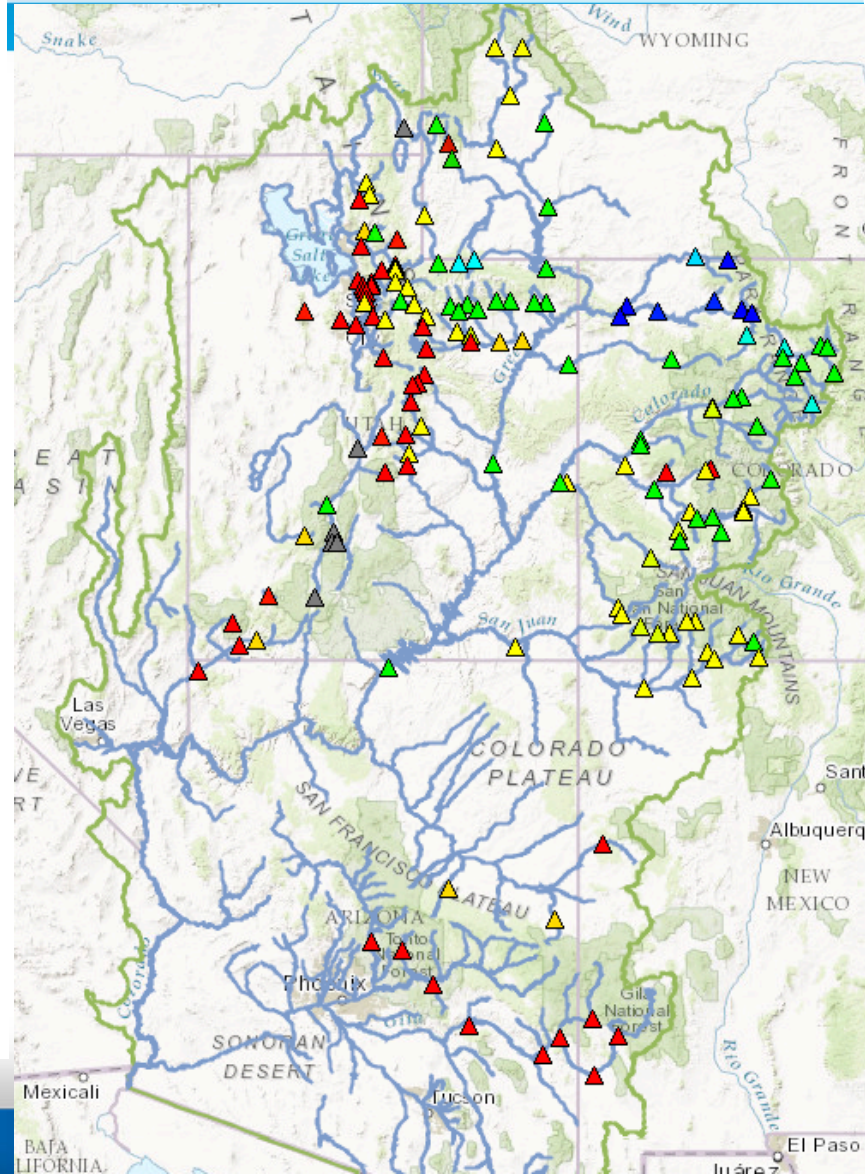
Products and Services



The latest (2016-07-14) 50% ESP forecast is 850 kaf.
 Plot Created 2016-08-17 07:48:57, NOAA / NWS / CBRFC
 **Purple ESP forecasts do not include observed and are not total runoff



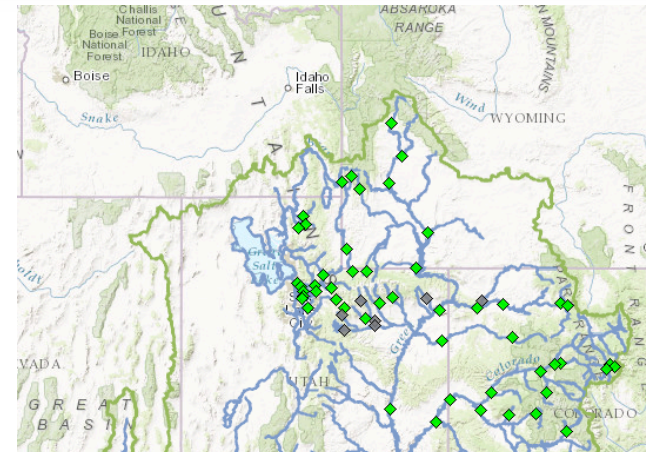
The latest (2016-05-30) 50% ESP forecast is 49 kaf.
 Plot Created 2016-08-24 07:21:43, NOAA / NWS / CBRFC
 **Purple ESP forecasts do not include observed and are not total runoff.



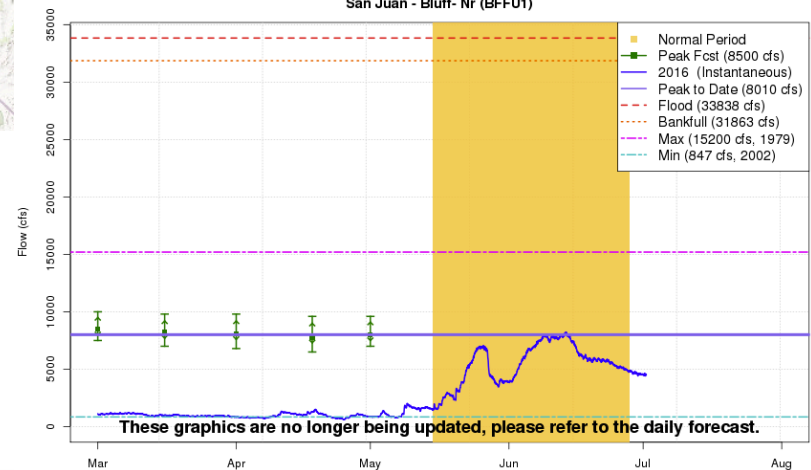
Products and Services

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- Peak Flow Forecasts
 - Mean Daily Peak Flow
 - Helpful for environmental resource managers
 - Meet environmental targets



2016 Mean Daily Peak Flow Forecast
San Juan - Bluff- Nr (BFFU1)



Plot Created 2016-07-01 11:40:14
CBRFC / NWS / NOAA

Coordination Efforts

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- Annual Stakeholder Open House
 - Broad range of stakeholders
 - Introduce new products and services
 - Reinforce traditional products and services
 - Important for us to get feedback
- Frequent webinars
 - Water supply, peak flows
 - Custom Webinars for your group
 - WFO Coordination



Coordination Efforts

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- Participation in stakeholder-run meetings and events
- Participation in multi-agency efforts
 - Landscape Conservation Cooperatives
 - Climate Science Centers
 - NOAA RISAs (like CLIMAS)
 - Others
- Direct contact by phone, e-mail, etc...



We Know The Climate Is Changing

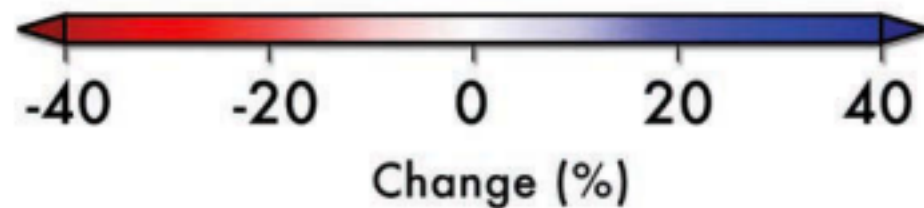
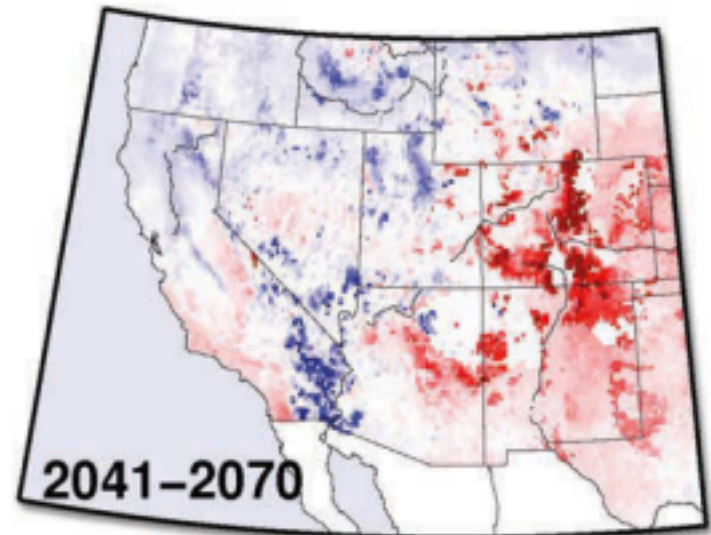
16

Temperatures are rising and will continue to rise

Precipitation outlook is uncertain, but we do expect more extreme events

Decreased water supply, particularly for the Southwest and Colorado River Basin

High-emissions scenario



And Our Stakeholder's Needs Are Changing

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- Where we were:
 - What is THE forecast?
 - How much water is there?
 - How much snow is there?
 - Will there be flooding?
- Where we are going:
 - What is the range of forecasts?
 - What is the likelihood of reaching this flow?
 - What if it's a dry/wet year?
 - What is the risk to filling my reservoir?
 - What is your uncertainty?



Challenges Ahead

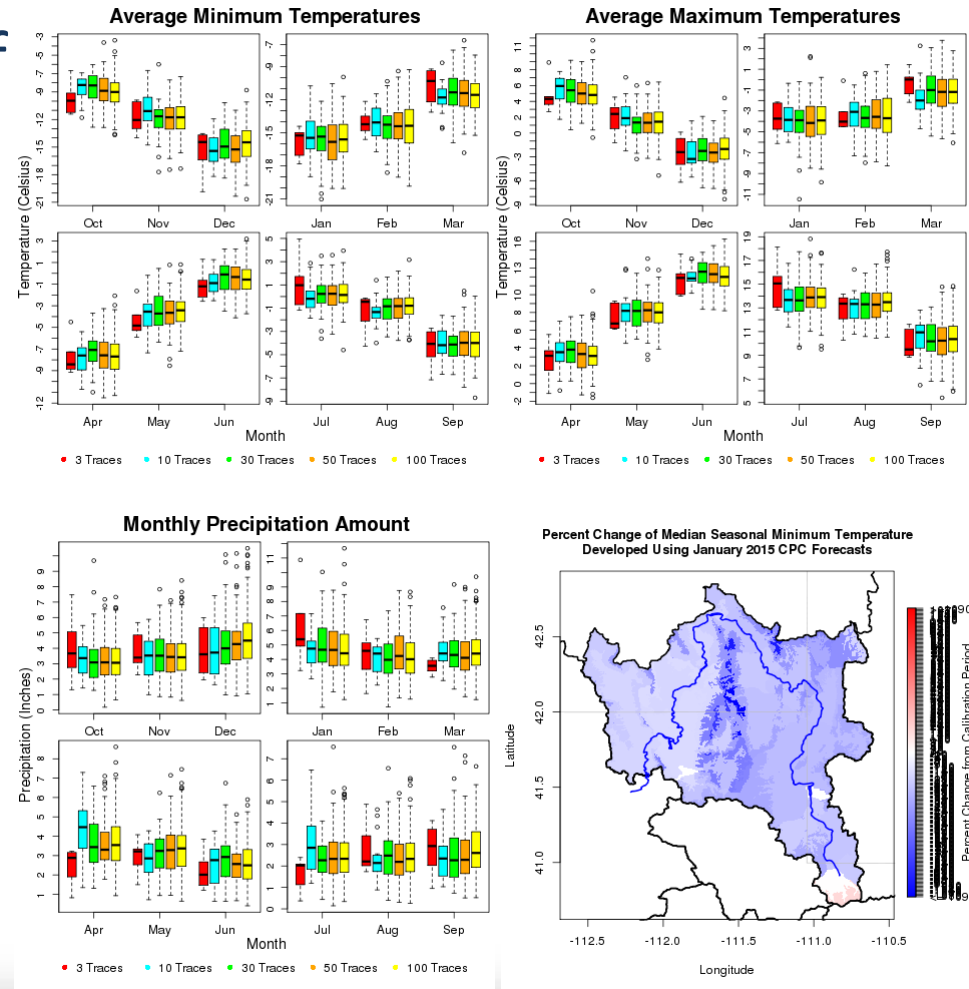
18

- Climate Change and its Impacts
 - Stationarity is in the past – but it's also how we look forward
 - Extreme Events – persistent drought and intense rains can impact our forecasts, and our stakeholder's ability to manage resources effectively
- Infrastructure and Operations
 - How do we continue to bridge the research to operations gap? AND the operations to research gap?
 - Our model from the 1970s was not built for the data we have access to now, so we have to be innovative
- Outreach
 - Facilitating cooperative and continued decision support
 - Reaching those partners we haven't met yet
 - A diverse area with diverse needs! Great Basin, Lower Basin, Upper Basin... and the users within those areas...



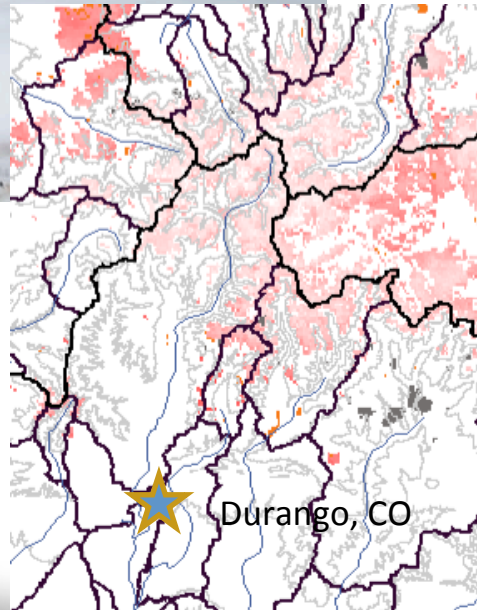
Moving Forward

- Investigating the use of a Stochastic Weather Generator
 - Reduce reliance on historical weather and climate
 - Understand variability and risk better
 - Incorporate climate information



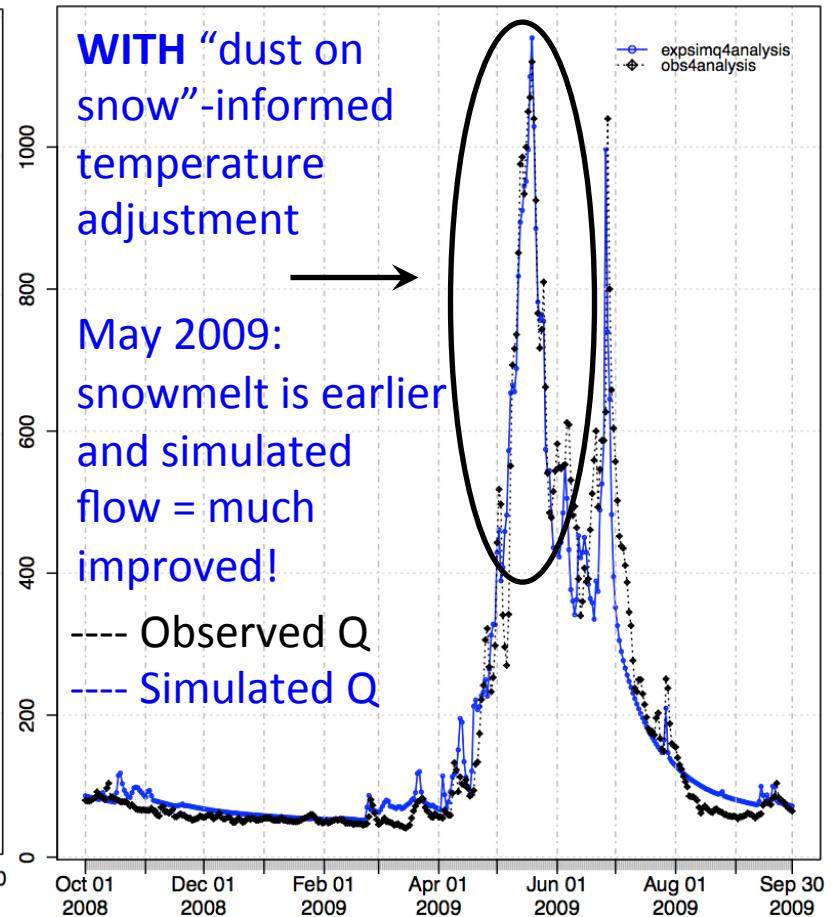
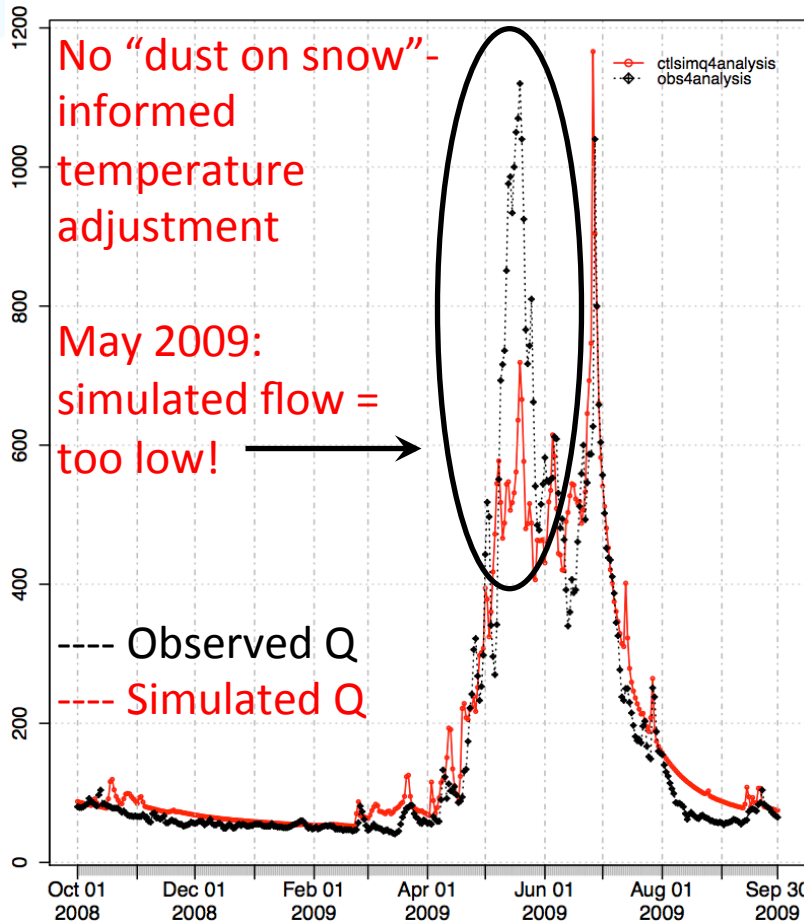
Moving Forward

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- Incorporation of remotely sensed snow information
 - Aerial extent
 - Dust on snow impacts
- An innovative way to get new information into an old model

Moving Forward



Moving Forward

Sixteen years of drought in the Colorado River Basin: Reality or talking point?

By Guest Columnist

Thursday, May 12, 2016

By Eric Kuhn

I was recently reading an article about Colorado River water when I was seeing for many years now that it was "after 14 years of drought"

May showers bring better outlook for Colorado River, but no miracle



A group of kayakers prepare to head down river while paddling the Black Canyon Water Trail on the lower Colorado River in Lake Mead National Recreation Area on the Nevada and Arizona border east of Las Vegas on Thursday, July 3, 2014. There are 16 routes within the National Water Trail system, and the Black Canyon Water Trail is the first water trail in the Southwest and the only water trail that traverses through a desert. (Jason Bean/Las Vegas Review-Journal)

By HENRY BREAN
LAS VEGAS REVIEW-JOURNAL

It wasn't the "Miracle May" that some observers called it, but a month of rain in Colorado and Utah did provide a significant boost to the outlook for the river.

A terrible year became merely below average.

"Miracle" is probably a bit of an overstatement, but the unusually wet winter and spring did provide a significant boost to the outlook for the river. "Impact on water supply," said Paul Miller, a senior hydrologist with the Service's Colorado Basin River Forecast Center in Salt Lake City.

Energy and Environment

'Climate change is water change' — why the Colorado River system is headed for major trouble

By Chelsea Harvey August 19



Cutbacks in Arizona Water deliveries possible

Lake Powell could dry up in as little as six years, study says

By Tony Davis Arizona Daily Star Updated Sep 4, 2016



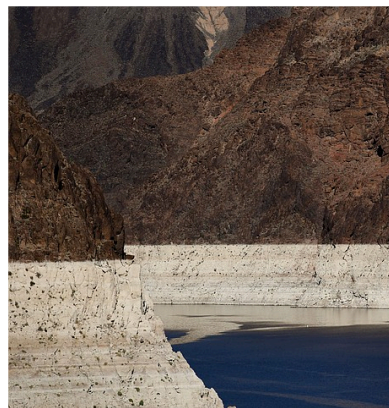
Cracks in the rock formation indicate the extent of the drought in the Colorado River Basin. The cracks are a result of the drought and the consequences for the lake.

The Rise of Water Optimism

Two new books offer hope for our aquatic future.

By Ben Goldfarb

Lake Mead shows extent of drought: Feds see 2



Jae C. Hong/The Associated Press, file A riverboat glides through Lake Mead on the Colorado River at Hoover Dam near

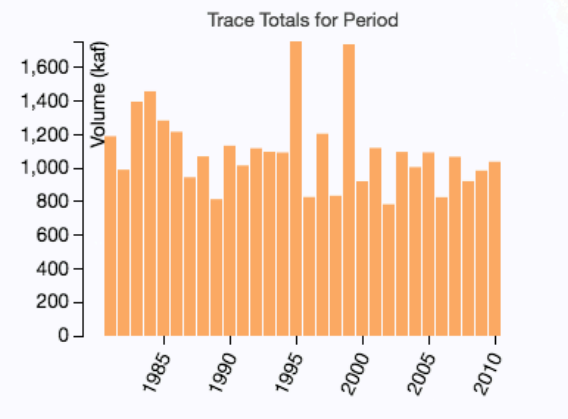
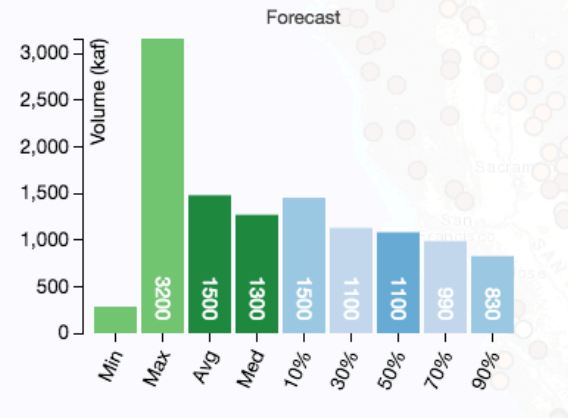
By Ken Ritter, The Associated Press



Moving Forward

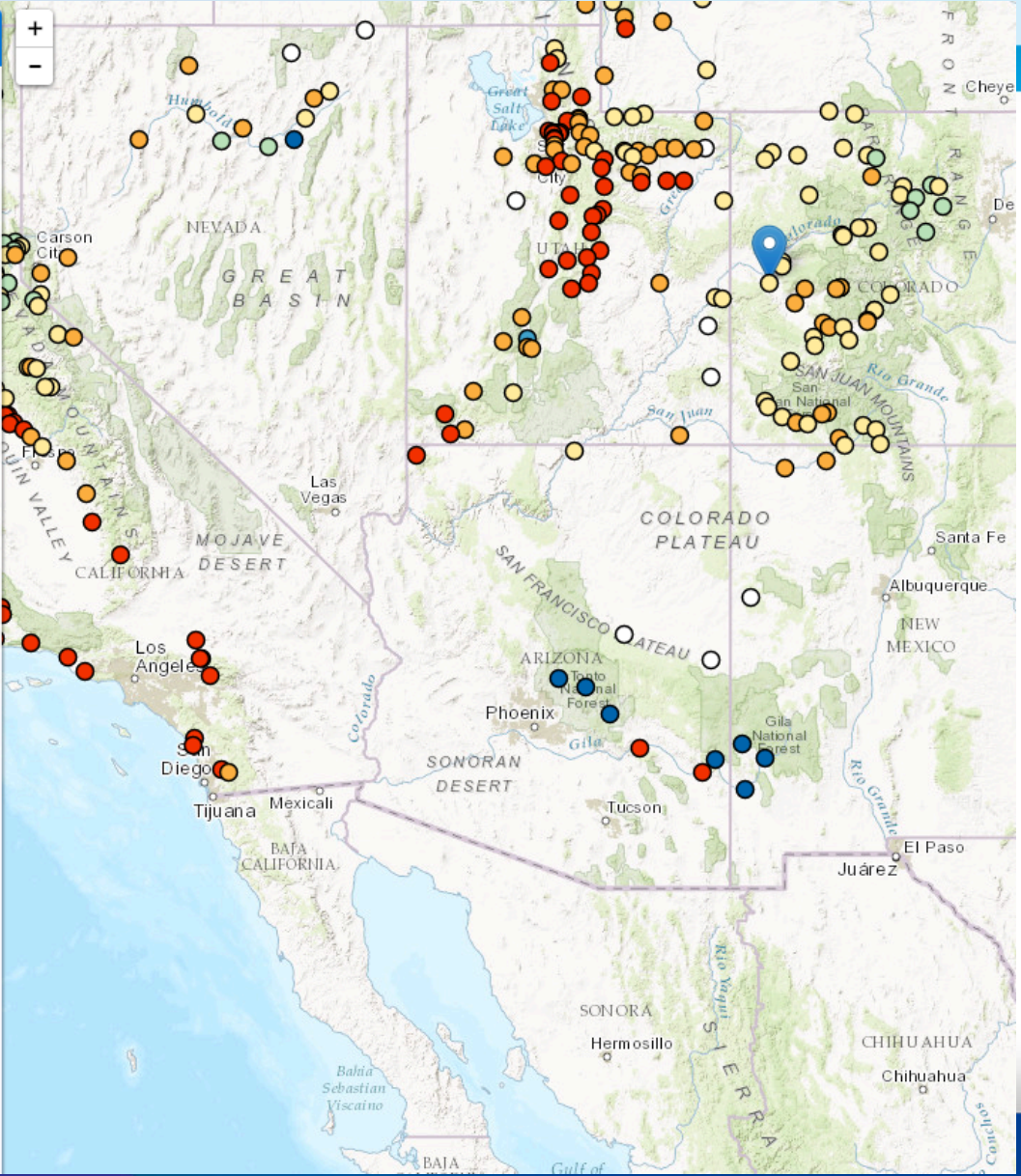
Forecast Point Details

Gunnison - Grand Junction, Nr



[View Forecast Evolution](#)

Station
ID GJNC2
Latitude 38.98
Longitude -108.45



National Water Center



National Water Model

Improving NOAA's Water Prediction Services



In August 2016, NOAA took a giant leap forward in its ability to forecast the flow of rivers and streams throughout the entire continental United States with the launch of the

new high resolution National Water Model (NWM).

The NWM will enhance and expand NOAA's water flow forecasts, which to date have been available for approximately 4,000 river locations with stream gauges operated by the U.S. Geological Survey. This new model will expand forecasts to 2.7 million stream locations nationwide. Leveraging the full network of nearly 8,000 U.S. Geological Service stream gauges and NOAA's investment in atmospheric modeling, the NWM will provide high-resolution forecasts of soil moisture, surface runoff, snow water equivalent, and other parameters.

We all recognize that water is an essential component of sustainable and resilient communities. But its also a stressed natural resource and potential threat to life, property, and livelihoods during extreme weather events.

Improved Water Information Services

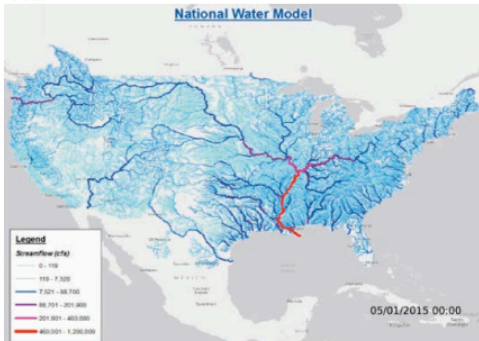
The new NWM improves the National Weather Service's ability to deliver impact-based decision support services nationwide by providing "street level" water information and guidance, as well as serve as the foundation for additional private sector water services. At a minimum, the NWM will immediately provide predictive water information for many locations where none previously existed.

Initially, this new NWM-based information will be particularly useful in headwater areas in support of NOAA's flash flood mission.

How it Works

The NWM simulates the water cycle with mathematical representations of the different processes and how they fit together. This complex representation of physical processes such as snowmelt and infiltration and water movement through the soil layers varies significantly with changing elevations, soils, vegetation types and a host of other variables.

Additionally, extreme variability in precipitation over short distances and times can cause the response on rivers and streams to change very quickly. Overall, the processes are so complex that to simulate it with a mathematical model means that it needs a "supercomputer" in order to run in the time frame needed to support decision makers when flooding is threatening.



National Water Model is a new forecasting tool that will help forecasters predict when and where flooding can be expected.

www.water.noaa.gov

National Water Model Image Viewer

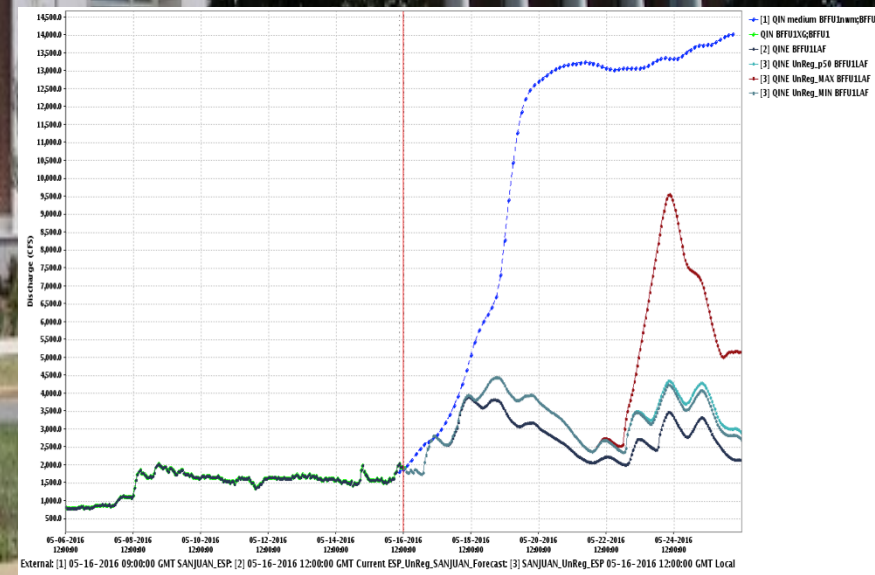
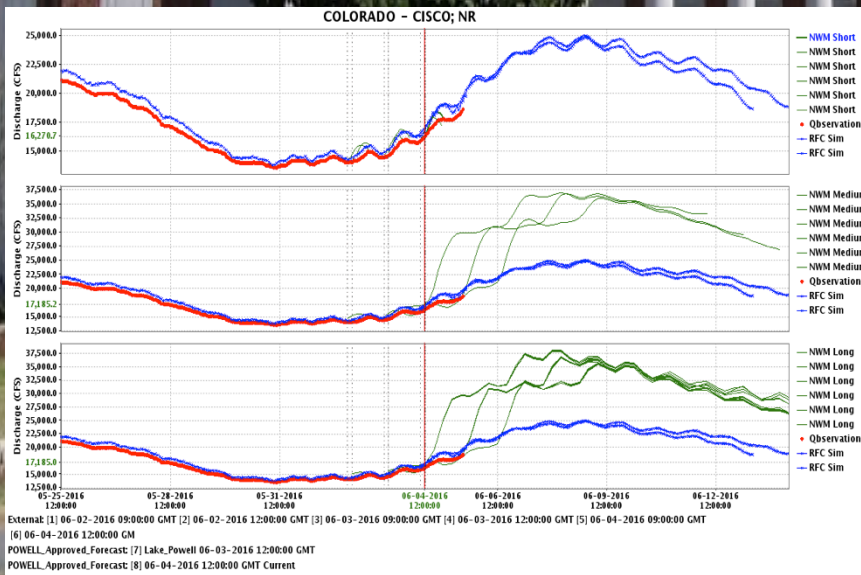
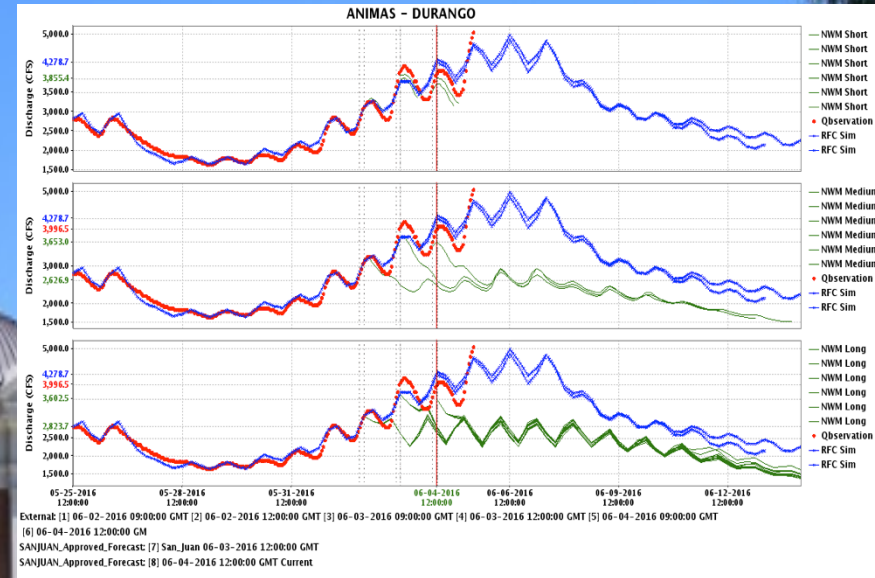
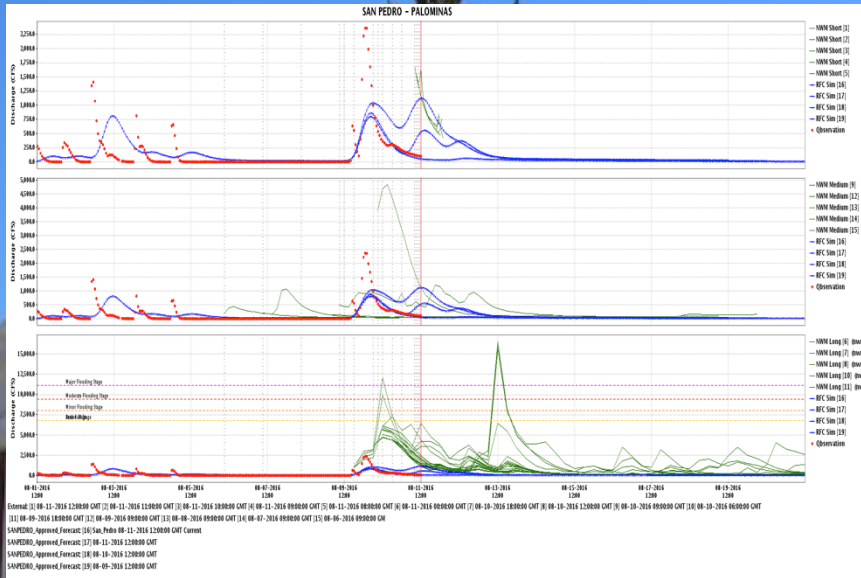
The viewer below has been made available to view the pre-generated imagery depicting output from the National Water Model. For direct access to the imagery shown in the viewer, visit the following location: http://www.noahrs.noaa.gov/pub/staff/keicher/WRFH_ppd/web/static_images/

Dataset: Stream Flow
Forecast Type: Long Range

Navigation controls: Home, Previous, Next, Refresh, 5.0 s, Apply

2016-09-09 06:00:00 UTC	2016-09-09 06:00:00 UTC
2016-09-09 12:00:00 UTC	
2016-09-09 18:00:00 UTC	
2016-09-10 00:00:00 UTC	
2016-09-10 06:00:00 UTC	
2016-09-10 12:00:00 UTC	
2016-09-10 18:00:00 UTC	
2016-09-11 00:00:00 UTC	
2016-09-11 06:00:00 UTC	
2016-09-11 12:00:00 UTC	
2016-09-11 18:00:00 UTC	
2016-09-12 00:00:00 UTC	
2016-09-12 06:00:00 UTC	

National Water Center



Moving Forward

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CADILLAC DESERT

THE AMERICAN WEST AND ITS
DISAPPEARING WATER



MARC REISNER

"A savagely witty history of America's reckless depletion of its water resources"
—Newsday

If we want to continue to thrive in a Cadillac Desert, we have to carpool!

We need to facilitate and champion the notion of a hydrologic community – we're one basin.

New partnerships, new voices, and new ideas are going to be needed – we can help!

