Streamflow/Reservoir Storage Forecasting and Probability-based Triggers

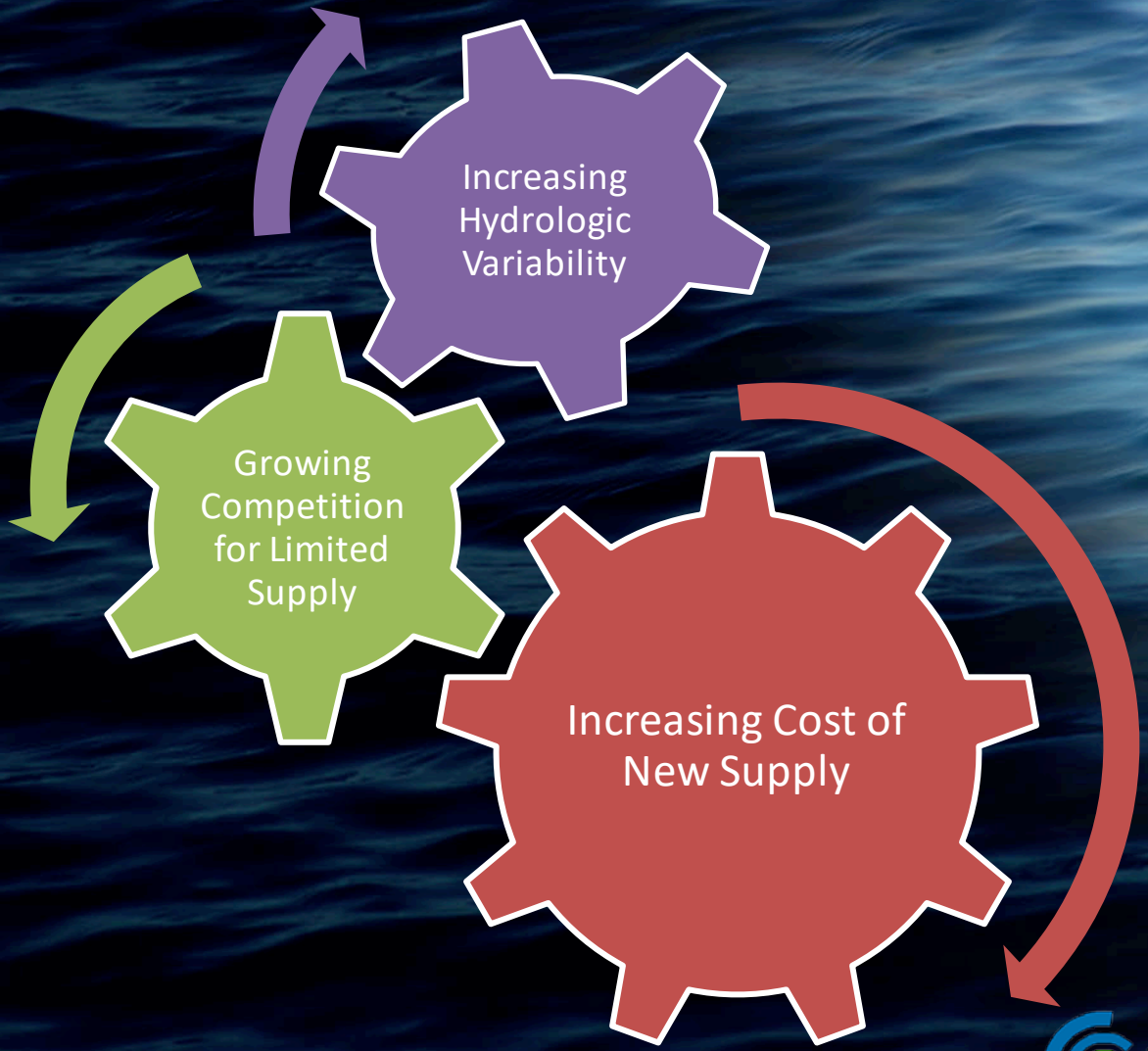
Steven Nebiker

MWCOG Drought Monitoring Workshop
March 19, 2018

Advancing the Management of Water Resources

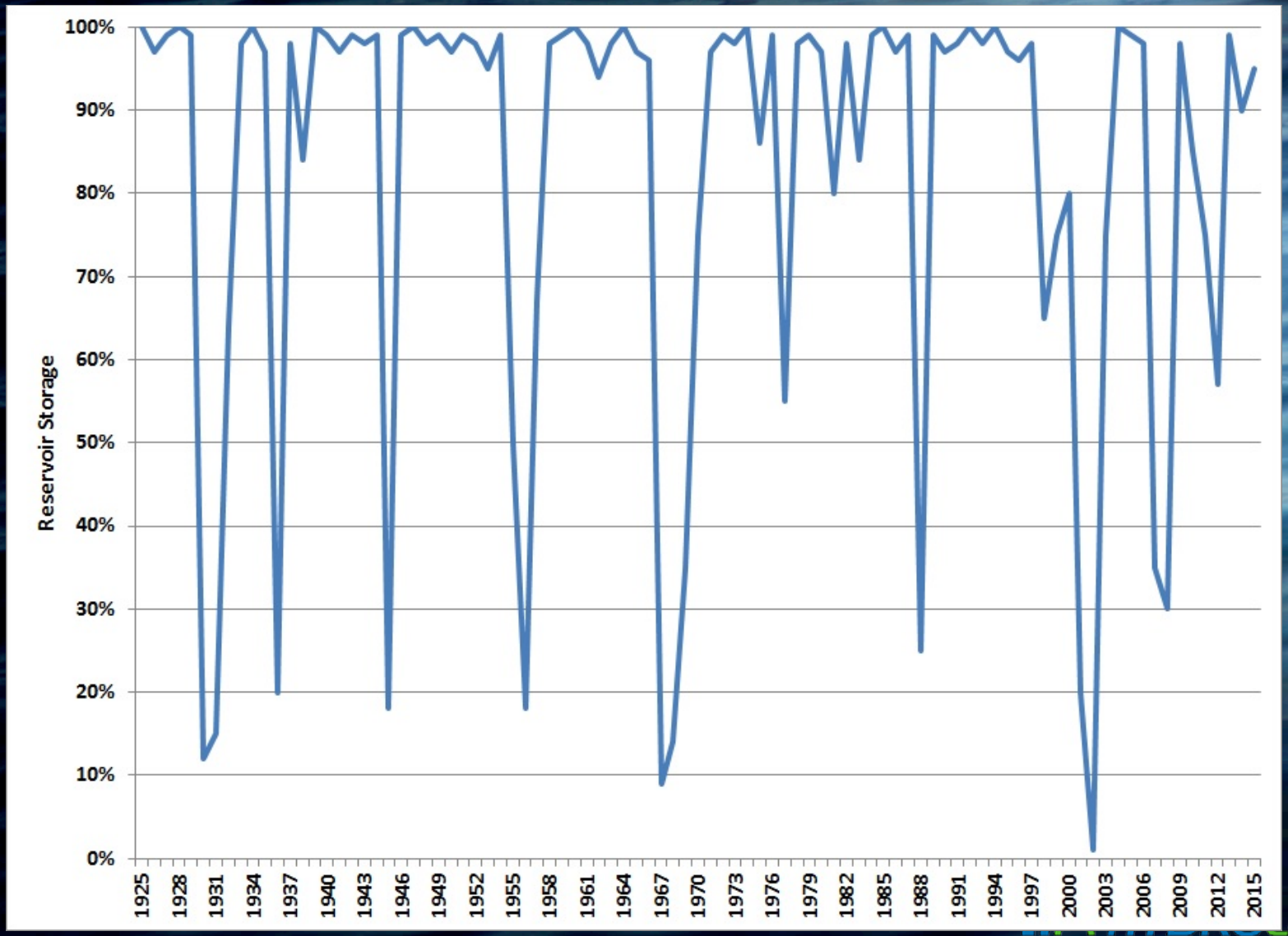
HYDROLOGICS
www.hydrologics.net

The New Normal



HYDROLOGICS

Safe Yield for Planning, But Not Operations

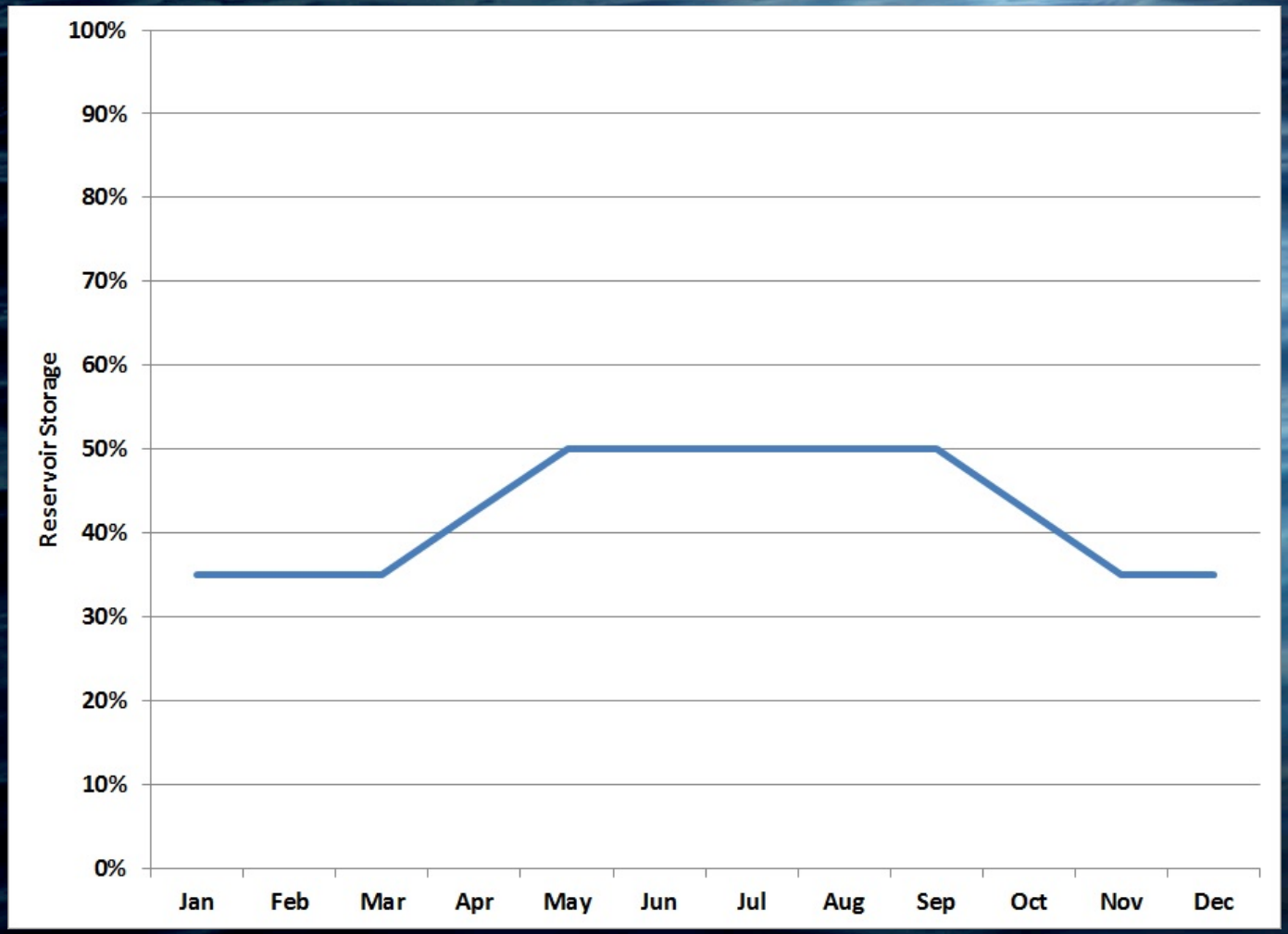


Easy Drought Trigger (Static)

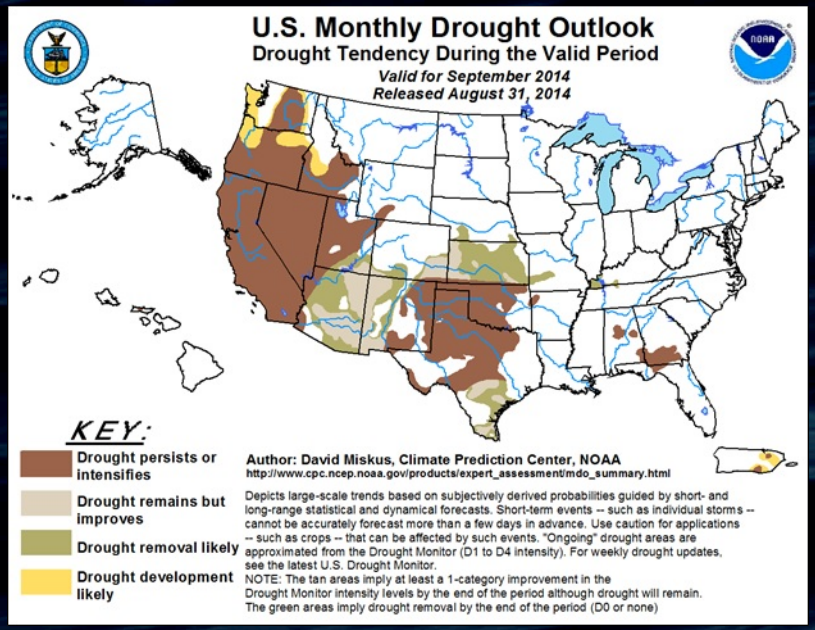
- Days of Supply Remaining

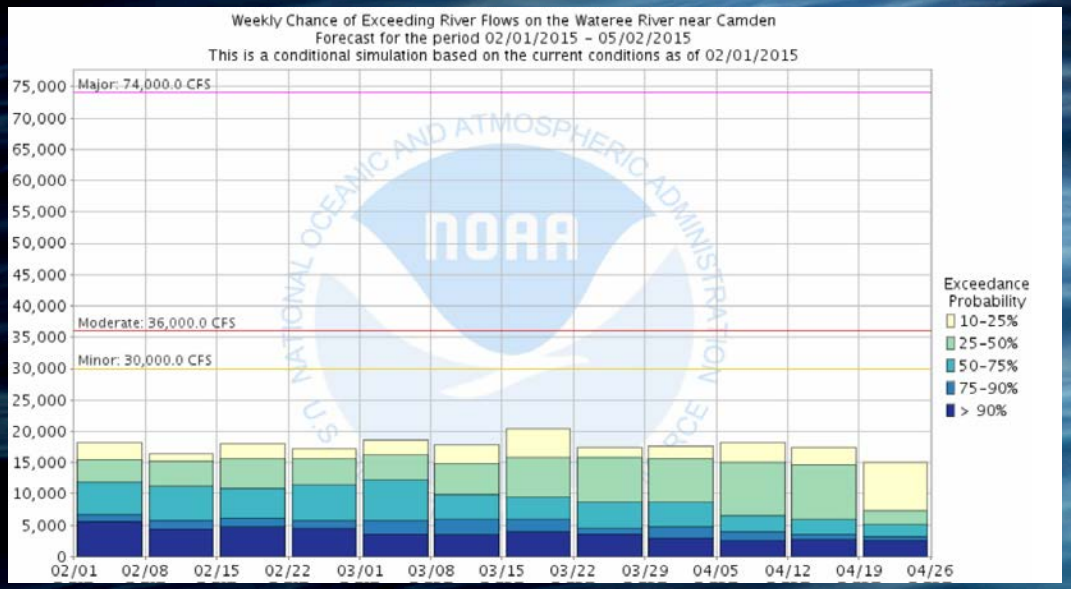
Medium Drought Trigger (Static)

- Rule curves



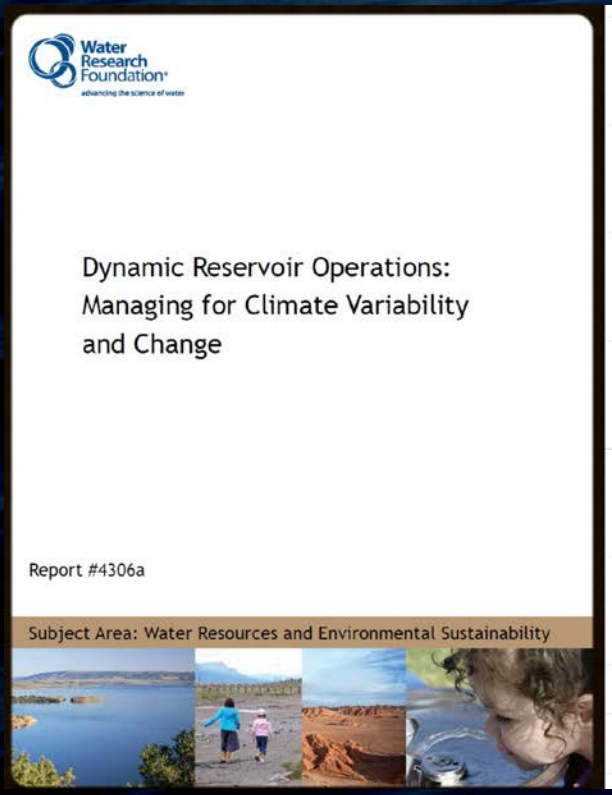
Advanced Drought Trigger (Dynamic)

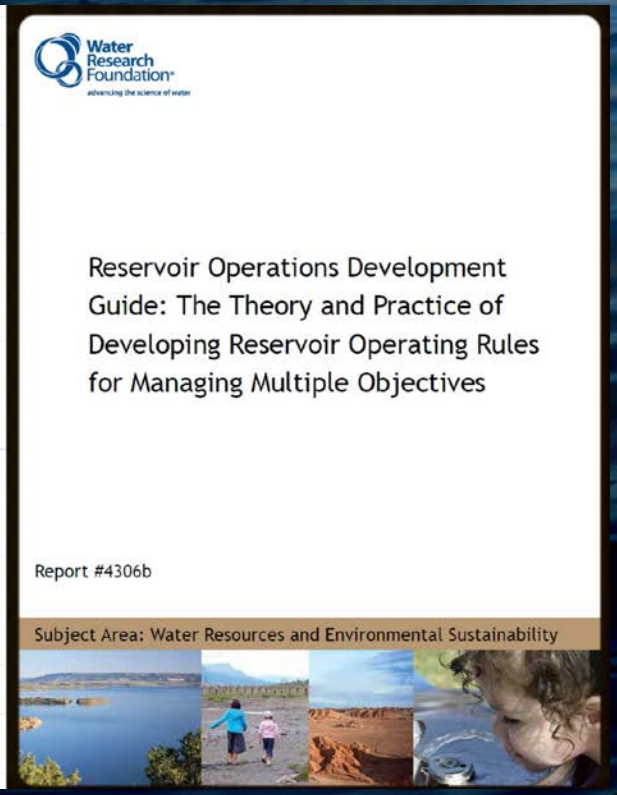




Need to be system specific!

DRO: Dynamic Reservoir Operations

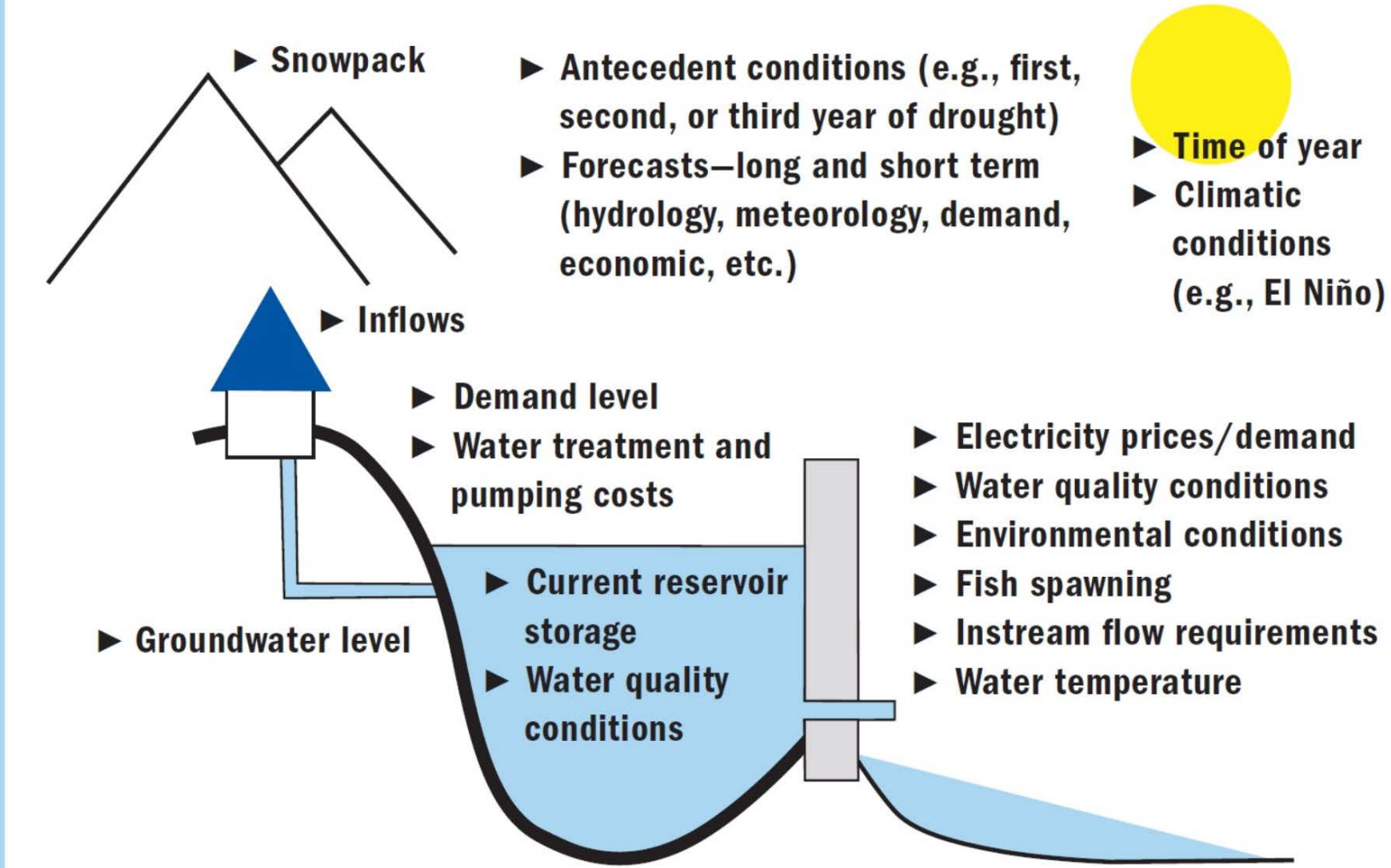




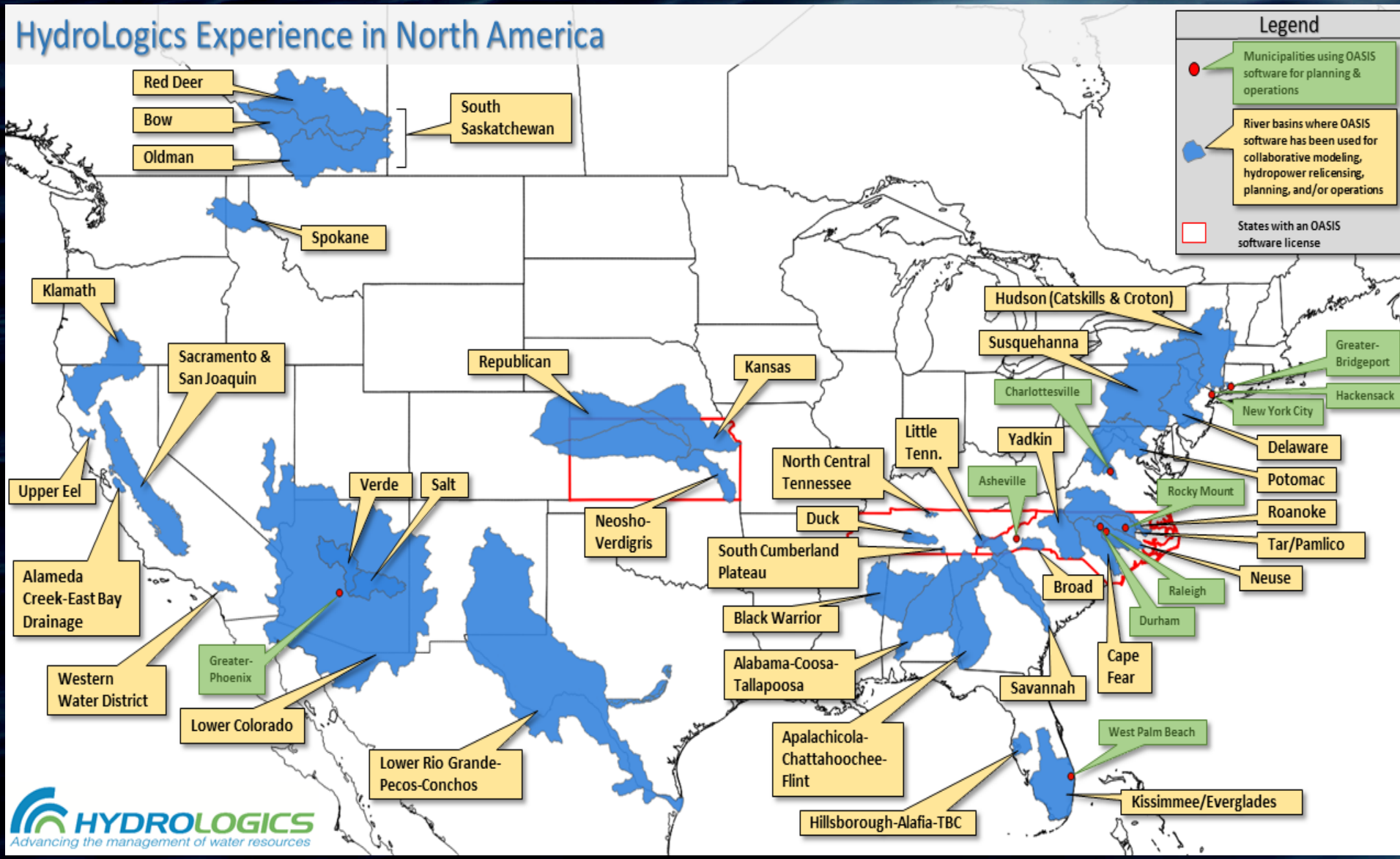
HYDROLOGICS

Figure 1. DRO Information

A variety of information is used to meet a utility's DRO objectives.



HydroLogics Experience in North America



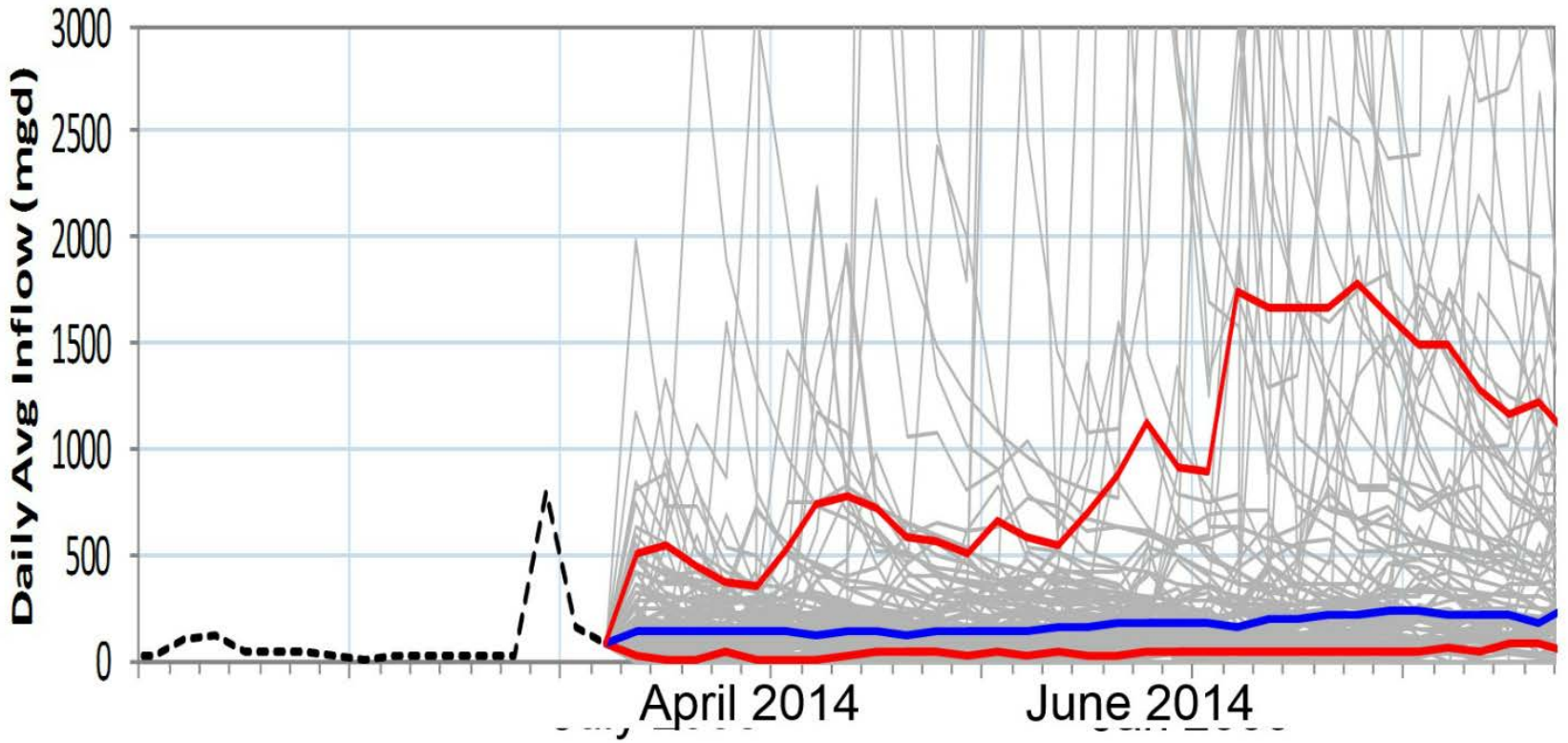
HYDROLOGICS
Advancing the management of water resources

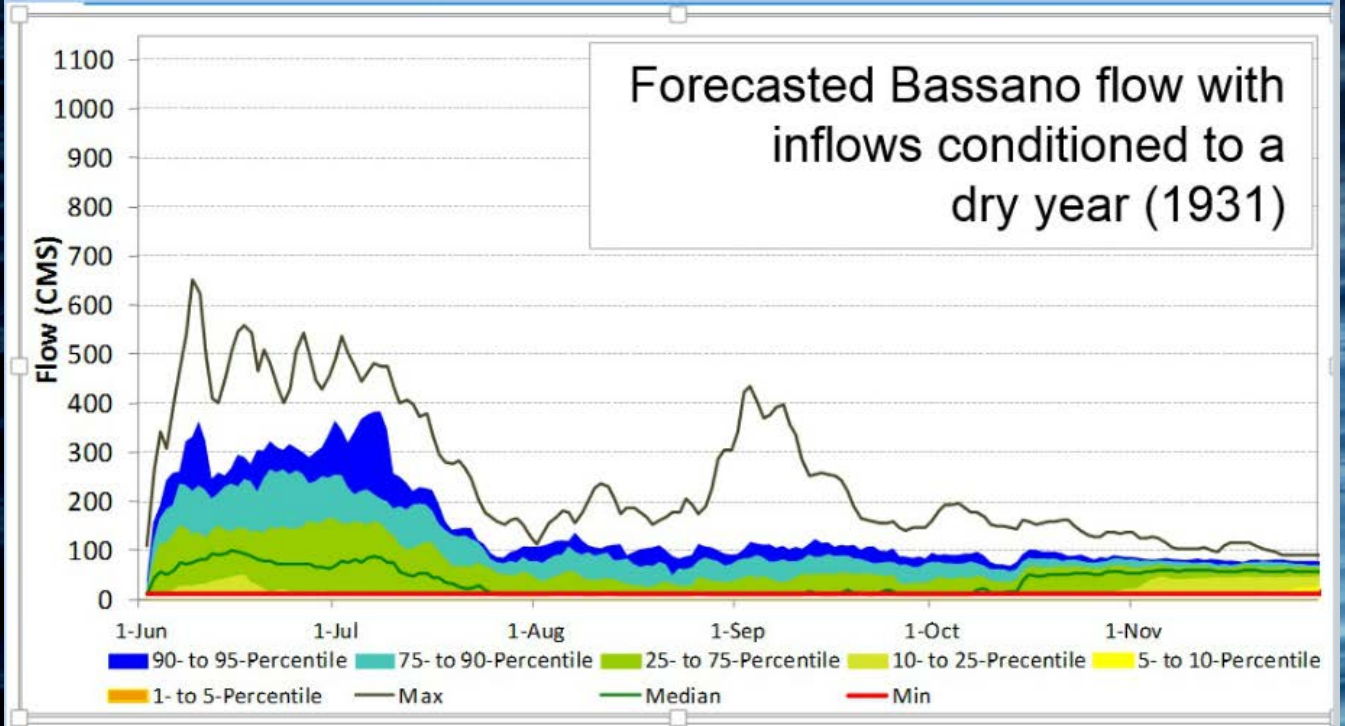
Taking the Doubt Out of Drought ™

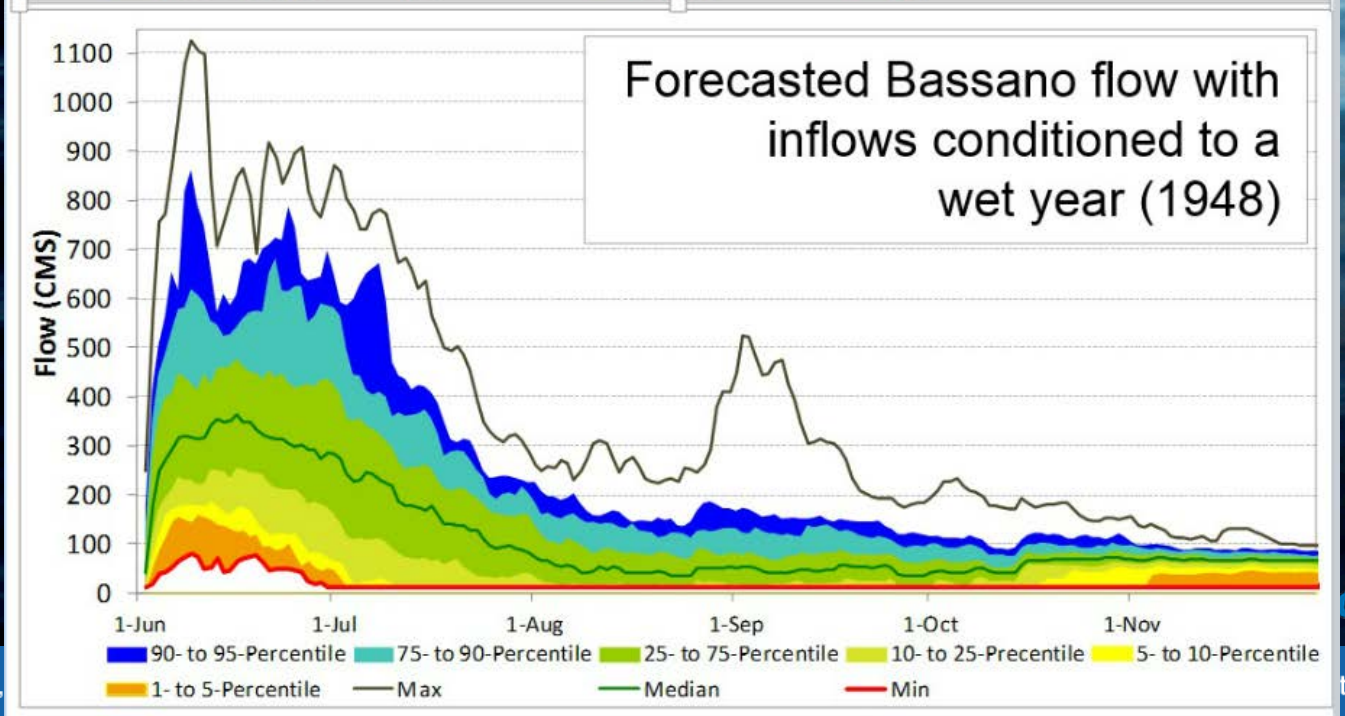
HYDROLOGICS

Columbia, MD • Raleigh, NC • Portland, OR • Boston, MA

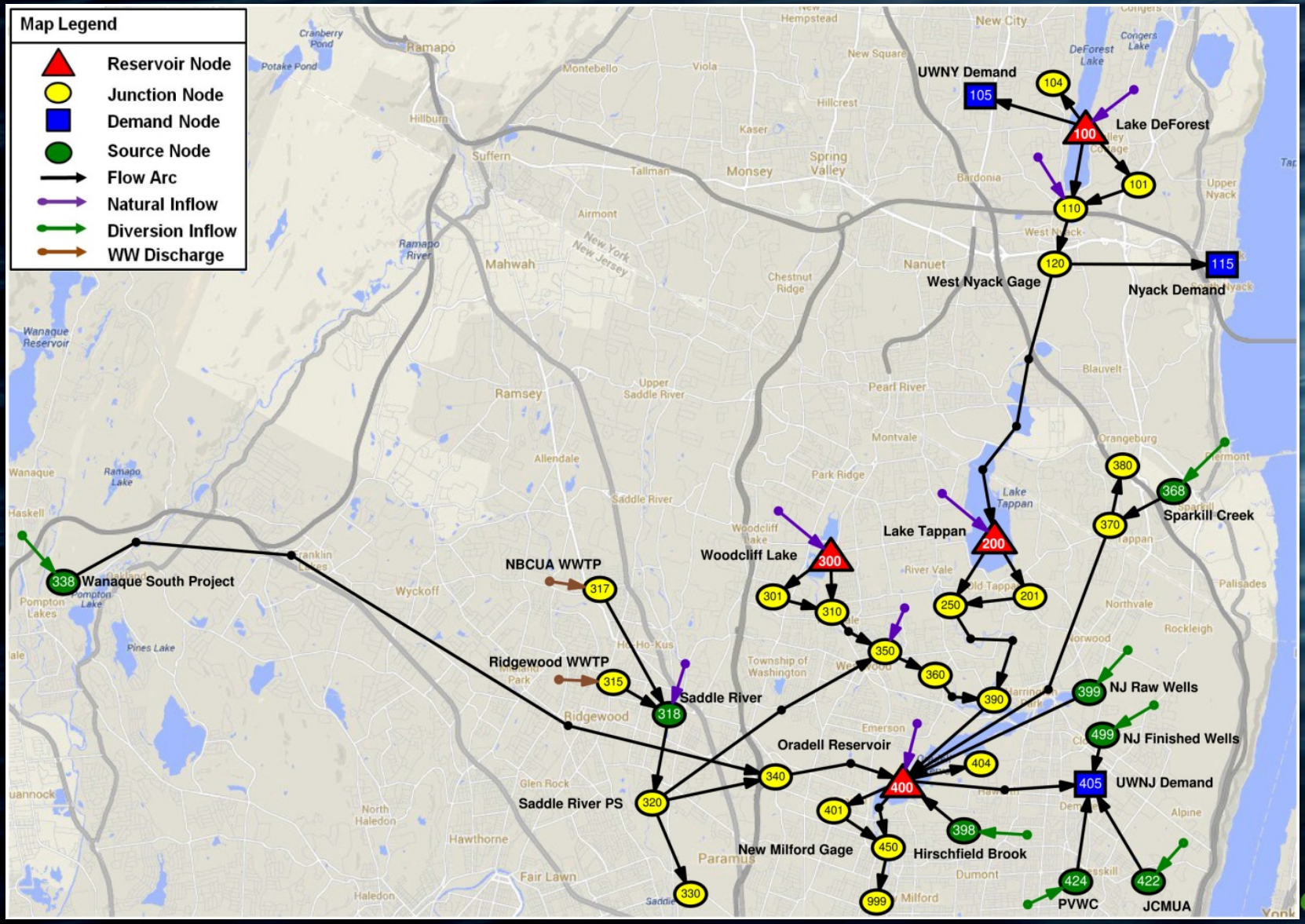
Sample Forecasts



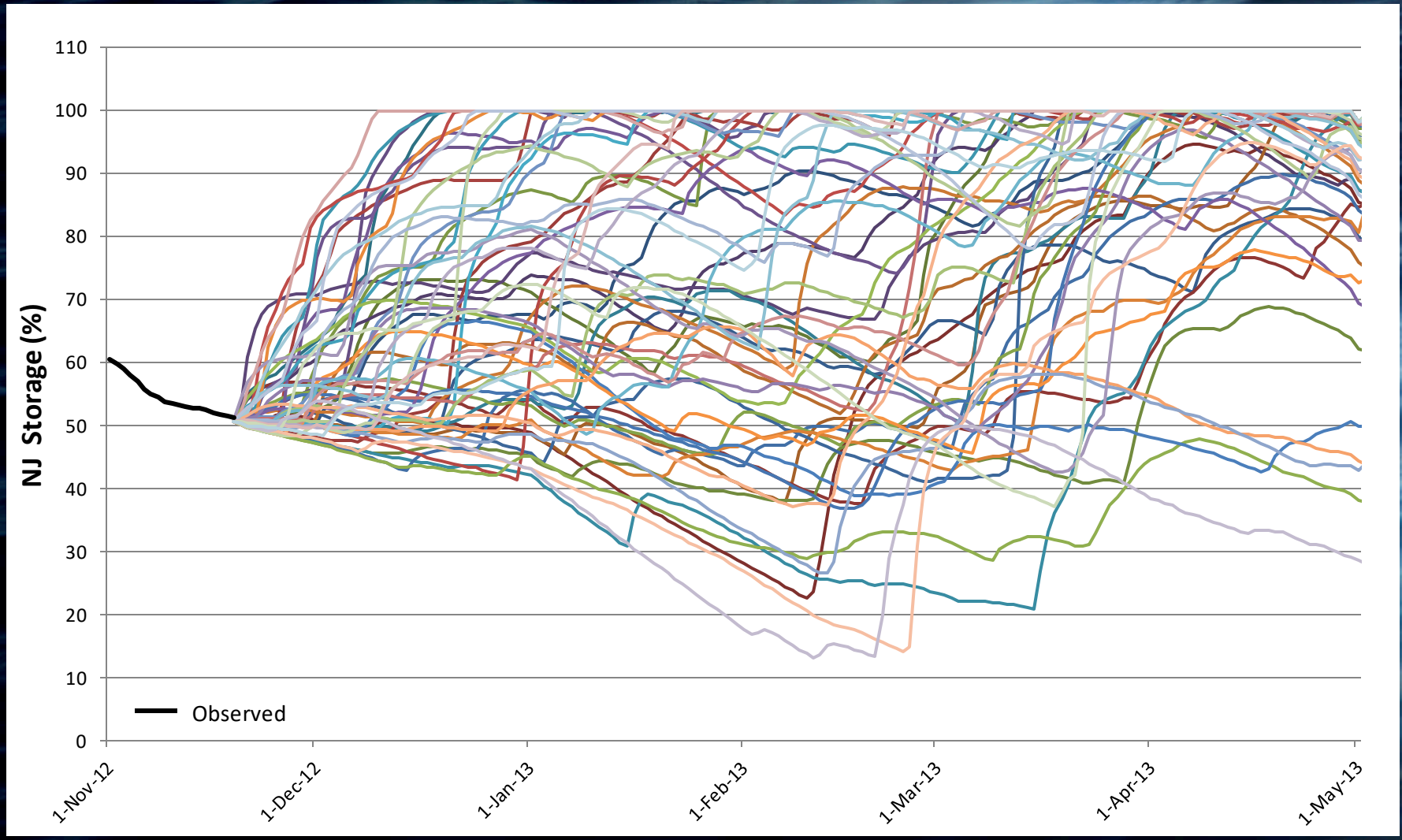

Forecasted Bassano flow with inflows conditioned to a dry year (1931)
Flow (CMS)
1100
1000
900
800
700
600
500
400
300
200
100
0
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
90- to 95-Percentile
75- to 90-Percentile
25- to 75-Percentile
10- to 25-Precentile
5- to 10-Percentile
1- to 5-Percentile
Max
Median
Min


Forecasted Bassano flow with inflows conditioned to a wet year (1948)
Flow (CMS)
1100
1000
900
800
700
600
500
400
300
200
100
0
1-Jun
1-Jul
1-Aug
1-Sep
1-Oct
1-Nov
90- to 95-Percentile
75- to 90-Percentile
25- to 75-Percentile
10- to 25-Precentile
5- to 10-Percentile
1- to 5-Percentile
Max
Median
Min

Schematic of Hackensack OASIS Model

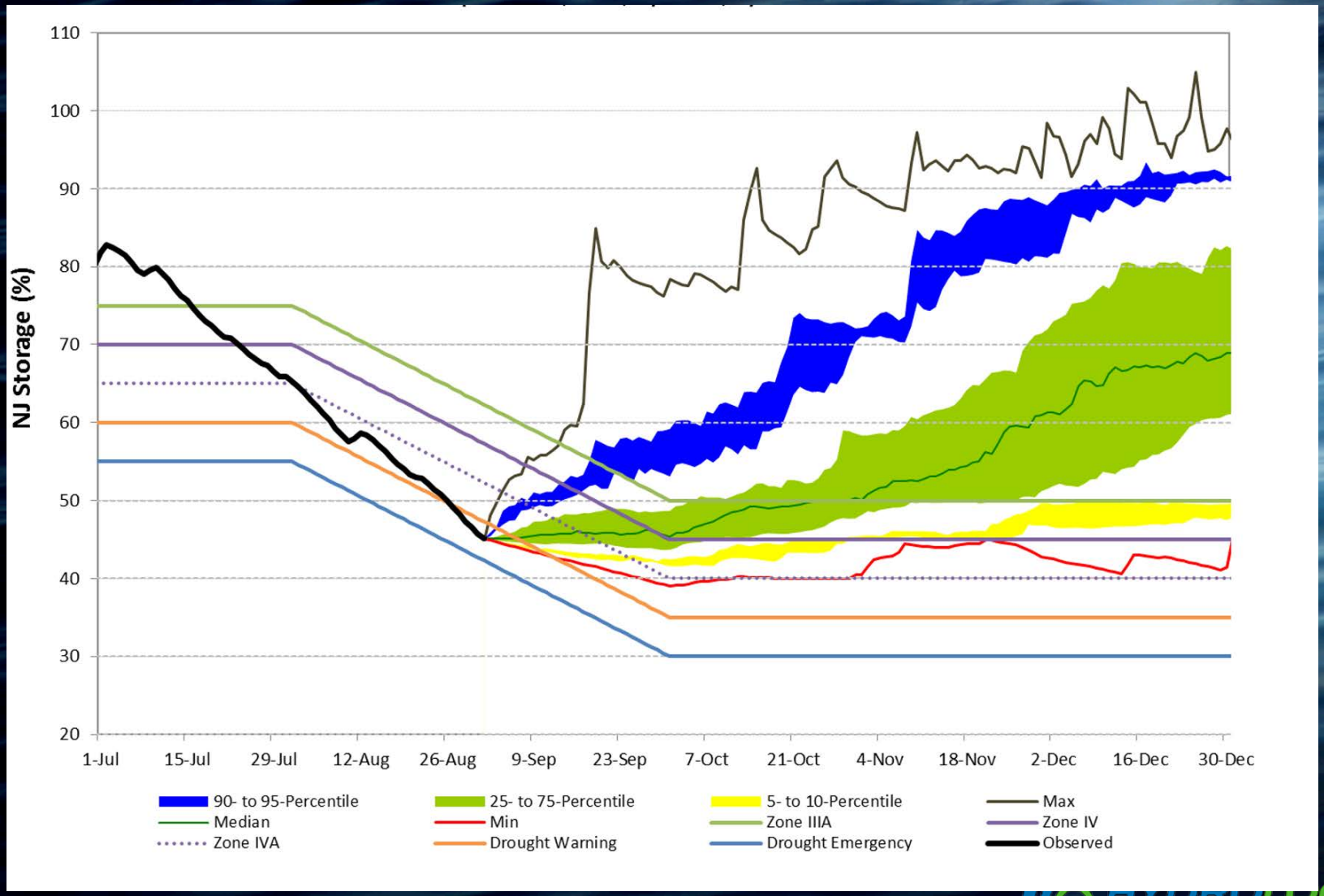


Sample Forecasts



HYDROLOGICS

Sample Forecasts



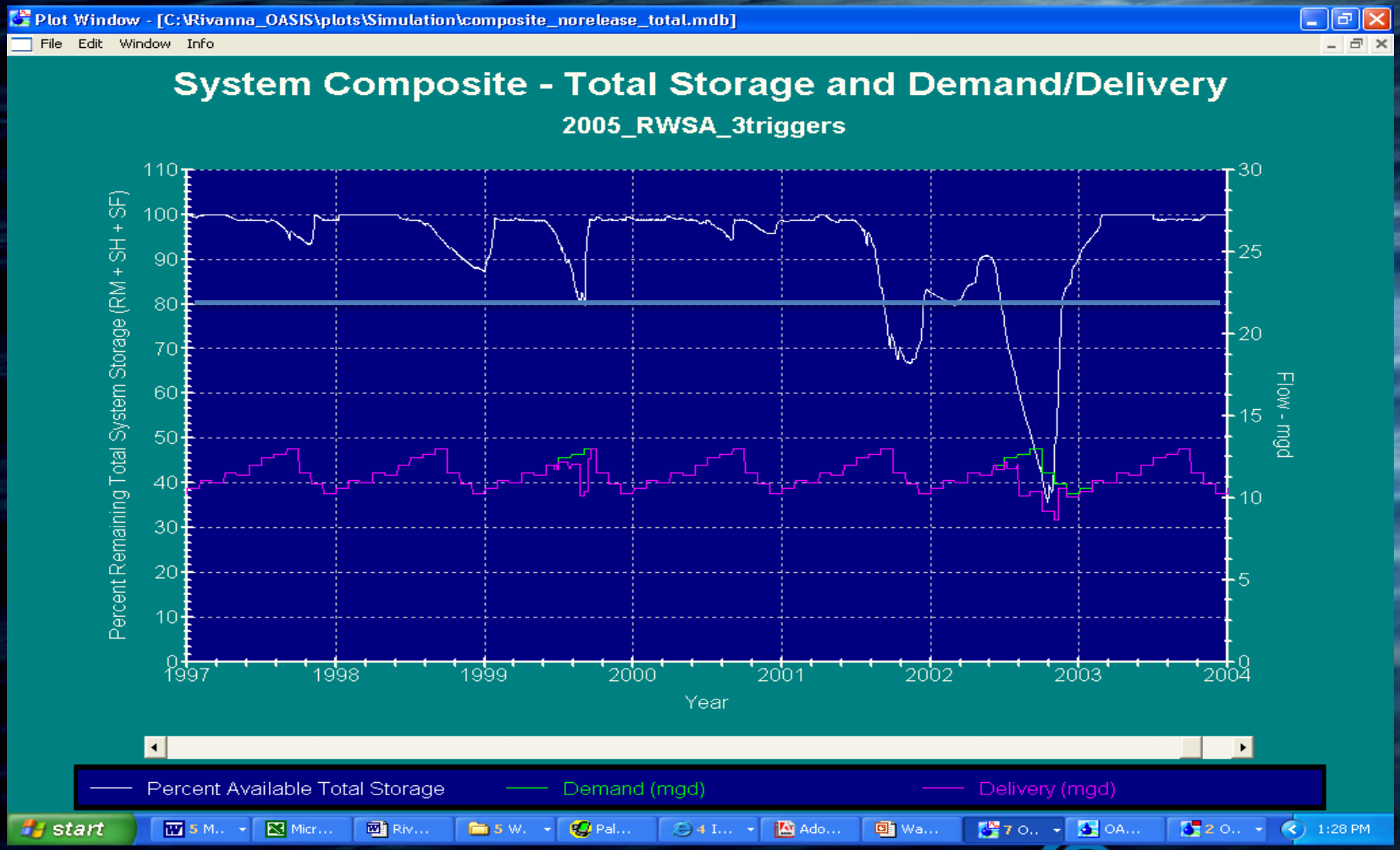
Superiority of Forecasts

- Detect droughts in time
- Minimize false alerts

Of the form:

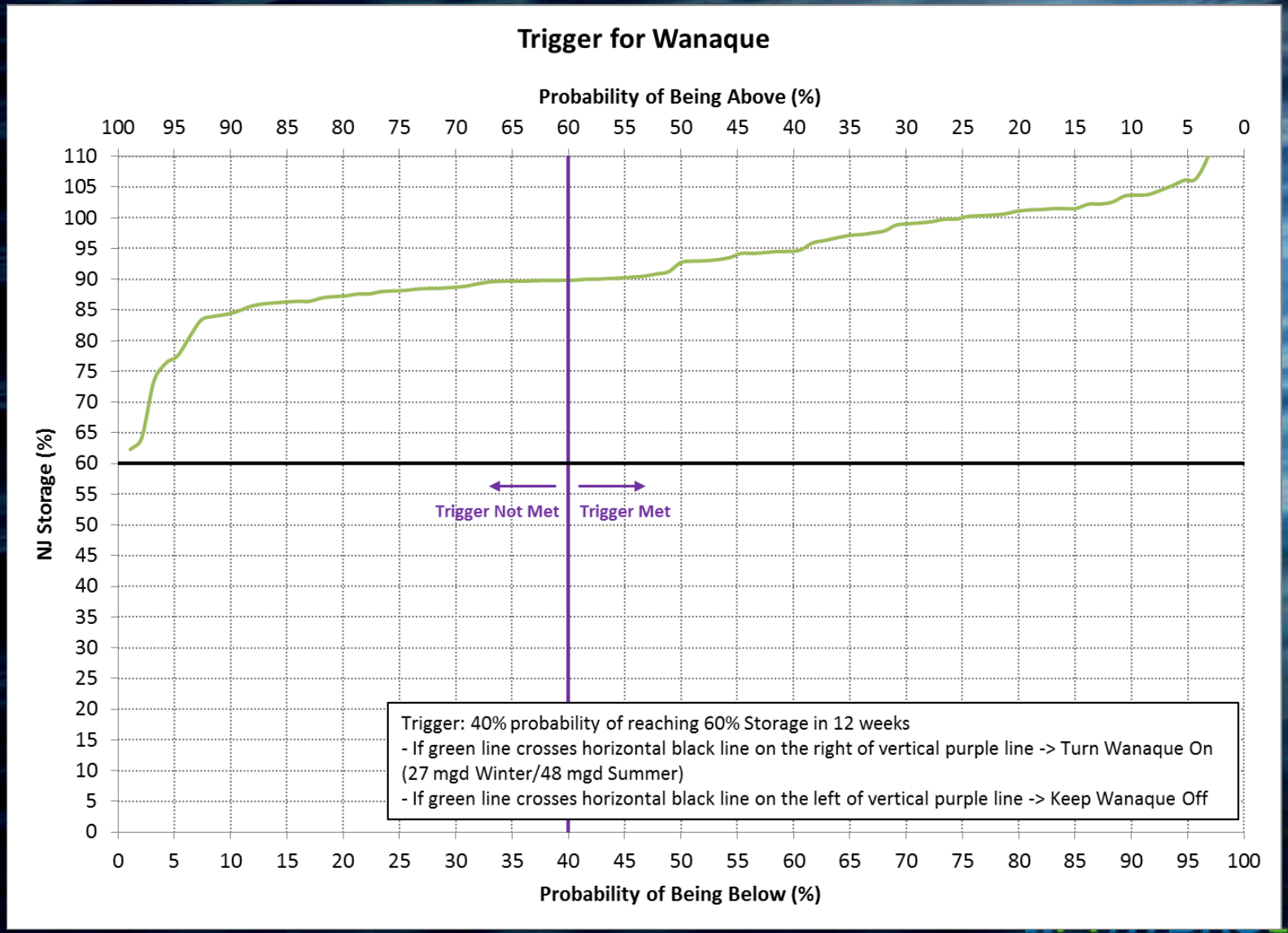
- *X% chance of reservoir storage (or river flows) reaching y% in z weeks*

Evaluate Triggers Over Inflow Record



Limits of Static Rules – Reliability and Cost

Dynamic Rules Based on the Forecasts



Dynamic Rules Based on the Forecasts

DURHAM 1869 CITY OF MEDICINE

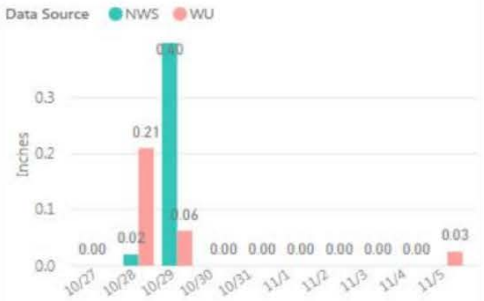
City of Durham Reservoir System Status Report

Displaying operations data through 10/26/2017
Displaying projections from OASIS run Forecasts_102317

Reservoir Storage Status

	Elevation (ft)	Prime Storage (%)	Prime Storage (MG)
Lake Michie	334.90	67.67	1,902.87
Little River	347.40	65.65	2,344.31
System		66.54	4,247.18

Precipitation Forecast



OASIS Run

Run 01 (Forecasts_102317)

Water Shortage Response Plan

Stage	% of Traces	Threshold	Action
Trigger 1-R (> 95% full @ 10 weeks)	51 %	95 %	None
Trigger 1-D (< 45% full @ 12 weeks)	5 %	30 %	None
Trigger 2-D (< 35% full @ 10 weeks)	0 %	20 %	None
Trigger 3-D (< 25% full @ 8 weeks)	0 %	10 %	None
Trigger 4-D (< 15% full @ 4 weeks)	0 %	5 %	None

Raw and Finished Water Delivery

	Latest Observation	7-day Avg	30-day Avg
Little River Withdrawal (54" at Brown) adj (mgd)	0.00	3.09	11.83
Lake Michie Withdrawal (MagMeter) (mgd)	18.95	20.56	17.89
Finished Flow Total adj (mgd)	25.11	24.23	24.88

System Prime Storage Forecast

Net Reservoir Inflow

	30-day Avg	Historical Median	30-day Avg (as % of Historical Median)
Lake Michie Net Inflow (cfs)	2	14.7	15 %
Little River Net Inflow (cfs)	2	5.4	29 %

Observed Precipitation

	YTD	Last 30 Days
Lake Michie	33.8"	2.7"
Little River	39.3"	2.8"

Forecasted Precipitation

Data Source	Forecast total
NWS	2-day total: 0.4" (10/27 8am to 10/29 8pm)
WU	10-day total: 0.3" (10/26 7pm to 11/5 7pm)

HYDROLOGICS

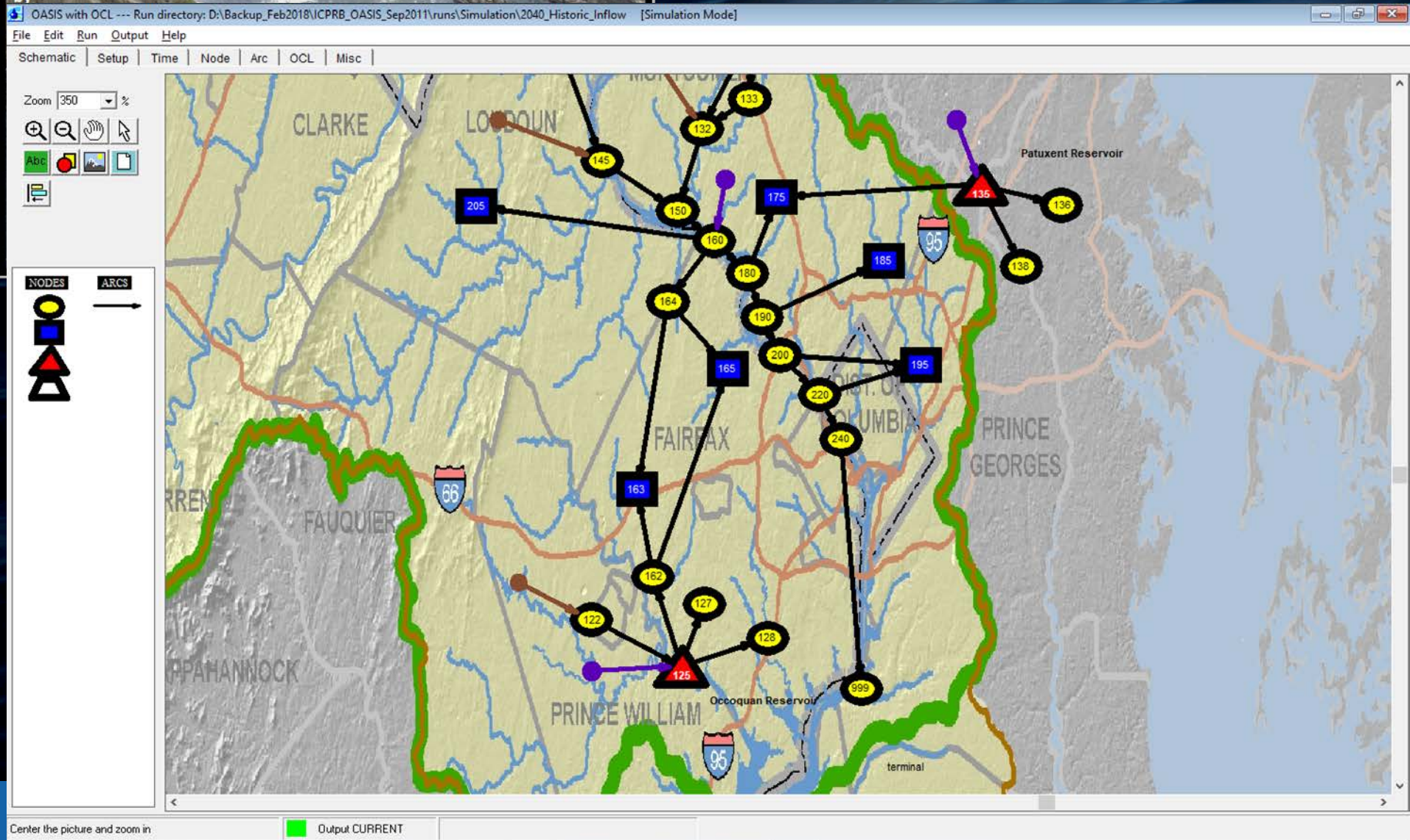
Drought Exercises to Refine the Rules

HYDROLOGICS

Potomac River Basin CO-OP Operations Model

Developed for the Interstate Commission on the Potomac River Basin

by



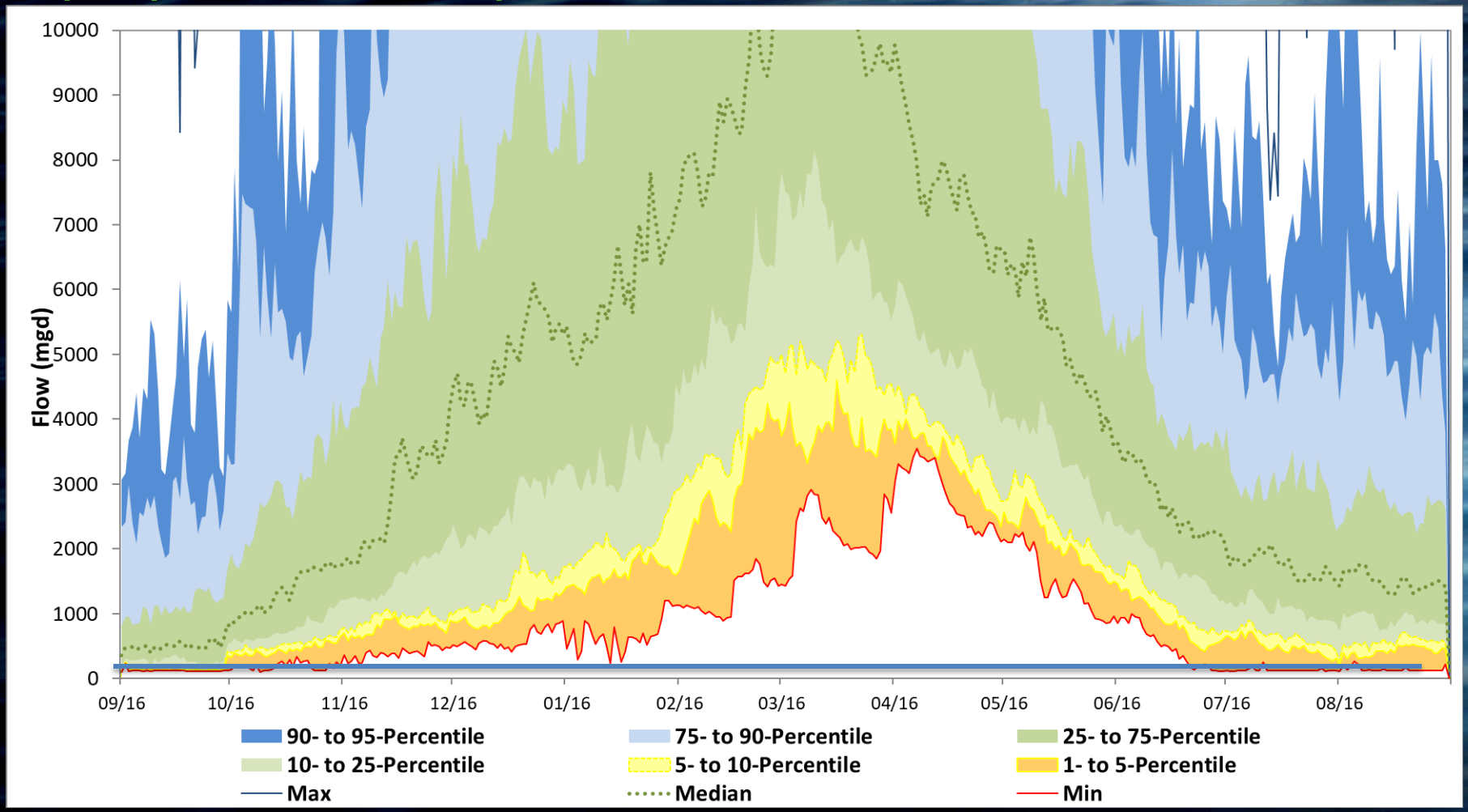
Sample ICPRB Forecast for Little Falls (Sept. 2011)

ICPRB outlook:

There is a 6 to 11 percent conditional probability that natural Potomac flow will drop below 700-million gallons per day (MGD) at Little Falls through December 31 of this year; at this flow level, water supply releases from Jennings Randolph and Little Seneca Reservoirs may occur. Releases occur when predicted flow is less than demand plus a required flow-by. Demand ranges from 400 to 700 MGD during the summer months and the minimum flow-by at Little Falls is 100 MGD. Note that natural flow is defined as observed flow at the Little Falls gage plus total Washington metropolitan Potomac withdrawals, with an adjustment made to remove the effect of North Branch reservoir releases on stream flow.

The conditional probability is estimated by analyzing the historical stream flow records and giving consideration to recent stream flow values, precipitation totals for the prior 12 months, current groundwater levels, and the current Palmer Drought Index. Past years in which watershed conditions most closely resemble current conditions are weighted more heavily in the determination of conditional probability. The historical, or unconditional, probability is based on an analysis of the historical stream flow record without weighting for current conditions. The conditional probability of 6 to 11 percent compares to a historical probability of 8 to 13 percent and is considered the more reliable indicator.

Sample Forecast for Little Falls, simulated (Sept. 15, 2002)



Companion Forecast for JR WS Storage