Water Supply Forecasting at Denver Water

January 24, 2005

Drought, Climate Variability, and Water Supply Workshop

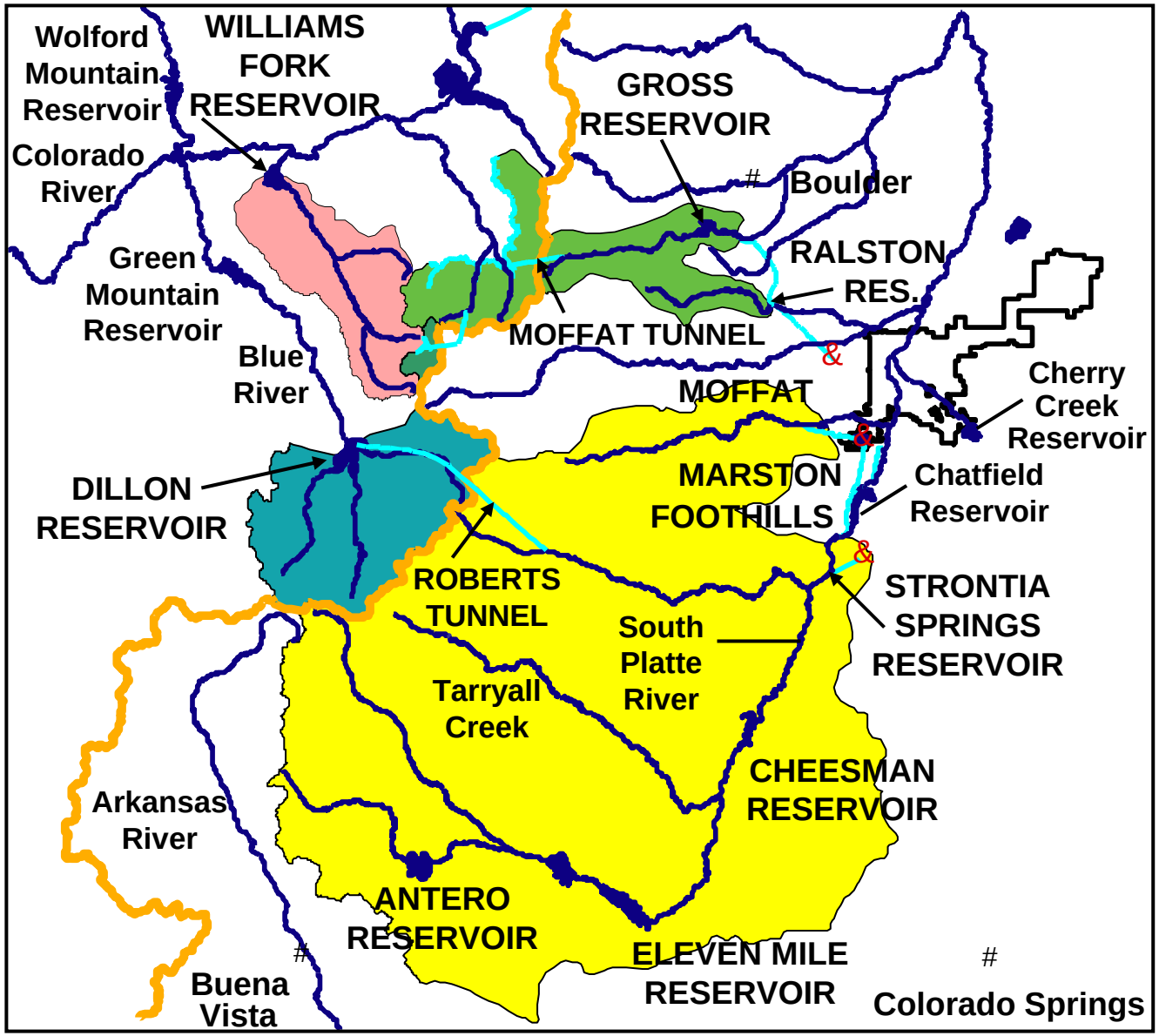
DENVER WATER

Outline

- DW raw water collection system
- Forecasting reservoir levels
- Limitations of forecasts
- Long-range forecasts
- Possibilities for improvement

Denver Board of Water Commissioners

Water Collection System

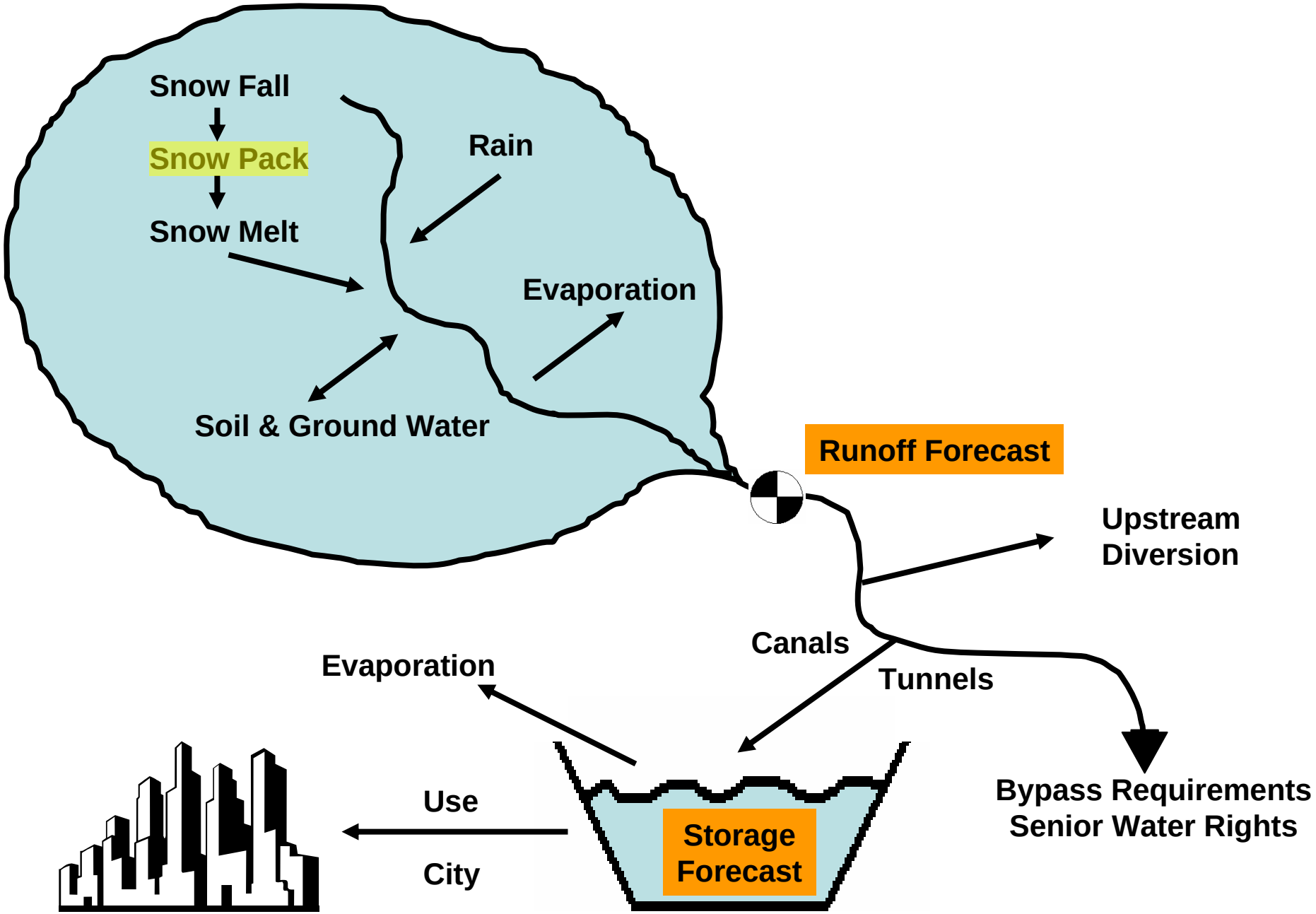


COLLECTION SYSTEMS

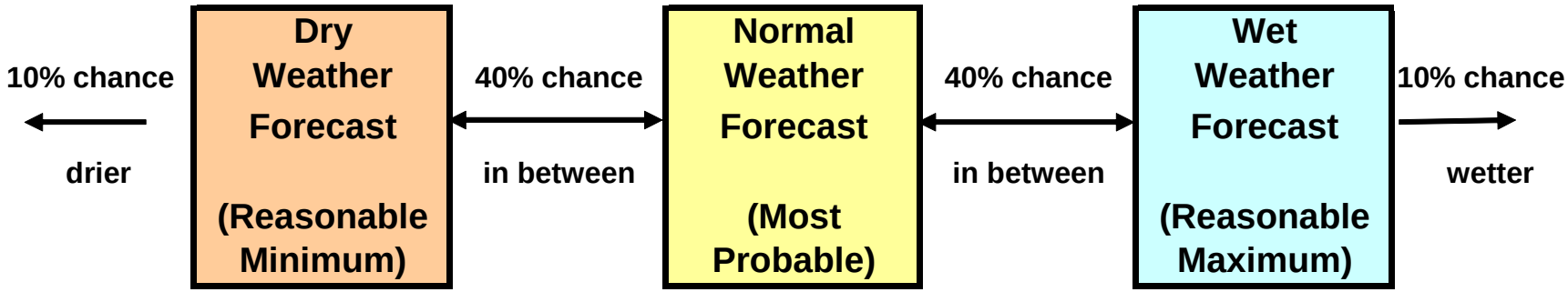
- SOUTH PLATTE
- MOFFAT TUNNEL
- ROBERTS TUNNEL
- WILLIAMS FORK WATERSHED

- TREATMENT PLANT
- CONTINENTAL DIVIDE
- STREAM OR RIVER
- TUNNEL, CANAL OR DITCH

Watershed

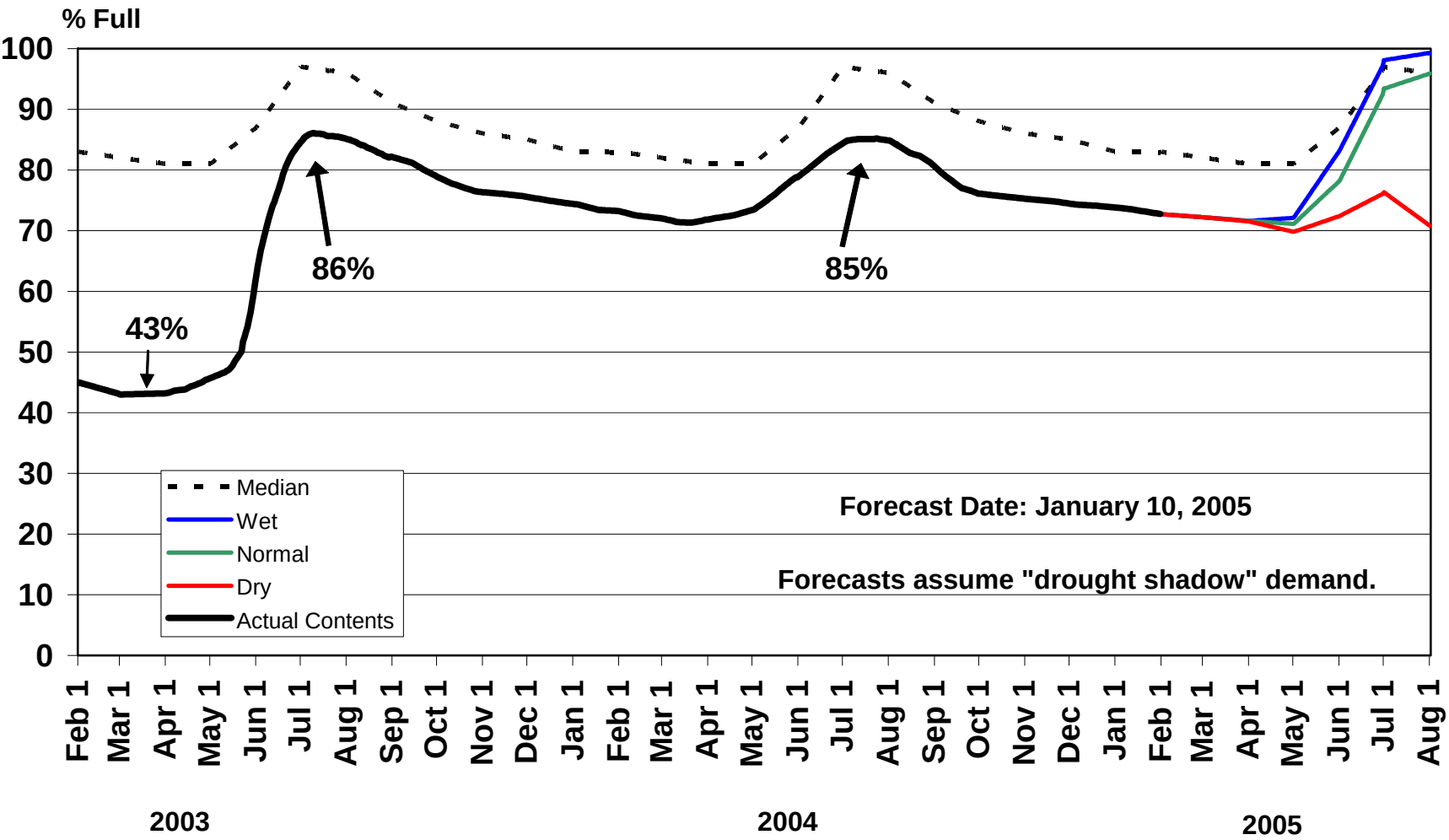

Snow Fall
Snow Pack
Snow Melt
Rain
Evaporation
Soil & Ground Water
Runoff Forecast
Upstream Diversion
Canals
Tunnels
Evaporation
Bypass Requirements Senior Water Rights
Use
City
Storage Forecast

Three Weather Scenarios Forecasted:

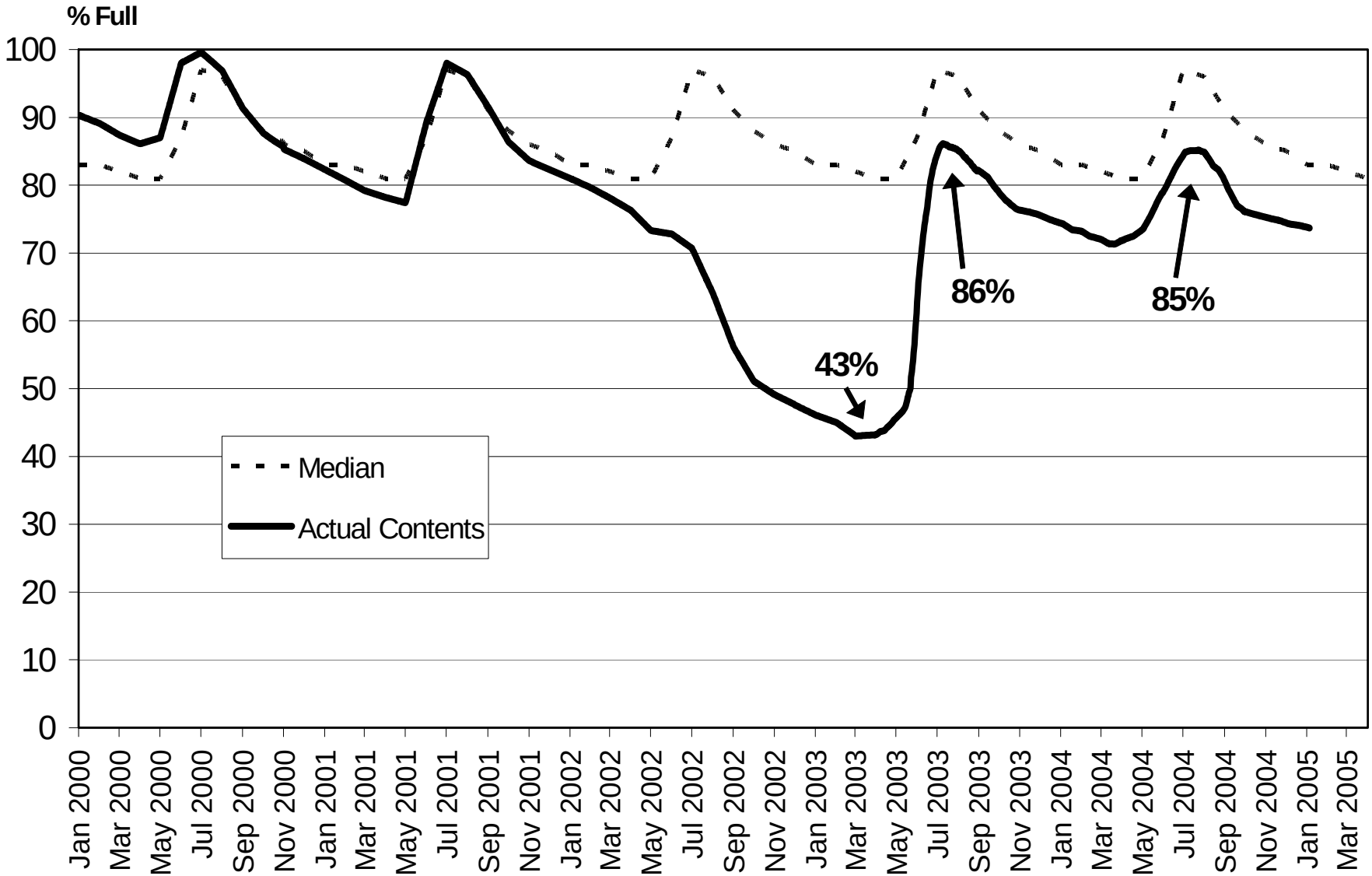


Reservoir level forecasts begin with the three streamflow forecasts indicated. Levels also affected by demand, water rights, upstream diversions, system constraints, etc.

Total Reservoir Storage
(Historic and Projected)

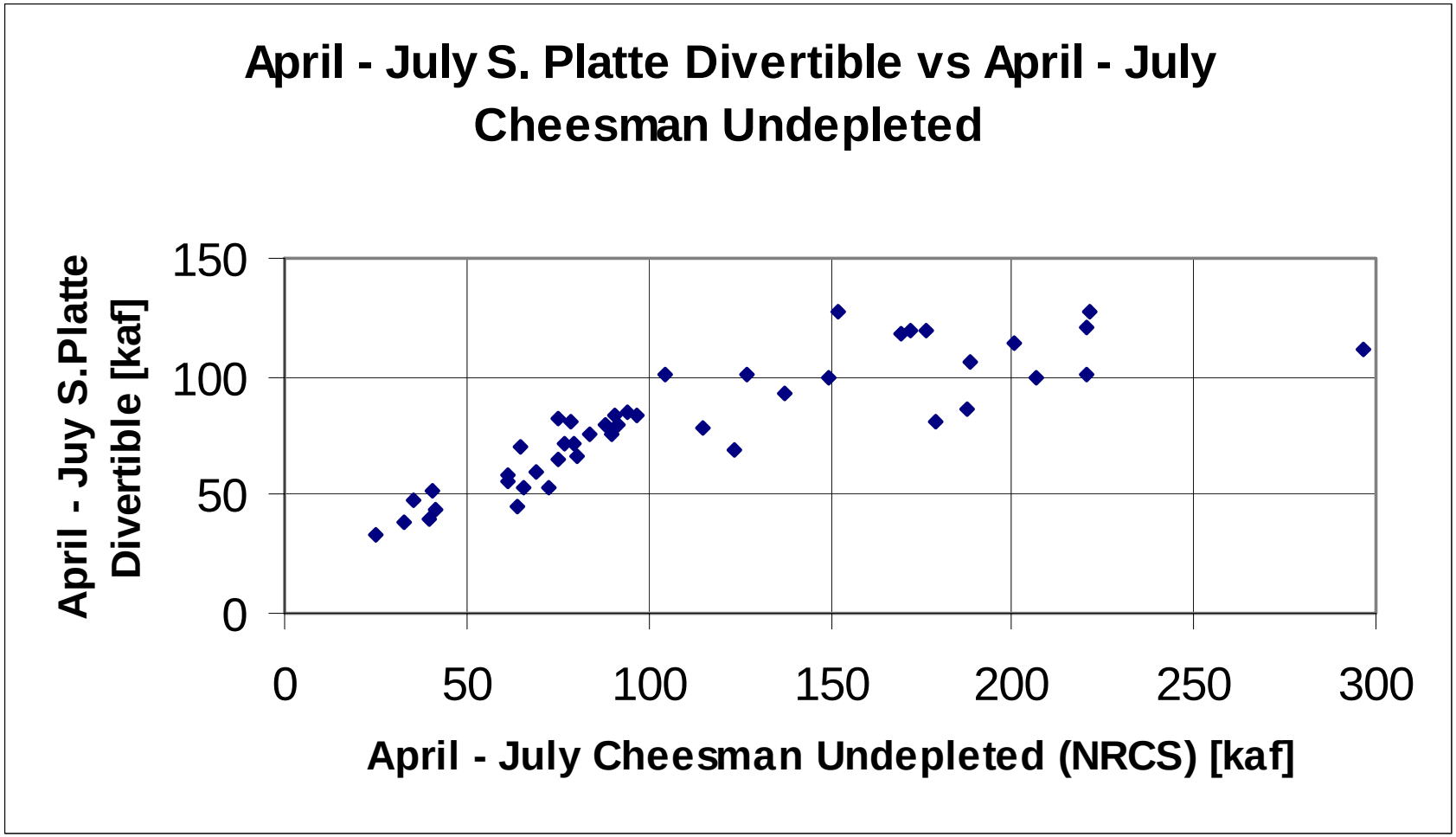


Total Reservoir Storage (Historic)



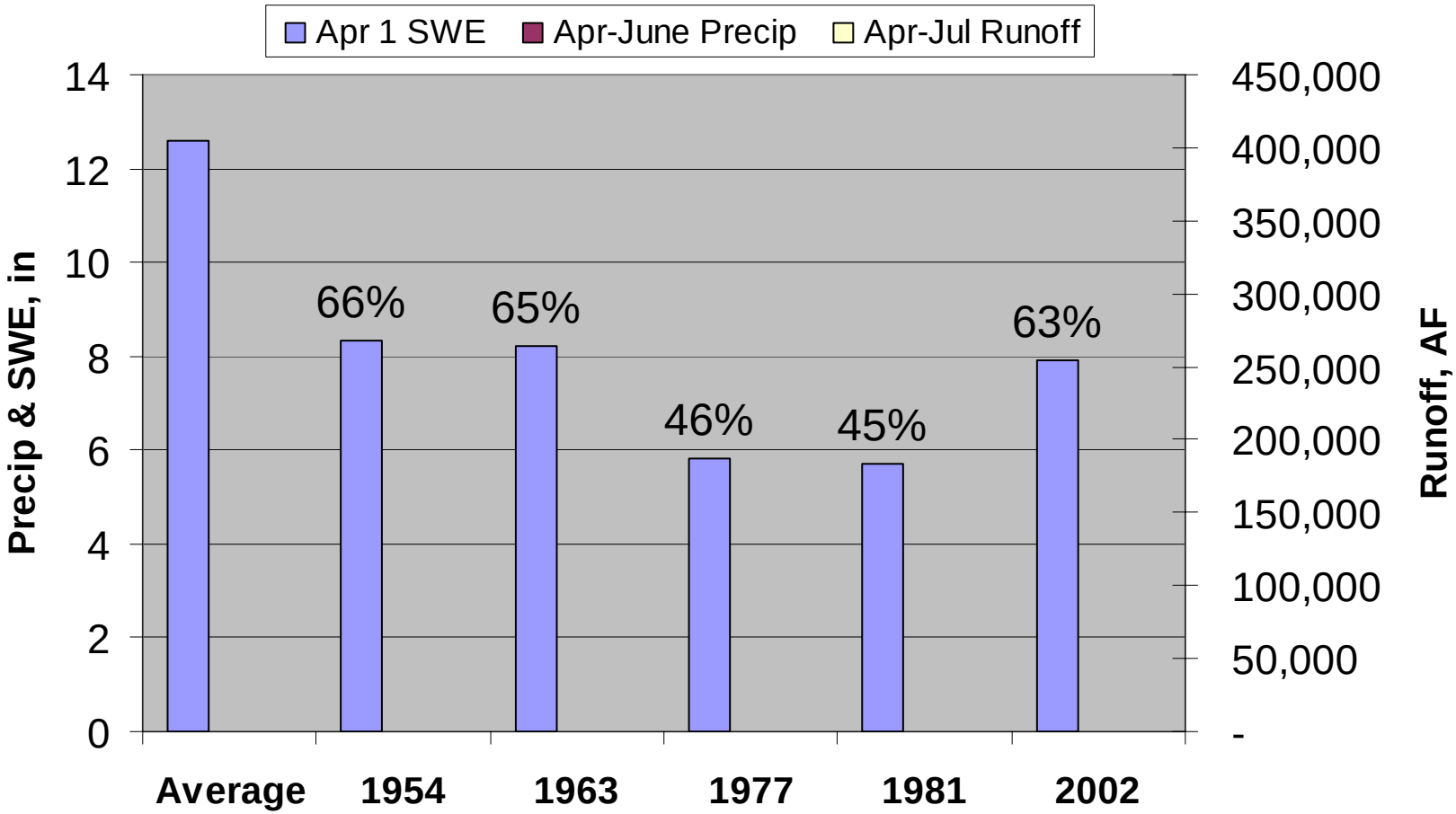
Sources of Error

- Undepleted streamflow
- Spring Precipitation
- Converting undepleted streamflow to divertible streamflow
- Predicting water use
- Predicting system outages

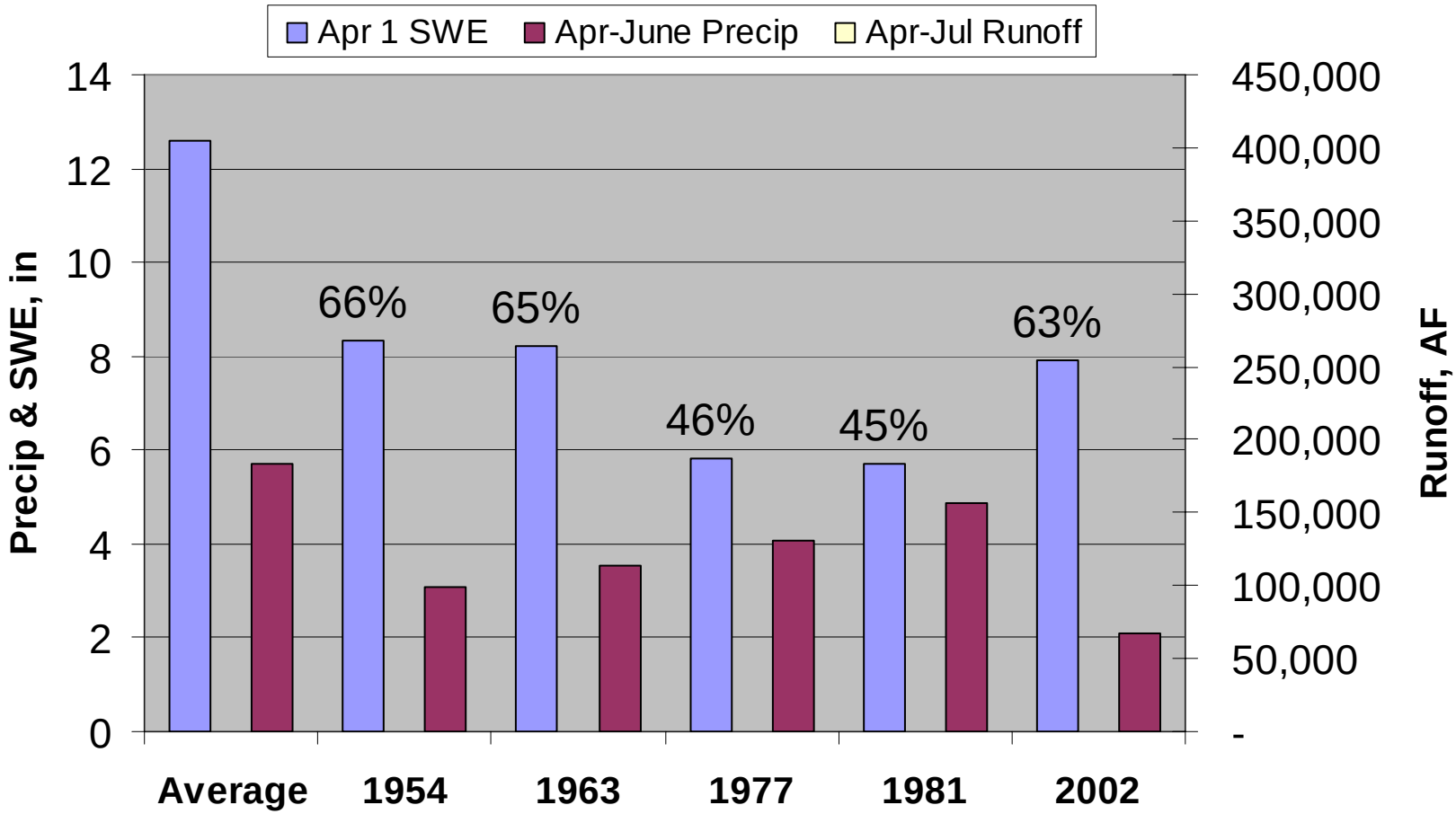


Based on 1947 – 1991 modeled data.

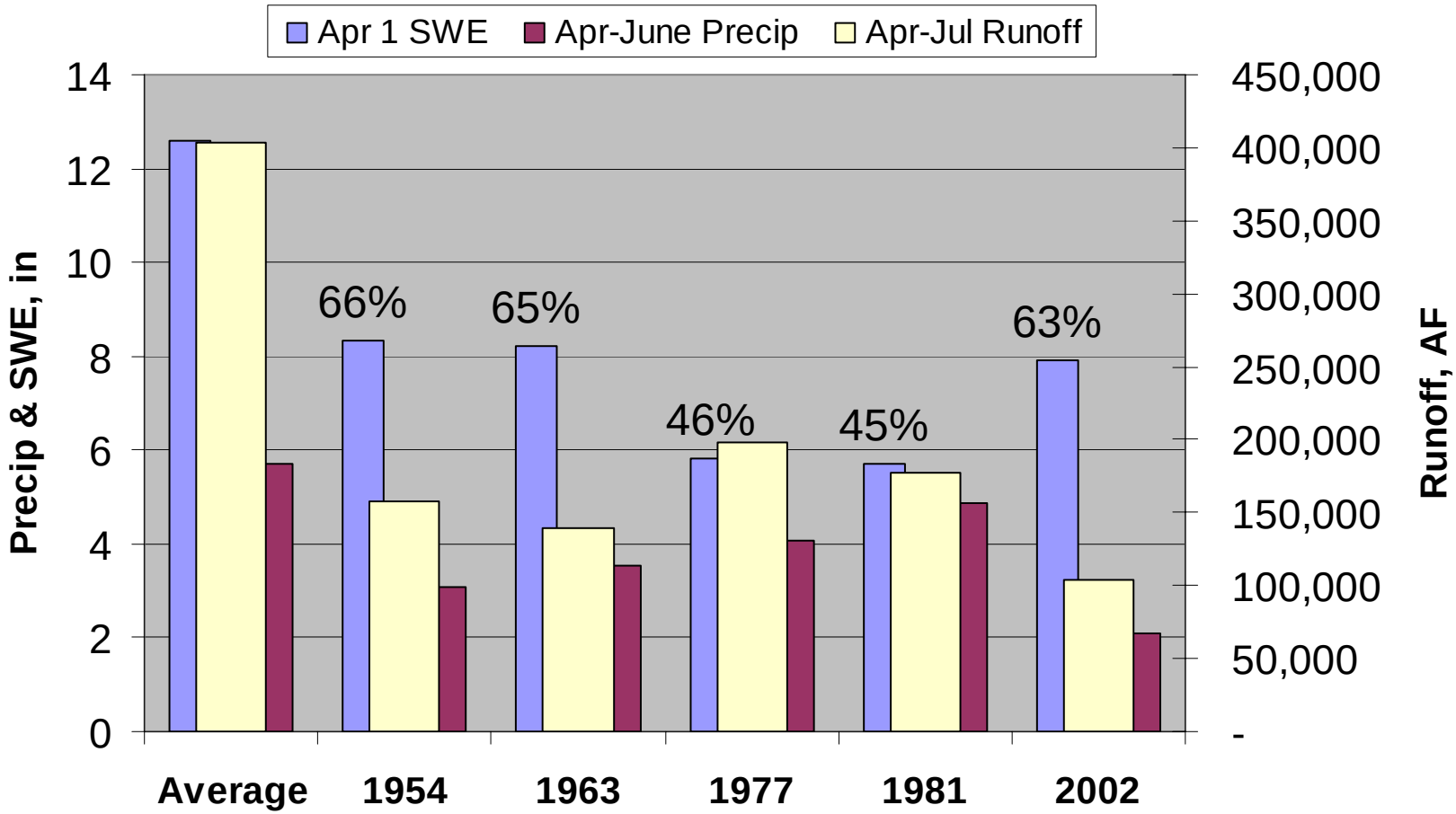
Dry Year Snow Pack, Precip, and Runoff
Denver Water Collection System

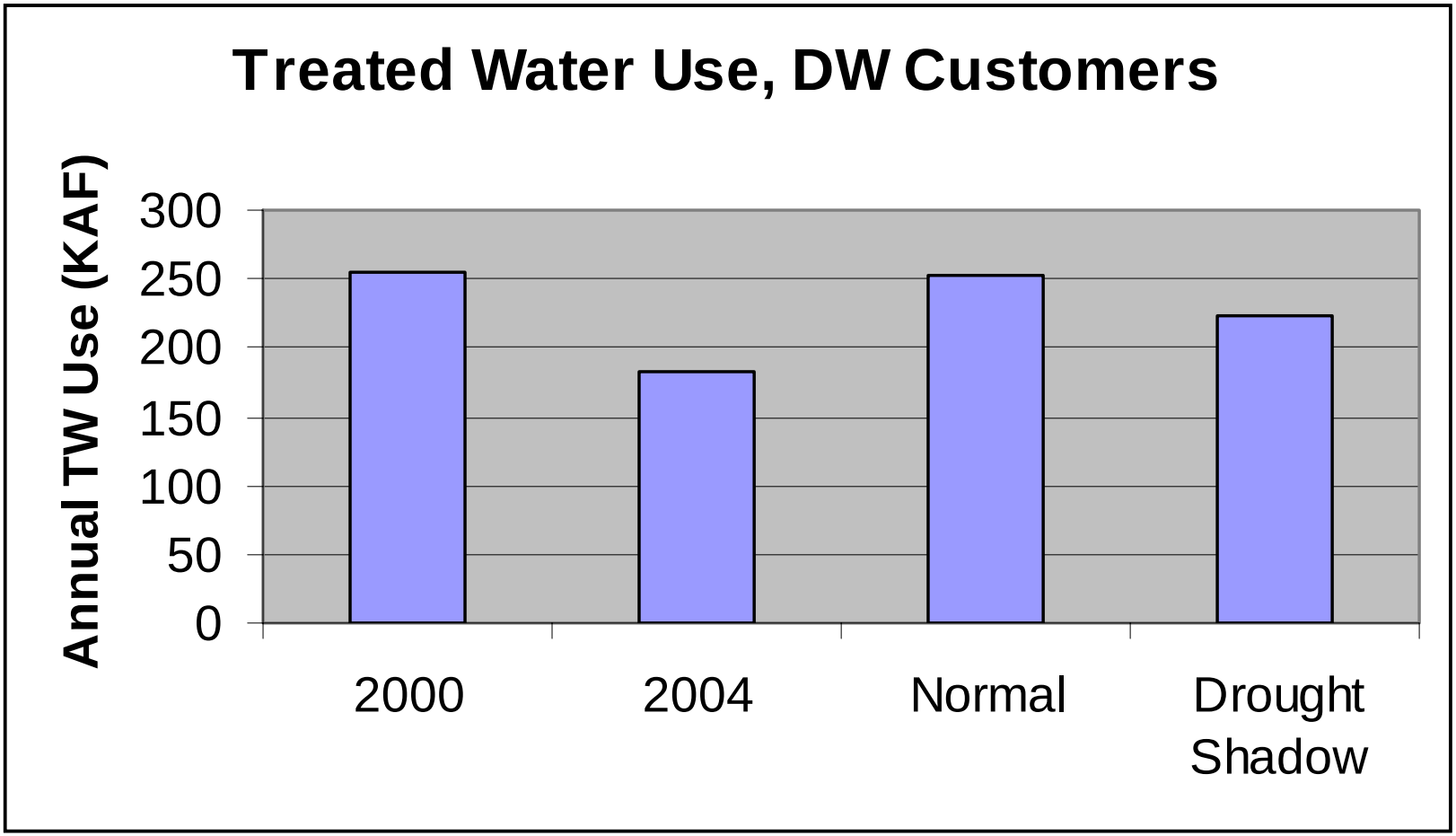


Dry Year Snow Pack, Precip, and Runoff
Denver Water Collection System



Dry Year Snow Pack, Precip, and Runoff
Denver Water Collection System

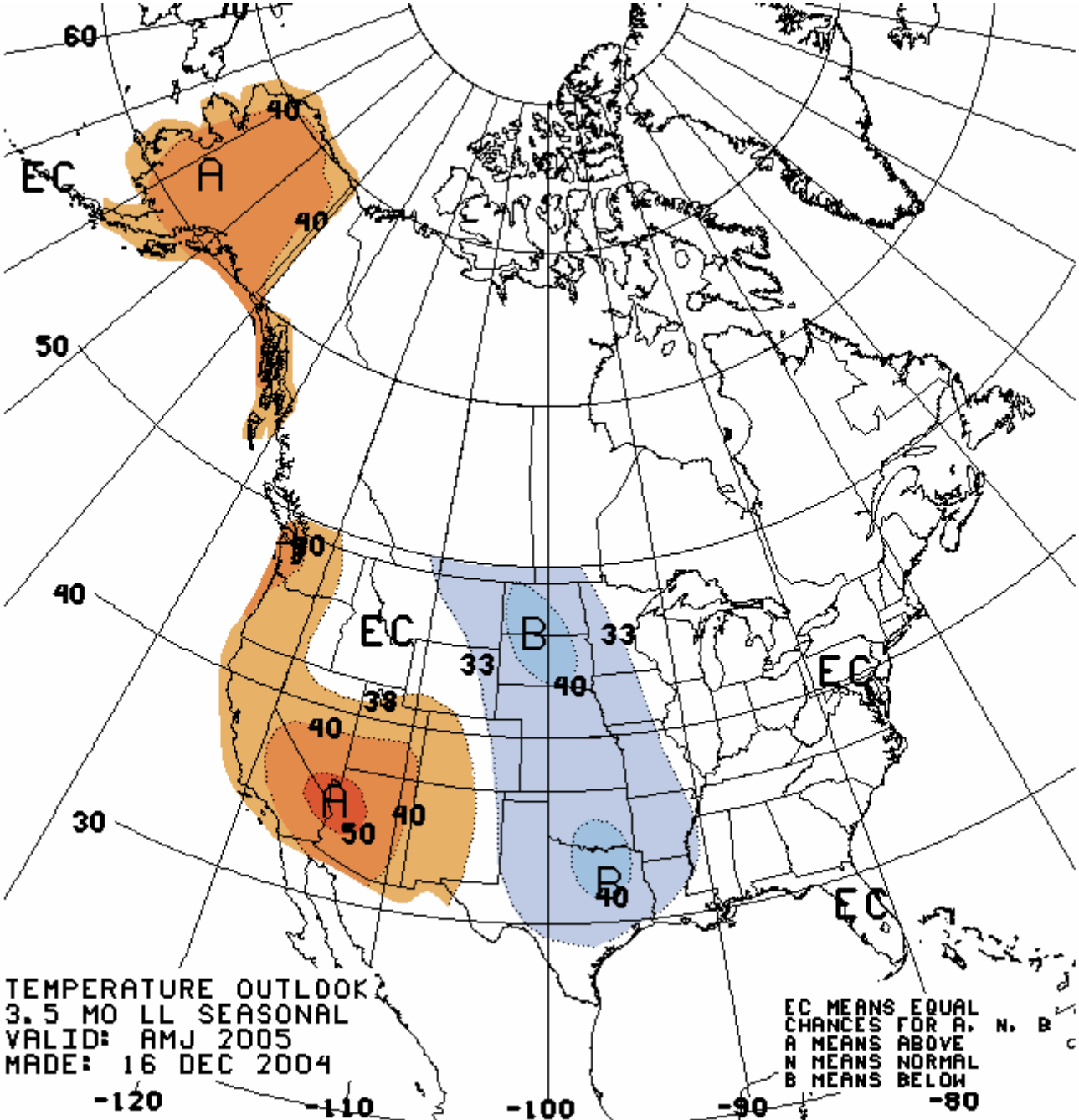



Treated Water Use, DW Customers
Annual TW Use (KAF)
300
250
200
150
100
50
0
2000
2004
Normal
Drought Shadow

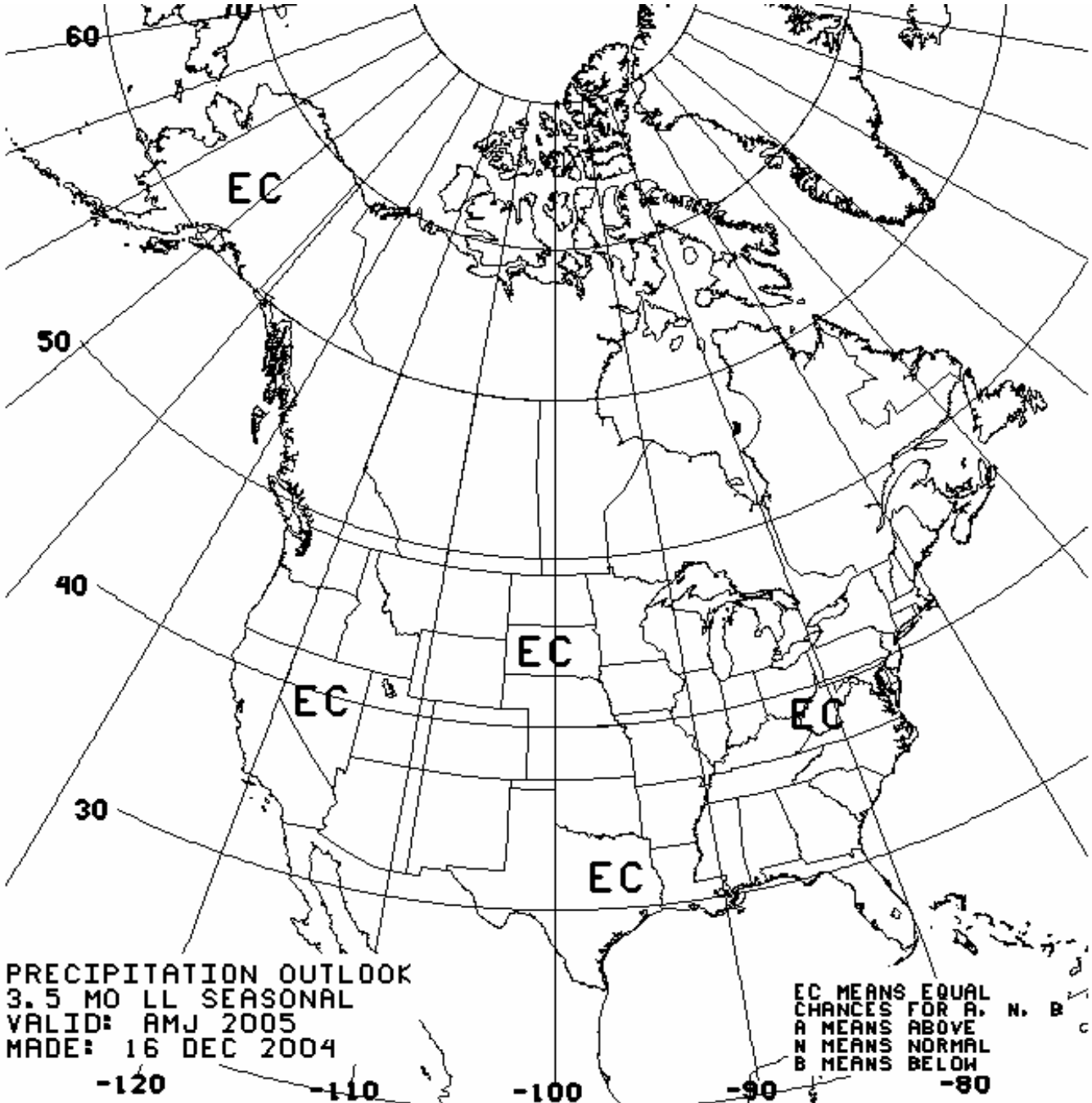
Long-Range Forecasts

- Temperature
- Precipitation
- Stream Flow

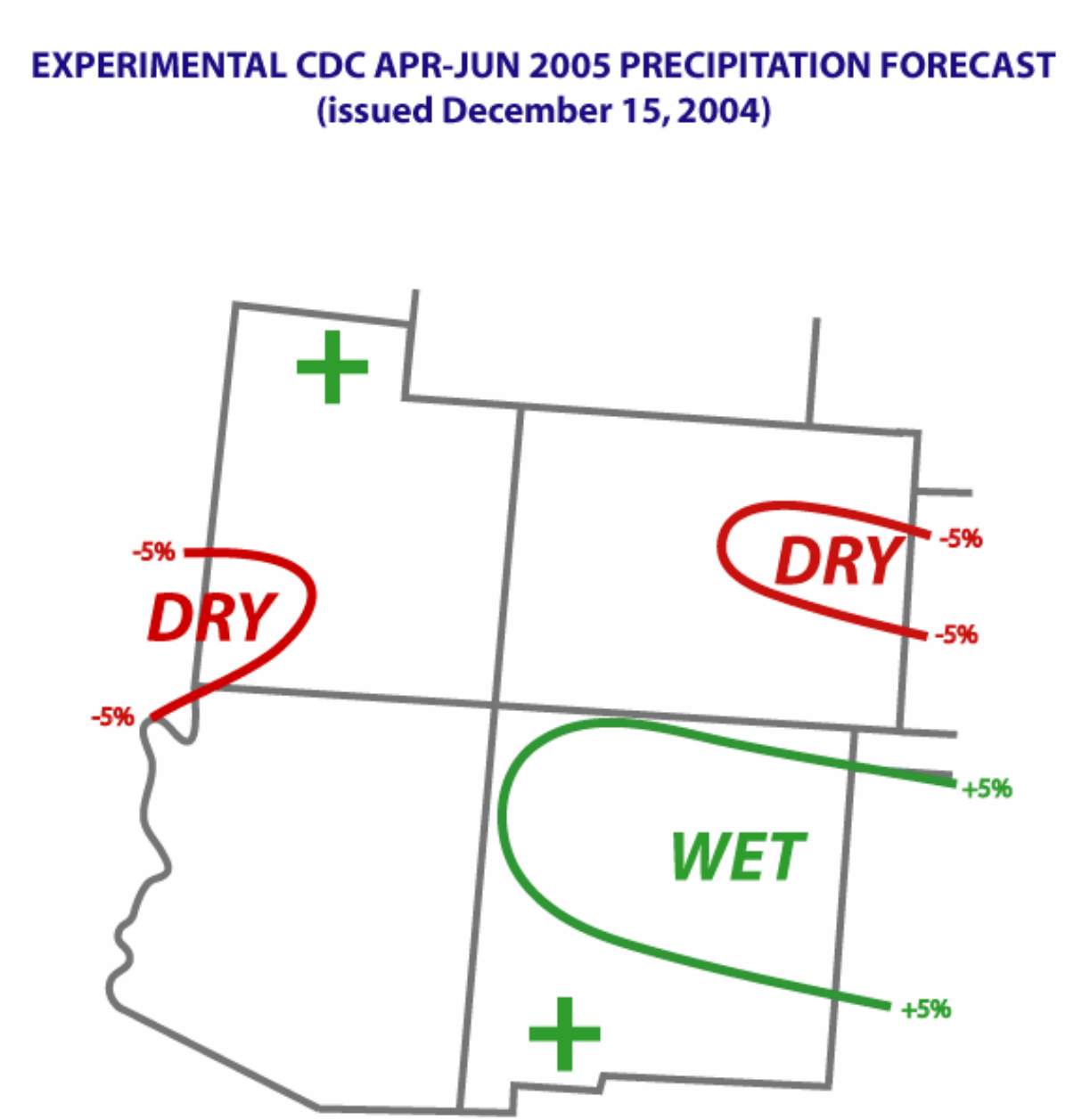
April – June Temperature Outlook

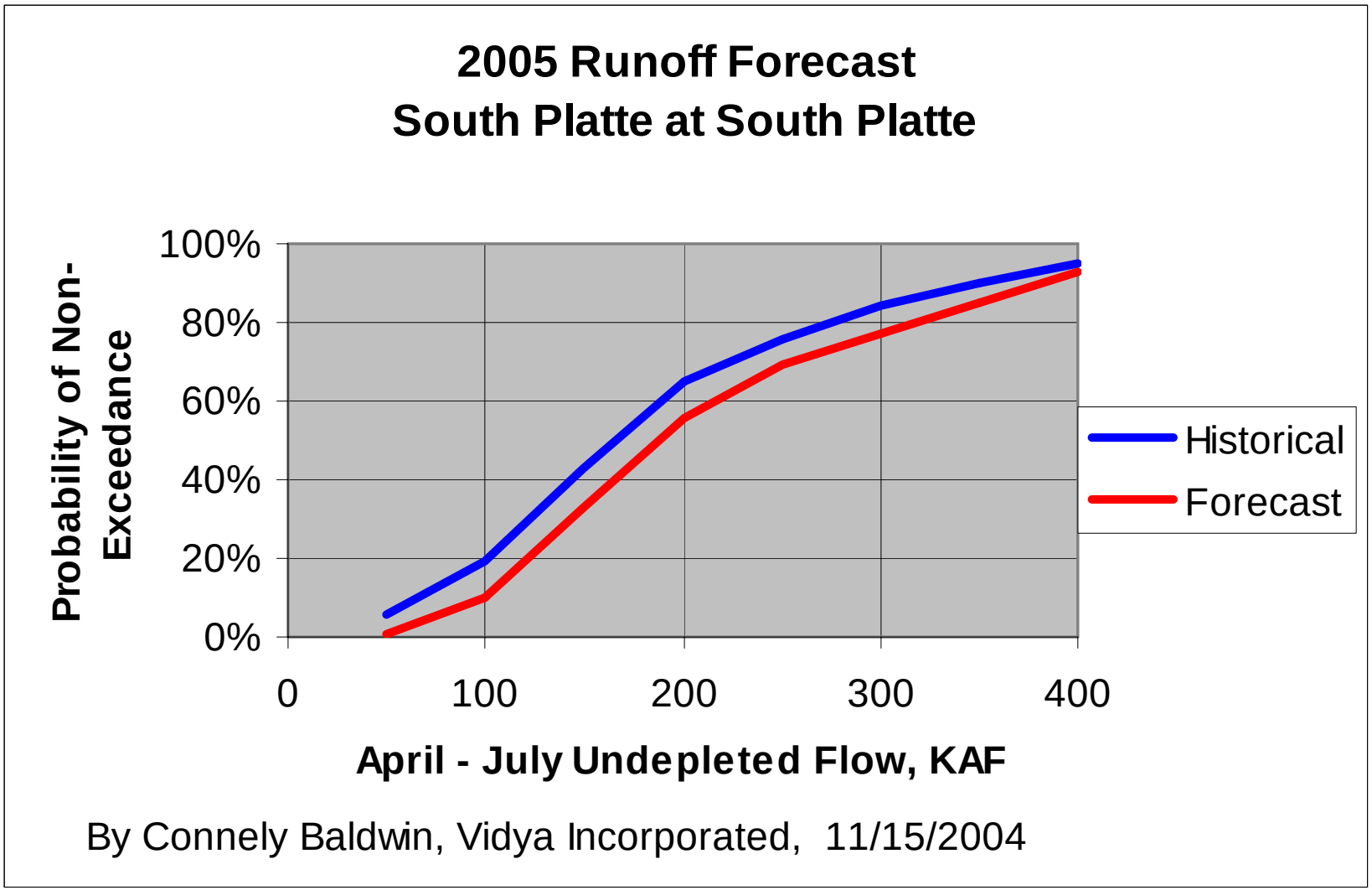


April – June Precipitation Outlook



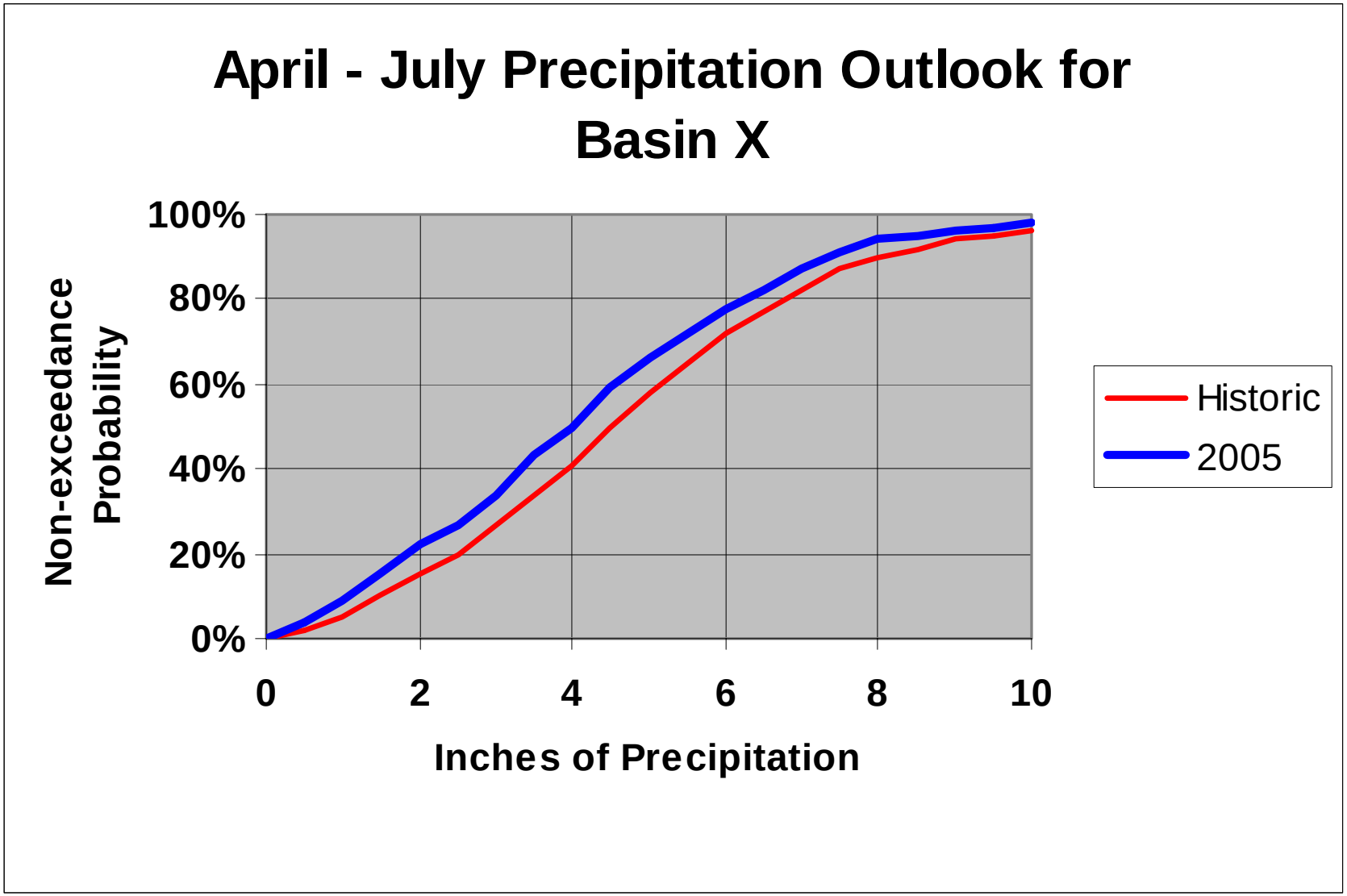
Klaus' April – June Experimental Precipitation Forecast



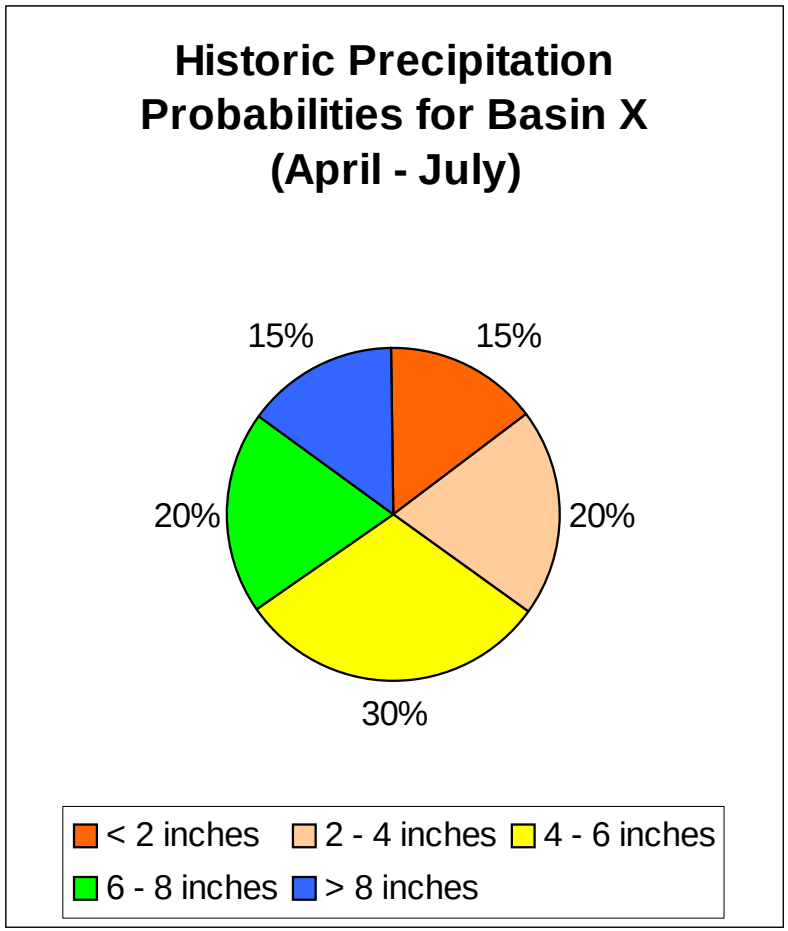


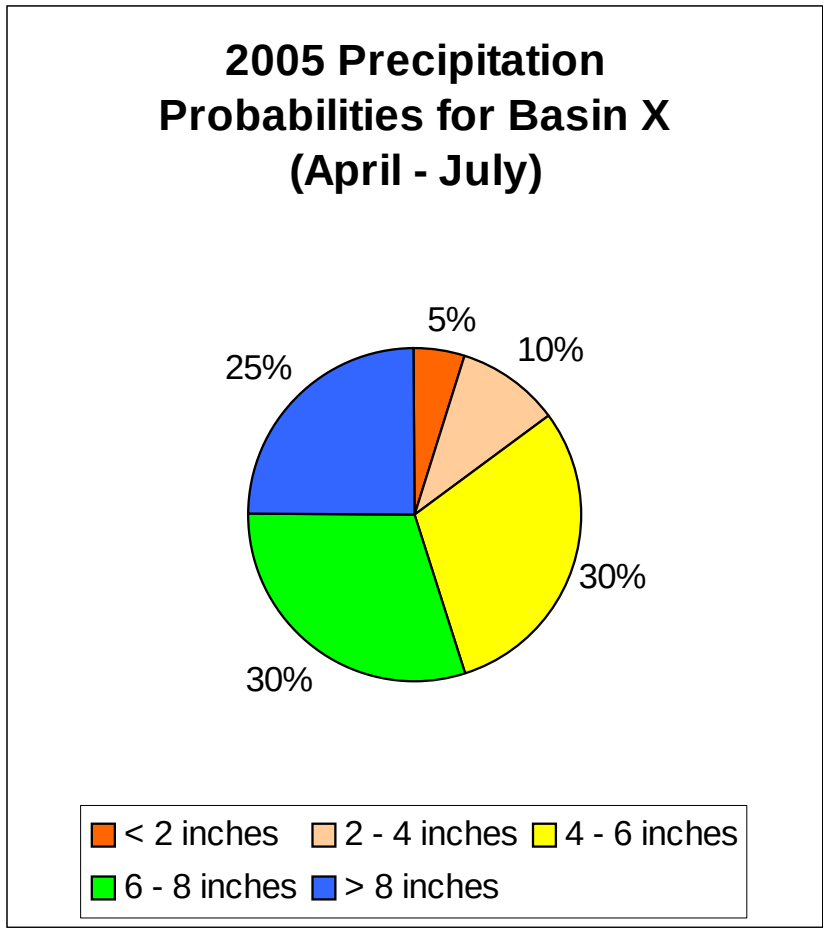
By Connely Baldwin, Vidya Incorporated, 11/15/2004

I'd like to be able to click on a map and get something like this:



Or something like this:





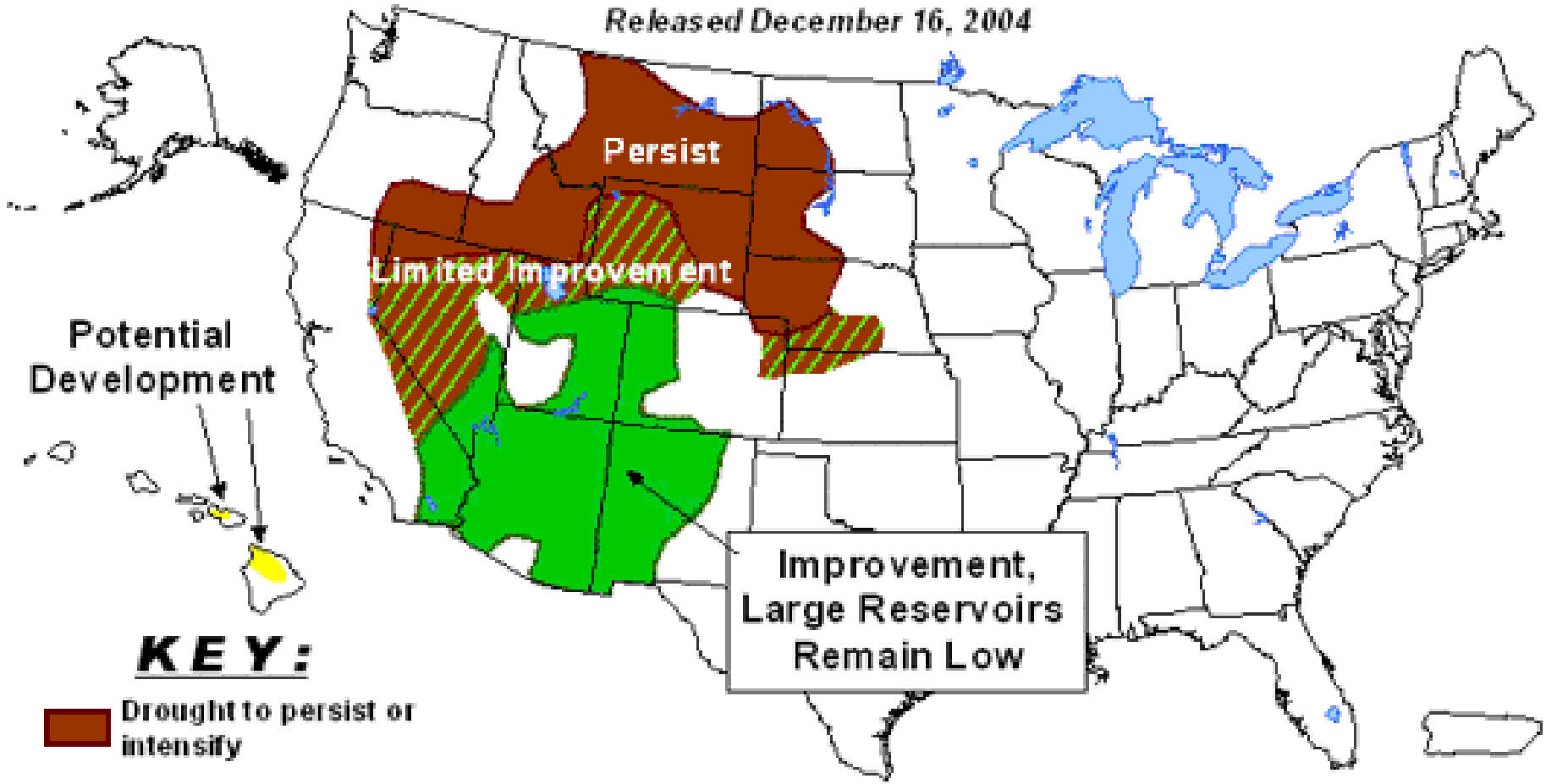
Conclusions

- There are several sources of error when forecasting reservoir levels
- Long-range forecasts are useful. As they become more reliable, their usefulness will increase.
- Areas for improvement:
  - More accurate streamflow forecasts.
  - Better methods to predict effects of water rights administration.
  - More options for viewing long-range weather forecasts.

U.S. Seasonal Drought Outlook

Through March 2005

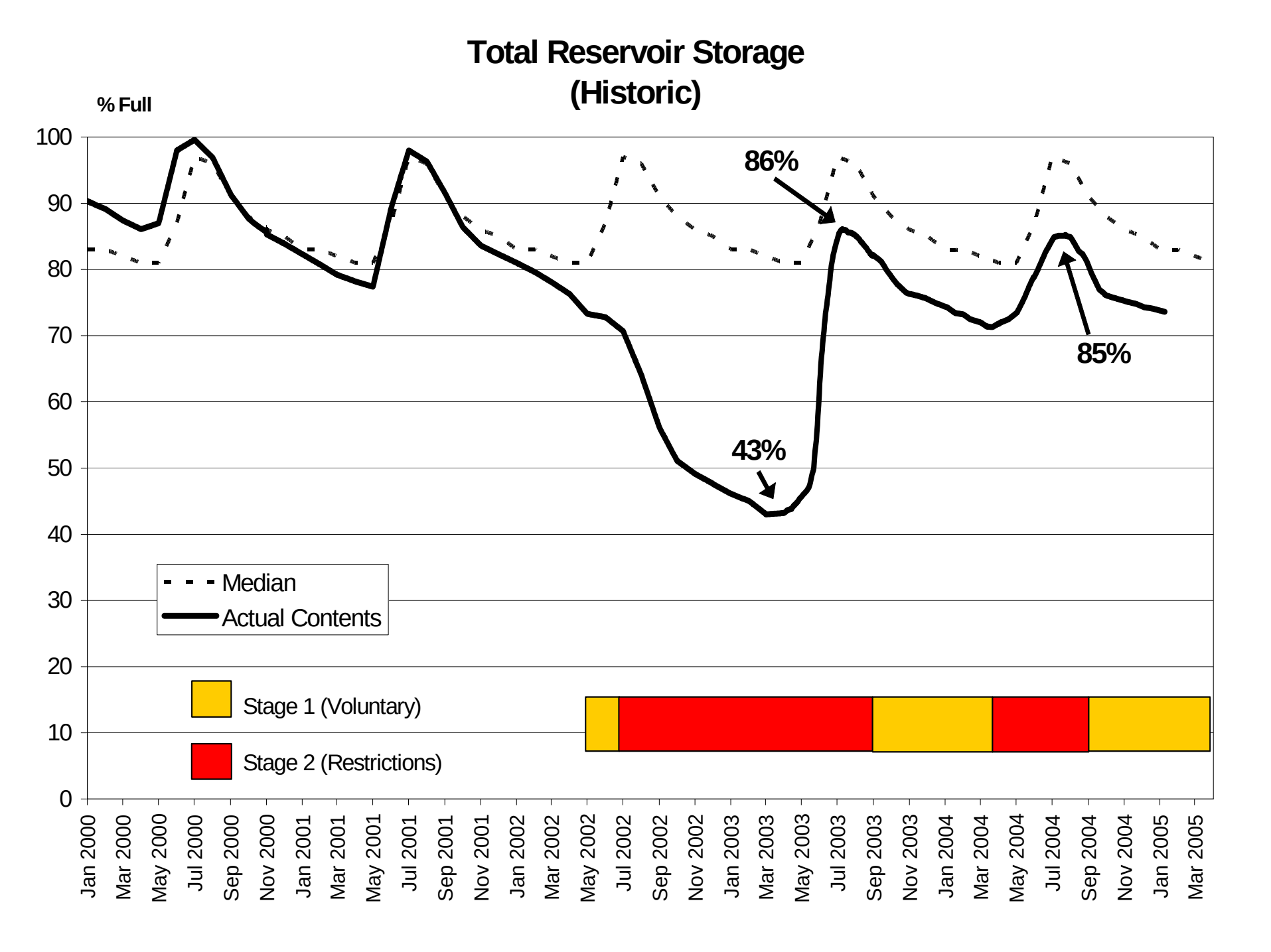
Released December 16, 2004



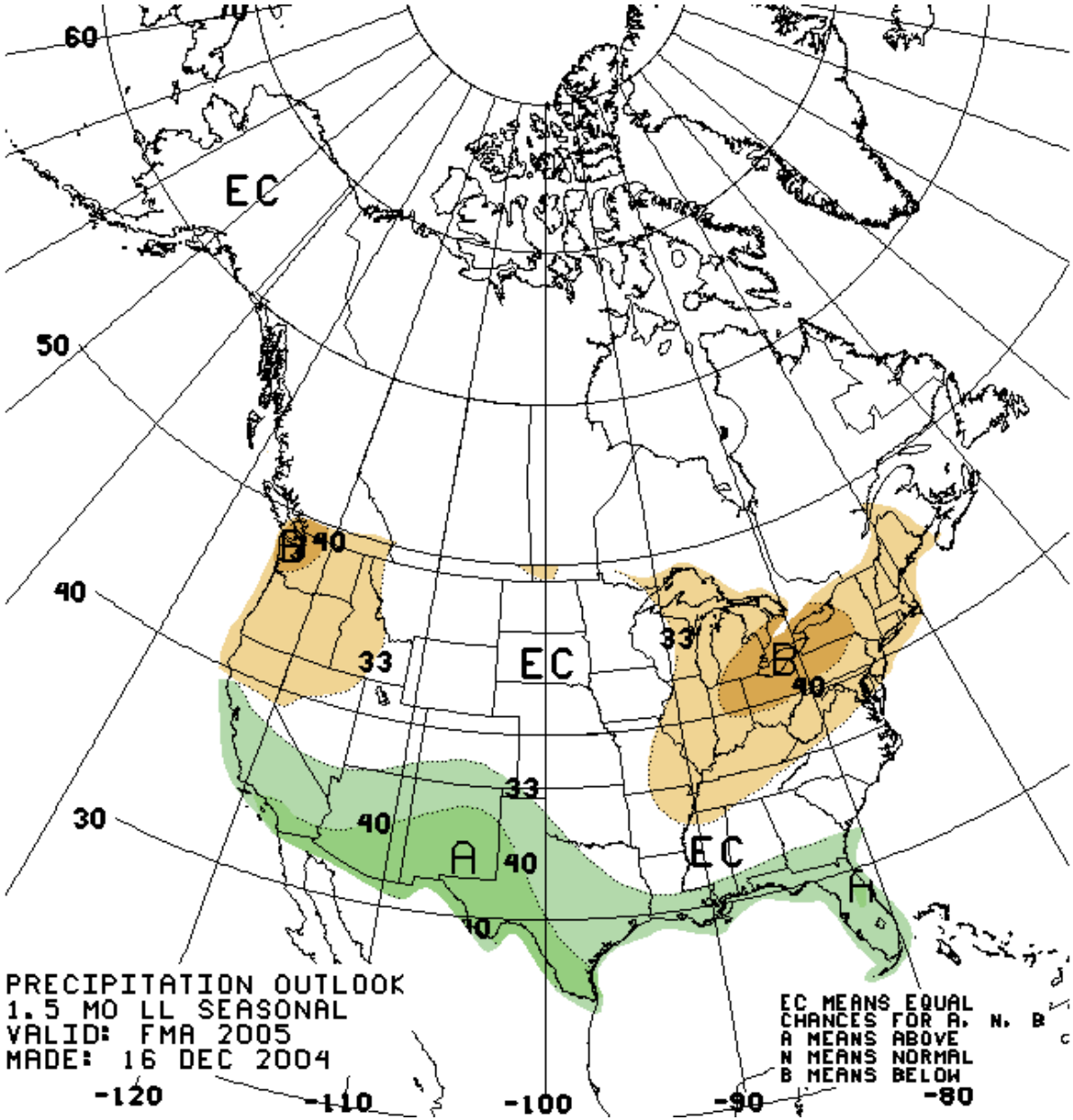
KEY:

- Drought to persist or intensify
- Drought ongoing, some improvement
- Drought likely to improve, impacts ease
- Drought development likely

Depicts general, large-scale trends based on subjectively derived probabilities guided by numerous indicators, including short- and long-range statistical and dynamical forecasts. Short-term events -- such as individual storms -- cannot be accurately forecast more that a few days in advance, so use caution if using this outlook for applications -- such as crops -- that can be affected by such events. "Ongoing" drought areas are schmatically approximated from the Drought Monitor (D1 to D4). For weekly drought updates, see the latest Drought Monitor map and text. NOTE: the green improvement areas imply at least a 1-category improvement in the Drought Monitor intensity levels, but do not necessarily imply drought elimination.


Total Reservoir Storage
(Historic)
% Full
100
90
80
70
60
50
40
30
20
10
0
86%
85%
43%
Median
Actual Contents
Stage 1 (Voluntary)
Stage 2 (Restrictions)
Jan 2000
Mar 2000
May 2000
Jul 2000
Sep 2000
Nov 2000
Jan 2001
Mar 2001
May 2001
Jul 2001
Sep 2001
Nov 2001
Jan 2002
Mar 2002
May 2002
Jul 2002
Sep 2002
Nov 2002
Jan 2003
Mar 2003
May 2003
Jul 2003
Sep 2003
Nov 2003
Jan 2004
Mar 2004
May 2004
Jul 2004
Sep 2004
Nov 2004
Jan 2005
Mar 2005

February – April Precipitation Outlook



NRCS April 1, 2002 Forecasts Spring Runoff, KAF					
Basin	Chance of Exceeding			*Actual Runoff*	*% of Average*
	10%	**50%**	**90%**		
South Platte (Apr-Sep)	**162**	**93**	**65**	***24***	***10%***
Upper CO (WF+DL, Apr-Jul)	**232**	**164**	**99**	***84***	***32%***

Conclusion:

Less than 10% chance on April 1 that actual runoff would occur