Planning Workshop

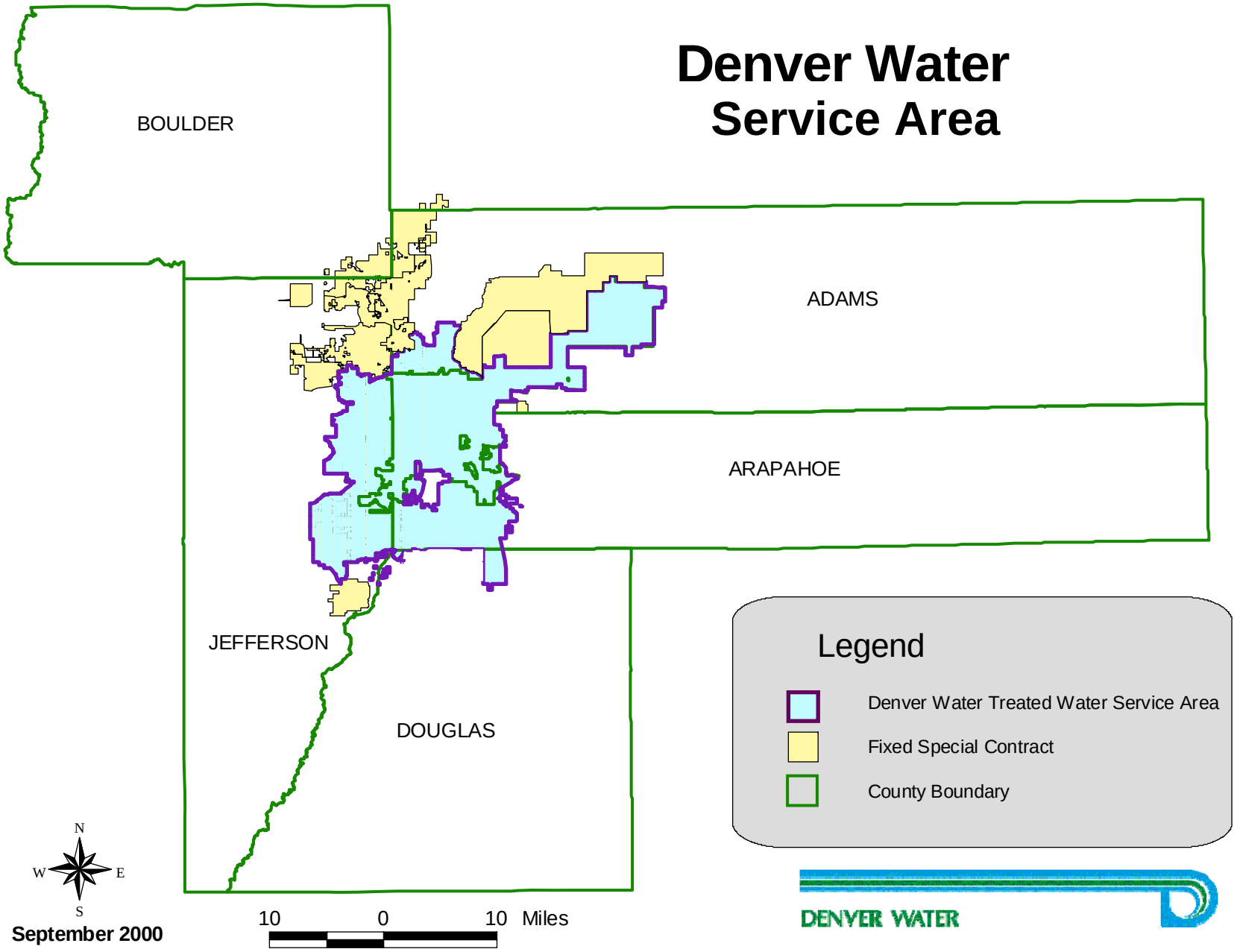
May 9, 2006

Denver Water's Use of Tree Ring-based Stream Flow Reconstructions in Water Resources Management

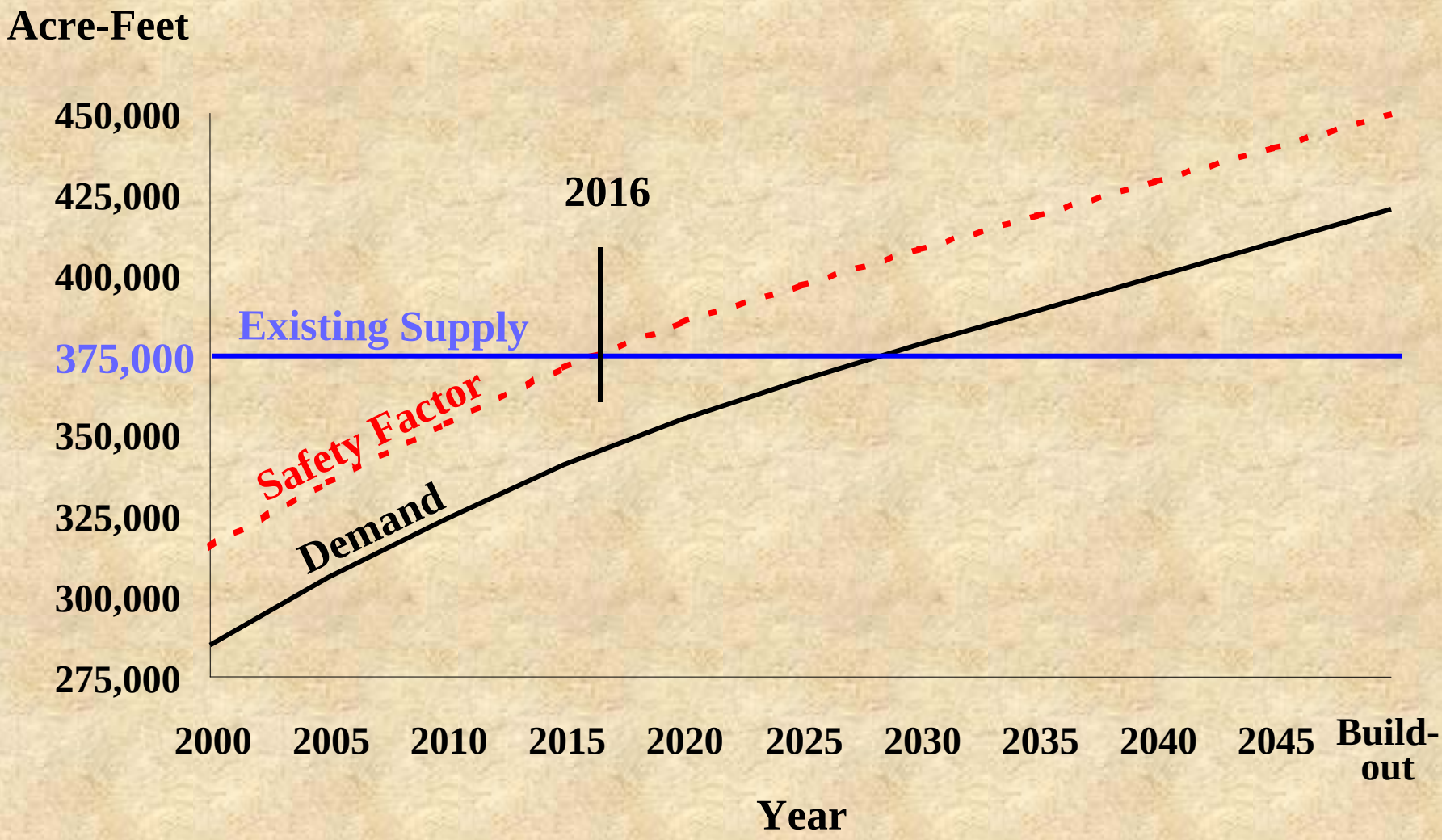
Steve Schmitzer

DENVER WATER

Denver Water Service Area



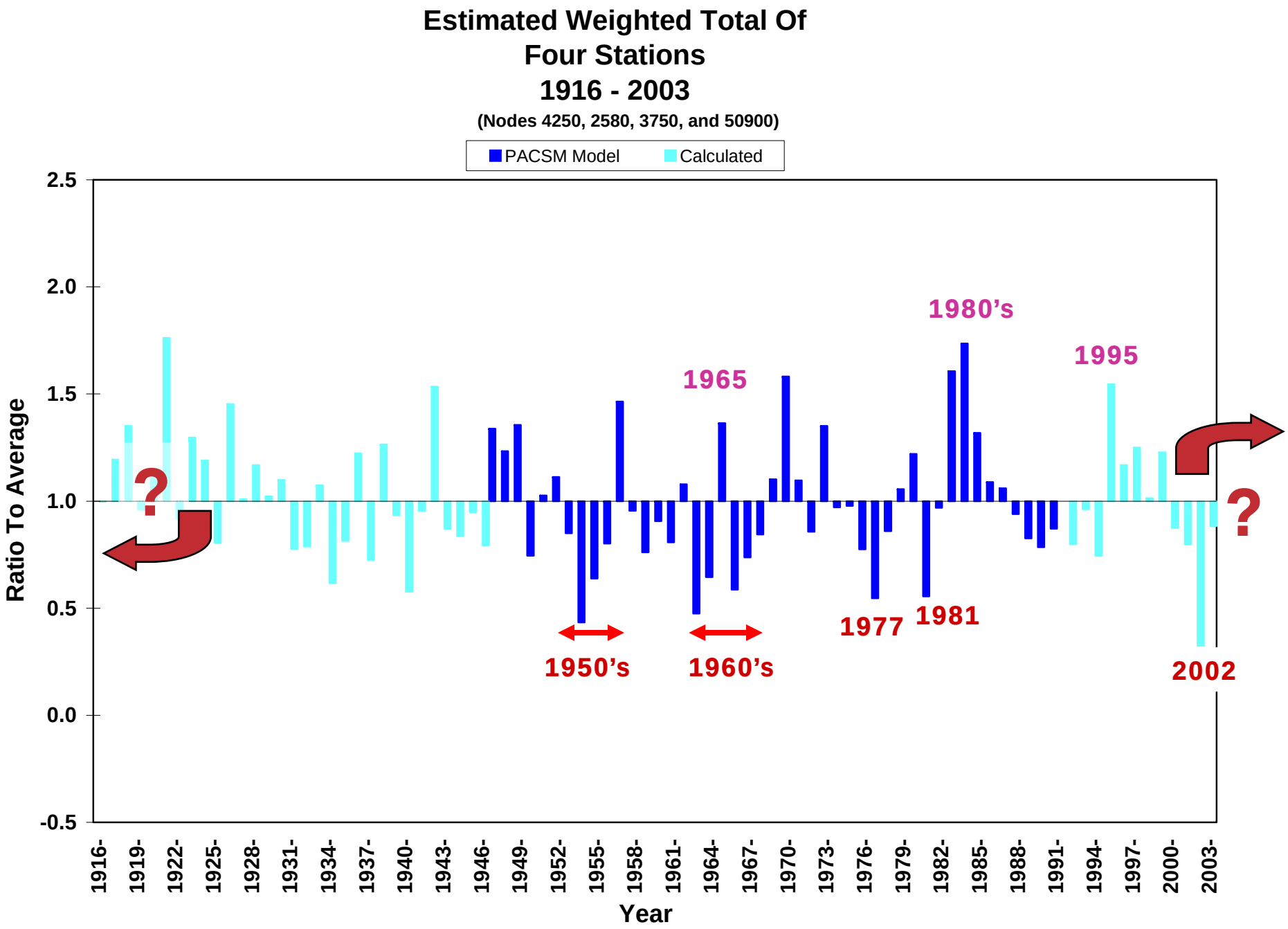
Demand and Supply



Platte and Colorado Simulation Model

PACSM

- Integrated system of computer programs that simulate stream flows, reservoir operations and water supply in the South Platte and Colorado River basins.
- Includes many water supply systems, etc.
- Hydrologic Period: 1947 – 1991
  - Includes the mid-1950's drought
  - Daily data, 450 locations


Estimated Weighted Total Of
Four Stations
1916 - 2003
(Nodes 4250, 2580, 3750, and 50900)
PACSM Model
Calculated
Ratio To Average
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
1916-
1919-
1922-
1925-
1928-
1931-
1934-
1937-
1940-
1943-
1946-
1949-
1952-
1955-
1958-
1961-
1964-
1967-
1970-
1973-
1976-
1979-
1982-
1985-
1988-
1991-
1994-
1997-
2000-
2003-
Year
?
1950's
1960's
1965
1977
1981
1980's
1995
2002
?

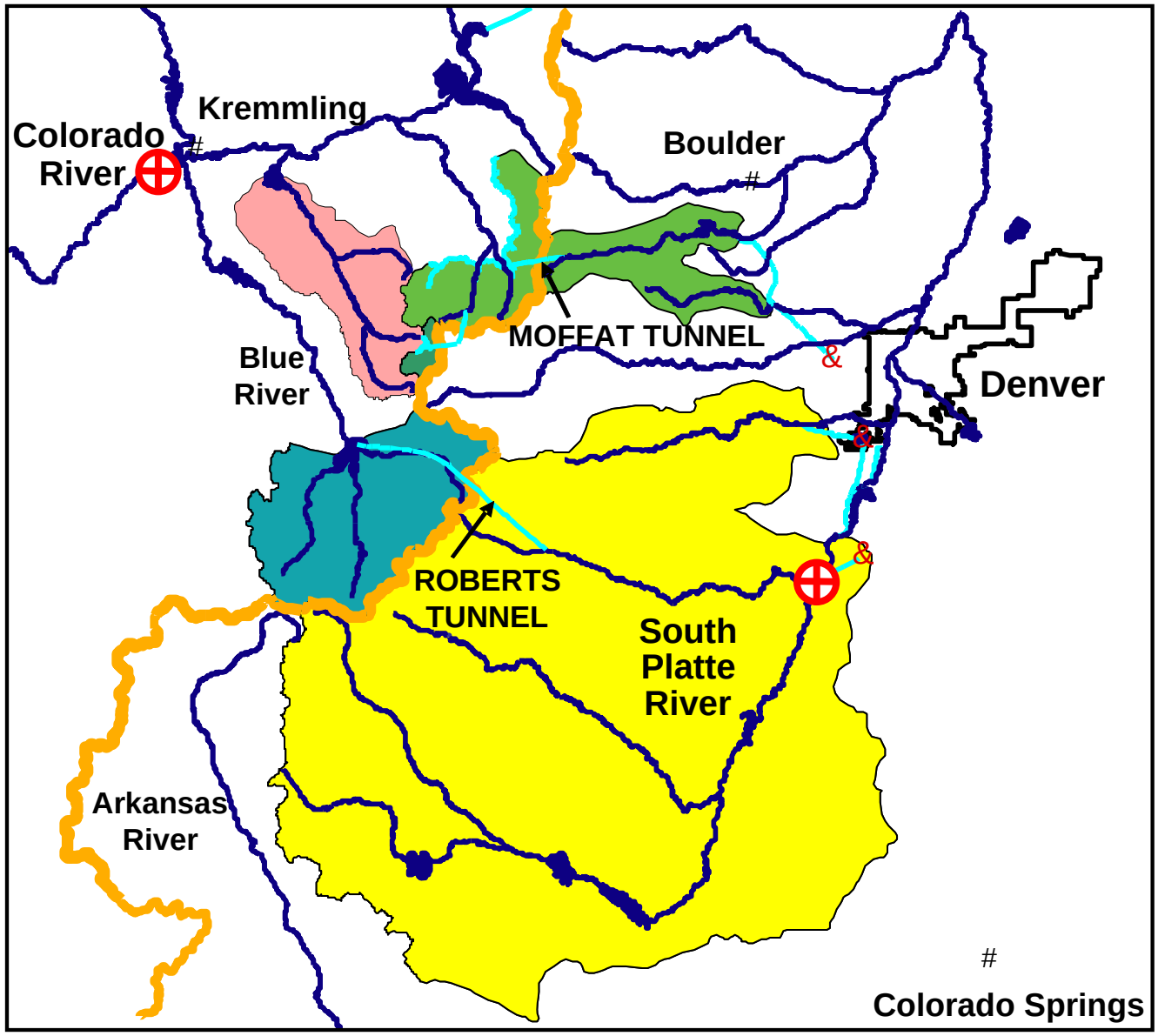
Tree Ring Based Streamflow Reconstructions

- **Use East Slope and West Slope tree ring based stream flow reconstructions.**
  1) **South Platte River at South Platte**
  2) **Colorado River at Kremmling Gage**

- **Tree Ring Data 1634 – 1946**
- **Gage Data 1947 – 2005**
- **Modified PACSM to analyze the longer time frame**

Denver Board of Water Commissioners

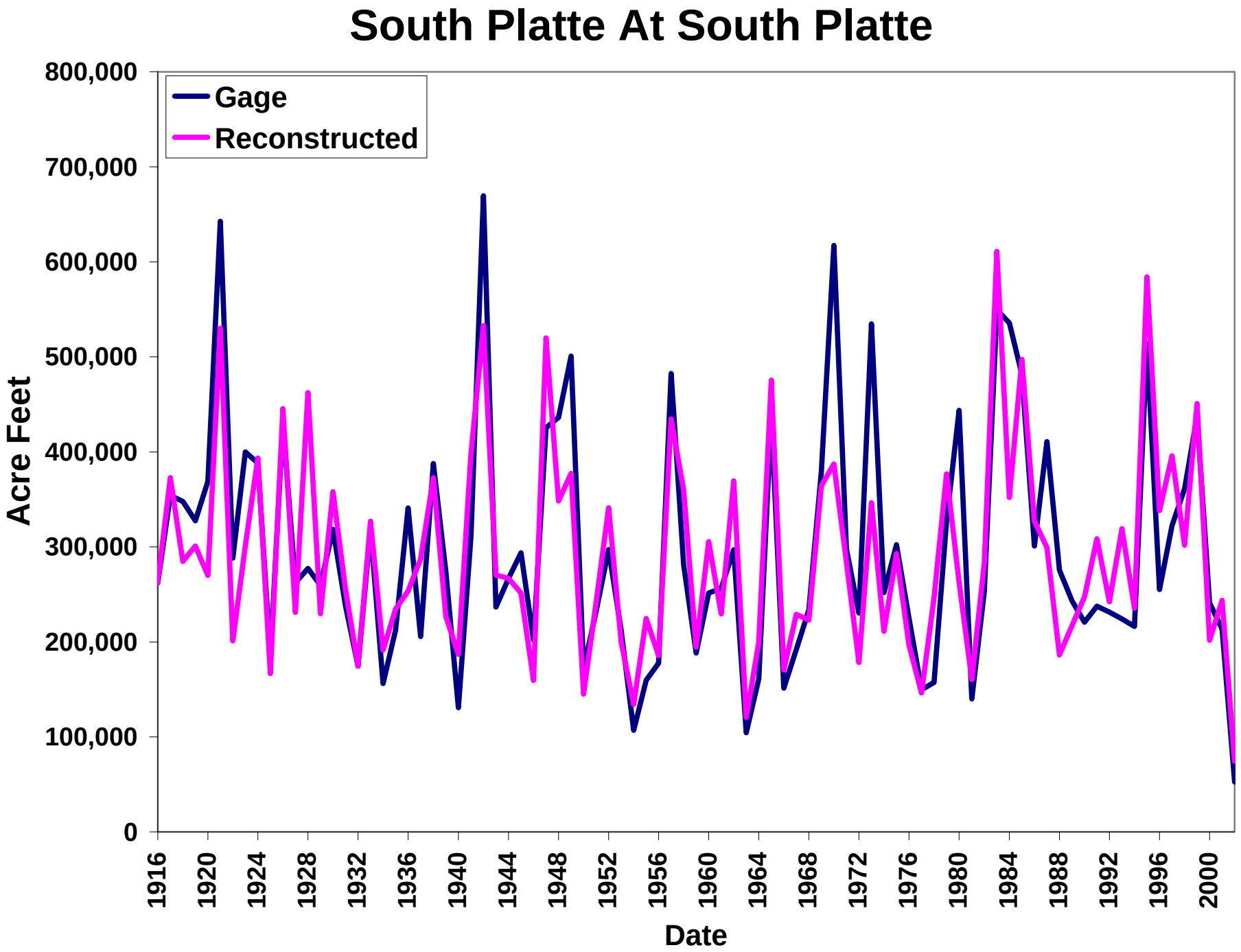
Water Collection System

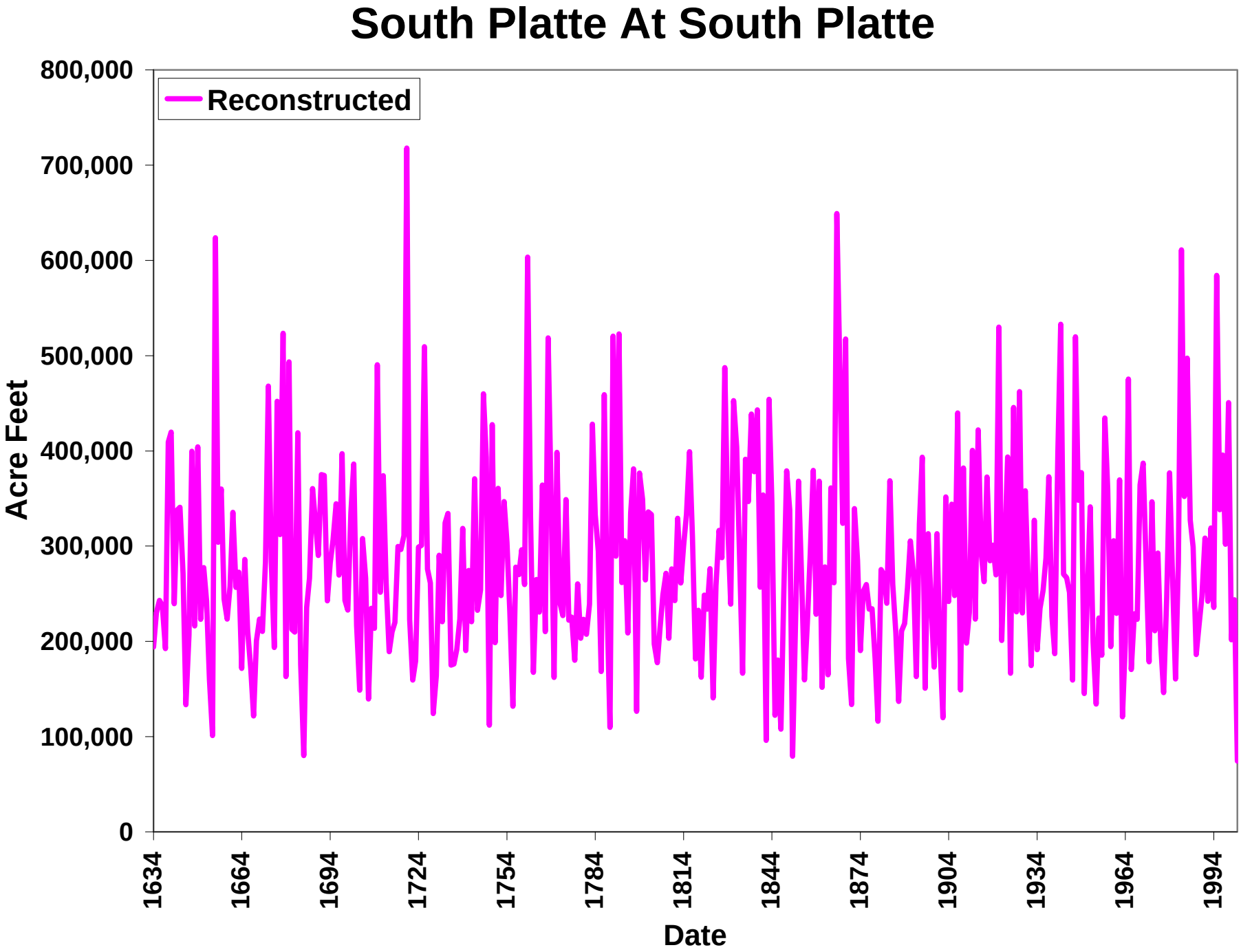


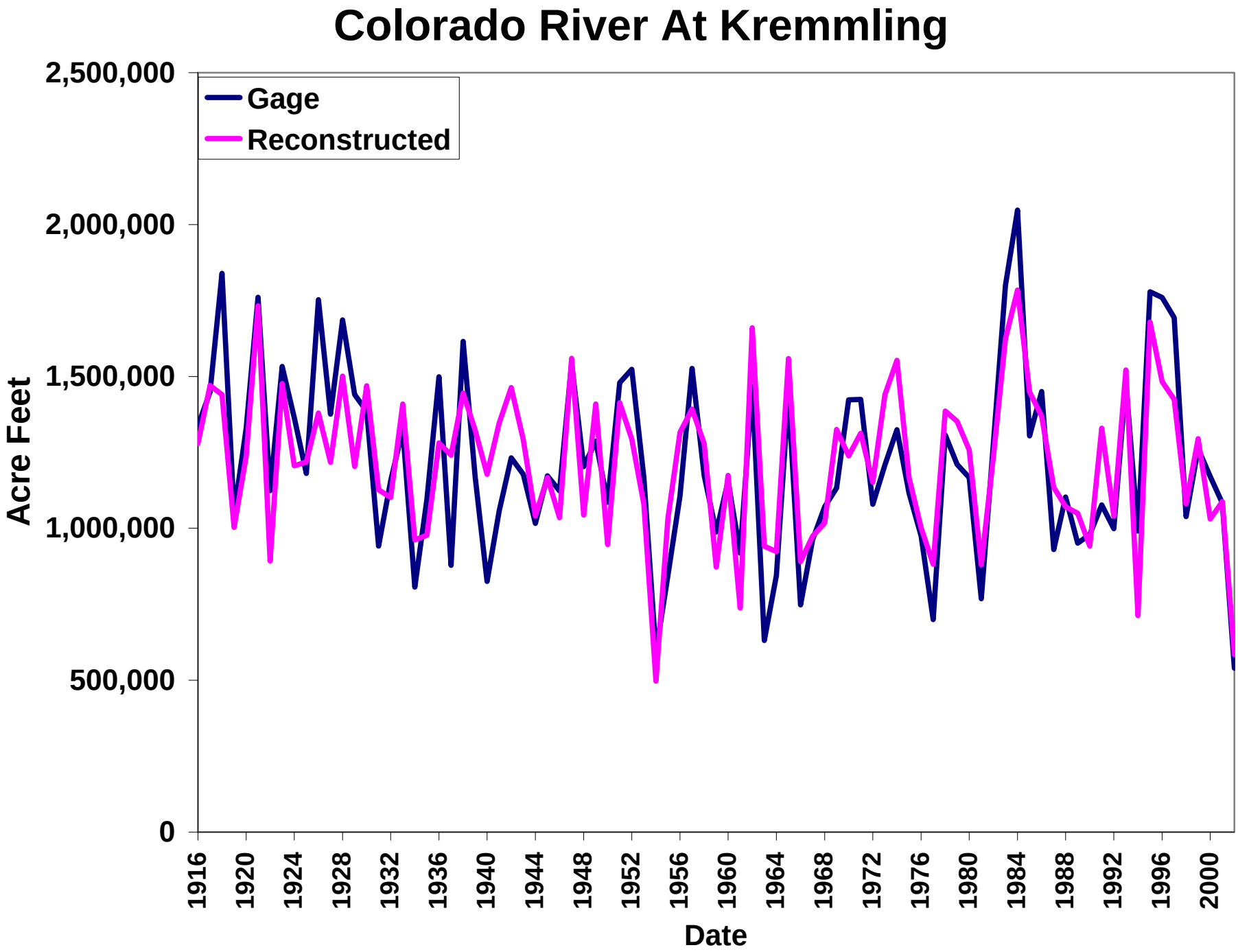
COLLECTION SYSTEMS

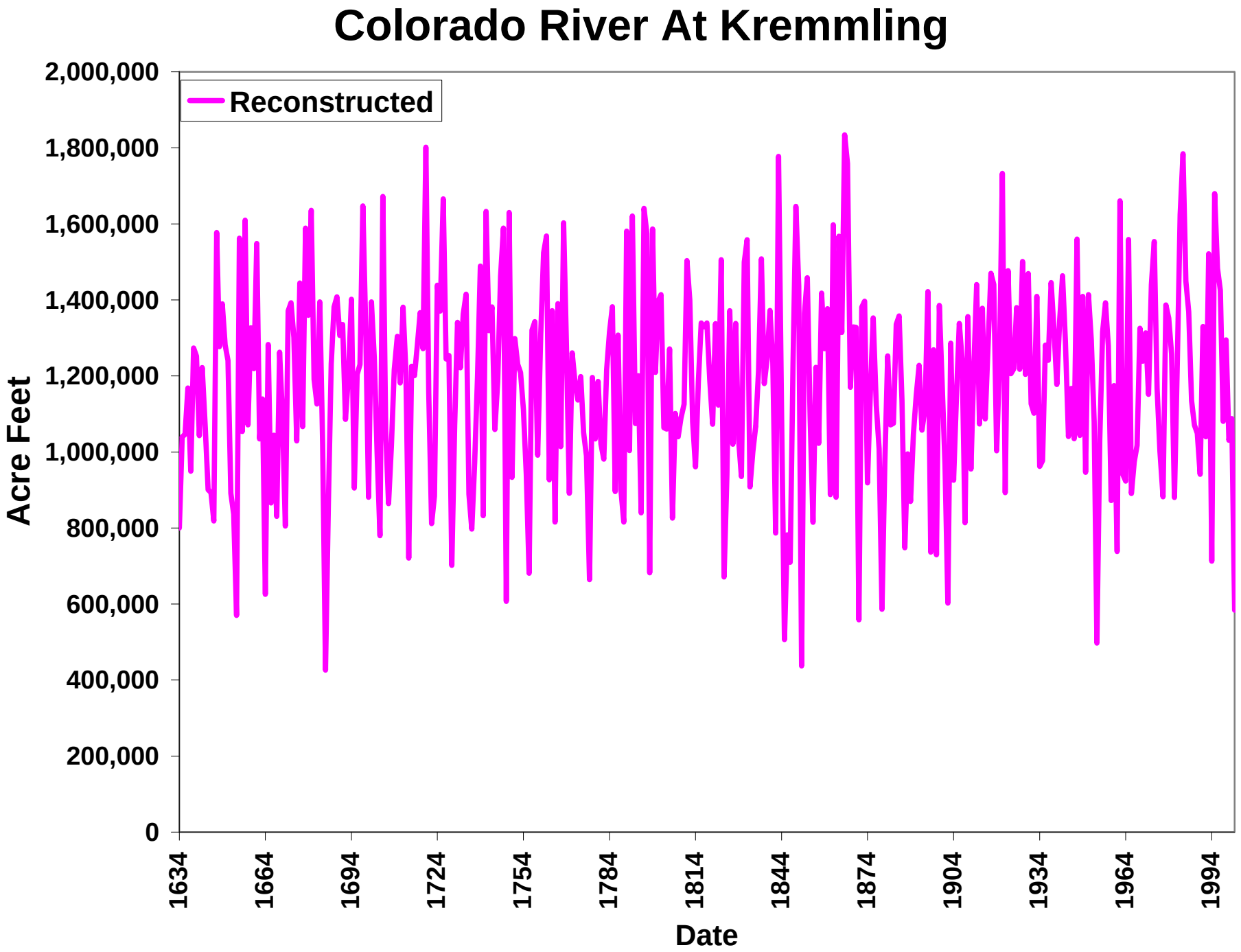
- SOUTH PLATTE
- MOFFAT TUNNEL
- ROBERTS TUNNEL
- WILLIAMS FORK WATERSHED

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


South Platte At South Platte
Gage
Reconstructed
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Acre Feet
1916
1920
1924
1928
1932
1936
1940
1944
1948
1952
1956
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
Date


South Platte At South Platte
Reconstructed
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Acre Feet
1634
1664
1694
1724
1754
1784
1814
1844
1874
1904
1934
1964
1994
Date

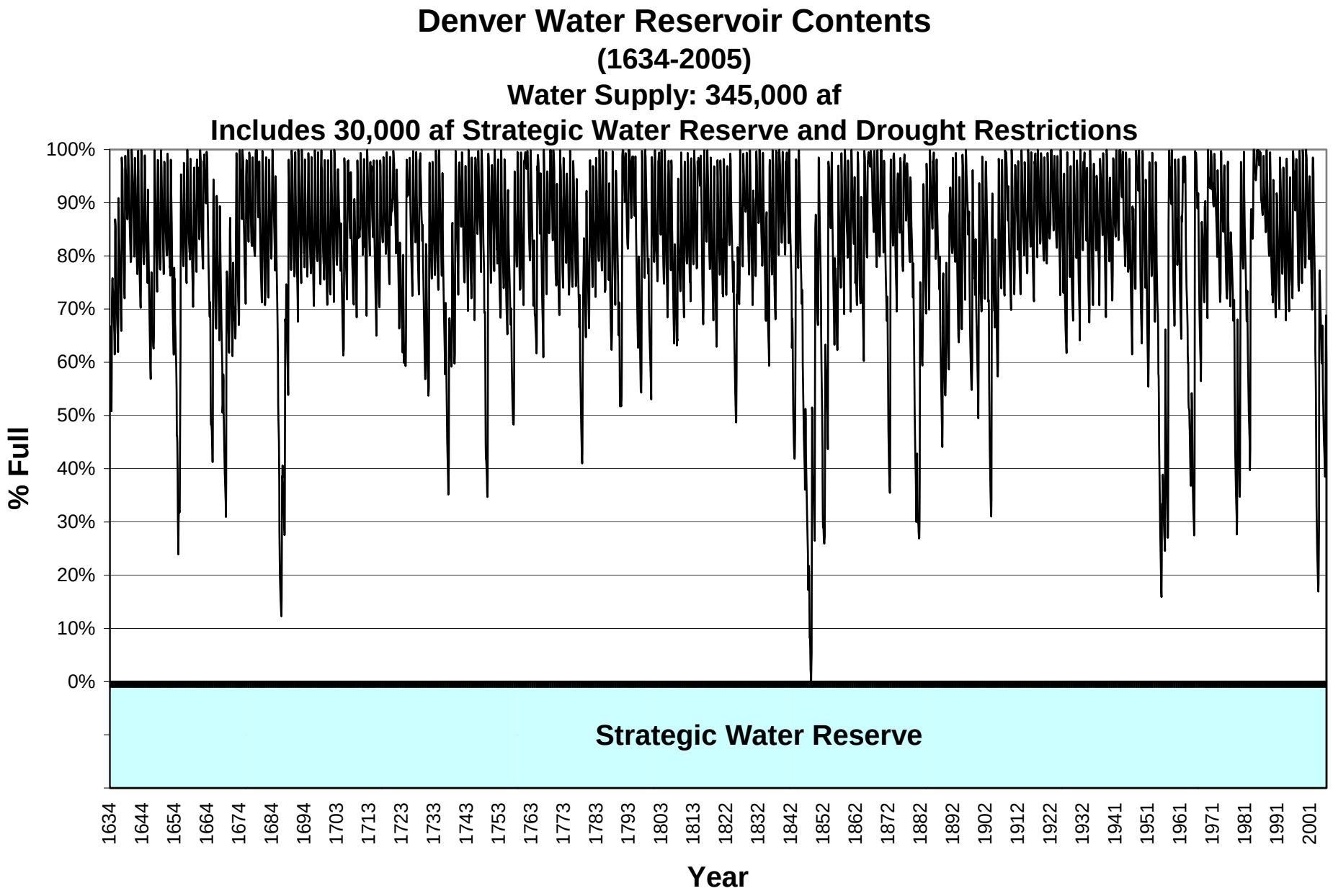

Colorado River At Kremmling
Gage
Reconstructed
Acre Feet
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
1916
1920
1924
1928
1932
1936
1940
1944
1948
1952
1956
1960
1964
1968
1972
1976
1980
1984
1988
1992
1996
2000
Date


Colorado River At Kremmling
Reconstructed
Acre Feet
2,000,000
1,800,000
1,600,000
1,400,000
1,200,000
1,000,000
800,000
600,000
400,000
200,000
0
1634
1664
1694
1724
1754
1784
1814
1844
1874
1904
1934
1964
1994
Date

Tree-Ring Based Streamflow Reconstructions

- Match "Year Type" for East Slope and West Slope
  - Each tree ring year is represented by one of 45 model years with known daily hydrology (e.g., 1963 similar to 1655 on West Slope)
  - Ratio extreme dry years from driest year in 45-year model period
  - Ratio extreme wet years from wettest year in the 45-year period
- Assemble data files as new sequences of model years
- Use PACSM to simulate entire period, currently 1634-2005
  - Determine what level of demand could be met through all tree ring years
  - Determine what level of demand could be met during various dry sequences and corresponding recurrence intervals

After



n:\@wra\becky\presentations\TreeWRestr290k.xls

Draft: IRP Development Process

Limitations of Using Tree Ring-based Reconstructions

- **Although correlations between tree rings and streamflow are generally good, reconstructions are not as sensitive in the extreme wet or dry years.**
- **Using mean values for reconstructions, confidence intervals not used.**
- **From only one number (annual flow), we assume an entire year of daily data.**
- **From one East Slope and one West Slope location, all 450 model nodes are adjusted.**

Major Assumptions

- No Drought Period Worse Than Tree Ring-based Period
- No Adjustments for Potential Global Climate Change
- Perfect Operation of the Water Supply System
- No Loss of Water Rights
- Estimate of Future Demand is Not Exceeded