

Managing Surface Water Resources for Western Oil Shale Development

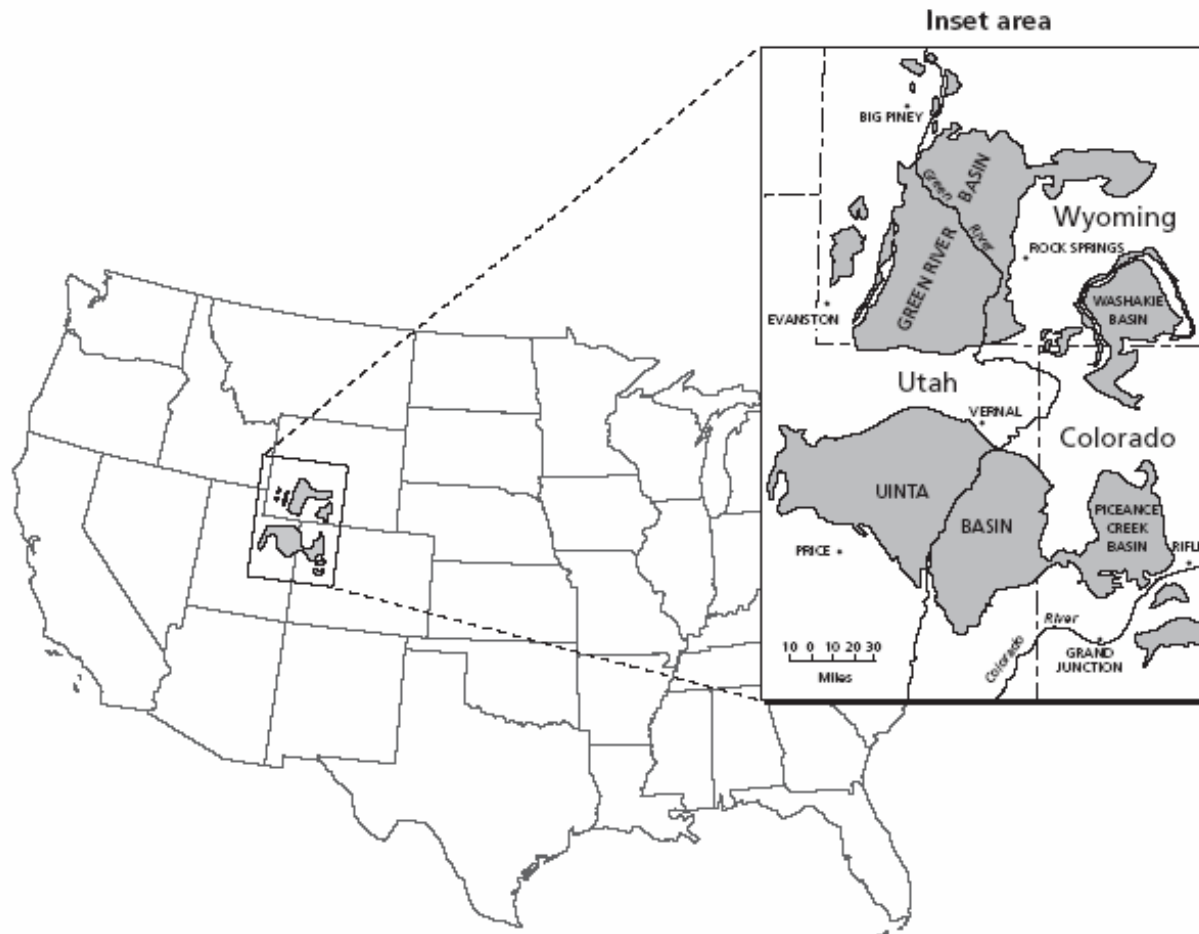
26th Oil Shale Symposium

October 2006

Cathy Wilson and Jean Foster

Western US Oil Shale Resource

Figure 2.1
Location of the Green River Formation Oil Shale and Its Main Basins



SOURCE: Adapted from Smith, 1980.

RAND MG414-2.1

Water Resource Questions

- How much fresh water will be required for commercial oil shale development in the Piceance basin?
- How does climate variability affect surface water availability in the basin?
- How can we manage surface water resources in the Piceance basin to accommodate oil shale development while protecting other water uses?

Projected Oil Shale Development in the USA

Rand Corp. for National Energy Technology Laboratory

Figure 3.4
Stages of Oil Shale Commercial Development

Development stage	Research and development	Scale-up and confirmation	Initial commercial operations	Production growth	
Facility size	Laboratory to pilot plant	1,000–5,000 bpd ^a	> 50,000 bpd	> 100,000 bpd	
Years to transition ^b	0	6–8	12–16	>20	>30
Total production (million bpd)	N/A	N/A	>0.1	>1	>3

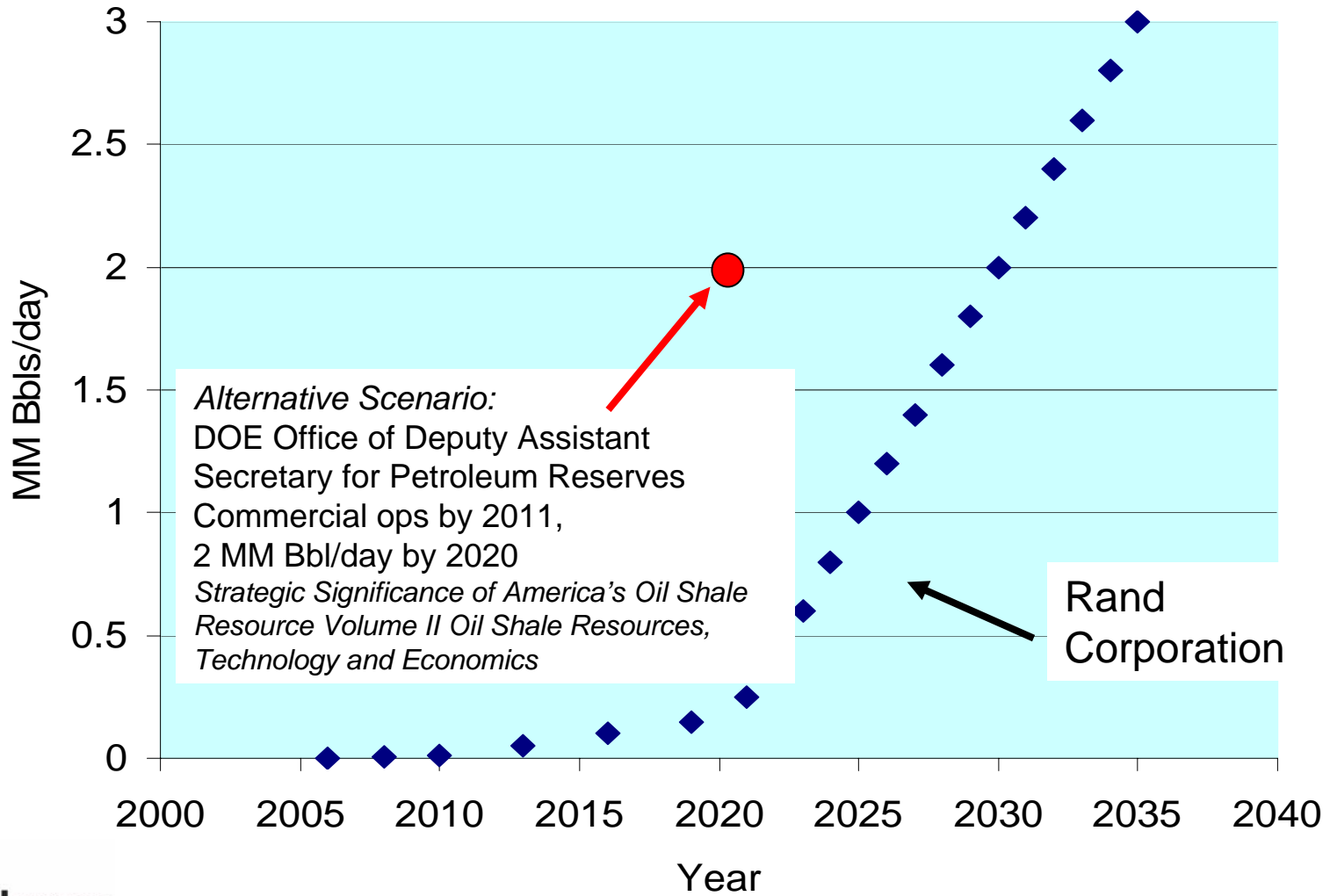
^abpd = barrels per day.

^bBeginning with transition from research and development.

RAND MG414-3.4

James T. Bartis, Tom LaTourrette, Lloyd Dixon,
D.J. Peterson, Gary Cecchine

Projected Oil Shale Development in the USA



Water Assumptions and Requirements

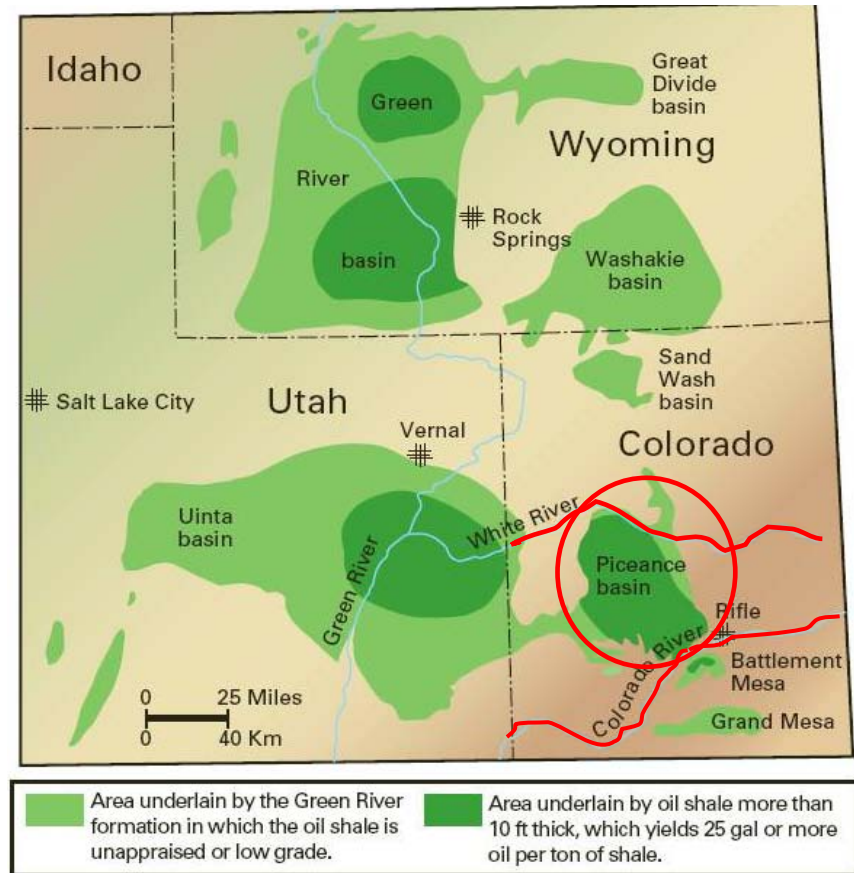
- 3 Bbls water per Bbl shale oil product, (U.S. Water Resources Council, 1981)
- 2.1 to 5.2 Bbls of water per Bbl of shale oil product (OTA, Volume I, 1980)

3 Bbl of Water per Bbl oil product		
Oil products (Bbls/day)	Water (cfs)	Water (acre-ft/yr)
250000	49	35283
500000	97	70569
1000000	195	141137
2000000	390	282275

Water Resources in the Piceance Basin

- Mean flow on the White River near Rangely ~ 740 cfs or ~ 533,560 acre-ft/yr.
- Mean flow on the Colorado River at the State line ~ 6130 cfs or 4,437,900 acre-ft/yr.
- 2 MM Bbls/day oil production would require approximately 282,275 acre-ft/yr or an additional 5.6% of combined flows of the White and Colorado Rivers at the Utah Border*.
- Colorado uses about 59% of its current Colorado River allotment.

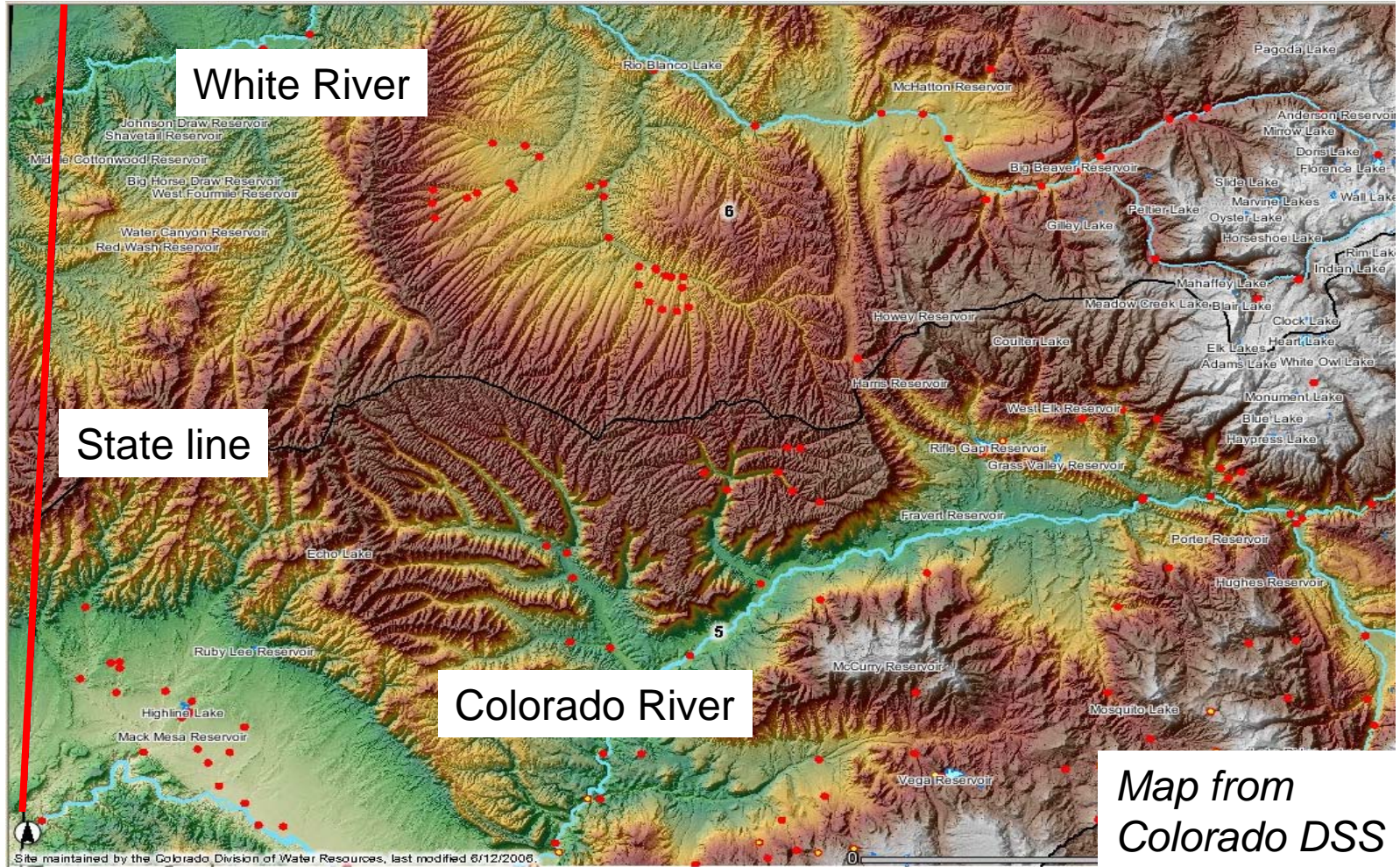
* *At 3 Bbls of water per Bbl of oil shale product*



Source: Oil and Gas Journal,

<http://www.fe.doe.gov/programs/reserves/publications/Pubs-NPR/40010-373.pdf>

Managing Water Resources to Accommodate Oil Shale Development



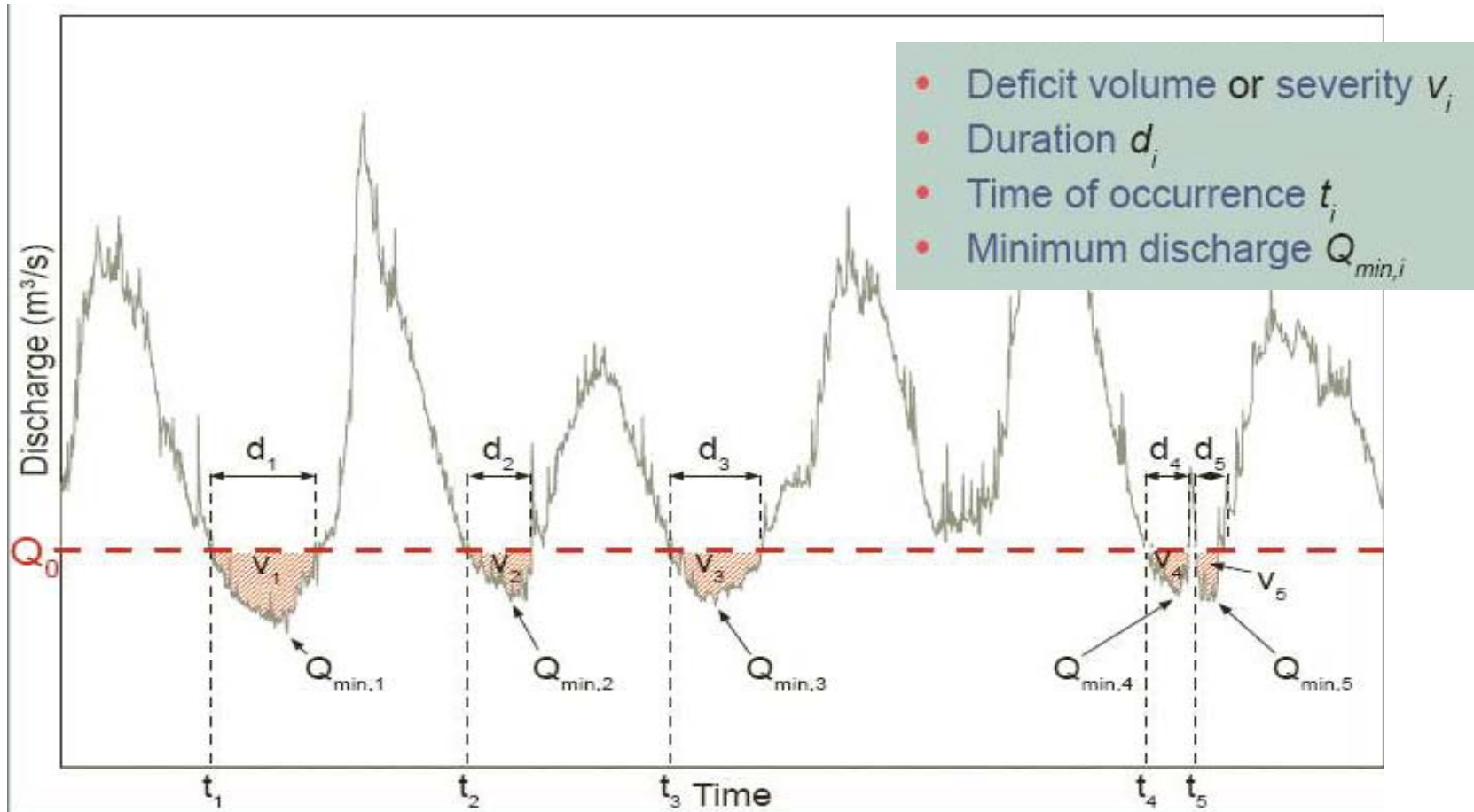
Map from Colorado DSS

Impact of Climate Variability of Water Resource

- Define low flow as one or more thresholds of interest:
 - Minimum instream flow
 - Minimum instream flow + other existing uses*
 - Minimum instream flow + other existing uses* + new demand
- Determine frequency of low flow(s) from historical record
- Determine additional reservoir storage requirements for the Piceance Basin to preserve minimum instream flows and other uses

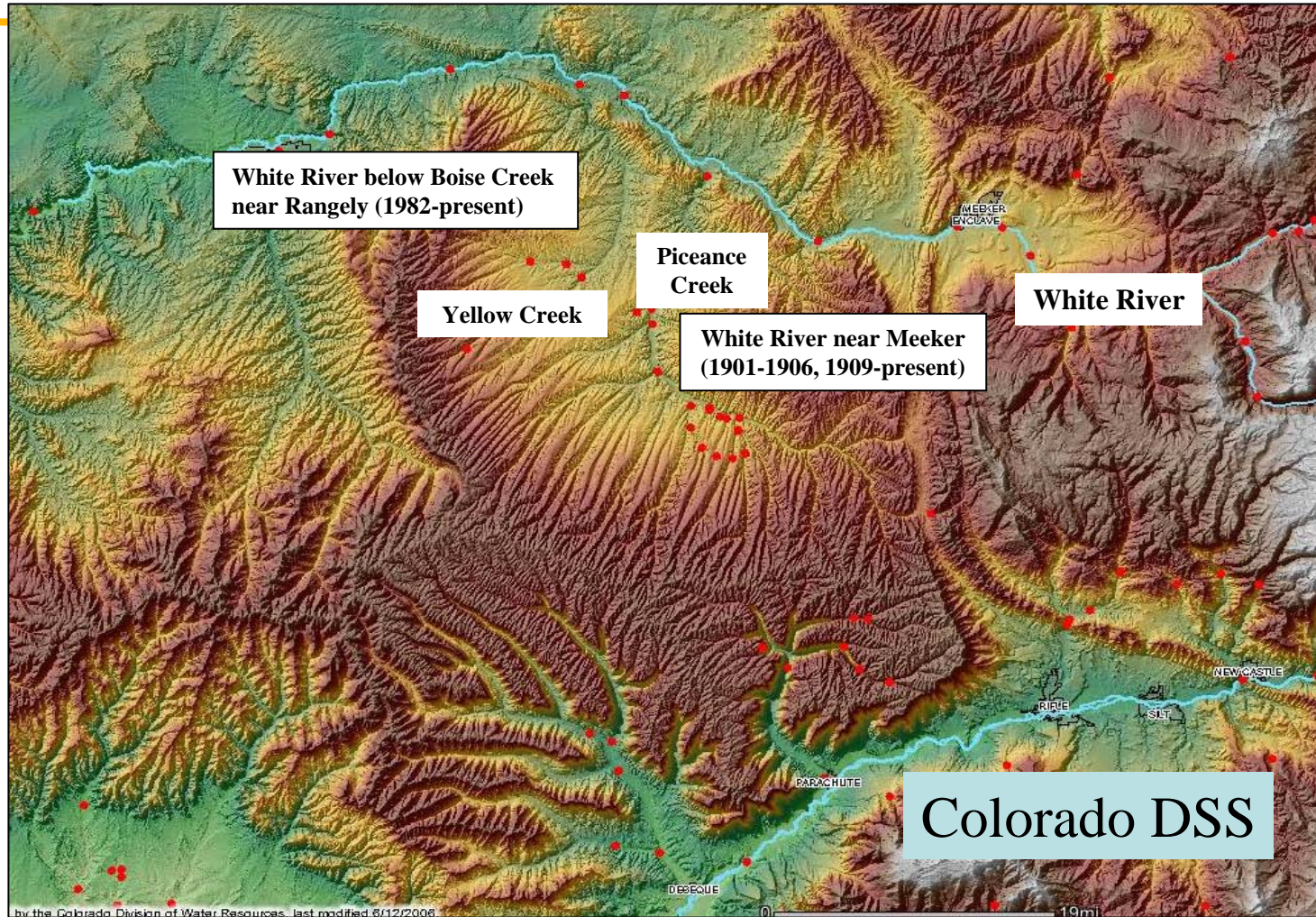
* Note: Historic flow records already include the existing diversions

Hypothetical Thresholds for Low Flow / Climate Variability Analysis



Source: A global evaluation of streamflow drought characteristics, Fleig et. al., http://meetings.copernicus.org/egu2006/download/poster_fleig.pdf

Initial Analysis Performed for White River

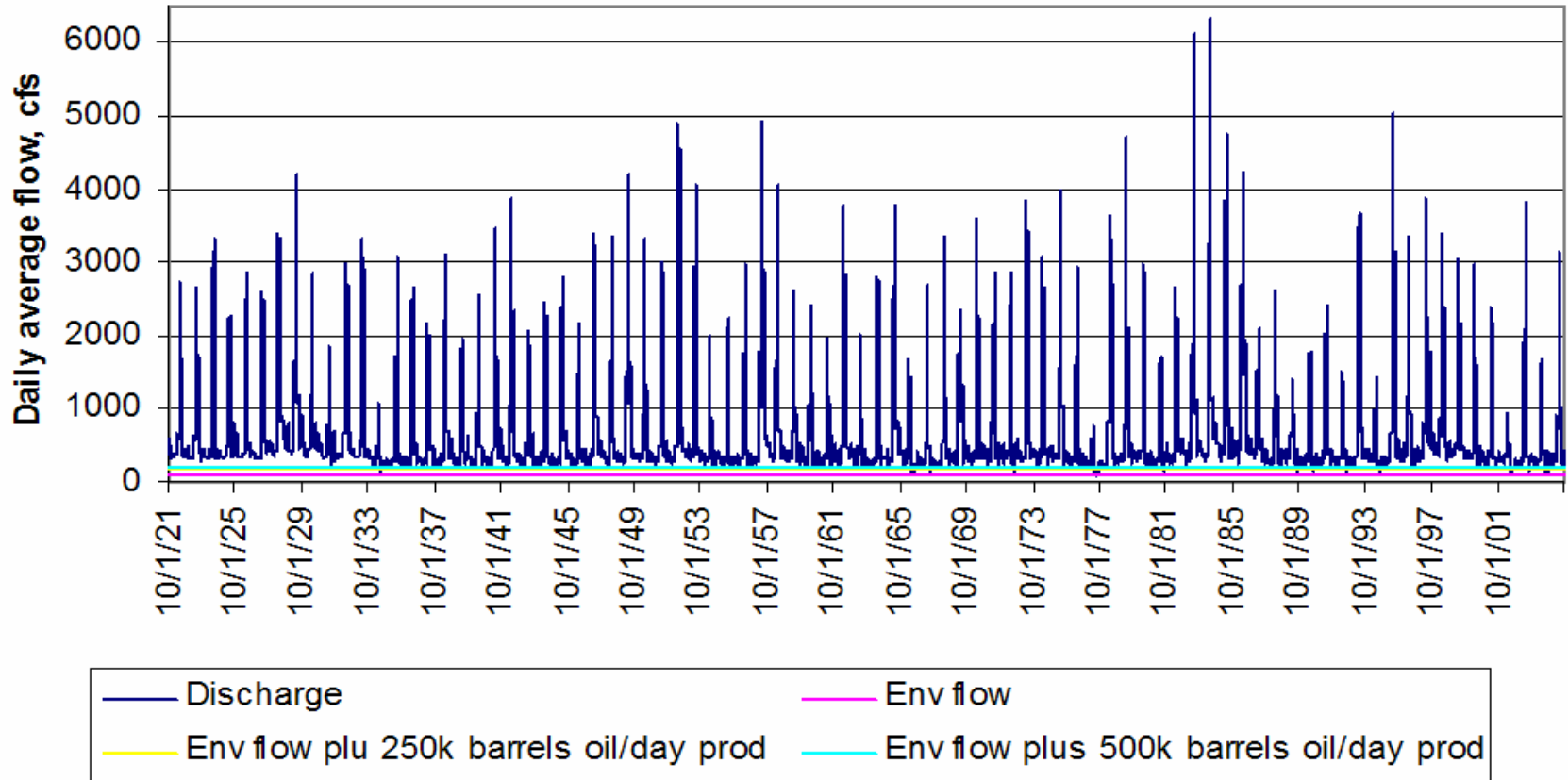


White River Low Flow Frequency Analysis

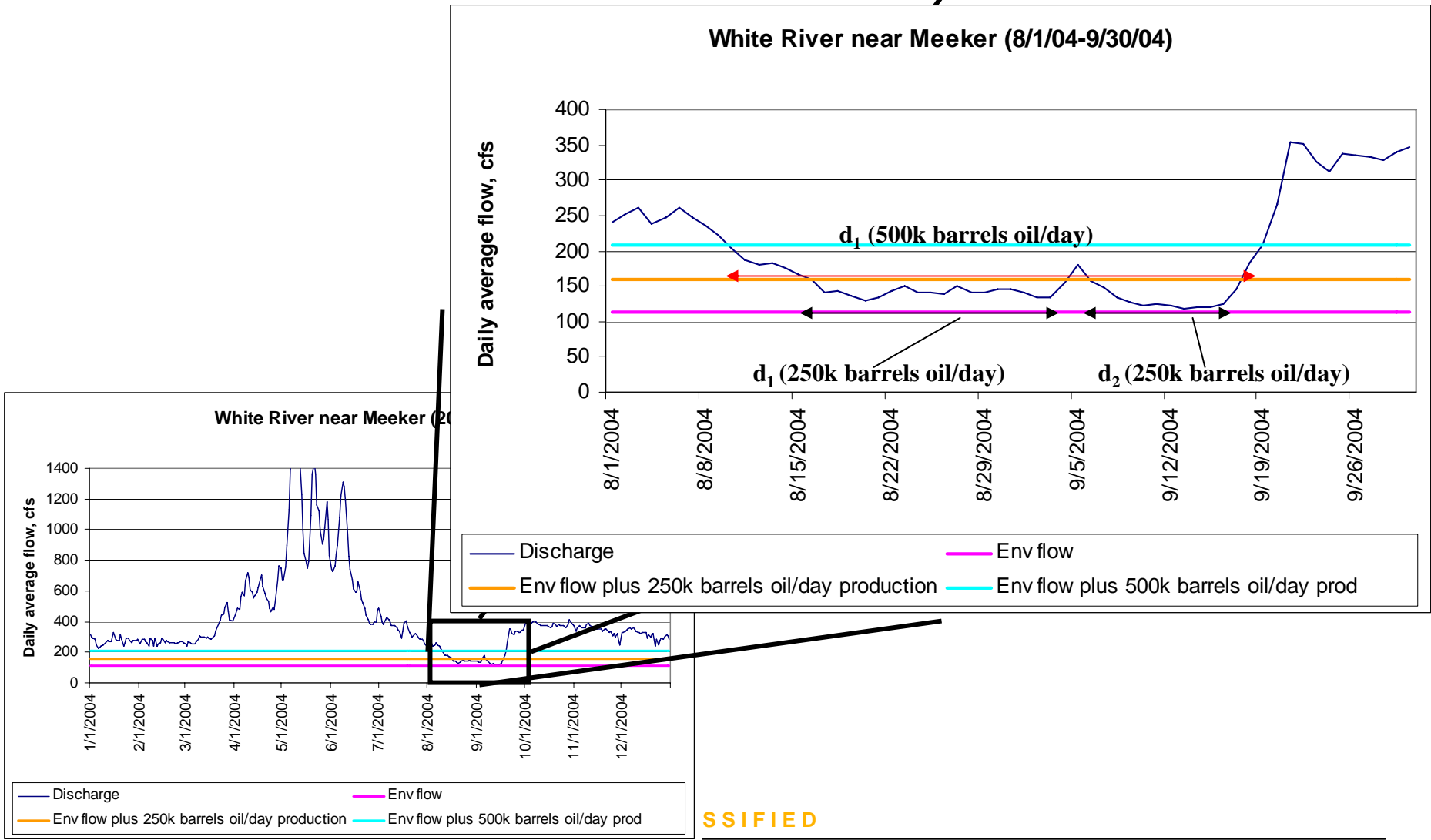
Threshold description	Minimum threshold values	
	White below Boise (cfs)	White near Meeker (cfs)*
(1) Min environmental flow for White River	200	113.09
(2) Min flow plus flow to support 250k barrels oil/day production	248.7	159.98
(3) Min flow plus flow to support 500k barrels oil/day production	297.5	206.95

White River Low Flow Frequency Analysis

White River near Meeker (1921-2005)

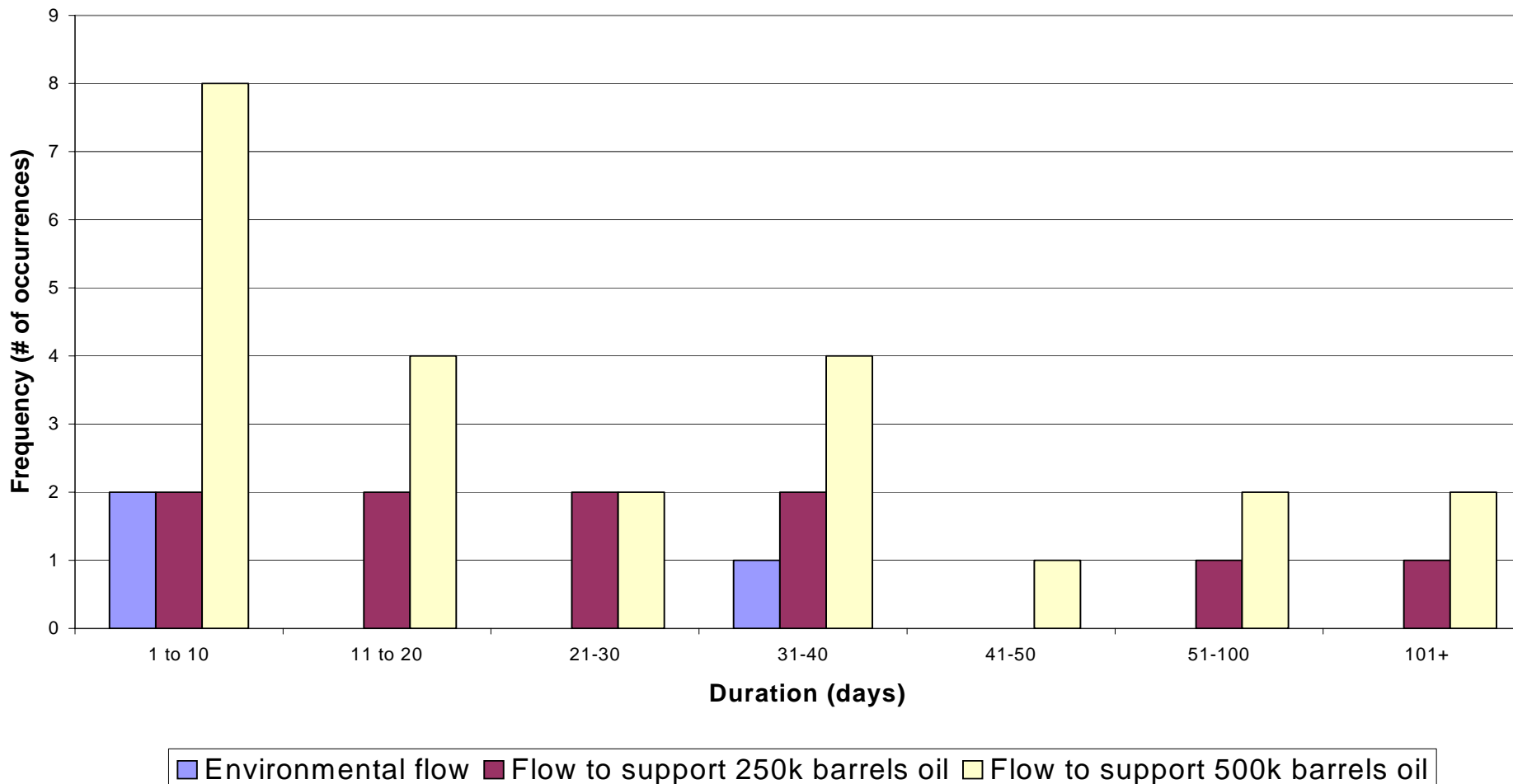


White River Low Flow Frequency Analysis

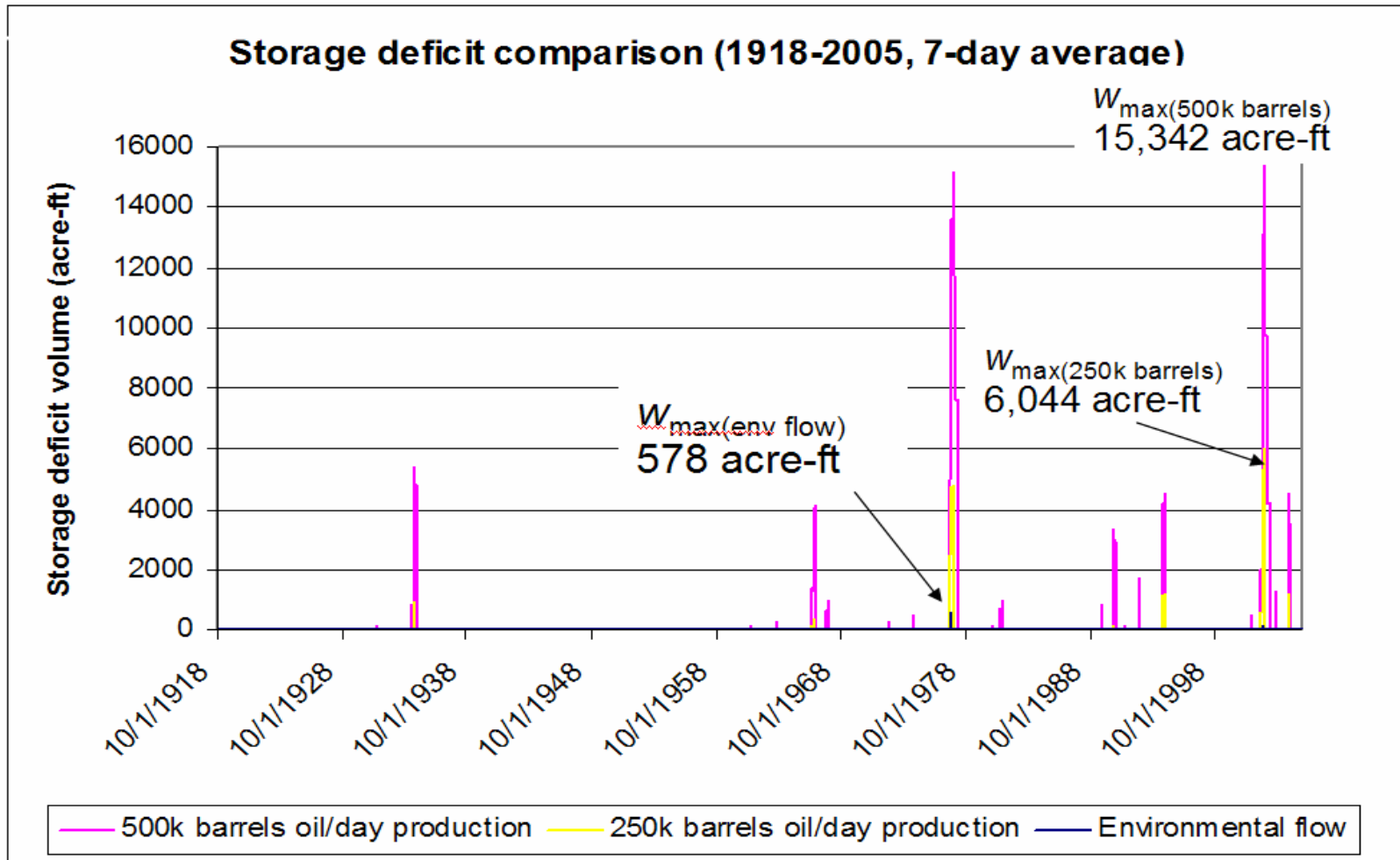


White River Low Flow Frequency Analysis

Duration-frequency analysis using 7-day averages of daily flow
(1901-1906, 1909-2005)

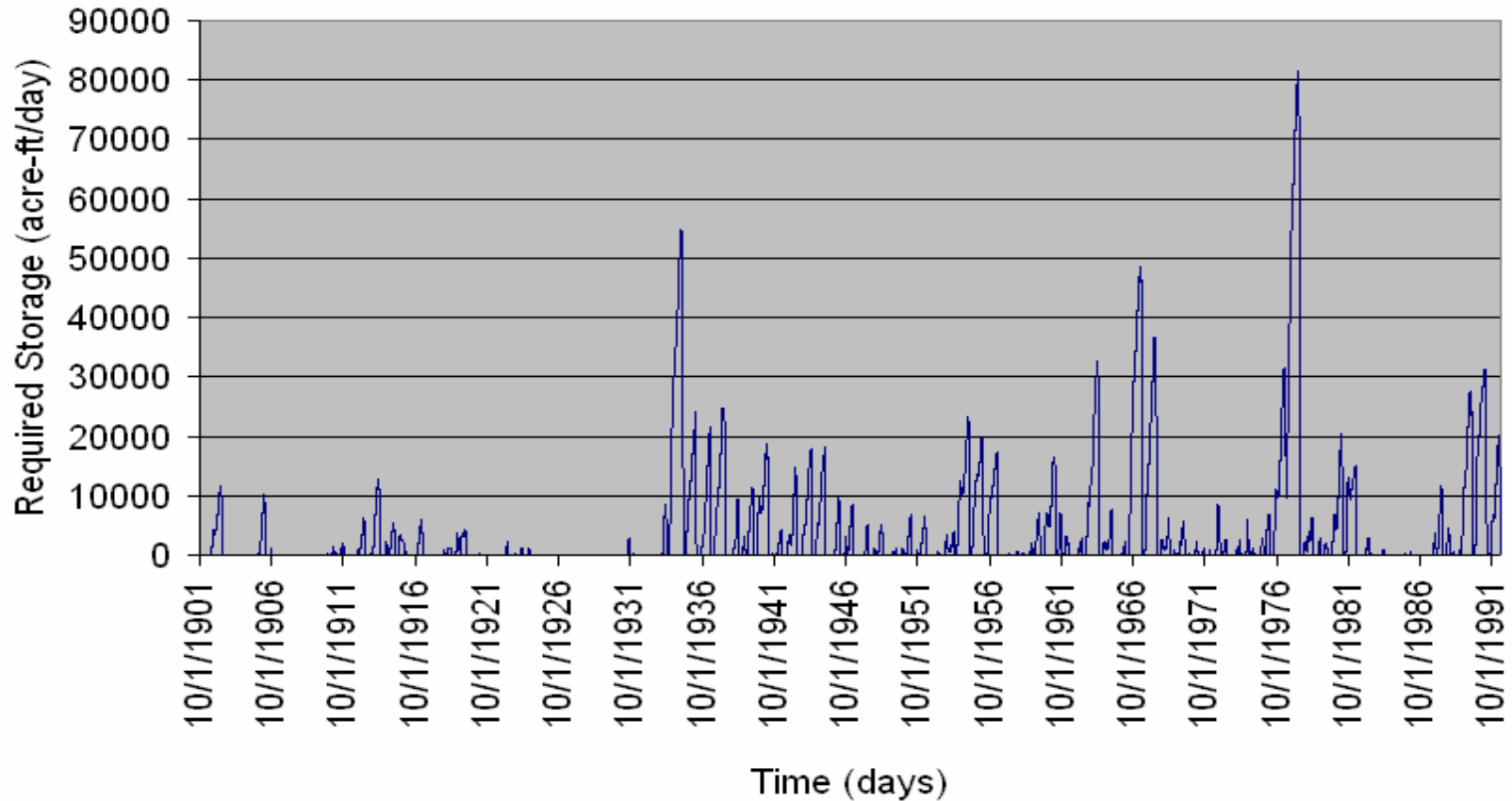


Managing Surface Water to Accommodate Oil Shale Production



Managing Surface Water to Accommodate Oil Shale Production

1.25 M BBIs/day



Conclusions

- The White River is able to support instream flows, current diversions and oil shale production of 500,000 Bbls/day with implementation of additional reservoir storage of ~ 16,000 acre-feet.
- Commercial production at levels of 1-3 MM Bbls/day will require additional withdrawals from the Colorado or other rivers in Western CO, and additional reservoir storage to meet diverse water needs.
- Surface water resource analyses for production rates of 1-3 MM Bbls/day are underway.
- The Colorado River allotment to the State of Colorado is about 3.9M acre-feet per year. 2 MM Bbls/day oil shale production will require ~ 5.6% increase in development of this allotment.