Impacts to Streamflow in the Republican River Basin

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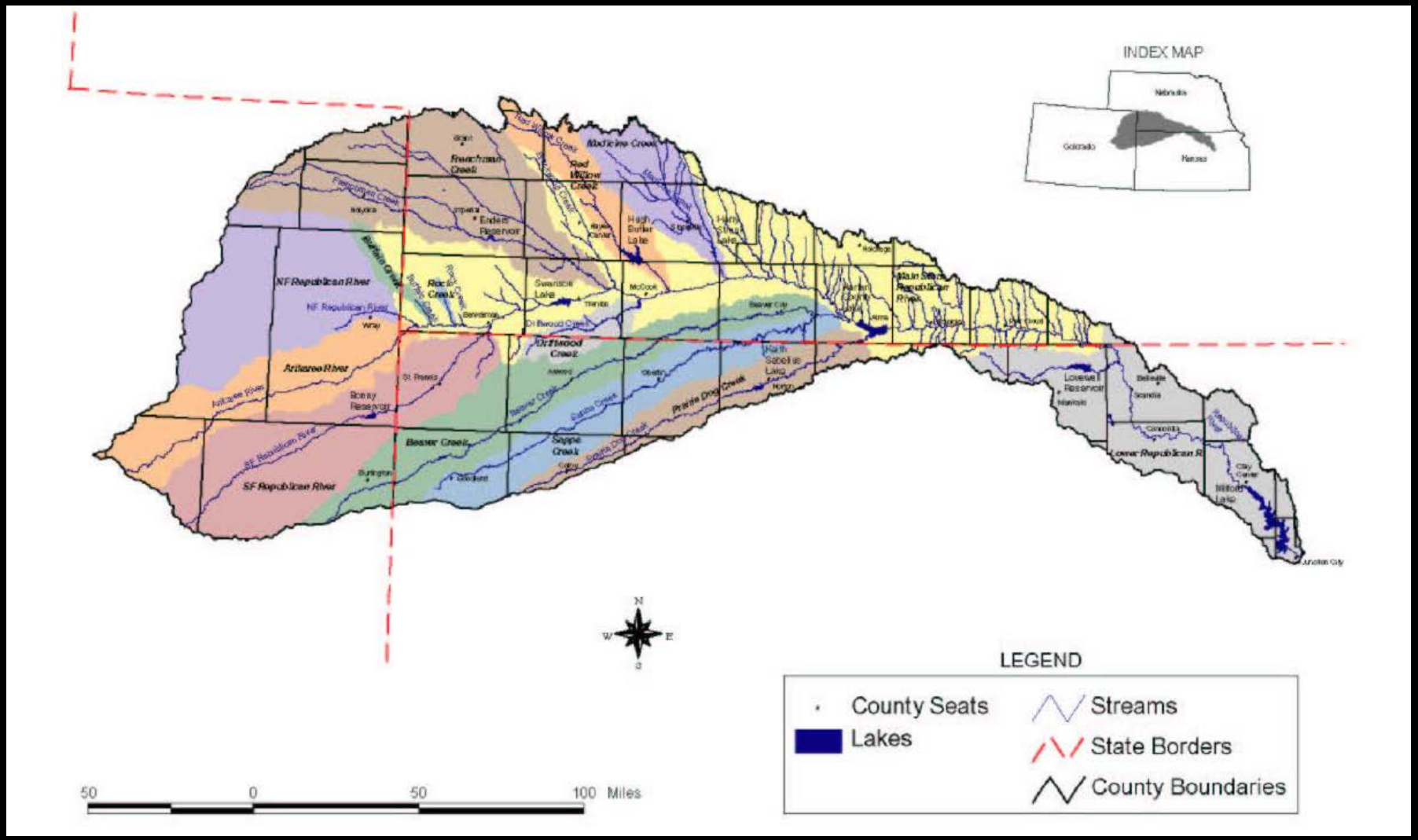
Nebraska
Department of Natural Resources

Overview

- Past impacts to Republican River surface water supply – trends and correlations
- More recent water supply impacts
- Benefits of the current IMPs
- Example of conjunctive management successes – Platte River

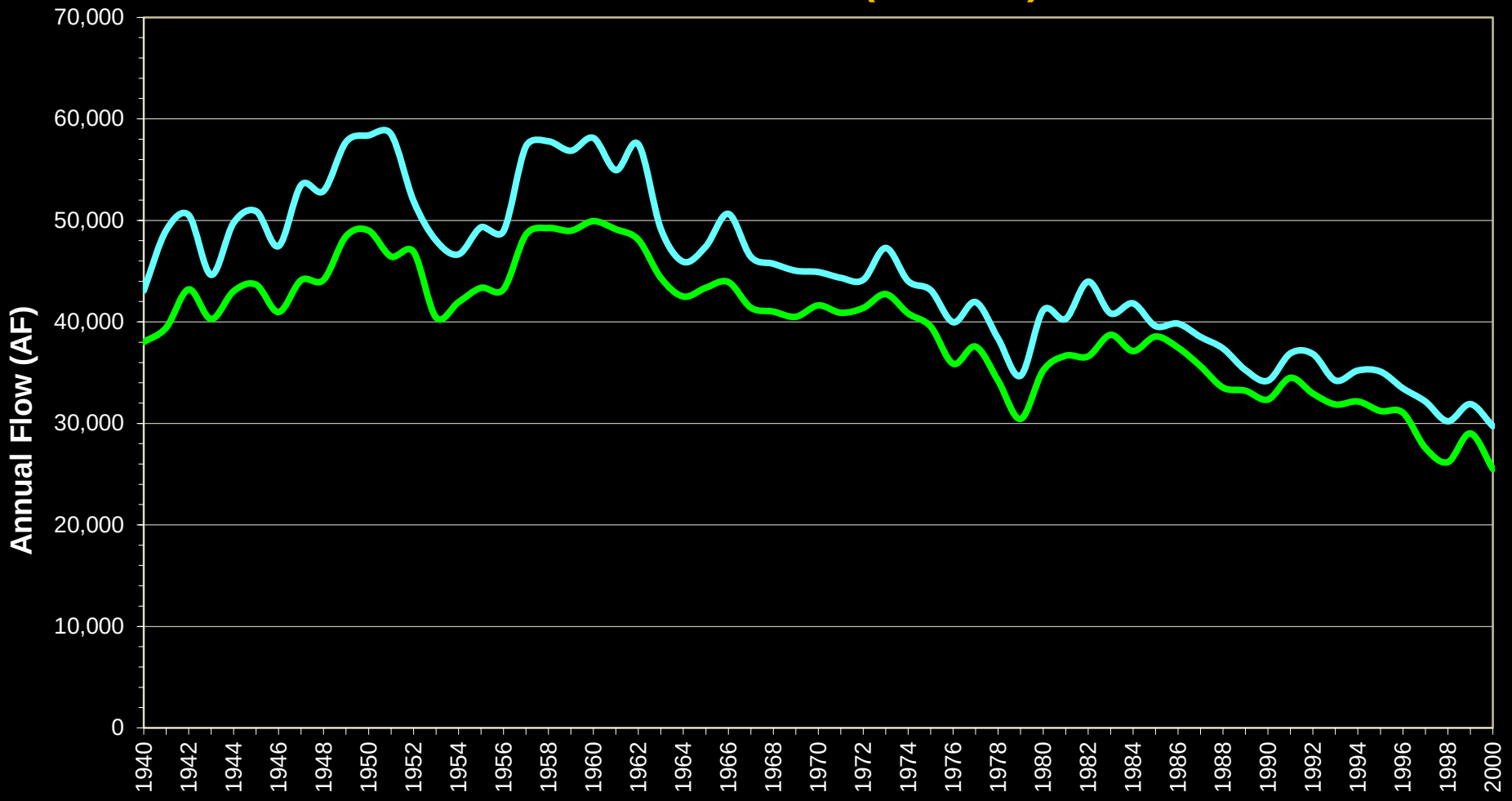
Republican River Basin



Data developed and summarized by the RRCA modeling committee

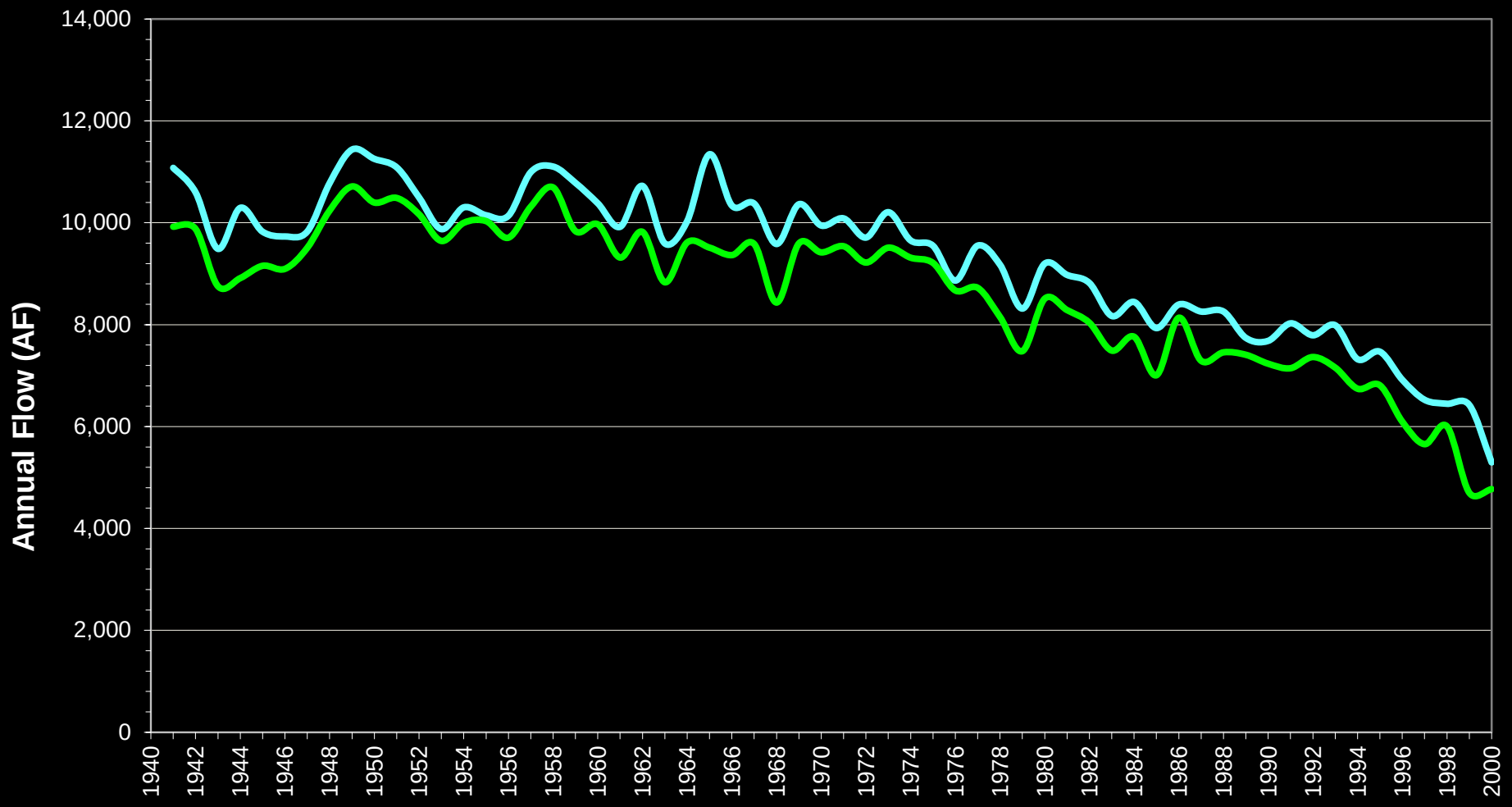
TRENDS IN STREAMFLOW AND BASEFLOW

Estimated Baseflow - North Fork of Republican River at the Colo-Neb Stateline (6823000)



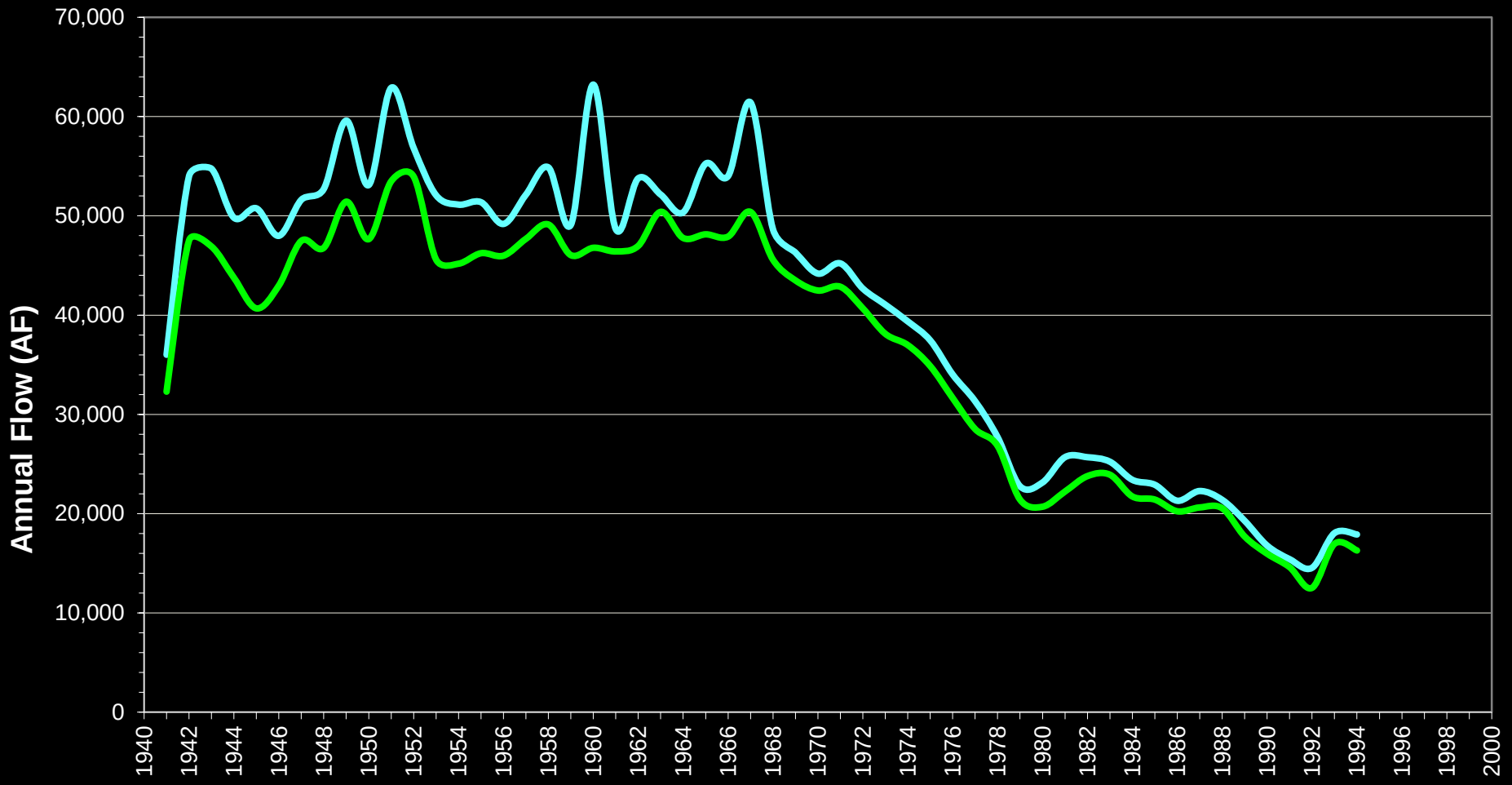
(values in AF)	Avg. 1950-1964	Avg. 1986-2000	Difference
Total	53,287	34,730	**-18,558**
Baseflow	46,139	31,616	**-14,523**

Estimated Baseflow - Rock Creek at Parks, Ne. (6824000)



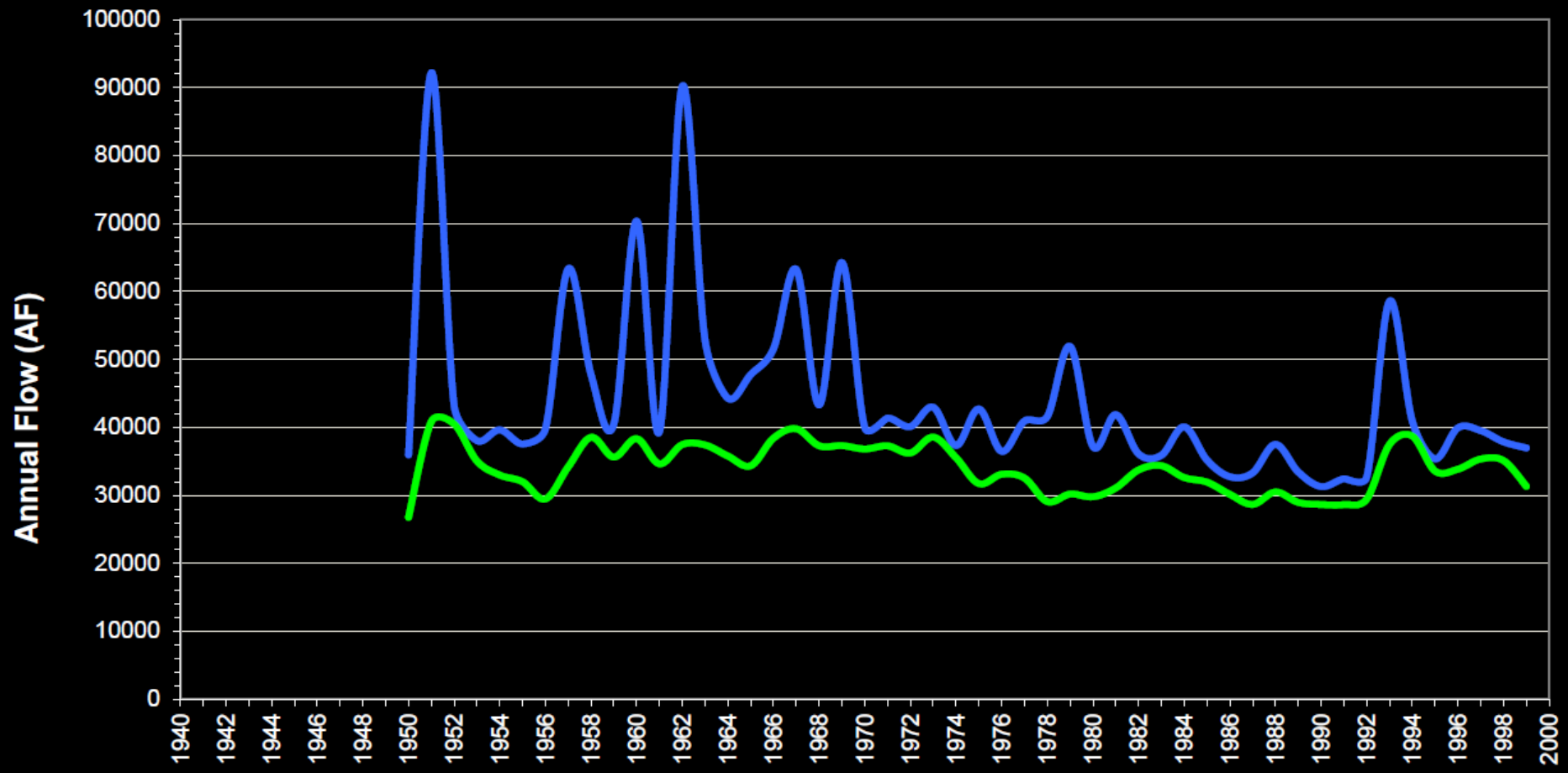
(values in AF)	Avg. 1950-1964	Avg. 1986-2000	Difference
Total	10,546	7,370	**-3,086**
Baseflow	9,922	6,665	**-3,257**

Estimated Baseflow - Frenchman Creek near Imperial, Ne (6831500)



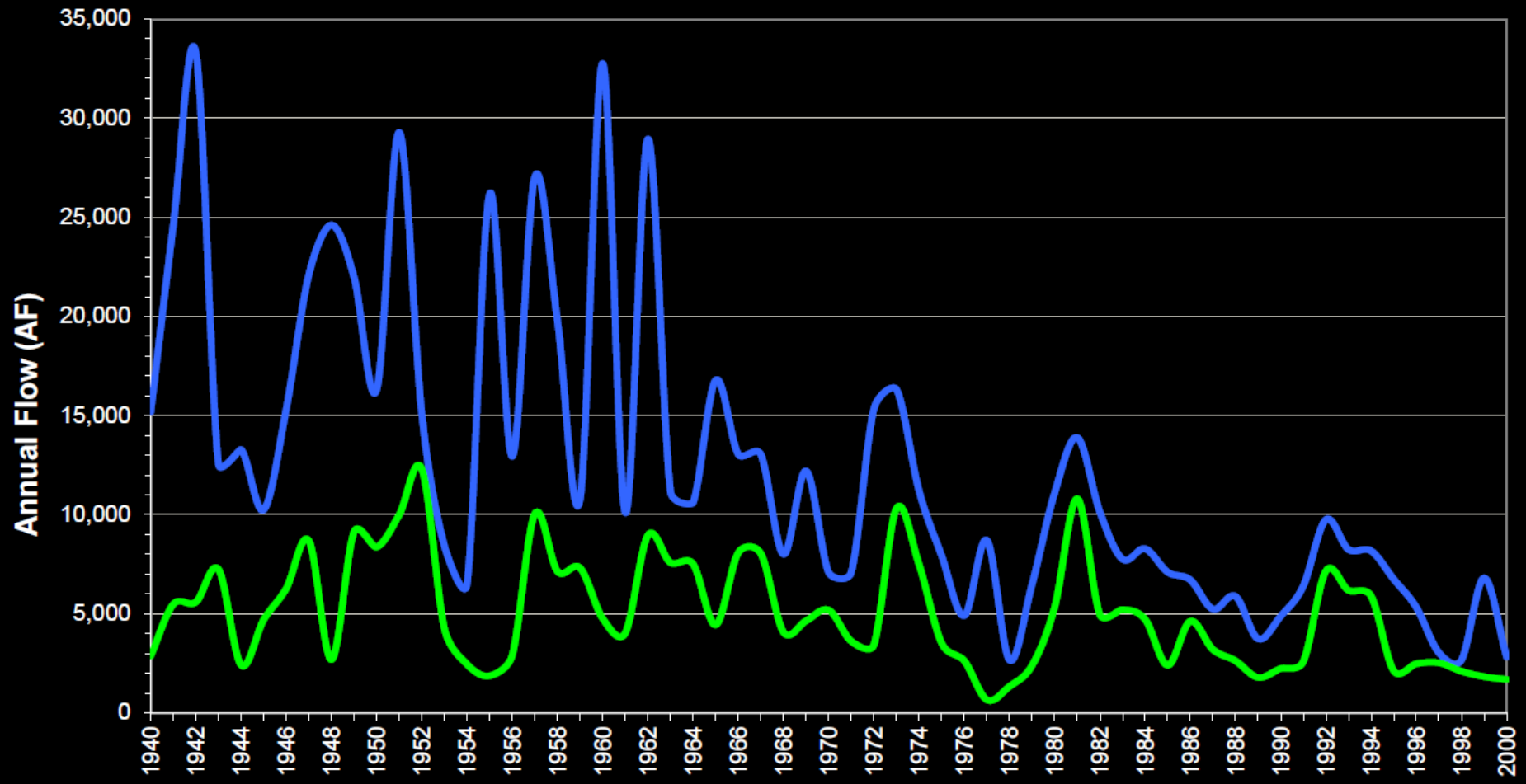
(values in AF)	Avg. 1950-1964	Avg. 1986-2000	Difference
Total	53,390	18,552	**-34,838**
Baseflow	47,952	17,278	**-30,674**

Estimated Baseflow - Medicine Creek above Harry Strunk Lake, Ne (6841000)



(values in AF)	Avg. 1950-1964	Avg. 1986-2000	Difference
Total	51,686	37,350	-14,336
Baseflow	35,332	32,198	-3,134

Estimated Baseflow - Arikaree River at Haigler, Ne. (6821500)



(values in AF)	Avg. 1950-1964	Avg. 1986-2000	Difference
Total	17,729	5,766	**-11,962**
Baseflow	6,636	3,275	**-3,360**

Observations Based on Trends

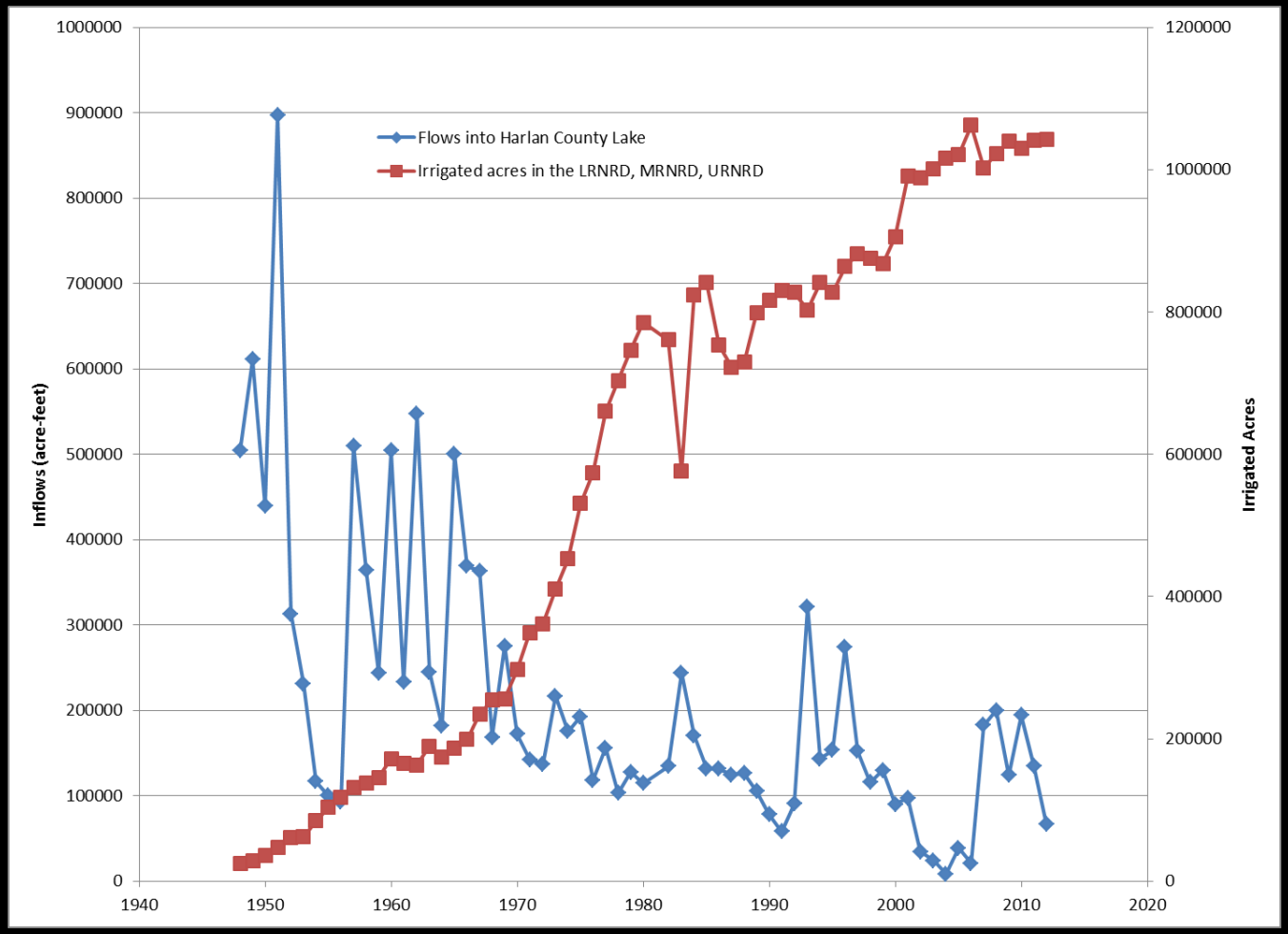
- Streamflows have generally declined in the Basin, particularly in the western and central portions

- There are noticeable declines in both baseflow and runoff

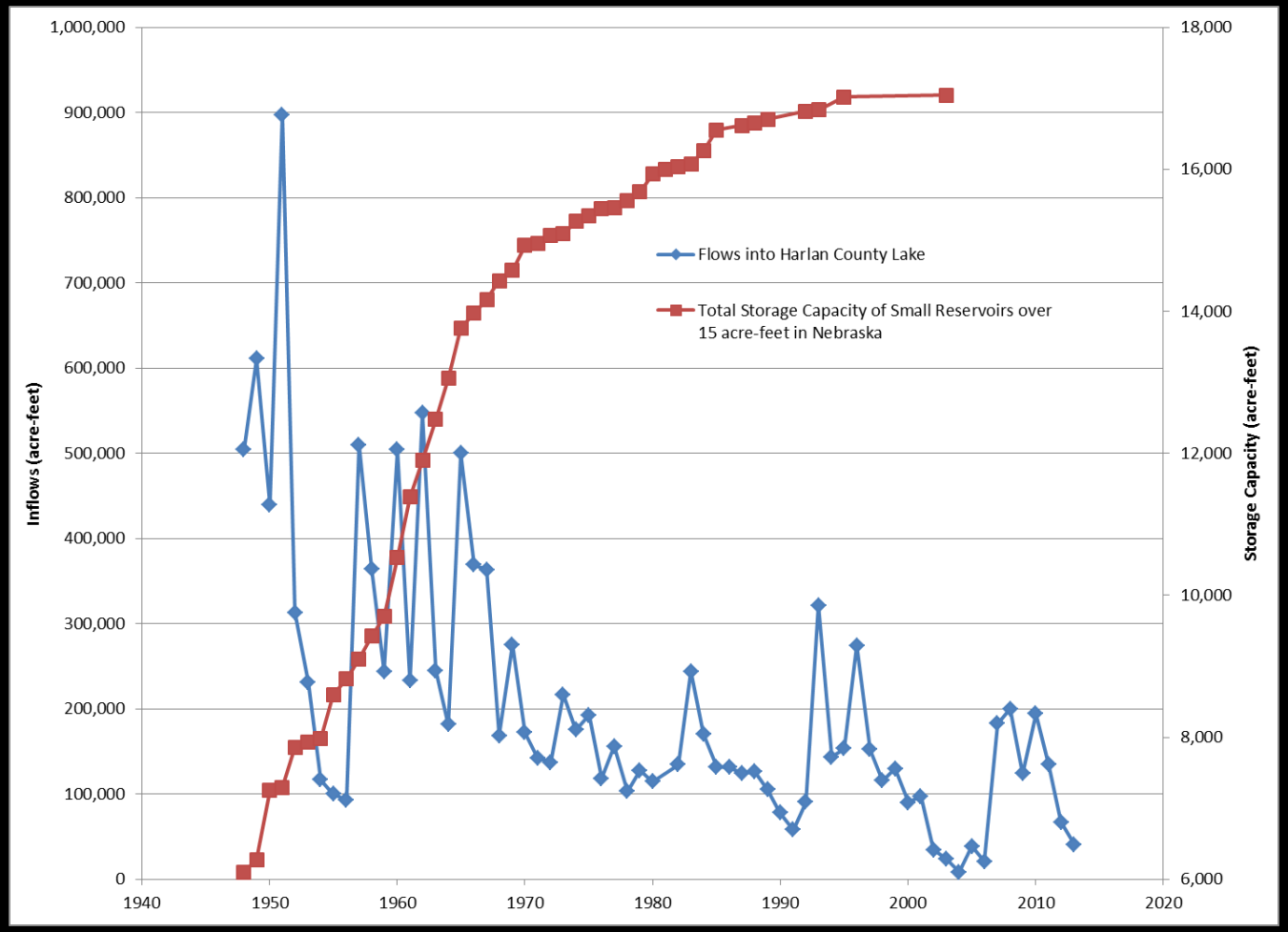
Comparison between inflows to Harlan County Lake and other changes in the Republican River Basin

CORRELATIONS

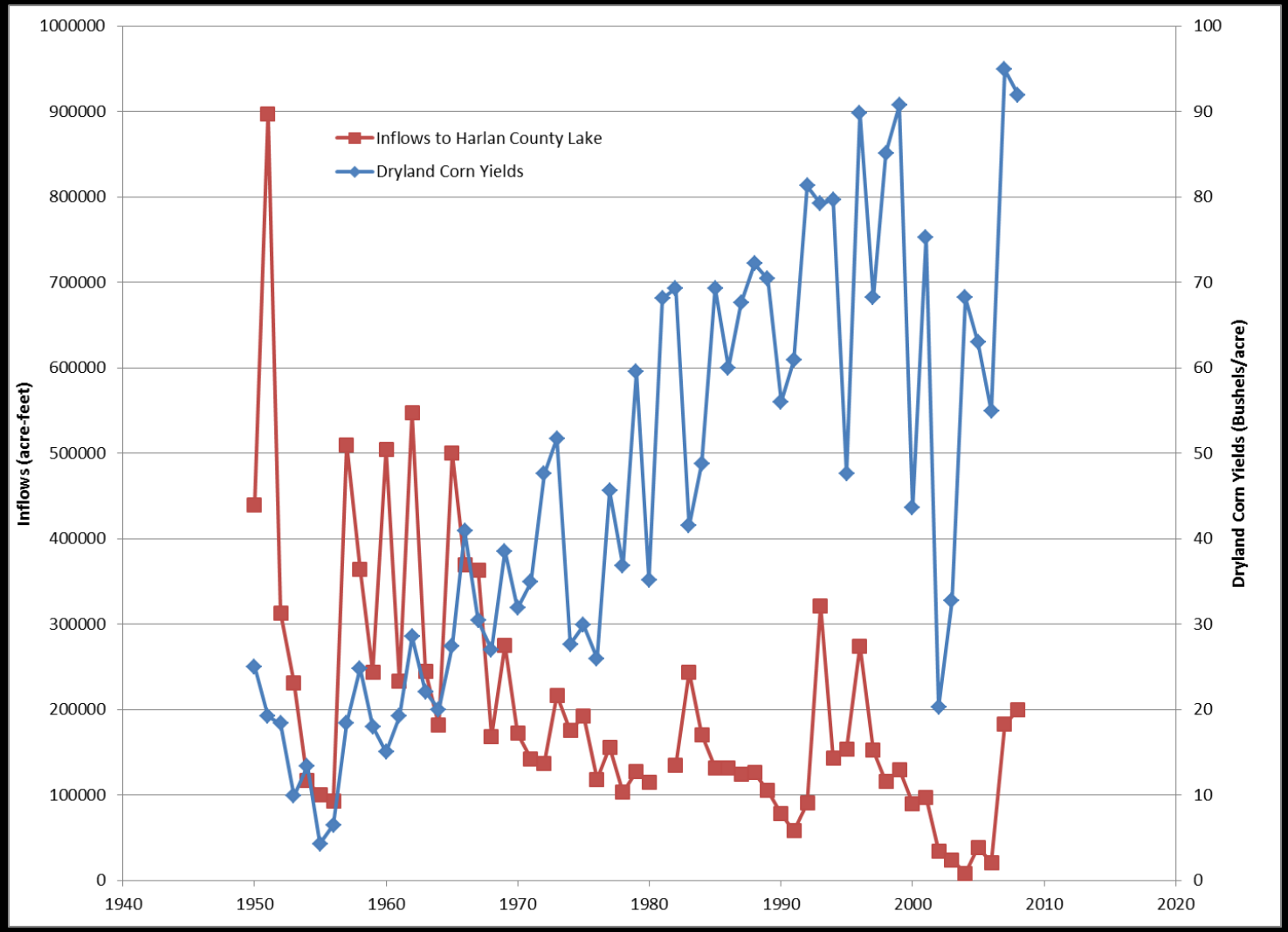
Inflows vs. Irrigated Acres



Inflows vs. Reservoirs



Inflows vs. Dryland Yields



Observations Based on Correlations

- Inflows into Harlan County Lake are inversely correlated with the development of groundwater irrigation, with the development of conservation practices such as farm ponds, and also with the increase in dryland crop yields in the Basin.
- The most significant declines in runoff appear to have occurred prior to 1970, during the time that the development of conservation practices increased the most.
- Baseflow declines have occurred more steadily over time in a manner more similar to the increase in groundwater irrigation and to the increase in dryland yields.

Causes of Reduced Streamflow Supply

Causes		Quantifying these impacts
Groundwater pumping by the three states	➔	Estimates of streamflow depletions due to groundwater pumping from the RRCA groundwater model
Reductions in runoff	➔	RRCA Conservation Study, analysis of historic streamflow and baseflow information to estimate reductions in runoff
Drought	➔	Comparison of 2000-2012 with longer-term averages to assess the impact of more recent drought

Using data from preceding streamflow and baseflow plots

COMPARISON BETWEEN 1950-1964 TIME PERIOD AND 1986-2000 TIME PERIOD

(values in AF)	Total (50-64)	Baseflow (50-64)	Total (86-00)	Baseflow (86-00)	Total Difference	Baseflow Difference	Runoff Difference
North Fork	53,287	46,139	34,730	31,616	18,557	14,523	4,034
Arikaree	17,729	6,636	5,766	3,275	11,963	3,361	8,602
Buffalo	5,775	5,336	3,271	2,793	2,504	2,543	(39)
Rock	10,456	9,922	7,370	6,665	3,086	3,257	(171)
South Fork	18,172	1,963	7,019	4,678	11,153	(2,715)	13,868
Frenchman (Imperial)	53,390	47,952	18,552	17,278	34,838	30,674	4,164
Frenchman (Enders-Palisade)	18,984	13,281	15,351	13,119	3,633	162	3,471
Frenchman (Palisade-Culbertson)	15,503	8,801	8,166	6,197	7,337	2,604	4,733
Driftwood	8,280	525	5,264	3,418	3,016	(2,893)	5,909
Red Willow Abv.	22,203	11,793	15,743	12,060	6,460	(267)	6,727
Red Willow Blw.	5,633	2,646	2,539	1,902	3,094	744	2,350
Medicine Abv.	51,686	35,332	37,350	32,198	14,336	3,134	11,202
Prairie Dog Abv.	10,725	1,562	7,043	2,632	3,682	(1,070)	4,752
MS Benkleman-Swanson	3,517	(8,516)	(3,135)	(9,047)	6,652	531	6,121
MS Swanson-McCook	8,833	(3,202)	12,750	7,563	(3,917)	(10,765)	6,848
MS McCook-Cambridge	7,032	(12,149)	10,680	(72)	(3,648)	(12,077)	8,429
MS Cambridge-Orleans	19,515	(8,131)	33,784	12,967	(14,269)	(21,098)	6,829
Total	330,720	159,890	222,243	149,242	108,477	10,648	97,829

Rainfall Comparison

Time Period	1918-2013	1950-1964	1986-2000
Nebraska Average	22.12 inches	21.37 inches (44%)	23.35 inches (65%)
Basin Average	21.05 inches	20.36 inches (43%)	22.17 inches (62%)

- Earlier period had slightly below average rainfall
- Later period had significantly above average rainfall
- Runoff was reduced by 98,000 acre-feet despite the increased rainfall

Post-2000 impacts

- 2000-2012
  - Increase in depletions due to groundwater pumping
  - Are there additional reductions in runoff?
  - Precipitation
    - Average Nebraska = 22.78 inches (58%)
    - Average Basin-wide = 21.41 inches (53%)
  - No baseflow separations
    - Use streamflow data
    - Account for changes in GWCBCU
    - Add in SWCBCU so comparable with baseflow separations (which accounted for all major diversions)

Impacts above Swanson Reservoir

	1951-1964	1986-2000	2000-2012
Average Annual Flow (Straton Gage)	112,000 AF	51,000 AF	21,000 AF
Reduction from Early to Late Period			91,000 AF

Pumping Impacts	
• **Nebraska**	20,000 AF
• **Kansas**	6,000 AF
• **Colorado**	25,000 AF
Total Pumping Impacts	51,000 AF
Reduction in Runoff	40,000 AF

1950-1964 compared to 2000-2012

Impacts on Red Willow

Reduction in Runoff	9,000 AF
Pumping Impacts	
• **Nebraska**	8,000 AF
Total Impacts	**17,000 AF**

1950-1964 compared to 2000-2012

Impacts Above Harry Strunk Reservoir

Reduction in Runoff	11,000 AF
Pumping Impacts	
• **Nebraska ***	20,000 AF
Imported Water (Nebraska)	10,000 AF
Total Impacts	**21,000 AF**

* Includes impacts below Harry Strunk

1950-1964 compared to 2000-2012

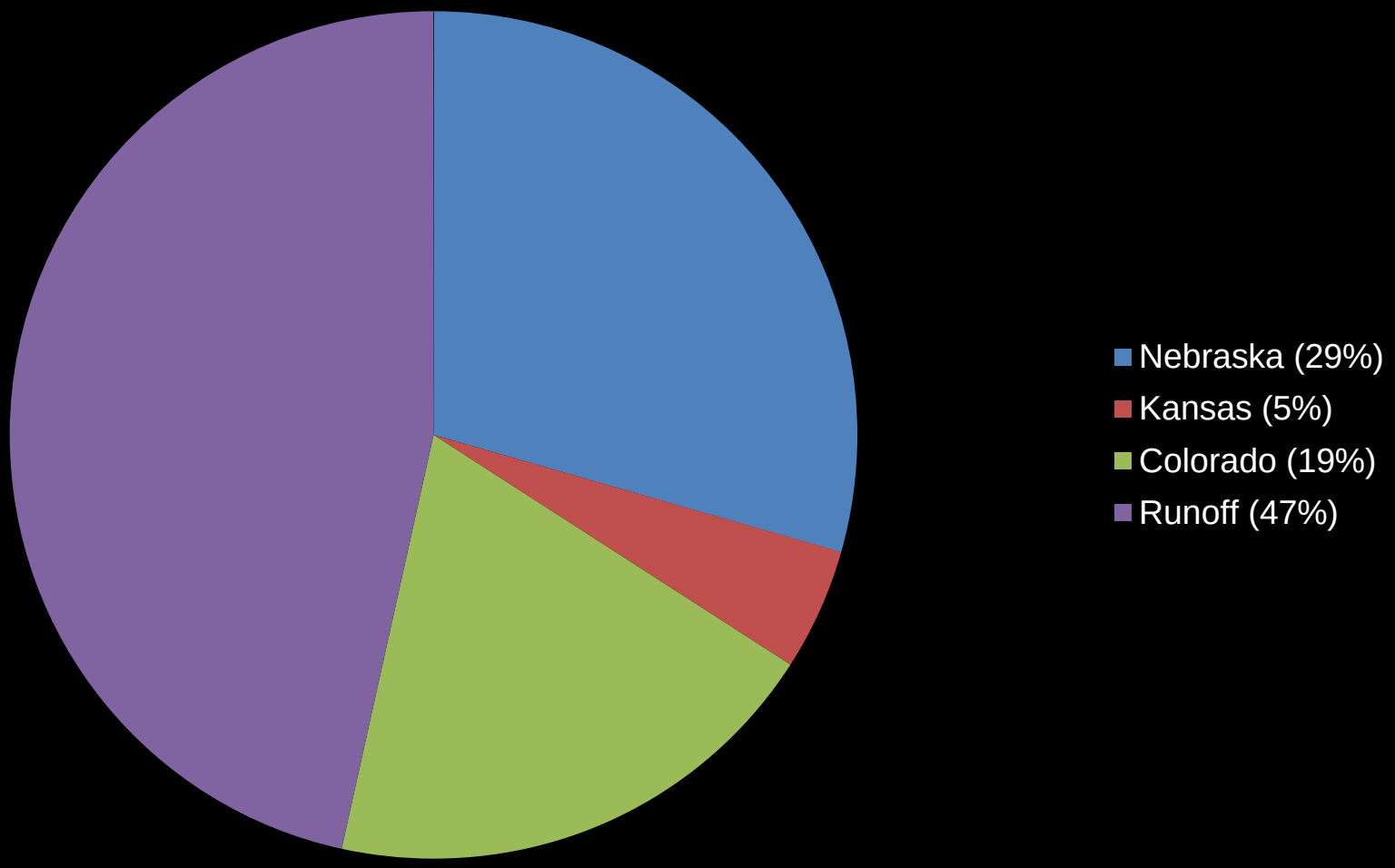
Impacts to Reservoirs Serving Frenchman Cambridge

Runoff Reduction	60,000 AF
Pumping Impacts	
• **Nebraska**	48,000 AF
• **Kansas**	6,000 AF
• **Colorado**	25,000 AF
Imported Water (Nebraska)	10,000 AF
Total Impacts	**129,000 AF**

Imported water subtracted from Nebraska pumping impact for a net Nebraska impact of 38,000 acre-feet

1950-1964 compared to 2000-2012

Impacts to Reservoirs Serving Frenchman Cambridge



1950-1964 compared to 2000-2012

Above Harlan County Lake

- 2000-2012

Orleans, Stamford, and Woodruff gages	93,000 AF
NE Surface Water CBCU above Harlan County Lake	30,000 AF
Total Streamflow available above Harlan County Lake	123,000 AF
Total Reduction from 1986-2000 period (222,000 AF)	99,000 AF

Impacts Above Harlan County Lake

	2000-2012	Increase from 1986-2000
Pumping Impacts		
• **Nebraska**	175,000 AF	23,000 AF
• **Kansas**	16,000 AF	-2,000 AF
• **Colorado**	26,000 AF	4,000 AF
Imported Water (Nebraska)	17,000 AF	Unchanged
Reduction in Runoff		74,000 AF

Accounts for 25,000 AF of the 99,000 AF reduction

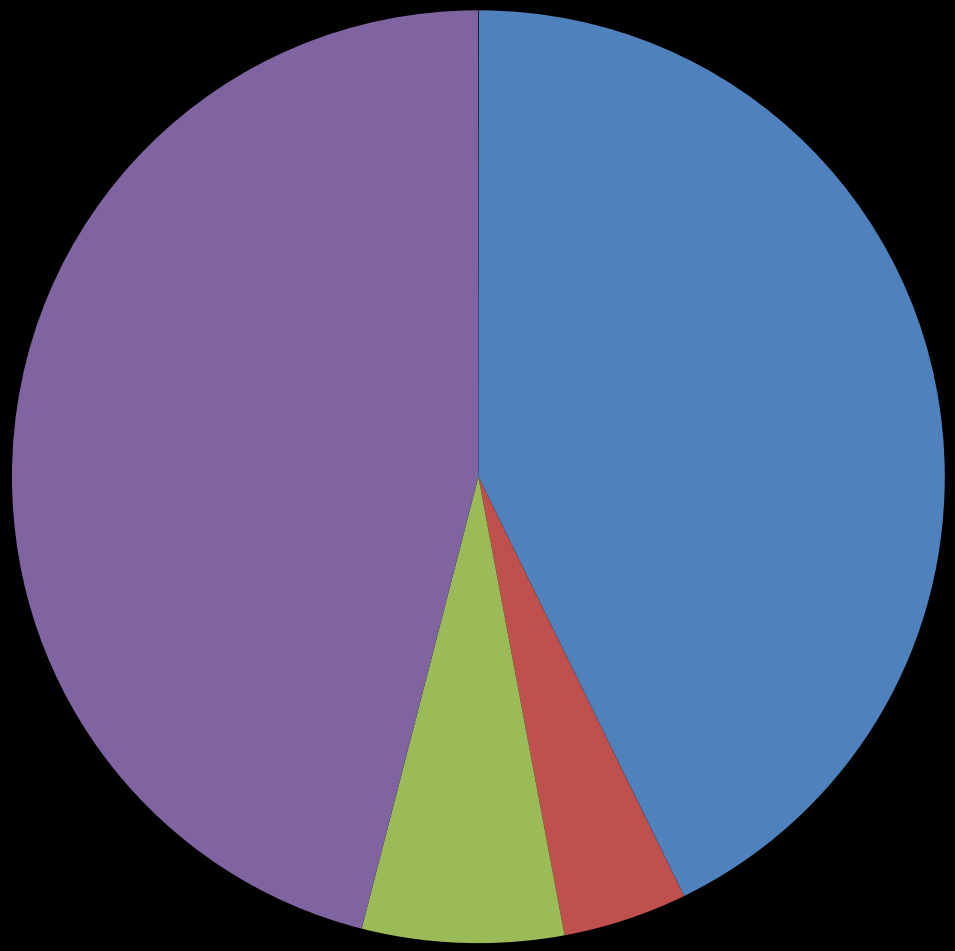
Impacts Above Harlan County Lake

Runoff Reduction	171,000 AF
Groundwater Depletions	
• **Nebraska**	176,000 AF
• **Kansas**	16,000 AF
• **Colorado**	26,000 AF
Imported Water (Nebraska)	17,000 AF
Total Impacts	**372,000 AF**

Imported water subtracted from Nebraska pumping impact for a net Nebraska impact of 159,000 acre-feet (inclusive of impacts above FCID)

1950-1964 compared to 2000-2012

Impacts above Harlan County Lake



1950-1964 compared to 2000-2012

Changes from 1986-2000 to 2000-2012

- Inflows to Harlan County Lake were reduced by about 100,000 acre-feet from the earlier to the later period
- This is largely (i.e., 75%) attributable to additional reductions in runoff, which could be due to more normal precipitation in the later period and/or could also be due to increased conservation practices

Summary of Impacts

- Basin streamflows have been dramatically reduced since the 1950s and 1960s

	Above Reservoirs serving FCID	Above Harlan County Lake
Streamflow reductions	~ 110,000 – 140,000 AF	~ 375,000 AF
Nebraska groundwater pumping causes	~ 20 - 30%	~ 40%
Streamflow reductions as a percentage of reservoir conservation (i.e. irrigation) storage capacity	~75-90% (Swanson, Hugh Butler, Harry Strunk)	~100% (Harlan, Swanson, Enders, Hugh Butler, Harry Strunk)

- These results are consistent across multiple studies

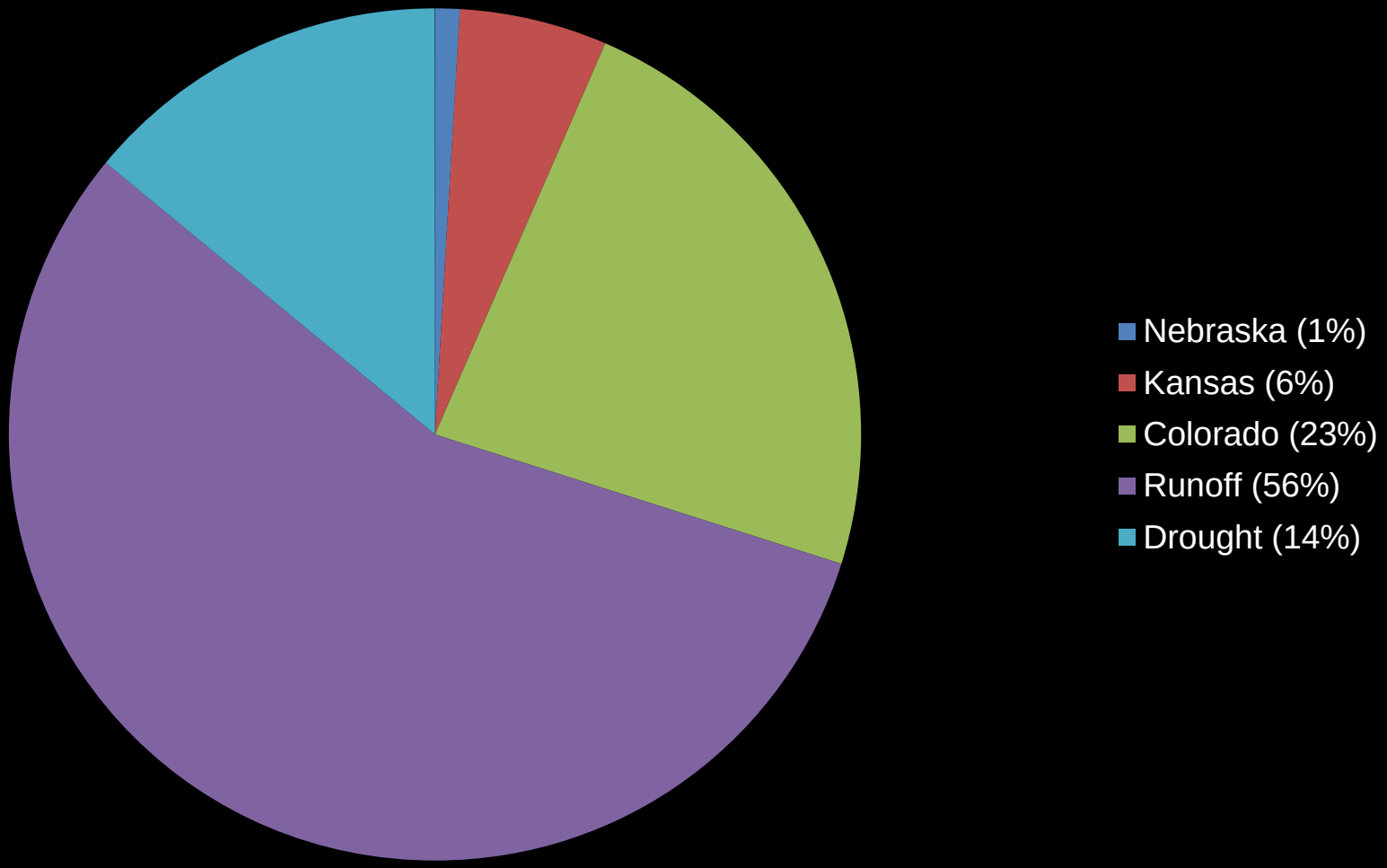
Estimated Impacts to Reservoirs Serving Frenchman Cambridge in 2014

Runoff Reduction	60,000 AF
Pumping Impacts	
• **Nebraska ***	11,000 AF
• **Kansas**	6,000 AF
• **Colorado**	25,000 AF
Imported Water (Nebraska)	10,000 AF
Drought	15,000 AF
Total	**107,000 AF**

Imported water subtracted from Nebraska pumping impact for a net Nebraska impact of 1,000 acre-feet

* Augmentation deliveries are 20,000 acre-feet from Rock Creek and 42,000 acre-feet from N-CORPE. Under the current accounting procedures Nebraska only receives 37,000 acre-feet of credit for these deliveries. This number is based on the average Nebraska depletion of 48,000 acre-feet adjusted by 37,000 acre-feet.

Estimated Impacts to Reservoirs Serving Frenchman Cambridge in 2014



ESTIMATES OF FUTURE IMPACTS

Comparison between IMPs and “Kansas Remedy”

Future Impacts to Basin Reservoirs

- Assumptions:
  - Reductions in runoff will not increase from 2000-2012 levels
  - Pumping impacts by Kansas and Colorado will not increase from 2000-2012 levels
  - Two scenarios for Nebraska pumping and IWS Credit
    - Current IMPs with stream augmentation estimated at an average of 5,000 acre-feet per year for Rock Creek and 20,000 acre-feet per year for N-CORPE
    - The “Kansas Remedy” – 90% reduction in pumping on 302,000 acres along river and tributaries
    - Used data provided by State of Kansas during litigation
    - Groundwater depletions are the average annual depletions from 2010-2069, which was modeled by repeating 1995-2009 four times

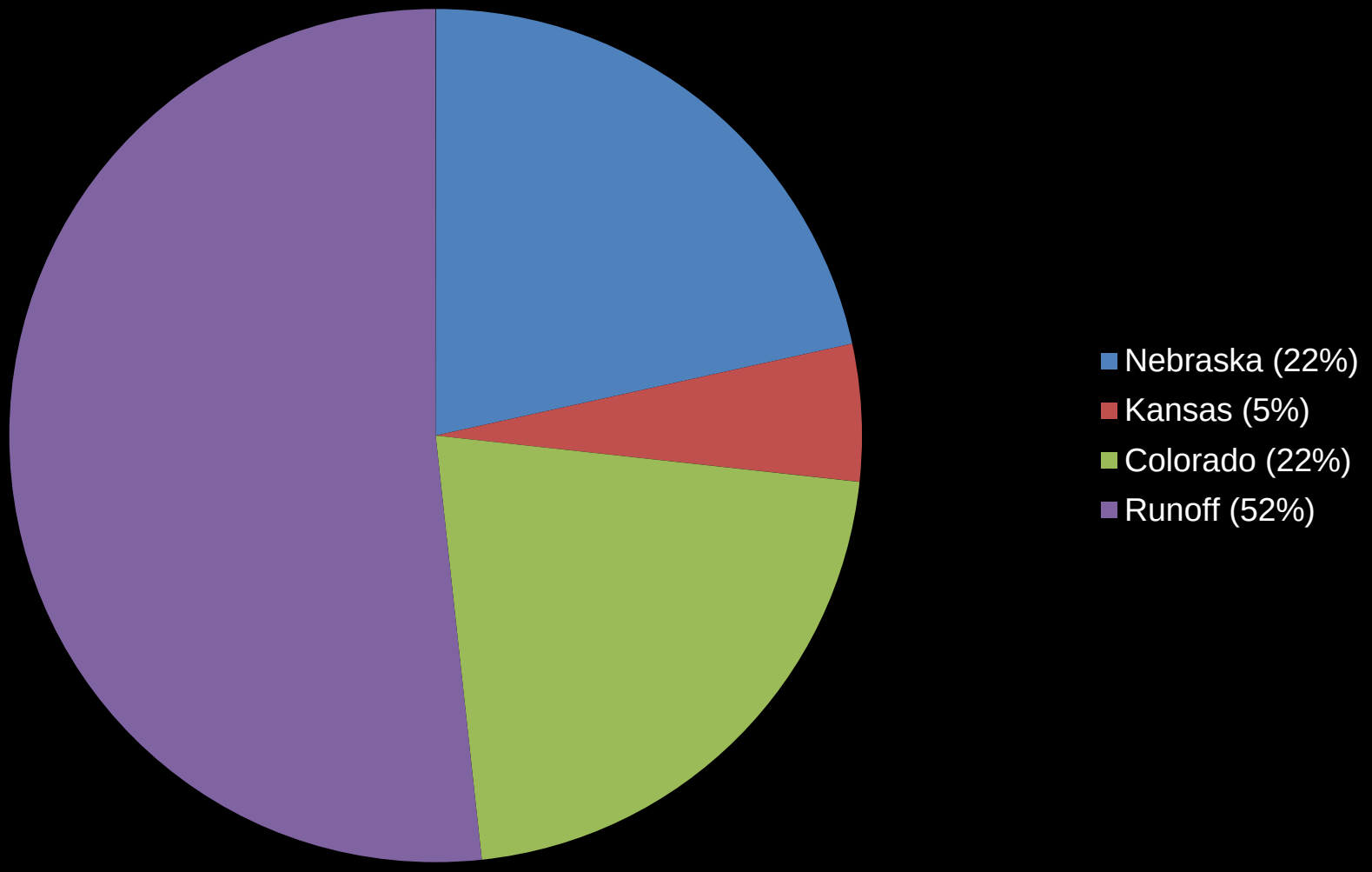
Future Impacts to Reservoirs Serving Frenchman Cambridge

	IMPs	KS Remedy
Runoff Reduction	60,000 AF	60,000 AF
Pumping Impacts		
• **Nebraska ***	58,000 AF	54,000 AF
• **Kansas**	6,000 AF	6,000 AF
• **Colorado**	25,000 AF	25,000 AF
Imported Water (Nebraska)	8,000	12,000 AF
Augmentation Water Supply	25,000	0 AF
Total Impacts	**116,000 AF**	**133,000 AF**

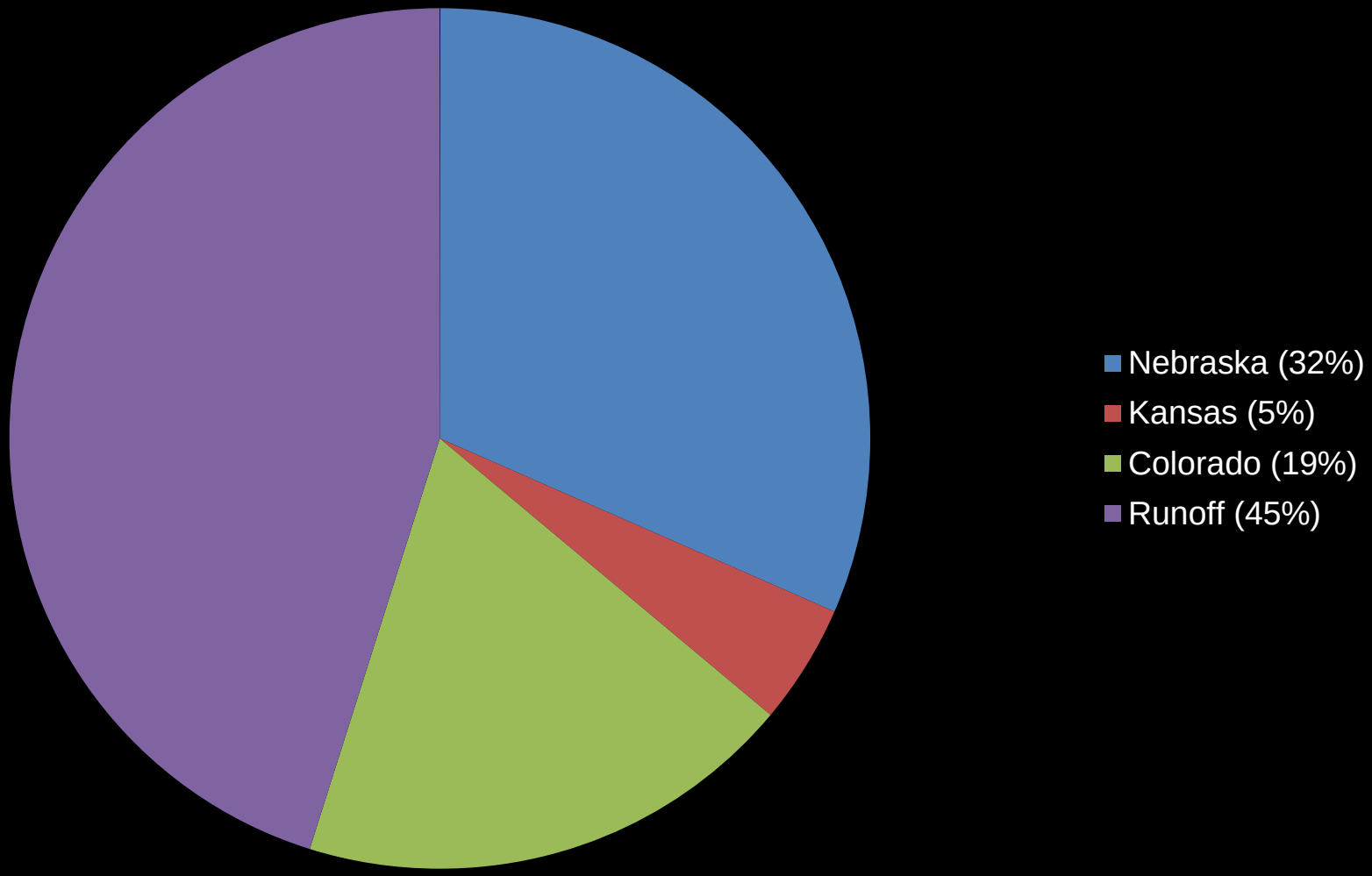
Imported water and augmentation water supply subtracted from Nebraska pumping impact for a net Nebraska impact of 25,000 acre-feet under the IMPs and a net Nebraska impact of 42,000 acre-feet under the Kansas Remedy

* Includes impacts below Harry Strunk and Hugh Butler

Future Impacts to Reservoirs Serving Frenchman Cambridge - IMPs



Future Impacts to Reservoirs Serving Frenchman Cambridge – Kansas Remedy



Result of Kansas Remedy vs. the IMPs

- Total average reductions in streamflow (from 50-60's baseline) still ~375,000 acre-feet (excluding additional drought impacts) under either plan
- Under the Kansas Remedy groundwater use would be limited to approximately 1 inch in the 5-mile stream corridor
- Users with both surface and groundwater would have significantly less water under the Kansas Remedy
- Users with only surface water would not have more water under the KS Remedy as compared to the IMPs

Future of surface water?

- If groundwater pumping had never been developed in Nebraska, average streamflows would still be ~200,000-225,000 acre-feet less today than when the USBR projects were built.
- Recent drought has reduced streamflow by an additional ~100,000 acre-feet for a total impact to the USBR reservoirs not attributable to Nebraska groundwater pumping of ~300,000-325,000 acre-feet.
- This equates to approximately 85% of the conservation (i.e., irrigation) storage allocation in the USBR reservoirs in Nebraska.

Future of surface water?

- Nebraska is offsetting a significant proportion of the impacts due to Nebraska groundwater pumping through stream augmentation in dry years for Compact compliance purposes
- Additional offsets through dramatic cuts in groundwater pumping, such as those proposed by Kansas, would only provide a minimal increase (~1 inch on all project acres) in surface water deliveries while essentially eliminating supplemental groundwater sources
- Augmentation projects ensure that supplemental groundwater is available to those surface water users with a well

Future of surface water?

- Traditional model of operating solely to provide irrigation water may not be feasible
- Basin reservoirs may be able to sustain deliveries to a portion of the project acres if reductions in runoff and depletions caused by Kansas and Colorado do not increase significantly
- Cooperation through conjunctive management could open up new revenue sources for surface water projects which could provide for long-term viability
- Cooperation between DNR, USBR, NRDs, and IDs is necessary

The DNR and the Platte Basin NRDs developed the science and the relationships that have allowed the study and pursuit of many conjunctive management opportunities, which have provided great benefits for the irrigation districts involved

CONJUNCTIVE MANAGEMENT ON THE PLATTE RIVER

2011 Demonstration Project

- For **groundwater recharge** and **flood reduction**
- Partners
  - 23 Canals
  - DNR
  - South Platte NRD
  - Tri-Basin NRD
  - Twin Platte NRD
  - Central Platte NRD
  - North Platte NRD
- Results
  - Diversion Total 142,000 AF
  - Seepage Total 64,000 AF
  - 2011-2019 Accretion Total 15,000 AF

Average annual accretion ~1,500 AF/yr

2013 Flood Flow Project

- Mitigate impact of Colorado flood flows while also recharging groundwater
  - DNR, NRDs, & irrigation districts

South Platte River Bridge, Buffalo Bill Road, North Platte, NE
Friday, September 20,2013 at 8:30 a.m.

South Platte River Bridge, Buffalo Bill Road, North Platte, NE
Saturday, September 21,2013 at 7:00 p.m.

Cozad Canal & Thirty-Mile Canal

- Cozad Canal (2014-2019) ~8,000 AF/yr
- Thirty-Mile Canal (2014-2019) ~8,000 AF/yr

Average annual accretion **~16,000 AF/yr**

Summary

- Current average streamflow supplies have been significantly reduced from historic levels
- The causes are groundwater pumping in the three states and reduced runoff; these are exacerbated by drought
- Cooperation/conjunctive management are better alternatives for long-term viability of the irrigation districts than significant proposed pumping reductions (KS remedy)
- Understanding how the water supply is changing is important for effective water planning

Summary

- These values were derived from a general review of readily available data. While it provides a useful overview of hydrologic changes in the Basin, the conclusions should be considered approximate and general in nature.

- The Department will be working to expand this work into many other basins of the state over the next couple of years

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