WateReuse - Inland Empire

Evaluation of Long-Term Trends and Variations in the Average Total Dissolved Solids Concentrations in Wastewater and Recycled Water

Unintended Consequences

May 8, 2018

Acknowledgements

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  - San Diego County Water Authority
  - Metropolitan Water District of Southern California
- Technical Direction - Risk Sciences

TDS Trends Study - Synopsis

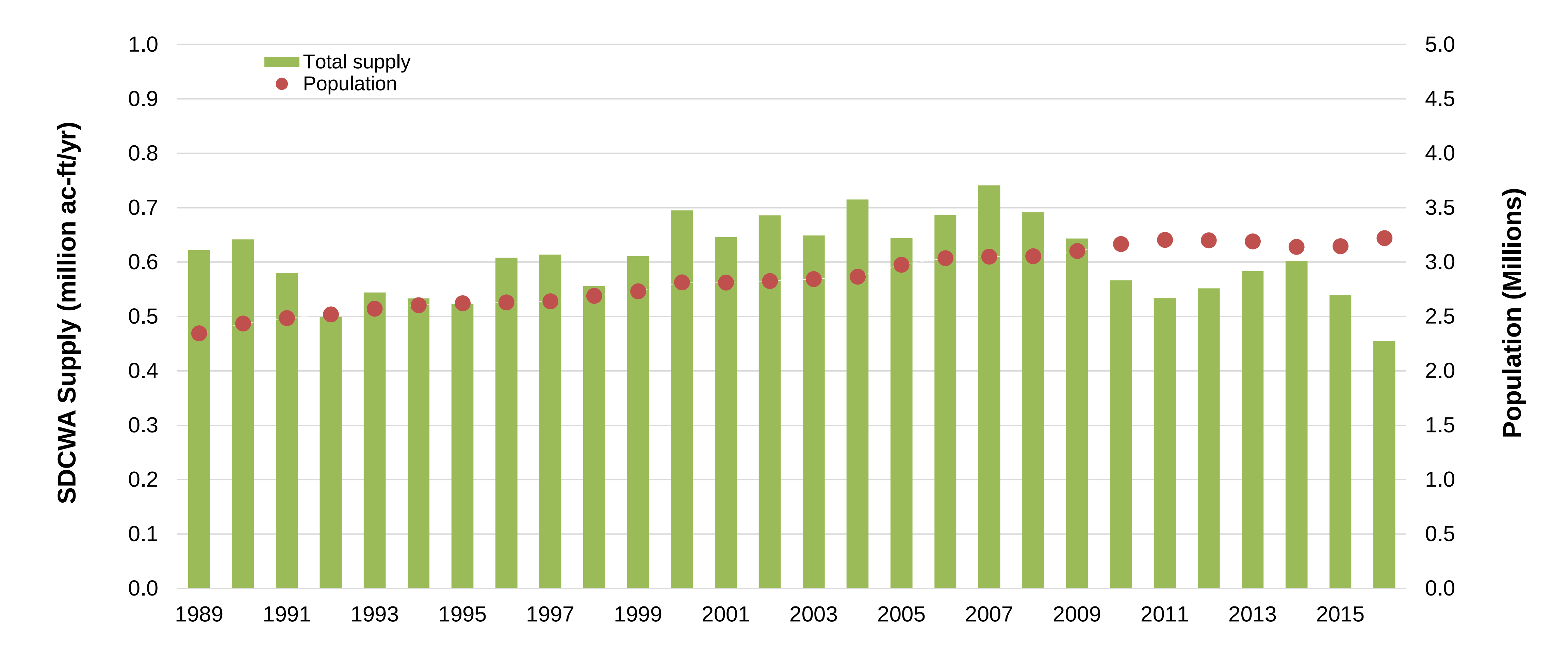
- Identify the effects of drought and water conservation measures on the long-term TDS trends in wastewater and recycled water
- Drought, water conservation measures, and other explanatory variables are auto-correlated to some degree
- Study analyzed both deterministic models and statistical models (multiple linear regression) to predict TDS in wastewater and recycled water
- Provide the science and statistical analysis to provide a framework for policy discussions
- Dovetails with CUWA's white paper - Utilities and declining flows.

Research Question 1

- Q: How has indoor per capita water use changed over time? What are the water quality implications if the trend continues for the next 20 years?

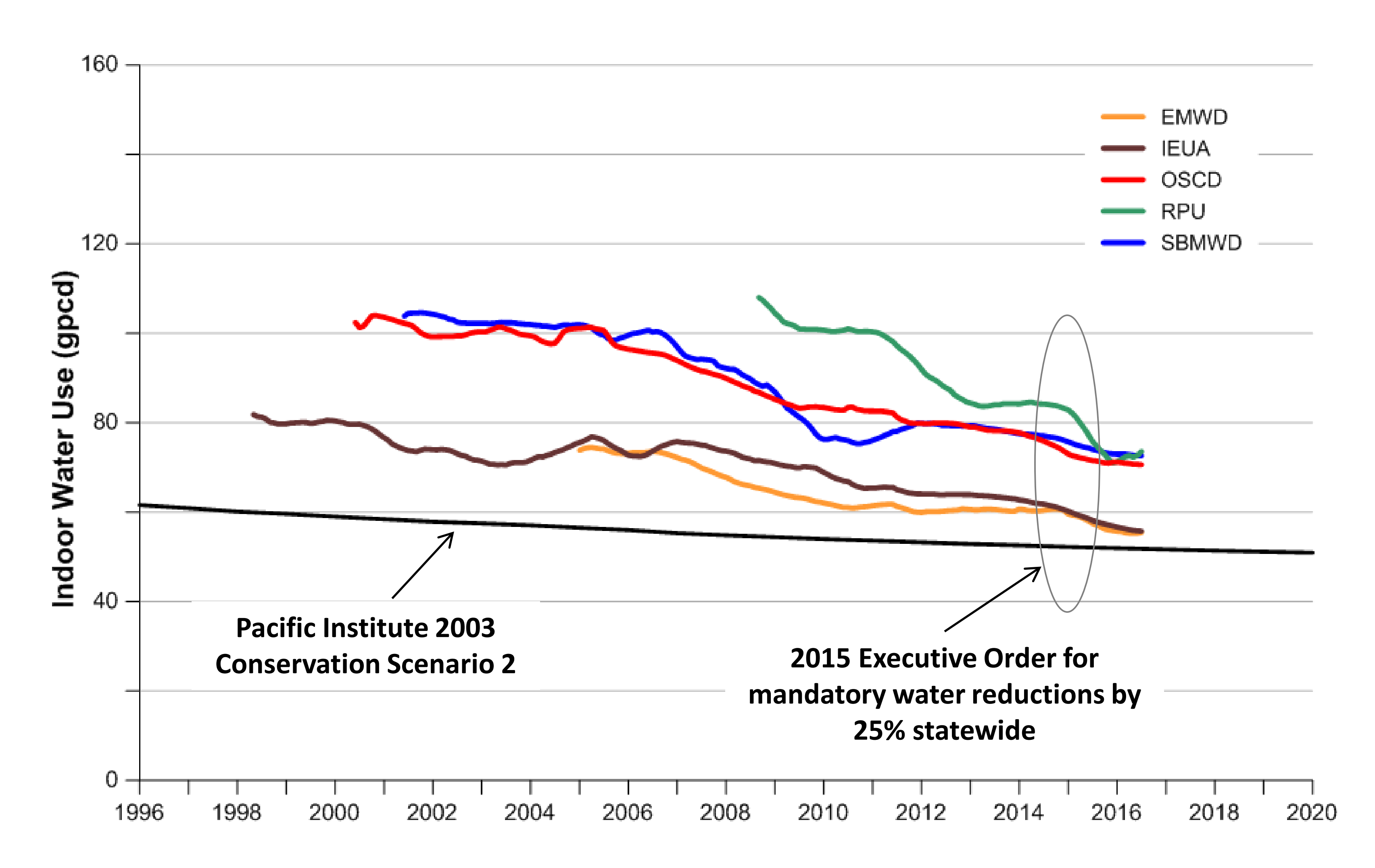
- A: Per capita water use is generally decreasing over time, from a range of 80 to 100 gpcd to a range of 50 to 75 gpcd.
- Expect to reduce per capita water use to 55 gallons per capita per day (gpcd) by 2020 (AB-968 Section 10608.25).
- 1.2 to 1.7 mg/L increase in influent TDS for every 1 gpcd decrease in indoor water use.

Conservation Measures: Total Supply



Conservation Measures: Indoor Use

- Decline of indoor per capita water use universally.
- California 2015 state mandate is part of an overall downward trend in water use.



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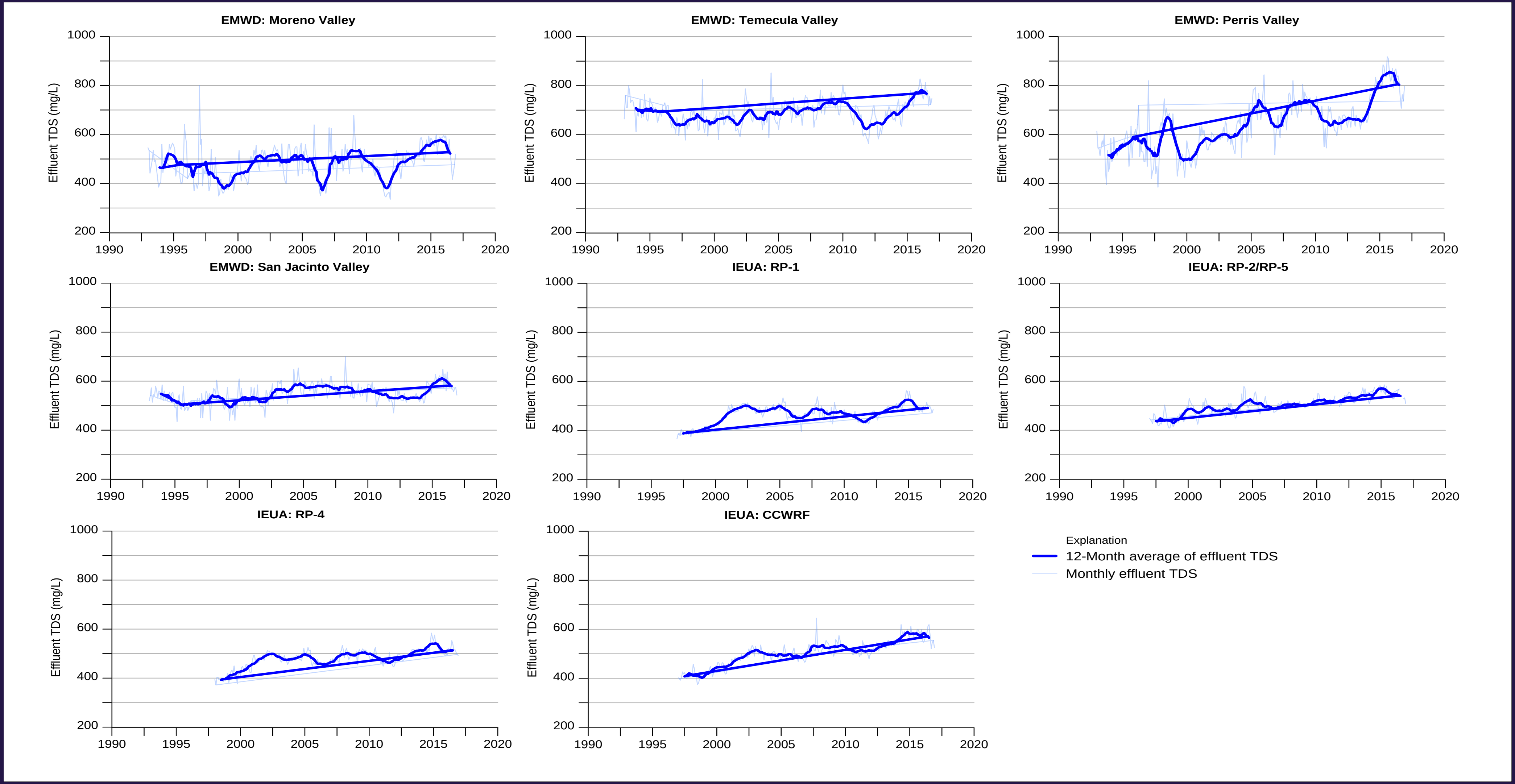
Research Question 2

- Q: How has the volume-weighted average concentration of TDS in municipal influent changed over time? What are the water quality implications if the trend continues for the next 20 years?

- A: A majority of the wastewater treatment plants exhibited an upward trend in TDS concentrations. Of the 26 WWTPs, 16 have an upward trend in TDS, 7 have no trend, and 3 have a downward trend in TDS.

TDS in WWTP Effluent over Time



Research Question 6

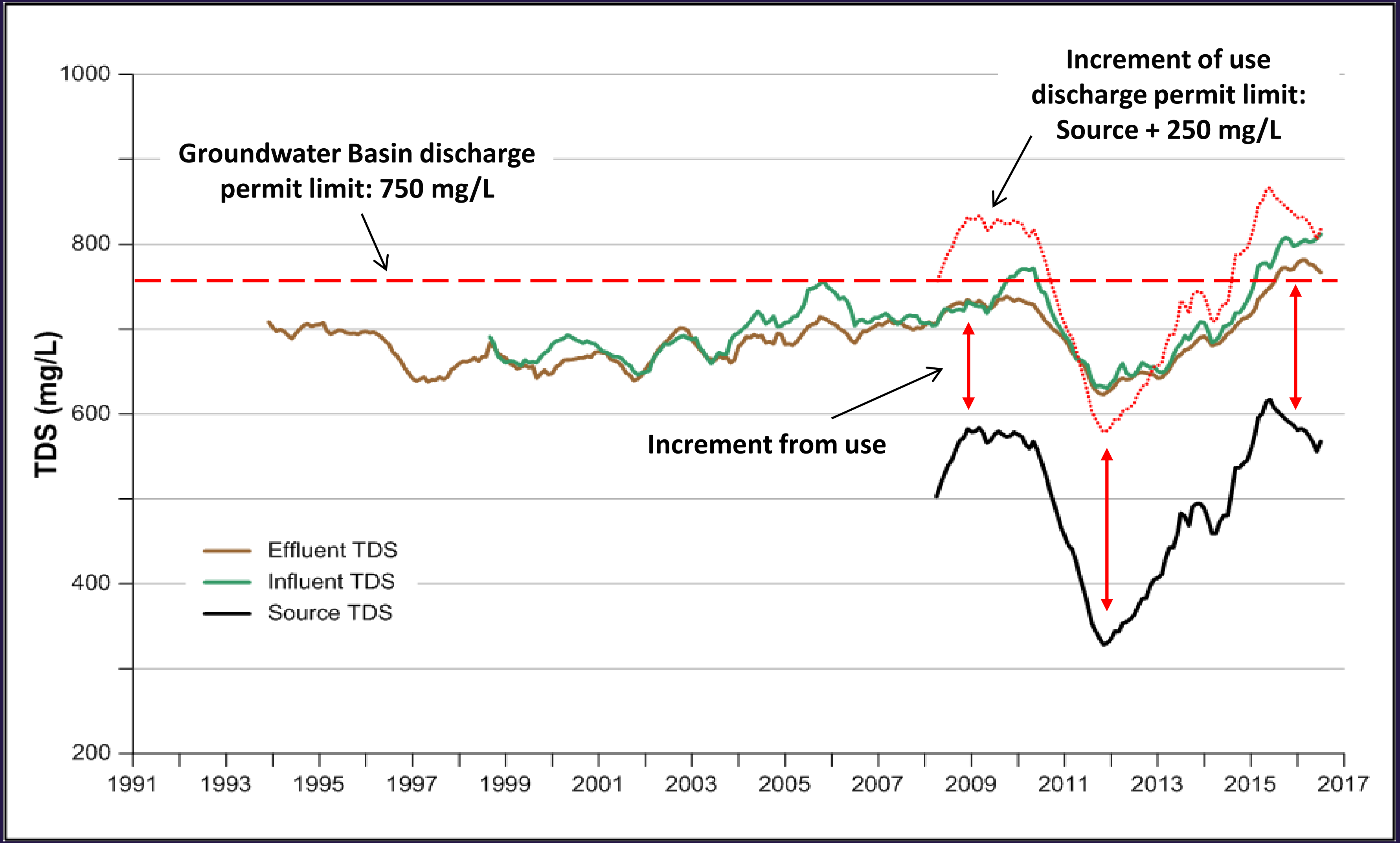
- Q: To what degree are fluctuations in the volume-weighted average concentration of TDS in recycled water correlated with variations in the volume-weighted average concentration of TDS in the wastewater influent?

- A: Influent TDS and effluent TDS concentrations are generally tightly correlated.

TDS Trends Example - Temecula Valley WRF

Considerations:

- 12-mo average period
- Influent ~ Effluent
- Discharge limit based on IFU limit and absolute limits.



Research Question 7

- Q: To what degree are fluctuations in the volume-weighted average concentration of TDS in recycled water correlated with variations in the volume-weighted average concentration of TDS in the municipal water supply?

- A: There is a high degree of correlation between the fluctuations of source TDS and the fluctuation of influent TDS. Source TDS is one of two most important explanatory variables. According to the statistical models, the relative importance values of source TDS ranges from 34 to 99 percent with an average of 78 percent.

Multiple Linear Regression: Influent TDS

$$y_i = b_0 + \sum_{j=1}^{n} b_j x_{ij} + e_i$$

where

y_i = the predicted value of the response variable y for data point i

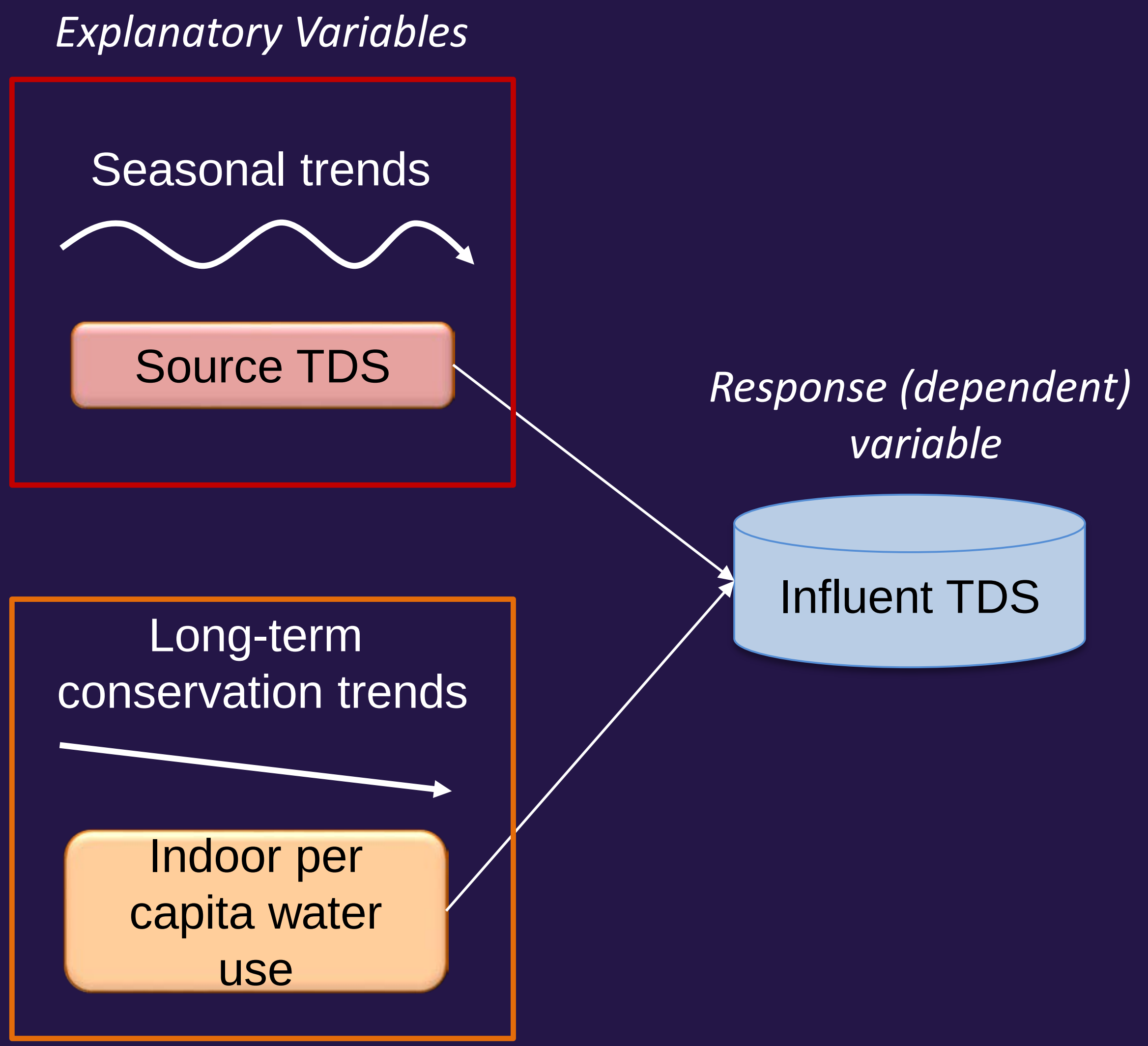
b_0 = the model intercept coefficient

b_j = the model slope coefficient for explanatory variable j

n = the total number of explanatory variables in the model

x_{ij} = the known value x of explanatory variable j for data point i

e_i = the residual error of data point i from the fitted model



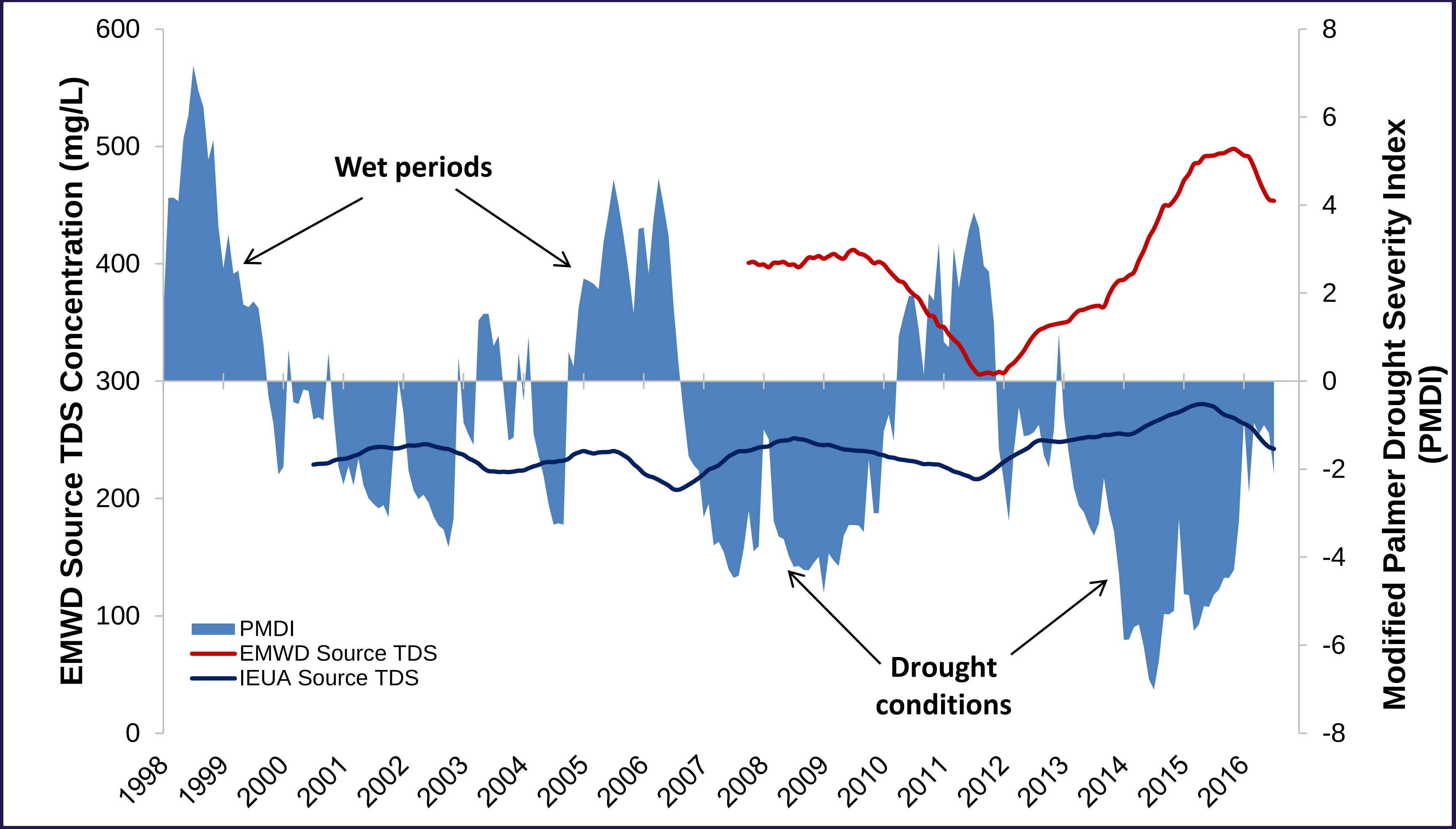
Research Question 8

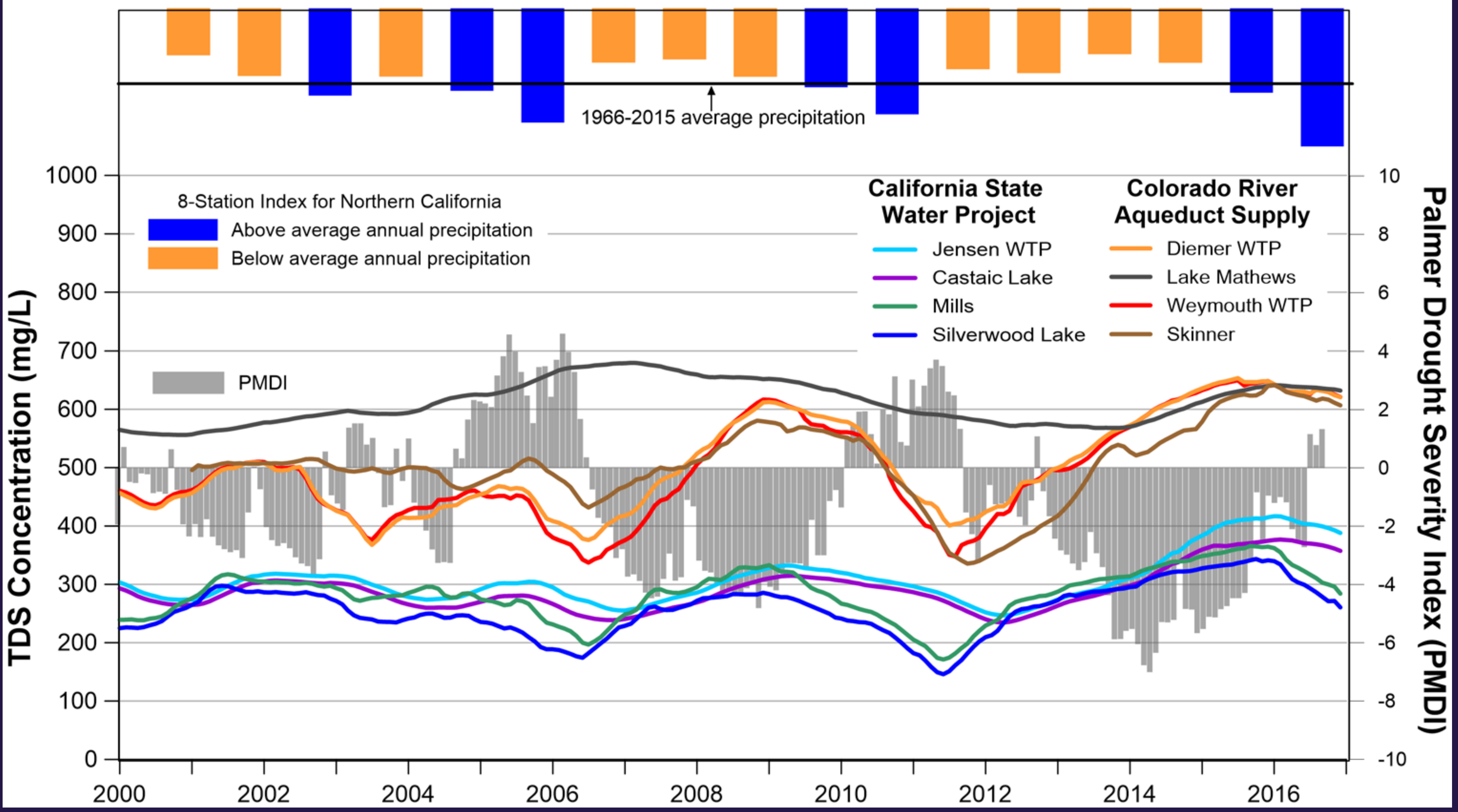
- Q: To what degree do fluctuations in the volume-weighted average concentration of TDS in recycled water correlate with long-term meteorological (drought) cycles?

- A: Where there is a higher degree of dependence on imported water, there is a higher degree of correlation with long-term meteorological cycles. This is evident in the difference between EMWD and IEUA.

Source Supply TDS Concentrations and Drought

- Higher TDS concentration with drought periods
- EMWD greater reliance on imported water
- IEUA greater reliance on groundwater and local water supply

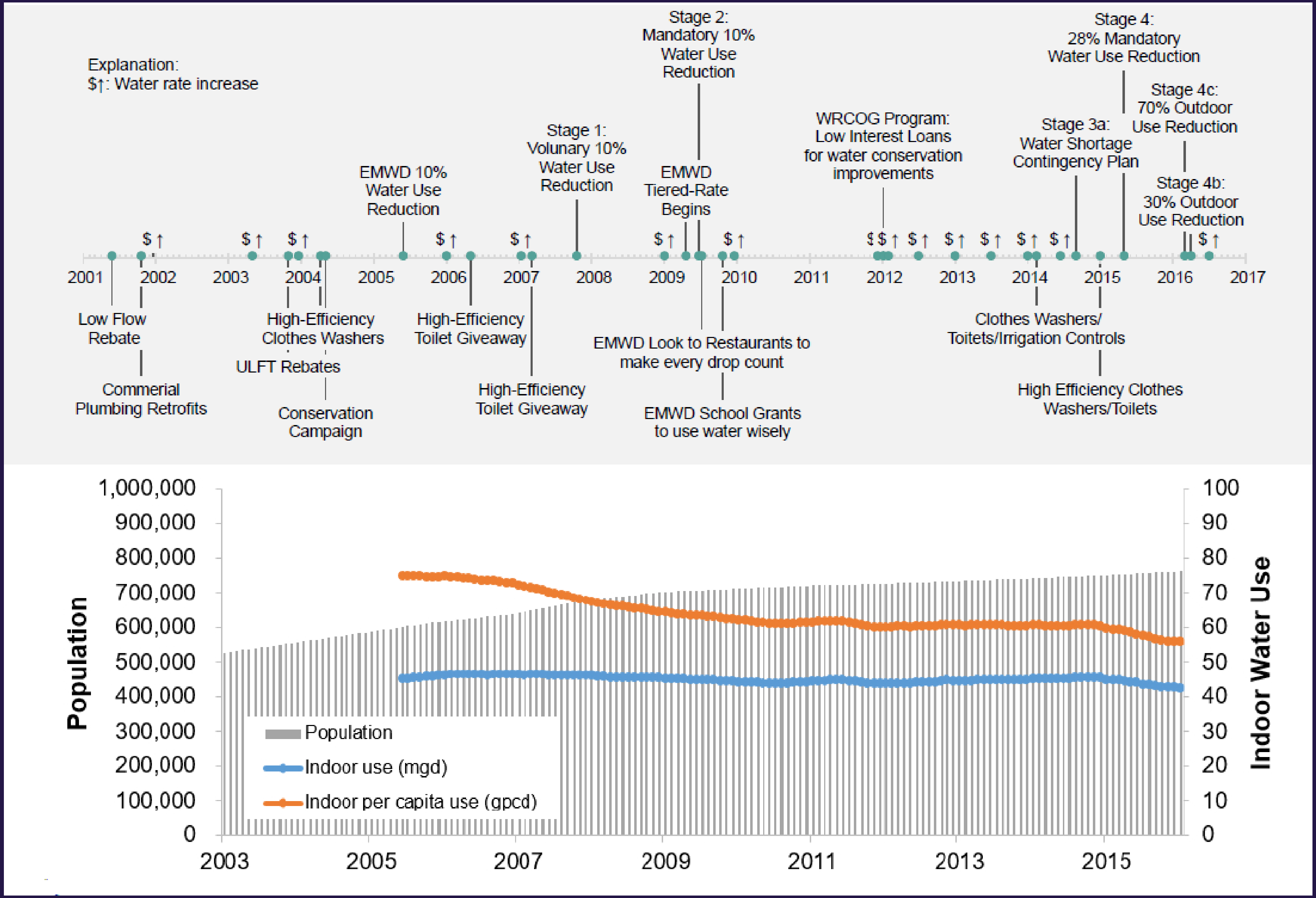



1966-2015 average precipitation
8-Station Index for Northern California
Above average annual precipitation
Below average annual precipitation
PMDI
California State Water Project
Jensen WTP
Castaic Lake
Mills
Silverwood Lake
Colorado River Aqueduct Supply
Diemer WTP
Lake Mathews
Weymouth WTP
Skinner
TDS Concentration (mg/L)
Palmer Drought Severity Index (PMDI)
1000
900
800
700
600
500
400
300
200
100
0
10
8
6
4
2
0
-2
-4
-6
-8
-10
2000
2002
2004
2006
2008
2010
2012
2014
2016

Research Question 9

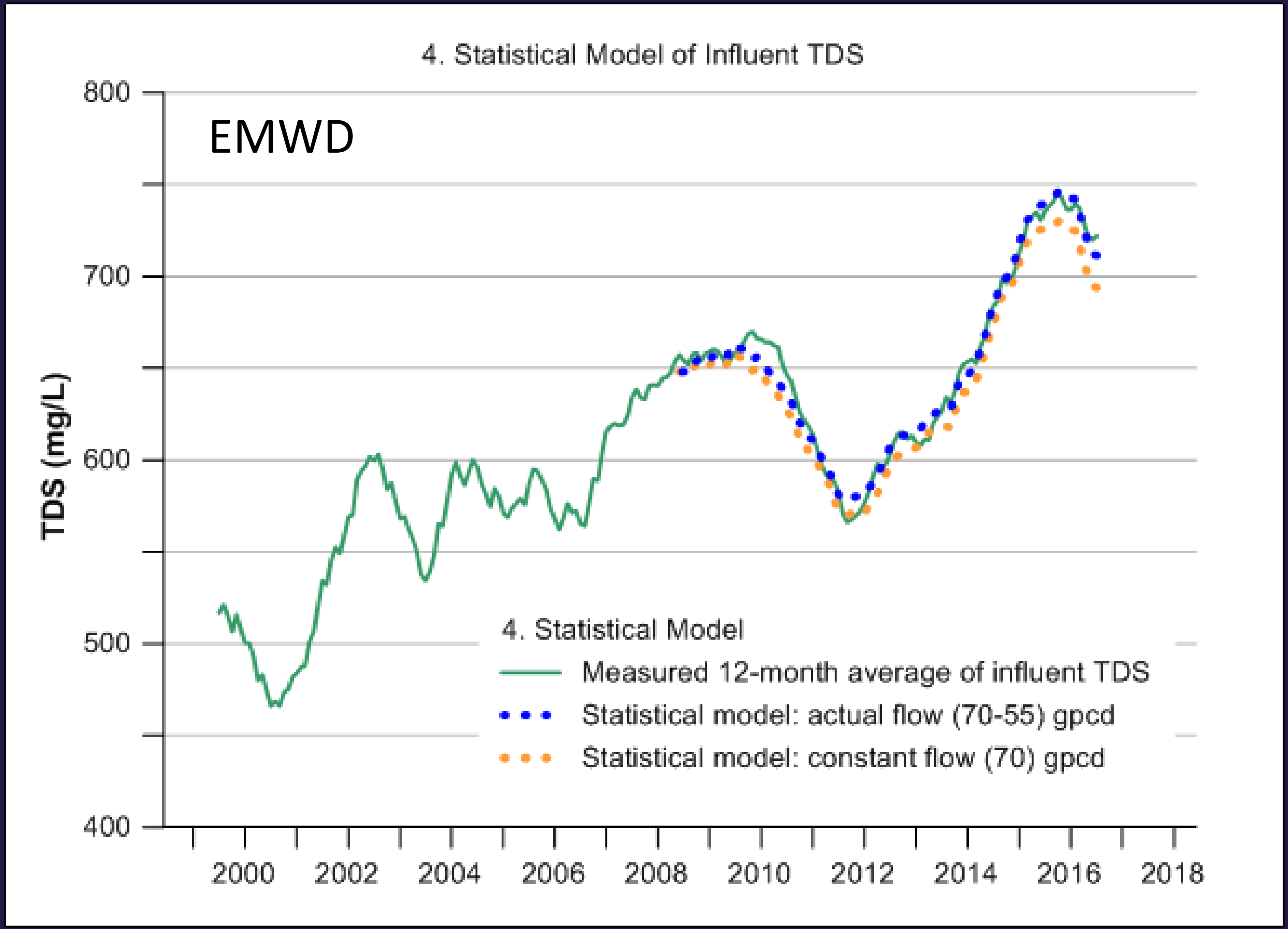
- Q: What effect, if any, did the state's mandatory conservation measures (2015-16), and the subsequent relaxation of these measures, have on average per capita indoor and outdoor water use?

- A: Between 2004 and 2010 there was a general decrease in per capita indoor water use. Between 2010 and 2015, per capita indoor water use remained constant at around 60 gpcd. In May 2015, per capita indoor water use began to decline again down to 55 gpcd in 2016.



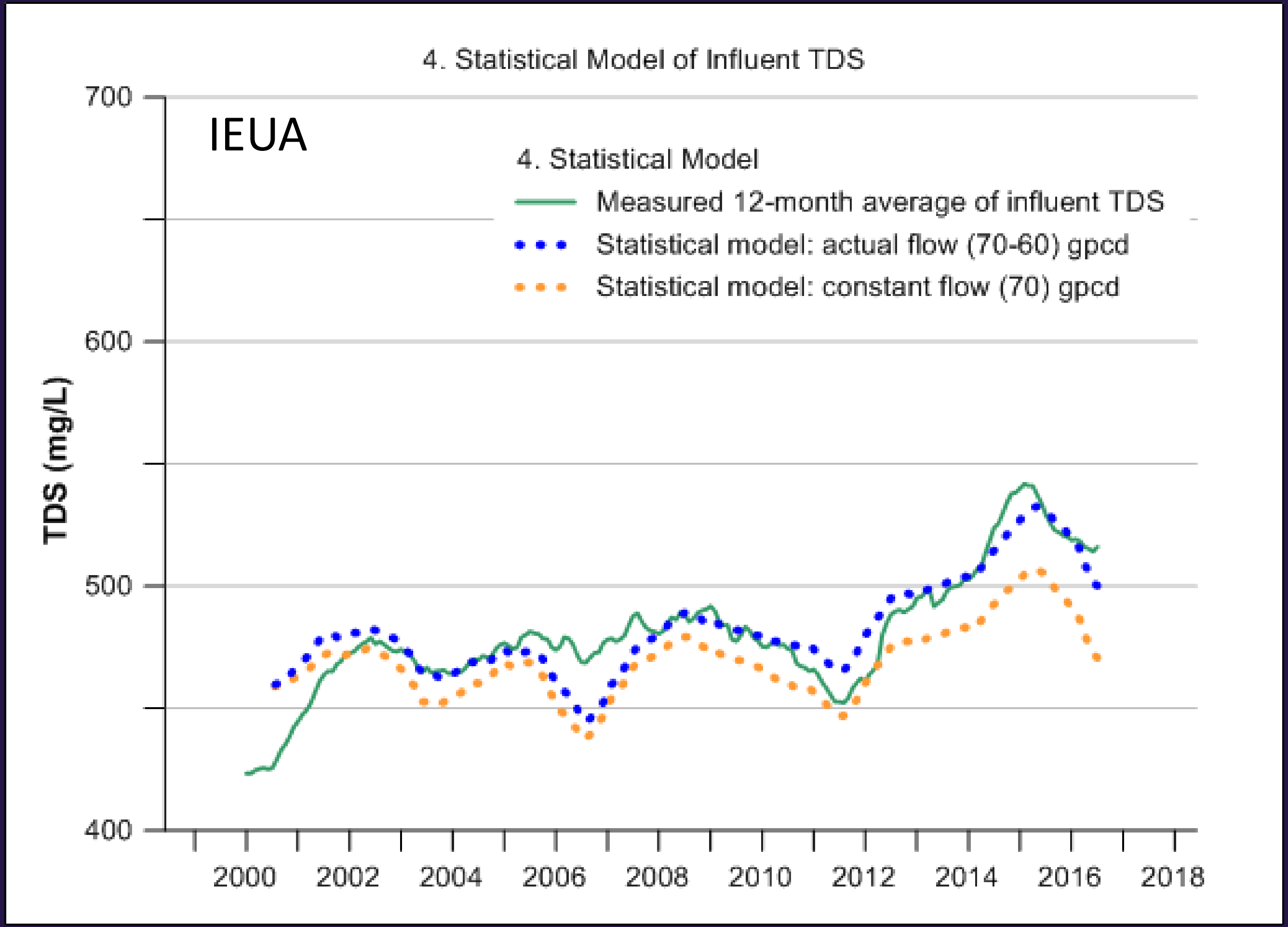
Explanation:
$↑: Water rate increase
Stage 2: Mandatory 10% Water Use Reduction
Stage 4: 28% Mandatory Water Use Reduction
Stage 4c: 70% Outdoor Use Reduction
Stage 3a: Water Shortage Contingency Plan
Stage 4b: 30% Outdoor Use Reduction
WRCOG Program: Low Interest Loans for water conservation improvements
Stage 1: Volunary 10% Water Use Reduction
EMWD 10% Water Use Reduction
EMWD Tiered-Rate Begins
Low Flow Rebate
Commerial Plumbing Retrofits
High-Efficiency Clothes Washers
ULFT Rebates
Conservation Campaign
High-Efficiency Toilet Giveaway
High-Efficiency Toilet Giveaway
EMWD Look to Restaurants to make every drop count
EMWD School Grants to use water wisely
Clothes Washers/ Toitets/Irrigation Controls
High Efficiency Clothes Washers/Toilets
Population
Indoor Water Use
Population
Indoor use (mgd)
Indoor per capita use (gpcd)

Multiple Linear Regression: Influent TDS



- Variables:
  - STDS: Source TDS
  - IGPCD: Influent per capita water use
- R -squared = 0.98
- Relative Importance (%)
  - STDS: 88.2
  - IGPCD: 11.8

Multiple Linear Regression: Influent TDS



- Variables:
  - STDS: Source TDS
  - IGPCD: Influent per capita water use
- R -squared = 0.75
- Relative Importance (%)
  - STDS: 67.2
  - IGPCD: 32.8

TDS Statistical Model Matrix

- Using the statistical models, matrices were developed to predict the effects of conservation and changes in source water TDS. Much of this variation was due to climatic factors such as drought.

- EMWD Example: During the peak of the drought, source water quality was approximately 500 mg/L and indoor per capita water use was 55 gpcd. The estimated water quality entering a WWTP would be approximately 750 mg/L.

Research Question 10

- Q: What effect, if any, did the 2015-16 changes in average per-capita indoor water use have on the average concentration of TDS in wastewater influent and recycled water?

- A: This study estimates that for every 1.0 gpcd decline in indoor water use, TDS increases by 1.7 mg/L for the EMWD service area. The state's mandatory conservation measure may have contributed to the estimated 8.5 mg/L added to the system during this time period.

Research Question 11

- Q: Based on water quality correlations with drought and conservation, what are the implications for the trends in per capita water use and TDS in recycled water if precipitation patterns over the next 20 years are drier than normal?

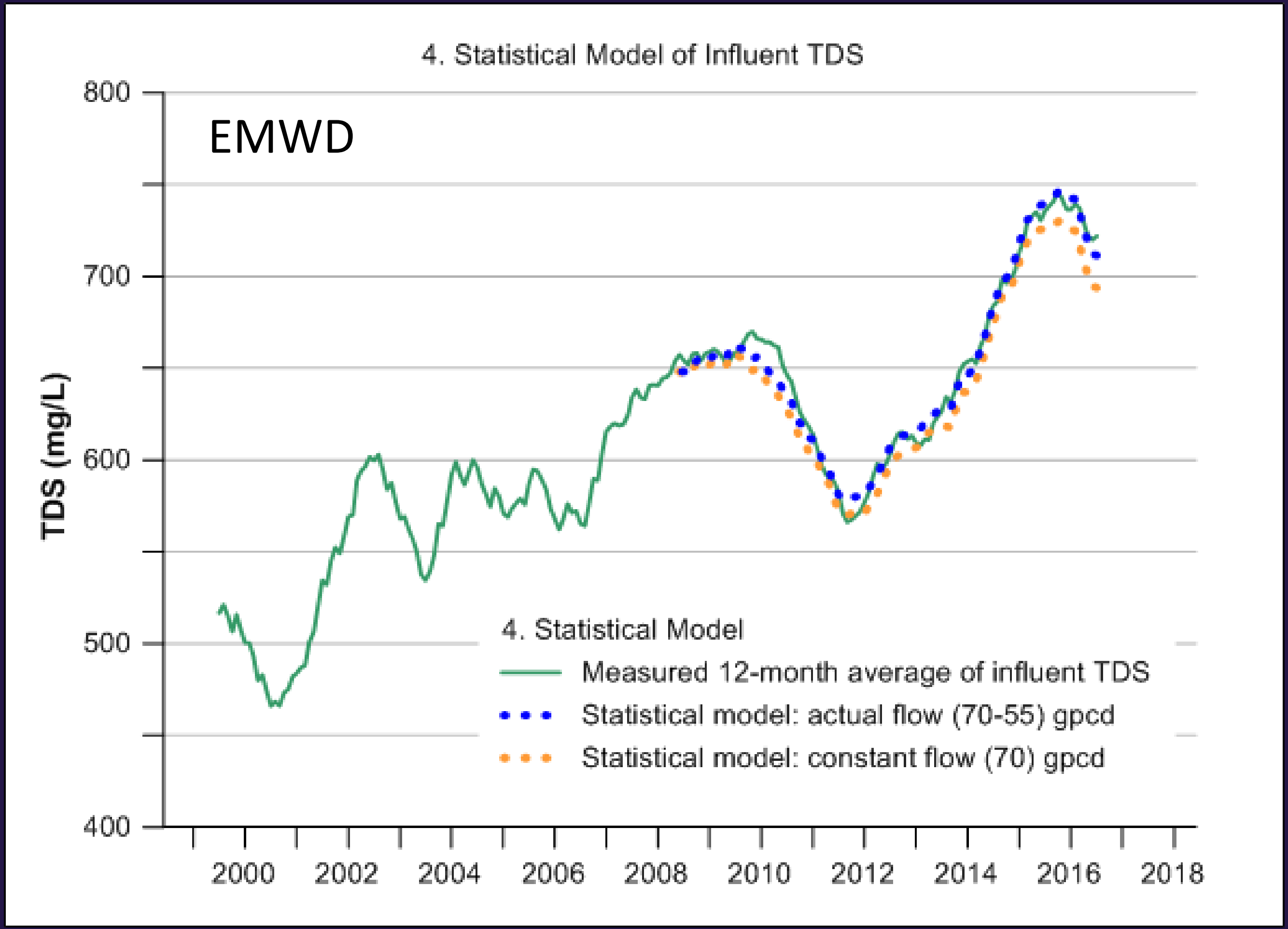
- A: Using the statistical models, matrices were developed to predict the effects of conservation and changes in source water TDS. Much of this variation was due to climatic factors such as drought.

EMWD Statistical Model Matrix for Influent TDS

Indoor Water Use (gpcd)	Source TDS (mg/L)												
	300	325	350	375	400	425	450	475	500	525	550	575	600
40	608	629	650	671	692	713	733	754	775	796	817	838	859
42	605	626	646	667	688	709	730	751	772	793	814	835	856
44	601	622	643	664	685	706	727	748	769	790	810	831	852
46	598	619	640	661	682	703	724	744	765	786	807	828	849
48	595	616	637	657	678	699	720	741	762	783	804	825	846
50	591	612	633	654	675	696	717	738	759	780	801	821	842
52	588	609	630	651	672	693	714	735	755	776	797	818	839
54	585	606	627	648	668	689	710	731	752	773	794	815	836
56	581	602	623	644	665	686	707	728	749	770	791	812	832
58	578	599	620	641	662	683	704	725	746	766	787	808	829
60	575	596	617	638	659	679	700	721	742	763	784	805	826
62	572	592	613	634	655	676	697	718	739	760	781	802	823
64	568	589	610	631	652	673	694	715	736	756	777	798	819
66	565	586	607	628	649	670	690	711	732	753	774	795	816
68	562	583	603	624	645	666	687	708	729	750	771	792	813
70	558	579	600	621	642	663	684	705	726	747	767	788	809

Every 1 gpcd decrease amounts to 1.7 mg/L increase in TDS

Multiple Linear Regression: Influent TDS



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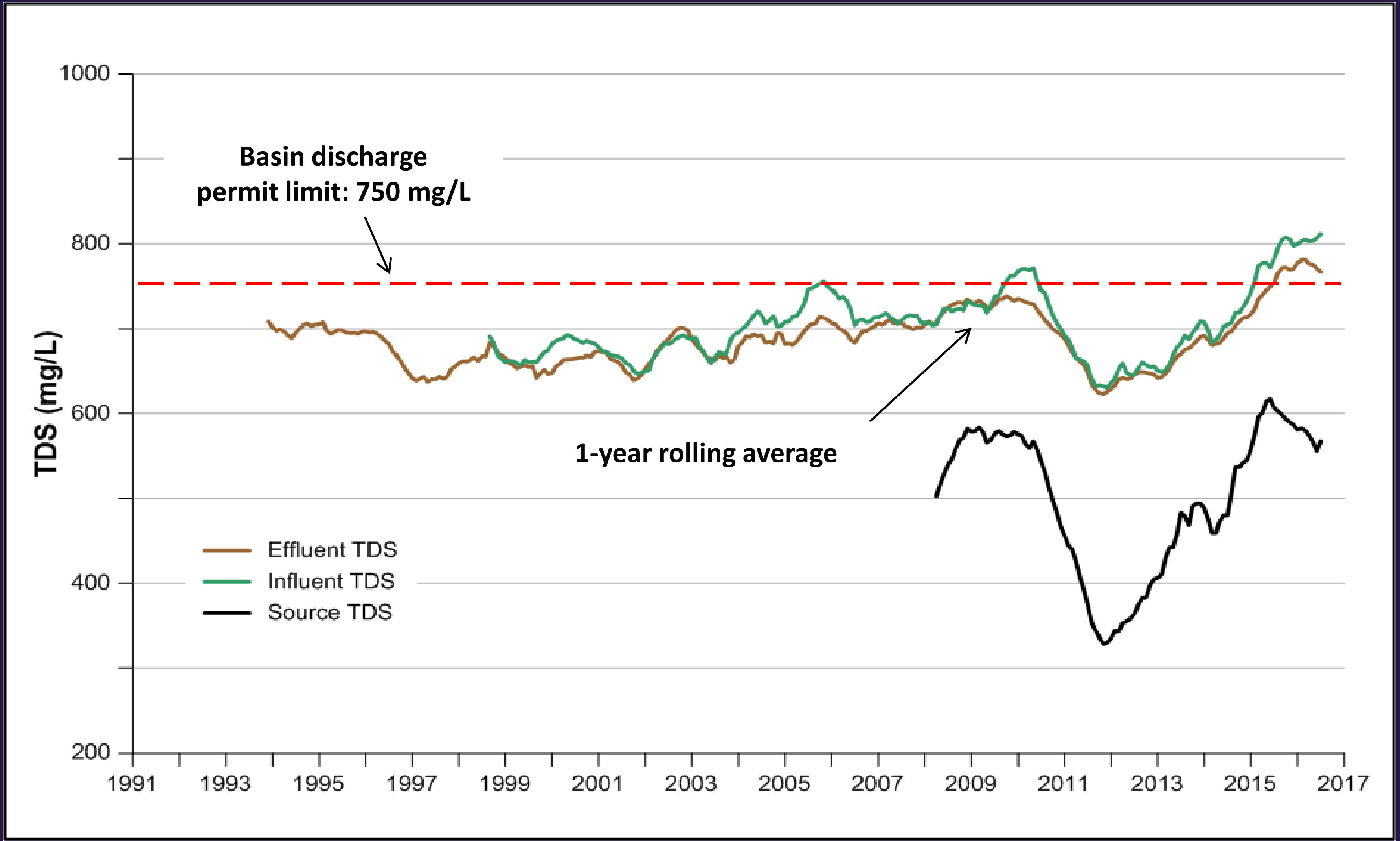
Long-term rolling averages

- How does the volume-weighted average TDS concentration in recycled water, and the related increment of use, vary using a range of rolling averaging periods (e.g., 1, 5, 10, and 15 years)?
- Longer-term rolling average periods smooth out annual variations of effluent trends. 10 year averages account for seasonal cyclicity.

TDS Trends Example - Temecula Valley

Considerations:

- Rolling average period
- Discharge limits based on Management Zone Water Quality Objectives
- Long term trends
- Sessional cyclicity (drought vs wet years)



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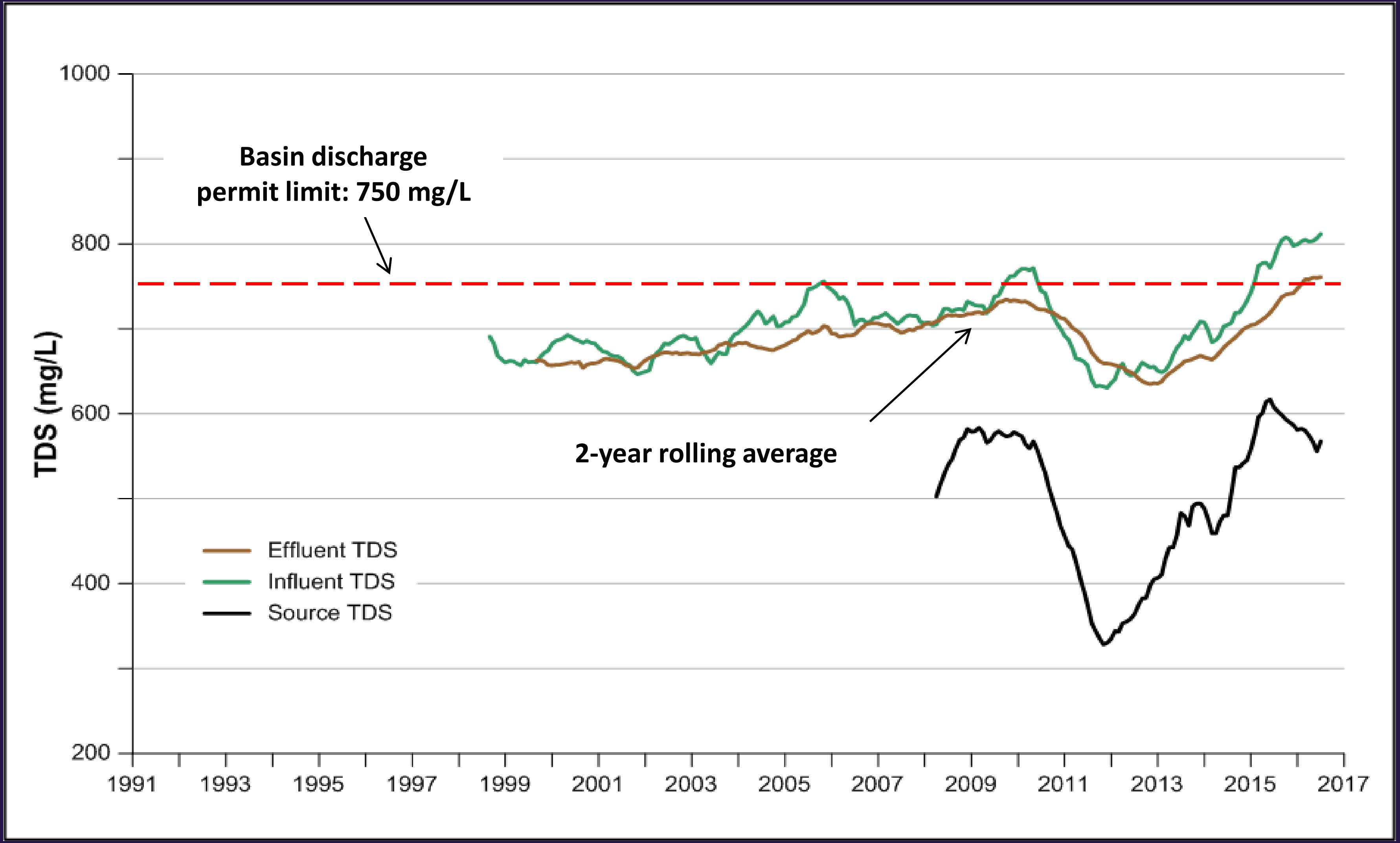

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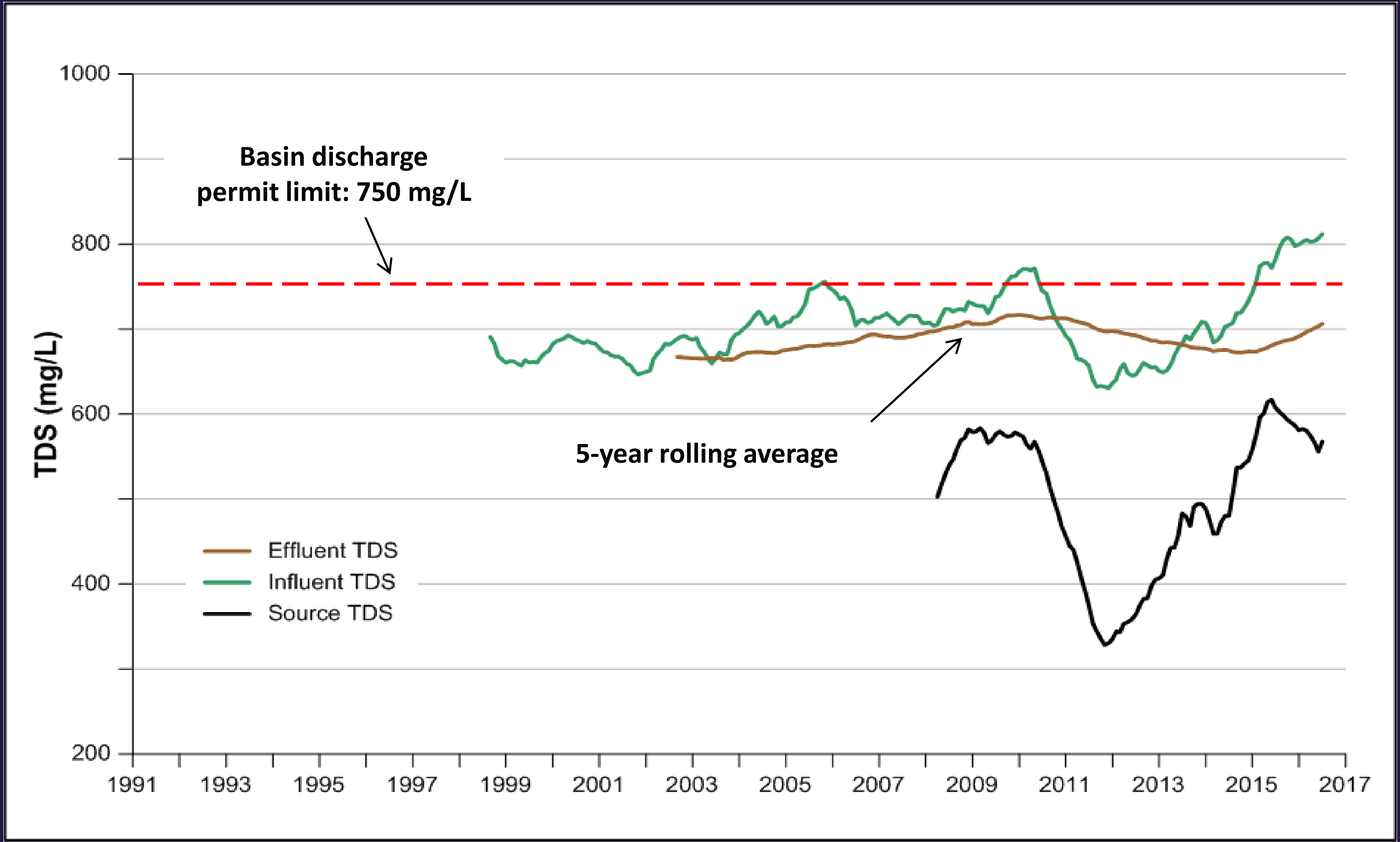

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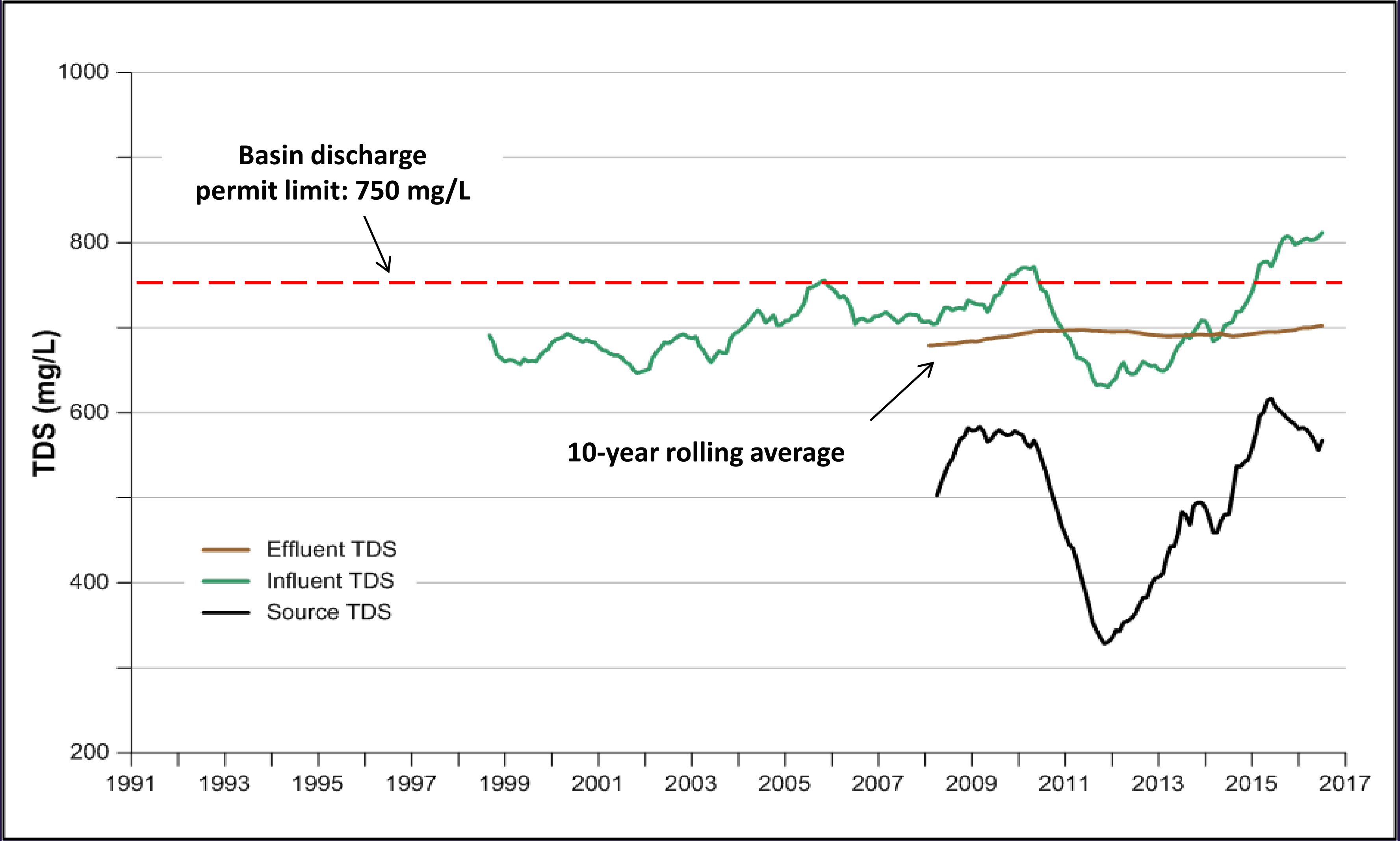

Summary

- Longer rolling averages (>5-years) minimize the influence of drought cycles. Long-term upward trends in TDS will still be present.
- Statistical modeling suggests that for every 1.0 gallon per capita per day that is conserved there will be an increase in TDS concentrations to the WWTPs of 1.2 mg/L to 1.7 mg/L
- Unintended consequences from water conservation measures
  - lower water quality (higher TDS)
  - less quantity of recycled water
  - less revenue
  - infrastructure O&M
  - Less energy uses
  - Less GHG emissions

Contact Information

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