The Drought Cycle and Groundwater Chemistry

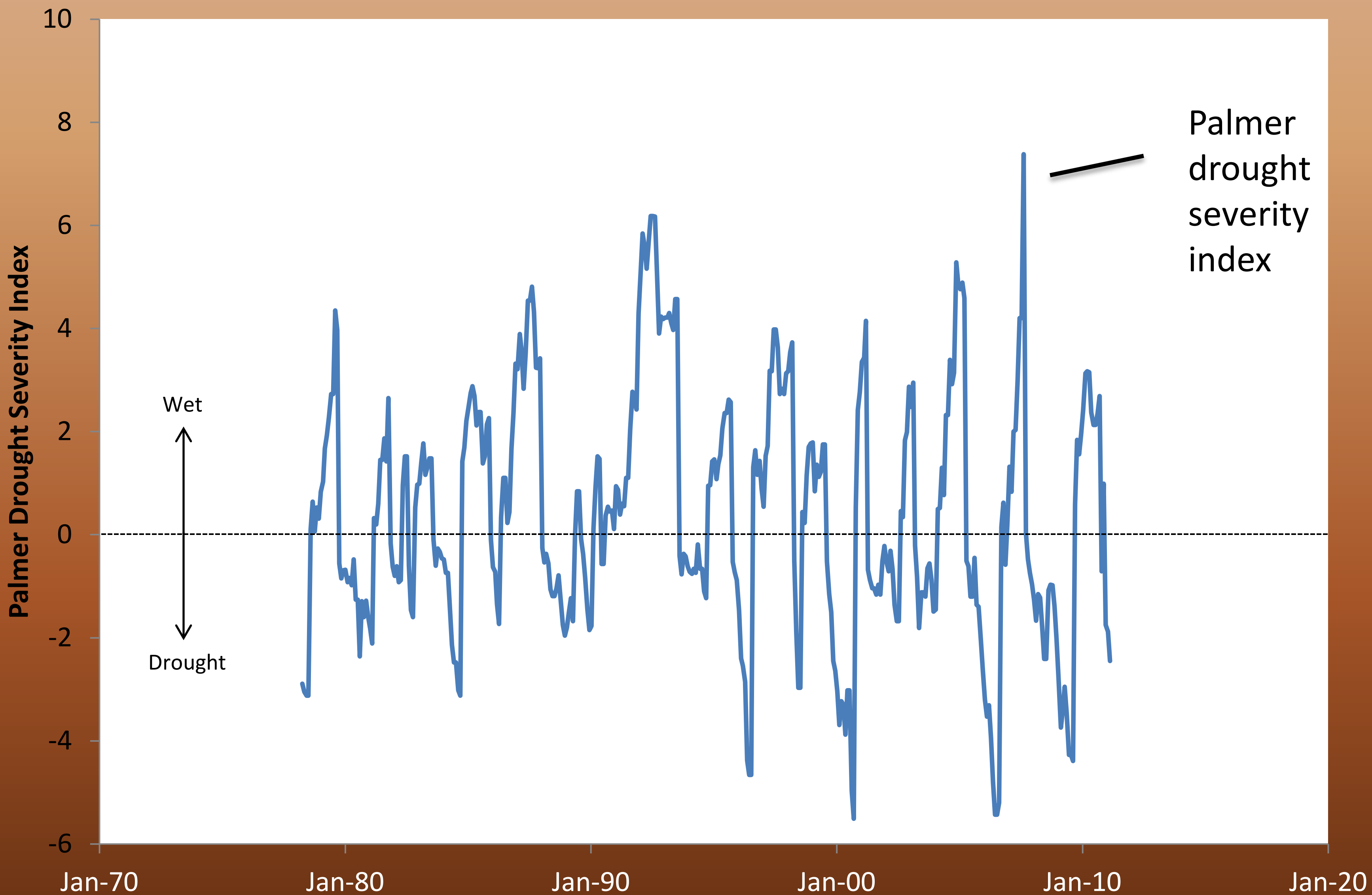
Barton Springs segment of the Edwards Aquifer

Barbara Mahler
U.S. Geological Survey
bjmahler@usgs.gov

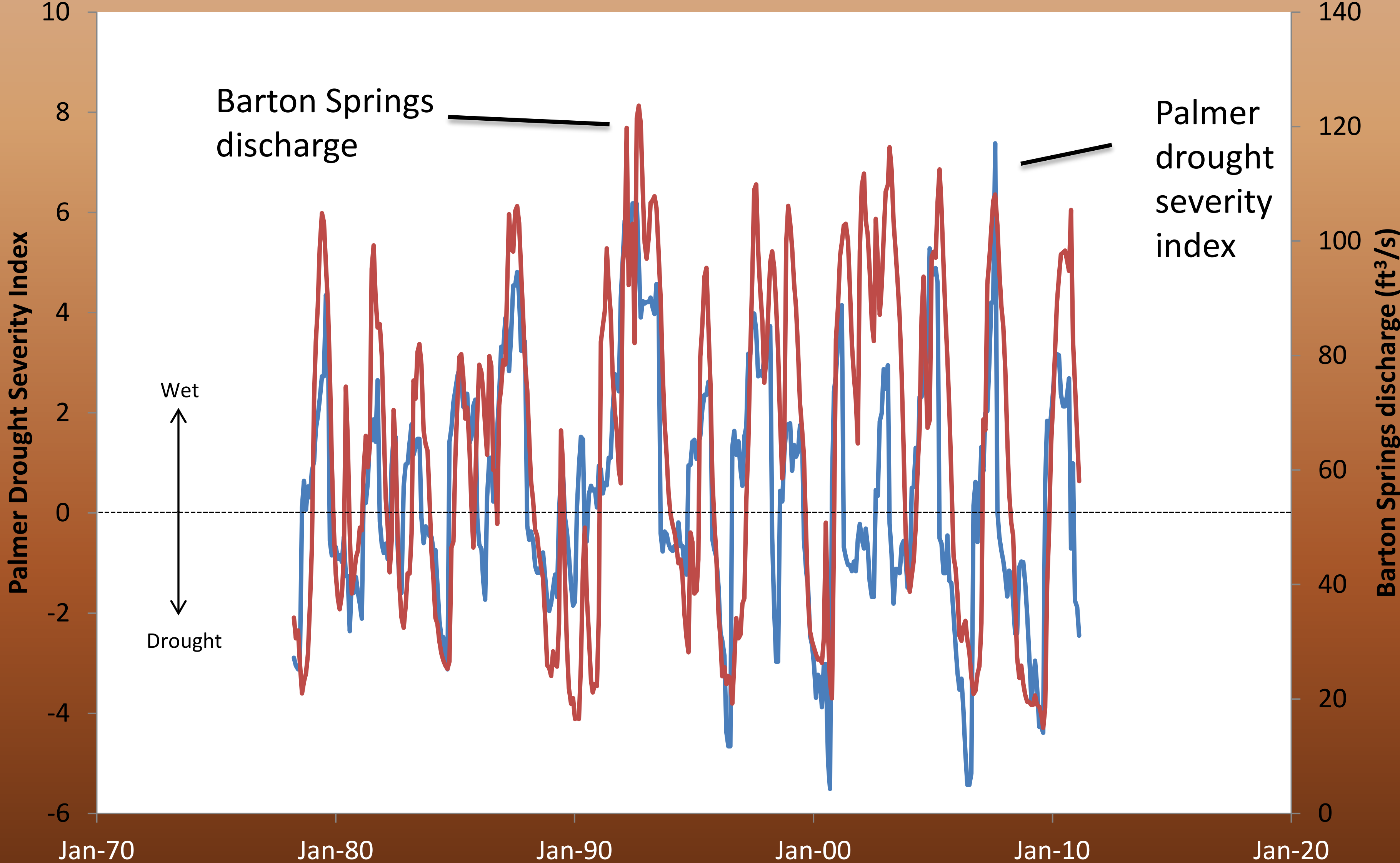

Apathy
RAIN
DROUGHT
"Hydro-Illogical"
Cycle
MORE
DROUGHT
Panic
Concern

USGS

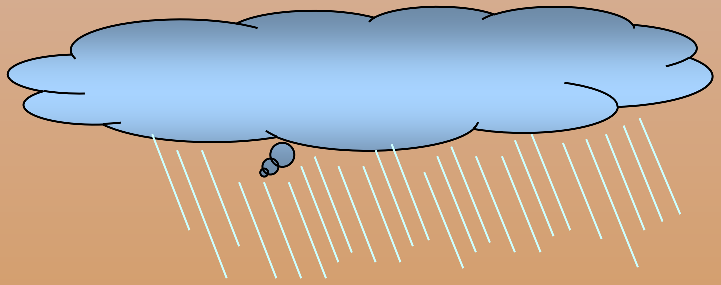
Central Texas drought cycles

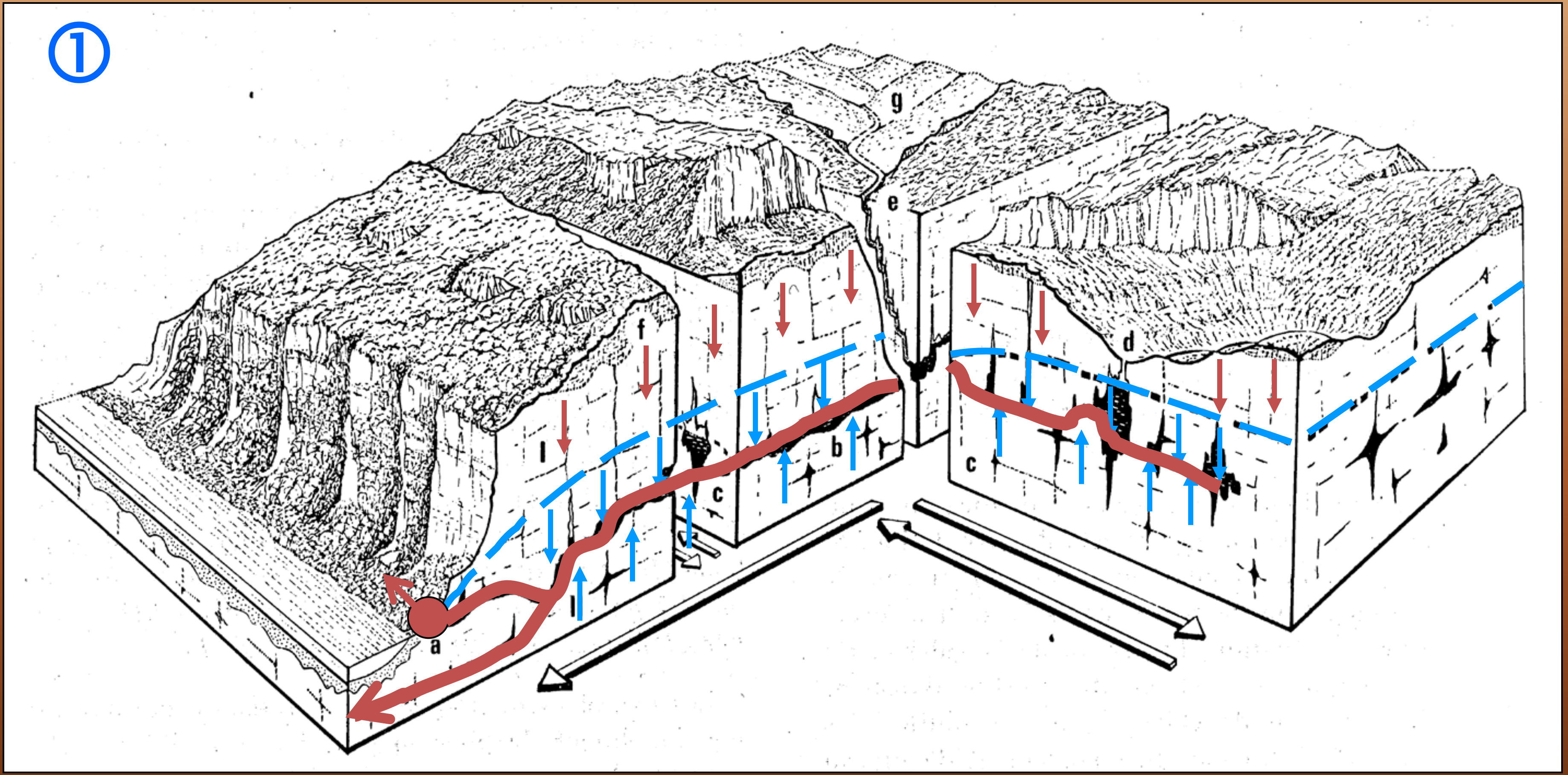


Central Texas drought cycles



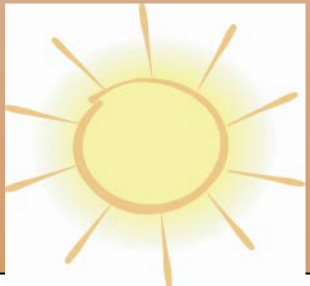
During rainfall, recharge occurs through streambeds and as direct infiltration

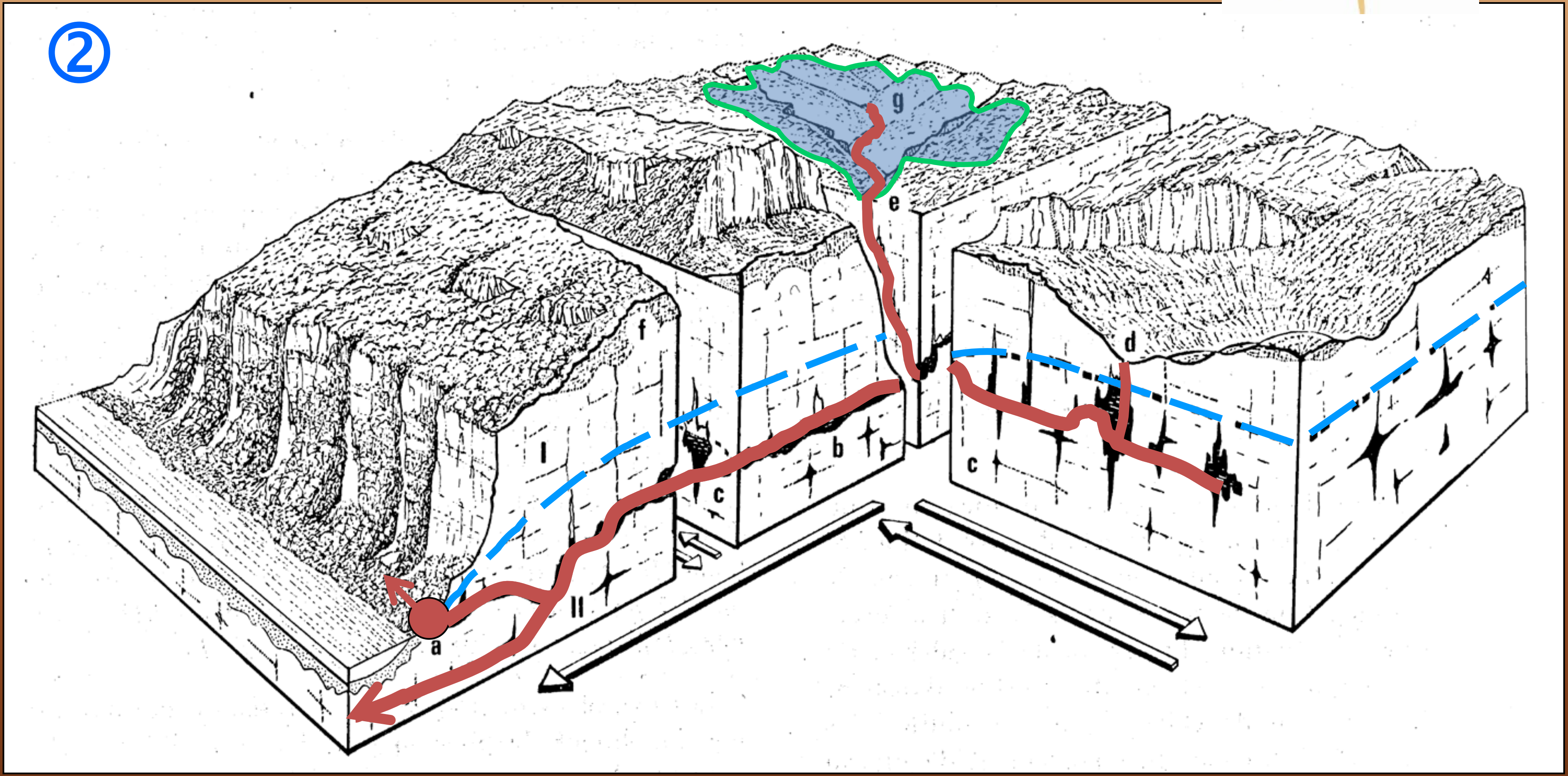




Nicolas Massei, UMR M2C, Université de Rouen

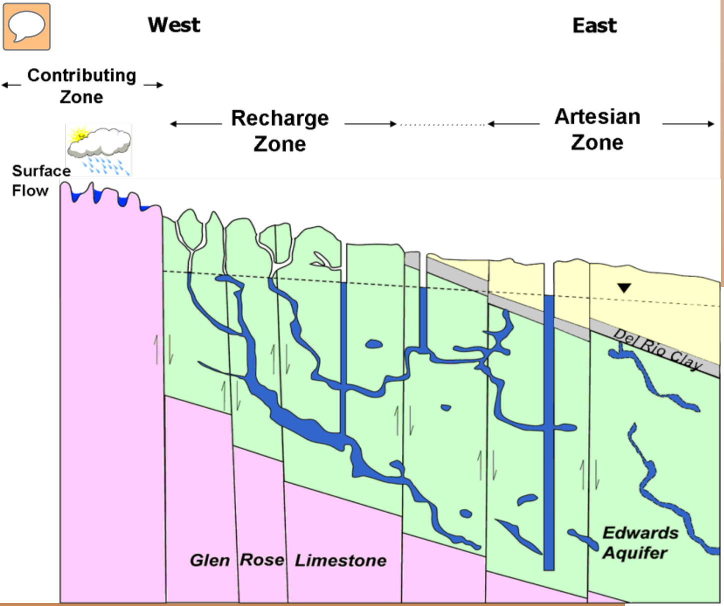
After rainfall, flow in streams continues to recharge the underlying aquifer through conduits



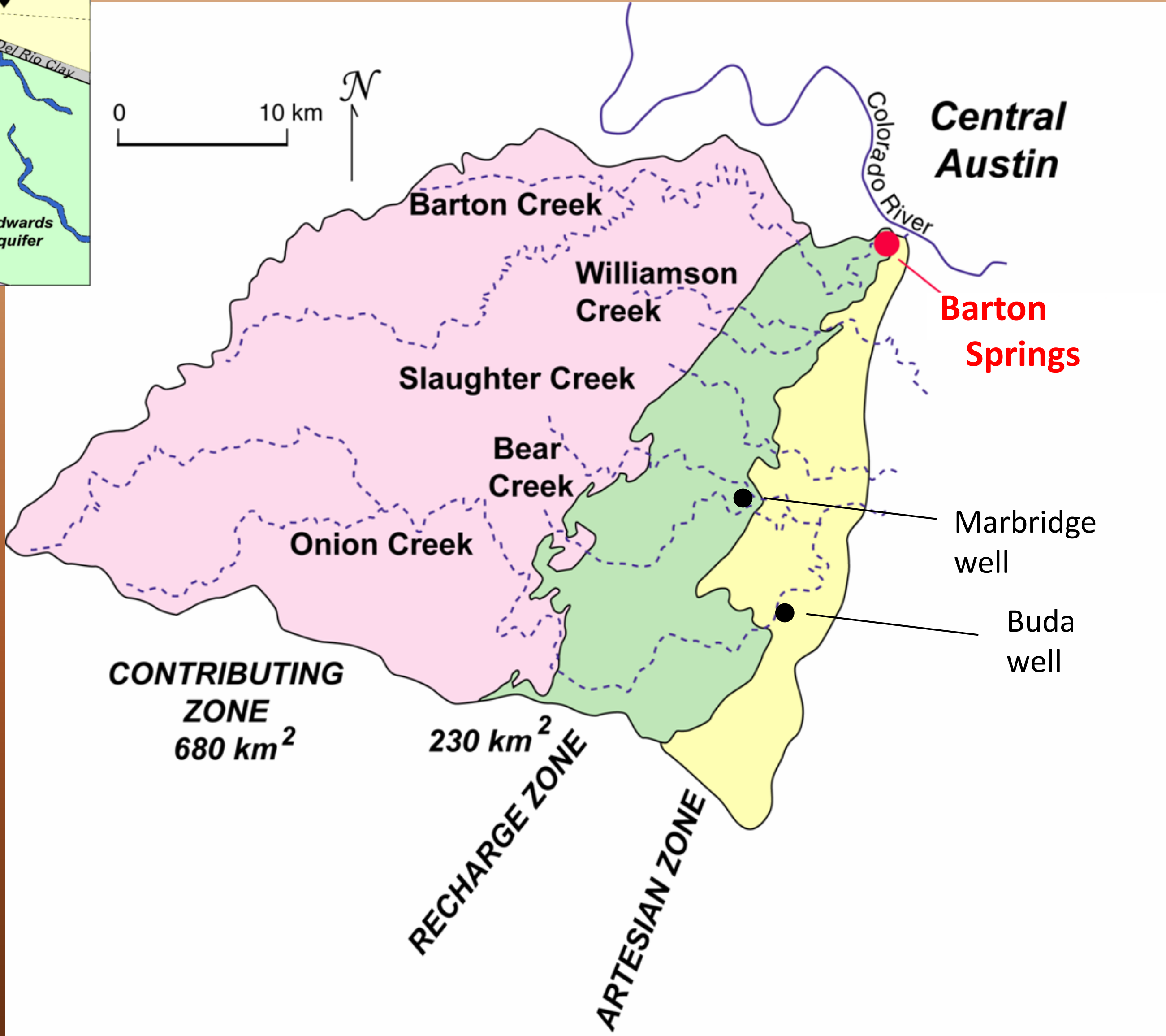


USGS

Nicolas Massei, UMR M2C, Université de Rouen

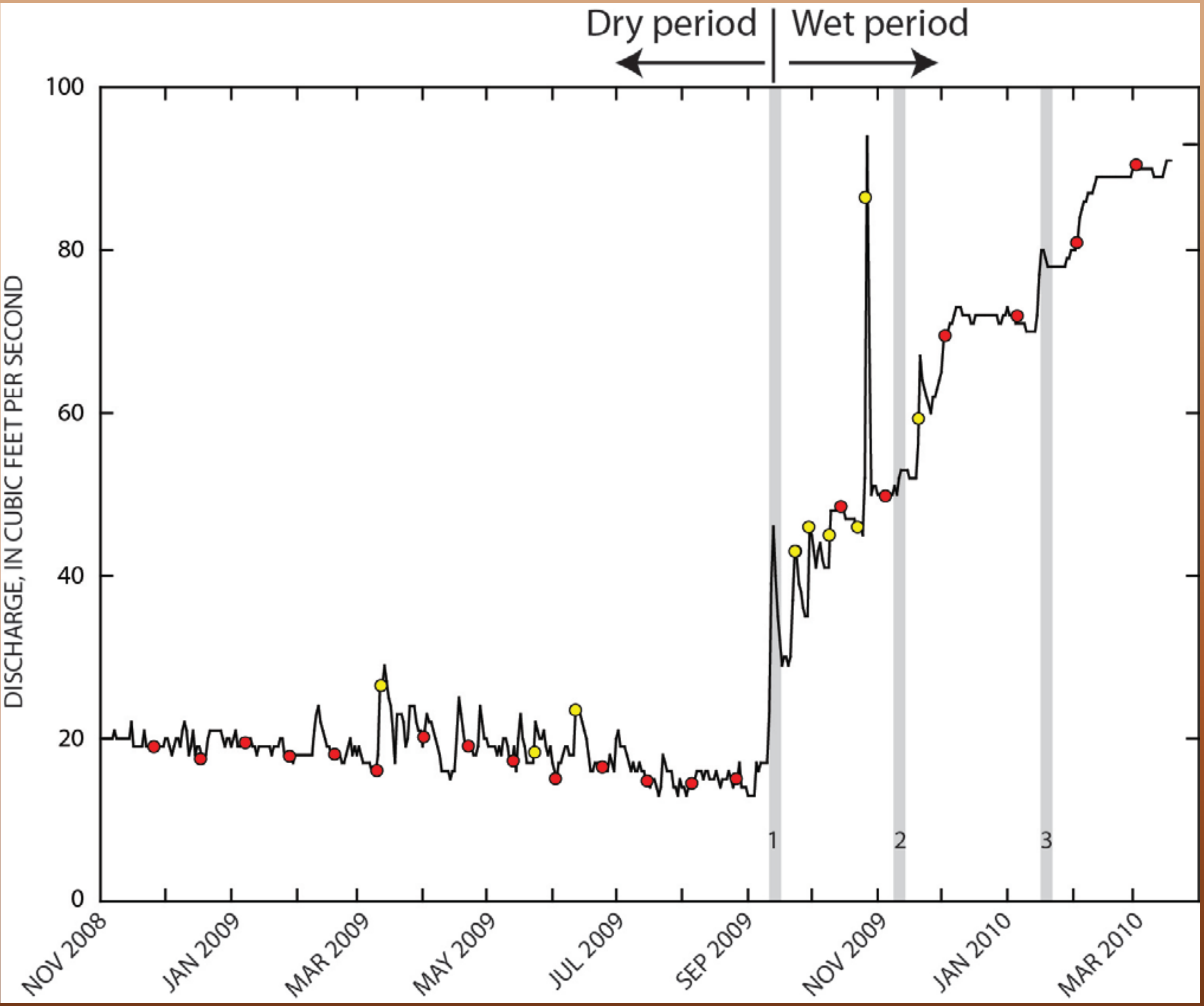


The Barton Springs segment of the Edwards aquifer

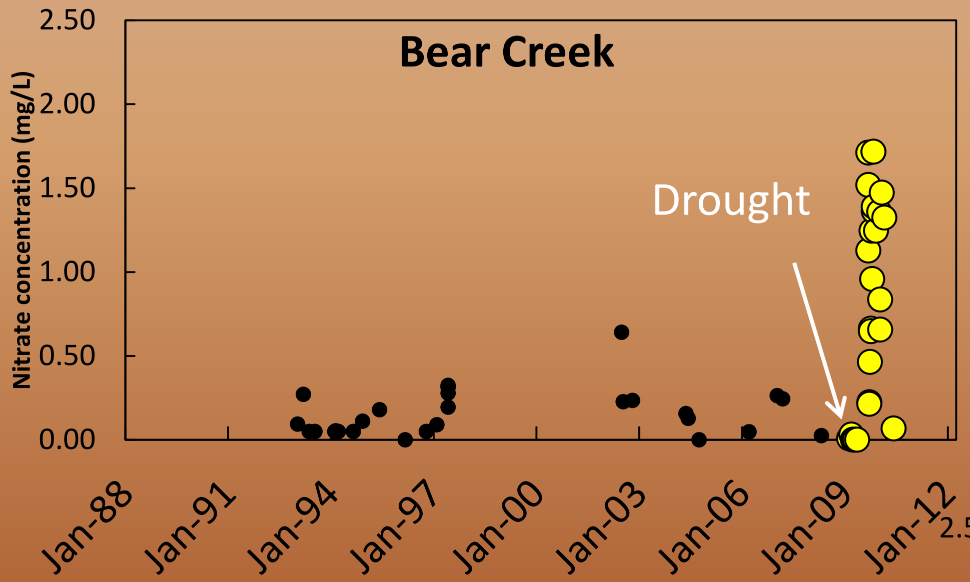


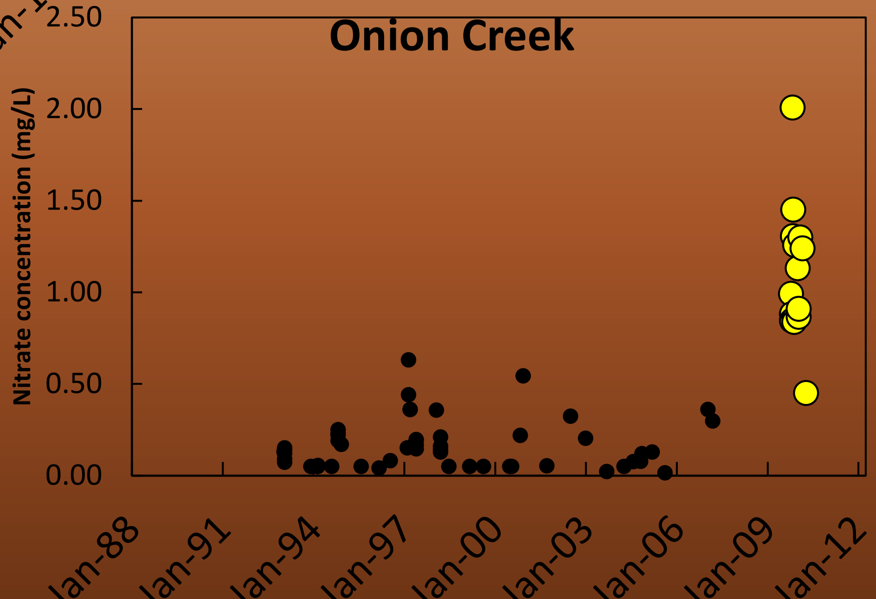
USGS

Hydrologic conditions: transition from drought to wet



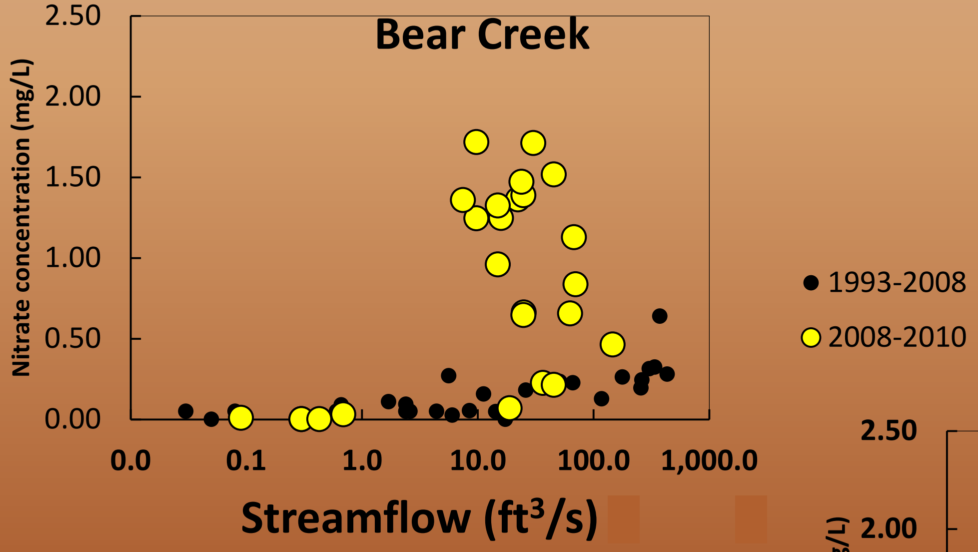
Nitrate concentrations in streams increased when the drought broke in Sept. 2009

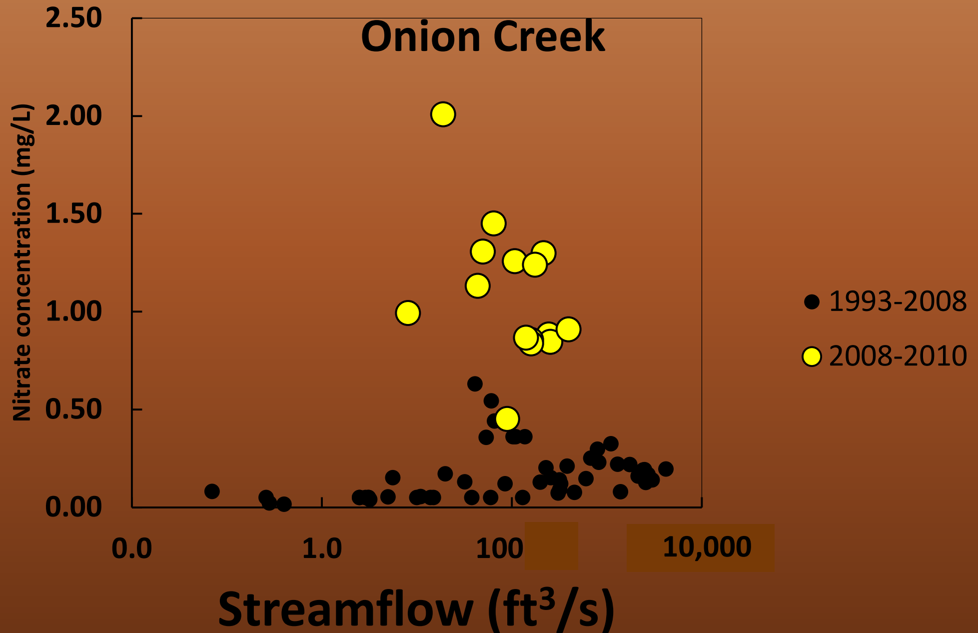




USGS

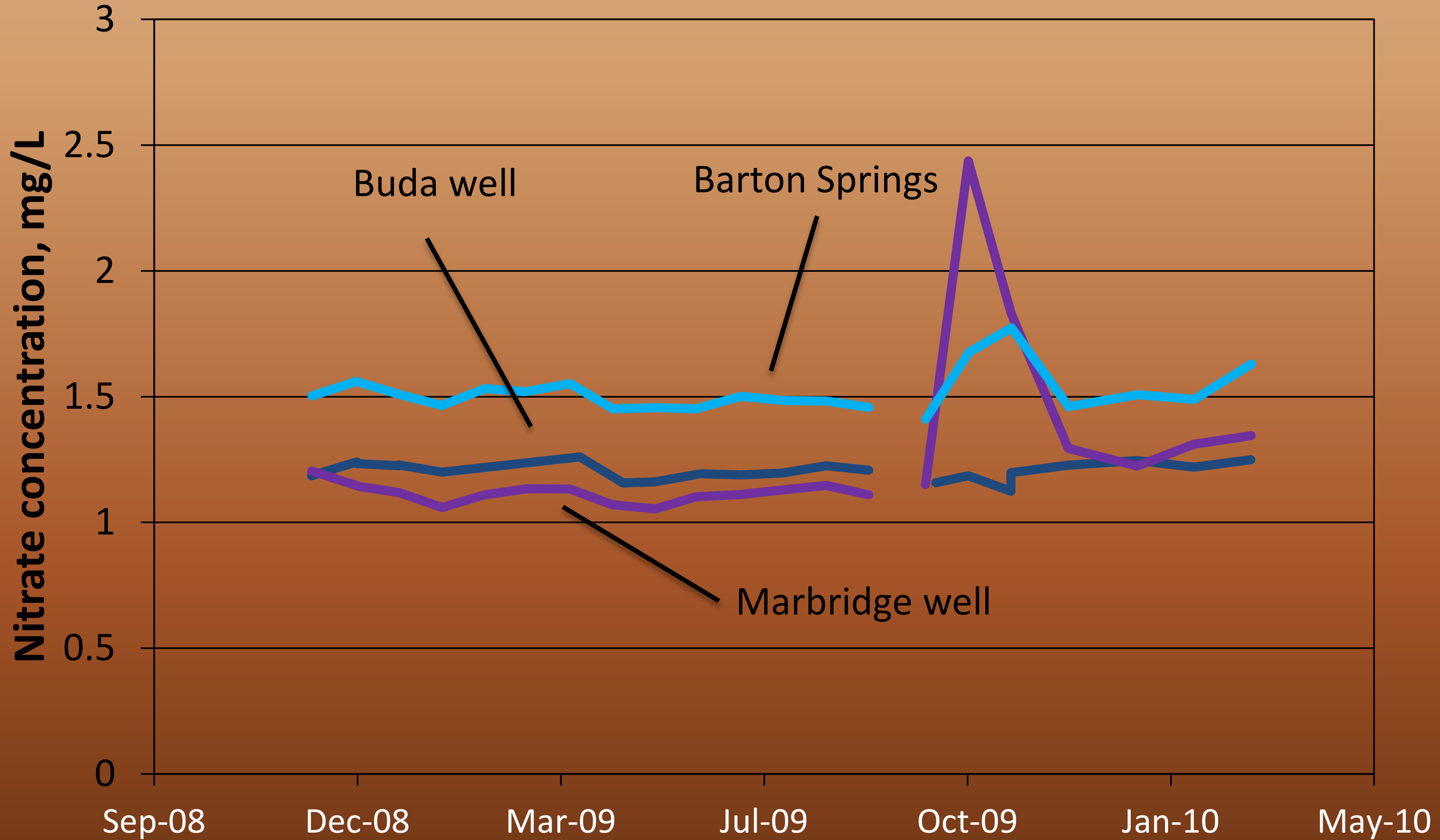
….and were high relative to measured streamflow



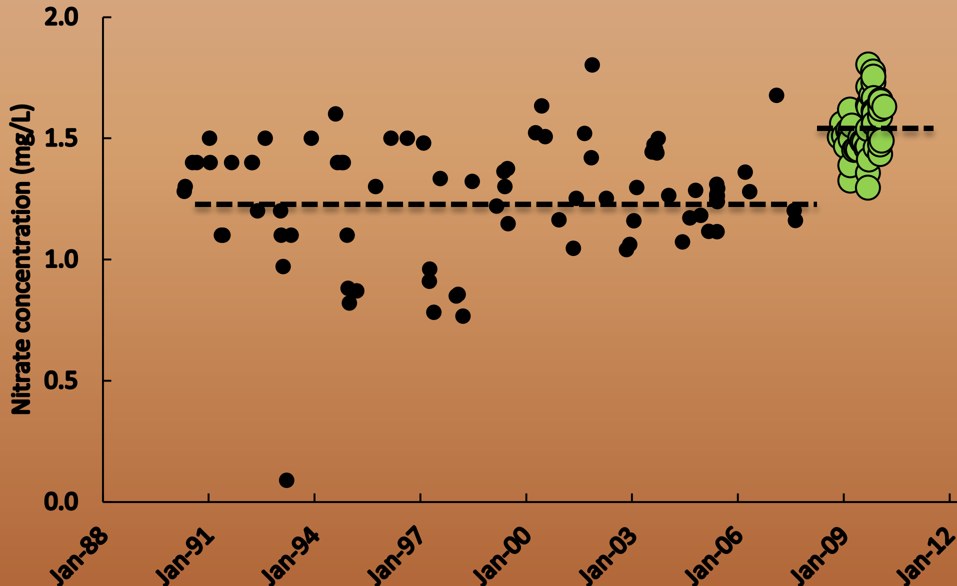


USGS

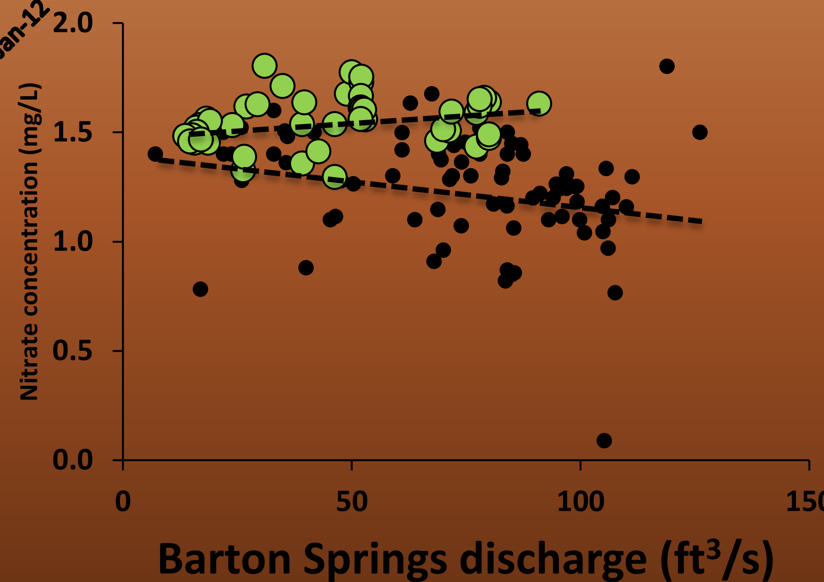
Nitrate concentrations in groundwater had contrasting responses to the break in the drought (Sept. 2009)



Barton Springs: Nitrate concentrations were higher relative to historical levels



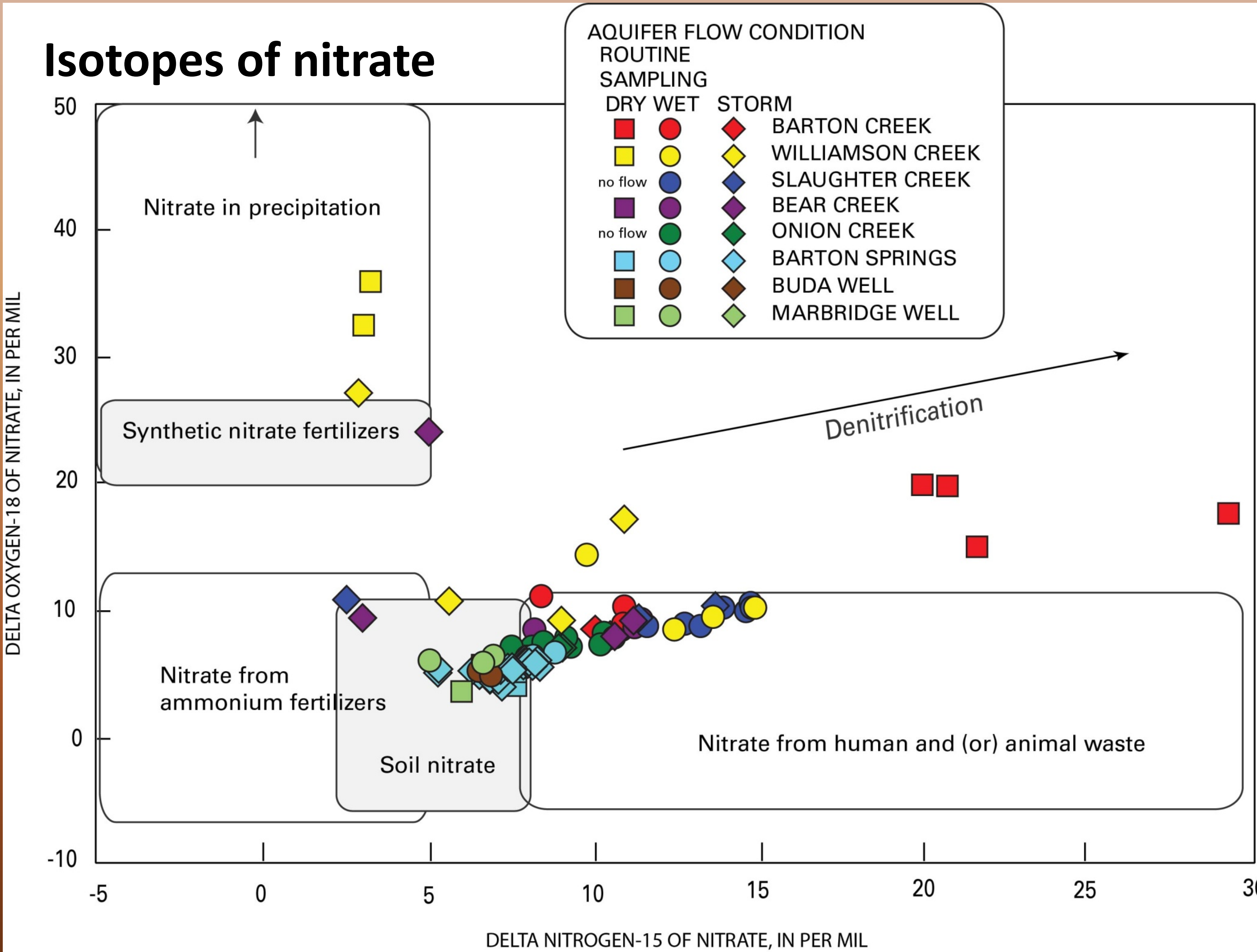
1988 to 2010



1993-2008
2008-10

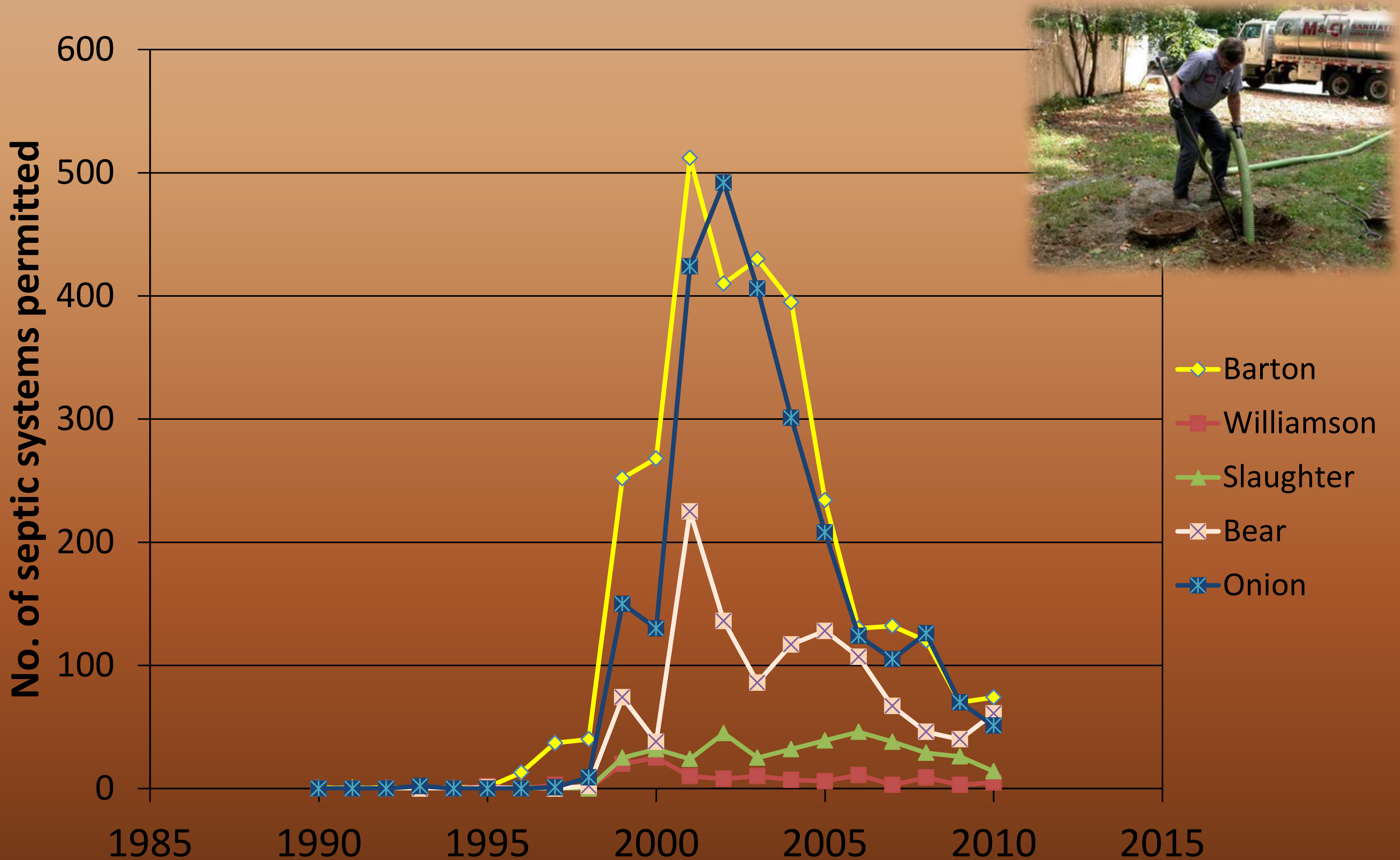
USGS

Isotopes of nitrate

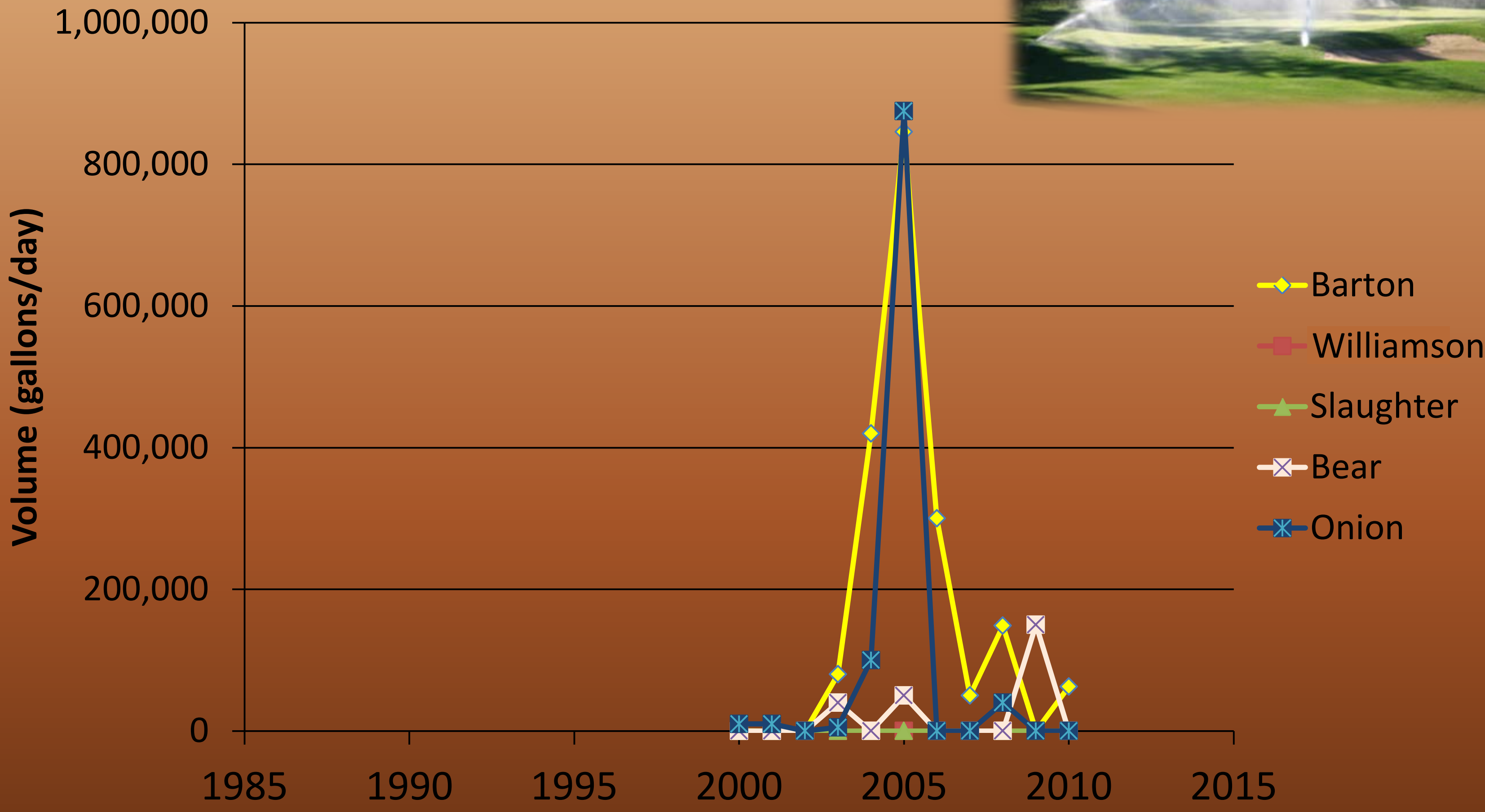


What's changed?

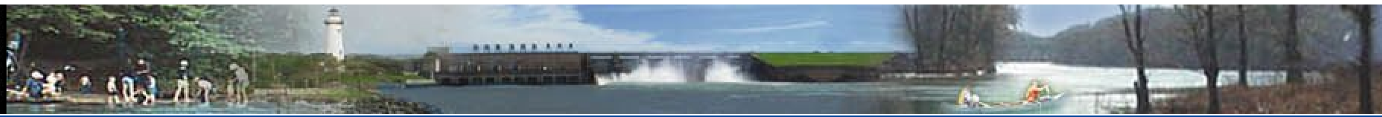
Septic systems permitted by year



Irrigation volume permitted by year



USGS



USGS Water Resources Applications Software: LOADEST

Load Estimator (LOADEST): A Program for Estimating Constituent Loads in Streams and Rivers

Welcome to the U.S. Geological Survey (USGS) Web page for the LOADEST software package. This page provides access to the LOADEST software and documentation. These items and additional features may be accessed using the navigational tabs at the top of the page.

LOAD ESTimator (LOADEST) is a FORTRAN program for estimating constituent loads in streams and rivers. Given a time series of streamflow, additional data variables, and constituent concentration, LOADEST assists the user in developing a regression model for the estimation of constituent load (calibration). Explanatory variables within the regression model include various functions of streamflow, decimal time, and additional user-specified data variables. The formulated regression model then is used to estimate loads over a user-specified time interval (estimation). Mean load estimates, standard errors, and 95 percent confidence intervals are developed on a monthly and(or) seasonal basis.

The calibration and estimation procedures within LOADEST are based on three statistical estimation methods. The first two methods, Adjusted Maximum Likelihood Estimation (AMLE) and Maximum Likelihood Estimation (MLE), are appropriate when the calibration model errors (residuals) are normally distributed. Of the two, AMLE is the method of choice when the calibration data set (time series of streamflow, additional data variables, and concentration) contains censored data. The third method, Least Absolute Deviation (LAD), is an alternative to maximum likelihood estimation when the residuals are not normally distributed. LOADEST output includes diagnostic tests and warnings to assist the user in determining the appropriate estimation method and in interpreting the estimated loads.

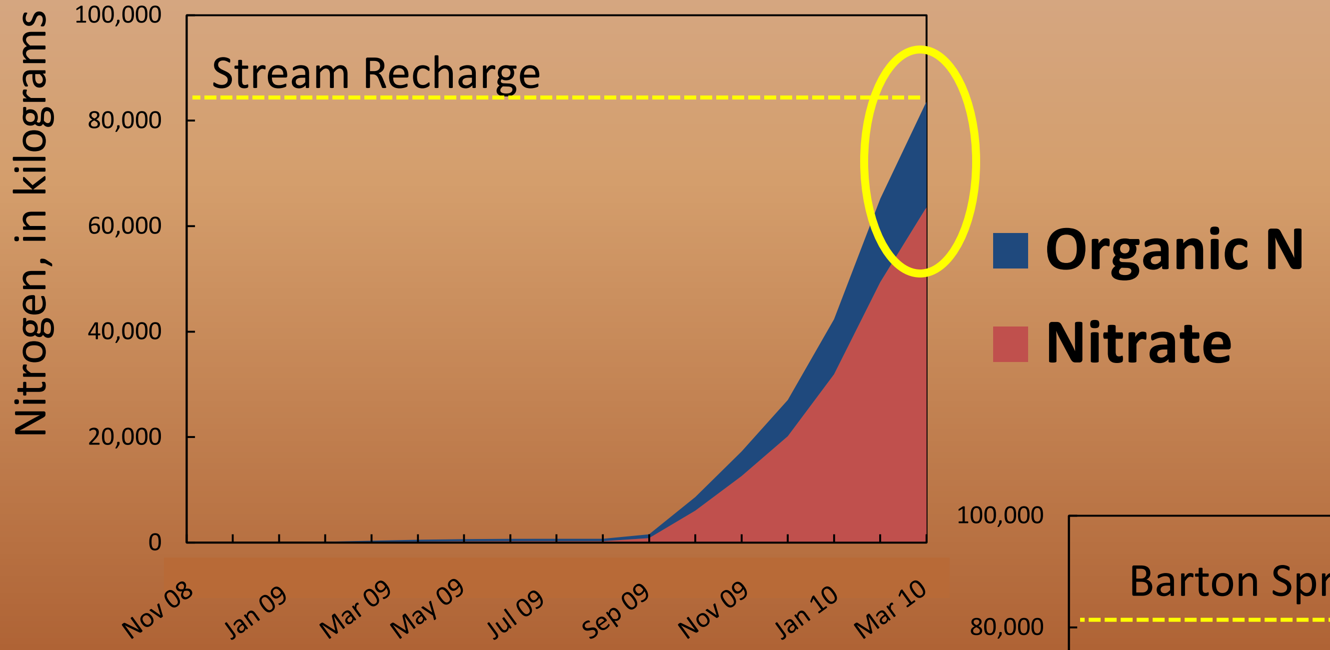
The LOADEST software and related materials (data and documentation) are made available by the U.S. Geological Survey (USGS) to be used in the public interest and the advancement of science. You may, without any fee or cost, use, copy, modify, or distribute this software, and any derivative works thereof, and its supporting documentation, subject to the USGS software User's Rights Notice.

Download it NOW

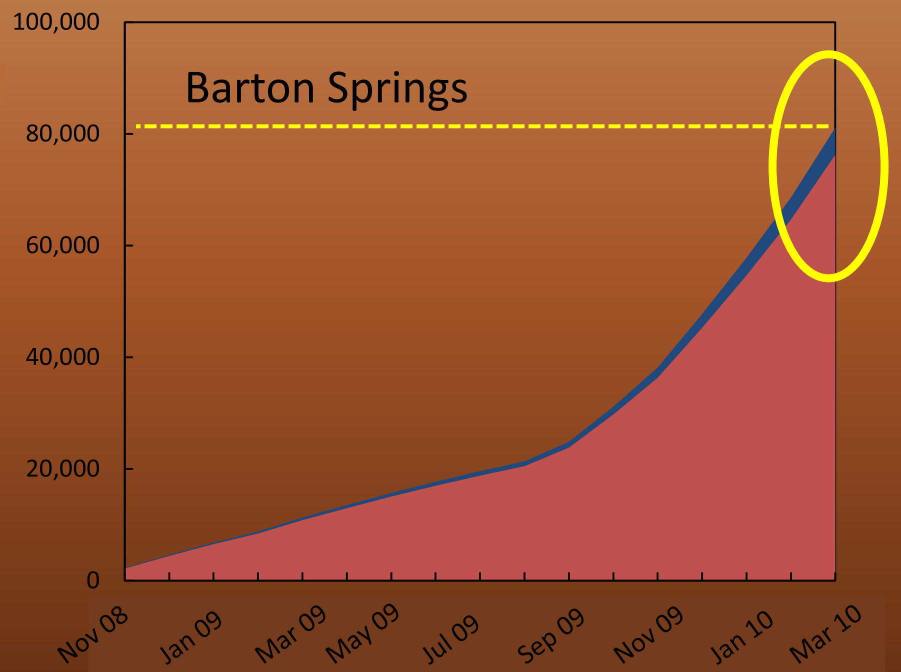
Search LOADEST Web Site

Google™ Custom Search Go

Cumulative N loading



- **Organic N is being converted to nitrate in the aquifer**
- **Total N is being stored (conservatively?) in the aquifer**

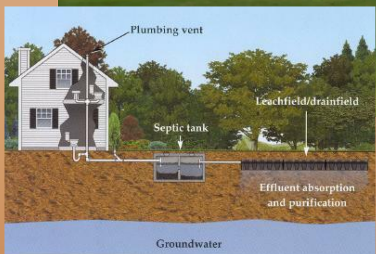


USGS

Implications of nitrification

- Organic nitrogen $\rightarrow NH_4^+$ (ammonification)
- $NH_4^+ + 1.5\ O_2 \rightarrow 2H^+ + 2H_2O + NO_2^-$
- $NO_2^- + 0.5\ O_2 \rightarrow NO_3^-$
- For every mg of ammonia oxidized to nitrate, 4.18 mg of oxygen are consumed
- Nitrification lowers the pH

USGS



Infiltration and discharge to surface water

Partial ammonification and nitrification; recharge to groundwater

Continued ammonification and nitrification of organic nitrogen

USGS

This work was done in cooperation with:

- Texas Commission on Environmental Quality
- City of Austin
- City of Dripping Springs
- Hays County
- Lower Colorado River Authority
- Barton Springs/Edwards Aquifer Conservation District

Additional information available

- Real-time physical properties at Barton Springs (site 08155500): http://tx.usgs.gov/
- USGS Fact Sheet: http://pubs.usgs.gov/fs/2011/3035/
- USGS Scientific Investigations Report: http://pubs.usgs.gov/sir/2011/5018/

USGS