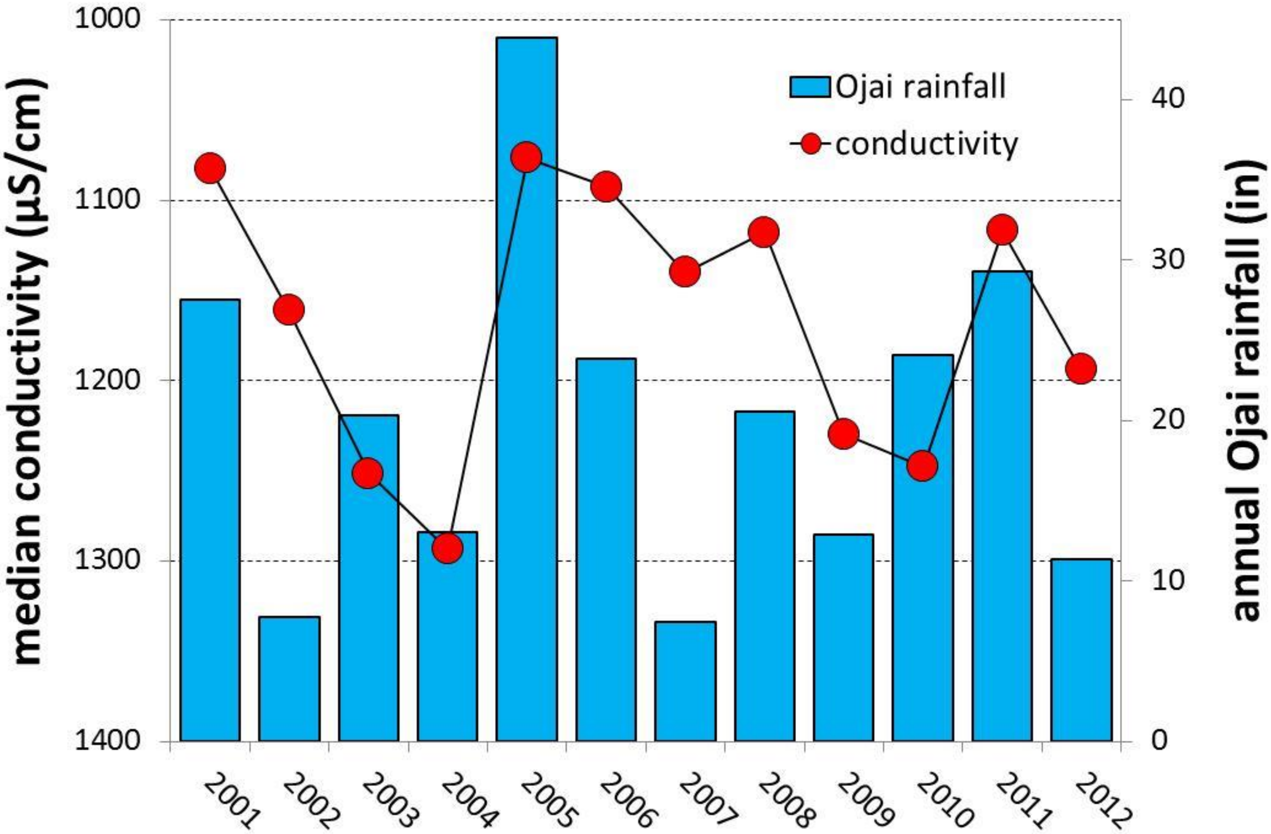
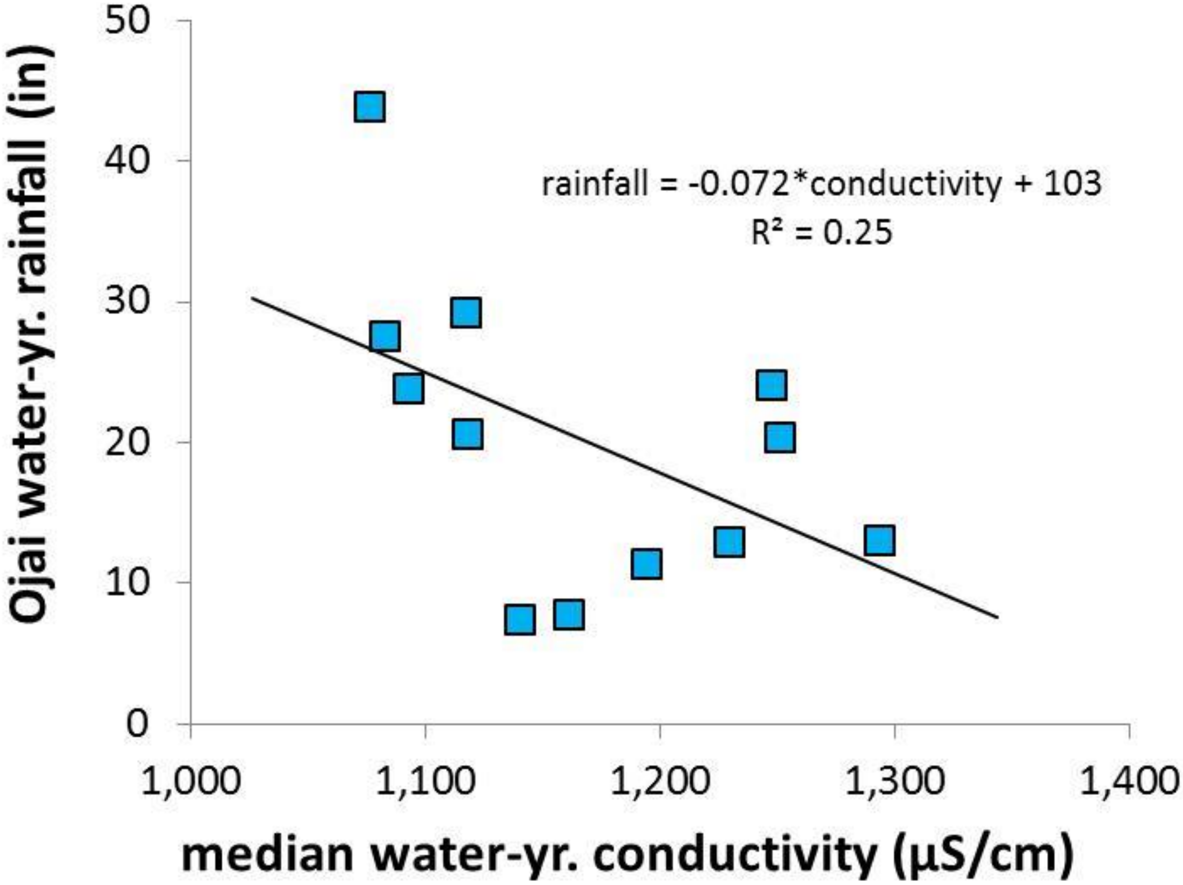


Flows in the Ventura watershed consist mainly of surfacing groundwater (aside from periods during and shortly after intense rain) and as groundwater ages, i.e. during years without substantial recharge from winter rainfall, its conductivity increases. Longer groundwater residence time spent in contact with subsurface geologic strata leads to increased mineral content. Thus there should be a clear relationship between the amount of winter rainfall and conductivity: big rainfall winters leading to "younger," lower conductivity streamflow; dry years yielding "older," higher conductivity waters.

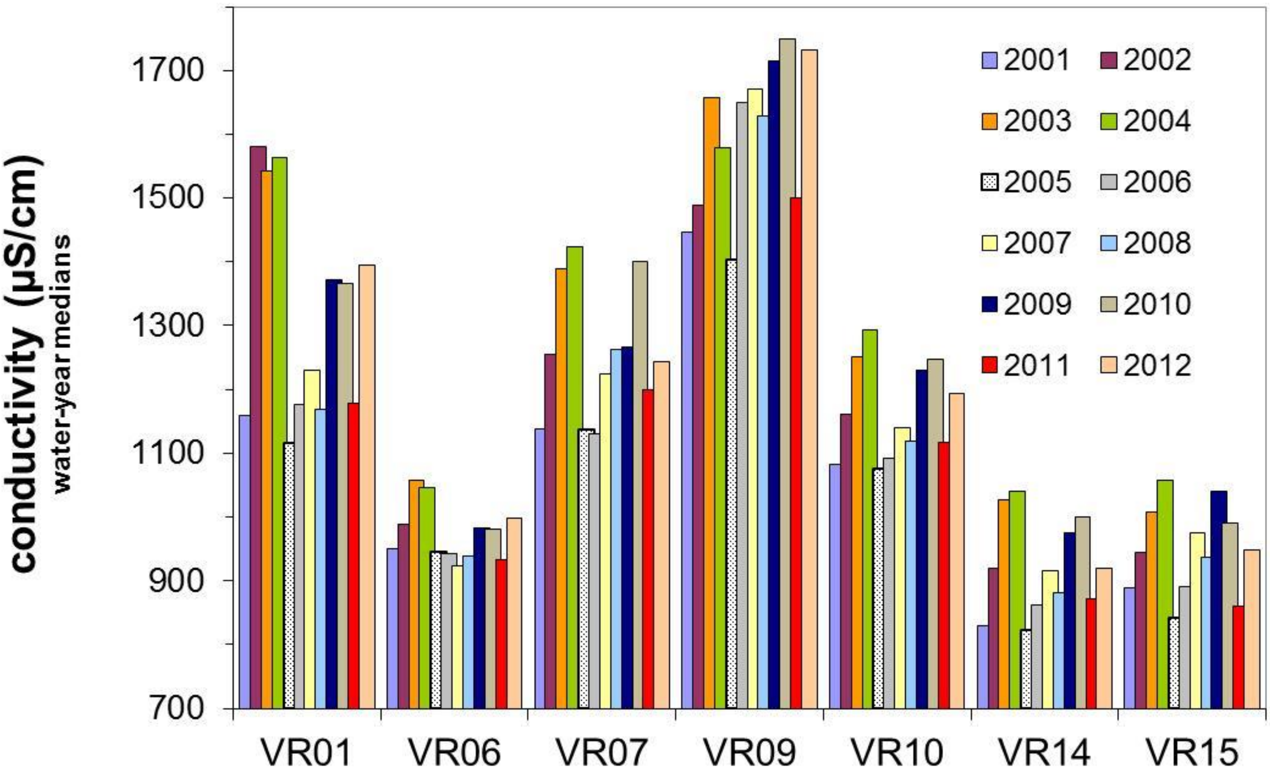
In the above graph the annual median standard conductivity of upper San Antonio Creek water is plotted along with annual Ojai rainfall for each listed water-year. Conductivity is shown on a decreasing scale to more easily demonstrate that as rainfall increases conductivity decreases, and visa versa. Big rainfall years cause a substantial decrease in conductivity, drier years, especially a series of dry years, cause a large increase.

(Conductivity data for 2012 is, as yet, incomplete and I've used what 's available to estimate this data point.)



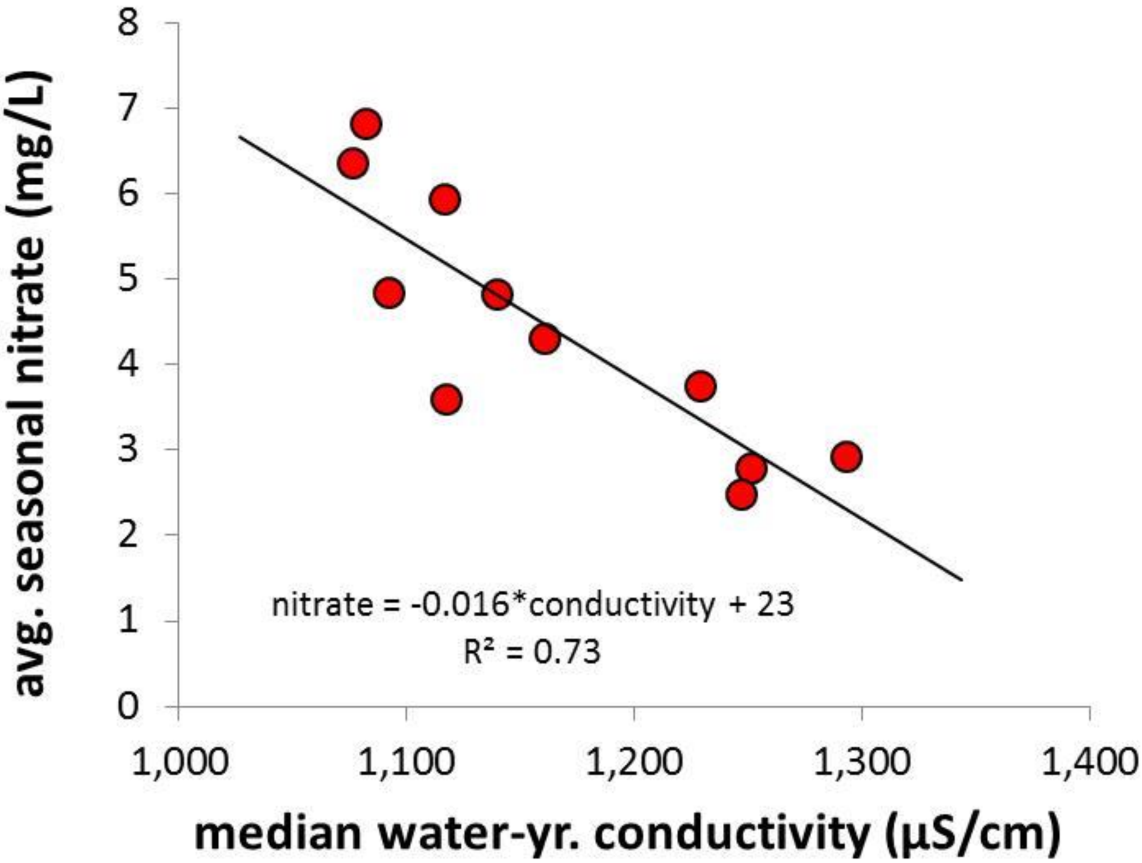
A scatterplot of annual rainfall plotted against annual conductivity at upper San Antonio Creek gives the above result. The R-square value indicates that water-year conductivity can explain 25% of that year's winter rainfall, or visa versa. The correlation would be even better if it were not for the wide spread in conductivity values during low rainfall years (perhaps more easily seen in the first graph). This is expected.

Groundwater aging is a multi-year process and a dry year following a wet year (e.g. 2002) will exhibit a lower conductivity than a similar, or even slightly wetter, dry year occurring after a series of dry winters (2004 being a good example). Then again, not all winters with the same rainfall are equal; it matters greatly just how the rain does fall: a single large storm contributes much greater groundwater recharge than a series of smaller storms even if the rainfall totals are the same. When the rain occurs also matters: closely spaced storms contribute greater recharge than storms spread out in time; rain on wet soil contributes greater amounts of recharge than rain on dry.



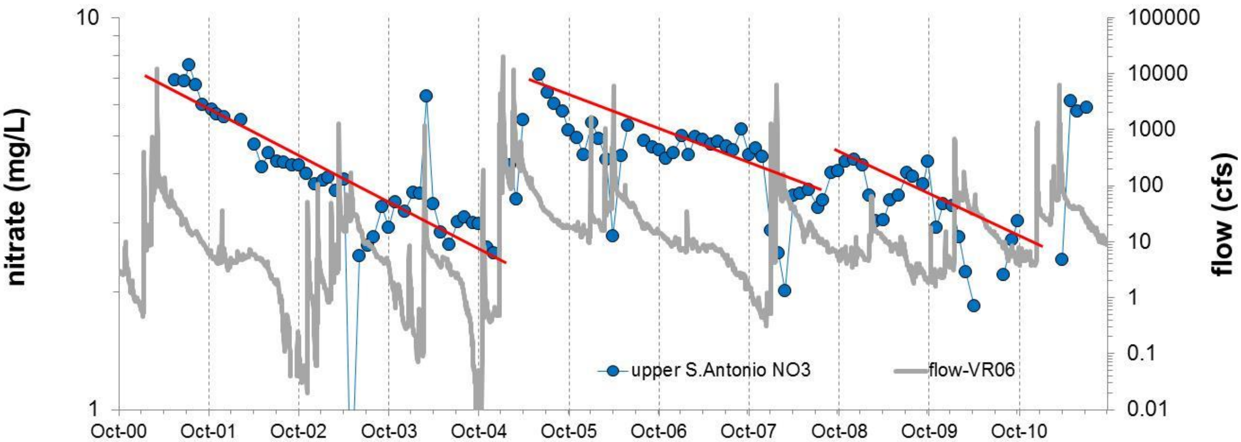
The previous graphs featured upper San Antonio Creek (SBCK site VR10), but the same relationship between conductivity and annual rainfall exists at every Ventura watershed location where flow consists mainly of groundwater from a single source. The annual median conductivities for VR09 (what I've been calling Pirie but others call Stewart Creek) in the above chart show the same pattern as at VR10, as do the medians for VR14 (North Fork Matilija Creek) and VR15 (Matilija Creek above the dam).

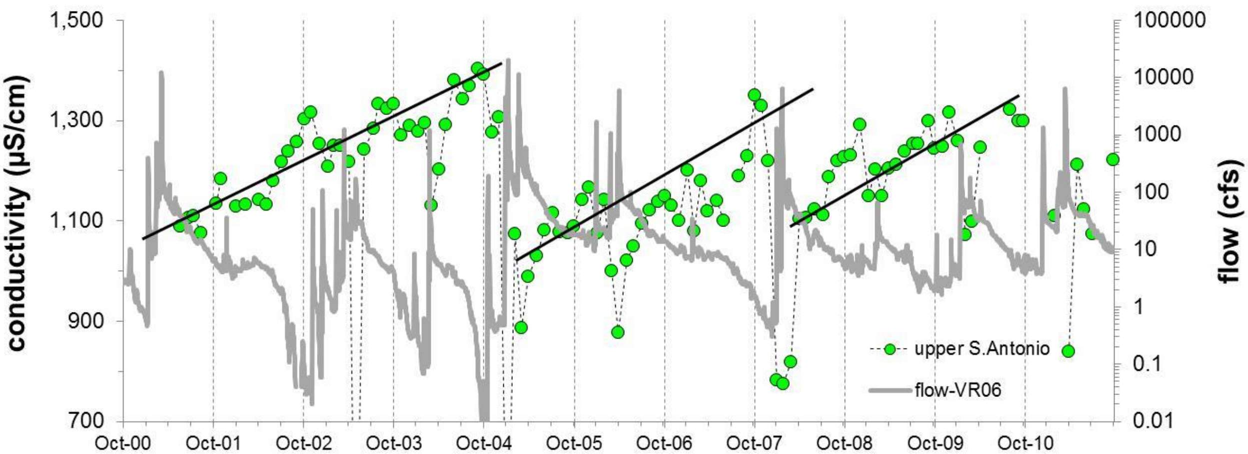
Foster Park (VR06) and lower San Antonio Creek (VR07) have slightly different but still recognizably similar patterns even though waters at these locations combine continually varying proportions of flow from different sources (e.g. Foster Park can have flow from both the upper Ventura and San Antonio Creek as well as locally surfacing groundwater). Even Main Street which combines treatment plant effluent and intermittent Canada Larga flows with whatever comes downstream from Foster Park has a similar overall pattern, because the same process – a groundwater increase in conductivity in years without significant recharge – is taking place throughout the watershed.



Nitrate (or nitrogen) concentrations also vary in step with rainfall and conductivity. The same lack of adequate winter rainfall that prevents recharge, and allows groundwater to age, also fails to carry new nitrogen accumulating in and on the surface of soils to the groundwater below. Absent new supply, existing groundwater nitrogen gradually decreases as it is utilized by various microbial and chemical processes. The same low rainfall winter that causes conductivity to increase, causes nitrate to decrease; conversely, a big rainfall year recharges the groundwater with high nitrate, low conductivity, waters.

This can be best seen on upper San Antonio Creek (above) where excessive nitrogen deposition by agriculture (both the commercial variety and that of home gardening and landscaping) yields the highest nitrate concentrations found in the Ventura watershed. The graph plots the average seasonal (May through Sept.) nitrate concentration against annual median conductivity. The R-square value indicates that the two are very closely related; 73% of the nitrate variation can be explained by changes in conductivity, and visa versa. The same relationship at Pirie Creek (VR09) is almost as good (R-square = 0.65).





Monthly data is, as might be expected, messier than using the mean or the median (which smooth out shorter duration fluctuations and minimize the impact of error), but the inverse relationship between nitrogen and conductivity is still clear – as are the abrupt changes that occur during, and following, a big rainfall winter. Average daily Foster Park flow is shown in the chart background and the lines were drawn free-hand.

I first noticed this relationship eight years ago, soon after the winter rains of 2005. We are now in the forth cycle of conductivity increase/nitrate decrease. James Bond said, "*once is happenstance, twice is coincidence, three times, it's enemy action*." This is enemy action: I am as sure of the causes behind this relationship as I am about anything in water science and I fully expect the more recent data (when made available) to again confirm the past pattern: recharge during the relatively wet winter of 2011 producing lowered conductivity and elevated nitrate, followed by a steady decline in both parameters during the dry years of 2012 and 2013.