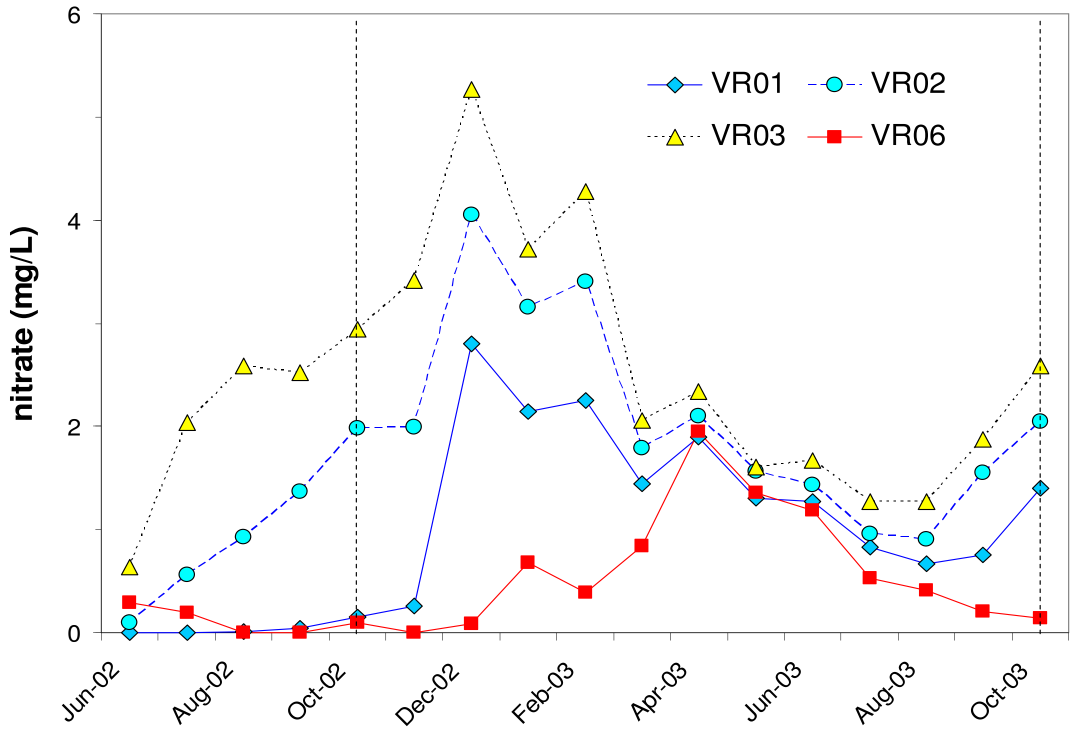


Figure 23. Nitrate concentrations on the lower Ventura River from June 2002 to October 2003: the vertical lines mark the beginning of the water year. The lower river provides an interesting view of what happens with nitrate over the course of a year.

VR06 (Foster Park) represents the normally expected variation in nitrate: a slow rise during the winter to peak values at the end of the rainy season (caused by increasing amounts of high nitrate soil and groundwaters entering the river as the rainy season progresses), followed by a slow decrease (as plants and algae remove nutrients) throughout the growing season.

The other sampling locations (VR03 to VR01) progressively follow the river downstream from below the Ojai wastewater treatment plant (VR03) to the tidal limit at Main Street (VR01). In this section, the variation in nitrate is different: the rise in concentration begins in summer and continues until December or January. This pattern, of a much earlier rise, is caused by high nitrate outflows from the Ojai plant. By late spring or early summer natural flows in the river have decreased to a point where treated sewage effluent becomes the major source of water. From then on, until the beginning of appreciably greater discharge due to winter rains, nitrate concentrations increase as effluent increasingly dominates river flow. The first storms of winter do not noticeably change river flow – most of the rain goes to replenish moisture deficits in dry soil. The early runoff that does enter the lower river comes from more developed parts of the watershed and is usually high in nitrate – thus the increase in nitrate continues until later in the winter. Put simply, winter rains increase concentrations in sections with low nitrate (VR06), decrease concentrations where nitrate is high. Note that concentrations always decrease from VR03 to VR02 to VR01; biological processes (plants, algae, bacteria) remove nitrate as the river flows towards the ocean.

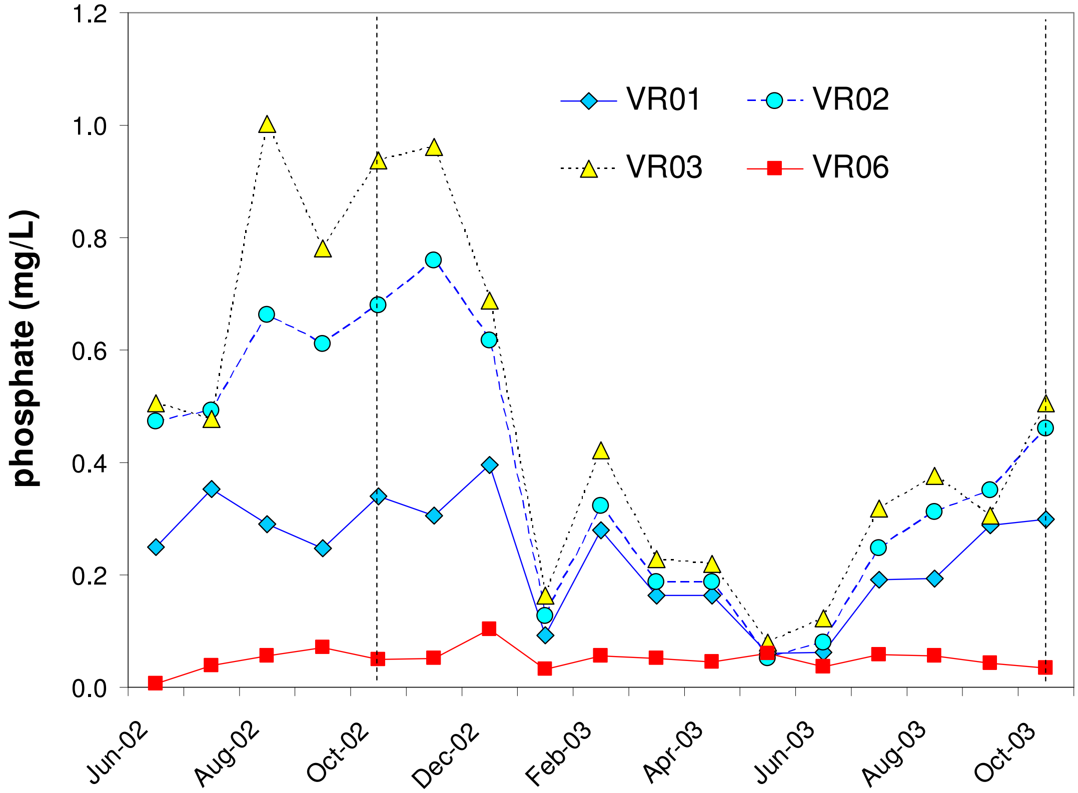
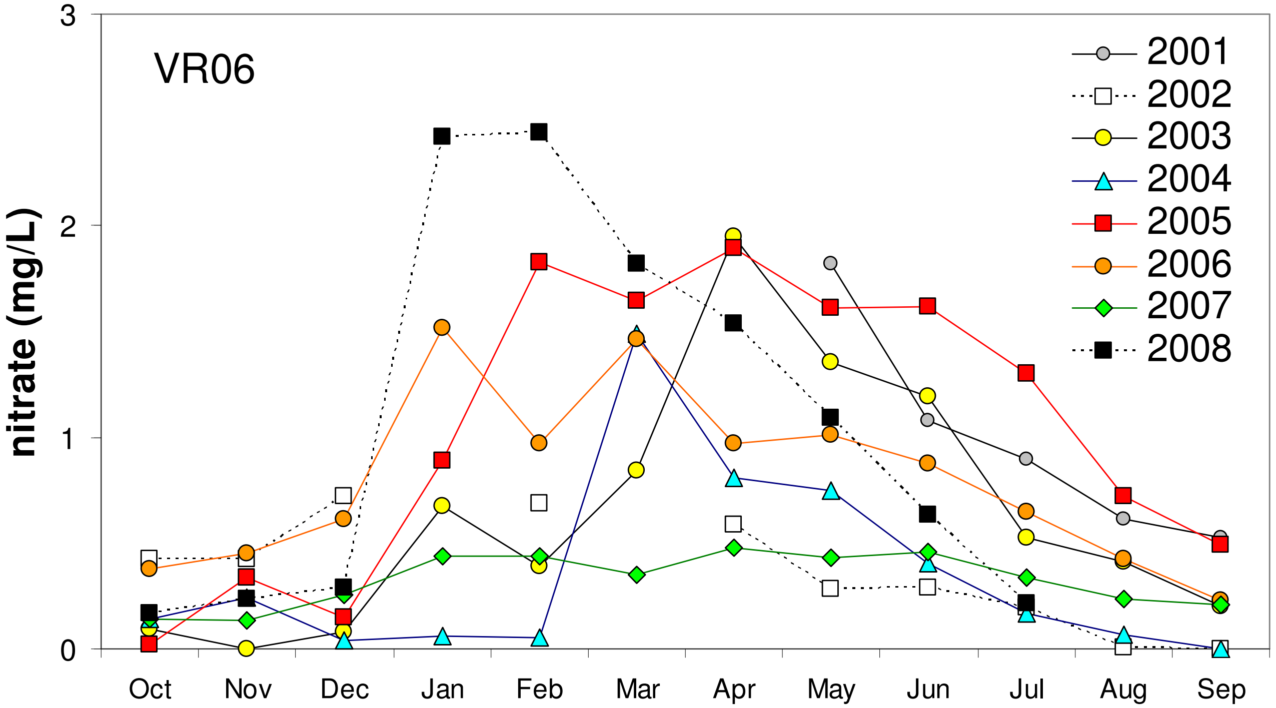


Figure 25. Phosphate concentrations on the lower Ventura River from June 2002 to October 2003: the vertical lines mark the beginning of the water year. Unlike nitrate (Figure 23), there is very little variation in phosphate concentrations at VR06 (Foster Park). Sometimes there is an increase in phosphate around the time of storms, particularly for the first storm of the year (Figure 24, middle and lower panels), but generally, concentrations are relatively stable.

However, the situation is quite different for sampling locations below the Ojai wastewater treatment plant (VR03 to VR01). Here, concentrations have a dramatic pattern: a continuous rise from the beginning of summer until late Fall. This pattern should sound familiar, it's the same one exhibited by nitrate at these sites and it has the same cause: outflows from the Ojai wastewater treatment plant. Treated effluent is not only high in nitrate it's also high in phosphorus, and as effluent increasing dominates flow in the lower river during the growing season, phosphate concentrations correspondingly rise. When winter runoff finally begins to influence flow, concentrations decrease.

Because of sewage effluent, these 3 sites have the highest phosphate concentrations on the river (Figure 24, upper panel). Again, as with nitrate, concentrations decrease downstream from VR03 to VR02 to VR01, as plants, algae and bacteria, and chemical transformations, remove phosphate.



This is Foster Park. 2008 provides the best example of a pattern, mainly because winter storms were concentrated in January and early February. We get a nice nitrate peak because of increased flows from relatively higher nitrate groundwaters – and the peak gradually diminishes as the year moves on. These were relatively shallow groundwaters. In 2003 the peak occurred in April – the month with the big storm. In 2001 the big storm was in March, but no Channelkeeper samples were taken until May (I do have LTER samples for the previous interval). In 2005 there were big storms from January through April. In 2006 the April concentration was influenced by stormflow, and is lower than it would have been had we sampled on another day. Even in 2002 and 2007 there is, to me at least, a pattern of higher winter nitrate concentrations, however muted, in spite of the absence of any significant rainfall.

Inter-annual variability helps disguise any simple pattern, there is no ah-ha moment, but I do think there is a pattern nevertheless. I think the best way of seeing it is to concentrate on the earlier months, when nitrate concentrations first rise after a pre-winter low. These low, pre-storm nitrate concentrations are usually little affected by river biology (algae and plants) because of low temperatures and being far past the peak of their growing season. These low concentrations are almost always followed by a rise – a rise caused by higher nitrate groundwater inflows following the storm. Very few concentrations are from storm periods (and those that were usually show lower than expected nitrate).

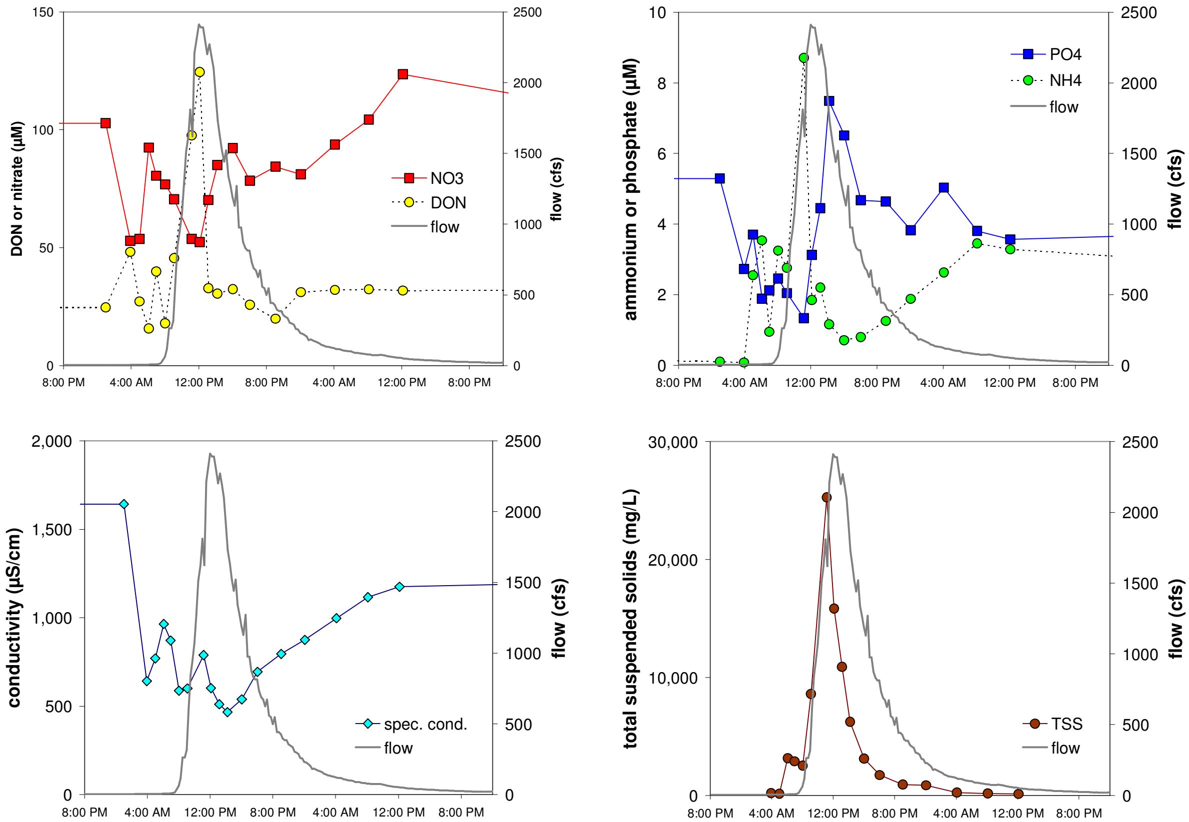
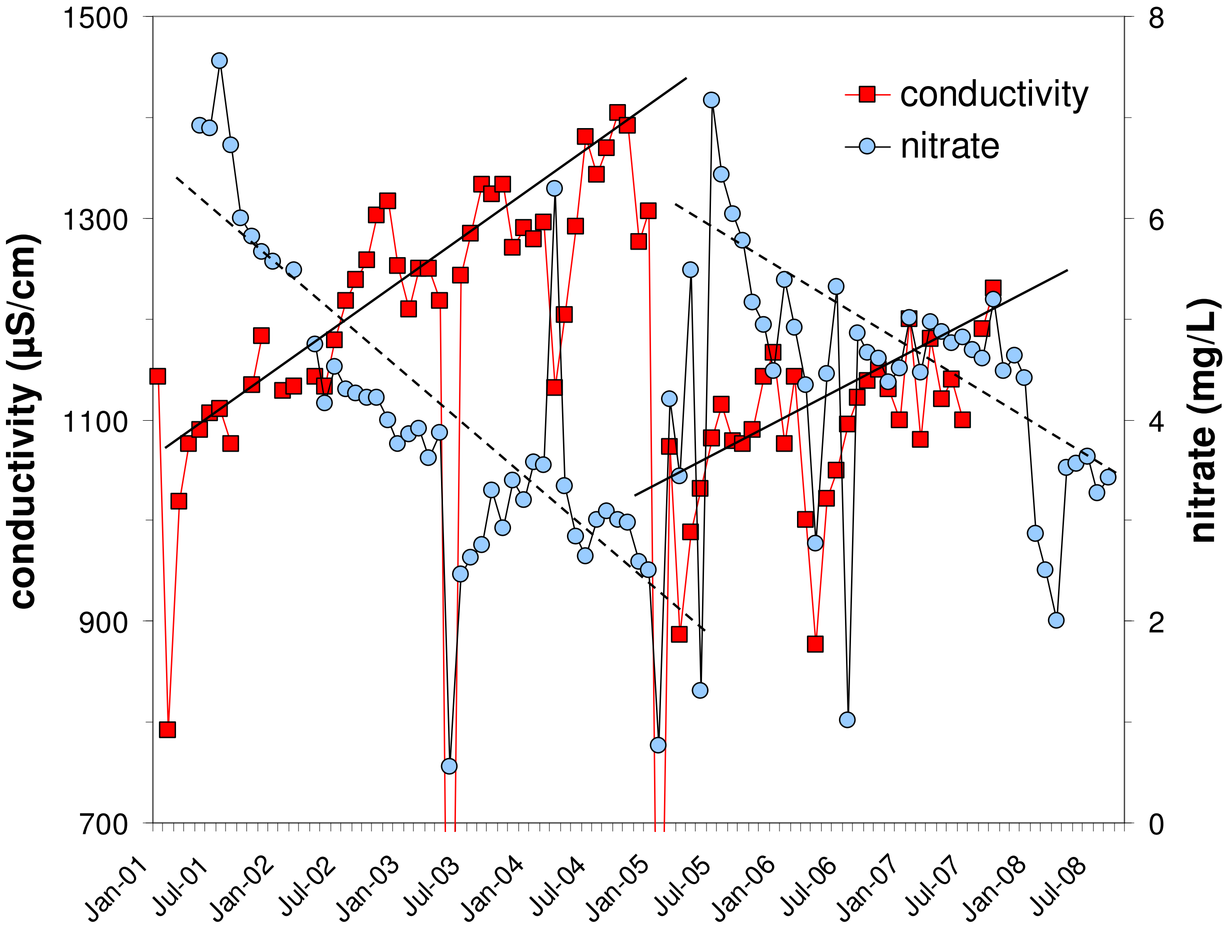


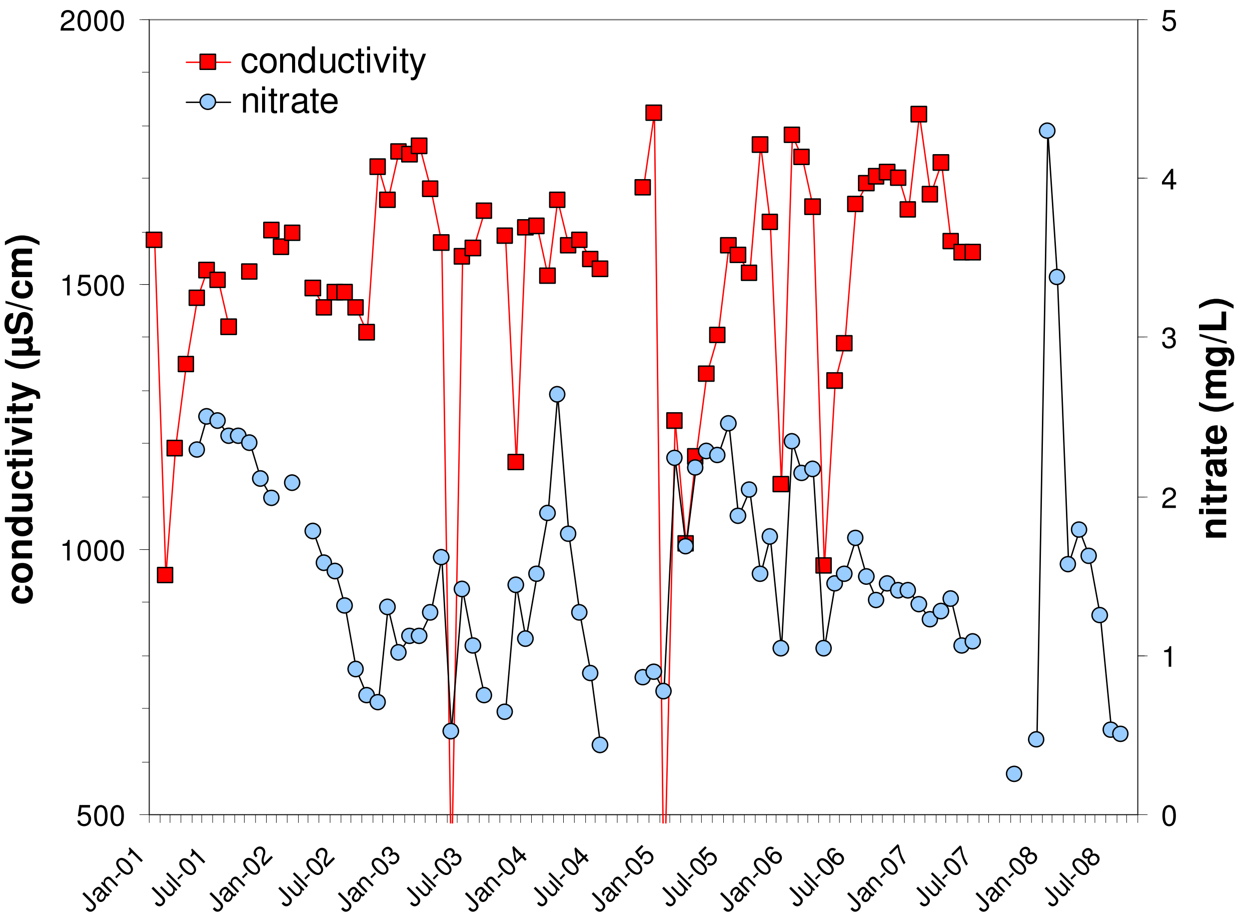
Figure 29. Variation in dissolved nutrients, conductivity and suspended sediment at Main Street (VR01) on March 15, 2003 (the largest storm of that year). The hydrograph measured at Foster Park (VR06) is shown; it only approximates conditions at VR01. The most intense rainfall occurred prior to 4 AM and the first third of the variations exemplify the response of the lower, more urbanized, Ventura watershed: initial pulses of urban runoff are characterized by a peak in ammonium, a rise in DON and depressed concentrations of nitrate, phosphate and conductivity. Maximum flow occurred hours after the rain had stopped; considerable time is needed for runoff from Ojai and more distant parts of the watershed to reach Foster Park.

The peak in ammonium, DON and sediment that occurred at VR01 just before peak flow at Foster Park probably marks the arrival of runoff from Ojai via San Antonio Creek. Notice that nitrate and phosphate concentrations were depressed at this same time. This is typical: storm runoff usually dilutes constituents with high background concentrations and increases those with low (flushes out pollutants).

Concentrations that occurred after peak discharge indicate contributions from the relatively pristine, higher-elevation, parts of the watershed within the National Forest; runoff from this area was relatively high in both phosphate and nitrate. Large storms flush out nitrate and mobilize phosphate from the up-country, particularly from chaparral. However, most of the sediment was flushed much earlier – on rising flood waters from the area between Ojai and Casitas Springs.



This is VR10, lower San Antonio. At this location we see the impact of mostly deeper groundwater. After the big storm of 2001, conductivity began a steady rise (and nitrate a steady decline) until the winter of 2005. Following that winter, which drastically lowered conductivity and increased nitrate concentrations, the pattern began to repeat itself. This pattern is caused by the aging of deeper groundwater, and is only broken by a very big year when significant recharge resets the clock. Note that this year, 2008, did not do that. Conductivity minimums are the result of sampling during, or soon after, storms – this is the best way of telling whether or not this was happening during any Channelkeeper sampling. Note that storm samples (low conductivity) are almost always accompanied by low nitrate – this is a high nitrate location and stormflow almost always reduces concentrations. (Very small, early, storms, can prove an exception.) Upstream land-use at VR10 is mostly agricultural.



For contrast, this is VR09, Pirie Creek. Upstream land-use is mostly Ojai urban/suburban. (I don't, as yet, have this year's conductivity results.) At this location we don't see the well-defined pattern noticeable at VR10. To me, this site is mostly influenced by shallower groundwaters. That doesn't mean no deeper groundwater impact – there may be hints of that in some of the longer period nitrate declines – but that most of the nitrate is coming from a shallower water table. This is best seen is this year's data, but almost all the peak values on the graph come after winter storms. Again, you have to mentally discount the low nitrate concentrations that co-inside with conductivity minimums as occurring during stormflow and, as such, are non-representative. The long nitrate decline from early in 2001 to the late fall of 2002 was caused by an almost total lack of storms in 2002. It's interesting that the nitrate in 2003 was much less than what occurred in 2004 – a year with less rainfall and a smaller big storm. I attribute this to the need for appreciable soilwater recharge following the 2002 drought.