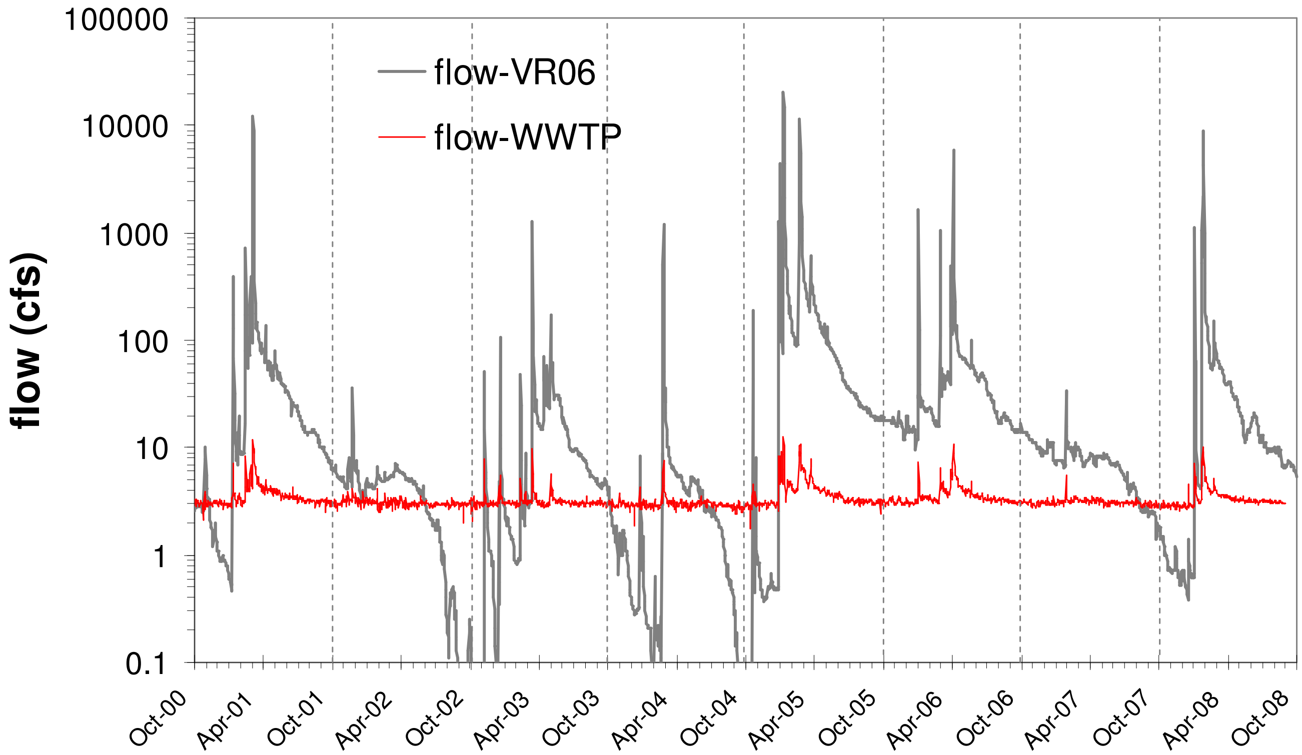
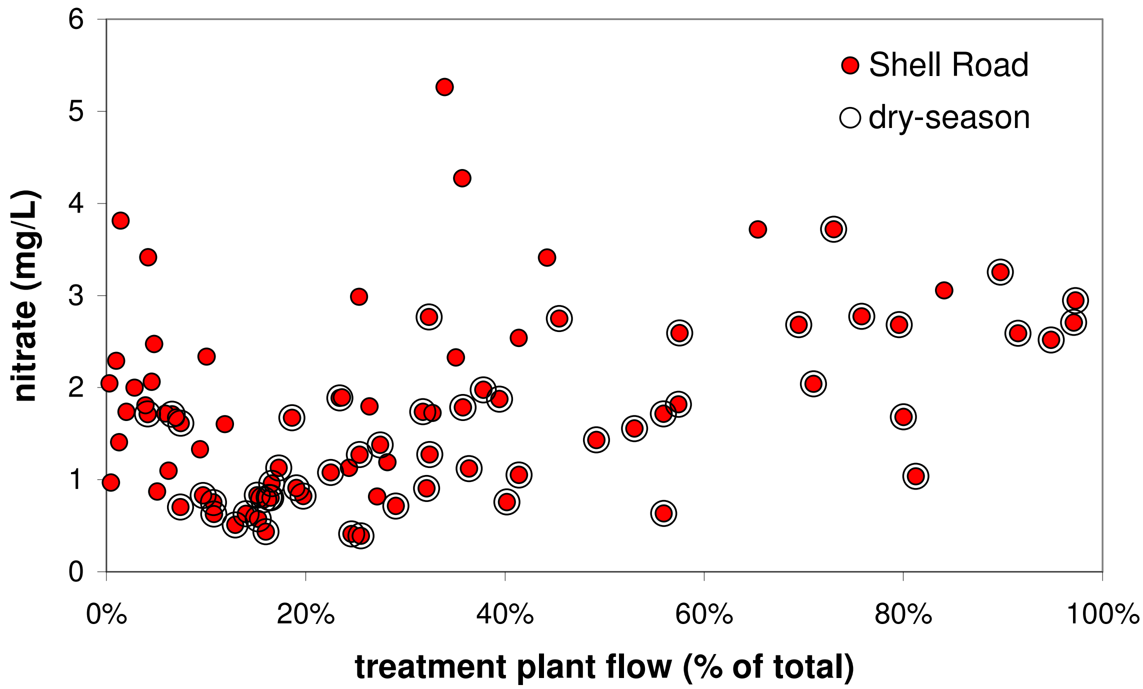
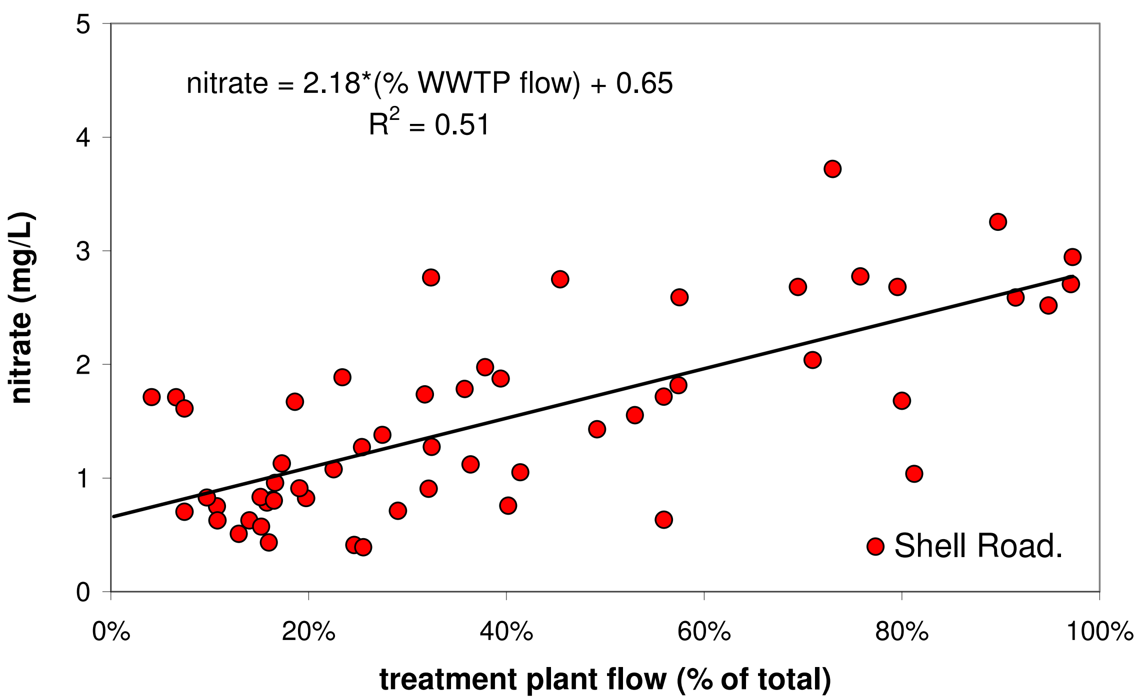
Al Leydecker, October 29, 2008



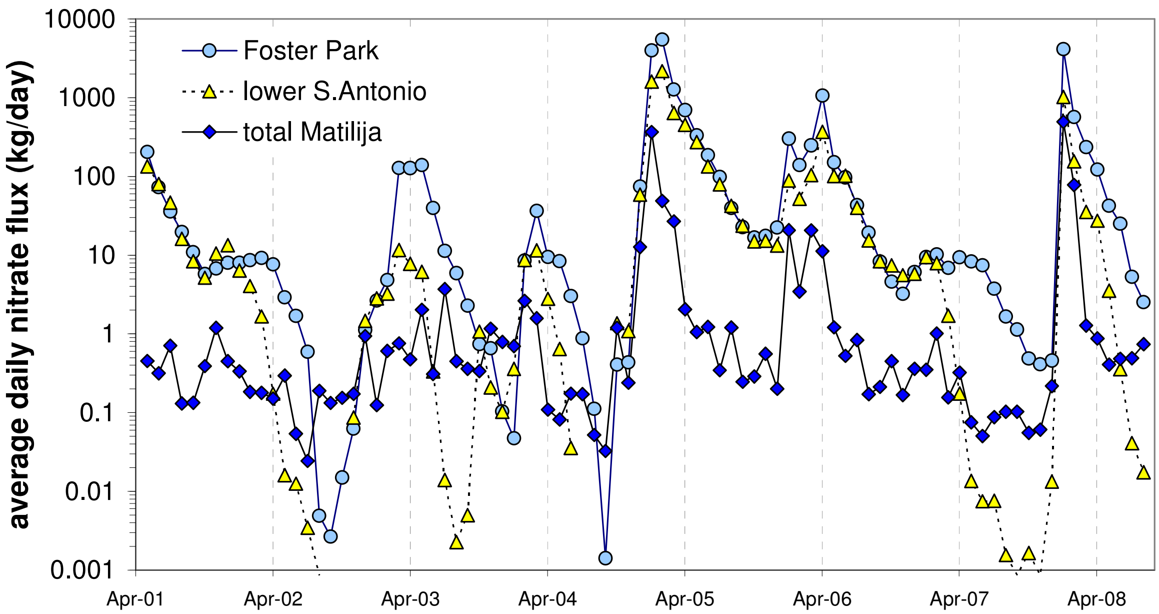
My nitrate files have gotten so damn complicated that I'm going to show a number of the graphs I've developed here. All these graphs, as well as the ones developed previously (Channelkeeper nitrate concentrations plotted along with representational flow) can be found in the Nitrate.II and Nitrate.III files. The Nitrate.I file still compares 2008 nitrate time-series for 2008 with mean monthly concentrations for all prior sampling years, and includes statistical summaries of mean annual and dry-season concentrations (and is the basic file showing monthly Channelkeeper nitrate concentrations).

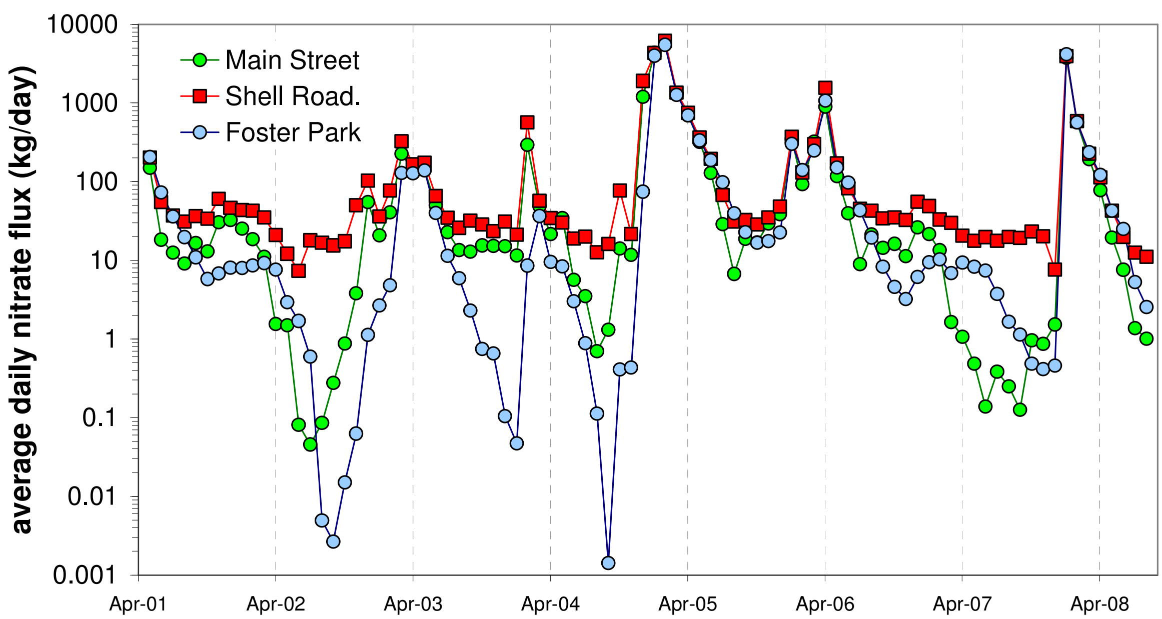
In this graph Waste Water Treatment Plant (WWTP) effluent outflows are contrasted with Foster Park flows: average daily figures are used in both cases. Treatment plant outflow looks like a constant line, except for the quantities that have to be either bypassed or rushed through the plant during storm periods. Normal outflows are not as consistent as the graph might indicate – the use of a log scale (and the 6 orders-of-magnitude needed to show the wide variation in Foster Park flows) just makes it seem so. Average daily flow (± standard deviation) for the time period shown was 2.15 ± 0.54 MGD (3.33 ± 0.83 cfs); this is higher than the 2.35 cfs value I've usually assumed in the past. The graph gives a good visual representation of those time periods when WWTP outflows dominate river flow below the plant: a good rule of thumb is Foster Park + WWTP outflow = flow below the treatment plant (this relationship breaks down and underestimates flow during storm periods when appreciable storm runoff enters the river below Foster Park).



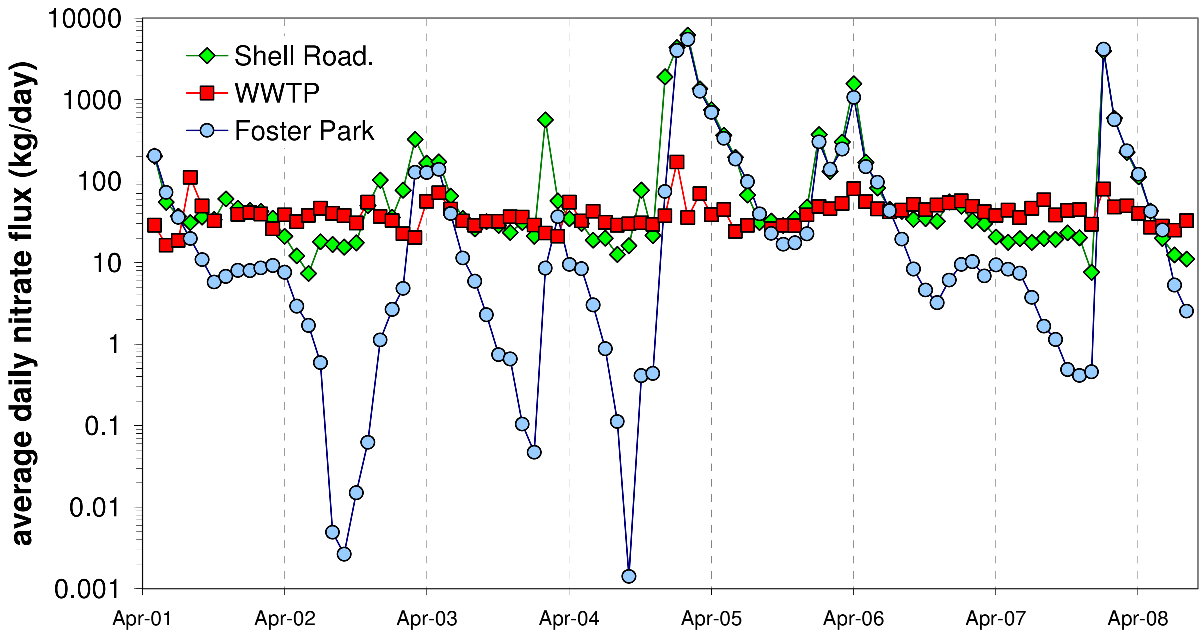


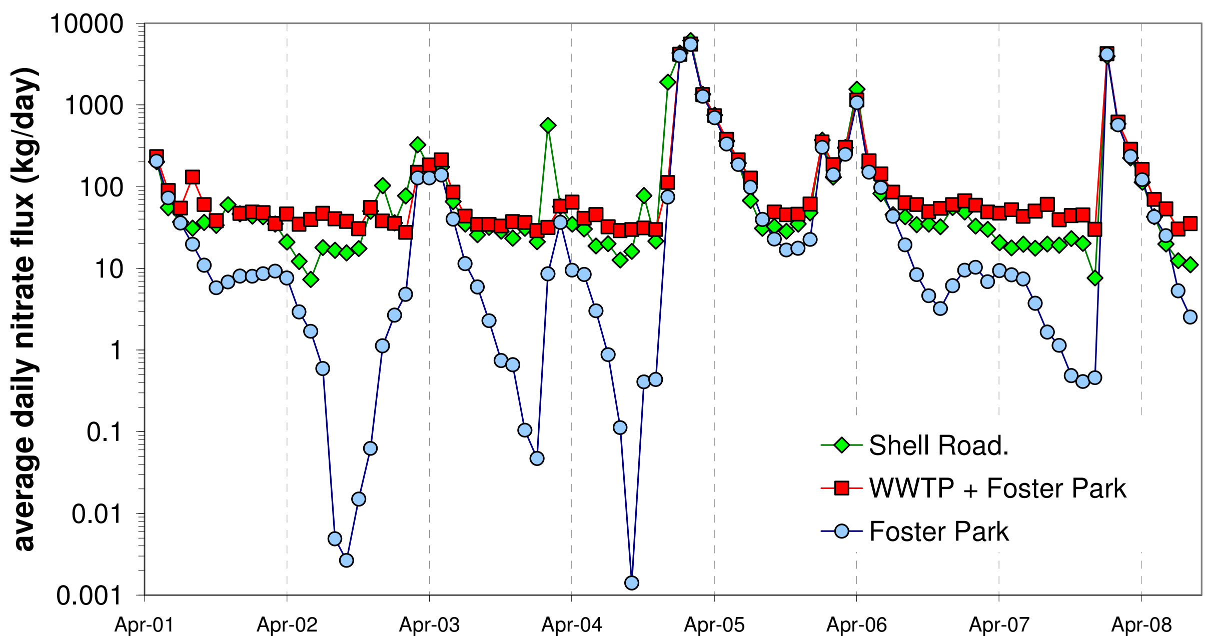
In these graphs nitrate concentrations at Shell Road plotted against treatment plant flow expressed as a percentage of total flow below the plant (WWTP/{Foster Park + WWTP}). The upper graph shows all data from 2001 until the present. The relationship is in the form of a "U" with a stretched-out second up-right. High nitrate values at low % flows are due to stormwater contributions from above the plant. The lower graph shows the relationship if only dry-season data (circled values in the upper graph) are used – eliminating those winter stormwater-influenced flows. This gives you the linear relationship you expected to see. WWTP effluent inflows explain 51 % of increased dry-season concentrations seen below the plant.



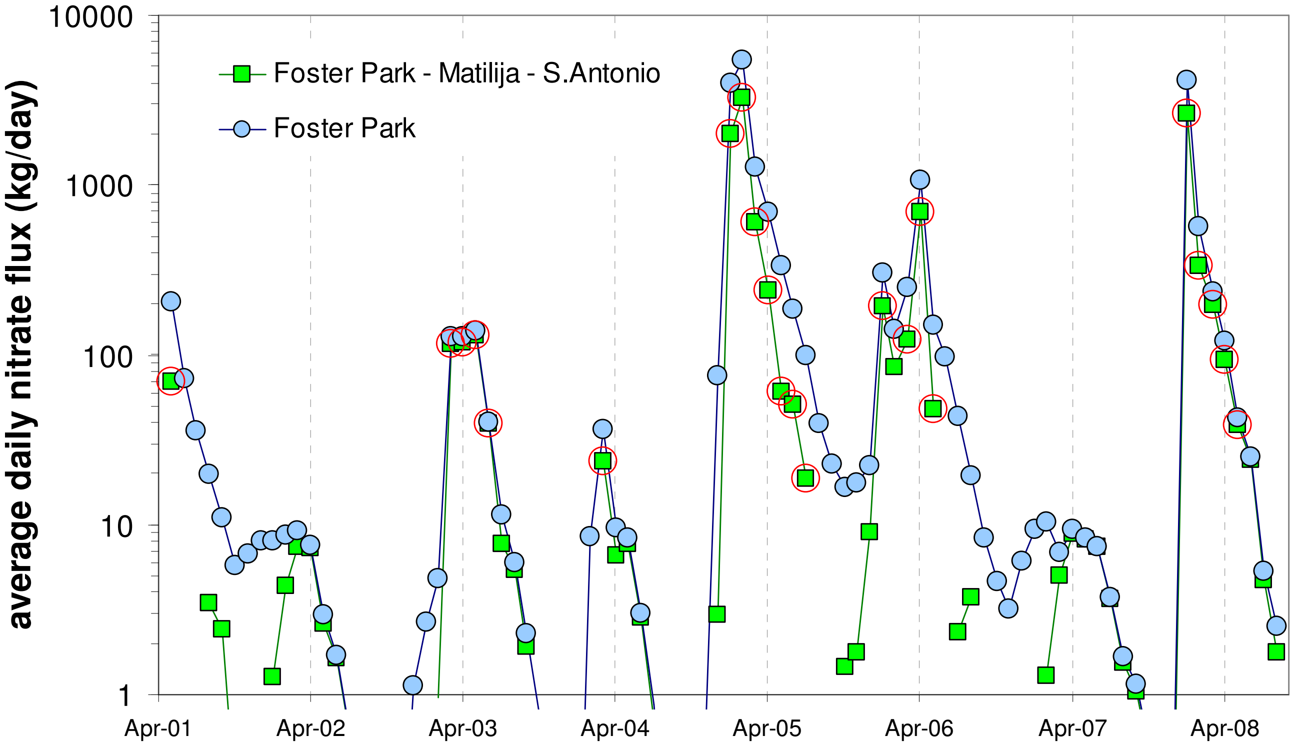


These two graphs show the nitrate flux (flow multiplied by concentration, expressed in kg/day) calculated from Channelkeeper concentrations and either USGS or Ventura County flow data. The upper graph shows the San Antonio and upper Matilija fluxes, along with the Foster Park flux. The difference between the Foster Park flux and the other two would be what comes out of those mysterious reaches on the middle Ventura. The lower graph shows the story further down the river – from Foster Park to Shell Road to Main Street. The difference between the Shell Road and Main Street fluxes indicates the amount of river uptake: almost none during the wet-season, appreciable amounts during the dry-season, and really large decreases during low flow years like 2002, 2003, 2004 and 2007. None of these 4 big uptake years were big algal years below the WWTP – 2001, 2005 and 2006 were big algal years in below-the-WWTP reaches. Big algal years follow big wet winters, and the higher dry-season flows that follow show lower flux decreases.





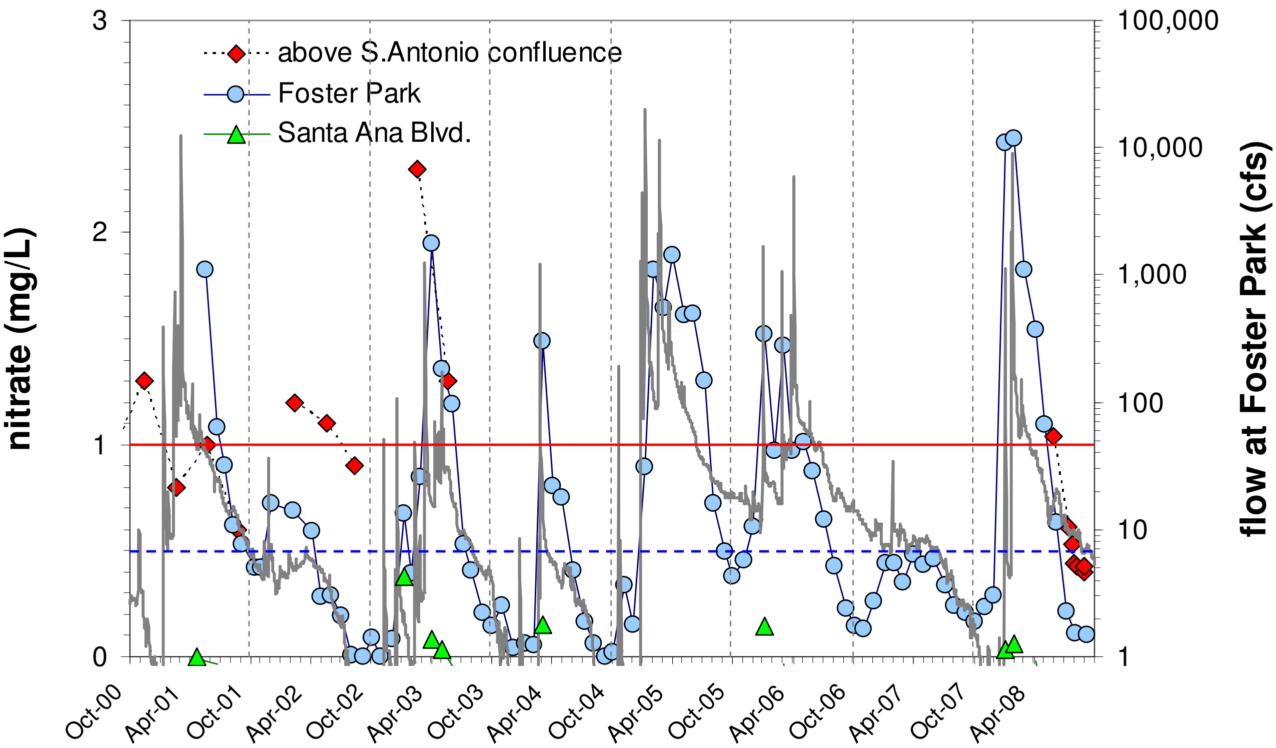
Again, the nitrate flux. In the upper graph I've added the nitrate flux from the WWTP to the flux measured at Foster Park and Shell Road. When the flux at Shell Road climbs above that from the WWTP (mainly during winter), appreciable nitrate is coming from upstream; appreciable dry-season uptake by plants and algae is taking place on the river when it dips below. In the lower graph the red boxes now represent the combined WWTP and Foster Park fluxes. This should always be equal to, or greater than, the flux at Shell Road, and it usually is: it's equal when negligible uptake occurs between the WWPT and Shell Road (winter), noticeably greater when uptake (Shell Rd. is approximately 3 km below the plant) becomes significant (dry-season). Those occasional points when the Shell Road flux is higher than the combined flux probably represent errors in nitrate concentration at one of the locations.



Another nitrate flux vs. time plot. Here I'm showing the flux at Foster Park along with a flux calculated by subtracting the Matilija (the sum of Matilija Creek and the North Fork of the Matilija) and lower San Antonio fluxes from that at Foster Park. In other words this flux represents the nitrate coming from the middle reaches of the Ventura River – from the mouth of Matilija Canyon to Foster Park. I will call this the middle-reach flux.

The points circled in red represent months when there was flow at Santa Ana Blvd., the closest sampling point above the confluence, i.e., those points not circled represent the nitrate flux derived solely from surfacing groundwater above Foster Park (in contrast, circled points represent flux from both surfacing groundwater and upstream flow). I've cut off the bottom of the graph at a minimum flux of 1 kg/day to expand the scale, but also because most of the above the confluence flux values below this value were negative. Why negative? The main reason is probably the abstraction of water above the Foster Park measuring point. The removal of flow (and nitrate) by horizontal wells below the river prevents an accurate determination of the true flux. If we could account for this abstraction both fluxes would be greater than shown, but the relative position of each curve with respect to the other would remain unchanged.

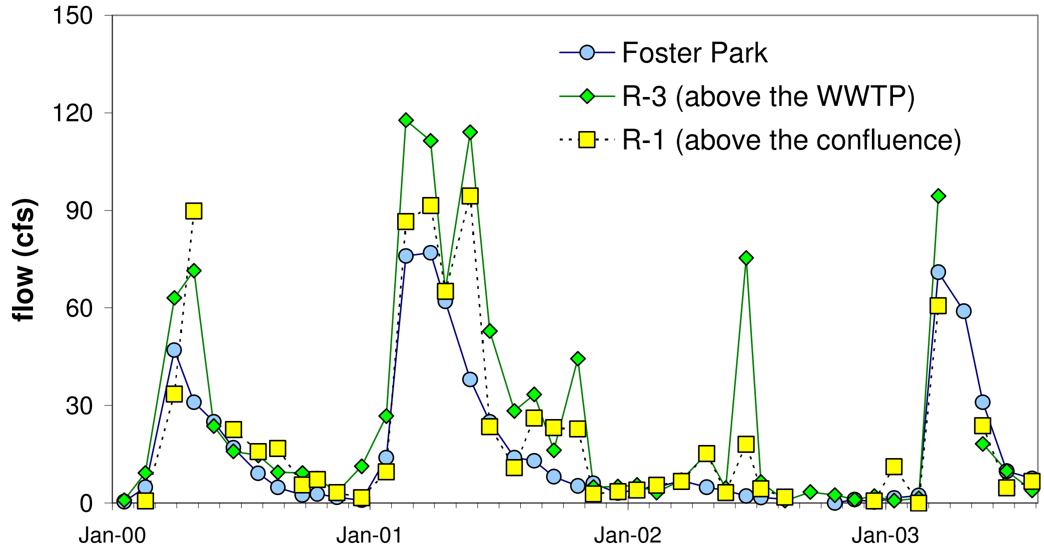
Similarity in value between the Foster Park and the middle-reach flux in any given month indicates that most of the nitrate at the former is coming from latter – and this is the usual case. A widening gap usually indicates an appreciable San Antonio Creek contribution; this typically occurs in early winter and by April the gap has usually disappeared. 2005 and 2006 are exceptions; usually high and continuous San Antonio flows contributed appreciable nitrate flux in those years. That didn't happen this year – by May 2008 almost all middle-reach nitrate was provided by groundwater inflows. The magnitude of the peak nitrate flux at Foster Park is dependent upon stormflow: big storm years produce the highest peaks (2005, 2006 – a real big April, 2008 – big January, and 2001 – a big March, which this data doesn't capture); dry years the lowest (2002 and 2007); and 2004 had lower rainfall than 2003, which was lower than in 2006.

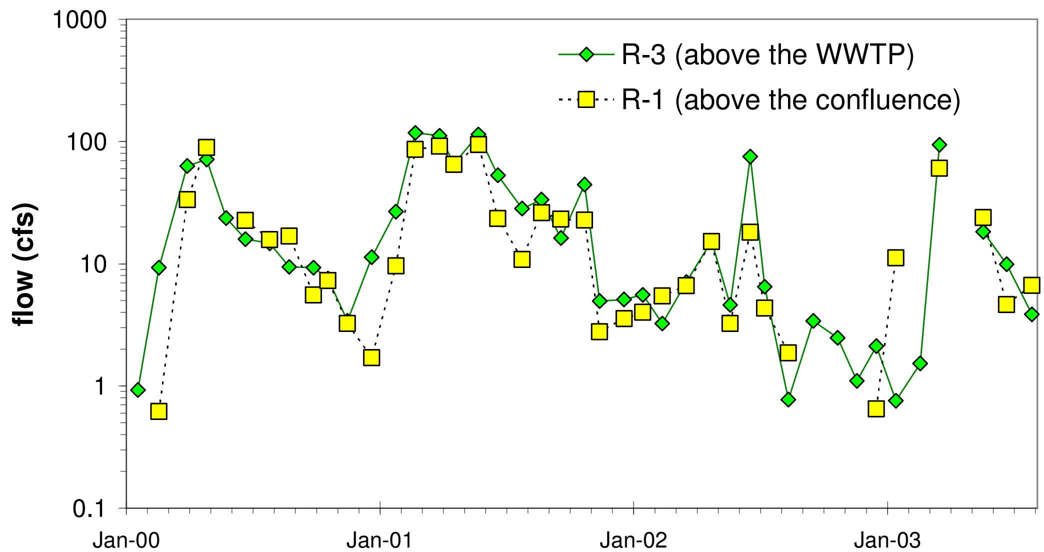


The previous graph showed the "middle-reach" flux. Here I want to look at where the principal contribution of that nitrate may be coming from. The graph shows the Channelkeeper nitrate time-series for Foster Park and Santa Ana Blvd. Also plotted are the limited measurements of nitrate concentrations above the San Antonio confluence that are available. The earlier data (up to May 2003) is from the Ojai Valley Sanitary District (OVSD, site R-1), the later is from Kristie's May sample and other samples I've collected during this dry-season. (This, and the following graphs, along with my compilation of OVSD data, can be found in the Nitrate.III file.)

Although the data is limited, it does indicate that nitrate above the confluence is higher, at times appreciably higher, than at Foster Park. Note that Santa Ana concentrations, representing surface flow towards the confluence, are usually very low, indicating that the dominant source of high "above the confluence" nitrate is surfacing groundwater. This is most visible in the 2002 data. 2002 was a drought year with no middle-reach surface flow above Santa Ana Blvd.

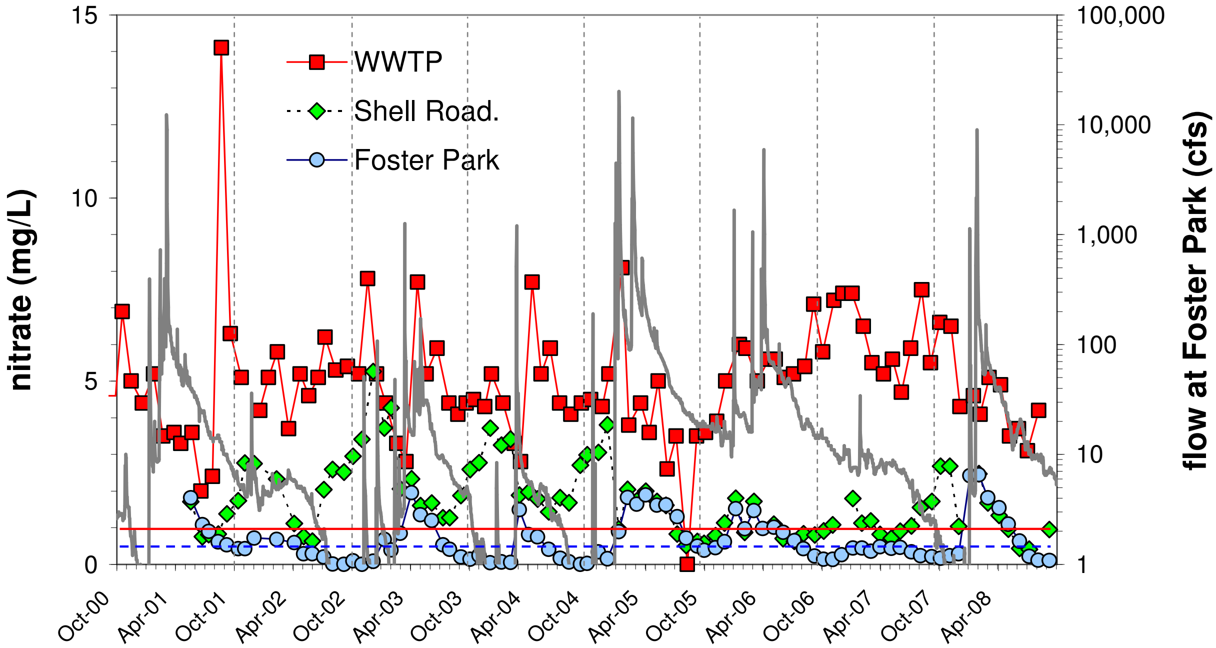
I find the dry-season decrease in these concentrations, both in 2002 and this year, interesting. I wonder how much of the decrease is due to N-uptake as flow diminishes, and how much might be due to the changing nature of the groundwater source. As flow diminishes we might assume that older, deeper groundwater sources become more dominant, and these sources are, presumably, lower in nitrate. Then, of course, there is the nagging, still unanswered, question of where this groundwater originates. And if there is more than one souce.

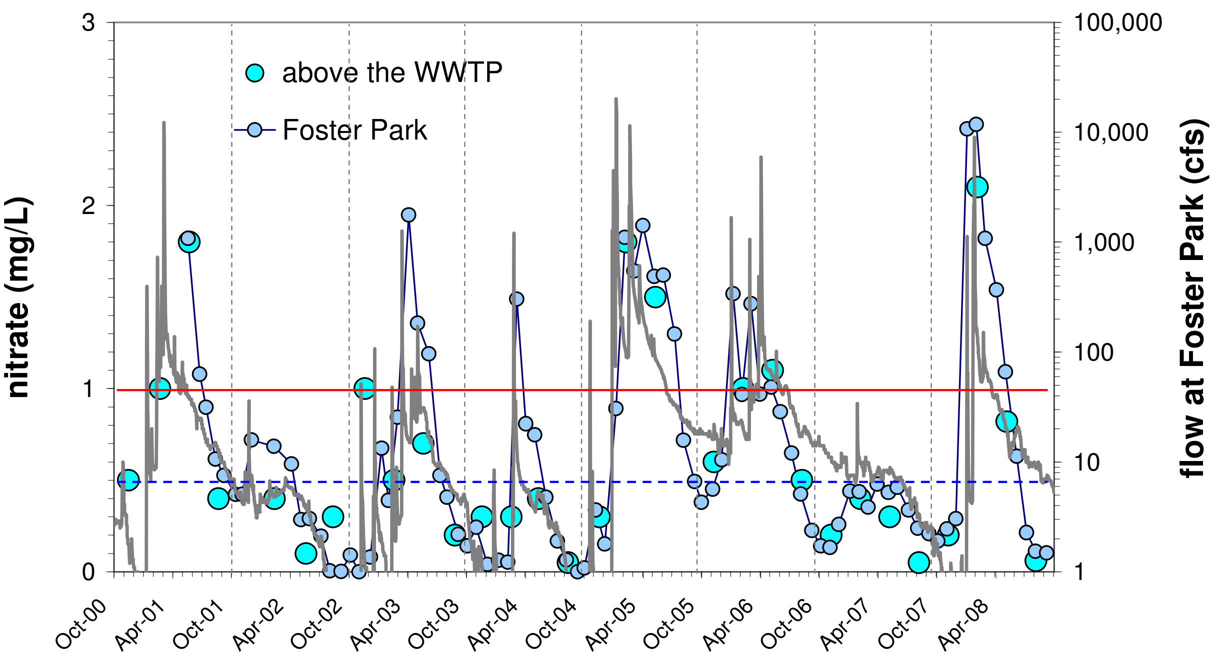




This is OVSD flow data. Although they only collected quarterly nutrient data at their sampled river sites, they did measure basic parameters and flow at a monthly interval (at 8 locations up through July 2003, 3 locations thereafter). On the above graph I'm showing monthly flow measurements at the R-1 (above the confluence, i.e., above Foster Park) and R-3 (above the WWTP, but below Foster Park) locations along with USGS daily flow for the same dates. It's not a completely fair comparison since flows do vary over the course of a day (especially during and soon after storms) and flows measured at a specific point in time cannot be expected to exactly match the average daily flow – but they should come close. The upper graph shows that R-3 generally does match up with Foster Park flow, and I believe we can have reasonable confidence in these data.

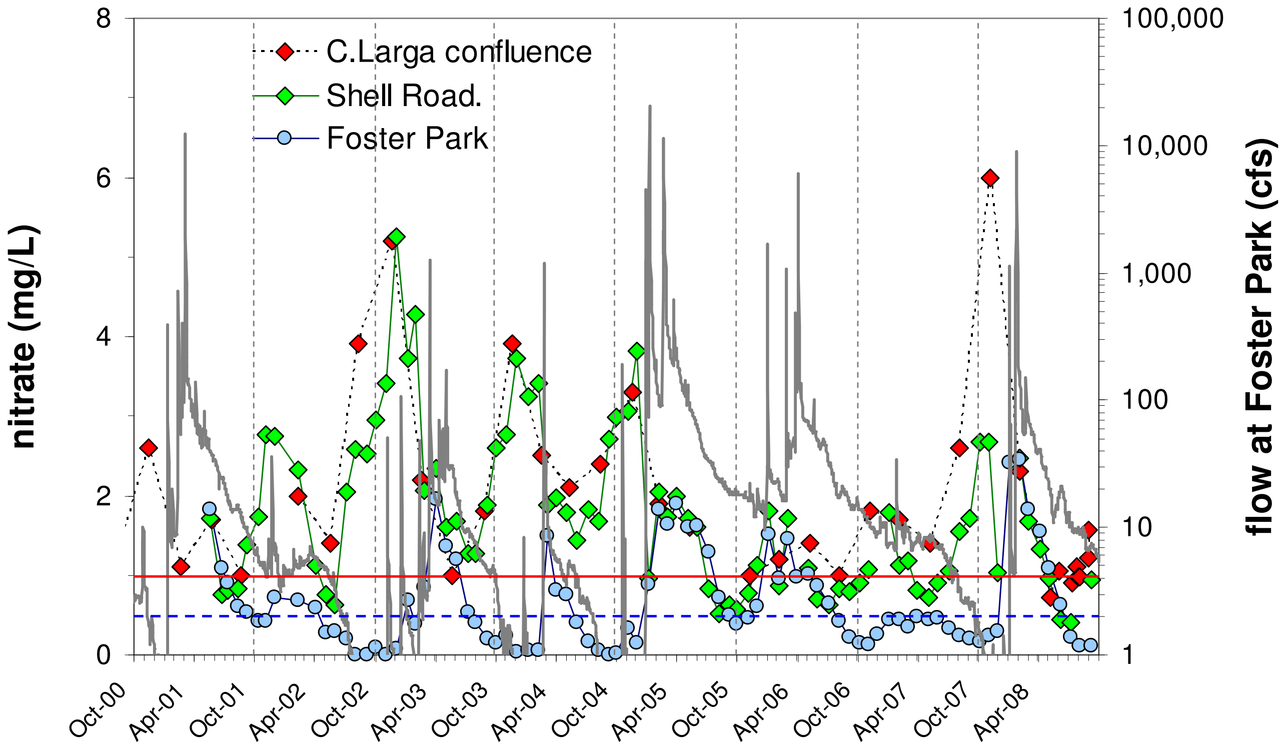
Concentrating on the R-1 and R-3 flows shown in the lower graph, there doesn't seem to be any consistent pattern of one having higher flows than the other – it's possible that any differences result from random error, and that flows at the two locations are roughly the same. This presents something of a problem: why the same? (My two recent measurements also show this.) Surely the abstraction of water from underneath the river above Foster Park diminishes flow downstream. What's going on?





The upper graph shows monthly nitrate concentrations in treated effluent coming out of the WWTP on a background of nitrate at Shell Rd. and Foster Park. Average monthly effluent nitrate (± standard deviation) for the time period shown was 5.03 ± 1.55 mg/L (360 ± 110 µM).

The lower graph shows OVSD quarterly nitrate concentrations measured above the WWTP (R-3) compared with Channelkeeper's monthly Foster Park data series. As you can see they, are well correlated, as we might expect since the two locations are not that far distant. Any discrepancies can be accounted for by different sampling dates and possible uptake between the two locations. Overall, the OVSD data is a good match with Channelkeeper concentrations (for nitrate, a look at phosphate will come next).



Finally, this is a plot of OVSD quarterly nitrate data collected just above the Canada Larga confluence (R-5), along with Channelkeeper Shell Road and Foster Park data (and Foster Park daily flow). This location is approximately 2.4 km above Shell Road so we should normally expect to see higher concentrations above the confluence (expect, perhaps, during storms and when appreciable flow is coming from Canada Larga – which would usually also occur only during storms). As for the other data (and except for occasional samples, usually during the earlier years), there is generally good agreement between the two data sets.