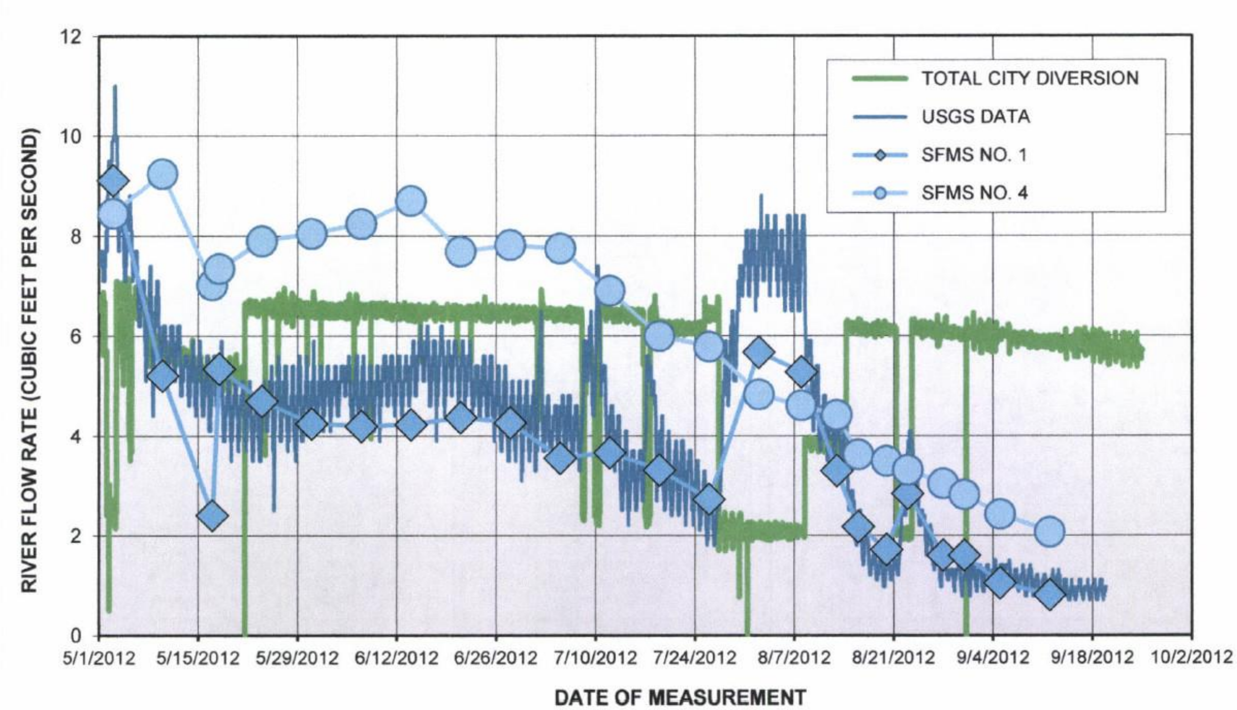
Ben,
I finished looking at the Foster Park water-level report you sent me and I have a few comments that you might be interested in, comments a little too extensive for an email, so I'm going to write them here.



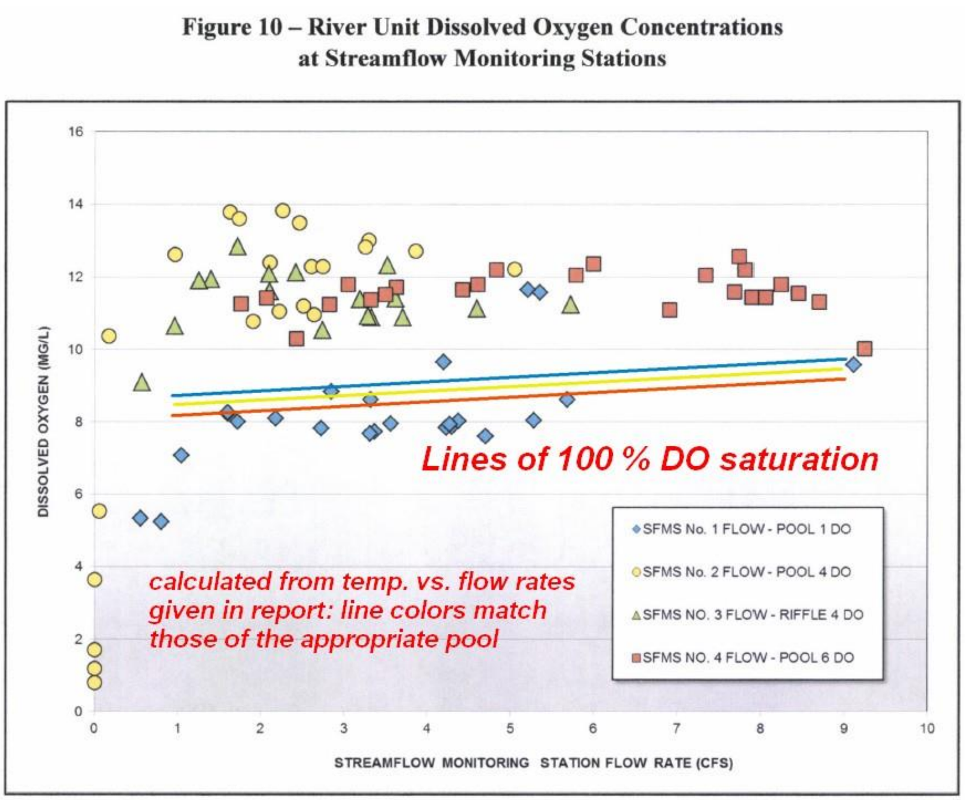
I thought their graphs pretty much explained the whole thing so I'm going to address my remarks around them. First about flow: They seem to rely more on their own measurements of flow and less heavily on the USGS gauging station record—possibly because their figures showed less of a water extraction impact. However, putting an almost countless number of pages of flow measurements into a report doesn't make any particular measurement more valid. Perhaps I didn't look hard enough, but nowhere did I find the units of measurement (deduced as depth in feet, flow in cfs) mentioned. And like other groups I forbear to name, they made no effort to estimate measurement precision or probable error by repeat measurements at the same location during the same time frame—or even better, by repeat measurements utilizing different personal.

You are already aware of the various errors and pitfalls associated with current meter measurement of flow, especially under low flow conditions at imperfect locations. The photo indicates the less-than-perfect conditions found at all of these locations (mainly the lack of steady flow through a relatively uniform cross-section). The use of sandbags to further restrict flow and increase current velocities increases the probability of error. Measurement under these circumstances is a difficult problem, especially if your only option is the area-velocity technique. And while I sympathize, failure to address the error problem—especially since some of the measured velocities may have fallen outside the range of the current meter used (a pigmy current meter, depending on the model, cannot accurately measure velocities below 0.25-0.1 ft./sec)—means that their measurements have to be taken with a grain of salt and cannot be simply declared to be superior to flow as recorded at the gauging station.

The best part of the study—"the let's stop pumping exercise"—is shown in the beginning graph. The typical extraction by the City was 6 cfs during the study: 2 cfs via the under-river gallery, 4 cfs by pumping from shallow wells. After a delay of about 4 days flow at the gauge increased by roughly 5 cfs: so 4 cfs of extraction diminished river flow by 5 cfs (the reason for the difference might have been error in USGS gauge calibration or it might be related to how groundwater flows around the active wells). Had extraction via the under-river gallery been also halted, I expect the increase in river flow would have been around 7-8 cfs. City extractions were therefore reducing flow by about 75 %. That percentage would have measurably increased had the stoppage been done at the end of the study: increasing the 1 cfs then seen at the bridge to about 8 cfs. In water-year 2013 that amount would have been the difference between measureable flows and the bone-dry conditions that actually occurred.

This Google Earth image, taken 4/17/2013, exemplifies the no-flow conditions typically found upstream of Foster Park Bridge during the final weeks of the study and the following two years. (The well location marked as 08B02 is probably Nye well #2.)

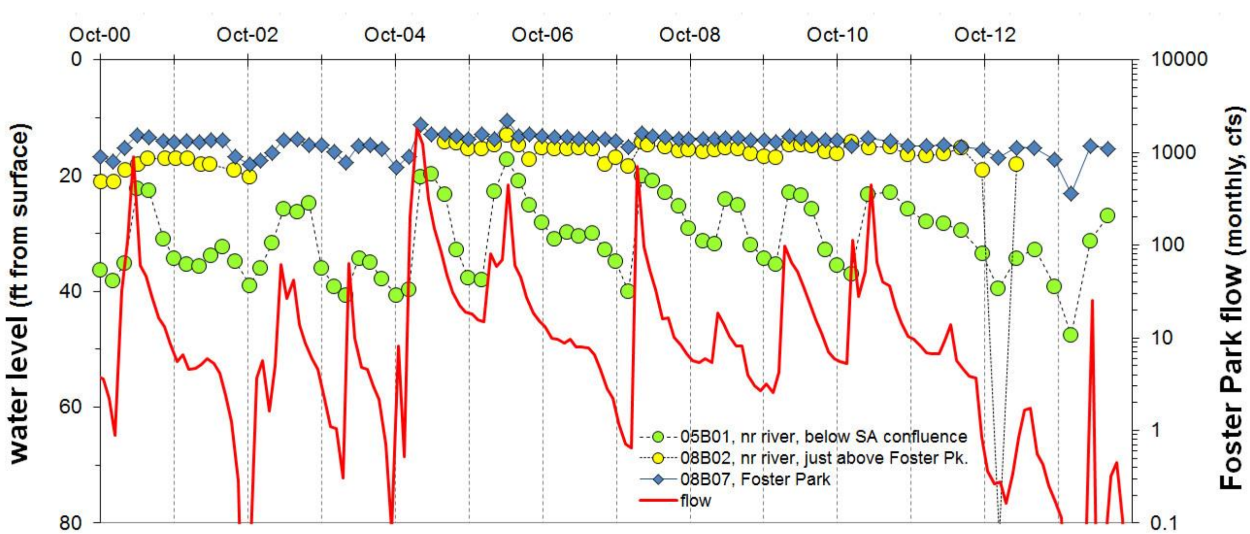
The basic Hopkins hypothesis relied heavily on DO: if DO stayed "healthy," the habitat was fine and the City could keep pumping. I'll leave it to the steelhead guys to comment on the other reported habitat conditions—lack of their suitability probably being the reason behind the NMFS recommendation of a 12 cfs minimum flow (vs. the 2 cfs recommended in the Hopkins Report)—but as far as DO was concerned I regard the report as severely deficient. Although there was a sentence towards the end as to how nighttime DO values



might be lower, no effort was made to actually measure these values before reaching the conclusion that DO remained acceptable as long as flow at the gauge remained above 2 cfs.

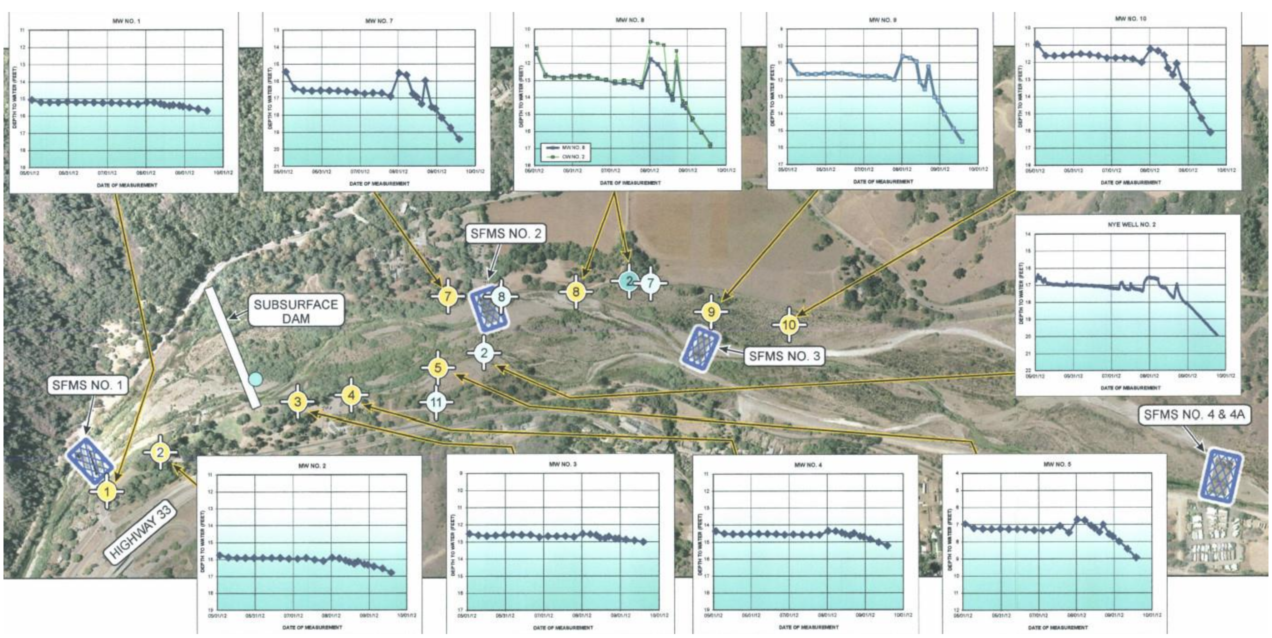
The report photos (e.g. the SFMS-2 photo above) show the presence of appreciable algae during the study. In the preceding graph I've added lines of 100 % DO saturation (calculated from temperatures measured during the study) to their Figure 10 for pools 1, 4 & 6 (under the bridge [SFMS 1], adjacent to Nye well #2 [SFMS 2], and the furthest upstream location [SFMS 4], respectively). Notice that almost all their DO measurements were far above saturation, i.e., impacted by the presence of algae. As past SBCK experience has shown, it doesn't take very much algae to adversely affect DO when flows are extremely low. And at low flows the decay of organic material can also play an important role in decreasing dissolved oxygen—and the presence of algae can mask this effect during daylight hours (when all their measurements were taken). Only nighttime or pre-dawn measurements can adequately measure DO during the dry-season. So their basic premise is fundamentally flawed.

In this next image I've taken their mid-September groundwater contour map and superimposed the 3 well locations for which I have relatively long-term records: 08B07 is a monitoring well, 08B02 is a currently unused production well (probably Nye well #2), and 05B01 most likely serves the subdivision on which it is located.



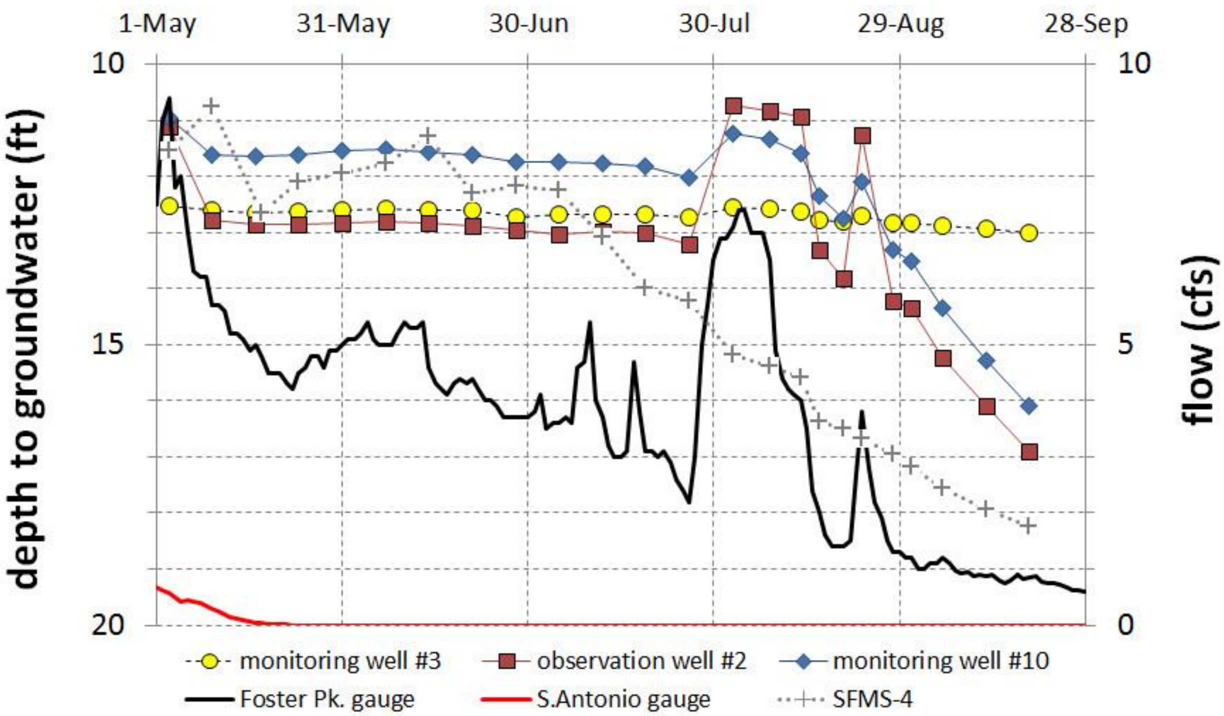
The graph shows these records from the start of water-year 2001 to the present, covering the years of SBCK monitoring. Monthly flows at the USGS gauge are shown in red, and the data points indicate depth to groundwater as measured from the top of each well. There are a couple of things to notice: One is the relative consistency of groundwater flow circa Foster Park. Note how little variation there is in the two "08" wells compared with the 05 well further up river. This is mostly due to groundwater being forced to the surface by local geology, aided by the City's subsurface dam (the dam is shown in the

report's charts and can be seen in this Google Earth image). The surrounding topography doesn't lend itself to any other meaningful groundwater sources other than flow down the riverbed from above. The obverse of this relatively constant Foster Park groundwater level is that it doesn't take very much of a decrease in water table elevation to drastically change dry-season flows on this reach of the river.



This next image from the Hopkins Report is a little hard to examine, but each individual graph represents the groundwater drawdown measured at a particular monitoring well during the course of the project: the horizontal gridlines are in 1 foot increments, the verticals one month intervals from May through September 2012. The upward "hump" just past the midpoint in each graph represents the pumping shutdown interval (another, much shorter, non-pumping interval in late August caused the upward "spike" that follows the hump). Lines connect each graph to the appropriate well: monitoring wells are shown as yellow circles, City production wells as light blue (#7, 8 & 11 actively pumping and #2 currently not in use), and the dark blue circle is another monitoring well (OW2).

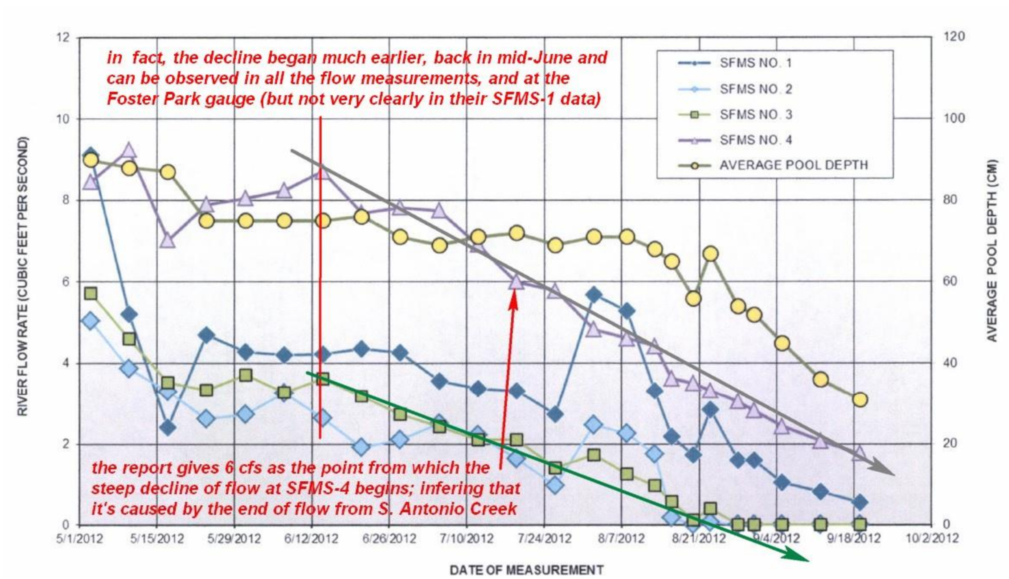
All wells show the hump. More so those near the biggest production wells (#7 normally pumping 2.5 cfs, and #8 pumping 1 cfs) with the least change at monitoring wells below the subsurface dam (least of all at monitoring well #1 located adjacent to the northeastern bridge abutment). All also show the



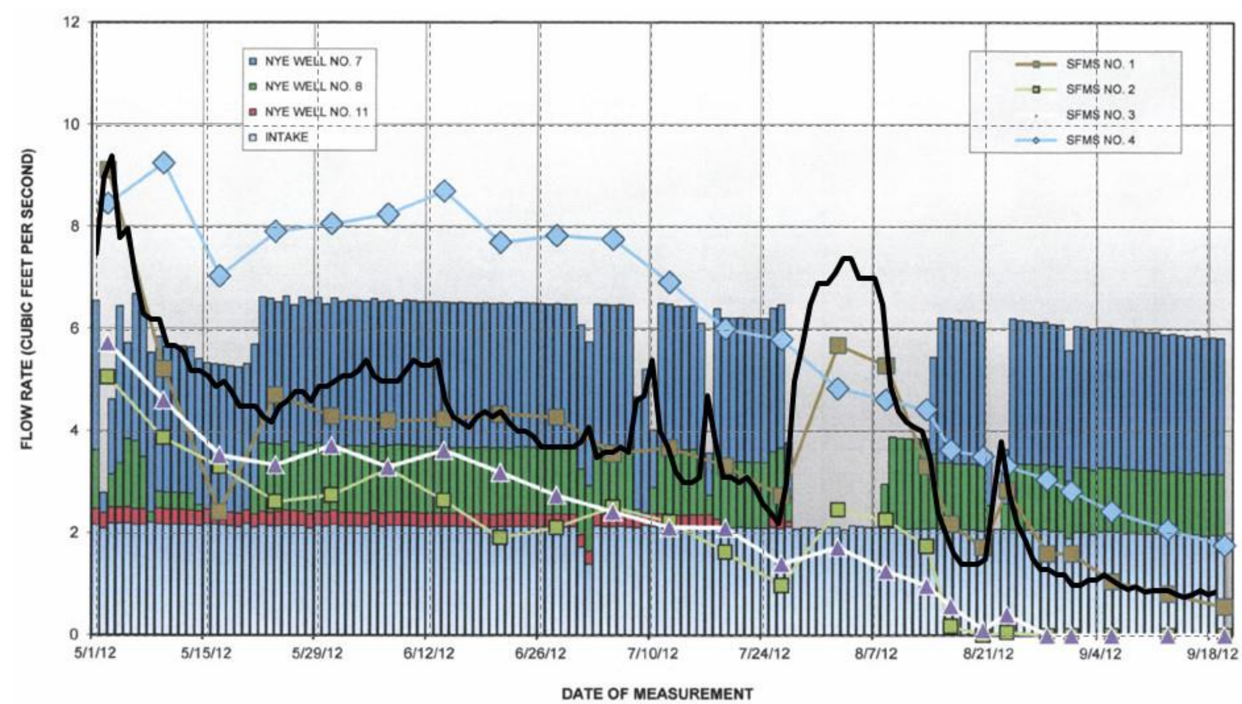
"spike" although it's difficult to see it in some of the charts.

To clarify the situation I've drawn a new graph showing data from three of the monitoring wells: monitoring well #3, which is below the City's pumping wells and just upstream of the subsurface dam and thus exhibits almost no variation during the course of the project; monitoring well #10, the furthest well upstream; and observation well #2, adjacent to Nye Well #7 (the production well doing most of the pumping) which naturally showed the greatest impact during the "stop pumping" experiment. I've also included averaged daily flow data from the USGS gauge at the Foster Park Bridge and from the County's San Antonio gauge (located at the Hwy 33 Bridge, about a thousand feet upstream of the confluence), and Hopkins flow measurements at SFMS-4 (Stream Flow Measuring Site #4) which were included in their report. The use of average daily flow at the two gauging station eliminates much of the chatter and fluctuation caused by the 15 minute gauging data used (presumably) in the report's charts. It also makes it easier to see the 5 cfs increase in Foster Park flow when the pumps were stopped.

Note that as the season wore on the surface flow response at Foster Park differed from that of groundwater. Groundwater levels remained nearly constant until roughly the first week in August when



the steep decline in levels—more easily seen in the September data—probably began (the stop-pumping test likely masked this point). However the decline in surface flow began back in mid-June and continued unabated—except whenever pumping was diminished or stopped. Off to the side is one of the report's charts on which I've written



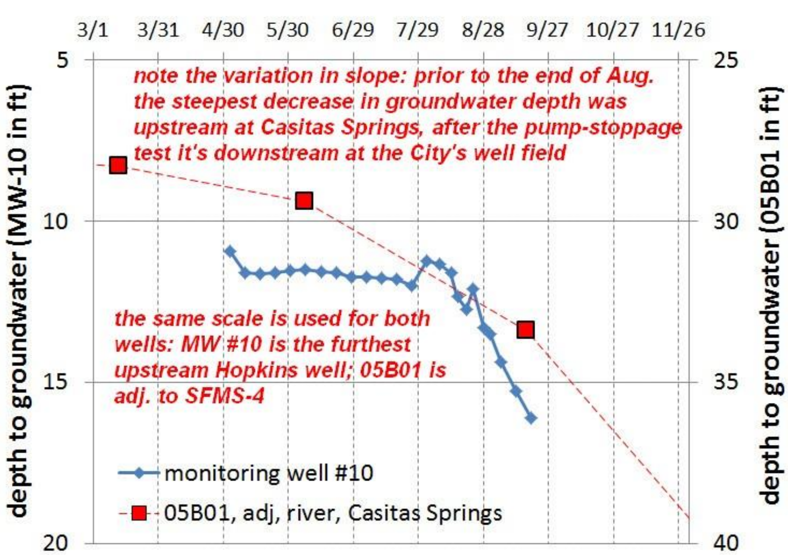
some comments to illustrate this point. The arrows illustrate the relatively steady decline in surface flow from mid-June on.

Above is another of the report's graphs (chart 6), this one showing the same measured flow data shown previously, but superimposed on extraction amounts from the City's three active production wells and their below-river intake gallery. Upon this, as if it weren't complicated enough, I've superimposed (in black) average daily flow at the Foster Park gauge. (The superposition is not perfect, but, if I say so myself, pretty good; I included SFMS-4 data in my original graph and matched both those data points and scale sub-divisions with the Hopkins chart before deleting the extraneous data.) The first thing to note is how much their SFMS-1 data (measurements at—or more accurately, below as the project wore on—the USGS gauge) varies from that of the gauge. In their report this comparison was made with 15 minute gauge data, the noise of which may have covered up a multitude of sins. (A better comparison would have been to select USGS gauge readings bracketing the times of their flow measurements and comparing these two sets of data.) I believe this underlines the points about flow measurement accuracy I tried to make earlier. The second thing: Note that pauses or reductions in the City's pumping cause all the upticks in the rather consistent (mentally overriding the abrupt increases) downward trajectory of gauge flow over the course of the project. Even pumping reductions smaller than half a cfs (e.g. circa the first week in July) increased flow at the gauge. The downward trajectory of flow at the gauge begins roughly, as did the SFMS measurements, in mid-June.

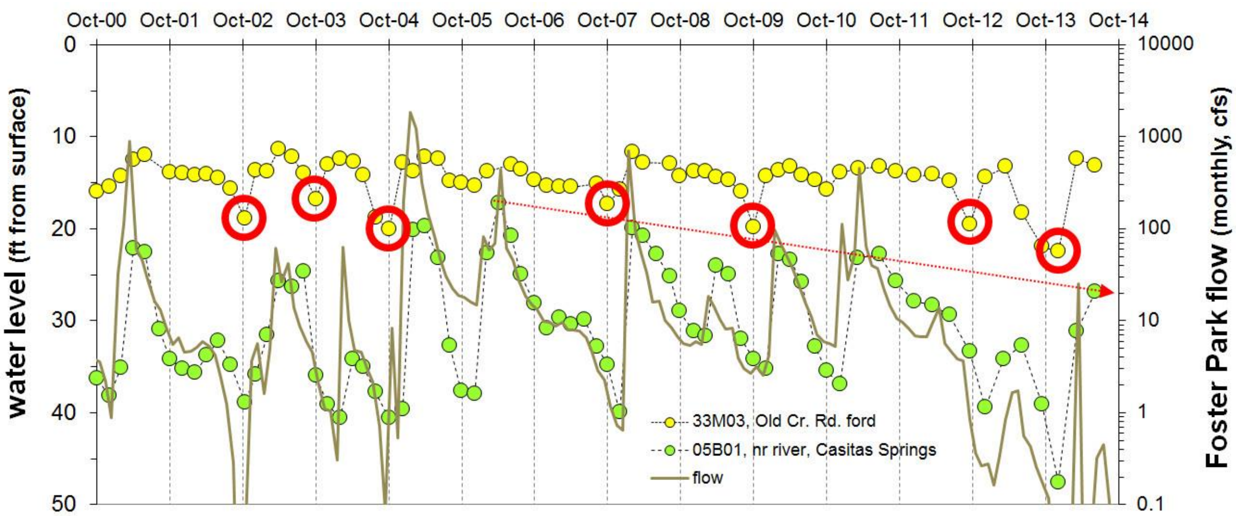
The report places a lot of emphasis on flow from San Antonio Creek. For example, from the executive summary: "*Inflow from S. Antonio Creek is a direct and significant influence on flow in this reach during the low-flow conditions observed by the study. High streambed infiltration rates resulting from high aquifer hydraulic conductivity cause a very rapid rate of groundwater recharge. These conditions result in a quick groundwater level response to changes in City production*."

Or from page 13: "*Over this period of time (May 24 to July 19) the upstream flow measured at SFMS-4 gradually declined from about 8 cfs to just 6 cfs. Subsequent upstream flow rate declines accelerated, and during the remaining 2 months of the study, the rate of surface water flowing into the Foster Park reach dropped from a rate of approximately 6 to less than 2 cfs. The decline appears to be coincident with the cessation in San Antonio Creek flows*."

While I don't doubt the statement on hydraulic conductivity or that City extractions present little problem when flow is coming into the Ventura/S. Antonio confluence from both S. Antonio and the Ventura reach above (and it's usually both when more than a trickle is flowing down S. Antonio—the Ventura reach above the confluence goes unmentioned in the report yet its flow typically greatly exceeds that of S. Antonio) this is far too simplistic view of what is taking place. There are also factual errors in these statements: The decline, as I've pointed out previously, began not in mid-July, but in mid-June. And either way, flow in S. Antonio (as measured at the County's gauge) stopped in mid-May—and fell below 1 cfs in mid-April. So by no stretch of the imagination can S. Antonio flow have meaningfully affected their study. What's been left out of the equation is groundwater flow from upstream.



Most of this groundwater comes into the confluence via the aquifer underlying S. Antonio Creek (see my piece on *Confluence Pool Water Levels*, October 2014). More on this shortly. For now, the graph on the left shows Hopkins depth-to-groundwater data for monitoring well #3 to which I've added the limited measurements available for 05B01, the well adjacent to SFMS-4; 05B01 is a half mile upstream of MW #3. I find the difference in drawdown slopes between the two wells—as noted on the graph—interesting. The limited data precludes any strong conclusions, but my interpretation is that prior to mid-August groundwater flows at Foster Park were strong enough to withstand City extractions with only slight decreases in measured groundwater levels (these slight decreases, however, did result in an appreciable decrease in surface flow towards the end of this period). Above Foster Park, drawdowns at 05B01 and other wells in the vicinity of Casitas Springs were having a much greater affect, lowering the water level by some 3-4 feet. After mid-August, when pumps were turned back on at the conclusion of the “stop-pumping” test, the Foster Park water table dropped appreciably: 4-5 feet over the next 30 or so days. This effect can be seen at all the monitoring wells in the vicinity and upstream of the City’s production wells; it’s also visible, but to a much lesser extent in the downstream monitoring wells (see the Hopkins chart on the bottom of page 4). This decrease in groundwater elevation was now much more rapid than the continued lowering of the water table at 05B01, and soon after it began the reach between SFMS-1 and -4 went dry. As the graph on page 5 shows, this mid-August turn-around point occurred a good two months after surface flow from S. Antonio had ceased.



The above graph, like the graph on page 3, shows, along with monthly average Foster Park flow, the depth to groundwater for two wells, the previously mentioned 05B01 (adjacent to SFMS-4) and 33M03 located adjacent to S. Antonio Creek about three tenths of a mile east of the confluence. The chart illustrates my earlier point that most of the groundwater seen during the dry-season at Foster Park is coming from that part of the Upper Ventura groundwater basin underlying S. Antonio Creek and not down the Ventura reach from above the confluence (wells in the vicinity of the river above show far more drastic drawdowns than that exhibited at 05B01).

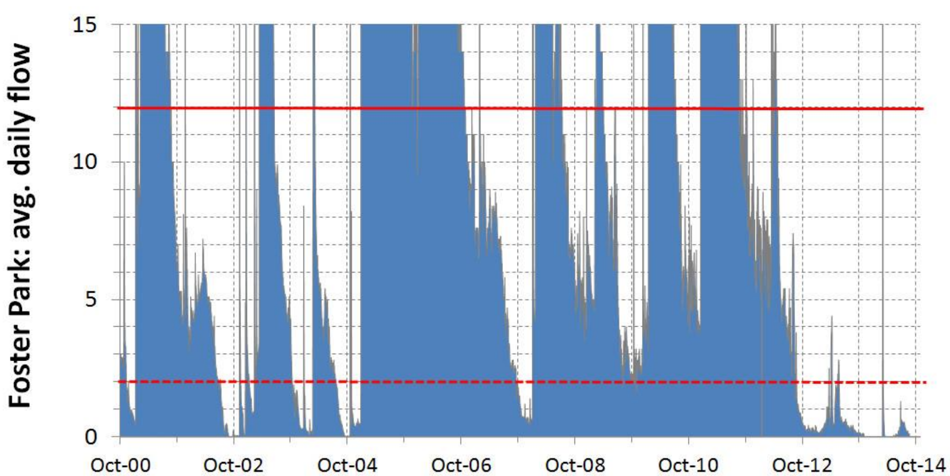
As the graph indicates, the nearly constant flow of San Antonio groundwater coming into the confluence rarely falters—except in low or very low rainfall years: I’ve indicated these episodes with red circles (the very dry water-years of 2002, 2007, 2009 and our current drought; and the relatively dry years of 2003 & 2004). The dates of water level measurement for both wells are identical and, although subsequent measurements were further apart than I might desire, the data show that groundwater recovery always occurs later at the Casitas well than it does at old creek ford; that in many cases groundwater levels at 05B01 were still decreasing at a time when levels at 33M03 had already fully recovered. One might suspect continued withdrawals at Foster Park as a possible cause. (The dates of measurement of the maximum drawdown at 33M03 are usually within a week of October 1; the next subsequent measurement was typically around the beginning of December.)

Notice that there was a substantial drawdown at 05B01 every year (the ends of the very high rainfall water-years of 2005 and 2010 appear strange because there was no subsequent recovery), even in wet years like 2001, 05, 06, 08, 09 or 10 that had little or no impact on 33M03. There also appears to be a decreasing trend in groundwater elevation recovery at 05B01 since 2005 (illustrated by the red line on the graph); the peak water table elevation this past June was about ten feet lower than in 2005 (33M03 fully recovered every year during the same time period).

It's time to bring this to a close. The report's conclusions are stated in the executive summary: *"The findings of this study indicate a flow threshold exists whereby when flows decrease below the threshold, the steelhead habitat suitability declines significantly. During the 2012 low-flow conditions when the City diversion was approximately 6.5 cfs and there was 4 cfs or greater upstream (at Casitas Springs) and 2 cfs (or greater downstream (at Casitas Vista Road Bridge), the HIS scores for adult steelhead remained fairly constant and the river pools maintained substantial depths.*" Without even considering the HIS score data, I regard this conclusion as invalid based on inadequate and incomplete measurement of daily minimum dissolved oxygen concentrations. That the reach between SFMS-1 and -4 went dry at a Foster Park gauge flow of 2 cfs would seem to make the obvious point that 2 cfs is far too low a benchmark flow.

There are two other statements in the executive summary I liked a lot better. The first being: "*Approximately 3-4 cfs can be produced by the City at Foster Park while the flow rate downstream at the Casitas Vista Road Bridge is virtually the same as the upstream flow rate at Casitas Springs where surface water enters the Foster Park reach of the river.*" The charts on page 6 show that this was the case at the very beginning of May. Thereafter flow at the gauge was always less than that measured at SFMS-4 (the Casitas Springs flow point referred to in the statement), except during the stop-pumping halt and the short pause that followed it. However, even with this '*USGS gauge flow greater than or equal to Casitas Springs flow'* criterion, flows at the gauge at the beginning of May were only 9 cfs, lower than the recommended NMFS 12 cfs minimum. Note also that the 3-4 cfs mentioned does not include the additional 2 cfs being extracted by the under-river gallery (see the page 6 chart).

The second statement, "*While the City has no control on how much water will seasonally flow into the Foster Park reach, the reduction and eventual cessation of pumping during the dry season will serve to maintain a minimum river flow rate and the associated steelhead habitat until the main stem of the river dries out,*" would be hard to disagree with. I would concur wholeheartedly.



What difference might a cubic foot or so make? The chart shows average daily Foster Park flow at the USGS gauge (in cfs) since the beginning of water-year 2001. The lines illustrate the Hopkins report 2 cfs minimum (dashed red) and the National Marine Fisheries Service recommended 12 cfs minimum (solid red). Neither would be restrictive in a wet year, but the NMFS limit would make all the dry-year difference in the world; little or no pumping would be allowed in years like 2002, 2007 or the current drought. Had even the Hopkins limit been adopted there would have been no Foster Park extraction during the last two years. Needless to say, it wasn't adopted. As we say in the west, "whiskey's for drinking, water's for fighting over."