Donner Summit Public Utility District

South Yuba River Water Quantity and Quality Report

As a supplement to the Donner Summit Public Utilities District (DSPUD) South Yuba River Biostimulation Field Survey Report (Report, ECO:LOGIC Engineering, July 2009), ECO:LOGIC Engineering compiled water quantity (i.e., flow) and water quality data for the DSPUD effluent and South Yuba River (SYR) for Spring 2008 and Spring 2009. The purpose of the compilation was to determine the magnitude and breadth of differences in water quantity and quality data between the two springs that may explain, or help to explain, the major differences in biostimulation observed in the SYR immediately downstream of the effluent discharge point in Spring 2008 compared to Spring 2009:

- In Spring 2008, major growths of filamentous green algae were observed in deep flowing river water immediately downstream of the DSPUD effluent discharge point. From the extent and condition of algal growths shown in SYR images dated 19 June 2008 (see Section 2 of the Report), it is a reasonable assumption that these algae flourished in the 10 to 20 June 2008 period. By 2 July 2008, these algae were dead or dying as discussed in Section 2 of the Report.
- In Spring 2009, major growths of filamentous green algae were observed in the SYR miles upstream and miles downstream of the effluent discharge point (as shown in Sections 4, 5, and 6 of the Report), but not immediately downstream of the effluent discharge point where heavy algal growths had been observed in 2008.

The differences in locale-specific biostimulation observed between these two Junes are extraordinary, with there being no known overtly obvious reason for the differences. Algal zygospores presumed to be left on the rocks downstream of the effluent discharge point from the Spring 2008 biostimulation event were forecast to predispose these rocks to, again, have algal growths in 2009, in the absence of aquatic environmental conditions in Spring 2009 being substantially different from aquatic environmental conditions in Spring 2008. This document presents and analyses the similarities and differences in water quantity and water quality between Spring 2008 and Spring 2009, in an effort to provide some explanation for the major differences in biostimulation observed in the two years. Special focus is placed on June 2008 and June 2009 when biostimulation in the SYR is most likely to occur based on available recent evidence.

WATER QUANTITIES: SYR AND EFFLUENT

SYR Flows. Running 7-day averages of SYR flows at Cisco Grove for Spring 2008 and Spring 2009 are presented in Figure 1. As shown, river flows in the critical month of June were somewhat greater in Spring 2009 than in Spring 2008. This flow difference does not appear to be the cause of the differences in biostimulation. This is because June 2008 SYR flows when significant biostimulation immediately downstream of the effluent discharge point was observed, also occurred in June 2009, but about 9 days later in the calendar month. Specifically, from 10 to 20 June 2008 when algae

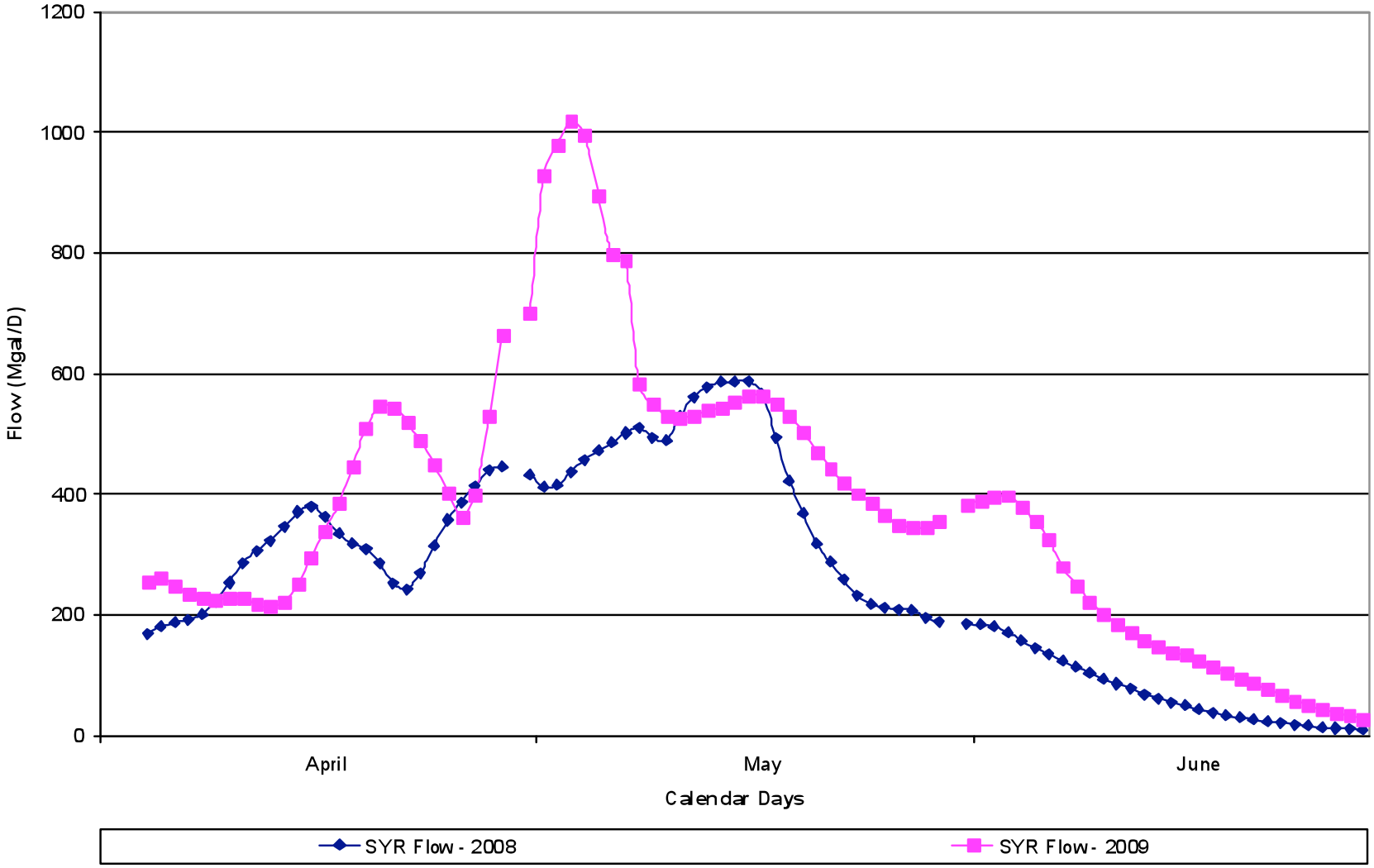

Figure 1
South Yuba River (SYR) Flow at Cisco Grove (7-day Average)

flourished in the SYR downstream of the DSPUD effluent discharge point, the SYR hydrograph receded from approximately 115 Mgal/d down to about 32 Mgal/d. In 2009, SYR flows receded from approximately 114 Mgal/d down to about 32 Mgal/d over the 10 day period from 19 June to 29 June. This 9-day offset in when similar river flow conditions occurred does not appear to be the cause of the difference in biostimulation observed because during most of June 2009, biostimulation of filamentous green algae similar to those seen in June 2008 was evident on a continuous basis in some SYR locations substantially upstream and substantially downstream of the effluent discharge point. This observation, documented in the Report, provides evidence that 1) conditions in the SYR in June 2009 were suitable for biostimulation of filamentous green algae to occur (i.e., there was not some general overriding condition preventing or inhibiting biostimulation of filamentous green algae in the SYR in June 2009), and 2) the biostimulation "season" for filamentous green algae in the SYR is not limited to just a few days in the calendar year such that a 9-day shift in the occurrence of similar environmental conditions would be the determinant of whether biostimulation would or would not occur.

Based on these observations, the 10-day SYR flow period in Spring 2009 that is most similar to the 10-day SYR flow period associated with flourishing biostimulation of filamentous green algae downstream of the effluent discharge point in June 2008 is presented in Table 1.

Table 1
Most Similar SYR Flow Conditions
Between June 2009 and the Biostimulation Event of June 2008

Parameter	10-Day June 2008 Period Associated with Biostimulation Downstream of the Effluent Discharge Point	Most Similar 10-Day Period in June 2009
Dates	10 to 20 June	19 to 29 June
SYR Flow at Cisco Grove, Mgal/d	115 receding to 32	114 receding to 32
Estimated SYR Flow at DSPUD Effluent Discharge Point, Mgal/d(a)	47 receding to 13	46 receding to 13

(a) Based on multiplying the SYR flow at Cisco Grove by 0.4054, the ratio of the SYR watershed at DSPUD's effluent discharge point over the SYR watershed at Cisco Grove.

Effluent Discharges. Running 7-day averages of DSPUD effluent discharges to the SYR in Spring 2008 and Spring 2009 are presented in Figure 2. As shown, effluent discharges in June 2009 were somewhat greater than effluent discharges in June 2008. This is expected because the amount of I/I (inflow/infiltration) occurring in the DSPUD wastewater collection system is a function of the same environmental parameters causing flow in the SYR: snowmelt and precipitation. In other words, higher SYR flows on any given date imply higher wastewater flows (because of higher I/I) on that same date, if actual wastewater flows from occupied dwelling units and businesses are held constant.

From a biostimulation perspective, a critical issue is the estimated percentages of effluent in the SYR at the effluent discharge point. These percentages are shown in Figure 3. As shown, the effluent percentages in the SYR in the critical 10 to 20 June 2008 biostimulation period also occurred in June 2009, but about 9 calendar days later under similar SYR flow conditions. Adding this information to Table 1 results in an overall summary of hydraulic conditions between June 2008 biostimulation conditions and June 2009 non-biostimulation conditions immediately downstream of the effluent discharge point (see Table 2).

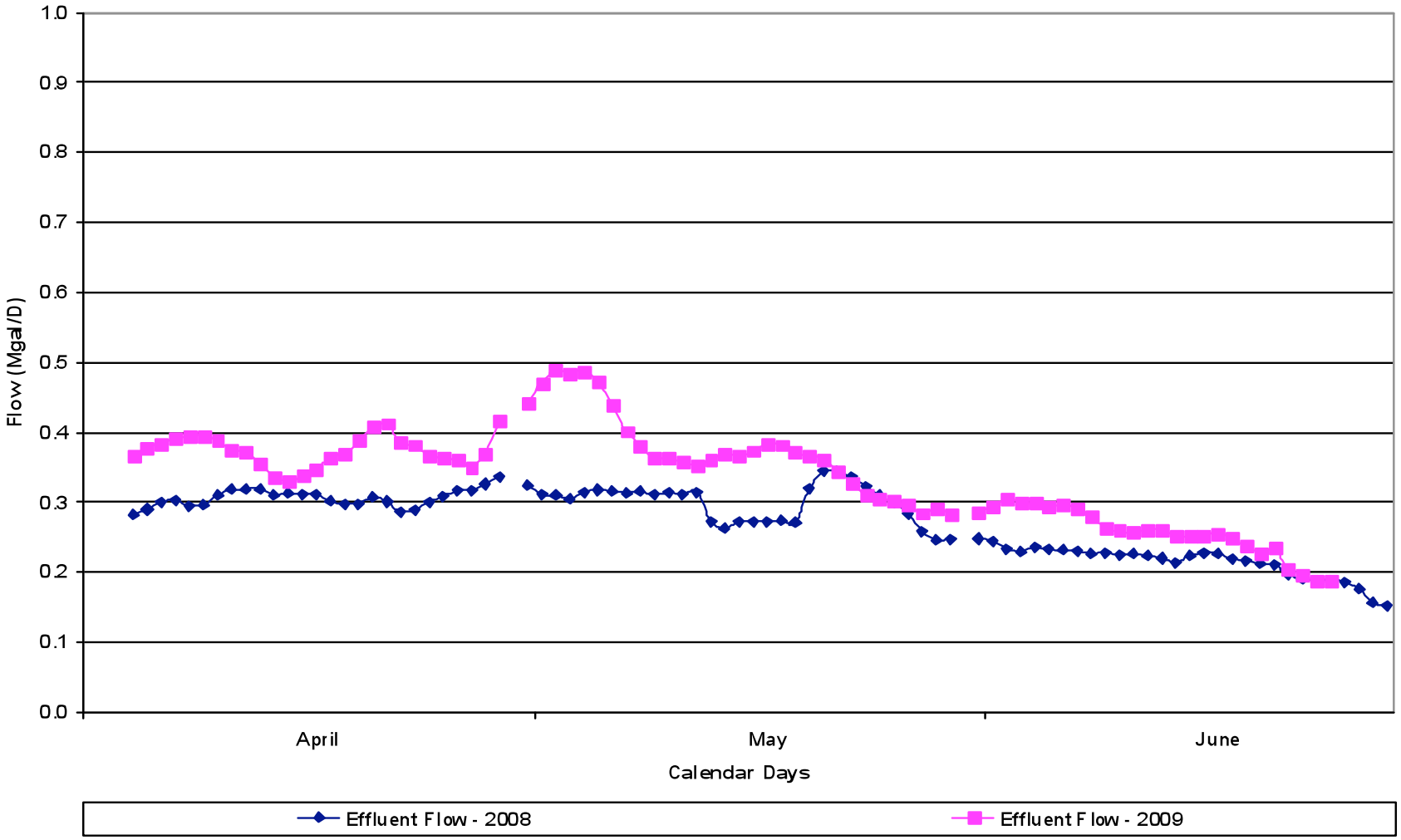

Figure 2
DSPUD Effluent Flow (7-day Average)

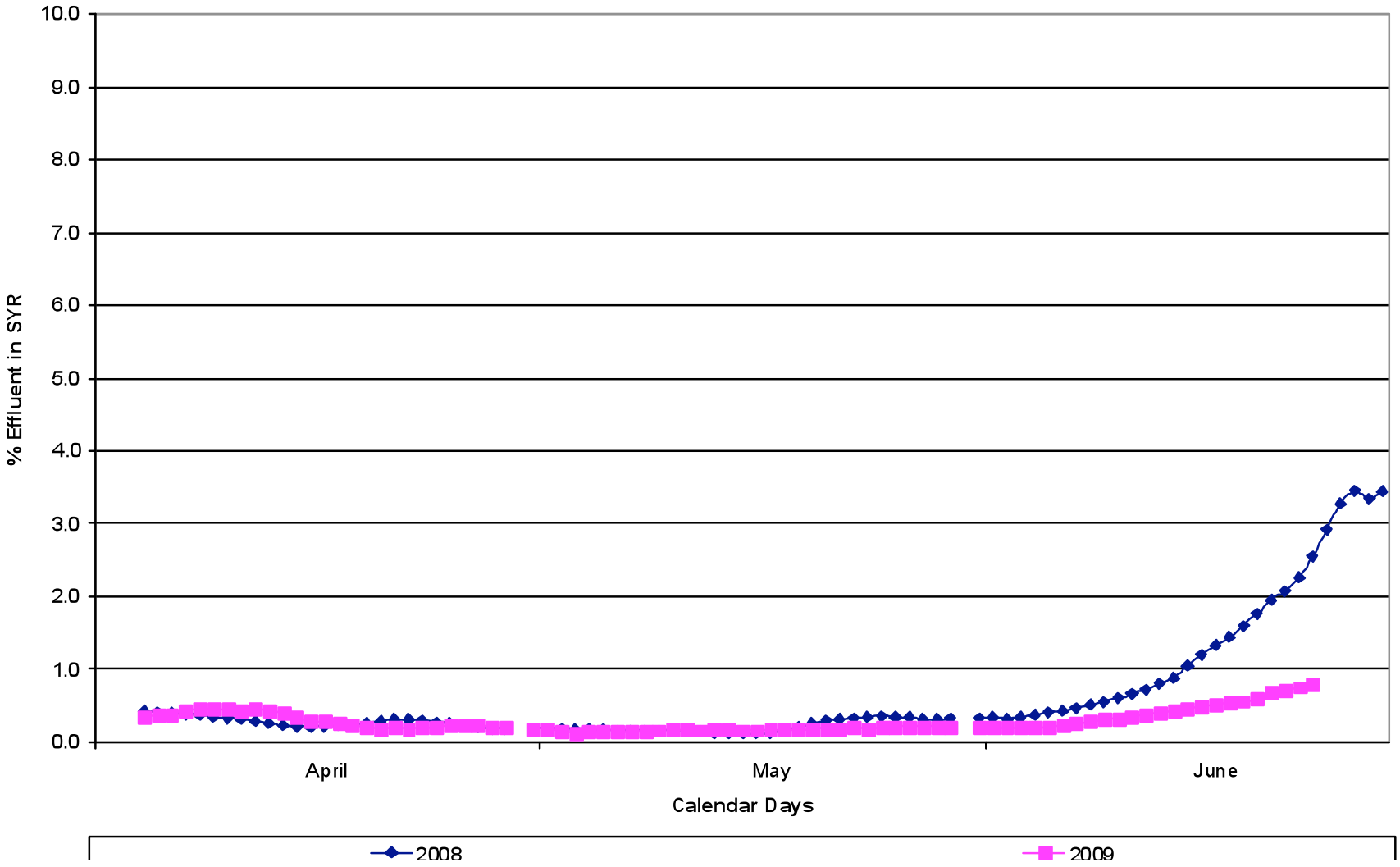

Figure 3

DSPUD Effluent Flow as a Percentage of Estimated SYR Flow at DSPUD Effluent Discharge Point (7-day Average)

Table 2
Summary of Similar Hydraulic Conditions: June 2008 and June 2009

Parameter	10-Day June 2008 Period Associated with Biostimulation Downstream of the Effluent Discharge Point	Most Similar 10-Day Period in June 2009
Dates	10 to 20 June	19 to 29 June
Estimated SYR Flow at DSPUD Effluent Discharge Point, Mgal/d(a)	47 receding to 13	46 receding to 13
Estimated % Effluent in the SYR at DSPUD Effluent Discharge Point(a)(b)	0.52 to 0.97	0.57 to 1.19

(a) Based on multiplying the SYR flow at Cisco Grove by 0.4054, the ratio of the SYR watershed at DSPUD's effluent discharge point over the SYR watershed at Cisco Grove.

(b) Using only the first seven days of the 10-day period based on data limitations for June 2009.

A difference between June 2008 and June 2009 that is significant, but does not appear to be the determinant of the differences in biostimulation observed in these two months is that the effluent discharge was continuous throughout the 10 to 20 June period when the algae flourished; whereas in 2009, the effluent discharge was stopped on 26 June within the 19 to 29 June SYR flow period most similar to 2008 conditions under which algae flourished immediately downstream of the effluent discharge point. This is not considered the determinant of the differences in biostimulation observed because the 19 June 2008 SYR images show extensive growths that would have taken several days to develop, i.e., they would have been very evident on 17 June 2008 as well as on 19 June 2008 when the image was taken. Hydraulically, 17 June 2008 is equivalent to 26 June 2009. As of 26 June 2009, biostimulation of filamentous green algae was not evident downstream of the effluent discharge point as documented in Section 6 of the Report.

WATER QUALITY: NITRATE AND TEMPERATURE

Of the many water quality variables potentially affecting SYR biostimulation from year-to-year, the most important are believed to be 1) readily available nitrogen (i.e., nitrate), and 2) temperature. SYR pH and readily available phosphate are also important, but are not believed to vary materially from year-to-year. SYR pH is variable, but is consistently in the 6.5 to 8.5 range (see DSPUD's 2007 Report of Waste Discharge, page G-10), which EPA reports has little effect on aquatic life. Regarding phosphate, the DSPUD WWTP does not remove phosphate. Based on effluent flow data and community activity, effluent phosphate concentrations in June 2008 and June 2009 should have been similar. No other potential source of phosphate is thought to have varied on the SYR watershed from 2008 to 2009, with the possible exception of land disturbing activities, discussed below.

SYR phosphate (or micronutrient) concentrations resulting from land disturbing activities on the watershed occurred in both June 2008 and June 2009. Two land disturbances were noted in 2008: CalTrans work on the I-80 Soda Springs interchange adjacent to the SYR, and earth work on private property adjacent to the SYR at R2 (the downstream DSPUD SYR monitoring location where heavy biostimulation occurred in June 2008. The extent of soil disturbance and resulting from the CalTrans

work on the I-80 Soda Spring interchange exposure leading up to June 2008 compared to June 2009 is not known, and has not been investigated, e.g., via review of construction management records for that job. This is because any direct impacts from CalTrans activities on SYR biostimulation in 2008 and 2009 appear to be minor based on observations of the SYR immediately downstream from their work area. However, the SYR downstream from the CalTrans work area is rather shaded, a condition not conducive to biostimulation of filamentous green algae. It is possible that CalTrans activities in 2008 altered SYR water quality in ways (e.g., release of soil phosphates or micronutrients) that reacted synergistically with DSPUD's effluent discharge (specifically, its nitrates) to stimulate the algae growth seen in June 2008 immediately downstream of the effluent discharge point. Though possible, this would be somewhat unexpected (unless a micronutrient is involved) because the effluent as it entered the SYR on 21 June 2009 was measured to have an N:P ratio of 16 (specifically 11 mg/L:0.69 mg/L), which is in agreement with the very generalized Redfield ratio of 106:16:1 for C:N:P for algae growing in environments that do not have a nutrient imbalance. In other words, DSPUD effluent appears to contain sufficient phosphate to "fuel" the biostimulation potential of the effluent's nitrate concentration. However, N:P ratios for specific algae can vary significantly. Algae do grow in the DSPUD WWTP clarifiers demonstrating that the effluent is capable of causing biostimulation, and has sufficient micronutrients to fuel biostimulation on at least the small scale of the clarifier launders.

The earth work on private property adjacent to the SYR and just north of R2 (and the 2008 biostimulation site) may have exacerbated biostimulation, but was not the primary cause. This is because the biostimulation "plume" of June 2008 continued upstream of R2 and this earth work area.

Water Temperature. SYR water temperature data at the DSPUD R2 monitoring station where biostimulation was observed to be heavy in June 2008 are presented in Figure 4. As shown, in the critical month of June, water temperatures in 2009 were very similar to those in 2008.

Nitrate Concentrations. Effluent nitrate concentrations and effluent total nitrogen concentrations are virtually identical in the May/June period, which simplifies the analysis. Effluent nitrate concentrations in Spring 2008 and Spring 2009 are presented in Figure 5. As shown, the June 2008 and June 2009 effluent nitrate concentrations generally fall in the 7 mg/L to 13 mg/L range. In June 2008, the higher concentrations tended to occur earlier in the month. In June 2009, the higher concentrations tended to occur later in the month.

The estimated effects of the effluent discharge on nitrate concentrations in the SYR at R2 (where biostimulation was observed in mid-June 2008) are presented in Figure 6. As shown, the nitrate effect of the effluent discharge on the SYR from 10 to 20 June 2008 is estimated to range from 0.03 to 0.17 mg/L, with an average of 0.09 mg/L. In the 19 to 29 June 2009 period most similar hydraulically to 10 to 20 June 2008, the effluent nitrate effect on the SYR is estimated to range from 0.05 to 0.18 mg/L, with an average of 0.08 mg/L (based on data to 6/25/2009, the effluent stopped on 6/26/2009). The comparable nitrate dataset for 10 to 16 June 2008 is a range of 0.03 to 0.09 mg/L, with an average of 0.07 mg/L.

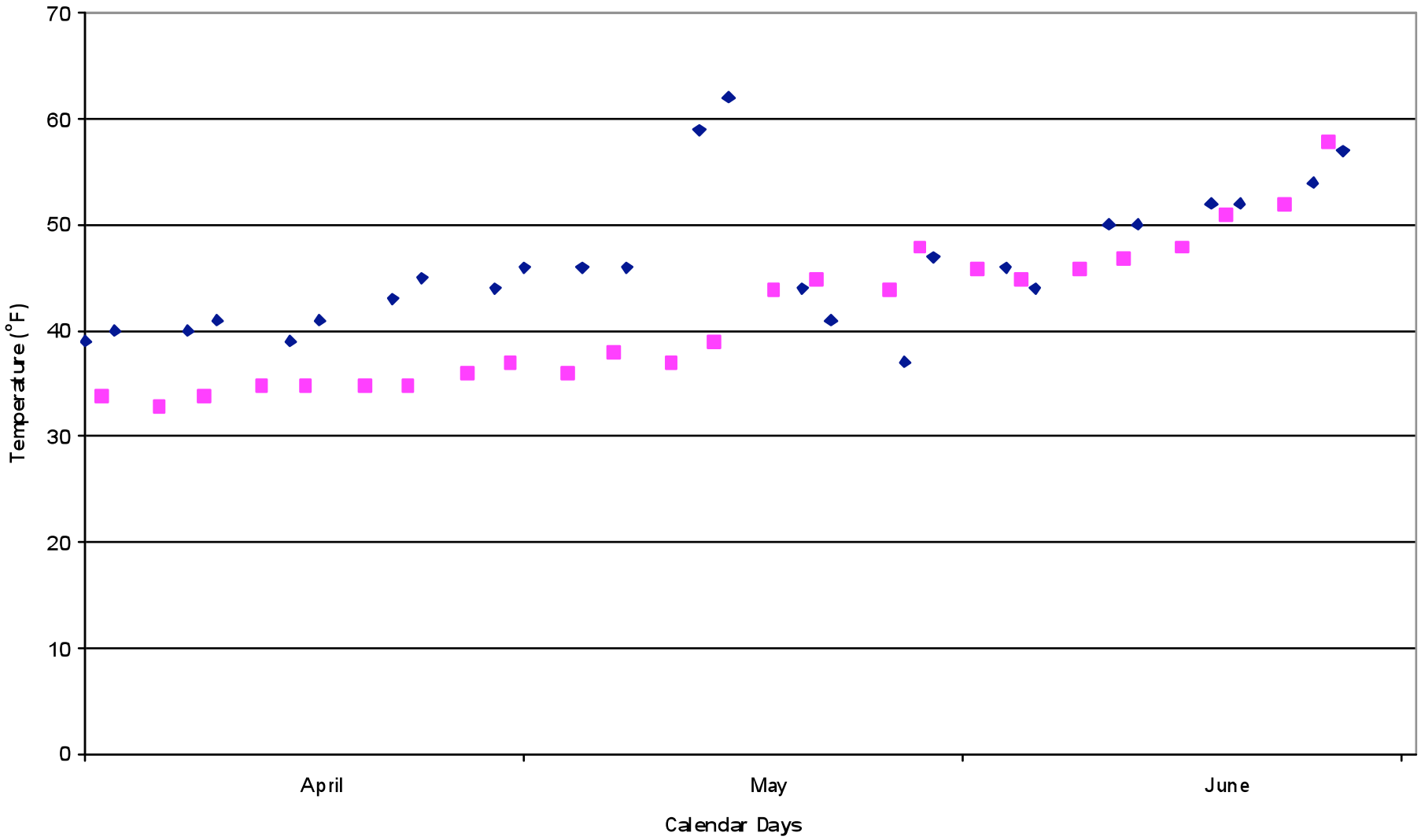

Figure 4
South Yuba River Water Temperature at R2

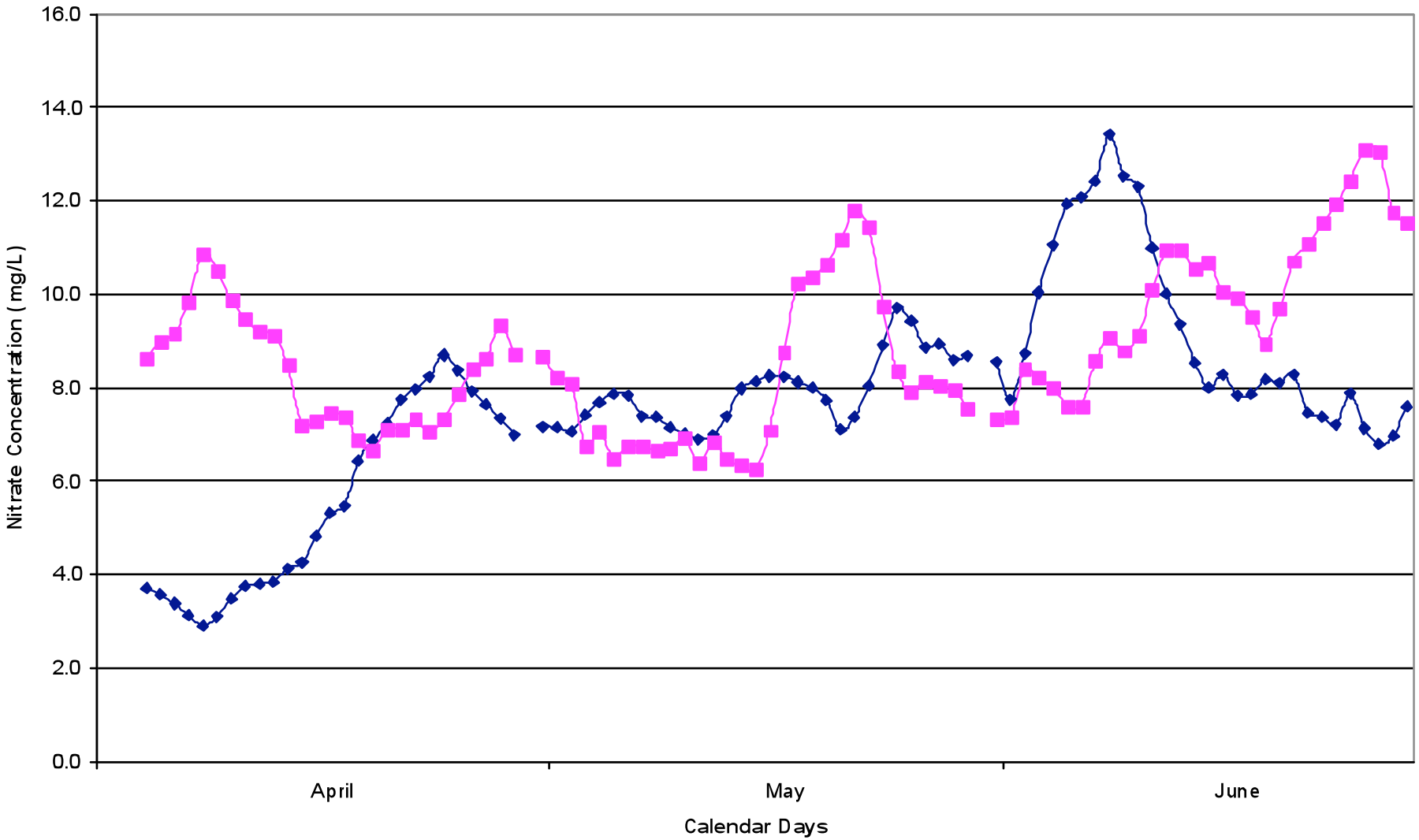

Figure 5
Seven-Day Running Average Nitrate Concentration in Effluent

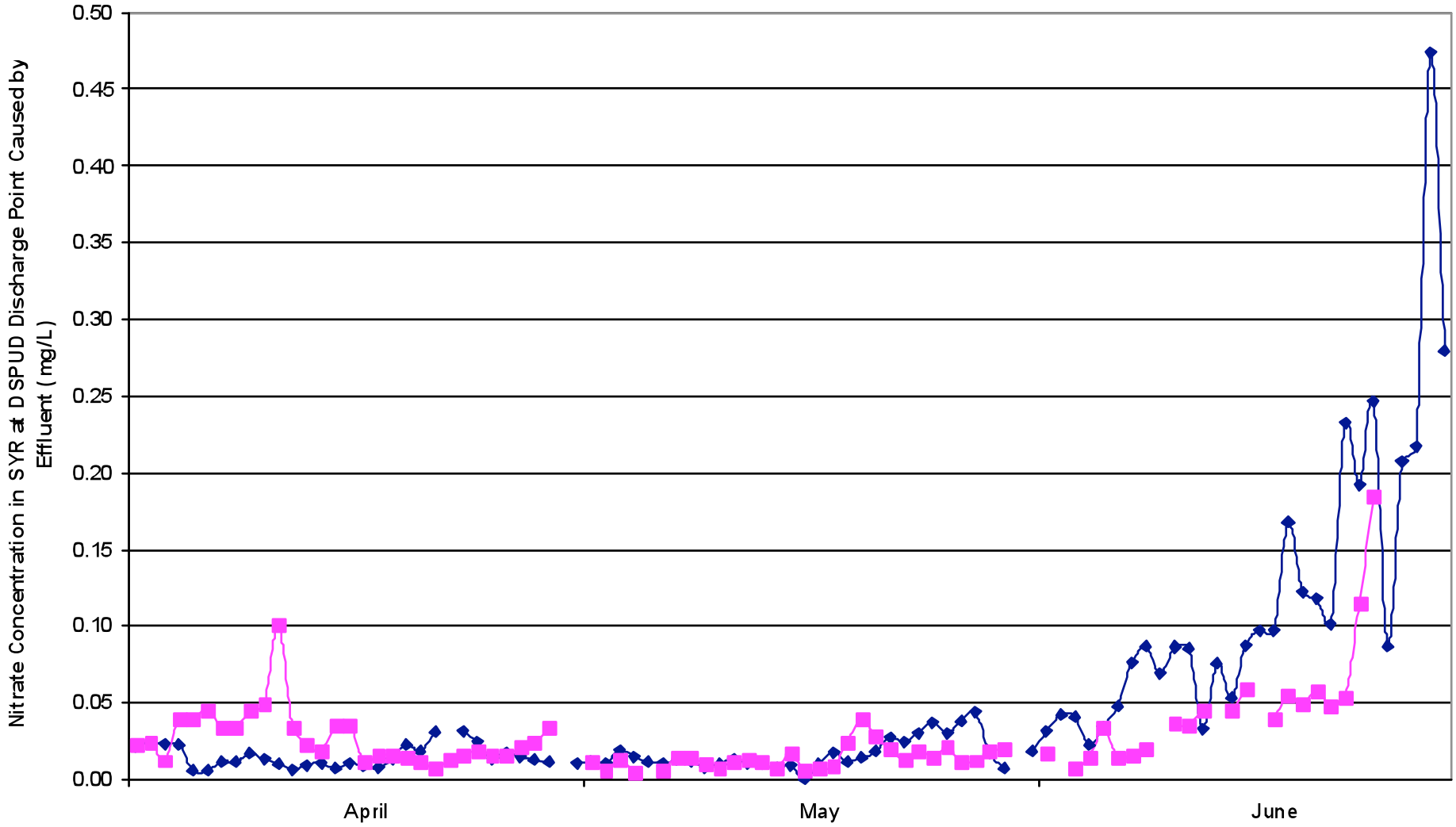

Figure 6
Effluent Nitrate Effects on SYR (Daily Data)

COMPARATIVE SUMMARY OF WATER QUANTITY AND WATER QUALITY DATA: 2008/2009

A comparative summary of SYR water quantity and water quality data from 2008 and 2009 believed to be pertinent to the SYR biostimulation issue is presented in Table 3.

Table 3
Comparative Summary of Water Quantity and Quality for June 2008 When Biostimulation Occurred, and June 2009 Under Most Similar Aquatic Environmental Conditions

Parameter	10-Day June 2008 Period Associated with Biostimulation Below the Effluent Discharge Point	Most Similar 10-Day Period in June 2009
Dates	10 to 20 June	19 to 29 June
Estimated SYR Flow at DSPUD effluent discharge point, Mgal/d(a)	47 receding to 13 26 average	46 receding to 23 35 average
Estimated % effluent in the SYR at the DSPUD effluent discharge point, Mgal/d(a)(b)	0.52 increasing to 0.97 0.72 average	0.5 increasing to 1.19 0.70 average
SYR Water temperature at DSPUD R2 monitoring station, °F(b)	50 increasing to 50	52 increasing to 58
Estimated increase in SYR nitrate concentration caused by effluent discharge, mg/L(a)(b)	0.07 average	0.08 average
Measured nutrient concentrations:		
▪ Date	Not tested	21 June
▪ Effluent as it enters the SYR:	- - -	
– Nitrate, as N, mg/L	- - -	11
– Ammonia, as N, mg/L	- - -	J 0.088
– Ortho phosphate as P, mg/L	- - -	0.69
▪ SYR at R2:		
– Nitrate, as N, mg/L	- - -	J 0.071
– Ammonia, as N, mg/L	- - -	< 0.060
– Ortho phosphate as P, mg/L	- - -	J 0.0070

(a) Based on multiplying the SYR flow at Cisco Grove by 0.4054, the ratio of the SYR watershed at DSPUD's effluent discharge point over the SYR watershed at Cisco Grove.

(b) Using only the first seven days of the 10-day period based on data limitations for June 2009.

As shown in Table 3, basic SYR water flow and water quality conditions associated with extensive biostimulation of filamentous green algae immediately downstream of the effluent discharge point on and about 10 to 20 June 2008 also occurred on and about 19 to 29 June 2009. Though aquatic environmental conditions appeared to be very similar during these two periods, the extent of biostimulation downstream of the effluent discharge point was dramatically different. The reason(s) for this major difference in biostimulation is unknown. It is known that SYR conditions in June 2009 were conducive to biostimulation as evidenced by the occurrence of significant growths of

filamentous green algae at SYR locations miles upstream and miles downstream of the effluent discharge point. However, with biostimulatory conditions bracketing the effluent discharge point, the effluent discharge caused no material biostimulation of filamentous green algae growths, though the effluent discharge point locale is known to be capable of experiencing significant biostimulation, as observed in June 2008.

As part of the 2009 SYR biostimulation study, SYR nutrient concentrations were monitored on 21 June 2009 under aquatic environmental conditions 1) known to be facilitating biostimulation miles upstream and miles downstream of the effluent discharge point in June 2009, and 2) known to be similar to aquatic environmental conditions that facilitated biostimulation immediately downstream of the effluent discharge point in June 2008. Results from this monitoring effort are reported in Table 4. As of 21 June 2009, nutrient concentrations in the SYR at R2 (immediately downstream of the effluent discharge point) were greater than either below the Lake Van Norden dam or between Rainbow Lodge and Cisco Grove. Curiously, biostimulation was virtually absent at R2 whereas biostimulation was readily apparent at these other two locations.

Table 4
Water Quality Results from 21 June 2009 Sampling Event

Sample Type and Site	Obvious Biostimulation (?)	Nitrate, as N, mg/L	Ammonia, as N, mg/L	Ortho Phosphate, as P, mg/L
SYR below Lake Van Norden dam: "Above Town"	Yes	<0.010	<0.060	<0.0060
SYR at R1: "Upstream of Effluent Discharge"	No	<0.010	<0.060	<0.0060
Effluent emerging from SYR gravel: "Effluent"	No	11	J 0.088	0.69
SYR at R2: "Downstream of Effluent Discharge"	No	J 0.071	<0.060	J 0.0070
SYR: "Below Kingvale"	No	<0.010	J 0.088	<0.0060
SYR: "Above Hampshire Rocks Campground"	Yes	<0.010	<0.060	<0.0060
SYR: "Rainbow Lodge/Cisco Grove"	Yes	<0.010	0.18	<0.0060

CONCLUSIONS AND RECOMMENDATIONS

A fundamental premise of the scientific method is that identical causes will result in identical effects. Though SYR conditions in 10 to 20 June 2008 were not identical to SYR conditions in 19 to 29 June 2009, they were very similar within the context of the natural variability under which life on earth exists. And yet, seemingly similar SYR conditions resulted in entirely different levels of biostimulation in June 2008 compared to June 2009:

- Heavy filamentous green algae biostimulation occurred in the SYR in the vicinity of R2 on or about 10 to 20 June 2008.
- Virtually no filamentous green algae biostimulation occurred in the SYR in the vicinity of R2 on or about 19 to 29 June 2009, when environmental conditions were most similar to those that had occurred one year before on or about 10 to 20 June 2008.

What can be concluded from the June 2009 biostimulation study is that the current effluent discharge does not necessarily cause material biostimulation 1) in the SYR, or 2) in the effluent/SYR mixing zone where effluent percentages are relatively high. This fact was documented in the June 2009 biostimulation study Report.

The cause(s) of the June 2008 filamentous green algae biostimulation event in the SYR in the vicinity of R2 may never be known. June 2009 was a study of what SYR conditions do not result in material biostimulation in the vicinity of the effluent discharge. However, material biostimulation was observed well upstream and well downstream of the effluent discharge point. In a situation like this, it is recommended that DSPUD monitor SYR conditions in Spring 2010 with special attention being given to the following areas as SYR flows at Cisco Grove recede to less than about 400 Mgal/d:

1. The Lake Van Norden dam area where significant biostimulation was observed in June 2009.
2. The effluent/SYR mixing zone where effluent percentages in the SYR are relatively high.
3. R2 with regards to both filamentous green algae observed in June 2008, and brown algae observed in the cataract in June 2009.
4. The SYR gorge upstream of Cisco Grove where significant biostimulation was observed in June 2009.

At SYR flows greater than about 400 Mgal/d (at Cisco Grove), it appears that overtly obvious biostimulation is unlikely as a result of hydraulic scour, snowmelt turbidity, cold water temperatures, and/or low nutrient concentrations.