Lower Boise River AQUATOX Model Updates

Algal Parameters and Ecosystem Bioenergetics

Darcy Sharp, DEQ State Office; Technical Services
Darcy.Sharp@deq.idaho.gov; 208-373-0133
12/3/2013 DEQ Regional Office Conference Rooms A & B

Algal Parameters

Periphyton	Topt	Tmax	Tresp	LightSat	Pmax	Lightex	P half-sat	N half-sat	Fcrit	%sl
Low-nutrient diatoms	15	39	2	64	.77	0.03	.006	.07	.007	90
High-nutrient diatoms	20	35	1.8	22.5	2.3	0.03	.055	.117	.008	90
Greens	25	42	2	110	1.7	0.03	.0093	.1	.007	90
Cladophora	15	25	2	135	1.08	.22	.01	.0586	.008	25
Oscillatoria	10	50	2.1	110	1.2	0.03	.006	.168	.008	90
Phytoplankton										
Low-nutrient diatoms	15	39	2	224	.7	.14	.006	.0154		
High-nutrient diatoms	20	35	1.8	45	1.87	.14	.055	.117		
Greens	26	42	2	220	1.5	.24	.0093	.1		
Blue-greens	27	50	2	60	2.2	.099	.006	.168		

Algal Parameters

* Blue-green phytoplankton
  * Phytoplankton and periphyton strongly linked in the model
    * Good assumption that phytoplankton is predominantly sestonic periphyton
      * Common assumption in the literature
      * Rapid travel time in LBR

AQUATOX- Edit Plant

Save | Cancel | OK | Print | GridMode | Export to Excel | Help | *Peri Low-Nut Diatom*

Plant Data:

Periphyton Linkage | Edit All

Plant: **Peri Low-Nut Diatom** (Search Names)

Scientific Name: **Fragilaria** (Search Scientific Names)

Plant Type: **Periphyton**

Toxicity Record: **Diatoms** (Edit All)

Taxonomic Type: **Diatoms**

Species Data:

Diatoms1: [Peri Low-Nut Diatom]
is the same species as

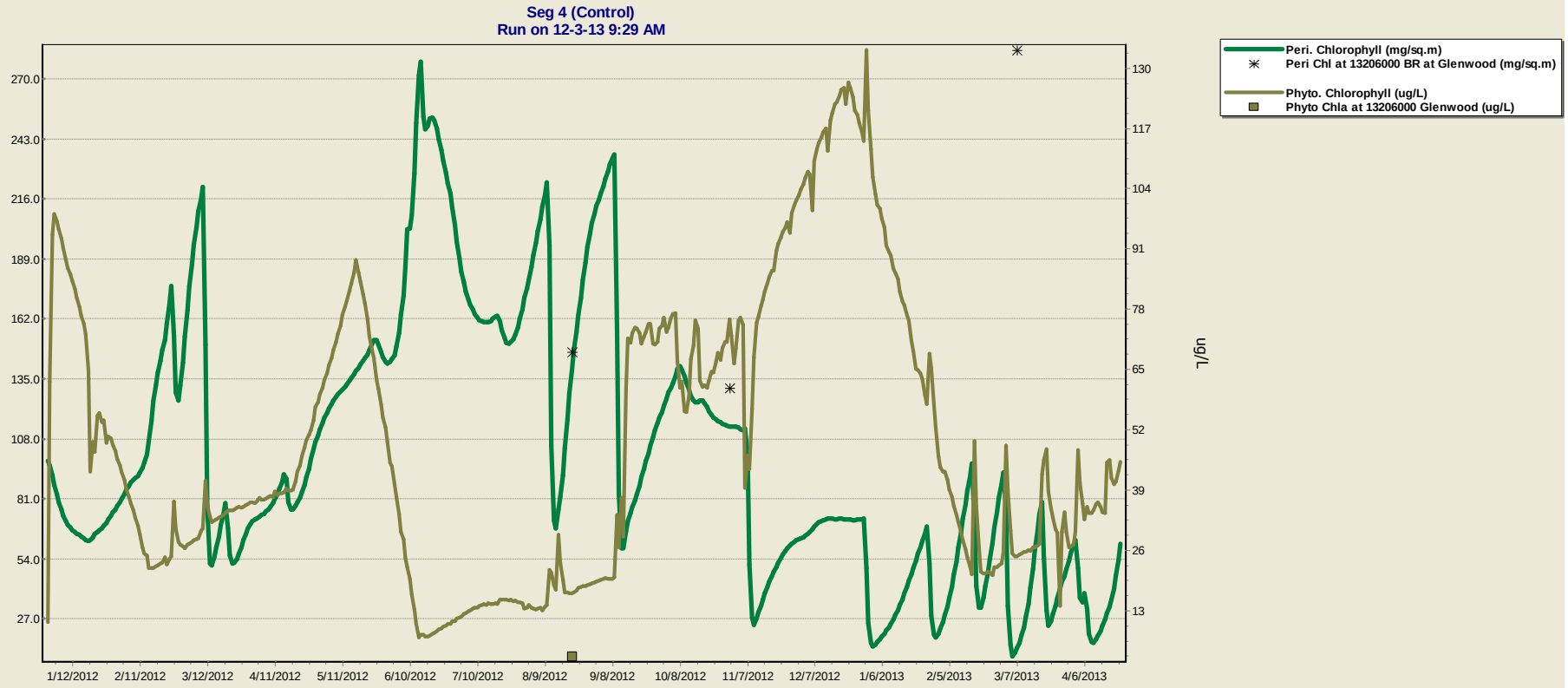
- Diatoms3: [Phyt High-Nut Diatom]
- Diatoms4: [Phyt Low-Nut Diatom]
- Greens4: [Phyto, Green]
- Cyanobacteria1: [Phyt, Blue-Greens]
- ** Scour to Detritus **

Help | OK | Cancel

			References:
Saturating Light	64	Ly/d (Convert)	15WB; Hill 1996;Goldsborough & Robinson 1996
Use Adaptive Light			
Max. Saturating Light	300	Ly/d (Convert)	Default
Min. Saturating Light	80	Ly/d (Convert)	Default
P Half-saturation	0.006	mg / L	0.002, cal for WB, Borchardt, 1996 (0.006)
N Half-saturation	0.07	mg / L	0.008; Horne and Goldman, 1994, p. 140 = 0.07
Inorg. C Half-saturation	0.054	mg / L	" (greens)
Temp. Response Slope	2		DeNicola, 1996
Optimum Temperature	15	°C	prof opinion (cold-water), DeNicola, 1996 (20-28)
Maximum Temperature	39	°C	DeNicola, 1996
Min Adaptation Temp.	2	°C	adapted to cold conditions
Max. Photosynthetic Rate	0.77	1 / d	calibrated; Fragilaria = 0.77
Photorespiration Coefficient	0.026	1 / d	same as high-nut
Resp Rate at 20 deg. C	0.08	g / g-d	Smith 1979, cited in C.& W.1983
Mortality Coefficient	0.001	g / g-d	prof. judgment
Exponential Mort. Coeff.	0.01	g / g-d	1%/d if phosynthesis = 0
P : Organics	0.018	ratio	Redfield et al., '63 stoichiometry
N : Organics	0.079	ratio	"
Light Extinction	0.03	1/m-g/m^3	0.14
Wet to Dry	5	ratio	<--- default
Fraction that is lipid	0.2	(wet wt.)	Default when loading simulation.

Phytoplankton Only:

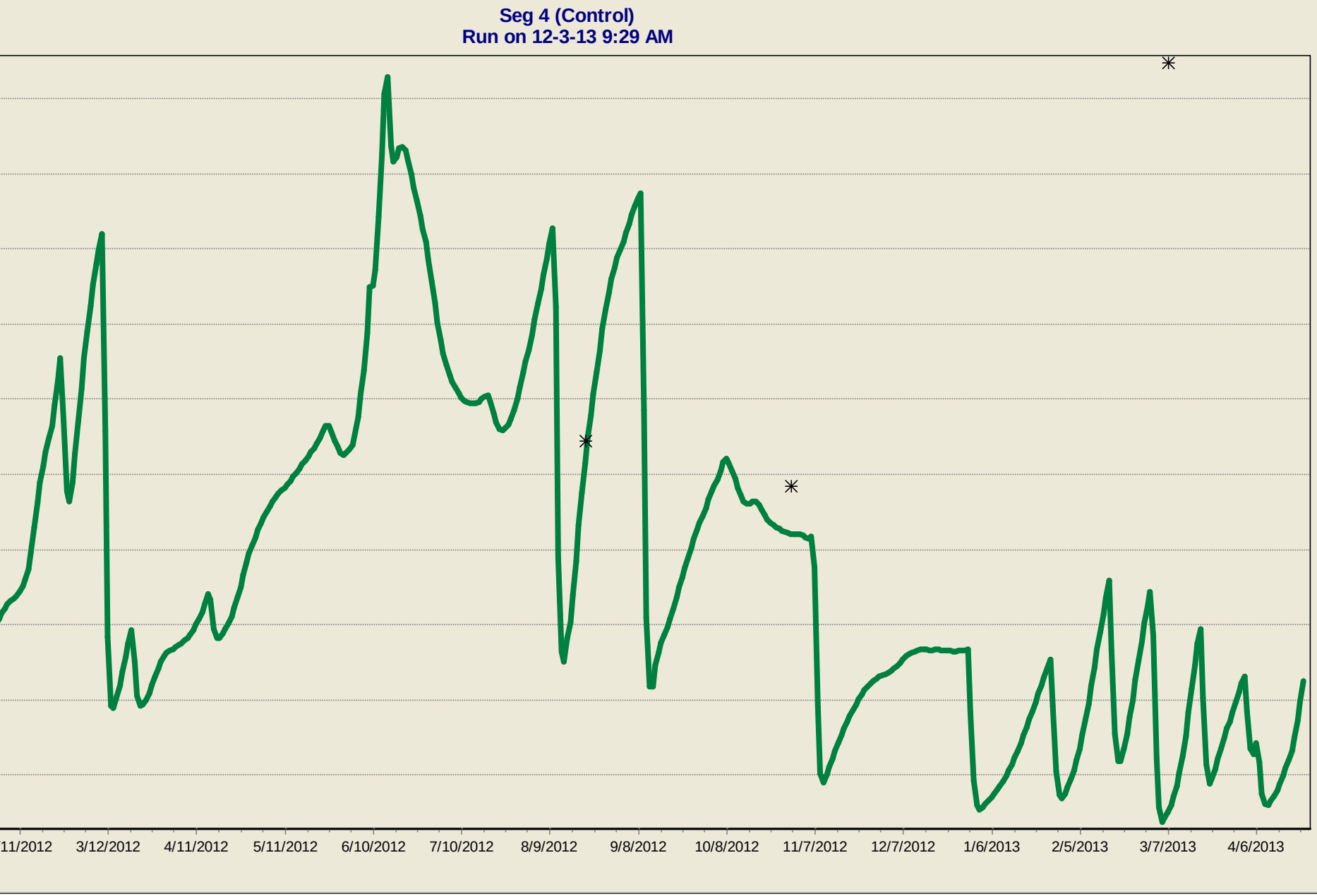
Version Cont... | Inbox - Mail... | AQUATOX R... | AQUATOX H... | Technical-D... | Mass and Lo... | 2013_112

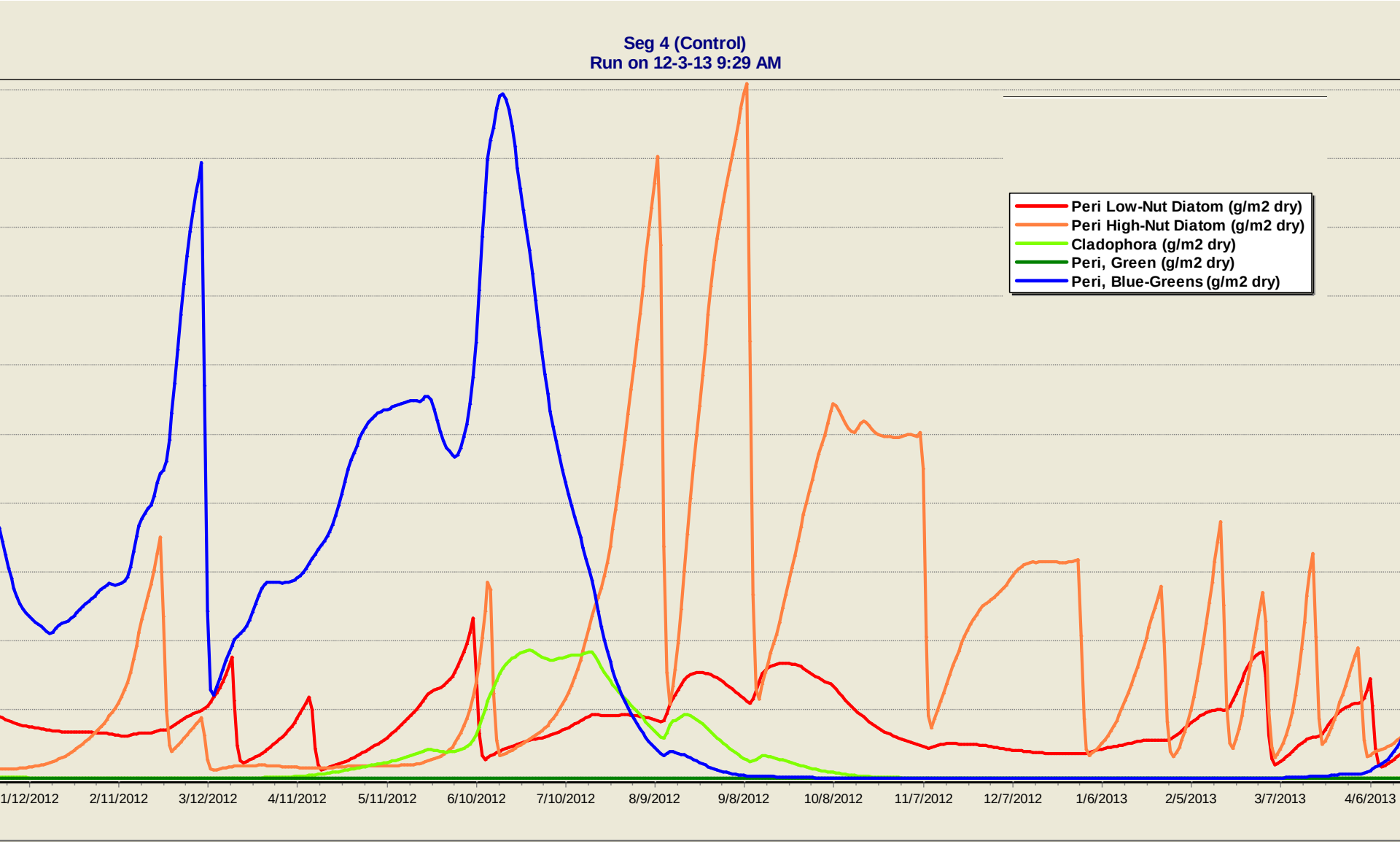

Seg 4 (Control)
Run on 12-3-13 9:29 AM
Peri. Chlorophyll (mg/sq.m)
Peri Chl at 13206000 BR at Glenwood (mg/sq.m)
Phyto. Chlorophyll (ug/L)
Phyto Chla at 13206000 Glenwood (ug/L)
270.0
243.0
216.0
189.0
162.0
135.0
108.0
81.0
54.0
27.0
130
117
104
91
78
65
52
39
26
13
ug/L
1/12/2012
2/11/2012
3/12/2012
4/11/2012
5/11/2012
6/10/2012
7/10/2012
8/9/2012
9/8/2012
10/8/2012
11/7/2012
12/7/2012
1/6/2013
2/5/2013
3/7/2013
4/6/2013

Algal Parameters

Periphyton	Topt	Tmax	Tresp	LightSat	Pmax	Lightex	P half-sat	N half-sat	Fcrit	%sl
Low-nutrient diatoms	15	39	2	64	.77	0.03	.006	.07	.007	90
High-nutrient diatoms	20	35	1.8	22.5	2.3	0.03	.055	.117	.008	90
Greens	25	42	2	110	1.7	0.03	.0093	.1	.007	90
Cladophora	15	25	2	135	1.08	.22	.01	.0586	.008	25
Oscillatoria	10	50	2.1	110	1.2	0.03	.006	.168	.008	90
Phytoplankton										
Low-nutrient diatoms	15	39	2	224	.7	.14	.006	.0154		
High-nutrient diatoms	20	35	1.8	45	1.87	.14	.055	.117		
Greens	26	42	2	220	1.5	.24	.0093	.1		
Blue-greens	27	50	2	60	2.2	.099	.006	.168		

Algal Parameter Values Used in Lower Boise River, Idaho, Simulations												
Periphyton	**Topt**	**Tmax**	**Tresp**	**LightSat**	**Pmax**	**Lightex**	**P half-sat**	**N half-sat**	**C half-sat**	**ExpMoCo**	**Fcrit**	**%sl**
Low-nutrient diatoms	**15**	39	2	64	**0.77**	0.03	0.006	0.07	0.054	0.01	**0.007**	**90**
High-nutrient diatoms	20	35	1.8	22.5	2.3	0.03	0.055	**0.117**	0.054	0.01	**0.008**	**90**
Greens	25	42	2	**110**	1.7	0.03	0.1	0.8	0.054	0.01	**0.007**	**90**
Cladophora	**15**	**25**	2	135	**1.08**	**0.22**	**0.01**	**0.0586**	0.054	0.05	**0.008**	**25**
Oscillatoria	**10**	50	**2.1**	**110**	**1.2**	0.03	**0.006**	**0.168**	0.024	0.01	**0.008**	90
Phytoplankton												
Low-nutrient diatoms	15	39	2	**224**	0.7	0.14	0.006	0.0154	0.054	0.05	NA	NA
High-nutrient diatoms	20	35	**1.8**	**45**	1.87	0.14	0.055	0.117	0.054	0.05	NA	NA
Greens	26	42	2	**220**	1.5	0.24	0.1	0.8	0.054	0.04	NA	NA
Blue-Greens	27	50	2	60	2.2	**0.099**	0.03	0.4	0.024	0.12	NA	NA


Seg 4 (Control)
Run on 12-3-13 9:29 AM
11/2012
3/12/2012
4/11/2012
5/11/2012
6/10/2012
7/10/2012
8/9/2012
9/8/2012
10/8/2012
11/7/2012
12/7/2012
1/6/2013
2/5/2013
3/7/2013
4/6/2013



From historic data:

- blue-greens and high nutrient diatoms should be high in March
- Cladophora and high-nutrient diatoms should be high in September

Algal Parameters

Periphyton	Topt	Tmax	Tresp	LightSat	Pmax	Lightex	P half-sat	N half-sat	Fcrit	%sl
Low-nutrient diatoms	15	39	2	64	.77	0.03	.006	.07	.007	90
High-nutrient diatoms	20	35	1.8	22.5	2.3	0.03	.055	.117	.008	90
Greens	25	42	2	110	1.7	0.03	.0093	.1	.007	90
Cladophora	15	25	2	135	1.08	.22	.01	.0586	.008	25
Oscillatoria	10	50	2.1	110	1.2	0.03	.006	.168	.008	90
Phytoplankton										
Low-nutrient diatoms	15	39	2	224	.7	.14	.006	.0154		
High-nutrient diatoms	20	35	1.8	45	1.87	.14	.055	.117		
Greens	26	42	2	220	1.5	.24	.0093	.1		
Blue-greens	27	50	2	60	2.2	.099	.006	.168		

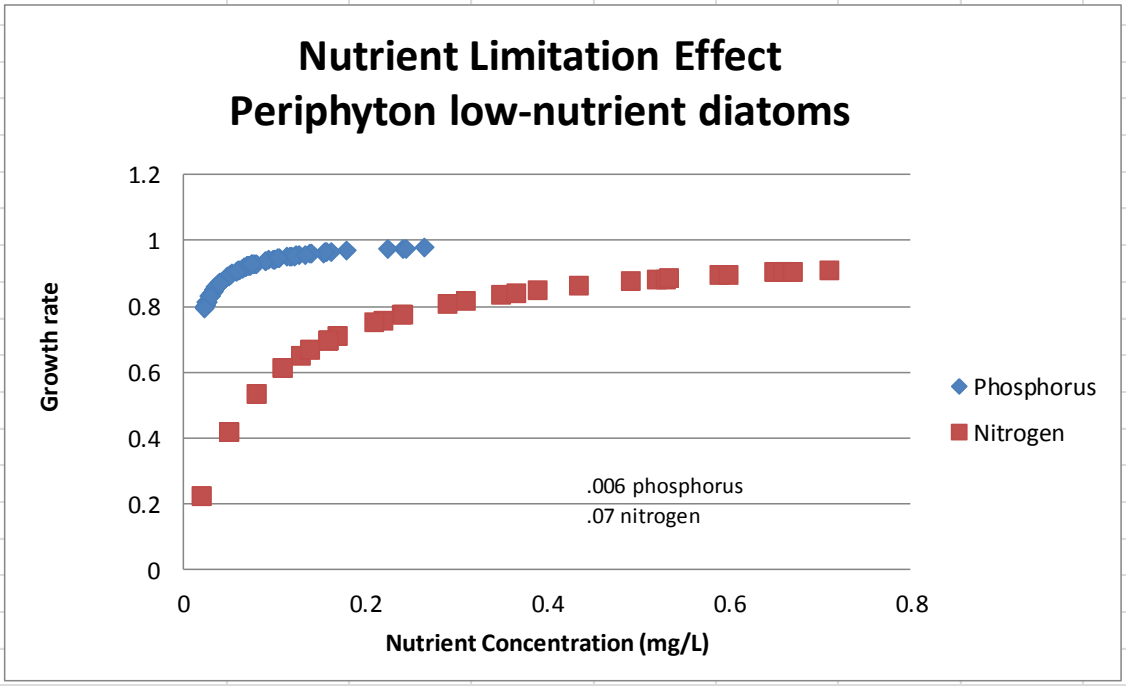
Algal Parameter Values Used in Lower Boise River, Idaho, Simulations												
Periphyton	**Topt**	**Tmax**	**Tresp**	**LightSat**	**Pmax**	**Lightex**	**P half-sat**	**N half-sat**	**C half-sat**	**ExpMoCo**	**Fcrit**	**%sl**
Low-nutrient diatoms	**15**	39	2	64	**0.77**	0.03	0.006	0.07	0.054	0.01	**0.007**	**90**
High-nutrient diatoms	20	35	1.8	22.5	2.3	0.03	0.055	**0.117**	0.054	0.01	**0.008**	**90**
Greens	25	42	2	**110**	1.7	0.03	0.1	0.8	0.054	0.01	**0.007**	**90**
Cladophora	**15**	**25**	2	135	**1.08**	**0.22**	**0.01**	**0.0586**	0.054	0.05	**0.008**	**25**
Oscillatoria	**10**	50	**2.1**	**110**	**1.2**	0.03	**0.006**	**0.168**	0.024	0.01	**0.008**	90
Phytoplankton												
Low-nutrient diatoms	15	39	2	**224**	0.7	0.14	0.006	0.0154	0.054	0.05	NA	NA
High-nutrient diatoms	20	35	**1.8**	**45**	1.87	0.14	0.055	0.117	0.054	0.05	NA	NA
Greens	26	42	2	**220**	1.5	0.24	0.1	0.8	0.054	0.04	NA	NA
Blue-Greens	27	50	2	60	2.2	**0.099**	0.03	0.4	0.024	0.12	NA	NA

Green periphyton Phosphorus

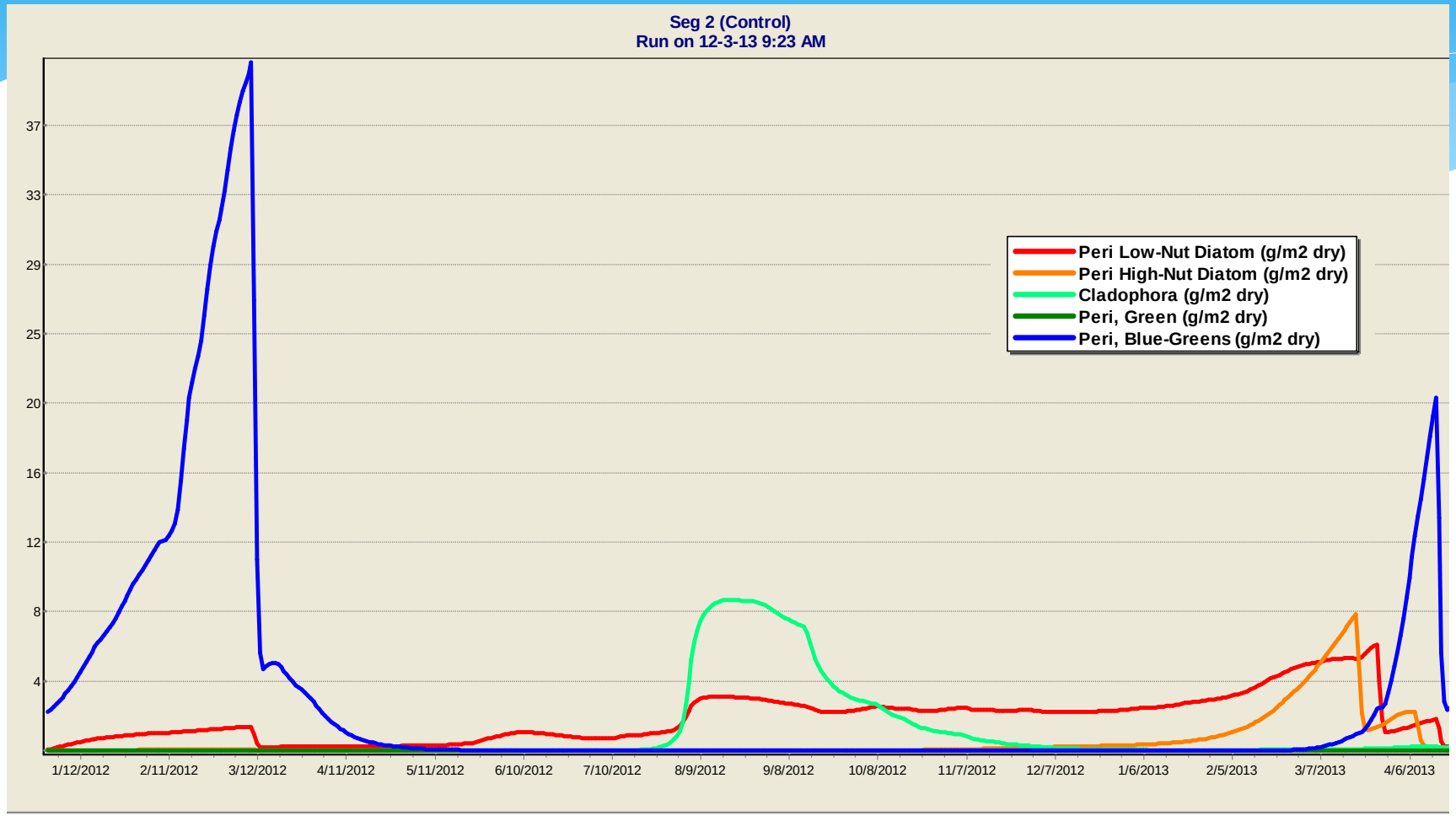
* 0.0093 mg/L P half-sat was referenced in the model documentation (Borchardt, 1996 = 0.0093)
* Clifton Bell mentioned that we had 0.1 mg/L P half-sat in the model and that 0.01 was generally the default value for green algae.
* Growth curve was not optimized at 0.1 mg/L and it was optimized at 0.01 mg/L

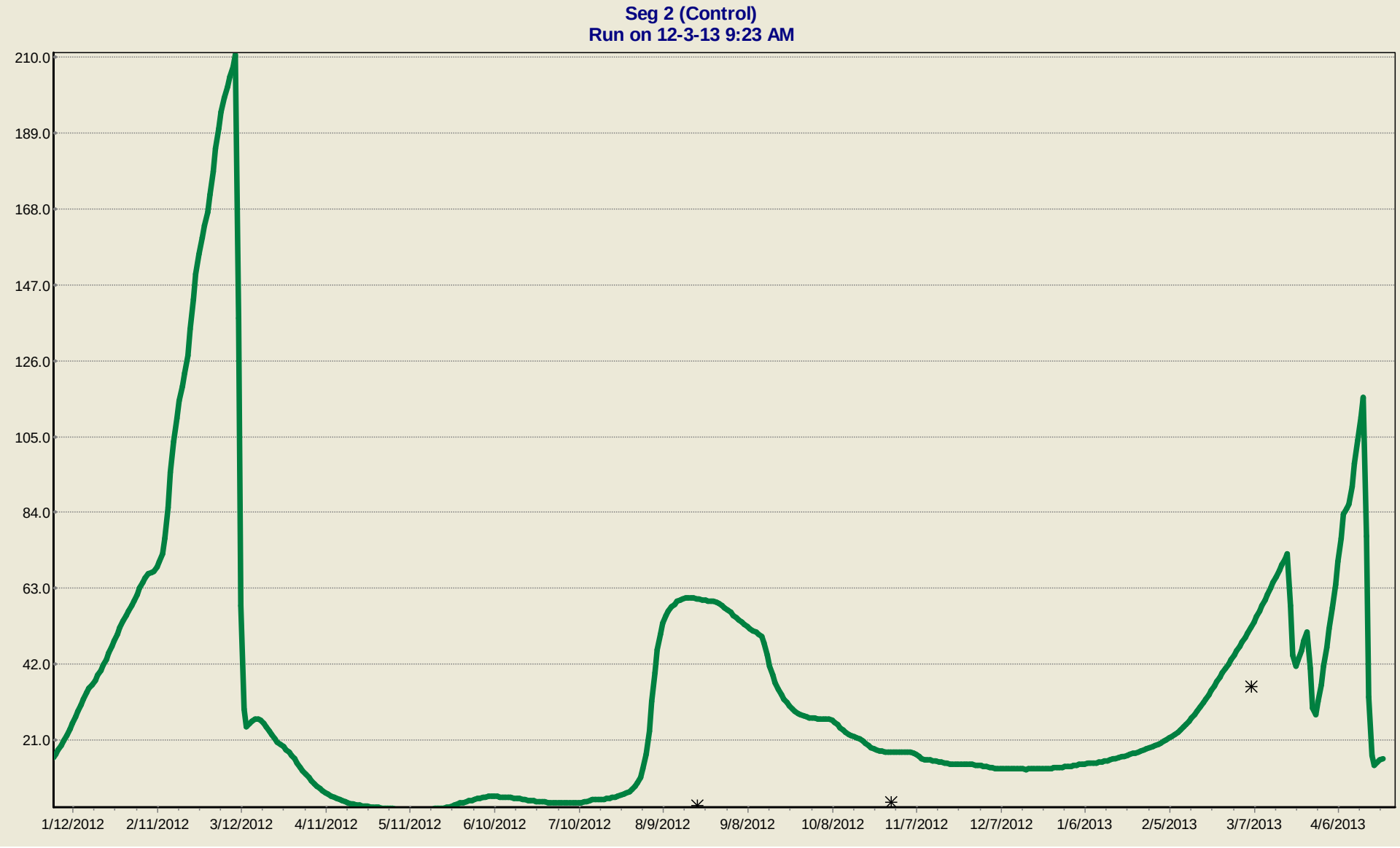
Segment 4 Nutrient Limitation Effect Periphyton low-nutrient diatoms

	Segment 4			G(N) = N/(Kmn + N)
	Nutrient limitation effect			N = nutrient concentration
	Periphyton low-nutrient diatoms			Kmn = half-saturation constant
	Phosphorus	**Nitrogen**		G(N) = growth rate
Half-sat	**0.006**	**0.07**		
	Phosphorus		**Nitrogen**	
1/3/2012	0.2426	0.975865	0.52	0.881356
1/3/2012	0.245	0.976096	0.59	0.893939
1/10/2012	0.2254	0.974071	0.65	0.902778
1/17/2012	0.265	0.97786	0.65	0.902778
1/24/2012	0.179	0.967568	0.66	0.90411
1/31/2012	0.14	0.958904	0.6	0.895522
2/7/2012	0.158	0.963415	0.31	0.815789
2/7/2012	0.154	0.9625	0.39	0.847826
2/14/2012	0.124	0.953846	0.22	0.758621
2/21/2012	0.1199	0.952343	0.17	0.708333
2/28/2012	0.0784	0.92891	0.16	0.695652
3/6/2012	0.0696	0.920635	0.08	0.533333
3/6/2012	0.0726	0.923664	0.05	0.416667
3/13/2012	0.0519	0.896373	0.05	0.416667
3/20/2012	0.0311	0.838275	0.11	0.611111
3/27/2012	0.0291	0.82906	0.35	0.833333
4/3/2012	0.0333	0.847328	0.05	0.416667



- At Eckert:
  In March, Green algae, high-nutrient diatoms, and low-nutrient diatoms should be common
  In September, Cladophora, green algae, and high-nutrient diatoms should be abundant

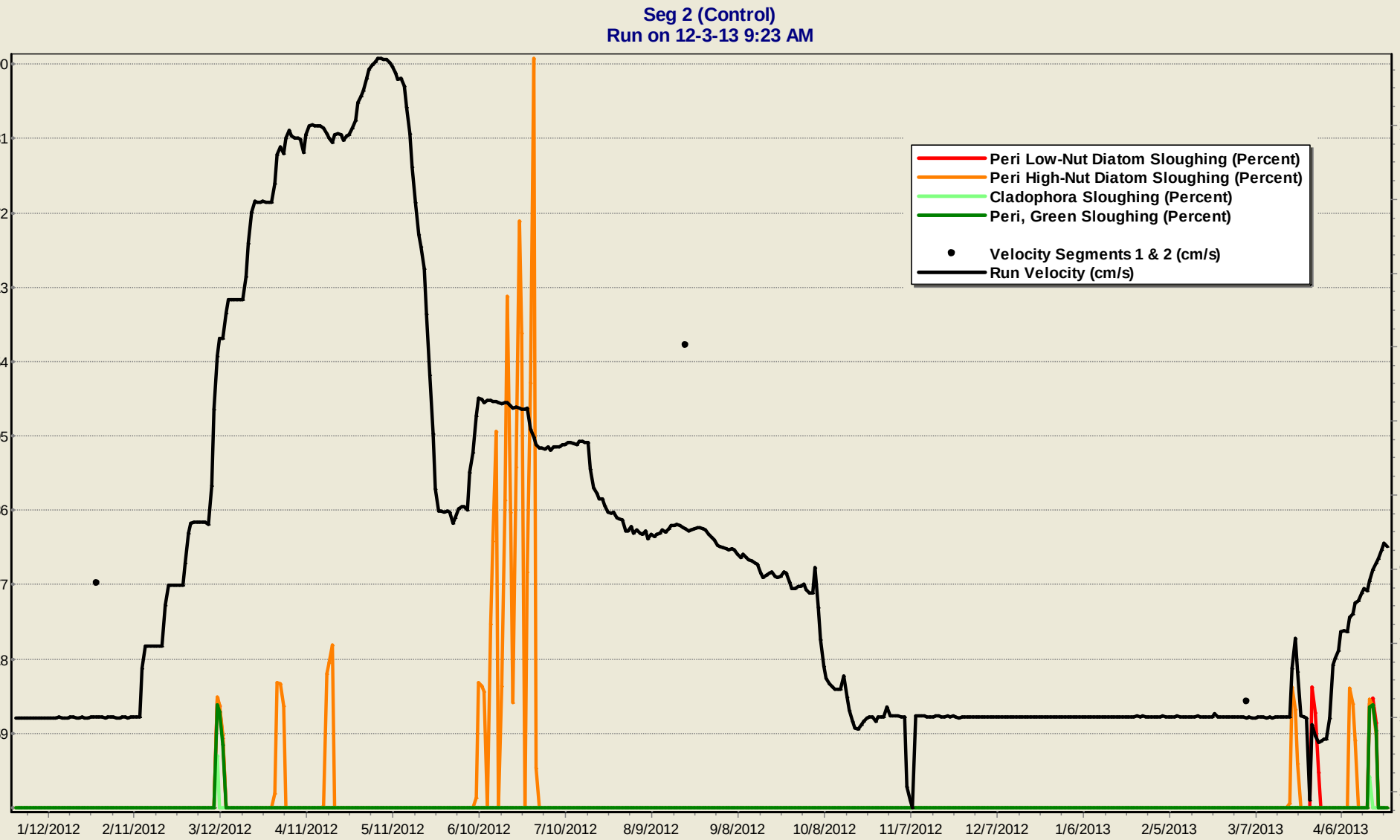



Seg 2 (Control)
Run on 12-3-13 9:23 AM
210.0
189.0
168.0
147.0
126.0
105.0
84.0
63.0
42.0
21.0
1/12/2012
2/11/2012
3/12/2012
4/11/2012
5/11/2012
6/10/2012
7/10/2012
8/9/2012
9/8/2012
10/8/2012
11/7/2012
12/7/2012
1/6/2013
2/5/2013
3/7/2013
4/6/2013

Ecosystem Bioenergetics

* Question: sloughing—is it primarily related to velocity, temperature, light, photosynthesis, extinction?

* Answer: factors related to the growth rate are primary drivers of sloughing.


Seg 2 (Control)
Run on 12-3-13 9:23 AM
Peri Low-Nut Diatom Sloughing (Percent)
Peri High-Nut Diatom Sloughing (Percent)
Cladophora Sloughing (Percent)
Peri, Green Sloughing (Percent)
Velocity Segments 1 & 2 (cm/s)
Run Velocity (cm/s)
209.
190.
171.
152.
133.
114.
95.0
76.0
57.0
38.0
1/12/2012
2/11/2012
3/12/2012
4/11/2012
5/11/2012
6/10/2012
7/10/2012
8/9/2012
9/8/2012
10/8/2012
11/7/2012
12/7/2012
1/6/2013
2/5/2013
3/7/2013
4/6/2013

Current Limitation

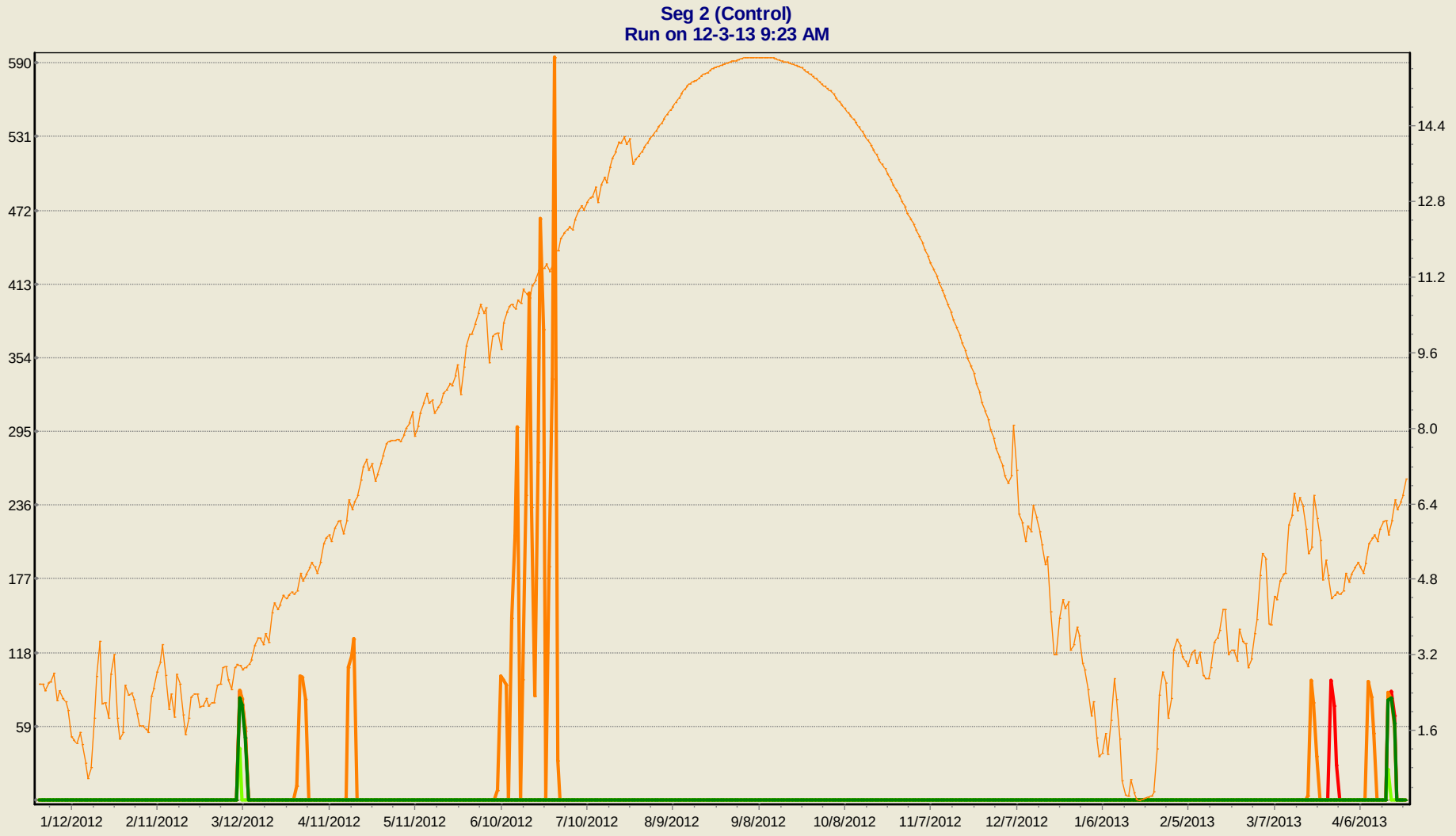
Because they are fixed in space, periphyton also are limited by slow currents that do not replenish nutrients and carry away senescent biomass. Based on the work of McIntire (1973) and Colby and McIntire (1978), a factor relating photosynthesis to current velocity is used for periphyton:

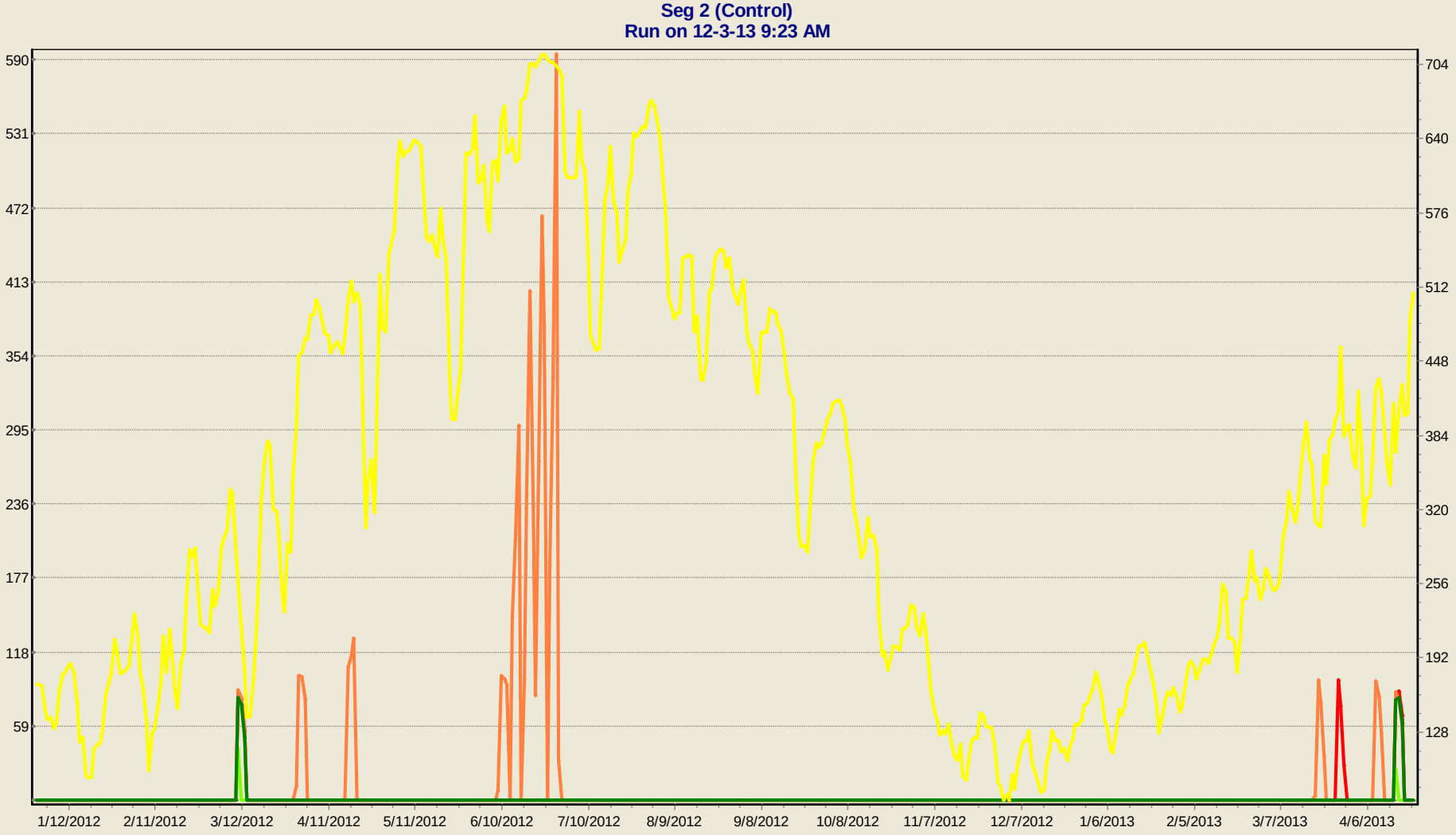
$$VLimit = \min\left(1, RedStillWater + \frac{VelCoeff \cdot Velocity}{1 + VelCoeff \cdot Velocity}\right) \quad \textbf{(56)}$$

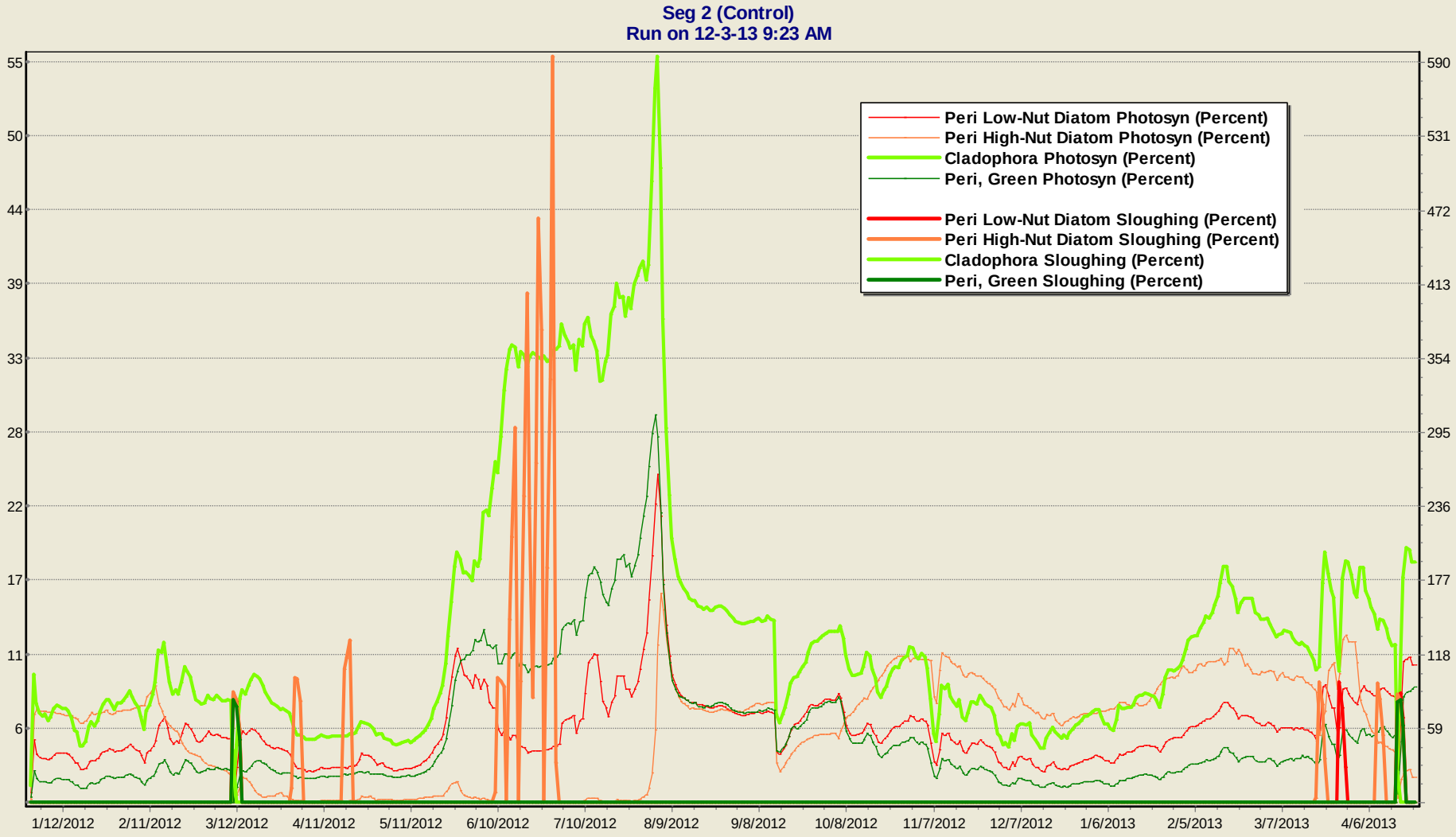
where:

VLimit	=	limitation or enhancement due to current velocity (unitless);
RedStillWater	=	user-entered reduction in photosynthesis in absence of current (unitless);
VelCoeff	=	empirical proportionality coefficient for velocity (0.057, unitless); and
Velocity	=	flow rate (converted to m/s), see **(14)**.

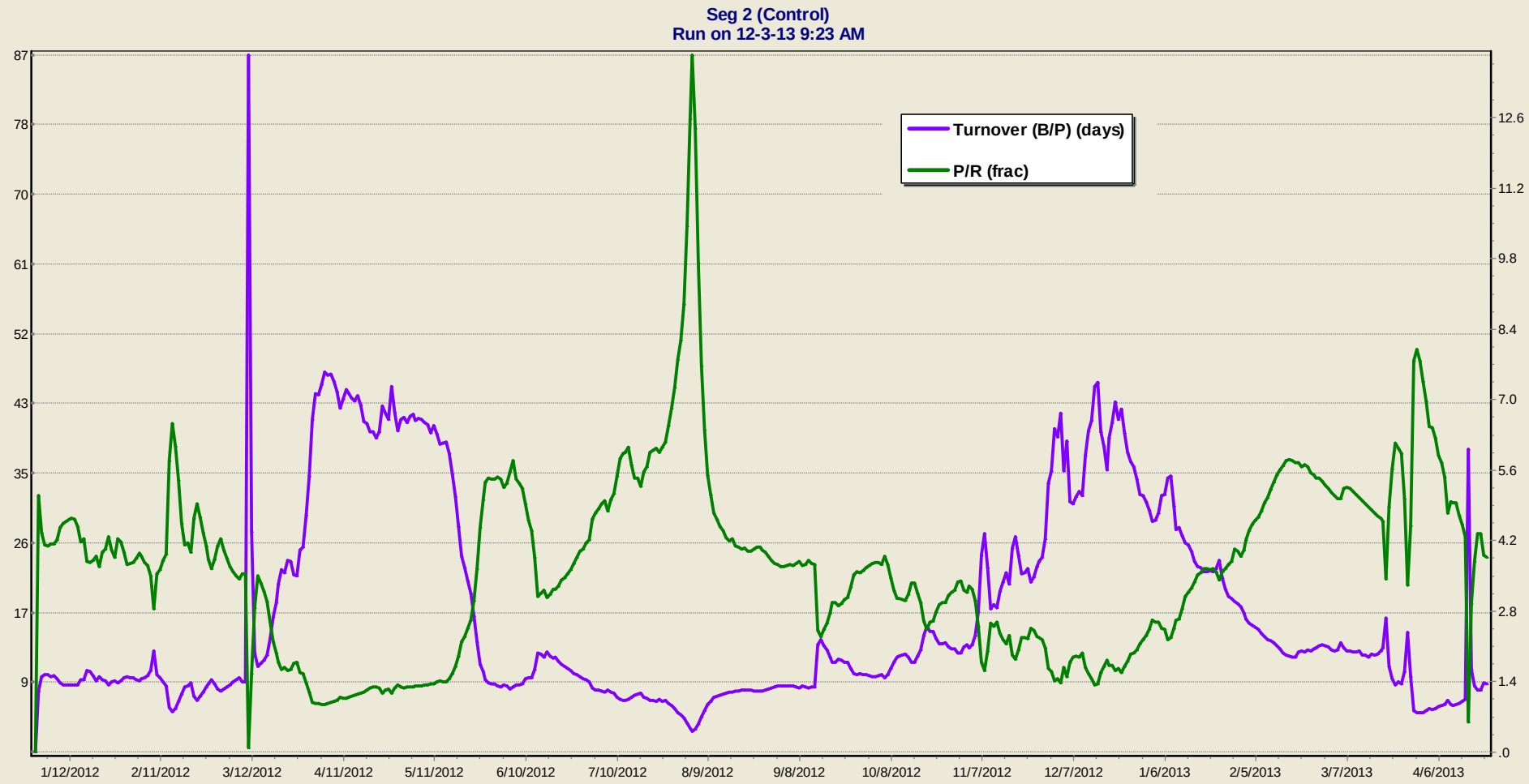
VLimit has a minimum value for photosynthesis in the absence of currents and increases asymptotically to a maximum value for optimal current velocity (Figure 58). In high currents scour can limit periphyton; see **(75)**. The value of *RedStillWater* depends on the circumstances


Seg 2 (Control)
Run on 12-3-13 9:23 AM
590
531
472
413
354
295
236
177
118
59
14.4
12.8
11.2
9.6
8.0
6.4
4.8
3.2
1.6
1/12/2012
2/11/2012
3/12/2012
4/11/2012
5/11/2012
6/10/2012
7/10/2012
8/9/2012
9/8/2012
10/8/2012
11/7/2012
12/7/2012
1/6/2013
2/5/2013
3/7/2013
4/6/2013

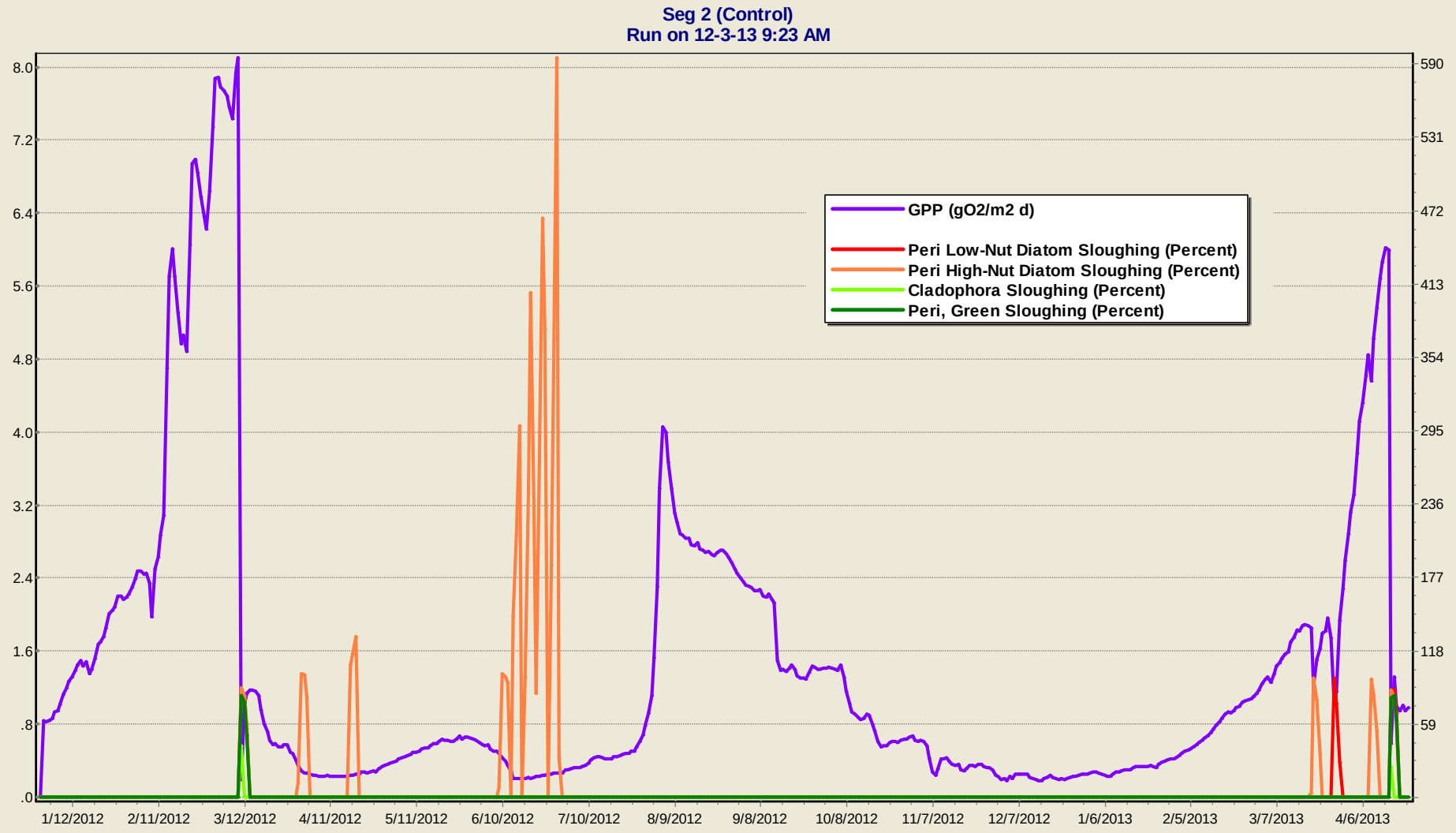

Seg 2 (Control)
Run on 12-3-13 9:23 AM
590
531
472
413
354
295
236
177
118
59
704
640
576
512
448
384
320
256
192
128
1/12/2012
2/11/2012
3/12/2012
4/11/2012
5/11/2012
6/10/2012
7/10/2012
8/9/2012
9/8/2012
10/8/2012
11/7/2012
12/7/2012
1/6/2013
2/5/2013
3/7/2013
4/6/2013


Seg 2 (Control)
Run on 12-3-13 9:23 AM
Peri Low-Nut Diatom Photosyn (Percent)
Peri High-Nut Diatom Photosyn (Percent)
Cladophora Photosyn (Percent)
Peri, Green Photosyn (Percent)
Peri Low-Nut Diatom Sloughing (Percent)
Peri High-Nut Diatom Sloughing (Percent)
Cladophora Sloughing (Percent)
Peri, Green Sloughing (Percent)
55
50
44
39
33
28
22
17
11
6
590
531
472
413
354
295
236
177
118
59
1/12/2012
2/11/2012
3/12/2012
4/11/2012
5/11/2012
6/10/2012
7/10/2012
8/9/2012
9/8/2012
10/8/2012
11/7/2012
12/7/2012
1/6/2013
2/5/2013
3/7/2013
4/6/2013

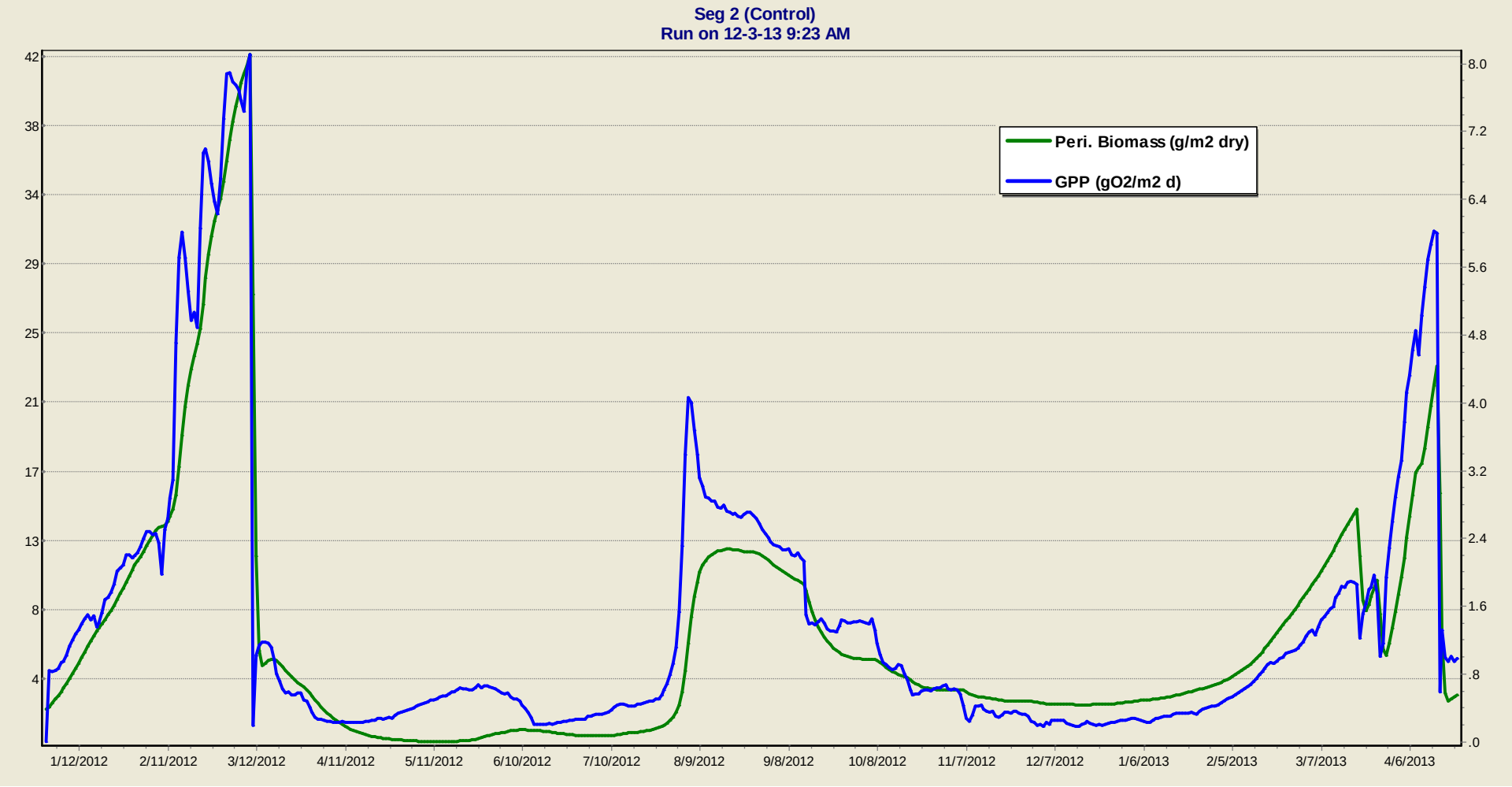
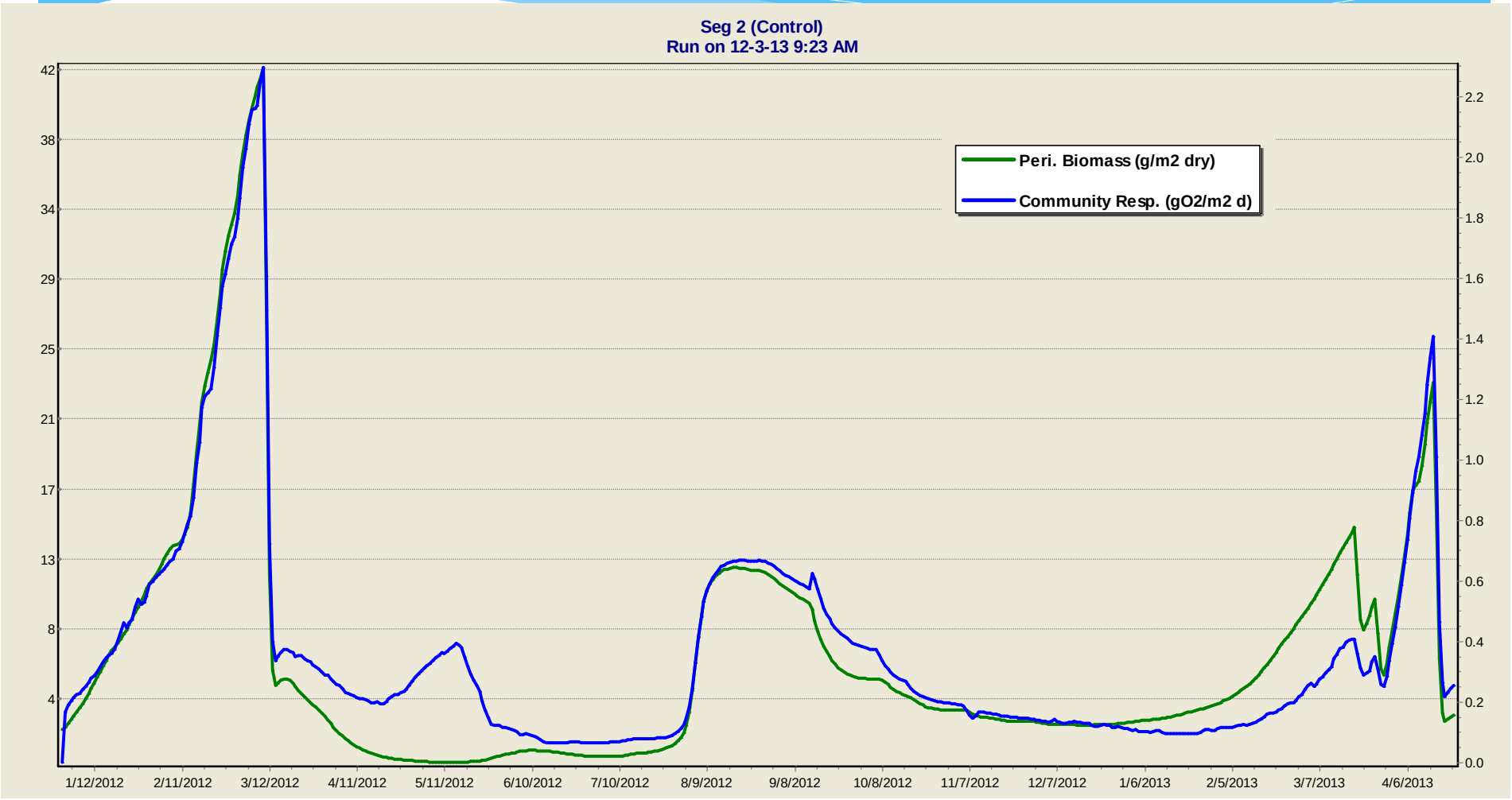
- Ecosystem bioenergetic—whole ecosystem metrics:
  - **Gross primary productivity, GPP** (g O_2/m^2 d) (Odum 1971), more meaningful if expressed as an annual measure (g O_2/m^2 yr) (Wetzel 2001)
  - **Community respiration, R** (g O_2/m^2 d) (Odum 1971), more meaningful if expressed as an annual measure (g O_2/m^2 yr) (Wetzel 2001)
  - **P/R** (ratio of GPP to community respiration) (Odum 1971)
  - **Turnover time** (P/B, ratio of GPP to biomass in days) (Odum 1971)



Gross Primary Production and Sloughing



Gross Primary Production and Biomass



Community Respiration and Biomass