Lake Tahoe Water Quality Investigations

Algal Bioassay • Phytoplankton • Atmospheric Nutrient Deposition • Periphyton

Annual Report

July 1, 2008 – June 30, 2009

Agreement No. 07-024-160-0

Submitted to:

State Water Resources Control Board
Lahontan Regional Water Quality Control Board

Submitted by:

Tahoe Environmental Research Center
University of California, Davis

Scott H. Hackley
Brant C. Allen
Debbie A. Hunter
John E. Reuter, Principal Investigator

Dec. 2, 2009

Table of Contents

Project Overview

The following document is our annual report for work completed during the second year (July 1, 2008 to June 30, 2009) of Agreement No. 07-024-160-0: Lake Tahoe Water Quality Investigations by the U.C. Davis – Tahoe Environmental Research Center (TERC).

Under terms of this contract TERC is to provide the SWRCB with water quality research and monitoring at Lake Tahoe to assess the progressive deterioration of the lake. This research and data will support the Lake Tahoe Interagency Monitoring Program (LTIMP). The State Water Board will be provided with scientific data needed to develop planning, management and enforcement strategies which will prevent future degradation of the lake's famous clarity and protect the surrounding watershed and streams.

The objective of this project is to continue monitoring critical ongoing long-term water quality parameters in Lake Tahoe. The primary research and monitoring tasks addressed in this project include:

<u>Algal growth bioassay tests to assess nutrient limitation (Task 3)</u>. The purpose of this task is to determine the nutrient or nutrients which limit phytoplankton growth. These findings have been very important in current efforts toward lake restoration. They have highlighted the need for an expanded erosion control strategy. Bioassays are to be done four times per year using Lake Tahoe water containing natural phytoplankton, collected at the TERC's Index station along the west shore. The bioassay method to be used is described in detail in Hackley et al. (2007).

<u>Enumeration and identification of phytoplankton and zooplankton species (Task 4)</u>. The purpose of this task is to provide ongoing information on phytoplankton and zooplankton species present in the water column. This task is particularly critical since changes in the biodiversity of the phytoplankton are both indicators of pollution and affect food-chain structure. Implementation of this task allows TERC to determine if new and undesirable species are colonizing the lake. In addition, the size and composition of particles, including phytoplankton cells in the water, have a significant effect on light transmittance, and hence affect the famed clarity of Lake Tahoe. Characterization of phytoplankton dynamics in Lake Tahoe fills a critical knowledge gap, allowing for more informed management decisions. Zooplankton are significant in the food chain structure of the lake. The zooplankton community is composed of both herbivorous species (which feed on phytoplankton) and predatory species (which feed on other zooplankton.)

Samples of both phytoplankton and zooplankton will be collected monthly from the Index and Mid-lake stations. At the Index station monthly phytoplankton samples will include: a 0-105m composite and discreet samples from depths of 5, 20, 40, 60, 75, 90m. At the Mid-lake station monthly phytoplankton samples will include: a 0-100m composite sample and a 150-450m composite. Monthly samples of zooplankton will include: a 150m to surface tow at both the Index and Mid-lake stations. Phytoplankton analysis is to include species present, cell numbers and biovolume measurements. Zooplankton analysis will include species present and numbers.

Atmospheric deposition of nitrogen and phosphorus (Task 5). The purpose of this task is to provide ongoing information on nutrient loading to the lake via atmospheric deposition. The historical TERC data shows that atmospheric deposition of nitrogen, and to a lesser extent phosphorus, is an important source of nutrients to the lake. Atmospheric deposition also contributes fine particles directly to the lake surface. Atmospheric deposition data from TERC monitoring was utilized in the Tahoe TMDL to help determine estimates of wet deposition loads and to provide additional information on dry loading of nutrients to the lake. Data collected from collectors located on buoys on the lake has proved valuable in providing estimates of N and P loading directly to the lake. Continued collection of atmospheric deposition data is important for updating and applying the Tahoe lake clarity model. In addition more information is needed on particle deposition to the lake. In Task 5, Atmospheric deposition monitoring will be continued at TERC's Lower Ward Valley station and on buoys on the lake. Approximately 35 dry bucket samples and 30 wet samples are to be collected over the year at Ward Lake level, 30 dry-bulk samples and approximately 15 snow tube samples are to be collected at the mid-lake station, and approximately 30 dry-bulk samples are to be collected at an additional lake buoy station i.e. TB-4. Samples are to be analyzed for NO_3-N, NH_4-N, TKN, DP and TP. In addition, a pilot program for determining the feasibility of collecting atmospheric deposition particles in collectors on the lake will be initiated. A literature search investigating feasibility of using simple buckets as collectors will be done by TERC. If determined to be feasible by the State Water Board's Contract Manager, initial tests of the method will be done at the TERC lab.

Monitoring of attached algae or periphyton along the shoreline (Task 6). The purpose of this monitoring is to assess levels of nearshore attached algae (periphyton) growth around the lake. The rate of periphyton growth is an indicator of local nutrient loading and long-term environmental changes. Monitoring trends in periphyton growth is important in assessing local and lake-wide nutrient loading trends. The near shore periphyton can significantly impact the aesthetic, beneficial use of the shore zone in areas where thick growth develops. Seven sites are to be monitored for periphyton biomass a minimum of five times per year in this project. Three of the samplings are to be done between January and June when attached algae growth in the eulittoral zone (0.5m) is greatest; the remaining two samplings are to be done between July – December. Duplicate biomass samples will be taken from natural substrate at each site for a total of 70 samples per year. Biomass is to be reported as chlorophyll *a* and Ash Free Dry Weight (AFDW). Twice a year, 39 additional sites will be visited and an above water visual assessment of the level of growth visible near shore (ranking 1-5) will be done.

The additional tasks associated with this project include: Project management (Task 1), quality assurance (Task 2), and reporting of data. Angora Burn Area Monitoring (Task 7) was added following the devastating Angora fire in summer 2007. The results of that monitoring are to be reported on in separate reports. The summary of % work completed based on a three-year granting period is shown in Table 1.

Table 1. The summary of % work completed (based on a 3 year granting period) for the period July 1, 2007 – July 1, 2009) for each task is listed below:

Task	% Completion (for full 3 yr granting period)
1 – Project Management	67%
2 – Quality Assurance	67%
3 – Algal Growth Bioassays	67%
4 – Phytoplankton and Zooplankton Analysis	67%
5 – Atmospheric Deposition of Nutrients	67%
6 – Periphyton	67%
7 – Angora Burn Area Monitoring (Separate Reports)	75%
8 - Reporting	67%

Task 1. Project Management and Administration

1.1. Project oversight – Entailed sampling coordination, overall project coordination, discussions with staff, assist in data evaluation, interfacing with agency staff, and incorporation of data into other Basin research/monitoring projects.

1.2. Quarterly invoicing – Entails ensuring that contract requirements were met through completion of this quarterly status report and the report was submitted to the SWRCB Project Representative on schedule. Ensure that invoicing is properly carried out.

Task 2. Project Quality Assurance

Standardized QA/QC practices for components were followed as specified in the TRG QA/QC Manual (Janik et al., 1990). For QA/QC applied to periphyton monitoring see “Periphyton Quality Assurance Project Plan” in Hackley et al. (2004). QA/QC procedures for algal bioassays are described in Appendix 7 of Hackley et al. (2007).

A primary objective for the atmospheric deposition quality control samples was to check for potential contamination associated with field monitoring and equipment. Table 2 presents the results for analyses of atmospheric deposition field quality control samples collected July 2007 to June 2009. Nutrient levels in field and container blank samples were compared with the source blank samples to check for levels of contamination. Levels of N and P were low in the majority of deionized water “DIW Blk” source blanks collected. One carboy blank had elevated TP (27 μg/l), however, the TP in equipment blank using this same water was 3.19 μg/l, so the high blank may resulted from bottle contamination or another source. Levels of contamination overall were very low in container and field blanks. For field blanks, the WLL Wet field blank collected 3/6/08, had unusually high NH_4-N (84 μg/l; rerun = 70 μg/l). The high NH_4-N occurred in the filtered water bottle for this sample, NH4-N in the unfiltered sample was less (TKN was measured in the unfiltered sample bottle and found to 48 μg/l, since TKN = Organic N + NH_4-N, the unfiltered sample NH_4-N had to be $\leq$ 48 μg/l). All other N and P levels were low in this sample. The high NH_4-N in the filtered sample, may have resulted from contamination during filtration, contamination associated with the bottle or another source. TP in one Snow Tube container blank was slightly elevated (12 μg/l). Critical attention will continue to be applied toward sample preparation and sample collection. QA/QC will be run quarterly.

Table 2. Quality Control samples collected for the atmospheric deposition monitoring July 1, 2007 to June 30, 2009.

QC Sample	Date	Type	Vol. liters	NO_3-N (µg/l)	NH_4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
DIW Blk	7/25/2007 19:35	Source Blk	-	4.28	0	10.12	NA	NA	3.19	1
DIW Blk	9/21/2007 11:00	Source Blk	-	2.22	0	8.11	4.75	6.70	3.83	1
DIW Blk	9/27/2007 11:40	Source Blk	-	1.13	NA	11.90	1.38	4.32	7.41	1
DIW Blk	12/28/07 12:50	Source Blk		0.67	3.72	1.36	NA	3.39	3.36	1
DIW Blk	3/5/08 12:35	Source Blk		0.70	4.09	21.54	2.37	3.09	3.09	1
DIW Blk	1/13/09 16:30	Source Blk	-	0.93	2.63	10.91	0.45	0.31	1.24	1
Carboy Blk	7/25/2007 20:15	Container Blk	-	2.74	0	11.88	NA	NA	27.43	2
Carboy Blk	3/5/08 14:25	Container Blk		1.39	5.55	29.15	1.80	4.17	3.40	
Grad. Cyl.	7/26/2007 10:18	Equip. Blk	-	1.88	0	33.45	NA	NA	3.19	3
Ward Wet										
FBWLLW	9/28/2007 10:10	Field Blk	0.5	1.61	7.48	0.96	1.62	5.86	4.62	6
FBWLLW	3/6/08 17:20	Field Blk	0.5	3.40	84/70*	47.67	2.71	5.82	3.09	6,9
FBWLLW	1/16/09 15:00	Field Blk	0.5	1.75	4.59	13.19	0.45	1.86	1.86	8
Ward Dry										
FBWLLD	9/21/2007 10:15	Container Blk	4.000	4.28	1.26	42.83	3.62	6.06	4.78	4
FBWLLD	12/28/07 12:05	Container Blk	3.990	1.01	3.72	4.24	0.69	4.64	3.66	4
FBWLLD	3/26/08 14:15	Container Blk	3.977	1.06	4.45	35.95	0.68	4.59	5.51	4
FBWLLD	1/14/09 17:25	Container Blk	4.000	1.49	3.45	2.16	0.45	0.93	1.24	4
TB-1 Dry										
FBTB1D	12/28/07 11:40	Container Blk	3.997	NA	NA	NA	NA	NA	NA	7
FBTB1D	3/26/08 14:35	Container Blk	4.000	0.89	5.77	49.94	0.09	4.59	4.90	7
FBTB1D	1/14/09 16:35	Container Blk	4.000	1.49	2.43	20.04	0.45	0.93	0.93	7
TB-1 ST										
FBTB1ST	9/21/2007 10:40	Container Blk	0.5	2.74	6.30	11.04	4.08	5.10	5.42	5
FBTB1ST	12/28/07 11:50	Container Blk	0.500	1.18	6.74	NA	0.58	4.97	12.43	5
FBTB1ST	3/26/08 15:05	Container Blk	0.500	0.89	4.67	23.56	0.45	3.06	3.67	5
FBTB1ST	1/14/09 17:05	Container Blk	0.5	1.49	3.04	15.09	0.45	0.93	0.93	5

Notes:

1- Deionized water system source blank.
2- Deionized water system water from storage carboy in lab.
3- Equipment check, deionized water ran through graduated cylinder on boat.
4- Ward Lake Level Dry Field Blank, 4 liters deionized water to sealed Dry bucket for at least 24 hours.
5- TB-1 Snow Tube (ST) Field Blank, 0.5 liters deionized water to sealed ST for at least 24 hours.
6- Ward Lake Level Wet Field Blank, 0.5 liters deionized water to Wet bucket in Aerochem Metrics sampler, overnight during dry period.
7- TB-1 Dry-Bulk Field Blank, 4 liters deionized water to sealed Dry-Bulk bucket for approx. 24 hours.
8- Ward Lake Level Wet Field Blank, 0.5 liters deionized water to Wet bucket in Aerochem Metrics sampler, overnight during dry period, note small green thread in sample noted when collected
9- FBWLLW 3/6/08 value of 84µg/l was re-run and again was very high. Note TKN in unfiltered water was much lower (48 µg/l), TKN=Organic N + NH_4-N, therefore NH_4-N had to be ≤ 48. Contamination may have come from bottle, filtration or another source. Note, only new HDPE bottles are used and these are precleaned with 0.1N HCl, and deionized water.

Task 3. Algal Growth Bioassays

The response of Lake Tahoe water to nitrogen and phosphorus enrichment has been tested using algal bioassays since the 1960s. The long record of bioassays for Lake Tahoe, using a consistent method, has proved extremely useful for evaluating long-term changes. When combined with lake chemistry data, and information on atmospheric and watershed nutrient loading ratios, these simple enrichment bioassays have provided valuable complementary evidence on the temporal dynamics of nutrient limitation in the lake.

In a typical bioassay, lake water is collected from the upper photic zone (0-20 m water was used for these bioassays), pre-filtered through 80 µm mesh netting to remove the larger zooplankton and returned to the lab. The water is distributed among experimental flasks to which small amounts of N (20 µg N/liter) or P (at two different levels: 2 µg P/liter and 10 µg P/liter) or the combination of both N and P are added. One set of flasks is left as a "control" and all treatments are triplicated. The flasks are then placed in a laboratory incubator under fluorescent lighting at ambient lake temperature and day length, and growth response of phytoplankton is measured over a period of six days. Relative growth was assessed by measuring changes in algal biomass (i.e. fluorescence or chlorophyll *a*). Treatments are "stimulatory" if the mean growth response exceeds the control at the $p \leq 0.05$ level of significance.

<u>Summary of Results 2008-2009</u>

In this annual data summary we present the results for four routine bioassay experiments done using lake water collected on the following dates: 7/24/08, 10/27/08, 1/30/09 and 5/1/09. The results for each bioassay are presented in Table 3. The results for all bioassays done during the period 2002-2009 are summarized in Table 4.

Some seasonal differences in bioassay response were seen. In the bioassay done in July, phytoplankton growth was stimulated by nitrogen added alone (N) and the combination of nitrogen plus phosphorus (N+P) caused the greatest amount of growth. The phosphorus alone treatments were not significantly stimulatory. In the late October 2009 bioassay, neither N nor P alone was stimulatory, but the combination of N+P was stimulatory and the phytoplankton community appeared co-limited by N and P. In the bioassays done in late January and early May 2009, phytoplankton growth was stimulated by phosphorus added alone and the combination of N+P in treatments caused slightly greater growth than P alone.

Looking at the frequency of N, P or N+P colimitation for bioassays done 2002- early May 2009 the following observations can be made. During the late winter and early spring period (Jan. – early May), P added alone has been stimulatory in 17 of 18 (or 94%) of the bioassays. During late spring and summer period (late May – Sept.), N + P colimitation (where addition of both N and P is required to stimulate growth) has been the most prevalent (occurring in 8 of 14 = 57% of bioassays). N limitation, (which occurred in summer 2008) has occurred in little over a third (5 of 14 = 36%) of the late spring and summer bioassays. P limitation has been much less frequent during this period (occurring in 1 of 14 = 7% of bioassays). During the fall and early winter period (Oct. – Dec.), P limitation has been most prevalent, occurring in 5 of 11 (or 45%) of bioassays. N+P colimitation, (such as seen in the October 2008 bioassay), occurred in 4 of 11 (or 36%) of bioassays. N limitation occurred in 2 of 11 (or 18%) of the bioassays.

The phytoplankton continue to remain sensitive to the combination of N and P throughout the year. The combination of N+P added together was nearly always stimulatory (42 of 43 or 98% of the bioassays). The consistent growth response to the combination of N+P continues to support the fact that Tahoe phytoplankton are still N and P co-deficient and that nutrient reduction is important for the management of excessive algal growth.

Finally, there were several interesting factors which occurred in summer of 2008 which should be remembered when reviewing the bioassay results. First, there was a high biomass of phytoplankton present for an extended period in summer 2008. During May to August 2008 phytoplankton total bio-volume and abundance peaked and remained extremely high (see Task 4 section on phytoplankton enumeration). The sharp increase in phytoplankton abundance began in early May and was sustained into August (see phytoplankton section). Second, there was a prolonged period of forest-fire-associated smoke in the basin from late June to about mid-July. This may have impacted solar radiation input in the upper water column and nutrient deposition. Third, during the smoky period an unusual ash fall event occurred (on July 9) in the northwest portion of the basin which appeared to contribute P deposition in the region where it occurred (Hackley et al., 2008). These factors may have had a role in the nutrient limitation seen during the summer 2008.

Table 3a. Bioassay done using 2,5,8,11,14,17,20m lake water collected 7/24/08.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response =“*”
Control	0.242	0.005	3	100	
N(20)	0.651	0.006	3	269	*
P(2)	0.263	0.009	3	109	
P(10)	0.253	0.008	3	105	
N(20)P(2)	0.709	0.028	3	293	*
N(20)P(10)	0.771	0.024	3	318	*

Table 3b. Bioassay done using 2,5,8,11,14,17,20m lake water collected 10/27/08.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. ($p \leq .05$) Response =“*”
Control	0.270	0.002	3	100	
N(20)	0.267	0.007	3	99	
P(2)	0.274	0.015	3	102	
P(10)	0.271	0.001	3	100	
N(20)P(2)	0.334	0.031	3	124	*
N(20)P(10)	0.460	0.039	3	171	*

Table 3c. Bioassay done using 2,5,8,11,14,17,20m lake water collected 1/30/09.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. (p≤.05) Response ="*"
Control	0.433	0.008	3	100	
N(20)	0.423	0.006	3	98	
P(2)	0.606	0.015	3	140	*
P(10)	0.623	0.034	3	144	*
N(20)P(2)	0.665	0.012	3	154	*
N(20)P(10)	0.689	0.002	3	159	*

Table 3d. Bioassay done using 2,5,8,11,14,17,20m lake water collected 5/1/09.

Treatment	Day 6 Mean Fluorescence	Std. Dev.	n	Day 6 Mean Fluorescence as % of Control	Statistically Signif. (p≤.05) Response ="*"
Control	0.430	0.013	3	100	
N(20)	0.432	0.020	3	100	
P(2)	0.660	0.023	3	153	*
P(10)	0.712	0.042	3	166	*
N(20)P(2)	0.707	0.023	3	164	*
N(20)P(10)	0.782	0.026	3	182	*

Table 4. Summary of N and P bioassay treatment responses as % of control done in: (a) 2002, (b) 2003, (c) 2004, (d) 2005, (e) 2006, (f) 2007, (g) 2008, (h) 2009. Treatment responses statistically significantly different from the control at the p≤.05 level are indicated with borders and shading.

(a) 2002 Bioassays

	2/7/02	4/1/02	6/12/02	8/30/02	10/28/02	12/30/02
Control	100	100	100	100	100	100
N20	104	97	101	101	93	101
P2	154	-	-	108	-	116
P10	135	157	104	100	113	110
N20P2	139	-	-	157	151	118
N20P10	138	178	180	231	238	116

(b) 2003 Bioassays

	1/30/03	2/26/03	4/8/03	5/21/03	6/16/03	7/10/03	8/29/03	10/20/03	12/3/03
Control	100	100	100	100	100	100	100	100	100
N20	101	98	102	138	116	141	129	101	107
P2	112	129	168	101	99	100	100	100	98
P10	114	134	181	98	104	106	105	106	104
N20P2	141	136	178	253	248	221	196	187	124
N20P10	159	147	190	264	297	317	280	334	142

(c) 2004 Bioassays

	1/5/04	4/23/04	8/20/04	10/28/04	12/11/04
Control	100	100	100	100	100
N20	100	97	112	104	99
P2	133	112	101	103	134
P10	135	122	112	114	150
N20P2	132	153	210	127	161
N20P10	134	202	248	185	173

(d) 2005 Bioassays

	2/16/05	4/15/05	6/10/05	8/15/05	10/20/05	12/15/05
Control	100	100	100	100	100	100
N20	99	97	109	105	109	113
P2	121	193	99	109	110	102
P10	122	233	105	105	121	108
N20P2	123	214	176	177	143	162
N20P10	127	241	239	258	193	190

(e) 2006 Bioassays

	2/21/06	4/12/06	6/19/06	8/9/06	10/31/06
Control	100	100	100	100	100
N20	98	98	84	117	98
P2	181	155	85	113	100
P10	214	162	91	141	113
N20P2	195	155	153	120	135
N20P10	200	161	253	173	273

(f) 2007 Bioassays

	1/9/07	3/2/07	4/13/07	6/12/07	9/27/07	11/9/07
Control	100	100	100	100	100	100
N20	99	100	97	100	143	114
P2	142	112	131	113	91	104
P10	143	112	136	93	89	108
N20P2	143	120	138	145	202	150
N20P10	146	118	136	176	284	180

(g) 2008 Bioassays

	1/30/08	4/24/08	7/24/08	10/27/08
Control	100	100	100	100
N20	102	99	269	99
P2	123	104	109	102
P10	127	102	105	100
N20P2	124	99	293	124
N20P10	127	102	318	171

(h) 2009 Bioassays

	1/30/09	5/1/09
Control	100	100
N20	98	100
P2	140	153
P10	144	166
N20P2	154	164
N20P10	159	182

Task 4.a. Phytoplankton Enumeration and Analysis

In recent years Lake Tahoe phytoplankton have become the defining biological measure of changing environmental conditions (Winder and Hunter, 2008). Communities are constantly changing with seasonal succession in a fairly predictable manner. However, the phytoplankton are also changing less predictably, more dynamically, and perhaps permanently altering the balance between algal groups in the long-term.

If we look at the phytoplankton assemblages only one decade ago, we've seen significant taxa change. The total bio-volume and abundance has consistently increased during those 10 years. On an annual basis, the precise timing of seasonal succession seems to be elusive and more complex than just nutrient availability. Also, when observing the phytoplankton assemblages at the species level, there is absolutely no predictability as to which taxa will be the seasonal best performers.

Annual reports are limiting because they confine analysis to a calendar year. Fortunately, phytoplankton are instantly responsive to surrounding environmental conditions, this is their hallmark advantage in the biological food chain. However, to acknowledge 'lasting' change requires inter-annual analysis. From one year to the next inter-annual variations often cloud the overall picture. Long-term data sets are the only way that seasonal and inter-annual 'noise' can be filtered out so that real change can be seen. That being said, an annual report does focus on the phytoplankton communities in a detailed manner. Small deviations can more easily be defined. This annual report, covers the period from July 2008-June 2009. Samples were collected on 6 dates from the mid-lake station and 9 dates from the Index station, with a mix of discreet depth (6 depths sampled individually) and composite samples collected. A total of 72 samples were collected and analyzed.

The most noteworthy event in the phytoplankton during the past year occurred from May – August 2008. During these four months the phytoplankton total bio-volume and abundance peaked and remained high. The intensity and longevity of this growth period is really spectacular (Figure 1 & 2).

The diatom population was the dominant algal family, especially the centric diatoms. *Stephanodiscus alpina* and *Cyclotella ocellata* were the early bio-volume dominants in May 2008. However, only one month later the *Stephanodiscus* taxa crashed, being out competed by *Cyclotella ocellata, Cyclotella stelligera* and *Cyclotella glomerata.* This typically summer assemblage continued well into August 2008. Interestingly, centric diatoms which have had very low populations for nearly 30 years, have been increasing in abundance. *Aulacoseira italica* and *Cyclotella bodanica* are examples of this phenomenon. Both of these cells are large and carry relatively large bio-volume estimates. Therefore, even small increases in their numbers will have an impact on the total bio-volume. This was the exact situation in the May-June 2009 samples where both of these species, together, accounted for 30% of the diatom bio-volume. However, they were only 2% of the diatom abundance. This impact can be seen in the community bio-volume (Fig 1) where the diatom bio-volume decrease in August is not reflected in the abundance numbers for the same month (Fig.2). Small diatoms continued to dominate throughout the summer, into September. However, the larger diatoms (which have greater impact on the sample bio-volume) were gone from the community by August.

Pennate diatoms have been dominant and controlling forces in the diatom community in years past. *Synedra acus var. radians, Achnanthes microcephala*, and *Asterionella formosa* were never abundant in the 2008-2009 year. This community change is a continuing trend and may well be associated with climate change. (Winder et. al. 2009)

There were several months of the year when diatoms did not overwhelm the phytoplankton assemblage. From September through January, the algal community had lower biomass and higher diversity. Physical and chemical parameters controlled resource availability during this time period. Upwelling events as well as the lack of mixing, temperature, and light availability impacted phytoplankton at all depths.

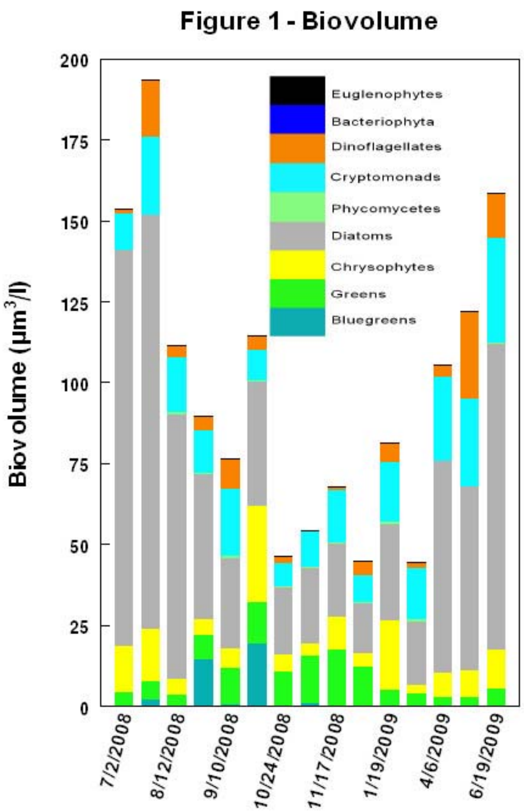
The green algae (chlorophyceae), blue-green algae (cyanophyceae), and yellow algae (chrysophyceae) were abundant in the early autumn. This was a period of relatively lower nutrient availability, warmer water, and a stable water column. These three algal families, collectively, yielded higher abundance and total bio-volume than the diatoms. The algal community at this time of year (autumn) reflect the ability of cells to withstand a challenging environment. Taxonomic changes that contribute to higher abundance of cells, reflect overall change in the lake. In 1998, for example, the total sample bio-volume for early autumn was 15 $\mu m^3/l$. In 2008, the bio-volume numbers were doubled and sometimes tripled.

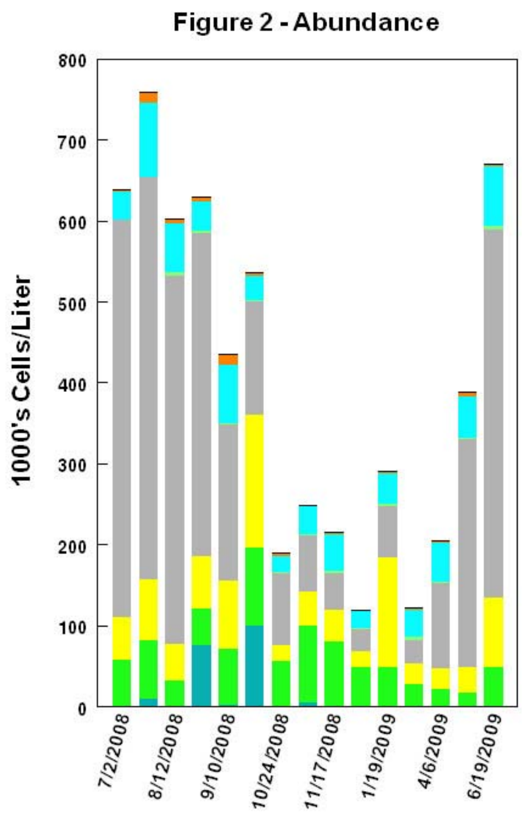
When the euphotic zone of the lake started to mix, in late October and November, there was a decrease in the algal bio-volume and abundance. The dominant groups from early autumn were replaced with the deeper dwelling cryptophyceae family of cells. This group of plankton thrived in low-light, turbulent, and higher nutrient conditions.

In January 2009 there was a bloom of *Dinobryon sociale var. americanum*. These small flagellated cells belong in the chrysophyceae family. Historically, January was a month of low algal bio-volume and abundance. While it was not atypical to see unexpected blooms of one species, it was unusual to see *Dinobryon* because its *modus operandi* prefers very low nutrient concentrations. In January, the nutrient conditions are typically not low. Additionally, the family of chrysophytes has been reported to be less important in the Tahoe phytoplankton community (Winder and Hunter, 2009). Their sporadic appearance in great quantities sometimes challenges the former conclusion.

Springtime and the annual diatom growth began in March/April 2009. The centric, *Stephanodiscus alpina* was dominant and the small pennate, *Achnanthes microcephala*, was sub-dominant. By late May 2009, any hint of pennate diatom revival was dead. The phytoplankton community was dominated by centrics *Aulacoseira italica, Cyclotella spp.,* and *Stephanodiscus alpina*. By mid-June the total bio-volume was over 150 $\mu m^3/l$ and the abundance was nearly 700,000 cells/l. These numbers were similar to those from 2007 and 2008. Compared to earlier in the decade, these bio-volumes at the annual peak are nearly 25% higher.

Diatoms remained the dominant phytoplankton group during the period July 1, 2008- June 30, 2009. The community continues to increase in annual bio-volume and abundance compared with historical records. The diversity remains high. These are all signals of increased productivity leading to trophic modifications. The phytoplankton community will herald environmental change, both biological and chemical. The phytoplankton monitoring program remains a very important part of the overall lake monitoring program.





Figures 1 and 2. Biovolume (Fig. 1) and abundance (Fig. 2) of phytoplankton in the upper water column (0-100m) of Lake Tahoe, July 1, 2008 – June 30, 2009.

Task 4.b. Zooplankton Enumeration and Analysis

During July 1, 2008 to June 30, 2009 ten 150-0m tows for zooplankton were collected at the mid-lake station and seven 150-0m tows were collected at TERC's Index station off of the west shore. These samples were preserved and archived for future identification and enumeration.

Task 5. Atmospheric Deposition of Nitrogen and Phosphorus

Monitoring of atmospheric deposition is crucial to an understanding of its role in degradation of the lake and for use in watershed management. Atmospheric deposition contributes nitrogen, phosphorus and fine particles which all impact lake clarity. Estimates in the nutrient and sediment budget for Lake Tahoe produced as part of the Tahoe TMDL project indicate that atmospheric deposition contributes about 55% of the Total Nitrogen, 15% of the Total Phosphorus and 15% of the Total Fine Sediment (<20µm) particles to the lake. A significant portion of the nitrogen, phosphorus and fine sediment particles in the atmospheric deposition is thought to originate in the basin. Control of air pollutants generated within the basin is therefore potentially a tool for watershed managers to reduce pollutants which impact the clarity of the lake. The atmospheric deposition monitoring program of TERC provides basic information on nutrient loading from this source (atmospheric deposition both in the watershed on land and directly to the lake surface), as well as on precipitation timing and amounts. The data also provides information on past and current trends in atmospheric deposition.

The current contract provides for atmospheric monitoring at 3 primary stations: the lower Ward Lake Level station, and two stations located on the lake: the Mid-lake buoy station (TB-1) and an additional lake buoy (buoy station TB-4).

Stations and Methods

Lower Ward Valley Lake Level Station

This station is located slightly south of the Ward Creek mouth on an estate, approximately 75-100 m back from the lake edge. It consists of a NovaLynx electrically-heated 8 inch diameter tipping bucket gage (TBG) located approximately 8 feet above the ground on a tower. The TBG was modified so that precipitation could also be caught for measurement. This station also has an Aerochem Metrics model 301 wet/dry deposition sampler. This sampler contains two deposition collection buckets and moveable lid, which automatically covers one, or the other bucket depending on whether precipitation is detected by a sensor. A 3 ½ gallon standard HDPE plastic bucket is used in the Wet-side of the sampler. This "Wet bucket" is covered by the lid during dry periods and exposed when wet precipitation is detected during a storm event. The Dry-side contains a modified HDPE bucket with reduced side-wall height, filled with 4 liters of deionized water, (and contains a heater in winter). This "Dry-bucket" is exposed during dry periods and covered by the lid when precipitation is detected. Wet samples are collected from this station also on an event basis, or as wet buckets fill with snow. Dry samples are collected about every 7-10 days and collection is often coordinated with lake buoy Dry-Bulk sample collection.

Mid-lake Buoy Station

This station is located in the northern middle portion of the lake. The station was located on a large anchored PVC spar buoy in earlier studies. During the current study the station was located on a large buoy (TB-1) in the north central portion of the lake (coordinates 39° 09.180 N and 120° 00.020 W). The collector consists of a HDPE plastic bucket similar to the Aerochem Metrics modified dry collector. It is filled with 4 liters of deionized water when placed out. However, the bucket also contains plastic baffles to dampen splash from the bucket. Unlike the

Dry bucket, this collector collects both Wet and Dry deposition and therefore is called a Dry-Bulk collector. The station also contains a Snow Tube for collection of wet precipitation. Sample collection from this station is done as much as possible on a regular basis (7-10 days if possible), however, lake conditions and weather govern frequency to a large extent. The buoy also has a variety of scientific instrumentation for NASA's studies on the lake in addition to the atmospheric deposition collectors.

Northwest Lake (TB-4) Station

Station TB-4 (coordinates 39° 09.300 N and 120° 04.330 W) was located between the mid-lake (TB-1) station and Tahoe City. This was desirable since it provided a second collection site to compare with Mid-lake data. The station contained a Dry-Bulk sampler similar to that used on the Mid-lake station. Samples were collected on the same frequency as the Mid-lake samples. The station was supported on a large buoy (TB-4). The buoy has a variety of scientific instrumentation for NASA's studies on the lake in addition to the atmospheric deposition collectors. (Note for more detailed methods at the different stations see the TERC's Standard Operating Procedures for precipitation monitoring).

Results

Data collected for this task included information on atmospheric deposition concentrations, nutrient loading, precipitation amounts and timing. Appendices 1-5 present summary tables for precipitation amounts, concentrations and nutrient loading from July 1 2008 through summer 2009. Sufficient data was available to calculate preliminary estimates of WY 2009 (note "WY" = Water year, which extends from October 1 to September 30 the following year) loads from the lower Ward Valley Wet/Dry station, however, enough data was still outstanding from the end of the WY for the lake buoys, that WY totals for these stations will be included with the next report. From July 1, 2008-July 5, 2009, 124 atmospheric deposition samples were collected from the 3 primary stations: 29 dry bucket and 31 wet bucket samples from the Ward Lake Level station, 25 dry-bulk samples from each of the lake buoy stations, 9 Mid-lake snow tube samples and 5 QA/QC samples. 26 additional samples have been collected at the sites from July – Sept. 2009. Samples were analyzed for ammonium (NH_4-N), nitrate (NO_3-N), total Kjeldahl nitrogen (TKN), soluble reactive phosphorus (SRP), total dissolved phosphorus and total phosphorus (TP).

The overall precipitation total during WY 2009 at the Lower Ward Valley station was intermediate among values recorded the past five WY's: (37.34 inches). More precipitation fell than occurred the last two years, in WY 2007 (27.92 inches) and WY 2008 (24.98 inches), but the WY 2009 total was less than occurred in WY 2005 (49.40 inches) and WY 2006 (65.99 inches). Figure 3 shows the distribution of precipitation (as amounts collected in Wet deposition buckets at the Lower Ward Valley precipitation station from July 1, 2008 to Oct.1, 2009. The majority of the precipitation occurred between October 2008 and mid-June 2009. There were several moderate-sized precipitation events through the period which stand out, these included: a storm which dropped 3.77 inches of rain Nov. 1-2, 2008; a rain/snow mix event March 2-4, 2009 which contributed 5.87 inches of precipitation; and a series of storms May 1-5, 2009 which dropped 4.96 inches of precipitation mostly as rain. Significant rain occurred in early May and early June of 2009 and this contrasts with WY 2008, when little precipitation occurred from April through the end of summer. The summer of 2009 was also relatively dry from about mid-June on, however a few small rain events did occur.

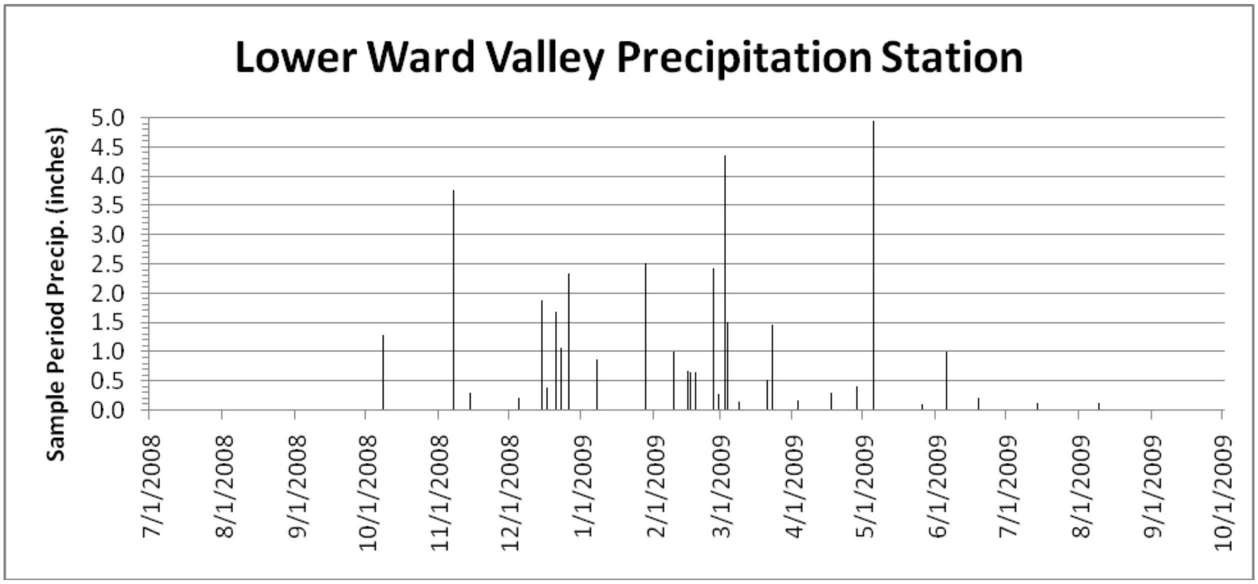


Figure 3. Chart showing precipitation amounts occurring at the Ward Valley Lake Level station during sample "Wet Bucket" collection periods 7/1/08-10/1/09. Each vertical bar corresponds to the total amount of precipitation which occurred during a particular collection period, in some cases two or more Wet buckets were combined in a collection period, (the date under each bar is the final collection date of the sample(s)).

A characterization of precipitation, along with potentially significant weather or atmospheric-deposition-related events during the period are summarized by quarter below:

(July – September, 2008 – from 2008 Annual Report)

- Smoke from fires in California continued to fill the Tahoe basin to varying degrees in through mid-July. A significant ash fall event was noted along parts of the northwest shore of Lake Tahoe on July 9, 2008. Pieces of ash including small pine needle ashes were carried by the air currents over the lake. This ash was likely from the American River Complex fires over 35 miles to the west of the basin. Strong up-canyon afternoon winds on July 9 were noted at the fire which caused "a significant run of the Westville fire to the east and north" (KCRA.com, 2008). It is possible the air currents carried ash from this fire to the Lake Tahoe Basin. Ash was deposited on the lake (at least as far east as mid-lake at buoy TB-1) as well as on land down the west shore at TERC's Ward Valley Lake Level precipitation station south of Pineland/Sunnyside. In Tahoe City a thin coating of ash was deposited on boats at the Tahoe City Marina and along the shoreline. Very light ash fall was observed also at TERC in Incline Village.
- The heaviest ash was likely closer to northwest shore, as there was a noticeable drop-off in the level of ash in buoy deposition collectors from the west shore out to the mid-lake buoy. Significant ash was collected in TERC's Dry deposition sampler at the Lower Ward Valley station, ash was also collected in TERC's Dry-bulk atmospheric deposition collectors at buoy TB-4 and buoy TB-1 at mid-lake.

- Smoke also decreased visibility in the basin again around July 26-28, a portion of this smoke was from fire near the Yosemite park entrance.
- The period July 1 through September 30 2008 was very dry with minimal precipitation along the northwest shore. At the Lower Ward Precipitation station, only 0.01 inches of precipitation was collected from storms during the week of July 15-21. A trace of precipitation also fell at the Lower Ward station on September 16th associated with thunderstorms. The first significant rain along the west shore did not occur until October 3-4.

(October – December, 2008)

- The first significant rain (1.29 inches) along the west shore occurred 10/3-10/4/08 after a very dry summer. Then, much of October was dry and relatively mild. Precipitation returned on 10/31 and significant rain occurred the following day on Nov. 1. The snow level was very high for this storm and moderate rain was observed at lake level. The high elevation rain appeared to impact Ward Cr. as significant very fine light brown silt was observed in the stream at the monitoring station (Ward Cr. below Confluence) in the upper Ward watershed. Overall precipitation at the Lower Ward station was 3.77 inches for the event which lasted into Nov. 2. Two relatively small events occurred during the rest of November, much of the month was relatively mild and dry. December was relatively dry until around Dec. 13. The first significant snow storm of the season occurred in mid-December, with approximately 2 feet of snow recorded at the Lower Ward Valley station. A series of storms with snow and some rain/snow mix impacted the basin over the following week. Very significant snow fell on 12/25 Christmas with a total of nearly 2 ½ feet total recorded between 12/24 and 12/26.
- The Aerochem Metrics Wet/Dry sampler at the Lower Ward station malfunctioned during several of the snow storms in mid-December. This resulted in Wet precipitation collected in the "Dry Bucket" for a portion of the period and also Dry deposition collected in the "Wet Bucket" for a portion of the period (see notes for individual samples. We replaced the Aerochem Metrics sampler on 12/23/08.

(January – March, 2009)

- January was characterized by storms early and late in the month. A storm in early January dropped 0.86 inches of precipitation as snow at the Lower Ward Valley station. After a dry spell with mild temperatures in the middle of the month, a series of rain and snow storms occurred during the period between Jan. 21-25, dropping another 2.5 inches of precipitation. The rain caused slight increases in discharge from the West shore tributaries. After approximately a 10 day break in the storms, relatively frequent storms occurred through much of February into early March. On March 2, significant mixed rain and snow occurred, which caused rises in the west shore streams. The rain changed to snow late on Mar. 2, then about 2 ½ feet of new snow fell at lake level from March 2-4. Overall, 5.87 inches of precipitation fell during this early March storm. Small amounts of precipitation then occurred in mid-March. Then a moderate snow-storm occurred about March 22, producing over a foot of snow at lake level.

(April – June, 2009)

- April was characterized by a few small snow events early and late in the month with a period of warm temperatures mid-month. Significant rainfall occurred during the first five days of May (three storms during May 1-May 5 deposited 4.96 inches of precipitation at the Lower Ward station, mostly as rain). Runoff from these storms combined with snowmelt and caused the highest peaks in stream stage for streams along the west shore during WY 2009. A long stretch of dry weather followed until about May 24 when a small amount of rain occurred. The first part of June was unsettled and frequently cloudy with periods of rain and thunderstorms. Significant rain and thunderstorms occurred on June 2. The latter half of June was more summer-like with warmer temperatures and less precipitation. Very little fire-associated smoke was observed in the basin in June this year in contrast with June of last year (2008) when very heavy smoke was observed over an extended period late in the month and into July.

(July – September, 2009)

- During the period July 1 to September 30, 2009 the weather was uneventful at the sites monitored. Typical Tahoe Basin summer weather prevailed with very limited precipitation, which often occurred as isolated thunderstorms. Small amounts of rain were recorded at the Lower Ward Valley station in July (0.12 in.) and in Aug. (0.12 in.). Little forest fire-associated smoke was observed in the basin this summer in contrast with the previous summer when heavy smoke was observed for an extended period in late June into July.

Probably the most interesting feature of the period July 1, 2008 to June 30, 2009 was the extended period of smoke which occurred in the basin derived from the large number of lightning-caused forest fires to the west of the basin in California. Smoke from some of these fires began filling the Tahoe basin soon after they started June 21 and varying levels of smoke were present in the basin for several weeks, through mid- July. The presence of smoke for such a prolonged period is unusual for the basin. During the period of heavy smoke an unusual ash fall event was observed on July 9, 2008 in the northwest portion of the basin. Phosphorus loading appears to have been quite high in samples collected during this ash fall event. Preliminary analysis of the data also indicates that deposition loads for samples collected July 10 (which included the ash fall) comprised a significant portion of the total Wet + Dry deposition of SRP for WY 2008. At Lower Ward, SRP in Dry deposition collected July 10 (105.94 g/ha) was 48% of total Wet + Dry SRP deposition for WY2008, at TB-1 deposition of 18.87 g/ha was 44% of the total Dry-bulk (Wet + Dry) SRP load for the WY, at TB-4 deposition of 19.62 g/ha was 44% of the WY SRP total. Based on anecdotal evidence, this ash fall may not have impacted the whole lake. The value from the lake buoys of 44% therefore might be considered an upper limit estimate of percent of annual atmospheric SRP loading contributed to the whole lake during the ash fall event. The ash-fall event in summer of 2008 was described in greater detail in last year's annual report (Hackley et al., 2008).

WY 2009 Loading of N and P at the Lower Ward Valley Station

The atmospheric deposition monitoring provides important information on annual N and P loading in Wet and Dry deposition at our station along the west shore (Lower Ward Valley) and Wet + Dry combined (Dry-bulk) loading from two buoys in the northern portion of the lake (TB-1, TB-4). Table 5 presents preliminary estimates for overall WY 2009 atmospheric deposition loading rates at the UC Davis TERC Lower Ward Valley station. (The overall WY2009 data for the lake buoy stations will be reported in the next report - not all WY data was available as of date of preparation of this report, however, individual sample concentrations, loads and loading rates for the TB-1 and TB-4 buoy samples are reported in Appendices 3-5).

The loading rate for dissolved inorganic nitrogen in Wet precipitation was higher than the past two years but still low when compared with historical data. WY 2009 loading of NO_3-N was 1.03 g/ha/d (1.16 g/ha/d if account for estimated precipitation caught by dry bucket when the Aerochem Metrics sampler malfunctioned) and NH_4-N was 0.95 g/ha/d (1.07 g/ha/d if account for estimated precipitation caught by dry bucket) while precipitation was 37.34 in. Loading of NO_3-N and NH_4-N were slightly lower in both WY 2007 and 2008 as were precipitation totals: (WY 2007 precipitation = 27.92 in.; NO_3-N = 0.71 g/ha/d; NH_4-N =0.79 g/ha/d), (WY 2008 precipitation = 24.98 in.; NO_3-N = 0.75 g/ha/d; NH_4-N =0.73 g/ha/d). Precipitation, NO_3-N and NH_4-N loading were much greater in WY 2005 (precipitation = 49.40 in., NO_3-N = 1.92 g/ha/d, NH_4-N =1.89 g/ha/d) and WY2006 (precipitation = 65.99 in., NO_3-N = 1.59 g/ha/d, NH_4-N =1.56 g/ha/d). Figure 4 shows WY precipitation and DIN (Dissolved Inorganic Nitrogen = NO_3-N + NH_4-N) for the historical Wet deposition data at the Ward Lake Level station. There does appear to be some association between WY precipitation and DIN, and this may account for the increase in DIN in WY2009, with increased precipitation, relative to the past two years. (However, note that the range in DIN values for given amounts of WY precipitation can be quite high, particularly in WY with high amounts of precipitation.) It is also interesting in Figure 4 that DIN loading the last three years has been relatively low.

The preliminary loading rate for TKN in Wet precipitation was slightly higher than the last two WY and lower than values in WY2005 and 2006. WY 2009 TKN loading in wet was 2.44 g/ha/d (2.75 g/ha/d if account for estimated TKN in precipitation caught in Dry bucket). TKN loading (g/ha/d) in by WY the previous four years was: 2005 (3.95); 2006 (2.83); 2007 (2.16); 2008 (1.90).

The WY 2009 loading rate for phosphorus in Wet precipitation was higher for SRP in WY 2009 than the past two years, but close to WY 2007 and 2008 values for DP and TP. Loading (g/ha/d) of phosphorus by form the past three years was: WY 2009 (SRP= 0.10, DP=0.14, TP=0.22 using estimate accounting for wet precipitation caught in Dry bucket); WY 2008 (SRP= 0.05, DP=0.13, TP=0.25); WY 2007 (SRP= 0.08, DP=0.12, TP=0.20). Similar to DIN, SRP loading has shown some association with WY precipitation in the historical data (Figure 5). However, there has been quite a lot of scatter in the data particularly with higher levels of precipitation. Figure 5 also shows that loading of SRP was relatively low in Wet precipitation in WY 2007 and 2008, and moderately high in WY 2008. Levels of DP and TP in Wet precipitation were noticeably higher in WY 2005 and 2006 compared with the past three WY (Table 5).

Table 5. Comparisons of loading rates (grams/ hectare/ day) of N and P at the Lower Ward Valley during Water Years 2005 to 2009. To determine dry deposition loading rate, the load for analyzed dry samples was divided by the total number of sampling days represented by analyzed samples. To determine a daily loading rate for Wet precipitation samples, the annual total load for a nutrient was first extrapolated by dividing the load total for samples analyzed (some samples did not have data for all analyses) by the proportion of total precipitation analyzed (amount of precipitation analyzed for a nutrient/ total annual precipitation). This number was divided by the number of days in the year to give the estimate of daily loading rate.

	Precip.	**NO_3-N**	**NH_4-N**	**TKN**	**SRP**	**DP**	**TP**
	(in)	**g/ha/d**	**g/ha/d**	**g/ha/d**	**g/ha/d**	**g/ha/d**	**g/ha/d**
Lower Ward (Wet) WY'05	49.40	1.92	1.89	3.95	0.10	0.21	0.36
Lower Ward (Wet) WY'06	65.99	1.59	1.56	2.83	0.06	0.24	0.42
Lower Ward (Wet) WY'07	27.92	0.71	0.79	2.16	0.08	0.12	0.20
Lower Ward (Wet) WY'08	24.98	0.75	0.73	1.90	0.05	0.13	0.25
Lower Ward (Wet) WY'09	37.34	1.03*	0.95*	2.44**	0.09*	0.12*	0.20*
Lower Ward (Dry) WY'05		0.84	1.39	12.73	0.23	0.64	1.16
Lower Ward (Dry) WY'06		0.89	1.00	11.94	0.17	0.51	1.31
Lower Ward (Dry) WY'07		0.74	1.01	12.55	0.26	0.44	1.03
Lower Ward (Dry) WY'08		0.98	1.01	14.29	0.56	0.80	2.00
Lower Ward (Dry) WY'09		0.75*	1.20*	11.19**	0.24*	0.38*	0.97*
Lower Ward (Wet+Dry) WY'05		2.76	3.28	16.68	0.33	0.85	1.52
Lower Ward (Wet+Dry) WY'06		2.48	2.57	14.78	0.23	0.75	1.73
Lower Ward (Wet+Dry) WY'07		1.45	1.80	14.71	0.34	0.56	1.23
Lower Ward (Wet+Dry) WY'08		1.73	1.74	16.19	0.61	0.93	2.25
Lower Ward (Wet+Dry) WY'09		1.78	2.15	13.63**	0.33	0.50	1.17

Notes: "*" – The Wet/Dry sampler malfunctioned in Dec. 2008, resulting in the Dry bucket collecting a portion of the precipitation for several storms, the Wet bucket loading values shown do not account for Wet precipitation in the Dry bucket, the Dry bucket values include some Wet precip. (If extrapolate Wet total based on missing precipitation caught in dry bucket the estimated loading values in (g/ha/d) would be higher, i.e.: NO_3-N (1.16), NH_4-N (1.07), TKN (2.75), SRP (0.10), DP (0.14), TP (0.22). **A portion of the TKN data was not yet ready for reporting from later in the WY, so estimates of WY loading may change.

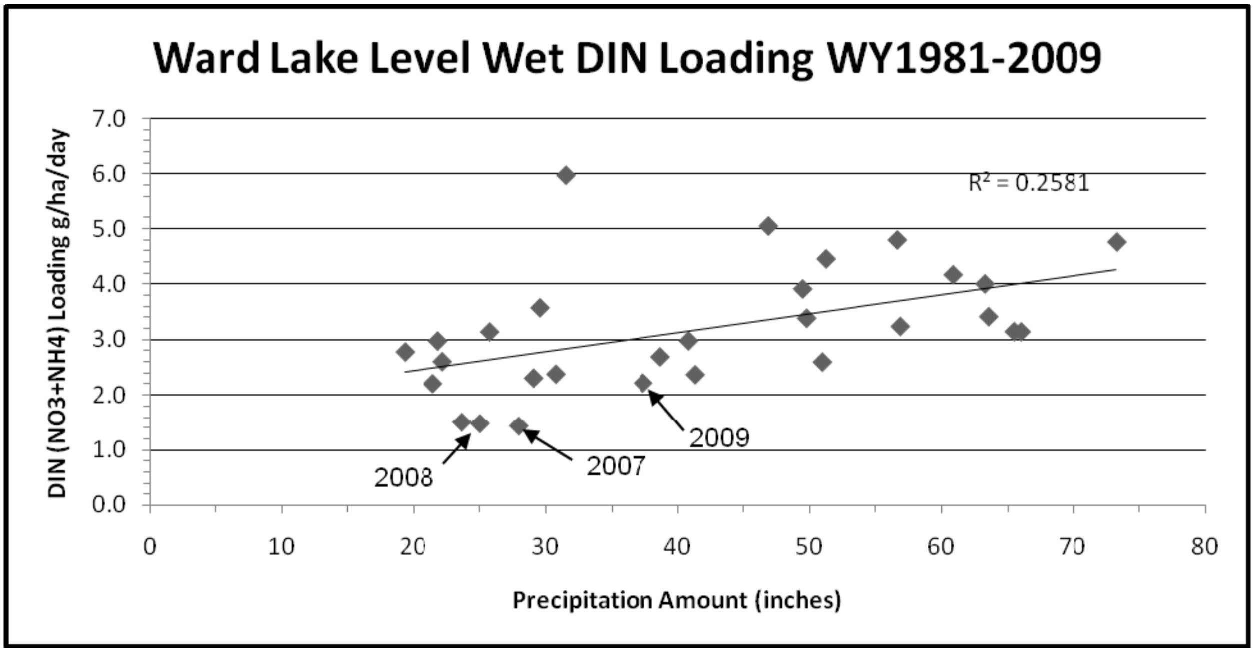


Figure 4. Dissolved Inorganic Nitrogen (NO_3-N + NH_4-N = DIN) average daily loading rates for WY plotted against precipitation amount 1981-2009. (A weak positive association has been found between DIN and precipitation amount R^2=0.25). DIN loading rates in Wet precipitation for recent Water Years (2007, 2008 and 2009) are also indicated.

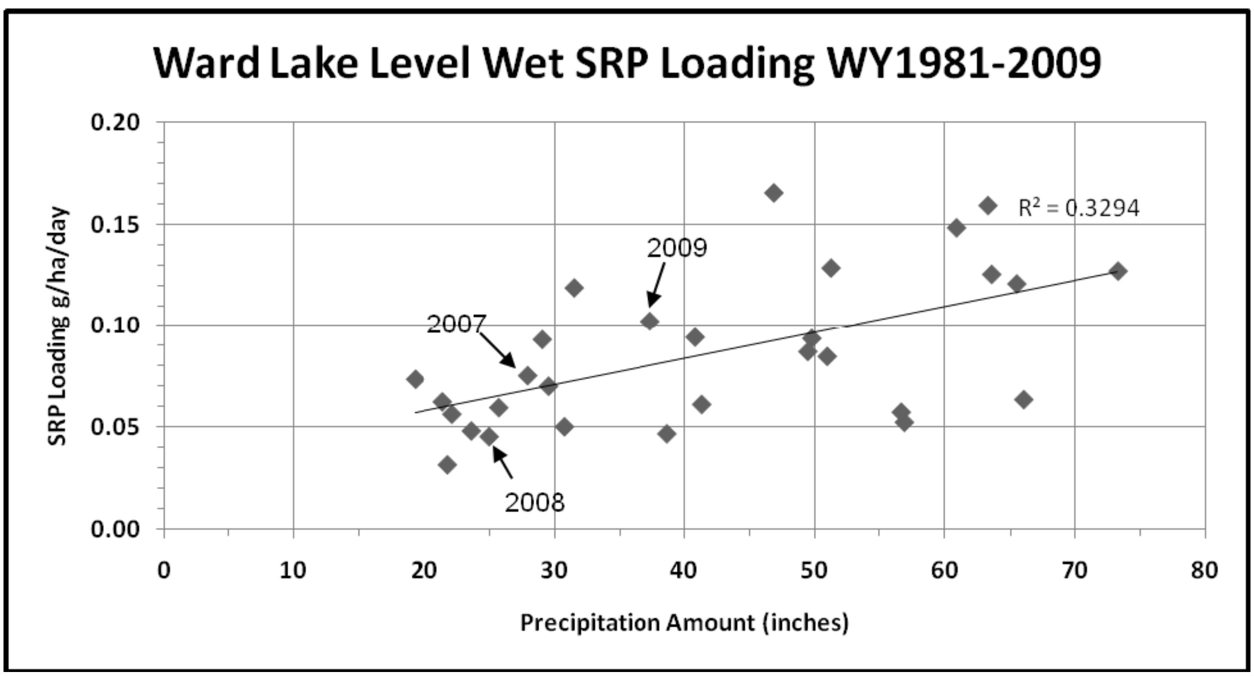


Figure 5. Soluble Reactive Phosphorus (SRP) average daily loading rates for WY and precipitation amounts 1981-2009. (A weak positive association has been found between SRP and precipitation amount R^2=0.3294). SRP loading rates in Wet precipitation for recent Water Years (2007, 2008 and 2009) are also indicated.

Dry deposition loading of dissolved inorganic nitrogen at the Lower Ward has been fairly consistent the last five WY. Loading of NO_3-N has ranged from 0.74-0.98 g/ha/d from WY 2005-2009 and the WY 2009 value was at the lower end of the range (0.75 g/ha/d). NH_4-N loading in dry deposition ranged from 1.00-1.39 g/ha/d, and the WY 2009 value was 1.20 g/ha/d.

Dry deposition loading of TKN was fairly consistent in WY 2005-2007, 2009, however, was slightly elevated in WY 2008. TKN in WY 2005-2007, 2008 ranged from 11.19-12.73g/ha/d. In WY 2008 TKN loading was slightly higher (14.29 g/ha/d).

Dry deposition loading of dissolved and total phosphorus showed slight variation for WY 2005-2007 and 2009, while P loading in WY 2008 was elevated. During WY 2005-07, 2009 period loading of SRP ranged from 0.17-0.26 g/ha/d in; DP loading ranged from 0.38-0.64 g/ha/d and TP ranged from 0.97-1.31g/ha/d. During WY 2008 dry deposition loading (g/ha/d) was higher, i.e.: SRP (0.56), DP (0.80), TP (2.00). The elevated P deposition in WY 2008 may largely be attributed to the deposition occurring during the smoke and ash fall event during the summer of 2008.

Based on the data in Table 5, some general patterns were apparent for the combined Wet + Dry deposition N and P loading at the Lower Ward site. These patterns include:

1) Loading of NO_3-N (1.78 g/ha/d) and NH_4-N (2.15 g/ha/d) was slightly higher in WY 2009 than in WY 2007 (NO_3-N = 1.45; NH_4-N=1.80) and 2008 (NO_3-N = 1.73; NH_4-N =1.74), but significantly lower than occurred in WY2005 (NO_3-N = 2.76; NH_4-N =3.28) and 2006 (NO_3-N = 2.48; NH_4-N =2.57) . There was a high contribution of dissolved inorganic N in Wet precipitation in WY 2005 and 2006.
2) SRP loading in WY 2009 was 0.33 g/ha/d which was within a fairly narrow range of 0.23-0.34 g/ha/d for WY 2005-2007, 2009, while WY 2008 SRP loading was elevated at 0.61 g/ha/d. There was a high contribution of SRP in the dry deposition (associated with ash fall) in 2008.
3) DP loading in WY 2009 was 0.50 g/ha/d. This was at the lower end of the range observed for WY 2005-2009 (0.50-0.93 g/ha/d). The highest value occurred in WY2008.
4) TP loading in WY 2009 was 1.17 g/ha/d. This was at the lower end of the range observed for WY 2005-2007, 2009 (1.17-1.73 g/ha/d). WY 2008 TP loading was notably higher at 2.25 g/ha/d.

Finally, Figures 6 and 7 present the WY 1981- 2009 data for Dissolved Inorganic Nitrogen (DIN) and Soluble Reactive Phosphorus (SRP) respectively in Wet deposition at the Lower Ward station. A couple of patterns are apparent for recent “Wet” DIN and SRP data. DIN average concentrations and total precipitation were low in WY 2007-2009 and overall DIN loads were very low in all three years, the low DIN loads (~500 g/ha) during WY 2007 and WY 2008 were the lowest since the record began in 1981, WY 2009 loading was slightly higher (~800 g/ha). The WY 2009 SRP average concentration was in the mid-range for values in precipitation. With moderate precipitation in WY 2009, the total load of SRP was intermediate between low and high values through time and higher than WY 2007 and 2008 values.

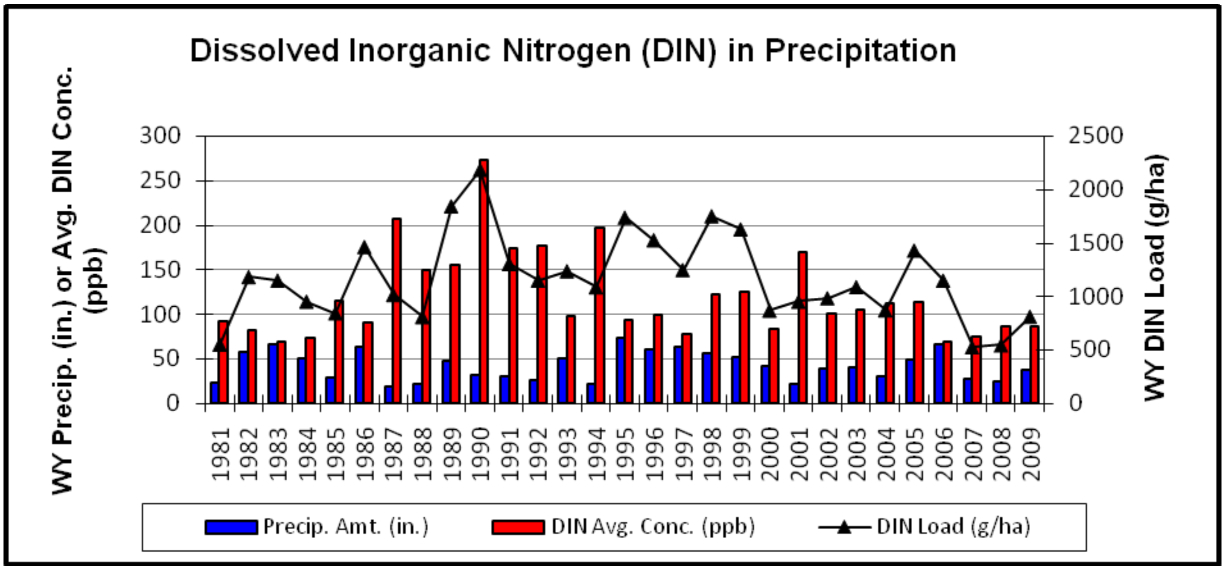


Figure 6. Summary plot of Water Year (WY) total precipitation (inches), average Dissolved Inorganic Nitrogen (DIN) concentration (ppb), and extrapolated annual DIN load (g/ha/yr) in Wet Deposition at the Ward Valley Lake Level station for WY 1981-2009. A Water Year begins October 1 and ends September 30 the following year). For WY 2009 a portion of wet precipitation (estimate 3.22 inches) was caught by the Dry Bucket due to Wet/Dry sampler malfunction. The WY2009 Wet load was adjusted upward by dividing load for analyzed samples, by percent of total precipitation analyzed, to estimate all Wet loading for the year.

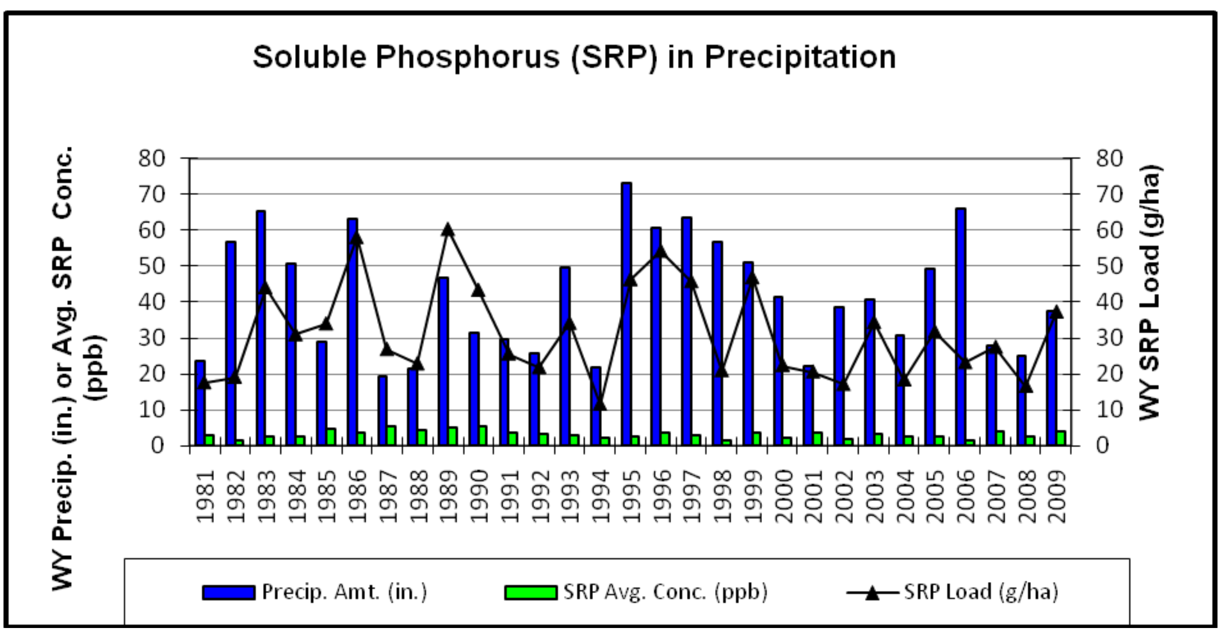


Figure 7. Summary plot of Water Year (WY) total precipitation (inches), average Soluble Reactive Phosphorus (SRP) concentration (ppb), and extrapolated annual SRP load (g/ha/yr) in Wet Deposition at the Ward Valley Lake Level station for WY 1981-2009. For WY 2009 a portion of wet precipitation (estimate 3.22 inches) was caught by the Dry Bucket due to Wet/Dry sampler malfunction. The WY2009 Wet load was adjusted upward by dividing load for analyzed samples, by percent of total precipitation analyzed, to estimate all Wet loading for the year.

Task 6. Periphyton

The purpose of periphyton monitoring is to assess the levels of nearshore attached algae (periphyton) growth around the lake. As for phytoplankton, nutrient availability plays a large role in promoting periphyton growth. The amount of periphyton growth can be an indicator of local nutrient loading and long-term environmental changes in lake condition.

Periphyton grows in the littoral (shore) zone of Lake Tahoe, which may be divided into the eulittoral zone and the sublittoral zone, each with distinct periphyton communities. The eulittoral zone is the shallow area between the low and high lake level and is significantly affected by wave activity. It represents only a very small (<1%) of the total littoral area, but it is the most visible to the general land-bound population. Substrata within this region dries out as the lake level declines, and periphyton must recolonize this area when lake level rises. The sublittoral zone extends from the bottom of the eulittoral to the maximum depth of the photoautotrophic growth. The sublittoral zone remains constantly submerged and represents the largest littoral benthic region of Lake Tahoe.

The eulittoral zone community is typically made up of a stalked diatom species *Gomphoneis herculeana* and filamentous green algae species such as *Mougeotia, Zygnema, Ulothrix* and others. The attached algae in the eulittoral zone display significant growth resulting in rapid colonization. These algae are able to take advantage of localized soluble nutrients, and can establish a thick coverage over the substrate within a matter of months. As nutrient concentrations diminish, and shallow nearshore water temperatures warm, with the onset of summer, periphyton in the eulittoral zone typically die back. When this occurs, the algae can slough from the substrate and disperse into the open water, as well as wash ashore. In areas where biomass is high, the slimy coating over rocks and sloughed material accumulated along shore can be a nuisance. The eulittoral zone periphyton plays an important role in the aesthetic, beneficial use of the shorezone.

The sublittoral zone is made up of different algal communities down through the euphotic zone. Cyanophycean (blue-green) algal communities make up a significant portion of the uppermost sublittoral zone. These communities are slower growing and more stable than the filamentous and diatom species in the eulittoral zone.

Ongoing monitoring has shown that lake level fluctuations associated with operation of the upper six feet of the lake as a reservoir, can have an important impact on algal assemblages and biomass near the surface in the eulittoral zone. During years when lake surface elevation drops significantly, biomass associated with the stable blue-green algal communities may be located in proximity to the surface (i.e. algae that typically resides in the sublittoral now inhabits the eulittoral only because of the drop in lake level). This can result in heavy biomass near the surface. This heavy biomass is not necessarily a consequence of high nutrient availability but rather is a consequence of the lowered lake level and persistent presence of blue green algae. During years of relatively stable lake levels, blue green algae may also establish on rocks which in the past were exposed by lower lake levels.

The following section summarizes the results of routine periphyton monitoring during July 1, 2008 – June 30, 2009 along with the results of an expanded monitoring survey done March-June,

2009. Periphyton monitoring done in 2009 also included some repeated monitoring at the South Shore synoptic sites (Tahoe Keys, Kiva Beach, South Elks Pt.) which have only been sampled once a year in the past. This monitoring was coordinated with additional natural substrate and artificial substrate monitoring for a SNPLMA Nearshore Study. Monitoring from the two studies combined should provide complementary information on patterns of periphyton growth in the nearshore zone.

Stations and Methods

Nine routine stations were monitored during July 2008-June 2009 (Rubicon Pt., Sugar Pine Pt., Pineland, Tahoe City, Dollar Pt., Zephyr Pt., Deadman Pt., Sand Pt., Incline West). These nine sites are located around the lake (Table 6) and represent a range of backshore disturbance levels from relatively undisturbed land (Rubicon Point and Deadman Point) to a developed urban center (Tahoe City).

Table 6. Locations of Routine Periphyton Monitoring Stations

SITE NAME	LOCATION
Rubicon Point	N38 59.52; W120 05.60
Sugar Pine Point	N39 02.88; W120 06.62
Pineland	N39 08.14; W120 09.10
Tahoe City	N39 10.24; W120 08.42
Dollar Point	N39 11.15; W120 05.52
Zephyr Point	N39 00.10; W119 57.66
Deadman Point	N39 06.38; W11957.68
Sand Point	N39 10.59; W119 55.70
Incline West	N39 14.83; W119 59.75

A detailed description of the sample collection and analysis procedures is given in Hackley et al. (2004). Briefly, the method entails collection while snorkeling of duplicate samples of attached algae from a known area of natural rock substrate at a depth usually of 0.5m, using a syringe and toothbrush sampler. These samples are transported to the laboratory where the samples are processed and split, with one portion of the sample analyzed for Ash Free Dry Weight (AFDW) and the other portion frozen for later analysis of Chlorophyll *a* concentration (both AFDW and chlorophyll *a* are used as measures of algal biomass). We also measure average filament length, % algal coverage, and estimate the visual score in field observations. The visual score is a subjective ranking (1-5) of the level of algal growth viewed above and/or below water where 1 is least offensive appearing (usually natural rock surface with little or no growth) and 5 is the most offensive condition with very heavy growth. We also assess what general types of attached algae are present in the field. We also viewed many samples under the microscope to get a better assessment of major types of algae present.

Results:

Monitoring at Routine Sites

In this report we focus on the data collected from July 2008-June 2009. The nine routine sampling sites were sampled five times at most sites during this period. Three of the sampling circuits were made during the period of heavier growth (spring through early summer). Additional sampling circuits were made during late summer 2008, and winter 2009. Figure 8 shows lake surface elevation fluctuation (and 0.5m sampling depth contour elevation fluctuation) for the last four years. Table 7 presents the results for biomass (chlorophyll *a*, AFDW) and field observations of visual score, average filament length, percent algal coverage and basic algal types at the nine routine periphyton sites for the period July 2008-June 2009. Figure 9 presents the results for chlorophyll *a* and AFDW biomass at each site for the last two years (July 2007 to June 2009).

Routine Monitoring Results July 1, 2008 to June 30, 2009

The typical seasonal pattern with a peak biomass in the spring was observed at six of nine sites in WY2009. Chlorophyll *a* biomass peaked in March or April at the five sites along the west and northwest portion of the lake and at one site along the east shore. WY2009 peak chlorophyll *a* levels at these sites were: Rubicon Pt. (78.34 mg/m^2), Sugar Pine Pt. (45.52 mg/m^2), Pineland (119.21 mg/m^2), Tahoe City (73.05 mg/m^2), Dollar Pt. (97.47 mg/m^2) and for Deadman Pt. on the east shore (31.27 mg/m^2). For the other routine sites, chlorophyll *a* biomass peaked in early summer at two sites in the northeast portion of the lake: Incline West (53.66 mg/m^2) and Sand Pt. (37.34 mg/m^2). At Zephyr Pt in the southeast portion of the lake, the highest biomass appeared in late January (24.88 mg/m^2).

The peak biomasses indicated above at four of the sites were significantly lower than observed in 2008. Last year (WY2008) very high, peak chlorophyll *a* levels were observed at Rubicon Pt. (168.17 mg/m^2), Tahoe City (183.72 mg/m^2), Dollar Pt. (156.52 mg/m^2) and Zephyr Pt. (76.45 mg/m^2). The WY2009 peak chlorophyll levels at three of these sites (Rubicon Pt., Dollar Pt. and Zephyr Pt. were lower and closer to peak values observed WY2005-WY2007. The peak values observed in WY2009 at Tahoe City were much lower than WY2008, and also significantly less than peak values observed in WY2005-WY2007. The reduced WY2009 peak at Tahoe City may have partly been a consequence of sloughing of algae during strong winds and waves at the end of March.

At the other routine sites peak biomass levels were either near or slightly higher than 2008 levels. Very high peak values were observed at Pineland the last two years (Chlorophyll *a* = 119 mg/m^2), while peak levels at Sugar Pine Pt., Incline West, Sand Pt. and Deadman Pt. were slightly higher in WY2009 than in 2008.

Based on visual observations in the field, several different assemblages of predominant attached algal types appeared to be present during peak growth at different sites. A mix of filamentous green algae, stalked diatoms and filamentous green algae appeared to be present at: Rubicon Pt., Pineland and Incline West. At Dollar Pt, stalked diatoms and filamentous greens were most apparent, although there were likely blue-green algae as well. Primarily stalked diatoms appeared to be present at the Tahoe City site. Primarily blue-green algae appeared to be present at Sugar Pine Pt. Filamentous green algae and blue-green algae appeared to predominate at Deadman Pt., Sand Pt. and Zephyr Pt. along the east shore.

Some of the factors which may have played a role in impacting periphyton biomass around the lake this past year included:

1) WY 2009 exhibited a somewhat typical pattern of lake level fluctuation, with a modest increase in surface elevation in the spring associated with runoff, leading to a peak in late June (see Figure 8). During the January/February 2009 sampling, the lake level was still very low, and the substrate sampled (which was well below the natural rim or 6223 ft) had been continually submerged for many years. The algae community had blue green algae associated with it at many sites. After the 1.5 foot rise in lake level to the peak surface elevation in June, the substrate sampled was the same that had been located just below the surface in December 2008. The prior exposure of this substrate to conditions near the surface in December 2008 may have had an impact on the periphyton biomass and species composition in spring 2009 (i.e. some of the heavy biomass from 2008 may have been decreased due to wave activity at the surface).
2) More storm activity occurred in 2009 than in 2008 (see atmospheric deposition section above). Increased storm activity can affect periphyton growth both positively and negatively. Inputs of nutrients from stream inputs and lake mixing associated with winter storms can potentially positively affect growth. With very strong winds and waves however, periphyton can slough from the rocks. Periods of strong winds occurred in late March and may have caused some sloughing of algae in some locations.
3) With moderate precipitation, inputs of surface runoff and groundwater and associated nutrients were likely moderate in WY2009.

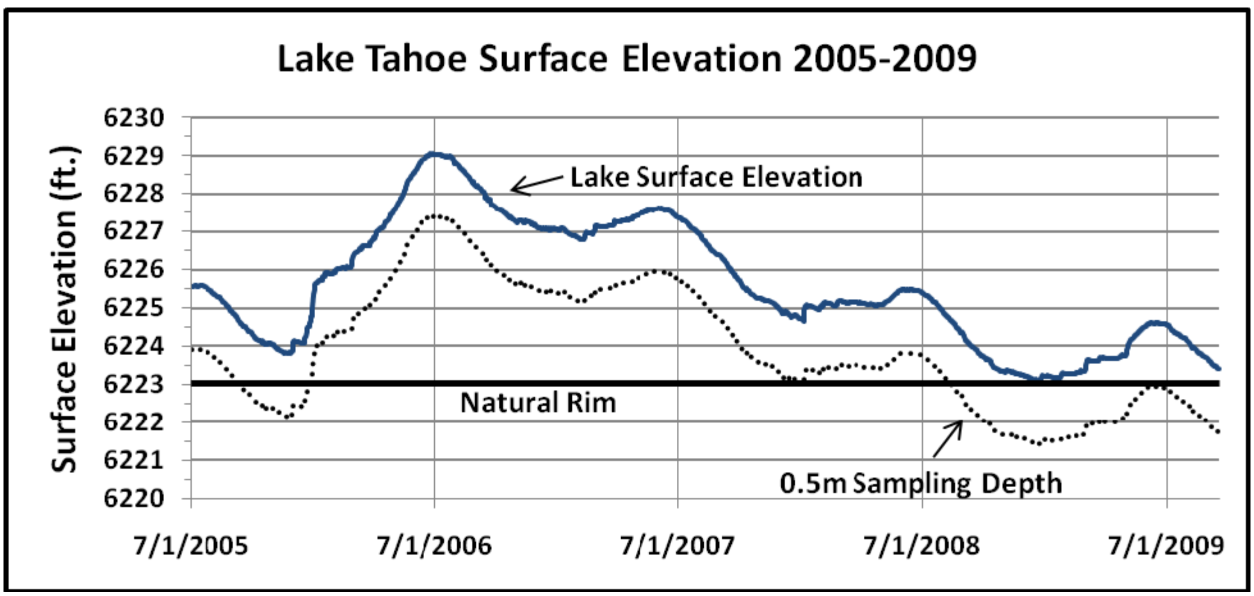


Figure 8. Fluctuation in Lake Tahoe surface elevation 7/1/05-9/16/09 (Lake level data from USGS web site: www.usgs.gov). Periphyton samples were collected during the period usually at a depth of 0.5m below the surface on natural rock substrata. The 0.5m sampling depth (shown as a dotted line) fluctuates with the lake surface elevation. The depth of the natural rim of Lake Tahoe is 6223 ft.

Table 7. Summary of eulittoral periphyton Chlorophyll a (Chlor.*a*), Ash Free Dry Weight (AFDW), visual score from above and below water, average filament length, percent algal coverage, and predominant algal types estimated visually underwater (where SD= stalked diatoms; FG= filamentous greens; CY= blue green algae) for routine periphyton monitoring sites during July 2008-June 2009. Note for Chlorophyll *a* and AFDW, n=2 unless otherwise indicated (i.e. two replicate samples were taken). Visual score is a subjective ranking of the aesthetic appearance of algal growth ("above" viewed above water; "below" viewed underwater) where 1 is the least offensive and 5 is the most offensive. Also,"na" = not available or not collected; "nes" = not enough sample for analysis.

Site	Date	Depth (m)	Chlor. *a* (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (g/m^2)	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Coverage (%)	Algal Type
Rubicon Pt.	8/13/08	0.5	10.13	2.92	11.98	5.73	1	1	<0.1	50%	CY
	1/23/09	0.5	62.47	29.98	36.85	11.69	2	3	1.0	60%	CY,FG
	3/10/09	0.5	38.26	6.70	27.70	2.05	3	3	0.4	70%	FG,CY
	3/31/09	0.5	78.34	12.57	27.92	9.74(n=3)	2	3	0.8	10-90%	CY,FG,SD
	6/25/09	0.5	19.59	5.19	27.62	3.74	3.5	3.5	1.0	80%	FG,CY,SD
Sugar Pine Pt.	8/13/08	0.5	7.61	4.39	10.10	6.59	NA	1	<0.1	70%	CY
	1/23/09	0.5	34.02	NA(n=1)	21.83	3.14	NA	2	0.1	80%	CY
	3/10/09	0.5	45.52	48.52	31.36	32.21	NA	2	0.2	80%	CY
	3/31/09	0.5	39.97	0.80	39.41	2.85(n=3)	2	3	0.5	80%	CY,SD,FG
	6/25/09	0.5	5.16	3.91	9.00	6.03	NA	2	<0.1	70%	CY,FG
Pineland	8/13/08	0.5	9.87	0.53	8.69	0.84	2	2	0.1	60%	SD,CY
	1/23/09	0.5	55.49	15.68	41.00	4.93	2	3	0.8	70%	SD,CY
	3/13/09	0.5	91.01	36.32	69.85	8.90	3	4	1.3	90%	SD
	3/31/09	0.5	119.21	23.05	53.68	10.35(n=3)	4	5	3.0	70%	SD,FG,CY
	6/26/09	0.5	26.04	0.25	28.98	2.11	2	3	0.5	70%	CY,SD
Tahoe City	9/8/08	0.5	17.58	11.13	13.77	4.22	2	2	<0.1	90%	SD
	1/27/09	0.5	26.83	0.31	NA	NA	2	2	0.3	90%	SD
	3/13/09	0.5	73.05	0.26	80.36	7.01	3	4	0.6	50%	SD
	4/7/09	0.5	39.98	2.38(n=3)	33.64	5.85(n=3)	4	4	1.2	50%	SD
	6/26/09	0.5	32.05	4.42	43.89	5.24	2	2	0.1	80%	SD

Site	Date	Depth (m)	Chlor. *a* (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (g/m^2)	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Coverage (%)	Algal Type
Dollar Pt.	9/8/08	0.5	5.64	0.81	3.81	0.41	5	2	0.3	70%	SD,CY
	1/27/09	0.5	10.30	2.63	NA	NA	2	2	0.1	80%	SD,CY
	3/13/09	0.5	31.14	8.23	20.04	2.65	2	2	0.2	40%	SD,CY,FG
	4/7/09	0.5	97.47	35.06(n=3)	49.12	12.23(n=3)	3	3	0.7	50%	SD,FG
	6/26/09	0.5	55.29	6.98	26.91	3.73	2	2	<0.1	80%	CY
Incline West	9/5/08	0.55	11.81	2.14	15.66	4.95	3	3	0.3	70%	CY,SD,FG
	1/23/09	0.5	18.83	4.97	28.34	13.07	3	3	0.3	80%	CY,FG
	3/10/09	0.5	40.19	8.34	38.52	4.98	3	3	0.4	80%	FG,SD,CY
	4/22/09	0.5	31.20	2.84(n=3)	47.21	3.92(n=3)	4	4	1.2	90%	FG,SD,CY
	6/25/09	0.5	53.66	18.28	67.01	22.62	3	3	0.7	90%	CY,SD,FG
Sand Point	8/15/08	0.34	12.67	1.75	22.99	2.59	3	3	0.8	50%	FG,CY
	1/23/09	0.5	23.44	1.47	30.09	1.89	3	3	0.2	90%	CY
	3/10/09	0.5	21.83	4.63	27.25	2.24	3	3	0.3	80%	FG,CY
	4/10/08	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	6/25/09	0.5	37.34	6.06	53.75	12.92	3.5	4	0.8	90%	FG,CY
Deadman Pt.	8/15/08	0.5	7.74	1.26	10.87	0.31	3	3	0.8	75%	FG,CY
	1/23/09	0.5	18.52	2.64	22.84	2.73	3	3	0.3	80%	CY,FG
	3/10/09	0.5	31.27	7.53	31.17	4.19	3	3	0.3	70%	CY,FG
	4/10/09	0.5	19.90	2.18(n=3)	30.85	3.67(n=3)	2	2	0.2	40%	CY,FG
	6/25/09	0.5	24.74	2.41	39.63	4.68	3.5	3.5	0.8	70%	FG,CY
Zephyr Point	8/15/08	0.5	7.42	1.76	8.84	2.40	3	2	0.1	70%	CY,SD,FG
	1/23/09	0.5	24.88	3.07	22.51	1.82	2	2	0.2	70%	CY,FG
	3/10/09	0.5	6.04	2.47	7.20	2.40	2	2	0.2	70%	FG,CY
	4/10/08	0.5	NA	NA	NA	NA	NA	NA	NA	NA	NA
	6/25/09		12.56	3.16	15.06	1.54	3.5	3.5	0.9	60%	FG,CY,SD

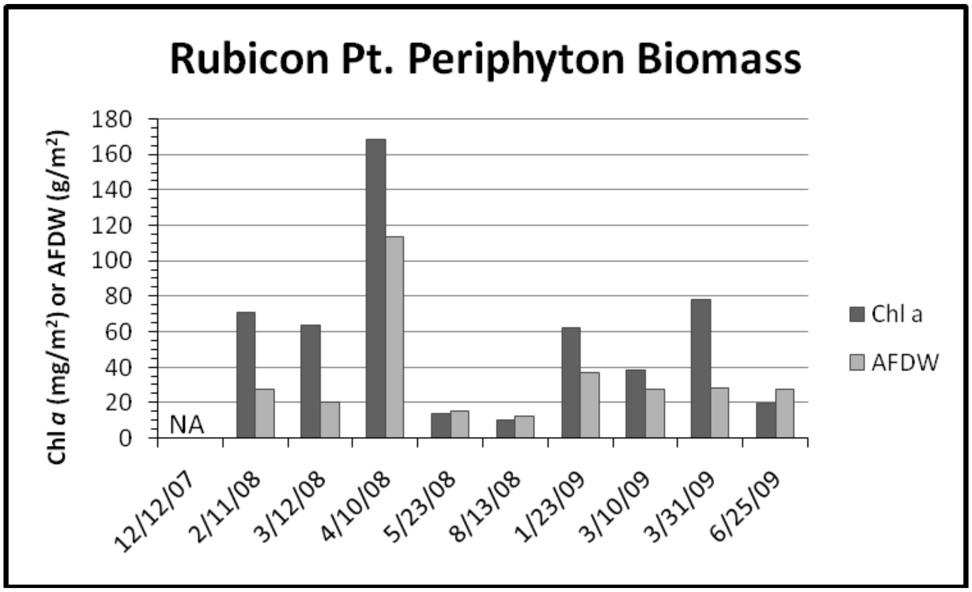


Figure 9.a. Rubicon Pt. periphyton Chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2009.

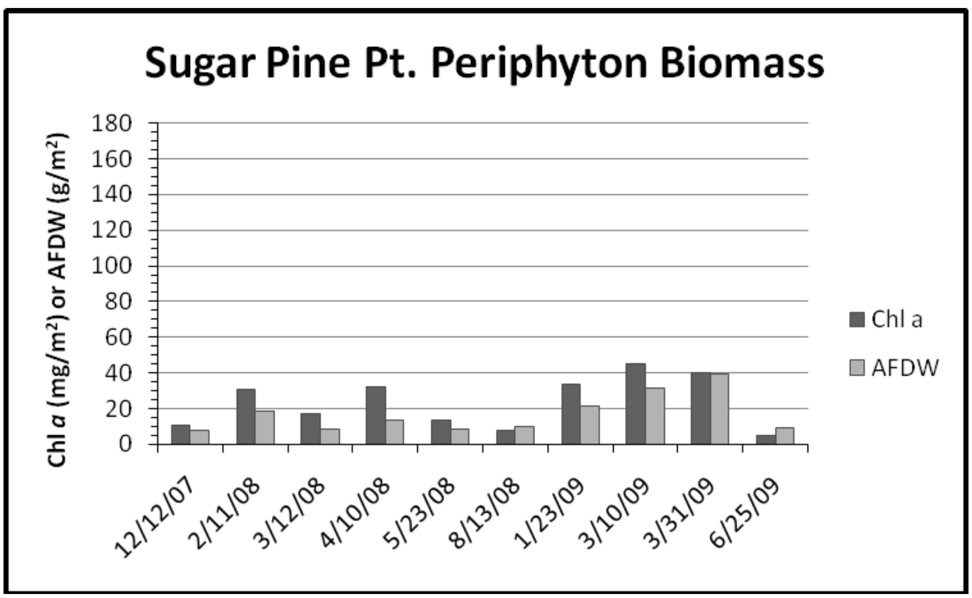


Figure 9.b. Sugar Pine Pt. periphyton Chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2009.

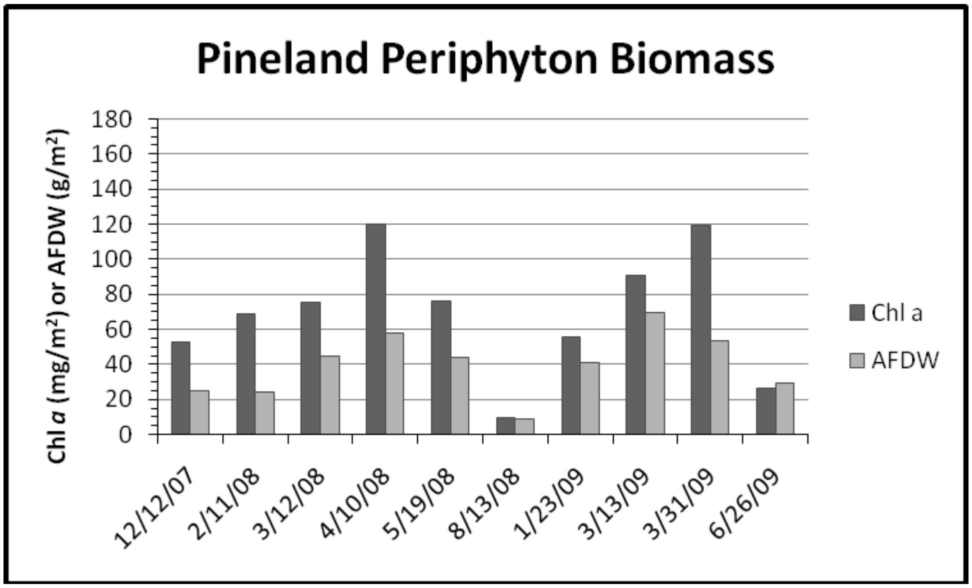


Figure 9.c. Pineland periphyton Chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2009.

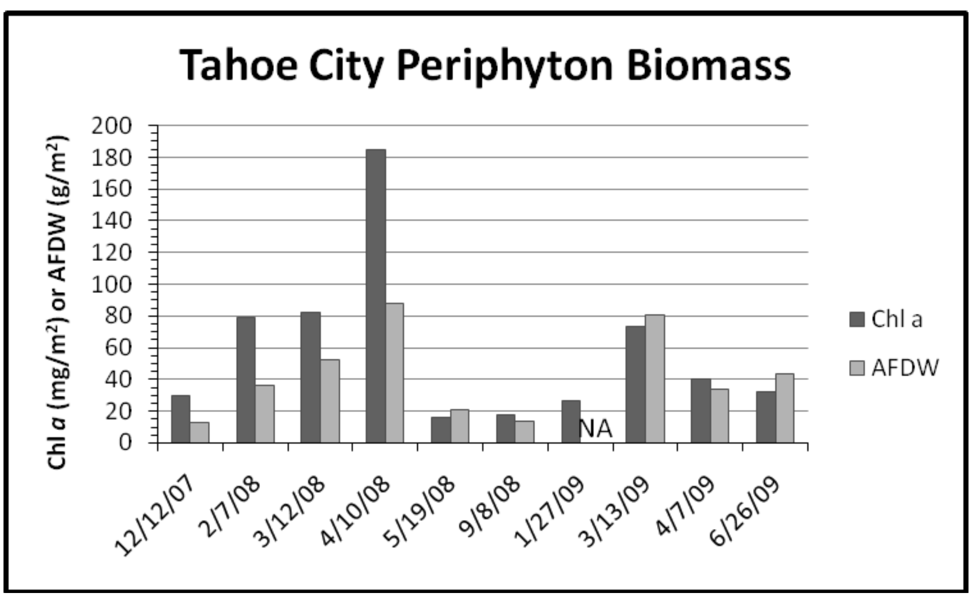


Figure 9.d. Tahoe City periphyton Chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2009.

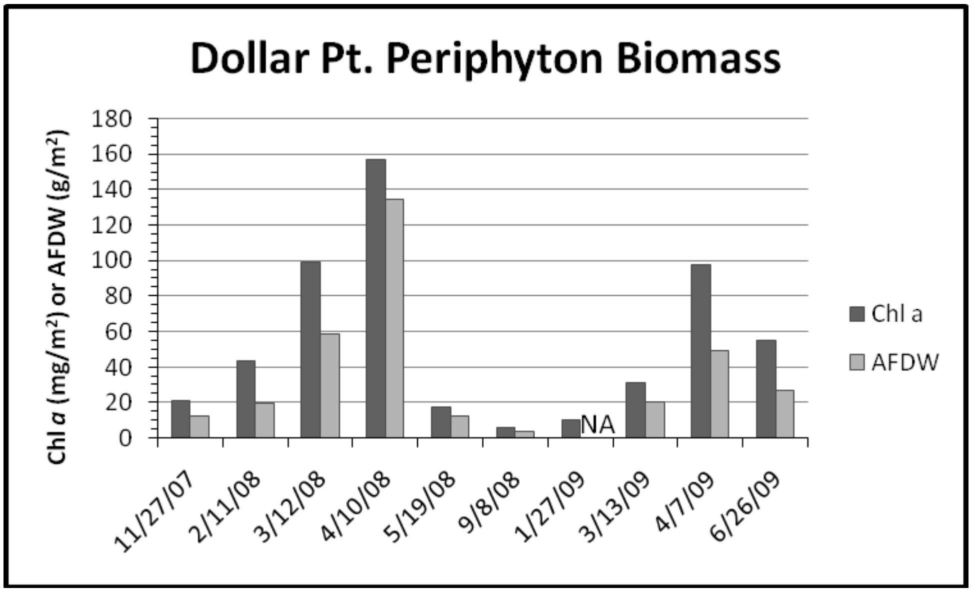


Figure 9.e. Dollar Pt. periphyton Chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2009.

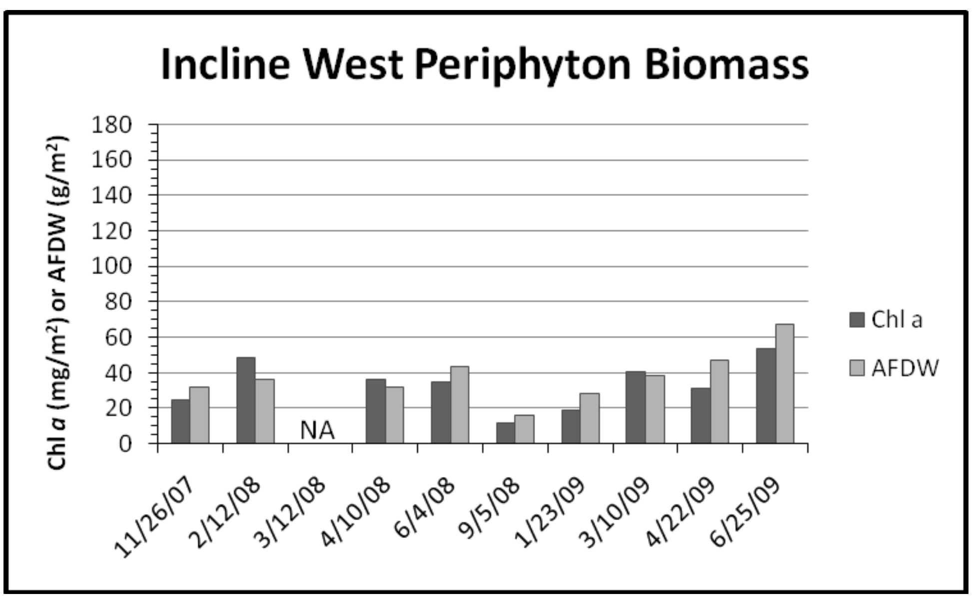


Figure 9.f. Incline West periphyton Chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2009.

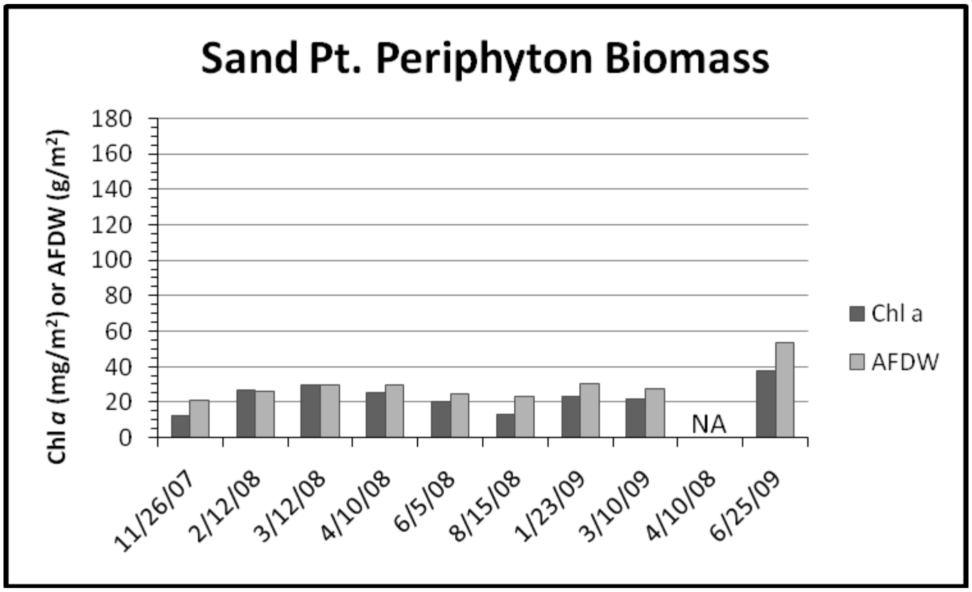


Figure 9.g. Sand Pt. periphyton Chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2009.

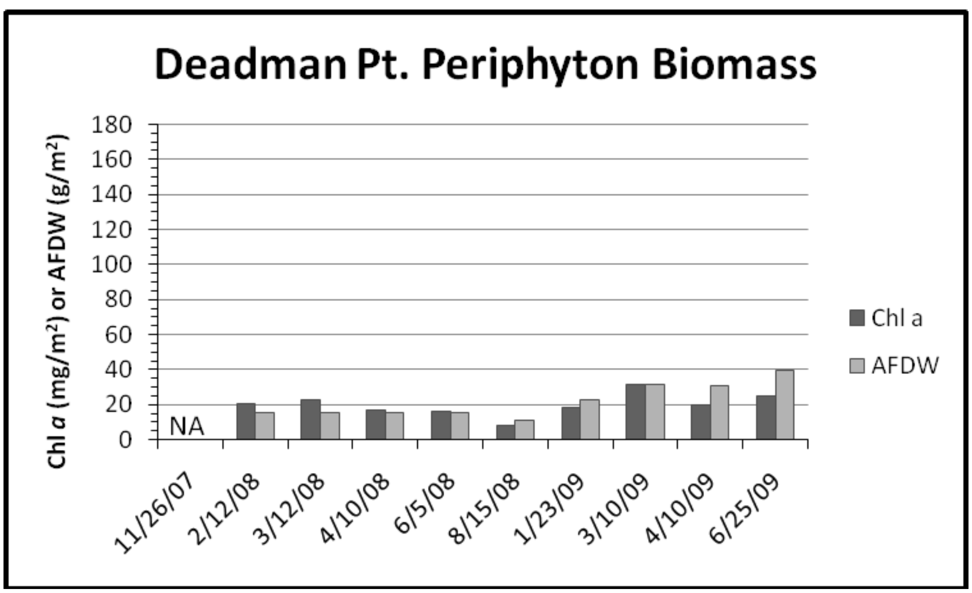


Figure 9.h. Deadman Pt. periphyton Chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2009.

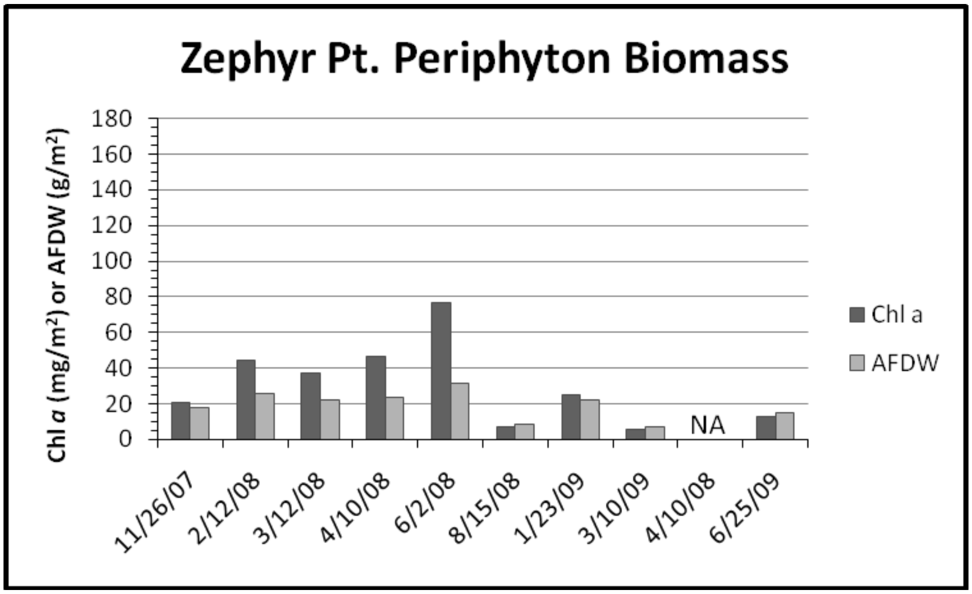


Figure 9.i. Zephyr Pt. periphyton Chlorophyll *a* (Chl *a*) and Ash Free Dry Weight Biomass (AFDW) at 0.5m July 1, 2007 to June 30, 2009.

Annual Maximum Biomass

WY 2006-WY2009 maximum biomass values as estimated by chlorophyll *a* for all sites are shown in Figure 10. Similar to recent years, maximum annual biomass levels in WY 2009 were high in the northwest portion of the lake (Pineland, Tahoe City and Dollar Pt.). Peak biomass was also high at Rubicon Pt. in WY 2009. Annual maximum chlorophyll *a* values at Incline West, Sand Pt., Deadman Pt. and Sugar Pine Pt. in 2009 were lower and relatively close to levels observed in WY 2006-WY2008. At Zephyr Pt., the WY2009 annual maximum was similar to that observed in WY2006 and WY2007 but much less than the maximum in WY2008. As noted above peak biomasses observed in WY2008 were very high at Zephyr Pt., Rubicon Pt., Dollar Pt. and Tahoe City.

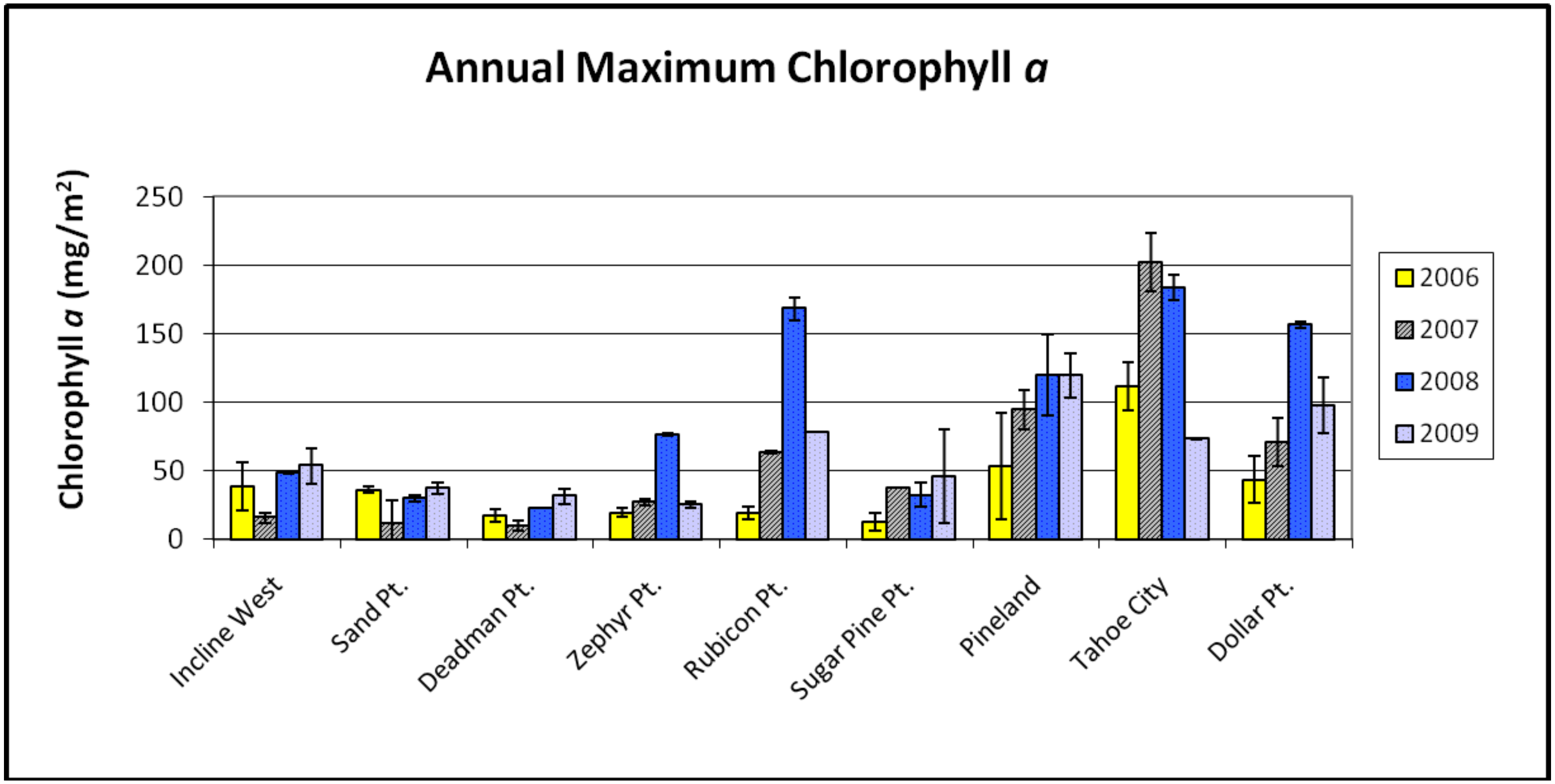


Figure 10. Annual maximum Chlorophyll *a* during Water Year 2009 compared with WY 2006-2008 at the nine routine periphyton monitoring sites at 0.5m. (*- Note, WY 2009 periphyton data was for partial year, i.e. through June 2009).

Expanded Monitoring Spring 2009

The expanded monitoring is designed to provide information on levels of growth at selected sites between the routine sites during the period of peak periphyton growth. For the expanded monitoring in 2009, a combination of visual assessments, interspersed with biomass sampling at selected sites was done. Samples for algal identification were also collected at many of the sites and archived. Sites used in the expanded monitoring in WY 2009 (Table 8) were many of the same used 2003-2008.

Expanded Monitoring Results

Results for the expanded monitoring done in 2009 are presented in Table 9. The expanded monitoring was divided into two periods this year. The west and north shores were sampled 3/31/09 – 4/16/09, a period when significant growth was observed there at many sites. Since growth of periphyton appeared to peak later in the spring and early summer along the east shore, we sampled there from 6/11/09-6/18/09. Some sites along the east shore ultimately may have been sampled past the peak. It is important to note that due to the issue of variable timing of growth and subsequent die-off of periphyton at various locations around the lake, this synoptic data is best considered as supplemental to the routine seasonal monitoring. Conclusions related to the ability of a specific site to support periphyton should be tempered by these considerations.

Along much of the west and northwest shores growth was variable with areas of heavy growth (underwater visual scores of 4-5) interspersed among stretches with low-to-moderate growth (underwater visual scores of 2 or 3). From Cascade Creek to So. Meeks Bay, growth was generally light (underwater visual scores of 2; Chlor. *a* at the two sites measured ranging 17-27 mg/m^2) except for the Emerald Bay/ Rubicon site where growth was relatively heavy (visual score of 4). From Tahoma to Agatam growth was variable, ranging from moderate (visual score of 3) to very heavy (scores of 5) at some sites. Sites with very heavy periphyton growth (underwater visual scores of 5) along the west and north portions of the lake included: a site near the mouth of Ward Cr. (Chlor. *a* was 211.26 mg/m^2), Tahoe City Tributary (Chlor. *a* was 118.54 mg/m^2), TCPUD boat ramp, and South Dollar Cr. These sites are in the northwest region of the lake where routine monitoring also indicates typically heavier spring growth. The algae at most of these sites appeared to be a mix of stalked diatoms and filamentous greens. At the Tahoe City Boat Ramp the assemblage appeared to be mostly stalked diatoms. There were also a couple of sites with moderate to heavy growth (visual scores of 4) in the region between Tahoma to Agatam, these included: S. Fleur du lac and Garwoods (where Chlor. *a* was 74.77 mg/m^2).

Along the stretch from Kings Beach to Burnt Cedar Beach in Incline Village, growth ranged from moderate (visual scores of 3) to moderate-heavy (visual scores of 4). Sites with visual scores of 4 included: Stillwater Cove and Brockway Springs.

Along the east shore from Observation Pt. to So. Elks Pt. generally moderate growth was observed in June. A couple sites with moderate-heavy growth (visual scores of 4) were observed and these included: So. Elk Pt. (Chlor. *a* 38.10 mg/m^2) and Cave Rock (Chlor. *a* 21.46 mg/m^2).

Table 8. Periphyton expanded monitoring locations.

SITE DESIGNATION	SITE NAME	LOCATION
	WEST SHORE	
A	Cascade Creek	N38 57.130; W120 04.615
B	S. of Eagle Point	N38 57.607; W120 04.660
C	E.Bay/Rubicon	N38 58.821; W120 05.606
D	Gold Coast	N39 00.789; W120 06.796
E	S. Meeks Point	N39 01.980; W120 06.882
G	Tahoma	N39 04.199; W120 07.771
H	S. Fleur Du Lac	N39 05.957; W120 09.774
I	Blackwood Creek	N39 06.411; W120 09.424
J	Ward Creek	N39 07.719; W120 09.304
K	N. Sunnyside	N39 08.385; W120 09.135
TCT	Tahoe City Tributary	(adjacent to T.C. Marina)
M	TCPUD Boat Ramp	N39 10.819; W120 07.177
O	S. Dollar Creek	N39 11.794; W120 05.699
P	Cedar Flat	N39 12.567; W120 05.285
Q	Garwood's	N39 13.486; W120 04.974
R	Flick Point	N39 13.650; W120 04.155
S	Stag Avenue	N39 14.212; W120 03.710
T	Agatam Boat Launch	N39 14.250; W120 02.932
	EAST SHORE	
E1	South side of Elk Point	N38 58.965; W119 57.399
E2	North Side of Elk Point	N38 59.284; W119 57.341
E3	South Side of Zephyr Point	N38 59.956; W119 57.566
E4	North Zephyr Cove	N39 00.920; W119 57.193
E5	Lincoln Park	N39 01.525; W119 56.997
E6	Cave Rock Ramp	N39 02.696; W119 56.935
E7	South Glenbrook Bay	N39 04.896;W119 56.955
E8	South Deadman Point	N39 05.998; W119 57.087
E9	Skunk Harbor	N39 07.856; W119 56.597
E10	Chimney Beach	N39 09.044; W119 56.008
E11	Observation Point	N39 12.580; W119 55.861
	NORTH SHORE	
E13	Burnt Cedar Beach	N39 14.680; W119 58.132
E15	North Stateline Point	N39 13.237; W120 00.193
E16	Brockway Springs	N39 13.560; W120 00.829
E17	Kings Beach Ramp Area	N39 14.009; W120 01.401
	SOUTH SHORE	
S1	Tahoe Keys Entrance	N38 56.398; W120 00.390
S2	Kiva Point	N38 56.555; W120 03.203

Table 9. Summary of 0.5m periphyton Chlorophyll a, Ash Free Dry Weight (AFDW), visual score, avg. filament length and % algal coverage, predominant algae present based on visual observations while snorkeling (FG=filamentous greens; SD=stalked diatoms; CY= blue green algae) for all expanded periphyton monitoring sites during 2009. Note for chlorophyll *a* and AFDW, n=2 unless otherwise indicated. Visual score is a subjective ranking of the aesthetic appearance of algal growth (viewed underwater) where 1 is the least offensive and 5 is the most offensive. "na" = not available or not collected; "nes" = not enough sample for analysis.

Site	Site Name	Date	Chl a (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (mg/m^2)	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Coverage %	Algal Type	Temp ºC
A	Cascade Creek	3/31/2009	26.93	3.57	11.80	5.02(n=3)	2	2	1.0	70%	FG	6.0
B	S. of Eagle Point	3/31/2009					2	2	0.5	30%	SD,FG	
C	E.Bay/Rubicon	3/31/2009					4	4	2.0	60%	SD,FG	
D	Gold Coast	3/31/2009					2	2	1.2	50%	SD,FG	6.0
E	S. Meeks Point	3/31/2009	17.44	5.54	19.35	6.34(n=3)	2	2	0.8	70%	FG,CY	5.9
G	Tahoma	3/31/2009					3	3	0.5	60%	SD	
H	S. Fleur Du Lac	3/31/2009					3	4	1.2	80%	FG,SD	7.5
I	Blackwood Creek	3/31/2009					2	3	0.3	70%	SD,SD,FG	6.5
J	Ward Creek	3/31/2009	211.26	22.68	80.35	17.46(n=3)	4	5	3.5	90%	SD,FG	5.5
K	N. Sunnyside	3/31/2009					3	3	1.0	60%	FG,SD	6.0
L	Tavern Pt.	3/31/2009					3	3	0.7	60%	SD,FG	8.8
TCT	Tahoe City Trib.	4/16/2009	118.54	41.20(n=3)	86.99	6.69(n=3)	5	5	4.0	100%	SD	7.0
M	TCPUD Boat R.	4/7/2009					5	5	1.5	70%	SD,FG	
N	S. Dollar Pt.	4/7/2009					2	3	0.5	40%	SD	
O	S. Dollar Creek	4/7/2009					5	5	3.5	80%	SD,FG	7.5
P	Cedar Flat	4/7/2009					3	3	0.7	60%	SD,FG	
Q	Garwood's	4/7/2009	74.77	16.41(n=3)	49.27	12.36(n=3)	NA	4	1.7	50%	SD,CY	7.0
R	Flick Point	4/7/2009					2	3	0.5	70%	SD,FG	8.0
S	Stag Avenue	4/7/2009					2	3	0.5	70%	SD,FG	8.0
T	Agatam Boat L.	4/7/2009	52.12	6.55(n=3)	33.81	5.96(n=3)	2	3	0.75	60%	SD	8.0
E1	So. side of Elk Pt	5/15/2009	38.10	13.56	27.12	6.32	NA	4	1.0	100%	SD,FG	
E4	No. Zephyr Cove	6/18/2009					3	3	0.5	50%	FG,SD	
E5	Lincoln Park	6/18/2009	18.07	3.72	22.93	0.47	2	3	0.5	50%	FG,CY	
E6	Cave Rock Ramp	6/11/2009	21.46	5.45	29.57	4.16	3	4	0.5	80%	FG,SD,CY	14.0
E7	So.Glenbrook Bay	4/10/2009					2	2	0.5	60%	CY,FG	6.5
E8	So. Deadman Pt.	4/10/2009					2	2	0.3	20%	SD,FG	6.0
E8	So. Deadman Pt.	6/18/2009					3	3	0.7	50%	FG,CY	

Site	Site Name	Date	Chl a (mg/m^2)	Std Dev (mg/m^2)	AFDW (g/m^2)	Std Dev (mg/m^2)	Above Visual Score	Below Visual Score	Fil. Length (cm)	Algal Coverage %	Algal Type	Temp ºC
E9	Skunk Harbor	6/18/2009					3.5	3.5	0.7	90%	FG,CY	
E10	Chimney Beach	6/11/2009	10.34	0.26	10.94	0.90	3	3	0.5	70%	SD,FG,CY	13.5
E11	Observation Point	6/18/2009	31.06	6.28	35.18	7.61	NA	3	1.0	70%	CY,SD,FG	
E13	Burnt Cedar Bch	4/16/2009	8.45	1.09(n=3)	15.47	4.05(n=3)	3	3	0.2	70%	SD,FG,CY	
E14	Stillwater Cove	4/22/2009					3	4	0.6	60%	FG,CY	
E15	North Stateline Pt	4/22/2009					3	3	0.3	70%	FG,CY	
E16	Brockway Springs	4/22/2009					3	4	0.7	70%	SD,FG,CY	9.2
E17	Kings Beach R.	4/16/2009					3	3	1.5	50%	SD	7.5
S1	T. Keys Entrance	3/20/2009	6.49	2.17	1.57	0.50	2	2	0.4	50%	SD,FG	
S2	Kiva Point	3/20/2009	103.28	0.50	60.40	4.91	NA	4	1.5	90%	SD	
E1	So. Elk Pt	2/3/2009	8.48	(n=1)	6.15	3.14	1	1	0.2	10%	SD	5.5
E1	So. Elk Pt	3/20/2009	7.42	0.50	3.66	0.72	NA	3	0.2	65%	SD,CY	6.5
E1	So. Elk Pt	5/15/2009	38.10	13.56	27.12	6.32	NA	4	1.0	100%	SD,FG	9.8
E1	So. Elk Pt	7/2/2009	32.42	15.42	30.79	6.40	3	4	0.9	80%	SD,FG	18.0*
S1	T. Keys Entrance	2/3/2009	83.79	39.76	40.52	2.75	3	3	0.4	40%	FG	4.0
S1	T. Keys Entrance	3/20/2009	6.49	2.17	1.57	0.50	2	2	0.4	50%	SD,FG	8.0
S1	T. Keys Entrance	5/13/2009	5.32	3.66	4.38	1.87	NA	3	0.2	40%	SD	14.5
S1	T. Keys Entrance	6/30/2009	4.30	0.41	3.62	(n=1)	3	2	0.2	50%	SD,FG	20.0
S2	Kiva Point	2/3/2009	25.66	1.91	21.29	1.35	NA	3	0.4	80%	SD	5.5
S2	Kiva Point	3/20/2009	103.28	0.50	60.40	4.91	NA	4	1.5	90%	SD	8.5
S2	Kiva Point	5/13/2009	27.59	8.83(n=3)	19.80	5.99	NA	3.5	1.2	80%	SD	13.0
S2	Kiva Point	6/30/2009	1.92	0.54	4.37	5.26	NA	2	NA	30%	SD	18.0

Growth of periphyton at three of the South Shore sites was monitored on four different dates during the period February to July 2009, this was more intensive than in the past. This monitoring was done to provide additional information for the SNPLMA Nearshore study and for our long-term monitoring. This monitoring provided valuable information on growth patterns and biomass peaks for periphyton in the South. At Kiva Beach, the highest biomass there was measured on March 20, 2009 and was very high (103.28 mg/m^2). Surprisingly large amounts of stalked diatoms were growing over the rocky substrate offshore of the sandy beach area at the Kiva site. Near the Tahoe Keys East Channel entrance, the peak biomass was measured on February 3, 2009 and found to be 83.79 mg/m^2. The algal assemblage was primarily filamentous green algae. Biomass at the So. Elks site was highest on the May 15, 2009 sampling and found to be 38.10 mg/m^2. The algal assemblage on that date was a mix of stalked diatoms and filamentous green algae.

Results from expanded monitoring done during the previous summer (2008) were included with last year's Annual Report (Hackley et al., 2008). Briefly, that monitoring showed that significant bright green filamentous periphyton was present at many sites around the lake near the surface in late summer. This algae became quite noticeable as the lake level declined rapidly at the end of the summer. Analysis of the algae indicated it was an attached form of *Zygnema* sp., and blue green algae were also present at many sites. Slightly deeper at 0.5m, at the routine sites during this period, biomass was at or near minimum levels for the year (see Figure 10 above).

Summer of 2008 was also extremely interesting as a bloom of masses of bright green filamentous algae *Zygnema* occurred in Marla Bay just above the bottom. This algae was not strictly attached to rocks or other substrate as periphyton, nor strictly free-floating, but was found as large clumps or masses hovering just above the bottom. (Such algae which is neither strictly attached as periphyton nor strictly planktonic as phytoplankton is called metaphyton.) TERC was involved with much work related to this bloom. For more information specifically related to this bloom the reader is directed to Wittmann et al. (2008).

Task 7. Angora Burn Area Monitoring

The results of the Angora Burn Area Monitoring will be discussed in a separate report.

References

Hackley, S. H., Allen, B.C., Hunter, D.A., and J.E. Reuter. 2004. Lake Tahoe water quality investigations: algal bioassay, phytoplankton, atmospheric nutrient deposition, periphyton. Final report submitted to State Water Resources Control Board, Lahontan Regional Water Quality Control Board. Tahoe Research Group, University of California, Davis.

Hackley, S. H., Allen, B.C., Hunter, D.A., and J.E. Reuter. 2007. Lake Tahoe water quality investigations: algal bioassay, phytoplankton, atmospheric nutrient deposition, periphyton, Final Report 2004-2007. Submitted to State Water Resources Control Board, Lahontan Regional Water Quality Control Board. Tahoe Environmental Research Center, University of California, Davis. 121p.

Hackley, S. H., Allen, B.C., Hunter, D.A., and J.E. Reuter. 2008. Lake Tahoe water quality investigations: algal bioassay, phytoplankton, atmospheric nutrient deposition, periphyton, Annual Report, July 1, 2007 – June 30, 2008. Submitted to State Water Resources Control Board, Lahontan Regional Water Quality Control Board. Tahoe Environmental Research Center, University of California, Davis. 67p.

Janik, M., Byron, E., Hunter, D., and Reuter J.E. 1990. Lake Tahoe Interagency Monitoring Program: Quality Assurance Manual, 2nd Edition. Division of Environmental Studies, Univ. of California, Davis. 75 p.

KCRA.com. 2008. 2 Fires Merge In American River Complex: Firefighters Work To Extinguish Government Springs, Westville Fires. News story 7/10/08, KCRA.com. http://www.kcra.com/print/16844961/detail.html

Winder, M. and Hunter, D. A. 2008. Temporal organization of phytoplankton communities linked to physical forcing. Oecologia 156:179–192

Winder, M. and Hunter, D. A. 2009. Long-term changes of the chrysophyte population in Lake Tahoe. Verh. Internat. Verein. Limnol., vol. 30, Part 7, p. 1051–1055

Winder, M., Reuter, J. E. and Schladow, S. G. 2009. Lake warming favors small-sized planktonic diatom species. Proc. Royal Society B. 276, 427-435

Wittmann, M., Reuter, J., Schladow, G., Hackley, S., Allen, B., Chandra, S. and Caires, A. 2008. Asian clam of Lake Tahoe: Preliminary scientific findings in support of a management plan. University of California at Davis, Tahoe Environmental Research Center and University of Nevada Reno, Department of Natural Resources.

Appendix Table 1.a. Precipitation amounts, N and P concentrations in wet deposition at the Ward Valley Lake Level Station 7/1/08-9/30/09.

Samp. No.	Ward Valley Wet Collection Date-Time	Lake Level Precip. (in)	Precip. Form	Collector Type	Wet Bkt Amt. (in)	(Conc.) NO_3-N (µg/l)	NH_4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
36	7/21/08 12:15	0.01	R	WET	0.01	45.77	75.51	72.49	3.17	6.42	8.85	63
	9/17/08 10:15	T	R	WET	T	NA	NA	NA	NA	NA	NA	71
37	10/8/2008 11:40	1.29	R	WET	1.29	28.52	11.13	58.92	10.56	10.23	14.88	85
38	11/7/2008 10:45	3.77	R+S	WET	3.77	37.98	46.71	97.92	8.99	10.97	11.89	
39	11/14/2008 10:00	0.29	R	WET	0.29	93.53	98.3	450.47	3.15	4.27	4.88	
40	12/5/2008 9:30	0.21	R+S	WET	0.21	113.69	41.15	86.94	0.9	1.54	2.47	
41	12/15/2008 17:30	1.88e	S	WET	0.43+	72.4	63.36	246.78	6.08	23.85	66.58	86
42	12/17/2008 10:30	0.39	S	WET	0.39	36.45	28.55	46.12	0.9	2.48	9.6	
43	12/21/2008 12:00	1.67e	R+S	WET	0.37+	14.08	8.63	73.04	2.25	3.72	13.94	87
44	12/23/2008 14:50	1.07e	S	WET	0.6+	17.81	11.64	30.03	2.93	4.96	5.26	88
45	12/26/2008 12:30	2.35	S	WET	2.35	10.45	8.42	41.57	2.95	4.34	6.81	89
46	1/7/2009 17:15	0.86	S	WET	0.86	30	13.08	64.38	4.31	5.9	10.84	
47	1/28/2009 10:05	2.51	R+S	WET	2.51	118.4	16.86	8.93	0.9	2.17	2.77	
48	2/9/2009 17:15	1.01	S	WET	1.01	40.26	61.38	112.21	2.71	4.35	8.04	98
49	2/15/2009 12:15	0.68	S	WET	0.68	34.37	39.5	98.08	2.03	3.41	4.97	
50	2/16/2009 14:30	0.64	S	WET	0.64	14.3	13.36	NA	1.58	3.1	3.41	
51	2/18/2009 13:15	0.64	S	WET	0.64	19.61	25.75	170.85	0.9	2.79	3.1	
52	2/26/2009 10:30	2.42	R+S	WET	2.42	22.73	16.51	71.75	2.26	4.25	5.16	
53	2/28/2009 13:15	0.28	R	WET	0.28	29.33	47.34	72.5	1.35	3.04	5.16	
54	3/3/2009 14:20	4.37	R+S+G	WET	4.37	21.81	40.53	119.67	4.51	3.64	10.32	99
55	3/4/2009 13:30	1.5	S	WET	1.39	10.45	14.57	82.07	1.13	1.72	1.87	100
56	3/9/2009 17:10	0.15	S	WET	0.15	129.07	141.04	477.23	2.26	3.11	6.22	
57	3/21/2009 14:00	0.52		WET	0.52	93.51	127.44	150.51	4.51	4.35	11.18	
58	3/23/2009 12:00	1.45	S	WET	0.66	41.31	34.72	80.31	1.8	2.17	6.21	101
59	4/3/2009 15:40	0.16	S+G	WET	0.16	78.99	121.24	161.16	7.23	9.01	21.73	111
60	4/17/2009 18:25	0.29	S	WET	0.29	133.71	139.05	263.53	11.25	17.01	21.96	
61	4/28/2009 10:00	0.41	S	WET	0.41	112.56	45.01	121.87	7.4	8.98	15.79	

Samp. No.	Ward Valley Wet Collection Date-Time	Lake Level Precip. (in)	Precip. Form	Collector Type	Wet Bkt Amt. (in)	(Conc.) NO_3-N (µg/l)	NH_4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
62	5/5/2009 16:45	4.96	R	WET	4.96	40.41	57.46	149.44	2.02	3.08	3.12	
63	5/26/2009 12:00	0.1	R	WET	0.1	246.3	442.62	NA	23.34	29.6	112.52	112
64	6/5/2009 13:20	1.0e	R+H	WET	1.0e	NA	NA	NA	NA	NA	NA	113
65	6/9/2009 11:30	0.02	R	WET	0.02	30.19	37.64	179.98	0.45	0.94	3.1	114
66	6/19/2009 12:25	0.21	R	WET	0.21	140.82	123.78	268.76	0.68	2.44	6.52	
67	7/14/2009 9:50	0.12	R	WET	0.12	107.44	39.77	167.09	5.61	8.14	10.37	121
68	8/9/2009 11:30	0.11	R	WET	0.11	135.81	58.2	137.62	0.67	1.54	5.84	122
69	8/28/2009 12:20	0.01	R	WET	0.01	49.36	45.77	NA	1.61	1.83	1.53	123
70	9/30/2009 16:40	T		WET	0.001	5.67	12.95	NA	2.65	NA	NA	124

Appendix Table 1.b. Precipitation loads of N and P in wet deposition at the Ward Valley Lake Level Station 7/1/08-9/30/09.

Samp. No.	Ward Valley Wet Collection Date-Time	Lake Level Precip. (in)	Precip. Form	Collector Type	Wet Bkt Amt. (in)	(Load) NO_3-N (g/ha)	NH_4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
36	7/21/08 12:15	0.01	R	WET	0.01	3.57	5.89	NA	0.25	0.50	0.69	63
	9/17/08 10:15	T	R	WET	T	NA	NA	NA	NA	NA	NA	71
37	10/8/2008 11:40	1.29	R	WET	1.29	9.34	3.65	19.31	3.46	3.35	4.88	85
38	11/7/2008 10:45	3.77	R+S	WET	3.77	36.37	44.73	93.77	8.61	10.50	11.39	
39	11/14/2008 10:00	0.29	R	WET	0.29	6.89	7.24	33.18	0.23	0.31	0.36	
40	12/5/2008 9:30	0.21	R+S	WET	0.21	6.06	2.19	4.64	0.05	0.08	0.13	
41	12/15/2008 17:30	1.88e	S	WET	0.43+	7.91	6.92	26.95	0.66	2.60	7.27	86
42	12/17/2008 10:30	0.39	S	WET	0.39	3.61	2.83	4.57	0.09	0.25	0.95	
43	12/21/2008 12:00	1.67e	R+S	WET	0.37+	1.32	0.81	6.86	0.21	0.35	1.31	87
44	12/23/2008 14:50	1.07e	S	WET	0.6+	2.71	1.77	4.58	0.45	0.76	0.80	88
45	12/26/2008 12:30	2.35	S	WET	2.35	6.24	5.03	24.81	1.76	2.59	4.06	89
46	1/7/2009 17:15	0.86	S	WET	0.86	6.55	2.86	14.06	0.94	1.29	2.37	
47	1/28/2009 10:05	2.51	R+S	WET	2.51	75.48	10.75	5.69	0.57	1.38	1.77	
48	2/9/2009 17:15	1.01	S	WET	1.01	10.33	15.75	28.79	0.70	1.12	2.06	98
49	2/15/2009 12:15	0.68	S	WET	0.68	5.94	6.82	16.94	0.35	0.59	0.86	
50	2/16/2009 14:30	0.64	S	WET	0.64	2.32	2.17	NA	0.26	0.50	0.55	
51	2/18/2009 13:15	0.64	S	WET	0.64	3.19	4.19	27.77	0.15	0.45	0.50	
52	2/26/2009 10:30	2.42	R+S	WET	2.42	13.97	10.15	44.10	1.39	2.61	3.17	
53	2/28/2009 13:15	0.28	R	WET	0.28	2.09	3.37	5.16	0.10	0.22	0.37	
54	3/3/2009 14:20	4.37	R+S+G	WET	4.37	24.21	44.99	132.83	5.01	4.04	11.45	99
55	3/4/2009 13:30	1.5	S	WET	1.39	3.69	5.14	28.98	0.40	0.61	0.66	100
56	3/9/2009 17:10	0.15	S	WET	0.15	4.92	5.37	18.18	0.09	0.12	0.24	
57	3/21/2009 14:00	0.52		WET	0.52	12.35	16.83	19.88	0.60	0.57	1.48	
58	3/23/2009 12:00	1.45	S	WET	0.66	6.93	5.82	13.46	0.30	0.36	1.04	101
59	4/3/2009 15:40	0.16	S+G	WET	0.16	6.16	9.45	12.56	0.56	0.70	1.69	111
60	4/17/2009 18:25	0.29	S	WET	0.29	9.85	10.24	19.41	0.83	1.25	1.62	
61	4/28/2009 10:00	0.41	S	WET	0.41	11.72	4.69	12.69	0.77	0.94	1.64	

Samp. No.	Ward Valley Wet Collection Date-Time	Lake Level Precip. (in)	Precip. Form	Collector Type	Wet Bkt Amt. (in)	(Load) NO_3-N (g/ha)	NH_4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
62	5/5/2009 16:45	4.96	R	WET	4.96	50.91	72.39	188.27	2.54	3.88	3.93	
63	5/26/2009 12:00	0.1	R	WET	0.1	6.26	11.24	NA	0.59	0.75	2.86	112
64	6/5/2009 13:20	1.0e	R+H	WET	1.0e	NA	NA	NA	NA	NA	NA	113
65	6/9/2009 11:30	0.02	R	WET	0.02	1.20	1.50	7.16	0.02	0.04	0.12	114
66	6/19/2009 12:25	0.21	R	WET	0.21	7.51	6.60	14.34	0.04	0.13	0.35	
67	7/14/2009 9:50	0.12	R	WET	0.12	3.27	1.21	5.09	0.17	0.25	0.32	121
68	8/9/2009 11:30	0.11	R	WET	0.11	10.59	4.54	10.73	0.05	0.12	0.46	122
69	8/28/2009 12:20	0.01	R	WET	0.01	3.85	3.57	NA	0.13	0.14	0.12	123
70	9/30/2009 16:40	T		WET	0.001	0.44	1.01	NA	0.21	NA	NA	124

Appendix Table 2.a. N and P concentrations in dry deposition at the Ward Valley Lake Level Station 6/23/08-10/2/09.

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	Conc. NO_3-N (µg/l)	NH_4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
32	6/23/2008 13:35	7/7/2008 17:55	1.852	DF	DRY	14.04	2.41	1003.98	12.64	43.6	124.16	64
33	7/7/2008 17:55	7/10/2008 13:10	3.462	DF	DRY	26.23	27.2	209.37	155.39	157.54	224.65	65
34	7/10/2008 13:10	7/15/2008 13:20	3.236	DF	DRY	15.08	5.95	492.37	28.55	32.73	58.43	66
35	7/15/2008 13:20	7/21/2008 12:15	3.055	DF	DRY	13.68	5.22	161.42	3.62	7.65	13.42	67
36	7/21/2008 12:15	7/29/2008 10:10	2.613	DF	DRY	9.2	5.23	162.14	NA	12.24	23.49	68
37	7/29/2008 10:10	8/20/2008 20:15	0.73	DF	DRY	C	C	C	C	C	C	69
38	8/20/2008 20:15	9/5/2008 17:45	1.655	DF	DRY	C	C	C	C	C	C	70
39	9/5/2008 17:45	9/17/2008 10:15	2.627	DF	DRY	15.97	9.54	268.75	1.35	3.4	11.14	72
40	9/17/2008 10:15	10/8/2008 11:40	2.637	DF	DRY	3.69	5.14	531.3	3.93	6.47	10.54	90
41	10/8/2008 11:40	10/20/2008 17:10	3.487	DF	DRY	3.31	10.95	194.07	19.99	25.57	26.48	91
42	10/20/2008 17:10	11/7/2008 10:45	3.5	DF	DRY	22.26	30.73	319.07	20.01	15.54	22.4	
43	11/7/2008 10:45	11/20/2008 10:45	3.807	DF	DRY	8.83	21.47	293.41	2.04	4.88	6.71	
44	11/20/2008 10:45	12/5/2008 9:30	2.917	DF	DRY	13.36	22.06	NA	2.71	4.95	6.49	92
45	12/5/2008 9:30	12/17/2008 10:30	4.206	DF+S	DRY	16.48	16.67	61.33	1.58	3.69	6.16	93
46	12/17/2008 10:30	12/23/2008 14:50	4.974	DF+S	DRY	11.54	12.62	70.59	3.83	6.35	8.36	94
47	12/23/2008 14:50	1/7/2009 17:15	2.939	DF	DRY	9.38	20.33	56.85	2.27	3.42	15.48	102
48	1/7/2009 17:15	1/15/2009 10:30	3.975	DF	DRY	4.86	8.81	32.58	1.36	3.42	12.72	103
49	1/15/2009 10:30	1/28/2009 10:05	3.105	DF	DRY	17.17	19.29	54.42	3.16	2.48	13.3	104
50	1/28/2009 10:05	2/5/2009 10:45	3.486	DF	DRY	8.5	17.68	74.96	2.25	13.35	13	105
51	2/5/2009 10:45	2/26/2009 10:30	3.901	DF	DRY	25.66	23.92	272.07	8.59	10.93	18.38	105
52	2/26/2009 10:30	3/9/2009 17:10	3.081	DF	DRY	20.51	31.57	81.68	2.49	4.35	11.2	
53	3/9/2009 17:10	3/20/2009 17:45	2.385	DF	DRY	16.49	14.5	59.76	1.58	1.86	10.55	
54	3/20/2009 17:45	4/3/2009 15:40	2.173	DF	DRY	21.17	17.28	101.45	4.07	1.86	21.73	
55	4/3/2009 15:40	4/17/2009 18:25	1.76	DF	DRY	42.94	40.16	144.35	4.05	8.04	21.65	
56	4/17/2009 18:25	4/28/2009 10:00	2.088	DF	DRY	26.77	10.89	314.4	2.92	9.29	24.15	115
57	4/28/2009 10:00	5/26/2009 12:00	2.048	DF	DRY	13.49	15.83	1098.96	9.2	38.79	146.55	113
58	5/26/2009 12:00	6/5/2009 13:20	3.907	DF	DRY	76.72	169.78	561.03	1.34	8.87	15.6	
59	6/5/2009 13:20	6/19/2009 12:25	2.743	DF	DRY	21.19	12.69	268.76	7.21	10.87	17.69	
60	6/19/2009 12:25	6/26/2009 12:30	3.048	DF	DRY	3.47	11.97	296.67	2.18	5.28	21.44	

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	Conc. NO_3-N (μg/l)	NH_4-N (μg/l)	TKN (μg/l)	SRP (μg/l)	DP (μg/l)	TP (μg/l)	Notes
61	6/26/2009 12:30	7/5/2009 11:00	2.705	DF	DRY	6.13	69.89	588.73	1.73	8.7	46.3	
62	7/5/2009 11:00	7/14/2009 9:50	2.552	DF	DRY	6.78	10.95	274.34	3.37	10.64	21.6	121
63	7/5/2009 11:00	7/22/2009 10:00	2.357	DF	DRY	7.68	25.14	543.47	2.37	3.05	14.33	125
64	7/22/2009 10:00	8/9/2009 11:30	2.798	DF	DRY	10.9	18.81	586.26	2.47	4.92	23.05	
65	8/9/2009 11:30	8/28/2009 12:20	1.47	DF	DRY	10.66	2.92	NA	3.14	7.03	117.02	126
66	8/28/2009 12:20	9/9/2009 13:30	2.325	DF	DRY	10.66	6.98	NA	2.7	4.91	11.35	
67	9/9/2009 13:30	9/22/2009 15:10		DF	DRY	C	C	C	C	C	C	127
68	9/22/2009 15:10	10/2/2009 10:45	3.013	DF	DRY	7.4	7.99	NA	22.73	NA	NA	128

Appendix Table 2.b. N and P loads in dry deposition at the Ward Valley Lake Level Station 6/23/08-10/2/09.

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load) NO_3-N (g/ha)	NH_4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
32	6/23/2008 13:35	7/7/2008 17:55	1.852	DF	DRY	5.13	0.88	366.95	4.62	15.94	45.38	64
33	7/7/2008 17:55	7/10/2008 13:10	3.462	DF	DRY	17.92	18.58	143.05	106.17	107.64	153.49	65
34	7/10/2008 13:10	7/15/2008 13:20	3.236	DF	DRY	9.63	3.80	314.44	18.23	20.90	37.32	66
35	7/15/2008 13:20	7/21/2008 12:15	3.055	DF	DRY	8.25	3.15	97.32	2.18	4.61	8.09	67
36	7/21/2008 12:15	7/29/2008 10:10	2.613	DF	DRY	4.74	2.70	83.61	NA	6.31	12.11	68
37	7/29/2008 10:10	8/20/2008 20:15	0.73	DF	DRY	C	C	C	C	C	C	69
38	8/20/2008 20:15	9/5/2008 17:45	1.655	DF	DRY	C	C	C	C	C	C	70
39	9/5/2008 17:45	9/17/2008 10:15	2.627	DF	DRY	8.28	4.95	139.33	0.70	1.76	5.78	72
40	9/17/2008 10:15	10/8/2008 11:40	2.637	DF	DRY	1.92	2.67	276.50	2.05	3.37	5.49	90
41	10/8/2008 11:40	10/20/2008 17:10	3.487	DF	DRY	2.28	7.54	133.55	13.76	17.60	18.22	91
42	10/20/2008 17:10	11/7/2008 10:45	3.5	DF	DRY	15.38	21.23	220.39	13.82	10.73	15.47	
43	11/7/2008 10:45	11/20/2008 10:45	3.807	DF	DRY	6.63	16.13	220.45	1.53	3.67	5.04	
44	11/20/2008 10:45	12/5/2008 9:30	2.917	DF	DRY	7.69	12.70	NA	1.56	2.85	3.74	92
45	12/5/2008 9:30	12/17/2008 10:30	4.206	DF+S	DRY	13.68	13.84	50.91	1.31	3.06	5.11	93
46	12/17/2008 10:30	12/23/2008 14:50	4.974	DF+S	DRY	11.33	12.39	69.29	3.76	6.23	8.21	94
47	12/23/2008 14:50	1/7/2009 17:15	2.939	DF	DRY	5.44	11.79	32.97	1.32	1.98	8.98	102
48	1/7/2009 17:15	1/15/2009 10:30	3.975	DF	DRY	3.81	6.91	25.56	1.07	2.68	9.98	103
49	1/15/2009 10:30	1/28/2009 10:05	3.105	DF	DRY	10.52	11.82	33.35	1.94	1.52	8.15	104
50	1/28/2009 10:05	2/5/2009 10:45	3.486	DF	DRY	5.85	12.16	51.57	1.55	9.18	8.94	105
51	2/5/2009 10:45	2/26/2009 10:30	3.901	DF	DRY	19.75	18.42	209.46	6.61	8.41	14.15	105
52	2/26/2009 10:30	3/9/2009 17:10	3.081	DF	DRY	12.47	19.20	49.67	1.51	2.64	6.81	
53	3/9/2009 17:10	3/20/2009 17:45	2.385	DF	DRY	7.76	6.82	28.13	0.74	0.88	4.97	
54	3/20/2009 17:45	4/3/2009 15:40	2.173	DF	DRY	9.08	7.41	43.51	1.75	0.80	9.32	
55	4/3/2009 15:40	4/17/2009 18:25	1.76	DF	DRY	14.91	13.95	50.14	1.41	2.79	7.52	
56	4/17/2009 18:25	4/28/2009 10:00	2.088	DF	DRY	11.03	4.49	129.56	1.20	3.83	9.95	115
57	4/28/2009 10:00	5/26/2009 12:00	2.048	DF	DRY	5.45	6.40	444.18	3.72	15.68	59.23	113
58	5/26/2009 12:00	6/5/2009 13:20	3.907	DF	DRY	59.16	130.91	432.59	1.03	6.84	12.03	
59	6/5/2009 13:20	6/19/2009 12:25	2.743	DF	DRY	11.47	6.87	145.49	3.90	5.88	9.58	
60	6/19/2009 12:25	6/26/2009 12:30	3.048	DF	DRY	2.09	7.20	178.46	1.31	3.18	12.90	

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load) NO_3-N (g/ha)	NH_4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
61	6/26/2009 12:30	7/5/2009 11:00	2.705	DF	DRY	3.27	37.31	314.29	0.92	4.64	24.72	
62	7/5/2009 11:00	7/14/2009 9:50	2.552	DF	DRY	3.41	5.51	138.17	1.70	5.36	10.88	121
63	7/5/2009 11:00	7/22/2009 10:00	2.357	DF	DRY	3.57	11.69	252.80	1.10	1.42	6.67	125
64	7/22/2009 10:00	8/9/2009 11:30	2.798	DF	DRY	6.02	10.39	323.73	1.36	2.72	12.73	
65	8/9/2009 11:30	8/28/2009 12:20	1.47	DF	DRY	3.09	0.85	NA	0.91	2.04	33.95	126
66	8/28/2009 12:20	9/9/2009 13:30	2.325	DF	DRY	4.89	3.20	NA	1.24	2.25	5.21	
67	9/9/2009 13:30	9/22/2009 15:10		DF	DRY	NA	C	C	C	C	C	127
68	9/22/2009 15:10	10/2/2009 10:45	3.013	DF	DRY	4.40	4.75	NA	13.52	NA	NA	128

Appendix Table 2.c. N and P loading per day in dry deposition at the Ward Valley Lake Level Station 6/23/08-10/2/09.

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load/day) NO_3-N (g/ha/d)	NH_4-N (g/ha/d)	TKN (g/ha/d)	SRP (g/ha/d)	DP (g/ha/d)	TP (g/ha/d)	Notes
32	6/23/2008 13:35	7/7/2008 17:55	1.852	DF	DRY	0.36	0.06	25.88	0.33	1.12	3.20	64
33	7/7/2008 17:55	7/10/2008 13:10	3.462	DF	DRY	6.40	6.63	51.05	37.89	38.41	54.78	65
34	7/10/2008 13:10	7/15/2008 13:20	3.236	DF	DRY	1.92	0.76	62.80	3.64	4.17	7.45	66
35	7/15/2008 13:20	7/21/2008 12:15	3.055	DF	DRY	1.39	0.53	16.34	0.37	0.77	1.36	67
36	7/21/2008 12:15	7/29/2008 10:10	2.613	DF	DRY	0.60	0.34	10.57	NA	0.80	1.53	68
37	7/29/2008 10:10	8/20/2008 20:15	0.73	DF	DRY	C	C	C	C	C	C	69
38	8/20/2008 20:15	9/5/2008 17:45	1.655	DF	DRY	C	C	C	C	C	C	70
39	9/5/2008 17:45	9/17/2008 10:15	2.627	DF	DRY	0.71	0.42	11.92	0.06	0.15	0.49	72
40	9/17/2008 10:15	10/8/2008 11:40	2.637	DF	DRY	0.09	0.13	13.13	0.10	0.16	0.26	90
41	10/8/2008 11:40	10/20/2008 17:10	3.487	DF	DRY	0.19	0.62	10.92	1.12	1.44	1.49	91
42	10/20/2008 17:10	11/7/2008 10:45	3.5	DF	DRY	0.87	1.20	12.43	0.78	0.61	0.87	
43	11/7/2008 10:45	11/20/2008 10:45	3.807	DF	DRY	0.51	1.24	16.96	0.12	0.28	0.39	
44	11/20/2008 10:45	12/5/2008 9:30	2.917	DF	DRY	0.51	0.85	NA	0.10	0.19	0.25	92
45	12/5/2008 9:30	12/17/2008 10:30	4.206	DF+S	DRY	1.14	1.15	4.23	0.11	0.25	0.42	93
46	12/17/2008 10:30	12/23/2008 14:50	4.974	DF+S	DRY	1.83	2.00	11.21	0.61	1.01	1.33	94
47	12/23/2008 14:50	1/7/2009 17:15	2.939	DF	DRY	0.36	0.78	2.18	0.09	0.13	0.59	102
48	1/7/2009 17:15	1/15/2009 10:30	3.975	DF	DRY	0.49	0.90	3.31	0.14	0.35	1.29	103
49	1/15/2009 10:30	1/28/2009 10:05	3.105	DF	DRY	0.81	0.91	2.57	0.15	0.12	0.63	104
50	1/28/2009 10:05	2/5/2009 10:45	3.486	DF	DRY	0.73	1.52	6.42	0.19	1.14	1.11	105
51	2/5/2009 10:45	2/26/2009 10:30	3.901	DF	DRY	0.94	0.88	9.98	0.32	0.40	0.67	105
52	2/26/2009 10:30	3/9/2009 17:10	3.081	DF	DRY	1.11	1.70	4.40	0.13	0.23	0.60	
53	3/9/2009 17:10	3/20/2009 17:45	2.385	DF	DRY	0.70	0.62	2.55	0.07	0.08	0.45	
54	3/20/2009 17:45	4/3/2009 15:40	2.173	DF	DRY	0.65	0.53	3.13	0.13	0.06	0.67	
55	4/3/2009 15:40	4/17/2009 18:25	1.76	DF	DRY	1.06	0.99	3.55	0.10	0.20	0.53	
56	4/17/2009 18:25	4/28/2009 10:00	2.088	DF	DRY	1.04	0.42	12.17	0.11	0.36	0.93	115
57	4/28/2009 10:00	5/26/2009 12:00	2.048	DF	DRY	0.19	0.23	15.82	0.13	0.56	2.11	113
58	5/26/2009 12:00	6/5/2009 13:20	3.907	DF	DRY	5.88	13.02	43.02	0.10	0.68	1.20	
59	6/5/2009 13:20	6/19/2009 12:25	2.743	DF	DRY	0.82	0.49	10.42	0.28	0.42	0.69	
60	6/19/2009 12:25	6/26/2009 12:30	3.048	DF	DRY	0.30	1.03	25.48	0.19	0.45	1.84	

Samp. No.	Ward Valley Dry Start Date-Time	Lake Level Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load/day) NO_3-N (g/ha/d)	NH_4-N (g/ha/d)	TKN (g/ha/d)	SRP (g/ha/d)	DP (g/ha/d)	TP (g/ha/d)	Notes
61	6/26/2009 12:30	7/5/2009 11:00	2.705	DF	DRY	0.37	4.17	35.16	0.10	0.52	2.77	
62	7/5/2009 11:00	7/14/2009 9:50	2.552	DF	DRY	0.38	0.62	15.44	0.19	0.60	1.22	121
63	7/5/2009 11:00	7/22/2009 10:00	2.357	DF	DRY	0.21	0.69	31.57	0.07	0.08	0.39	125
64	7/22/2009 10:00	8/9/2009 11:30	2.798	DF	DRY	0.33	0.58	17.92	0.08	0.15	0.70	
65	8/9/2009 11:30	8/28/2009 12:20	1.47	DF	DRY	0.16	0.04	NA	0.05	0.11	1.78	126
66	8/28/2009 12:20	9/9/2009 13:30	2.325	DF	DRY	0.41	0.27	NA	0.10	0.19	0.43	
67	9/9/2009 13:30	9/22/2009 15:10		DF	DRY	C	C	C	C	C	C	127
68	9/22/2009 15:10	10/2/2009 10:45	3.013	DF	DRY	0.45	0.48	NA	1.38	NA	NA	128

Appendix Table 3.a. Precipitation amounts, N and P concentrations in bulk deposition collected in Snow Tube collector at the Mid-lake Buoy (TB-1) Station 6/25/08-9/22/09.

No.	Mid-lake (TB-1) Start Date-Time	Snow Tube Collection Date-Time	Precip. (in.)	Precip. Form	Collector Type	(Conc.) NO_3-N (µg/l)	NH_4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
	6/25/2008 10:20	7/3/2008 10:50	0		ST	NA	NA	NA	NA	NA	NA	
	7/3/2008 10:50	7/10/2008 8:12	0		ST	NA	NA	NA	NA	NA	NA	73
	7/10/2008 8:12	7/15/2008 10:25	0		ST	NA	NA	NA	NA	NA	NA	
	7/15/2008 10:25	7/29/2008 9:28	0		ST	NA	NA	NA	NA	NA	NA	
	7/29/2008 9:28	8/15/2008 9:50	0		ST	NA	NA	NA	NA	NA	NA	74
	8/15/2008 9:50	9/16/2008 10:00	0		ST	NA	NA	NA	NA	NA	NA	
12	9/16/2008 10:00	10/8/2008 10:40	0.46	R	ST	C	C	C	C	C	C	84
	10/8/2008 10:40	10/17/2008 10:30	0		ST	NA	NA	NA	NA	NA	NA	
13	10/17/2008 10:30	11/7/2008 9:45	1.05	R+S	ST	337.35	164.29	371.86	28.78	35.66	52.73	
14	11/7/2008 9:45	11/21/2008 10:22	0.12	R	ST	358.79	178.52	NA	6.11	11.28	NA	
15	11/21/2008 10:22	12/5/2008 8:31	0.12	R+S	ST	163.29	105.08	192.41	3.95	6.18	6.8	95
16	12/5/2008 8:31	1/6/2009 10:47	0.99	R+S	ST	264.67	88.19	296.53	9.75	13.63	24.16	97
	1/6/2009 10:47	1/19/2009 9:45	0		ST	NA	NA	NA	NA	NA	NA	
17	1/19/2009 9:45	1/28/2009 9:50	1.01	R+S	ST	170.73	113.89	154.47	5.42	4.66	7.74	
	1/28/2009 9:50	2/4/2009 15:47	0		ST	NA	NA	NA	NA	NA	NA	
18	2/4/2009 15:47	2/20/2009 8:15	0.12	S	ST	52.05	39.81	623.83	2.26	4.62	NA	106
19	2/20/2009 8:15	3/10/2009 9:48	1.48	R+S	ST	95.47	90.15	229.94	3.62	4.04	5.91	
	3/10/2009 9:48	3/20/2009 10:55	T		ST	NA	NA	NA	NA	NA	NA	
20	3/20/2009 10:55	4/10/2009 9:50	0.36	S	ST	111.2	248.16	618.48	7.88	18.49	47.23	
	4/10/2009 9:50	5/15/2009 14:10	NA		ST	256.86	230.45	406	9.65	14.66	25.97	116
	5/15/2009 14:10	6/11/2009 9:12	0.42	R+H?	ST	C	C	C	C	C	C	117
	6/11/2009 9:12	6/18/2009 10:55	T		ST	NA	NA	NA	NA	NA	NA	118
	6/18/2009 10:55	6/25/2009 9:45	0		ST	NA	NA	NA	NA	NA	NA	
	6/25/2009 9:45	7/2/2009 10:05	0		ST	NA	NA	NA	NA	NA	NA	
21	7/2/2009 10:05	7/13/2009 9:50	0.08	R	ST	128.57	71.25	221.25	11.9	20.34	34.12	129
	7/13/2009 9:50	7/21/2009 9:55	0		ST	NA	NA	NA	NA	NA	NA	
	7/21/2009 9:55	7/30/2009 7:25	0		ST	NA	NA	NA	NA	NA	NA	
	7/30/2009 7:25	8/7/2009 8:35	T		ST	NA	NA	NA	NA	NA	NA	

No.	Mid-lake (TB-1) Start Date-Time	Snow Tube Collection Date-Time	Precip. (in.)	Precip. Form	Collector Type	(Conc.) NO_3-N (µg/l)	NH_4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
	8/7/2009 8:35	8/25/2009 9:10	T		ST	NA	NA	NA	NA	NA	NA	
22	8/25/2009 9:10	9/22/2009 9:26	0.01	R	ST	34.39	33.45	NA	15.11	NA	NA	130

Appendix Table 3.b. Precipitation amounts, N and P loads in bulk deposition collected in Snow Tube collector at the Mid-lake Buoy (TB-1) Station 6/25/08-9/22/09.

No.	Mid-lake (TB-1) Start Date-Time	Snow Tube Collection Date-Time	Precip. (in.)	Precip. Form	Collector Type	(Load) NO_3-N (g/ha)	NH_4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
	6/25/2008 10:20	7/3/2008 10:50	0		ST	NA	NA	NA	NA	NA	NA	
	7/3/2008 10:50	7/10/2008 8:12	0		ST	NA	NA	NA	NA	NA	NA	73
	7/10/2008 8:12	7/15/2008 10:25	0		ST	NA	NA	NA	NA	NA	NA	
	7/15/2008 10:25	7/29/2008 9:28	0		ST	NA	NA	NA	NA	NA	NA	
	7/29/2008 9:28	8/15/2008 9:50	0		ST	NA	NA	NA	NA	NA	NA	74
	8/15/2008 9:50	9/16/2008 10:00	0		ST	NA	NA	NA	NA	NA	NA	
12	9/16/2008 10:00	10/8/2008 10:40	0.46	R	ST	C	C	C	C	C	C	84
	10/8/2008 10:40	10/17/2008 10:30	0		ST	NA	NA	NA	NA	NA	NA	
13	10/17/2008 10:30	11/7/2008 9:45	1.05	R+S	ST	89.97	43.82	99.18	7.68	9.51	14.06	
14	11/7/2008 9:45	11/21/2008 10:22	0.12	R	ST	10.94	5.44	NA	0.19	0.34	NA	
15	11/21/2008 10:22	12/5/2008 8:31	0.12	R+S	ST	25.17	16.20	29.66	0.61	0.95	1.05	95
16	12/5/2008 8:31	1/6/2009 10:47	0.99	R+S	ST	66.55	22.18	74.57	2.45	3.43	6.08	97
	1/6/2009 10:47	1/19/2009 9:45	0		ST	NA	NA	NA	NA	NA	NA	
17	1/19/2009 9:45	1/28/2009 9:50	1.01	R+S	ST	43.80	29.22	39.63	1.39	1.20	1.99	
	1/28/2009 9:50	2/4/2009 15:47	0		ST	NA	NA	NA	NA	NA	NA	
18	2/4/2009 15:47	2/20/2009 8:15	0.12	S	ST	8.02	6.14	96.15	0.35	0.71	NA	106
19	2/20/2009 8:15	3/10/2009 9:48	1.48	R+S	ST	35.89	33.89	86.44	1.36	1.52	2.22	
	3/10/2009 9:48	3/20/2009 10:55	T		ST	NA	NA	NA	NA	NA	NA	
20	3/20/2009 10:55	4/10/2009 9:50	0.36	S	ST	10.17	22.69	56.55	0.72	1.69	4.32	
	4/10/2009 9:50	5/15/2009 14:10	NA		ST	NA	NA	NA	NA	NA	NA	116
	5/15/2009 14:10	6/11/2009 9:12	0.42	R+H?	ST	C	C	C	C	C	C	117
	6/11/2009 9:12	6/18/2009 10:55	T		ST	NA	NA	NA	NA	NA	NA	118
	6/18/2009 10:55	6/25/2009 9:45	0		ST	NA	NA	NA	NA	NA	NA	
	6/25/2009 9:45	7/2/2009 10:05	0		ST	NA	NA	NA	NA	NA	NA	
21	7/2/2009 10:05	7/13/2009 9:50	0.08	R	ST	19.90	11.03	34.24	1.84	3.15	5.28	
	7/13/2009 9:50	7/21/2009 9:55	0		ST	NA	NA	NA	NA	NA	NA	
	7/21/2009 9:55	7/30/2009 7:25	0		ST	NA	NA	NA	NA	NA	NA	
	7/30/2009 7:25	8/7/2009 8:35	T		ST	NA	NA	NA	NA	NA	NA	

No.	Mid-lake (TB-1) Start Date-Time	Snow Tube Collection Date-Time	Precip. (in.)	Precip. Form	Collector Type	(Load) NO_3-N (g/ha)	NH_4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
	8/7/2009 8:35	8/25/2009 9:10	0		ST	NA	NA	NA	NA	NA	NA	
22	8/25/2009 9:10	9/22/2009 9:26	0.01	R	ST	5.35	5.21	NA	2.35	NA	NA	130

Appendix Table 4.a. N and P concentrations in dry-bulk deposition (buoy bucket) at Mid-lake Buoy (TB-1) Station 6/25/08-9/22/09.

Samp. No.	Mid-lake (TB-1) Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Conc.) NO_3-N (µg/l)	NH_4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
22	6/25/2008 10:20	7/3/2008 10:50	1.205	DF	DRY-BULK	C	C	C	C	C	C	58
23	7/3/2008 10:50	7/10/2008 8:12	0.939	DF	DRY-BULK	158.48	277.85	NA	101.81	110.39	184.6	75
24	7/10/2008 8:12	7/15/2008 10:25	2.04	DF	DRY-BULK	64.62	130.54	270.85	10.57	11.93	19.43	76
25	7/15/2008 10:25	7/22/2008 7:38	0.822	DF+R?	DRY-BULK	147.29	347.93	328.84	7.46	10.71	13.12	77
26	7/22/2008 7:38	7/29/2008 9:28	0.676	DF	DRY-BULK	268.32	634.22	510.96	6.07	10.4	20.44	78
27	7/29/2008 9:28	8/15/2008 9:50	0.5	DF	DRY-BULK	169.41	101.17	420.73	11.46	24.77	56.97	79
28	8/15/2008 9:50	9/5/2008 13:50	0.5	DF	DRY-BULK	38.75	149.34	463.32	12.61	25.39	89.32	79
29	9/5/2008 13:50	9/16/2008 10:00	0.69	DF	DRY-BULK	227.35	231.76	323.08	5.41	8.66	38.99	
30	9/16/2008 10:00	10/8/2008 10:40	0.535	DF+R	DRY-BULK	488.38	354.86	1434.63	2.7	7.13	28.22	80
31	10/8/2008 10:40	10/17/2008 10:30	0.695	DF	DRY-BULK	129.5	85.18	179.1	1.35	5.48	8.52	
32	10/17/2008 10:30	11/7/2008 9:45	1.33	DF+R+S	DRY-BULK	227.69	294.37	419.94	6.07	6.4	8.23	
33	11/7/2008 9:45	11/21/2008 10:22	1.515	DF+R	DRY-BULK	94.97	82.47	290.14	3.17	2.74	4.88	
34	11/21/2008 10:22	12/5/2008 8:31	1.268	DF+R+S	DRY-BULK	152.81	136.37	164.9	2.03	4.02	2.78	
35	12/5/2008 8:31	1/6/2009 10:47	0.6	DF +R+S	DRY-BULK	247.03	123.62	387	6.57	9.29	31.9	97
36	1/6/2009 10:47	1/19/2009 9:45	1.381	DF	DRY-BULK	102.1	64.46	113.65	0.68	1.55	2.17	107
37	1/19/2009 9:45	1/28/2009 9:50	2.348	DF +R+S	DRY-BULK	35.59	12.2	172.99	0.45	2.17	1.86	
38	1/28/2009 9:50	2/4/2009 15:47	2.875	DF	DRY-BULK	33.47	24.63	40.72	0.68	2.02	2.17	
39	2/4/2009 15:47	2/20/2009 8:15	1.27	DF+S	DRY-BULK	72.58	65.83	163	1.92	3.37	6.71	
40	2/20/2009 8:15	3/10/2009 9:48	1.463	DF +R+S	DRY-BULK	75.77	87.01	197.4	2.03	2.49	4.04	108
41	3/10/2009 9:48	3/20/2009 10:55	1.77		DRY-BULK	59.13	72.13	211.86	1.8	2.17	5.59	
42	3/20/2009 10:55	4/10/2009 9:50	0.5	DF+S	DRY-BULK	71.99	340.3	445.6	10.35	11.15	12.98	109
43	4/10/2009 9:50	5/15/2009 14:10	0.5	DF+S	DRY-BULK	425.56	446.48	420.29	7.18	11.91	41.85	119
44	5/15/2009 14:10	6/11/2009 9:12	0.5	DF+R+H?	DRY-BULK	C	C	C	C	C	C	120
45	6/11/2009 9:12	6/18/2009 10:55	1.469	DF+T	DRY-BULK	81.94	85.4	102.59	3.6	4.04	7.45	
46	6/18/2009 10:55	6/25/2009 9:45	0.775	DF	DRY-BULK	141.91	303.03	408.5	5.32	6.53	21.44	
47	6/25/2009 9:45	7/2/2009 10:05	1.072	DF	DRY-BULK	103.11	95.3	164.51	4.2	6.21	15.85	
48	7/2/2009 10:05	7/13/09 09:50	0.500	DF+R	DRY-BULK	C	C	C	C	C	C	131
49	7/13/09 09:50	7/21/2009 9:55	0.622	DF	DRY-BULK	C	C	C	C	C	C	132
50	7/21/2009 9:55	7/30/2009 7:25	0.51	DF	DRY-BULK	172.96	46.49	476.05	5.62	18.6	50.91	133

Samp. No.	Mid-lake (TB-1) Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Conc.) NO_3-N (μg/l)	NH_4-N (μg/l)	TKN (μg/l)	SRP (μg/l)	DP (μg/l)	TP (μg/l)	Notes
51	7/30/2009 7:25	8/7/2009 8:35	0.5	DF	DRY-BULK	527.18	806	1283.83	13.94	24.9	41.5	134
52	8/7/2009 8:35	8/25/2009 9:10	0.5	DF+T	DRY-BULK	241.28	127.8	462.35	7.62	10.69	47.66	135
53	8/25/2009 9:10	9/10/2009 9:30	0.5	DF	DRY-BULK	200.21	110.99	NA	6.74	11.04	25.15	135
54	9/10/2009 9:30	9/22/2009 9:26	0.5	DF	DRY-BULK	469.38	861.55	NA	1.13	NA	NA	136

Appendix Table 4.b. N and P loads in dry-bulk deposition (buoy bucket) at the Mid-lake Buoy (TB-1) Station 6/25/08-9/22/09.

Samp. No.	Mid-lake (TB-1) Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load) NO_3-N (g/ha)	NH_4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
22	6/25/2008 10:20	7/3/2008 10:50	1.205	DF	DRY-BULK	C	C	C	C	C	C	58
23	7/3/2008 10:50	7/10/2008 8:12	0.939	DF	DRY-BULK	29.37	51.49	NA	18.87	20.46	34.21	75
24	7/10/2008 8:12	7/15/2008 10:25	2.04	DF	DRY-BULK	26.02	52.56	109.04	4.26	4.80	7.82	76
25	7/15/2008 10:25	7/22/2008 7:38	0.822	DF+R?	DRY-BULK	23.89	56.44	53.35	1.21	1.74	2.13	77
26	7/22/2008 7:38	7/29/2008 9:28	0.676	DF	DRY-BULK	35.80	84.61	68.17	0.81	1.39	2.73	78
27	7/29/2008 9:28	8/15/2008 9:50	0.5	DF	DRY-BULK	16.72	9.98	41.52	1.13	2.44	5.62	79
28	8/15/2008 9:50	9/5/2008 13:50	0.5	DF	DRY-BULK	3.82	14.74	45.72	1.24	2.51	8.81	79
29	9/5/2008 13:50	9/16/2008 10:00	0.69	DF	DRY-BULK	30.96	31.56	43.99	0.74	1.18	5.31	
30	9/16/2008 10:00	10/8/2008 10:40	0.535	DF+R	DRY-BULK	51.56	37.47	151.47	0.29	0.75	2.98	80
31	10/8/2008 10:40	10/17/2008 10:30	0.695	DF	DRY-BULK	17.76	11.68	24.57	0.19	0.75	1.17	
32	10/17/2008 10:30	11/7/2008 9:45	1.33	DF+R+S	DRY-BULK	59.76	77.27	110.23	1.59	1.68	2.16	
33	11/7/2008 9:45	11/21/2008 10:22	1.515	DF+R	DRY-BULK	28.40	24.66	86.75	0.95	0.82	1.46	
34	11/21/2008 10:22	12/5/2008 8:31	1.268	DF+R+S	DRY-BULK	38.24	34.13	41.27	0.51	1.01	0.70	
35	12/5/2008 8:31	1/6/2009 10:47	0.6	DF +R+S	DRY-BULK	29.25	14.64	45.83	0.78	1.10	3.78	97
36	1/6/2009 10:47	1/19/2009 9:45	1.381	DF	DRY-BULK	27.83	17.57	30.97	0.19	0.42	0.59	107
37	1/19/2009 9:45	1/28/2009 9:50	2.348	DF +R+S	DRY-BULK	16.49	5.65	80.16	0.21	1.01	0.86	
38	1/28/2009 9:50	2/4/2009 15:47	2.875	DF	DRY-BULK	18.99	13.97	23.10	0.39	1.15	1.23	
39	2/4/2009 15:47	2/20/2009 8:15	1.27	DF+S	DRY-BULK	18.19	16.50	40.85	0.48	0.84	1.68	
40	2/20/2009 8:15	3/10/2009 9:48	1.463	DF +R+S	DRY-BULK	21.88	25.12	56.99	0.59	0.72	1.17	108
41	3/10/2009 9:48	3/20/2009 10:55	1.77		DRY-BULK	20.65	25.20	74.01	0.63	0.76	1.95	
42	3/20/2009 10:55	4/10/2009 9:50	0.5	DF+S	DRY-BULK	7.10	33.58	43.97	1.02	1.10	1.28	109
43	4/10/2009 9:50	5/15/2009 14:10	0.5	DF+S	DRY-BULK	41.99	44.06	41.47	0.71	1.18	4.13	119
44	5/15/2009 14:10	6/11/2009 9:12	0.5	DF+R+H?	DRY-BULK	C	C	C	C	C	C	120
45	6/11/2009 9:12	6/18/2009 10:55	1.469	DF+T	DRY-BULK	23.76	24.76	29.74	1.04	1.17	2.16	
46	6/18/2009 10:55	6/25/2009 9:45	0.775	DF	DRY-BULK	21.70	46.35	62.48	0.81	1.00	3.28	
47	6/25/2009 9:45	7/2/2009 10:05	1.072	DF	DRY-BULK	21.81	20.16	34.80	0.89	1.31	3.35	
48	7/2/2009 10:05	7/13/09 09:50	0.500	DF+R	DRY-BULK	C	C	C	C	C	C	131
49	7/13/09 09:50	7/21/2009 9:55	0.622	DF	DRY-BULK	C	C	C	C	C	C	132
50	7/21/2009 9:55	7/30/2009 7:25	0.51	DF	DRY-BULK	17.41	4.68	47.91	0.57	1.87	5.12	133

Samp. No.	Mid-lake (TB-1) Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load) NO_3-N (g/ha)	NH_4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
51	7/30/2009 7:25	8/7/2009 8:35	0.5	DF	DRY-BULK	52.02	79.53	126.68	1.38	2.46	4.10	134
52	8/7/2009 8:35	8/25/2009 9:10	0.5	DF+T	DRY-BULK	23.81	12.61	45.62	0.75	1.05	4.70	135
53	8/25/2009 9:10	9/10/2009 9:30	0.5	DF	DRY-BULK	19.76	10.95	NA	0.67	1.09	2.48	135
54	9/10/2009 9:30	9/22/2009 9:26	0.5	DF	DRY-BULK	46.32	85.01	NA	0.11	NA	NA	136

Appendix Table 4.c. N and P loading per day in dry-bulk deposition (buoy bucket) at Mid-lake Buoy (TB-1) Station 6/25/08-9/22/09.

Samp. No.	Mid-lake (TB-1) Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load/day) NO_3-N (g/ha/d)	NH_4-N (g/ha/d)	TKN (g/ha/d)	SRP (g/ha/d)	DP (g/ha/d)	TP (g/ha/d)	Notes
22	6/25/2008 10:20	7/3/2008 10:50	1.205	DF	DRY-BULK	C	C	C	C	C	C	58
23	7/3/2008 10:50	7/10/2008 8:12	0.939	DF	DRY-BULK	4.26	7.47	NA	2.74	2.97	4.96	75
24	7/10/2008 8:12	7/15/2008 10:25	2.04	DF	DRY-BULK	5.11	10.32	21.41	0.84	0.94	1.54	76
25	7/15/2008 10:25	7/22/2008 7:38	0.822	DF+R?	DRY-BULK	3.47	8.20	7.75	0.18	0.25	0.31	77
26	7/22/2008 7:38	7/29/2008 9:28	0.676	DF	DRY-BULK	5.06	11.96	9.63	0.11	0.20	0.39	78
27	7/29/2008 9:28	8/15/2008 9:50	0.5	DF	DRY-BULK	0.98	0.59	2.44	0.07	0.14	0.33	79
28	8/15/2008 9:50	9/5/2008 13:50	0.5	DF	DRY-BULK	0.18	0.70	2.16	0.06	0.12	0.42	79
29	9/5/2008 13:50	9/16/2008 10:00	0.69	DF	DRY-BULK	2.86	2.91	4.06	0.07	0.11	0.49	
30	9/16/2008 10:00	10/8/2008 10:40	0.535	DF+R	DRY-BULK	2.34	1.70	6.88	0.01	0.03	0.14	80
31	10/8/2008 10:40	10/17/2008 10:30	0.695	DF	DRY-BULK	1.98	1.30	2.73	0.02	0.08	0.13	
32	10/17/2008 10:30	11/7/2008 9:45	1.33	DF+R+S	DRY-BULK	2.85	3.68	5.26	0.08	0.08	0.10	
33	11/7/2008 9:45	11/21/2008 10:22	1.515	DF+R	DRY-BULK	2.02	1.76	6.18	0.07	0.06	0.10	
34	11/21/2008 10:22	12/5/2008 8:31	1.268	DF+R+S	DRY-BULK	2.75	2.45	2.96	0.04	0.07	0.05	
35	12/5/2008 8:31	1/6/2009 10:47	0.6	DF +R+S	DRY-BULK	0.91	0.46	1.43	0.02	0.03	0.12	97
36	1/6/2009 10:47	1/19/2009 9:45	1.381	DF	DRY-BULK	2.15	1.36	2.39	0.01	0.03	0.05	107
37	1/19/2009 9:45	1/28/2009 9:50	2.348	DF +R+S	DRY-BULK	1.83	0.63	8.90	0.02	0.11	0.10	
38	1/28/2009 9:50	2/4/2009 15:47	2.875	DF	DRY-BULK	2.62	1.93	3.19	0.05	0.16	0.17	
39	2/4/2009 15:47	2/20/2009 8:15	1.27	DF+S	DRY-BULK	1.16	1.05	2.60	0.03	0.05	0.11	
40	2/20/2009 8:15	3/10/2009 9:48	1.463	DF +R+S	DRY-BULK	1.21	1.39	3.16	0.03	0.04	0.06	108
41	3/10/2009 9:48	3/20/2009 10:55	1.77		DRY-BULK	2.06	2.51	7.37	0.06	0.08	0.19	
42	3/20/2009 10:55	4/10/2009 9:50	0.5	DF+S	DRY-BULK	0.34	1.60	2.10	0.05	0.05	0.06	109
43	4/10/2009 9:50	5/15/2009 14:10	0.5	DF+S	DRY-BULK	1.19	1.25	1.18	0.02	0.03	0.12	119
44	5/15/2009 14:10	6/11/2009 9:12	0.5	DF+R+H?	DRY-BULK	C	C	C	C	C	C	120
45	6/11/2009 9:12	6/18/2009 10:55	1.469	DF+T	DRY-BULK	3.36	3.50	4.21	0.15	0.17	0.31	
46	6/18/2009 10:55	6/25/2009 9:45	0.775	DF	DRY-BULK	3.12	6.67	8.99	0.12	0.14	0.47	
47	6/25/2009 9:45	7/2/2009 10:05	1.072	DF	DRY-BULK	3.11	2.87	4.96	0.13	0.19	0.48	
48	7/2/2009 10:05	7/13/09 09:50	0.500	DF+R	DRY-BULK	C	C		C	C	C	131
49	7/13/09 09:50	7/21/2009 9:55	0.622	DF	DRY-BULK	C	C	C	C	C	C	132
50	7/21/2009 9:55	7/30/2009 7:25	0.51	DF	DRY-BULK	1.96	0.53	5.39	0.06	0.21	0.58	133

Samp. No.	Mid-lake (TB-1) Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load/day) NO_3-N (g/ha/d)	NH_4-N (g/ha/d)	TKN (g/ha/d)	SRP (g/ha/d)	DP (g/ha/d)	TP (g/ha/d)	Notes
51	7/30/2009 7:25	8/7/2009 8:35	0.5	DF	DRY-BULK	6.46	9.88	15.74	0.17	0.31	0.51	134
52	8/7/2009 8:35	8/25/2009 9:10	0.5	DF+T	DRY-BULK	1.32	0.70	2.53	0.04	0.06	0.26	135
53	8/25/2009 9:10	9/10/2009 9:30	0.5	DF	DRY-BULK	1.23	0.68	NA	0.04	0.07	0.15	135
54	9/10/2009 9:30	9/22/2009 9:26	0.5	DF	DRY-BULK	3.86	7.09	NA	0.01	NA	NA	136

Table 5.a. N and P concentrations in dry-bulk deposition (buoy bucket) at the Northwest Buoy (TB-4) Station 6/25/08-9/22/09.

Samp. No.	Buoy TB-4 Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Conc.) NO_3-N (µg/l)	NH_4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
22	6/25/2008 9:40	7/3/2008 10:22	0.962	DF	DRY-BULK	197.27	194.93	449.26	18.06	30.3	45.23	61
23	7/3/2008 10:22	7/10/2008 7:50	0.91	DF	DRY-BULK	144.07	326	325.11	109.26	118.74	164.81	81
24	7/10/2008 7:50	7/15/2008 10:55	1.837	DF	DRY-BULK	72.77	151.1	205.8	5.17	7.65	29.45	
25	7/15/2008 10:55	7/22/2008 7:20	0.615	DF	DRY-BULK	317.78	423.81	522.95	4.98	7.04	13.27	
26	7/22/2008 7:20	7/29/2008 8:50	0.545	DF	DRY-BULK	278.12	850.82	1084.4	6.07	10.71	38.39	78
27	7/29/2008 8:50	8/15/2008 9:50	0.5	DF	DRY-BULK	152.2	195.75	203.66	11.88	43.03	22.6	
28	8/15/2008 9:50	9/5/2008 13:25	0.5	DF	DRY-BULK	46.26	92.52	1223.57	28.03	42.83	149.28	
29	9/5/2008 13:25	9/16/2008 9:35	0.248	DF	DRY-BULK	568.38	590.87	1209.22	4.28	9.59	80.45	
30	9/16/2008 9:35	10/8/2008 10:15	0.5	DF+R	DRY-BULK	453.21	342.86	557.58	7.19	10.85	22.02	82
31	10/8/2008 10:15	10/17/2008 10:12	0.965	DF	DRY-BULK	C	C	C	C	C	C	96
32	10/17/2008 10:12	11/7/2008 9:25	1.46	DF+R+S	DRY-BULK	154.18	567.42	672.34	3.94	6.4	6.71	
33	11/7/2008 9:25	11/21/2008 10:10	0.925	DF+R	DRY-BULK	155.41	174.27	325.77	2.38	3.35	4.88	
34	11/21/2008 10:10	12/5/2008 8:12	1.36	DF+R+S	DRY-BULK	157.18	138.46	211.83	2.37	4.33	4.95	
35	12/5/2008 8:12	1/6/2009 10:27	0.371	DF +R+S	DRY-BULK	447.72	291.05	546.46	11.11	14.25	34.38	97
36	1/6/2009 10:27	1/19/2009 9:26	1.085	DF	DRY-BULK	113.34	71.55	107.81	1.59	1.71	9.01	107
37	1/19/2009 9:26	1/28/2009 9:33	2.156	DF +R+S	DRY-BULK	25.29	12.41	21.45	1.02	2.48	2.48	
38	1/28/2009 9:33	2/4/2009 13:04	2.409	DF	DRY-BULK	38	35.79	36.87	0.45	1.86	2.33	
39	2/4/2009 13:04	2/20/2009 7:59	1.158	DF+S	DRY-BULK	83.94	89.34	NA	1.58	3.39	NA	
40	2/20/2009 7:59	3/10/2009 9:33	1.01	DF +R+S	DRY-BULK	73.6	97.23	161.99	1.8	2.49	5.91	
41	3/10/2009 9:33	3/20/2009 10:55	1.483		DRY-BULK	75.62	94.44	388.01	2.03	3.11	3.73	
42	3/20/2009 10:55	4/10/2009 9:50	0.505	DF+S	DRY-BULK	74.27	372.76	548.32	8.78	8.7	22.16	110
43	4/10/2009 9:50	5/15/2009 14:33	0.5	DF+S	DRY-BULK	552.57	853.7	933.61	9.65	11	48.57	119
44	5/15/2009 14:33	6/11/2009 9:00	0.5	DF+R+H?	DRY-BULK	991.9	681.01	1864.93	7.43	17.7	36.62	120
45	6/11/2009 9:00	6/18/2009 10:30	1.26	DF+R	DRY-BULK	110.63	108.85	459.53	3.83	4.04	7.45	137
46	6/18/2009 10:30	6/25/2009 9:25	0.575	DF	DRY-BULK	148.03	346.89	491.86	3.3	6.21	16.78	
47	6/25/2009 9:25	7/2/2009 9:45	1.362	DF	DRY-BULK	81.67	53.21	128.47	1.5	2.49	11.19	
48	7/2/2009 9:45	7/13/2009 9:25	0.5	DF+R	DRY-BULK	243.19	313.47	561	15.94	21.91	46.32	135
49	7/13/2009 9:25	7/21/2009 9:30	0.696	DF	DRY-BULK	159.01	116.74	216.98	1.47	5.61	12.8	
50	7/21/2009 9:30	7/30/2009 7:10	0.5	DF	DRY-BULK	189.84	125.7	522.92	1.12	4.57	16.16	138

Samp. No.	Buoy TB-4 Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Conc.) NO_3-N (µg/l)	NH_4-N (µg/l)	TKN (µg/l)	SRP (µg/l)	DP (µg/l)	TP (µg/l)	Notes
51	7/30/2009 7:10	8/7/2009 8:20	0.5	DF	DRY-BULK	296.77	955.32	1151.59	3.15	6.46	12.6	139
52	8/7/2009 8:20	8/25/2009 8:50	0.5	DF	DRY-BULK	217.98	112.71	317.73	6.5	8.86	19.86	135
53	8/25/2009 8:50	9/10/2009 9:10	0.5	DF	DRY-BULK	174.34	88.99	NA	2.25	6.13	19.93	135
54	9/10/2009 9:10	9/22/2009 9:11	0.5	DF	DRY-BULK	329.85	401.7	NA	4.28	NA	NA	135

Appendix Table 5.b. N and P loads in dry-bulk deposition (buoy bucket) at the Northwest Buoy (TB-4) Station 6/25/08-9/22/09.

Samp. No.	Mid-lake (TB-4) Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load) NO_3-N (g/ha)	NH_4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
22	6/25/2008 9:40	7/3/2008 10:22	0.962	DF	DRY-BULK	23.22	43.36	125.47	3.47	5.99	NA	62
23	7/3/2008 10:22	7/10/2008 7:50	0.91	DF	DRY-BULK	25.87	58.55	58.39	19.62	21.32	29.60	81
24	7/10/2008 7:50	7/15/2008 10:55	1.837	DF	DRY-BULK	26.38	54.78	74.61	1.87	2.77	10.68	
25	7/15/2008 10:55	7/22/2008 7:20	0.615	DF	DRY-BULK	38.57	51.44	63.47	0.60	0.85	1.61	
26	7/22/2008 7:20	7/29/2008 8:50	0.545	DF	DRY-BULK	29.91	91.51	116.64	0.65	1.15	4.13	78
27	7/29/2008 8:50	8/15/2008 9:50	0.5	DF	DRY-BULK	15.02	19.32	20.10	1.17	4.25	2.23	
28	8/15/2008 9:50	9/5/2008 13:25	0.5	DF	DRY-BULK	4.56	9.13	120.74	2.77	4.23	14.73	
29	9/5/2008 13:25	9/16/2008 9:35	0.248	DF	DRY-BULK	27.82	28.92	59.18	0.21	0.47	3.94	
30	9/16/2008 9:35	10/8/2008 10:15	0.5	DF+R	DRY-BULK	44.72	33.83	55.02	0.71	1.07	2.17	82
31	10/8/2008 10:15	10/17/2008 10:12	0.965	DF	DRY-BULK	C	C	C	C	C	C	96
32	10/17/2008 10:12	11/7/2008 9:25	1.46	DF+R+S	DRY-BULK	44.42	163.49	193.72	1.14	1.84	1.93	
33	11/7/2008 9:25	11/21/2008 10:10	0.925	DF+R	DRY-BULK	28.37	31.81	59.47	0.43	0.61	0.89	
34	11/21/2008 10:10	12/5/2008 8:12	1.36	DF+R+S	DRY-BULK	42.19	37.16	56.86	0.64	1.16	1.33	
35	12/5/2008 8:12	1/6/2009 10:27	0.371	DF +R+S	DRY-BULK	32.78	21.31	40.01	0.81	1.04	2.52	97
36	1/6/2009 10:27	1/19/2009 9:26	1.085	DF	DRY-BULK	24.27	15.32	23.09	0.34	0.37	1.93	107
37	1/19/2009 9:26	1/28/2009 9:33	2.156	DF +R+S	DRY-BULK	10.76	5.28	9.13	0.43	1.06	1.06	
38	1/28/2009 9:33	2/4/2009 13:04	2.409	DF	DRY-BULK	18.07	17.02	17.53	0.21	0.88	1.11	
39	2/4/2009 13:04	2/20/2009 7:59	1.158	DF+S	DRY-BULK	19.18	20.42	NA	0.36	0.77	NA	
40	2/20/2009 7:59	3/10/2009 9:33	1.01	DF +R+S	DRY-BULK	14.67	19.38	32.29	0.36	0.50	1.18	
41	3/10/2009 9:33	3/20/2009 10:55	1.483		DRY-BULK	22.13	27.64	113.56	0.59	0.91	1.09	
42	3/20/2009 10:55	4/10/2009 9:50	0.505	DF+S	DRY-BULK	7.40	37.15	54.65	0.88	0.87	2.21	110
43	4/10/2009 9:50	5/15/2009 14:33	0.5	DF+S	DRY-BULK	54.53	84.24	92.13	0.95	1.09	4.79	119
44	5/15/2009 14:33	6/11/2009 9:00	0.5	DF+R+H?	DRY-BULK	97.88	67.20	184.02	0.73	1.75	3.61	120
45	6/11/2009 9:00	6/18/2009 10:30	1.26	DF+R	DRY-BULK	27.51	27.07	114.27	0.95	1.00	1.85	137
46	6/18/2009 10:30	6/25/2009 9:25	0.575	DF	DRY-BULK	16.80	39.36	55.82	0.37	0.70	1.90	
47	6/25/2009 9:25	7/2/2009 9:45	1.362	DF	DRY-BULK	21.95	14.30	34.53	0.40	0.67	3.01	
48	7/2/2009 9:45	7/13/2009 9:25	0.5	DF+R	DRY-BULK	24.00	30.93	55.36	1.57	2.16	4.57	135
49	7/13/2009 9:25	7/21/2009 9:30	0.696	DF	DRY-BULK	21.84	16.04	29.80	0.20	0.77	1.76	
50	7/21/2009 9:30	7/30/2009 7:10	0.5	DF	DRY-BULK	18.73	12.40	51.60	0.11	0.45	1.59	138

Samp. No.	Mid-lake (TB-4) Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load) NO_3-N (g/ha)	NH_4-N (g/ha)	TKN (g/ha)	SRP (g/ha)	DP (g/ha)	TP (g/ha)	Notes
51	7/30/2009 7:10	8/7/2009 8:20	0.5	DF	DRY-BULK	29.28	94.27	113.63	0.31	0.64	1.24	139
52	8/7/2009 8:20	8/25/2009 8:50	0.5	DF	DRY-BULK	21.51	11.12	31.35	0.64	0.87	NA	135
53	8/25/2009 8:50	9/10/2009 9:10	0.5	DF	DRY-BULK	17.20	8.78	NA	0.22	0.60	NA	135
54	9/10/2009 9:10	9/22/2009 9:11	0.5	DF	DRY-BULK	32.55	39.64	NA	0.42	NA	NA	135

Appendix Table 5.c. N and P load per day in dry-bulk deposition (buoy bucket) at the Northwest Buoy (TB-4) Sta. 6/25/08-9/22/09.

Samp. No.	Buoy TB-4 Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load/day) NO3-N (g/ha/d)	NH4-N (g/ha/d)	TKN (g/ha/d)	SRP (g/ha/d)	DP (g/ha/d)	TP (g/ha/d)	Notes
22	6/25/2008 9:40	7/3/2008 10:22	0.962	DF	DRY-BULK	2.89	5.40	15.63	0.43	0.75	NA	62
23	7/3/2008 10:22	7/10/2008 7:50	0.91	DF	DRY-BULK	3.75	8.49	8.47	2.85	3.09	4.29	81
24	7/10/2008 7:50	7/15/2008 10:55	1.837	DF	DRY-BULK	5.14	10.68	14.55	0.37	0.54	2.08	
25	7/15/2008 10:55	7/22/2008 7:20	0.615	DF	DRY-BULK	5.63	7.51	9.26	0.09	0.12	0.24	
26	7/22/2008 7:20	7/29/2008 8:50	0.545	DF	DRY-BULK	4.24	12.96	16.51	0.09	0.16	0.58	78
27	7/29/2008 8:50	8/15/2008 9:50	0.5	DF	DRY-BULK	0.88	1.13	1.18	0.07	0.25	0.13	
28	8/15/2008 9:50	9/5/2008 13:25	0.5	DF	DRY-BULK	0.22	0.43	5.71	0.13	0.20	0.70	
29	9/5/2008 13:25	9/16/2008 9:35	0.248	DF	DRY-BULK	2.57	2.67	5.46	0.02	0.04	0.36	
30	9/16/2008 9:35	10/8/2008 10:15	0.5	DF+R	DRY-BULK	2.03	1.54	2.50	0.03	0.05	0.10	82
31	10/8/2008 10:15	10/17/2008 10:12	0.965	DF	DRY-BULK	C	C	C	C	C	C	96
32	10/17/2008 10:12	11/7/2008 9:25	1.46	DF+R+S	DRY-BULK	2.12	7.80	9.24	0.05	0.09	0.09	
33	11/7/2008 9:25	11/21/2008 10:10	0.925	DF+R	DRY-BULK	2.02	2.27	4.24	0.03	0.04	0.06	
34	11/21/2008 10:10	12/5/2008 8:12	1.36	DF+R+S	DRY-BULK	3.03	2.67	4.08	0.05	0.08	0.10	
35	12/5/2008 8:12	1/6/2009 10:27	0.371	DF +R+S	DRY-BULK	1.02	0.66	1.25	0.03	0.03	0.08	97
36	1/6/2009 10:27	1/19/2009 9:26	1.085	DF	DRY-BULK	1.87	1.18	1.78	0.03	0.03	0.15	107
37	1/19/2009 9:26	1/28/2009 9:33	2.156	DF +R+S	DRY-BULK	1.19	0.59	1.01	0.05	0.12	0.12	
38	1/28/2009 9:33	2/4/2009 13:04	2.409	DF	DRY-BULK	2.53	2.38	2.45	0.03	0.12	0.16	
39	2/4/2009 13:04	2/20/2009 7:59	1.158	DF+S	DRY-BULK	1.22	1.29	NA	0.02	0.05	NA	
40	2/20/2009 7:59	3/10/2009 9:33	1.01	DF +R+S	DRY-BULK	0.81	1.07	1.79	0.02	0.03	0.07	
41	3/10/2009 9:33	3/20/2009 10:55	1.483		DRY-BULK	2.20	2.75	11.29	0.06	0.09	0.11	
42	3/20/2009 10:55	4/10/2009 9:50	0.505	DF+S	DRY-BULK	0.35	1.77	2.61	0.04	0.04	0.11	110
43	4/10/2009 9:50	5/15/2009 14:33	0.5	DF+S	DRY-BULK	1.55	2.39	2.62	0.03	0.03	0.14	119
44	5/15/2009 14:33	6/11/2009 9:00	0.5	DF+R+H?	DRY-BULK	3.66	2.51	6.87	0.03	0.07	0.13	120
45	6/11/2009 9:00	6/18/2009 10:30	1.26	DF+R	DRY-BULK	3.90	3.83	16.18	0.13	0.14	0.26	137
46	6/18/2009 10:30	6/25/2009 9:25	0.575	DF	DRY-BULK	2.42	5.66	8.03	0.05	0.10	0.27	
47	6/25/2009 9:25	7/2/2009 9:45	1.362	DF	DRY-BULK	3.13	2.04	4.92	0.06	0.10	0.43	
48	7/2/2009 9:45	7/13/2009 9:25	0.5	DF+R	DRY-BULK	2.18	2.82	5.04	0.14	0.20	0.42	135
49	7/13/2009 9:25	7/21/2009 9:30	0.696	DF	DRY-BULK	2.73	2.00	3.72	0.03	0.10	0.22	
50	7/21/2009 9:30	7/30/2009 7:10	0.5	DF	DRY-BULK	2.10	1.39	5.80	0.01	0.05	0.18	138

Samp. No.	Buoy TB-4 Start Date-Time	Dry-Bulk Collection Date-Time	Vol. Liters	Precip. Form	Collector Type	(Load/day) NO_3-N (g/ha/d)	NH_4-N (g/ha/d)	TKN (g/ha/d)	SRP (g/ha/d)	DP (g/ha/d)	TP (g/ha/d)	Notes
51	7/30/2009 7:10	8/7/2009 8:20	0.5	DF	DRY-BULK	3.64	11.71	14.12	0.04	0.08	0.15	139
52	8/7/2009 8:20	8/25/2009 8:50	0.5	DF	DRY-BULK	1.19	0.62	1.74	0.04	0.05	NA	135
53	8/25/2009 8:50	9/10/2009 9:10	0.5	DF	DRY-BULK	1.07	0.55	NA	0.01	0.04	NA	135
54	9/10/2009 9:10	9/22/2009 9:11	0.5	DF	DRY-BULK	2.71	3.30	NA	0.04	NA	NA	135

Table Legend:

Precipitation Form: (S=snow; R=rain; DF= dry fall (Dry deposition); H=hail; G=graupel; NA=information on type not available; T=trace of precip.)

Collector Type: (ST= 8 in. dia. Snow tube; TBG= 8 in. dia. Electrically heated tipping bucket rain and snow gauge; Wet= Aerochem Metrics Wet Bucket; Dry= Dry-Bulk bucket with 4 liter deionized water added, placed in dry-side of Aerochem Metrics sampler; Dry-Bulk= Aerochem Metrics bucket with reduced side height, filled with 4 liters of deionized H2O)

pH: (NES= not enough sample); C= sample contaminated; NA= not measured.

Nutrient Concentrations: (C= sample contamination; NA= Not available or not enough sample for analysis; note units are micrograms/liter; TBA= data not yet available).

Table Notes

(63) 10 ml of precip + 490 ml of deionized water to process; (64) very heavy ash on screen in bucket and in sample, pieces of small charred pine needles, some suds upon mixing, significant ash fall event along at least northwest portion of the basin from American River Complex fire to the west, charred bay leaves actually found near Tahoe City marina; (65) some ash in sample, probably residual from surrounding surfaces; (66) not as much smoke this pd.; (67) some smoke during pd., one day of heavy smoke from fire near Yosemite, filter has some organic wind-blown debris, filtered first through non-precombusted GF/C filter then through precombusted GF/F filter; (68) dead moth in sample, possible contamination; (69) small dead bee in sample, possible contamination, very difficult to filter; (70) windy previous day associated with thunderstorms:; (71) trace of precip associated with thunderstorms and wind previous day, no precip in bucket, left out; (72) some aspen leaves in dry bucket; (73) obvious ash in ST sample; (74) ST dry, left out; (75) obvious ash in dry-bulk bucket from ash fall event 7/9/08, 6-7 small midge flies in dry-bulk sample too; (76) no obvious ash, much pollen in sample; (77) small amount of precip and pollen this period; (78) periods of smoke during period, one day of heavy smoke from fire near Yosemite entrance; (79) bucket dry, added 500ml deionized water; (80) 85ml of sample +450ml deionized water, small spider in sample, possible contamination; (81) obvious ash in sample, more than bucket at TB-1; (82) 10ml of precip + 490 ml deionized water to process; (83) bucket dry, added 500ml deionized water to process, much particulate debris in sample, likely bird feces; (84) small dead spider in ST sample, possible contamination; (85) many aspen leaves in dry bucket, possible contamination; (86) Aerochem Metrics Wet/Dry sampler malfunctioned, dry bucket caught at 10-12" of snow, most of this was removed from over dry bucket and dry bucket left out since lacking replacement, used estimate of precipitation during period as SNOTEL Ward #3 precip 12/15 + Ward #3 precip. 12/17) /1.5) - WLL precip. 12/17; (87) Aerochem Metrics Wet/Dry sampler malfunctioned again, Dry bucket caught much of snow, estimate precip amount as Ward #3/1.5; (88) Aerochem Metrics Wet/Dry sampler malfunctioned again – replaced the complete sampler with newer Aerochem sampler on loan from CARB, estimated precip as SNOTEL Ward #3/1.5; (89) Aerochem Metrics lid stuck over dry-side after storm, snow about 1.5 ft above wet bucket rim, collected in second cleaned bucket and combined samples for processing; (90) 1 aspen leaf in sample; many aspen leaves on dry bucket screen, a few leaves in water, possible contamination; (92) Aerochem Metrics sampler malfunctioned during the storm, dry side caught a portion of wet precip., approx 10-12 inches of snow over dry bucket on 12/15/08 was swept off bucket and not collected; (93) Aerochem Metrics sampler malfunctioned again, collected much Wet precip this period, – replaced the complete sampler with newer Aerochem sampler on loan from CARB; (94) Aerochem Metrics lid frozen over dry side portion of the period, i.e. until 12/26/08, 1230; (95) 100ml of sample + 400ml deionized water added to process; (96) medium-sized dead spider in sample, likely contamination; (97) rough conditions when sampled; (98) snow accumulated about 5 inches above Wet bucket rim, Aerochem lid frozen over Dry-side so some dry deposition in Wet bucket; (99) snow 2-3 inches above bucket rim, compacted; (100) snow 1 foot above bucket rim, compacted down, Aerochem lid stuck over Dry-side, so some dry deposition in Wet bucket; (101) snow 4-5 inches above bucket rim, compacted; (102) placed out wet bucket with 500ml deionized water during this period as field blank, bird feces on Aerochem sensor caused lid to cover Dry side for portion of period and expose wet field blank, combined the field blank water (500ml) with Dry-side (3475ml) for analysis as Dry sample; (103) small amount sample spilled; (104) filter dirty with road

dust; (105) lid stuck over dry-side a portion of collection period, Wet caught some Dry deposition, dry side water frozen portion of the period, heater not plugged in; (106) 96ml precip + 404ml deionized water; (107) sample sat for 8 days chilled before processing; (108) small rip in bucket bag during transport, possible contamination from particles on bag falling into sample, sample knocked over during processing, volume likely slightly off; (109) 250ml Dry-Bulk sample + 250 ml of deionized water to process; (110) 150ml sample + 355ml deionized water; (111) 255ml sample + 245ml deionized water; (112) precipitation associated with thunderstorm previous night; (113) Aerochem sampler unplugged this period due to heater malfunction, heavy precipitation likely hail and rain associated with intense thunderstorm on 6/2/09 and possibly on other days, Dry bucket caught all wet and dry deposition this period; (114) 39ml of sample + 216ml of deionized water added for processing; (115) Dry bucket out for unusually long period, Aerochem sensor overheating this period; (116) leak in ST bag corner, many bugs in sample, volume not measured; (117) bird feces in sample, sample contaminated; (118) trace of precip from isolated thunderstorms; (119) dry-bulk bucket sat for very long period on buoy, dry, added 500ml deionized water to process; (120) precipitation from thunderstorms during period, bucket dry, added 500ml deionized water; (121) trees cut down near station possibly producing debris during pd.; (121) trees cut down near station during pd., opened canopy and possibly produced debris; (122) 185ml sample + 315ml DIW to process; (123) 23ml sample + 477ml DIW to process; (124) 2ml sample + 498ml DIW to process; (125) dead fly in sample, possible contamination; (126) much orange-yellow debris in dry bucket from either construction activity or tree cutting on property; (127) dead bee and many aspen leaves in sample, probable contamination, not processed; (128) significant new construction on land near station, trees to south of site removed, backhoe excavating, workers trying to control dust using hose spray; (129) pieces of unknown organic debris in ST sample, possible contamination; (130) 5ml sample + 500ml DIW to process; (131) probable contamination; (132) many small black bugs in sample; (133) possible contaminant on bucket rim; (134) 262ml sample + 238ml DIW; (135) bucket dry added 500ml DIW to process; (136) 80ml sample + 420ml DIW; (137) small amt of sample spilled in transit, estimate 125 ml, accounted for in final volume; (138) 162ml sample + 338 ml DIW to process; (139) 235ml sample + 265ml DIW;