Lahontan Reservoir:

General Analysis of Water Quality Data

2003 – 2005

Near Dam Site LR5

Nevada Division of Environmental Protection
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LAHONTAN RESERVOIR: 2003 - 2005 WATER QUALITY DATA

1. INTRODUCTION

In 1983, the Desert Research Institute (DRI) released a report entitled *The Lahontan Reservoir Water Quality Project*. The report consisted of six volumes which covered empirical water quality modeling, phosphorus load calculations, dynamic water quantity modeling and in situ fertilization studies. An empirical prediction model was used to set the current TP standard (≤ 0.06 mg/L) in the reservoir. The primary water quality problem in the reservoir was determined to be the proliferation of Cyanobacteria or nitrogen-fixing (heterocystous) blue-green algae, Aphanizomenon flos-aquae. Aphanizomenon can use nitrogen from the atmosphere once it is depleted in the water column, out-competing more desirable, less noxious algae species. The report also concluded that the primary source of phosphorus in the reservoir was coming from the Carson River. Load breakdowns are summarized in Table 1.

TABLE 1 Average Annual Phosphorus Loads to Lahontan Reservoir, DRI 1983

Source	TP, tons/year	% of Total	OP, tons/year	% of Total
Carson River	102	52	44.2	43
Truckee Canal	67.2	34	35.5	34
Sediment Release (internal load)	24	12	24	23
Bulk Precipitation	2.6	1	--	--
Runoff/Septic Tanks	0.25	<1	--	--
	Total = 196	**100**	**Total = 103.7**	**100**

DRI reported that only two pathways were available to change the nutrient limitation – increasing nitrogen or reducing the phosphorus loadings. In 1987, all sewage effluent discharges were eliminated from the Carson River, effectively reducing both N and P loads to the reservoir. However, it is unclear what the overall impact removing the point sources had on reservoir water quality. It has been 23 years since DRI's comprehensive investigation and the reservoir had only been sampled once in the interim (summer 1993) by the Nevada Division of Environmental Protection (NDEP). In spring 2003, NDEP commenced a new monitoring program to characterize current conditions and collect data for possible future standard revisions or Total Maximum Daily Load (TMDL) development. Six monitoring sites were selected (Figure 1) and are in the same approximate locations as the original DRI sampling stations.

This paper provides a general review of the physical and chemical data collected from Lahontan Reservoir from 2003 to 2005. Changes in nutrient *loading* have been evaluated in a separate document. Analysis and discussion will focus on the following data sets or topics:

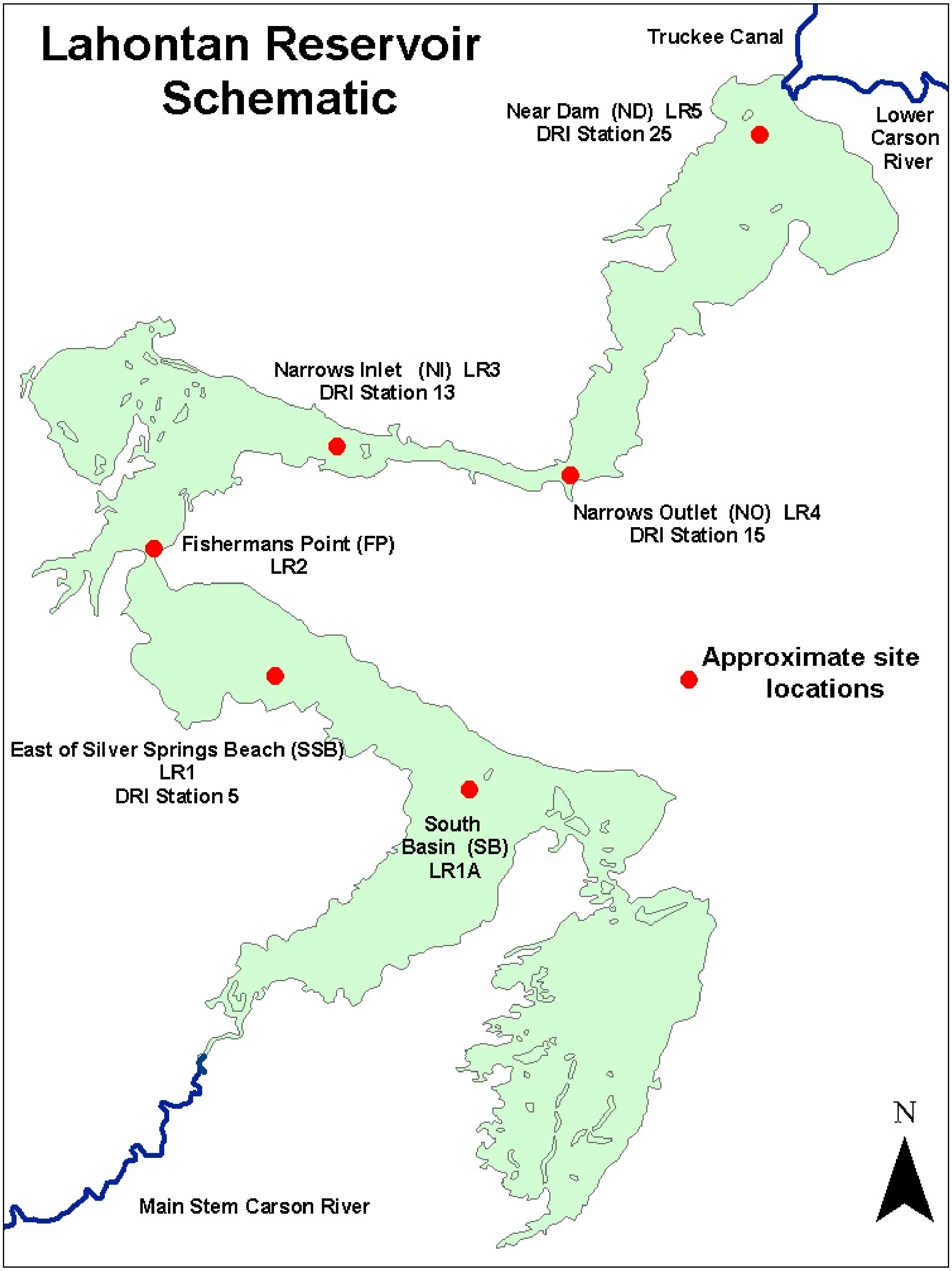
- Sonde depth profiles for chlorophyll a, Dissolved Oxygen (DO) and Temperature
- Chlorophyll a grab sample concentrations as an estimate of algae growth
- Change in Total Nitrogen (TN) and Total Phosphorus (TP) concentrations over time and with depth
- Relationship between TN, TP and chlorophyll a
- Comparing 1980, 1981 data with 2003 values
- Changes in nutrient concentration at Weeks Bridge

As urbanization increases within the watershed, municipalities are again investigating the possibility of discharging treated sewage effluent to the river. Impacts to the river and Lahontan reservoir must be weighed carefully against the social need.

2. YSI SONDE DATA – DEPTH PROFILES

YSI data was collected in 2003, 2004 and May 2005. The Sonde recorded temperature, conductivity, % oxygen, dissolved oxygen concentration, % fluorescence and chlorophyll a concentration. According to a paper entitled *In Vivo Measurements of Chlorophyll and the YSI 6025 Wiped Chlorophyll Sensor* found on the YSI website (https://www.ysi.com/DocumentServer/DocumentServer?docID=YSI_WP_E44), Sonde

FIGURE 1



Lahontan Reservoir Schematic
Truckee Canal
Near Dam (ND) LR5
DRI Station 25
Lower Carson River
Narrows Inlet (NI) LR3
DRI Station 13
Narrows Outlet (NO) LR4
DRI Station 15
Fishermans Point (FP)
LR2
Approximate site locations
East of Silver Springs Beach (SSB)
LR1
DRI Station 5
South Basin (SB)
LR1A
N
Main Stem Carson River

fluorescence measurements for chlorophyll a are not as accurate as lab-analyzed samples. The YSI chlorophyll data actually needs to be corrected for temperature. However, compensating for temperature does not guarantee accurate field readings. Other factors such as species of algae, shape & size of algae and level of photosynthetic activity can influence fluorescence. Comparison of the uncorrected June 2003 and 2004 YSI chlorophyll data with grab sample data indicate considerable differences between the field measurements and the lab-analyzed grab samples (Table 2). Correcting the equipment values and determining if the YSI is providing sufficient accuracy for screening algae growth in the field, will be determined at a later date. At this point in time, the grab sample data should be used for evaluating trophic condition in the Reservoir.

TABLE 2 Comparison of selected June YSI Sonde and Grab Sample Chlorophyll a Data

Monitoring Site	Depth m	2003 YSI Chlorophyll a, ug/L	2003 Grab Chlorophyll a, ug/L	% Difference	Depth m	2004 YSI Chlorophyll a, ug/L	2004 Grab Chlorophyll a, ug/L	% Difference
Silver Springs Beach	1	3.7	2.14	73	1	2.6	12.96	80
	4	3.0	0.77	290	6	2.1	1.15	83
Fishermans Point	1	3.5	1.75	100	1	2.5	2.74	8.8
	5	3.6	0.76	374	7	1.8	1.53	18
Narrows Inlet	1	1.5	1.44	4.2	1	1.2	2.26	47
	6	2.3	1.17	96	14	3.2	0.88	264
Narrows Outlet	1	1.1	1.22	9.8	1	0.9	2.61	66
	8	2.0	1.31	53	5	1.1	1.09	1
Near Dam	1	1.4	1.61	13	1	2.5	5.53	55
	13	1.5	0.73	105	4	2.4	3.19	25
	22	1.6	0.72	122	23	3.4	1.38	146

Note: Relative % Difference = Absolute Value of: {(Estimated – Measured)/Measured} x 100 (Christensen *et al*, 2000)
YSI concentrations are considered estimated values; Grab samples are measured values.

It can be determined from the Sonde readings at what depth DO falls below the 5.0 mg/L minimum aquatic life standard (Table 3). Low DO concentrations can promote the release of orthophosphate from sediment at the bottom of the reservoir and contribute to the nutrient load. An example profile plot for DO, chlorophyll a and temperature is given in Figure 2. The remaining data can be provided upon request.

FIGURE 2

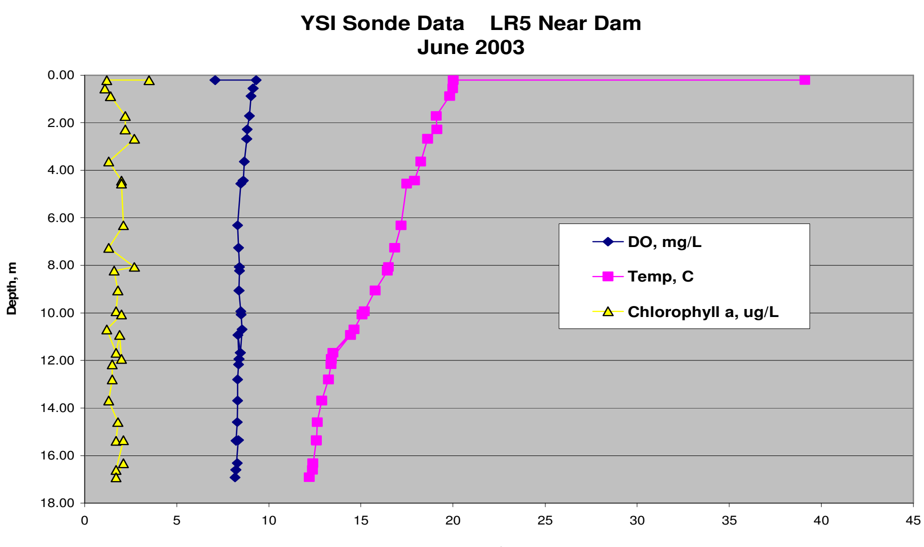


TABLE 3 YSI Sonde Depth (meters) Readings corresponding to DO Standard Violations

Year	Month	South Basin	Silver Springs Beach	Fishermans Point	Narrows Inlet	Narrows Outlet	Near Dam
2003	**June**	No record	Meets or xcds std	Meets or xcds std	Meets or xcds std	Meets or xcds std	Meets or xcds std
	July	No record	Meets or xcds std	**8.7**	**14.2**	**16**	**21**
	Aug	No record	No record	Meets or xcds std	**10**	**13**	**12**
	Sep	No record	Meets or xcds std	Meets or xcds std	Meets or xcds std	Meets or xcds std	**19**
2004	**Feb**	No record	Meets or xcds std	Meets or xcds std	Meets or xcds std	Meets or xcds std	Meets or xcds std
	May	Meets or xcds std	Meets or xcds std	Meets or xcds std	Meets or xcds std	Meets or xcds std	Meets or xcds std
	Jun	Meets or xcds std	Meets or xcds std	Meets or xcds std	Meets or xcds std	**17**	**23.6**
	Aug 4	**3.4**	**5.1**	Meets or xcds std	Meets or xcds std	No record	No record
	Aug 24	No record	Meets or xcds std	Meets or xcds std	No record	**13.2**	Meets or xcds std
2005	**May**	Record incomplete	No record	Meets or xcds std	Meets or xcds std	Meets or xcds std	**19.5**

Eleven percent (21/198) of the grab samples collected between 2003-2005 violated the minimum aquatic life standard for DO (Appendix A). Most of these samples were collected in summer 2005. The lowest measurement was recorded at Near Dam on 8/25/05 (0.08 mg/L) and corresponded to an OP concentration of 0.420 mg/L. This may indicate available phosphorus was being released from benthic sediments.

3. Chlorophyll a

a. Comparison of Mean Concentrations

Mean chlorophyll data from 1980 and 1981 was compared to NDEP's 2003 – 2005 data using box plots. Only 4 sites were plotted because data was not provided by the 1983 DRI report for South Basin and Fishermans Point. In order to obtain monthly means, data from the DRI Report was approximated from the graphs pictured on page 45 of Volume V. Data was tabulated and averaged for each monitoring site. Figure 3 indicates the DRI Study found the upper basin site (Silver Springs Beach) was lower in chlorophyll a concentration compared to the lower basin sites. NDEP's data suggests the reverse results. Chlorophyll a concentrations collected from the upper sites in 2003 – 2005 are higher compared to the lower basin.

b. 2003 – 2005 Grab Samples

Figure 4 shows the mean concentrations at South Basin (SB), Silver Springs Beach (SSB) and Fishermans Point (FP) were much higher compared to Narrows Inlet (NI), Narrows Outlet (NO) and Near Dam (ND) for the 3 year time period 2003 - 2005. The highest chlorophyll a concentrations were measured in July 2005, increasing the annual mean in comparison to 2003 and 2004 (Figure 5). In general, higher concentrations of chlorophyll a are found near the surface or in the epilimnion. The stratified layers of a lake or reservoir are designated the epilimnion, metalimnion and hypolimnion. The warmer, less dense epilimnion is separated from the cooler, denser hypolimnion by the metalimnion or thermocline, a layer of rapidly changing temperature and density (Moore and Thornton, 1988).

Box plots (Appendix B) for each monitoring station during each individual year show that the means at each site were greatest in 2005. In 2004 and 2005 the mean concentrations were greater at SB, SSB and FP compared to NI, NO and ND. In 2003, this trend was less pronounced but still evident. Mean chlorophyll a was much higher at the South Basin in 2003 compared to the other stations.

FIGURE 3

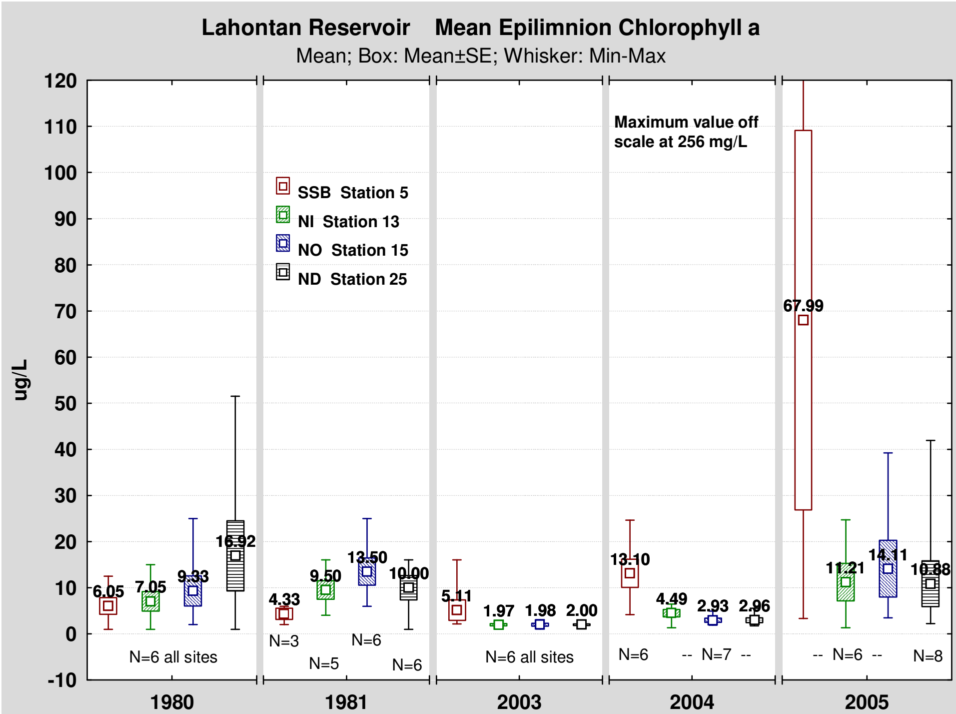
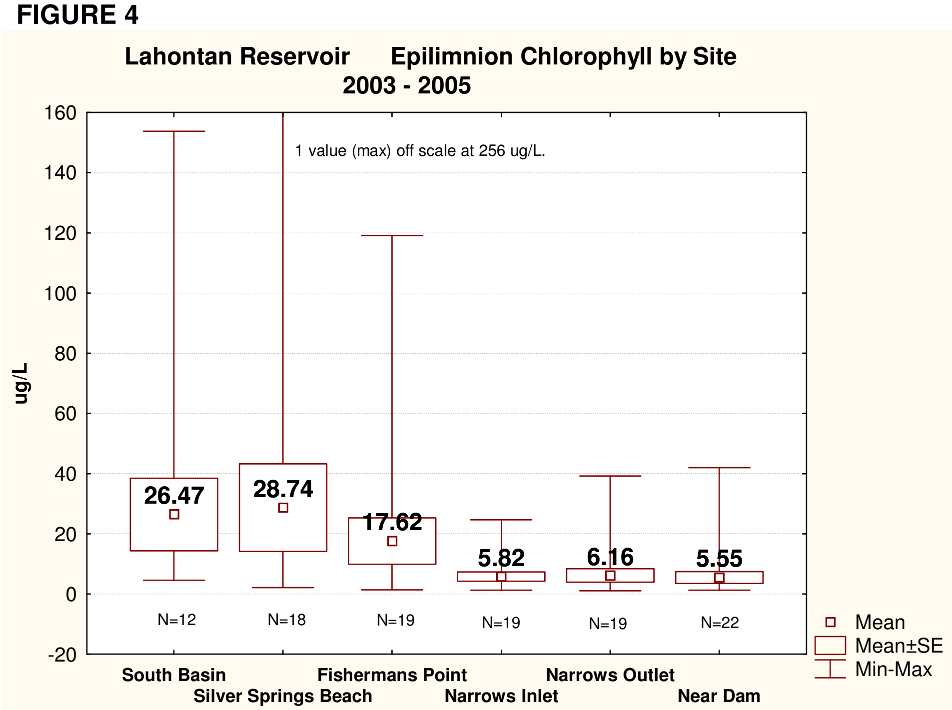


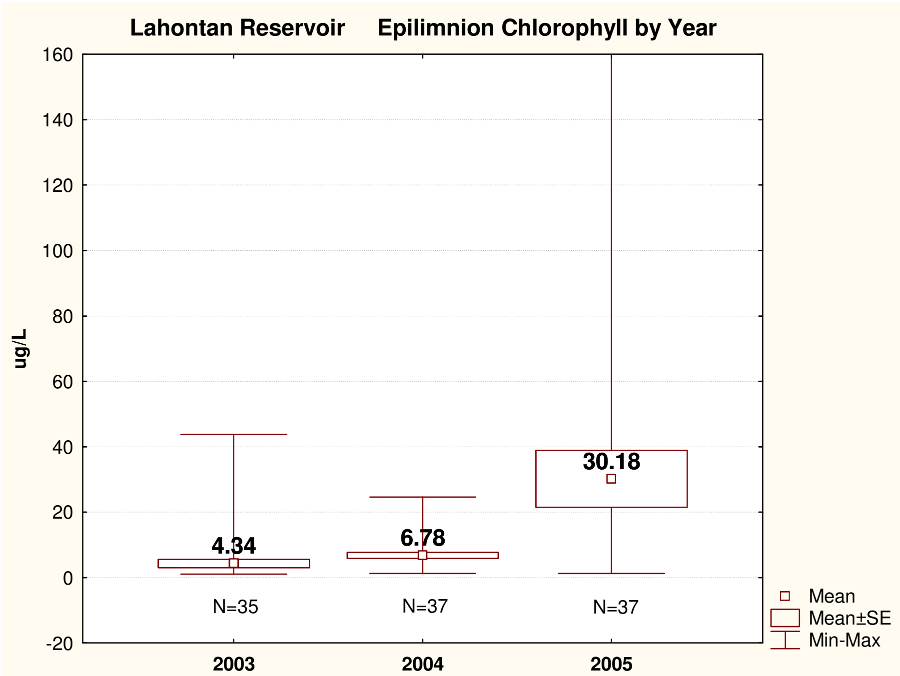
FIGURE 4



c. Relationship with Secchi Depth (SD)

As shown Appendix C, changes in Secchi Depth (SD) follow a similar pattern at each site. Clarity increases May to June, then generally decreases as summer progresses into fall. The sample representing the greatest clarity was collected August 2005 at Near Dam (76 inches or 1.93 meters), but the epilimnion chlorophyll a concentration was low (2.32 ug/L). This implies a factor other than light was restricting algae growth at this particular point in time.

FIGURE 5



Moderately strong inverse relationships (R^2 = 0.46, 0.43) were found between Epilimnion chlorophyll a and Secchi Depth (SD) after combining and transforming the 2003 and 2004 data collected from SB, SBB and FP (upper reservoir sites). There is an extremely weak correlation between SD and chlorophyll a in 2005. Scatterplots of the combined NI, NO and ND (lower reservoir sites) data suggest no clear correlation between surface/epilimnion chlorophyll and the Secchi readings for 2003, 2004 or 2005. These results may imply the downstream reservoir sites are not light-limited due to algae particles. Lack of clarity may be the result of inorganic turbidity similar to what was determined for Lake Carl Blackwell in Oklahoma. Investigators found a low correlation (R = 0.41 or R^2 = 0.16) between Secchi Depth and chlorophyll a. Light attenuation in this reservoir was primarily due to clay particles (Randolph and Wilhm, 1984). Phytoplankton growth in Lake Chapala, Mexico was also determined to be light-limited due to high inorganic turbidity (Davalos et al, 1989 as cited in Lind et al, 1992).

Individual site regressions did not yield significant correlations between chlorophyll a and SD. Analysis of all the site data transformed and grouped by year yielded relatively weak but significant relationships for 2003 and 2004 only. Weak or insignificant relationships between chlorophyll a and TSS or NTU for most of the data sets also support light limitation due to non-algal turbidity. Moderately strong correlations were found for 2003 and for South Basin.

A number of studies evaluated factors that represent light climate to predict chlorophyll a or algal biomass. Smith (1986) estimated biomass of blue-green algae from a multiple regression equation incorporating the ratio of Secchi depth to depth of the mixed layer (Z_m) as one of the independent variables. Lind *et al* (1992) calculated depth of the euphotic zone (Z_{eu} or the lower limit of photosynthesis) from Secchi depth, but found the ratio of Z_m/Z_{eu} contributed only weakly to equations predicting chlorophyll a at two of their sampling sites. Jensen *et al* (1994) also calculated Z_{eu} from Secchi depth but used Z_{eu}/Z_m to estimate dominance of Cyanobacteria in 178 shallow lakes located in Denmark. The study found only a weak relationship between the parameters.

4. Orthophosphorus / Total Phosphorus

Phosphorus concentrations in Lahontan Reservoir generally increase *within* each layer (Epi, Meta, and Hypo) as the summer progresses. Most samples were comprised of 40% or greater orthophosphorus (OP). The OP (or soluble reactive phosphorus, SRP) concentrations fall off dramatically (to <20%) in several July 2005 samples most likely due to increased utilization of the available nutrients for algae growth. As noted in the previous section, the greatest chlorophyll concentrations were observed in July 2005. An example plot is provided in Figure 6. The remaining plots will be provided upon request. Mean annual phosphorus (Figure 7) is fairly constant for 2003-2005. The changes in the data distribution by site are illustrated in Figure 8. Mean values decrease from South Basin to Near Dam. All individual TP values exceed the single value standard of 0.06 mg/L that applies from Lahontan Dam upstream to Weeks Bridge (NAC 445A.158).

FIGURE 6

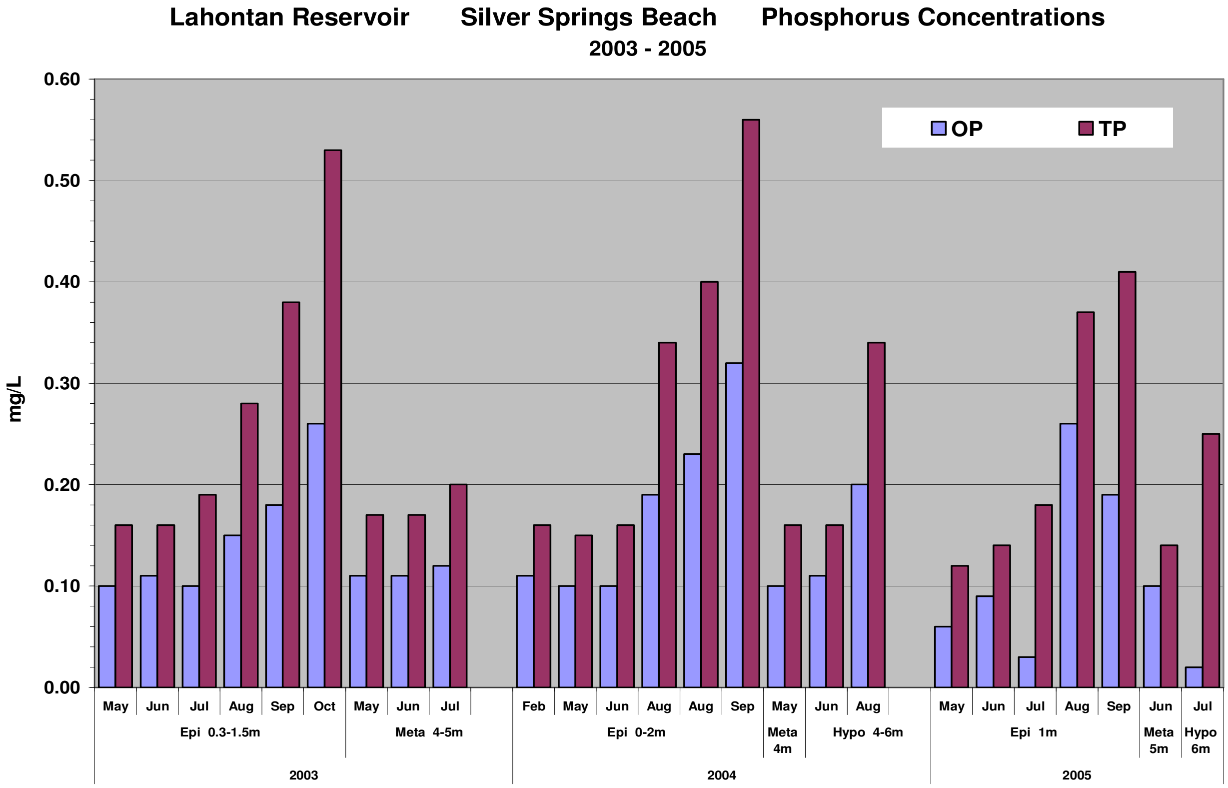


FIGURE 7

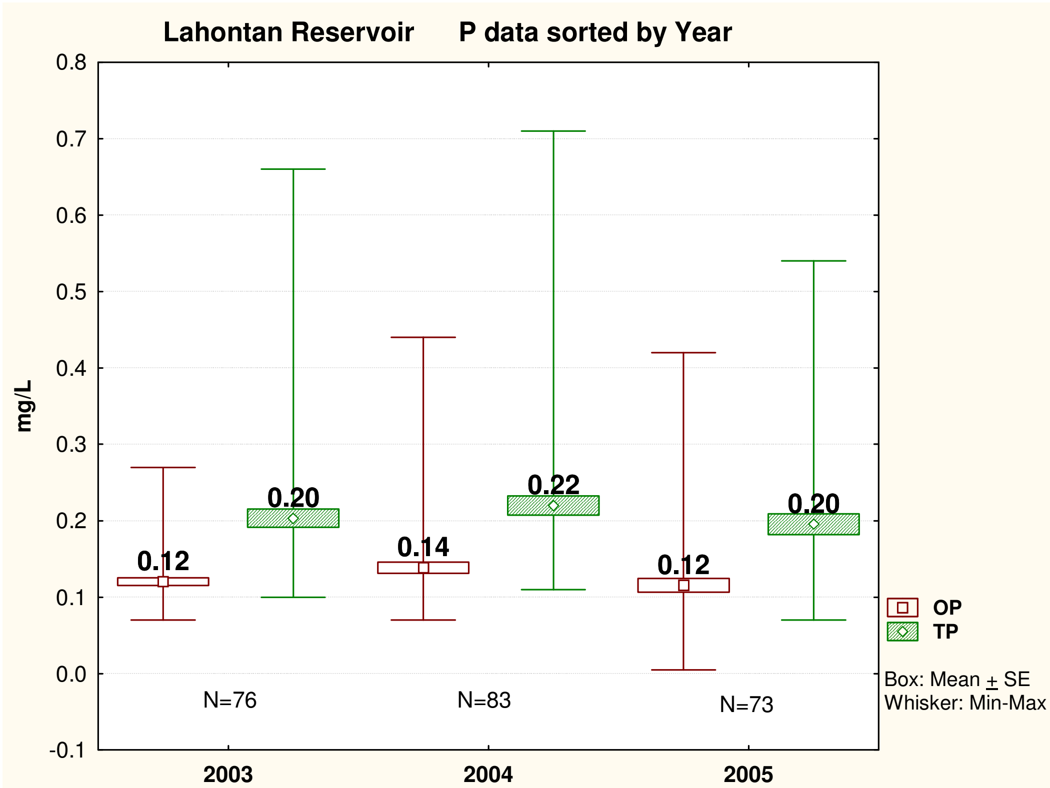
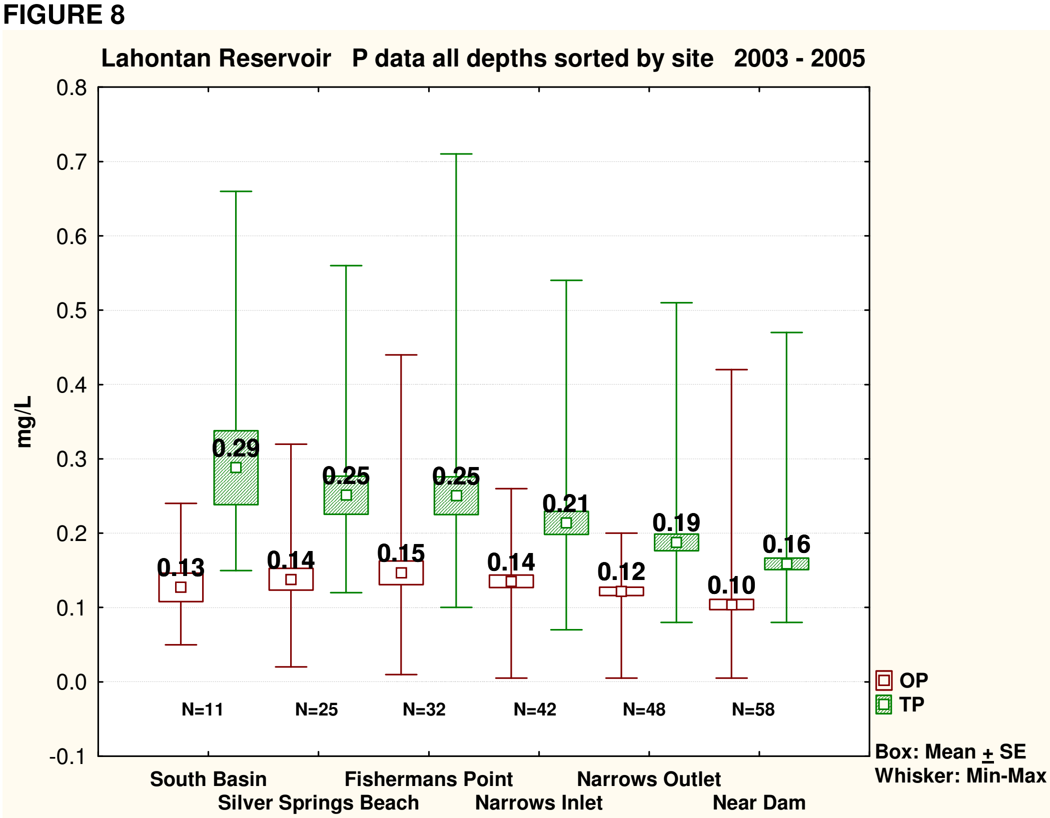

Lahontan Reservoir P data sorted by Year
mg/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.12
0.20
0.14
0.22
0.12
0.20
N=76
N=83
N=73
2003
2004
2005
OP
TP
Box: Mean + SE
Whisker: Min-Max

FIGURE 8


Lahontan Reservoir P data all depths sorted by site 2003 - 2005
mg/L
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.13
0.29
0.14
0.25
0.15
0.25
0.14
0.21
0.12
0.19
0.10
0.16
N=11
N=25
N=32
N=42
N=48
N=58
South Basin
Silver Springs Beach
Fishermans Point
Narrows Inlet
Narrows Outlet
Near Dam
OP
TP
Box: Mean + SE
Whisker: Min-Max

5. Nitrogen / Phosphorus

The TN/TP ratio can be an appropriate means to identify *potential* nutrient limitation in a waterbody. Dodds (2003, 2006) recommends using TN/TP ratios as more accurate indicators of nutrient limitation than a ratio of the dissolved inorganic nitrogen (DIN) and soluble reactive phosphorus (SRP) because the inorganic concentrations measured may not represent actual supply. Other fractions of the total N or P pools may also be bioavailable. Dzialowski and others (2005) found that bioassay experiments conducted on samples collected from 19 reservoirs in Kansas confirmed the water column TN/TP ratios correctly predicted the limiting nutrient in 88% of the locations. However, TN/TP may not be a good predictor variable in a regression equation. Downing *et al* (2001) determined that a biomass index for blue-green algae (% BG/100-%BG) is more strongly correlated to TN, TP or chlorophyll a than the stoichiometric ratio TN/TP.

A system can be considered nitrogen-limited for algae growth if TN/TP < 10 by weight and phosphorus-limited if TN/TP > 17 (Smith, 1982). Studies of marine plankton determined the N:P or Redfield Ratio to be 7.2:1 by weight (16:1 molar). However, algae in lake environments can deviate markedly from this stoichiometry (Wetzel, 2001). Species of phytoplankton in a natural assemblage can have different nutrient requirements and uptake N and P at different rates. Investigators (Suttle and Harrison, 1988) found N fixers Anabaena planctonica and Aphanizomenon flos-aquae are less competitive for P than non N fixers such as the diatoms Synedra acus and Asterionella formosa. Even in an N-limited system, Cyanobacterial production may be inhibited because of a poor affinity for phosphorus.

TN/TP ratios calculated for 2003 – 2005 *suggest* that Lahontan Reservoir is still N-limited. Annual mean epilimnion values (Figure 9) indicate that the ratio increased slightly in 2005. Data stratified by site (Figure 10) illustrates a *general* decrease in mean concentration between the upper and lower reservoir sites but the ratio remains relatively the same (3 or 4 to 1). In 2003 and 2004, monthly TN/TP ratios were all < 5. The DIN/OP ratios were < 2. In 2005, the TN/TP ratios determined for a number of samples indicate an apparent change in limitation or nutrient supply during July and August (Figures 11 and 12). Values ≥ 10 and ≤ 17 may infer possible co-limitation. DIN concentrations for these samples were all measured at less than the laboratory reporting limit and OP concentrations were < 20% of TP except for the Near Dam sample taken 8/25/05. For this particular sample, OP may be limiting (chlorophyll a = 2.32 ug/L). The DIN concentration was 0.444 mg/L (primarily NH_4^+) and OP was 0.050 mg/L for a DIN/OP = 9 (TN/TP = 12).

Box plots (Figure 13) were used to compare DIN/OP ratios from 1980-81 and 2003-05 at four sites. TN or TP concentrations were not provided in the DRI Report. Refer to Appendix D for table of data used to calculate box plots. Not all box plots were constructed using the same number of data points. In addition, two of the sites, South Basin and Fisherman's Point were not part of the original DRI project. The 1980 and 1981 data sets were obtained from page 57 of the 1983 DRI Report (Volume 5).

The box plots suggest that the N-limited conditions in the reservoir have not changed between the 1980-81 study periods and NDEP's 2003-05 sampling program, except for the significant increase in DIN/OP seen at the near Dam site in 2005. The concentration of OP in July 2005 was measured at less than the laboratory reporting limit (<0.01 mg/L), *suggesting* possible P-limitation. Replicate DIN values were recorded at 0.153 and 0.100 mg/L. The nitrite, ammonium and unionized values were left out of the DIN calculations for 2003-05 if the values were listed at less than the laboratory reporting limit.

According to DRI (p 74, Volume 5), the reservoir will remain nitrogen-limited unless a substantial reduction in phosphorus is attained *without* a corresponding drop in nitrogen. Upstream sources of nonpoint source pollution and internal cycling of P in the reservoir may be two factors maintaining phosphorus saturation and the apparent N-limitation.

Total Kjeldahl Nitrogen (TKN = organic N + ammonia) data indicates organic nitrogen dominates. Plots of TKN and TN are available upon request. General observations show nitrogen at all depths increases as summer progresses, however, some sites exhibited a maximum value in July 2005.

FIGURE 9

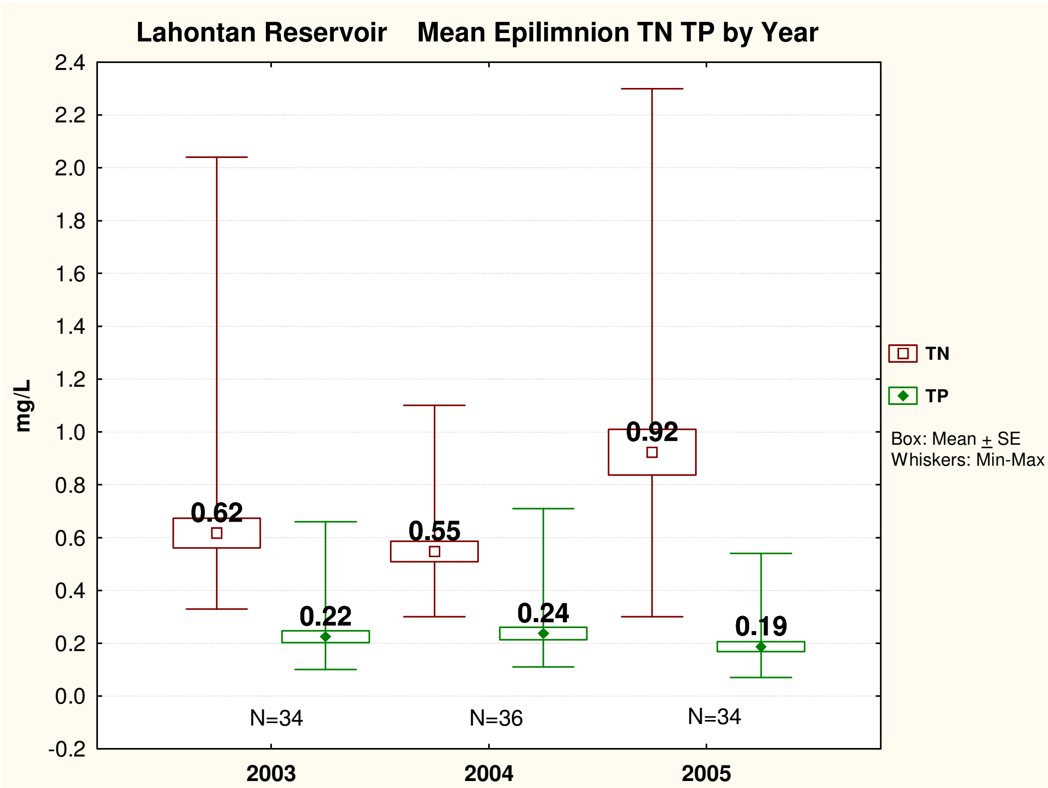


FIGURE 10

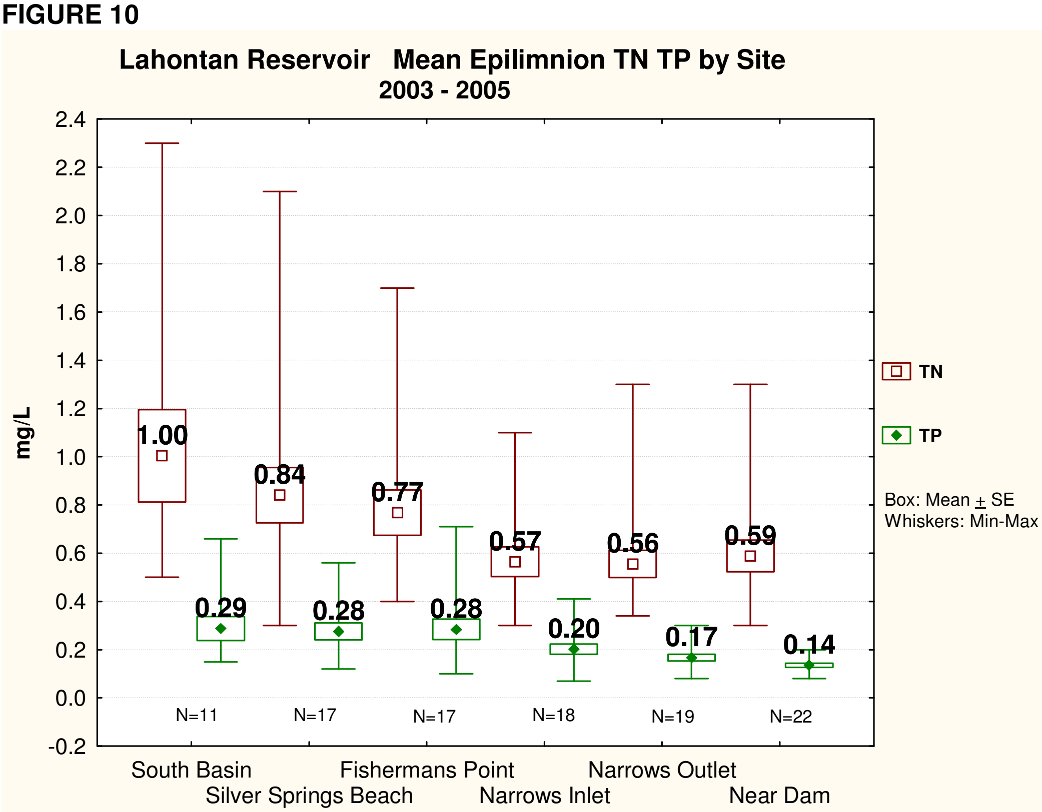


FIGURE 11

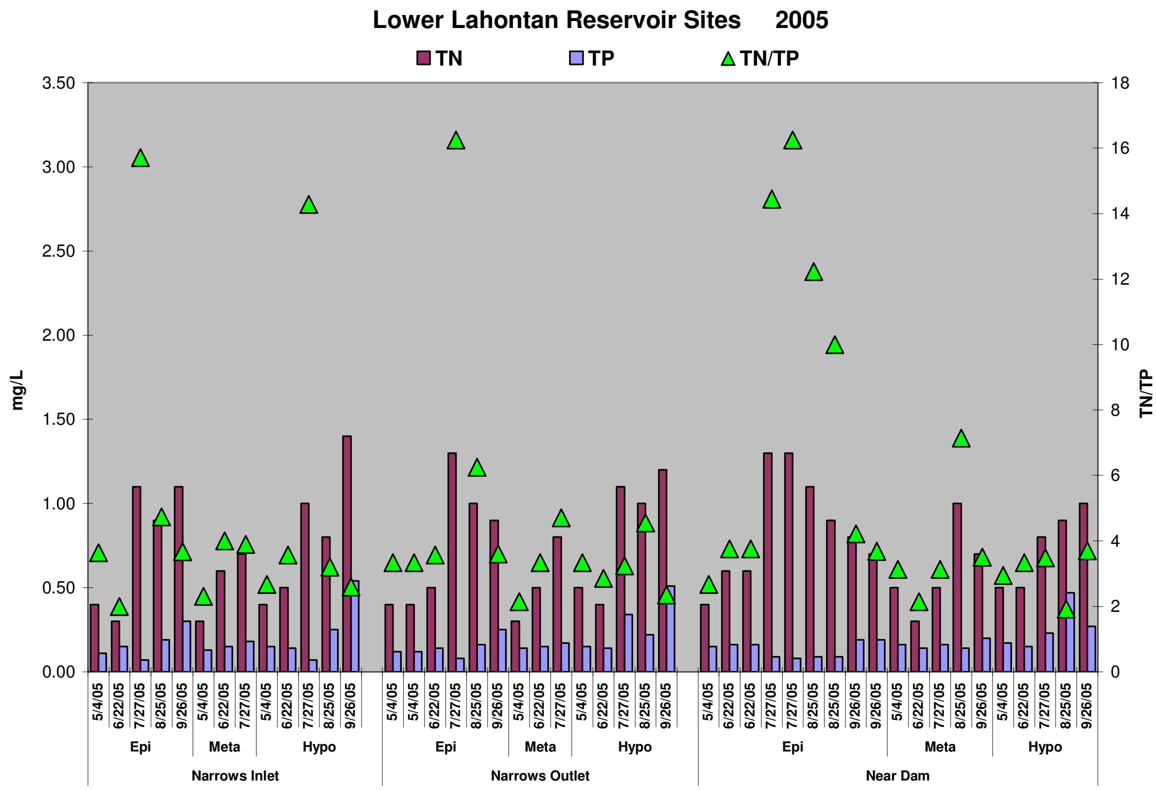


FIGURE 12

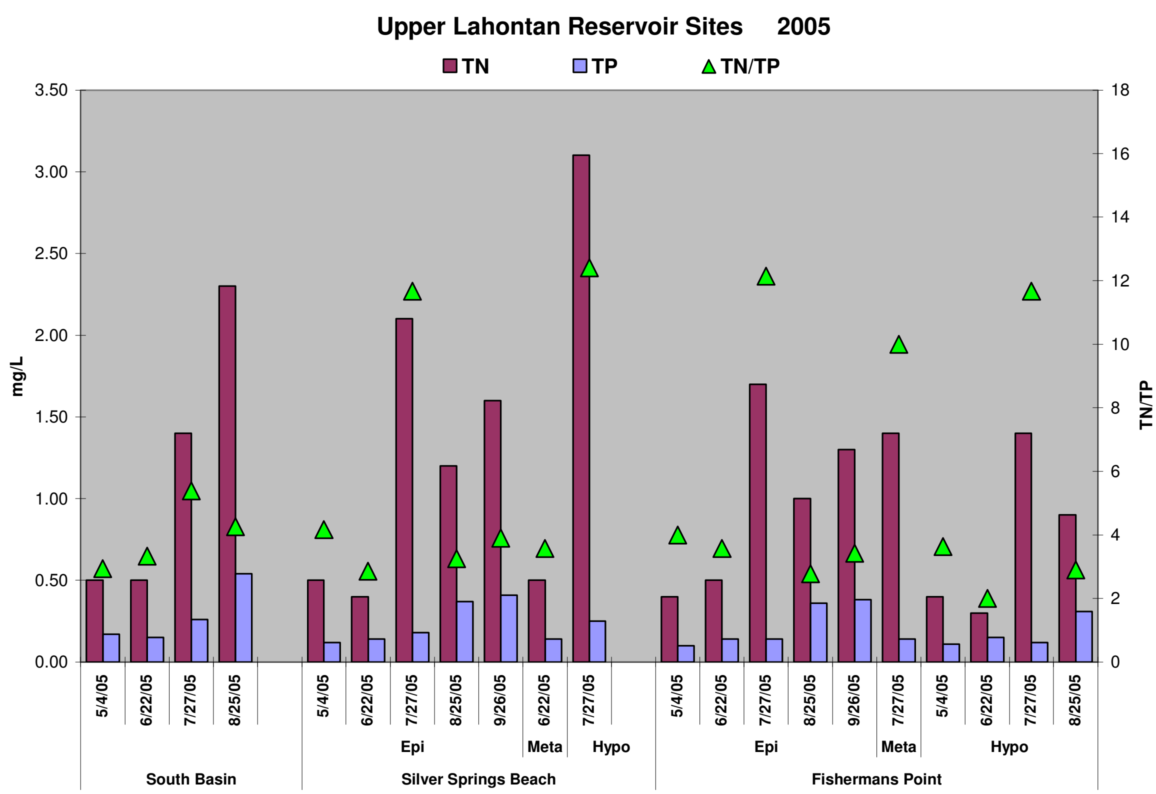
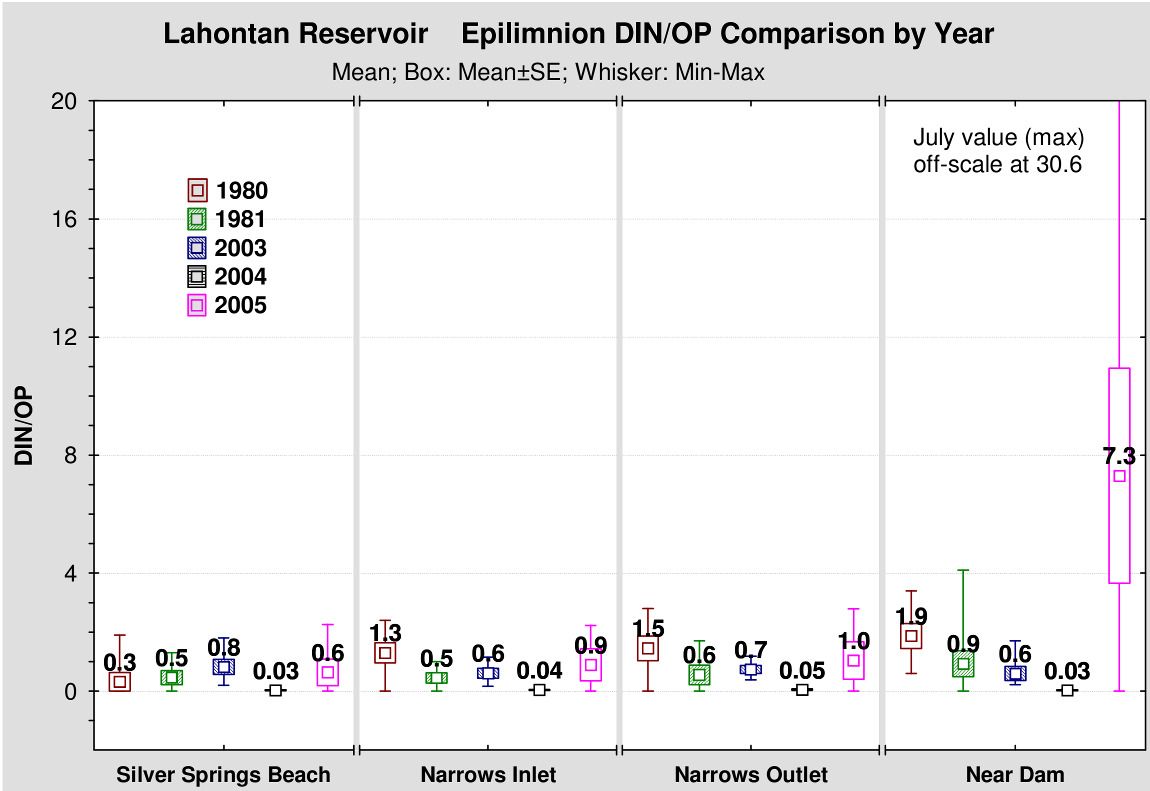


FIGURE 13



6. Comparison of mean 1980 nutrient data with 2003 values

The 1983 DRI report did not supply the raw data. A Table on p. 51 in Volume V provided mean nitrogen and phosphorus values measured for 1-meter surface samples collected from 4 sampling sites – Station 5 (E of Silver Springs Beach), Station 13 (Narrows Inlet), Station 15 (Narrows Outlet) and Station 25 (Near Dam). In order to make an appropriate comparison with the 1980 values, 2003 data was analyzed in the same manner. Concentrations for "bottom" samples at Station 25 were also listed but are not mean values. It is unclear at what depth the 1980 benthic or hypolimnion samples were collected. The 2003 hypolimnion samples were collected from 15 to 23 meters.

Box plots (Figure 14 & 15) indicate that the TKN means are higher in 1980 and 1981 compared to 2003. It should be noted that most of the 2003 NH3 and NO2 samples were measured below the reporting limit, so this data was left out of the graphs. There appears to be no difference between phosphorus means in the epilimnion comparing 1980 and 2003; 1981 has somewhat higher OP and TP. The mean "bottom" or hypolimnion values for TP and OP are lower in 2003 than in 1980 and 1981.

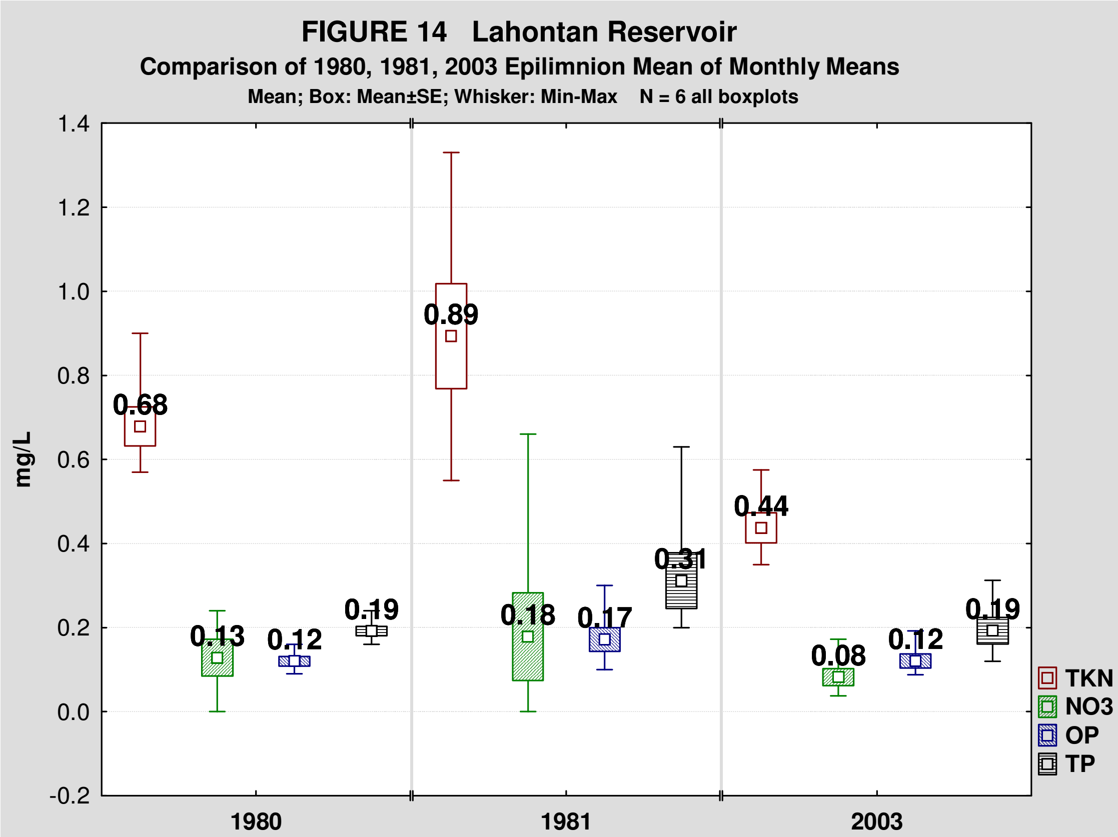


FIGURE 14 Lahontan Reservoir
Comparison of 1980, 1981, 2003 Epilimnion Mean of Monthly Means
Mean; Box: Mean±SE; Whisker: Min-Max N = 6 all boxplots
mg/L
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
0.68
0.13
0.12
0.19
0.89
0.18
0.17
0.31
0.44
0.08
0.12
0.19
1980
1981
2003
TKN
NO3
OP
TP

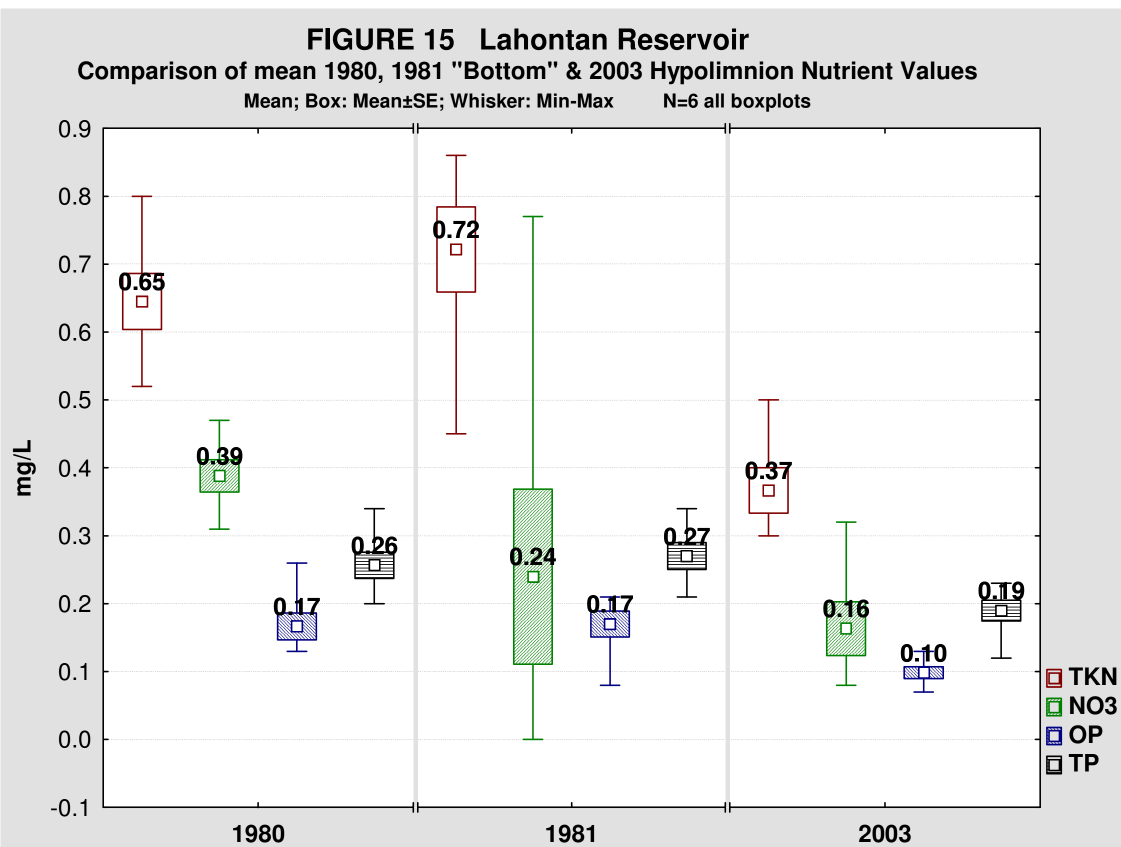


FIGURE 15 Lahontan Reservoir
Comparison of mean 1980, 1981 "Bottom" & 2003 Hypolimnion Nutrient Values
Mean; Box: Mean±SE; Whisker: Min-Max N=6 all boxplots
mg/L
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
0.65
0.39
0.17
0.26
0.72
0.24
0.17
0.27
0.37
0.16
0.10
0.19
1980
1981
2003
TKN
NO3
OP
TP

7. RELATIONSHIP BETWEEN NUTRIENTS AND CHLOROPHYLL a

a. Trophic Status

Trophic status is a convenient means of classifying organic matter production in a lake or reservoir. Eutrophic lakes are usually characterized by high nutrients and excessive algae growth. According to Vollenweider (1968), as discussed in Carroll et al (1996), trophic status is defined by the mean TP concentration (ug/L) in the epilimnion:

Ultra-oligotrophic	<5
Oligo-mesotrophic	5-10
Meso-eutrophic	10-30
Eutrophic	30-100
Hypereutrophic	>100

The definition of trophic status provided by Reckhow & Chapra (1983), which is also described in Carroll et al, is based on mean chlorophyll a:

Oligotrophic	<4
Mesotrophic	4-10
Eutrophic	10-25
Hypereutrophic	>25

The trophic status of Lahontan Reservoir (Table 4) was evaluated according to these two classification systems by organizing the epilimnion TP and chlorophyll a data into 3 separate combinations:

- Combining values from all 6 sites for the time period 2003-2005
- Stratifying data by year
- Stratifying data by each site for the time period 2003-2005

TABLE 4 Trophic Status of Lahontan Reservoir

Data Group	Site or Year	Mean Epilimnion TP, mg/L	Vollenweider System	Mean Epilimnion Chlorophyll a, ug/L	Reckhow & Chapra System
All sites	2003-2005	0.22	Hypereutrophic	13.94	Eutrophic
All sites by year	2003	0.22	Hypereutrophic	4.34	Mesotrophic
	2004	0.24	Hypereutrophic	6.78	Mesotrophic
	2005	0.19	Hypereutrophic	30.18	Hypereutrophic
By site for 2003-2005	South Basin	0.29	Hypereutrophic	26.47	Hypereutrophic
	Silver Springs Beach	0.28	Hypereutrophic	28.74	Hypereutrophic
	Fishermans Point	0.28	Hypereutrophic	17.62	Eutrophic
	Narrows Inlet	0.20	Hypereutrophic	5.82	Mesotrophic
	Narrows Outlet	0.17	Hypereutrophic	6.16	Mesotrophic
	Near Dam	0.14	Hypereutrophic	5.55	Mesotrophic

b. Re-evaluate Griebe Equation – observed vs. predicted chlorophyll a 2003 – 2005

The Grieb Equation (Chlorophyll a = 0.9 TP $^{0.6}$) used by DRI in Volume V (p. 22) of *The Lahontan Reservoir Water Quality Project* report (1983) for empirical modeling no longer applies. The equation was derived from a data set collected from artificial lakes. Chlorophyll a concentrations were calculated from observed TP concentrations using the Grieb equation, but the predicted Chlorophyll a values were much higher in most cases than the observed value (Appendix E). Predictive relationships should be developed from site-specific data and may require multiple regression analysis. Smith (1982) derived a multiple regression model (log Chl a = b_0+b_1 Log TP+b_2 Log TN) from data collected from 127 northern latitude lakes, which reduced the error of chlorophyll a prediction. A second study by Smith (1986) incorporated Secchi depth and depth of the mean mixed layer into a regression analysis to estimate the effects of light climate on algae biomass. Walker (1982) determined that the limiting effects of both nitrogen *and* turbidity must be accounted for when evaluating the empirical models that describe chlorophyll as a function of TP.

However, it should be noted that extra explanatory variables x_{k+1} to x_m may not provide a multiple regression model with any additional power to explain the variation in y (Helsel and Hirsch, 2000). Some of the multiple regression equations developed using the Lahontan Reservoir data showed the inclusion of TP does not significantly contribute to the variation in chlorophyll a (Appendix F).

c. Correlation between TN, TP and Chlorophyll a

Linear regression analysis of the LN transformed data from all 6 sites combined for the 2003-2005 time period indicates TN explains a greater portion of the variation in chlorophyll a than TP (Appendix F). Stratifying the data by year or by site also shows chlorophyll a is more strongly correlated to TN than to TP. Lind et al (1992) reported the variation in N explained the greatest variation in chlorophyll a at each monitoring station in Lake Chapala, Mexico. Stronger relationships were found in Lahontan Reservoir between chlorophyll a and TP in 2003 and 2004 compared to 2005. Sorting the data by site for 2003 through 2005 indicates the correlation between chlorophyll a and TP was greatest at South Basin. The relationship was weak but significant at Silver Springs Beach. The regressions were insignificant at the remaining 4 sites. Similar results, albeit stronger correlations in some cases were found by evaluating only the epilimnion data. However, it appears that the insignificant relationships or poor correlations are due to only one or two outliers per site that are much higher in chlorophyll a than the other samples, increasing the scatter or skew in the data set. Increasing the sampling frequency during the critical summer months or bloom periods may improve the correlations. Any linear regression model developed for predicting a response variable must also be evaluated to ensure it meets the normality assumption.

Epilimnion concentrations were also grouped into upper reservoir (SB, SSB, FP) and lower reservoir (NI, NO, ND) data sets. Linear regression analyses again suggest that chlorophyll a is more strongly correlated to TN than TP. However, a non-linear model (exponential or power fit similar to Griebe equation) may be a more appropriate expression of the relationship between N or P and chlorophyll a. Overall, the analyses suggest that nutrients may not be the only variables regulating algae growth in the reservoir. The equations explain only a portion of the variance in chlorophyll a concentration.

Cyanobacteria or heterocystous blue-green algae may dominate under conditions of N deficiency because of their ability to fix nitrogen from the atmosphere. However, Ferber et al (2004) determined that although Cyanobacteria comprised 81-98% of the phytoplankton in a Vermont lake, minimal N fixation was occurring (low heterocysts). The investigators suggest the more buoyant Cyanobacteria dominated by storing benthic ammonium, migrating upward and accumulating on the surface to shade out other species of algae. Low CO2 and high pH may also promote Cyanobacteria growth (Levine and Schindler, 1999). Paerl and Ustach (1982) concluded that Cyanobacteria prefer CO2 to carbonate or bicarbonate for photosynthesis. Once all of the CO2 is consumed in the water column, the Cyanobacteria form surface scums by utilizing CO2 directly from the atmosphere. The blooms limit the amount of light available to underlying algae, reinforcing their competitive advantage. Shapiro (1997) also found that N-fixers such as Aphanizomenon and Anabaena actually uptake CO2 more efficiently than other phytoplankton. At high pH, low levels of free CO2 are available only to Cyanobacteria which further deplete the concentrations to levels only they can utilize, increasing their population and guaranteeing their dominance.

8. Algae Identification

The 1983 DRI report stated that low DIN is associated with blooms of blue-green algae. Once all the DIN is depleted in the water column, heterocystous blue-greens may fix atmospheric nitrogen and dominate the algal population. This occurred in the early 1980's and again in 1991, three years after the effluent discharge was eliminated in the Carson River. The 1991 bloom resulted in a massive fish kill as reported by the Lahontan Valley News (Appendix G). Establishing impairment or developing an appropriate "Recreational" TMDL may require a specific species standard in addition to Chlorophyll or nutrient criteria. Cyanobacteria can be toxic to humans and animals. Several Cyanobacteria, including Microcystis, Anabaena, Planktothrix and Aphanizomenon can produce a neurotoxin, β-N-methylamino-L-alanine, which causes amyotrophic lateral sclerosis/Parkinsonism dementia complex (ALS/PDC) in humans (Cox et al 2005 as cited in Kotak and Zurawell, 2006).

For additional information refer to the summer 2006 issue of *LakeLine,* published by the North American Lake Management Society or to the following websites:

http://www.cdc.gov/hab/cyanobacteria/activities.htm or
http://www.nalms.org/Resources/BlueGreenInitiative/Overview.htm.

DRI identified the algae species present in samples collected during summer 2004. Table 5 summarizes the top 2 species found at the selected sites. According to the data DRI collected, biovolumes fluctuated considerably and the Cyanobacteria (Aphanizomenon flos-aquae) did not always dominate the algal population, despite low N:P ratios (TN/TP and DIN/OP) which *suggest* nitrogen limitation and more favorable conditions for N-fixing blue-greens. The highest biovolume of Aphanizomenon flos-aquae was measured at the Near Dam site in June, but phytoplankton dominated the surface layer at Fishermans Point.

The water chemistry collected by NDEP was not necessarily measured at the same depth an algal sample was taken, but XY plots of biovolume and OP concentration or chlorophyll a suggest moderately strong relationships (R^2 = 0.61 and 0.59). Future investigations should ensure that algae biomass and water quality samples are collected concurrently in order to more accurately evaluate any correlations.

Figure 16 compares biovolume of the individual algal taxa to the percentage of the total measured biovolume. The Aphanizomenon flos-aquae (CB in plot), as stated previously, did not always dominate. When the measured Cyanobacteria production was greatest, the biovolume was less than the highest volume measurements for the other algal species reported as dominant at other times. It is unknown at this time what biomass or chlorophyll a concentration would be considered a nuisance by the general public and be unacceptable for recreational use.

TABLE 5 Dominant Algae at Selected Sites in Lahontan Reservoir (DRI, 2004)

Date	Site Name	Site ID	DRI Depth m	TAXA	Biovolume um^3/ml	% of Total Measured Biovolume	NDEP Depth, m	OP, mg/L	Chlorophyll a, ug/L
6/22/04	Fishermans Point	LR2 Surface	**0**	**Ceratium sp. (phytoplankton)**	**122,207**	**74**	**1**	0.100	2.74
		LR2 Meta/Hypo[2]	**7**	**Astrionella formosa (diatom)**	**25,206**	**48**	**7**	0.110	1.53
	Near Dam	LR5 Surface	**0**	**Aphanizomenon flos-aquae**	**184,767**	**86**	**1**	0.070	5.53
		LR5 Meta	**4**	**Aphanizomenon flos-aquae**	**62,551**	**67**	**4**	0.080	3.19
8/4/04	Fishermans Point	LR2 Surface	**0**	**Cryptomonas (phytoplankton)**	**322,491**	**85**	**1**	0.160	19.76
		LR2 Meta	**2**	**Cryptomonas**	**83,828**	**56**	**2**	0.180	17.99
	Near Dam	LR5 Surface	**0**	**Aphanizomenon flos-aquae**	**12,156**	**23**	**1**	0.080	2.46
		LR5 Meta	**5**	**Cryptomonas**	**1213**	**34**	**5**	0.080	1.06
8/24/04	Fishermans Point	LR2 Epi	**1**	**Aphanizomenon flos-aquae**	**22,972**	**84**	**No data**	No data	No data
		LR2 Meta	No data	No data	No data	No data	**2**	0.240	14.32
		LR2 Hypo	**NA**	**Aphanizomenon flos-aquae**	**68,738**	**47**	**No data**	No data	No data
	Near Dam	LR5 Epi	**1**	**Ceratium (phytoplankton)**	**16,620**	**65**	**1**	0.100	2.33
		LR5 Meta	**NA**	**Aphanizomenon flos-aquae**	**48,116**	**65**	**10**	0.100	1.26
9/21/04	Fishermans Point	LR2 Surface	**0**	**Cocconeis* (diatom)**	**293,209**	**79**	**0**	No data	11.41
		LR2 Epi	**1**	**Pediastrum (green algae)**	**281,932**	**52**	**1**	0.320	8.51
	Near Dam	LR5 Epi	**1**	**Cryptomonas**	**16,690**	**61**	**1**	0.120	2.61
		LR5 Meta	**NA**	**Cryptomonas**	**24,660**	**56**	**9**	0.120	1.90
		LR5 Hypo	**NA**	**Gyrosigma* (diatom)**	**23,929**	**16**	**17**	0.110	1.39
10/21/04	Fishermans Point	LR2 Epi	**1**	**Cryptomonas**	**415,479**	**79**	**0**	0.440	15.02
	Near Dam	LR5 Epi	**1**	**Aphanizomenon flos-aquae**	**7057**	**47**	**0**	0.140	1.89
		LR5 Meta	**NA**	**Cryptomonas**	**61,816**	**55**	**8**	0.130	2.64

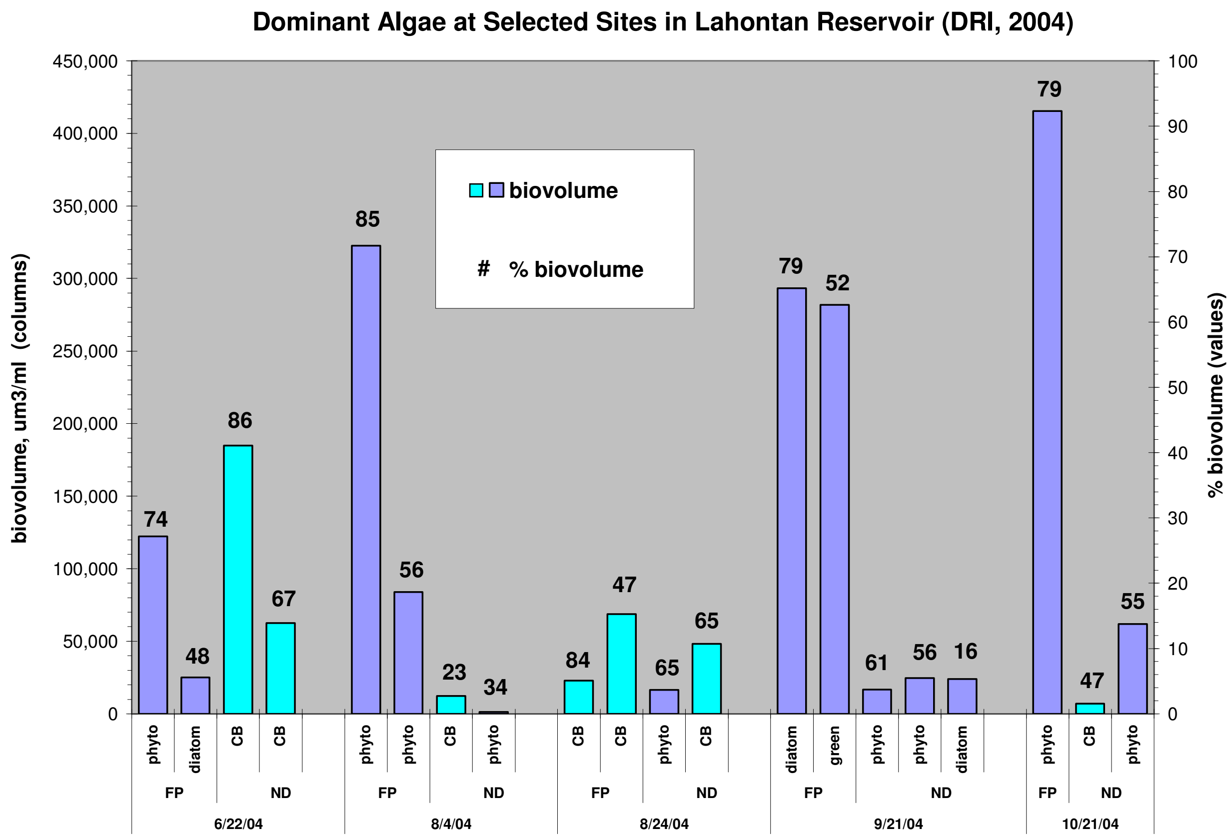
[1] Dissolved Inorganic nitrogen species measured at less than the reporting limits.

[2] Meta in DRI Algae Report; 7 meters listed as Hypo in NDEP's water quality database.

NA - not available

*** - TAXA listed with the greatest Biovolume for that date at the specified depth, but was not highlighted as such in the DRI report.**

FIGURE 16



9. Nutrients in the Carson River at Weeks Bridge: Before and After Effluent Discharge

The NDEP routine monitoring site located on the Carson River at Weeks Bridge is approximately 35 miles upstream of the reservoir. Boxplots illustrate the mean and median change in nutrients before the Carson City effluent discharge (Figure 17) and after the discharge was eliminated (Figure 18). The mean OP and TP for the years 1985 – 1987 during the effluent discharge are higher compared to the mean concentrations calculated for the years 1988 – 2006 (Table 6).

TABLE 6 Phosphorus Levels at Weeks Bridge

TIME PERIOD	MEAN TP	MEAN OP	MEAN % OP	MEDIAN TP	MEDIAN OP	MEDIAN % OP
1985 - 1987	0.189	0.156	82	0.210	0.160	76
1988 – 2006 After effluent discharges removed	0.133	0.064	48	0.06	0.100	60

FIGURE 17

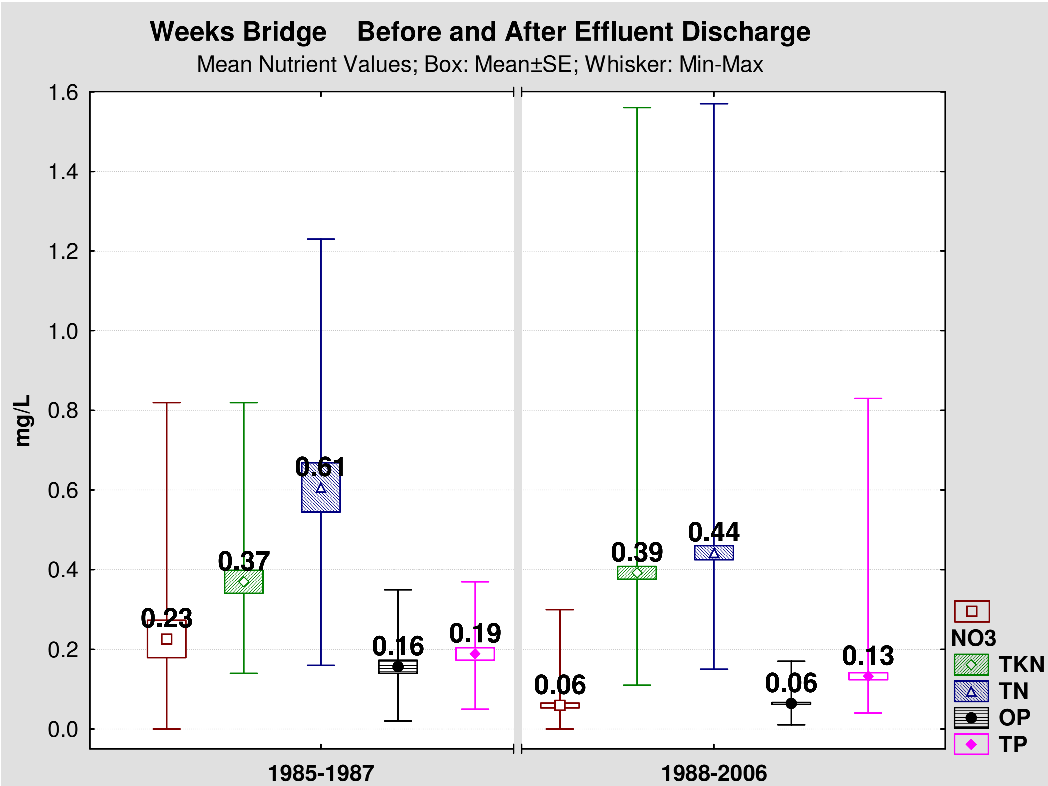
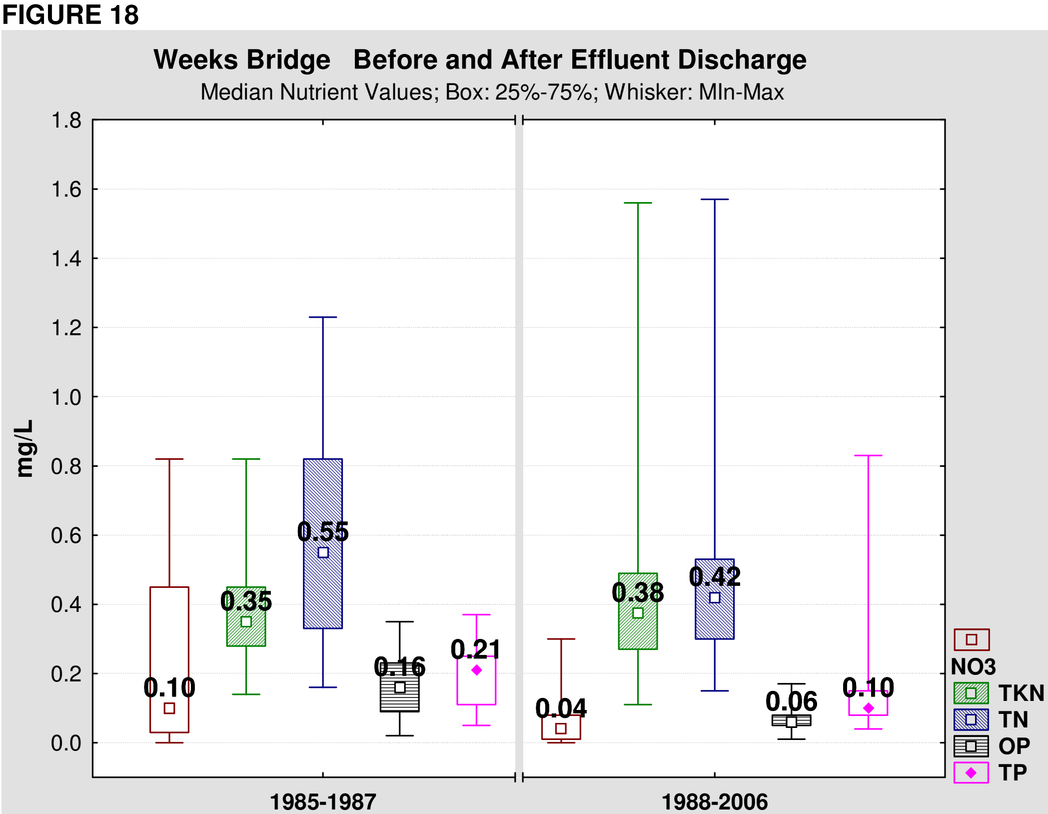


FIGURE 18



10. Summary

The collected water quality data suggests blooms of Cyanobacteria may still be a problem in Lahontan Reservoir, but it is unknown at this point if an empirical model will adequately address the growth of Aphanizomenon flos aquae. More intense sampling during an actual bloom may be needed to clarify the relationship between chlorophyll a and nutrients at each monitoring station and establish more meaningful water quality standards for the reservoir. The Grieb Equation has been shown to no longer apply and chlorophyll a appears to be more strongly related to TN than to TP. Another nonlinear model or a linear or multiple regression model which includes TN and TP may be a more appropriate expression of chlorophyll concentration in the reservoir. Models specific to each site or group of sites may also be necessary to account for differences in depth and topography. An adequate P supply may be controlling production, but for the Cyanobacteria to dominate, N-limited conditions may be necessary. Additional environmental factors may also need to be considered when predicting the production of Cyanobacteria in the reservoir. A wide variety of physical, chemical and biological variables influence the degree and diversity of algae growth in a lake or reservoir system.

In general, it can be said that water quality in the Lahontan Reservoir has improved simply due to the removal of the wastewater treatment plant discharge in 1987, evidenced by the drop in nitrogen levels. Total phosphorus levels at all reservoir sites currently exceed the standard, so there is likely adequate P available during most times of the year to stimulate algae growth. Attempting to compare the data collected by DRI in the 1980-81 time periods to the data collected by NDEP between 2003 and 2005 is difficult because the sampling frequency was different, not all the same locations were sampled and not all the earlier data was available for analysis. It is also apparent that pollutant levels or conditions conducive to blue green algae blooms still exist. DRI investigators found Aphanizomenon flos aquae dominated the algae population at the Near Dam site in June 2004. In addition, the chlorophyll levels during the 2005 study period are about 10 times higher at Silver Springs Beach compared to the 1980-81 concentrations. The mean concentration and spread of the data was greater at the Near Dam site in 1980 compared to 2005, but the levels measured for the 1981 samples taken from the lower reservoir sites are similar to the 2005 concentrations. It is unknown what type of algae corresponded to the increase in chlorophyll or dominated each of the reservoir sites from June through October 2005. Shallow water and high temperatures in 2005 may have been the primary contributors to the high levels of algae growth and chlorophyll.

The data from the 1980-81 study also indicates that the upper basin was lower in chlorophyll a concentration compared to the lower basin sites. However, only Silver Springs Beach was sampled by the DRI investigators. During 2003-2005, NDEP sampled at South Basin, Silver Springs Beach and Fishermans Point. Figure 4 on page 8 and the graphs in Appendix B show higher concentrations were found in the upper basin compared to the lower basin sites at Narrows Inlet, Narrows Outlet and Near Dam, suggesting conditions opposite to those which occurred during the earlier study.

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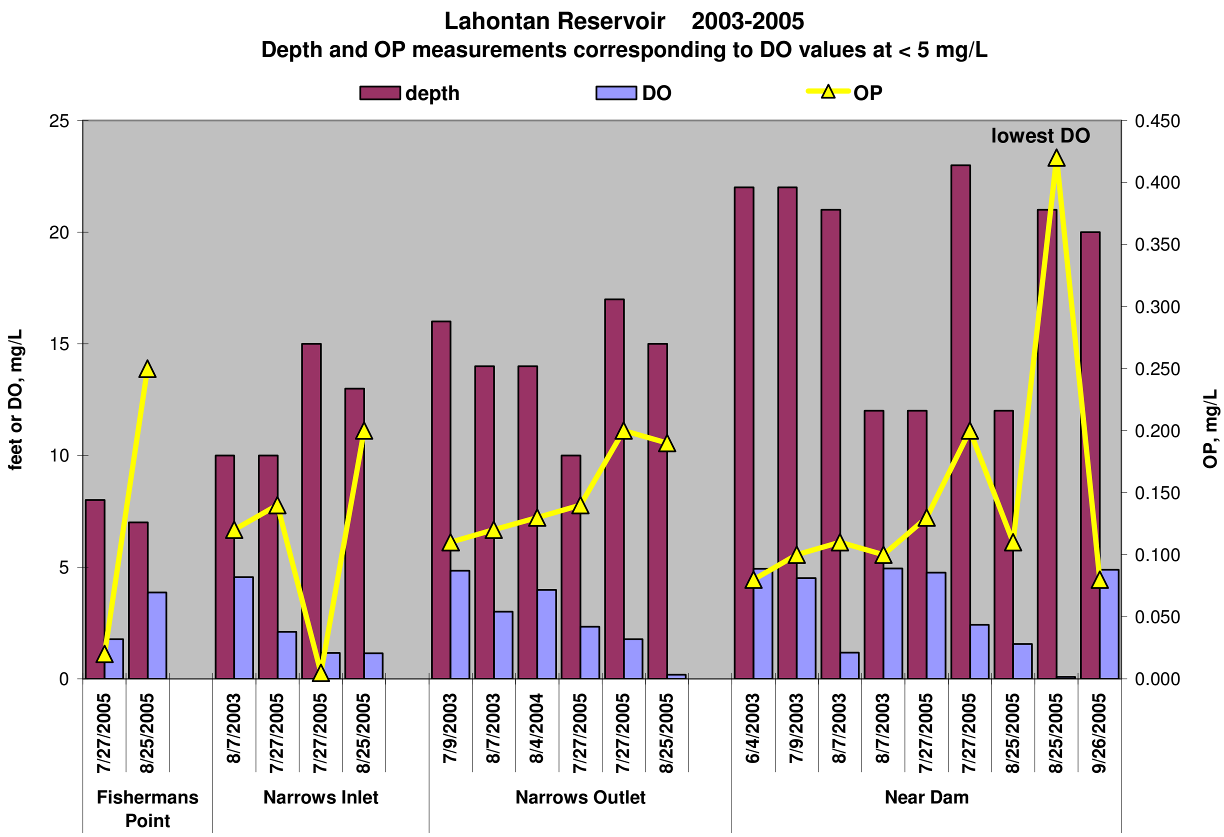
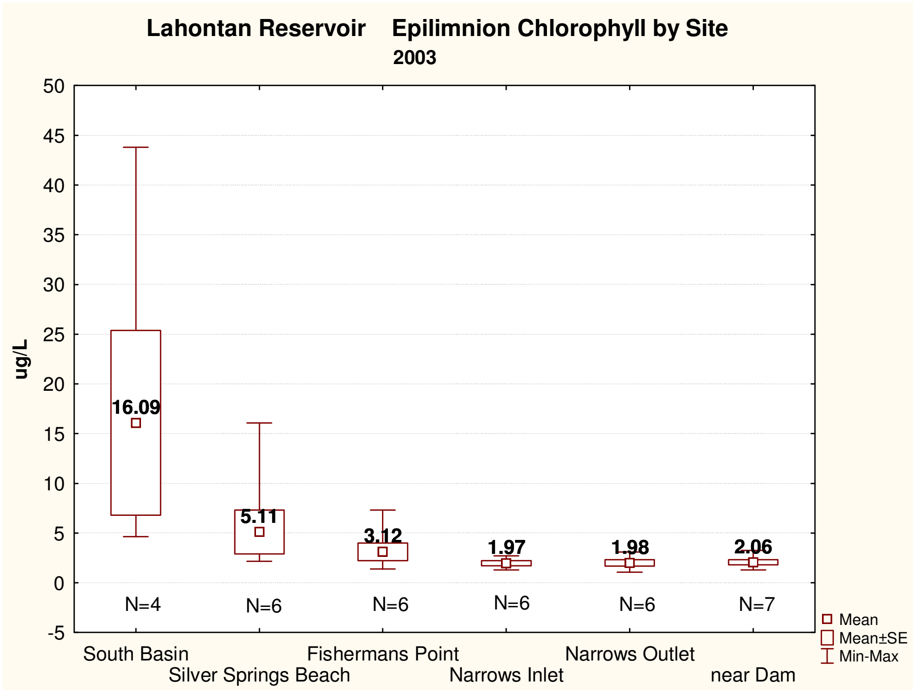
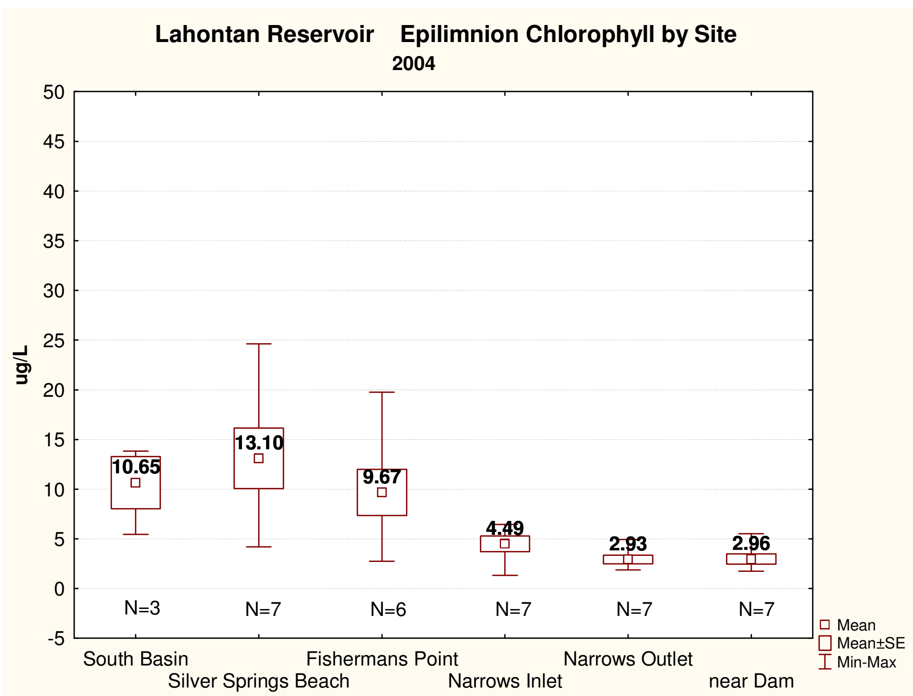
APPENDIX A

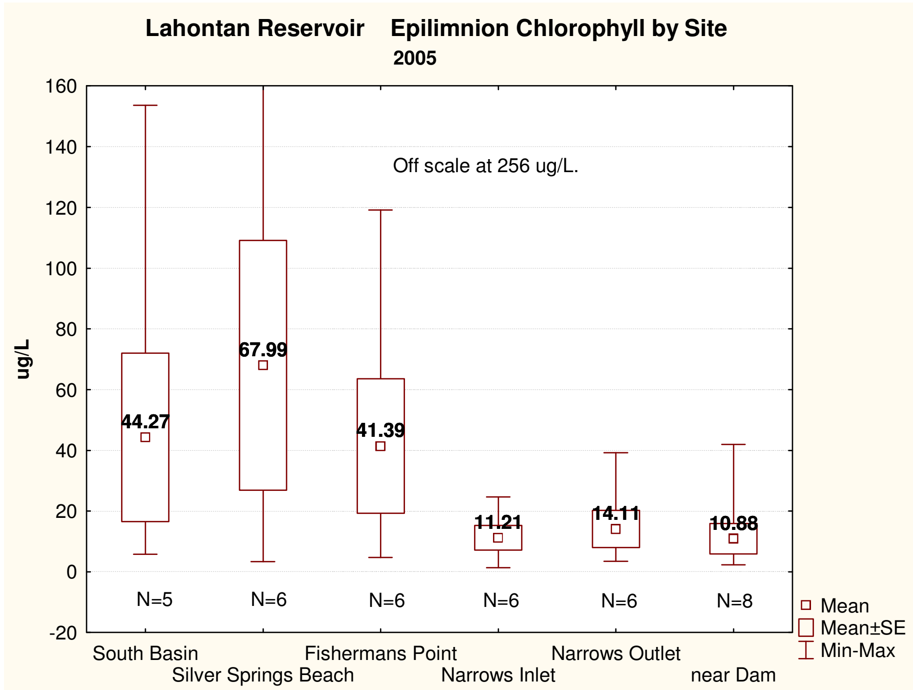

Lahontan Reservoir 2003-2005
Depth and OP measurements corresponding to DO values at < 5 mg/L
depth
DO
OP
lowest DO
feet or DO, mg/L
OP, mg/L
0
5
10
15
20
25
0.000
0.050
0.100
0.150
0.200
0.250
0.300
0.350
0.400
0.450
7/27/2005
8/25/2005
8/7/2003
7/27/2005
7/27/2005
8/25/2005
7/9/2003
8/7/2003
8/4/2004
7/27/2005
7/27/2005
8/25/2005
6/4/2003
7/9/2003
8/7/2003
8/7/2003
7/27/2005
7/27/2005
8/25/2005
8/25/2005
9/26/2005
Fishermans Point
Narrows Inlet
Narrows Outlet
Near Dam

APPENDIX B

Epilimnion Chlorophyll at each Monitoring Station 2003 through 2005

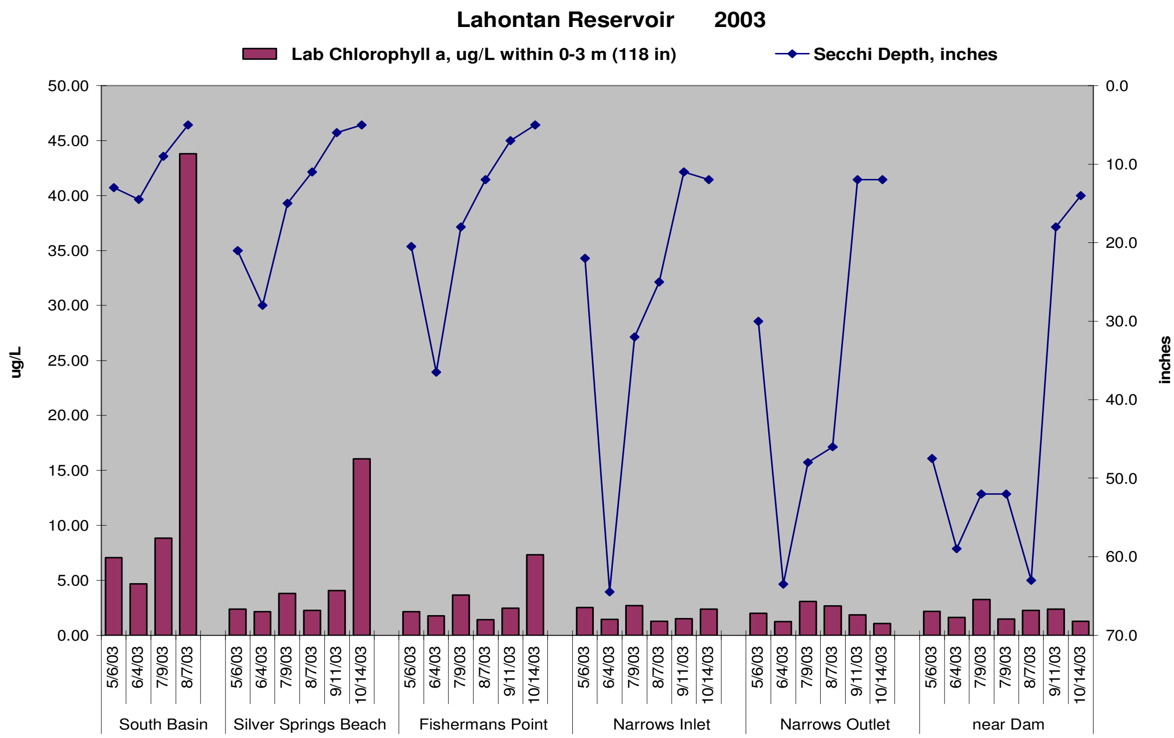


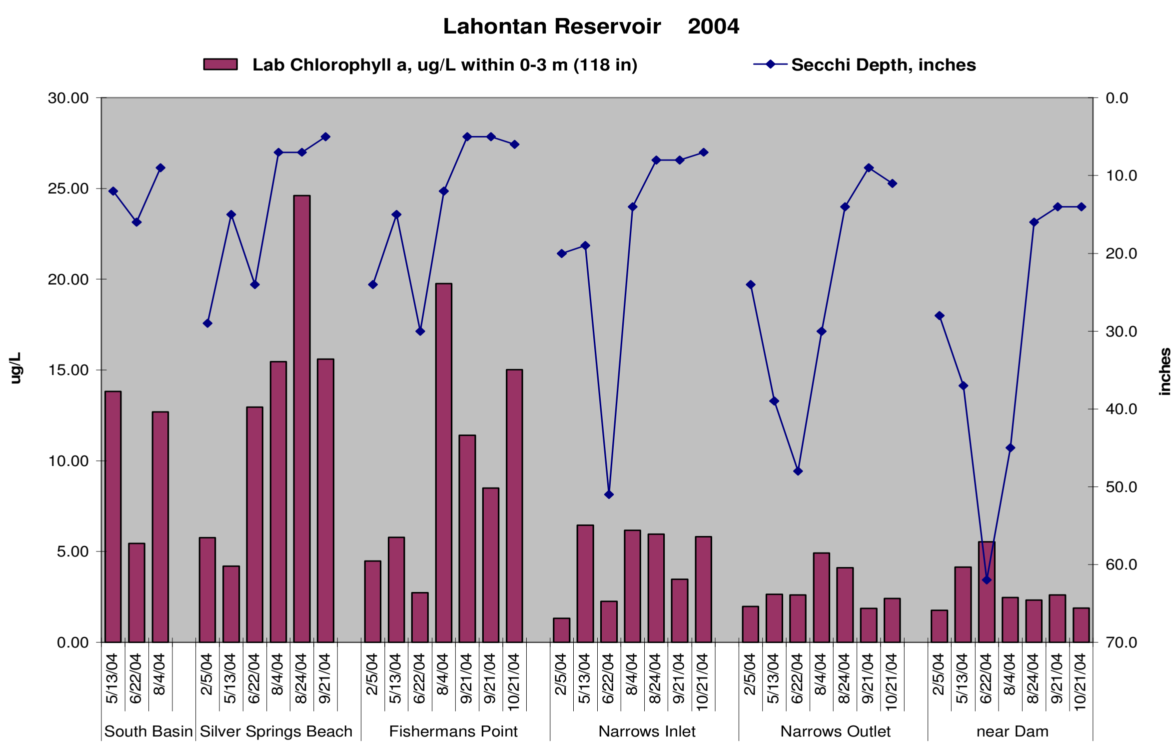


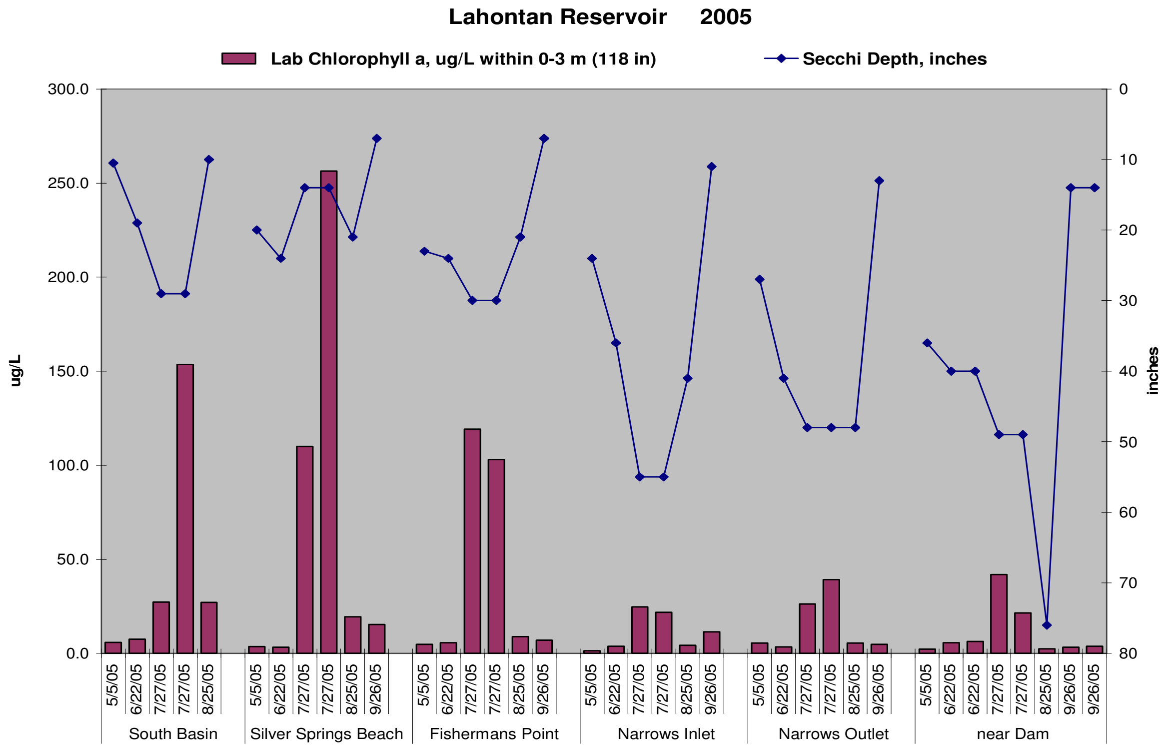

Lahontan Reservoir Epilimnion Chlorophyll by Site
2005
ug/L
160
140
120
100
80
60
40
20
0
-20
Off scale at 256 ug/L.
44.27
67.99
41.39
11.21
14.11
10.88
N=5
N=6
N=6
N=6
N=6
N=8
South Basin
Silver Springs Beach
Fishermans Point
Narrows Inlet
Narrows Outlet
near Dam
Mean
Mean±SE
Min-Max

APPENDIX C

CHLOROPHYLL A & SECCHI DEPTH







Lahontan Reservoir 2005
Lab Chlorophyll a, ug/L within 0-3 m (118 in)
Secchi Depth, inches
ug/L
inches
300.0
250.0
200.0
150.0
100.0
50.0
0.0
0
10
20
30
40
50
60
70
80
South Basin
Silver Springs Beach
Fishermans Point
Narrows Inlet
Narrows Outlet
near Dam

APPENDIX D

WORKSHEET FOR DIN/OP DATA

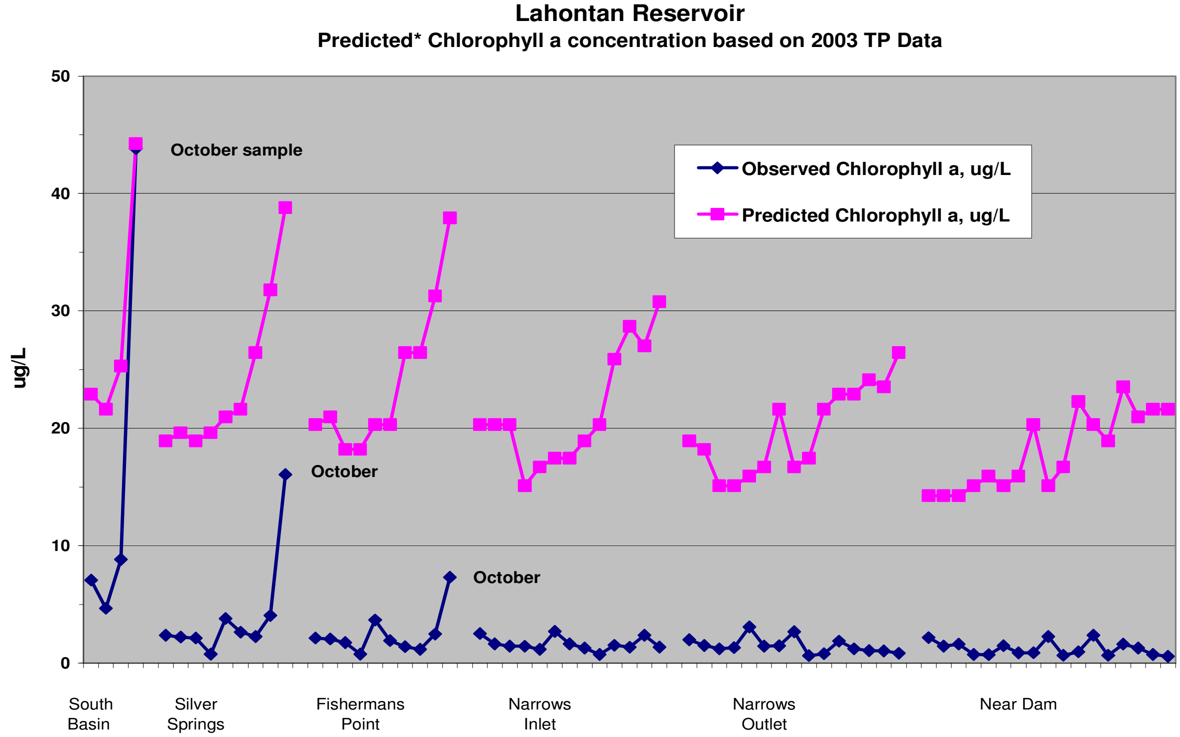
For Statistica Box Plots **DIN/OP ratios not averaged**

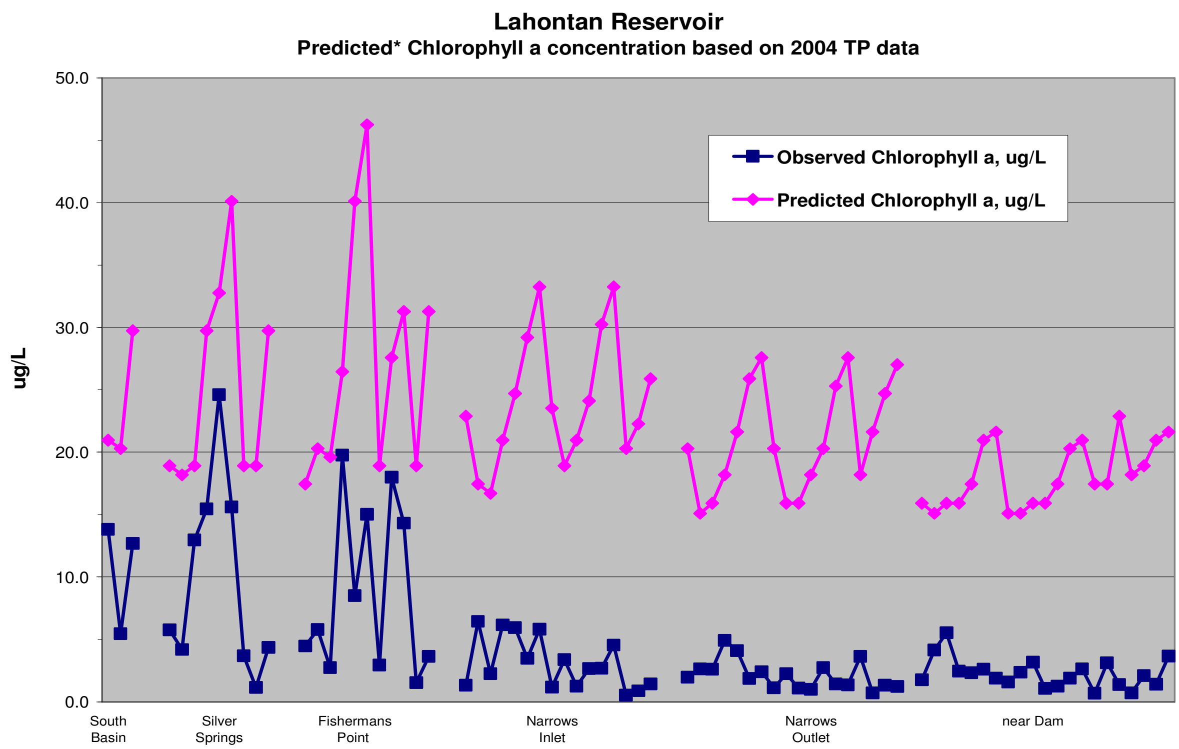
Site	***month***	***1980***	***1981***	***2003***	***2004***	***2005***
Silver Springs Beach	May	0.00	0.5	0.2	0	0
Silver Springs Beach	Jun	1.90	1.3	0.45	0	0
Silver Springs Beach	Jul		0.5			
Silver Springs Beach	Jul	0.00	0	1.8	0	0
Silver Springs Beach	Aug	0.00	0	1.27	0.11	0.92
Silver Springs Beach	Sep	0.00		0.89	0.04	2.26
Silver Springs Beach	Oct	0.00		0.31	0.03	
Narrows Inlet	May	2.40	0.5	0.17	0	0
Narrows Inlet	Jun	1.90	1	0.67	0	0
Narrows Inlet	Jul		0.3			
Narrows Inlet	Jul	0.00	0	0.2		0
Narrows Inlet	Aug	0.90	0	0.45	0	2.23
Narrows Inlet	Aug				0.06	
Narrows Inlet	Sep	1.50	0.9	1	0.10	2.21
Narrows Inlet	Oct	1.10		1.15	0.08	
Narrows Outlet	May	2.80	1.5	0.55	0.08	0
Narrows Outlet	Jun	1.90	0.1	0.38	0	0
Narrows Outlet	Jul		0			
Narrows Outlet	Jul	0.00	0	0.63	0	0
Narrows Outlet	Aug	0.50	0	1.11	0	2.79
Narrows Outlet	Sep	1.70	1.7	0.54	0.13	2.38
Narrows Outlet	Oct	1.80		1.18	0.10	
Near Dam	May	3.40	2.2	0.71	0.09	0
Near Dam	Jun	1.10	0	0.43	0	0
Near Dam	Jun					0
Near Dam	Jul	1.30	0	0.22	0	30.6
Near Dam	Jul		0			20
Near Dam	Jul		0			
Near Dam	Aug	0.60	0	0.25	0	8.9
Near Dam	Aug		0.2			0.2
Near Dam	Sep	2.40	1.0	0.27	0	3
Near Dam	Sep		1.8			3
Near Dam	Oct	2.40	4.1	1.71	0.07	

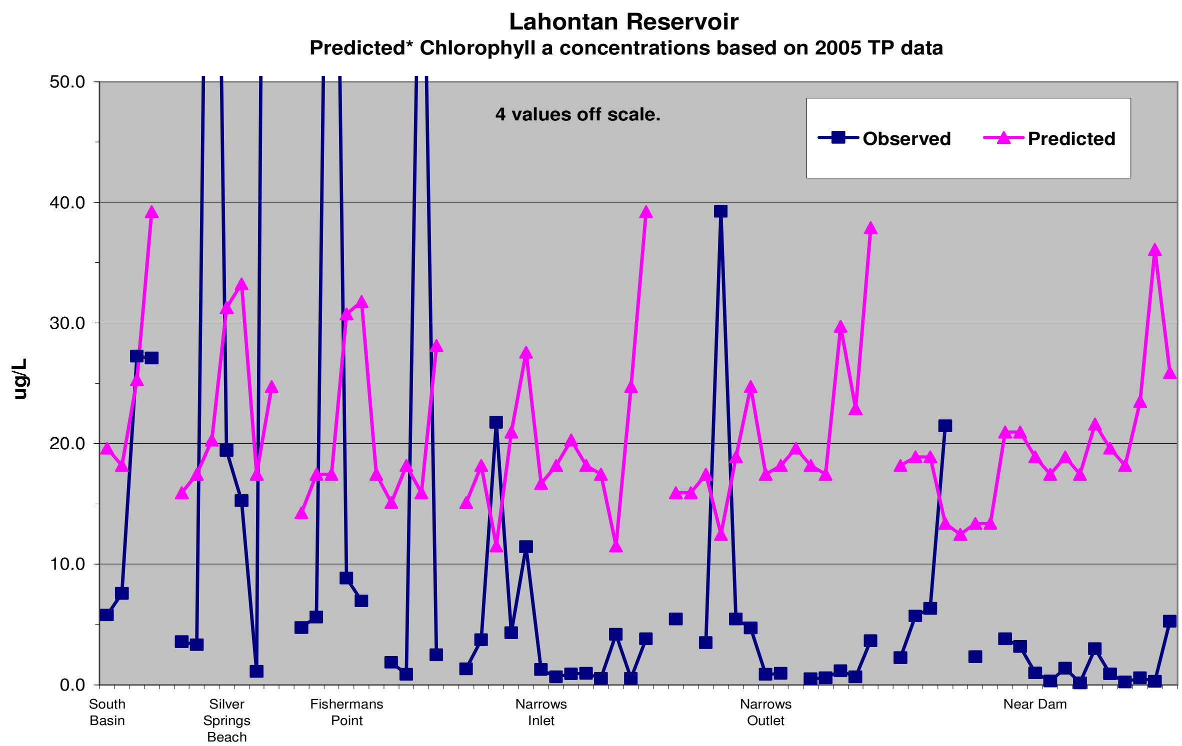
DIN values were based mostly on NO3.
Most of the NO2, NH4 and unionized NH3 were less than reporting limit.
1980, 1981 data on p. 57 1983 DRI report V. 5

APPENDIX E

COMPARISON GRIEB PREDICTED CHLOROPHYLL VS. OBSERVED VALUES







* Predicted values calculated using Grieb equation Chlorophyll a = $0.9\ TP^{0.6}$

APPENDIX F

Lahontan Reservoir: Linear Regression Analysis Results   Significant at $\alpha \leq 0.05$

1. 2003-2005: Data combined from all 6 sites

Parameters	R^2	p value	Comments
TP vs. Chlorophyll a	0.02	0.07293	Not significant (NS)
LN TP vs. LN Chlorophyll a	0.06	0.00025	Extremely weak correlation
TN vs. Chlorophyll a	0.56	≤0.00001	
LN TN vs. LN Chlorophyll a	0.35	≤0.00001	
TP, TN vs. Chlorophyll a	0.66	≤0.00001	
LN TP, LN TN vs. LN Chlorophyll a	0.36	≤0.00001	LN TP does not significantly contribute to variation in Chlorophyll a p=0.1145

2. Data sorted by year

Parameters	Year	R^2	p value	Comments
TP vs. Chlorophyll a	2003	0.48	≤0.00001	
	2004	0.29	≤0.00001	
	2005	0.0002	0.9150	NS
LN TP vs. LN Chlorophyll a	2003	0.24	0.00002	
	2004	0.19	0.00007	
	2005	0.004	0.6147	NS
TN vs. Chlorophyll a	2003	0.64	≤0.00001	
	2004	0.49	≤0.00001	
	2005	0.60	≤0.00001	
LN TN vs. LN Chlorophyll a	2003	0.31	≤0.00001	
	2004	0.41	≤0.00001	
	2005	0.41	≤0.00001	
TP, TN vs. Chlorophyll a	2003	0.64	≤0.00001	TP does not significantly contribute to variation in Chlorophyll a p=0.3595
	2004	0.50	≤0.00001	TP does not significantly contribute to variation in Chlorophyll a p=0.1829
	2005	0.76	≤0.00001	
LN TP, LN TN vs. LN Chlorophyll a	2003	0.31	≤0.00001	LN TP does not significantly contribute to variation in Chlorophyll a p=0.8783
	2004	0.43	≤0.00001	LN TP does not significantly contribute to variation in Chlorophyll a p=0.1060
	2005	0.48	≤0.00001	

3. Data Sorted by Site 2003-2005

Parameters	**Site**	**R^2**	**p value**	**Comments**
TP vs. Chlorophyll a	South Basin	0.77	0.0004	Only 11 data points
	Silver Springs Beach	0.004	0.7717	Not Significant (NS)
	Fishermans Point	0.011	0.5891	NS
	Narrows Inlet	0.001	0.8757	NS
	Narrows Outlet	0.05	0.1589	NS
	Near Dam	0.03	0.2154	NS
LN TP vs. LN Chlorophyll a	South Basin	0.68	0.0019	
	Silver Springs Beach	0.22	0.0190	
	Fishermans Point	0.03	0.3418	NS
	Narrows Inlet	0.001	0.8412	NS
	Narrows Outlet	0.06	0.1101	NS
	Near Dam	0.04	0.1358	NS
TN vs. Chlorophyll a	South Basin	0.78	0.0003	
	Silver Springs Beach	0.84	$\leq$0.00001	
	Fishermans Point	0.50	0.00001	
	Narrows Inlet	0.22	0.0016	
	Narrows Outlet	0.28	0.0002	
	Near Dam	0.24	0.0001	
LN TN vs. LN Chlorophyll a	South Basin	0.73	0.0008	
	Silver Springs Beach	0.69	$\leq$0.00001	
	Fishermans Point	0.48	0.00002	
	Narrows Inlet	0.11	0.0313	
	Narrows Outlet	0.14	0.0109	
	Near Dam	0.02	0.3378	NS
TP, TN vs. Chlorophyll a	South Basin	0.81	0.0014	TN TP NS p values > 0.05
	Silver Springs Beach	0.92	$\leq$0.00001	
	Fishermans Point	0.74	$\leq$0.00001	
	Narrows Inlet	0.31	0.00064	
	Narrows Outlet	0.54	$\leq$0.00001	
	Near Dam	0.37	0.00001	
LN TP, LN TN vs. LN Chlorophyll a	South Basin	0.74	0.0044	TN TP NS
	Silver Springs Beach	0.69	$\leq$0.00001	TP NS
	Fishermans Point	0.56	0.00002	
	Narrows Inlet	0.12	0.0844	
	Narrows Outlet	0.33	0.0021	
	Near Dam	0.09	0.0815	

4. *Epilimnion* Data sorted by *Group*

Parameters	**Group**	**Site**	R^2	**p value**	**Comments**
TP vs. Chlorophyll a	Upper	South Basin	0.007	0.5852	NS
		Silver Springs Beach			
		Fishermans Point			
	Lower	Narrows Inlet	0.04	0.1391	NS
		Narrows Outlet			
		Near Dam			
LN TP vs. LN Chlorophyll a	Upper	South Basin	0.14	0.0124	Significant but weak
		Silver Springs Beach			
		Fishermans Point			
	Lower	Narrows Inlet	0.03	0.2294	NS
		Narrows Outlet			
		Near Dam			
TN vs. Chlorophyll a	Upper	South Basin	0.48	<0.00001	
		Silver Springs Beach			
		Fishermans Point			
	Lower	Narrows Inlet	0.47	<0.00001	
		Narrows Outlet			
		Near Dam			
LN TN vs. LN Chlorophyll a	Upper	South Basin	0.50	<0.00001	
		Silver Springs Beach			
		Fishermans Point			
	Lower	Narrows Inlet	0.33	<0.00001	
		Narrows Outlet			
		Near Dam			
TP, TN vs. Chlorophyll a	Upper	South Basin	0.64	<0.00001	Both TP TN significant
		Silver Springs Beach			
		Fishermans Point			
	Lower	Narrows Inlet	0.54	<0.00001	Both TP TN significant
		Narrows Outlet			
		Near Dam			
LN TP, LN TN vs. LN Chlorophyll a	Upper	South Basin	0.53	<0.00001	TP NS
		Silver Springs Beach			
		Fishermans Point			
	Lower	Narrows Inlet	0.38	<0.00001	Both TP TN significant
		Narrows Outlet			
		Near Dam			

APPENDIX G

ALGAE BLOOM NEWS ARTICLES

SEVON MIKE
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FALLON

...ontan Valley News

and Fallon Eagle Standard 423-6041

"Fallon & Churchill County's Award-Winning Daily Community Newspaper" 25 cents

Aug. 9, 1991

Fish kill blamed on deadly lake algae

By JOHN SANTINI
Staff Writer

Before you see them, you smell them. Thousands of dead fish, littering the beaches of Lake Lahontan and attracting insects the way only dead fish can.

Most of them are carp -- thought to be the victims of last week's poisonous blue green algae bloom that caused state health officials to issue a warning against swimming in the lake.

Other fish, such as bass, catfish and walleye, survived because they do not feed on algae the way carp do. In fact, other than carp, wildlife at the lake has not been noticeably affected by the deadly toxin, Park Ranger Gary Orr said. Even birds that may be eating the infected fish seem unharmed so far.

"We're not anticipating really any wildlife being lost," Orr said. Carp were killed because they ate the toxic algae, he explained, but other wildlife that does not directly ingest the algae shouldn't be affected.

However, pets and even deer or wild horses that drink a lot of water from the lake could get sick or even die, he said.

Another local concern has been that toxins from the algae might be spread throughout the valley once they got into the irrigation system. (Irrigation water is stored in Lake Lahontan). According to Orr, that is "extremely unlikely."

"Once the water is turned through the irrigation system and tumbled up, any toxin that might be in there is completely dissolved," he explained.

Even though the algae is not expected to have much of an effect on wildlife or irrigation, people are susceptible to the toxin, and health officials have issued a warning to stay out of the water.

Contact with the algae -- considered to be slightly more poisonous than cobra venom -- can make people sick and may even cause death in extreme cases, said Darrell Rasner, chief of Health Protection Services for the state. Some symptoms include nausea, vomiting, diarrhea, headaches and cramps, he said.

Orr recalled one woman who refused to stop going in the lake because she had been water skiing with her two sons all weekend and said none of them felt sick.

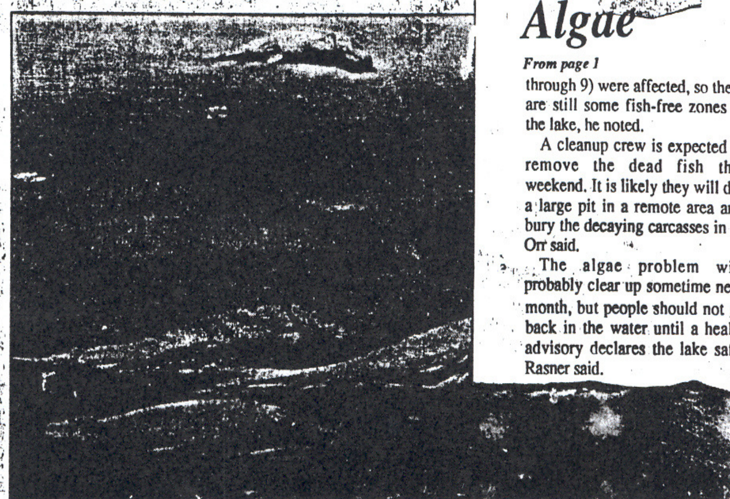
Later in the week, Terry Hall of the Nevada Health Division reported calls from people who said they had been swimming in the lake over the weekend and were feeling sick.

Although officials urge people not to go in the water, park beaches are still open.

"Most people probably aren't going to sunbathe with a lot of dead fish around, but you never know," Orr said.

Only about four or five miles of shoreline (mainly beaches two

See Algae, page ...



Dead fish -- thought to be the victims of a toxic blue green algae -- litter the beaches of Lake Lahontan.

Photo by Laurie Lauinger

Algae

From page 1

through 9) were affected, so there are still some fish-free zones at the lake, he noted.

A cleanup crew is expected to remove the dead fish this weekend. It is likely they will dig a large pit in a remote area and bury the decaying carcasses in it, Orr said.

The algae problem will probably clear up sometime next month, but people should not go back in the water until a health advisory declares the lake safe, Rasner said.

Fish kill in lake high, worst over

Lah. Valley News Aug. 14, 1991

By CURT ASHER
Staff Writer

State biologists this weekend counted 18,700 dead fish at Lahontan Reservoir but found that the algae that produces the toxin that killed the fish has largely cleared out of the lake.

Nevada Department of Wildlife Biologist Mike Sevon said that 98 percent of the dead fish were carp and 2 percent were Sacramento blackfish, a species that is fished commercially in the lake.

The fish deaths were discovered around Aug. 1. The naturally occurring toxin was caused by the bloom of an algae in the lake. The toxin, when extracted from the algae and injected into mice, is twice as potent as cobra venom, Sevon said.

Atmospheric conditions, mainly winds, cleaned out most of the algae on Sunday, he said.

Although carp offspring serve as food for gamefish species, they are one of the least desirable species in the lake and their deaths didn't hurt the Lahontan fishery, Sevon said.

"Before the end of the year you'll see more detrimental things," he said.

Irrigation in late fall may lower the lake to 6,000 acre feet. When the reservoir is full it contains 300,000 acre feet of water. The shallowness will hurt the gamefish population, probably resulting in poor fishing next year, he said.