

5-1-1989

# Total maximum daily loads and waste load allocations for Las Vegas Bay: Rationale and calculations

State of Nevada: Division of Environmental Protection

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TOTAL MAXIMUM DAILY LOADS AND WASTE LOAD ALLOCATIONS  
FOR  
LAS VEGAS BAY

Rationale and Calculations

Prepared by:

Nevada Division of  
Environmental Protection  
May, 1989

## SUMMARY

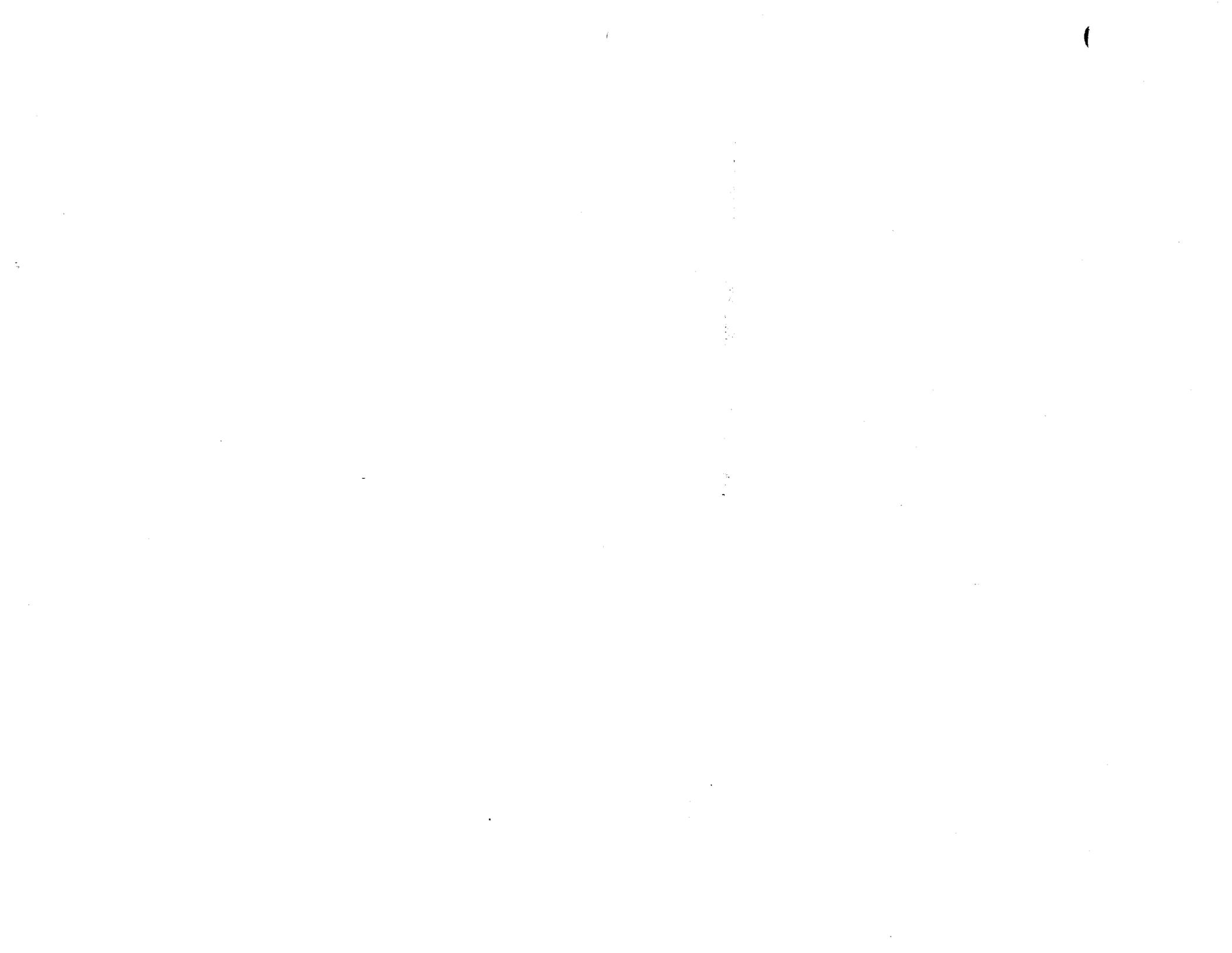
In September 1987 the Nevada Division of Environmental Protection revised Water Quality Standards for Las Vegas Wash (LVW) and Lake Mead. Standards were set for chlorophyll a and unionized ammonia in Las Vegas Bay (LVB) (NDEP 1987). The 1986 and 1987 LVB data showed non-achievement of both the chlorophyll a and unionized ammonia standard which triggered an analysis of total phosphorus and total ammonia Total Maximum Daily Loads and Waste Load Allocations which are presented in this report.

This report is separated into three sections:

1. 1987 Las Vegas Bay Water Quality Conditions and Seasonal Periodicity.
2. Concentration Estimates at Northshore Road to Meet Water Quality Standards in Las Vegas Bay.
3. Total Maximum Daily Loads at North Shore Road and Waste Load Allocations.

Blue-green algae were present in 1987 but did not build to bloom levels observed in 1986. Mean summer chlorophyll a at station 3 was 53.2 ug/l which is considerably higher than the standard of 30 ug/l (4 year mean). From April 9 through August 3 unionized ammonia was never below the .04 mg/l chronic toxicity standard at station 2. The acute unionized ammonia standard (.45 mg/l) was not exceeded. The standards were not achieved from April through September but were met from October through March.

Over the period of record examined (1977-1987) the density of LVW has decreased significantly in comparison to LVB. At present, there are months when LVW enters LVB as a neutrally buoyant or buoyant jet.



1987 Las Vegas Bay Water Quality Conditions  
and Seasonal Periodicity

Prepared by:

Nevada Division of Environmental Protection

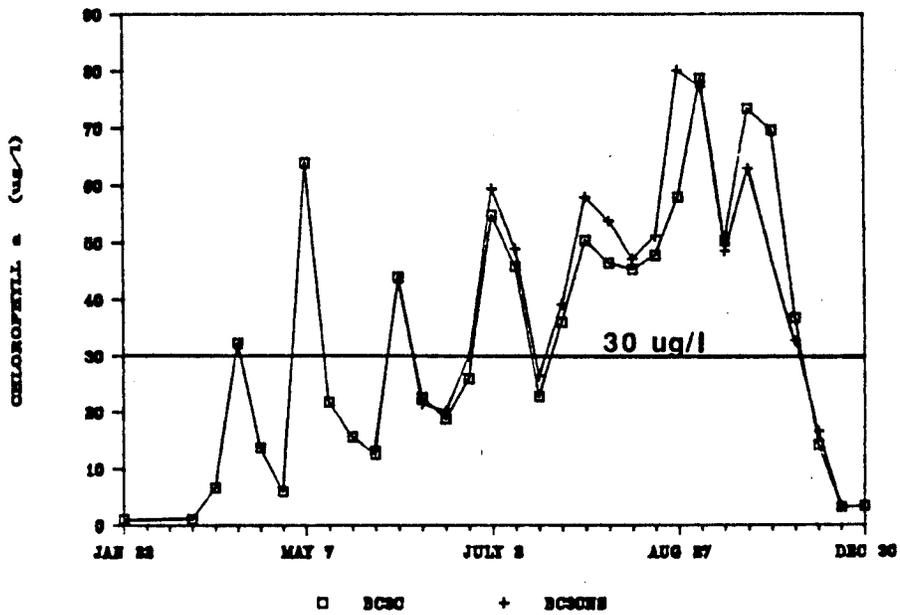
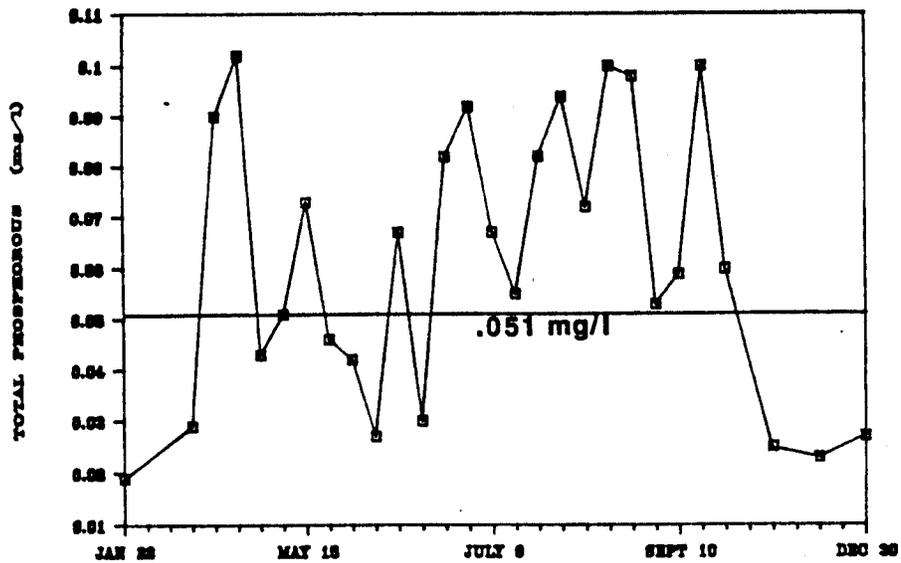


Figure 1 . Daily total phosphorus and chlorophyll a concentrations at station 3 in 1987.

Table 1 . Summer Station 3 Chlorophyll a from 1985-1987.

YEAR	1985	1986	1987
July	32.2	49.3	42.0
August	35.9	113.9	49.5
September	30.4	15.1	68.0
Mean Summer	32.8	59.4	53.2

## Unionized Ammonia

Unionized ammonia ( $\text{NH}_3$  -N) is calculated from the total ammonia ( $\text{NH}_4$  -N) concentration and the fraction of unionized ammonia (FUI). The FUI is dependent on pH and temperature. It should be mentioned that the FUI was not corrected for diurnal variation or ionic strength in this analysis.

The FUI for 1987 is presented in Figure 3. FUI exhibited a seasonal cycle with values generally less than .04 from January through March and October through November. The exception was on October 29 when FUI went up to .119. FUI peaked on July 28 at .373.

The most important factor influencing FUI in Las Vegas Bay (LVB) is pH which is primarily controlled by the rate of algal production. As described previously the rate of algal production is much higher in summer than winter which is reflected in the seasonal nature of the FUI. The diurnal cycle of FUI has been defined and will be discussed in a later section of this report.

Total ammonia also exhibited a seasonal cycle with concentrations increasing from January through April and then decreasing through the end of the year (Figure 3). Peak concentrations were observed from mid-April through mid-May. This again is consistent with the idea that the plume has less effect on LVB surface water in the late fall through early spring period.

Unionized ammonia at station 2 was similar to previous years although peak values were somewhat lower (Figure 3.) Average growing season (April - September) unionized ammonia was significantly higher than the chronic toxicity standard of .04 mg/l.

Data for three diurnal sampling runs for total ammonia are presented in Figure 4. Total ammonia was highest in the May samples and lowest in the

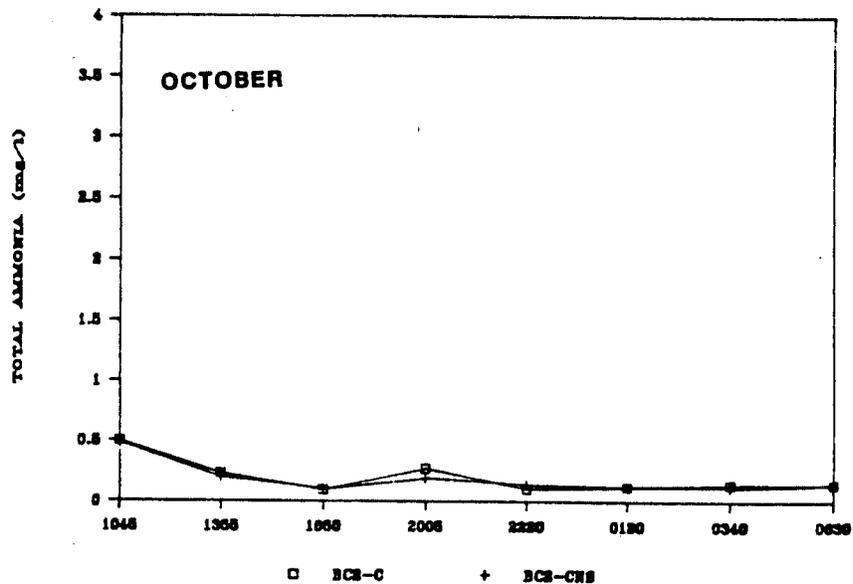
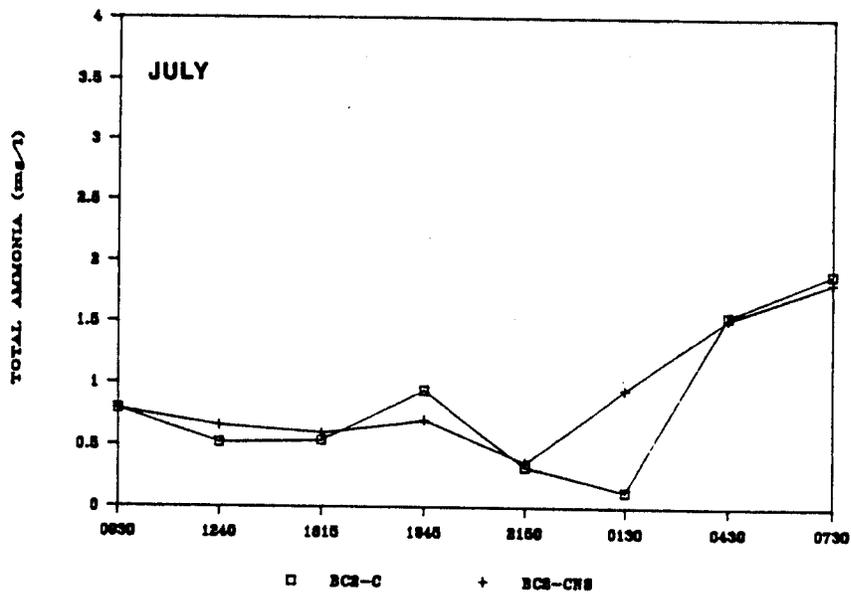
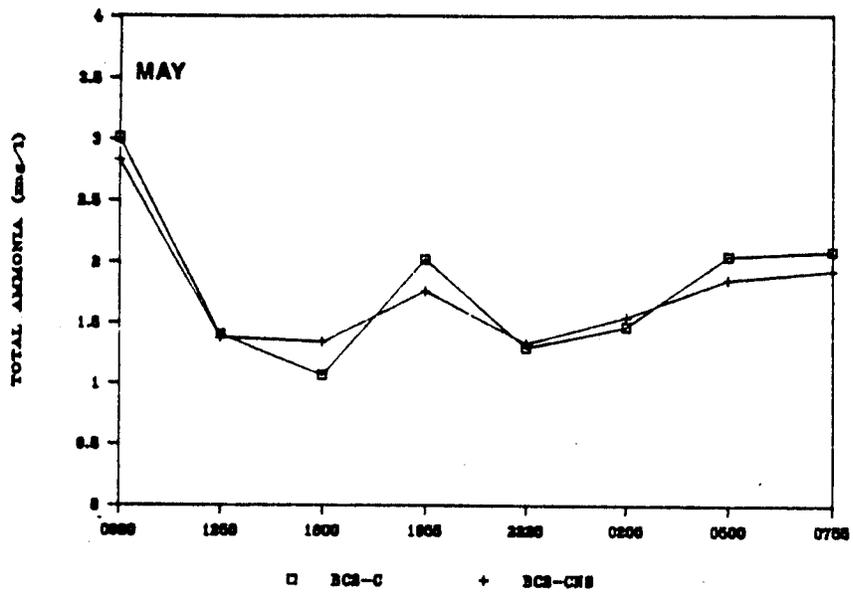
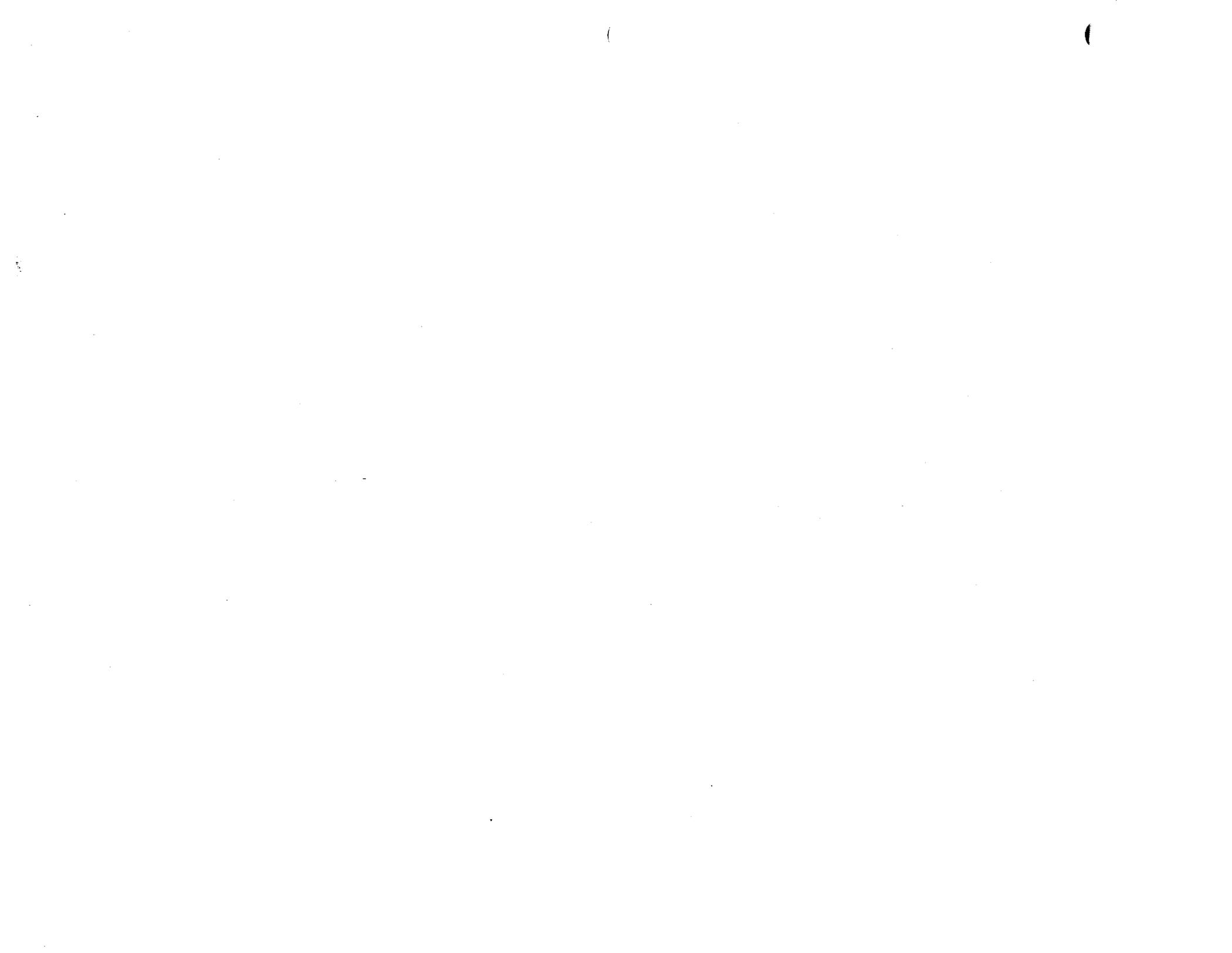


Figure 4. Diurnal and cross-sectional variation in total ammonia at station 2 on May 7 & 8, July 30 & 31, and October 7 & 8, 1987.



CONCENTRATION ESTIMATES AT NORTHSORE ROAD  
TO MEET WATER QUALITY STANDARDS IN LAS VEGAS BAY

Prepared For:

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Report No. 88/02/88313

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## 1. INTRODUCTION

The estimation of appropriate Las Vegas Wash (LVW) mass loadings of phosphorus and total ammonia to Las Vegas Bay (LVB) that will meet the water quality standards, Anon. (1987), requires that the hydrodynamics of the LVW-LVB interaction be defined. It is the goal of this report to identify and justify an appropriate model for describing the hydrodynamic interaction of LVW with LVB and enable the LVW mass loadings that will meet the new water quality standards in LVB to be estimated. The selection of an appropriate hydrodynamic model is based on the analysis of the historical data available for LVW and LVB. The data sources and periods of time used in this report are summarized in Table 1.1.

It is the premise of this investigation that LVB water quality is controlled by the mass loading of LVW to LVB, and the amount and direction of mixing that occurs between the LVW inflow and the epilimnetic waters of LVB. While the mass loading can be controlled by administrative action, the mixing processes and their magnitude are controlled by nature and are beyond the control of administrative action. The magnitude and direction of mixing between the LVW inflow and LVB is controlled by the LVW volumetric inflow, the momentum of the LVW inflow, and the difference in buoyancy (density) between the LVW inflow and the ambient waters of LVB. In Chapter 2 of this report the historical trends in the LVW density are examined. In Chapter 3, the historical trends in the LVB densities are examined. In Chapter 4, the historical density data regarding LVW and LVB are

compared. In Chapter 5, an appropriate model for describing the LVW-LVB interaction is recommended and the allowable LVW concentrations of nitrogen and phosphorus at North Shore Road (NSR) that will satisfy the LVB water quality standards are estimated.

$$+ 4.99 \times 10^{-8} T^2 \quad (2.3)$$

where  $C_{TDS}$  concentration in ( $g/m^3$  or  $mg/l$ ) and  $T$  = water temperature in degrees Centigrade. The typical measurements of TDS in LVW at Northshore Road are in terms of the specific conductance of the water; see for example Anon. (1980). According to Anon. (1980)

"..., the concentration of dissolved solids (in milligrams per liter) is about 65 percent of the specific conductance (in micromhos)," Anon. (1980, p. 19).

In Anon. (1980), it is further noted that the relationship between specific conductance and the concentration of TDS varies from stream to stream and may also vary in the same stream with time due to changes in the composition of the source water. In the case of LVW at Northshore Road, there are sufficient data to directly establish a regression relationship between TDS (in  $mg/l$ ) and specific conductance (in micromhos) or

$$[TDS] = -293. + 0.830 [SC] \quad (2.4)$$

with a correlation coefficient of 0.973 and normally distributed residuals. It should be noted that Equation (2.4) is based on USGS field and laboratory data and utilizes none of the Clark County Sanitation District (CCSD) data since CCSD chose to use a laboratory procedure different from that of the USGS to determine the concentration of TDS.

The density increment due to suspended solids was determined

FIGURE 2.1 Monthly average LVW water temperature at Northshore Road for the period October, 1969 through August, 1987

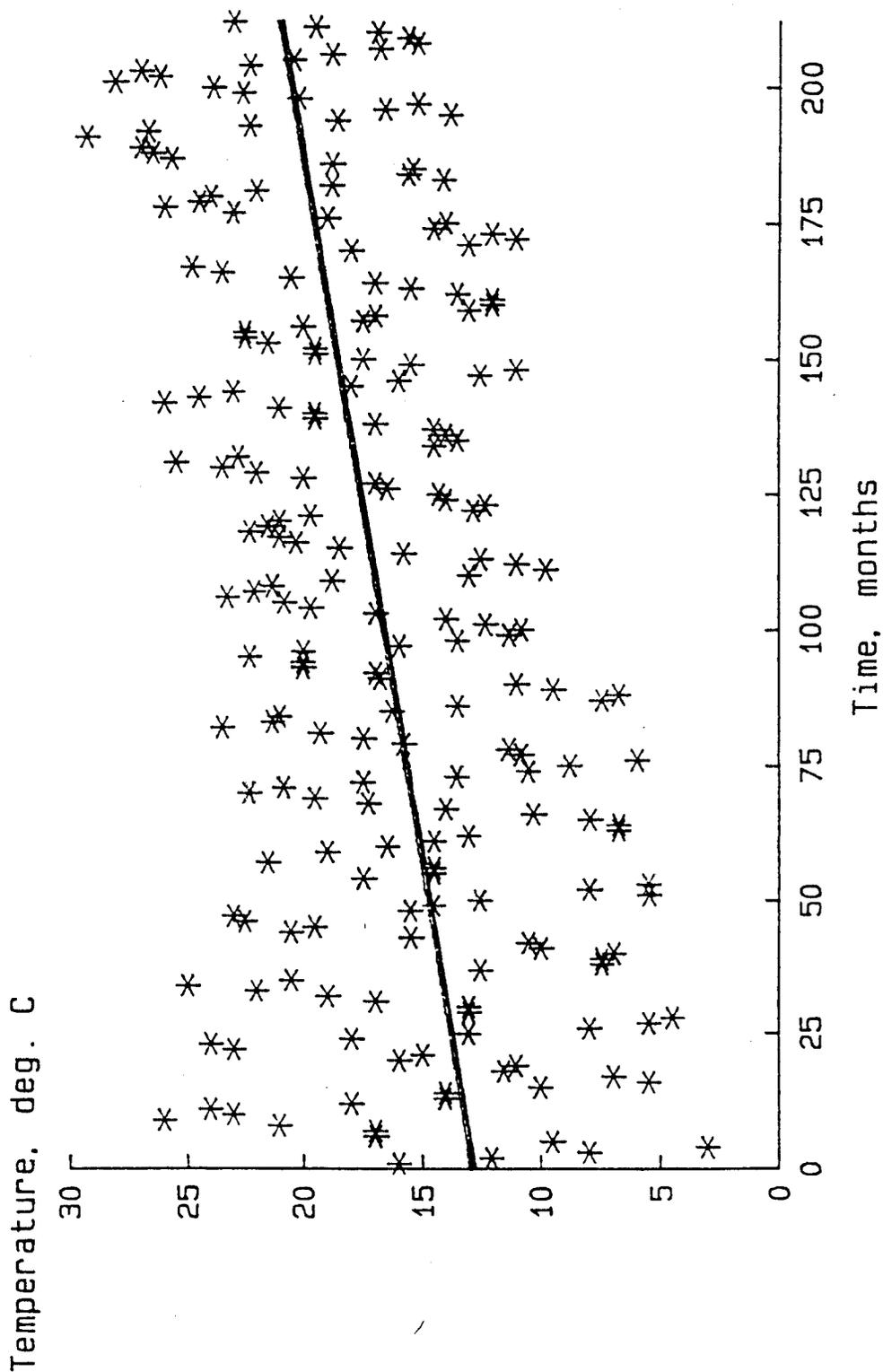
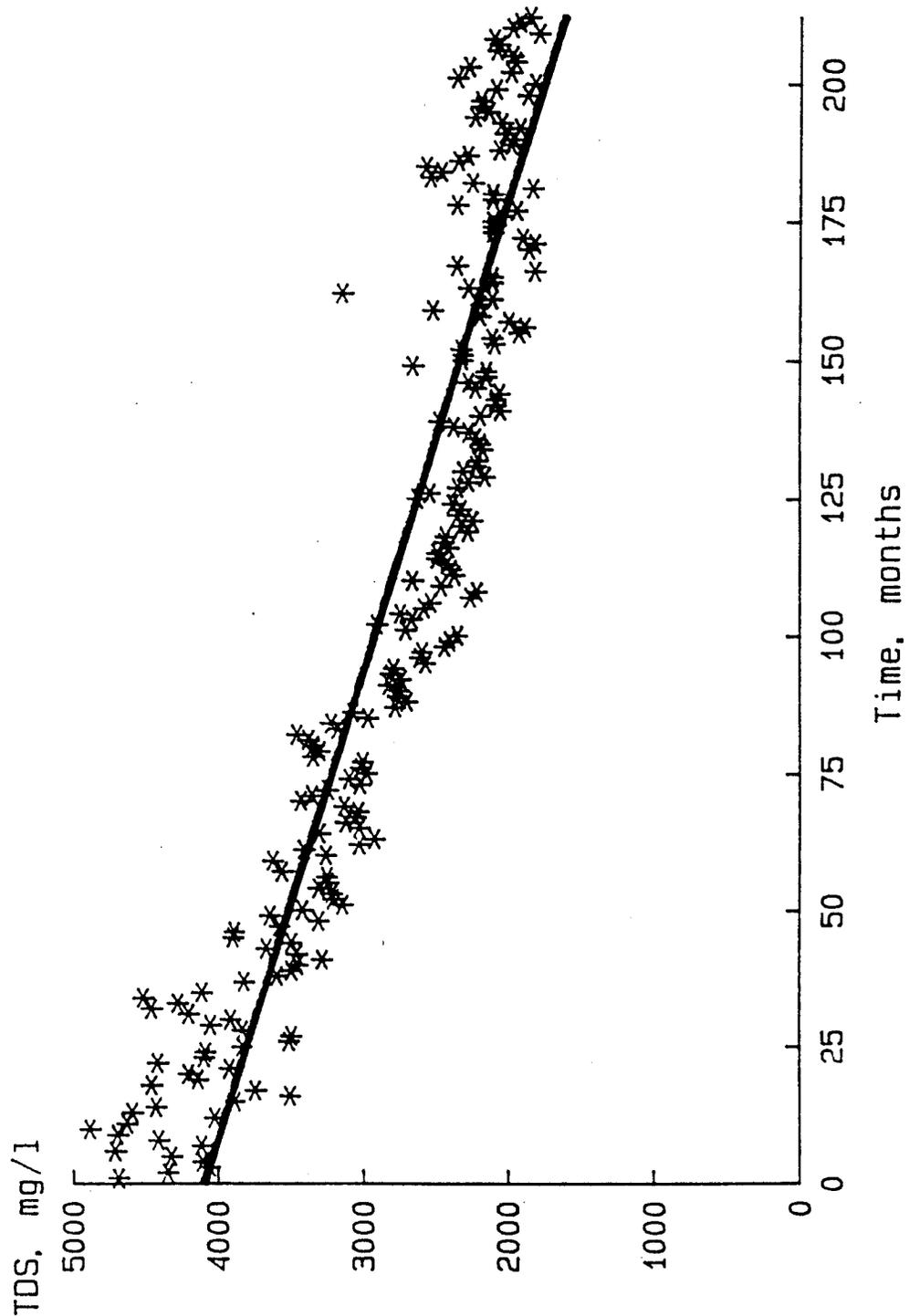


FIGURE 2.2 Monthly average LVW TDS concentrations at Northshore Road for the period October, 1969 through August, 1987



has been over the period of record examined a clear and significant trend to decreasing monthly average concentrations of TDS in LVW at Northshore Road. Second, in recent years, the monthly average concentration of TDS at Northshore Road appears to have stabilized. Given this observation, it would be inappropriate to extrapolate the assumption of linear trend and/or assume that there will be further significant decreases in the LVW TDS concentration. Third, examination of Equation (2.3) demonstrates that decreased concentrations of TDS result in reduced water densities.

#### 2.4 Suspended Solids

The analysis of the effect of suspended solids on the density of the LVW at Northshore Road is not considered in this discussion because of the poor, unreliable, and intermittent data record available.

#### 2.5 LVW Density Trends

In this section, LVW monthly average flow density at Northshore Road is examined for the period October, 1969 through August, 1987. For this analysis both USGS and CCSD temperature and specific conductance data are used with Equations (2.1), (2.2), (2.3) and (2.4) to estimate water density. All other definitions remain as they were noted in previous sections.

The monthly average values of density are plotted in Figure 2.3 and again there are 212 points in this plot. Assuming a linear trend, the resulting regression equation for long-term trend is

$$[\text{LVW-rho}] = 1002. - 0.0156 [\text{N}] \quad (2.9)$$

where  $[\text{LVW-rho}]$  = monthly average flow density in  $\text{kg/m}^3$  at Northshore Road and  $\text{N}$  = number of months since October, 1969. The correlation coefficient associated with Equation (2.9) is 0.555 which, although low is not surprising given the significant effect of the seasonal variation of temperature on water density, the residuals are normally distributed, and a t-test of the slope (-0.0156) demonstrates that it is significantly different than zero.

Consideration of the data plotted in Figure 2.3, Equation (2.9), and the foregoing discussion of LVW temperature and TDS trends provides results in the following conclusions. First, during the period of time examined, increasing average monthly temperatures and decreasing concentrations of TDS combined to decrease the monthly average flow density at Northshore Road. Second, although the monthly average TDS concentration appears to have stabilized there are no indications that monthly average flow temperatures have stabilized. Third, in order to be conservative and protective of beneficial uses in LVB, it must be assumed that monthly average flow densities Northshore Road will continue to decrease in the future although perhaps at a slower rate than in the past. Note, this conclusion does not and cannot consider the possible intervention of man on the variables such as the conveyance of the LVW flow in a pipe below the proposed Lake at Las Vegas development.

inclusive, which is also a critical period from the viewpoint of water quality. Third, of the stations sampled on a regular basis in LVB one station must be selected as being representative of the ambient density conditions encountered by LVW as it enters LVB. For this discussion, the sampling station designated as BC-5 is used as the representative station. Fourth, in many months vertical profiles of temperature and specific conductivity are available for several dates and one of these must be selected as being representative of the month. In this discussion, the profiles measured in the middle to the end of the month are used.

### 3.2 LVB Average Epilimnetic Water Temperature Trends

In this section, the LVB representative monthly average epilimnetic water temperatures at Station BC-5 are examined for the period January, 1977 through July, 1987. The data for this analysis derive from Lake Mead Limnological Research Center at the University of Nevada, Las Vegas.

The representative monthly average epilimnetic values of water temperature are plotted in Figure 3.1. In all, 71 points are plotted in this figure. Visually, this figure is confusing; and there is no apparent trend in these temperature data. Using the linear trend analysis discussed in Chapter 2, the long-term linear trend equation for the data in Figure 3.1 is

$$[\text{LVBE-Temp}] = 23.0 + 0.0037 [N] \quad (3.1)$$

where  $[\text{LVBE-Temp}]$  = representative monthly average epilimnetic water temperature in degrees Centigrade at Station BC-5 and  $N$  = number of months since January, 1977. The correlation

coefficient associated with Equation (3.1) is 0.001; the residuals are normally distributed; and a t-test of the slope demonstrates that it is significantly different from zero.

### 3.3 LVB Average Epilimnetic TDS Trends

In this section, the LVB representative monthly average epilimnetic TDS concentrations at Station BC-5 are examined for the period January, 1977 through July, 1987. Note, the TDS concentrations for LVB was based on converting field measured values of specific conductance to values of TDS by Equation (2.4) since no specific conductance - TDS data were available for this area of Lake Mead.

The representative monthly average epilimnetic values of TDS are plotted in Figure 3.2. Again, a total of 71 points are plotted in this figure. Assuming a linear trend, the resulting equation for long-term trend is

$$[\text{LVBE-TDS}] = 719. - 1.79 [N] \quad (3.2)$$

where  $[\text{LVBE-TDS}]$  = monthly average epilimnetic concentration of TDS (mg/l) at Station BC-5 and  $N$  = number of months since January, 1977. The correlation coefficient associated with Equation (3.2) is 0.471; the residuals are normally distributed; and a t-test of the slope demonstrates that it is significantly different from zero. Note, the data trends in Figure 3.2 would be better represented by two lines. That is, for  $N$  greater than 0 and less than 50 there appears to be an increasing trend while for  $N$  greater than 50 and less than 125 there is a decreasing trend.

### 3.4 LVB Average Epilimnetic Density Trends

In this section, the LVB representative monthly average epilimnetic water densities at Station BC-5 are examined for the period January 1977 through July 1987. For this analysis, the temperature and specific conductance data presented in Sections 3.2 and 3.3 are used with Equation (2.1) to estimate water density.

The 71 representative monthly average values of epilimnetic density are plotted in Figure 3.3. Assuming a linear trend, the resulting equation for long-term trend is

$$[\text{LVB-rho}] = 998. - 0.00211 [\text{N}] \quad (3.3)$$

where  $[\text{LVB-rho}]$  = monthly average epilimnetic water density in  $\text{kg/m}^3$  at Station BC-5 and  $\text{N}$  = number of months since January, 1977. The correlation coefficient associated with Equation (3.3) is 0.008; the residuals are normally distributed; and a t-test of the slope demonstrates that the slope is significantly different from zero.

### 3.5 Conclusions

The discussions in the preceding sections yield the following conclusions regarding LVB trends in temperature, TDS concentrations, and density. The conclusions are valid regardless of whether only the representative monthly average epilimnetic values or the values at various depths below the free surface are considered.

First, over the period of time examined the representative monthly values of LVB water density at Station BC-5 has

decreased. Second, during the period of time examined the noted decrease in density was primarily the result of increasing water temperatures and decreasing concentrations of TDS. The representative values of monthly TDS concentration appear to have reached a maximum during 1981 and subsequently decreased rapidly. Although the noted decrease in TDS is most likely due to dilution and salinity control, the noted decrease in TDS shows no sign of abating. The trends in epilimnetic water temperature are much less clear and no conclusions can be stated.

entirely inappropriate to interpret the following discussion as a comparison of specific values; rather, the following discussion addresses historic trends in the LVW-LVB density difference.

#### 4.2 LVW-LVB Average Epilimnetic Density Difference Trend

In this section, the difference trend between the monthly average LVW inflow density and the representative monthly average epilimnetic density is examined. The period of record used for this discussion is January, 1977 through July, 1987 with only the months of April through October, inclusive, considered. The average density of the epilimnetic waters are defined according to the 'rule' discussed in Chapter 3.

In Figure 4.1 the variable  $[\Delta]$  is plotted as a function of  $[N]$  where

$$[\Delta] = [\text{LVW-rho}] - [\text{LVB-rho}] \quad (4.1)$$

with  $[\text{LVW-rho}]$  estimated as discussed in Chapter 2 and  $[\text{LVB-rho}]$  estimated as discussed in Chapter 3. Assuming, as described before, that  $[\Delta]$  has a linear trend, the resulting equation for long-term trend is

$$[\Delta] = 2.40 - 0.0127 [N] \quad (4.2)$$

where  $N$  = number of months since January, 1977. The correlation coefficient associated with Equation (4.2) is 0.315; the residuals are normally distributed; and a t-test of the slope demonstrates that it is significantly different than zero.

The importance of the data in Figure 4.1 and Equation (4.2) to the analysis of water quality in LVB is significant. First,

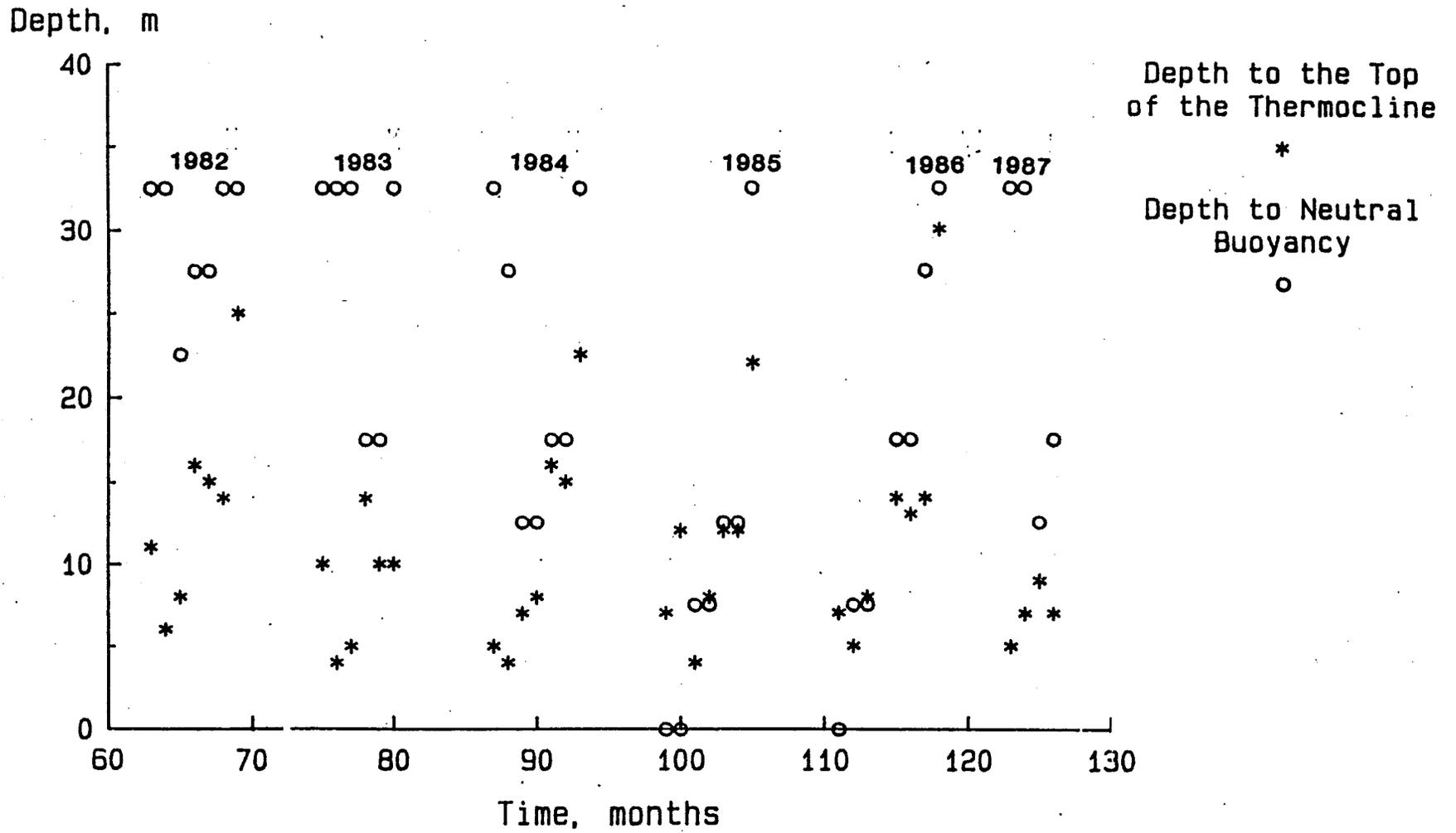
Figure 4.1 graphically demonstrates that  $[\Delta]$  has decreased in value over the period of time examined. Furthermore, there have been months in which  $[\Delta]$  was negative; that is, the representative monthly average LVB epilimnetic density was greater than the density of LVW. Second, Equation (4.2) demonstrates that over the period of time examined the hydrodynamic interaction of LVW and LVB has dramatically changed. In the early part of the period examined, LVW entered LVB as a negatively buoyant jet. In the latter part of the period examined, LVW entered LVB as a neutrally buoyant or buoyant jet. Furthermore, since the slope in Equation (4.2) is negative and non-zero, it must be assumed that  $[\Delta]$  will continue to decrease in value.

In Figure 4.2  $[\Delta]$  is plotted in bar graph form as a function of time. This graph presents additional evidence that the trend in  $[\Delta]$  has caused and could continue to cause serious water quality problems in LVB for the following reasons. First,  $[\Delta]$  typically has a relatively small value in April and May and generally increases in value until mid or late summer when it again decreases in value. Second, during periods of time in 1985 and 1986  $[\Delta]$  was negative indicating LVW may have entered LVB as a buoyant or neutrally buoyant jet. Under such circumstances, the nutrients contained in the LVW inflow and were injected directly into the epilimnetic waters of LVB at the beginning of the growing season or period of increased biological activity. Recall that in 1986 chl a values in LVB reached objectionable levels.

In Figure 4.3 the depth of neutral buoyancy and the depth to the top of the thermocline at Station BC-5 are plotted as a function of time. By definition, the depth of neutral buoyancy is the depth at which the density of the inflow equals the density of the ambient receiving water. In Figure 4.3, the depth to neutral buoyancy is plotted as a circle in five meter intervals; for example greater than 30m but less than 35m. The depth to the top of the thermocline is plotted as an asterisk in Figure 4.3, and as an exact depth.

Important information regarding the changing nature of the hydrodynamic interaction between LVW and LVB can also be found in Figure 4.3. For example, when the depth to the point of neutral buoyancy is much greater than the depth to the top of the thermocline, LVW enters LVB as a negatively buoyant plume and the probability of pollutants in the LVW inflow mixing with the epilimnetic waters of LVB are minimal. In contrast, when the vertical separation between the depth to neutral buoyancy and the top of the thermocline is small, the pollutants in the LVW inflow are much more likely to be mixed into the epilimnetic waters of LVB. An examination of the data presented in Figure 4.3 demonstrates that in the period 1977-1979 the depth to neutral buoyancy was significantly below the top of the thermocline. Therefore, during this period of time, there was minimal mixing between the LVW inflow and the epilimnetic waters of LVB. During the period 1980-1984, the difference in the depth to neutral buoyancy and the top of the thermocline declined. In particular, during mid to late summer the difference between these depths was often negligible. In 1985 and 1986, the LVW inflow was often

FIGURE 4.3 Continued



pollutants present in the LVW inflow were injected directly into the epilimnetic waters of LVB. Although the data set for 1987 is incomplete, it would appear that LVW entered LVB as a negatively buoyant inflow in the late spring but entered in the thermocline region in June.

In addressing the estimation of allowable LVW loads of nitrogen and phosphorus to meet the water quality standards in LVB, there are two primary considerations. First, a technique of describing the interaction of LVW and LVB must be selected for the near term. Second, consideration must be given to how this interaction may change in the long term.

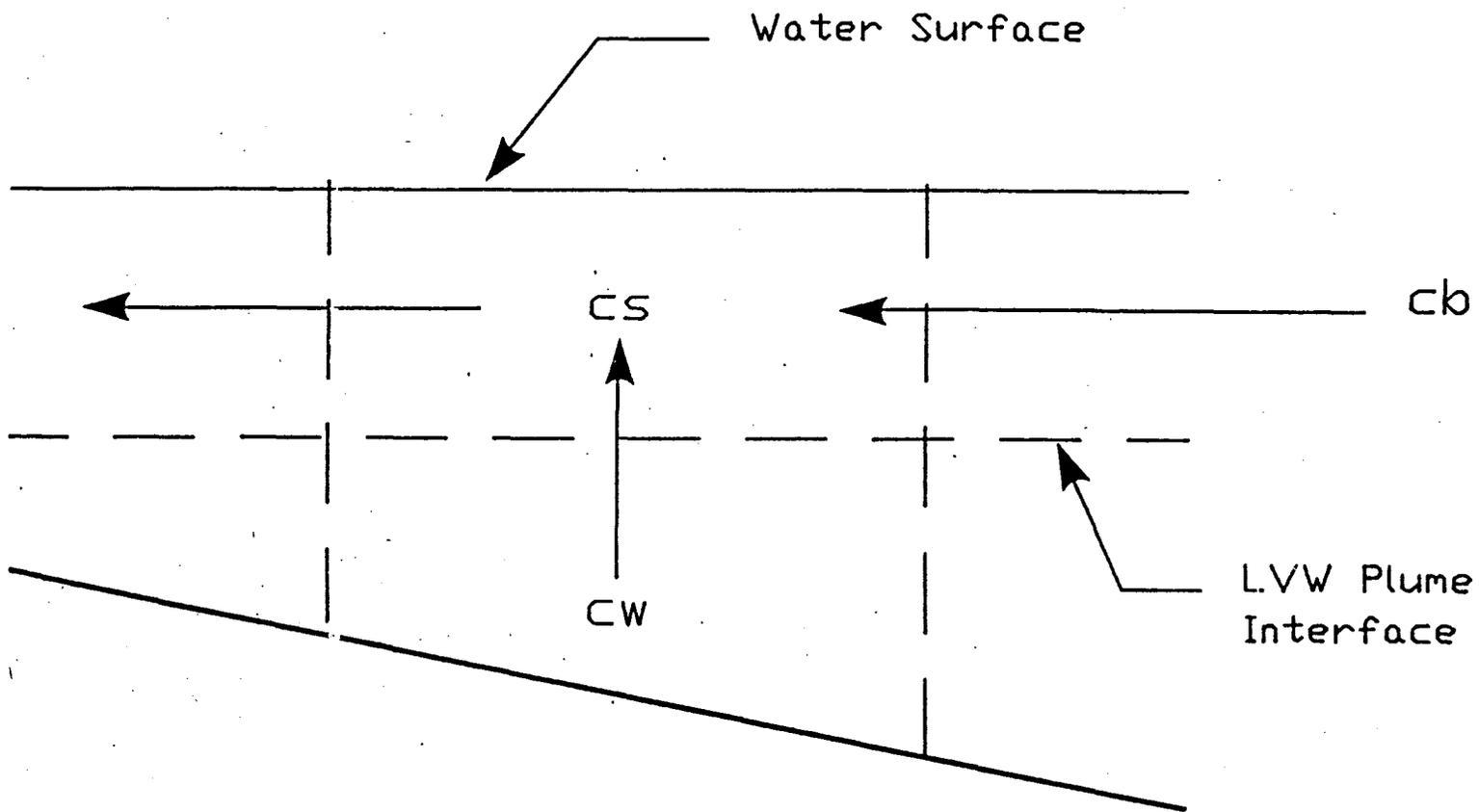
discharges of pollutants will have to be removed from the LVW flow to meet the LVB water quality standards. The new jet models [Roberts (1984) and Roberts and Matthews (1987)] were developed to describe the entry of a high momentum axisymmetric jet into a stratified fluid. The LVW inflow is neither a high momentum nor an axisymmetric jet, and thus the results of Roberts (1984) and Roberts and Matthews (1987) do not apply exactly to this situation.

3. Stochastic Models: There are a number of purely statistical methods available for using the available data to estimate allowable LVW concentrations. However, these models do not directly relate LVW and LVB data; and this is felt to be a serious problem that precludes their use in this situation.

4. Dilution Ratio: The dilution ratio method for describing the LVW-LVB interaction was first discussed by Anon. (1982). This technique has the advantages of being based on the law of conservation of mass and directly relating the available LVW and LVB data. This method has the further advantage of simplicity.

After careful consideration of both the available models and data, it was concluded that the dilution ratio technique was the best model available for estimating, in the near term, the LVW concentrations at NSR of phosphorus and nitrogen that will satisfy the LVB water quality standards.

FIGURE 5.1 Schematic definition of variables in dilution ratio model



relationship between total phosphorus concentrations and chl a for LVB a regression equation was developed. This is a technique that has been widely used to predict the effect of changes in the concentration of total phosphorus on algal biomass.

The equation developed by Cooper (1988) was derived from data collected at LVB Stations BC-3, BC-4, and BC-5 during 1979-1987. Data from Station BC-2 were not used because of possible light and nitrogen limitations at this site. The data were also screened to remove those data that could be considered to be nitrogen limited (TN:TP less than 10). This screening procedure removed only 12 of the 267 available data points and only one of these points was in the period 1985-1987. The data for this analysis are plotted in Figure 5.2, and the regression equation developed was

$$\text{chl } \underline{a} = 0.603 [\text{TP04}] - 0.704 \quad (5.3)$$

with a correlation coefficient of 0.83 and where TP04 = the concentration of total phosphorus.

Solution of Equation (5.3) for a long-term mean chl a of 30 ug/l at Station BC-3 predicts a summer mean total phosphorus concentration of 0.051 mg/l, Cooper (1988). The results of a previous study on Lake Mead yielded similar results, Anon. (1982). Although regression equations such as Equation (5.3) can vary from lake to lake, Equation (5.3) is very similar to the chl a - TP04 developed for other lakes; see for example Sakamoto (1966), Dillon and Rigler (1974) and Jones and Bachmann (1976).

In this application, the following interpretation of the

TABLE 5.1 SUMMARY OF MONTHLY AVERAGE VALUES FOR THE TP04 DILUTION RATIO CALCULATIONS

M O N T H	1985				1986				1987			
	TP04 mu NSR mg/l	TP04 mu BC-8 mg/l	TP04 mu BC-3 mg/l	D	TP04 mu NSR mg/l	TP04 mu BC-8 mg/l	TP04 mu BC-3 mg/l	D	TP04 mu NSR mg/l	TP04 mu BC-8 mg/l	TP04 mu BC-3 mg/l	D
4	0.820	0.020	0.047	29.6	0.753 <sup>3</sup>	0.012	0.032	36.0	0.680	0.009	0.062	11.7
5	0.900	0.017	0.064	17.8	0.848	0.010	0.069	13.2	1.43	0.008	0.069	22.3
6	1.04	0.024	0.110	10.8	1.34	0.008	0.062	23.7	0.830 <sup>4</sup>	0.008	0.052	17.7
7	1.34 <sup>1</sup>	0.007	0.068	20.9	0.748	0.007	0.088	8.14	0.873 <sup>5</sup>	0.008	0.082	10.7
8	0.797 <sup>2</sup>	0.006	0.072	16.2	0.802	0.009	0.104	7.35	0.784	0.008	0.091	8.35
9	0.986	0.006	0.077	30.6	0.868	0.006	0.043	22.3	0.793	0.009	0.068	12.3

<sup>1</sup>Data on 7/22/85 ignored because of unusually high flow

<sup>2</sup>Data on 8/5/85 ignored because of unusually high flow

<sup>3</sup>Data on 4/7/86 ignored because of unusually high flow

<sup>4</sup>Data on 6/8/87 ignored because of unusually high flow

<sup>5</sup>Data on 7/27/87 ignored because of unusually high flow

250

TABLE 5.2 MONTHLY AVERAGE VALUES OF D AND mu BC-8 FOR THE PERIOD 1985-1987

Month	D		TP04 Concentrations at BC-8	
	mu D	sig D	mu (BC-8) mg/l	sig (BC-8) mg/l
4	25.8	12.6	0.011	0.005
5	17.8	4.55	0.010	0.004
6	17.4	6.46	0.010	0.006
7	13.2	6.75	0.008	0.002
8	10.6	4.85	0.008	0.003
9	21.7	9.16	0.007	0.002

not exceed more often than once every three years 0.04 mg/l."

It is assumed and can be shown that if the chronic unionized ammonia standard is met then acute unionized ammonia standard will also be satisfied.

The unionized ammonia standard also indicates that diurnal fluctuations of the concentration of unionized ammonia in the top 2.5m of water will be taken into account.

Since the available historic data regarding unionized ammonia at LVB Station BC-2 were taken at various times throughout the day, the first step in this analysis was to develop a technique for reducing historic values of unionized ammonia to average daily values. During the summer of 1987, a data sonde was emplaced for varying periods of time in the center of the X-section at Station BC-2 in LVB. The data sonde monitored on a hourly basis water temperature and pH, and with these variables known, the hourly fraction of unionized ammonia (fui) can be estimated by [Emerson et al (1975)]

$$fui = 1./[1+10^{**}((0.0902-pH) + 2730/(273.2+T))] \quad (5.3)$$

where T = water temperature in degrees Centigrade. These values can then be used to define the time at which the daily average fui occurs and with the large number of values available Figure 5.3 can be constructed. Note, Equation (5.3) does not take into account the effect of total dissolved solids on the value of fui because it was not felt that TDS changed sufficiently over the periods of time considered to have a significant effect. In Figure 5.3, the ratio of the fraction unionized ammonia to the

daily average fraction unionized ammonia is plotted as a function of the number of hours elapsed after midnight. In this figure, the vertical lines associated with each point represent the expected value of the fui ratio plus or minus one standard deviation. Figure 5.3 can be used to transform the historic values of unionized ammonia to average values of unionized ammonia. In this figure, the daily average value of fui occurs at approximately 1300 Pacific Daylight Time (PDT); the maximum at approximately 1600 (PDT); and the minimum at approximately 0800 (PDT).

In Table 5.3 the monthly average total ammonia (TNH mu) data are summarized for LVW, Station BC-2 (the standard station) and Station BC-8 (the background station) for the years 1985-1987. Also summarized in Table 5.3 are the monthly average values of fui. The values of fui in this table were corrected for TDS concentrations using the methodology suggested by Stumm and Morgan (1970). Again, given the previously described changes in LVW and LVB water densities and the geometric changes that have occurred in the LVW channel at the point it enters LVB, it is not appropriate to use data previous to 1985 for this analysis. Also summarized in this table are monthly average values of the dilution ratio, D, calculated from the average concentrations summarized in this table. Finally, some total ammonia data at NSR have been deleted from the data base because on these dates LVW flow rates exceeded 110% of average. In Table 5.4, the critical season (April-September inclusive) average values and the standard deviations associated with these averages are

TABLE 5.4 CRITICAL SEASON PARAMETER AVERAGES AND STANDARD DEVIATIONS

nu	D	$\sigma$	nu	fui	$\sigma$	mu	cb	$\sigma$
22.2		10.2	0.234		0.109	0.019		0.010

These target daily average values can then be combined to estimate target four day running average values which can then be combined to estimate target critical period concentrations.

A computer code was developed to perform the stochastic simulation and 50 years of record was simulated. The key calculation in the code - the target daily average value of total ammonia at NSR was

$$TNH = (0.04/f_{ui}) * (D+1) - D * c_b$$

where TNH = target concentration of total ammonia at NSR (mg/l).

The fifty years of simulated data had the following characteristics.

Target minimum average NSR total ammonia concentration  
(TNH) = 1.56 mg/l

Standard deviation associated with  
target minimum average = 0.30 mg/l

At this point it is appropriate to note that by the terminology 'target minimum average NSR concentration' the following computational and data selection process is indicated. During each yearly critical period there are 183 days; and thus, 183 daily average values of total ammonia. After four day averages are formed, there are 180 values for the critical period. From each of the 50 critical periods simulated, the minimum concentration of TNH that will satisfy the water quality standard

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*Total Maximum Daily Loads at North Shore Road  
and  
Waste Load Allocations*

*Prepared by:*

*Nevada Division of Environmental Protection*

Point source discharges into Las Vegas Wash include:

1. City of Las Vegas
2. Clark County Sanitation District
3. TIMET
4. Kerr-McGee
5. Stauffer

The City of Henderson may be discharging to Las Vegas Wash in the future. TIMET discharges noncontact cooling water and other relatively uncontaminated flows. Kerr McGee discharges noncontact cooling water and stormwater, and Stauffer discharges stormwater. The discharges from both Kerr-McGee and Stauffer are intermittent, and have been relatively uncommon in the past. Additionally, there are no data available on the concentration of nutrients in Kerr-McGee and Stauffer's discharges. TIMET discharges approximately 4 MGD and both the total ammonia and total phosphorus concentrations in these discharges are approximately 0.01 mg/l or less. Therefore, only the discharge from the City of Las Vegas and Clark County treatment plants were used to estimate the total monthly average point source load discharged to Las Vegas Wash.

The U.S.G.S. flow gage at North Shore Road was destroyed in 1984 and has not been replaced. Therefore, to estimate the load at North Shore Road, 4 cubic feet per second was added to the gaged flow at Babco Road. The 4 cfs correction was derived by the U.S.G.S. There is

were used to obtain the overall average nonpoint source load. As can be seen in this figure, there is a rather large variation from month to month in the estimated nonpoint source load. In figure 2, the load coming from the treatment plants and the load at North Shore Road are plotted on the same graph. It would appear that the variation in the estimated nonpoint source load is due to variation load at North Shore Road rather than variation in the point source discharges.

The variation in the total phosphorus load at North Shore Road is likely due to the sporadic nature of stormwater flows. A good relationship between suspended solids and total phosphorus exists (correlation coefficient = 0.95) which implies that a portion of the total phosphorus is bound to the sediments. There is a satisfactory relationship between total phosphorus and flow and between suspended solids and flow. It is likely that the particulate component of the load settles and resuspends with scour; consequently, the travel time of this portion of the load may be substantially longer than the hydraulic time of travel (EPA Technical Guidance for Performing Waste Load Allocations - Book IV Lakes and Impoundments, Chapter 2 Eutrophication pg. 3-15, 3-16). The intermittent nature of the transport of particulates could be partly responsible for the variation in the total phosphorus load at North Shore Road.

## Total Phosphorus Loads

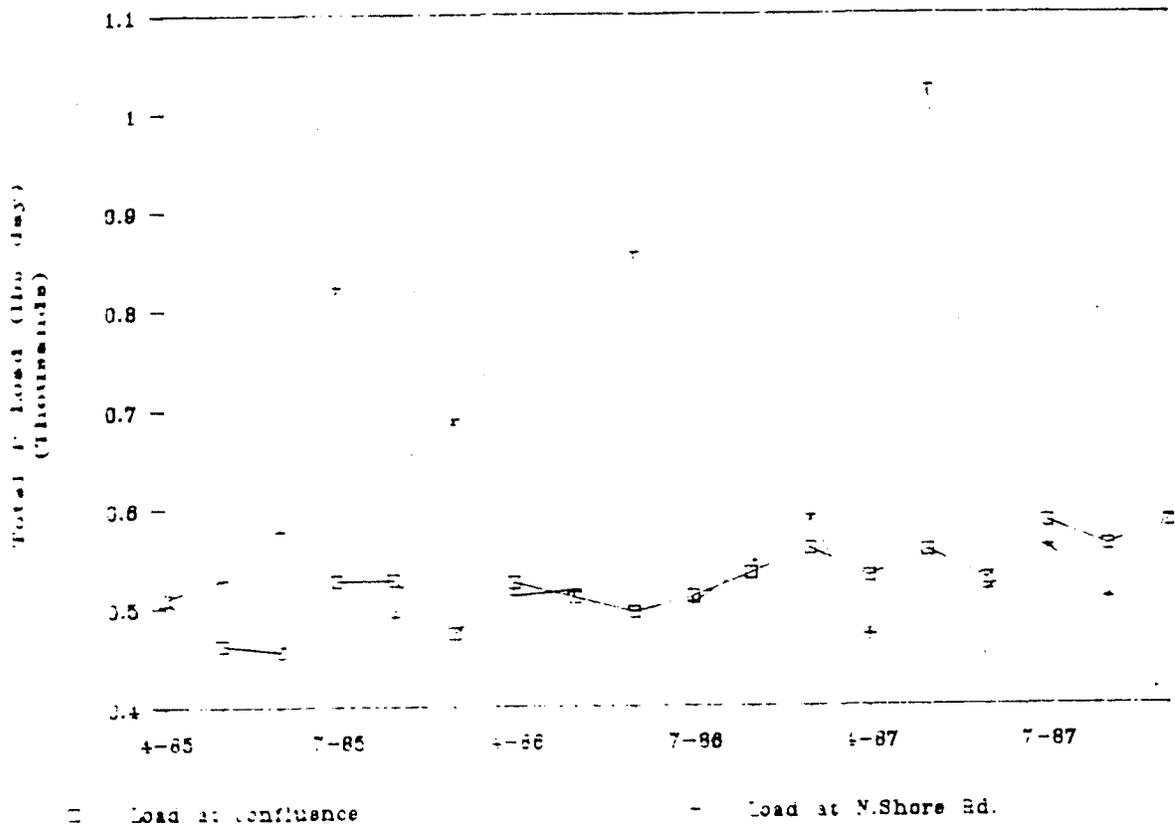


Figure 1: Total Phosphorus Loads Discharged by the City and County Compared to Total Phosphorus Load at North Shore Rd.

## Total Ammonia Loads

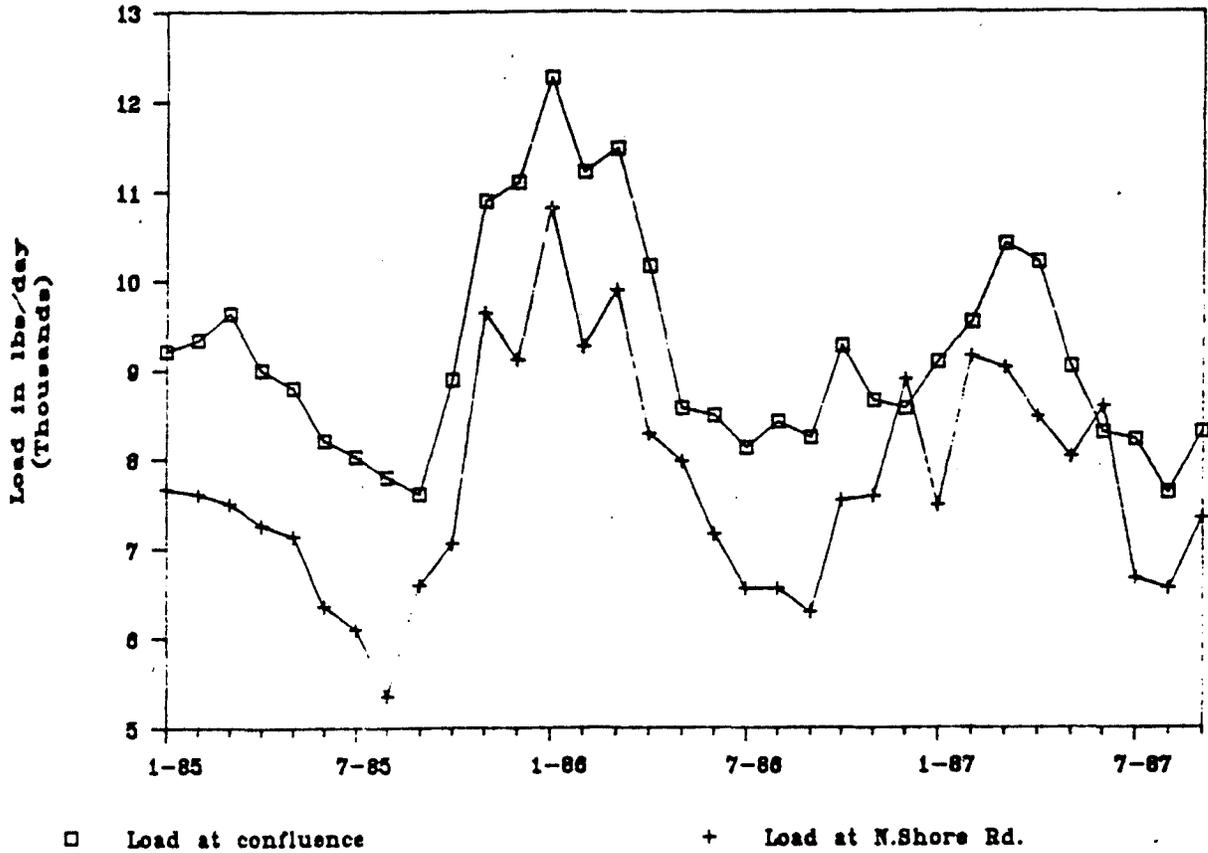


Figure 3: Total Ammonia Loads Discharged by the City and County Compared to Total Ammonia Load at North Shore Rd.

Equal Effluent Concentration:

Allocating the load proportional to current effluent flows results in 44% of the remaining controllable load allocated to the City of Las Vegas and 56% allocated to Clark County Sanitation District (CCSD). Using the above percentages the following loads were calculated:

City - 147 lbs/day total phosphorus  
427 lbs/day total ammonia

CCSD - 187 lbs/day total phosphorus  
543 lbs/day total ammonia

The City of Henderson has expressed to NDEP no desire to discharge to Las Vegas Wash during the period April through September.

INTERIM WASTE LOAD ALLOCATION:

The following total phosphorus loads will be allowed until April, 1990:

City - 231 lbs/day  
CCSD - 293 lbs/day

Achieve compliance with waste load allocations for ammonia by April, 1993.