STEMPLE CREEK

WATER QUALITY CHARACTERISTICS AND A MAXIMUM DAILY LOAD PROCESS

MARIN AND SONOMA COUNTIES

PREPARED BY
STAFF
William D. Winchester
Rhonda L. Raymond
Dennis L. Salisbury
OF THE
CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
NORTH COAST REGION

August 15, 1995

INTRODUCTION

Stemple Creek is a relatively small coastal watershed of approximately 50 square miles located in Marin and Sonoma Counties, California, north of San Francisco. Stemple Creek flows into the Estero de San Antonio, designated as part of the Gulf of the Farallones National Marine Sanctuary. The Estero discharges into Bodega Bay, and is closed at times by a sand bar at its mouth. Land use in the watershed is rural agriculture, mainly dairies and livestock ranches. There are 32 dairies in the watershed, supporting an estimated 9,900 milk cows, 1,790 dry cows, 321 heifers, and 1,290 calves. The number of beef livestock and poultry are unknown.

Rainfall averages about 30 inches per year, with most of it occurring in the winter. Stemple Creek normally goes dry in its upper and middle watershed areas in the summer. Local landowners tell us that the stream supported a small salmonid run, probably steelhead, until the 1960's. This run no longer exists. In 1990, the North Coast Regional Water Quality Control Board listed both Stemple Creek and the Estero de San Antonio as impaired waterbodies under Section 303(d) of the federal Clean Water Act. The reasons for this listing were high ammonia concentrations and low dissolved oxygen levels. Nonpoint source runoff principally from dairies is believed to be the main contributor to these conditions.

The North Coast Regional Board has been addressing this issue through its Clean Water Act Section 319(h) nonpoint source program in cooperation with locaf agencies and landowners. This effort has included nonpoint source outreach participation, grants, and limited water quality sampling. Regional Board staff has conducted periodic water quality sampling in Stemple Creek from 1990 - 1994 for the purpose of assessing conditions and trends over time. These data are presented here.

Additionally, Section 303(d) specifies that a Total Maximum Daily Load (TMDL) process be developed for waterbodies listed as impaired. Towards this end, Regional Board staff has investigated the use of two different water quality models for Stemple Creek for use in developing waste load reduction strategies. Discussion of these are also presented here.

METHODS

Twelve sites were sampled by Regional Board staff during the study period. Sampling frequency ranged from 13 times at one site to only one spot check at four sites. Sampling locations were chosen from the top of the watershed down to the Estero, and were selected to bracket areas of concern, for sampling practicality (i.e. bridges), and from recommendations made by a U. S. Environmental Protection Agency (USEPA) consultant, Tetra Tech, Inc., for data needs for the water quality model STREAMDO IV. Water quality monitoring station locations and station name acronyms are shown in Figure 1.

Field measurements for dissolved oxygen, pH, specific conductance, water temperature, and stream flow were performed by Regional Board staff using accepted Regional Board protocols. All other analyses were sent to a contract laboratory.

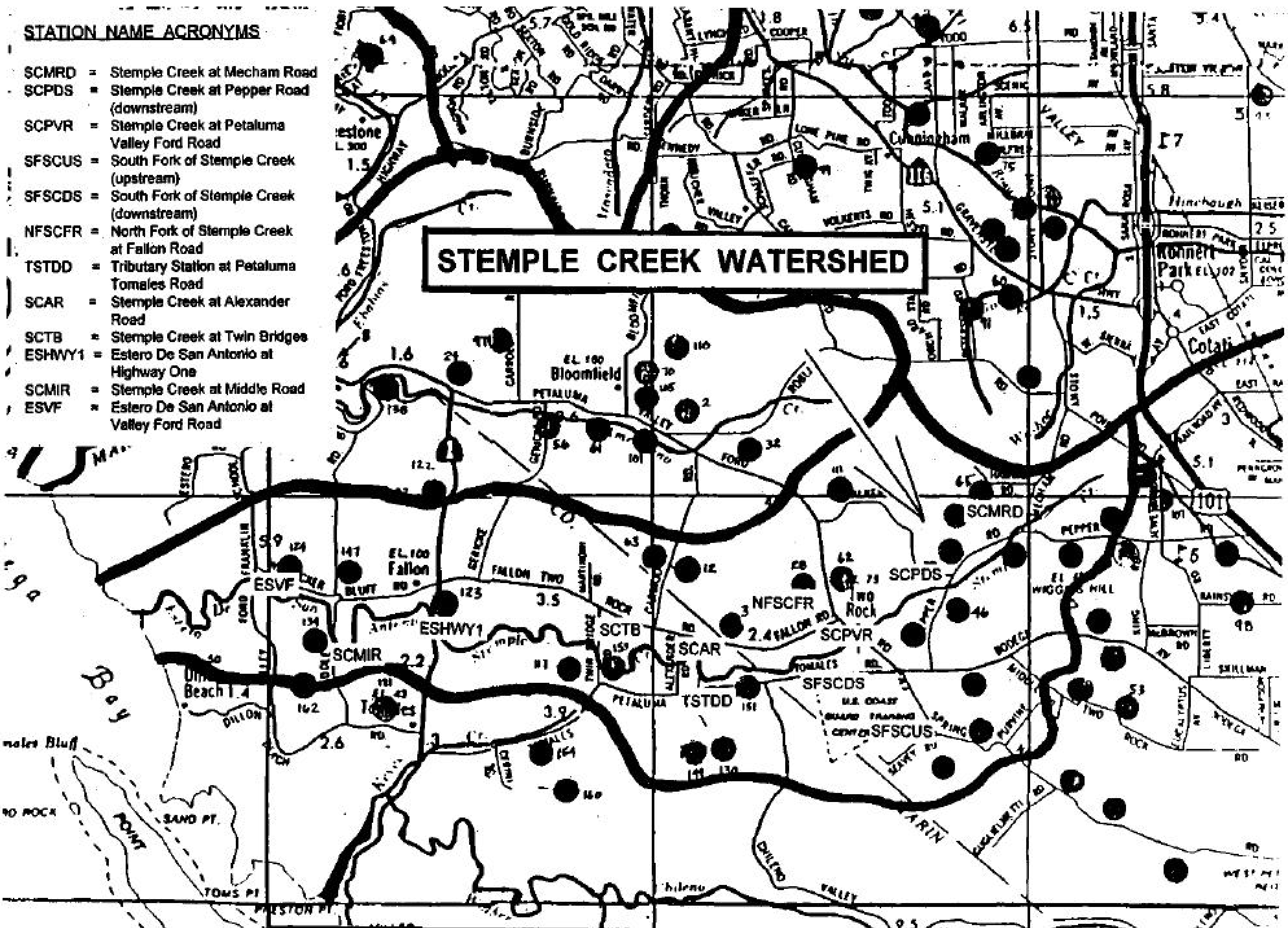


Figure 1. Stemple Creek watershed showing sampling station locations. Dairy sites are shown as round dots on the map.

RESULTS

Water Quality Assessment

Stemple Creek surface water quality studies conducted by Regional Board staff have concentrated on nutrient and physical water quality parameters associated with animal waste nonpoint source runoff. The data is given in Appendix A. In order to help the reader interpret this data in an easy visual format, we have displayed in the discussions below a series of graphs showing water quality parameter concentrations at two selected stations in Stemple Creek. These two stations are Stemple Creek at Petaluma Valley Road (SCPVR), and a downstream station in Stemple Creek at Alexander Road (SCAR). SCPVR is in the upper watershed, and SCAR is the first station above tidal influence from the Estero. Both these stations were sampled together five times and help provide a snapshot as to how water quality was changing in Stemple Creek down through the watershed on a given sampling date. Additionally, selected water quality parameters are displayed in graph form showing all stations monitored for the five sampling dates illustrated above.

Total Ammonia-nitrogen (NIB-N)

Total ammonia-nitrogen (NH3-N) can be formed by the chemical and bacterial decomposition or breakdown of animal wastes. Animal wastes have high ammonia-nitrogen concentrations. Since ammonia in surface waters normally quickly oxidizes to other forms of nitrogen, high levels of ammonia usually indicate a recent source of nitrogen discharge. This makes it an excellent water quality parameter for monitoring and evaluating nonpoint source discharges from animal wastes and other nitrogen sources.

Maximum and minimum NH3-N concentrations at all stations ranged from a high of 68.0 mg/L at station SCMRD to a low of 0.07 mg/L at station ESVF. Figures 2 and 3 display selected NH3-N concentrations. These figures illustrate generally decreasing total NH3-N concentrations in Stemple Creek as it flows downstream. The sharp increase at station TSTDD on February 11, 1993 is at a location on a small tributary downstream from two dairies.

Un-ionized Ammonia

Un-ionized ammonia can be toxic to aquatic life at relatively low concentrations. The percent of total ammonia that is in the toxic un-ionized form increases with increased water temperature and/or increased pH level. The U.S. Environmental Protection Agency (USEPA) has established a national criterion for un-ionized ammonia at 0.025 mg/L for protection of freshwater aquatic life. Un-ionized ammonia concentrations were calculated for this report using equations and coefficients derived from Emerson (1975). Regional Board staffuses the un-ionized ammonia national criterion of 0.025 mg/L as the level of concern. One of the ultimate goals for the Regional Board is to not exceed this criterion in Stemple Creek.

Maximum and minimum un-ionized ammonia concentrations at all stations ranged from a high of 2.66 mg/L at station SCPDS to a low of .001 mg/L at both stations SCPDS and SCMIRD. Figures 4 and 5 display selected un-ionized ammonia concentrations. These figures illustrate that the un-ionized criterion of 0.025 mg/L was exceeded at all stations graphed during some time of the year. As expected, these concentrations did not directly correlate with the total ammonia-

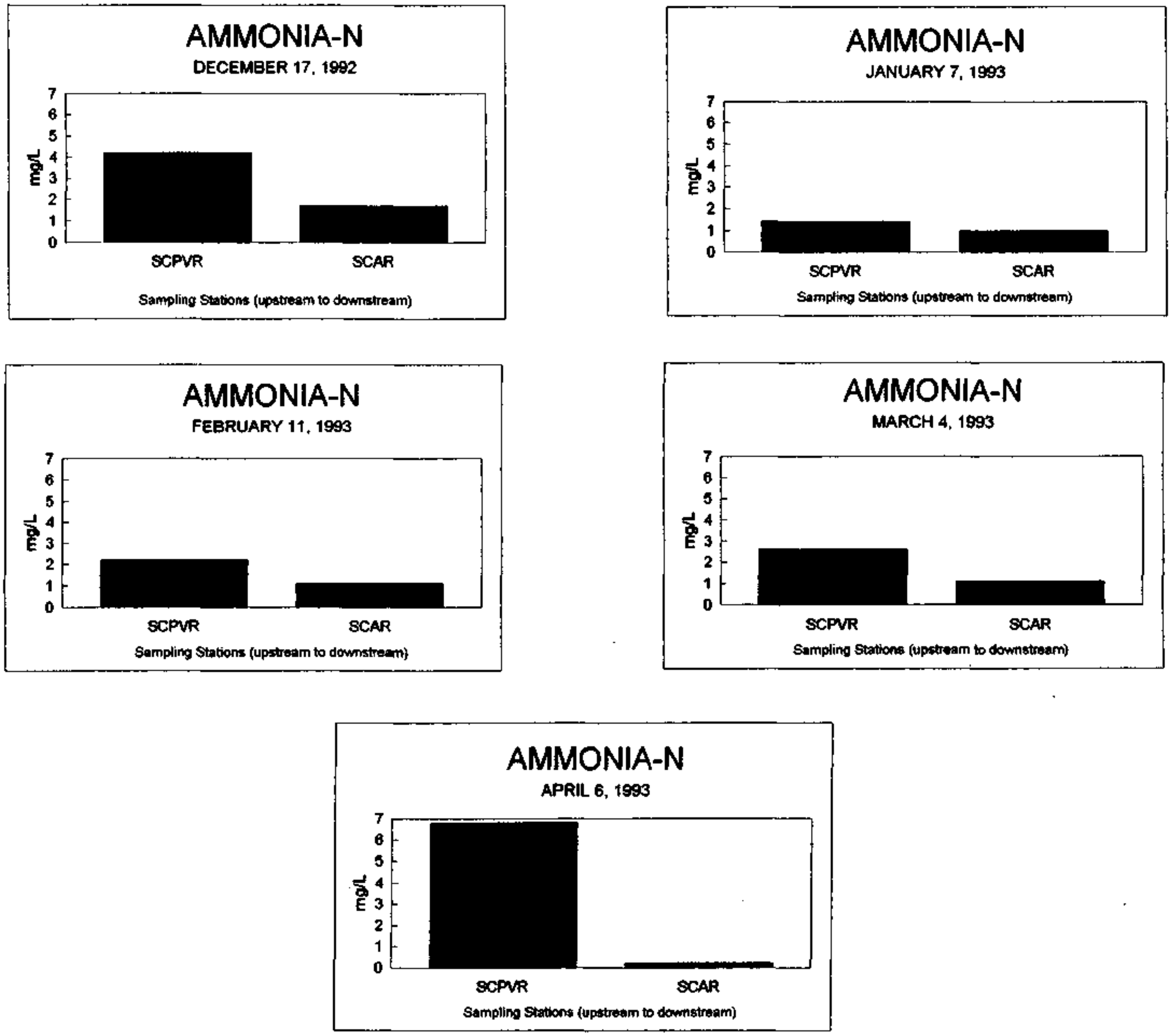


Figure 2. Total Ammonia - N concentrations at stations SCPVR and SCAR on 1992 - 1993 sampling dates.

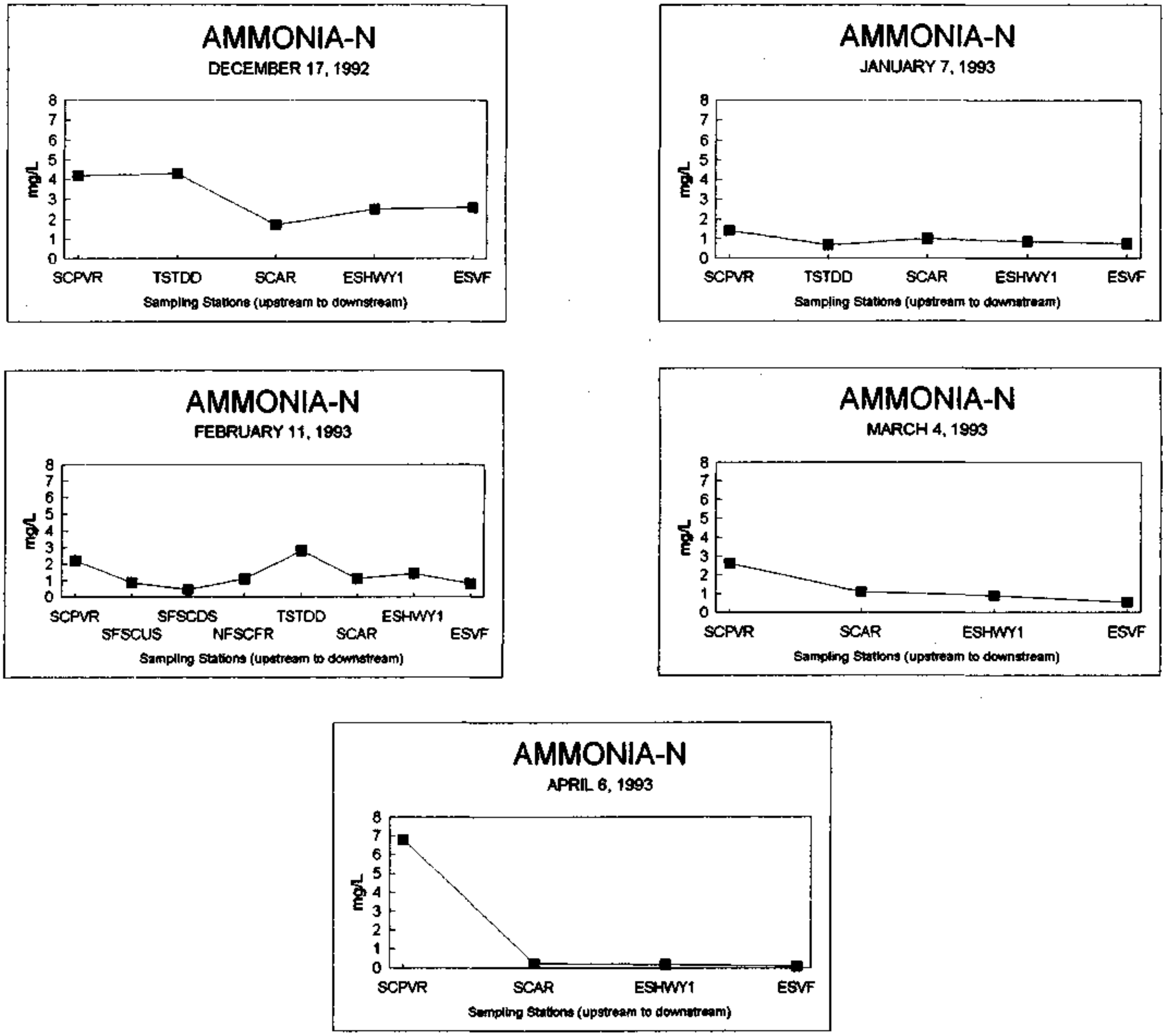


Figure 3. Total Ammonia - N concentrations at Stemple Creek sampling stations (moving upstream to downstream) on selected 1992 - 1993 sampling dates.

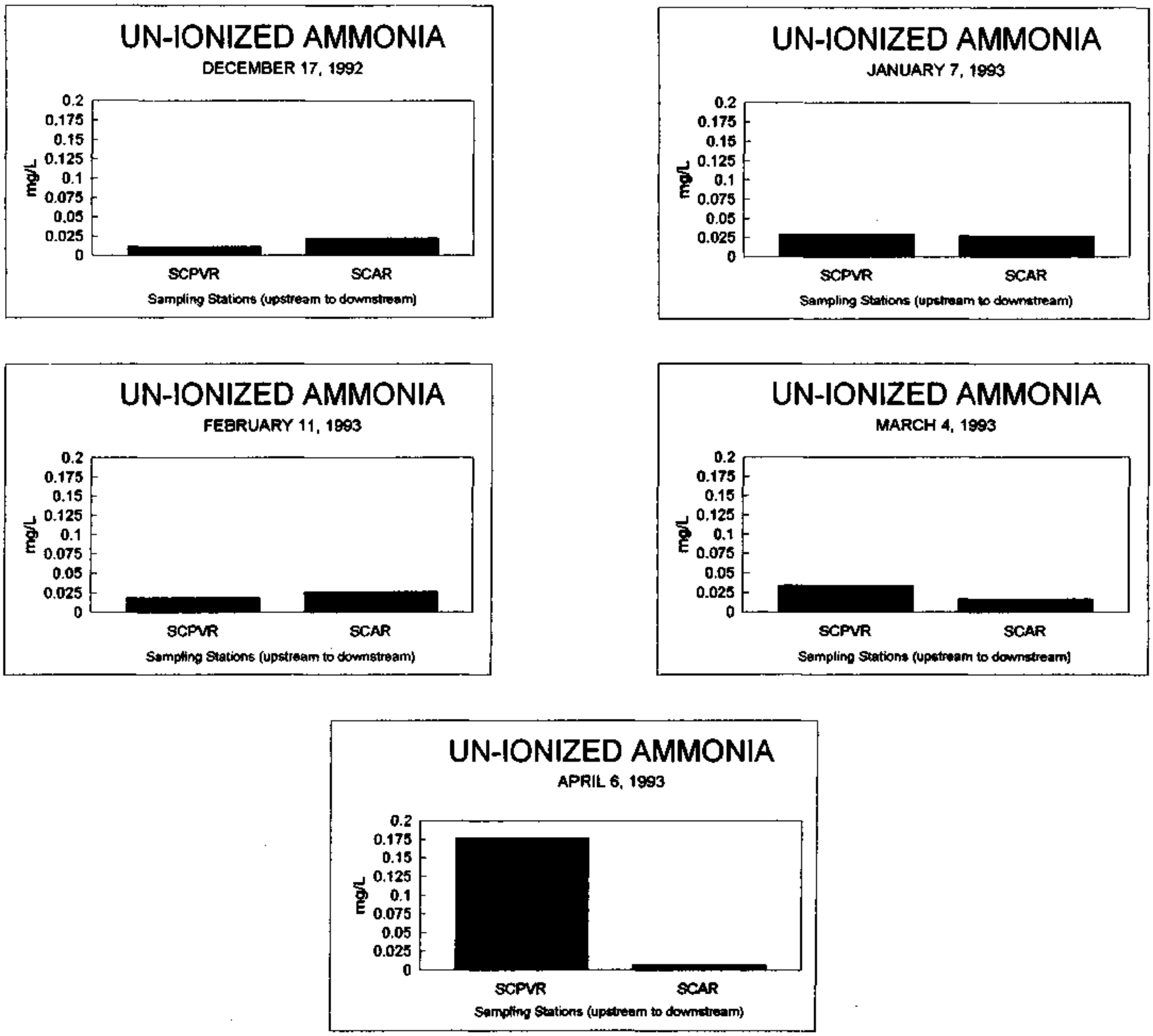


Figure 4. Un - ionized Ammonia concentrations at stations SCPVR and SCAR on 1992 - 1993 sampling dates.

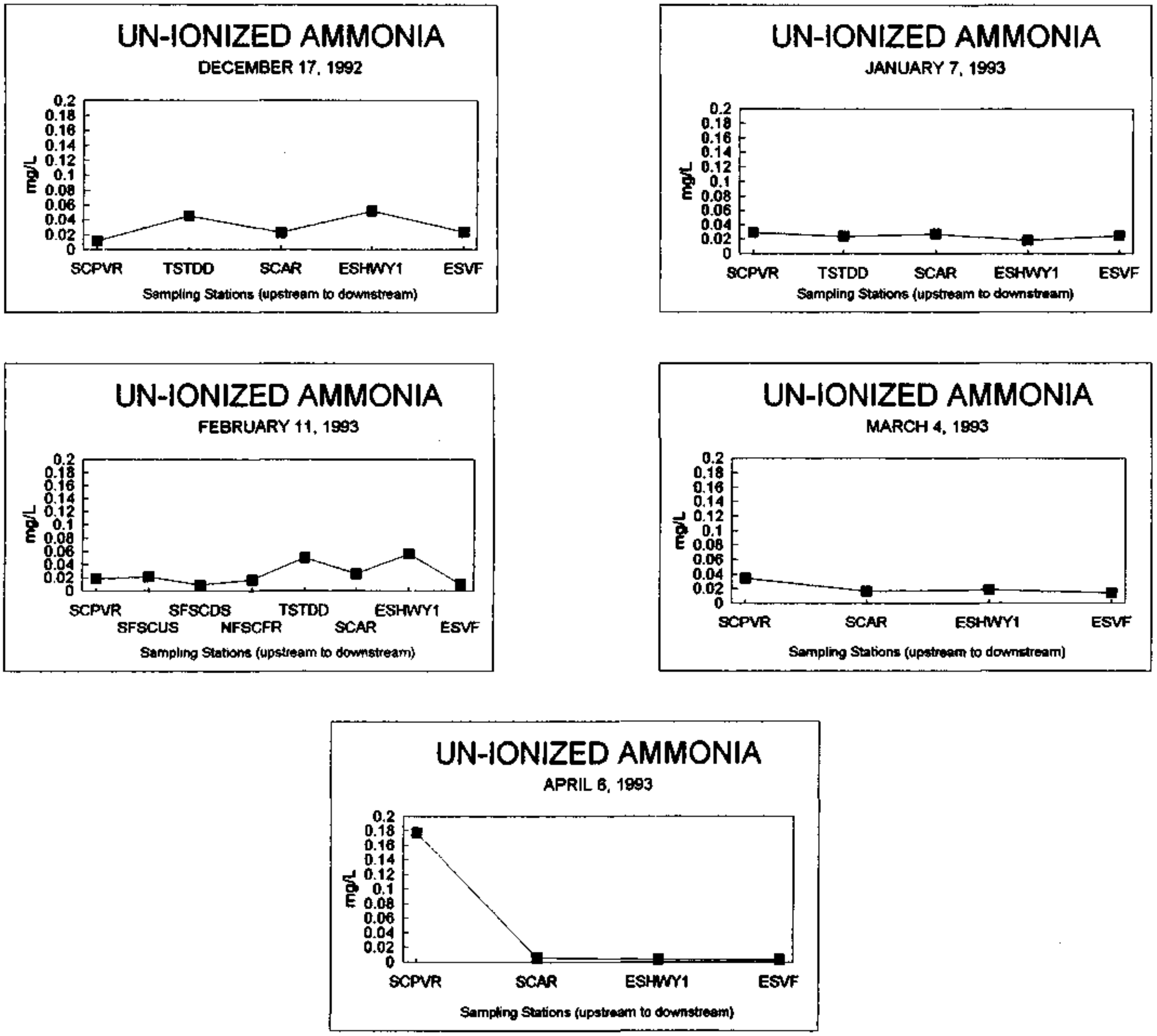


Figure 5. Un - ionized Ammonia concentrations at Stemple Creek sampling stations (moving from upstream to downstream) on selected 1992 - 1993 sampling dates.

nitrogen concentrations shown above which generally decreased moving downstream. This shows the importance of reducing the total ammonia load year round since it converts easily to the toxic un-ionized form at relatively small changes in water temperature and pH levels, even in the winter period. The March and April, 1993 concentrations at SCPVR shown in Figure 4 were collected when dairy cows were in the creek. Note that the criterion was exceeded at this spot on these two dates.

Total Kjeldahl Nitrogen (TKN)

Total Kjeldahl Nitrogen (TKN) is the total of the organic and ammonia nitrogen. A stream which is high in animal waste and/or algae for instance can be expected to have high TKN concentrations.

Maximum and minimum TKN concentrations at all stations ranged from a high of 160.0 mg/L at station SCMRD to a low of 0.85 mg/L at station SCTB. Figures 6 and 7 display selected TKN concentrations. There is a general trend towards decreasing TKN concentrations as Stemple Creek flows downsream. Note that there is a strong coorelation between TKN concentrations and total ammonia concentrations given above, indicating the significant contribution of ammonia nitrogen in the nitrogen cycle of Stemple Creek.

Nitrate (NO3)

Ammonia in surface water will oxidize to nitrite (NO2) and then to nitrate (NO3). NO3 is used by algae and other aquatic plants as a nutrient. Surface waters high in NO3 can be subject to nuisance algae blooms and excessive aquatic plant growth. This in turn can suppress dissolved oxygen levels to the detriment of fish and other aquatic life. The North Coast Regional Board's Water Quality Control Plan for the North Coast Region (Basin Plan) (1994) sets narrative objectives for biostimulatory substances. The Basin Plan specifies that "Waters shall not contain biostimulatory substances in concentrations that promote aquatic growths to the extent that such growths cause nuisance or adversely affect beneficial uses". Numeric objectives for these nutrients have not been established for Stemple Creek.

Maximum and minimum NO3 concentrations at all stations ranged from a high of 11.0 mg/l at station TSTDD to a low of 0.015 mg/L at both stations SCMRD and SCPDS. Figures 8 and 9 display selected NO3 concentrations. Nitrate concentrations were highest during the winter period. Station TSTDD on a small tributary stream downstream from two dairies consistently exhibited the highest concentrations. Note declining NO3 concentrations in the spring when eutrophication problems can begin to occur.

Total Phosphates (TPO4)

Phosphorus, as total phosphates (TPO4), can be a nutrient for algae and vascular plant growth leading to the same eutrophic water quality conditions as nitrate discussed above. The inorganic dissolved form of phosphorus is orthophosphate (OPO4) which is the form of phosphorus most readily available to algae. Much of the TPO4 measured in our data consisted of a high proportion of OPO4.

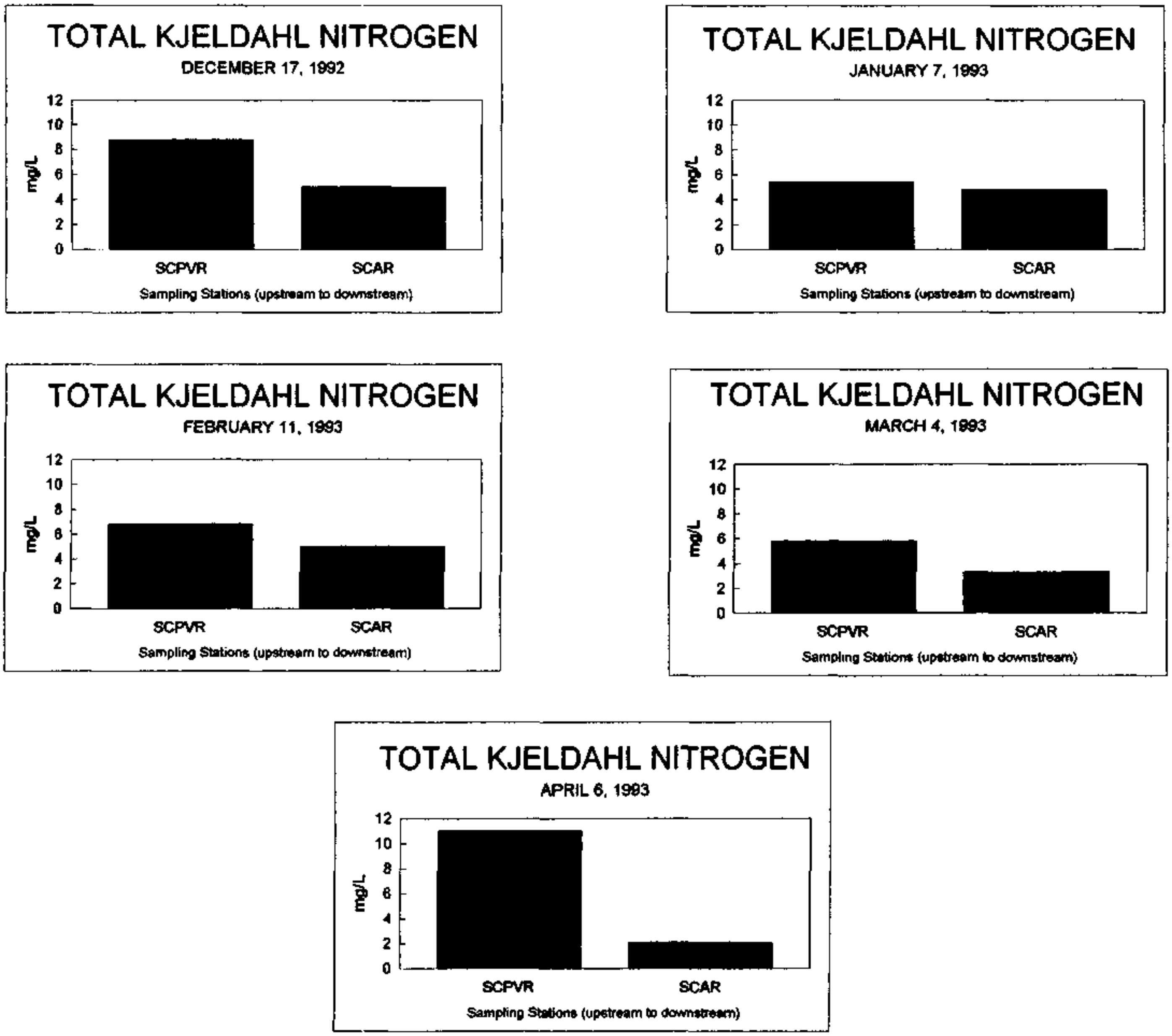


Figure 6. Total Kjeldahl Nitrogen concentrations at stations SCPVR and SCAR on 1992 - 1993 sampling dates.

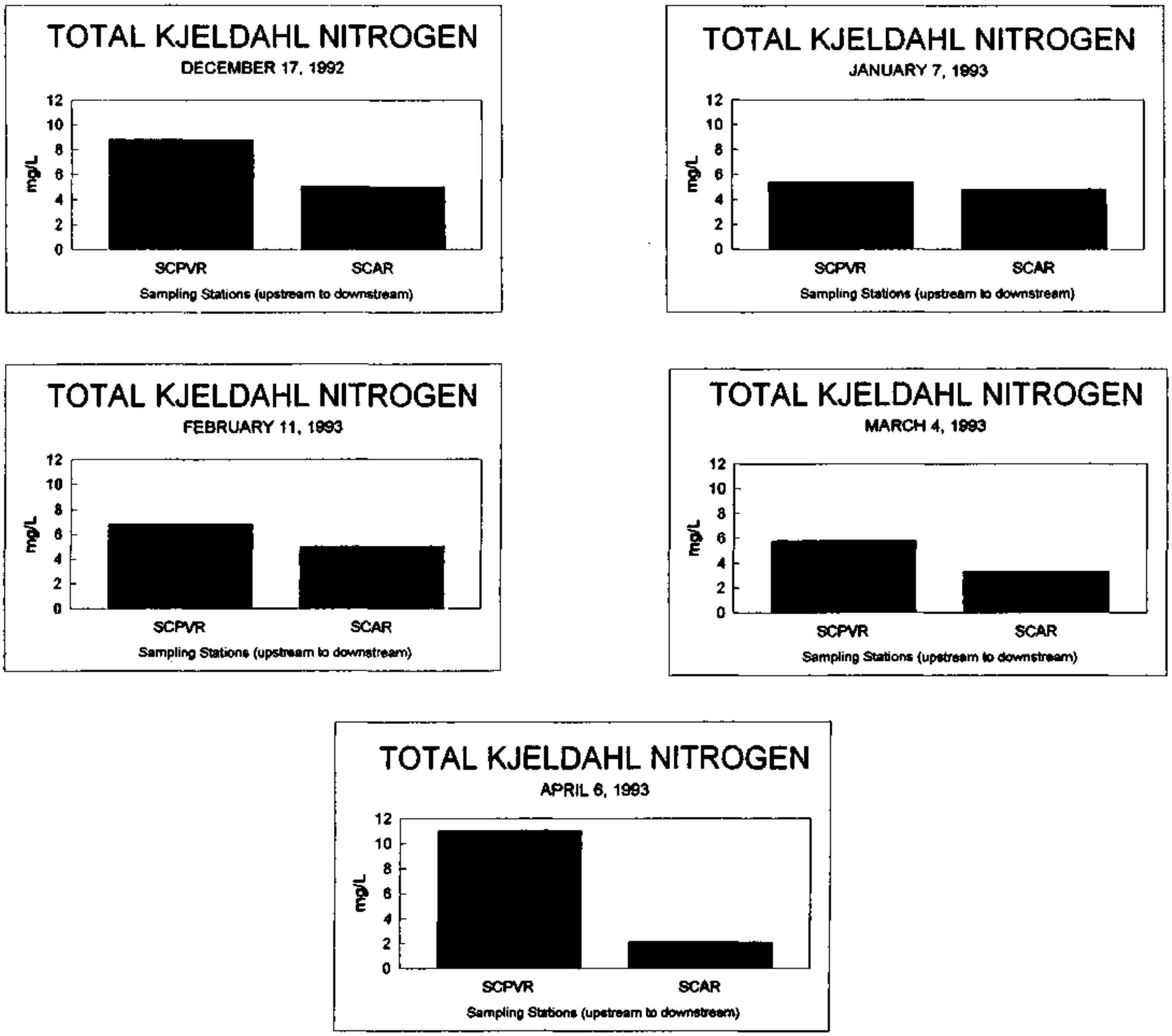
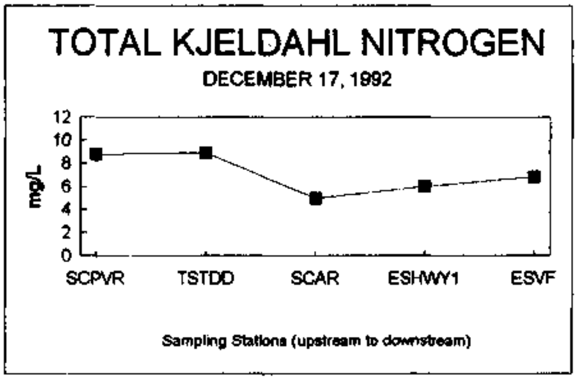
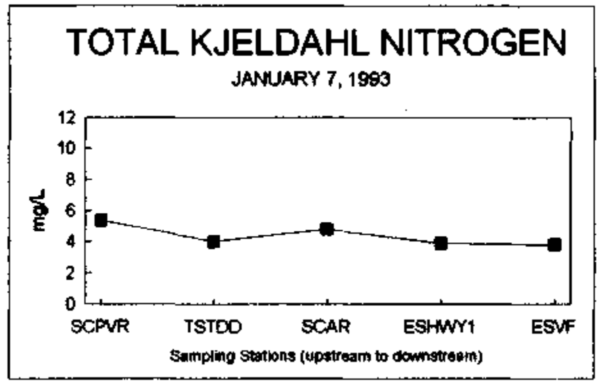
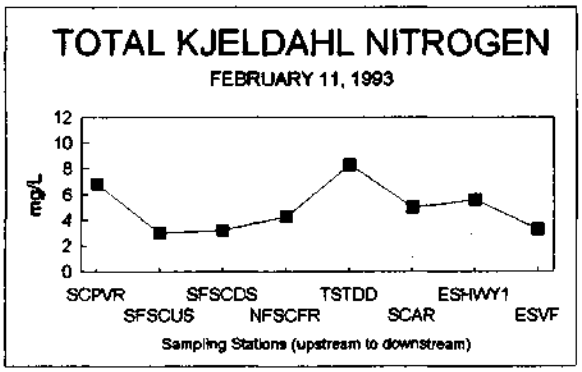
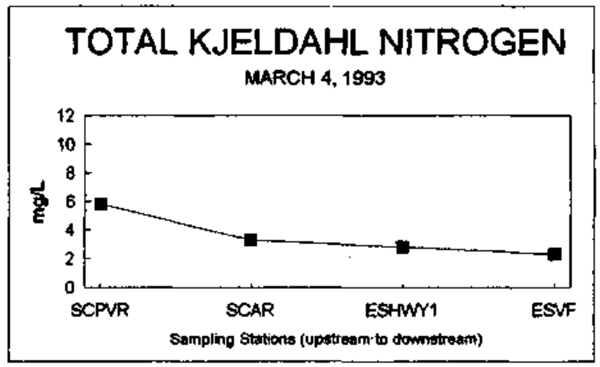


Figure 6. Total Kjeldahl Nitrogen concentrations at stations SCPVR and SCAR on 1992 - 1993 sampling dates.









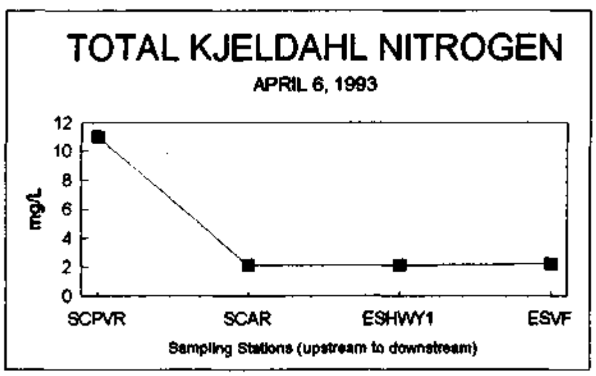


Figure 7. Total Kjeldahl Nitrogen concentrations at Stemple Creek sampling stations (moving upstream to downstream) on selected 1992 - 1993 sampling dates.

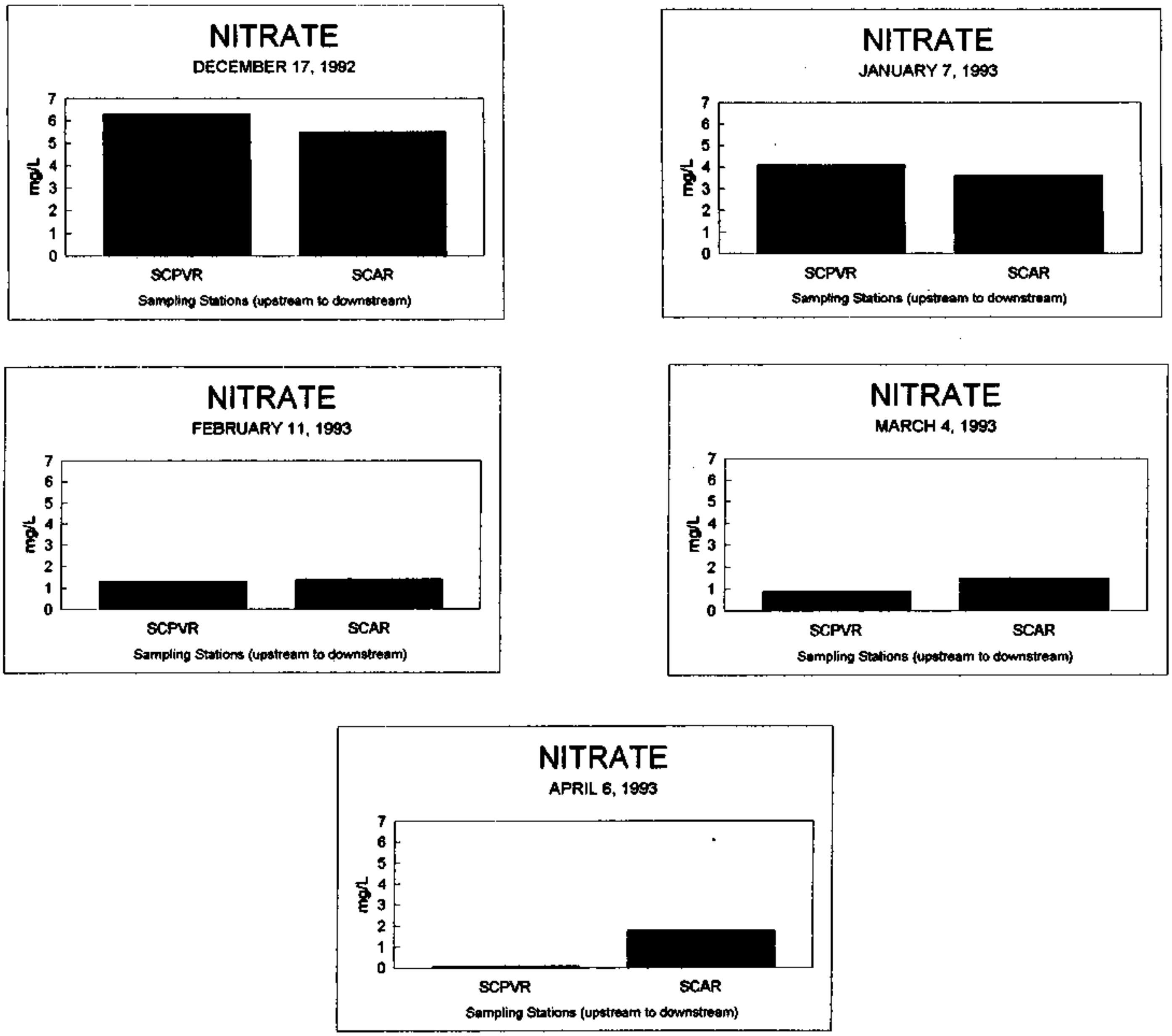


Figure 8. Nitrate concentrations at stations SCPVR and SCAR on 1992 - 1993 sampling dates.

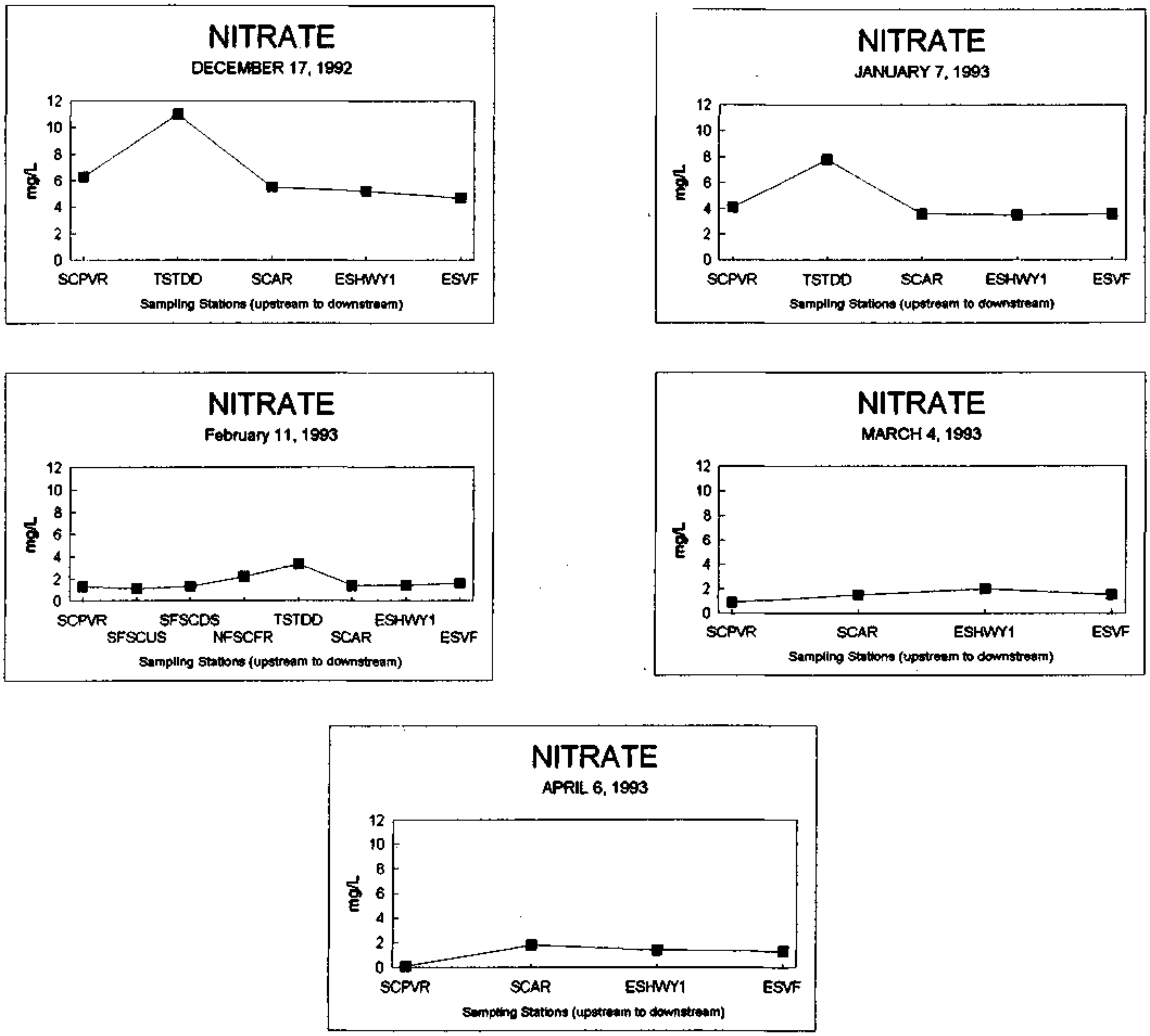


Figure 9. Nitrate concentrations at Stemple Creek sampling stations (moving from upstream to downstream) on selected 1992 - 1993 sampling dates.

Maximum and minimum TPO4 concentrations at all stations ranged from a high of 9.60 mg/L at station SCMRD to a low of 0.08 mg/L at station ESVF. Figures 10 and 11 display selected TPO4 concentrations. Total phosphate concentrations generally showed a downward trend as Stemple Creek flowed downstream. Total phosphate concentrations correlated strongly with TKN and total ammonia concentrations shown above. This suggests common nutrient sources in Stemple Creek.

Dissolved Oxygen (D.O.)

A small stream such as Stemple Creek which is subject to high nutrient levels will often experience algae blooms. One of the results of these blooms may be significantly depressed dissolved oxygen (D.O.) levels from algal and aquatic plant respiration during the night, although we conducted no diel sampling and no chlorophyll a sampling during the study period to confirm this. Excessive amount of algal and plant respiration can lead to low D.O. levels adversely affecting aquatic life. The Basin Plan specifies a minimum D.O. water quality objective of 6.0 mg/L for inland waters including Stemple Creek designated with the beneficial use Cold Freshwater Habitat, and a minimum D.O. water quality objective of 7.0 mg/L for the designated beneficial use Spawning.

Maximum and minimum D.O. concentrations at all stations ranged from a high of 11.0 mg/L at both stations SFSCUS and ESHWY1 to a low of 0.1 mg/L at station SCMRD. Figures 12 and 13 display selected D.O. concentrations. It is interesting to note that the D.O. levels are generally inversely proportional to nutrient concentrations in Stemple Creek. The lowest D.O. levels were found in the upper watershed when water temperatures were beginning to warm. The upstream station SCPVR consistently had lower D.O. concentrations than the downstream station SCAR in both winter and spring. The Basin Plan D.O. objectives were not met at station SCPVR on both spring-time sampling dates.

pH

pH is a measure of hydrogen ion activity in water The Basin Plan water quality objective for pH in Stemple Creek is a minimum of 6.5 and a maximum of 8.5. pH is a very important factor in Stemple Creek because increasing pH results in a higher level of the toxic un-ionized ammonia. pH in Stemple Creek is most likely significantly influenced by primary productivity resulting from increased nutrient loadings which causes an increase in pH levels due to the increased level of algal and vascular aquatic plant photosynthesis.

Maximum and minimum pH levels at all stations ranged from a high 8.4 at station ESVF to a low of 6.0 at station SCMERD. Figures 14 and 15 display selected pH levels. There was a very narrow range of variation in pH levels, and most all of the time pH levels were within Basin Plan water quality objectives.

Specific Conductance

Specific Conductance is a measure of the ionized or dissolved minerals in water. In an area of nonpoint source runoff from animal wastes we can expect higher specific conductivity levels because animal wastes are high in ionized salts.

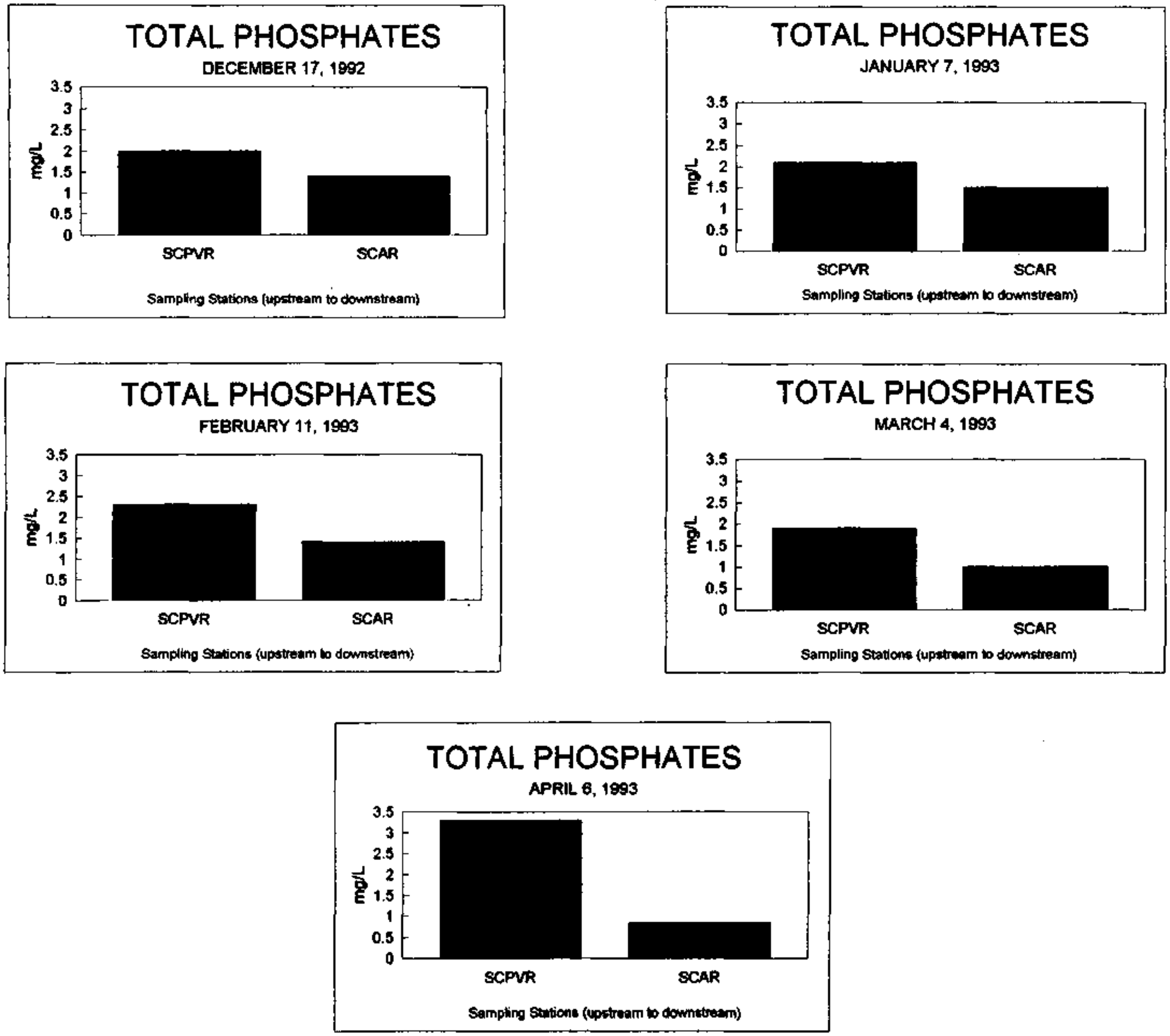


Figure 10. Total Phosphate concentrations at stations SCPVR and SCAR on 1992 - 1993 sampling dates.

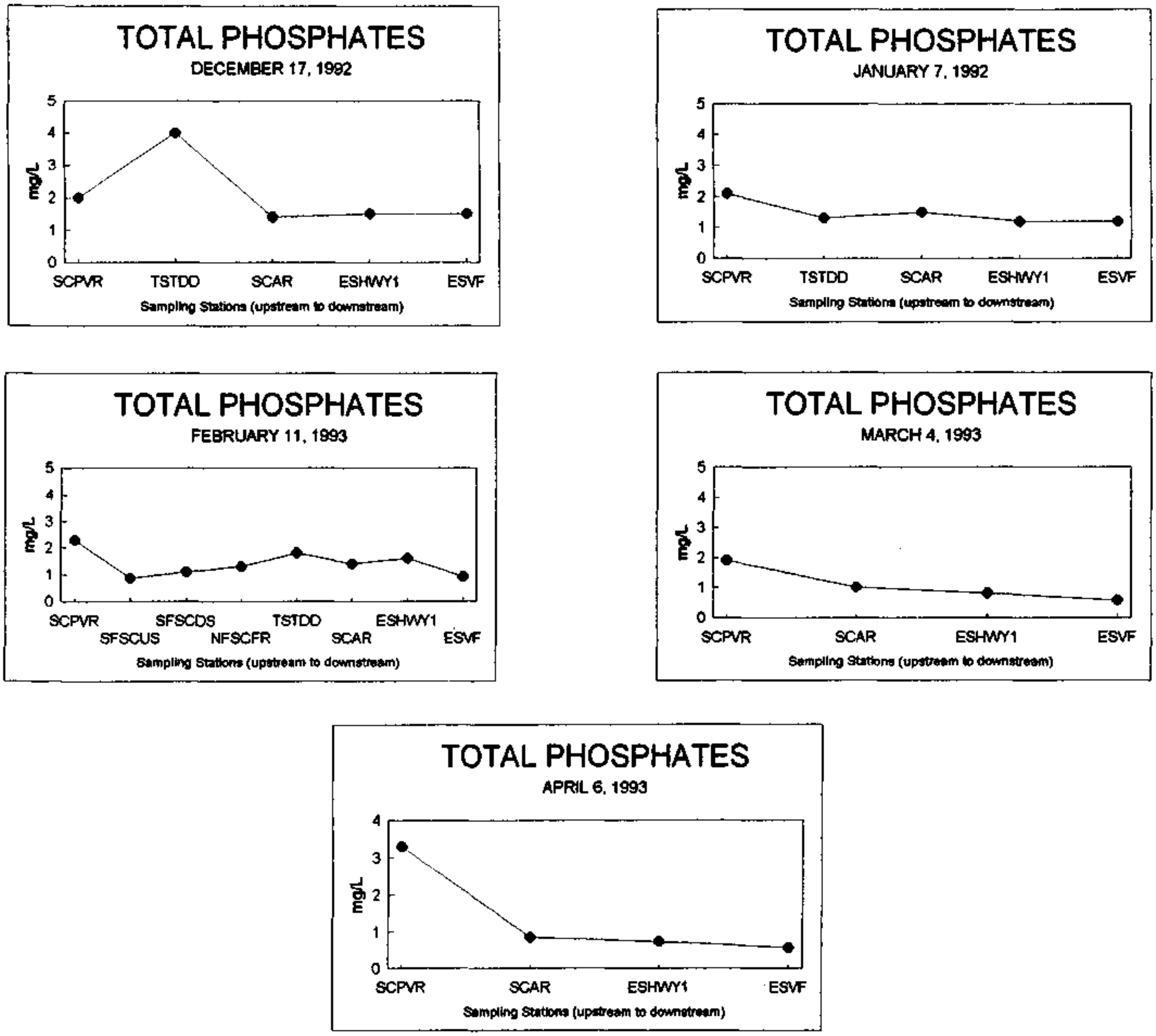


Figure 11. Total Phosphate concentrations at Stemple Creek sampling stations (moving upstream to downstream) on selected 1992 - 1993 sampling dates.

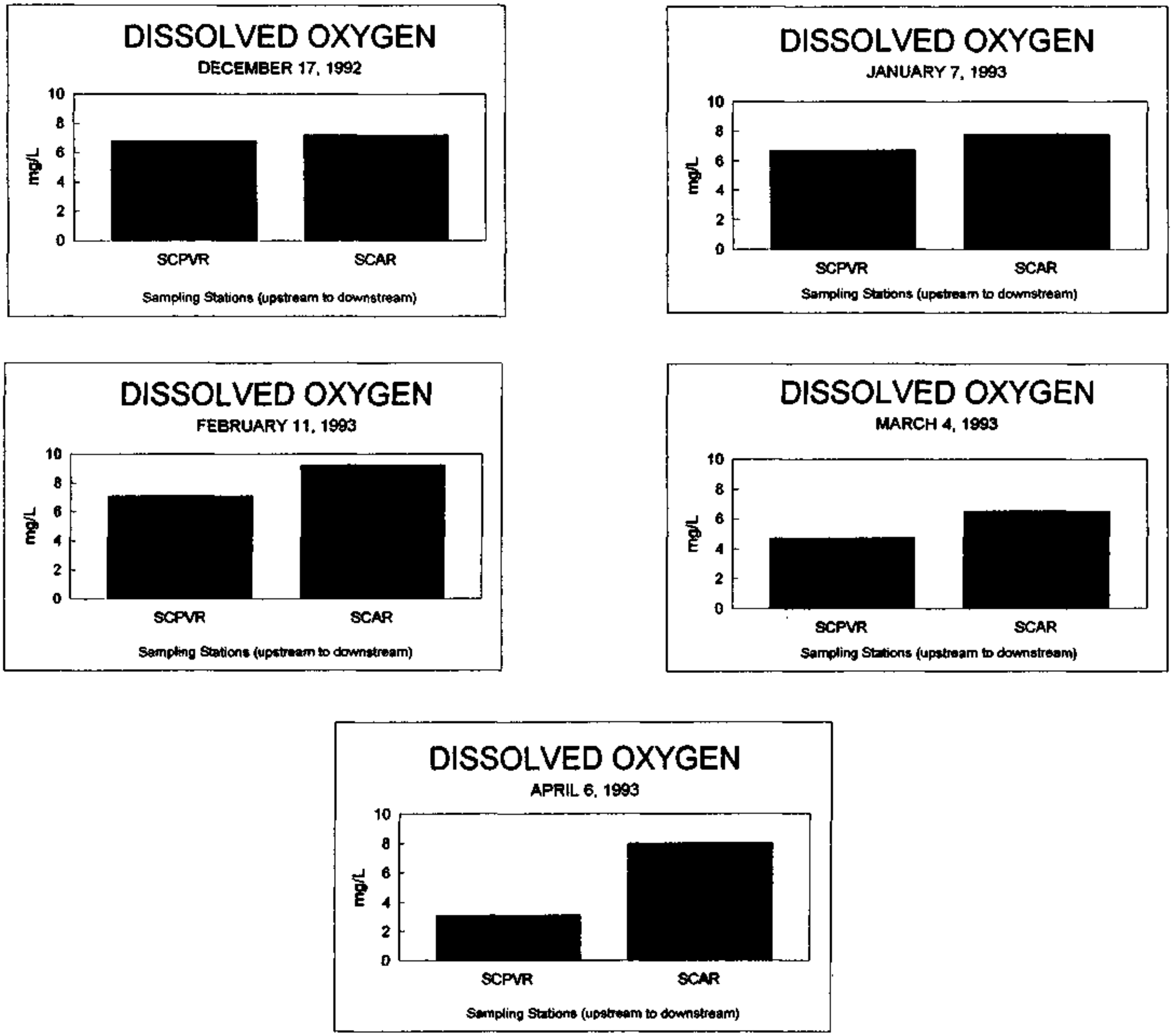


Figure 12. Dissolved Oxygen concentrations at stations SCPVR and SCAR on 1992 - 1993 sampling dates.

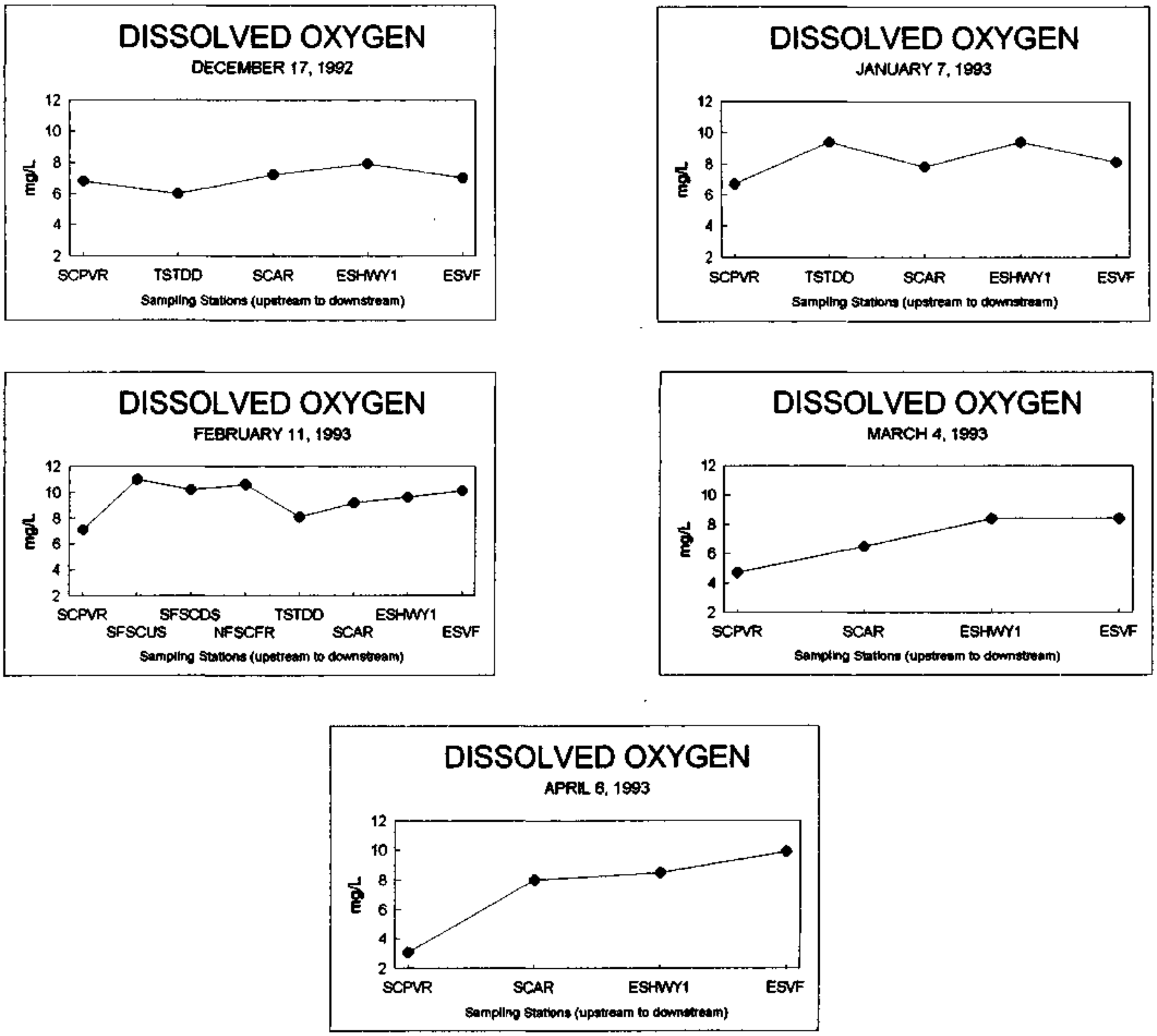


Figure 13. Dissolved Oxygen concentrations at Stemple Creek sampling stations (moving upstream to downstream) on selected 1992 - 1993 sampling dates.

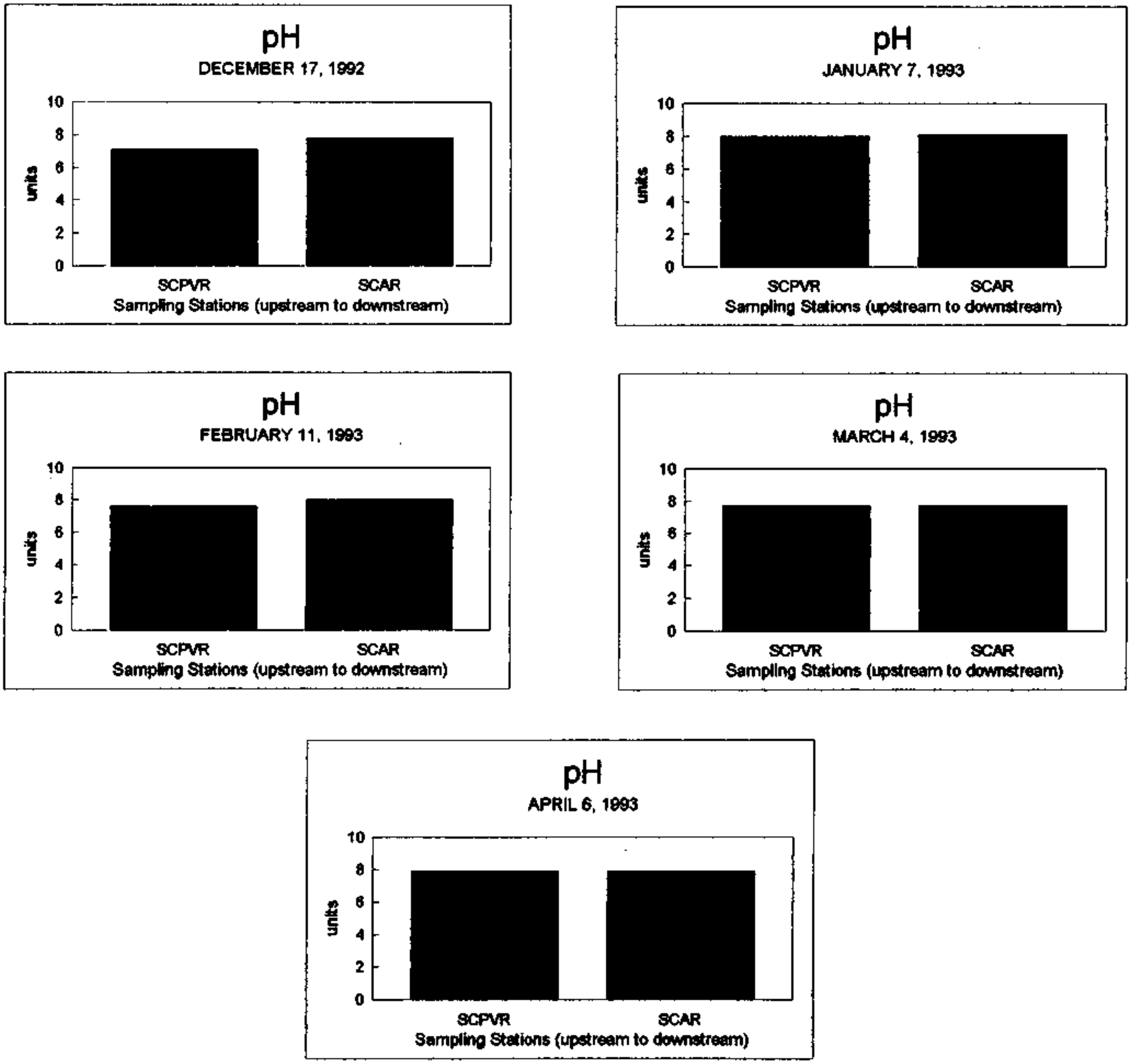


Figure 14. pH levels at stations SCPVR and SCAR on 1992 - 1993 sampling dates.

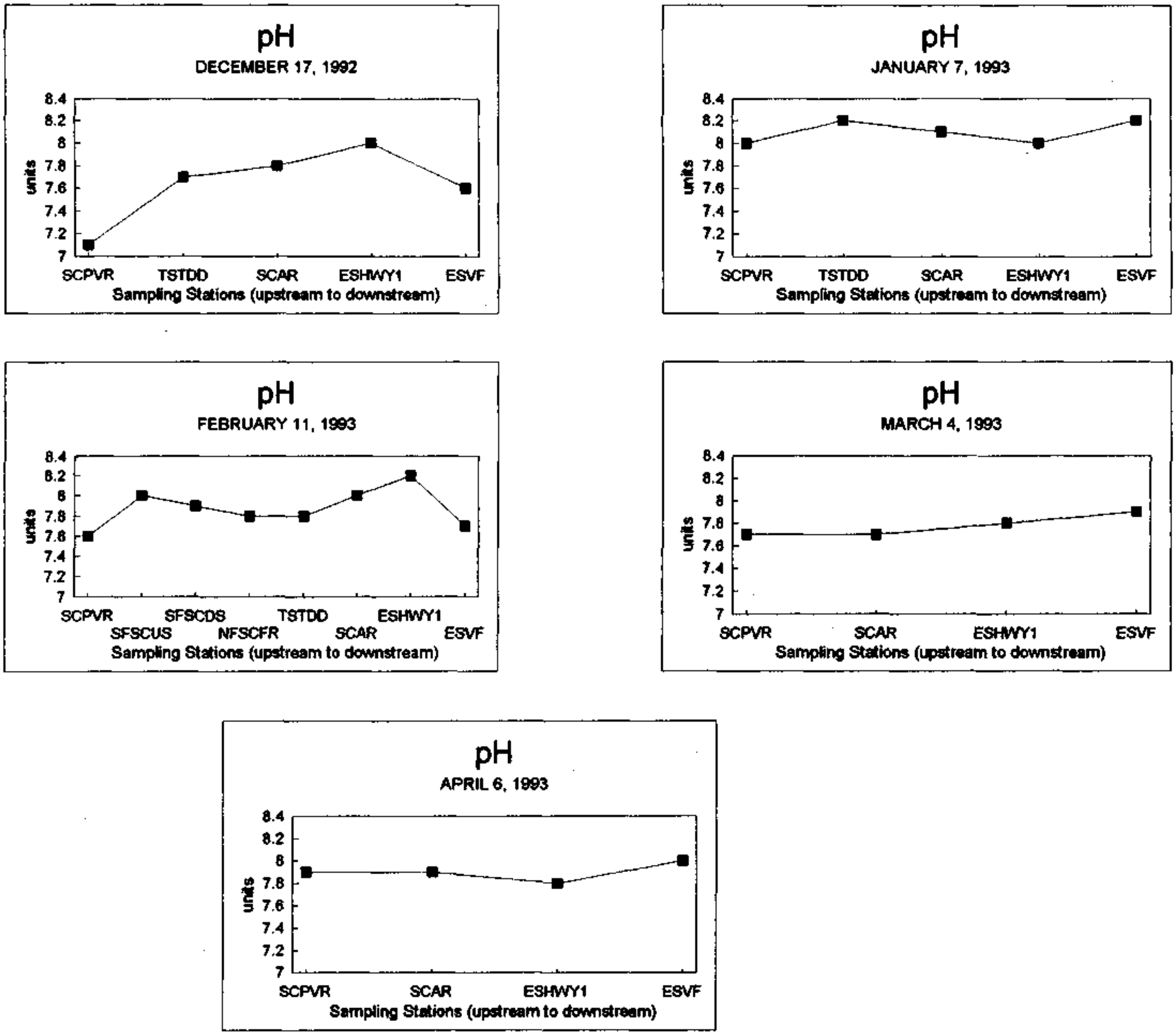


Figure 15. pH levels at Stemple Creek sampling stations (moving upstream to downstream) on selected 1992 - 1993 sampling dates.

Maximum and minimum specific conductivity levels at all stations not influenced by high tidal activity at the moment of sampling ranged from a high of 2,200. micromhos per centimeter (mhos/cm) at both stations SCMRD and SCPDS to a low of 310 mhos/cm at station ESHWY1. Figures 16 and 17 display selected specific conductance levels. Specific conductance levels generally decreased as Stemple Creek flowed downstream. The high levels shown at times at station ESVF are the result of tidal influence from the Estero. Note that the upstream station SCPVR always had higher specific conductivity levels than the downstream station SCAR.

Water Temperature

The nutrient cycles and productivity impacts discussed above are accelerated with warmer water temperatures. The water temperature of a small stream such as Stemple Creek is significantly influenced by warming air temperature, lower flows, and long stretches of stream banks with no riparian vegetation due to grazing. Cold water fish normally need water temperature of less than 20 degrees Centigrade to thrive.

Maximum and minimum water temperatures at all stations ranged from a high of 24.2 degrees Centigrade at station ESHWY1 to a low of 6.8 degrees Centigrade at station SCPDS. Figures 18 and 19 display selected water temperature levels. Overall, water temperatures were warmest in the lower watershed, most likely influenced by the closing of the Estero mouth to the ocean, plus the fact that the upper watershed stations go dry in the spring when water temperatures start to warm up.

Sediment Cores

One of the problems with nonpoint source runoff from animal wastes is its high organic content which will eventually settle to the stream bottom where it slowly releases nutrients over time. This can result in high nutrient releases to the water column long after the initial discharge of the wastes into the stream.

In June 1992, stream bottom sediment cores were taken from stations SCPDS, SCTB, and ESVF. Nutrient levels in the sediment of Stemple Creek were high. Maximum and minimum NH3-N concentrations ranged from a high of 220 mg/Kg at station SCTB to a low of 12 mg/Kg at station ESVF. Maximum and minimum TKN concentrations ranged from a high of 2,100 mg/Kg at station SCPDS to a low of 290 mg/Kg at station ESVF. By comparison, a range of TKN concentrations in sediment cores taken by Regional Board staff in the Laguna de Santa Rosa in May, 1992 ranged from 1,300 mg/Kg to 175 mg/Kg.

Maximum and minimum TPO4 concentrations in sediment cores ranged from a high of 53 mg/Kg at station SCTB to a low of 5.9 mg/Kg at station ESVF. By comparison, the above-referenced Laguna de Santa Rosa sampling found a range of TPO4 concentrations from 36.5 mg/Kg to 20.5 mg/Kg.

TOTAL MAXIMUM DAILY LOAD PROCESS

Stemple Creek is listed as an impaired waterbody under Section 303(d) of the federal Clean Water Act. This section of the act specifies that a process for determining waste load allocations be developed through a process known as the Total Maximum Daily Load (TMDL). As a starting

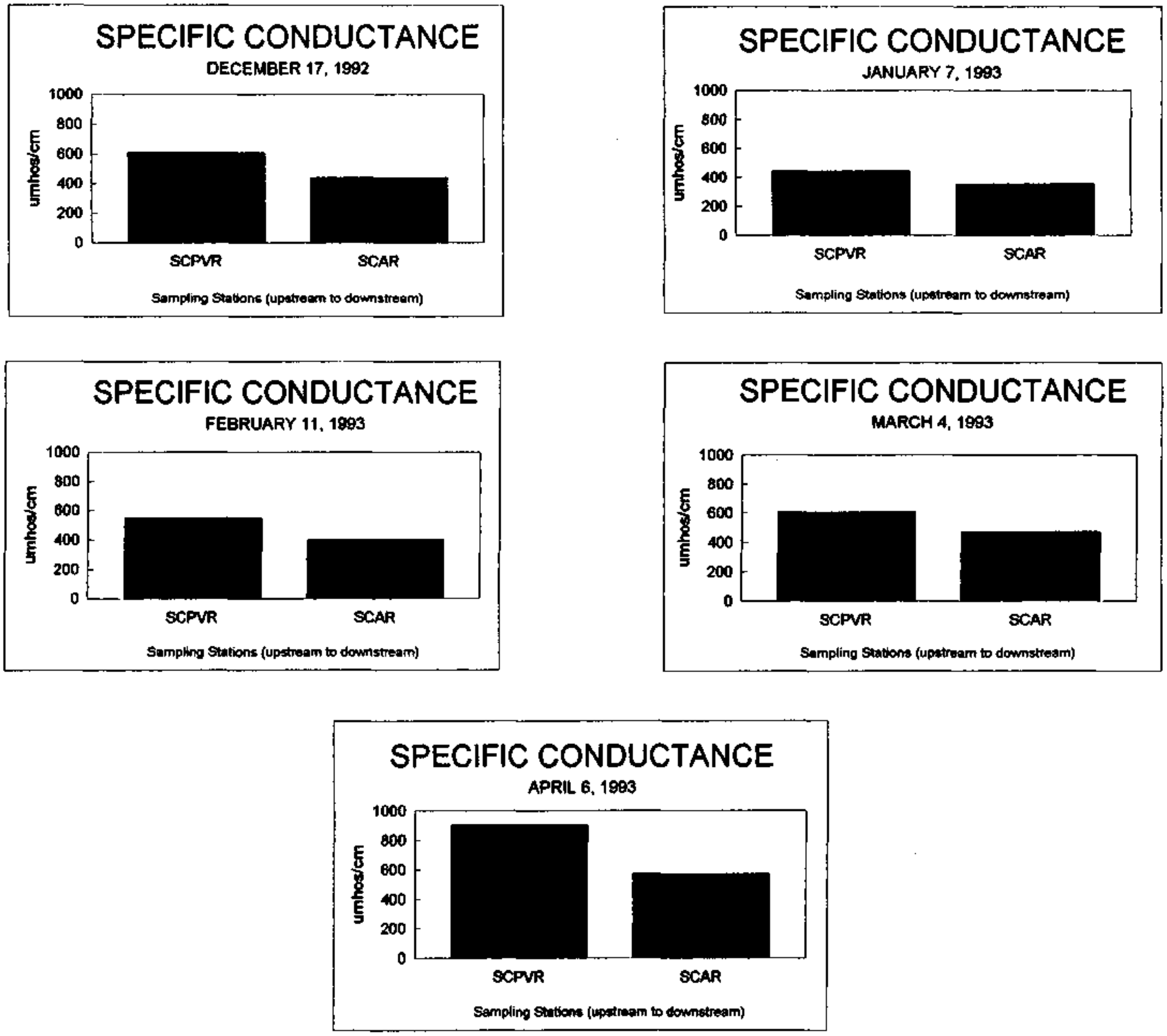
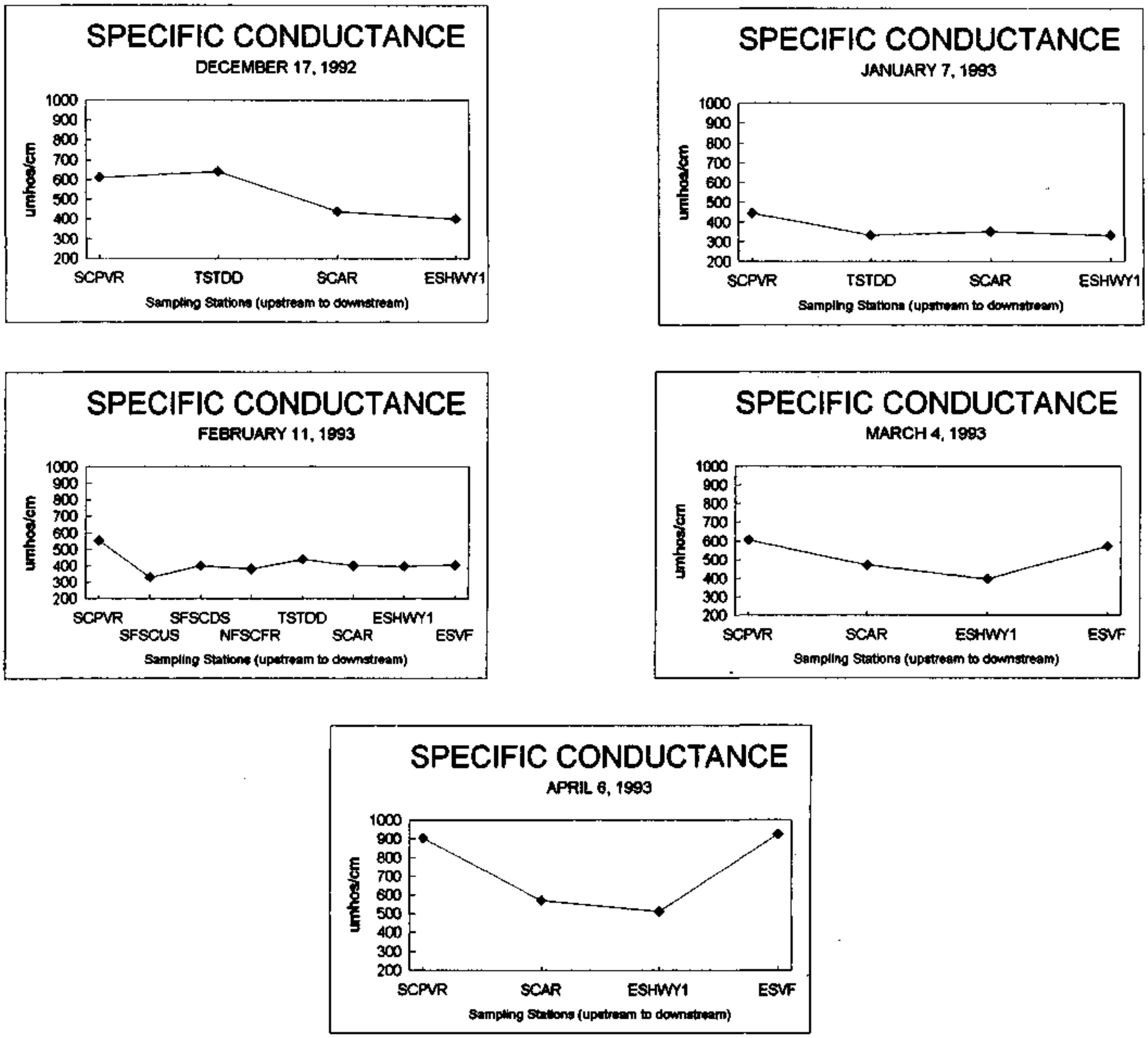
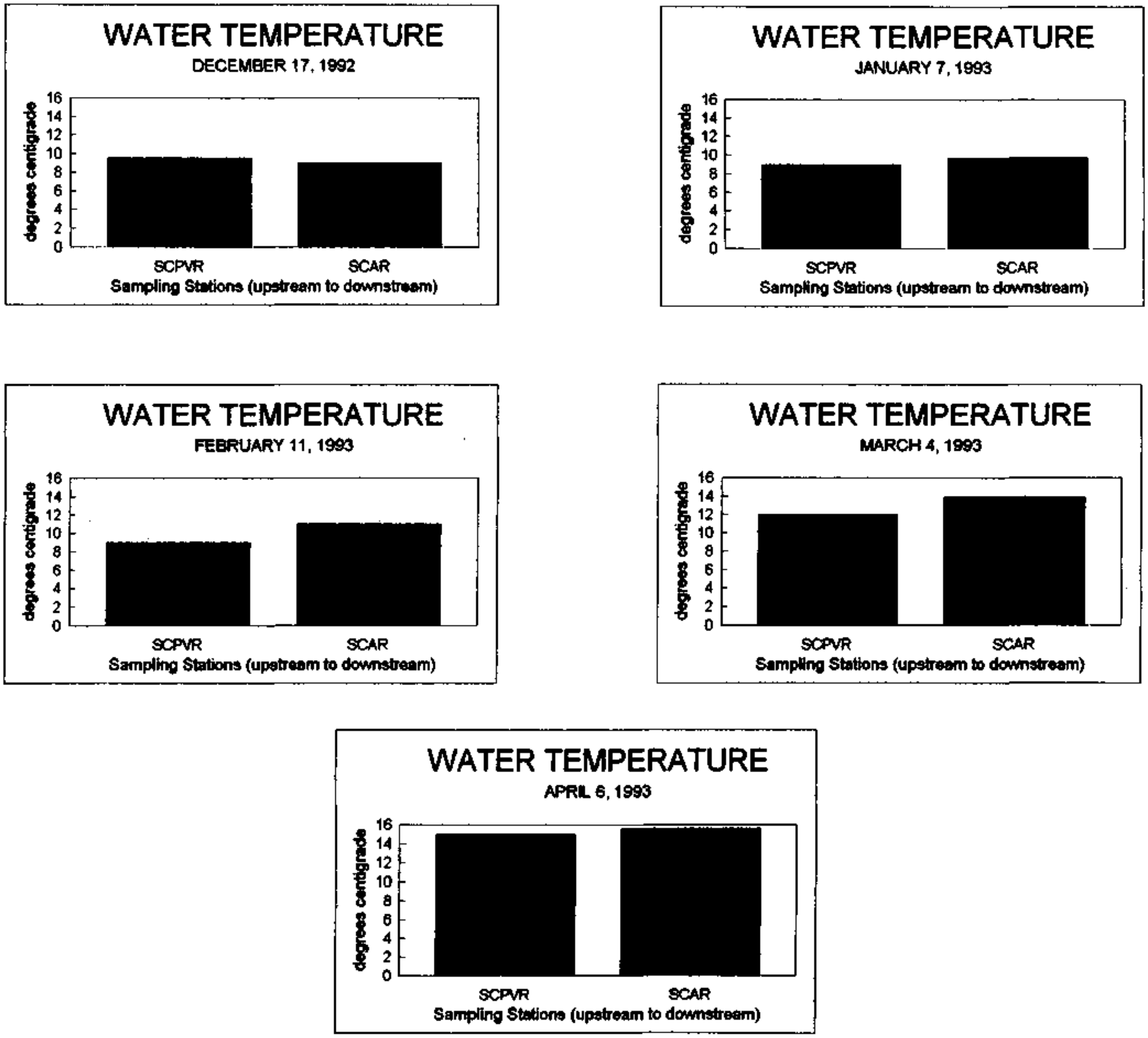


Figure 16. Specific Conductance levels at stations SCPVR and SCAR on 1992 - 1993 sampling dates.



<u>Figure 17.</u> Specific Conductance levels at Stemple Creek sampling stations (moving from upstream to downstream) on selected 1992 - 1993 sampling dates.



<u>Figure 18.</u> Water Temperatures at stations SCPVR and SCAR on 1992 - 1993 sampling dates.

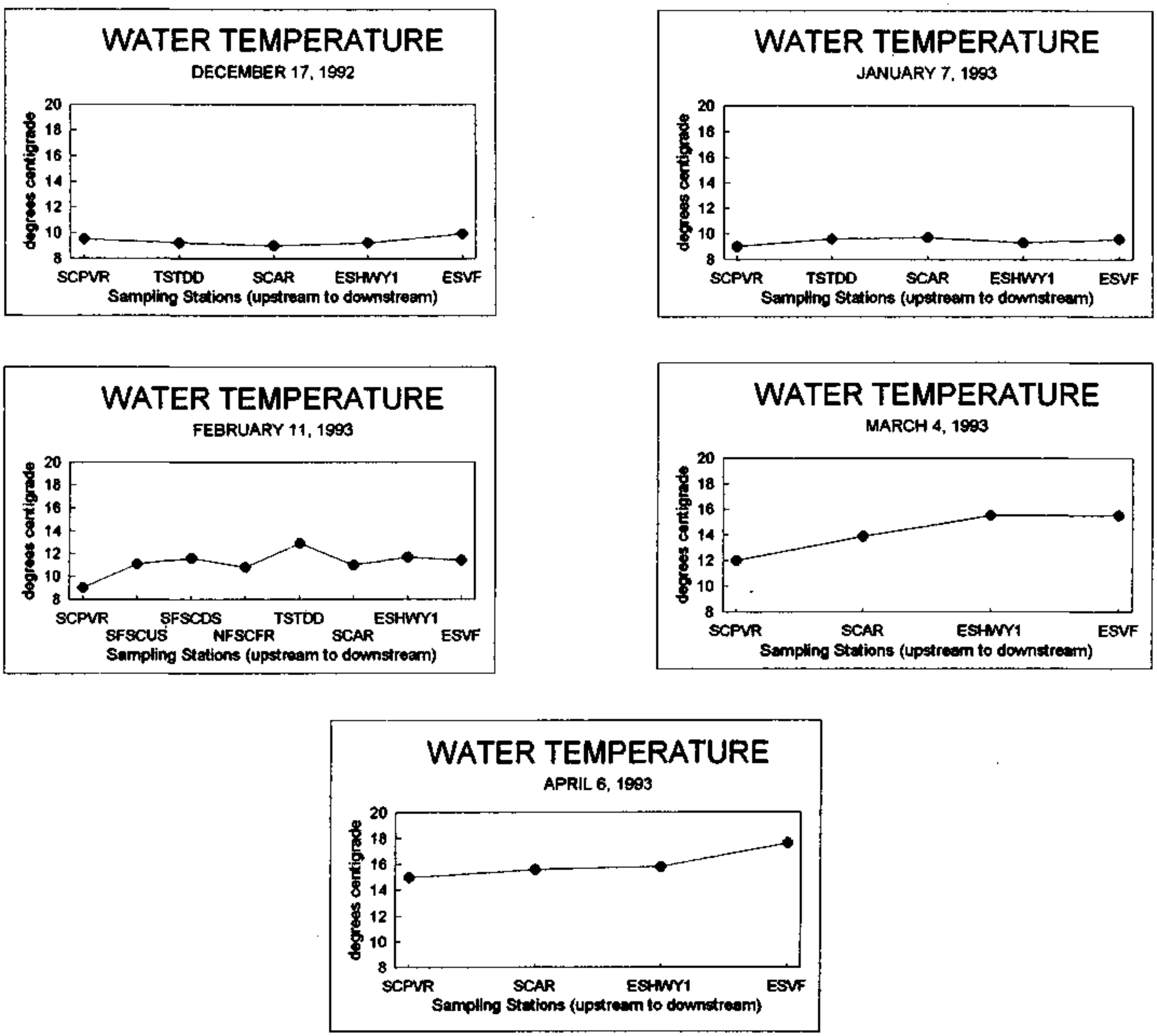


Figure 19. Water Temperatures at Stemple Creek sampling stations (moving from upstream to downstream) on selected 1992 - 1993 sampling dates.

point for this effort, Regional Board staff evaluated the recent waste reduction goal for nutrients discharged to Stemple Creek recommended by the U.S. Natural Resources Conservation Service (NRCS, 1995) in its Stemple Creek reauthorization Report, a required step in the PL 566 watershed project planning process that NRCS has undertaken for Stemple Creek. The objective of the NRCS "is to reduce the amount of nutrients reaching the creek and Estero by 75 percent... It is expected that this will reduce the ammonia amounts to within the standards for cold water fisheries. Implementation of this plan to control nutrients would also improve the potential for restoration of an anadromous fishery in the Stemple Creek watershed". This process has been requested from NRCS by the Marin County RCD and Southern Sonoma County RCD, and would also help implement recommendations from the RCD's 1994 Stemple Creek/Estero de San Antonio Watershed Enhancement Plan (Prunuske Chatham, 1994).

To test the efficacy of this goal, Regional Board staff investigated two different water quality computer models provided us by the USEPA for possible use in the Stemple Creek watershed. These two models are named STREAMDO IV (USEPA, 1990) and AGNPS (Young, R., et al. U.S. Department of Agriculture, 1987).

The STREAMDO IV water quality model is a spreadsheet model using LOTUS 123. STREAMDO IV is a steady-state mathematical model which can be used in wasteload allocation/total maximum daily load analyses related to dissolved oxygen and ammonia. In 1992, USEPA consultant Tetra Tech, Inc. used all available Stemple Creek flow and water quality data to build the basic model for the Regional Board. While more water quality and flow data is needed for more precise calibration and verification runs, we do have enough information to make general observations from the model. To test whether this model would be a good tool for use in the Stemple Creek watershed, and to test the NRCS nutrient reduction goal of 75 percent, we input flow and water quality data collected on December 17, 1992 as shown in this report. We then ran the model using total NH3-N, and Biochemical Oxygen Demand (BOD) reductions of 25, 50, and 75 percents, temperature increases of 5 and 10 degrees C, and increasing pH units. We then observed the predicted un-ionized ammonia concentrations and compared these to the USEPA national criterion of .025 mg/L.

From the above exercise with STREAMDO IV, the model predicted that with no change in pH or D.O levels, that NH3-N and BOD reductions of 75 percent and also reductions of 50 percent resulted in Stemple Creek meeting un-ionized ammonia criteria. The criteria was not met at a 25 percent reduction level.

From this point we increased the water temperature up to 10 degrees C from its December 17, 1992 level as can be expected in actual summer conditions. At the 75 percent NH3-N and BOD reduction along with a 10 degree C increase, the model predicted an un-ionized ammonia concentration of .023 mg/L at station ESVF, just under the criteria of .025 mg/L. All other stations met the criteria also.

We then increased pH units from its December 17, 1992 level as also can be expected in actual summer conditions. At the 75 percent NH3-N and BOD reduction and 10 degree C increase, an increase in pH of 0.4 units resulted in the upper and middle watershed stations in Stemple Creek not meeting un-ionized ammonia criteria Downstream station ESVF did meet the criteria.

Recognizing that other nutrients such as OP04 would also be reduced with a waste reduction strategy, that pH fluctuations from excessive algal blooms would moderate, and that water temperatures would not rise to current levels because of riparian restoration efforts, Regional Board staff agrees with the NRCS that a 75 percent nutrient reduction goal for Stemple Creek is appropriate.

AGNPS was developed by the U.S. Department of Agriculture as an agricultural nonpoint source pollution model. The Regional Board has received a copy of AGNPS from USEPA for possible use in watersheds such as Stemple Creek. AGNPS works by segmenting watersheds into cells of specified size (large or small), and provides outputs on hydrology, sediment, and estimates of pollutants nitrogen, phosphorus, and chemical oxygen demand for specified storm events for each cell area or the entire watershed. Regional Board staff has reviewed the model user's guide and concluded that AGNPS looks good for use as a tool for comparing waste reduction strategies in Stemple Creek. We determined that it would take 1-2 months of staff time to map and input necessary data into 50 cells of a square mile size. We have applied to the State Water Resources Control Board and USEPA for a 319(h) TMDL setaside grant ($15,000) to do this work, and to collect additional water quality data needed for this model and also STREAMDO IV.

CONCLUSIONS AND RECOMMENDATIONS

Stemple Creek exceeded the national criterion for un-ionized ammonia throughout the watershed at different times of the year. Stream bottom sediments were high in nutrients. Water temperatures were high starting in the spring. A comparison of the data presented in this report to other data presented in a California Department of Fish and Game data set (Rugg, 1995) show similar findings. It is good to report that while these above data show need for water quality improvement, we found generally better water quality than shown by data from 1988 to 1992 presented in the Stemple Creek/Estero de San Antonio Watershed Enhancement Plan. This is undoubtedly the result of the recent landowner and agency animal waste nonpoint source control programs taking place in this area.

A review of the data presented in this report in a watershed context indicates that the most significant nutrient loadings to Stemple Creek are occurring near the top of the watershed. The effects of these discharges are then influencing water quality throughout the length of the stream.

Regional Board staff recommends the use of both the STREAMDO IV and AGNPS water quality models for modelling and evaluating effects of different animal waste reduction strategies in the Stemple Creek watershed. We envision this will be a cooperative effort on the part of all involved landowners and agencies. These models should be useful for the RCD's and landowners in making the best decisions for nonpoint source waste control.

Regional Board staff recognizes the excellent efforts of the members of the Stemple Creek Watershed Advisory Committee and the NRCS - Americorps - U.C. Ag Extension educational outreach and volunteer monitoring programs. Staff recommends that the Regional Board continue to support these programs, and continue this participation through our 319(h) grant program and TMDL process.

Regional Board staff also recommends support for the 75 percent nutrient waste reduction goal of the NRCS for the Stemple Creek watershed. We recommend that the RCD's watershed plan be further implemented towards this goal, and that firm time schedules be developed by the Stemple Creek Advisory Committee towards this 75 percent goal for the next three year period. At the end of three years, the waste reduction goal and strategies should then be re-evaluated and revised as appropriate.

BIBLIOGRAPHY

Emerson, K., R.C. Russo, R.E. Lund, and R.V. Thurston. 1975. Aqueous ammonia equilibrium calculations: effect of pH and temperature. J. Fish. Res. Board Can. 32(12): 2379-2383.

Natural Resources Conservation Service. USDA. 1995 Preauthorization Report. Stemple Creek. Marin and Sonoma Counties. 29 pp.

North Coast Regional Water Quality Control Board. 1994. Water Quality Control Plan for the North Coast Region.

Prunuske Chatham, Inc. 1994. Stemple Creek/Estero de San Antonio Watershed Enhancement Plan.

Rugg, M. 1995. California Department of Fish and Game, Region3. Stemple Creek data files.
State Water Resources Control Board. 1990. Water Quality Assessment.

U.S. Environmental Protection Agency, 1990. STREAMDO IV and Supplemental Ammonia Toxicity Models. 21 pp.

Young, R., C. Onstad, D. Bosch, and W. Anderson. 1987. AGNPS, Agricultural Non-Point-Source Pollution Model. A Watershed Analysis Tool. U.S. Department of Agriculture, Conservation Research Report 35. 80 pp.

NO DATA INDICATED BY A "BLANK SPACE"

STATION	SAMDATE	TIME	NO3 mg/L	N02 mg/L	NH3-N mg/L	TKN mg/L	OP04 mg/L	TP04 mg/L	H20-T °c	D02 mg/L	pH units	SC umhos/cm	BOD mg/L	COD mg/L	HARDNESS mg/L	TOT CU mg/L.	DISS CU mg/L
SCMRD	02/13/92	13:50	0.680	0100	1.30	3.60	1.70	2.00	14.8	6.9	7.30	440			140	0.080	0.010
SCMRD	05/06/92	09:30	0.015	0.015	68.00	160.00	9.60	19.00	14.7	0.1	7.80	2.200			540	0.090	0.010
SCPDS	01/19/90	09:40	2.200	0.080	1.70	2.70	1.10	1.10	6.8	7.8	6.32	650	6.2				
SCPDS	02/13/92	13:30	1.800	0.250	1.50	4.10	2.30	2.40	"3.8	5.2	7.30	540			160	0.010	0.010
SCPDS	05/08/92	10:00	0.015	0.015	50.00	79.00	8.80	13.00	VxS	1.4	8.20	2.200			530	0.030	0.010
SCPVR	12/17/92	09:00	6.300	0.280	4.20	8.80	1.40	2.00	9.5	6.8	7.10	610	2.5	84.00			
SCPVR	01/07/93	10:50	4.100	0.090	1.40	5.40	2.10	2.10	9.0	6.7	8.00	445	7.0	130.00			
SCPVR	02/11/93	09:30	1.300	0.070	2.20	6.80	1.80	2.30	9.0	7.1	7.60	551	8.0	150.00			
SCPVR	03/04/93	09:30	0.870	0.190	2.60	5.80	1.90	1.90	12.0	4.7	7.70	608					
SCPVR	04/06/93	10:00	0.070	0.090	6.80	11.00	3.00	3.30	15.0	3.1	7.90	904					
SFSCUS	02/11/93	12:00	1.100	0.040	0.89	3.00	0.80	0.87	11.1	11.0	8.00	330	2.5	59.00			
SFSCDS	02/11/93	16:15	1.300	0.050	0.46	3.20		1.10	11.6	10.2	7.90	399	2.5	74.00			
NFSCFR	02/11/93	11:40	2.200	0.040	1.10	4.30	1.20	1.30	10.8	10.6	7.80	379	6.0	87.00			
TSTDD	12/17/92	09:45	11.000	1.900	4.30	8.90	2.50	4.00	9.2	6.0	7.70	640	2.5	100.00			
TSTDD	01/07/93	11:00	7.800	0.100	0.70	4.00	1.10	1.30	9.6	9.4	8.20	334	6.0	92.00			
TSTDD	02/11/93	15:50	3.300	0.170	2.80	8.30	1.50	1.80	12.9	8.1	7.80	440	29.0	130.00			
SCAR	12/17/92	10:45	5.500	0.280	1.70	5.00	1.40	1.40	9.0	7.2	7.80	439	2.5	65.00			
SCAR	01/07/93	11:10	3.600	0.080	1.00	4.80	0.14	1.50	9.7	7.8	8.10	353	6.0	110.00			
SCAR	02/11/93	15:35	1.400	0.060	1.10	5.00	1.20	1.40	11.0	9.2	8.00	400	8.0	100.00			
SCAR	03/04/93	10:40	1.500	0.200	1.10	3.30	0.98	1.00	13.9	6.5	7.70	470					
SCAR	04/06/93	10:15	1.800	0.110	0.23	2.10	0.74	0.85	15.8	8.0	7.90	570					
SCTB	01/19/90	10:30	1.600	0.620	3.00	470	1.80	1.50	9.1	6.8	6.52	550	5.9				
SCTB	02/13/92	13:10	1.600	0.100	1.50	3.60	1.60	1.90	14.1	7.0	7.60	360			110	0.010	0.010
SCTB	05/08/92	12:15	0.040	0.015	0.18	0.85	2.10	2.40	20.4	7.7	8.00	780			260	0.010	0.010
ESHWY1	02/13/92	11:20	1.700	0.080	1.20	3.60	1.50	1.20	12.9	7.7	7.50	310			92	0.010	0.010
ESHWY1	05/08/92	11:55	0.070	0.015	0.11	2.40	1.10	1.20	18.2	11.0	8.30	640			190	0.010	0.010
ESHWY1	12/17/92	11:30	5.200	0.260	2.50	6.00	1.40	1.50	9.2	7.9	8.00	400	5.0	77.00			
ESHWY1	01/07/93	11:25	3.500	0.070	0.86	3.90	0.12	1.20	9.3	9.4	8.00	334	7.0	120.00			
ESHWY1	02/11/93	15:15	1.400	0.090	1.40	5.60	1.30	1.60	11.7	9.6	8.20	396	9.0	120.00			
ESHWY1	03/04/93	11:30	2.000	0.220	0.88	2.80	0.58	0.81	15.5	8.4	7.80	397					
ESHWY1	04/08/93	11:15	1.400	0.090	0.17	2.10	0.63	0.73	15.8	8.5	7.80	511					
ESHWY1	06/24/93	10:55	0.100	0.005	0.15	2.00	1.10	8.10	24.2	4.3	8.00	779					
ESHWY1	06/30/93	11:35	0.015	0.015	0.05	2.10	1.30	1.90	23.2	4.0	8.30	871					
SCMRD	01/19/90	11.00	2800	0.360	2.40	3.40	1.60	1.10	9.0	8.5	600	1,100	1.0				
ESVF	02/13/92	11:00			1.10	2.70	1.00	0.82	13.3	7.8	7.50	2,200			250	0.010	0.010
ESVF	05/08/92	11:30	0.015	0.100	0.26	1.90	0.65	0.65	19.6	3.8	7.70	20,000			2,300	0.010	0.010
ESVF	08/11/92	10:00	0.400	0.015	0.87	1.70	0.43	0.50	19.1	5.8	7.80	36,000			4,500	0.010	0.010
ESVF	06/26/92	11:35	0.140	0.015	0.10	1.90	0.50	0.65	22.8	5.8	7.60	39,000			4,200	0.010	0.010
ESVF	06/30/92	10:25	0.100	0.015	0.14	1.30	0.54	0.73	21.2	6.0	7.90	39.000			3,700	0.010	0.010
ESVF	12/17/92	12:10	4700	0.430	2.60	6.60	1.90	1.50	9.9	7.0	7.60	6,200	5.0	110.00			
ESVF	01/07/93	11:40	3.600	0.080	0.74	3.80	0.08	1.20	9.6	8.1	8.20		6.0	120.00			
ESVF	02/11/93	11:15	1.600	0.080	0.82	3.30	0.78	0.91	11.4	10.1	7.70	402					
ESVF	03/04/93	14:00	1.500	0.150	0.55	2.30	0.45	0.57	15.5	8.4	7.90	573					
ESVF	04/06/93	11:45	1.300	0.080	0.09	2.20	0.47	0.57	17.6	9.9	8.00	925					
ESVF	06/24/93	11:20	1.000	0.005	0.07	2.80	0.12	0.12	21.4	6.8	8.40						
ESVF	06/30/93	11:55	0.015	0.015	0.07	1.40	0.35	0.46	20.5	5.4	8.10						
ESVF	06/07/94	09:45	0500	0.500	0.32	1.21			17.1	5.7	760	29,000	2.5	1300.00	4.700	0.005	0.005
SEDIMENT DATA:			**Expressed in mg/Kg**														
ESVF-T1	06/26/92	11:45			19.00	350.00		13.00								1.000	
ESVF-M1	06/26/92	11:45			12.00	360.00		20.00								1.000	
ESVF-B1	06/26/92	11:45			15.00	290.00		5.90								1.000	
SCPDS	06/26/92	09:45			170.00	2,100.00		21.00								16.000	
SCTB	06/20/92	10:15			220.00	680.00		53.00								3.500	

APPENDIX "A" (CONTINUED) DATA USED FOR CALCULATING UN - IONIZED AMMONIA CONCENTRATIONS

Expressed in mg/L

STN	SAMDATE	TIME	NH3-N	TOTAL	PH	H20-T	pka	UN-IONIZED
			mg/L	AMMONIA	units	•c		AMMONIA
SCMRD	02/13/92	13:50	1.30	1.582	7.30	14.6	9.58	0.008
SCMRD	05/08/92	09:30	68.00	82.725	7.80	14.7	9.57	1.374
SCPDS	01/19/90	09:40	1.70	2.068	6.32	6.8	9.84	0.001
SCPDS	02/13/92	13:30	1.50	1.825	7.30	13.8	9.60	0.009
SCPDS	05/08/92	10:00	50.00	60.827	8.20	15.8	9.54	2.659
SCPVR	12/17/92	09:00	4.20	5.109	7.10	9.5	9.75	0.011
SCPVR	01/07/93	10:50	1.40	1.703	8.00	9.0	9.76	0.029
SCPVR	02/11/93	09:30	2.20	2.676	7.60	9.0	9.76	0.018
SCPVR	03/04/93	09:30	2.60	3.163	7.70	12.0	9.66	0.034
SCPVR	04/06/93	10:00	6.80	8.273	7.90	15.0	9.56	0.177
SFSCUS	02711/93	12:00	0.89	1.083	8.00	11.1	9.69	0.022
SFSCDS	02/11/93	16:15	0.46	0.560	7.90	11.6	9.68	0.009
NFSCFR	02/11/93	11:40	1.10	1.338	7.80	10.8	9.70	0.017
TSTDD	12/17/92	09:45	4.30	5.231	7.70	9.2	9.76	0.045
TSTDD	01/07/93	11:00	0.70	0.852	8.20	9.6	9.74	0.024
TSTDD	02/11/93	15:50	2.80	3.406	7.80	12.9	9.63	0.050
SCAR	12/17/92	10:45	1.70	2.068	7.80	9.0	9.76	0.022
SCAR	01/07/93	11:10	1.00	1.217	8.10	9.7	9.74	0.027
SCAR	02/11/93	15:35	1.10	1.338	8.00	11.0	9.70	0.026
SCAR	03/04/93	10:40	1.10	1.338	7.70	13.9	9.60	0.017
SCAR	04/06/93	10:15	0.23	0.280	7.90	15.6	9.54	0.006
SCTB	01/19/90	10:30	3.00	3.650	6.52	9.1	9.76	0.002
SCTB	02/13/92	13:10	1.50	1.825	7.60	14.1	9.59	0.018
SCTB	05/08/92	12:15	0.18	0.219	8.00	20.4	9.39	0.009
ESHWY1	02/13/92	11:20	1.20	1.460	7.50	12.9	9.63	0.011
ESHWY1	05/08/92	11:55	0.11	0.134	8.30	18.2	9.46	0.009
ESHWY1	12/17/92	11:30	2.50	3.041	8.00	9.2	9.76	0.052
ESHWY1	01/07/93	11:25	0.86	1.046	8.00	9.3	9.75	0.018
ESHWY1	02/11/93	15:15	1.40	1.703	8.20	11.7	9.67	0.056
ESHWY1	03/04/93	11:30	0.88	1.071	7.80	15.5	9.55	0.019
ESHWY1	04/06/93	11:15	0.17	0.207	7.80	15.8	9.54	0.004
ESHWY1	06/24/93	10:55	0.15	0.182	8.00	24.2	9.27	0.009
ESHWY1	06/30/93	11:35	0.05	0.061	8.30	23.2	9.30	0.006
SCMIRD	01/19/90	11:00	2.40	2.920	6.00	9.0	9.76	0.001
ESVF	02/13/92	11:00	1.10	1.338	7.50	13.3	9.62	0.010
ESVF	05/08/92	11:30	0.26	0.316	7.70	19.6	9.41	0.006
ESVF	06/11/92	10:00	0.87	1.058	7.80	19.1	9.43	0.024
ESVF	06/26/92	11:35	0.10	0.122	7.60	22.8	9.31	0.002
ESVF	06/30/92	10:25	0.14	0.170	7.90	21.2	9.36	0.006
ESVF	12/17/92	12:10	2.60	3.163	7.60	9.9	9.73	0.023
ESVF	01/07/93	11:40	0.74	0.900	8.20	9.6	9.74	0.025
ESVF	02/11/93	11:15	0.82	0.998	7.70	11.4	9.68	0.010
ESVF	03/04/93	14:00	0.55	0.669	7.90	15.5	9.55	0.015
ESVF	04/06/93	11:45	0.09	0.109	8.00	17.6	9.48	0.004
ESVF	06/24/93	11:20	0.07	0.085	8.40	21.4	9.36	0.008
ESVF	06/30/93	11:55	0.07	0.085	8.10	20.5	9.39	0.004
ESVF	06/07/94	09:45	0.32	0.389	7.60	17.1	9.49	0.005

FORMULAS USED:

Un- ionized ammonia = $\frac{\text{total ammonia}}{1 + 10.0}$

1 + 10.0

Total ammonia = NH3-N / 0.822

APPENDIX "A" (CONTINUED)

STREAM FLOW

STATION	DATE	TIME	FLOW cfs
SCPVR	12/17/92	09:25	0.936
TSTDD	12/17/92	09:45	0.167
SCAR	12/17/92	10:45	5.504
SCHWY1	12/17/92	11:30	5.688
SCPVR	03/04/93	09:55	5.093
SCAR	03/04/93	10:55	16.993
SCHWY1	03/04/93	11:45	26.480
SCAR	04/06/93	10:20	24.074
SCHWY1	04/06/93	11:15	6.819

PRECIPITATION

(Rainfall on sampling dates including the proceeding 24 hours)

SAMPLING DATES	INCHES
02/13/92	2.02
05/08/92	0
06/11/92	0
06/26/92	0
06/30/92	.76
12/17/92	.10
01/07/93	1.70
02/11/93	.64
03/04/93	.63
04/06/93	0
06/24/93	0
06/30/93	0
06/07/94	0