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LOST RIVER
WATERSHED AREA IN CALIFORNIA

(TRIBUTARY TO KLAMATH RIVER)

WATER QUALITY CHARACTERISTICS

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NORTH COAST REGION
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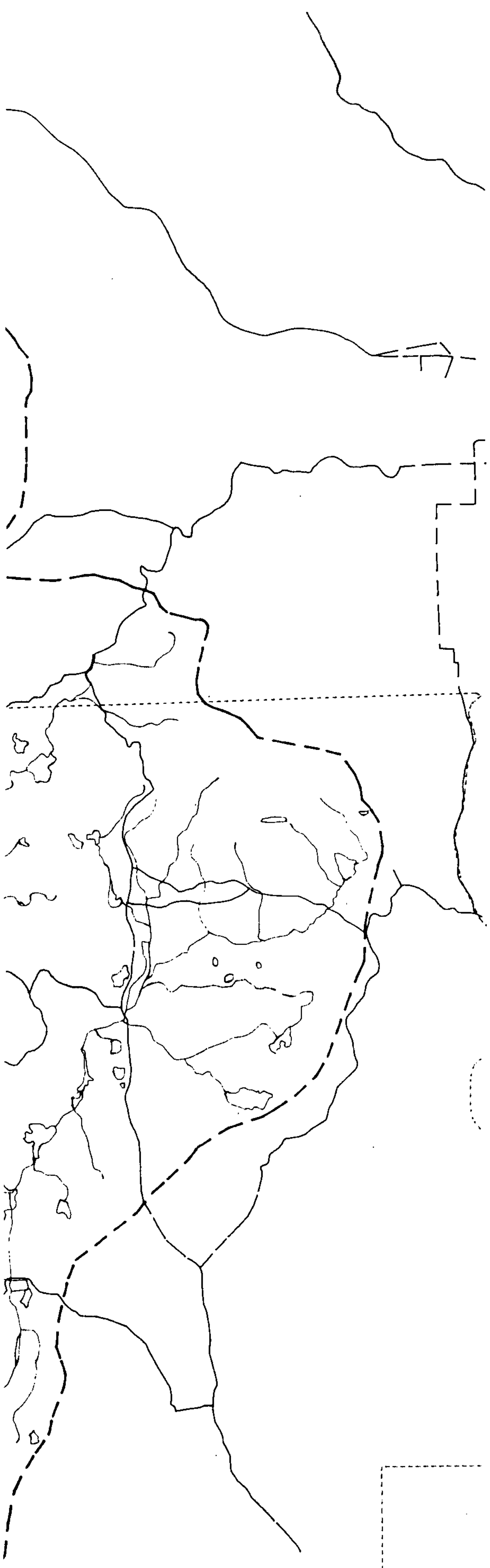
INTRODUCTION

Lost River is a unique bi-state stream flowing along the California-Oregon border (Figure 1). The headwaters of Lost River are tributaries to Clear Lake located mostly in Modoc County, California. The outflow from Clear Lake into Lost River flows north into Oregon and then loops back south into California where it historically ended in a closed sump known as Tule Lake. A large U.S. Bureau of Reclamation (BOR) agriculture project known as the Klamath Project has been constructed in this watershed, and has significantly altered the flows and flow direction of Lost River. The Lost River is now cross connected with the Klamath River through a constructed canal and drain system in Oregon. Water in the Lost River flowing south back into California may now be a combination of Lost River and Klamath River water depending on the time of year. Tule Lake is no longer a closed sump. The BOR has constructed pumps to move water from Tule Lake west into Lower Klamath Lake. Lower Klamath Lake then discharges north back into Oregon through the Klamath Straits Drain. This drain then flows northward and is pumped back into the Klamath River in Oregon. The Klamath River then continues in its south-west direction downstream back into California.

As the Lost River makes its journey described above, its natural and altered environmental characteristics change dramatically. It begins as high desert streams tributary to Clear Lake located mostly in Modoc National Forest. Boles Creek and Willow Creek are the principal tributaries. These streams and Clear Lake, as does the rest of the watershed down to Tule Lake, support fisheries. These include two species of federally listed endangered sucker species, the Lost River sucker and the shortnose sucker (Federal Register, 1994). The principal nonpoint source discharge influences in this part of the watershed are from rangeland cattle grazing. This has been recognized in the Modoc National Forest Land and Resource Management Plan (Modoc National Forest, 1991), and is a focus of the North Coast Regional Water Quality Control Board's Clean Water Act 319(h) nonpoint source control program working with Modoc National Forest, Lava Beds Resource Conservation District (RCD), and the U.S. Fish and Wildlife Service (USFWS). Clear Lake is also part of the Clear Lake National Wildlife Refuge.

Lost River, a short distance downstream from Clear Lake, enters the State of Oregon where its use as a source of water and also drainage for agriculture begins. Agriculture primarily includes grains, hay and forage, and potatoes. By the time it once again re-enters California just north of the town of Tulelake, it has been influenced by nonpoint source discharges from production agriculture, water imports or exports, and channel modifications. Lost River habitat characteristics become a shallow lake/wetland type of habitat soon after it enters California and flows into Tule Lake. Tule Lake is highly eutrophic (Boyer, 1994). Some natural levels of eutrophic conditions and poor water quality can be expected in this area because of the fact that historic conditions found this area to be a vast sink (lakebed/marshland) of biomass propagated by nutrient-rich "recent " volcanic formations. This reservoir of biomass has become the soil of today's basin. Eutrophic conditions remain the principal water quality concern in this area. The water quality questions are 1) to what extent these eutrophic conditions are natural, 2) to what extent nonpoint source discharges from agricultural activities impact this situation, and 3) what is



California Upper Klamath River Basin
Lost River Data

A-RDAM	Anderson Rose Dam
JCBORD	"J" Canal at Cal-Ore Border
LRBORD	Lost River at Cal-Ore Border
PUMP 3	North Shore of Tule Lake
PUMP 5	East of Tule Lake National Wildlife Reserve
PUMP B	South of "Sump 1-B" Tule Lake
PUMP 10	East Shore of Tule Lake
PUMP 9	South of "Sump 1-A" Tule Lake
PUMP D	Tule Lake Pump
KSD	Klamath Straits Drain at Cal-Ore Border
OD	Oregon Drain at Cal-Ore Border
KBORD	Klamath River at Cal-Ore Border

National Forest Boundary

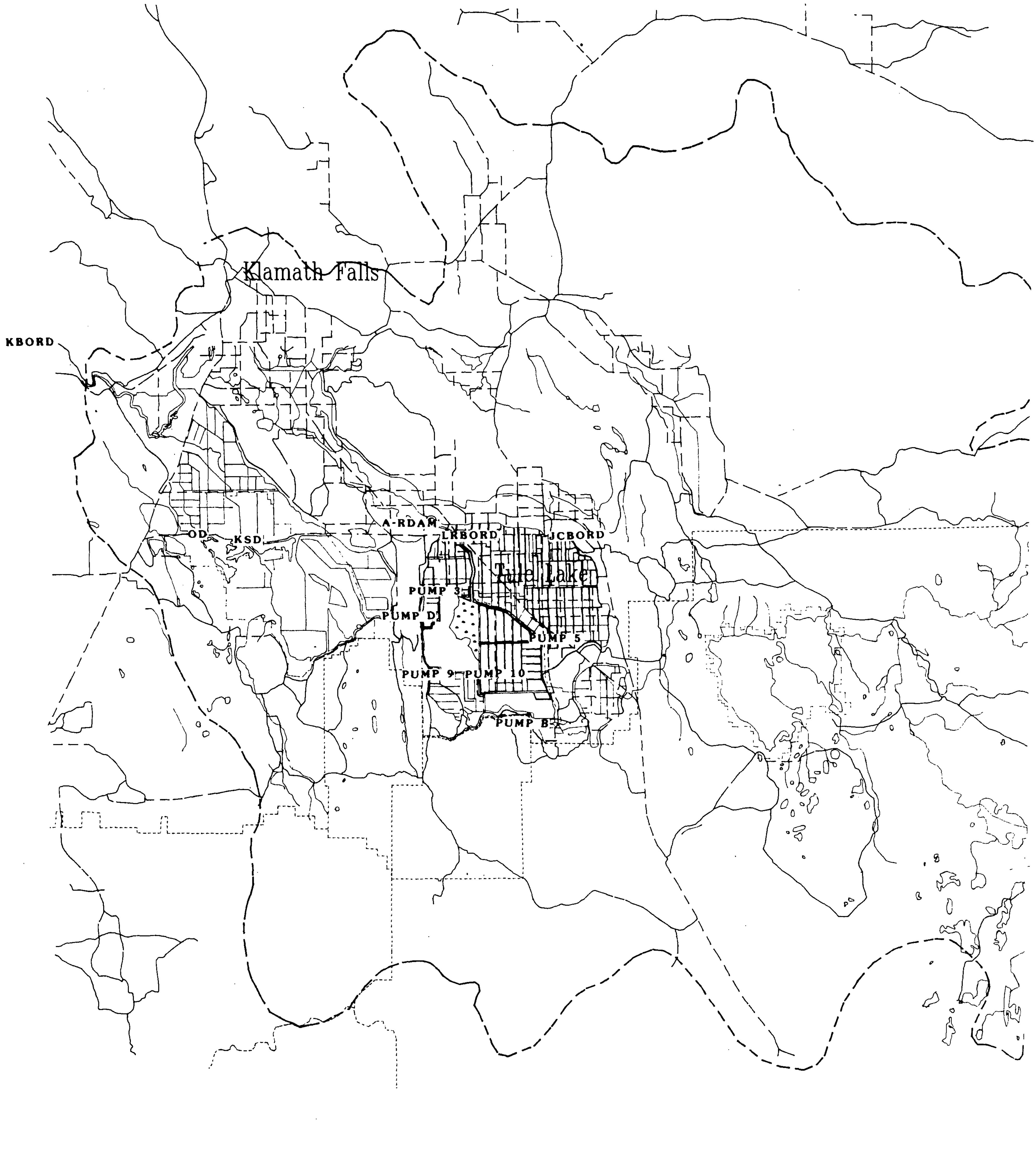
Wildlife Refuge Boundary

Roads

Hydrography

Watershed Boundary

Map plotted by: NCRWQCB


Klamath Falls
KBORD
A-RDAM
LKBORD
JCBORD
Tule Lake
OD
KSD
PUMP 3
PUMP D
PUMP 5
PUMP 9
PUMP 10
PUMP B

the water quality significance of these nonpoint source discharges, if any. These eutrophic conditions remain as the water is pumped and flows through Lower Klamath Lake and into Klamath Straits Drain north back into Oregon. Both Tule Lake and Lower Klamath Lake are part of the National Wildlife Refuge system.

California's water quality concern again starts at the California - Oregon border downstream in the Klamath River. The question here is whether the water quality conditions in the Klamath River at this point can be correlated to water quality in the Lost River watershed, and specifically to nonpoint source discharges into the Lost River system in California. California has no authority to investigate water quality in Oregon, but is working with Federal and State agencies in Oregon to coordinate our monitoring efforts and better delineate sources of concern.

RESULTS AND DISCUSSION

Water Quality Monitoring

North Coast Regional Board staff monitored water quality parameters in the lower Lost River watershed during 1992-1995. This monitoring focused on nutrients, heavy metals, general ionic minerals, and physical parameters, and also included pesticide and herbicide monitoring in the Tulelake area. Pesticide and herbicide data can be found in Regional Board files and staff reports (Winchester, 1994) located in the Regional Board's office in Santa Rosa. These pesticide and herbicide data raised no significant water quality issues of concern for the Regional Board. The monitoring for the other chemical and physical parameters are the data presented in this report. All samples collected were "grab" samples collected in accordance with Regional Board protocol. Analyses for water and air temperature, specific conductance, pH, and dissolved oxygen were performed in the field by Regional Board staff, with assistance at times from staff of the Tulelake Irrigation District. All other samples were sent to contract laboratories for analyses.

The primary emphasis of this monitoring was oriented towards attempting to gain more knowledge about the role of nonpoint source discharges from agriculture in California on the water quality in the lower Lost River watershed in California. The focus has been on eutrophic conditions. The narration of this report is intended to deal primarily with eutrophic conditions, but other water quality data is also shown in Appendix A, for reader information, as collected during the same time period by Regional Board staff. This additional data will be analyzed in future reports after more data is available. Additionally, we have included in this report limited data collected in the Klamath River at the California - Oregon border to show any general correlation that may exist from this point and the Lost River watershed upstream.

This report is prepared with data collected by Regional Board staff available to us by mid-June, 1995. The amount of data is limited, but is being presented here for use by interested parties. An on-going, more intensive monitoring effort has been implemented for the summer of 1995 with Regional Board student help from the College of the Siskiyous funded through U.S. Environmental Protection Agency Clean Water Act Sections 319(h), 604(b), and 104(b) grant funds. There is also increasing coordination and sharing of monitoring efforts among the two States and Federal agencies in 1995.

Figure 1 also shows monitoring station locations and station name acronyms. All data is presented in Appendix A. For ease of reader interpretation, selected data is presented in bar graph format at individual stations and also at stations generally moving down through the watershed areas. Due to the fact that some of the stations around the Tule Lake Sumps are not actually "downstream" of one another because of regulated water movement through the basin, care must be taken when interpreting the graphs to not conclude otherwise.

<u>Total Ammonia-Nitrogen (NH3-N)</u>

Total ammonia-nitrogen (NH3-N) can be found in the Lost River system likely from several different primary sources. It can be originating from Klamath River water diverted into the Lost River below Upper Klamath Lake during the irrigation season, it can be formed by the chemical and bacterial decomposition or breakdown of animal wastes or natural organic material, from resuspended bottom sediments, or it can be introduced as a crop fertilizer. Without knowledge from a study designed specifically to identify nitrogen sources in a specific area, the shallow eutrophic waters of Tule Lake and Lower Klamath Lake receiving imported water and agricultural drain water make for an endless scenario of possibilities as to the primary origins of a given NH3-N concentration found at any one particular point in time. This makes data from a set of monitoring stations located throughout the watershed difficult to interpret unless overall consistent seasonal NH3-N concentrations are found at stations or an obvious trend between stations is observed over time.

Figures 2 and 3 display NH3-N concentrations. Lost River at the California-Oregon border (station LRBORD) consistently exhibited the highest NH3-N concentrations. Tulelake Irrigation District pumps 3, 10, 9, and D around Tule Lake exhibited higher concentrations than most other stations (except LRBORD on most sampling dates) on different sampling dates, but show no trend between stations, and no correlation with results from Anderson Rose Dam, the diversion point for Lost River water into the Tulelake area. This suggests the multiple sources of NH3-N as described above. Maximum and minimum NH3-N concentrations at all stations ranged from a high of 2.6 mg/L at station LRBORD to a low of .025 mg/L at station KBORD.

<u>Un-ionized Ammonia</u>

Un-ionized ammonia can be toxic to aquatic life at low concentrations. USEPA has established a national criterion for un-ionized ammonia concentration for the protection of aquatic life at .025 mg/L. The percent of this toxic un-ionized form of the total ammonia-nitrogen present increases with increased water temperature and/or increased pH level. During the summer period, the lower Lost River system exhibits both high water temperatures and very high pH. The high pH results partly from photosynthetic activity from the highly eutrophic conditions.

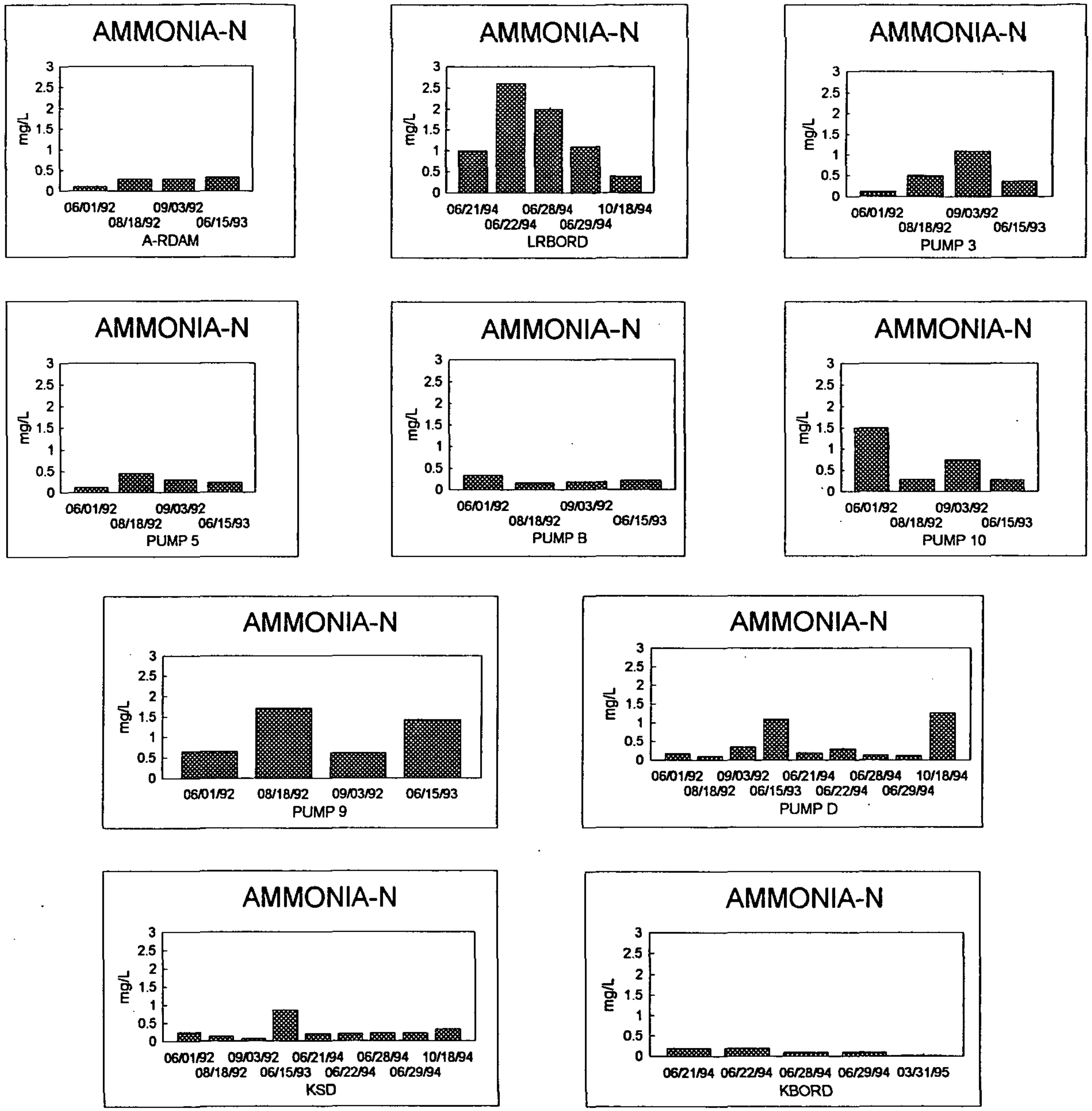


Figure 2. Total Ammonia - N concentrations at individual Lost River watershed stations and at Klamath River state line border, 1992 - 1995.

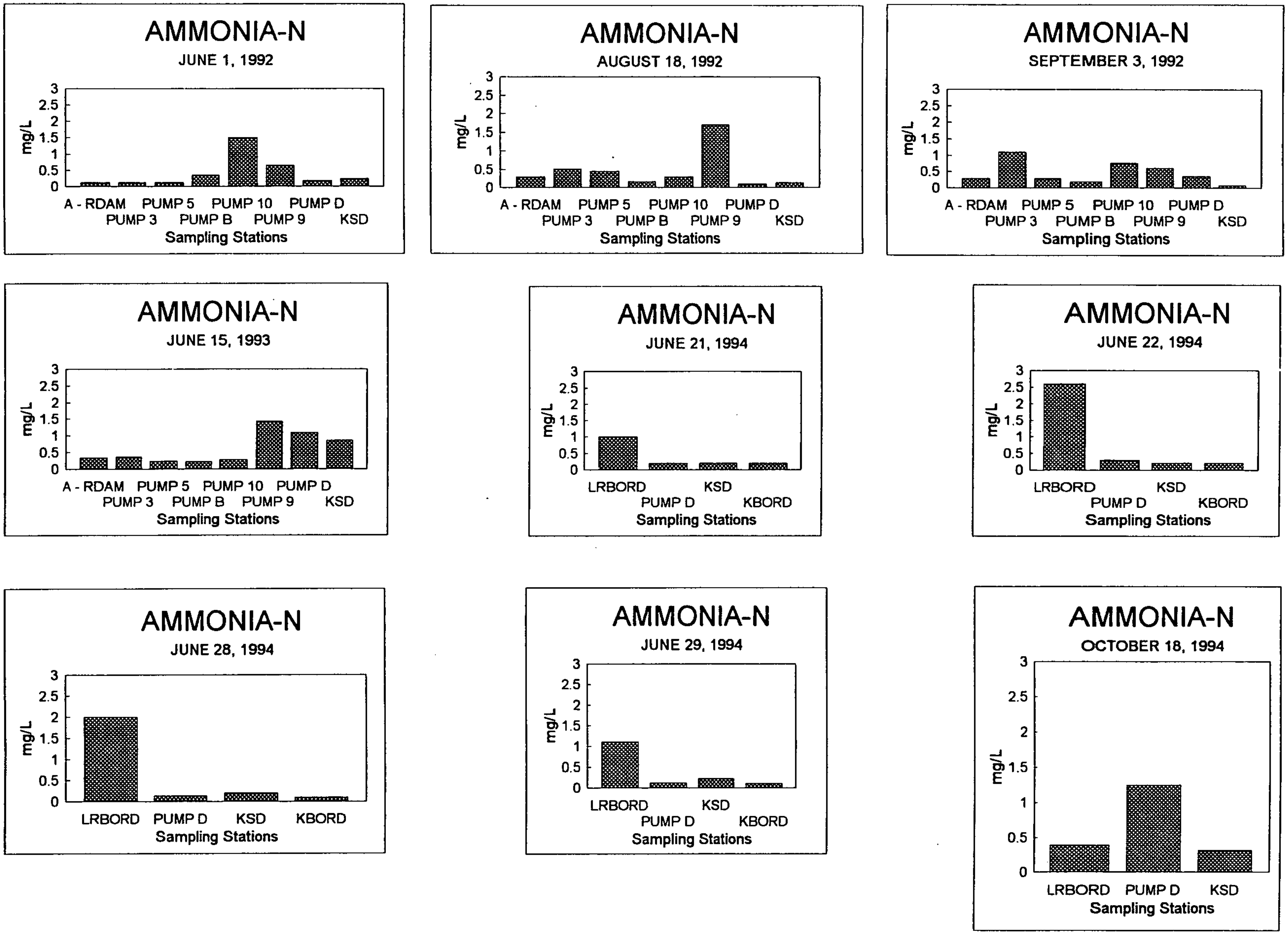


Figure 3. Total Ammonia - N concentrations on 1992 - 1994 sampling dates at Lost River watershed stations, generally moving down through the watershed and at Klamath River state line border.

Recent U.S. Department of the Interior studies (MacCoy, 1994) of the Klamath Project area found high levels of un-ionized ammonia in the lower Lost River system. Regional Board staff discussions with U.S. Fish and Wildlife officials (Schwarzbach S., personal communication, 1994) involved in the study found that they concluded that un-ionized ammonia may be the most consistently toxic material for aquatic life in this area.

Figures 4 and 5 display un-ionized ammonia concentrations. These un-ionized ammonia concentrations were calculated by formula presented in Emerson, 1975 and shown in Appendix A. The national criterion of .025 mg/L was exceeded on some sampling dates at all sampling locations. The highest concentrations were at the Tulelake stations at Pumps 9, 10, and D. Maximum and minimum un-ionized ammonia concentrations at all stations ranged from a high of .613 mg/L at station Pump D to lows of 0.0 mg/L at numerous stations at one time or another.

Total Kjeldahl Nitrogen (TKN)

Total Kjeldahl Nitrogen (TKN) is the total of the organic and ammonia nitrogen. Lost River water high in organic material such as algae for instance can be expected to have high TKN concentrations regardless of ammonia-nitrogen concentrations. TKN and other nitrogen concentrations reported here should strongly reflect that elemental nitrogen resides, in great mass, within the soils of the sedimentary reservoir of the lower Lost River watershed, and is continuously being oxidized and reduced by living organisms.

Figures 6 and 7 display TKN concentrations. Maximum and minimum TKN concentrations at all stations ranged from a high of 7.80 mg/l at station KSD to a low of .25 mg/L at station KBORD. A review of these TKN values show no trend over time at any given station or between stations. A comparison of TKN values with NH3-N values shown above show that the majority of the TKN value is normally from organic nitrogen.

Nitrate (NO3)

Ammonia in surface water will oxidize to nitrite (NO2) and then to nitrate (NO3). NO3 is a plant nutrient and depending on conditions can cause nuisance algal blooms and excessive aquatic vascular plant growth. This in turn can suppress dissolved oxygen levels and increase pH 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 ar adversely affect beneficial uses". Numeric objectives for these nutrients have not been established for Lost River.

Figures 8 and 9 display NO3 concentrations. Maximum and minimum NO3 concentrations at all stations ranged from a high of 1.44 mg/L at station KSD to a low of .015 mg/L at numerous stations at one time or another. No obvious trends or correlation over time or between stations

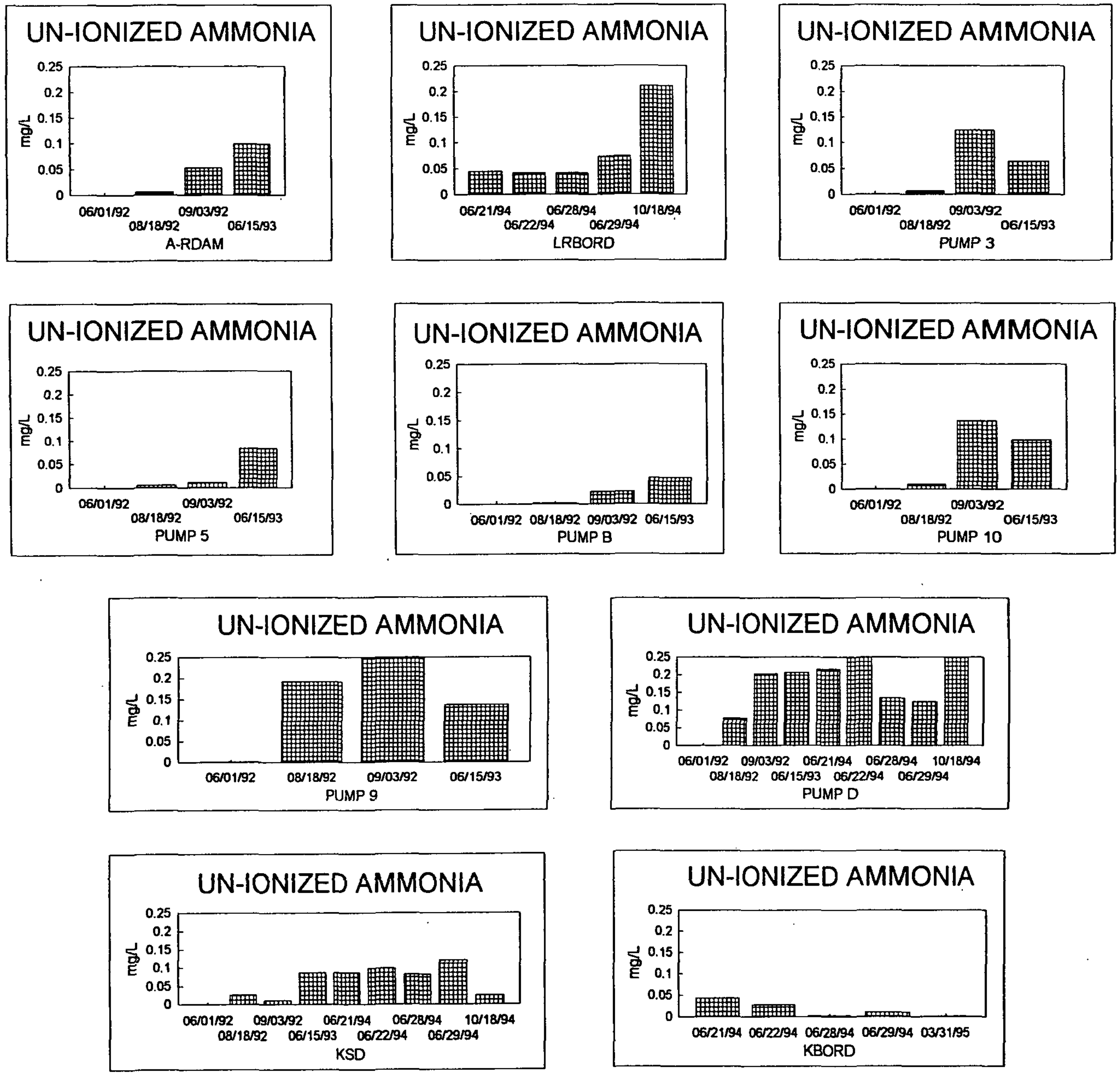


Figure 4. Un - ionized ammonia concentrations at individual Lost River watershed stations and at Klamath River state line border, 1992 - 1995.

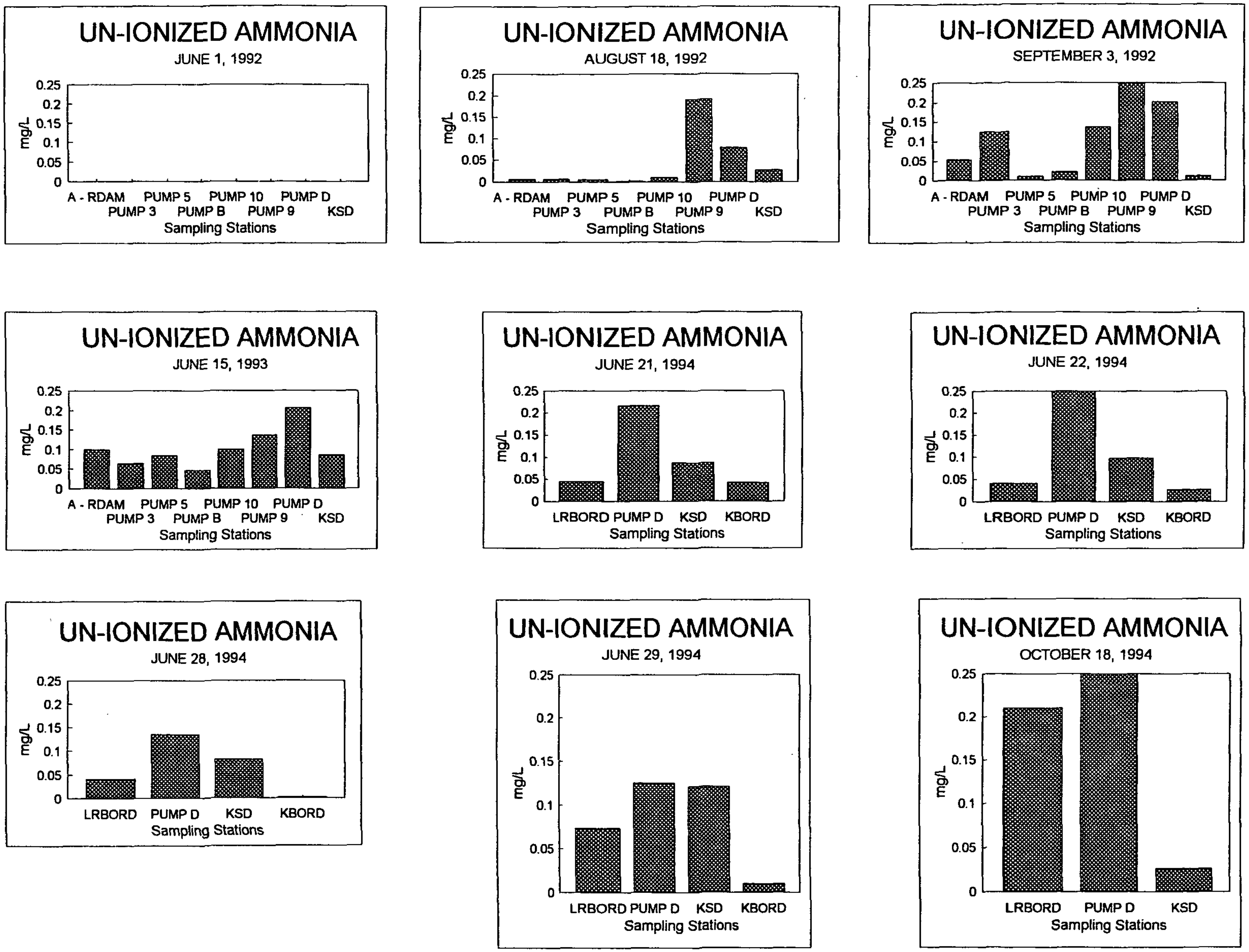


Figure 5. Un - ionized ammonia concentrations on 1992 - 1994 sampling dates at Lost River watershed stations, generally moving down through the watershed and at Klamath River state line border.

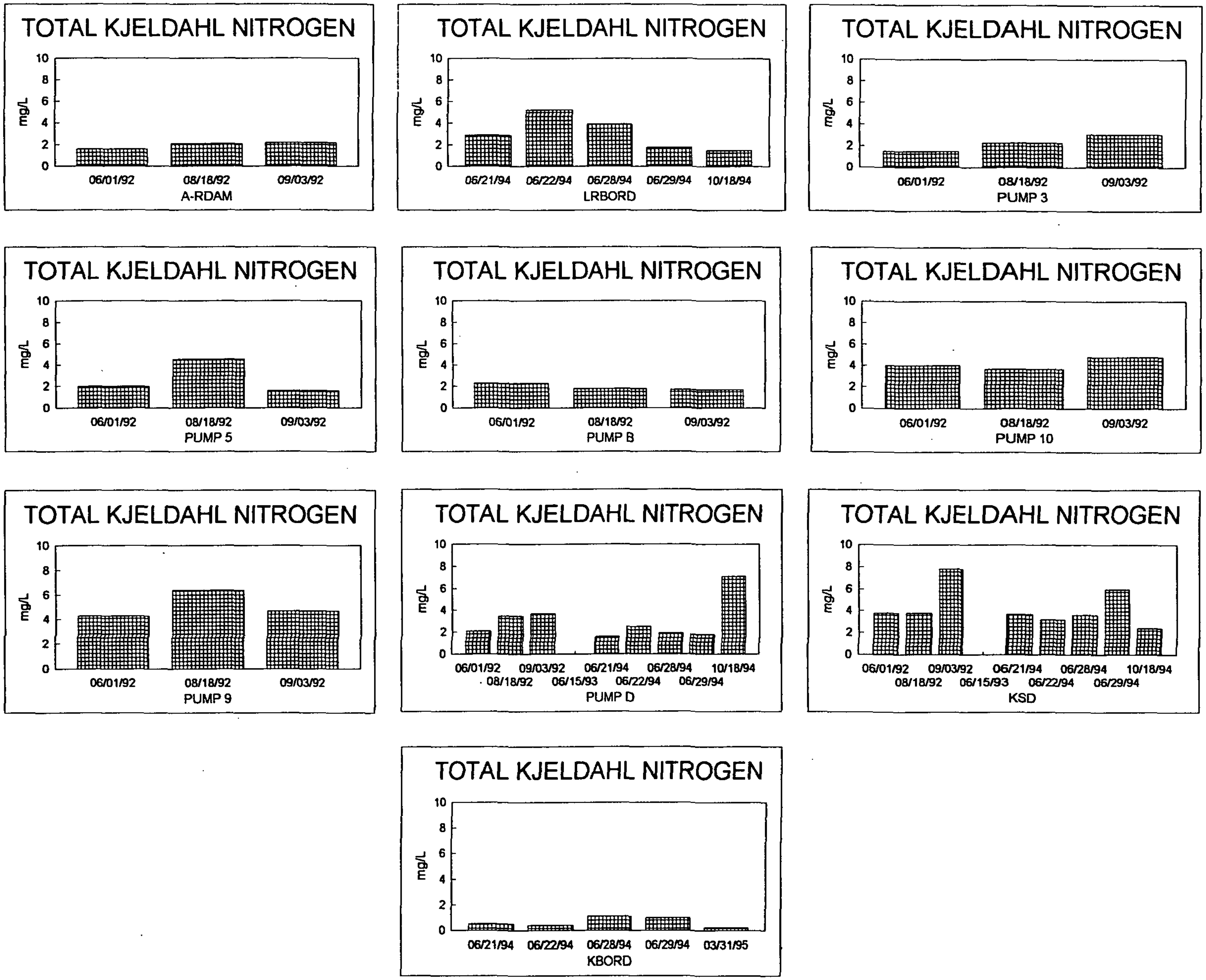


Figure 6. Total Kjeldahl Nitrogen concentrations at individual Lost River watershed stations and at Klamath River state line border, 1992 - 1995.

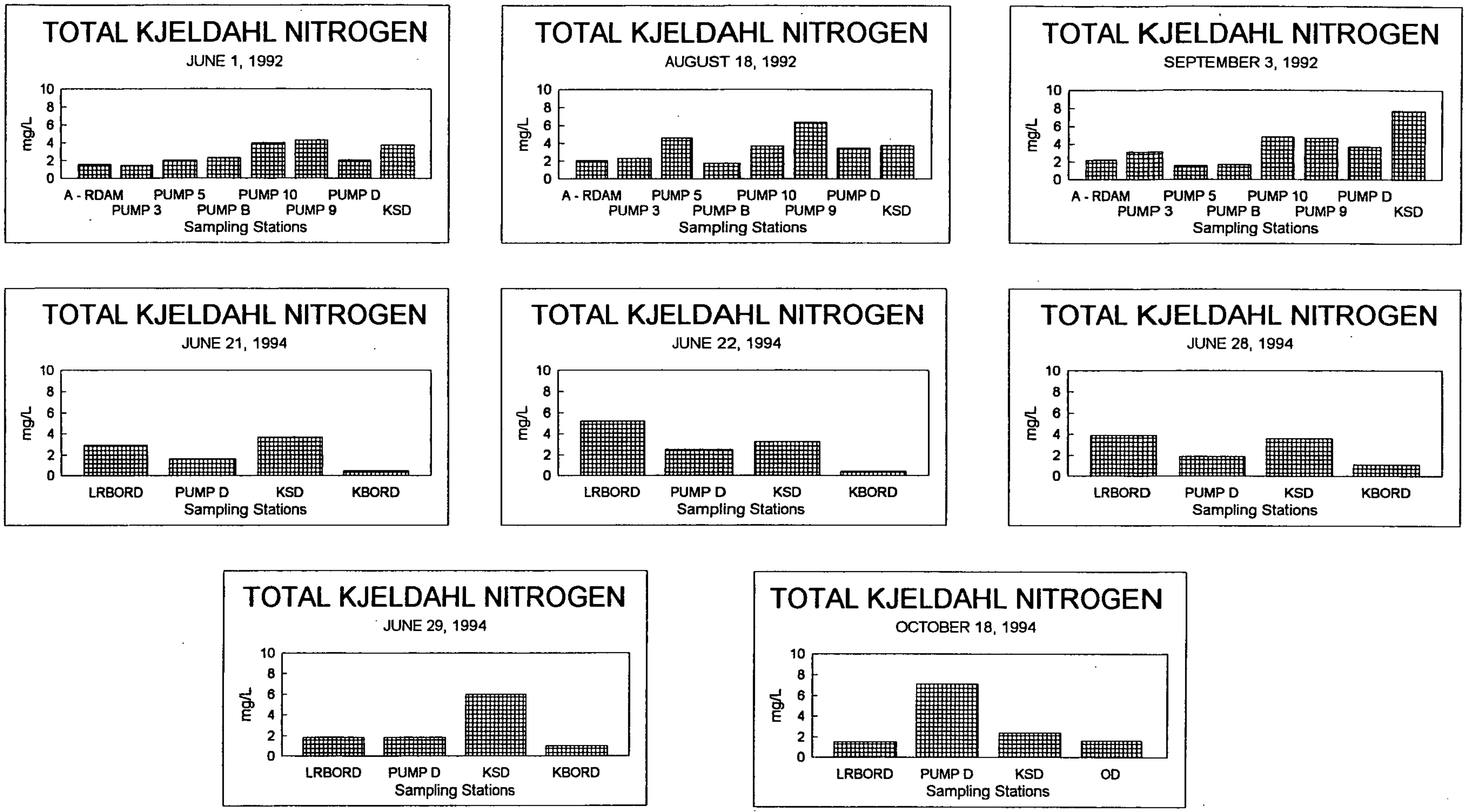


Figure 7. Total Kjeldahl Nitrogen concentrations on 1992 - 1994 sampling dates at Lost River watershed stations, generally moving down through the watershed and at Klamath River state line border.

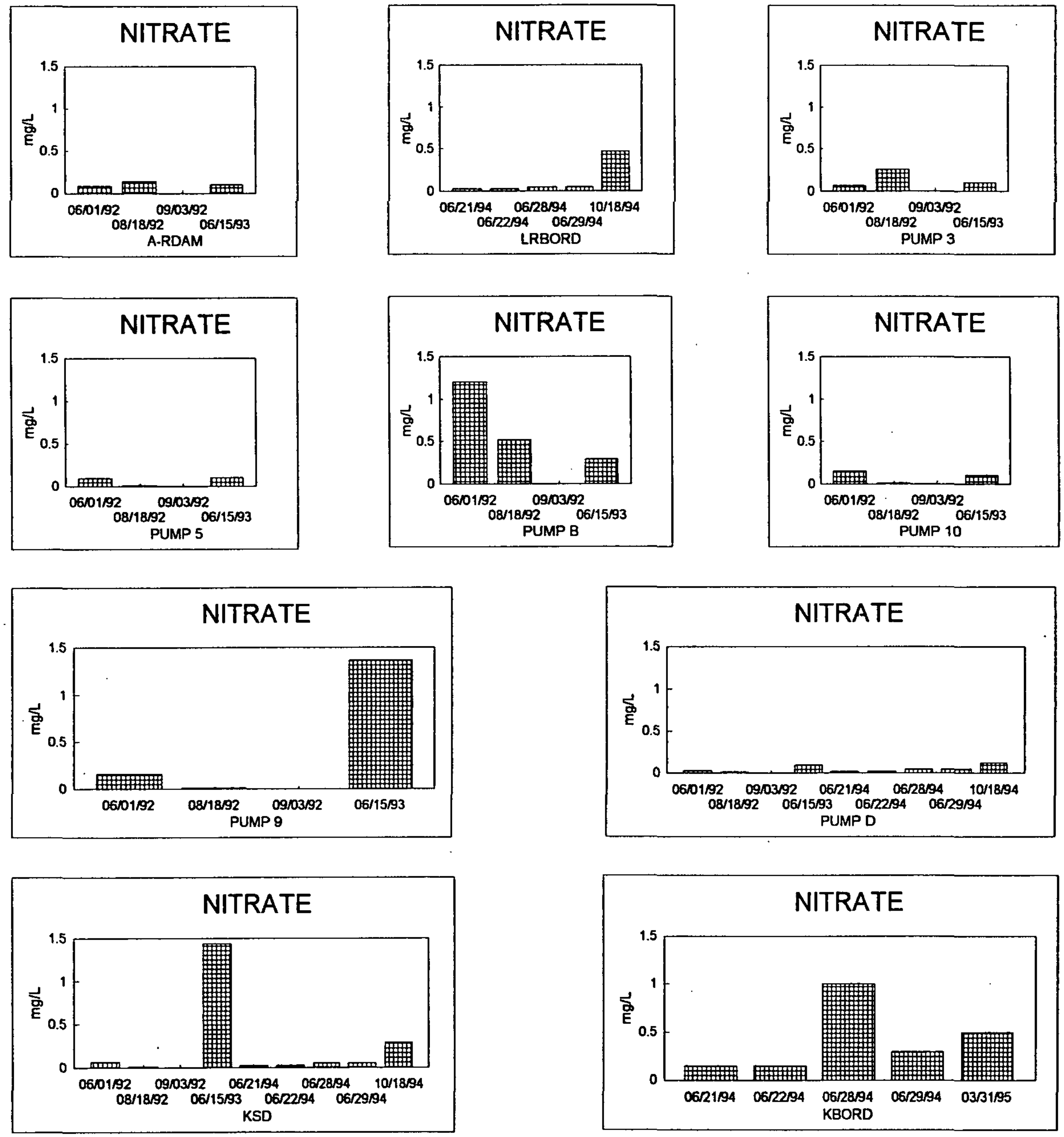


Figure 8. Nitrate concentrations at individual Lost River watershed stations and at Klamath River state line border, 1992 - 1995.

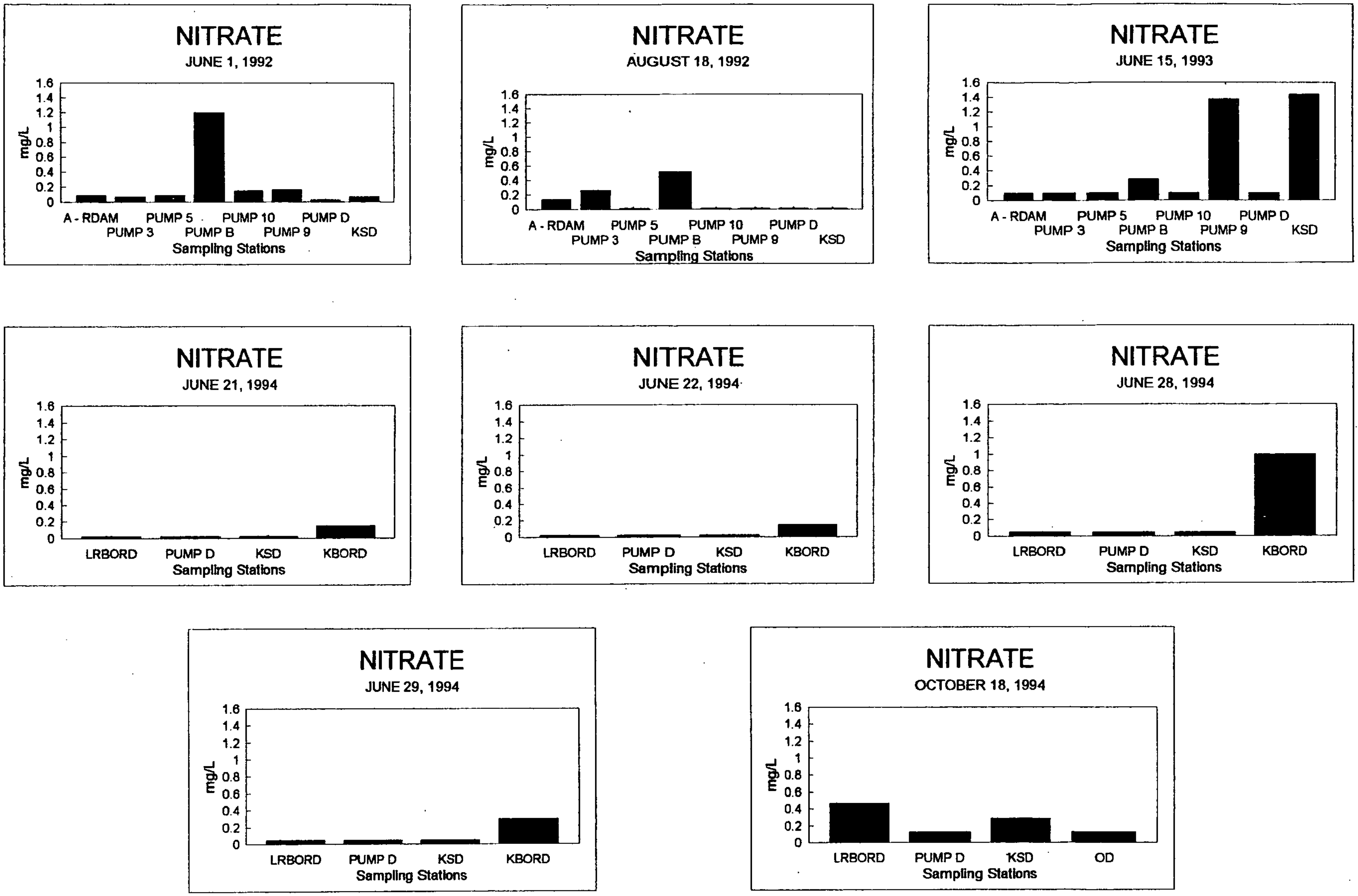


Figure 9. Nitrate concentrations on 1992 - 1994 sampling dates at Lost River watershed stations, generally moving down through the watershed and at Klamath River state line border.

can be seen with the data collected. Additionally, there is no obvious consistent correlation between NH3 and NO3 comparing all stations.

Total Phosphates (TPO4)

Phosphorus, as total phosphates (TPO4), can be a nutrient for algae and vascular aquatic plant growth as NO3 above. The inorganic dissolved form of phosphorus is orthophosphate (OPO4). This OPO4 form is the most readily available form of phosphorus for algae to use. For the data collected, both organic and inorganic phosphorus contibuted to the total phosphorus concentrations monitored, with OPO4 generally contributing the major portion.

Figures 10 and 11 display TPO4 concentrations. Maximum and minimum TPO4 concentrations at all stations ranged from a high of 1.2 mg/L at station KSD to a low of .025 mg/L at several stations in October, 1994.

As with the other water quality constituents monitored above, TPO4 showed no obvious trends over time or correlations between stations. This again suggests multiple sources and environmental factors are significantly responsible for nutrient levels in the lower Lost River watershed.

Dissolved Oxygen (D.O.)

Eutrophic water conditions such as those which exist in the lower Lost River system can often result in low dissolved oxygen (D.O.) conditions. The Basin Plan water quality objectives for D.O. specifies a minimum concentration of 5.0 mg/L for the Lost River and 7.0 mg/L for the Klamath River above Iron Gate Dam for the protection of aquatic life.

Figures 12 and 13 display D.O. concentrations. Maximum and minimum D.O. concentrations at all stations ranged from a high of 14.2 mg/L at station LRBORD on May 18, 1995 to a low of 2.2 mg/L on June 29, 1994 at the same station.

The minimum D.O. objective of 5.0 mg/L for the Lost River was not met at one time or more at seven of the ten stations monitored. These readings were all taken during the daytime hours when higher diel D.O. levels are expected to occur. As above with other water quality parameters, the D.O. data collected exhibits sporatic concentrations both over time and between stations. This illustrates that multiple factors among sites are likely responsible for water quality conditions at any one point in time.

The Oregon Department of Environmental Quality has found that the Klamath River in Oregon from Upper Klamath Lake to Keno routinely violates their D.O. standard of 5.0 mg/L (Baumgartner, 1994). The North Coast Regional Board's Basin Plan minimum D.O. objective of 7.0 mg/L for the Klamath River in California above Iron Gate Dam was met for station KBORD for the dates and time collected.

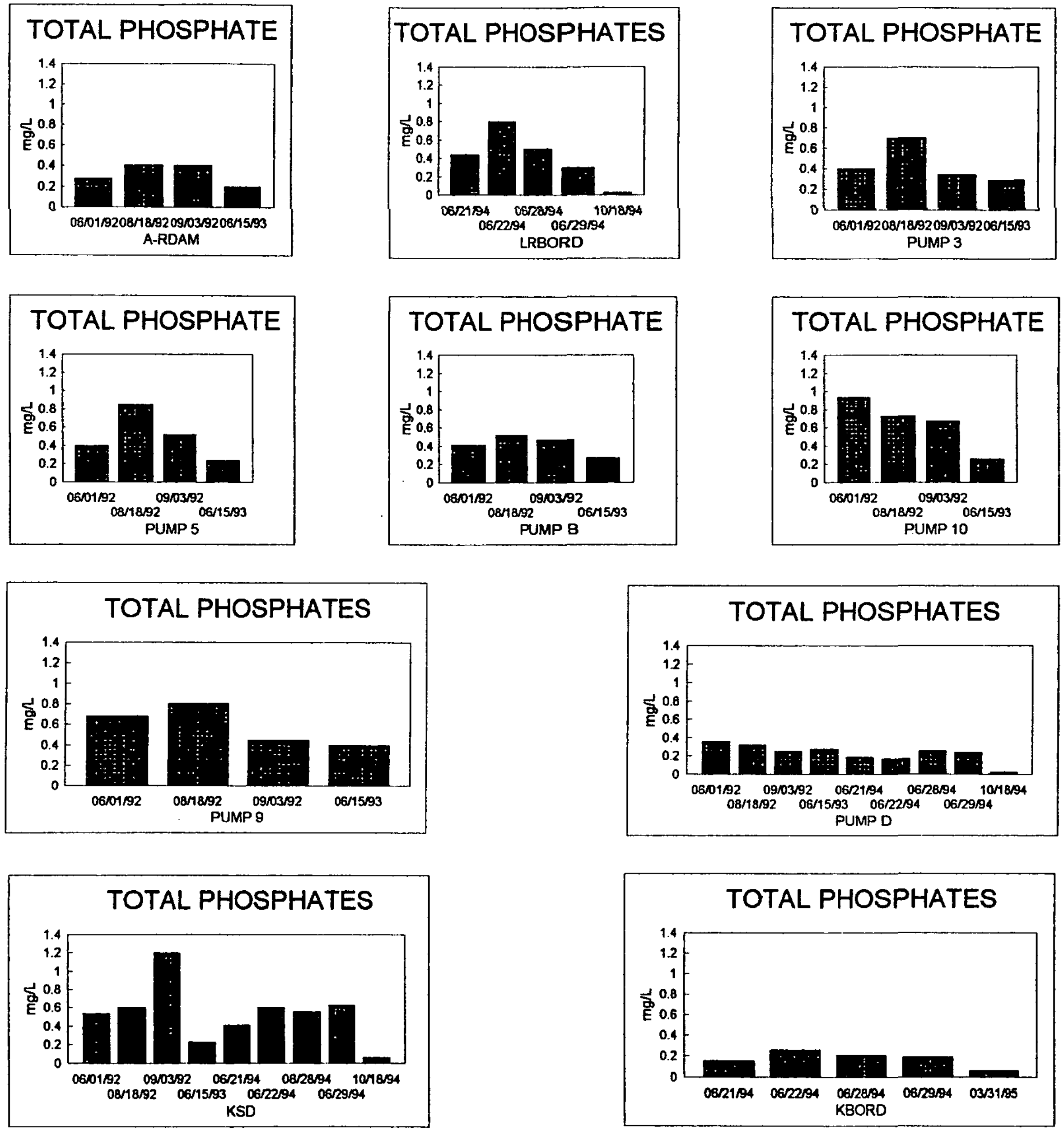


Figure 10. Total Phosphate concentrations at individual Lost River watershed stations and at Klamath River state line border, 1992 - 1995.

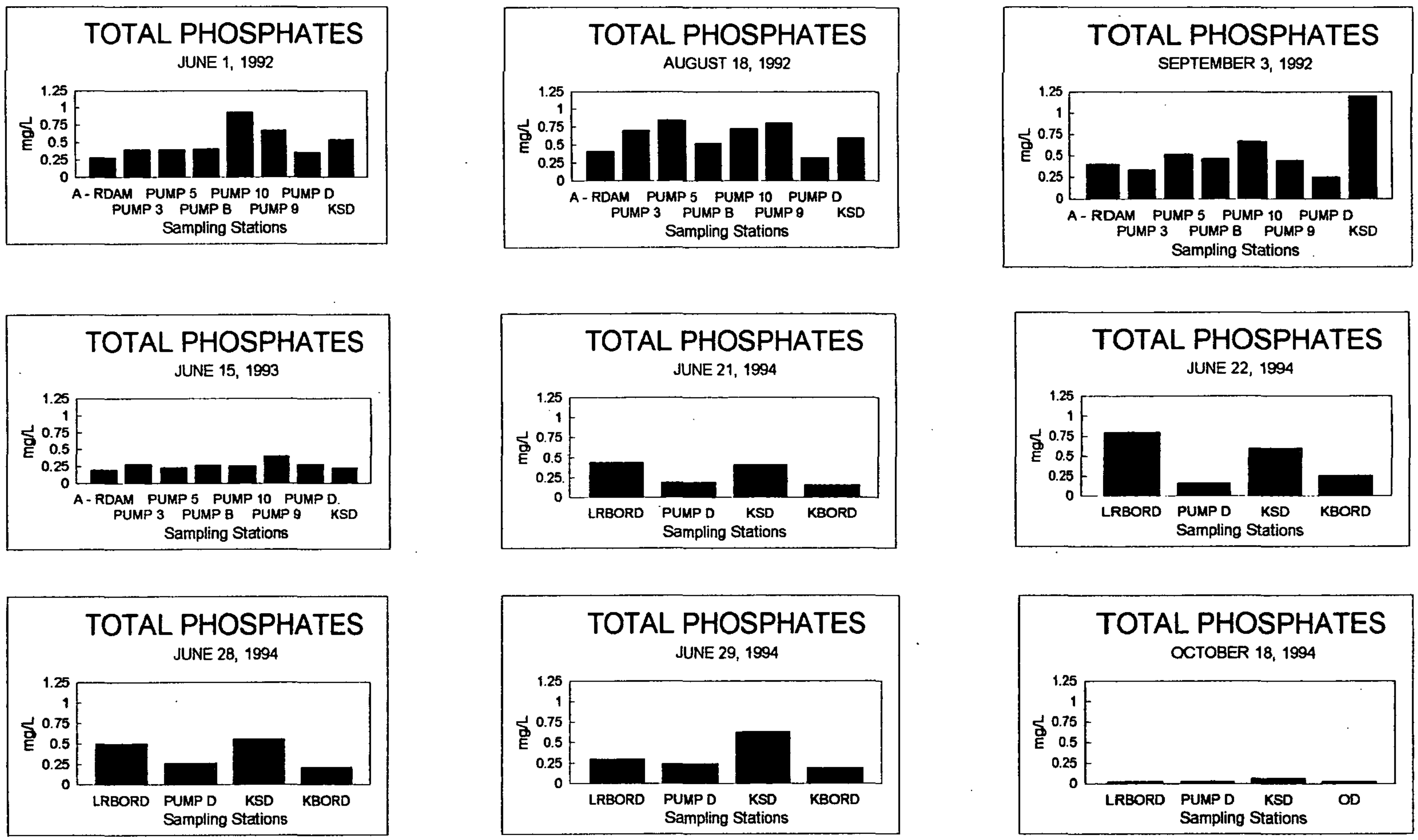


Figure 11. Total Phosphate concentrations on 1992 - 1994 sampling dates at Lost River watershed stations, generally moving down through the watershed and at Klamath River state line border.

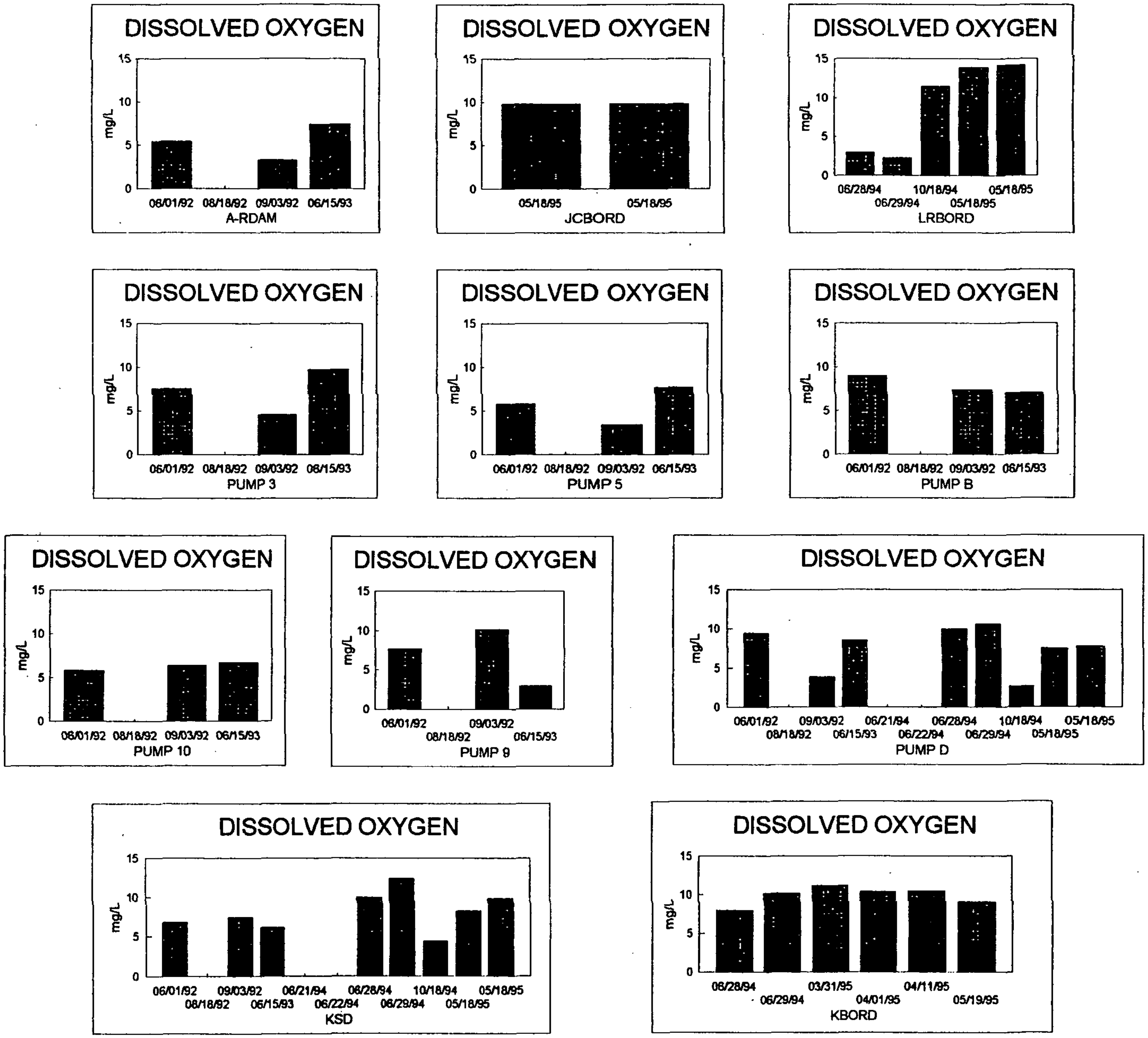


Figure 12. Dissolved Oxygen concentrations at individual Lost River watershed stations and at Klamath River state line border, 1992 - 1995.

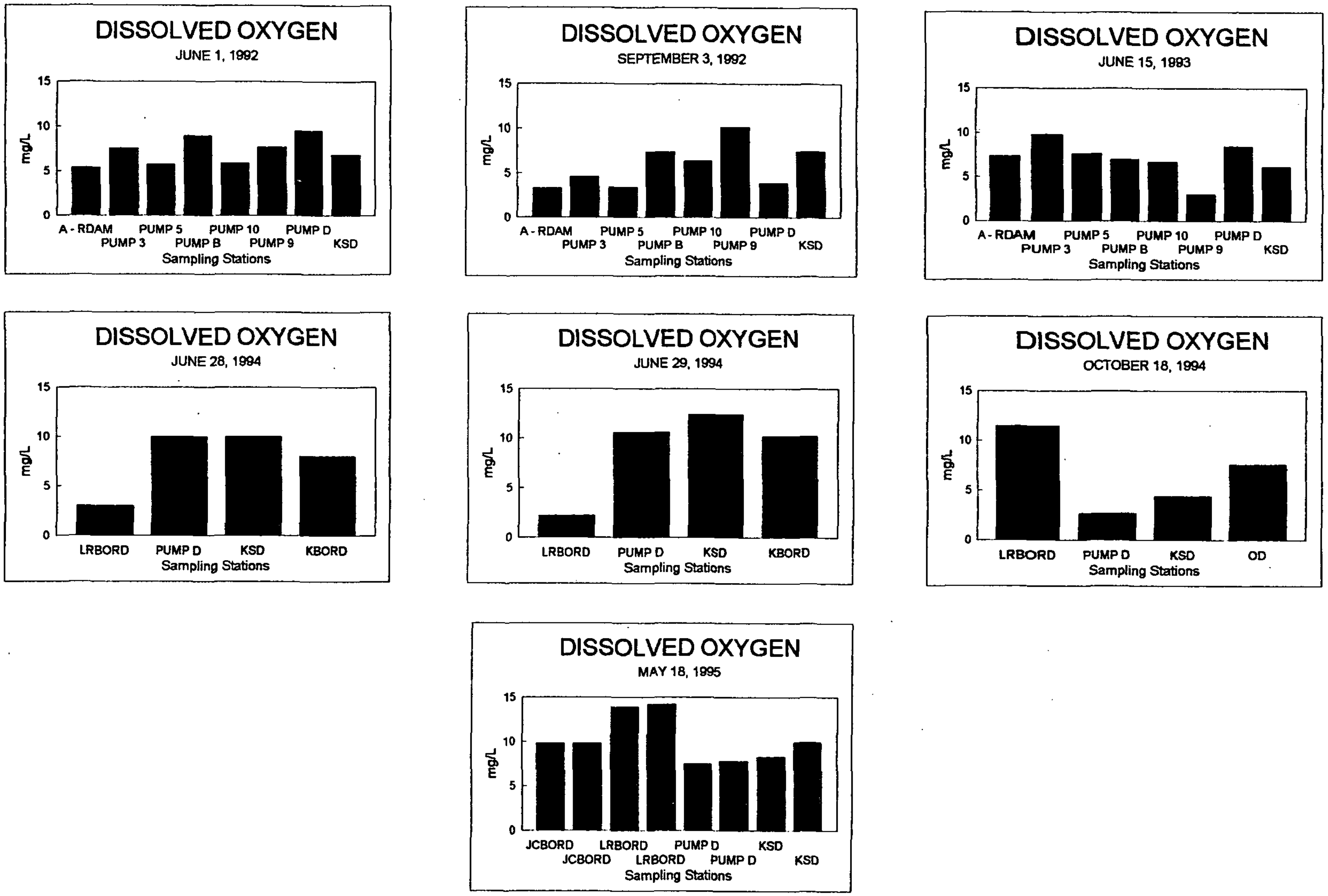


Figure 13. Dissolved Oxygen concentrations on 1992 - 1995 sampling dates at Lost River watershed stations, generally moving down through the watershed and at Klamath River state line border.

Additionally, BOR Klamath Project staff (Berg, M., personal communication, 1995) has told us that BOR has a significant amount of diel water quality data, including D.O. measurements, from this area. Regional Board staff will be reviewing this with BOR staff in the future to get an idea of algal production and Biochemical Oxygen Demand in the Lost River watershed in California.

pH

pH is a measure of the hydrogen ion activity in water. High photosynthetic activity in eutrophic waters can result in high pH levels. The North Coast Regional Board's Basin Plan specifies water quality objectives for pH in the Lost River to be a minimum of 7.0 units and a maximum of 9.0 units. pH objectives for the Klamath River above Iron Gate Dam are a minimum of 7.0 units and a maximum of 8.5 units.

pH concentrations are displayed in Figures 14 and 15. All Lost River stations except for station JCBORD did not meet Basin Plan minimum and/or maximum pH objectives at one time or another. Maximum and minimum pH levels at all stations ranged from a low of 4.6 at station KSD to a high of 10.2 on two dates at station Pump D. pH levels are consistently high throughout the lower watershed, and are particularly high over time at the Tule Lake station Pump D. In bioassay tests, juvenile sucker mortality has been observed at pH values of 10 or more. pH levels of 10 or more were observed on three sampling dates at station Pump D.

Bureau of Reclamation diel pH data from the Lost River system needs to be reviewed as mentioned above to better understand diel pH fluctuations and how long these higher levels are sustained over a day or other time period.

Specific Conductance

Specific conductance is a measure of the ionized or dissolved minerals in water. Basin Plan water quality objectives for specific conductance for the Lost River Hydrologic Unit are shown in Table 1. The data presented in this report are not enough to meaningfully compute monthly means for a calendar year for these objectives. We can however make general observations regarding specific conductance levels.

It is normally expected that ionized salts as measured by specific conductivity will increase through an agricultural area as soils are leached and water used and evaporated. Any number of other reasons in this area for an increase in ionized salts can include ground water inflow and spring activity, and surface evaporation from the large shallow lakes.

Specific conductance levels are displayed in Figures 16 and 17. As expected, an increase in specific conductivity levels is observed as water flows through the lower Lost River system. Highest levels were found during June, 1994 at station KSD. Maximum and minimum specific conductance levels at all stations ranged from a high of 1,548 micromhos/cm (umhos/cm) at station KSD to a low of 190 umhos/cm at station KBORD.

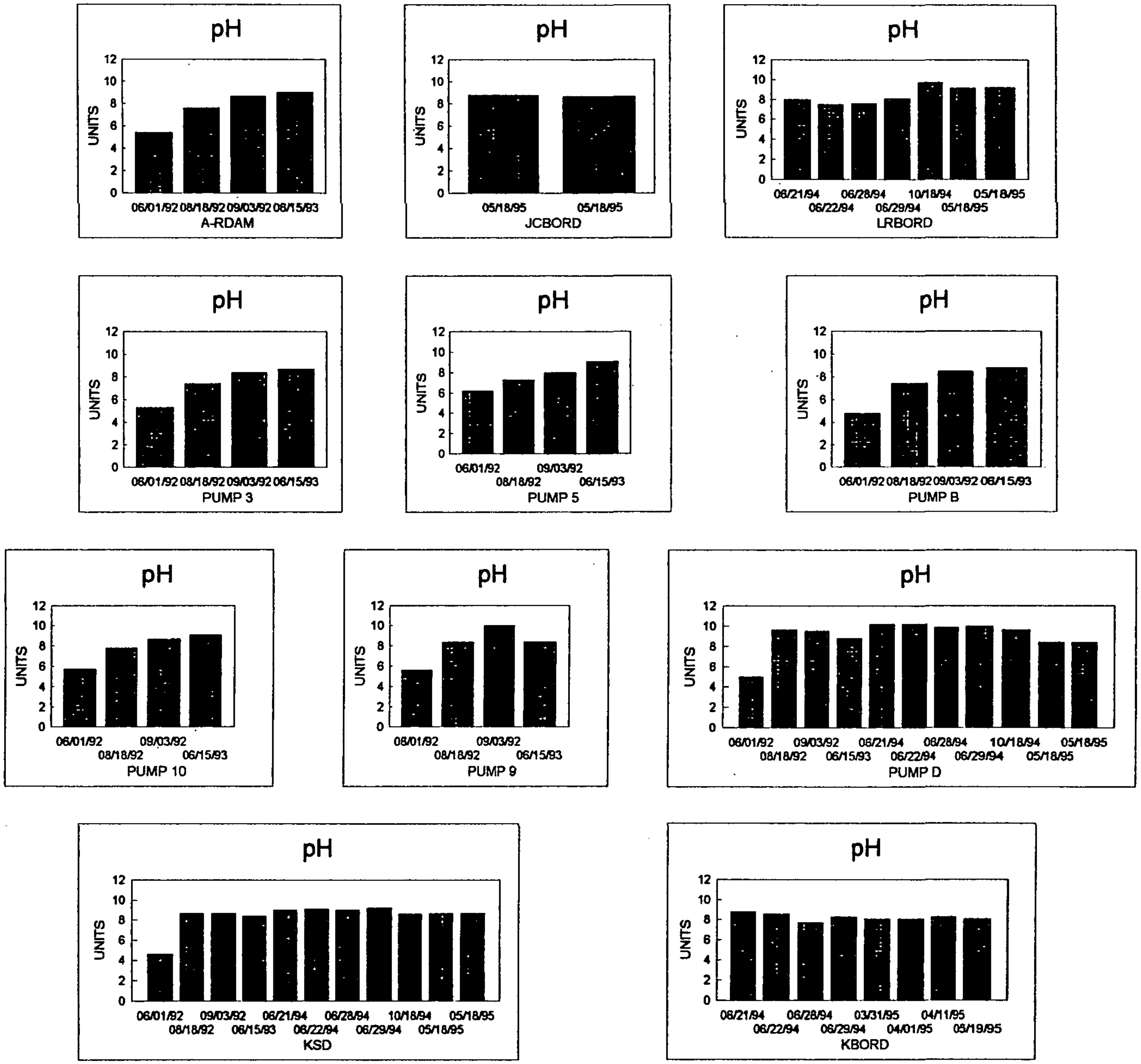


Figure 14. pH units at individual Lost River watershed stations and at Klamath River state line border, 1992 - 1995.

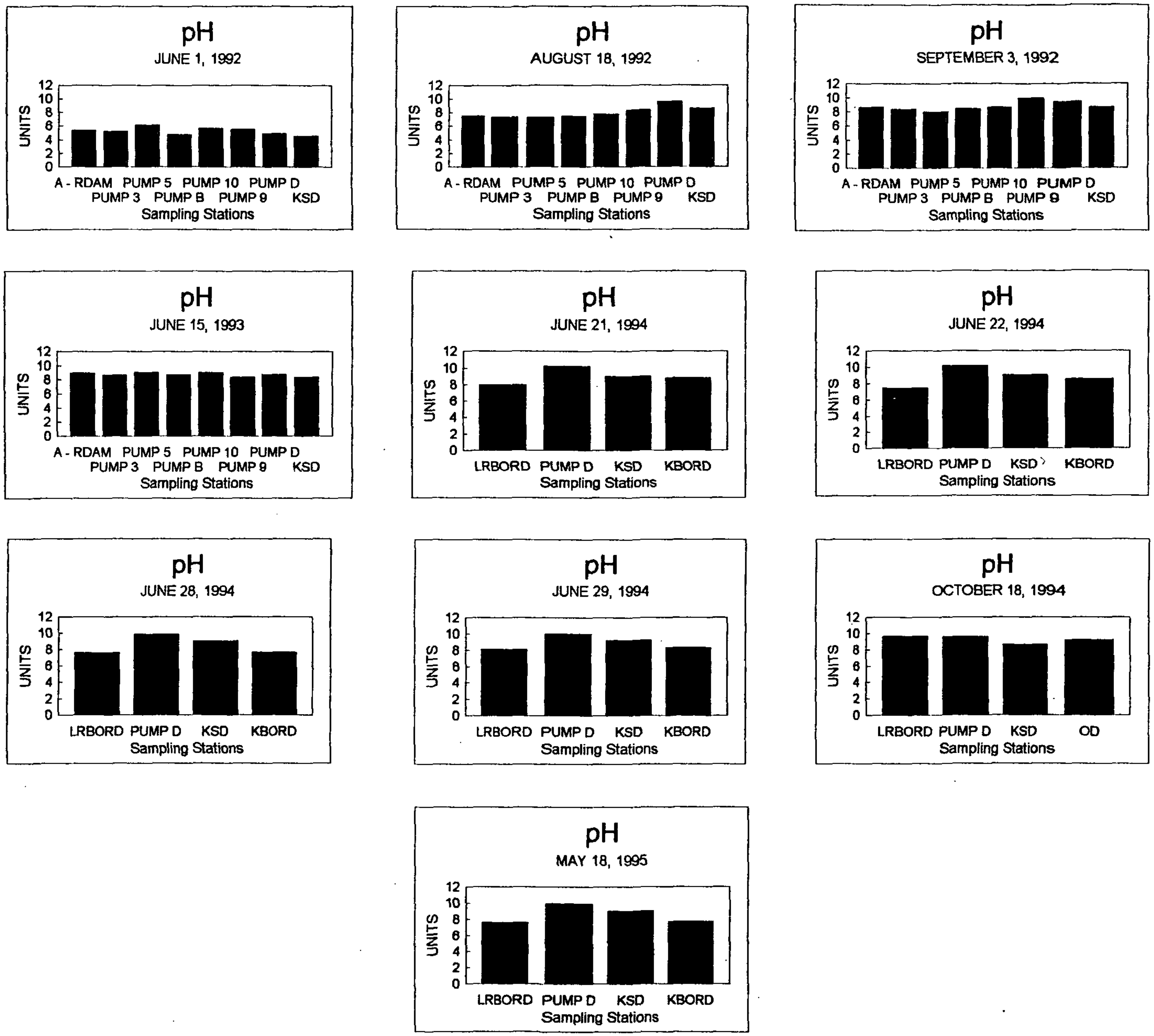


Figure 15. pH units on 1992 - 1995 sampling dates at Lost River watershed stations, generally moving down through the watershed and at Klamath River state line border.

Adapted from: Water Quality Control Plan
for the North Coast Region

Table 1

SPECIFIC WATER QUALITY OBJECTIVES FOR NORTH COAST REGION

Water Body[1]	Specific Conductance (micromhos) @ 77 F. 90% Upper Limit [3]	Specific Conductance (micromhos) @ 77 F. 50% Upper Limit [2]	Total Dissolved Solids (mg/l) 90% Upper Limit [3]	Total Dissolved Solids (mg/l) 50% Upper Limit [2]	Dissolved Oxygen (mg/l) Min	Dissolved Oxygen (mg/l) 90% Lower Limit [3]	Dissolved Oxygen (mg/l) 50% Lower Limit [2]	Hydrogen Ion (pH) Max	Hydrogen Ion (pH) Min	Hardness (mg/l) 50% Upper Limit [2]	Boron (mg/l) 90% Upper Limit [3]	Boron (mg/l) 50% Upper Limit [2]
Lost River HA												
Clear Lake Reservoir & Upper Lost River	300	200			5.0		8.0	9.0	7.0	60	0.5	0.1
Lower Lost River	1000	700			5.0		-	9.0	7.0	-	0.5	0.1
Other Streams	250	150			7.0		8.0	8.4	7.0	50	0.2	0.1
Tule Lake	1300	900			5.0		-	9.0	7.0	400	-	-
Lower Klamath Lake	1150	850			5.0		-	9.0	7.0	400	-	-
Groundwaters [4]	1100	500			-		-	8.5	7.0	250	0.3	0.2
Middle Klamath River HA												
Klamath River above Iron Gate Dam including Iron Gate & Copco Reservoirs	425	275			7.0		10.0	8.5	7.0	60	0.3	0.2
Klamath River below Iron Gate Dam	350	275			8.0		10.0	8.5	7.0	80	0.5	0.2
Other Streams	300	150			7.0		9.0	8.5	7.0	60	0.1	0.0
Groundwaters [4]	750	600			-		-	8.5	7.5	200	0.3	0.1
Applegate River HA												
All Streams	250	175			7.0		9.0	8.5	7.0	60	-	-
Upper Trinity River HA												
Trinity River [5]	200	175			7.0		10.0	8.5	7.0	80	0.1	0.0
Other Streams	200	150			7.0		10.0	8.5	7.0	60	0.0	0.0
Clair Engle Lake and Lewiston Reservoir	200	150			7.0		10.0	8.5	7.0	60	0.0	0.0

1 Water bodies are grouped by hydrologic unit (HU), hydrologic area (HA), or hydrologic subarea (HSA).

2 50% upper and lower limits represent the 50 percentile values of the monthly means for a calendar year. 50% or more of the monthly means must be less than or equal to an upper limit and greater than or equal to a lower limit.

3 90% upper and lower limits represent the 90 percentile values for a calendar year. 90% or more of the values must be less than or eq to an upper limit and greater than or equal to a lower limit.

4 Value may vary depending on the aquifer being sampled. This value is the result of sampling over time, and as pumped, from more th one aquifer.

5

Daily Average Not to Exceed	Period	River Reach
60°F	July 1 - Sept. 14	Lewiston Dam to Douglas City Bridge
56°F	Sept. 15 - Oct. 1	Lewiston Dam to Douglas City Bridge
56°F	Oct. 1 - Dec. 31	Lewiston Dam to confluence of North Fork Trinity River

6 Does not apply to estuarine areas.

7 pH shall not be depressed below natural background levels.

8 Russian River (upstream) refers to the mainstem river upstream of its confluence with Laguna de Santa Rosa.

9 Russian River (downstream) refers to the mainstem river downstream of its confluence with Laguna de Santa Rosa.

10 The State's Ocean Plan applies to all North Coast Region coastal waters.

11 Dissolved oxygen concentrations shall not at any time be depressed more than 10 percent from that which occurs naturally.

12 pH shall not be changed at any time more than 0.2 units from that which occurs naturally.

\- no water body specific objective available.

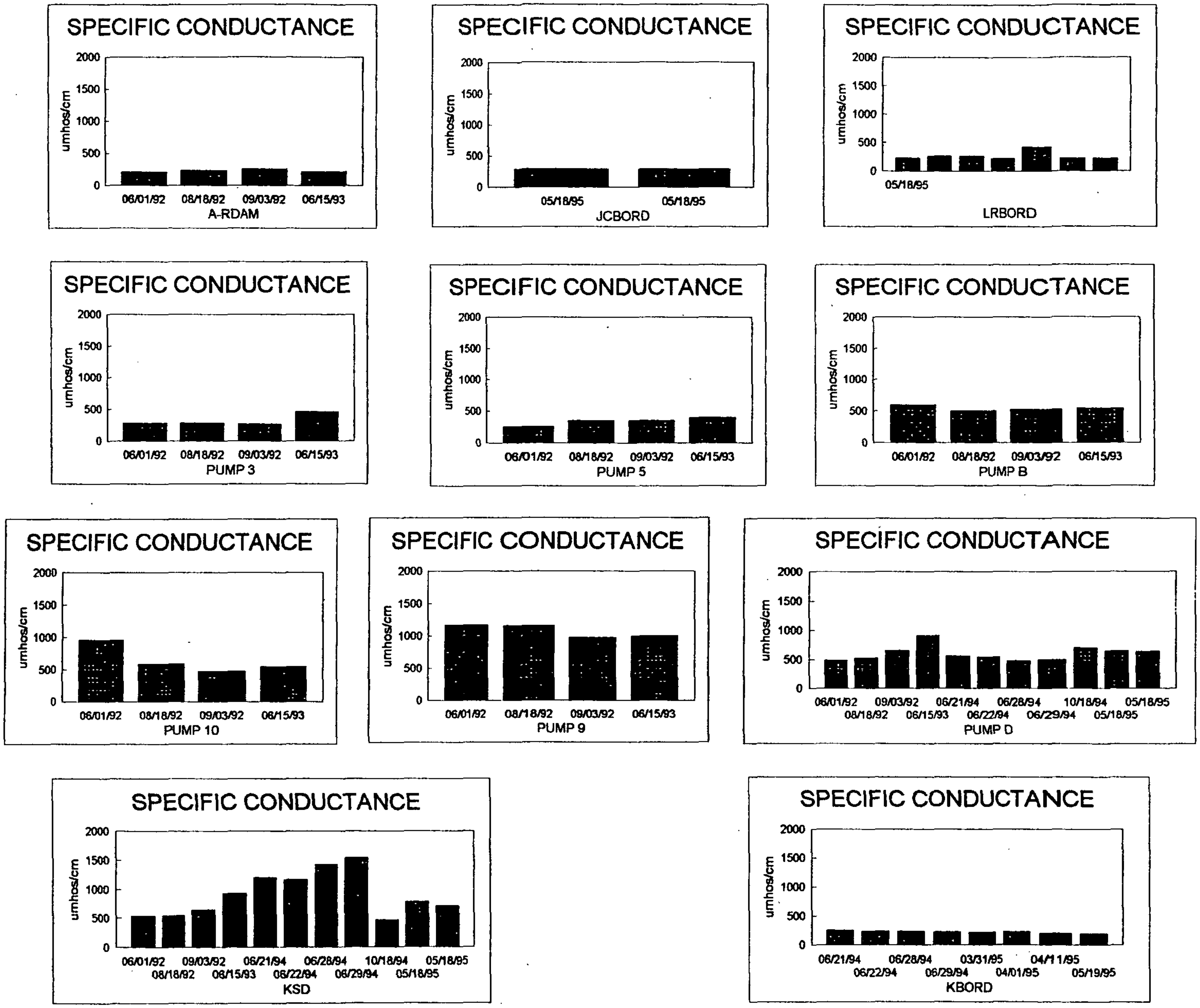


Figure 16. Specific Conductance levels at individual Lost River watershed stations and at Klamath River state line border, 1992 - 1995.

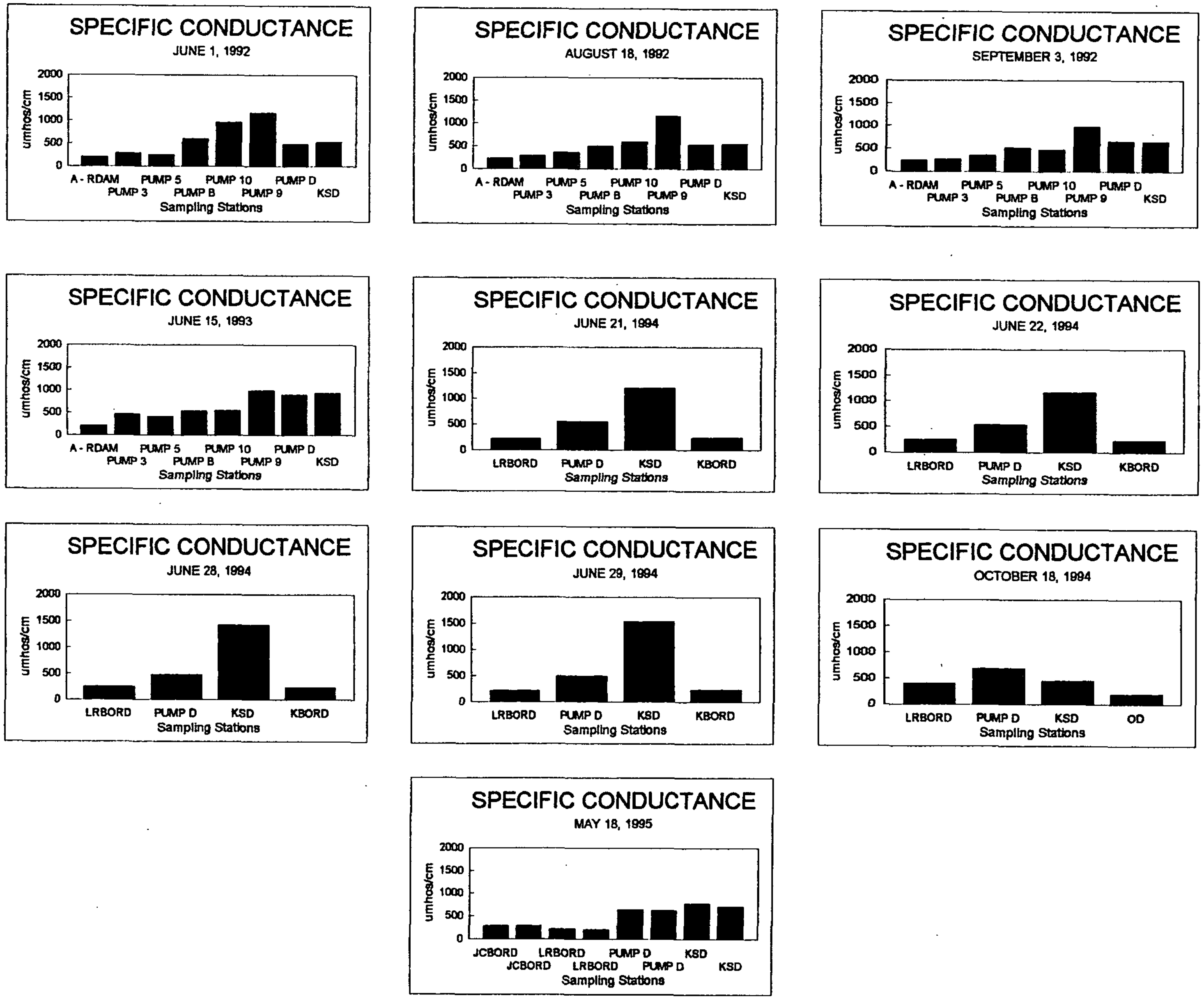


Figure 17. Specific Conductance levels on 1992 - 1995 sampling dates at Lost River watershed stations, generally moving down through the watershed and at Klamath River state line border.

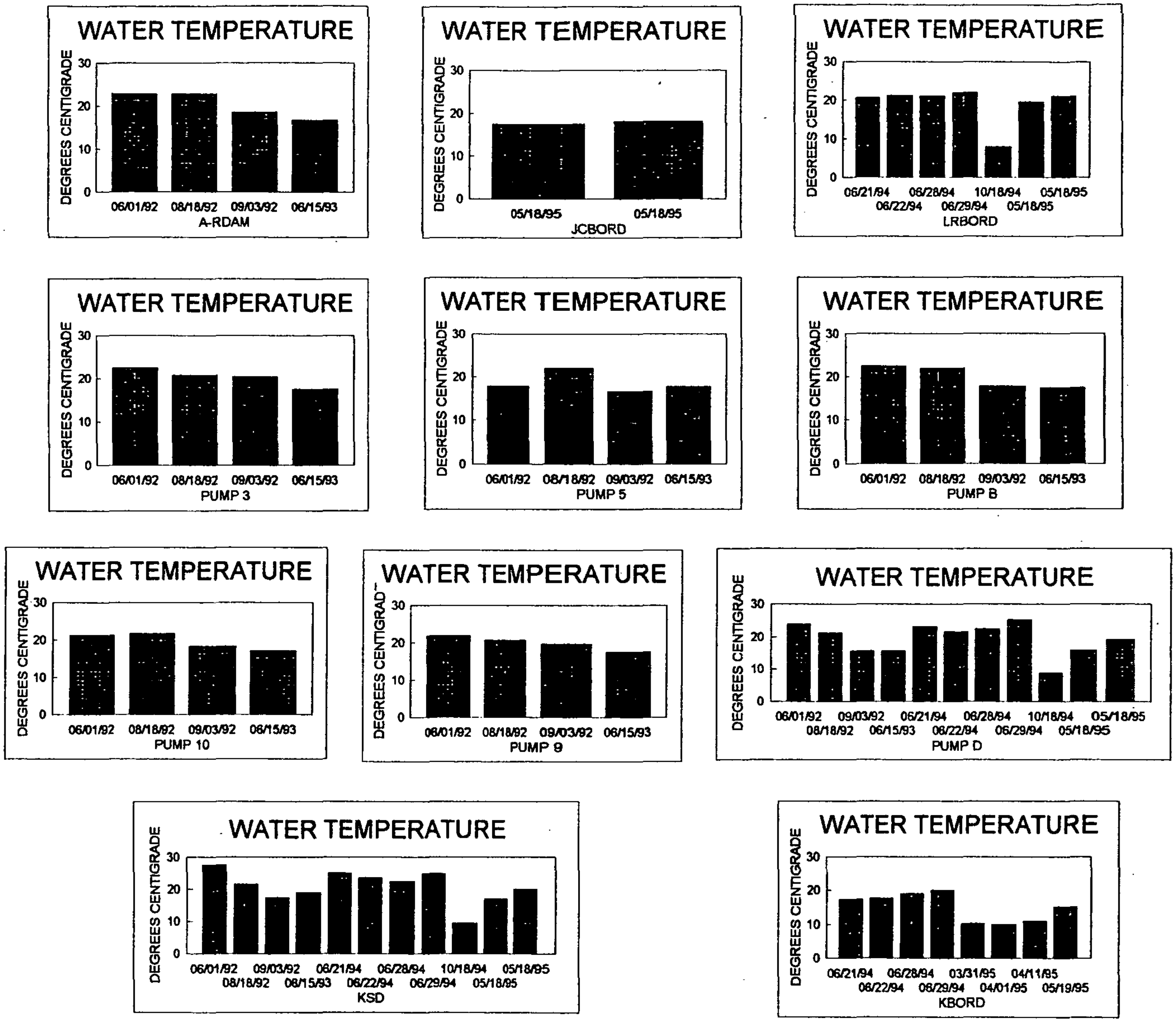


Figure 18. Water Temperatures at individual Lost River watershed stations and at Klamath River state line border, 1992 - 1995.

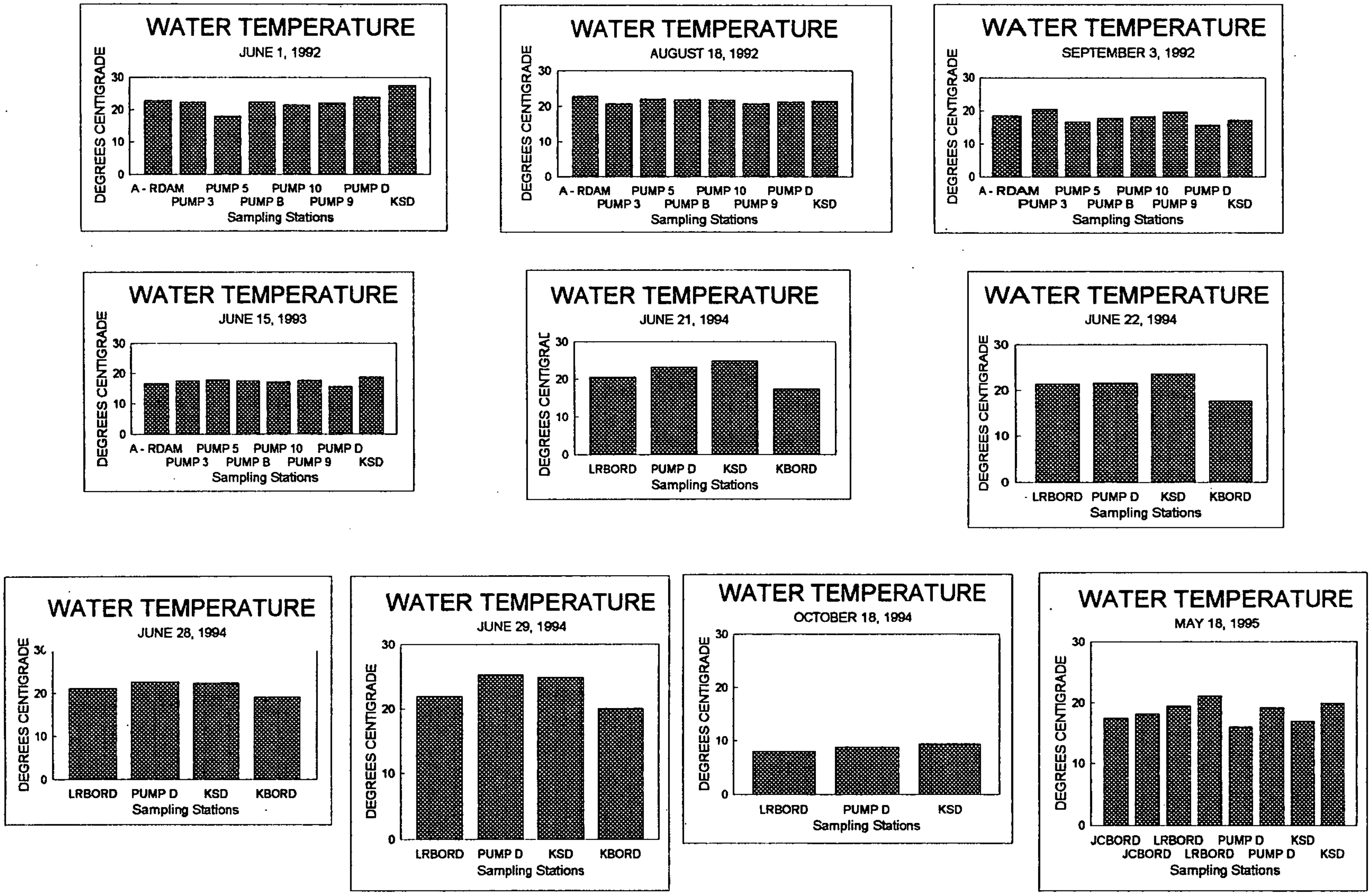


Figure 19. Water Temperatures on 1992 - 1995 sampling dates at Lost River watershed stations, generally moving down through the watershed and at Klamath River state line border.

A review of BOR Klamath Project data for specific conductance levels through the Lost River system will likely give us a better idea about these specific conductance levels regarding any relationships with irrigation practices and movement of water.

Water Temperature

The nutrient cycles and productivity impacts discussed above are accelerated with warmer water temperatures. The slow moving, shallow waters of the lower Lost River system combined with hot summer air temperatures makes for very warm water temperatures.

Water temperatures are displayed in Figures 18 and 19. Water temperatures throughout the lower Lost River system commonly exceeded 20 degrees Centigrade (C) throughout the summer months. Maximum and minimum water temperatures at all stations ranged from a high of 27.5 degrees C at station KSD to a low of 8.0 degrees C at station LRBORD. In the Klamath River at station KBORD, a high of 20.1 degrees C was recorded on June 29, 1994. Water temperatures had dropped substantially in the lower Lost River system by the October 18, 1994 sampling run.

CONCLUSIONS AND RECOMMENDATIONS

The data presented in this report substantiate previously collected data from other agencies and parties in the Lost River system. The lower Lost River system in California exhibits very high summertime levels of un-ionized ammonia, pH, and water temperatures, and low dissolved oxygen levels. How these conditions are related to nonpoint source discharges in California are complex and remain unclear to Regional Board staff. As the California State agency charged with the control of water pollution, it is becoming clear to us that three very specific water quality studies need to be completed as follows:

1) California at times receives water of poor quality in the Lost River and its distribution system from Oregon. The changes in water quality from this point to the Klamath Straits Drain where California then discharges this water back to Oregon are complex and varied. Regional Board staff, in reviewing the data above and from other sources in the context of controllable waste discharges, recommends a site-specific investigation into the issue of high un-ionized ammonia levels. The contribution of ammonia from site-specific fertilizer and irrigation practices and subsequent nonpoint source discharges need to be documented in the Tule Lake basin. The University of California, Davis and Intermountain Research and Extension Center has begun work on this issue (Kaffka, et al., 1995).

2) A correlation, if any, between water quality discharged from the Klamath Straits Drain and water quality in the Klamath River at the California-Oregon state line needs to be investigated. California obviously contributes to water quality conditions in the Klamth Straits drain. California's contribution to this correlation, if any, needs to be a part of this investigation. The best avenue for proceeding with a complex investigation such as this may be a joint effort on the part of both States and irrigation interests through the Clean Water Act Section 205(j) grant program and/or Total Maximum Daily Load process.

3) Regional Board staff recommends coordination with BOR Klamath Project staff for a review of BOR flow data and Datasonde diel data to look at flow/water quality relationships. This is important since water import/export through the lower Lost River system is likely a significant factor in the variations in data observed above for this report. Once this is better understood over time, it could possibly lead to improved timing of water flow for water quality benefits, i.e. flushing refuge cell areas of poor water quality during the fall and winter of wet years.

For data compilation, organization, and interpretation, the North Coast Regional Board should continue to support the Klamath Restoration Information System (KRIS) funded through the Clean Water Act Section 319(h) grant program.

Additionally, the North Coast Regional Board should continue to support stream restoration and rangeland grazing nonpoint source control efforts on the part of landowners, Lava Beds RCD, Modoc National Forest, and the USFWS in the upper Lost River-Clear Lake watershed through the Clean Water Act Section 319(h) grant program.

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APPENDIX "A" NO DATA INDICATED BY A "BLANK SPACE"

STATION	SAMDATE	TIME	CADMIUM ug/L	CHROMIUM ug/L	COPPER ug/L	LEAD ug/L	MERCURY ug/L	NICKEL ug/L	SELENIUM ug/L	SILVER ug/L	ZINC ug/L	ARSENIC mg/L
A - RDAM	06/01/92	11:52	2.5	2.5	10	1		2.5	2.5	10	10	
A - RDAM	08/18/92	07:00										
A - RDAM	09/03/92	13:30										
A - RDAM	06/15/93	07:26	20	20	20	20	0.25	20		20	20	0.006
JCBORD	05/18/95	13:40										
JCBORD	05/18/95	15:15										
LRBORD	06/21/94	16:15	3	10	20	2.5	0.1	20			20	
LRBORD	06/22/94	13:50	3	10	20	2.5	0.1	20			20	
LRBORD	06/28/94	12:20	0.1	1	0.5	4	0.1	1			5	
LRBORD	06/29/94	13:10										
LRBORD	10/18/94	10:10										
LRBORD	05/18/95	13:25										
LRBORD	05/18/95	15:30										
PUMP 3	06/01/92	10:32					0.25					0.005
PUMP 3	08/18/92	06:40					0.25					0.008
PUMP 3	09/03/92	12:20					0.25					0.008
PUMP 3	06/15/93	10:30					0.25					0.007
PUMP 5	06/01/92	08:35					0.25					0.007
PUMP 5	08/18/92	04:36					0.25					0.011
PUMP 5	09/03/92	10:30					0.25					0.014
PUMP 5	06/15/93	08:05	20	20	20	20	0.25	20		20	20	0.014
PUMP B	06/01/92	09:00					0.25					0.010
PUMP B	08/18/92	05:06					0.25					0.011
PUMP B	09/03/92	10:45					0.25					0.012
PUMP B	06/15/93	08:30	20	20	20	20	0.25	20		20	20	0.015
PUMP 10	06/01/92	10:14					0.25					0.012
PUMP 10	08/18/92	05:31					0.25					0.011
PUMP 10	09/03/92	11:15					0.25					0.011
PUMP 10	06/15/93	09:00					0.25					0.014
PUMP 9	06/01/92	09:39	2.5	2.5	10	1	0.25	2.5	2.5	10	10	0.018
PUMP 9	08/18/92	05:55					0.25					0.014
PUMP 9	09/03/92	11:45					0.25					0.014
PUMP 9	06/15/93	09:25					0.25					0.020
PUMP D	06/01/92	11:10	2.5	2.5	10	1		2.5	2.5	10	20	
PUMP D	08/18/92	06:20										
PUMP D	09/03/92	09:45										
PUMP D	06/15/93	10:00	20	20	20	20	1	20		20	20	0.017
PUMP D	06/21/94	16:40	3	10	20	2.5	0.1	20			20	
PUMP D	06/22/94	14:10	3	10	20	2.5	0.1	20			20	
PUMP D	06/28/94	12:45										
PUMP D	06/29/94	13:40										
PUMP D	10/18/94	09:45										
PUMP D	05/18/95	12:45										
PUMP D	05/18/95	15:50										
KSD	06/01/92	12:09	2.5	2.5	10	7		2.5	2.5	10	10	
KSD	08/18/92	07:34										
KSD	09/03/92	09:01										
KSD	06/15/93	11:10	20	20	20	20	0.25	20		20	20	0.023
KSD	06/21/94	15:50	3	10	20	2.5	0.1	20			20	
KSD	06/22/94	13:20	3	10	20	2.5	0.1	20			20	
KSD	06/28/94	11:50	0.1	1	2	2	0.1	4			5	
KSD	06/29/94	12:45										
KSD	10/18/94	10:40										
KSD	05/18/95	12:10										
KSD	05/18/95	16:25										
OD	10/18/94	10:55										
KBORD	06/21/94	09:45	3	10	20	2.5	0.1	20			20	
KBORD	06/22/94	10:10	3	10	20	2.5	0.1	20			20	
KBORD	06/28/94	09:10	1.5	1	0.5	5	0.1	1			5	
KBORD	06/29/94	10:25										
KBORD	03/31/95	11:05										
KBORD	04/01/95	09:40										
KBORD	04/11/95	14:15										
KBORD	05/19/95	10:55										

STATION	SAMDATE	TIME	CYANIDE mg/L	HARDNESS mg/L	CALCIUM mg/L	MAGNESIUM mg/L	SODIUM mg/L	IRON ug/L	CHLORIDE mg/L	SULFATE mg/L	SILICA mg/L	BORON ug/L
A - RDAM	06/01/92	11:52										
A - RDAM	08/18/92	07:00										
A - RDAM	09/03/92	13:30										
A - RDAM	06/15/93	07:26	0.005	96	17.89	12.52	25.18	170	6.2	32	0.125	60
JCBORD	05/18/95	13:40										
JCBORD	05/18/95	15:15										
LRBORD	06/21/94	16:15		74	12.3	8.19	18.6	140	5	2.5	25.0	50
LRBORD	06/22/94	13:50		75	11.9	8.80	22.4	250	5	10	28.0	50
LRBORD	06/28/94	12:20		73								
LRBORD	06/29/94	13:10										
LRBORD	10/18/94	10:10		144	27.8	18.30	41.8	25	12	32	36.8	100
LRBORD	05/18/95	13:25										
LRBORD	05/18/95	15:30										
PUMP 3	06/01/92	10:32										
PUMP 3	08/18/92	06:40										
PUMP 3	09/03/92	12:20										
PUMP 3	06/15/93	10:30		157	33.37	18.57	39.59	120	6.5	193	0.125	70
PUMP 5	06/01/92	08:35										
PUMP 5	08/18/92	04:36										
PUMP 5	09/03/92	10:30										
PUMP 5	06/15/93	08:05	0.005	133	24.01	17.69	39.34	100	6.5	76	0.125	80
PUMP B	06/01/92	09:00										
PUMP B	08/18/92	05:06										
PUMP B	09/03/92	10:45										
PUMP B	06/15/93	08:30	0.005	172	37.41	20.46	53.44	90	8.7	142	0.125	80
PUMP 10	06/01/92	10:14										
PUMP 10	08/18/92	05:31										
PUMP 10	09/03/92	11:15										
PUMP 10	06/15/93	09:00		182	38.51	22.28	53.83	200	6.2	215	0.125	90
PUMP 9	06/01/92	09:39										
PUMP 9	08/18/92	05:55										
PUMP 9	09/03/92	11:45										
PUMP 9	06/15/93	09:25	0.005	301	52.66	42.60	109.72	180	16.7	275	0.125	160
PUMP D	06/01/92	11:10										
PUMP D	08/18/92	06:20										
PUMP D	09/03/92	09:45										
PUMP D	06/15/93	10:00		308	56.12	40.81	98.22	320	11.2	266	0.125	150
PUMP D	06/21/94	16:40		148	29.3	18.70	59.2	130	10	92	17.0	50
PUMP D	06/22/94	14:10		142	30.5	17.90	57.9	140	10	98	18.0	50
PUMP D	06/28/94	12:45										
PUMP D	06/29/94	13:40										
PUMP D	10/18/94	09:45		230	37.4	31.70	97.4	25	20	110	48.8	191
PUMP D	05/18/95	12:45										
PUMP D	05/18/95	15:50										
KSD	06/01/92	12:09										
KSD	08/18/92	07:34										
KSD	09/03/92	09:01										
KSD	06/15/93	11:10	0.005	284	50.64	40.28	101.33	480	19.9	339	0.125	160
KSD	06/21/94	15:50		331	56.8	53.20	138.0	470	28	380	21.0	520
KSD	06/22/94	13:20		304	47.9	46.90	122.0	210	27	321	16.0	430
KSD	06/28/94	11:50		330								
KSD	06/29/94	12:45										
KSD	10/18/94	10:40		190	43.3	21.90	33.1	25	11	62	51.3	228
KSD	05/18/95	12:10										
KSD	05/18/95	16:25										
OD	10/18/94	10:55		58	14.1	6.96	16.2	53.4	8	7	49.0	81
KBORD	06/21/94	09:45		75	12.5	9.25	24.1	50	6	25	22.0	50
KBORD	06/22/94	10:10		75	13.3	8.60	22.5	50	8	18	23.0	50
KBORD	06/28/94	09:10		65								
KBORD	06/29/94	10:25										
KBORD	03/31/95	11:05		73	18	8.00	23.0	166	6	33	34.1	76
KBORD	04/01/95	09:40										
KBORD	04/11/95	14:15										
KBORD	05/19/95	10:55										

APPENDIX "A" (CONTINUED)

NO DATA INDICATED BY A "BLANK SPACE"

STATION	SAMDATE	TIME	ALKALINITY mg/L	CARBONATE mg/L	BICARBONATE mg/L	CO2 mg/L	TDS mg/L	EC umhos/cm	pH units	TKN mg/L	NH3-N mg/L	NO3 mg/L	NO2 mg/L
A - RDAM	06/01/92	11:52						208	5.40	1.60	0.120	0.090	0.015
A - RDAM	08/18/92	07:00						230	7.59	2.10	0.290	0.140	0.060
A - RDAM	09/03/92	13:30						252	8.70	2.20	0.290		
A - RDAM	06/15/93	07:26	114	0.5	139	0.5	177	210	9.00		0.340	0.100	
JCBORD	05/18/95	13:40						297	8.80				
JCBORD	05/18/95	15:15						298	8.70				
LRBORD	06/21/94	16:15	98	0.5	120		156	227	7.96	2.90	1.000	0.025	0.005
LRBORD	06/22/94	13:50	111	0.5	135		162	262	7.48	5.20	2.600	0.025	0.005
LRBORD	06/28/94	12:20						259	7.60	3.90	2.000	0.050	0.005
LRBORD	06/29/94	13:10						212	8.10	1.80	1.100	0.050	0.005
LRBORD	10/18/94	10:10	182		223			412	9.70	1.50	0.390	0.470	
LRBORD	05/18/95	13:25						220	9.10				
LRBORD	05/18/95	15:30						213	9.20				
PUMP 3	06/01/92	10:32						282	5.30	1.50	0.120	0.070	0.030
PUMP 3	08/18/92	06:40						283	7.42	2.30	0.510	0.260	0.080
PUMP 3	09/03/92	12:20						273	8.40	3.10	1.100		
PUMP 3	06/15/93	10:30	150	0.5	183	0.5	285	465	8.70		0.370	0.100	
PUMP 5	06/01/92	08:35						258	6.20	2.00	0.120	0.090	0.015
PUMP 5	08/18/92	04:36						359	7.31	4.60	0.440	0.015	0.015
PUMP 5	09/03/92	10:30						359	8.00	1.60	0.290		
PUMP 5	06/15/93	08:05	155	0.5	189	0.5	268	410	9.10		0.230	0.100	
PUMP B	06/01/92	09:00						601	4.80	2.30	0.340	1.200	0.190
PUMP B	08/18/92	05:06						501	7.45	1.80	0.160	0.520	0.110
PUMP B	09/03/92	10:45						526	8.50	1.70	0.190		
PUMP B	06/15/93	08:30	194	0.5	237	0.5	383	543	8.80		0.220	0.290	
PUMP 10	06/01/92	10:14						960	5.70	4.00	1.500	0.150	0.060
PUMP 10	08/18/92	05:31						589	7.79	3.70	0.290	0.015	0.100
PUMP 10	09/03/92	11:15						474	8.70	4.80	0.750		
PUMP 10	06/15/93	09:00	181	0.5	221	0.5	358	550	9.10		0.280	0.100	
PUMP 9	06/01/92	09:39						1,169	5.60	4.30	0.650	0.160	0.130
PUMP 9	08/18/92	05:55						1,162	8.39	6.40	1.700	0.015	0.030
PUMP 9	09/03/92	11:45						972	10.00	4.70	0.610		
PUMP 9	06/15/93	09:25	267	0.5	326	0.5	689	997	8.40		1.430	1.370	
PUMP D	06/01/92	11:10						491	5.00	2.10	0.180	0.030	0.015
PUMP D	08/18/92	06:20						527	9.62	3.50	0.100	0.015	0.015
PUMP D	09/03/92	09:45						657	9.50	3.70	0.350		
PUMP D	06/15/93	10:00	237	0.5	289	0.5	667	904	8.80		1.100	0.100	
PUMP D	06/21/94	16:40	144	72.0	29		363	556	10.20	1.60	0.200	0.025	0.005
PUMP D	06/22/94	14:10	138	62.0	41		361	541	10.20	2.50	0.300	0.025	0.005
PUMP D	06/28/94	12:45						478	9.90	1.90	0.140	0.050	0.005
PUMP D	06/29/94	13:40						495	10.00	1.80	0.120	0.050	0.005
PUMP D	10/18/94	09:45	213		260			699	9.60	7.10	1.250	0.125	
PUMP D	05/18/95	12:45						647	8.40				
PUMP D	05/18/95	15:50						636	8.40				
KSD	06/01/92	12:09						537	4.60	3.80	0.240	0.070	0.015
KSD	08/18/92	07:34						549	8.66	3.80	0.130	0.015	0.015
KSD	09/03/92	09:01						646	8.70	7.80	0.070		
KSD	06/15/93	11:10	231	0.5	282	4.4	639	932	8.40		0.850	1.440	
KSD	06/21/94	15:50	167	12.0	179		885	1,207	8.99	3.70	0.200	0.025	0.005
KSD	06/22/94	13:20	152	22.0	140		777	1,166	9.12	3.20	0.200	0.025	0.005
KSD	06/28/94	11:50						1,430	9.00	3.60	0.210	0.050	0.005
KSD	06/29/94	12:45						1,548	9.20	6.00	0.210	0.050	0.005
KSD	10/18/94	10:40	193		235			464	8.60	2.40	0.320	0.290	
KSD	05/18/95	12:10						777	8.70				
KSD	05/18/95	16:25						708	8.70				
OD	10/18/94	10:55	86		105			194	9.20	1.60	0.340	0.125	
KBORD	06/21/94	09:45	84	0.5	102		168	251	8.81	0.50	0.200	0.150	0.005
KBORD	06/22/94	10:10	81	0.5	99		161	237	8.58	0.40	0.200	0.150	0.005
KBORD	06/28/94	09:10						237	7.70	1.10	0.100	1.000	0.005
KBORD	06/29/94	10:25						231	8.30	1.00	0.110	0.300	0.005
KBORD	03/31/95	11:05	84	0.5	102		240	220	8.10	0.25	0.025	0.500	0.005
KBORD	04/01/95	09:40						229	8.10				
KBORD	04/11/95	14:15						197	8.30				
KBORD	05/19/95	10:55						190	8.10				

STATION	SAMDATE	TIME	NO3-NO2 mg/L	TPO4 mg/L	OPO4 mg/L	TSS mg/L	H2O-T 'C	DO2 mg/L	AIR-T 'C	HYDROXIDE mg/L	CHLOROPHYLL-A mg/L
A - RDAM	06/01/92	11:52		0.280	0.19		22.80	5.4			
A - RDAM	08/18/92	07:00		0.410	0.22		22.84				
A - RDAM	09/03/92	13:30	0.330	0.410			18.60	3.3			
A - RDAM	06/15/93	07:26		0.200			16.80	7.4		0.5	
JCBORD	05/18/95	13:40					17.50	9.8	23.0		
JCBORD	05/18/95	15:15					18.20	9.8	24.8		
LRBORD	06/21/94	16:15		0.440	0.38	18	20.69				
LRBORD	06/22/94	13:50		0.800	0.62	16	21.36				
LRBORD	06/28/94	12:20		0.500	0.31		21.10	3.0	29.9		
LRBORD	06/29/94	13:10		0.300	0.19		22.00	2.2	24.4		0.020
LRBORD	10/18/94	10:10		0.025			8.00	11.5			
LRBORD	05/18/95	13:25					19.50	13.9	23.0		
LRBORD	05/18/95	15:30					21.10	14.2	25.5		
PUMP 3	06/01/92	10:32		0.400	0.30		22.40	7.6			
PUMP 3	08/18/92	06:40		0.700	0.47		20.79				
PUMP 3	09/03/92	12:20	0.260	0.340			20.40	4.6			
PUMP 3	06/15/93	10:30		0.290			17.50	9.8		0.5	
PUMP 5	06/01/92	08:35		0.400	0.31		18.00	5.8			
PUMP 5	08/18/92	04:36		0.850	0.43		22.09				
PUMP 5	09/03/92	10:30	0.810	0.520			16.70	3.4			
PUMP 5	06/15/93	08:05		0.240			17.90	7.7		0.5	
PUMP B	06/01/92	09:00		0.410	0.32		22.50	9.0			
PUMP B	08/18/92	05:06		0.520	0.36		22.01				
PUMP B	09/03/92	10:45	0.270	0.470			17.90	7.4			
PUMP B	06/15/93	08:30		0.270			17.50	7.0		0.5	
PUMP 10	06/01/92	10:14		0.940	0.46		21.50	5.9			
PUMP 10	08/18/92	05:31		0.730	0.39		21.86				
PUMP 10	09/03/92	11:15	0.200	0.670			18.40	6.4			
PUMP 10	06/15/93	09:00		0.260			17.20	6.7		0.5	
PUMP 9	06/01/92	09:39		0.680	0.49		22.10	7.7			
PUMP 9	08/18/92	05:55		0.810	0.55		20.81				
PUMP 9	09/03/92	11:45	0.015	0.450			19.70	10.2			
PUMP 9	06/15/93	09:25		0.400			17.70	3.0		0.5	
PUMP D	06/01/92	11:10		0.360	0.29		24.00	9.5			
PUMP D	08/18/92	06:20		0.320	0.10		21.28				
PUMP D	09/03/92	09:45	0.015	0.250			15.80	3.9			
PUMP D	06/15/93	10:00		0.280			15.70	8.5		0.5	
PUMP D	06/21/94	16:40		0.190	0.19	18	23.14				
PUMP D	06/22/94	14:10		0.170	0.17	19	21.60				
PUMP D	06/28/94	12:45		0.260	0.16		22.60	10.0	20.3		
PUMP D	06/29/94	13:40		0.240	0.16		25.30	10.6	28.3		0.005
PUMP D	10/18/94	09:45		0.025			8.80	2.7			
PUMP D	05/18/95	12:45					16.00	7.5	23.0		
PUMP D	05/18/95	15:50					19.20	7.8	25.0		
KSD	06/01/92	12:09		0.540	0.21		27.50	6.9			
KSD	08/18/92	07:34		0.600	0.16		21.51				
KSD	09/03/92	09:01	0.015	1.200			17.30	7.5			
KSD	06/15/93	11:10		0.230			18.90	6.2		0.5	
KSD	06/21/94	15:50		0.410	0.40	10	24.96				
KSD	06/22/94	13:20		0.600	0.54	9	23.55				
KSD	06/28/94	11:50		0.560	0.44		22.40	10.0	23.4		
KSD	06/29/94	12:45		0.630	0.43		24.90	12.4	26.8		0.005
KSD	10/18/94	10:40		0.060			9.40	4.4			
KSD	05/18/95	12:10					17.00	8.3	23.0		
KSD	05/18/95	16:25					19.90	9.9	24.5		
OD	10/18/94	10:55		0.025			9.30	7.6			
KBORD	06/21/94	09:45		0.160	0.16	6	17.31				
KBORD	06/22/94	10:10		0.260	0.25	3	17.65				
KBORD	06/28/94	09:10		0.210	0.16		19.10	8.0	20.2		
KBORD	06/29/94	10:25		0.190	0.14		20.10	10.2	23.3		0.005
KBORD	03/31/95	11:05		0.060	0.07		10.30	11.2	19.5	0.5	
KBORD	04/01/95	09:40					10.00	10.4	16.5		
KBORD	04/11/95	14:15					11.00	10.5	21.0		
KBORD	05/19/95	10:55					15.10	9.1	26.0		

APPENDIX "A" (CONTINUED)

DATA USED FOR CALCULATING UN - IONIZED AMMONIA CALCULATIONS
Expressed in mg/L

STN	SAMDATE	TIME	NH3-N mg/l	TOTAL AMMONIA	pH units	H2O-T 'C	pKa	UN-IONIZED AMMONIA
A - RDAM	06/01/92	11:52	0.120	0.146	5.40	22.80	9.31	0.000
A - RDAM	08/18/92	07:00	0.290	0.353	7.59	22.84	9.31	0.007
A - RDAM	09/03/92	13:30	0.290	0.353	8.70	18.60	9.45	0.053
A - RDAM	06/15/93	07:26	0.340	0.414	9.00	16.80	9.5	0.099
LRBORD	06/21/94	16:15	1.000	1.217	7.96	20.69	9.38	0.044
LRBORD	06/22/94	13:50	2.600	3.163	7.48	21.36	9.36	0.041
LRBORD	06/28/94	12:20	2.000	2.433	7.60	21.10	9.37	0.041
LRBORD	06/29/94	13:10	1.100	1.338	8.10	22.00	9.34	0.073
LRBORD	10/18/94	10:10	0.390	0.474	9.70	8.00	9.80	0.210
PUMP 3	06/01/92	10:32	0.120	0.146	5.30	22.40	9.33	0.000
PUMP 3	08/18/92	06:40	0.510	0.620	7.42	20.79	9.38	0.007
PUMP 3	09/03/92	12:20	1.100	1.338	8.40	20.40	9.39	0.124
PUMP 3	06/15/93	10:30	0.370	0.450	8.70	17.50	9.48	0.064
PUMP 5	06/01/92	08:35	0.120	0.146	6.20	18.00	9.46	0.000
PUMP 5	08/18/92	04:36	0.440	0.535	7.31	22.09	9.33	0.005
PUMP 5	09/03/92	10:30	0.290	0.353	8.00	16.70	9.51	0.011
PUMP 5	06/15/93	08:05	0.230	0.280	9.10	17.90	9.47	0.084
PUMP B	06/01/92	09:00	0.340	0.414	4.80	22.50	9.32	0.000
PUMP B	08/18/92	05:06	0.160	0.195	7.45	22.01	9.34	0.002
PUMP B	09/03/92	10:45	0.190	0.231	8.50	17.90	9.47	0.022
PUMP B	06/15/93	08:30	0.220	0.268	8.80	17.50	9.48	0.046
PUMP 10	06/01/92	10:14	1.500	1.825	5.70	21.50	9.35	0.000
PUMP 10	08/18/92	05:31	0.290	0.353	7.79	21.86	9.34	0.010
PUMP 10	09/03/92	11:15	0.750	0.912	8.70	18.40	9.45	0.138
PUMP 10	06/15/93	09:00	0.280	0.341	9.10	17.20	9.49	0.099
PUMP 9	06/01/92	09:39	0.650	0.791	5.60	22.10	9.33	0.000
PUMP 9	08/18/92	05:55	1.700	2.068	8.39	20.81	9.38	0.192
PUMP 9	09/03/92	11:45	0.610	0.742	10.00	19.70	9.41	0.590
PUMP 9	06/15/93	09:25	1.430	1.740	8.40	17.70	9.47	0.136
PUMP D	06/01/92	11:10	0.180	0.219	5.00	24.00	9.28	0.000
PUMP D	08/18/92	06:20	0.100	0.122	9.62	21.28	9.36	0.079
PUMP D	09/03/92	09:45	0.350	0.426	9.50	15.80	9.54	0.203
PUMP D	06/15/93	10:00	1.100	1.338	8.80	15.70	9.54	0.206
PUMP D	06/21/94	16:40	0.200	0.243	10.20	23.14	9.30	0.216
PUMP D	06/22/94	14:10	0.300	0.365	10.20	21.60	9.35	0.320
PUMP D	06/28/94	12:45	0.140	0.170	9.90	22.60	9.32	0.135
PUMP D	06/29/94	13:40	0.120	0.146	10.00	25.30	9.24	0.125
PUMP D	10/18/94	09:45	1.250	1.521	9.60	8.80	9.77	0.613
KSD	06/01/92	12:09	0.240	0.292	4.60	27.50	9.17	0.000
KSD	08/18/92	07:34	0.130	0.158	8.66	21.51	9.35	0.027
KSD	09/03/92	09:01	0.070	0.085	8.70	17.30	9.49	0.012
KSD	06/15/93	11:10	0.850	1.034	8.40	18.90	9.44	0.086
KSD	06/21/94	15:50	0.200	0.243	8.99	24.96	9.25	0.087
KSD	06/22/94	13:20	0.200	0.243	9.12	23.55	9.29	0.098
KSD	06/28/94	11:50	0.210	0.255	9.00	22.40	9.33	0.082
KSD	06/29/94	12:45	0.210	0.255	9.20	24.90	9.25	0.121
KSD	10/18/94	10:40	0.320	0.389	8.60	9.40	9.75	0.026
OD	10/18/94	10:50	0.340	0.414	9.20	9.30	9.75	0.090
KBORD	06/21/94	09:45	0.200	0.243	8.81	17.31	9.49	0.042
KBORD	06/22/94	10:10	0.200	0.243	8.58	17.65	9.48	0.027
KBORD	06/28/94	09:10	0.100	0.122	7.70	19.10	9.43	0.002
KBORD	06/29/94	10:25	0.110	0.134	8.30	20.10	9.40	0.010
KBORD	03/31/95	11:05	0.025	0.030	8.10	10.30	9.72	0.001

FORMULAS USED:

$$\text{Un-ionized ammonia} = \frac{\text{total ammonia}}{1 + 10.0^{(pka - pH)}}$$

Total ammonia = NH3-N / 0.822