United States Department of the Interior

BUREAU OF RECLAMATION

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IN REPLY REFER TO:

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RES-3.20

OCT 10 1995

MEMORANDUM

To: All on Attached List

From: David L. Wegner, Acting Manager
Technical Service Center, Environmental Resources Service
Glen Canyon Environmental Studies Group

Subject: Results of September 1995 Quarterly Water Quality Monitoring Survey - Lake Powell

Enclosed are the results of the quarterly water quality monitoring survey of Lake Powell conducted by the Bureau of Reclamation Glen Canyon Environmental Studies. The report summarizes late summer limnological conditions observed from September 6 to September 13, 1995.

Profiles were collected for the physical parameters of temperature, specific conductance, dissolved oxygen, pH, oxidation/reduction potential and turbidity at 28 stations on Lake Powell (see Table I). Secchi transparency, weather conditions, and other observations were recorded at each station. At 17 locations, water samples were collected for laboratory determination of major ionic constituents, nutrients, and, in 7 cases, selected trace elements. Biological samples for chlorophyll, phytoplankton, and zooplankton were collected at 17 to 19 sites. Shipboard alkalinity measurements were taken to gather baseline data for carbonate precipitation dynamics at selected sites.

Data from this program is processed by the GCES office and stored in the Ingres WQWM database for subsequent retrieval. This database contains 30 years of information from various phases of Reclamation's long-term monitoring effort on Lake Powell, and is available to the public.

Appreciation is expressed to the crew (Robert Radtke, LeAnn Skrzynski, Kevin Berghoff, John Nagy, Jeff Wilkerson), agencies (Upper Colorado Region of USBR, Glen Canyon National Recreation Area, and GCES) and many others who aided in the sampling and monitoring effort.

This report was developed to distribute the information collected by Reclamation's Lake Powell program to those interested in conditions in the lake. Please direct any questions or requests for further information to Susan Hueftle (email: shueftle@gces.uc.usbr.gov) or Bill Vernieu (bvernieu@gces.uc.usbr.gov), phone: (520) 556-7363. Your comments, suggestions, and feedback are encouraged. To eliminate needless mailings, please indicate your desire to remain on this list of recipients for future reports.

Dave Wegner

Attachments: mailing list
10 figures

TRIP REPORT FOR LAKE POWELL QUARTERLY WATER QUALITY MONITORING SURVEY

SEPTEMBER 6 TO SEPTEMBER 13, 1995

CURRENT STATUS OF LAKE POWELL

The floods experienced in the spring and early summer have left their mark on Lake Powell. The lake reached its highest elevation in eight years on August 3rd, peaking at 3693.75 feet amsl--6.25 feet below full pool. The lake is dropping slowly and over the 7 days of sampling, fell from 3690.69 to 3689.93 feet. Dam operators will continue to release high monthly volumes to meet the target reservoir content levels by January 1, 1996. The experimental spike flood releases are still scheduled for next spring.

The localized fecal coliform contamination that occurred last summer around popular beaches has abated, though Glen Canyon National Recreation Area continues its monitoring.

A over flight of Lake Powell was made on August 8th from the USBR helicopter. Inundated vegetation was videotaped as well as the "whiting" of the lake from the dam to above Dangling Rope Marina, and in sections of the Escalante channel. The "whiting" or bright turquoise color results from calcium carbonate precipitating in the lake waters, a phenomena that occurs regularly in late summer at Lake Powell. The causes are complex and interrelate temperature, algal activity, ion concentrations and probably other factors. Unfortunately, only a few side canyons near the dam were in the turquoise color phase at the time of the sampling, and further observations and evaluation are necessary.

Twenty eight stations were sampled on this survey, listed below in Table I. For site locations, refer to the map in figure 1.

TABLE 1: STATIONS SAMPLED ON THE SEPTEMBER 1995 LAKE POWELL WATER QUALITY MONITORING SURVEY

Main Channel Stations (kilometers from dam)		San Juan Arm (kilometers from main channel)	
Wahweap	2.4	Cha Canyon	19.3
Crossing of the Fathers	45.3	Lower Piute Bay	32.9
Oak Canyon	90.5	Upper Piute Bay	43.1
San Juan Confluence	100.1	Lower Zahn Bay	62.5
Escalante	116.9	Nokai Canyon	72.0
Iceberg Canyon	140.0		
Lake Canyon	158.7	**Escalante Arm (kilometers from main channel)**	
Bullfrog Bay	169.2	Davis Gulch	11.9
Moki Canyon	177.2	Cow-Fence Canyons	31.9
Knowles Canyon	193.3	Escalante inflow	39.7
Lower Good Hope Bay	208.5		
Scorup Canyon	225.5	**Miscellaneous Stations (off main channel)**	
Hite Basin	238.7	Navajo Canyon	12.4
North Wash gap	248.3	Face Canyon	3.9
Hite Bridge	252.1	Labyrinth Canyon	
Palmer Canyon	289.7		
Colorado River inflow, Below Imperial Canyon	299.0		

RESULTS AND DISCUSSION:

BIOLOGICAL SAMPLING:

Analysis of phytoplankton and zooplankton samples is not yet available. Observations made during sampling suggested the greatest numbers of zooplankton (primarily cladocerans followed by copepods) lived below the epilimnion, from 10 to 20 meters, in most of the lake. Diatoms were the most common algae seen, with *Lyngbya* sp. evident closer to the dam.

Chlorophyll analysis (figure 3) demonstrates the typical trend of highest productivity in the inflows, decreasing downstream as nutrients are exploited or settle out of the water column. Chlorophyll-*a* values peaked in the Colorado River below Imperial Canyon at 19 mg/m^3. Surface values ranged between 5 to 10 mg/m^3 in the transitional zone from Bullfrog to Hite Marina, and 1 to 2 mg/m^3 from the dam to Bullfrog. Similar trends occurred in the San Juan and Escalante arms, peaking around 6 and 10 mg/m^3, respectively.

Results from chemical analysis will be reported when available.

PHYSICAL DATA AND ANALYSIS:

Late summer conditions at Lake Powell were strongly marked by 4 distinct strata in the reservoir. The epilimnion occupied the top 10 meters; the spring-summer flood water lay beneath at approximately 10 to 45 meters; an upper hypolimnion occurred from about 40 to 75 meters, and a lower hypolimnion rested from approximately 75 meters to the bottom. Isopleths (contour maps) of the water-quality parameters for each arm of Lake Powell are included in figures 2, 4, 5, and 7. These plots represent two-dimensional cross-sections of Powell's three main river channels (Colorado, San Juan and Escalante) from the deepest areas to the inflows. This representation of water quality is valuable in showing patterns that exist throughout the lake such as inflow density currents, thermal stratification patterns, or areas of oxygen minima or maxima.

Also included in this report are individual profiles of six stations that detail the progression of physical conditions from the dam to the inflow on Lake Powell. These profiles represent changes in temperature, specific conductance, dissolved oxygen, pH, ORP, and turbidity with depth. They are helpful in tracking how various physical parameters are influenced by each other.

Throughout the lake the epilimnion was consistently truncated at about 10 meters of depth with a steep gradient in temperature, dissolved oxygen, conductivity, pH, and oxidation/ reduction potential. Temperature ranged from 25 to 27°C, and dissolved oxygen values had dropped from late spring values of 8 to 9 mg/L to 6 to 8 mg/L, with the low point centered at the confluence of the Escalante River (figure 2). The dissolved oxygen was also depressed near the inflow where the late summer river discharges produced a high biological oxygen demand. Conductivity values (figure 4) in the epilimnion were higher near the dam; lowest values occurred near Iceberg Canyon (river kilometer 140) where the summer flood was mixing with the epilimnion. From Lake Canyon (159 km) to Hite Marina (248 km) the warmer, highly saline waters of the late summer inflows can be seen at about 7 to 20 meters between the surface and the fresher, cooler, earlier summer flood waters. The precipitous drop in the hydrograph (figure 6) between late July and mid August helps explain the difference in the spring-summer floods and the late summer flow. The lower stream discharge produces higher temperatures, in combination with other basin conditions, with the resultant elevation of dissolved salts. The Colorado River at Imperial Canyon was flowing at 960 µS/cm , 23.5°C, 6.74 mg/L dissolved oxygen, and pH 8.39.

The slug of spring and summer flood water with its signature low conductivity (360's to 600 µS/cm) distinguishes the summer reservoir from near the dam to the Hite Marina (a distance of 230 km). Its boundaries (see figures 2 and 4) are characterized by a lower pH of 7.4 to 7.6, and by depressed dissolved oxygen values, reflecting the continued effect of the higher biological oxygen demand resulting from organic matter and nutrients associated with the riverine water. A rough approximation of the flood's velocity through the lake can be made by tracing the leading edge of low conductivity from June to September, returning a value of approximately 2.2 kilometers per day (or 2.5 cm/sec). This powerful advective current has pushed through and over last year's lake water.

Below these flood waters, from about 40 meters down to 75 to 90 meters is an upper hypolimnion characterized by higher dissolved oxygen left from last winter's mixing and its accompanying elevated pH. We can also see conductivities of 700 µS/cm, typical of last winter's surface water, especially from Iceberg Canyon to the dam. Another chemocline occurs at a depth of 75 m to 100 m where the cold (~7 to 8 °C), saline, (900 to 990 µS/cm) deep hypolimnetic waters occur, showing almost no change since last June's sampling.

As noted earlier, conditions in the San Juan and Escalante arms paralleled those found in the mainstem of Lake Powell. The four strata were present; but in different proportions. The Escalante's inflow (see figure 7) had a conductivity of 510 to 590 µS/cm, and a temperature of 24 to 27 °C. No flow could be distinguished at the upper navigable endpoint of the Escalante arm and some stratification was evident. This observation is reinforced by the lack of a noticeable "late summer" high conductivity plume near the surface. Dissolved oxygen values in the upper 40 meters of the arm had decreased from 9 to 11 mg/L in June to no greater than 7 mg/L in September, a result of the summer's productivity and the advective introduction of organic matter. Figure 2 demonstrates how the lowered oxygen content of the Escalante arm impacts the entire depth of the main channel at its confluence.

The San Juan arm (figure 5) clearly demonstrates a thin wedge of saline, late summer river water near the surface of the lake. While the samples were not taken in visibly flowing water, results indicate the San Juan River inflow had a conductivity of ~380 µS/cm.

CONCLUSIONS

The spring and summer floods waters are dominating the current flow patterns in the lake. The high inflows will clearly have a marked affect on the reservoir in the future, as has been indicated in past high water years. Chemical and biological analyses for this sampling should help determine existing and potential energy flow in the Lake Powell system. Glen Canyon Environmental Studies continues its commitment to long-term monitoring of Lake Powell.

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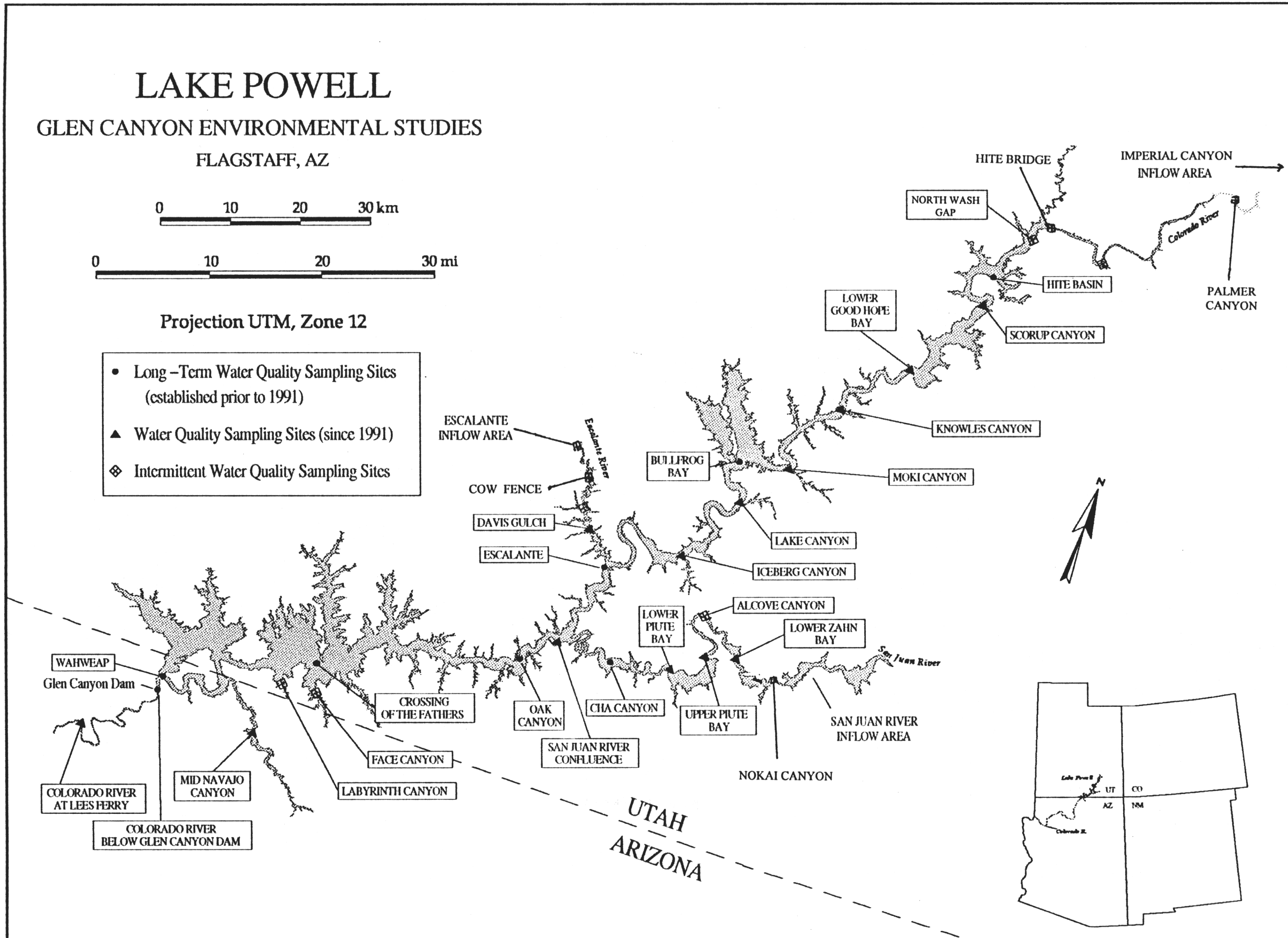


LAKE POWELL
GLEN CANYON ENVIRONMENTAL STUDIES
FLAGSTAFF, AZ
0
10
20
30 km
0
10
20
30 mi
Projection UTM, Zone 12
Long –Term Water Quality Sampling Sites (established prior to 1991)
Water Quality Sampling Sites (since 1991)
Intermittent Water Quality Sampling Sites
HITE BRIDGE
IMPERIAL CANYON INFLOW AREA
NORTH WASH GAP
Colorado River
HITE BASIN
PALMER CANYON
LOWER GOOD HOPE BAY
SCORUP CANYON
KNOWLES CANYON
ESCALANTE INFLOW AREA
Escalante River
BULLFROG BAY
MOKI CANYON
COW FENCE
DAVIS GULCH
LAKE CANYON
N
ESCALANTE
ICEBERG CANYON
LOWER PIUTE BAY
ALCOVE CANYON
LOWER ZAHN BAY
San Juan River
WAHWEAP
Glen Canyon Dam
CROSSING OF THE FATHERS
OAK CANYON
CHA CANYON
UPPER PIUTE BAY
SAN JUAN RIVER INFLOW AREA
FACE CANYON
SAN JUAN RIVER CONFLUENCE
NOKAI CANYON
COLORADO RIVER AT LEES FERRY
MID NAVAJO CANYON
LABYRINTH CANYON
UT
CO
AZ
NM
UTAH
ARIZONA
COLORADO RIVER BELOW GLEN CANYON DAM

FIGURE 1:

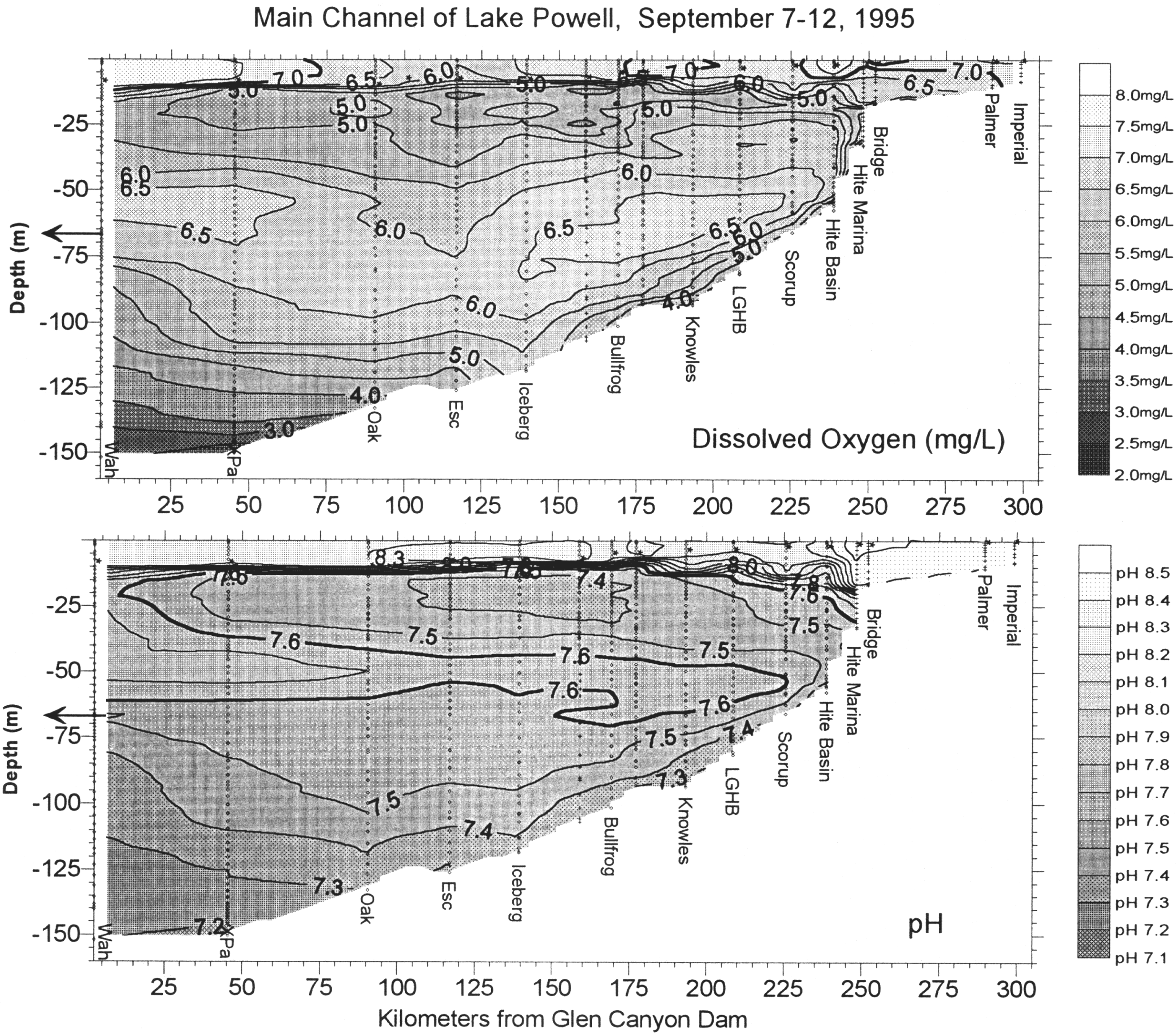


Figure 2: Dissolved oxygen (mg/L) and pH in the main channel of Lake Powell, September 7-12, 1995. Secchi disk depths represented by * asterisks. Penstock depth at 67 meters indicated by arrow.

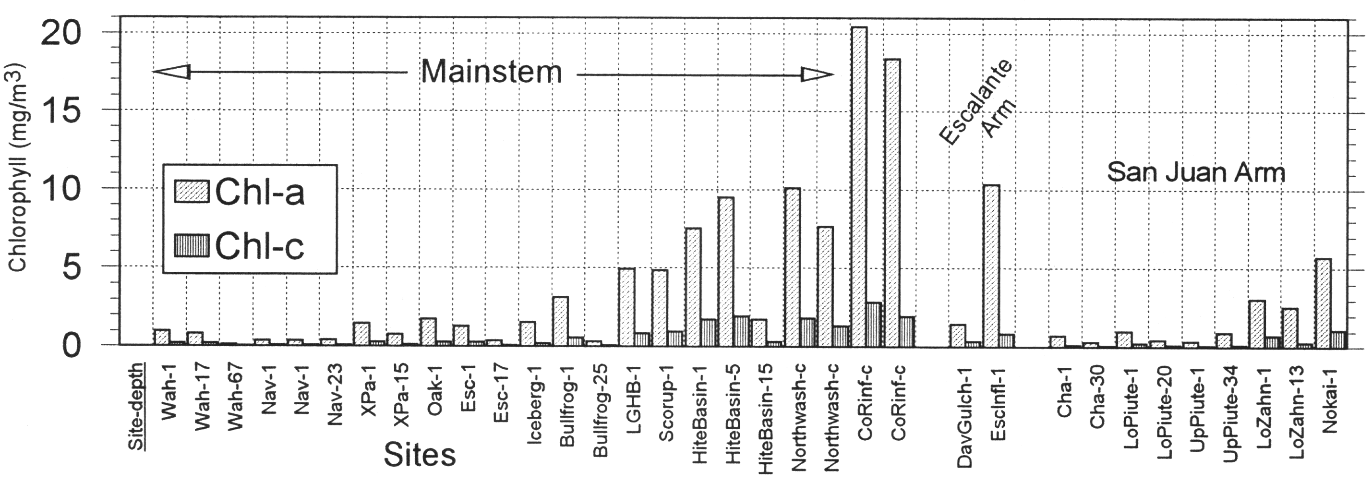


Figure 3: Concentrations of chlorophyll a and c (mg/m^3) in the mainstem, Escalante, and San Juan arms of Lake Powell, proceeding left to right from downstream sites to inflow areas for each arm.

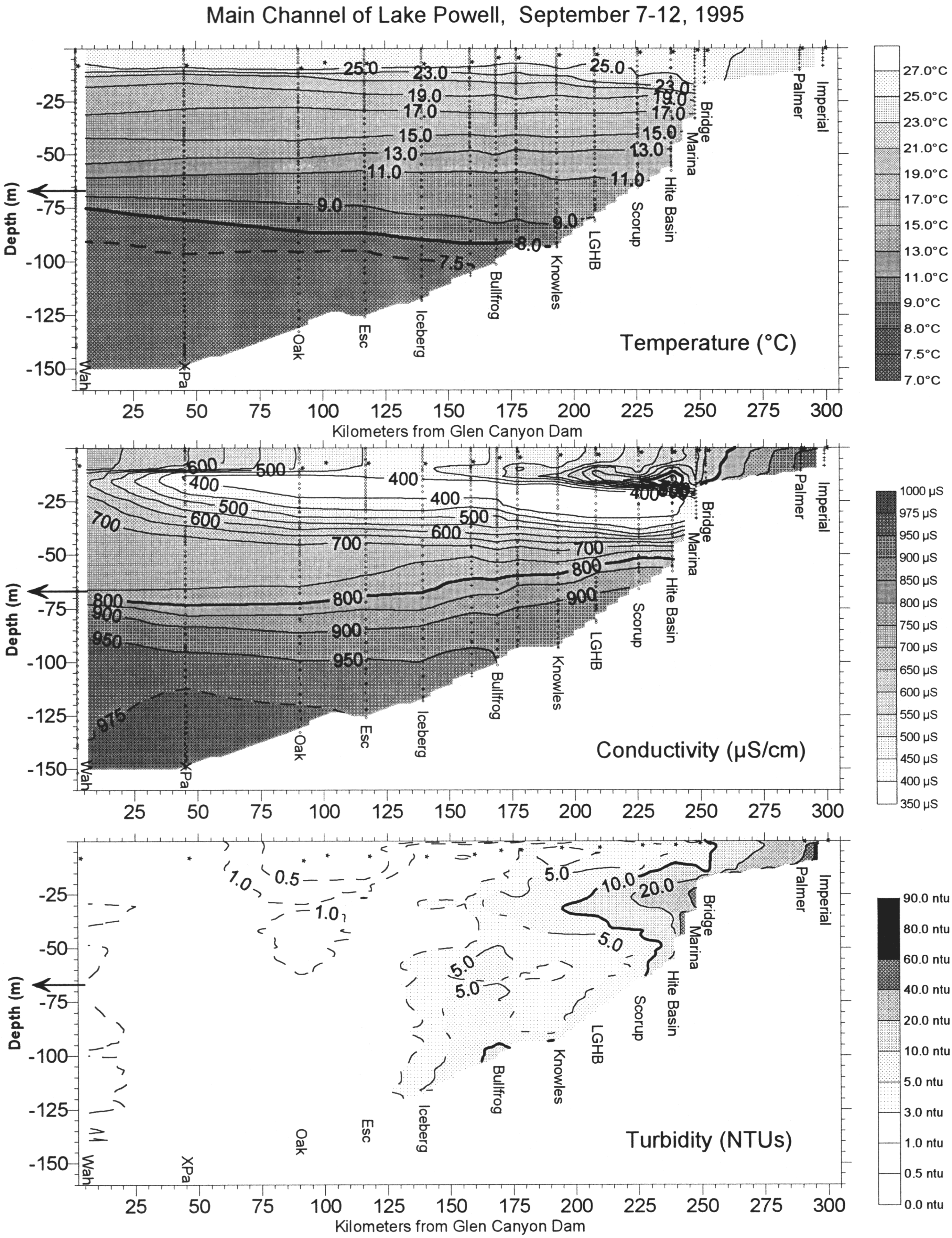


Figure 4: Temperature (°C), conductivity (µS/cm), and turbidity (NTUs) in the main channel of Lake Powell, September 7-12, 1995. Secchi disk depths are represented by * asterisks. Penstock depth is indicated by left axis arrow at a depth of 67 meters.

San Juan Channel, September 10-11th, 1995

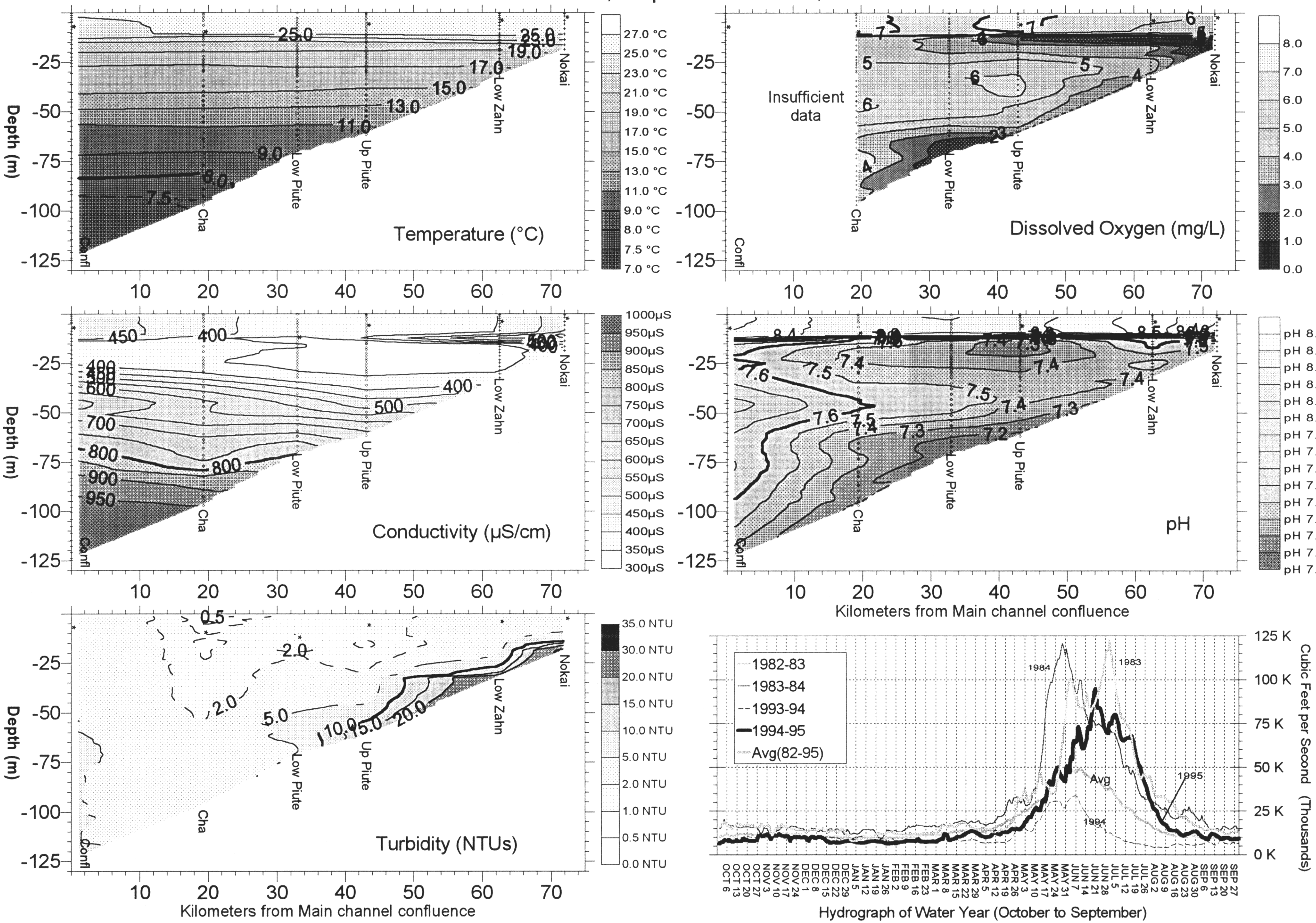


Figure 5: Temperature (°C), conductivity (µS/cm), turbidity (NTUs), dissolved oxygen (mg/L) and pH in the Escalante Channel, September 8th, 1995. Secchi disk depths indicated by asterisk. Dashed contour lines are out of normal sequence but are added to aid interpretation.

Figure 6: Hydrograph of the combined flows (in cfs) of the Colorado and San Juan Rivers' to Lake Powell, comparing current water year to last year and past flood years.

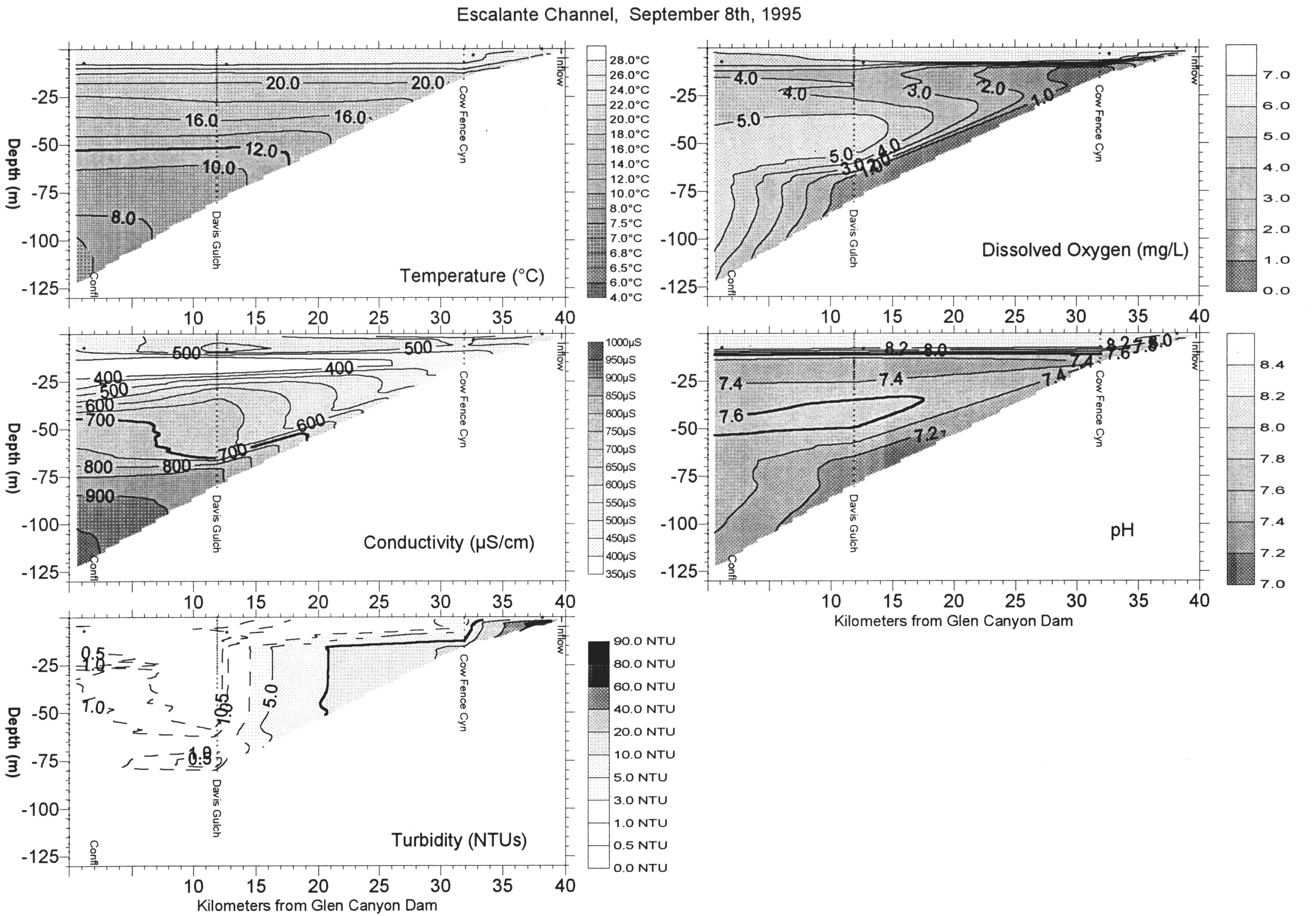
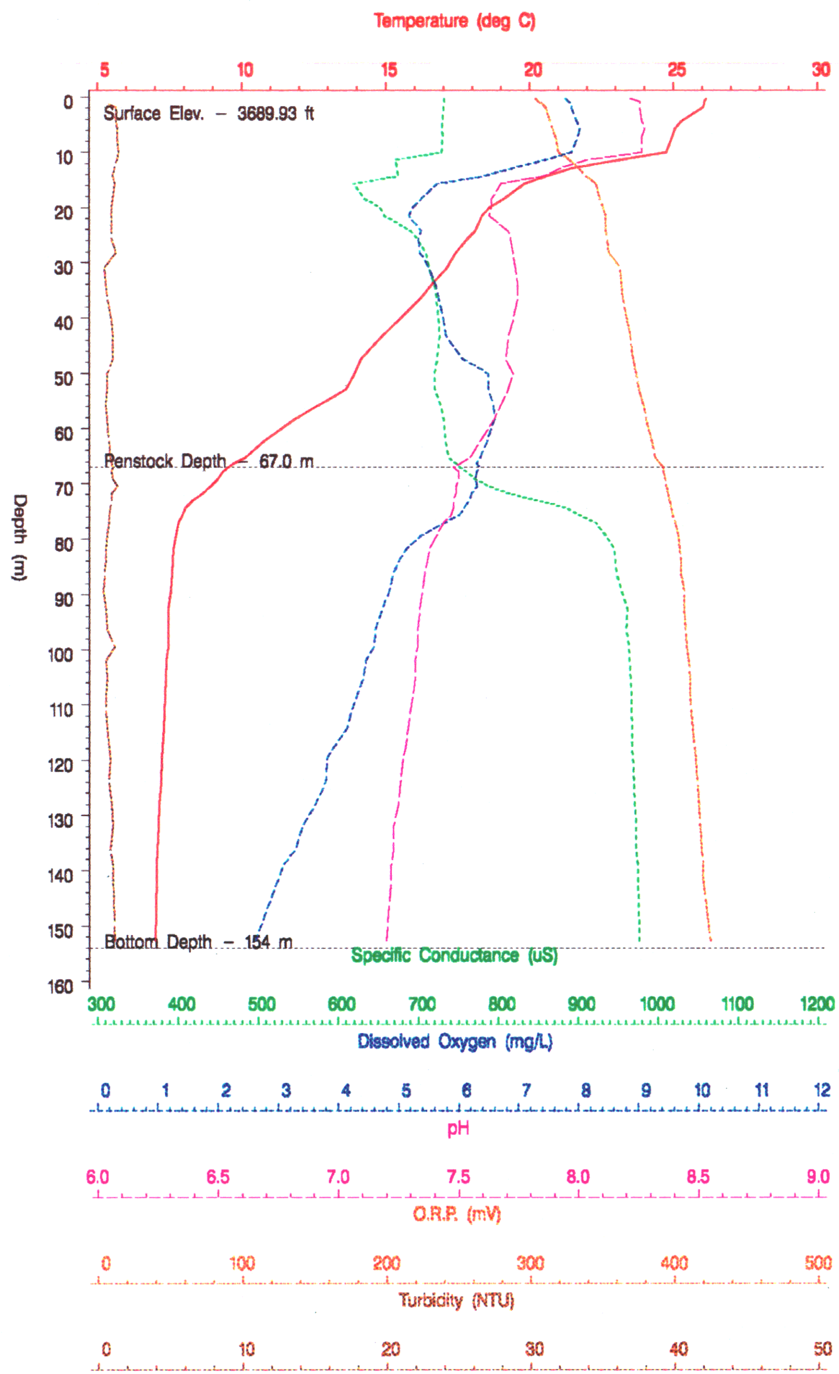


Figure 7: Temperature (°C), conductivity (µS/cm), turbidity (NTUs), dissolved oxygen (mg/L) and pH in the Escalante arm of Lake Powell on September 8th, 1995. Secchi disk depths indicated by * asterisks.

Wahweap

LPCR0024

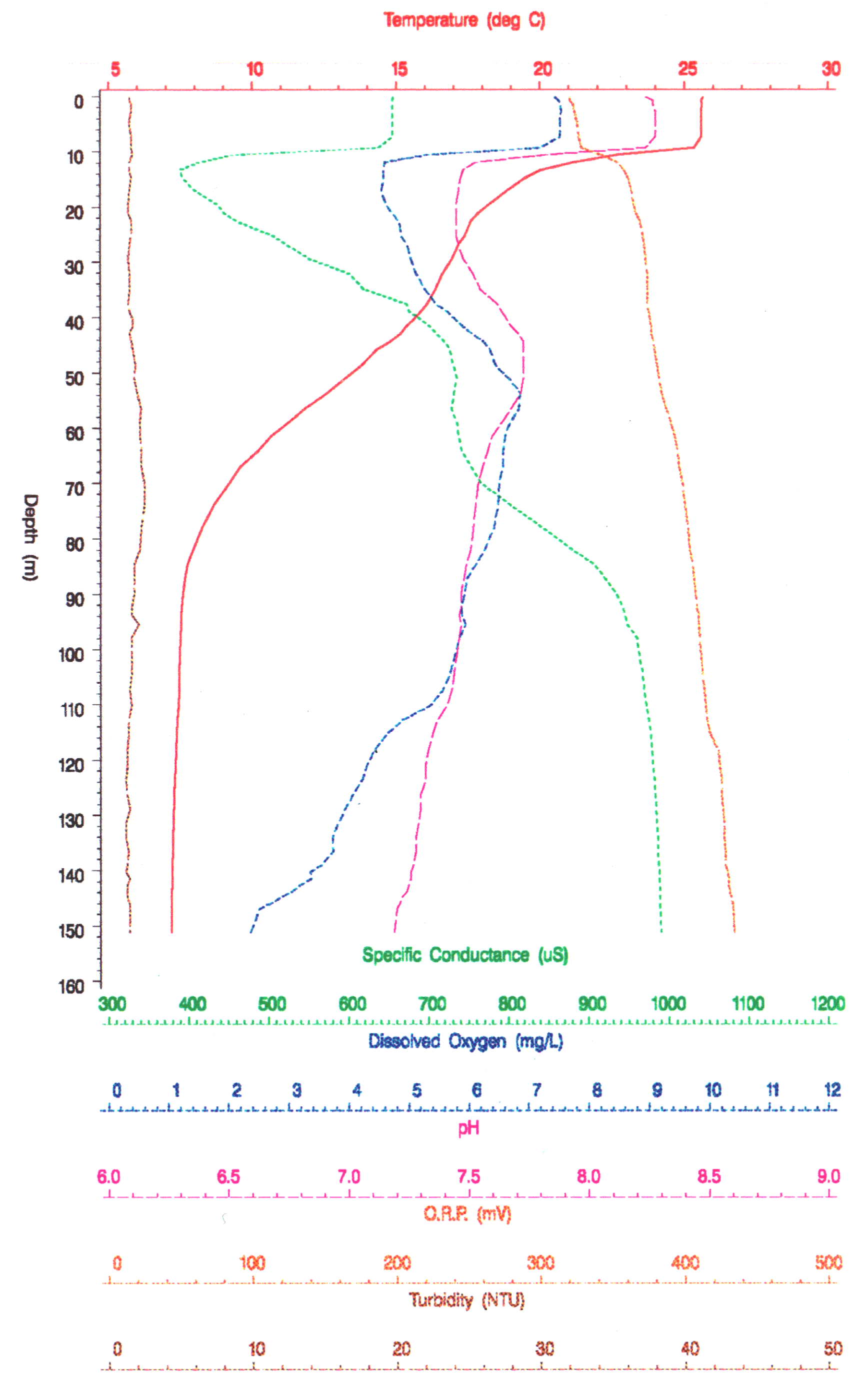
12SEP95



Crossing of the Fathers

LPCR0453

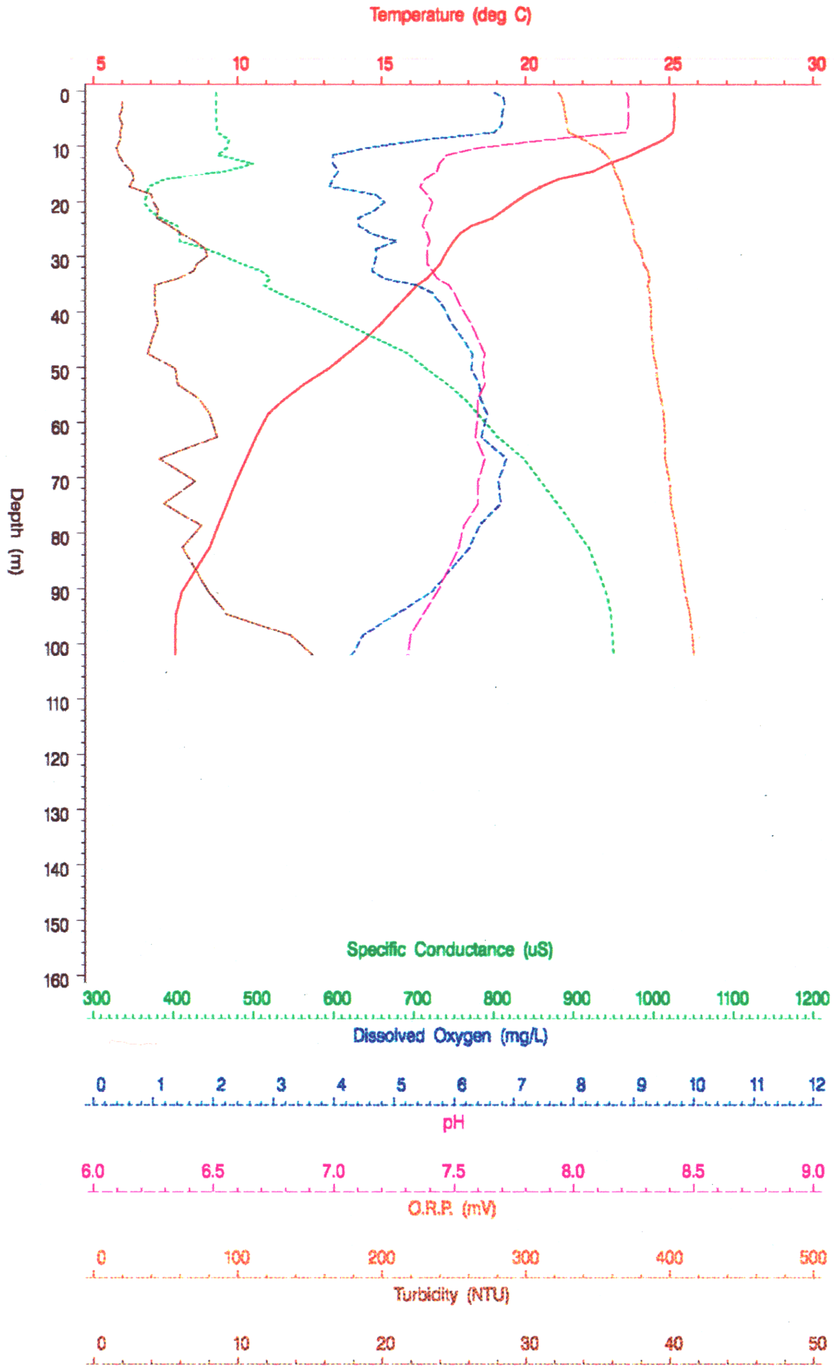
12SEP95



Bullfrog Bay

LPCR1692

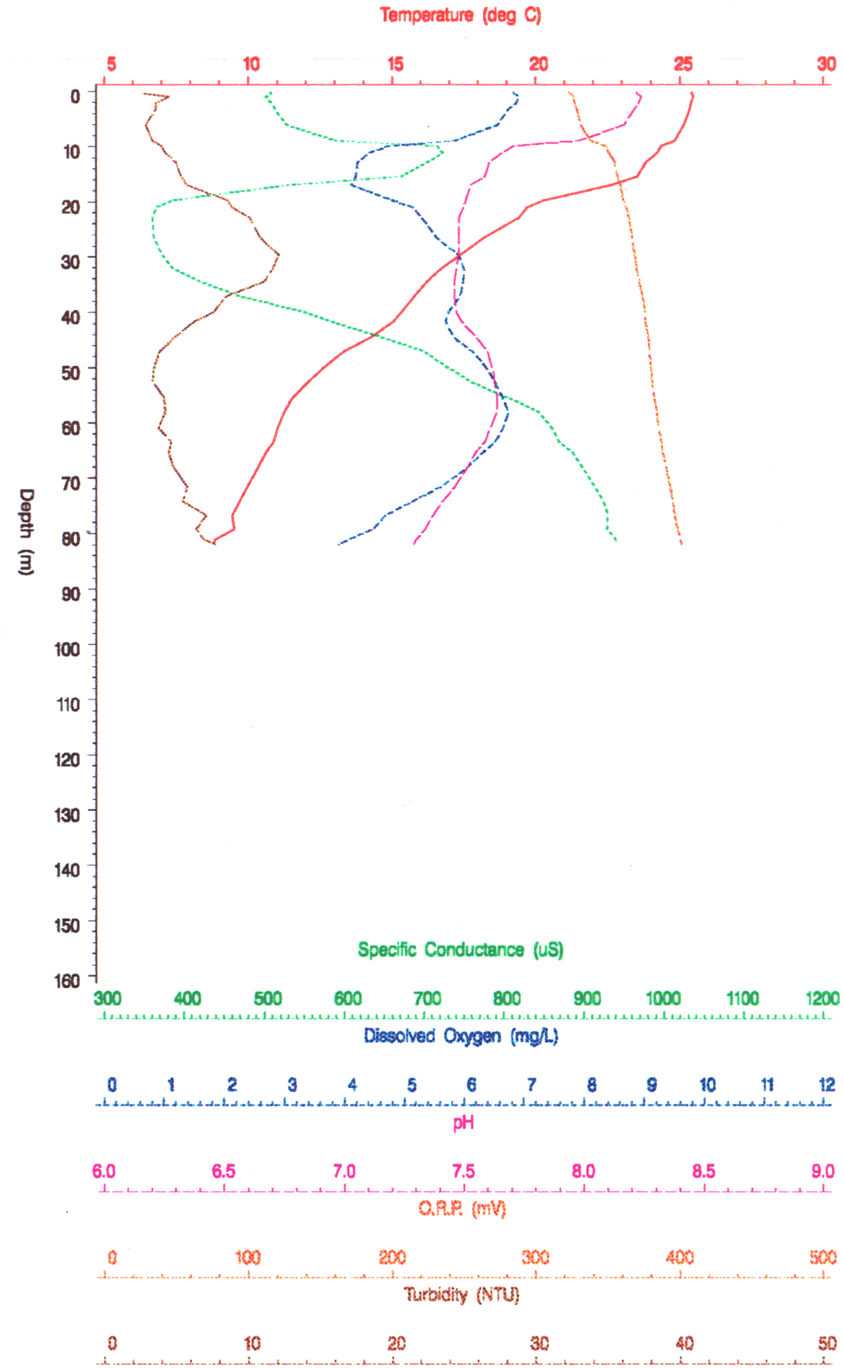
10SEP95



Lower Good Hope Bay

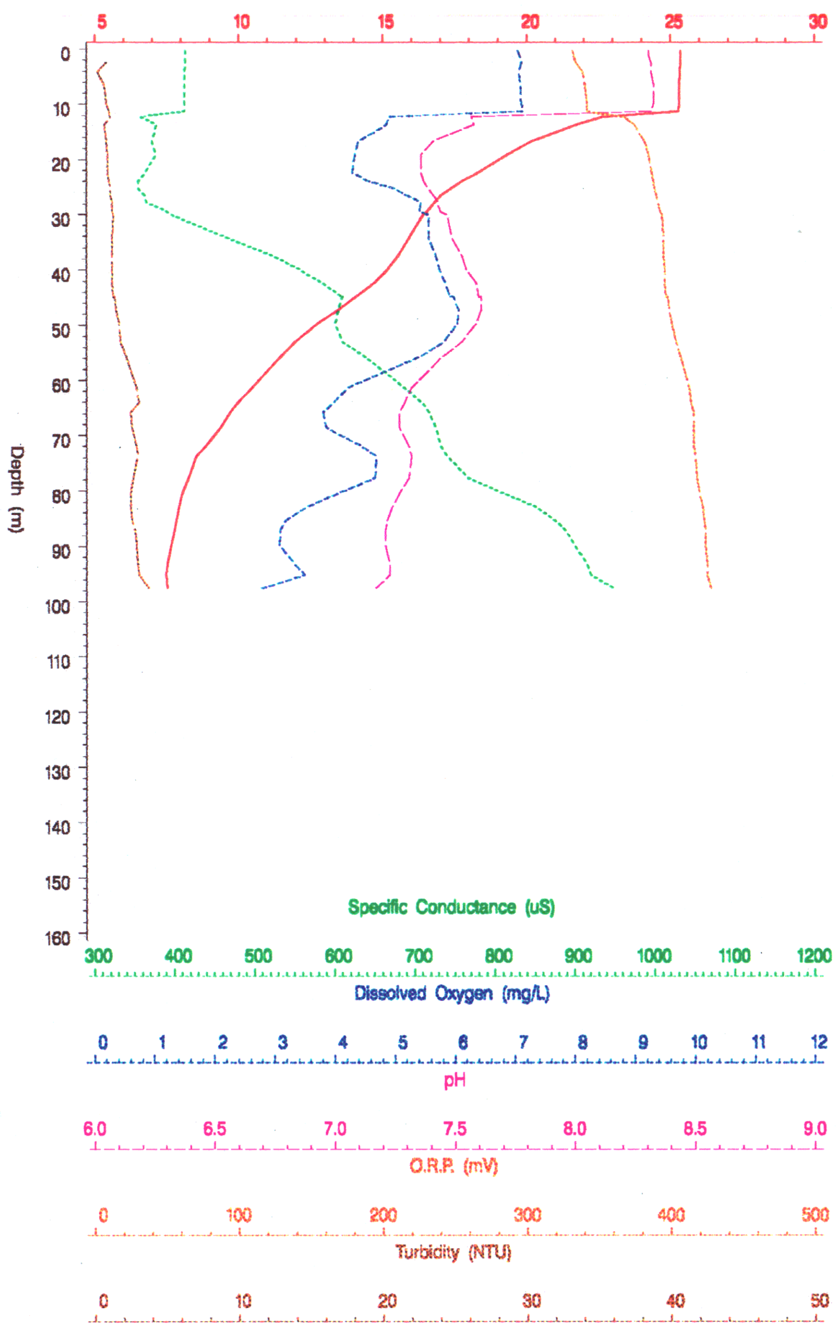
LPCR2085

09SEP95



Cha Canyon (SJR)

LPSJR193
11SEP95



Escalante at Davis Gulch

LPESC119
07SEP95