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ANALYSIS OF SELECTED WATER QUALITY FACTORS IN THE UPPER ST. JOHNS RIVER BASIN

Report to the St. Johns River Water Management District, Palatka

By

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Key:

SMOC = South Mormon Outside Canal

TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWU = Lake Washington Outlet

CHAPTER I

INTRODUCTION

The upper St. Johns River basin has undergone rapid agricultural development and urbanization in recent years, and this has affected the water quality and reduced the storage capacity of the river and marsh. The marsh and floodplain, necessary for natural filtration of pollutants, have been altered and reduced drastically due to the creation of levees and canals. Historical data indicate that levels of dissolved solids, trace metals and various mineral and nutrient components have been gradually increasing (Mason and Belanger, 1979). The pumpage of excess water from agricultural lands has also been implicated as a factor contributing to frequent fish kills by causing dissolved oxygen sags in certain sections of the river.

Today nearly 50 percent of the original floodplain storage of the St. Johns River no longer exists. It appears that the delicate balance of the St. Johns River ecosystem has been upset, particularly in the upper basin. A healthy system requires adequate space and time to work efficiently. When channelization and diking activities reduce the size of the marsh too much, the slow moving sheet-flow system that filters pollutants and provides flood protection is disrupted. Pollutant loads are then short circuited into the system through canals and agricultural pumps and these inputs serve as sources of point source pollution, often resulting in fish kills and algal and aquatic plant growth.

The primary objectives of this study were twofold. These were:

(1) to monitor specific agricultural pumps in the upper basin and determine loading rates to the canals and river, and

(2) to perform sediment coring and bathymetric transect studies on the chain of six lakes in the upper St. Johns river basin for comparison with previous and future studies so that sedimentation rate estimates can be made.

The sedimentation and agricultural pumpage research was subcontracted to Florida Institute of Technology and funded as part of an EPA Clean Lakes Grant given to the St. Johns Water Management District for a Phase I Diagnostic Feasibility Study of the upper St. Johns River and Lakes as provided in EPA Regulation 40 CFR Part 25. Other phases of the Clean Lakes Phase I Study undertaken by the SJWMD include: 1) further sedimentation work; 2) water quality studies and 3) optimum hydroperiod studies. The majority of this work will not be presented in this report.

Secondary objectives of our research included (research not funded by the grant): 1) nutrient and suspended solids loading estimates from selected canals in the upper basin, 2) nutrient and suspended solids loading estimates into and out of Lake Washington and associated mass balance calculations, 3) Diurnal and light-dark bottle productivity studies at U.S. 192 near the entrance of Lake Washington so that community and phytoplankton production estimates could be made; 4) light-dark bottle *in situ* experiments to investigate the occurrence of a photochemical ferrous-ferric catalytic cycle operating as an oxygen sink in the system, and 5) water hyacinth decomposition studies in Lake Washington.

Detailed methodologies of these objectives are presented in Chapter III. The water hyacinth decomposition studies and diurnal oxygen studies will be discussed separately in the report.

CHAPTER II

SITE DESCRIPTION

UPPER BASIN

The upper basin of the St. Johns River is located in East Central Florida. The location of the upper St. Johns River Basin, within the entire basin, is shown in Figure 1. The upper basin has a length of 110 miles and an average width of 22 miles (SJRWMD, 1979). Originally the river flowed via sheet flow from the St. Lucie Marsh to a point just south of Lake Hellen Blazes where the river channel begins. Due to extensive development, including highway construction and artificial drainage canals, the area south of the Florida turnpike provides almost no source water to the upper St. Johns River basin (SJRWMD, 1979). The rest of the basin has not been spared either as drainage canals crisscross the area and during normal conditions carry most of the water present to the river channel.

Flow in the basin is generally slow as the average river gradient is only 0.20 feet per mile (SJRWMD, 1979). The gradient between U.S. 192 and Lake Washington is only 0.05 feet per mile (Mason and Belanger 1979). Because of this small gradient, runoff from heavy rainfall events often leads to localized flooding (SJRWMD, 1979). Rainfall in the upper basin is characterized by high intensity and short duration and averages approximately 55 inches of rainfall per year (Cox et al., 1976). About 50% of this precipitation falls during the months from June to October (SJRWMD, 1979). The climate of this area is classified as humid subtropical and is characterized by hot, humid summers and mild dry winters.

This study does not include the entire upper basin but covers an area within the basin that extends northward from state road 60 to state road 520 (Figure 2). Water in this area flows via sheet flow and drainage canals to a point just south of Lake Hellen Blazes where a proper channel is formed and the St. Johns River

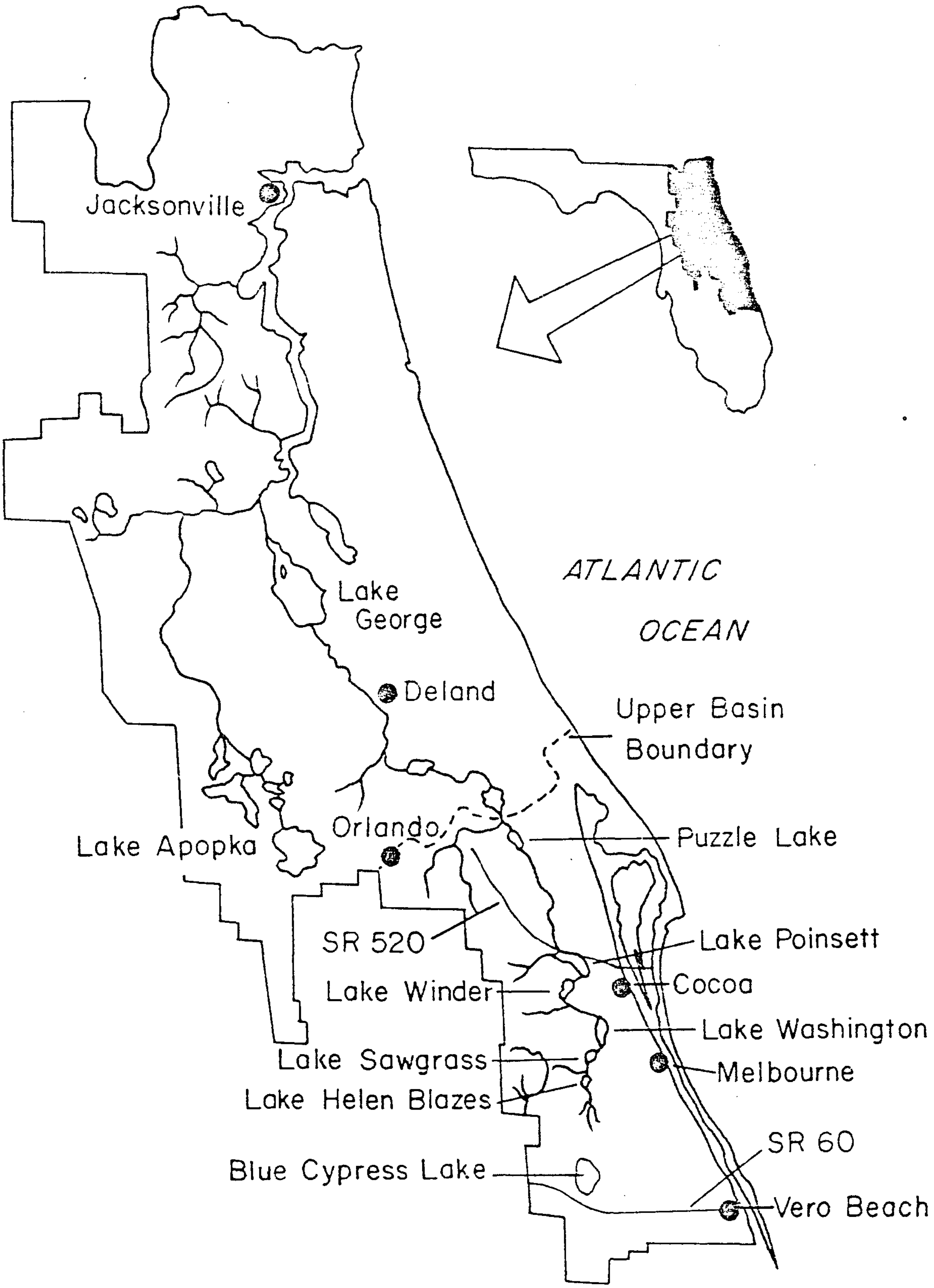


Fig. 1. Location map.

actually begins. The river extends northward from that point and is interrupted only by a chain of small lakes. From south to north in order of appearance these lakes include Lake Hellen Blazes, Sawgrass, Washington, Winder and Poinsett. Blue Cypress Lake, located near the southern boundary of the upper basin, was also included in the sedimentation portion of the study.

SAMPLING SITES

Sampling sites from Lake Washington south refer to Figure 2. The sampling sites in Lake Washington were located at the inlet and outlet of the lake (Figure 2). The inlet site, site 30, was located approximately 100 yards north of U.S. 192. The outlet site, site 33, was located at the Lake Washington low level dam and only water passing over the dam was sampled.

The canal sites were all located south of Lake Hellen Blazes and are shown in Figure 2, also. Site 13 was located on South Mormon Outside Canal approximately 100 yards south of Three Forks Run. Site 14 was located about 50 yards upstream from the mouth of Three Forks Run. Site 16 was located about 50 yards upstream from the confluence of South Mormon Outside Canal and the St. Johns River on Bulldozer Canal. These sites were chosen to match sampling sites used in the past by the St. Johns River Water Management District, Florida Game and Fresh Water Fish Commission and Florida Institute of Technology for data comparison purposes. All other numbered sites on Figure 2 refer to water quality and field sampling sites and were not routinely sampled. Field data at these sites are presented in Appendix A.

The agricultural pump sites chosen represent those selected by the SJRWMD for the Phase I Diagnostic/Feasibility Study of the upper St. Johns River chain of lakes. The pumps were chosen based on pump capacities, frequency of pumping and land use types present in each specific pump drainage area. The most southern pump is the Zig Zag pump and it is located in Indian River County on Ditch 34 which runs into Zig Zag Canal (Site #1 on Figures 2 and 3). This pump has a rated

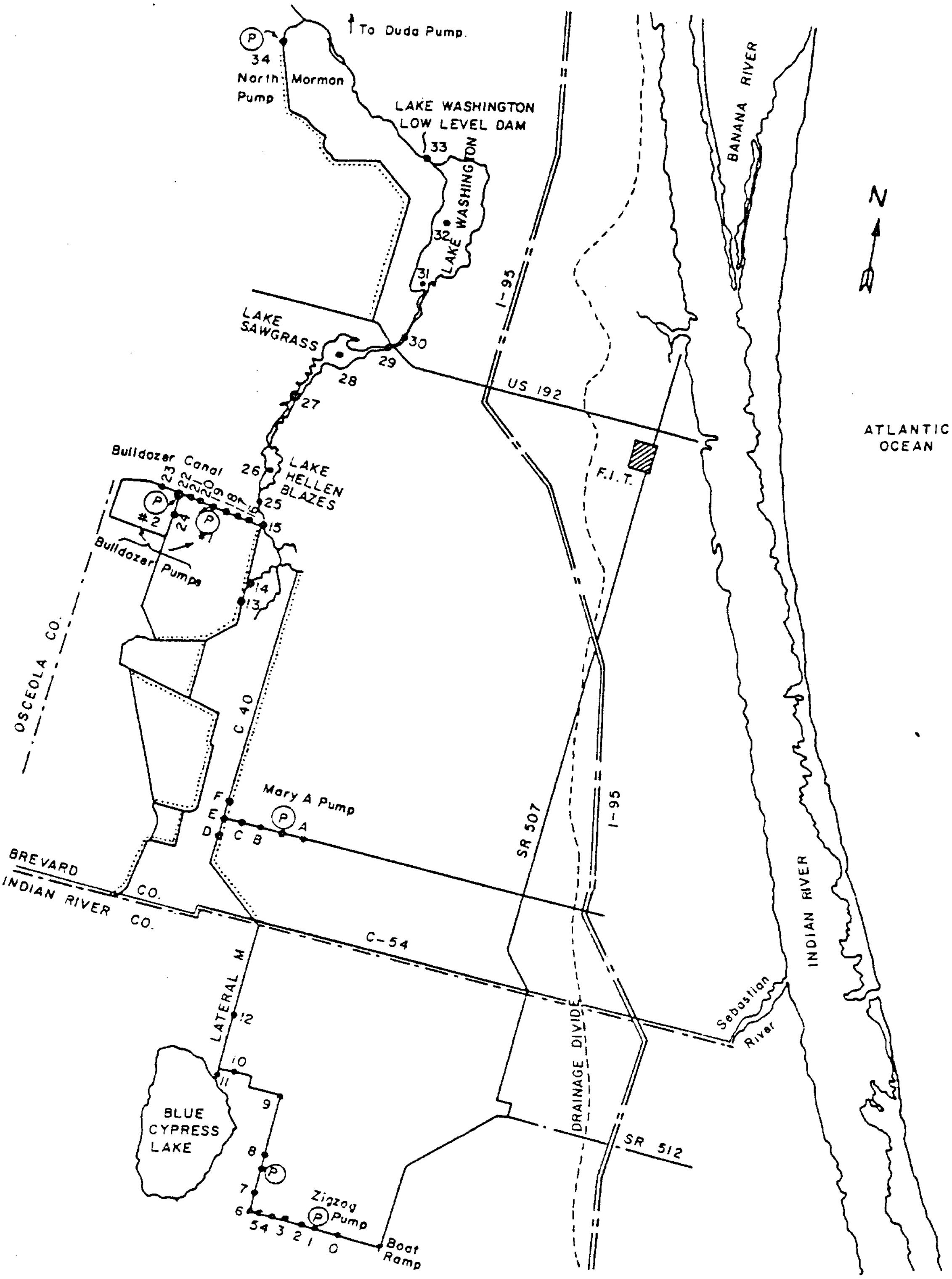


Fig. 2. Sampling sites.

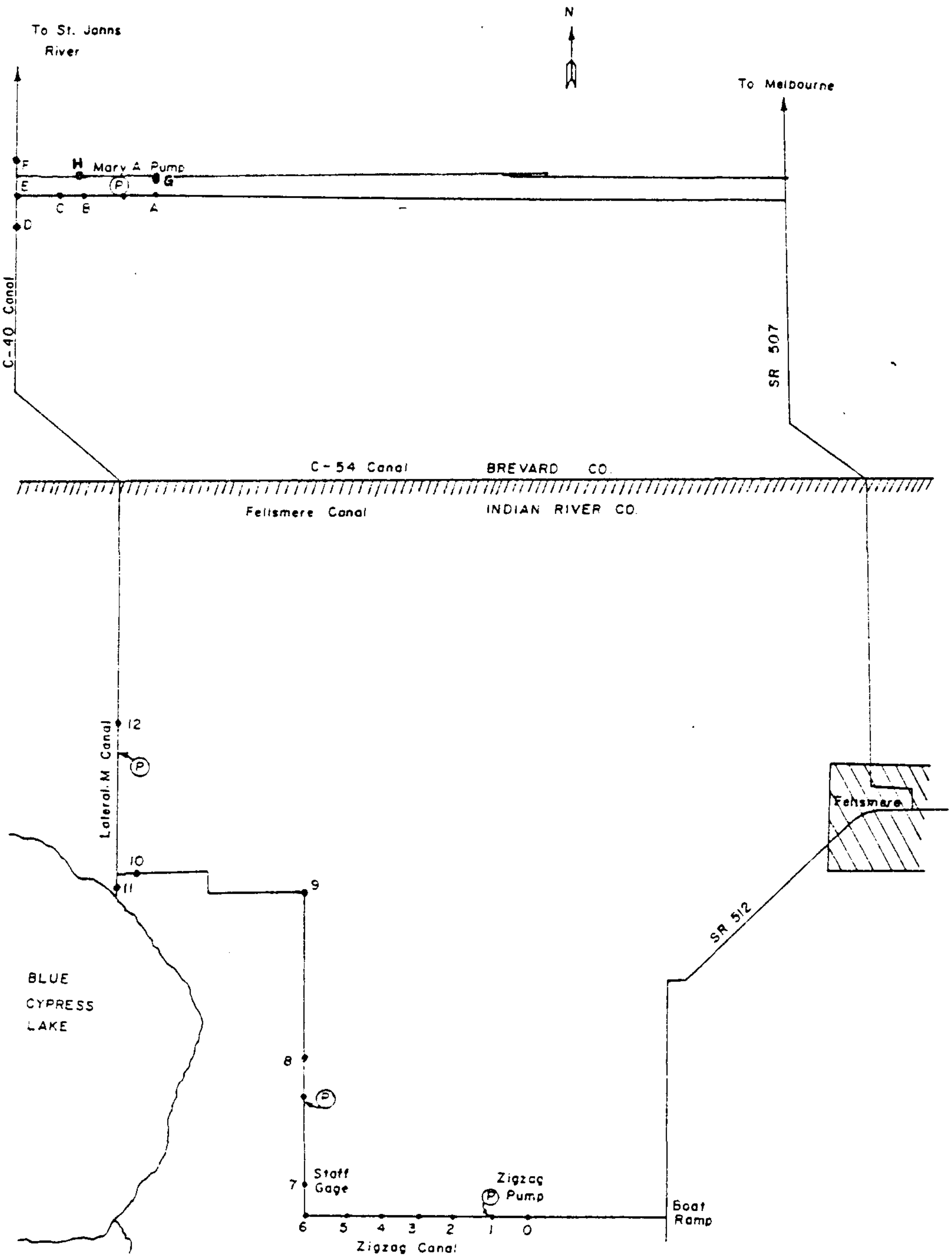


Fig. 3. ZigZag Canal and Mary A pump sites.

capacity of 150,000 GPM and drains primarily citrus area. North of this is the Mary A pump, located on Old Sottile Outside Canal in South Brevard County (Figure 3). This pump has a rated capacity of 120,000 GPM and drains improved pasture and row crops. Just south of Lake Hellen Blazes are the Bulldozer pumps, located on the Bulldozer Canal system (Sites 22 and 19 on Figures 2 and 4). Bulldozer pump #2 is the most western pump sampled and it drains citrus and has a rated capacity of 16,000 GPM. Bulldozer pump #1 is rated at 32,000 GPM and drains improved pasture. The remaining pumps are located north of Lake Washington, although they were not sampled by Florida Institute of Technology during operation in this study, The North Mormon pump, located on North Mormon Outside Canal, drains improved pasture and is rated at 12,000 GPM (Figure 5). The most northern pump is the Duda pump, located on the Duda & Sons Canal north of Lake Winder (Figure 6). This pump drains improved pasture area and has a rated capacity of 57,000 GPM.

Each of these sampling sites, with the exception of the Lake Washington sites, represent a distinct point source of pollution and should provide valuable loading information to management and enforcement agencies.

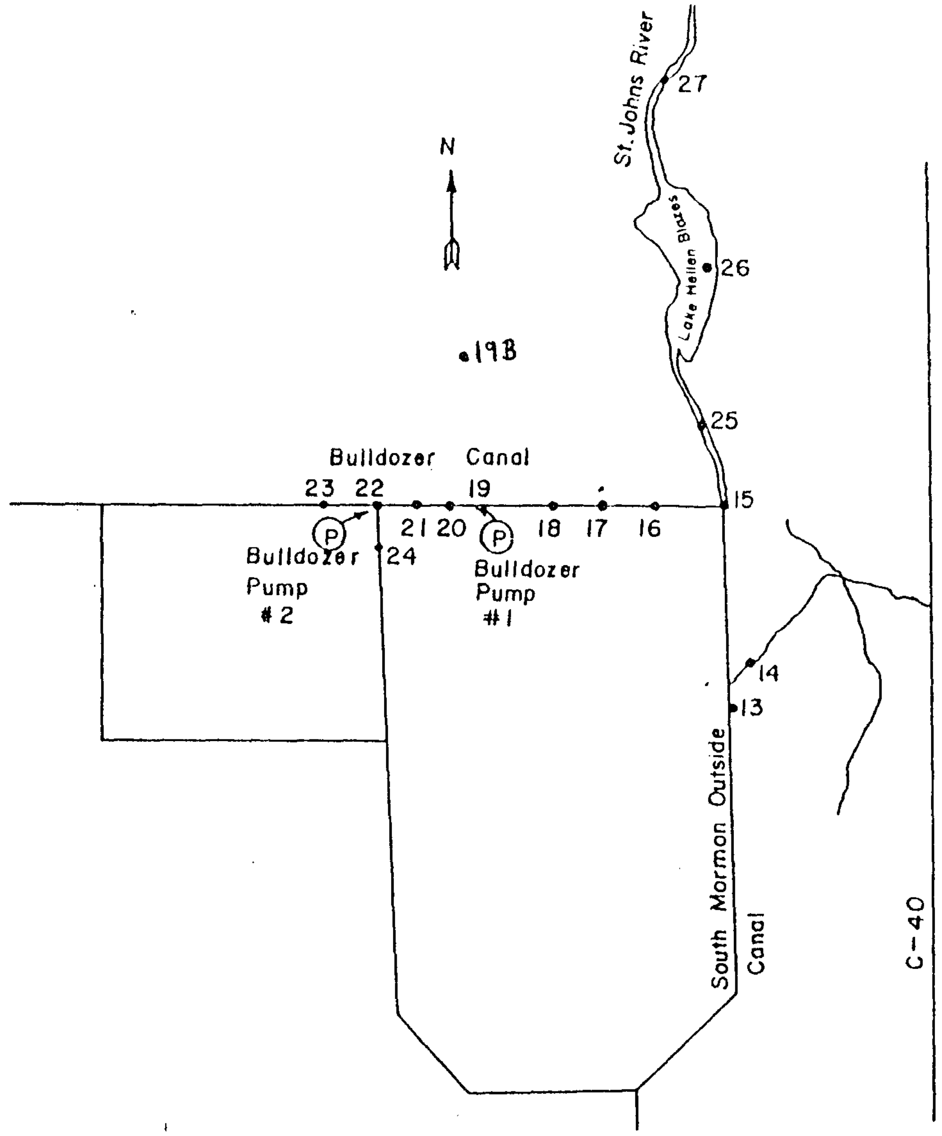


Fig. 4. Bulldozer Canal pump site.

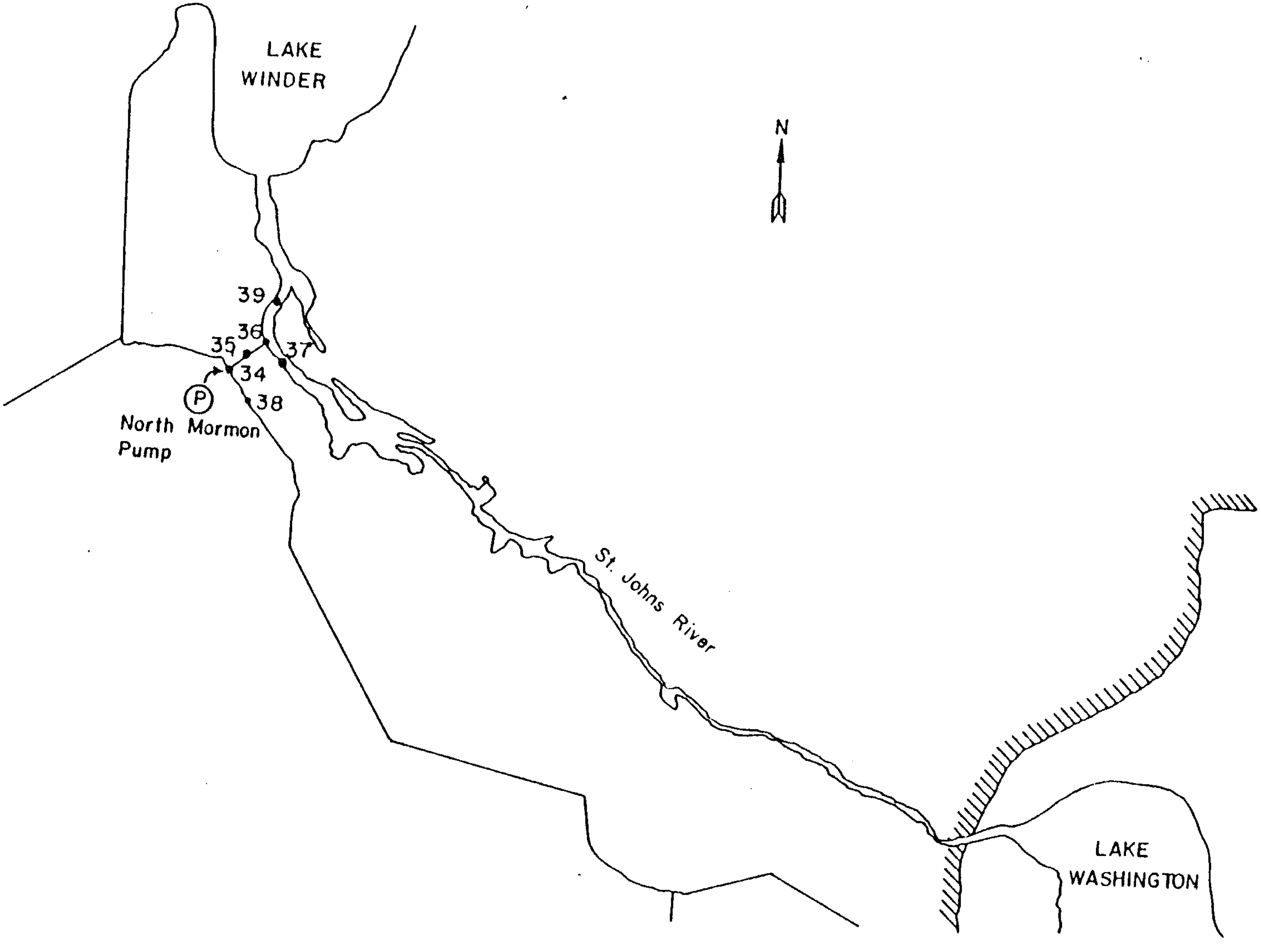


Fig. 5. North Mormon Canal pump site.

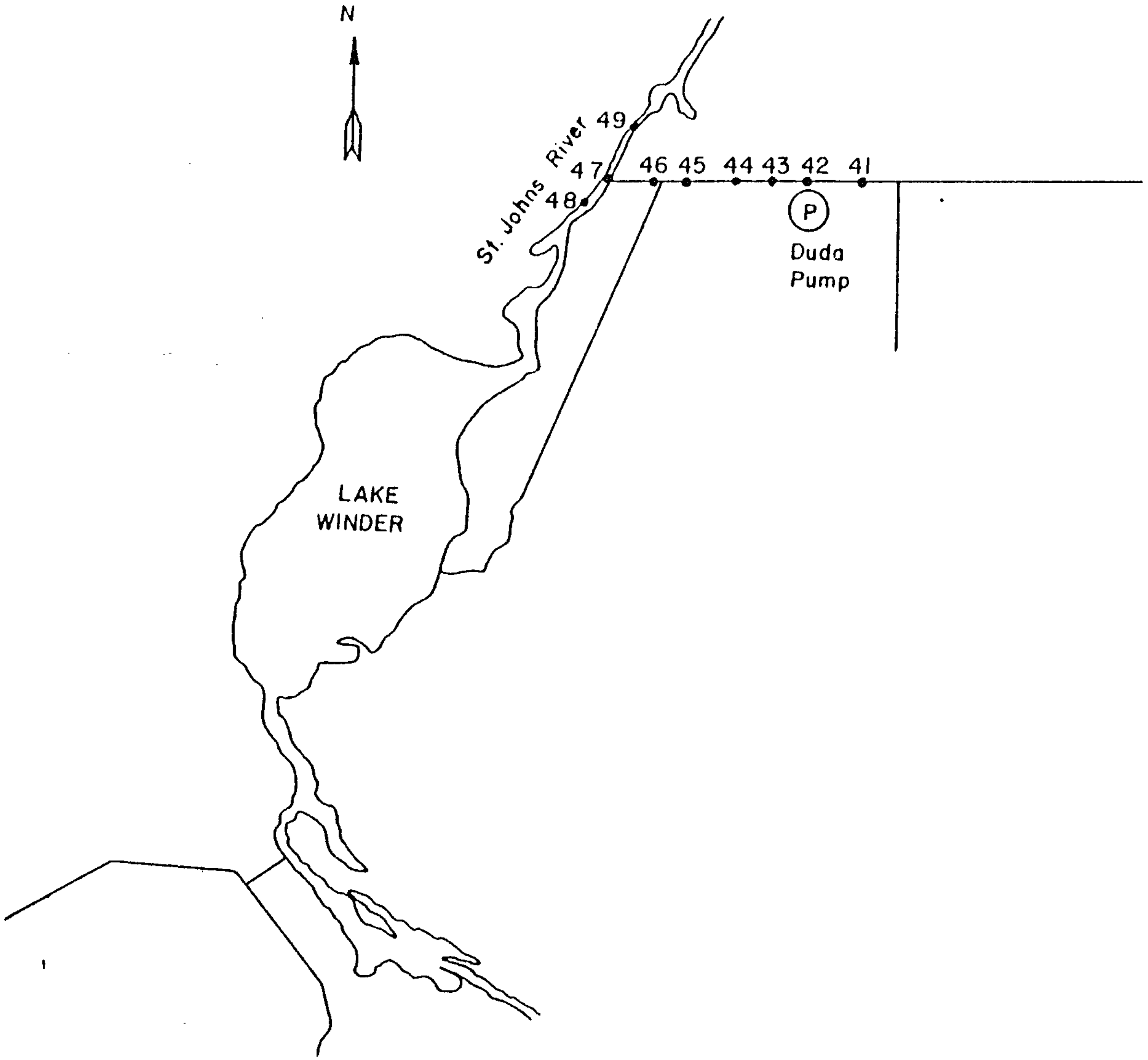


Fig. 6. Duda pump site.

CHAPTER III

METHODS

CANALS, LAKE WASHINGTON AND AGRICULTURAL PUMPS

We decided at the outset of this study to sample the Three Forks, South Mormon and Bulldozer Canal sites as well as the inlet and outlet of Lake Washington at least twice monthly. In addition, the agricultural pump sites were to be sampled as often as possible when the pumps were operating. However, due to mechanical boat problems and drought conditions this schedule could not always be maintained.

The canal sites were viewed as specific point sources of discharge into the St. Johns river; the quality of these sources reflect the individual drainage areas. These sites and the Lake Washington sites were located so that comparisons could be made with historical data collected by other researchers (Cox et al., 1976; Mason and Belanger, 1979; SJRWMD, 1980). The agricultural pump station sampling locations were chosen after consultation with the St. Johns River Water Management District. Five pump stations were identified as high priority pumps and the three pumps sampled during this study (Bulldozer, Mary A and Zig Zag) were given the highest priority in order to maximize information for the Phase I Diagnostic/Feasibility Study.

At each canal site flow (ft/s) was measured using a Marsh-McBirney model 201 flowmeter. The method of measurement used at each site was dependent upon water depth. At depths of 3.5 ft. or less, a single flow measurement was taken at a depth equal to 40% of the water column depth. At depths greater than 3.5 ft. two separate measurements of flow were made; one at a depth equal to 20% of the water column and the other at a depth equal to 80% of the water column. The values obtained at each depth were averaged to obtain a single value at each site. Depth measurements were made by stretching a rope marked in one foot intervals across the channel and securing it to each side. Channels of 35 ft. or less required flow measurements at distances equivalent to 25% and 75% of the channel width. Three flow measurements were made in larger channels at locations equivalent to 17%, 50%, and 83% of the distance across the channel. Area (ft^2) was calculated for each section of the channel and multiplied by the average flow rate (ft/s) in that section to obtain discharge (ft^3/s). Total discharge for the entire channel was obtained by adding the individual section discharges. If no measurable flow was observed, water samples were taken for background data.

Sampling at the outlet of Lake Washington was accomplished by collecting water as it passed over the weir with a Van Dorn Water Sampler held parallel to the flow. For each sample date the head above the weir was recorded so that discharge could be calculated with the standard equation for a sheet pile weir (Mason and Belanger, 1979). Samples were taken at sites located 33% and 66% of the distance across the channel. Data were averaged for use with the calculated total discharge in order to obtain loading rates leaving Lake Washington.

Water samples taken at the other sites were collected with a tube sampler. This sampler consisted of a four foot section of PVC pipe that had a 1.5 in. inside diameter. A length of rope was passed through the pipe and attached to a rubber stopper which sealed the tube. At each site, the sampler was placed vertically into the water and rapidly sealed at the bottom by pulling on the rope. This was done quickly to prevent fallout of suspended matter in the water column. It was felt that the tube sampler would give a more representative sample for the entire water column than a grab sample. Each sample was mixed and poured into a previously acid washed one liter bottle. Samples were taken in duplicate at each site and placed on ice for return to the lab, at which time they were refrigerated.

Sampling methods for the agricultural pump events were somewhat different than those described above. Access to all sites required the use of an F.I.T. airboat. One gallon grab samples were taken at the pump, 250 meters upstream from the pump, 250 meters downstream from the pump, and at the confluence of the drainage canal associated with the pump and the river channel.

The agricultural pumps were sampled for background concentrations when the pumps were not running and as often as possible during operation. Initially our field team depended upon fishermen and others to inform us when the pumps were running. We found this method, however, to be an unreliable source of information. We then began checking the pumps as often as possible ourselves, particularly after rainfall events. The pump samples were taken as close to the discharge pipe as possible to minimize dilution effects from surrounding water. Grab samples at the other sites were collected two feet below the surface in the center of the channel. Upstream and downstream flow measurements were made, when possible, for estimates of pump discharge according to methods described earlier in this section. When this was not possible, due to pump flow directly into the marsh, subjective judgements on whether the pump was operating at full capacity, half capacity, etc. were made.

Chemical analysis of all samples were done in accordance with EPA recommended procedures as described in EPA Document EPA/600-4-79-020. METHODS FOR CHEMICAL ANALYSIS OF WATER AND WASTES.

All pertinent analyses were run with a full set of standards which bracketed the sample and EPA reference sample concentrations. One sample from each site was run in duplicate and an EPA reference sample was routinely run as well. Results of the reference sample comparison are presented in Chapter IV.

Water samples were analyzed for parameters found in Table 1. The following methods were used to analyze the water samples:

Table 1. Field and laboratory parameters.

Field:

- Water temperature
- Dissolved oxygen
- pH
- Specific conductance
- Transparency
- Flow

Lab:

- Turbidity
- True color
- Suspended solids
- Alkalinity
- Hardness
- Chloride
- Sulfate
- Ortho phosphate (unfiltered and filtered)
- Total phosphorus (unfiltered and filtered)
- Total Kjeldahl nitrogen (unfiltered and filtered)
- Ammonia nitrogen
- Nitrate-nitrite nitrogen
- Chlorophyll
- BOD
- Iron
- Calcium
- Magnesium
- Potassium

LABORATORY MEASUREMENTS

Nitrate Nitrogen was determined using the Brucine method which involves the formation of a yellow color caused by the reaction of the nitrate ion with Brucine sulfate in an acidic medium. The color intensity was measured using a Perkin Elmer Model 124 double beam spectrophotometer. Results were recorded to the nearest 0.1 milligram nitrate-nitrogen per liter. (1979 EPA Manual Storet No. 00620).

Nitrite Nitrogen was determined colorimetrically after the diazotization of sulfanilamide by the nitrite ion produced a reddish purple color. Results were recorded to the nearest 0.01 milligram nitrite-nitrogen per liter (1979 EPA Manual Storet No. 00615). With the acquisition of a Technicon Autoanalyzer I the method for nitrate-nitrite nitrogen was changed to the automated cadmium reduction method. A filtered sample was passed through a cadmium column and nitrate was reduced to nitrite. The nitrite was reacted with sulfanilamide and concentrations were measured colorimetrically to the nearest 0.02 milligrams nitrate-nitrite nitrogen per liter. (1979 EPA Manual Storet No. 00630; 14th Edition of Std. Methods).

Ammonia Nitrogen was determined using the automated phenate method. In this method ammonia reacts with hypochlorite and alkaline phenol to form indophenol blue. The color is intensified with sodium nitroprusside. Results were recorded to the nearest 0.02 milligrams ammonia nitrogen per liter (1979 EPA Manual Storet No. Total 00610; 14th Edition of Std. Methods).

Total Kjehldahl Nitrogen was determined by the semi-automated block digester method. The sample was heated in an acidic solution of K_2SO_4 in the presence of selenium boiling chips until clear. The samples were then analyzed for ammonia using the autoanalyzer. Results were recorded to the nearest 0.1 milligrams total kjeldahl nitrogen per liter (1979 EPA Manual Storet No. 00625).

Total Phosphorous was measured using the ascorbic acid single reagent method. Samples were digested with persulfate until clear. Addition of the single reagent formed an antimo-phospho-molybdate complex which was reduced by ascorbic acid to produce a blue complex which was measured colorimetrically. Results were recorded to the nearest 0.01 milligrams phosphorous per liter (1979 EPA Manual Storet No. 00665). Ortho phosphorus was determined by the colorimetric, automated ascorbic acid method and recorded as milligrams phosphorus per liter. (EPA Storet No. 70507).

Total Nonfiltrable Residue (Suspended Solids) was determined gravimetrically. A well mixed sample was passed through a previously weighed and prepared standard 0.45 micron filter (Whatman 934-AH 2.1 centimeter Glass Microfibre Filter). The filter was dried to a constant weight at 103° to 105°C, cooled, dissicated and weighed to the nearest 0.1 milligram residue per liter (1979 EPA Manual Storet No. 00530) Volatile Residue and Fixed Residue were measured after the incineration of the total nonfiltrable residue sample at 600°C for one-half hour. Samples were cooled, dessicated and weighed. Volatile residue was measured as that residue lost upon ignition. The quantity that remained was weighed and defined as fixed residue. Results were recorded to the nearest 0.1 milligrams residue per liter (1979 EPA Manual Storet No. 00535; 14th Edition of Std. Methods) Total filtrable residue (dissolved solids) was measured as the residue dried at 103-105 C. (14th Edition of Std. Methods).

True Color was determined using the spectrophotometric modification of the visual platinum-cobalt method. Results were recorded in chloroplatinate units. (14th Edition of Std. Methods).

Alkalinity was determined using the bromcresol green-methyl red titration. (14th Edition of Std. Methods).

Hardness was determined by the EDTA titrimetric method. (14th Edition of Std. Methods).

BOD_5 was measured using the five day incubation. (14th Edition of Std. Methods; EPA Storet No. 00310).

Chloride was measured with the colorimetric, automated ferricyanide procedure (1979 EPA Manual Storet No. 00940).

Sulfate was determined with the turbidimetric method. (14th Edition of Std. Methods).

Chlorophyll a, b, and c were measured by the trichromatic spectrophotometric method. (14th Edition of Std. Methods).

Iron was determined by the atomic absorption spectrophotometric method. (14th Edition of Std. Methods).

Calcium - (same as above).

Magnesium - (same as above).

Potassium - Flame photometric method. (14th Edition of Std. Methods).

Results of all raw analytical data were recorded in laboratory notebooks and later transferred to laboratory data sheets by the individual analyst.

FIELD MEASUREMENTS

In situ reading of conductivity and temperature were measured with a YSI Model 33 SCT meter. Dissolved oxygen was measured with a Leeds and Northrup 7932 portable dissolved oxygen meter. This meter, unlike the standard YSI meter, is independent of sensor fouling and flow rate. Measurement of all *in situ* field parameters were taken at 0.5m depth increments, when possible. Transparency and depth were measured using a secchi disk. Flow measurements were made using a Marsh McBirney electromagnetic flow meter. *In situ* field data were recorded in Field Notebooks and later transferred to Field Data Sheets similar to those used by the SJRWMD.

CORING AND BATHYMETRIC TRANSECTS

The sedimentation portion of the research program was intended to provide information on the rate and nature of sedimentation in the lakes of the upper St. Johns River Basin. A hand corer similar to that referred to by Baker, Pugh and Kimball (1977) was constructed and used for routine coring. The core consists of a clear plastic core tube with a two inch check valve unit and rubber seal. Core profiles and bathymetric transects were taken in the lakes in the upper St. Johns River (Lakes Poinsett, Winder, Washington, Sawgrass, Hellen Blazes and Blue Cypress). The locations of these lakes in the upper basin are shown in Figure 1. Three radial core transects in each lake, extending to a distance of 150 m from the river's entrance, were taken. The cores were taken at 30 m intervals yielding a total of 16 radial cores per lake. The 30 m intervals were determined by operating the boat at a predetermined throttle speed for a predetermined length of time. Buoys were then placed at each sampling location. This same technique was used to determine coring intervals for longitudinal and transverse transects in Lakes Hellen Blazes, Sawgrass, Washington and Winder, while siting across the lake using landmarks. Longitudinal transect cores were taken at points equal to 10% of the total length (11 samples) while transverse transects were taken at intervals equal to 20% of the lake width (6 samples). For each core, sediment depths and types were recorded down to sand substrate. Bathymetric profiles were obtained for each transect with a Ratheon fathometer depth recorder. A calibrated rate indicator automatically selected coring points in the larger lakes (Lakes Poinsett and Blue Cypress) at regular intervals by an audible signal, while compass readings kept each transect on line. The location of the transects and radials in each lake are shown in Figure 7 through 12. Each core was analyzed for total organic sediment thickness and for the thickness and nature of any r distinguishable strata. Coring locations on the longitudinal and transverse ric profiles were marked on the sounder chart paper.

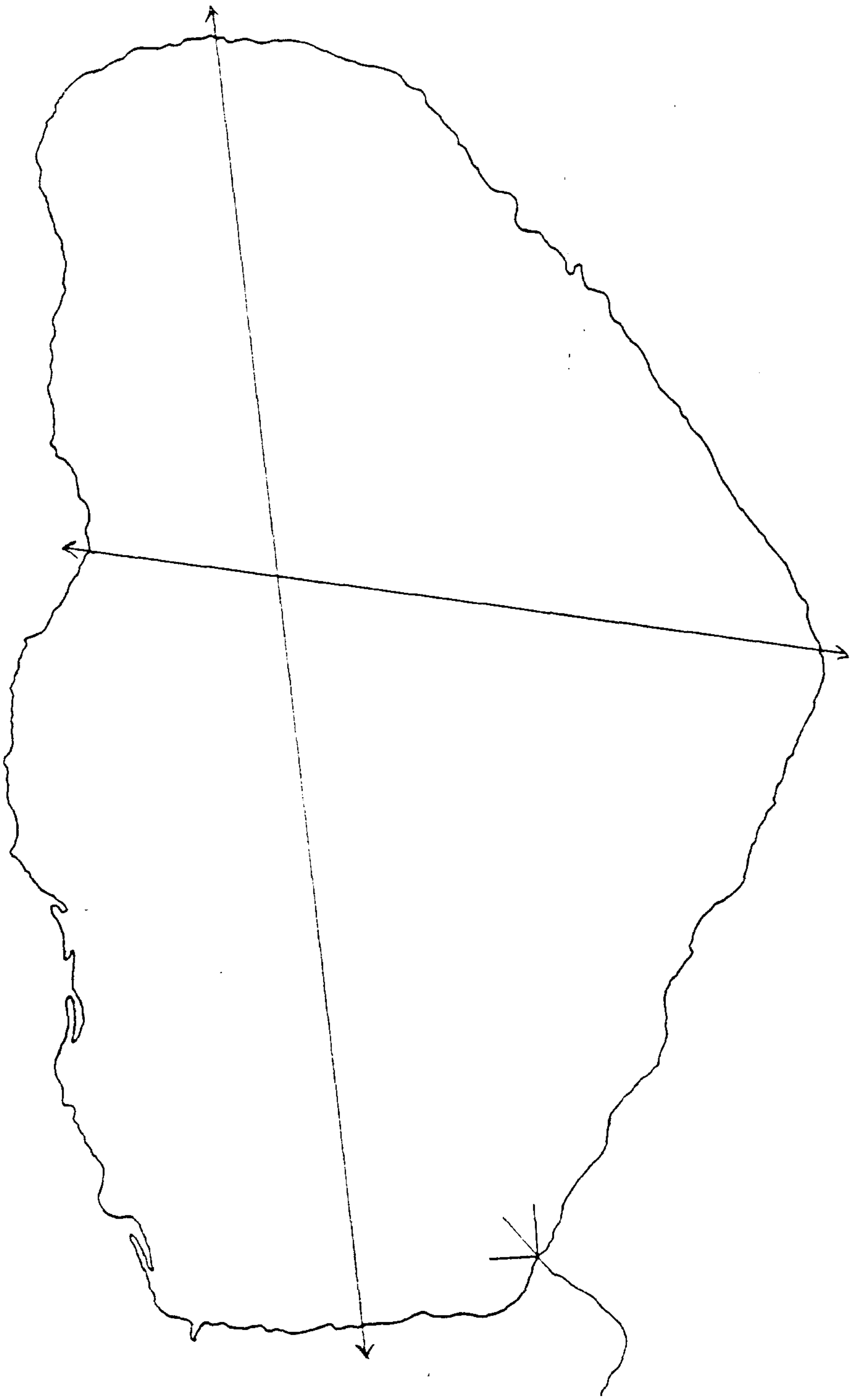


Fig. 7. Transect locations in Blue Cypress Lake.

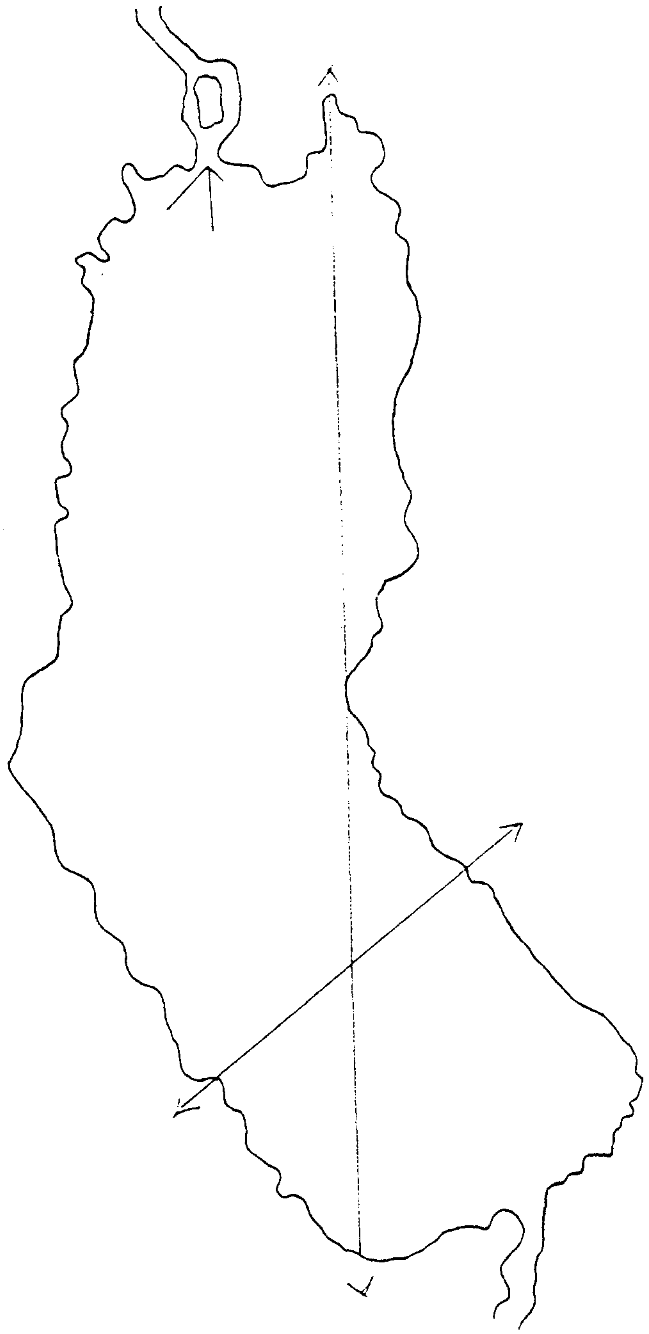


Fig. 8. Transect locations in Lake Hellen Blazes.

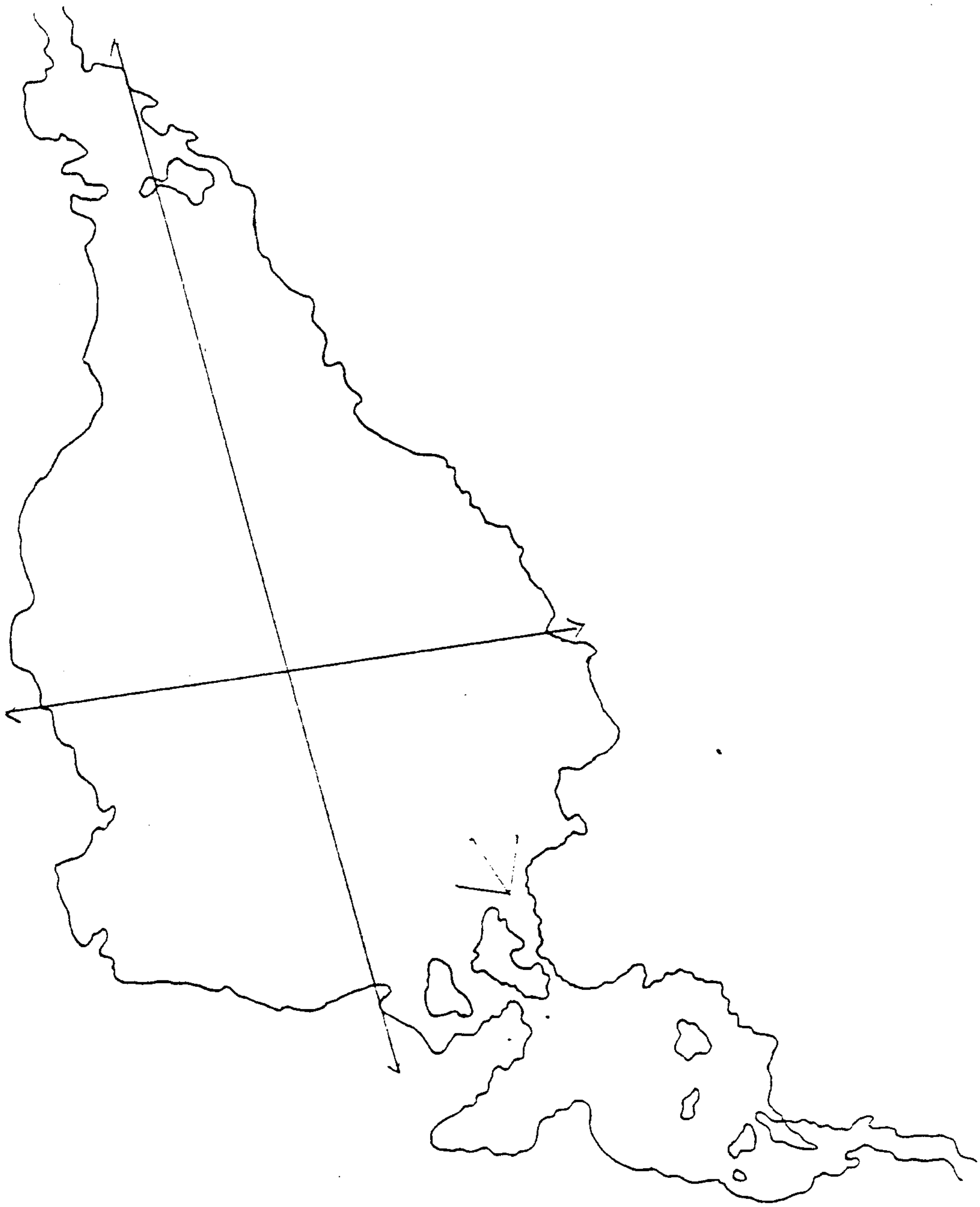


Fig. 9. Transect locations in Lake Sawgrass.

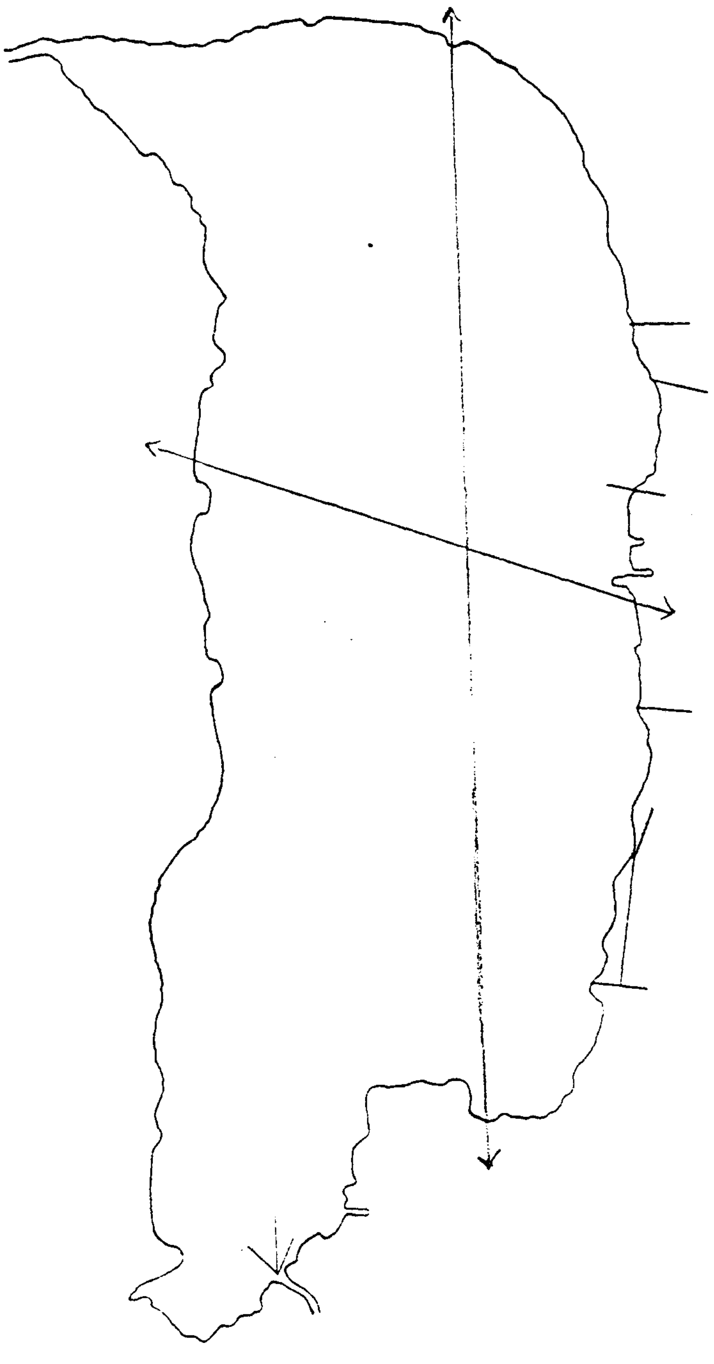


Fig. 10. Transect locations in Lake Washington.

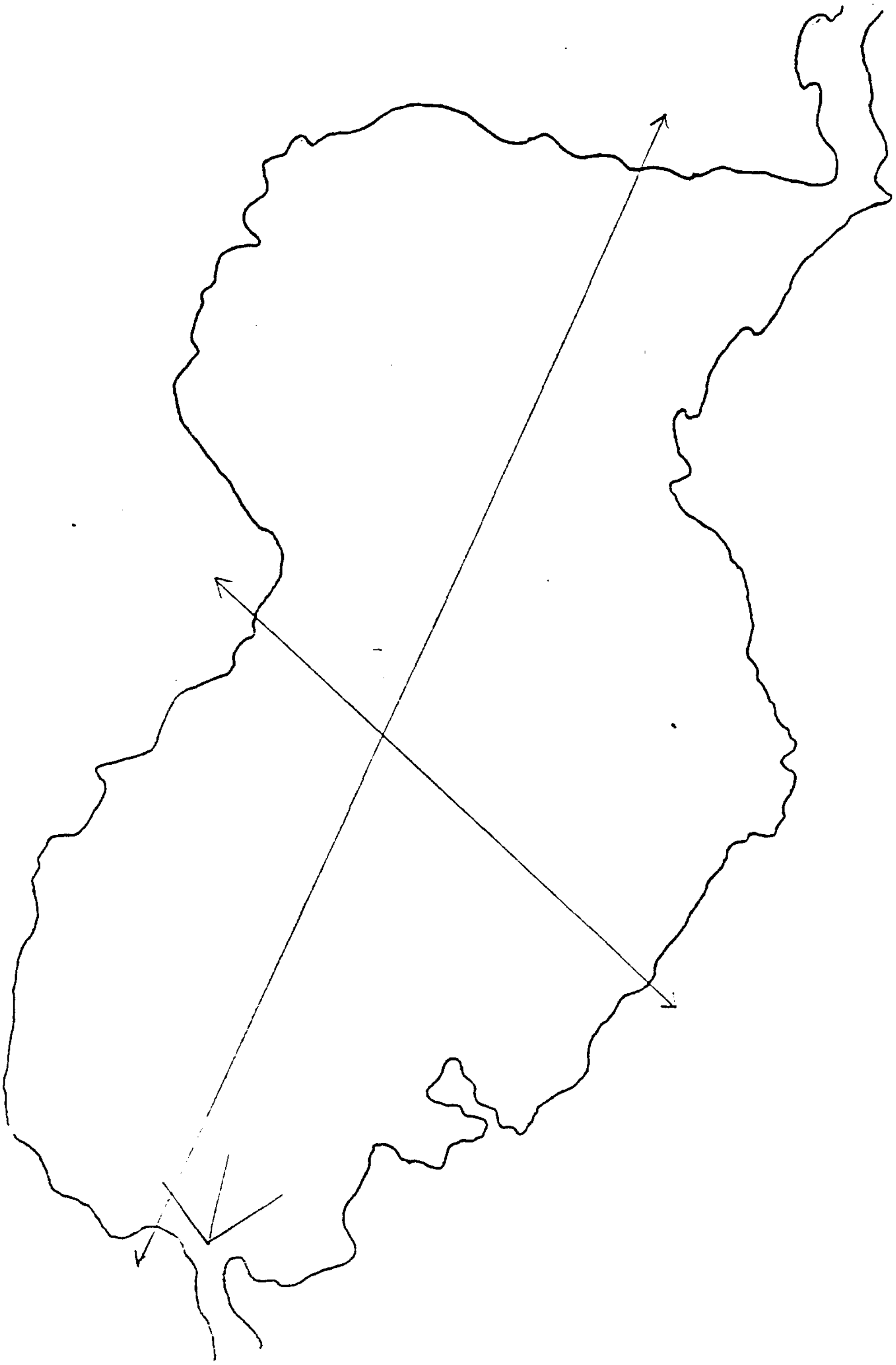


Fig. 11. Transect locations in Lake Winder.

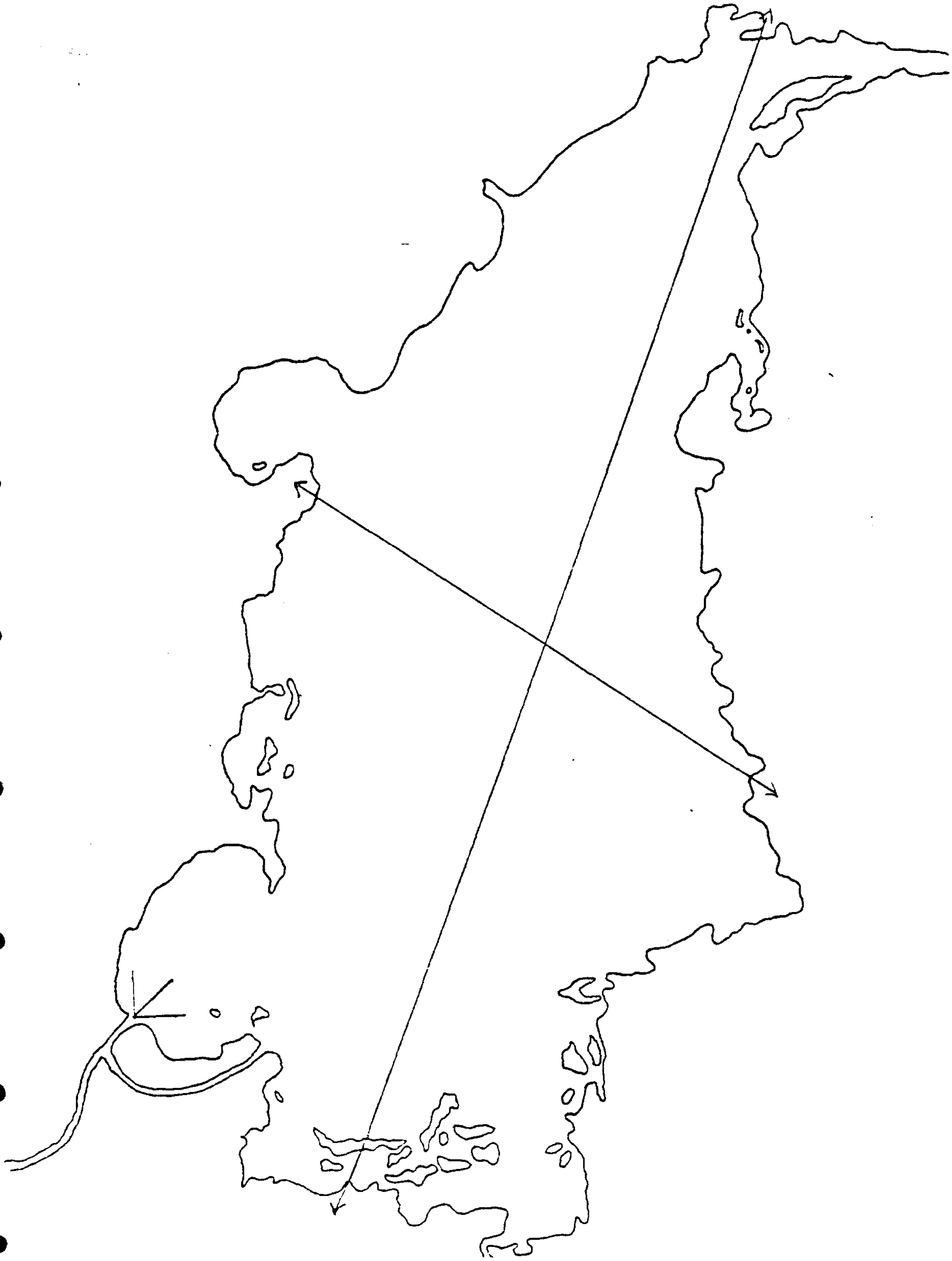


Fig. 12. Transect locations in Lake Poinsett.

CHAPTER IV

QUALITY CONTROL

LABORATORY QUALITY CONTROL

1. All glassware was Class A.

2. Analytical reagent grade chemicals were used whenever called for in the method.

3. Laboratory water was distilled/deionized with a negligible conductivity (<5 µmhos/cm).

4. All glassware was washed in a soap solution, acid washed and then rinsed in distilled water.

5. All analyses were done with EPA approved methods and time frames.

6. Replicates were done on approximately 10 percent of the duplicate samples as an estimate of precision. Results were recorded in the laboratory notebooks.

7. Spikes were done on 20 percent of the samples and results were recorded in the laboratory notebooks as percent recovery.

8. Blanks were run with each set of analyses.

9. A minimum of four standards were used to construct a standard curve. Subsequent use of a standard curve was verified by the use of at least a reagent blank and one standard.

10. This environmental laboratory participated in a sample exchange program with Enviropact Inc., Jacksonville, Florida.

11. EPA reference samples were routinely run with the collected samples.

DATA HANDLING AND RECORD KEEPING

1. As stated previously, field data were recorded in Field Notebooks for later transferral to Field Data Sheets. Field data sheets were catalogued by date and site number and kept in a separate notebook (Field Data Sheet Notebook) by the Project Director.

2. Each analyst was responsible for certain specific parameters. The raw analytical and quality control data for these parameters were recorded in the analyst's own laboratory notebook. When the tests were completed each analyst transferred his data to Master Laboratory Data Sheets, which were catalogued by date and site and kept in a separate notebook (Laboratory Data Sheet Notebook) by the Project Director.

FIELD QUALITY CONTROL

Field equipment was calibrated by the following methods:

1. Temperature was calibrated to ± 0.5°C by comparison with a laboratory grade thermometer.
2. Dissolved oxygen was routinely air calibrated and periodically checked against Winkler titrations.
3. Conductivity was periodically calibrated using a 0.010 M KCl solution (1413 μmhos/cm).
4. pH was calibrated to ± 0.1 pH unit using known buffers.
5. Turbidity was calibrated to ± 0.5 NTU using Formazine ampule standards.

All calibrations were performed just prior to a series of measurements. Turbidity, pH and dissolved oxygen measurements were often re-calibrated during the analyses. In addition, duplicate samples and field data were collected at all sites to verify reproducibility. The flow meter was routinely checked in surface waters of known velocity (by measuring the time it takes a float to travel a certain distance).

LAKE WASHINGTON OUTLET DISCHARGE CHECK

On 12/8/82 discharge was measured at the Lake Washington low level dam for comparison with the calculated discharge computed from the standard sheet pile weir formula discussed later. The stage height on this date was 14.68 ft. msl. Results from the two methods compared very well as the measured discharge was 536 ft^3/s and the calculated discharge was 546 ft^3/s.

SAMPLE EXCHANGE

The results of the F.I.T. sample exchange with Enviropact, Incorporated of Jacksonville, Florida are presented in Table 2. Two pump event samples were sent to Enviropact for analysis. Although the samples were kept cool on ice, the lag time of approximately 4 to 8 days may account for some of the differences between the F.I.T. and Enviropact values, particularly for the nutrients. Results of EPA reference sample analyses are shown in Table 3. In general, agreement between F.I.T. and EPA/Enviropact values were good and within acceptable limits.

s.

able 2. Sample Exchange

ample Site	Zig Zag		Mary A River Down	
ollection Date	8/16/82		8/12/82	
	Enviropact	F.I.T.	Enviropact	F.I.T.
issolved Solids (mg/L)	550	546	236	253
ardness (mg/L as $CaCO_3$	241	292	76	94
O_3^-N/L (mg/L)	0.24	0.32	--	--
H_4^+ (mg/L)	0.39	0.23	0.08	0.05
KN (mg/L)	2.95	3.4	--	--
otal P (mg/L)	0.15	0.14	0.17	0.16
rtho P (mg/L)	0.14	0.10	0.16	0.12
ulfate (mg/L)	--	--	51	68
hloride (mg/L)	--	--	53	52
alcium mg/L	78.0	100	22.0	20.0
agnesium mg/L	11.1	10.2	--	--

ample received by Enviropact on 8/20/82

eport # J1188

ab ID # 86119

nviropact of Jacksonville, Inc.
27 East 8th Street
acksonville, Florida 32206

Table 3. Comparison of Florida Institute of Technology with EPA Reference Samples.

Parameter	Date	F.I.T.	EPA
NO_3/NO_2	7/23	0.35	0.31
NO_3/NO_2	8/9	0.31	0.31
NO_3/NO_2	8/17	0.28	0.31
NO_3/NO_2	9/4	0.25	0.31
$O\text{-}PO_4$	7/21	0.02	0.031
$O\text{-}PO_4$	7/26	0.03	0.031
$O\text{-}PO_4$	9/4	0.03	0.031
Cl^-	7/26	21	18.7
Cl^-	8/24	21	18.7
Cl^-	9/7	20	18.7

CHAPTER V

RESULTS AND DISCUSSION

LAKE WASHINGTON INLET-OUTLET

Results from our study indicate there is an overall imbalance between loading rates for the inlet and outlet of Lake Washington. The outlet generally had higher discharge rates and higher concentrations of nutrients during the study period, resulting in the imbalance. Discharge concentrations and loading and export rates from Lake Washington are presented graphically in Figures 13 through 16. Several sources of water other than the inlet enter Lake Washington and increase outflow. These sources are primarily drainage canal and marsh flow. The drainage canals, located along the east side of Lake Washington discharge heavily during low stage conditions. During high stage conditions these canals drain with the surrounding marsh as sheet flow. At a critical lake stage height of approximately 15-15.5 ft. msl the canals and marsh generally stop flowing and act as an extension of the lake, significantly increasing the storage capacity of the lake. Inflow - Outflow characteristics are influenced by rainfall, agricultural pumpage and stage height in the upper basin draining into Lake Washington.

Discharge into Lake Washington varied greatly from week to week; however, we feel the numerous measurements have given us a fairly good data base for a mass balance approach. Discharge measurements for the Lake Washington inlet and cutlet, South Mormon Outside Canal, Three Forks Run and Bulldozer Canal are shown in Table 4. Nutrients were not measured until January, 1982, and consequently loading rate data presented in the figures begin at that time. At high stages, when the Marsh became submerged, nutrient concentrations were slightly higher. This is not unusual and is probably due to organic inputs from the marsh, nonpoint source runoff from surrounding lands and periodic agricultural pumpage. Wind mixing and bottom resuspension may also be important in periodically increasing nutrient concentrations and export rates from Lake Washington.

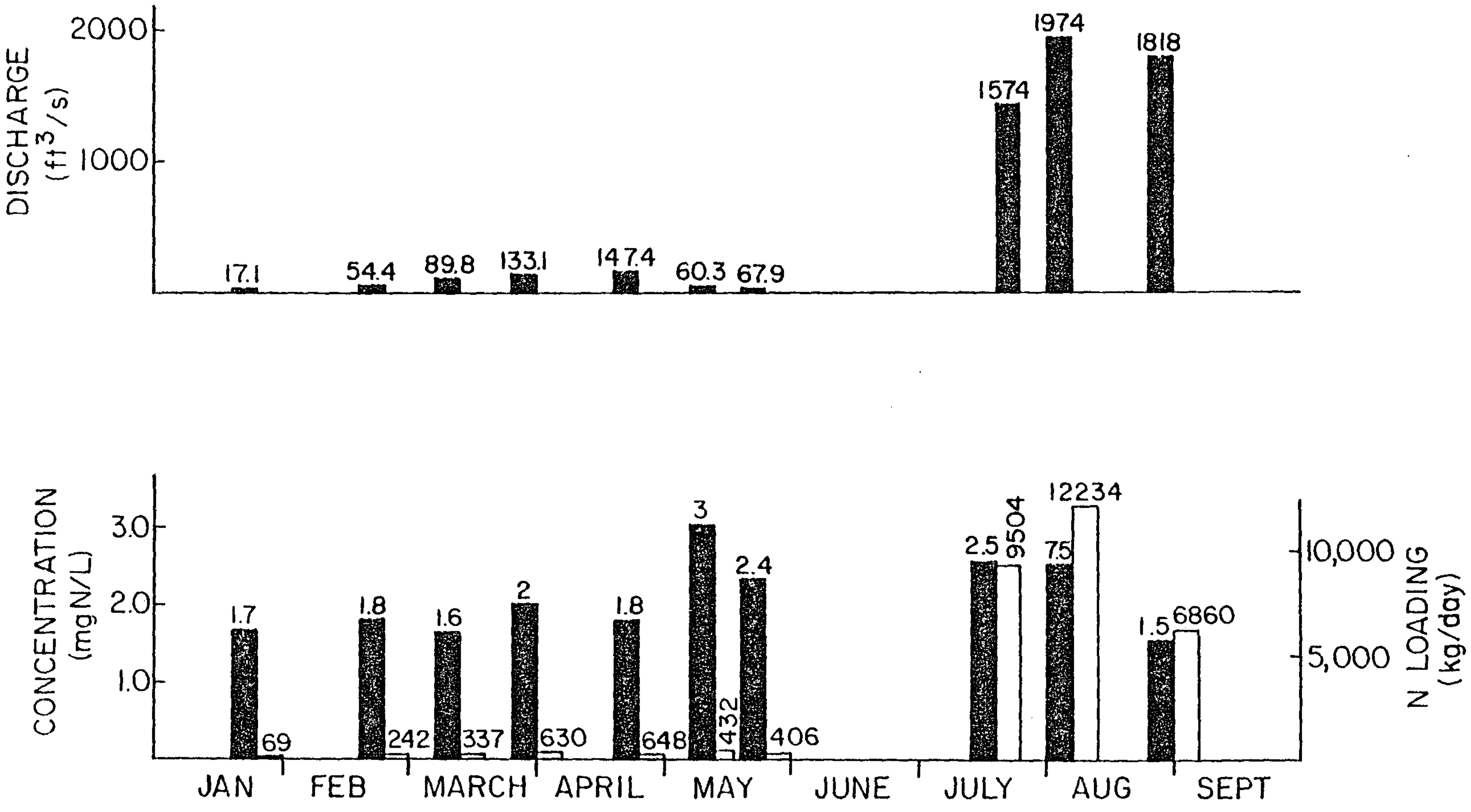


Fig. 13 . Discharge and total nitrogen concentrations (▮) and loading (▯) at the entrance to Lake Washington.

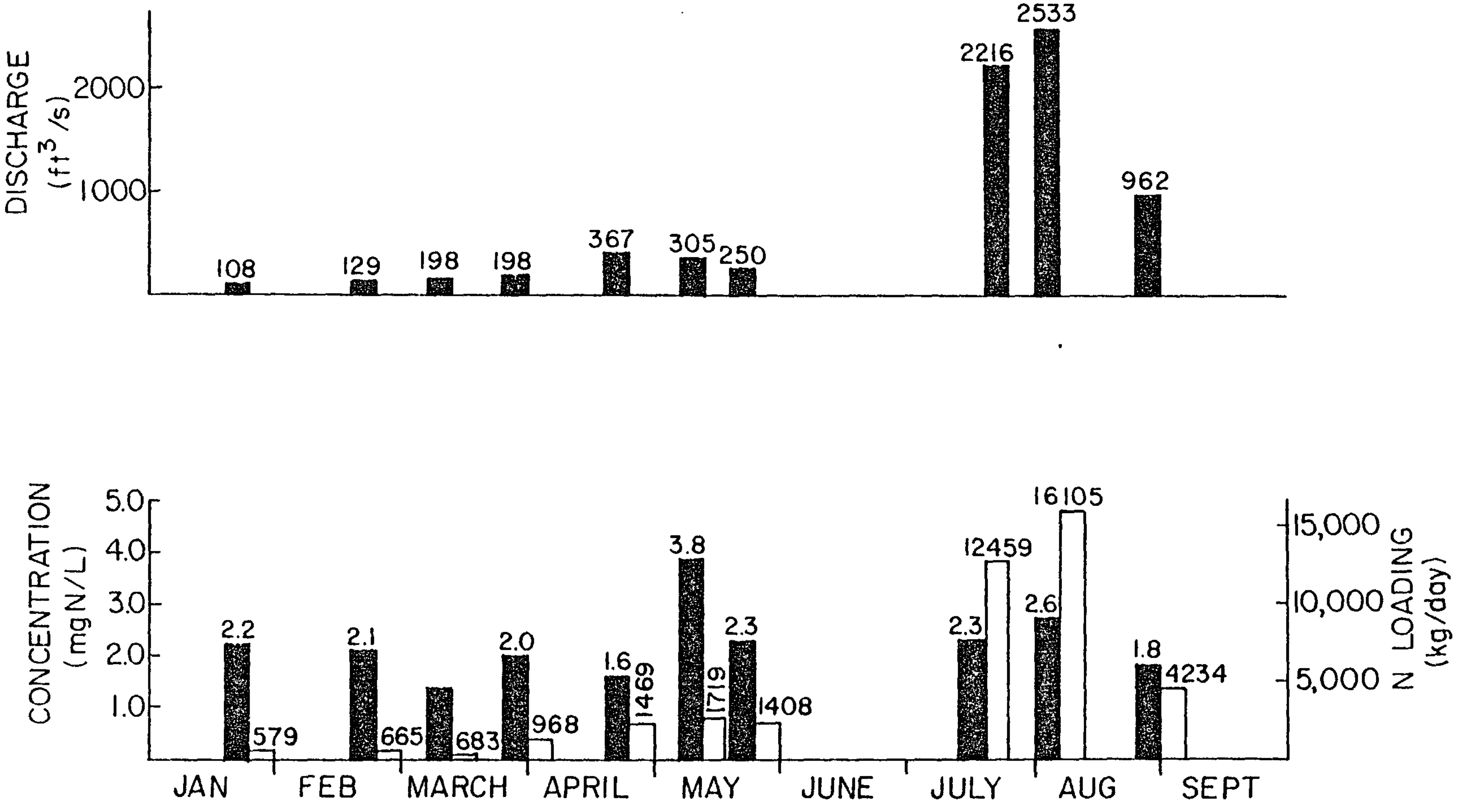


Fig. 14. Discharge and total nitrogen concentrations (■) and export (□) at the outlet of Lake Washington.

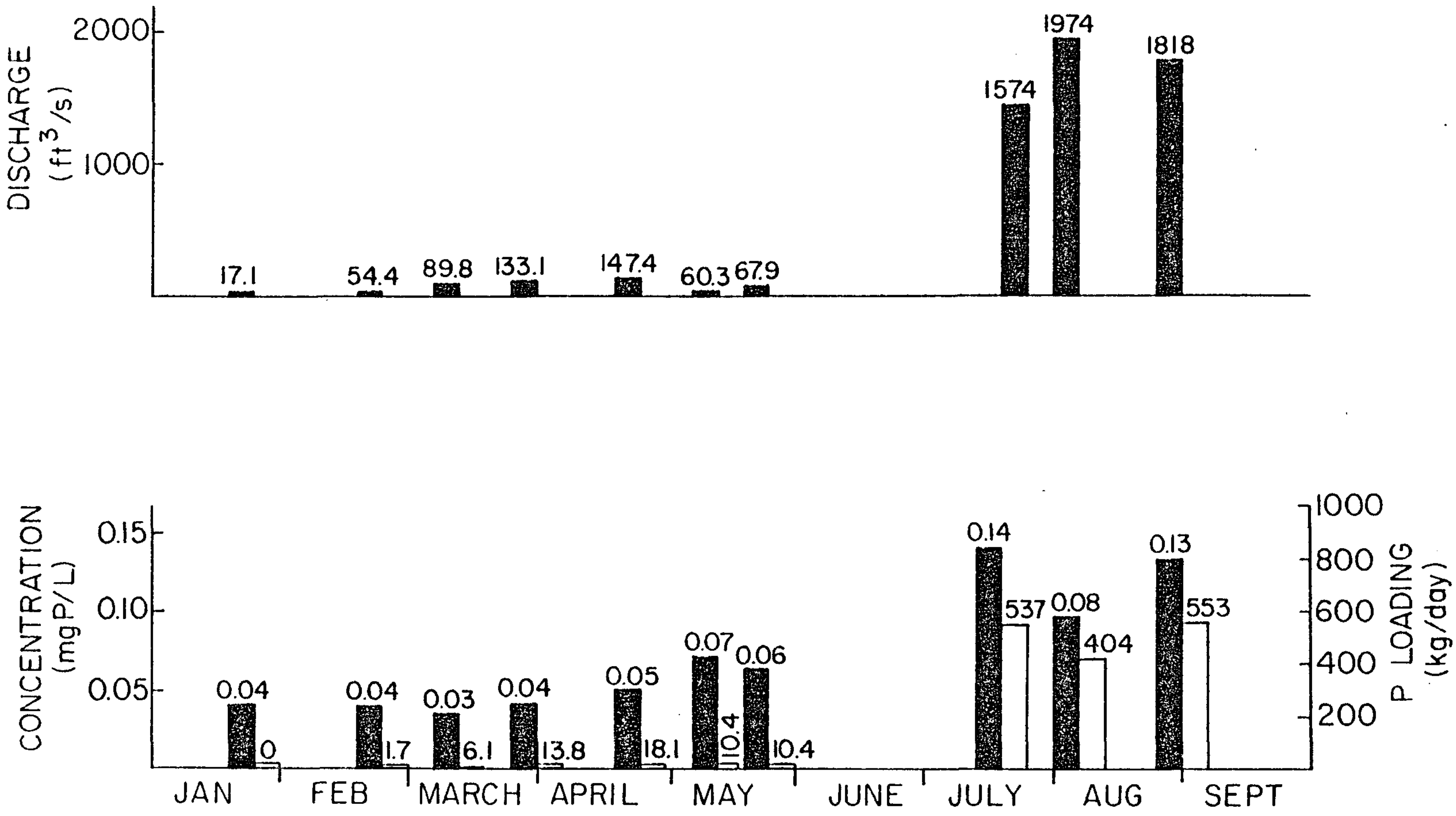


Fig. 15. Discharge and total phosphorus concentrations (■) and loading (□) at the entrance to Lake Washington.

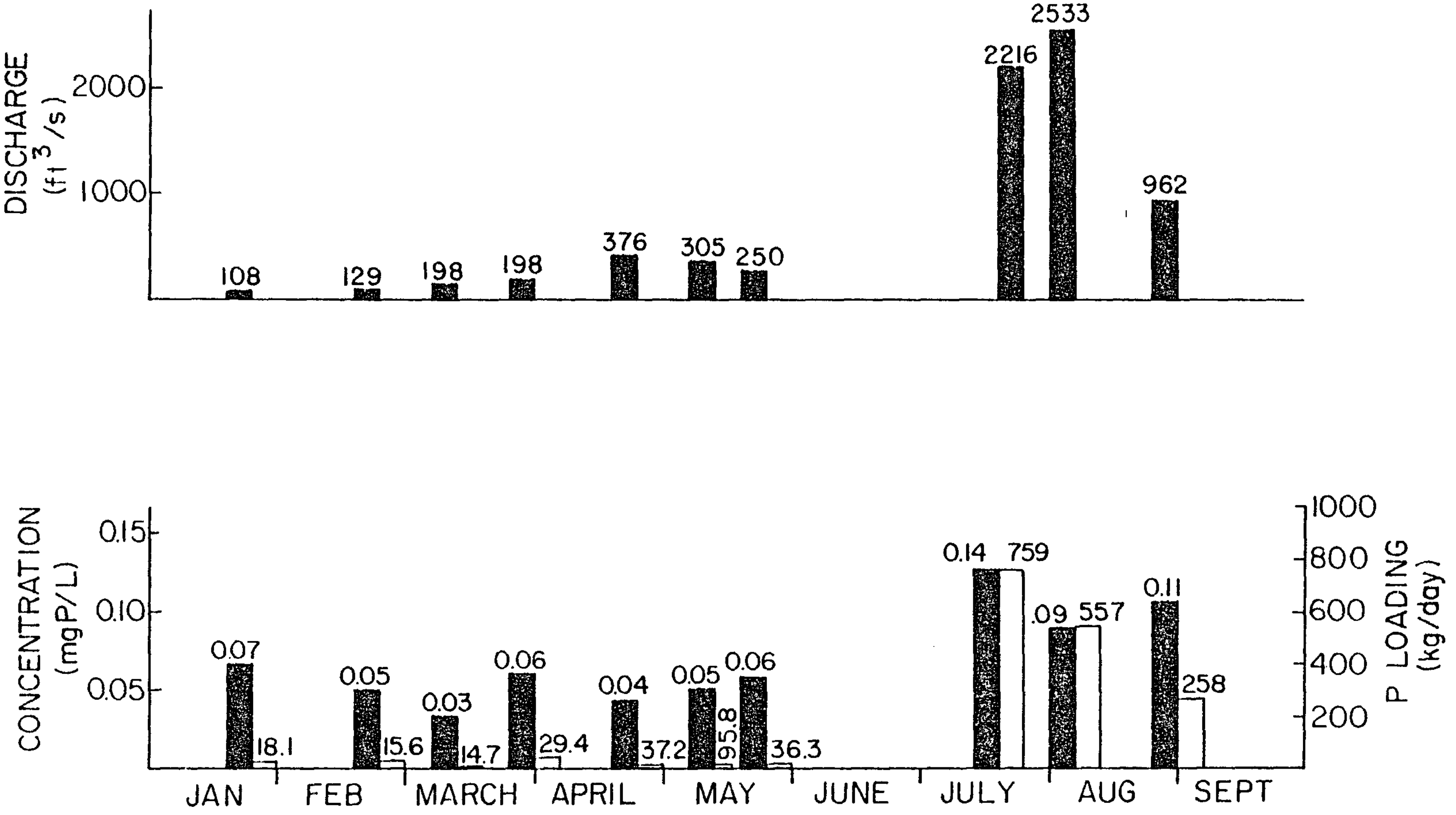


Fig. 16. Discharge and total phosphorus concentrations (▮) and export (▯) at the Lake Washington Outlet.

The only parameter which exhibited a net input into Lake Washington was suspended solids. This is logical as the sediment particles settle out as the velocity of the river slows upon entering Lake Washington. Results of coring throughout the lake, showing sediment types, are shown in Figure 27.

Discharge at the outlet ranged from 0 CFS when the river stage was below the head of the weir (13.5 ft msl), to 2538 cfs. The outlet discharges were calculated using the following USGS equation for a sheet pile weir:

$$Q = CLH^{3/2}$$

where

Q = Discharge (cfs)

C = 2.63

L = 162.16 ft. (effective length of the weir when clear of obstructions)

H = Head above the weir (ft).

This equation is used effectively when the head above the weir is two feet or less. This was the case for most of the sample dates. On one date, an actual discharge measurement was made and results were compared with the equation value showing good agreement.

The inlet discharges ranged from 17.1 cfs to 1974 cfs. As a quality control check our discharge data were compared with USGS data for comparable sample dates, although measurements were seldom made on exactly the same days. Results of this comparison can be found in Table 4 and show acceptable agreement. We found, however, that discharges can vary significantly from day to day and this fact should be taken into consideration in the comparisons.

Nutrient concentrations are presented in Appendix B. Total N and Total P concentration loading and export rates are presented in Figures 13 through 16. Total nitrogen concentrations at the outlet ranged from 1.4 mg/l to 3.8 mg/l with a mean concentration of 2.2 mg/1. Most of this nitrogen was present as organic nitrogen which is expressed as total kjeldahl nitrogen (organic + ammonia). Kjeldahl nitrogen had the same ranges as total nitrogen. Analysis for ammonia nitrogen was not initially run and only a few values were obtained. The range for those samples analyzed was <0.02 mg/1 to 0.26 mg/1 at the outlet. For those dates when ammonia concentrations are missing the ammonia concentrations are included in the total kjeldahl nitrogen. Due to this fact, inorganic nitrogen is expressed as nitrate-nitrite nitrogen. This form of nitrogen made up a small percentage of total nitrogen present and ranged from <0.02 mg/1 to 0.23 mg/1 nitrate-nitrite nitrogen at the outlet.

At the inlet, total nitrogen ranged from 1.5 mg/1 to 3.0 mg/1 and, again,total kjeldahl nitrogen had the same ranges,as well. Concentrations of ammonia at the inlet varied from <0.02 mg/1 to 0.19 mg/1. Nitrate-nitrite levels were much lower at the inlet than at the outlet, with concentrations ranging from <0.02 mg/1 to 0.03 mg/1.

Phosphorous concentrations at the outlet ranged from 0.03 mg/1 to 0.14 mg/1. Elevated levels were found during the summer months when rainfall-runoff and stage levels were high and this trend is similar to historical trends. The inlet samples in Lake Washington exhibited similar concentrations to the outlet,but differences in discharge between the two sites resulted in a greater phosphorus export rate than input rate.

UPPER ST. JOHNS RIVER CANALS

Three additional canals in the upper reaches of the basin were studied as they each represent a distinct source of water and materials into the St. Johns River. Three Forks Run (TFR) drains the entire east side of the St. Johns marsh via C-40 canal and others that drain into C-40, and drains into South Mormon Outside Canal south of Lake Helen Blazes. South Mormon Outside Canal (SMOC) drains the west side of the upper St. Johns River basin. Bulldozer Canal (BDZ),an east-west canal that drains portions of the marsh west of SMOC, joins SMOC at the origin of the original St. Johns River channel.

Discharges in these canals were quite variable throughout the study period. At the beginning of the study period, during low stage conditions, TFR was the strongest flowing canal sampled. By June 1982, this canal had completely stopped flowing and did not flow again until the end of August, when a negligible flow was detected. In the summer, when the river was at high stage levels, the marsh became inundated with water and sheet flow across the marsh into SMOC became the major mode of transportation for water coming from the east, replacing the flow in TFR. This is shown by the fact the flow stoppage in TFR correlated with a dramatic increase in discharge in SMOC (Table 4). The critical stage height (at U.S. 192) for this occurrence appears to be approximately 15 ft. msl. Bulldozer canal (BDZ) did not discharge at all in the initial phases of the study and most recorded discharges were quite low until June 1982. At that time discharges were fifty times greater than previous values, but, the discharge was reversed in the canal. A large percentage (>60%) of the strong South Mormon Outside Canal discharge was entering BDZ and flowing to the west. Any discharge from BDZ was being directed into the marsh, to the month of Bulldozer Canal, as was the SMOC flow that entered the canal.

This marsh input was then discharged via sheetflow back into the St. Johns north of Lake Hellen Blazes.

Total nitrogen followed a seasonal pattern in SMOC and BDZ. Low concentrations were found in the winter and high concentrations were found in the summer. SMOC had total nitrogen concentrations ranging from 1.2 mg/l to 3.4 mg/l while levels in BDZ varied from 0.8 mg/l to 3.1 mg/l. The high values for BDZ were recorded during the reverse flow conditions and are actually downstream duplications of SMOC samples. TFR showed very littler variation in total nitrogen concentrations and ranged from 1.5 mg/l to 2.7 mg/l. Most of the samples,however, were in a 2.1 mg/l to 2.7 mg/l range.

Total kjeldahl nitrogen comprised the majority of the total nitrogen present and exhibited nearly identical ranges to those of total nitrogen. Ammonia-nitrogen showed similar trends to those found in Lake Washington. In TFR ammonia-nitrogen ranged from <0.02 mg/l to 0.11 mg/l, in SMOC it ranged from 0.02 mg/l to 0.25 mg/l while BDZ concentrations varied from <0.02 mg/l to 0.21 mg/l. The highest concentrations were found during the summer months. Nitrate-nitrite levels showed an opposite trend to that of ammonia-nitrogen, with elevated concentrations during the winter and very low concentrations during the summer. The canals all displayed levels of nitrate-nitrite nitrogen well above the levels found at Lake Washington. The seasonal trends for ammonia and nitrate-nitrite are quite easily explained as similar trends have occurred in the past. The summer oxygen levels in the St. Johns River and marsh were severely depressed to levels below 1.0 mg/l most of this time and the marsh was completely flooded.Under these low oxygen to anaerobic conditions in the summer, nitrate-nitrogen cannot occur in abundance and reduction or denitrification may occur, producing ammonia-nitrogen. When oxygen is more available, as in the winter months, ammonia oxidation can occur in additions to biological nitrification.

These processes decrease the ammonia-nitrogen available and increase nitrate-nitrite concentrations.

Total P concentrations found in the canals were also higher than those found at the Lake Washington sites. Loading values were considerably lower, however, due to the lower discharge rates in the canals. Phosphorus showed a seasonal variation of low winter and high summer concentrations. These elevated levels are probably due to increased runoff that occurs during the summer rainy season. TFR concentrations ranged from 0.05 mg/l to 0.15 mg/l. SMOC levels ranged from 0.02 mg/l to 0.45 mg/l, with the higher concentrations occurring during the summer when rainfall was high. BDZ ranged from <0.01 mg/l to 0.24 mg/l, but the high levels are representive of South Mormon Outside Canal due to the reverse flow phenomenon.

Suspended solids concentrations in the canals were variable. Generally, suspended solids concentrations increased with increased discharge, although there was considerable variability and statistical correlations between these two parameters were very poor (r = .05). TFR concentrations ranged from 0.8 mg/l to 10.3 mg/l and SMOC levels ranged from 1.9 mg/l to 26.2 mg/L. The high value in SMOC occurred when a huge silt plume passed through the area as the transect and flow measurements were being made. A plume such as this is generally indicative of a pump discharge from an upstream location. Both total phosphorous and total nitrogen were at maximum concentrations at this time, also. Bulldozer Canal had suspended solids concentrations varying from 0.6 mg/l to 10.4 mg/l.

The suspended solids levels found in the canal areas are generally higher than the values recorded further downstream at the Lake Washington inlet. The solids are therefore settling out in the lakes before they reach downstream areas. Lake Hellen Blazes, the first lake encountered north of the canals, has a bottom consisting of loose organic muck with a thickness of up to three feet. This muck layer is thicker than layers in lakes located farther downstream, indicating that most of the suspended solids entering this lake settle out.

Conductivity levels at the canal sites were higher than any other sites sampled, reflecting groundwater irrigation and seepage directly into canals. Conductivity ranged from 315 to 1440 µmhos/cm in South Mormon Outside Canal from 310 to 1190 µmhos/cm in Bulldozer Canal. Three Forks Run ranged from 305 to 900 µmhos/cm. The lower values for conductivity at all sites were recorded during the summer months due to the dilution effect from rainfall/runoff. Lake Washington inlet conductivity levels varied from 300 to 845 µmhos/cm during the same period.

The canal data from each site were grouped together (49 cases) and analyzed statistically to identify significant relationships. In particular, we investigated relationships between rainfall (3 day) and discharge and all measured parameters at the canal sites. The only significant correlations were between discharge and ammonia ($r = .68$; $P<.01$) and discharge and conductivity ($r = -.32$; $P<.05$). Also, total phosphorus and total kjeldahl nitrogen were significantly ($p<.01$) related to suspended solids with r values of .74 and .44, respectively. Discharge, nutrient concentration and loading data for Mormon Outside, Three Forks and Bulldozer canals are presented in Figures 17 through 22. The raw water quality data for these canals are shown in Appendix B.

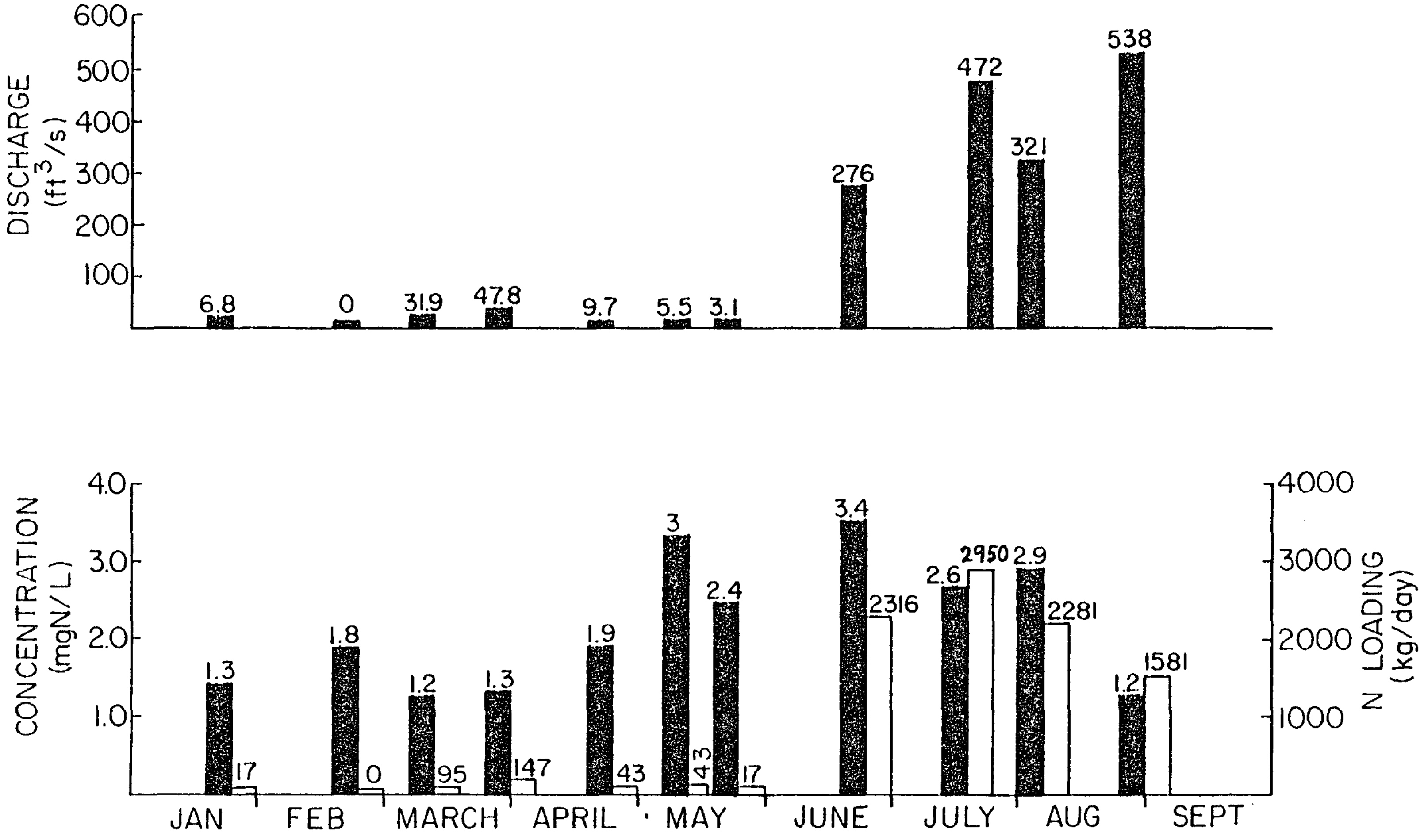


Fig. 17. Discharge and total nitrogen concentrations (■) and loading (□) at Mormon Outside canal.

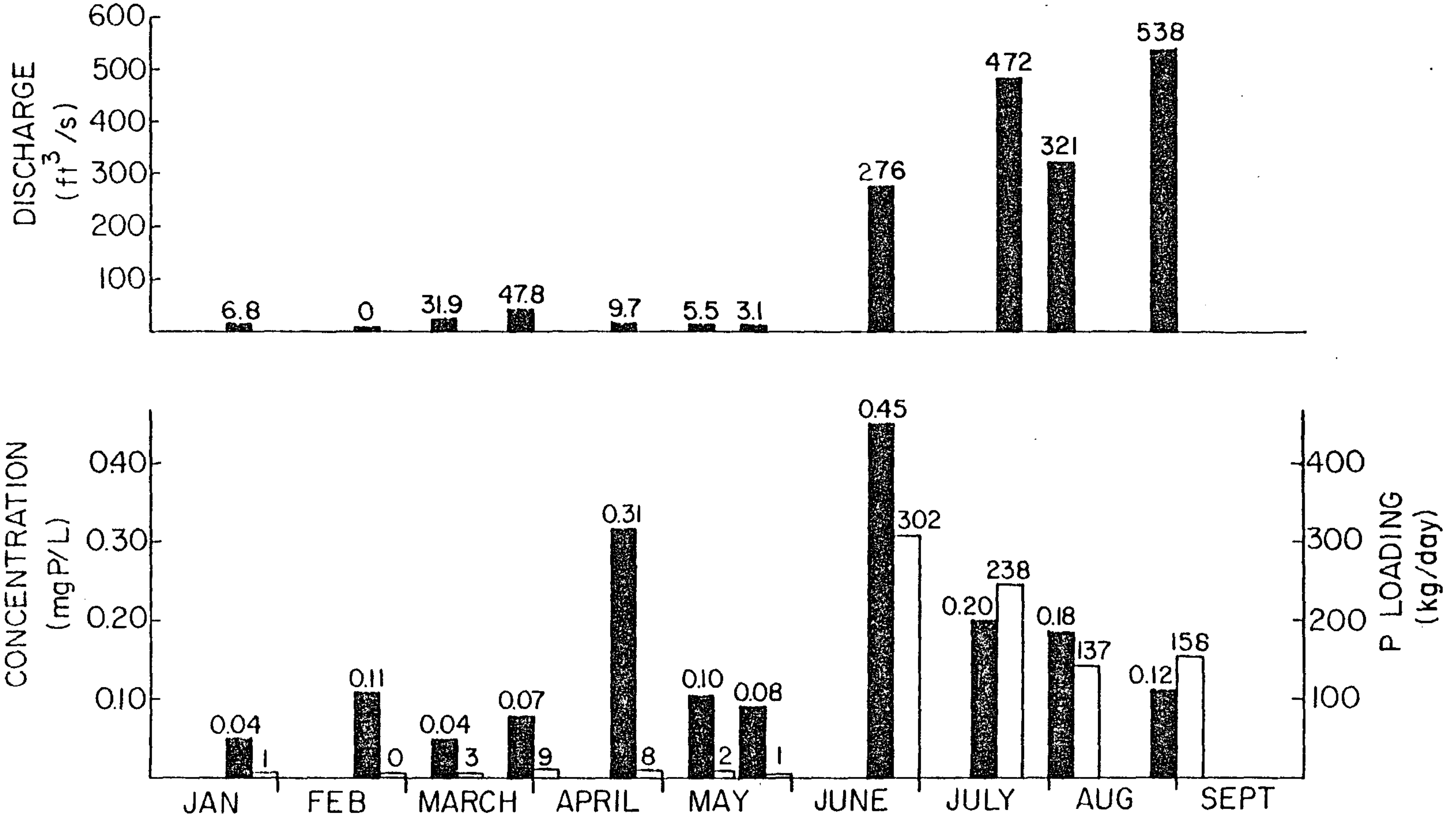


Fig. 18. Discharge and total phosphorus concentrations (■) and loading (□) at Mormon Outside canal.

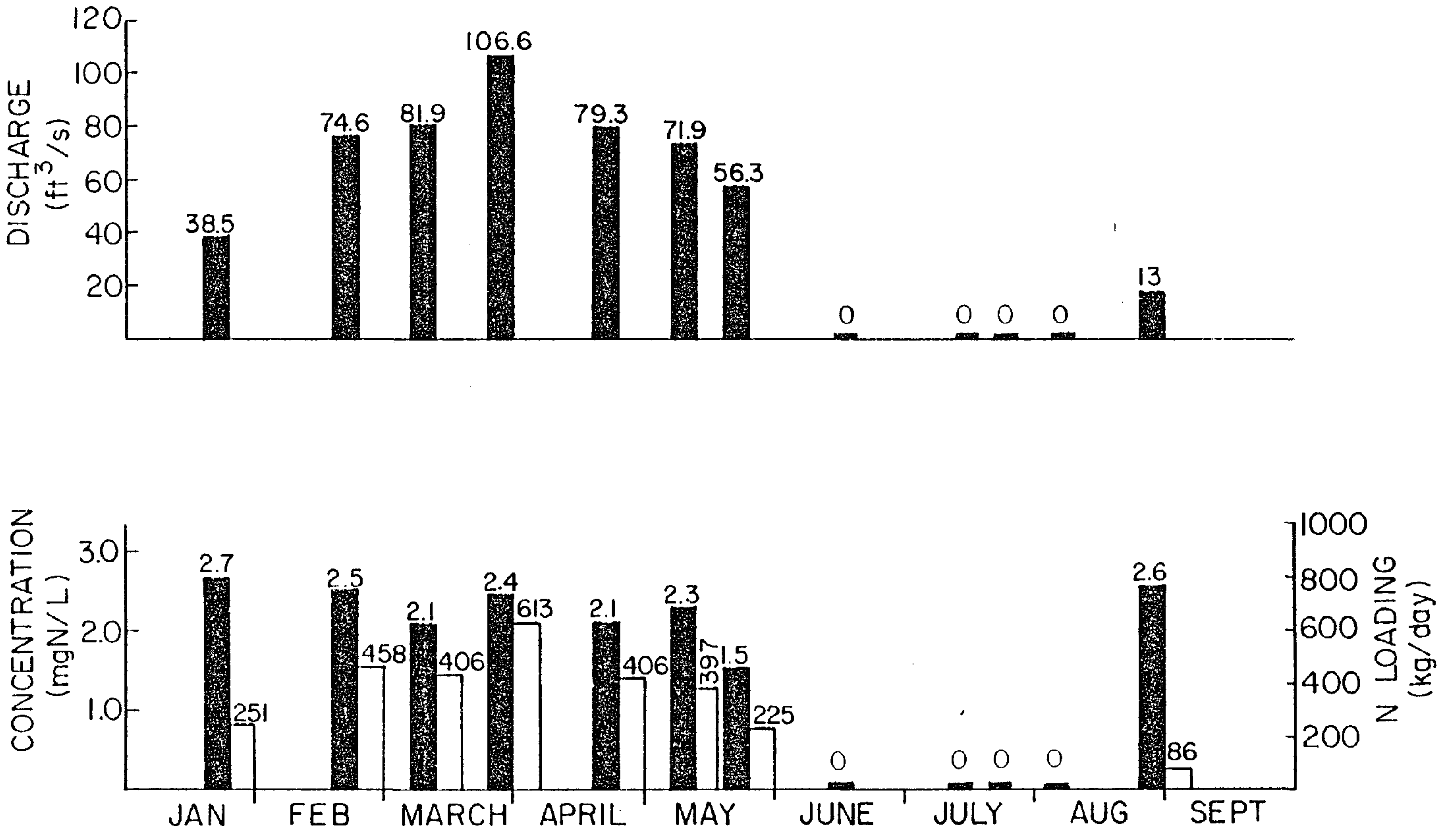


Fig. 19. Discharge and total nitrogen concentrations (▮) and loading (▯) at Three Forks tributary.

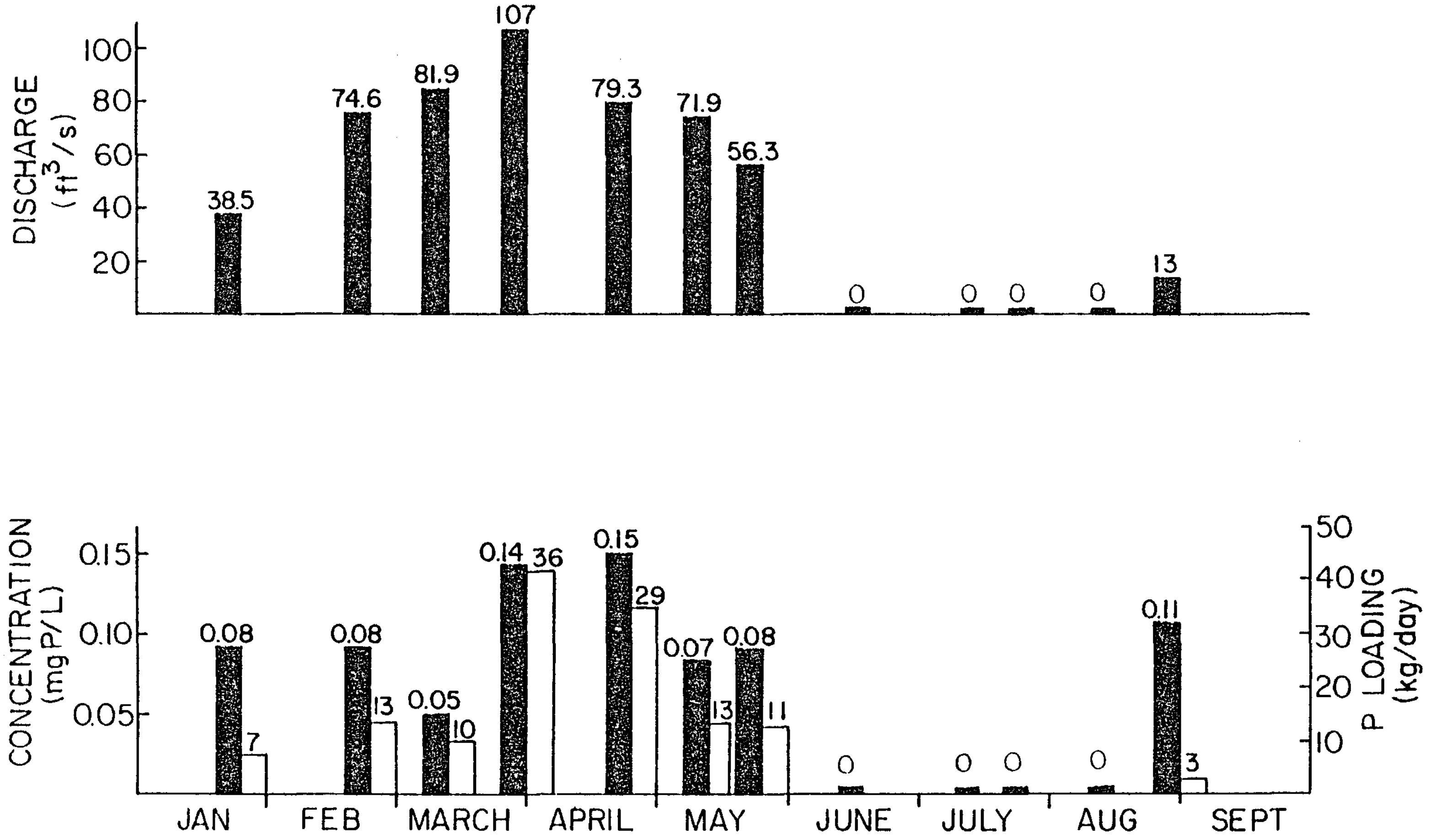


Fig. 20. Discharge and total phosphorus concentrations (▨) and loading (☐) at Three Forks tributary.

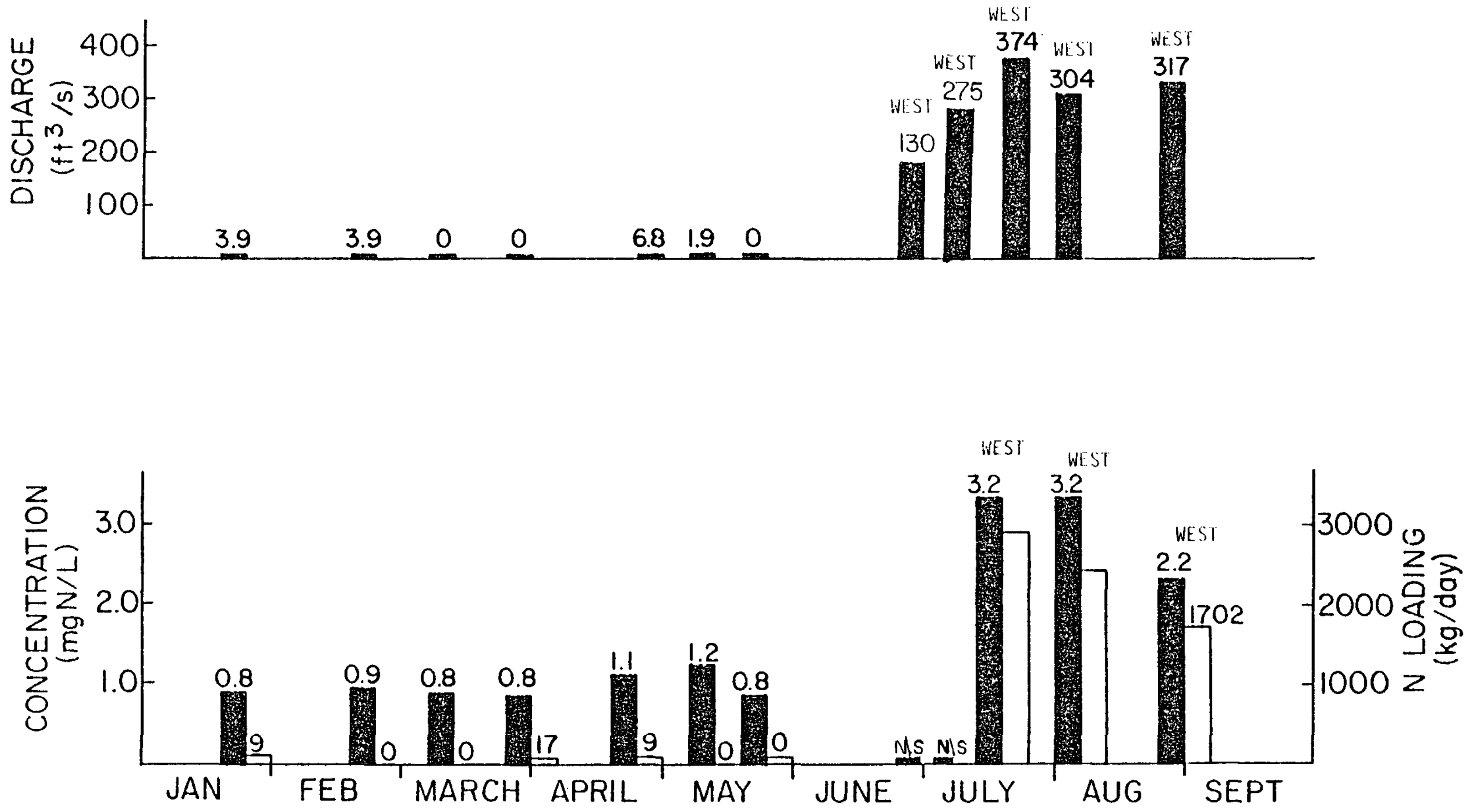


Fig. 21. Discharge and total nitrogen concentration (■) and loading (□) at Bulldozer canal.

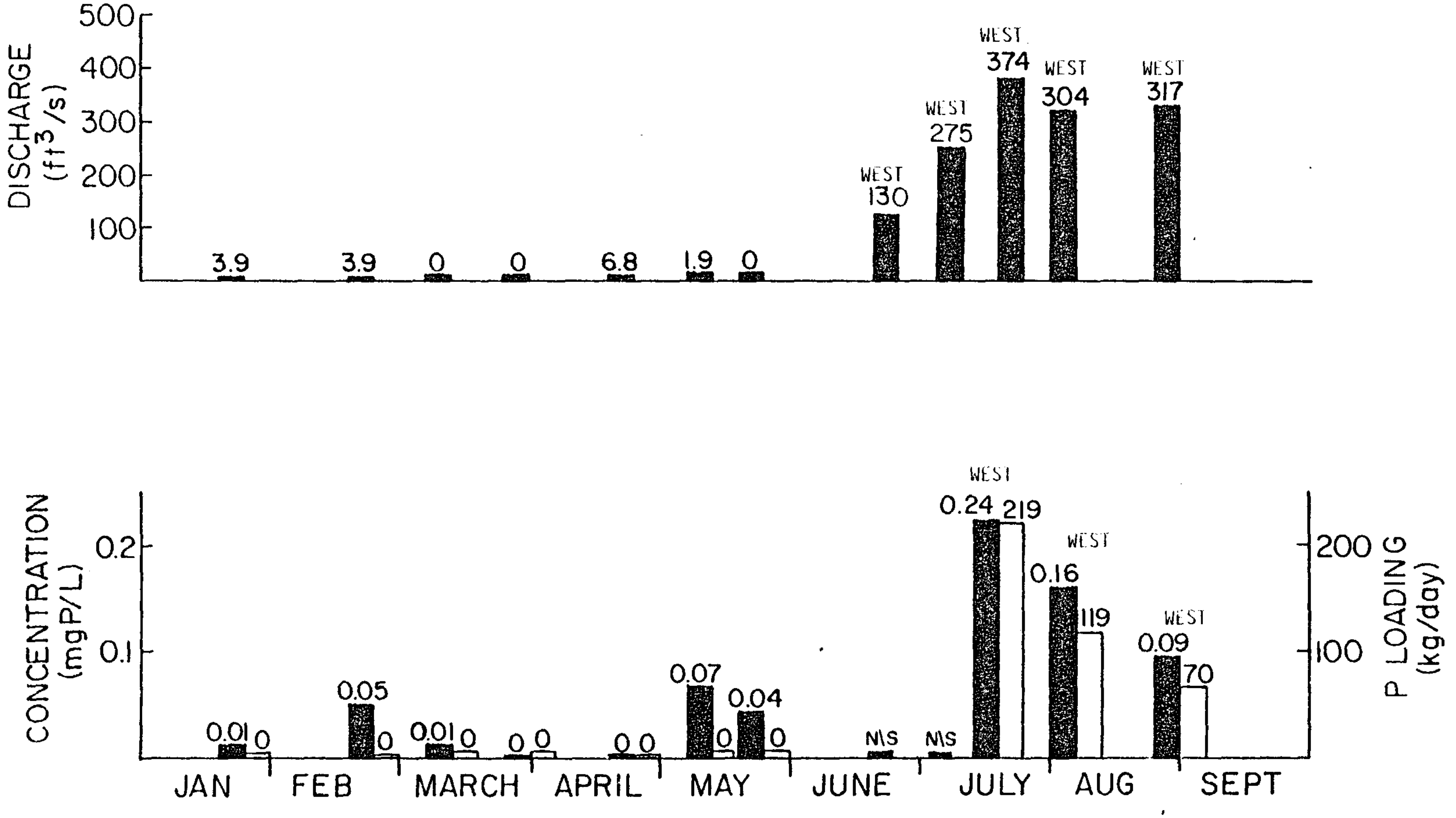


Fig. 22. Discharge and total phosphorus concentrations (■) and loading (□) at Bulldozer canal.

DISCHARGE PATTERNS IN THE UPPER ST. JOHNS RIVER STUDY AREA

Routine discharge rates were measured at several locations in the upper St. Johns River (Table 4). These locations were the Lake Washington inlet and outlet (LWI & LWO), South Mormon Outside Canal (SMOC), Three Forks Run (TFR) and Bulldozer Canal (BDZ). Suspended solids and nutrient loading rate data collected at these sampling points are discussed elsewhere in this Chapter. Field observations and measured discharges shown in Table 4 indicate that above a stage height of 13.5 ft. msl (height of weir) the discharge leaving Lake Washington was slightly greater on sampling days than the inflow (Inflow and outflow data were collected on the same day eighteen times during the study year, consequently these data are very limited and inconclusive.) This may be due to additional water inputs from the marsh (located primarily on the southeast and west sides of the lake), from canal inputs on the east side of the lake, and from groundwater seepage. It was noticed that at high stage levels (>15 ft. msl), the drainage canals entering Lake Washington cease to flow and the marsh and canals act as an extension of the lake. At these stage heights, the discharge differences between inflow and outflow are minimized. A detailed water budget for the lake was not done at this time for 1982 but was constructed in detail by Mason and Belanger (1979) for 1978.

A paucity of discharge data are available for the summer months (1982) as our efforts were primarily concentrated on sampling pump events at that time. However, based on our data, the following generalizations hold true. It appears that SMOC exhibits a small flow rate until the stage height reaches a critical level of approximately 15 ft. msl, at which point the discharge dramatically increases. This critical stage height cannot be pinpointed due to a lack of data. At this same critical stage level, TFR ceases to flow and a large

Table 4. Discharge Measurements in the Upper St. Johns River, 1982
Department of Environmental Science, Florida Institute of Technology (ft^3/s)

Lake Washington Stage Ht. (ft)		Lake Washington Inlet	Lake Washington Outlet	South Mormon Outside Canal			Three Forks Run		Bulldozer Canal
12.03	8/28/81	26	0						
12.12	9/1/81	34	0						
12.99	9/15/81	435	0	9/15/81	24	9/15/81	53	9/15.81	0
14.10	9/23/81	299	277	9/23/81	32	9/23/81	87	9/23/81	0
14.13	10/2/81	219	239	10/8/81	9	10/8/81	98	10/8/81	0
14.04	10/8/81	123	239						
14.13	11/6/81	56	250						
13.98	11/16/81	83*	142						
13.80	12/15/81	101*	108						
13.76	12/17/81	23	129	12/17/81	17	12/17/81	28	12/17/81	28
13.75	1/20/82	17	108	1/20/82	7	1/20/82	39	1/20/82	39
13.72	2/9/82	74*	44						
13.77	2/24/82	54	129	2/22/82	0	2/22/82	75	2/22/82	0
13.85	3/12/82	90	198	3/10/82	32	3/10/82	82	3/10/82	0
13.87	3/30/82	133	198	3/31/82	48	3/31/82	107	3/31/82	7
13.96	4/7/82	94*	133						
14.15	4/22/82	147	376	4/22/82	10	4/22/82	79	4/22/82	2
14.10	5/13/82	60	305	5/13/82	6	5/13/82	72	5/13/82	0
14.10	5/26/82	68	250	5/26/82	3	5/26/82	56	5/26/82	0
14.40	6/3/82	350*	575	6/18/82	203	6/18/82	0	6/18/82	130 (west)
				6/24/82	276	6/24/82	0	No measure	
16.46	7/19/82	1574	2216			7/12/82	0	7/12/82	275 (west)
16.78	8/4/82	1974 (2580)*	2533	7/20/82	481	7/20/82	0	7/20/82	374 (west)
16.20	8/26/82	1818	1962	8/2/82	321	8/2/82	0	8/2/82	307 (west)
15.73	9/28/82	1510*	1419	8/31/82	538	8/31/82	13	8/31/82	317 (west)

* = USGS Field Measurement

percentage of the SMOC discharge enters BDZ and travels west. The percentage of SMOC flow entering BDZ was found to be 64 and 78% on 6/18/82 and 7/20/82, respectively. The westerly flow in BDZ gradually enters the marsh on the north side of the canal near BDZ pump #1 and travels northward as diffuse flow, probably re-entering the St. Johns River channel near Jane Green Creek. Any pump discharge in BDZ at high stage heights also enters the north marsh and is not observed directly as canal flow. TFR stops flowing at this high stage level because discharge which normally enters TFR from lateral M canal and C-40 canal crosses the marsh east of SMOC and enters SMOC, contributing to the high discharges in that canal. The measured discharge rates are shown graphically in Appendix C.

AGRICULTURAL PUMPAGE

There have been conflicting reports in the past on the relationship of agricultural activities in the upper St. Johns River Basin to water quality problems in the area. Sullivan (1979) concluded, based primarily on an extensive literature review, that agricultural activities have adversely affected water quality. In particular, his report states that agricultural runoff and pumped water can degrade water quality by increasing loadings of suspended solids, BOD and nutrients. The report was primarily concerned with the activities of Deseret Ranches of Florida Inc., although the conclusions can apply to other ranches as well. A report by CH_2M Hill, however, a firm hired by Deseret Ranches, indicated the runoff and pumpage activities had an insignificant affect on receiving water (CH_2M Hill, 1979). These conclusions were based on a preliminary water sampling program at and within the vicinity of Deseret pumping stations. The sampling program covered only two sampling periods, however, and these occurred on October 2-3, 1978 and January 12-13, 1979. In view of this paucity of agricultural pumpage data, the information provided within this report is timely and sorely needed.

Thirteen pump events were monitored during this study, in addition to periodic background sampling. Pump discharge rates and total nitrogen and total phosphorus concentrations and loading rates are presented in Tables 5 and 6 and Figure 23 and 24. The thirteen pump events were collectively analyzed in numerous ways to determine statistical relationships. Water quality parameters were regressed against rainfall and discharge, as well as against each other. Very significant relationships were found between discharge and ammonia ($r = .95$; $p < .01$), but no other significant relationships were found.

DUDA CANAL AND NORTH MORMON PUMP SITES

The North Mormon Pump was visited several times, but was never pumping. Background data collected on 5/28/82 are presented in Table 7. The Duda pump was also not on during the F.I.T. sampling trips, however the GFWFC reported it pumping on 12/7/82 and they collected water samples at the entrance of Duda canal to the river (approximately 1 mile downstream of the pump). The GFWFC upstream, downstream and Duda canal data, along with F.I.T. background data collected on 9/3/82 at the pump, are presented in Table 8 . These data indicate the pump was discharging high concentrations of ortho (.22 mg P/L) and total (.31 mg P/L) phosphorus and inorganic nitrogen, particularly ammonia nitrogen (.92 mg NH_3-N/L). Hardness (275 mg/L as $CaCO_3$) and chloride (590 mg/L) levels were also very high. Although loading could not be computed because discharge was not measured, it was probably significant as the Duda pump capacity is 57,000 GPM and the GFWFC noticed a very swift flow entering the river from the canal. If this pump was discharging at 50% capacity (28,500 GPM or 63.5 ft^3/s) the TN and TP loads entering the river would be 379 and 48 Kg/day, respectively. This loading is higher than that recorded for the Bulldozer pumps (at the outfall) and indicates that this pump could be a potentially significant pollutional source to the St. Johns River.

Table 5. Agricultural Pump Discharge, Loading and Concentration Data From the Zig Zag and Mary A Pump Locations

Location	Zig Zag Pump	Mary A Pump
Pump Capacity	334 ft^3/s	267 ft^3/s

Date	Discharge ft^3/s	% Capacity	TN MgN/L	TP Mg P/L	TN Loading K_g/day	TP Loading K_g/day	Date	Discharge ft^3/s	% Capacity	TN MgN/L	TP Mg P/L	TN Loading K_g/day	TP Loading K_g/day
6/15/82	195	58	2.5	.04	1193	19.1	7/22/82	178	66	4.9	1.03	2134	448
6/18/82	282	84	2.7	.24	1866	166	8/12/82	240	90	5.1	1.16	2995	681
6/24/82	129	39	2.9	.08	916	25	9/1/82	89	33	1.87	.19	675	41
6/25/82	150	45	2.5	.12	916	44			X =	3.96	0.79		
8/16/82	180	54	3.7	.14	1633	61							
		X =	2.86	0.12									
	Background Conc. Data (Pumps Off)							No Background Conc. Data					
5/5/82	--	--	2.16	.05	--	--							
4/27/82	--	--	2.23	.10	--	--							
		X =	2.19	0.07									

Note: All Zig Zag pump discharges were determined from field upstream and downstream measurements. The 6/15/82 Zig Zag data were taken at the canal bend approximately one mile downstream of the pump, and consequently may be an underestimate. Discharge and loading data of the Mary A and Bulldozer pumps were estimated based on % capacity estimates of pump discharges. This was necessary as field measurements made at these locations were inaccurate due to diffuse pump flow into the marsh and adjoining canals.

Table 6. Agricultural Pump Discharge, Loading and Concentration Data from the Bulldozer Pump Locations.

Location	Bulldozer Pump #1	Bulldozer Pump #2
Capacity	72 ft^3/s	36 ft^3/s

Bulldozer Pump #1

Date	Discharge ft^3/s	% Capacity	TN MgN/L	TP Mg P/L	TN Loading K_g/day	TP Loading K_g/day
7/12/82	36	50	2.89	.14	238	12.3

No Background Conc. Data

Bulldozer Pump #2

Date	Discharge ft^3/s	% Capacity	TN MgN/L	TP MgP/L	TN Loading K_g/day	TP Loading K_g/day
7/12/82	18	50	2.4	.27	106	11.9
7/20/82	18	50	1.8	.11	79	4.8
8/3/82	13	36	2.4	.14	73	4.4
8/31/82	No meas.	--	2.38	.29	--	--
		.X =	2.25	.20		
	Background Conc. Data (Pumps Off)					
5/26/82	--	--	.97	.06	--	--

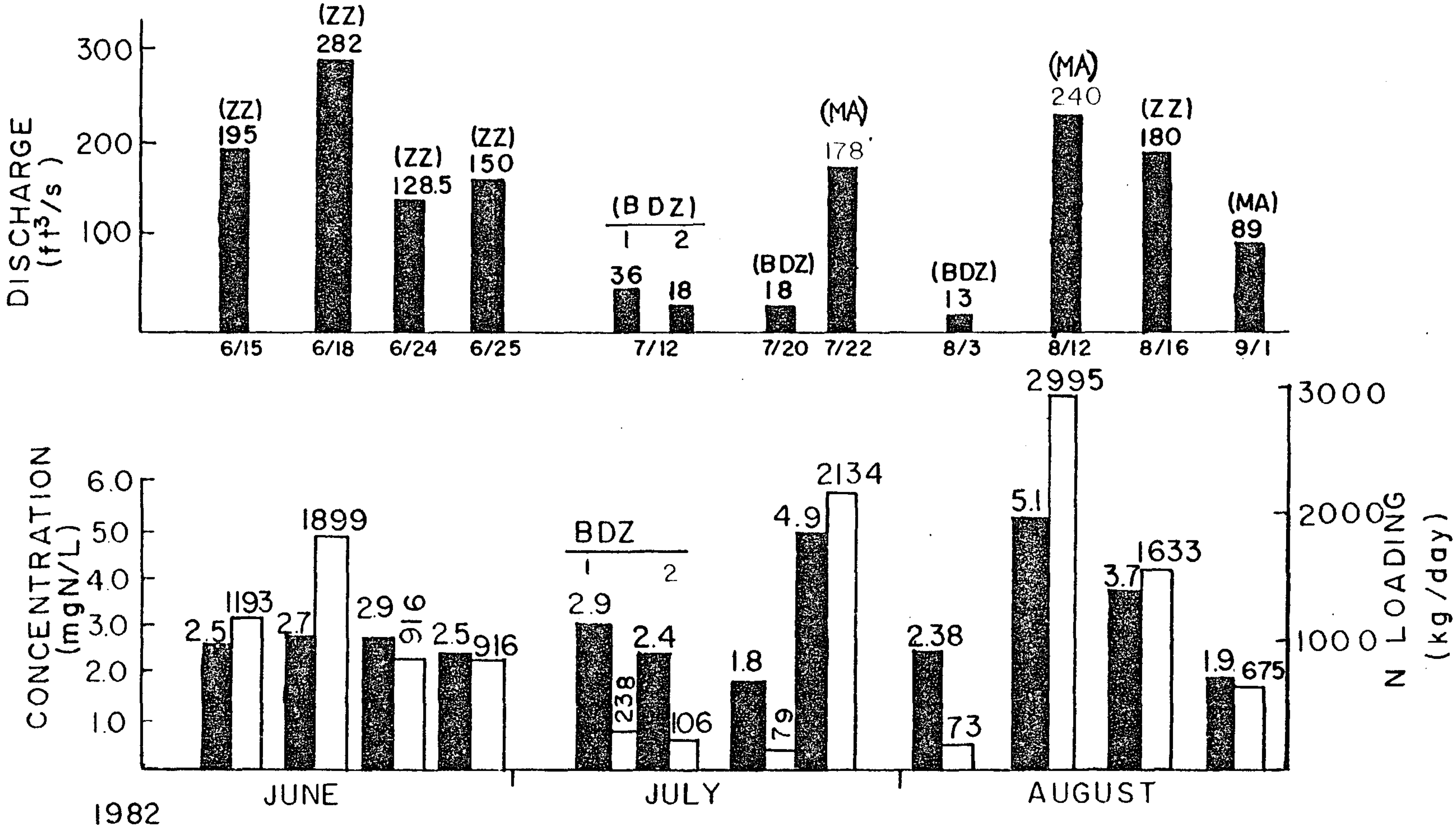


Fig. 23. Discharge and total nitrogen concentrations (■) and loading (□) from Zigzag Canal (Z.Z), Mary A Canal (M.S.) and Bulldozer Canal (BDZ) agricultural pumps.

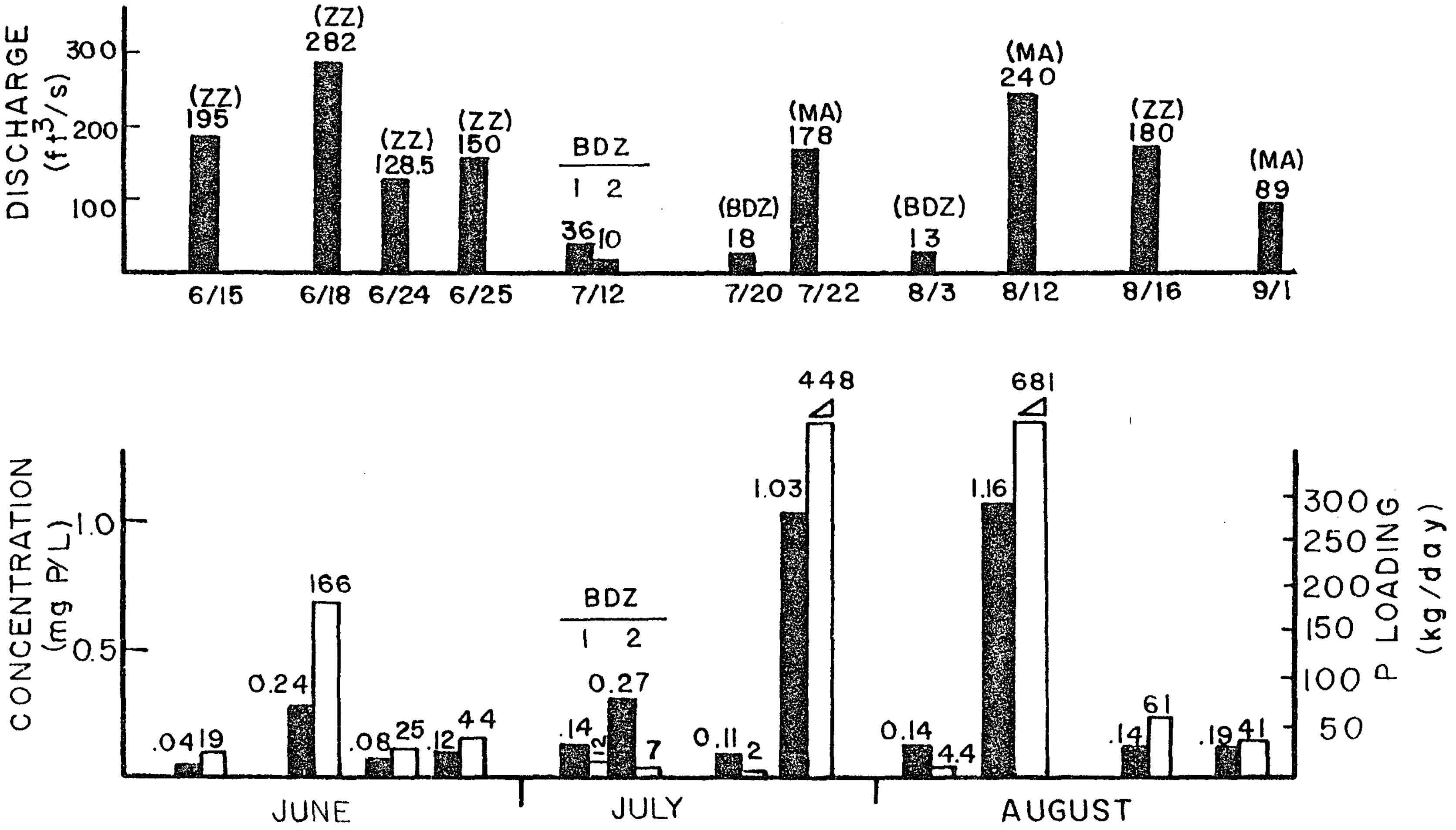


Fig. 24. Discharge and total phosphorus concentrations (▨) and loading (☐) from the Zigzag Canal (Z.Z.), Mary A Canal (M.A.) and Bulldozer Canal (BDZ) agricultural pumps.

Table 7. North Mormon Canal background data (5/28/82).

Turbidity (NTU)	20
True Color (CPU)	226
Suspended Solids (mg/L)	1.6
Dissolved Solids (mg/L)	295
Volatile Suspended Solids (mg/L)	1.6
Fixed Suspended Solids (mg/L)	0.0
Volatile Dissolved Solids (mg/L)	94
Fixed Dissolved Solids (mg/L)	201
Alkalinity (mg/L as $CaCO_3$)	46
Hardness (mg/L as $CaCO_3$)	114
Chloride (mg/L)	72
Sulfate (mg/L)	45
Ortho Phosphate - Filt. (mg/L)	< 0.01
Ortho Phosphate - unfilt. (mg/L)	0.02
Total P-filt. (mg/L)	0.11
Total P-unfilt. (mg/L)	0.13
TKN-filt. (mg/L)	1.6
TKN-unfilt. (mg/L)	2.2
Ammonia-Nitrogen (mg/L)	0.28
Nitrate, Nitrite-Nitrogen (mg/L)	< 0.02
BOD_5 (mg/L)	--
Chlorophyll a (mg/m^3)	9.3
Iron (mg/L)	0.3
Calcium (mg/L)	33.0
Magnesium (mg/L)	7.3
Potassium (mg/L)	2.5

Table 8. Duda Canal Water Chemistry Data

	Background at Pump 9/3/82	Exit of Lake Winder 12/7/82	Entrance of Duda Canal 12/7/82	Downstream of Duda Canal(½ mile) 12/7/82
pH	6.6	6.6	7.9	7.8
Conductivity (µmhos/cm)	435	450	1700	840
Total Residue (180°C)	304	316	1113	596
Sulfate	14.5	23	69	45
Turbidity (JTU)	--	34	20	28
Turbidity (NTU)	2.4	--	--	--
Calcium	25.6	54	66	67
Magnesium	15.1	6.1	26.6	12.3
Sodium	--	29.5	156	66.2
Potassium	2.9	1.6	5.9	2.7
Total Iron	0.32	0.34	.43	0.39
Hardness (mg/L as $CaCO_3$)	126	161	2.75	219
Chloride	78	69	590	210
NO_3^--N/L	0.08	0.03	0.16	0.07
NH_3-N/L	0.19	0.58	0.92	0.52
Org N/L	1.61	1.80	1.36	1.64
Ortho P (as P)	.06	.04	.22	.09
Total P (as P)	0.13	.07	.31	.13

Note: 9/3/82 and 12/7/82 data collected by F.I.T. and GFWFC, respectively.

ZIGZAG CANAL PUMP SITE

The water chemistry data for the Zigzag pump, a pump draining primarily citrus land use, are shown in Table 9. Zigzag pump discharges were characterized by very high color, often much higher than the upstream station, but the color was not as high in the nearby Mary A pump site. The pumped water was characterized by fairly high inorganic nitrogen concentrations, as ammonia-nitrogen ($\bar{x}$ = .15 mg NH_4^+-N/L) and nitrate-nitrite-nitrogen (x = .64 mg NO_3, NO_2-N/L) were elevated and much higher than the average background concentrations of .05 and .08 mg/L, respectively. Total phosphorus (as P) averaged .15 mg/L, compared to background TP concentrations of .10 and .05 mg/L on 4/27/82 and 5/5/82, respectively.

In terms of total nutrients, the discharge water appeared to be overloaded with nitrogen, as the average TN and TP concentrations were 2.86 mg N/L and .15 mg P/L, respectively. Background data taken on 4/27/82 and 5/5/82 showed average TN and TP levels of 2.19 mg N/L and 0.07 mg P/L. Based on TP:TN ratios it appears that the canal system and pumped water are P limited as ratios of > 20 mg/L were found. Dillon and Rigler (1974) suggest ratios greater than 12 indicate limitation of primary production by phosphorus. However, the average inorganic N:soluble reactive P ratios of 7.1 and 3.1 for the pumpage and upstream canal water, respectively, suggest N is more likely to limit production. TN and TP loading rate estimates, based on measured discharge and nutrient concentrations, are given in Table 5 and Figures 23 and 24. This pump ranked second in terms of nutrient loading among the sampled pumps.

Discharge BOD_5 for the five pump events averaged 2.4 mg/L and was similar to the average upstream BOD_5 of 2.5 mg/L. This indicates that elevated concentrations of oxygen consuming labile organic matter were not being discharged to the canal. However, since oxygen levels throughout the entire system were so

Table 9. Zigzag canal pump event data.

[illegible]	Date	Turbidity	True Color	SS	DS	VSS	FSS	VDS	FDS	Alk.	Hard.	Cl^-	$SO_4^=$	Ortho PO_4 Filt/Unfilt		Total P Filt/Unfilt		TKN Filt/Unfilt		NH_4-N	NO_3-NO_2 (as N)	BOD_5	Chlorophyll A	B	C	Fe	Ca	Mg	K
ground Pump(1)	4/27	4.2	232	3.9	557	2.4	1.5	164	393	162	297	105	74	<0.01	0.02	0.01	0.10	1.6	2.0	0.11	0.12	--	0.4	2.6	11.8	0.2	90.9	17.0	6.0
	5/5	1.2	190	1.8	644	1.2	0.6	176	468	175	331	130	86	<0.01	<0.01	<0.01	0.05	1.7	2.1	<0.02	0.04	--	1.4	1.9	6.0	0.2	96.9	21.6	8.5
p (1)	6/18	7.3	120	13.2	443	3.2	10.0	107	336	109	202	100	56	0.14	0.23	0.18	0.24	1.9	2.3	0.15	0.39	2.1	1.1	0.0	0.0	0.9	62.5	11.2	6.6
(1)	6/24	3.3	284	5.8	547	2.6	3.2	134	413	151	262	110	72	0.03	0.05	0.06	1.1	1.1	2.3	0.24	0.58	1.4	3.6	1.1	2.4	1.0	75.3	18.0	7.0
(1)	6/25	3.6	342	5.6	560	1.6	4.0	155	405	119	272	112	78	0.09	0.04	0.12	2.0	2.4	2.4	0.11	0.83	3.0	1.6	0.0	0.0	1.0	73.7	21.4	9.4
(1)	6/25	5.6	286	20.8	593	4.4	16.4	161	432	161	306	97	90	0.07	0.10	0.11	0.17	1.7	1.8	0.07	1.08	2.6	8.7	0.0	0.0	0.8	91.3	19.0	7.1
(1)	8/16	4.6	498	2.4	546	1.6	0.8	191	355	186	29.2	110	68.3	0.09	0.10	--	0.14	3.3	3.4	0.18	0.32	2.7	5.9	5.3	12.1	1.02	100.1	10.2	2.48
250																													
(0)	6/18	6.4	139	12.4	499	4.8	7.6	131	368	117	222	112	60	0.10	0.19	0.13	0.20	1.5	1.9	<0.10	0.14	2.0	1.7	0.0	0.0	0.3	67.3	13.1	7.5
(0)	6/24	2.0	230	2.0	423	1.8	0.2	114	309	118	198	90	44	0.01	0.02	0.07	0.07	1.4	2.0	0.04	0.06	0.4	5.8	0.1	4.5	0.7	50.5	17.5	6.7
(0)	6/25	1.7	241	4.6	372	0.8	3.8	104	268	118	234	83	55	0.02	0.03	0.04	0.05	1.8	2.1	0.02	0.09	3.5	9.1	0.0	0.0	0.9	56.9	22.4	6.6
(0)	6/25	1.3	257	6.8	443	2.0	4.8	128	315	121	212	93	53	0.03	0.03	0.05	0.08	1.6	2.9	0.07	0.29	2.7	18.9	0.0	0.0	0.6	56.9	17.0	6.8
(0)	8/16	4.2	236	0.8	402	0.4	0.4	130	272	107	166	80	26.9	0.01	0.02	0.01	0.02	2.2	2.4	0.05	0.03	3.7	11.2	4.8	5.1	0.34	41.6	15.1	3.25
n 250																													
(2)	6/18	8.2	121	16.8	450	7.6	9.2	124	326	108	204	109	58	0.14	0.22	0.18	0.24	1.3	1.9	0.09	0.36	1.4	1.8	0.0	0.0	0.7	60.9	12.6	6.4
(2)	6/24	4.1	305	8.0	541	4.8	3.2	161	380	135	272	9.7	75	0.03	0.06	0.06	0.08	2.3	3.4	0.15	0.78	0.6	3.8	1.4	0.0	0.2	78.5	18.5	7.2
(2)	6/25	2.0	250	3.8	471	1.4	2.4	121	350	123	222	100	72	0.03	0.08	0.04	0.14	2.1	2.3	0.04	0.16	3.1	0.9	0.0	0.0	0.4	56.9	19.4	7.3
(2)	8/16	3.7	434	2.0	375	1.2	0.8	133	242	98	174	70	37.2	0.04	0.04	0.04	0.05	2.8	2.8	0.11	0.10	3.6	3.8	0.0	2.8	0.54	48.9	12.6	2.55
d (6)	6/18	3.2	136	7.6	490	2.4	5.2	112	378	109	218	130	54	0.04	0.07	0.13	0.18	1.2	1.8	0.05	0.14	1.7	1.5	0.5	1.6	0.8	64.1	14.1	7.2
(6)	6/24	2.0	200	4.8	483	1.0	3.8	110	373	102	194	117	47	0.01	0.02	0.04	0.05	1.5	1.6	<0.02	<0.02	.4	0.8	0.0	0.0	0.3	44.9	19.9	7.3
(6)	6/25	1.5	228	3.8	464	0.6	3.2	110	354	101	200	112	56	0.01	0.02	0.05	0.05	1.6	2.1	0.02	0.23	3.3	0.6	0.0	0.0	0.2	48.1	10.2	7.1
(6)	8/16	3.4	282	1.6	313	0.8	0.8	97	216	88	150	75	35.7	0.02	0.04	0.02	0.04	2.1	2.2	0.05	0.04	3.2	1.9	0.0	0.4	0.28	43.3	10.2	2.61
(6)	5/5	0.8	183	1.6	6.8	1.2	0.6	152	466	104	247	187	58	<0.01	<0.01	<0.01	0.04	1.3	1.8	<0.02	0.06	--	1.7	2.2	7.9	0.2	65.7	20.2	7.3
(6)	6/15	0.9	232	3.4	540	1.4	2.0	121	419	109	226	153	58	0.02	0.02	0.04	0.04	2.0	2.5	<0.02	<0.02	3.0	2.4	1.0	1.1	1.0	63.3	16.5	7.4

depressed during the abnormally wet sampling period (usually < 2.0 mg/L), this was not an important consideration. During normal years, agricultural pumpage could very well represent a significant BOD_5 input to the system. Although the dissolved solids concentrations of discharge and upstream water were similar, suspended solids were higher in the pumped water, averaging 9.6 and 5.3 mg/L, respectively, at the two sites.

Nitrification could be occurring in Zigzag Canal as nitrate concentrations remained high at downstream stations, while ammonia levels dropped off. If nitrification was occurring the BOD_5 may be an underestimate. However, the high color and dissolved humic levels and low DO's in the canal do not favor nitrification (Wetzel, 1975). Such was the case in several European waters (Nyguard, 1938; Karker 1939). It is likely that ammonia reduction downstream was due to plant uptake and that nitrification is not a major process in this system. However, nitrification may have occurred near the pump outfall where oxygen levels were higher and extremely high NO_3-NO_2 concentrations were found.

BULLDOZER CANAL PUMP

Two pumps were sampled on Bulldozer Canal (Figure 2). Pump No. 1 was sampled once and pump #2 was sampled 5 times. These pumps drain improved pasture and citrus areas, respectively. The nutrient levels from these pumps were not high and most data indicate that the water quality (BOD_5,nutrients, etc.) of the northward flowing South Mormon Outside Canal (SMOC) was worse than the BDZ pump water. Bulldozer pump TN and TP loading rate information is presented in Table 6. Loading rates are low due primarily to the low discharge rates encountered. The chloride, hardness, alkalinity suspended solids and dissolved solids levels of pump #2 were fairly high; much higher than upstream levels, SMOC levels or pump #1 discharge (Table 10). Pump #1, although sampled only once, exhibited higher TKN (2.7 mg N/L), NH_4-N (0.10 mg N/L) and BOD_5

Table 10. Bulldozer canal pump event data.

Site	Date (1982)	Turbidity	True Color	SS	DS	VSS	FSS	VDS	FDS	Alk.	Hard.	Cl^-	$SO_4^=$	Ortho P		Total P		TKN		NH_4-N	NO_3-NO_2 (as N)	BOD_5	Chlorophyll			Fe	Ca	Mg	K
														Filt	Unfilt	Filt	Unfilt	Filt	Unfilt				A	B	C				
Up 250																													
(24)	5/27	6.4	77	5.4	671	2.2	3.2	170	501	155	326	192	7.20	<0.01	<0.01	0.04	0.04	0.6	0.8	0.03	0.02	0.7	3.5	1.7	4.7	0.4	81.7	29.6	4.2
(24)	7/12	14.0	617	12.8	268	10.4	2.4	122	146	37	122	30	1.3	0.11	0.13	0.13	.18	2.0	2.2	0.03	<.02	--	4.2	0.9	1.3	.73	36.8	7.3	1.99
(24)	7/20	7.7	475	8.4	240	6.8	1.6	100	140	42	120	31	8.7	0.15	0.19	0.17	0.23	1.9	2.3	0.03	0.05	0.4	3.8	0.0	0.0	0.61	37.6	6.3	1.75
(24)	8/3	7.8	534	5.6	180	4.5	2.5	87	93	63	104	22	0.5	0.15	0.18	0.19	0.22	2.0	2.0	0.05	0.05	1.1	29.5	6.7	0.0	0.79	25.6	9.7	1.14
(24)	8/31	2.1	379	5.6	176	4.4	1.2	86	90	63	90	48	4.3	0.08	0.09	0.20	0.31	0.8	1.8	0.07	0.05	4.2	3.7	0.0	0.0	0.60	28,8	18.0	1.96
Pump #2																													
(22)	5/27	1.7	68	6.8	632	3.8	3.0	138	494	147	322	199	95.0	0.01	0.01	0.04	0.05	0.7	1.2	0.04	0.02	2.0	1.9	1.6	4.2	0.2	84.9	26.7	4.8
(22)	7/12	15.0	432	12.0	--	11.4	1.6	--	--	75	238	62	20.7	0.19	0.23	0.21	0.27	1.9	2.4	0.18	<0.02	2.4	7.9	2.5	0.8	0.84	64.1	19.0	4.93
(22)	7/20	7.4	244	10.8	542	8.8	2.0	148	393	89	296	113	58.7	0.06	0.07	0.09	0.11	1.6	1.7	0.10	0.05	--	5.2	0.7	0.0	0.61	84.1	20.9	4.06
(22)	8/3	7.9	267	6.8	528	5.2	1.6	142	385	183	288	110	47.1	0.08	0.09	0.11	0.14	1.8	2.2	0.10	0.08	0.4	13.3	3.2	0.0	0.41	80.1	21.4	2.83
(22)	8/31	8.8	243	23.3	439	10.6	12.7	154	285	135	224	83	31.2	0.06	0.06	0.08	0.29	0.7	2.5	0.09	0.04	3.3	19.4	1.4	0.0	0.84	88.9	2.0	3.49
(22)	5/26	1.4	75	4.0	681	0.6	3.4	162	519	173	352	199	76.0	<0.01	0.01	0.03	0.06	0.8	0.9	0.05	0.02	2.55	3.4	5.1	24.3	0.1	100.9	24.3	3.6
ump #1																													
(19)	7/12	14.0	472	10.0	242	8.4	1.6	110	132	36	120	21	9.3	0.05	0.06	0.11	0.14	2.1	2.7	0.19	<0.02	4.2	10.9	2.6	1.0	0.96	34.4	8.3	2.14
own 250																													
(21)	5/27	1.5	66	3.6	677	2.2	1.4	126	551	150	328	196	95.0	<0.01	<0.01	0.08	--	0.8	1.0	0.05	<0.02	1.3	1.5	0.0	2.4	0.1	81.7	30.1	4.0
(21)	7/12	1.5	444	10.0	429	8.0	2.0	142	287	73	230	58	20.5	0.13	0.19	0.18	0.21	2.3	2.3	<0.02	<0.02	2.2	6.0	2.0	0.0	0.27	60.9	19.0	4.09
(21)	7/20	7.8	308	8.8	459	7.2	1.6	141	158	78	246	96	45.0	0.09	0.11	0.10	0.16	1.5	0.08	0.08	0.05	0.07	5.3	0.5	0.0	0.27	68.1	18.5	3,34
(21)	8/3	8.6	378	10.0	368	4.8	5.2	125	243	119	200	64	30.5	0.10	0.12	0.13	0.17	2.2	2.2	0.05	0.06	1.7	4.8	0.0	0.0	0.63	57.7	13.6	2.20
(21)	8/31	2.8	340	9.0	275	6.5	2.5	120	155	90	144	75	13.7	0.08	0.09	0.20	0.31	0.8	1.8	0.07	0.05	4.2	21.3	0.3	0.0	0.60	46.5	28.0	2.81
onfluence of anal & River																													
(15)	5/27	1.2	250	1.4	512	1.0	0.4	116	396	99	220	177	52.0	<0.01	0.02	0.11	0.13	1.8	1.8	0.05	0.05	0.8	0.7	0.1	3.7	0.2	48.9	23.8	4.1
(15)	7/12	16	552	9.2	349	7.2	2.0	130	219	40	138	62	7.2	0.20	0.21	0.23	0.25	1.7	3.2	<0.02	<0.02	--	20.4	0.0	0.0	0.38	37.6	10.7	3.20
(15)	7/20	7.9	582	10.4	331	8.4	2.0	130	160	39	132	71	13.2	0.14	0.15	0.17	0.24	3.0	3.1	0.19	0.05	3.2	15.2	0.0	0.0	0.73	38.4	8.7	2.52
(15)	8/3	8.0	546	4.4	288	2.0	2.4	100	188	74	136	66	13.3	0.09	0.10	0.11	0.14	2.0	2.9	0.19	0.08	1.5	18.2	0.0	0.0	0.79	36.8	10.7	1.75
(15)	8/31	2.9	464	4.0	256	3.6	0.4	109	147	62	106	55	9.4	0.06	0.07	0.08	0.13	1.8	2.7	0.22	0.04	4.3	15.1	0.0	0.0	0.50	30.4	30.0	2.57
arsh																													
(15B)	8/31	2.3	435	4.8	264	3.8	1.0	104	160	63	108	53	8.7	0.07	0.08	0.10	0.12	1.2	2.7	0.20	0.02	4.3	14.9	0.0	0.0	0.52	30.4	32.0	2.52
outh Mormon																													
anal (13)	8/31	2.6	417	4.0	254	3.8	1.0	100	154	64	102	55	8.7	0.07	0.08	0.09	0.12	1.4	3.0	0.24	<0.02	3.6	11.0	0.9	2.3	0.50	30.4	26.0	2.52
(13)	7/12	15	539	9.6	321	7.2	2.4	44	84	37	136	60	5.8	0.17	-0.19	0.19	0.25	2.8	2.8	<0.02	<0.02	4.5	16.6	0.0	0.0	1.31	34.4	12.1	3.10
(13)	7/20	7.4	494	8.8	313	6.6	1.2	100	212	40	136	71	13.8	0.13	0.15	0.16	0.21	1.9	2.6	0.19	<0.02	4.7	10.0	0.0	0.0	1.65	36.8	10.7	2.68

(4.2 mg/L) than pump #2 (Table 10). The BOD_5 (4.2 mg/L) was significantly higher than the average BOD_5 of pump #2 (2.0 mg/L), but this value was similar to those recorded from South Mormon Canal (SMOC) and the Marsh. Chlorophyll was generally much higher in SMOC than in the BDZ canal, except on 8/31/82 when an algal bloom was present in the BDZ canal. Iron was high in Bulldozer canal at the upstream and pump stations, but very high levels ($\bar{x}$ = 1.15 mg/L) were found in SMOC, also. One interesting observation on the pump discharges concerns color. Pump #2 exhibited lower average color (266 CPU) than upstream (416 CPU) or SMOC (483 CPU). Pump #1 had a higher average color (472 CPU), and this value was similar to upstream values (444 CPU), but lower than SMOC (539 CPU) levels.

Pump chemistry data collected on several different dates by Bionomics Analytical Laboratory for Deseret Ranches of Florida, Inc. are presented in Tables 11 and 12. These data are for Bulldozer pumps #1 (Table 11) and #2 (Table 12), and F.I.T. pump discharge data on the closest dates to those sampled by Bionomics Lab are included for comparison. We are not sure of the sampling conditions encountered such as how long the pumps were on before sampling occurred and the discharge rates, etc. Some differences in the data may be due to the fact that they sampled behind the dikes, whereas we sampled outside the dikes directly at the pump outfall.

On the average, F.I.T. and Bionomic water quality data were similar. On 7/12/82 our TKN level was slightly higher and the TP level was significantly higher than concentrations found during the 6/1/82 pump event at BDZ pump #1. Also, F.I.T. recorded higher suspended solids (10 mg/L) than did Bionomics (5 mg/L). The F.I.T. pump #2 data generally indicated higher TKN and suspended solids levels than the Bionomics data, but the BOD_5 was usually lower.

Table 11. Comparison of Pump #1 Water Quality Data.

	Deseret Sampling			F.I.T.
	6/1/82	6/3/82	6/4/82	7/12/82
pH	7.9	7.8	7.9	6.65
BOD_5 (mg/L)	4	3	2	4.2
Chlorides (mg/L)	47	80	90	21
Conductivity (μmho/cm)	490	680	750	290
Total Nitrogen as N (mg/L)	2.36	2.60	2.50	2.70
NO_3-NO_2 Nitrogen as N (mg/L)	0.32	0.13	0.14	<0.02
TKN as N (mg/L)	2.04	2.47	2.36	2.70
Total Phosphorus as P (mg/L)	0.019	0.019	0.004	0.14
Total Solids (mg/L)	328	473	513	252
Total Dissolved Solids (mg/L)	324	468	508	242
Total Suspended Solids (mg/L)	4	5	5	10
Sulfate as SO_4 (mg/L)	40	69	75	9.3

Table 12. Comparison of Bulldozer Pump #2 Water Quality Data.

	Deseret Sampling			F.I.T. Sampling				Deseret Sampling		
	6/1/82	6/7/82	6/11/82	7/12/82	7/20/82	8/3/82	8/31/82	7/26/82	8/4/82	8/10/82
pH	7.9	7.9	7.6	7.1	6.9	6.65	6.7	7.2	6.3	6.3
BOD$_5$ (mg/L)	3	5	6	2.4	-	0.4	3.3	4	4	3
Chloride (mg/L)	179	161	164	62	113	110	83	75	28	47
Conductivity (μmhos/cm)	1400	1000	1300	650	750	800	580	560	200	320
Total Nitrogen as N (mg/L)	1.18	1.88	1.98	2.4	1.75	2.3	2.54	2.05	2.14	1.89
NO$_3$-NO$_2$ Nitrogen as N (mg/L)	<0.1	<0.1	0.48	<.02	0.05	0.08	0.04	0.15	0.12	<0.1
TKN as N (mg/L)	1.17	1.88	1.50	2.4	1.7	2.2	2.5	1.90	2.12	1.89
Total Phosphorus as P (mg/L)	0.093	0.11	0.11	0.27	0.11	0.14	0.29	0.29	0.21	0.15
Total Solids (mg/L)	744	684	755	-	553	535	463	412	201	279
Total Dissolved Solids (mg/L)	741	680	752	-	542	528	439	410	198	279
Total Suspended Solids (mg/L)	3	4	3	12	11	7	24	2	3	<1
Sulfate as SO$_4$ (mg/L)	79	71	77	21	59	47.1	31	38	<1	17

On 8/3/82 a marsh sample was taken near Bulldozer canal at site 19B (Figure 4) approximately 0.5 miles north of BDZ pump #1 (see Appendix A; Sampling Dates and Field Data). This sample was collected for water quality comparison with pump #2 and SMOC data. The results are presented in Table 12A. and show that the water quality in the marsh is very similar to SMOC water quality, more so than with the pump #2 downstream sample, indicating the dominance of SMOC discharge into Bulldozer canal and the adjoining marsh.

Table 12A. Bulldozer pump #2, SMOC and marsh water quality data.

Site	Bulldozer pump #2	Marsh (site 19B)	SMOC (site 13)
Turbidity (NTU)	8.8	2.3	2.6
True Color (CPU)	243	435	417
Suspended Solids (mg/L)	23.3	4.8	4.0
Dissolved Solids (mg/L)	439	264	254
Volatile Suspended Solids (mg/L)	10.6	3.8	3.8
Fixed Suspended Solids (mg/L)	12.7	1.0	1.0
Volatile Dissolved Solids (mg/L)	154	104	100
Fixed Dissolved Solids (mg/L)	285	160	154
Alkalinity (mg/L as $CaCO_3$)	135	63	64
Hardness (mg/L as $CaCO_3$)	224	108	102
Chloride (mg/L)	83	53	55
Sulfate (mg/L)	31	8.7	8.7
Ortho-PO_4-filt. (mg/L)	0.06	0.07	0.07
Ortho-PO_4-unfilt. (mg/L)	0.06	0.08	0.08
Total P-filt. (mg/L)	0.08	0.10	0.09
Total P-unfilt. (mg/L)	0.29	0.12	0.12
TKN-filt. (mg/L)	0.7	1.2	1.4
TKN-unfilt. (mg/L)	2.5	2.7	3.0
NH_4-N (mg/L)	0.09	0.20	0.24
NO_3,NO_2-N (mg/L)	0.04	0.02	<0.02
BOD_5 (mg/L)	3.3	4.3	3.6
Chlorophyll a (mg/L)	19.4	14.9	11.0
Iron (mg/L)	0.84	0.52	0.50
Calcium (mg/L)	88.9	30.4	30.4
Magnesium (mg/L)	2.0	32.0	26.0
Potassium (mg/L)	3.49	2.52	2.52

MARY A PUMP

The Mary A pump is listed as draining improved pasture although we observed row cropping uses, particularly corn. The water quality from the Mary A pump was, by far, the worst of the pumps sampled and discharge from this pump had the greatest pollutional potential. The average TN and TP concentrations for the three sample dates were 3.96 mg N/L and 0.79 mg P/L, respectively (Table 5). Phosphorus levels of over 1.0 mg P/L were recorded on 7/22/82 and 8/12/82 at this pump site. Nutrient loading rates were high and reflect the high concentrations and discharge rates at this site (Table 5). The upstream background site does not reflect upstream conditions and should be neglected for comparison as pump water backed up and moved in all directions and hyacinth jams prevented reaching an appropriate upstream site. In fact, Mary A discharge rates could not be measured due to diffuse flow across the adjacent marsh in various directions making it necessary to estimate discharge rates.

Mary A pumpage exhibited very high average levels of ortho PO_4 (0.52 mg P/L), total P (0.79 mg P/L), TKN (3.9 mg N/L), NH_4-N (0.31 mg N/L), NO_3-N (0.48 mg N/L) iron (1.68 mg/L), turbidity (18.1 NTU), BOD_5(5.5 mg/L), hardness (223 mg/L as $CaCO_3$) and calcium (67 mg/L). The mean color of the pump discharge (525 CPU) was very high, higher than the upstream station on lateral M canal (380 CPU). Chlorophyll a was very high at the pump and in the canal on 7/22/82 and 8/12/82 with concentrations at the pump of 23 and 29 mg/m^3, respectively. These levels were much higher than Lateral M canal on those dates and reflect the "algal bloom" conditions present in the canal at those times. The pump discharge and upstream and downstream water chemistry data are shown in Table 13.

Table 13. Mary A pump event data.

ite	Date	Turbidity	True Color	SS	PS	VSS	FSS	VDS	FDS	Alk.	Hard	Cl$^-$	SO$_4^=$	Ortho P Filt/Unfilt		Total P Filt/Unfilt		TKN Filt/Unfilt		NH$_4$N	NO$_3$-NO$_2$ (as N)	BOD$_5$	Chlorophyl A	B	C	Fe	Ca	Mg	K
ap	7/22	33	833	187.0	404	91.0	96.0	1570	2470	123	192	52	27.4	0.58	0.62	0.62	1.03	3.1	4.2	0.35	0.72	6.7	23.4	0.0	0.0	2.92	60.1	10.2	4.4
	8/12	16	479	56.0	284	24.0	32.0	136	148	78	126	38	15.8	0.77	0.84	0.91	1.16	3.7	4.4	0.42	0.67	6.6	29.4	9.2	25.8	1.59	36.0	8.7	3.85
	9/1	5.3	265	10.0	700	4.8	5.2	204	496	237	352	175	41.3	0.09	0.10	0.13	0.19	1.5	3.0	0.17	0.06	3.1	7.3	0.0	0.0	0.52	104.9	21.9	3.72
250 (A)	7/22	26	858	71.0	399	37.0	34.0	1700	2290	120	184	52	31.3	0.65	0.66	0.66	0.96	3.4	3.7	0.04	0.70	5.5	13.6	0.4	0.0	1.88	55.3	11.2	4.3
(G)	8/12	4.4	518	10.4	218	4.8	5.6	104	114	59	100	28	15.2	0.68	0.73	0.80	0.87	3.3	3.4	0.33	0.17	5.3	27.8	4.4	10.3	0.70	28.0	7.3	3.68
(A)	9/1	5.9	265	12.4	732	5.6	6.8	217	515	230	332	175	44.3	0.09	0.10	0.13	0.19	1.5	2.9	0.16	0.06	3.7	7.2	0.5	0.2	0.50	109.7	14.1	3.81
n 250 (B)	7/22	24	902	78.0	414	40.0	38.0	1780	2360	118	184	50	28.4	0.66	0.68	0.66	0.87	3.8	3.8	0.42	0.68	5.3	13.4	1.9	0.2	2.11	58.5	9.2	4.11
(B)	8/12	4.8	534	6.8	223	4.4	2.4	106	117	61	9.8	29	13.5	0.72	0.75	0.82	0.88	3.3	3.5	0.38	0.13	5.5	25.8	2.4	8.2	0.57	27.2	7.3	3.75
(B)	9/1	2.6	377	1.8	207	1.2	0.6	82	125	44	76	48	9.4	0.08	0.09	0.09	0.15	1.5	1.7	0.11	0.06	3.4	3.2	0.0	2.9	0.36	30.4	0.0	2.50
ver up [illegible]	7/22	7.3	384	4.0	327	2.8	1.2	104	223	53	128	82	40.0	0.06	0.06	0.07	0.09	1.9	1.9	0.13	0.23	0.8	3.9	0.4	1.1	0.61	30.4	12.6	2.40
[illegible]	8/12	2.9	379	8.8	238	4.4	4.4	82	156	45	84	52	16.4	0.07	0.07	0.07	0.09	1.7	2.0	0.14	0.09	2.6	4.5	1.5	4.9	0.50	22.4	6.8	1.79
[illegible]	9/1	3.4	379	12.0	207	6.4	5.6	79	128	40	76	48	9.4	0.08	0.08	0.09	0.17	1.2	1.7	0.15	0.08	3.2	2.8	0.0	3.1	0.52	21.6	5.3	2.09
et down [illegible]	8/12	3.3	393	5.2	253	4.4	0.8	100	153	48	94	52	16.0	0.12	0.12	0.12	0.16	1.9	2.2	0.04	0.10	9.0	3.9	1.4	5.2	0.47	20.0	10.7	2.02
[illegible]	9/1	2.5	378	4.8	190	2.2	2.6	72	118	44	80	48	8.7	0.08	0.09	0.09	0.13	1.4	1.5	0.15	0.07	2.9	2.3	0.0	1.1	0.35	25.6	6.3	2.34
let (I)	7/22	7.7	365	13.2	283	10.4	2.8	93	190	56	116	68	21.5	0.07	0.08	0.07	0.12	1.6	1.7	0.08	0.09	1.0	5.5	0.7	2.2	0.61	27.2	11.7	2.3

DIURNAL PUMP EVENT

One Zigzag canal pump event was sampled three times over a 24 hr. period. We sampled the Zigzag pump when it was turned on and again approximately 14 and 23 hours later. The data for the upstream (Station 0), pump (Station 1) and one mile downstream (Station 6) sites are presented in Table 14 . Most parameters were fairly consistent throughout the 24 hour period. The level of nitrate-nitrogen was high at the pump, averaging 0.83 mg/L, and remained fairly high one mile downstream. TKN, and BOD_5 concentrations, although not extremely high, remained similar to pump discharge levels at the downstream station. Total phosphorus was not extremely high in the pump discharge and it appears that the discharge of inorganic nitrogen is the major problem associated with this pump. Studies by the SJRWMD generally show an upper basin system which is nitrogen limited. However, the Canal 40 and Lateral M areas exhibited the most frequent phosphorus limitation and pump discharge with high inorganic nitrogen concentrations could be a possible reason for this.

Table 14. ZIGZAG PUMP DIURNAL DATA

DATE	6/24/82			6/25/82			6/25/82		
TIME	5:45 P.M.			8:30 A.M.			5:00 P.M.		
STATION	0	1	6	0	1	6	0	1	6
pH	-	-	-	6.8	6.9	7.0	7.1	6.9	7.1
Discharge(ft^3/s)	4.4	-	133	4.4	-	154	-	-	-
Turbidity (NTU)	2.0	3.3	2.0	1.7	3.6	1.5	1.3	5.6	-
True Color (CPU)	230	284	200	241	342	228	257	286	-
S.S. (mg/L)	2.0	5.8	4.8	4.6	5.6	3.8	6.8	20.8	-
D.S. (mg/L)	423	547	483	372	560	464	443	593	-
Alkalinity (mg/L as $CoCO_3$)	118	151	102	118	119	101	121	161	-
Hardness (mg/L as $CaCO_3$)	198	262	194	234	272	200	212	306	-
Chloride (mg/L)	90	110	117	83	112	112	93	97	-
Sulfate (mg/L)	44	72	47	55	78	56	53	90	-
Ortho P (mg/L)	0.22	0.05	0.02	0.03	0.09	0.02	0.03	0.10	-
Total P (mg/L)	0.07	0.08	0.05	0.05	0.12	0.05	0.08	0.17	-
TKN (mg/L)	2.0	2.3	1.6	2.1	2.4	2.1	2.9	1.8	-
NH_4^-N (mg/L)	0.04	0.24	<.02	0.02	0.11	<.02	0.07	0.07	-
$NO_3^-NO_2$(as N)	0.06	0.58	.02	0.09	0.83	0.23	0.29	1.08	-
BOD_5 (mg/L)	0.4	1.4	0.4	3.5	3.0	3.3	2.7	2.6	-
Chlor. a (g/m^3)	5.8	3.6	0.8	9.1	1.6	0.6	18.9	8.7	-
Fe (mg/L)	0.7	1.0	0.3	0.9	1.0	0.2	0.6	0.8	-
Ca (mg/L)	50.5	75.3	44.9	56.9	73.7	48.1	56.9	91.3	-
Mg (mg/L)	17.5	18.0	19.9	22.4	21.4	19.4	17.0	19.0	-
K (mg/L)	6.7	7.0	7.3	6.6	9.4	7.1	6.8	7.1	-
$\bar{x}$ D.O. (mg/L)	-	1.2	2.4	0.7	2.3	1.0	0.6	4.5	2.7
Conductivity	-	-	-	610	760	700	790	880	790

Note: Pumps turned on at 5:45 P.M. on 6/24/82. Station 6 data represent background data. Only one outlet pipe at the site was discharging and the discharge was approximately 140 ft^3/s.

SEDIMENTATION STUDIES

This phase of the study provided background data on the rate and nature of sedimentation for comparison with past and future studies.

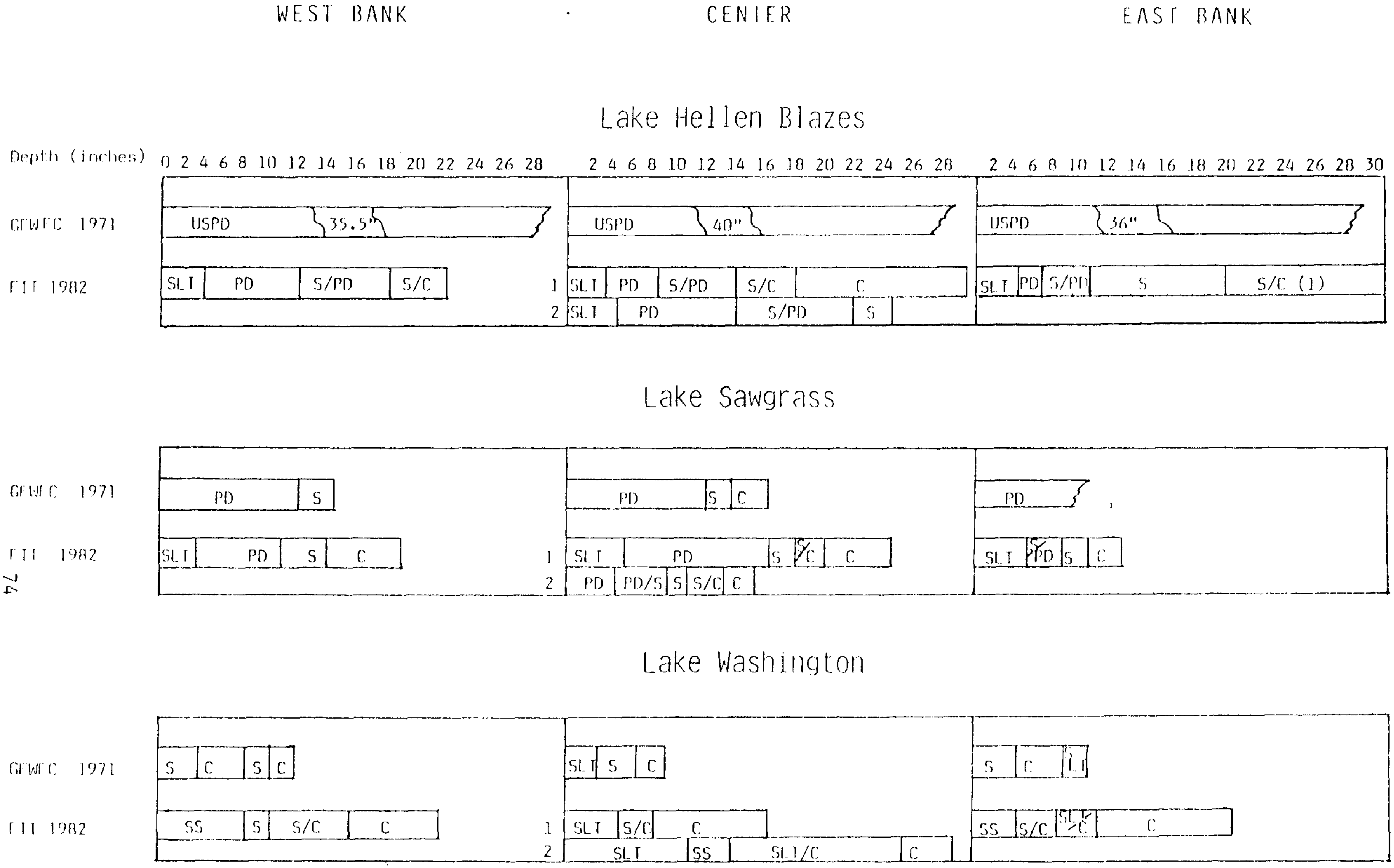
CORING PHASE

Sediment cores produced profiles and depths of sediment strata along longitudinal and transverse transects in each lake, as well as profiles along radials positioned at the river entrance into each lake. The methodology and coring locations are discussed in detail in Chapter III. The location of the longitudinal and transverse transects are shown in Figures 7 through 12. Also included in this section is a Lake Washington sediment type map constructed from numerous dredges taken throughout the lake in 1978 (Mason and Belanger, 1979). Bathymetric profiles of the longitudinal and transverse transects are presented in Appendix B; coring locations in these transects are indicated on the chart paper. Although the Ratheon Fathometer was set on the lowest depth range (0-55'), very little detail can be seen from the transect profiles due to the shallow and uniform nature of the lakes.

Core data indicate all the lakes generally have a layer of fine organic matter on the sediment surface with layers of sand and clay beneath the surface at various depths. The U.S. Fish and Wildlife Service (1951) described the sediments of Lake Washington as "hard sand and silty mud". We found that the lake is characterized by large amounts of fine organic matter on the surface (more than the other lakes), underlain by clay and some sand. We frequently encountered clay in Lake Washington at lower core depths. The sediment at the inlet to Lake Washington is primarily comprised of sand. Lakes Sawgrass and Hellen Blazes have very shallow layers of fine organic matter on the surface, but these southern lakes in the chain exhibited more fibrous or woody organic matter beneath the fine layer than other upper St. Johns Lakes. These data seem to indicate that aquatic plant sedimentation dominates in Lakes Hellen Blazes and Sawgrass, while algal and allochthonous sediment inputs are important in Lake Washington. Cox et al. (1976) stated that the sediments of Lakes Hellen Blazes and Sawgrass are primarily organic oozes or mucks with some firm peat, mostly derived from hyacinths and marsh vegetation. The U.S. Fish and Wildlife Service (1951) described the sediments as just "plant debris over sand". Organic build-up occurs wherever hyacinth rafts decay and sink. However, waves can move and distribute these organic sediments throughout the lake basin. On the average, longitudinal and transverse cores in Lake Hellen Blazes exhibited greater depths of organic matter than cores from the other lakes. Based on the 17 longitudinal and transverse cores taken in each lake (Appendix D), there was a progressive decrease in the depth of organic matter present in the lakes as they progress northward from Lake Hellen Blazes (with the exception of Lake Poinsett). Lakes Hellen Blazes, Sawgrass, Washington, Winder and Poinsett exhibited average organic matter depths of 13.8, 9.7, 9.5, 3.4 and 5.4 inches, respectively.

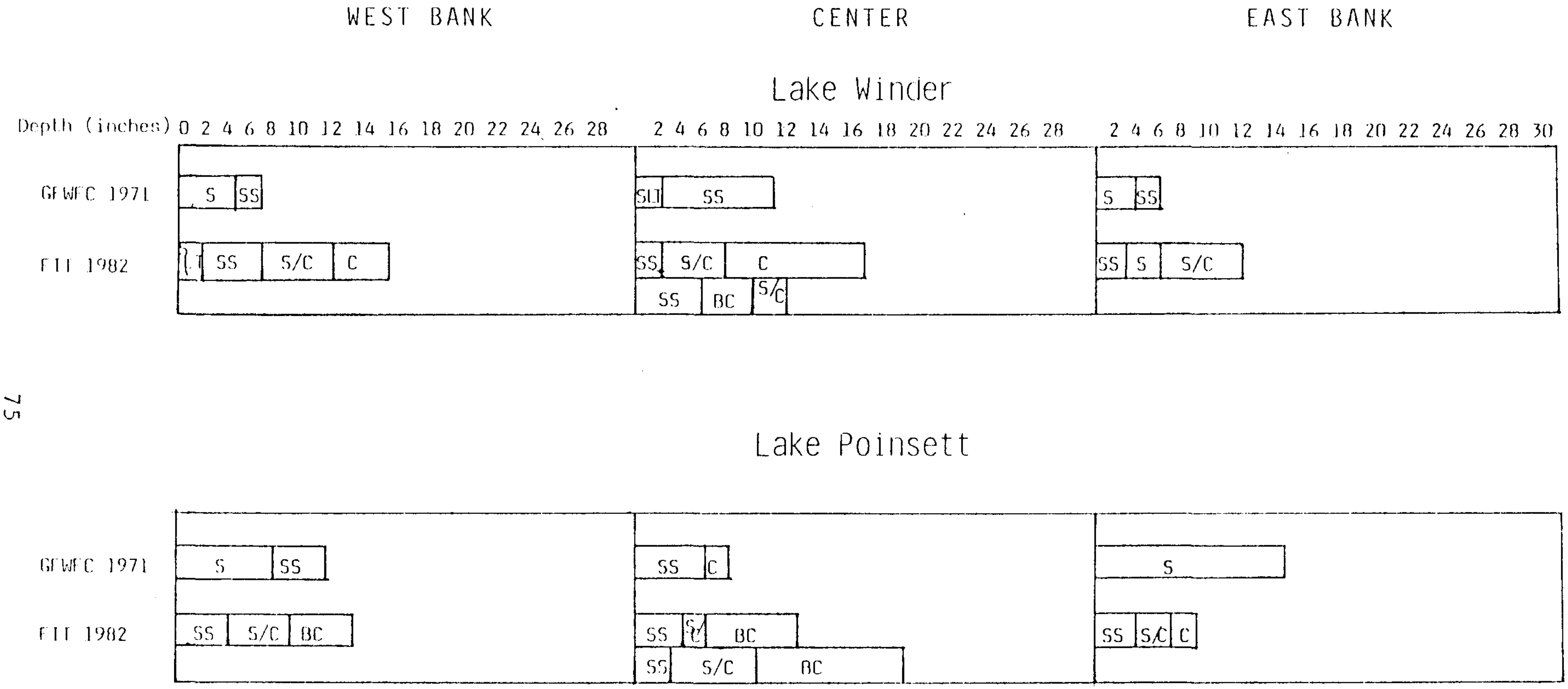
Blue Cypress, which is considered separately, had the greatest depth of organic matter of any lake, averaging 17.7 inches for the 17 longitudinal and transverse cores. Most of this organic matter appeared to be well decomposed material of algal origin. More peat was encountered in this lake than the others. In fact, all of the radial cores had a loose peat bottom, and sand or clay levels were never found.

Cores taken from transverse transects during this study (1982) were compared with cores taken during the FGFWFC 1971 sedimentation/vegetation transects (Figures 25 and 26). Our transverse transects were positioned in Lakes Hellen Blazes through Poinsett to duplicate, as closely as possible, the transect



KEY:
USPD = Unconsolidated silt and plant detritus
PD = Plant detritus
SLT = Silt
S/PD = Sand and plant detritus
S/C = Sand and clay
S = Sand
SLT/C = Silt and clay
C = Clay
SS = Silty sand
(1) = Clay found at 38"
⌇ = Depth of strata
⌐ = Did not reach hardpan

FIGURE 25. West bank, Center and East Bank cores in lakes Hellen Blazes, Sawgrass and Washington



KEY:

SLT = Silt
SS = Silty sand
S/C = Sand & Clay
C = Clay
BC = Black Clay
S = Sand

FIGURE: 26 West bank, Center and East bank cores in Lakes Winder and Poinsett.

locations of the GFWFC. We realize, however, that considerable error may be involved in the duplication of the exact coring locations. Two F.I.T. center cores are presented in Figures 25 and 26, as we took cores 40 and 60% across the lake from the west, instead of in the exact center as did the GFWFC. The GFWFC corer was 20 inches long and, therefore, very limited. Our coring device was longer and was used to reach a hard sediment stratum whenever possible. Figure 26 shows the sandy, less organic nature of the bottoms of Lake Winder and Poinsett, while Figure 25 shows the more organic nature of the sediment of Lakes Hellen Blazes and Sawgrass. Figures 25 and 26, comparing 1971 and 82 core data, indicate Lake Hellen Blazes presently has significantly less sediment organic matter than in 1971. Lake Washington's bottom has a large percentage of sand and clay, but the sediment type is extremely variable in the lake with location. The variable nature of the Lake Washington sediment can be seen in Figure 27 from sediment classification of the Lake based on Ponar dredge samples taken in 1978 (Mason and Belanger, 1978). The visual description of the sediment and the percent volatile solids content are shown in Figure 27, also. The depths of organic matter in each lake are presented in Figures 28 through 33 for easy visual comparison. Transverse cores (1971 and 1982) from Lake Sawgrass indicate similar organic layer depths while the 1982 Lake Washington sediment cores show the lake has a slightly deeper organic layer. One 1982 core from the center of Lake Washington, however, indicates considerable organic deposition. Cores from Lakes Winder and Poinsett show slightly more organic silt in the surface sedimen- than in 1971, although the depth of this layer is not high.

Pb-210 analysis was attempted in Lake Hellen Blazes by others but I feel the results are of questionable value as sediment mixing often occurs below the sediment-water interface. Cox et al, (1976) state that in many areas of the upper

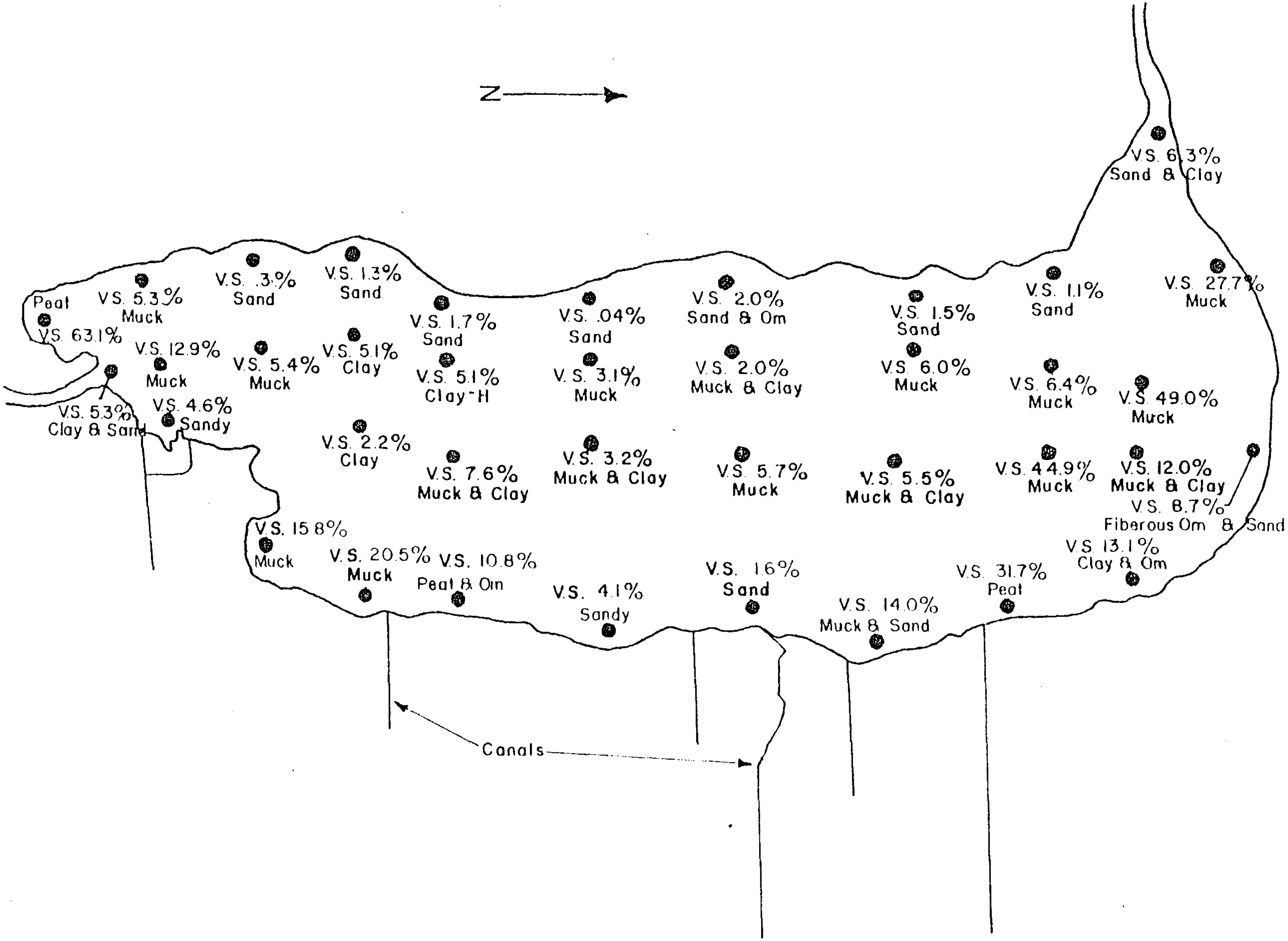


Fig. 27. Lake Washington sediment types.

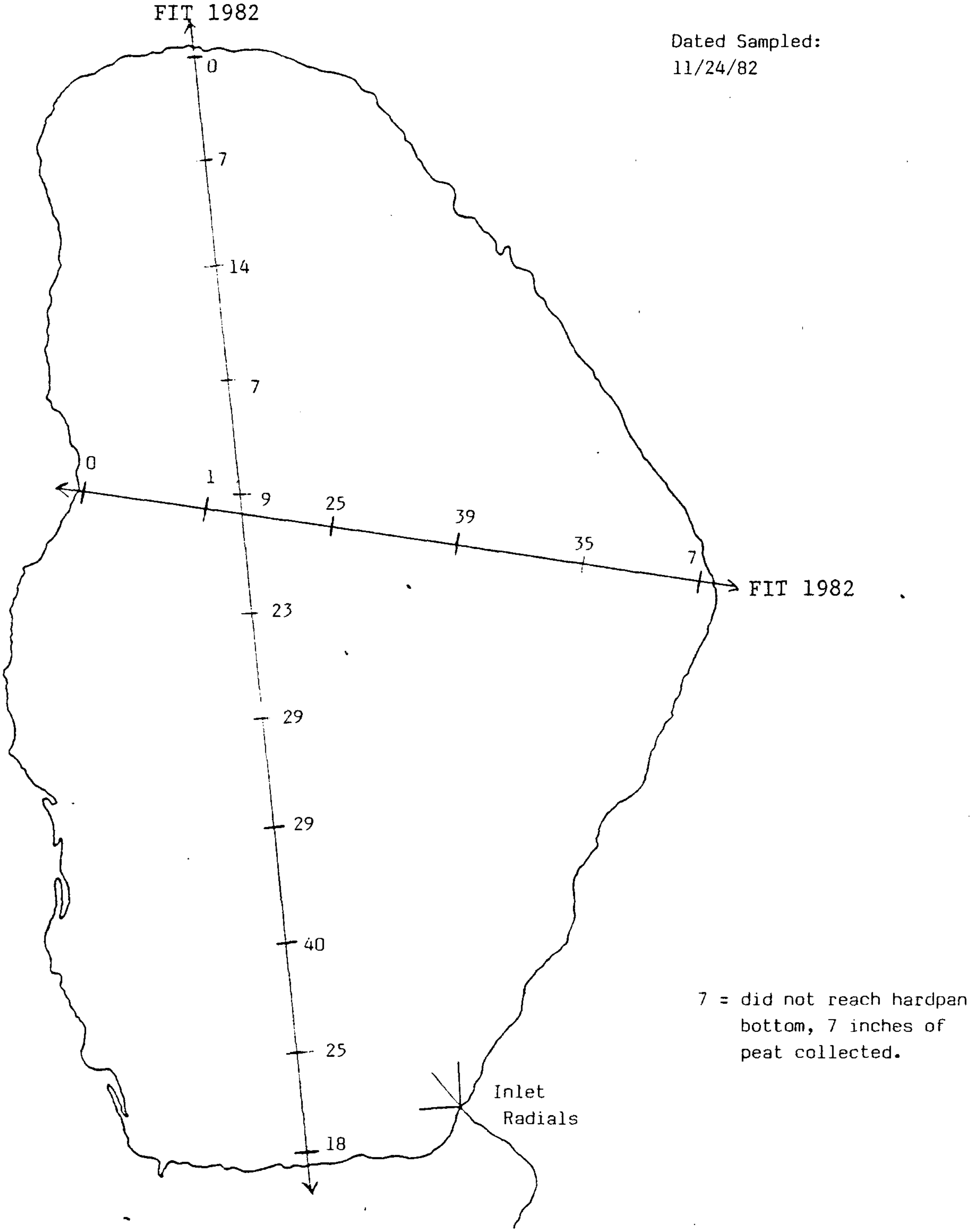
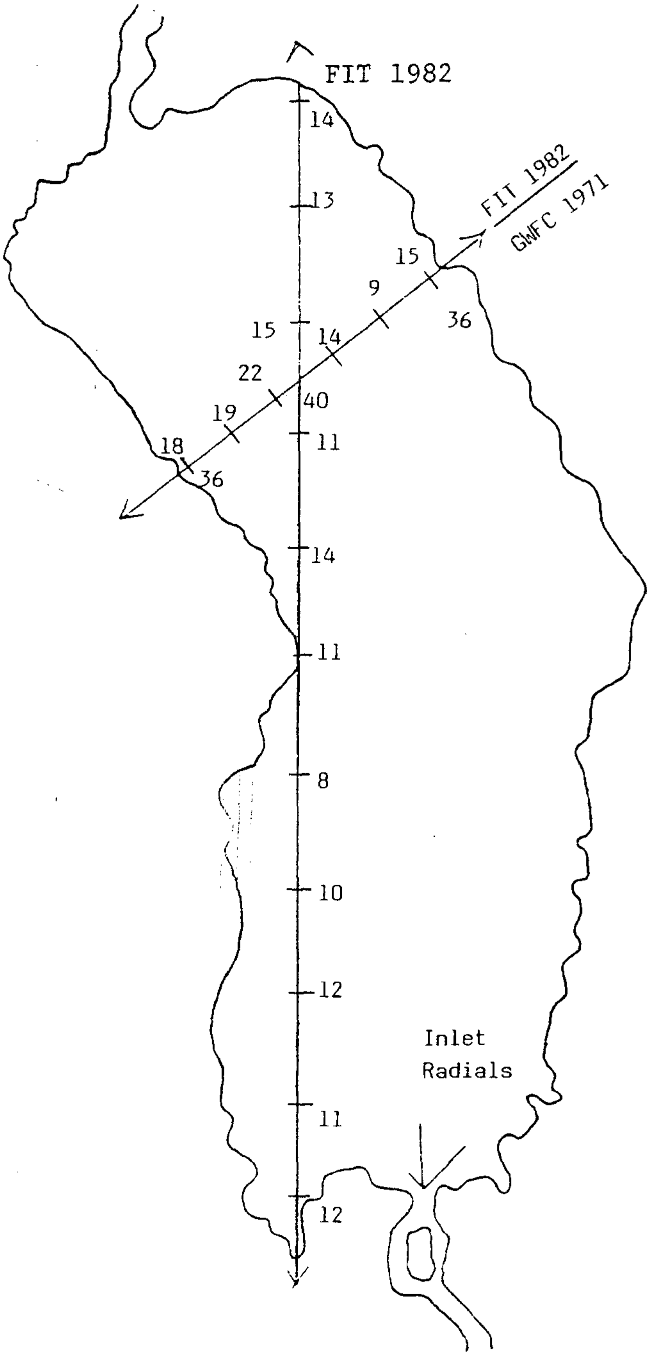


Fig. 28. Depth of organic sediment in Blue Cypress Lake (inches).

(Specific strata and depths for longitudinal, transverse and inlet radial transects are presented in Appendix D.)



Date Sampled:
1/18/82

Fig. 29. Depth of organic sediment in Lake Hellen Blazes (inches).

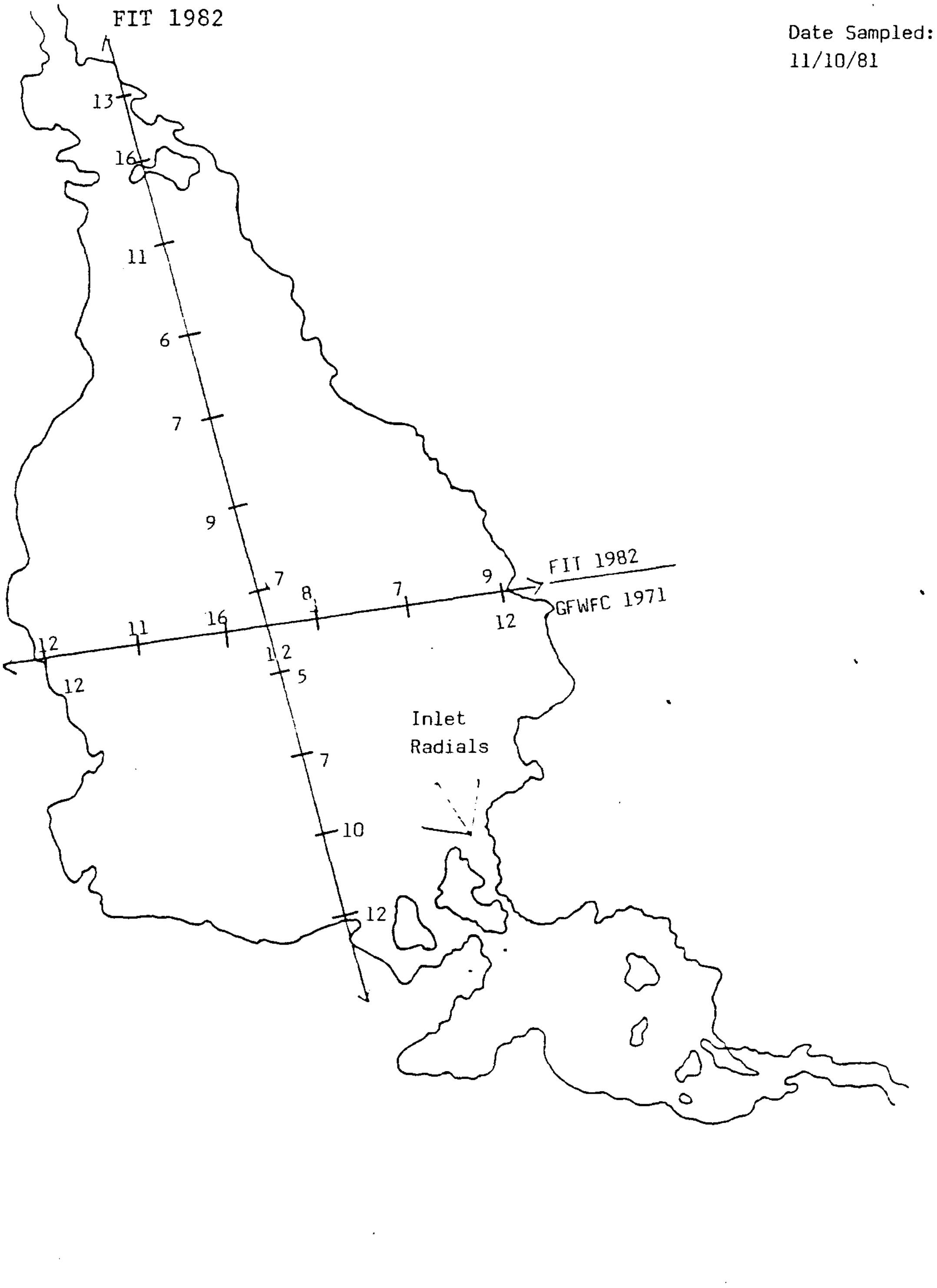


Fig. 30. Depth of organic sediment in Lake Sawgrass (inches).

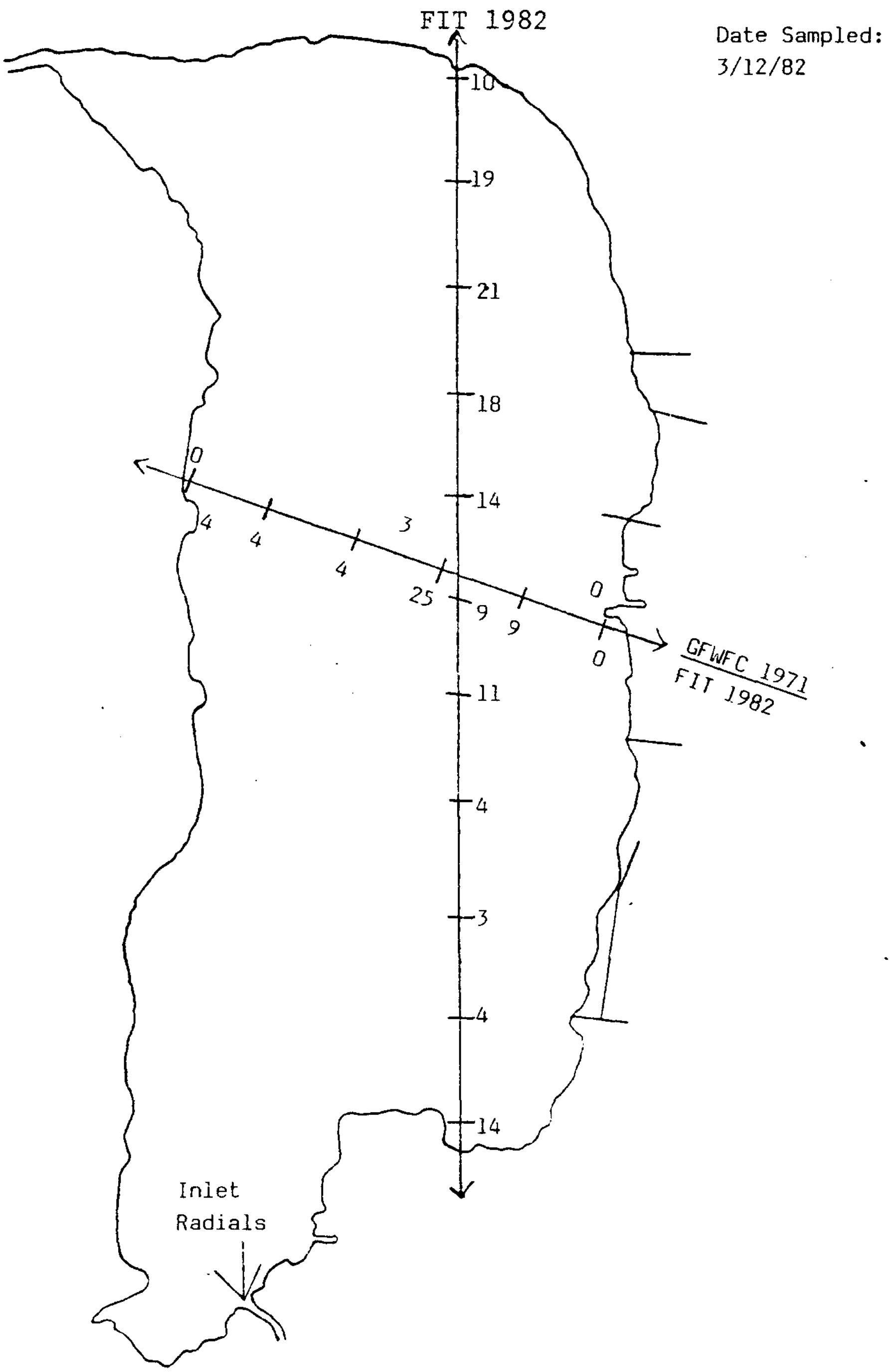
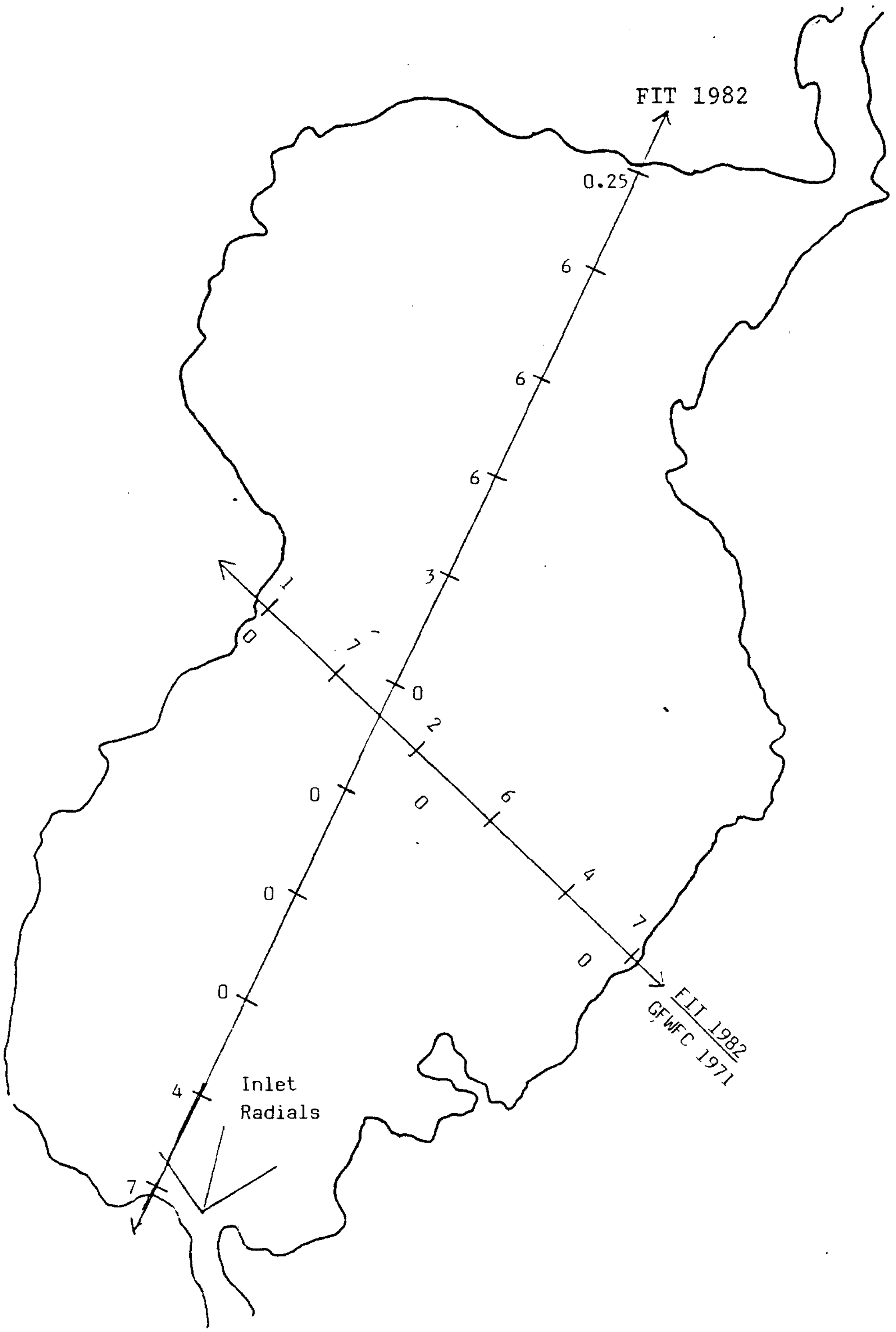


Fig. 31. Depth of organic sediment in Lake Washington (inches).



Date Sampled:
10/22/82

Fig. 32. Depth of organic sediment in Lake Winder (inches).

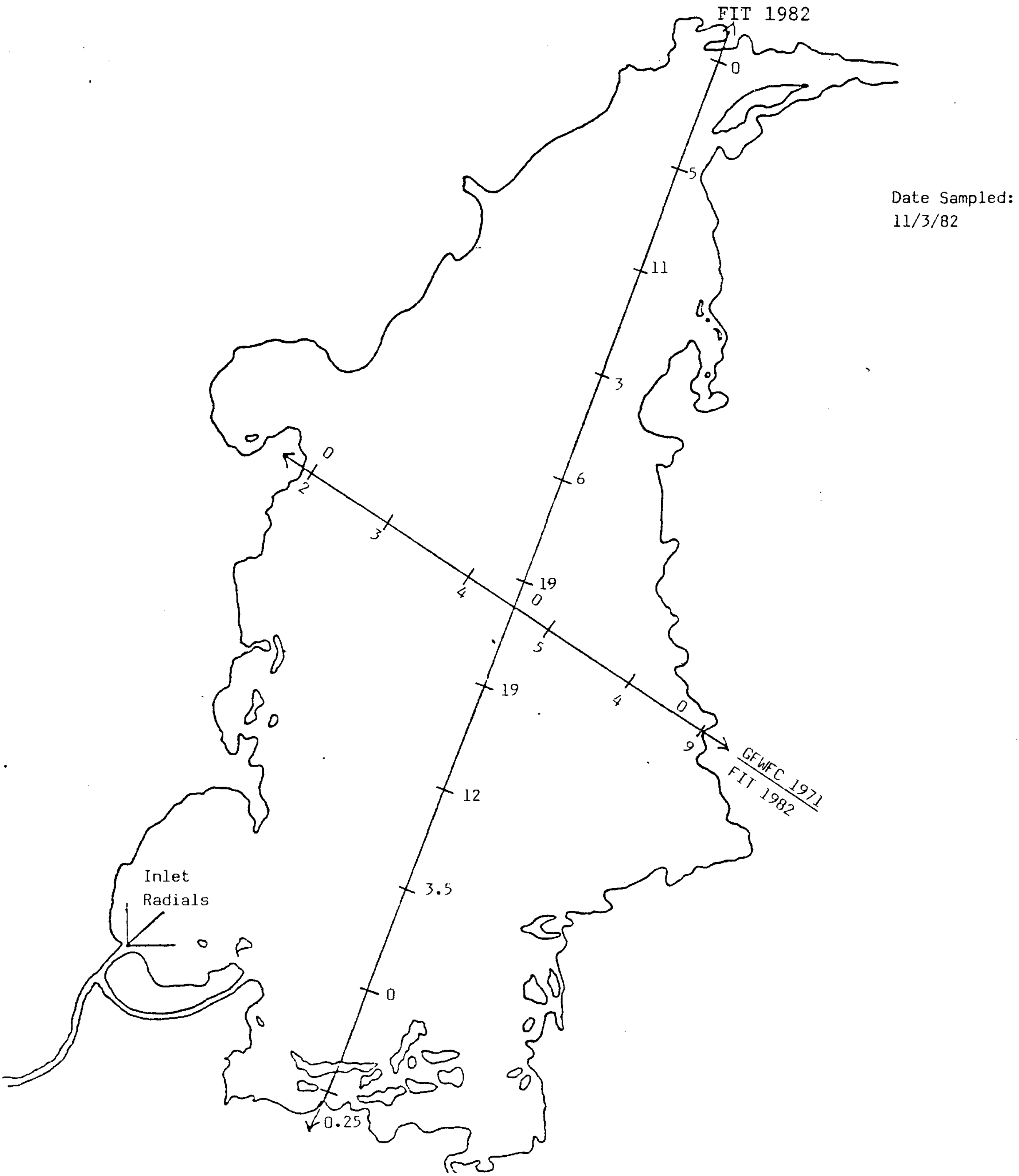


Fig. 33. Depth of organic sediment in Lake Poinsett (inches).

St. Johns River lakes there is actually no defined sediment-water interface, and a gradual change from thin suspensions of watery sediment to more compact strata often occurs over depths of a meter or more. Although results from our study indicated lower average organic layer depths of from 3.4 to 17.7 inches in the six upper St. Johns lakes, these mixing depth in shallow lakes are still great enough to invalidate the use of Pb-210 dating.

SUSPENDED SOLIDS LOADING DATA

Based on data from our seventeen sampling days (August, 1981 - August, 1982), suspended solids data indicate a very small net input into Lake Washington as inlet and outlet loading rates averaged 3500 and 3450 Kg/day, respectively (Table 15). At the outlet the suspended solids concentrations ranged from 0.0 mg/L to 3.8 mg/L, compared to a range of 0.8 to 7.7 mg/L at the inlet. The suspended solids averages were 2.6 mg/L and 2.2 mg/L for the inlet and outlet, respectively (Table 16). Volatile suspended solids made up more than 50% of the total solids content ($\bar{x}$ = 54%; n = 27), showing the organic nature of the solids. The average suspended solids concentrations for Three Forks, Bulldozer and South Mormon Outside Canals were 3.5, 2.6 and 5.0 mg/L, respectively, while the loading levels were 409, 9 and 1181 Kg/day for these same canals (Tables 17 and 18). Bulldozer canal usually exhibited a negligible flow and, in fact, reversed its flow during the summer of 1982. The data indicate that Three Forks was a significant solids source during the dry season (September, 1981 - May, 1982), and that Mormon Outside Canal was a very significant source of solids during the wet season, when stage levels rose (June - Augus, 1982). Since Three Forks ceased to flow in the summer, flow from the C-40 area undoubtedly crossed the marsh south of Three Forks Run during that time and contributed to the hight discharge, suspended solids and nutrient levels in South Mormon Canal. Silt plumes were occasionally observed in the canal and are believed to be caused by agricultural pumping.

Table 15. Suspended solids loading and export from the Lake Washington entrance and exit. (kg/day).

INLET		OUTLET	
8/28	43	8/28	0
9/1	156	9/1	0
9/15	8545	9/15	0
9/23	1650	9/23	1763
10/2	1279	10/2	1460
10/8	890	10/8	1400
12/17	69	12/17	406
1/20	86	1/20	950
2/24	225	2/24	536
3/12	0	3/12	0
3/30	207	3/30	1261
4/22	905	4/22	2851
5/13	484	5/13	2670
5/26	328	5/26	1529
7/19	6973	7/19	13003
8/4	22274	8/4	23535
8/26	15388	8/26	7327
	$\bar{x}$ = 3500		$\bar{x}$ = 3452

Table 16. Suspended Solids data for the Lake Washington Inlet and Outlet.

OUTLET	(mg/L) SS	%	VSS	%	FSS	INLET	(mg/L) SS	%	VSS	%	FSS
8/28	0.0		0.0		0.0	8/28	0.8	63	0.5	37	0.3
9/1	0.0		0.0		0.0	9/1	1.9	53	1.0	47	0.9
9/15	0.0		0.0		0.0	9/15	1.7	69	5.3	31	2.4
9/23	2.6	65	1.7	35	0.9	9/23	2.3	65	1.5	35	0.8
10/2	2.5	52	1.3	48	1.2	10/2	2.7	74	2.0	26	0.7
10/8	2.4	58	1.4	42	1.0	10/8	2.9	83	2.4	17	0.5
12/17	1.3		--		--	12/17	1.0		--		--
1/20	3.6	50	1.8	50	1.8	1/20	1.9	37	0.7	63	1.2
2/24	1.7	41	0.7	59	1.0	2/24	1.8	44	0.8	56	1.0
3/12	--		--		--	3/12	--		--		--
3/30	2.6	92	2.4	8	0.2	3/30	0.8	50	0.4	50	0.4
4/22	3.1	58	1.8	42	1.4	4/22	3.3	45	1.5	55	1.8
5/13	2.9	41	1.2	59	1.7	5/13	3.1	48	1.5	52	1.6
5/26	2.5	80	2.0	20	0.5	5/26	1.9	63	1.2	37	0.7
7/19	2.4	67	1.6	33	0.9	7/19	1.8	50	0.9	50	0.9
8/4	3.8	29	1.1	71	2.7	8/4	4.7	36	1.7	64	3.0
8/26	3.1	19	0.6	81	2.5	8/26	3.5	17	0.6	83	2.9
	$\bar{x}$ = 2.2						$\bar{x}$ = 2.6				

Table 17. Suspended solids data for upper basin canals.

Three Forks Canal

Date	SS	%	VSS	%	FSS
9/15	3.6	56	2.0	44	0.6
9/23	6.5	46	3.0	54	3.5
10/8	3.5	57	2.0	43	1.5
12/17	0.8	-	--	-	--
1/20	10.3	41	4.2	59	6.1
2/22	2.0	50	1.0	50	1.0
3/10	3.1	55	1.7	45	1.4
3/3	3.3	67	2.2	33	1.1
4/22	1.9	63	1.2	37	0.7
5/13	2.3	65	1.5	35	0.9
5/26	1.7	47	0.8	53	0.8
8/31	3.4	24	0.8	76	2.6

$\bar{x}$ = 3.5

South Mormon Outside Canal

Date	SS	%	VSS	%	FSS
9/15	4.2	64	2.7	36	1.5
9/23	2.1	67	1.4	33	0.7
12/17	--	-	--	-	--
1/20	4.1	46	1.9	54	2.2
2/22	2.9	45	1.3	55	1.6
3/10	2.3	57	1.3	43	1.0
3/31	3.4	71	2.4	29	1.0
4/22	2.6	81	2.1	19	0.5
5/13	2.9	59	1.7	41	1.2
5/26	1.9	42	0.8	58	1.1
6/24	26.2	56	14.8	44	11.1
7/20	6.3	29	1.8	71	4.6
8/2	4.6	24	1.1	76	3.4
8/31	2.0	45	0.9	55	1.2

$\bar{x}$ = 5.0

Bulldozer Canal

Date	SS	%	VSS	%	FSS
12/17	0.6	-	--	-	--
1/20	1.7	53	0.9	47	0.8
2/22	2.9	45	1.3	55	1.6
3/10	2.1	62	1.3	38	0.8
3/31	2.0	65	1.3	35	0.7
4/22	1.4	64	0.9	36	0.5
5/13	3.8	55	2.1	45	1.7
5/26	1.5	27	0.4	73	1.1
8/2	6.4	27	1.7	73	4.7
8/31	3.4	24	0.8	76	2.6

$\bar{x}$ = 2.6

Table 18. Suspended solids loading in upper basin canals (Kg/day)

3F		MO		BDZ	
9/15	423	9/15	242	12/17	9
9/23	1426	9/23	156	1/20	17
10/8	804	12/17	0	2/22	0
12/17	17	1/20	52	3/10	0
1/20	968	2/22	0	3/31	35
2/22	354	3/10	156	4/22	9
3/10	622	3/31	372	5/13	0
3/31	847	4/22	60	5/26	0
4/22	372	5/13	35	7/12	8535 west
5/13	415	5/26	17	7/20	9513 west
5/26	233	6/24	1778	8/2	5020 west
6/24	0	7/20	7344		
7/12	0	8/2	3689		
7/20	0	8/31	2635		
8/2	0				
8/31	60	7/12	–	8/31	2635 west
	$\bar{x}$ = 409		$\bar{x}$ = 1181		$\bar{x}$ = 9

The mass-balance method of using gaged stream flow and collecting suspended ediments at the inlet and the outlet to Lake Washington to determine net sediment nflow has been previously criticized by the USGS and consequently the technique s abandoned by the GFWFC. However, most of the critism centered aroung the accuracy of measuring flow by stream gaging (stage ht.) in a river with as allow a gradient as the St. Johns River. We felt our mass balance approach uld at least give us ballpark answers as we made detailed flow measurements each me suspended solids samples were taken. For loading rate calculations, we also lt that the effect of bottom resuspension would not be large as the influent mpling point is preceded by approximately 1-2 miles of sand bottom stream annel and the outflow sampling point consisted of only surface water flowing over e weir. The data are intended to give only approximate estimates, due to the ove mentioned sources of error.

SUSPENDED SOLIDS LOADING FROM AGRICULTURAL PUMPS

Suspended solids data for the four pump sites are presented in Tables 19 d 20 and indicate variable but high concentrations, particulary for Mary A. e solids are generally highly organic in nature, as indicated by the high rcent VSS levels. Loading rate data (kg/day) presented in Table 21 indicate at the pumps are important sources of suspended solids. Mary A (37,877 Kg/day) Zigzag pumps (3,511 Kg/day) were much greater contributors of suspended lids than the Bulldozer pumps (#1 = 881 Kg/day; #2 = 359 Kg/day). The suspended ids concentrations and loading rates were much lower in the canals south of e Hellen Blazes (Table 18), but the high average SMOC suspended solids loading 81 Kg/day) may be partially due to the upper basin pumpage. The low average ue (3.5 Kg/day) at the Lake Washington entrance, however, indicates most of suspended solids settle out in Lakes Hellen Blazes and Sawgrass before reaching e Washington.

ump

Table 19. Suspended solids data for the Zigzag and Mary A agricultural pumps.

Zigzag

Date		SS	%	VSS	%	FSS
4/27	P	3.9	62	2.4	38	1.5
5/5	P	1.8	67	1.2	33	0.6
5/5	R	1.6	63	1.0	37	0.6
6/15	R	3.4	41	1.4	59	2.0
6/18	P	13.2	24	3.2	76	10.0
6/18	U	12.4	39	4.8	61	7.6
6/18	D	16.8	45	7.6	55	9.2
6/18	R	7.6	32	2.4	68	5.2
6/24	P	5.8	45	2.6	55	3.2
6/24	U	2.0	90	1.8	10	0.2
6/24	D	8.0	60	4.8	40	3.2
6/24	R	4.8	21	1.0	79	3.8
6/25	P	5.6	29	1.6	71	4.0
6/25	U	4.6	17	0.8	83	3.8
6/25	D	3.8	37	1.4	63	2.4
6/25	R	3.8	16	0.6	84	3.2
6/25	P	20.8	21	4.4	79	16.4
6/25	U	6.8	29	2.0	71	4.8
8/16	P	2.4	67	1.6	33	0.8
8/16	U	0.8	50	0.4	50	0.4
8/16	D	2.0	60	1.2	40	0.8
8/16	R	1.6	50	0.8	50	0.8

Mary A

Date		SS	%	VSS	%	FSS
7/22	P--	187.0	49	91.0	51	96.0
	U	71.0	52	37.0	48	34.0
	D	78.0	51	40.0	49	38.0
	R	13.2	79	10.4	21	2.8
8/12	P =	56.0	43	24.0	57	32.0
	U	10.4	46	4.8	54	5.2
	D	6.8	65	4.4	45	2.4
	RU	8.8	50	4.4	50	4.4
	RD	5.2	85	4.4	15	0.8
9/1	P	10.0	48	4.8	52	5.2
	U	12.4	45	5.6	55	6.8
	D	1.8	67	1.2	33	0.6
	RU	12.0	53	6.4	47	5.6
	RD	4.8	46	2.2	54	2.6

P = pump

U = upstream 250 yds

D = downstream 250 yds

R = bend in canal, 1 mile downstream of ~~pu~~ pump

RU = Lateral M canal upstream

RD = Lateral M canal downstream

Note: upstream station at Mary A not representative of background conditions.

Table 20. Suspended solids data for the Bulldozer Canal agricultural pumps.

Bulldozer #2

Date		SS	%VSS		%FSS	
5/26	P	4.0	15	0.6	85	3.4
5/27	P	6.8	56	3.8	44	3.0
	U	5.4	41	2.2	59	3.2
	D	3.6	61	2.2	39	1.4
	R	1.4	71	1.0	29	0.4
7/12	P	12.0	95	11.4	5	1.6
	U	12.8	81	10.4	19	2.4
	D	10.0	80	8.0	20	2.0
7/20	P	10.8	81	8.8	19	2.0
	U	8.4	81	6.8	19	1.6
	D	8.8	89	7.2	11	1.6
8/3	P	6.8	76	5.2	24	1.6
	U	5.6	80	4.5	20	7.5
	P	10.0	48	4.8	52	5.2
8/31	P	23.3	45	10.6	55	12.7
	U	5.6	79	4.4	21	1.2
	D	9.0	72	6.5	28	2.5
	R	4.8	79	3.8	21	1.0

Bulldozer #1

Date		SS	%VSS		%FSS	
7/12	P	10.0	84	8.4	16	1.6

North Mormon Outside Background

Date		SS	%VSS		%FSS	
5/28	P	1.6	100	1.6	0	0.0

Duda Background

Date		SS	%VSS		%FSS	
9/3	P	4.0	75	3.0	25	1.0

P = pump

U = upstream 250 yds

D = downstream 250 yds

R = confluence of canal and river

Table 21. Suspended solids loading from measured pump events.

(Kg/day)

	PUMP			
Date	ZigZag	Mary A	BDZ #2	BDZ #1
6/18/82	9108			
6/24/82	1823			
6/25/82	2055			
7/12/82			529	881
7/20/82			476	
7/22/82		81,446		
8/3/82			73	
8/12/82		30,008		
8/16/82	1057			
9/1/82		2178		
$\overline{X}$	3511	37,877	359	881

WATERHYACINTH STUDIES

Recent information generated from an F.I.T. Masters thesis by Thomas Debusk (1983) on "Standing Crop Changes, Detritus Production and Decomposition of Eichornia crassipes (Mart.) Solms" is pertinent to this discussion on sedimentation. Mr. Debusk was under the supervision of Dr. F.E. Dierberg, Assistant Professor of Enrivonmental Science. In his study Debusk (1983) measured the decomposition rate of waterhyacinth plant tissues at two locations: 1) Lake Washington, and 2) a wastewater treatment facility in Pompano Beach, Florida. The study was conducted in 1981 and 1982.

Waterhyacinth aerial tissues submerged at the sewage lagoon decomposed more rapidly than roots (Fig. 34). The dry weight loss of aerial tissue in the first seven days was equal to ($p < .05$) the loss of root tissue during the entire 120 day incubation period. Also, decomposition of aerial and root tissues in the nitrogen rich wastewater facility were much greater than corresponding rates in the low nitrogen Lake Washington site. Aerial tissues comprised 88% of the standing crop biomass of plants collected at the Pompano Beach sewage lagoon and only 68% of the standing crop biomass of plants obtained from Lake Washington, where roots are more important to the total biomass.

Standing crop growth and detritus production by the waterhyacinths were affected both by nitrogen availability and by the amount of biomass in the standing crop (Table 22). Table 22 shows that from July 11, 1981 to May 10, 1982, the greatest quantity of detritus was produced by waterhyacinths maintained under high-nitrogen, non-harvested conditions. Slightly lower mean detritus production was found in harvested high-nitrogen tanks followed by that in both harvested and non-harvested low nitrogen tanks. Detritus production by low nitrogen waterhyacinths varied seasonally, and was significantly lower than that of high nitrogen plants. Highest detritus values occurred in the late spring and fall in the low nitrogen plants.

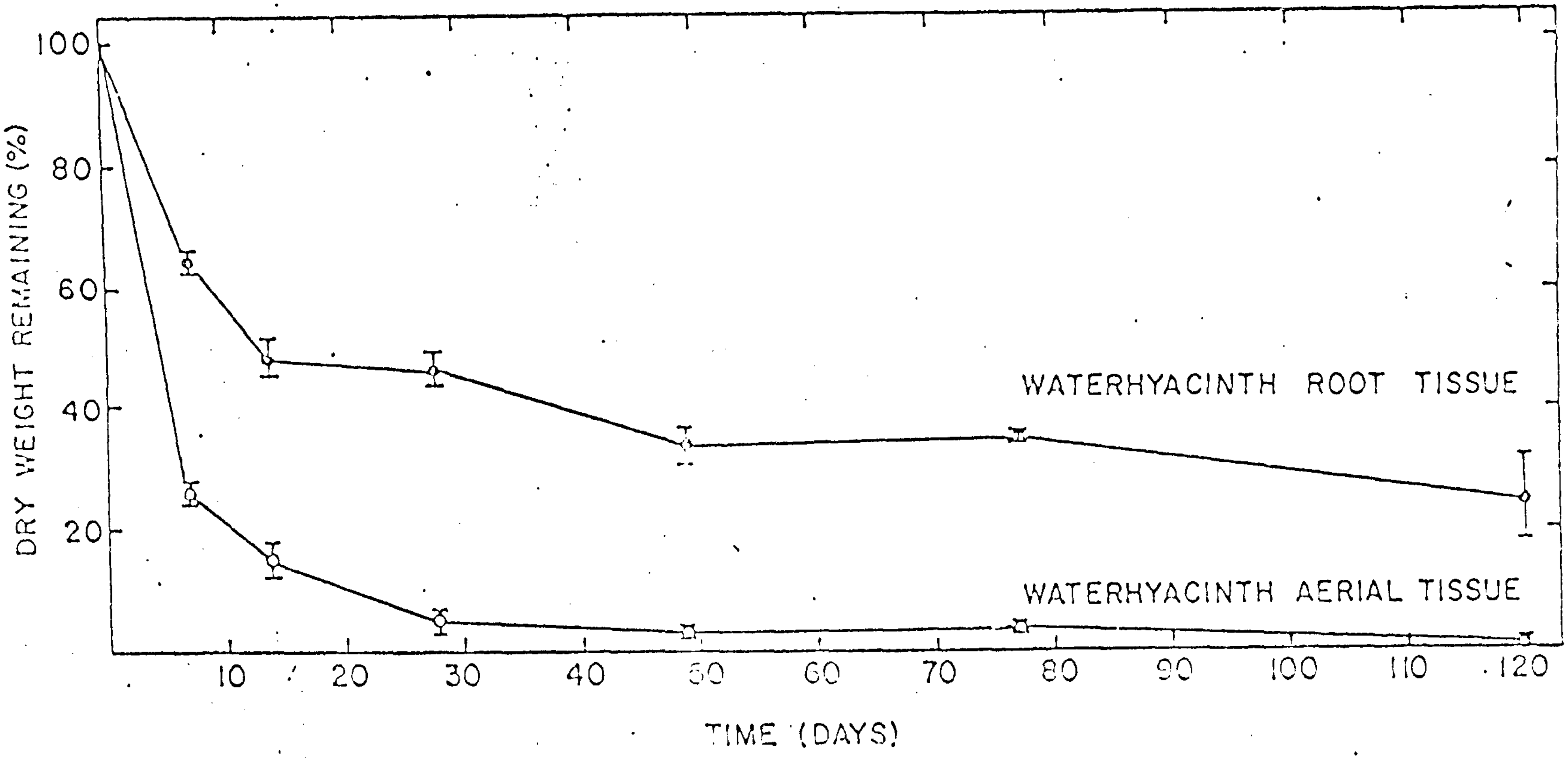


Fig. 34. Dry weight loss of waterhyacinth aerial and root tissues during decomposition at the Pompano Beach sewage lagoon from June 17 - October 14, 1982. Points and bars represent $\bar{x} \pm 1$ S-E., n = 4. (From Debusk, 1983).

Table 22. Mean waterhyacinth standing crop growth and detritus production from July 11, 1981 to May 10, 1982. (From Debusk, 1983).

Treatment	Standing crop growth (g dry wt m^{-2} day^{-1})	Detritus production (g dry wt m^{-2} day^{-1})
High nitrogen, harvested	14.9 a*	2.28 a
High nitrogen, non-harvested	6.4 b	2.96 b
Low nitrogen, harvested	10.8 a b	0.79 c
Low nitrogen,+ non-harvested	4.7 b	1.13 c

*Letters denote least significant difference (LSD) at 0.05 level as determined by the Student-Newman-Keuls test. Vertical comparisons only.

+Lake Washington situation.

The highest mean standing crop occurred in harvested high nitrogen tanks followed by harvested, low nitrogen; non-harvested, high nitrogen; and non-harvested, low nitrogen. The exact conditions and nitrogen concentrations used are specified in Debusk (1983).

Although considerable literature exists on the "productivity" or standing crop growth of Eichhornia (see Pieterse, 1978), there is a paucity of information on detritus production by this species. Unlike many plants, Eichhornia detritus (material sloughed from the mat) consists primarily of root, rather than aerial tissues. In addition, because floating waterhyacinths are rarely inundated by fluctuating water levels, dead aerial tissues are infrequently washed from the mats and usually decompose within or near the mat. Dead aerial tissues decompose fairly rapidly while held in the floating plant stand. Vega (1978) reported that about 33% of the original dry weight of waterhyacinth plants remained after four weeks incubation in the mat. Thus, aerial tissues which fall through the waterhyacinth mat into the water column are frequently already well decomposed.

As with standing crop losses, no relationship was observed between positive standing crop changes and detritus production by Eichhornia. The factors which affect the sloughing of tissues (roots) from the floating mat therefore occur independently of standing crop changes. The importance of the turnover, or sloughing rate of root tissues, is also emphasized by the poor correlation between detritus production and the absolute biomass of roots present in the standing crop. Turnover rates of root tissues were thus calculated from detritus production and average root biomass estimates for each treatment (Table 23).

Table 23. Average detritus production, root biomass and turnover time for root tissues of waterhyacinths maintained under four culture regimes from July 11, 1981 to May 10, 1982. (From DeBusk, 1983).

Treatment	Detritus production (g dry wt m^{-2} day^{-1})	Root biomass (g dry wt m^{-2})	Root turnover (days)
High nitrogen harvested	2.28	303	133
Low nitrogen harvested	0.79	246	311
High nitrogen non-harvested	2.96	457	154
Low nitrogen* non-harvested	1.13	680	602

*Lake Washington situation.

SEDIMENTATION FROM WATERHYACINTHS

Sedimentation beneath natural waterhyacinth stands can be estimated using a detritus production rate and a decomposition rate for root tissues. If a detritus production rate of 2.96 g dry wt/m^2/day for the non-harvested, high nitrogen root tissue is used and the decomposition rate obtained from Figure 34, we can calculate sediment deposition. For example, the amount of detritus which remains in the sediment is calculated as the product of 355 g/m^2 (amount of detritus sloughed off per m^2 by a mat of waterhyacinths in 120 days) and 0.39 (g detritus remaining)/(g detritus deposited). This latter term is the area under the water hyacinth root decomposition curve at the Pompano Beach sewage lagoon. Thus, 138 g dry wt/m^2 of detritus would remain after 120 days. Assuming a bulk density of waterhyacinth sediment of 0.25 g/cm^3 (Mitsch, 1977), 0.06 cm of sediment would be deposited in 120 days, or 0.18 cm in one year.

The above calculations would be for a nutrient (N) rich aquatic system. However, if we want to more closely approximate sedimentation beneath natural waterhyacinth stands in the upper St. Johns River, different detritus production and decomposition rate values should be used. Experiments indicated (before they were terminated due to vandalism) that the decomposition rate of low nitrogen root tissues, such as found in waterhyacinths from Lake Washington, is approximately 50 percent of that found in high nitrogen root tissues. Also, the detritus production rate of 1.13 g dry wt/m^2/day for non-harvested low N treatments should be substituted for the high N detritus production value. These calculations indicate that approximately 136 g dry wt of detritus would be sloughed off (per m^2) in 120 days in this system. The amount of detritus remaining in the sediment is the product of 136 g/m^2 and .75 (approximately twice value obtained from Fig.34 for high N root tissue). These calculations show that 102 g dry wt/m^2 of detritus would remain after 120 days, resulting in .04 cm of sediment (per 120 days) or .12 cm in one year. Thus, although detritus production is greater in a high N than a low N environment, more of the root tissue is decomposed there and consequently a lower percentage of the root tissue is deposited in the sediment. These calculations suggest the above differences nearly balance each other and similar annual sedimentation rates of .12 and .18 cm were found for low N and high N systems, respectively.

SEDIMENTATION DISCUSSION

Contrary to previous opinion, our mass balance calculations and waterhyacinth sedimentation calculations discussed here indicate that sedimentation in Lake Washington may not be a significant problem. The mass balance technique showed only a very slight net input into the lake, which was negligible when extrapolated to a sedimentation rate for the entire lake. Even if the lake were covered by a waterhyacinth mat the sedimentation rate would not be great (.12 cm/year). The obvious error in the mass balance approach, however, are the lack of inflow and outflow data and inability to correct for lake residence time so that the same mass of water could be sampled at the lake entrance and exit. As a result, our calculations may be somewhat misleading.

The practice of spraying waterhyacinths and other aquatic plants in the river increases sedmentation in the area over the natural unsprayed rate as more dead aerial and root tissue would reach the sediment. Large mats of waterhyacinths in the upper St. Johns River are frequently eradicated by the use of herbicides by the SJRWMD (i.e., 2,4-D). Chemically treated waterhyacinths usually die at the surface, with the dead material sinking within two to four weeks. The immediate fate of these dead tissues will vary depending on their composition. High quality waterhyacinths (assume a standing crop of 2 kg m^{-2}; 85% aerial and 15% root tissue; N content 2.5%; water 1 m deep) would rapidly decompose within one month, depositing little sediment (0.23 kg m^{-2}) but releasing a large quantity of nitrogen to the water (46 g N m^{-2}, or 46 mg NL^{-1}). In contrast, low quality waterhyacinths (assume 65% aerial and 35% root tissues, N content 1%), similar to those found in the upper St. Johns River and canal systems, would produce more sediment (0.92 kg m^{-2}) but release less nitrogen to the water column (14 g N m^{-2} or 14 mg N L^{-1}). Because the composition, or quality of waterhyacinth tissues varies both with season (Tucker and Debusk, 1981) and with nitrogen availability in the water (Tucker, 1981) chemical control practices for this species could be timed to limit the impact of nutrient or detritus additions to the water column and sediment.

SEDIMENTATION CONCLUSIONS

Although data are lacking and conclusions are preliminary in nature, our study indicates that sedimentation in the upper St. Johns chain of lakes is not unusually high, on an annual basis. These result are not what we thought we would find. Sedimentation may be seasonally great when aquatic plant spraying is increased, but it appears that periodic (seasonal) high flows in the system and accompanying bottom resuspension allow most of the solids to be carried downstream with surface waters. The shallow nature of the system and the fact that most of the total solids are organic in nature ($\bar{x}$ = 54%) with a low specific weight support this contention. The high suspended solids concentrations and loading rates found at pump sites and in upper basin canals (TF, BDZ, SMOC) were significantly reduced before reaching Lake Washington, indicating some sedimentation occurs in Lakes Hellen Blazes and Sawgrass. The solids (sediment) accumulate in the upper basin lakes to a great extent under low flow conditions, such as occurred in 1974 and 1975, but are largely carried downstream by high seasonal discharges, as experienced in 1978, 1979, (Hurricane David 9/3/79), and 1982. Comparison of cores taken during this study (1982) with cores taken during a FGFWFC 1971 sedimentation transect study indicates there has been no significant increase of organic matter in Lakes Hellen Blazes and Sawgrass. Lakes Washington, Winder and Poinsett, however, did show increases in organic matter of .4 to .6 inches/yr, based on core comparisons. (Fig. 28-33). Periodic bottom scouring and shifting under high flow conditions appears to reduce long term sediment accumulation in the system. The data indicate there is presently significantly less organic matter in the sediment of Lake Hellen Blazes than in 1971 and slightly more in Lakes Washington, Winder, and Poinsett.

The sediment core data presented here for the inlet, transverse and longitudinal transects in the upper St. Johns River lakes should provide valuable baseline data for future studies.

DIURNAL OXYGEN STUDIES

Figure 35 displays numerous percent saturation oxygen curves constructed from diurnal oxygen data collected over the last several years at Camp Holly, near the entrance to Lake Washington. These data show very little diurnal fluctuation of oxygen in this system. Table 24 presents color, total iron, ferrous iron and solar radiation data collected during each diurnal. Visually, it appears that low color corresponds to high percent saturation curves while high color occurred during low oxygen saturation periods. Total iron seems to vary positively with color, since humic material forms very stable complexes with iron. Light-dark bottle phytoplankton productivity and diurnal community productivity were calculated, but are not presented in this report.

We feel that a significant chemical oxygen sink in the system may be related to the ferrous-ferric catalytic cycle noted by Miles and Brezonik (1982). This cycle may explain the extremely low oxygen curves during high color-high iron conditions (Fig. 35). The cycle consists of the photoreduction of Fe(III) to Fe(II) by humic matter and the subsequent oxidation of Fe(II) back to Fe(III) by dissolved oxygen. Rates of 0.12 mg O_2/L/hr were attributed to this mechanism by Miles and Brezonik (1982).

Studies are continuing to investigate this phenomenon with a modification of the light/dark bottle productivity technique. Filtered surface water from the sites are saturated with oxygen by compressed air and transferred to BOD bottles, which are uncapped for 10 minutes to allow entrained air to escape. One-half of

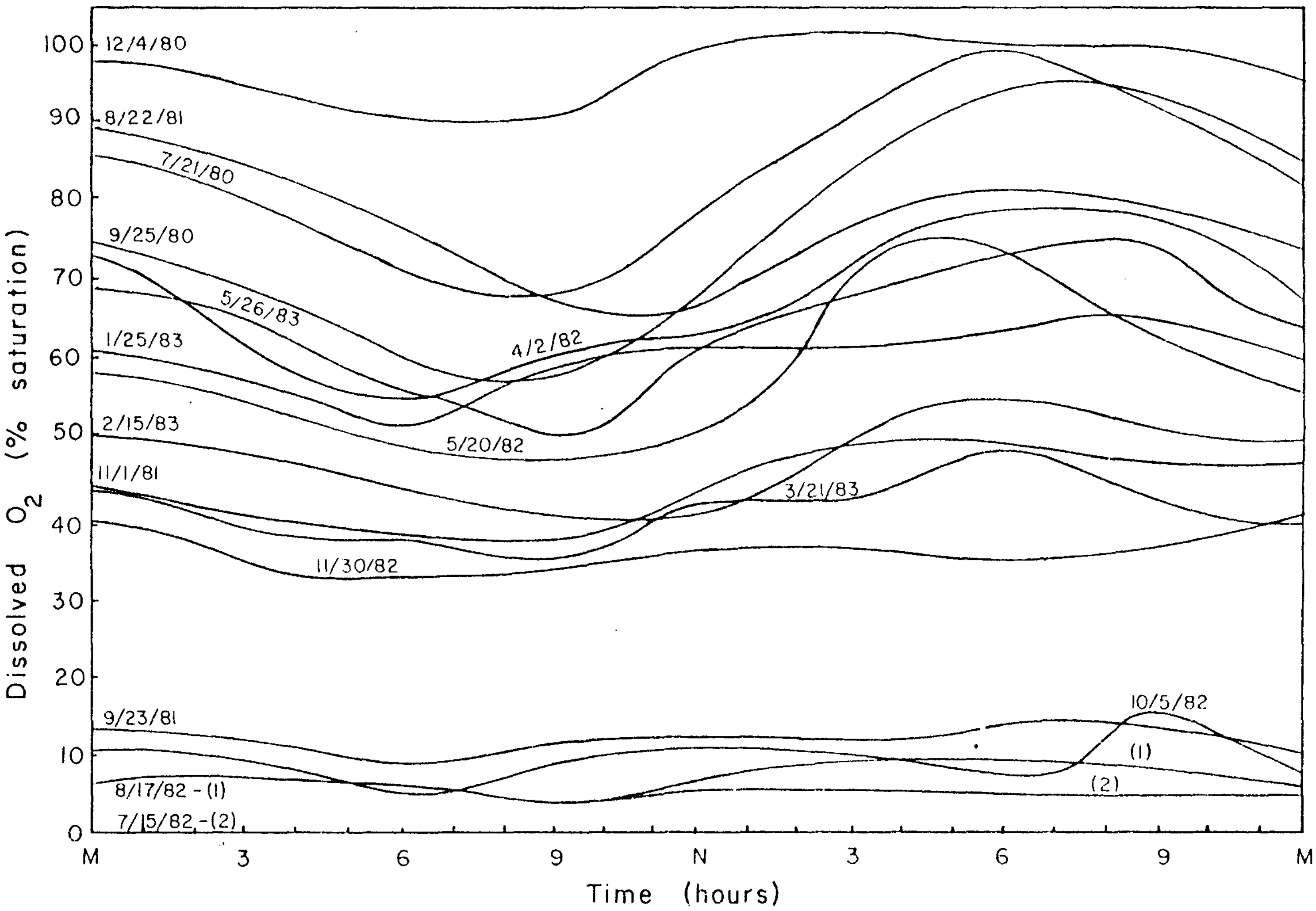


Figure 35. Diurnal oxygen curves (percent saturation) at Camp Holly, near the entrance to Lake Washington.

Table 24. Water chemistry and solar radiation data for diurnal curves presented in Figure 35.

12/4/80	Color = 60 CPU; Total Fe = 0.10 mg/L
8/22/81	Color = 65 CPU; Total Fe = 0.08 mg/L; SR = 32.5 Kcal/m^2-hr
7/21/80	Color = 35 CPU; Total Fe = 0.03 mg/L
9/25/80	Color = 38 CPU; total Fe = 0.04 mg/L
4/2/82	Color = 270 CPU; Total Fe = 0.21 mg/L; Fe II = 0.09 mg/L; SR = 17.5 Kcal/m^2-hr
1/25/83	Color = 243 CPU; Total Fe = 0.21; Fe II = 0.14 mg/L; SR = 15.6 Kcal/m^2-hr
5/20/82	Color = 394 CPU; Total Fe = 0.24 mg/L; Fe II = 0.15 mg/L; SR = 26.4 Kcal/m^2-hr
2/15/83	Color = 243 CPU; Total Fe = 0.26 mg/L; Fe II = 0.08 mg/L; SR = 1.4 Kcal/m^2-hr
11/1/81	Color = 265 CPU; total Fe = 0.20 mg/L
11/30/82	Color = 332 CPU; total Fe = 0.27; Fe II = 0.18 mg/L; SR = 13.8 Kcal/m^2-hr
9/23/81	Color = 232 CPU; Total Fe = 0.18 mg/L
10/5/82	Color = 401 CPU; Total Fe = 0.37 mg/L; Fe II = 0.28 mg/L; SR = 23.4 Kcal/m^2-hr
8/17/82	Color = 438 CPU; total Fe = 0.42 mg/L; Fe II = 0.32 mg/L; SR = 19.8 Kcal/m^2-hr
7/15/82	Color = 440 CPU; total Fe = 0.27 mg/L; Fe II = 0.25 mg/L; SR = 22.8 Kcal/m^2-hr
3/21/83	Color = 304 CPU; Total Fe = 0.30 mg/L; Fe II = 0.13 mg/1; SR = 25.3 Kcal/m^2-hr

the bottles receive 1 ml of saturated mercuric chloride to prevent microbial respiration, and are incubated in situ in clear and opaque BOD bottles along with untreated (no mercuric chloride) bottles. Replicate bottles of each of the four treatments and controls are retrieved after 0, 4, and 8 hours and D.O. levels are measured. In addition, total iron by atomic absorption spectrophotometry, ferrous iron by colorimetry, dissolved organic color by absorbance at 420 nm on centrifuged water, temperature, conductance, pH, Secchi depth, bottom depth and light energy are measured for the surface water. Solar radiation is measured with a mechanical pyranograph.

The data collected in this phase will be analyzed to determine the importanc- of the photochemical ferrous-ferric catalytic cycle compared to uptake via microbial respiration in the water column (by comparing rates of dissolved oxygen disappearance in the poisoned light and dark bottles with that in the unpoisoned light and dark bottles). In addition, the rates of oxygen produced by the phytoplankton community will be determined using the unpoisoned light and dark bottles, respiration, and net and gross productivity rates will be computed.

Diurnal oxygen and field measurements made beginning on 2/16/83, 3/21/83 and 5/26/83 were used for single station metabolism calculations outlined in the USGS Computers Program User's Manual as referenced in Table 25. Single station calculations were made for stations 1, 2 and 3 with the 5/26/83 data, in addition to two station computer calculations (Figure 36). The single station technique (5/26/83) indicates net daytime production, P/R and community metabolism increase in a northward direction from station 1 to 3. The simultaneous two station technique, however, indicates a dominance of respiration over production and negative 24 hr. community metabolism values. Respiration and negative metabolism also dominated at Camp Holly (Station 1) on 2/15/83 and 3/21/83. These data indicate that this area is low in community production and studies are continuing to confirm that hypothesis.

Table 25. Single and two station oxygen metabolism measurements near Camp Holly.[1]

Date	Discharge (ft^3/s)	Color (CPU)	Solar Radiation ($cal/cm^2/day$)	Net Daytime Production ($g\ O_2/m^2/day$)	Night Respiration ($g\ O_2/m^2/day$)	P/R[2]	24. Hr. Community Metabolism ($g\ O_2/m^2/day$)
2/16/83[3]	--	243	11.4	1.77	4.63	0.38	-2.86
3/21/83[4]	--	305	365	0.43	3.23	-0.13	-3.66
5/26/83[5]							
(1)	98	296	585	2.75	3.54	.77	- .79
(2)	98			3.42	2.88	1.19	.54
(3)	98			5.23	3.38	1.55	1.85
5/26/83[6]	98	296	585	- .43	0.20	-1.59	-0.63
5/26/83[7]	98	296	585	- .19	0.07	-2.14	-0.25
5/26/83[8]	98	296	585	-.14	0.06	-1.76	-0.20

[1] Metabolism data were calculated using the Computer Program User's Manual entitled "Determination of Primary Productivity and Community Metabolism in Streams and Lakes Using Diel Oxygen Measurements", developed by Doyle Stephens and Marshall Jennings at the U.S.G.S. Water Resources Division of the Gulf Coast Hydroscience Center, Bay St. Louis, Mississippi.

[2] Net daytime production divided by night respiration.

[3] Daytime rain occurred; single station method.

[4] Single station method.

[5] Single station method, stations 1, 2, and 3,(Figure 36).

[6] Two station method; stations 1 - 2,(Figure 36).

[7] Two station method; station 2 - 3, (Figure 36).

[8] Two station method; station 1 - 3, (Figure 36).

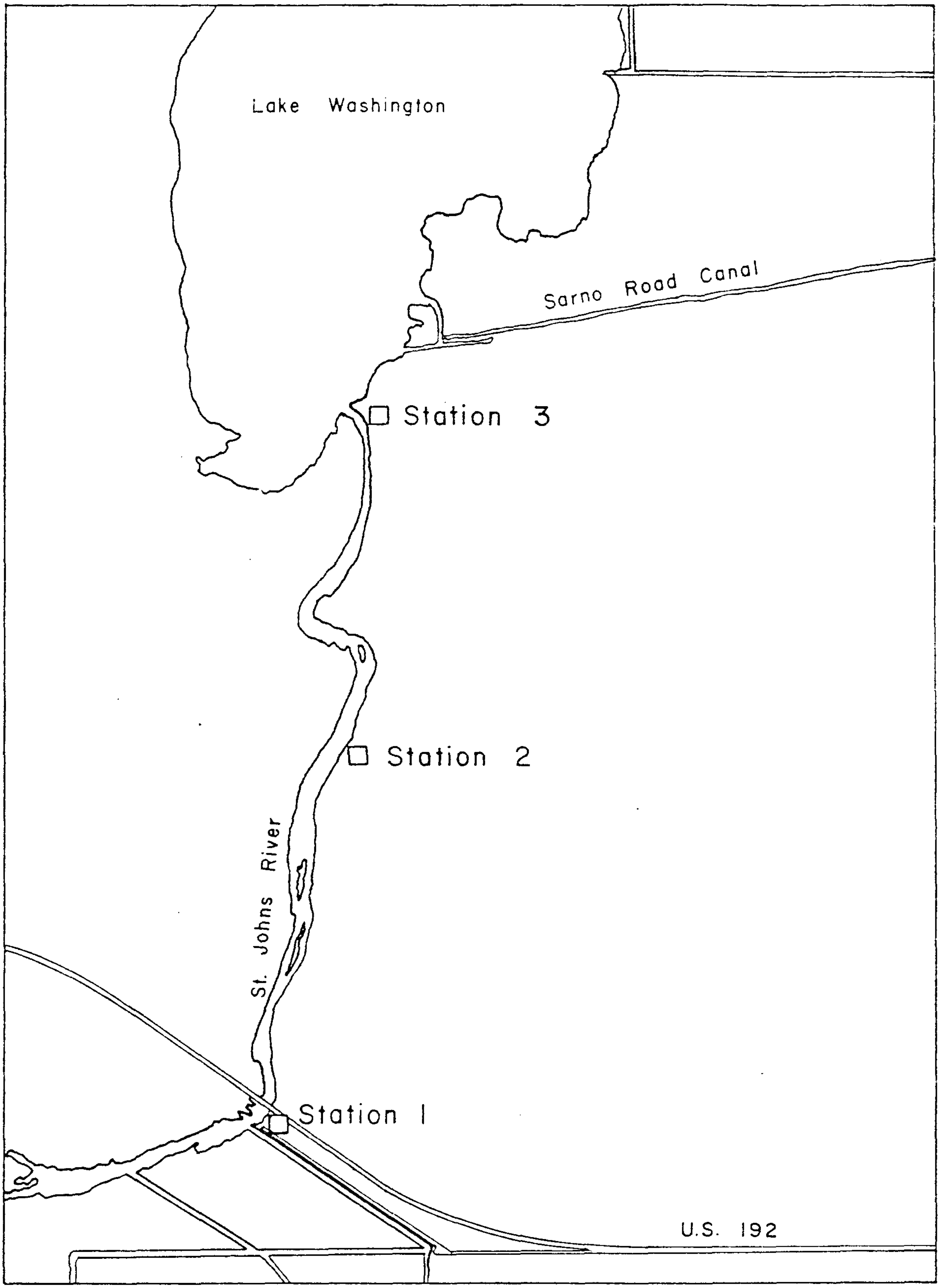


Figure 36. Oxygen metabolism measurement stations.

CHAPTER VI

SUMMARY AND CONCLUSIONS

AGRICULTURAL PUMPAGE

Thirteen pump events were monitored during the Summer of 1982 for the Zigzag, Mary A and Bulldozer Canal pumps. Background data were collected for these pumps, in addition to the Duda and North Mormon pump sites. A very significant statistical correlation was found between pump discharge rates and ammonia ($r = .95; p<.01$), but no other relationships were found.

The GFWFC collected data on 12/7/82 at the entrance of Duda canal to the St. Johns River when the Duda pump was operating. These data indicate the pump was discharging high concentrations of ortho (.22 mg P/L) and total (.31 mg P/L) phosphorus and high levels of inorganic nitrogen,particularly ammonia nitrogen (.92 mg NH_3-N/L). Hardness (275 mg/L as $CaCO_3$) and chloride (590 mg/L) levels were also high. The high inorganic nutrient and chloride concentrations and the close proximity of the pump to the river indicate that this pump, which drains primarily improved pasture, is a potentially significant pollutional source to the river.

Zigzag pump drains primarily citrus areas and has a rated capacity of 150,000 GPM. Zigzag pump discharges were characterized by very high color ($\bar{x}$ = 300 CPU), ammonia-nitrogen ($\bar{x}$ = .15 mg N/L) and nitrate-nitrogen ($\bar{x}$ = .64 mg N/L). Pump discharge from this area is overloaded with nitrogen as background concentrations of these same parameters averaged only .05 and .08 mg/L, respectively. Total phosphorus, however, was only slightly elevated ($\bar{x}$ = .15 mg P/L) over background concentrations ($\bar{x}$ = .08 mg P/L). Discharge BOD_5 for the five pump events was not high ($\bar{x}$ 2.4 mg/L) and was similar to the upstream BOD_5. Diurnal sampling of a 6/24-6/25/82 pump event indicated most parameter levels were fairly constant throughout the 24 hr. period. Nitrate-nitrite nitrogen was high at the pump ($\bar{x}$ = .64 mg N/L) and remained fairly high at downstream stations.

Two pumps were sampled on Bulldozer canal. Pump #1 was sampled once (improved pasture drainage) and pump #2 was sampled 5 times (citrus drainage). Nutrient, BOD_5 and other parameter levels from these pumps were not excessively high and the data indicate the water quality of South Mormon Outside Canal was worse than the Bulldozer pump discharge water. Pump #2 exhibited higher chloride, hardness, alkalinity and suspended solids concentrations than pump #1; pump #1, however, showed higher color, TKN, NH_4-N and BOD_5. BOD_5 from pump #2 was high (4.2 mg/L), but this value was similar to recorded values in South Mormon Canal.

The Mary A pump is listed as draining improved pasture although we observed row cropping uses (corn) during sampling trips. This pump has a high rated capacity (120,000 GPM) and the water quality from this pump was the worst of any pump and appears to have the greatest pollutional potential. The average TN and TP concentrations for the three sample dates were 3.96 mg N/L and 0.79 mg P/L, respectively. Mary A pumpage also exhibited very high average levels of ortho PO_4(0.52 mg P/L), TKN (3.9 mg N/L), NH_4-N (0.31/mg N/L) NO_3-N (0.48 mg N/L), iron (1.68 mg/L), turbidity (18 NTU), BOD_5 (5.5 mg/L), Hardness (223 mg/L) and color (525 CPU). Chlorophyll _a_ was very high at the pump and in the canal, reaching concentrations of 23 and 29 mg/m^3 on 7/22/82 and 8/12/82, respectively.

Total P and total N pump loading rates reflect discharge rates to a large degree and they are one way of looking at the pollutional potential of the pumps. The total N loading rates for the Mary A, Zigzag, Bulldozer #2 and Bulldozer #2 pumps were 1935, 1305, 238 and 86 Kg/day, respectively. The total P loading rates for these same pumps were 390, 63, 12 and 7 Kg/day. These calculations show that the pumps that drain into C-40 (Zigzag and Mary A) are the worst offenders in terms of nutrient loading. Mary A was extremely high in both N and P. Bulldozer pump nutrient loading rates were not exceedingly high, with pump #1 levels (improved pasture; one sampling) exceeding nutrient loading rates from pump #2 (citrus).

LAKE WASHINGTON INLET-OUTLET STUDIES

During the study the outlet to Lake Washington generally had higher discharge rates and nutrient concentrations than the inlet. From August, 1980,through September, 1982,the inlet discharge ranged from 1.7 to 1974 cfs ($\bar{x}$ = 390 cfs) while the outlet discharge varied from 0 to 2533 cfs ($\bar{x}$ = 492 cfs). Total nitrogen concentrations at the outlet ranged from 1.4 to 3.8 mg/L from January through September, 1982, with a mean concentrations of 2.2 mg/L. At the inlet, total nitrogen varied from 1.5 to 2.0 mg/L. Higher discharge at the outlet, throughout most of the study, resulted in a slightly greater nutrient (TN + TP) export rate from the lake than nutrient input rate. The average TN and TP loading rates to Lake Washington were 3136 and 155 Kg/day, respectively, while the export rates from the lake for these same parameters were 4029 and 182 Kg/day. Total phosphorus concentrations at the inlet and outlet were similar, ranging from 0.03 to 0.14 mg/L. The only parameter that exhibited a slight net input into Lake Washington, in spite of the greater outlet discharge, was suspended solids. Based on seventeen sampling days exhibiting different flow regimes, inlet and outlet loading rates were 3500 and 3450 Kg/day, respectively. The suspended solids averages were 2.6 and 2.2 mg/L for the inlet and outlet, respectively. Core data from the transverse profile indicate that the depth of organic matter has increased in Lake Washington since 1971, more than in the other lakes. Other lakes in the chain showed a slight increase in organic matter, except for Lake Sawgrass which had an organic layer depth profile similar to the 1971 profile and Lake Hellen Blazes which had less surface organic matter than the 1971 cores indicate.

UPPER ST. JOHNS RIVER CANALS

Discharge south of Lake Hellen Blazes was dominated by South Mormon Outside Canal (SMOC). At low stage heights, Three Forks was the strongest flowing tributary, although the discharge only reached a maxium level of 107 cfs. As the stage height rose (>15 ft msl), Three Forks stopped flowing altogether and the discharge in SMOC began rising dramatically, reaching a maximum value of 538 cfs in August, 1982. Bulldozer Canal showed a negligible flow at low stage heights (<15 ft. msl), and actually flowed west at high stage levels as a large percentage of the South Mormon Outside Canal discharge entered Bulldozer Canal before entering the marsh to the north of the canal.

As would be expected from the above discharge patterns, SMOC dominated nutrient and suspended solids loading. SMOC had total nitrogen concentrations ranging from 1.2 to 3.4 mg/L. Nitrate-nitrite nitrogen and Total P levels were higher than those recorded in Lake Washington. SMOC total N loading varied from 0 to 2950 Kg/day, while total P loading ranged from 0 to 302 Kg/day. These loading rates are less than at Lake Washington due to the lower discharge. The only significant correlations in these canals were between discharge and ammonia ($r = .68$; $P<.01$) and discharge vs. conductivity ($r = -.32$; $P<.05$). Generally, suspended solids concentrations increased with increasing discharge, although statistical correlation these two parameters was poor. South Mormon Outside Canal suspended solids concentrations varied from 1.9 to 26.2 mg/L. The SMOC canal suspended solids concentrations were generally less than those recorded downstream at Lake Washington as some solids settle out enroute.

DIURNAL OXYGEN STUDIES

Sixteen diurnal oxygen curves (percent saturation) were constructed from 24 hours diurnal oxygen measurements made at the entrance to Lake Washington at U.S. 192. These data show very little fluctuation of oxygen in the system. Color, total iron, ferrous iron, and solar radiation data were collected during the diurnal sampling and it was found that low percent saturation curves correlate positively with high color and high iron values. Studies are continuing to investigate the operation of a ferrous-ferric catalytic cycle, described by Miles and Brezonik (1982), in the upper St. Johns River system. Community production rates, calculated from diurnal and field data, were consistently low at the sampling stations.

SEDIMENTATION STUDIES

Core data indicate all upper St. Johns lakes have a layer of fine organic matter on the sediment surface, underlain by various layers of sand and clay. The southern lakes of the chain, Lakes Sawgrass and Hellen Blazes, had more fibrous or woody organic matter beneath the fine surface layer than the other lakes and this may reflect a greater degree of waterhyacinth decomposition and sedimentation in these lakes than in other upper basin lakes. However, organic layer depths in Lakes Hellen Blazes and Sawgrass were similar or less than found in a 1971 core survey by the GFWFC, indicating periodic high discharge rates since that time have carried much organic bottom debris downstream. Based on seventeen longitudinal and transverse cores taken in each lake (1982), there was a progressive decrease in the depth of organic matter present in the lakes as they progress northward from Lake Hellen Blazes (with the exception of Lake Poinsett). Lakes Hellen Blazes, Sawgrass, Washington, Winder and Poinsett exhibited average organic matter depths of 13.8,9.7, 9.5, 3.4 and 5.4 inches, respectively. Blue Cypress Lake, the deepest of all the lakes, had the greatest depth of organic matter found, averaging 17.7 inches for the seventeen longitudinal and transverse cores. Also, more peat was encountered in Blue Cypress lake than any of the other lakes.

Our studies indicate, although more data should continue to be collected, that sedimentation in the upper St. Johns Chain of lakes is not extremely high, on an annual basis. If we can assume our coring sites are duplications of the 1971 GFWFC coring sites, data indicate average accumulations of 4.5 to 7 inches of organic matter in Lakes Washington, Winder, and Poinsett since 1971. This translates to a sedimentation rate of approximately 0.5 inches/yr. Calculations based on recent waterhyacinth studies indicate that natural sedimentation beneath hyacinth stands would only be approximately .12 in/yr. The sedimentaion from hyacinths is great when these plants are chemically sprayed, as then more dead aerial and root tissue reach the sediment.

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APPENDICES

APPENDIX A

SAMPLING DATES AND FIELD DATA

1981 - 82

SAMPLING DATES - 1981

8-28-81

Measured flow and sampled Inlet and Outlet of Lake Washington.

9-1-81

Sampled Inlet of Lake Washington in conjunction with USGS Field Representative.

9-15-81

Measured flow and sampled at Mormon Outside Canal, Three Forks, Bulldozer Canal and the Inlet and Outlet of Lake Washington.

9-23-81

Measured flow and sampled at Mormon Outside Canal, Three Forks, Bulldozer Canal and the Inlet and Outlet of Lake Washington.

10-2-81

Measured flow and sampled at Mormon Outside Canal, Three Forks, Bulldozer Canal and the Inlet and Outlet of Lake Washington.

10-8-81

Measured flow and sampled at the Inlet and Outlet of Lake Washington.

11-6-81

Measured flow and sampled at the Inlet and Outlet of Lake Washington.

12-17-81

Measured flow and sampled at Mormon Outside Canal, Three Forks, Bulldozer Canal and the Inlet and Outlet of Lake Washington.

Coring Dates - 1981

10-24-81

Obtained the Inlet radial cores for Lake Washington.

10-28-81

Obtained the Inlet radial cores for Lake Sawgrass.

10-30-81

Completed the inlet radial cores for Lake Sawgrass.

11-6-81

Obtained the inlet radial cores for lake Hellen Blazes.

11-10-81

Obtained the longitudinal transect cores for Lake Sawgrass.

11-20-81

Obtained the transverse transect cores for Lake Sawgrass.

SAMPLING DATES - 1982

1-20-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal, Bulldozer Canal, Lake Washington Inlet and Lake Washington Outlet.

2-22-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal and Bulldozer Canal.

2-24-82

Sampled and measured flow at Lake Washington inlet and outlet.

3-10-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal and Bulldozer Canal. Checked pumps on Bulldozer Canal. (Not pumping).

3-12-82

Sampled and measured flow at Lake Washington inlet and outlet.

3-19-82

Checked pumps on Zig Zag canal. (Not pumping).

3-30-82

Sampled and measured flow at Lake Washington inlet and outlet.

3-31-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal and Bulldozer Canal. Checked pumps on Bulldozer Canal. (Not pumping).

4-22-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal, Bulldozer Canal, Lake Washington Inlet and Lake Washington Outlet. Checked pumps on Bulldozer Canal. (Not pumping).

4-27-82

Sampled pumps on Zig Zag Canal for background data.

5-5-82

Sampled pumps on Zig Zag Canal. Pumps reported running this morning, however, the pumps were not running when we arrived.

5-13-82

Checked pumps on Zig Zag Canal. Not on. Sampled and measured flow at 3 Forks, Mormon outside Canal, Bulldozer Canal, Lake Washington Inlet and Lake Washington Outlet.

SAMPLING DATES - 1982

1-20-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal, Bulldozer Canal, Lake Washington Inlet and Lake Washington Outlet.

2-22-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal and Bulldozer Canal.

2-24-82

Sampled and measured flow at Lake Washington inlet and outlet.

3-10-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal and Bulldozer Canal. Checked pumps on Bulldozer Canal. (Not pumping).

3-12-82

Sampled and measured flow at Lake Washington inlet and outlet.

3-19-82

Checked pumps on Zig Zag canal. (Not pumping).

3-30-82

Sampled and measured flow at Lake Washington inlet and outlet.

3-31-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal and Bulldozer Canal. Checked pumps on Bulldozer Canal. (Not pumping).

4-22-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal, Bulldozer Canal, Lake Washington Inlet and Lake Washington Outlet. Checked pumps on Bulldozer Canal. (Not pumping).

4-27-82

Sampled pumps on Zig Zag Canal for background data.

5-5-82

Sampled pumps on Zig Zag Canal. Pumps reported running this morning, however, the pumps were not running when we arrived.

5-13-82

Checked pumps on Zig Zag Canal. Not on. Sampled and measured flow at 3 Forks, Mormon outside Canal, Bulldozer Canal, Lake Washington Inlet and Lake Washington Outlet.

5-26-82

Sampled and measured flow at 3 Forks, Mormon Outside Canal, Bulldozer Canal, Lake Washington Inlet and Lake Washington Outlet. Checked pumps on Bulldozer Canal. Water running from pipe but pump motors off. We feel that pumps had been on due to moderate bottom displacement. Sampled at pumps.

*5-27-82

Checked pumps on Bulldozer Canal. Pump Event. Pump motors on and water flowing from pump. Sampled at pump, 250 meters upstream, 250 meters downstream and at confluence of Bulldozer Canal and St. Johns River.

5-28-82

Carol Fall indicated N. Normon pump running on previous day. Checked pumps on North Mormon Outside Canal, pumps not running. Pump surrounded by heavy vegetation. Sampled at pump for background data. Checked pumps on Zig Zag Canal. Not running either. A pump south of boat ramp was running that discharged east under highway 512. Sampled there.

6-15-82

Checked pumps on Zig Zag Canal. Motors running but water was being pumped from one canal to another. Pumps reportedly shut off that morning at 6:00 a.m. Strong flow at bend (probably reflects pumpage water quality). Sampled and measured flow. Measured oxygen levels, pH and conductivity along canal from pumps to lateral M Canal. Did same at Blue Cypress Outlet and North of pumps on Lateral M canal.

*6-18-82

Checked pumps on Zig Zag Canal. Pump Event. All pump motors on. Sampled at pump, 250 meters downstream, 250 meters upstream and at bend. Also measured flow upstream and downstream. Very strong flow.

*6-24-82

Attempted to check pumps on Bulldozer Canal, but could not get to them due to heavy hyacinths. Sampled and measured flow at Mormon Outside canal. Measured oxygen levels from Mormon Outside Canal to Mid Lake Washington. Checked pumps on Zig Zag Canal. Pumps not running initially, took background sample at bend and upon return pump's running. Only one motor on. Pump Event. Sampled at pump, 250 meters upstream, 250 meters downstream and at bend. Took field measurement between bend and downstream site.

*6-25-82

Same Pump Event. Checked pumps on Zig Zag Canal in morning (8:00 a.m.). Pumps still running. Sampled at pump, 250 meters upstream, 250 meters downstream and at bend. Took field measurements between bend and downstream site checked pumps in evening (5:00 p.m.) still running and second pump motor running. Took field measurements and sampled at pump and 250 meters upstream. (Measurements made at start, 14 hrs and 22 hrs after pumps turned on).

Boats down for two weeks for repairs. Beginning of 4th Quarter

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*7/12/82 – Both pumps in BDZ canal. Pump event. Pumps & stations sampled. Significant flow ($275 ft^3/sec$) west in BDZ canal before entering north marsh prior to pump # 2. Chemical data are

4th Quarter

Sampling Dates - 1982

7-12-82 Bulldozer pumps #1 + 2 on Pump Event.

7-19-82

Sampled and measured flow at Lake Washington inlet and outlet.

7-20-82

Checked Bulldozer pumps. Pump Event - Pump #2 running. Sampled at pump, 250 meters downstream and upstream. The mouth of Bulldozer Canal and South Mormon Outside Canal. Strong odor from pump water at pump.

7-22-82

Checked Mary A pump. Pump Event - Two out of three motors running. Canal heavily choked with hyacinths. Sampled at pump, 250 meters upstream and downstream, at the confluence of canal and river, and also a background from Triangle Canal. Strong flow here due to flood gates being open on Fellsmere Grade. Water at pump very dirty with corn cobs floating by.

8-2-82

Sampled and measured flow at South Mormon Outside Canal and Bulldozer Canal.

8-3-82

Checked Bulldozer pumps. Pump Event - Sampled pump #1. 250 meters upstream and 250 meters downstream.

8-4-82

Sampled and measured flow at Lake Washington inlet and outlet.

8-12-82

Checked Mary A pump. Pump Event - All pumps running strongly. Sampled pump flow - seemed to move across flood plain to far canal. Pump canal closed up to 50 meters on either side with hyacinths. Sampled far canal upstream and downstream of canal. Confluence with marsh. Sampled at points P, A, C, F, & D.

8-13-82

Checked pumps at ZigZag Canal. Not running.

8-16-82

Checked pumps at ZigZag. Pump Event - Sampled at pump, 250 meters upstream and downstream and at bend. Only one pump running. Sampled at points 6, 5, 3, 1 and 0.

8-26-82

Sampled and measured flow at Lake Washington outlet and inlet.

8-31-82

Checked Bulldozer pumps. Pump Event - Pump #2 running strongly. Took pump sample and then Bulldozer #2 pump was shut down. Sampled 250 meters upstream and downstream. Sampled mouth of Bulldozer Canal and sampled marsh where flow seemed to enter from Bulldozer Canal. Also sampled and measured flow at South Mormon Ouside Canal and Three Forks Canal. Sampled at 24, 23, 21, in marsh, 16, 13 and 14.

9-1-82

Checked Mary A pump. Pump Event - Only one pump running. Sampled pump and upstream in pump canal. Sampled downstream in Far canal across flood plain. Sampled upstream and downstream of Far Canal confluence. Sampled at A, H, F & G.

9-2-82

Checked ZigZag Canal - pump not on.

9-3-82

Checked Duda pump. Not running. Took background sample.

9-23-82

Checked North Mormon Outside Canal pump. Not running.

9-27-82

Checked C-40 and South end of Three Forks Canal to check flows. Flow not strong with Fellsmere grade flood gates closed. Most of flow from C-40 entering South Mormon through marsh. Very little flow in C-40 north of Three Forks

FIELD DATA

KEY

All data refers to number station locations described here and shown in Fig. 1.

No. Description

0 - 250 m upstream of Zig Zag Canal pump

1 - At pump

2 - 250 m downstream of pump

3 - 500 m downstream of pump

4 - 1000 m downstream of pump

5 - 1500 m downstream of pump

6 - approx. 2000 m downstream, at bend of canal

7 - north of bend at stage gage

8 - 400 m past pump on north-south canal

9 - at bend where canal turns west

10 - 20 m east of north-south lateral M canal

11 - 200 m north of Blue Cypress Lake on lateral M canal

12 - 200 m north of pump, midway on lateral M canal

13 - Mormon Outside Canal, 200 m south of Three Forks confluence

14 - In Three Forks, 30 m upstream of confluence with Mormon Canal

15 - At confluence of Bulldozer Canal and Mormon Canal

16 - In Bulldozer Canal, 30 m upstream of mouth

17 - 1/3 distance between Bulldozer Canal mouth and 1st pump

18 - 2/3 distance between Bulldozer Canal mouth and 1st pump

19 - At pump

20 - 500 m downstream of second pump

21 - 250 m downstream of second pump

22 - At pump

23 - 250 m upstream (west) of pump in Bulldozer Canal

24 - 250 m upstream of pump on lateral canal

25 - In Mormon Canal midway between Bulldozer Canal and Lake Hellen Blazes

26 - Middle of Lake Hellen Blazes

27 - Midway between Lake Hellen Blazes and Lake Sawgrass

28 - Middle of Lake Sawgrass

29 - Near Camp Holly at U.S. 192

30 - 400 m north of U.S. 192

31 - Lake Washington inlet

32 - Middle of Lake Washington

33 - At weir at north end of Lake Washington

34 - At North Mormon Outside Canal pump

FIELD DATA

5-5-82

Station	Depth	Time	Discharge	D.O.	T°	Cond.	pH	S.D.
0	6.5	11:00 am	none					
- 1	7.0	2:50 pm		S 5.5	25.0	920	7.15	5.5
				1m 3.6	23.6			
				2m 2.7	23.3			
6	12.2 ft	3:40 pm		S 4.0	24.4	925	6.7	6.0
				1m 3.8	24.3			
				2m 3.8	24.3			
2	6.7		5.5 ft^3/sec					

Comments: High east wind, slow surface flow to west. Measurements indicate that when pumps not on there is normally no flow in Zig Zag Canal, or a small wind induced or seepage flow of around 5 ft/sec.* Substantiated by later data. Carol Fall indicated pumps running on previous day. Not running on this date.

5-28-82

29		2:30 pm		S 4.4	27.2	-	-	-
				1m 4.0	26.6	-	-	-
34	8.5 ft	11:45 am	Δ					
				S 2.1	25.0	490		3.0 ft
				1m 1.9	24.3	490		
				2m 1.7	23.7	490		

4-27-82 - Background

1	8.7 ft	11:00 am	*	S 5.6	24.5	850	7.1	4.0
				1m 6.2	23.5	850	-	
				2m 6.1	23.1	850	-	

---

*No upstream or downstream flow

A
North Mormon pump not on.

FIELD DATA

Date: 5-25-82

Station	Depth	Time	Discharge	DO (mg/L)	Cond. (μmhos/cm)	pH	T(°C)	S.D.(ft.)
33		10:00 am		S 5.8			26.0	
31		11:00 am		S 3.5			26.8	
				1m 3.0			25.8	
				2m 3.0			25.7	
13		12:30 pm						
				S 4.3			28.1	
				1m 4.7			27.4	
14		12:45 pm		S 2.8			27.1	
16		1:25 pm		S 4.3			27.9	
22	3.5	2:10 pm	A*	S 4.0	1100	6.65	26.4	4.0
25		2:30 pm		S 3.0			28.0	
				1m 3.1			27.9	
26		2:40 pm		S 5.1			29.1	
				1m 4.8			27.0	
27		2:50 pm		S 4.6			29.5	
28		3:00 pm	*	S 8.3			29.8	

Comments: *Lake Sawgrass very wind mixed

^{A}Water running from pipe - very slow

Date: 5-27-82

23	1.5 ft	12:30 pm	-	5.5	1100	7.15	26.5	To bottom
22	3.0	12:50 pm	*	3.7	1150	6.80	26.4	3.0
21	3.5	1:00 pm	-	5.5	1125	6.95	26.8	3.5

*Pump on - slow flow
No discharge measurements made

6-15-82 Zig Zag Canal

FIELD DATA

Station	Depth	Time	Discharge	D.O.	Cond.	pH	T°	S.D.
0			None					
1		4:50 pm		S 1.5			29.9	
				1m 1.1			30.0	
				2m 0.7			29.9	
11	11.0	2:30 pm		S 7.3	450	7.2	34.9	4.0
				1m 7.2			34.1	
				2m 7.0			33.2	
12	15.0	3:00 pm		S 3.6	520	6.4	29.8	
				1m 3.4			29.9	3.5
				2m 3.4			29.8	
4	9.25	12:20 am	-	S 1.2	1000	6.7	30.2	5.25
				1m 1.0	1000		30.1	
				2m 0.9	1000		30.1	
6	7.0	12:00am	-	S 1.0	960	6.7	29.5	5.5
				1m 0.8	960		29.7	
				2m 0.7	960		29.6	
7	10.0	11:00 am	195 ft^3/sec	S 0.8	960	6.7	29.6	4.5
				1m 0.7	960		29.4	
				2m 0.5	960		24.3	
8	8.75	1:00 pm	-	S 0.8	960	6.5	30.1	5.0
				1m 0.6	960	6.5	30.0	
				2m 0.8	960		30.0	
9	9.5	1:30 pm	-	S 0.8	950	-	30.5	5.0
				1m 0.5	950		30.4	
				2m 0.3	950		30.4	
10	10.0		-	S 0.6	850	-	29.3	4.0
				1m 0.3			29.3	
				2m 0.2			29.2	

6-15-82

Comments: Clear and Sunny - Apparently pumps turned off at approximately 7:00 am. But obvious flow at station 7 was measured at 10:50 am. - believed to be residual of night pumping. High flow out of Blue Cypress Lake and oxygen content much greater.

6-18-82

FIELD DATA - Pump Event

Location: Zig Zag Canal

Station	Time	Depth	Discharge	D.O.	Cond.	pH	T°	S.D.
0	4:15 pm	6.5 ft	None	S 3.9	625	7.1	26.5	2 ft
				1m 3.6	625		26.4	
				2m 0.5	625		26.2	
1	4:00 pm	7.6	-	S 4.6	575	7.2	26.7	2.5
				1m 4.4	575		26.7	
				2m 4.4	575		26.7	
2	3:45 pm	7.5		S 4.1	485	7.3	26.5	2.0
				1m 3.9	585		26.5	
				2m 3.0	585		26.6	
7	2:44 pm	11.0	282 ft^3/sec	S3.5	660	7.2	26.2	3.5
				1M 3.3	660		26.2	
				2m 3.2	660		26.1	
				3m 3.1	660		26.0	

Comments: All three pumps on. Very strong wind from southwest, partly cloudy. Discharge 282 ft^3/sec or 126,500 gal/min. Discharge measurement made around the bend at staff gage.

6/24/82

Station	Time	Depth	Discharge	DO (mg/L)	Cond. (μmhol/cm)	T (°C)
Bulldozer						
16	10:30 am	6.4 ft	130 ft^3/sec (west)	0.4 mg/L (surf)	500	28.5
				0.2 mg/L (1m)	500	28.5
(200 m west of mouth)						
South Mormon						
13	11:00 am	7.2 ft	203 ft^3/sec (north)	0.4 S		29.1
				0.1 2m		27.2
25	12:30 pm			0.3 S		29.8
				0.2 1m		29.3
26	12:45 pm			0.3 S		29.8
				0.2 1m		29.3
27	1:00 pm			0.4 S		28.9
				0.2 1m		28.7
29	1:15 pm			0.5 S		28.6
				0.3 1m		28.6
				0.2 2m		28.6
32	1:30 pm			0.5 S		29.3
				0.3 1m		29.1

Comments: Bulldozer Choked with hyacinths. Visable flow west - strong. Three Forks choked with hyacinths and no flow. South Mormon Outside showed very strong northward flow with frequent turbid clouds of water. Very Silty. 203 ft^3/s - 130 ft^3/s = 73 ft^3/sec flowing north of entrance to Bulldozer Canal. More than ½ of South Mormon

6-24-82

BACKGROUND FIELD DATA BEFORE PUMPS TURNED ON

Station	Time	DO	T°	
1	5:00 pm	1.2 mg/L	28.4	- Pump not on
		1.1	28.5	
6	5:35 pm	2.6	28.6	
		2.4	28.6	
		2.3	28.5	
7	5:15 pm	2.5	28.5	* Water
		2.3	28.5	- Sample taken for nutrient analysis.
		2.2	28.6	

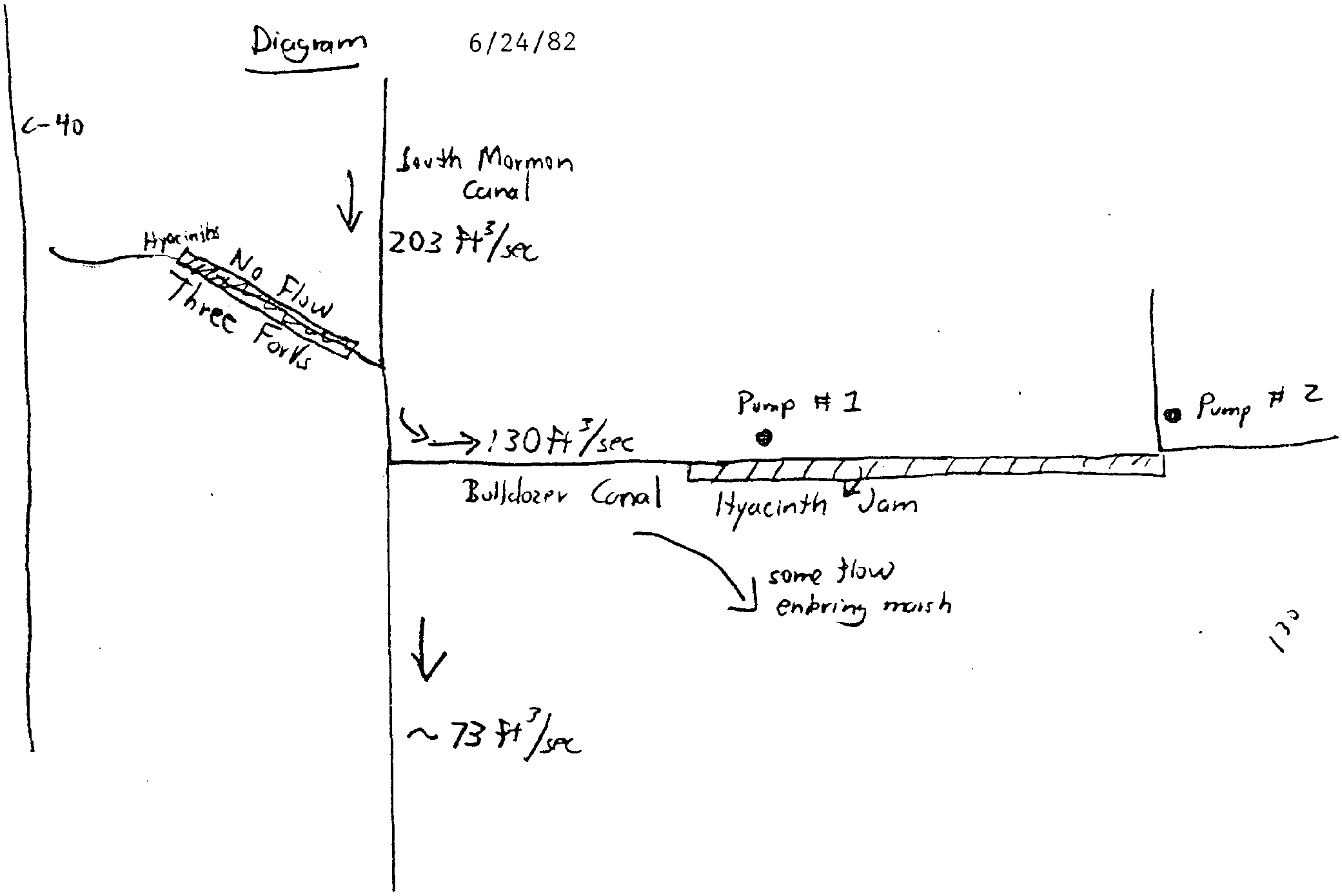


Diagram 6/24/82

FIELD DATA - Pump Event

Date: 6-24/ 6-25-82

Location: Zig Zag Canal

Date	Station	Depth	Time	Discharge	D.O. (mg/L)	Conductivity (µmhos/cm)	pH	T°(C)	S.D.(ft)
6-25-82	0	6.75'	8:30 am	4.4 ft^3/sec	0.8 surf	600	6.8	27.6	3.5
					0.6 1m	610		27.6	
					0.6 2m	610		27.6	
	1	8.25'	8:40 am		2.5 surf	750	6.9	26.4	3.0
					2.3 1m	760		26.4	
					2.1 2m	760		26.5	
	2	7.5'	8:50 am		0.8 s	700	7.0	27.1	3.5
					0.5 1m	700		27.1	
					0.4 2m	710		27.0	
	3	7.5'	9:00 am		0.8 s	750	6.6	26.8	3.5
					0.5 1m	750		26.8	
					0.5 2m	760		26.7	
	4	7.5	9:15 am		1.2 s	750	6.7	26.6	4.5
					1.1 1m	750		26.6	
					1.1 2m	750		26.6	
	5	9.5	9:20 am	133 ft^3/sec	1.1 s	740	6.8	26.7	4.5
					1.0 1m	740		26.6	
					1.0 2m	740		26.6	
	6	9.5	9:35 am		1.2 s	710	7.0	26.6	4.5
					1.0 1m	700		26.6	
					1.0 2m	700		26.6	
					1.0 3m	700		26.5	
6-25-82	0		5:30 pm	4.4 ft^3/sec	0.8	790	7.1	28.0	4.5
					0.6	790		28.0	
					0.4	790		27.9	
	1		4:30 pm		4.6	880	6.9	28.4	2.5
					4.5	880		28.4	
					4.5	880		28.4	
	2		5:15 pm		4.3	910	7.1	28.2	3.0
					4.1	910		28.2	
					4.0	910		28.2	
	3		5:00 pm		3.4	850	7.0	28.0	3.5
					3.4	850		28.0	
					3.1	850		28.0	
	4		4:50 pm		2.8	790	7.0	28.2	4.5
					2.7	790		28.1	
					2.6	790		28.1	

Date	Station	Depth	Time	Discharge	D.O. (mg/L)	Conductivity (µmhos/cm)	pH	T°(C)	S.D.(ft)
6-25-82 (cont)	5		4:45 pm	154 ft^3/sec	2.9	790	7.1	28.3	4.5
					2.7	790		28.2	
					2.7	790		28.2	
-	6		4:40 pm		2.8	790	7.1	28.1	4.5
					2.7	790		28.1	
					2.7	790		28.1	

Comments: Raining. Pumps turned on at 5:45 p.m. 6-24-82 - only one pump on and one outlet pipe discharging. Upstream flow was 4.4 ft^3/sec on both 6-24 and 6-25. Downstream flow was 133 ft^3/sec on 6-24 and 154 ft^3/sec on 6-25 ($\bar{x}$ = 144 ft^3/sec).

Pump discharge ≈ 140 ft^3/sec.

Background water sample taken at station 7 prior to pumping. Heavy rain on sampling days and previous days.

Location: Bulldozer Canal (BDZ)

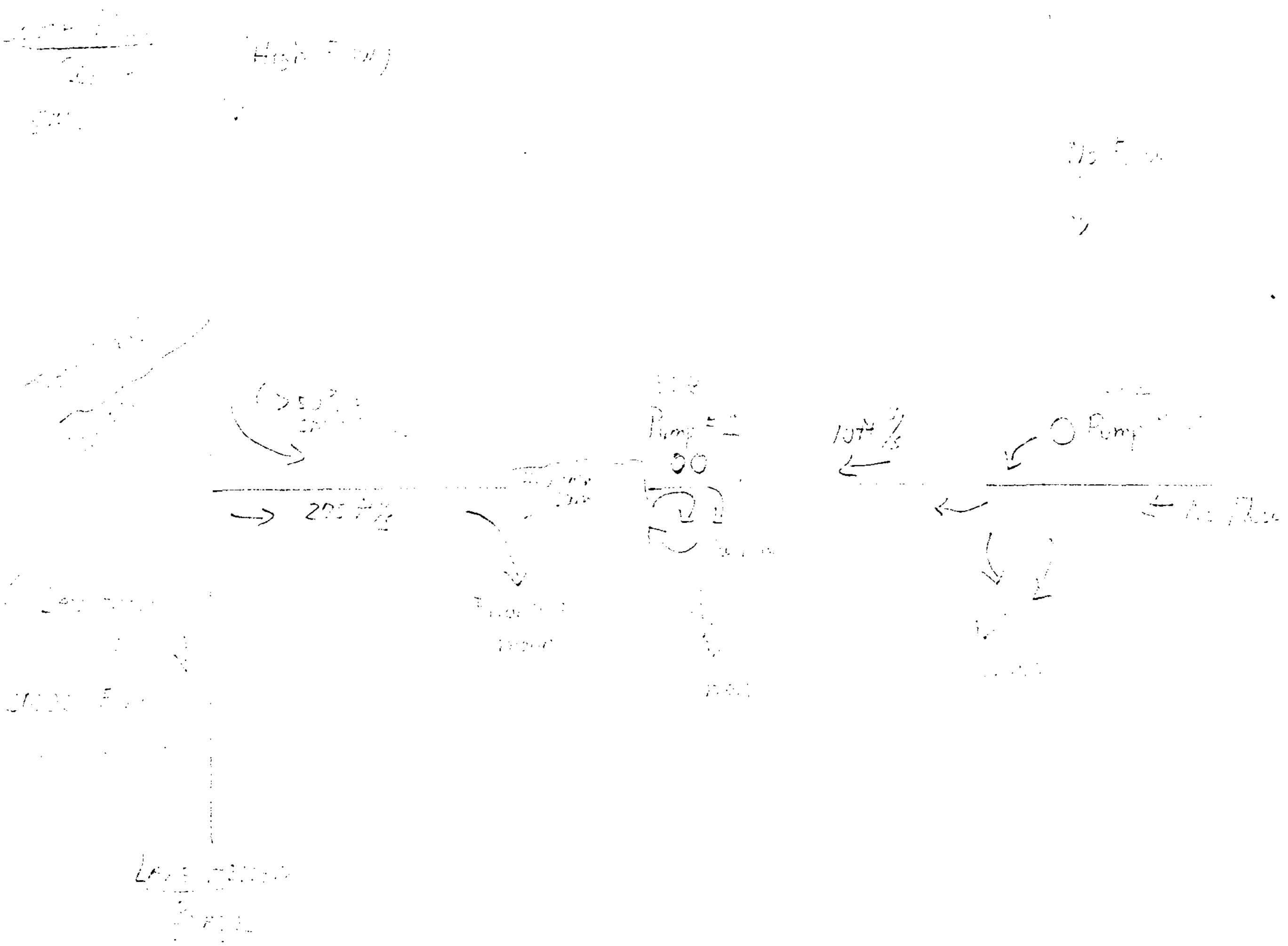
Date: 7/12/82

Station	Depth ft	Time	Discharge ft/sec	DO (mg/L)	Cond. (µmhos/cm)	pH	T^{o}C	SD ft.
24	6.4	4:00 P.M.	none	0.9 S	290	6.95	31.1	2.5
				0.7 1m			29.4	
				0.4 2m			28.7	
22	9.0	4:25	--	1.4 S	650	7.1	30.1	1.5
				1.1 1m			30.1	
21	6.0	4:40	10 ft^3/sec East	1.2 S	600	7.1	30.4	2.0
				0.9 1m			30.4	
19	5.5	5:05 P.M.		4.2 S	290	6.65	31.2	2.0
				4.0 1m			31.2	
18	3.5	4:50 P.M.		4.3 S	290	6.65	31.3	2.0
17	6.5	5:20		0.7 S	440	6.56	30.4	2.0
				0.5 1m			30.5	1.5
16	6.6	6:00 P.M.	275 ft^3/sec West	0.4 S	450	6.65	30.7	1.5
				0.2 1m			30.4	
13	6.5	6:30 P.M.	Flow meter broke	0.7 S	440	6.7	31.6	1.5
			High flow	0.3 1m			31.5	

Comments:

Received call from Vicki at SJRWMD that both BDZ pumps on (1:30 P.M.). Got to pump #2 at 4:00 P.M. No flow in upstream canals (Station 23 & 24). Pump #2 pumping at high rate. Pump cover ½ open. Flow traveling from pump #2 east, but entering northern marsh as diffuse flow. Only discharge of 10 ft^3/sec measured in BDZ canal at Station 21. Both pumps at BDZ #1 pump running. Significant output. Covers ½ open. Heavy white foam covering area and flow swirling in circular motion in canal. Most of pump output entering marsh on north side of canal. (Did not go east into South Mormon canal). In fact, significant westerly flow in BDZ canal (275 ft^3/sec) was measured at site 16. Most of South Mormon flow was entering Bulldozer canal

(BDZ) and flowing west until reaching a dense water hyacinth jam, before going into northern marsh (see diagram). Three Forks did not appear to be flowing into South Mormon Canal. Flow meter broke while making flow measurements on Mormon Canal, consequently we do not know the magnitude of this flow (although it was high).



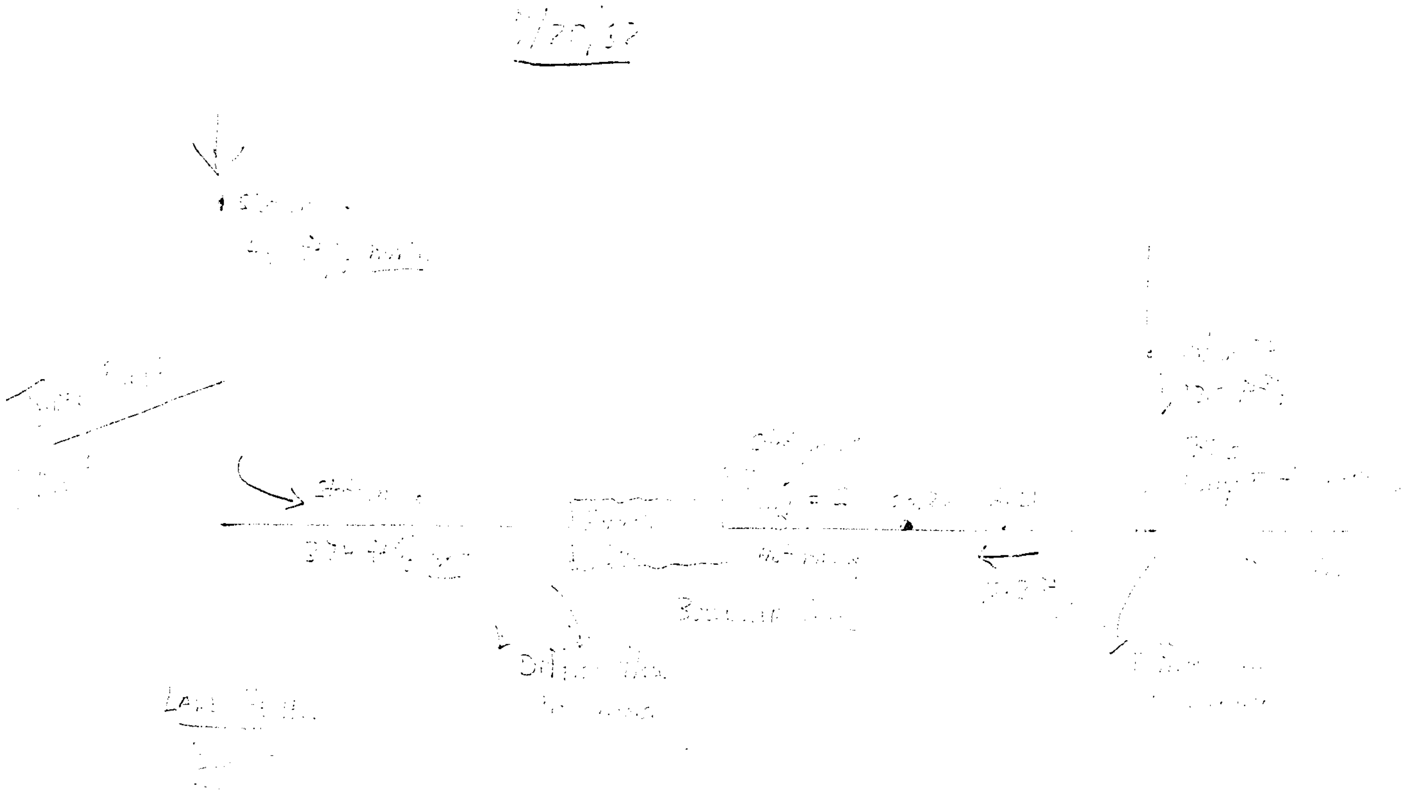
7/12/82

Measurements made during high water conditions on 6/18/82 and 7/12/82 indicate a large percentage of the South Mormon Canal flow enters BDZ canal and flows west and then into the north marsh area.

Location: Bulldozer Canal

Date: 7/20/82

Station	Depth ft	Time	Discharge ft^3/sec	DO mg/L	Cond. (μmhos/cm)	pH	T°C	SD ft.
o. Mormon 13	7.0	10:30 A.M.	481 ft^3/sec	0.3 surf	450	6.73	29.0 surf	2.0
				0.1 1m			28.9 1m	
stream 24	6.0	10:55 A.M.	12.5 ft^3/sec	0.8 surf	305 surf	6.76	29.3	1.7
				0.5 1m	320 1m		28.7	
t pump 22	6.0	11:10 A.M.		1.0 surf	750	6.86	28.2	2.0
250 down 21	6.5	11:30 A.M.	18.2 ft^3/sec	1.1 surf	720	7.3	28.7	2.5
				0.8 1m	720		28.4	
				0.7 2m	720		28.2	
20	--	12:00 P.M.		1.2 surf	380	6.4	29.4 surf	1.5
				0.8 1m	380		28.1 1m	
16	6.5	12:30 P.M.	374 ft^3/sec	0.4	470	6.7	29.0	1.5
				0.2			28.9	



Note: Three Forks not flowing. Pump #2 running, definite odor present. Pumps #1 not on. 78% of South Mormon flow entering Bulldozer canal and then flowing north into marsh. Some of discharge from Pump #2 enters marsh to north. See diagram. Only small discharge (∿ 6 ft^3/sec) flowing east from Pump #2.

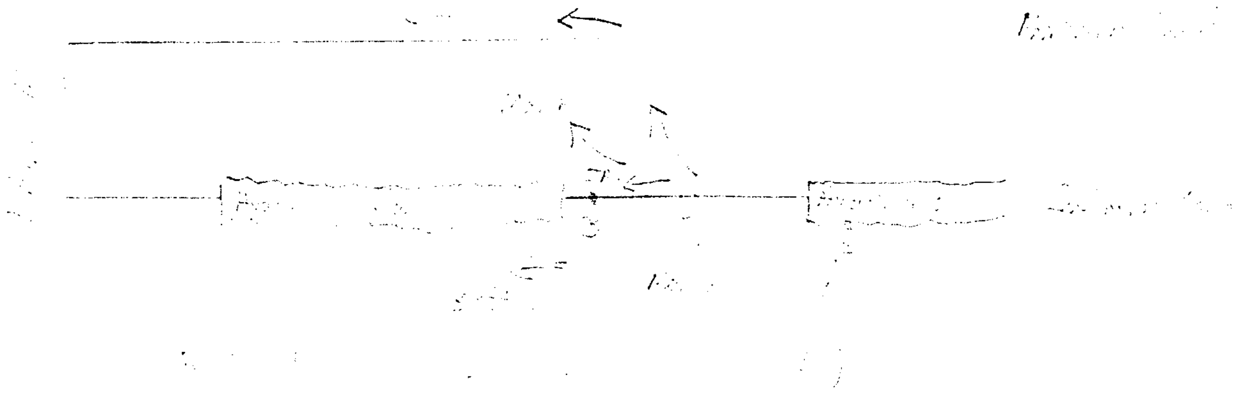
Location: Mary A

Date: 7/22/82

	Station	Depth ft	Time	Discharge ft^3/sec	DO (mg/L)	Cond. (µmhos/cm)	pH	T°C	SD ft
p tream	A	6.5'	3:30 P.M.	No flow	4.9 S	600	7.03	32.7	1.0'
					4.6 1m	600		31.8	
t Pump	P	9.0'	3:45	2 of 3 pumps on	5.2 S	600	7.22	33.0	5.0"
					5.2 1m	600		33.0	
					5.0 2m	600		33.0	
50 down	B	8.5 in hyacinths soft bottom	4:15 P.M.	*$33\ ft^3/sec$ 16,850 gal/min	5.1 S	600	6.7	32.9	5"
					4.7 1m			32.8	
					2.2 2m			27.3	
t lat. M	E		4:45	very high discharge!	1.4 S	550	6.62	30.7	1.5'
					1.5 1m			30.8	
t confl. f lat. M -54	G		5:15	--	Sample taken No field meas. storm coming in.				

Comments:

Mary A pumps on. White foam. Some of flow could be crossing marsh and entering northern canal - (we couldn't tell, although it didn't appear to be occurring)* Therefore, our discharge measurment may be an underestimate. Very high productivity in area. (hyacinths and duckweed). Water very turbid! Wind shifting directions constantly. Very high flow in Lateral M canal.(2 of 3 pumps on. Discharge probably 40,000-80,000 gpm).



Location: Bulldozer Canal

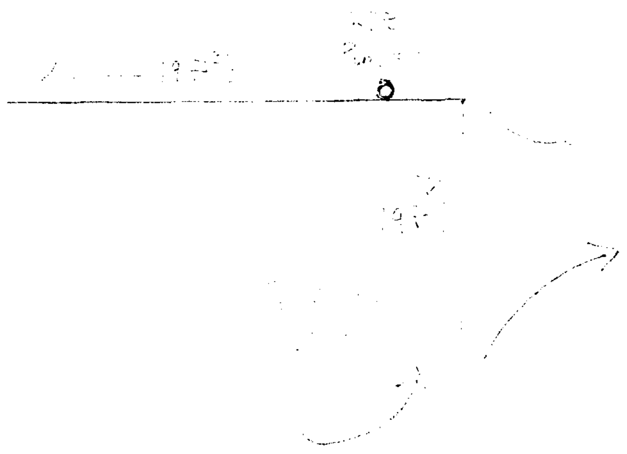
Date: 8/3/82

	Station	Depth ft	Time	Discharge ft^3/sec	DO (mg/L)	Cond. (μmhos/cm)	pH	T°C	SD ft
	24	7.0'	11:30	19 ft^3/s	0.6S	210	6.65	30.0	2.0'
				South	0.3 1m	350		29.7	
A Pump	22*	9'	11:05 A.M.	--	0.7S	800	7.03	28.8	3'
					0.6 1m	800		28.8	
					0.5 2m	800		28.8	
25 Down	21	7.5'		19 fr^3/s	0.9S	600	7.03	30.0	3'
					0.5 1m	650		29.3	
	15	6.5'		--	0.2S	430	6.83	30.2	2'
					0.1 1m	430		30.2	

*Measured pump output at least 38 ft^3/sec

Comments:

Pump #2 on. Low flow of water out of pipe. Flow in lateral canal south, due to wind some of pumpage into marsh. Most of South Mormon flow entering BDZ, from south.



Location: Mary A Pump

Date: 8/12/82

	Station	Depth ft	Time	Discharge ft³/sec	DO (mg/L)		Cond. (µmhos/cm)	pH	T°C	SD ft.
: Pump	P		12:15 P.M.	--	1.5	S	320	6.61	26.9	8"
					1.2	1m	340		27.2	
					1.2	2m			26.9	
	G	8'			1.2	S	260	6.57	27.0	1'
	In north canal				.5	1m	345		26.2	
) down	H In north canal	9.5'		80 ft^3/s	0.8	S	290	6.26	27.6	1.7'
					0.5	1m	280		26.7	
					0.2	2m	280		26.1	
	F	>16'			1.3	S	345	6.25	28.4	1.5'
					1.1	1m	345		28.3	
					1.0	2m	345		28.3	
5 upstream n lateral M	D			236 ft^3/sec	1.7	S	300	6.56	28.3	1.5'
					1.6	1m	300		28.3	

Comments:

All pumps on. Pumps running previous day and night. Looked like running at capacity. Pumping off flooded corn field. Swirling foam.

8/13/82 Checked pumps at Zigzag - Flat tire - Didn't appear to be on.

Location: Zigzag canal

Date: 8/16/82

Station	Depth ft	Time	Discharge ft^3/sec	DO (mg/L)		Cond. (µmhos/cm)	pH	T°C	SD ft.
at bend 6	9.5'	1:00 P.M.	--	0.8	S	500	7.0	28.0	3.0
				0.6	1m	500		27.9	
				0.5	2m	500		27.8	
5	9.5			1.5	S	500	7.05	28.2	2.0
				0.8	1m	550		27.8	
				0.7	2m	550		27.4	
3 (500 down)	9.5'	--	182 ft^3/sec	2.1	S	550	7.03	29.2	2.3
				1.2	1m	610		27.6	
				0.5	2m	650		27.2	
				0.4	3m			27.0	
1 (at pump)	13.0'	--		1.6	S	810	7.37	29.4	3.0
				1.4	1m	820		28.4	
				1.3	2m	820		28.3	
0 (250 up)	7.0'	--	~3 ft^3/sec	1.4	S	600	7.36	28.5	3.0
				0.6	1m	610		27.2	
				0.3	2m	610		26.7	

Comments:

Wind from East, sunny, partly cloudy. Only one pump running, west pipe. upstream flow - negligible.

Location: Bulldozer

Date: 8/31/82

Station	Depth ft	Time	Discharge ft^3/sec	DO (mg/L)	Cond. (µmhos/cm)	pH	T°C	SD ft
24	7'	∿1:30 P.M.		1.0	265 S	6.54	27.9	2.5
				0.4	300 1m		27.4	
					510 2m			
22	—				580			
20	5.75		Flow is west	1.2	385 S	6.73	27.3	2.5
				0.5	460 1m		27.2	
					510 2m			
16	6.5		317 ft^3/s (west)		310 S			
13	7.8		538 ft^3/sec		315 S			
14	6.0		12.8 ft^3/sec		305 S			

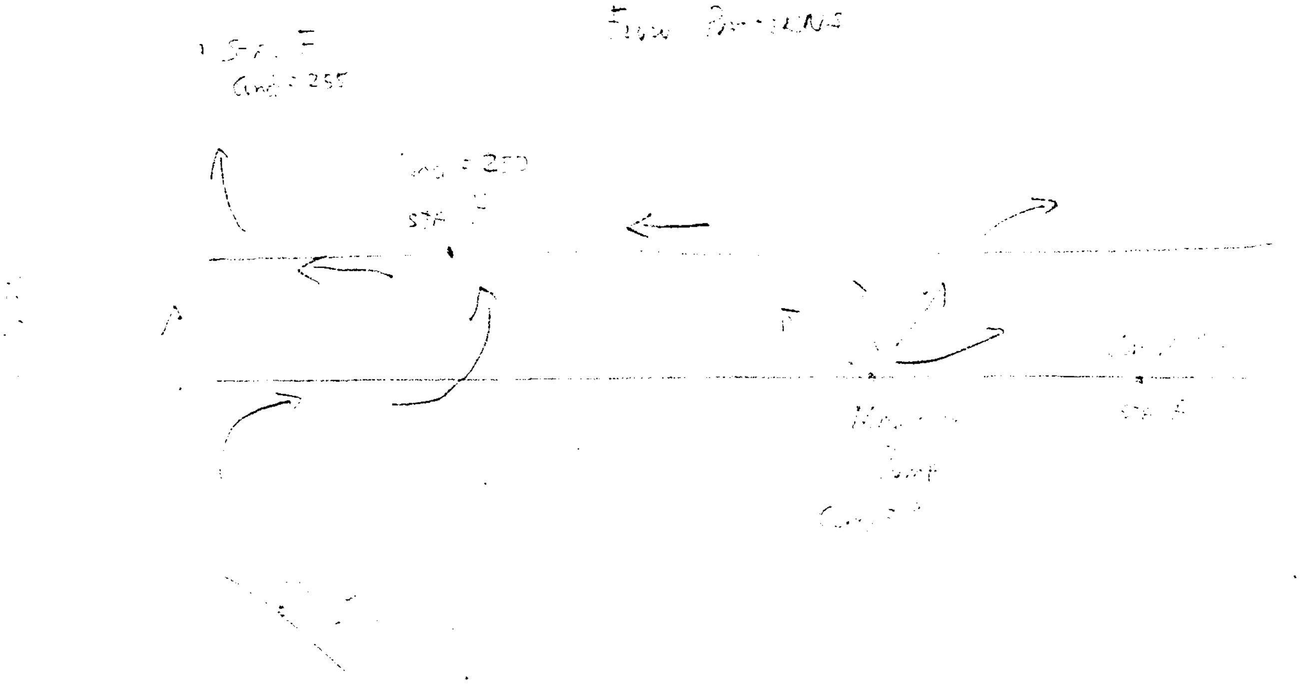
Comments:

Total discharge south of entrance to BDZ is 538 ft^3/sec + 13 ft^3/s from 3 Forks = 551 ft^3/s. Of that 317 ft^3/s flowed west into BDZ canal. Evidence of spray in canal. Took marsh sample ½ mile north of BDZ #1 pump. Difficult to tell where flow from #2 pump is going as 500 m downstream - no flow. Appears to be entering marsh. Also, was very slight flow to south at station 24.

Location: Mary A

Date: 9/1/82

Station	Depth ft	Time
Pump	N'	~11:00 A.M.



Comments:

No field measurements taken due to impending rainstrom. Center pump was on. Both canals packed with hyacinths Hyacinths at pump also. Sampled at A, pump, H, F & D. Upstream site not representative as reflects pumpage water. Pumpage water backing up to east, some filtering intonorthern canal and flowing west into lateral M. Large portion at lateral M flow entering Mary A canal to the east for a short distance and then filtering into northern canal and flowing west into later M canal. Conductivities reflect that. See diagram.

Location: Duda - pump not on

Date: 9/3/82

Station	Depth ft	Time	Discharge ft^3/sec	DO (mg/L)	Cond. (μmhos/cm)	pH	T°C	SD ft
42	11.0	1:00 P.M.	--	0.6	430	6.63	27.1	2.5'
pump				0.4	435		27.0	
				0.3	440		27.0	
					440			

Comments:

Visable flow to east. Took background water sample.

Location: Lake Washington

Date: 8/26/82

			Condition		
	Station	Discharge	South	North	Stage
t weir	33*	--	320 S	390 S	16.22
	30*	1818 ft^3/sec	330/m	390/m	

Samples taken.

APPENDIX B

Three Forks Canal, Bulldozer Canal, South Mormon Outside Canal and Lake Washington Inlet and Outlet Discharge and Concentration Data.

Table B-1. Water Quality and discharge data for Three Forks Canal.

SITE	DATE	DISCHARGE ft^3/S				TN	TKN	NH_4-N	NO_3-NO_2 as N	TP	Suspended Solids mg/L				VSS mg/L			FSS mg/L			$\bar{x}$ Cond.
		N	C	S	Total	mg/L	mg/L	mg/L	mg/L	mg/L	N	C	S	$\bar{x}$	N	C	S	N	C	S	µmhmo/cm
3F	9/15/81	3.8	31.0	18.1	53						4.4	3.2	3.2	3.6	2.2	1.9	1.8	2.2	1.3	1.4	
3F	9/23/81	8.7	64.8	13.1	87						6.2	6.8	6.6	6.5	3.5	3.2	2.2	2.7	3.6	4.2	
3F	10/8/81	8.0	55.0	35.0	98						4.0	3.3	3.3	3.5	1.7	2.2	2.1	2.3	1.1	1.2	
3F	12/17/81	0.0	-	28.0	28				0.41	0.07	1.3	-	0.3	0.8							
3F	1/20/82	14.9	-	23.6	39	2.7	2.4		0.29	0.08	10.1	-	10.4	10.3	4.1	-	4.2	6.0	-	6.2	
3F	2/22/82	31.8	-	42.8	75	2.5	2.2		0.38	0.08	1.9	-	2.0	2.0	1.0	-	0.9	0.9	-	1.1	900
3F	3/10/82	33.9	-	48.0	82	2.1	2.0		0.11	0.05	3.0	-	3.2	3.1	1.8	-	1.6	1.2	-	1.6	730
3F	3/31/ 82	58.0	-	48.6	107	2.4	2.3		0.12	0.14	3.3	-	3.2	3.3	2.1	-	2.2	1.2	-	1.0	780
3F	4/22/82	49.0	-	30.3	79	2.1	2.0		0.06	0.15	1.9	-	1.9	1.9	1.2	-	1.2	0.7	-	0.7	730
3F	5/13/82	33.4	-	38.5	72	2.3	2.3	0.0	<0.02	0.07	2.1	-	2.6	2.3	1.4	-	1.6	0.7	-	1.0	725
3F	5/26/82	18.7	-	37.6	56	1.5	1.5	0.03	0.04	0.08	1.5	-	1.8	1.7	0.9	-	0.7	0.6	-	1.1	700
3F	8/31/82	13.0	-	0.0	13	2.6	2.6	0.11	<0.02	0.11	2.0	-	4.8	3.4	0.8	-	0.8	1.2	-	4.0	305

Table B-2.Water Quality and Discharge data for Bulldozer Canal.

SITE	DATE	DISCHARGE ft^3/S				TN	TKN	NH_4-N	NO_3-NO_2 as N	TP	Suspended Solids mg/L				VSS mg/L			FSS mg/L			$\bar{x}$ Cond.
		N	C	S	Total	mg/L	mg/L	mg/L	mg/L	mg/L	N	C	S	$\bar{x}$	N	C	S	N	C	S	µmhmo/cm
BDZ	12/17/81	4.5	2.0	0.0	7				<0.02	0.01	0.4	0.7	6.7*	0.6							
BDZ	1/20/82	3.9	0.0	0.0	4	0.8	0.8		<0.02	0.01	1.4	1.9	1.8	1.7	0.8	1.2	0.8	0.6	0.7	1.0	
BDZ	2/22/82	0.0	0.0	0.0	0	0.9	0.9		<0.02	0.05	4.8	1.7	2.3	2.9	2.5	0.6	0.9	2.3	1.1	1.4	870
BDZ	3/10/82	0.0	0.0	0.0	0	0.8	0.7		0.11	0.01	2.5	2.4	1.4	2.1	1.4	1.6	0.9	1.1	0.8	0.5	975
BDZ	3/31/82	6.8	0.0	0.0	7	0.8	0.8		0.02	<0.01	2.0	1.4	2.5	2.0	1.3	0.9	1.6	0.7	0.5	0.9	900
BDZ	4/22/82	0.5	1.4	0.0	2	1.1	1.1		0.01	<0.01	1.3	1.5	1.4	1.4	0.9	1.2	0.7	0.4	0.3	0.7	925
BDZ	5/13/82	0.0	-	0.0	0	1.2	1.2		<0.02	0.07	3.5	-	4.0	3.8	2.0	-	2.1	1.5	-	1.9	990
BDZ	5/26/82	0.0	-	0.0	0	0.8	0.8	0.03	<0.02	0.04	1.4	-	1.5	1.5	0.3	-	0.4	1.1	-	1.1	1190
BDZ	8/2/82	120.5	-	183.4	304	3.2	3.2	0.21	<0.02	0.16	4.4	-	8.3	6.4	1.6	-	1.7	2.8	-	6.6	445
BDZ	8/3/82	-	317.0	-	317	2.2	2.2	0.20	0.02	0.09	-	3.4	-	3.4	-	0.8	-	-	2.6	-	310

water quality and discharge data for South Mormon Outside Canal.

		DISCHARGE ft^3/S				TN	TKN	NH_4-N	NO_3-NO_2 as N	TP	Suspended Solids mg/L				VSS mg/L			FSS mg/L			$\bar{x}$ Cond.
SITE	DATE	E	C	W	Total	mg/L	mg/L	mg/L	mg/L	mg/L	E	C	W	$\bar{x}$	E	C	W	E	C	W	µmhmo/cm
M.O.	9/15/81	5.6	11.4	6.6	24	-	-	-	-	-	4.7	4.2	3.8	4.2	3.0	3.0	2.1	1.7	1.2	1.7	-
M.O.	9/23/81	5.4	17.7	9.1	32						2.3	1.9	2.1	2.1	1.5	1.4	1.3	0.8	0.5	0.8	
M.O.	12/17/81	1.4	15.1	0.0	17				0.18	0.02	0	0	0	0	0	0	0	0	0	0	
M.O.	1/20/82	0.0	4.8	2.0	6.8	1.3	0.9	-	0.35	0.04	7.2	2.7	2.2	4.0	3.4	1.3	0.9	3.8	1.4	1.3	
M.O.	2/22/82	0	0	0	0	1.8	1.6	-	0.23	0.11	1.8	3.7	3.1	2.9	0.8	1.7	1.4	1.0	2.0	1.7	1000
M.O.	3/10/82	5.3	18.8	7.8	32	1.3	1.0	-	0.25	0.04	2.3	1.5	3.1	2.3	1.4	1.1	1.5	0.9	0.4	1.6	1095
M.O.	3/31/82	10.3	20.9	16.5	48	1.3	1.2	-	0.06	0.07	4.4	2.2	3.7	3.4	3.1	1.7	2.5	1.3	0.5	1.2	1090
M.O.	4/22/82	0.0	6.8	2.9	9.7	1.9	1.8	-	0.15	0.31	2.9	2.9	2.0	2.6	2.0	2.4	1.8	0.9	0.5	0.2	880
M.O.	5/13/82	0.0	5.5	0.0	5.5	3.0	3.0	-	<0.02	0.10	3.2	2.6	2.8	2.9	2.0	1.4	1.6	1.2	1.2	1.2	965
M.O.	5/26/82	0.0	3.1	0.0	3.1	2.4	2.4	0.03	<0.02	0.08	1.6	2.2	1.9	1.9	0.7	1.0	0.8	0.9	1.2	1.1	1440
M.O.	6/24/82	53.6	130.0	92.2	276	3.4	3.4	0.25	<0.02	0.45	26.0	27.0	25.7	26.2	16.3	13.4	14.7	9.7	12.6	11.0	520
M.O.	7/20/82	118.3	207.6	146.3	472	2.6	2.6	0.17	<0.02	0.20	6.0	6.4	6.6	6.3	1.8	1.8	1.8	4.4	4.6	4.8	450
M.O.	8/2/82	84.6	146.4	90.1	321	2.9	2.9	0.18	<0.02	0.18	4.2	5.3	4.2	4.6	1.0	1.0	1.4	3.2	4.3	2.8	425
M.O.	8/31/82	120	248	17.0	538	1.2	1.2	0.25	<0.02	0.12	2.0	2.0	2.0	2.0	0.8	0.8	0.9	1.2	1.2	1.1	315

Table B-4. Water Quality and discharge data for Lake Washington Inlet,

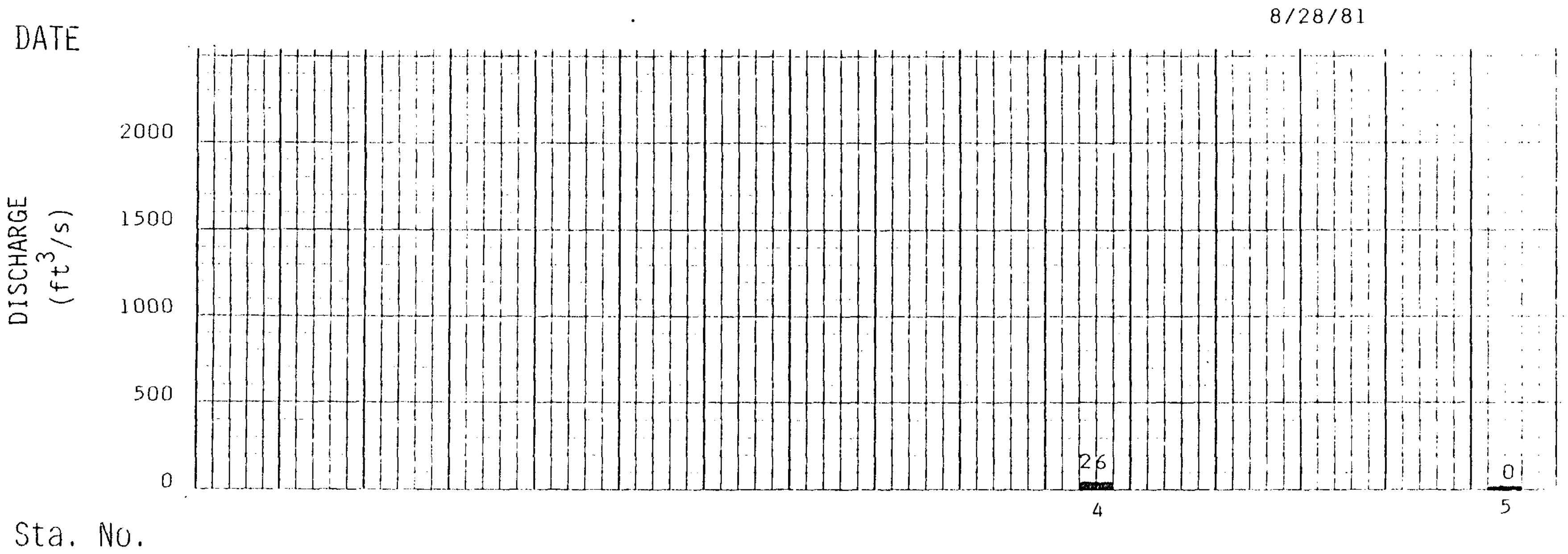
SITE	DATE	DISCHARGE ft^3/S				TN	TKN	NH$_4$-N	NO$_3$-NO$_2$ as N	TP	Suspended Solids mg/L				VSS mg/L			FSS mg/L			$\bar{x}$ Cond.
		E	C	W	Total	mg/L	mg/L	mg/L	mg/L	mg/L	E	C	W	$\bar{x}$	E	C	W	E	C	W	µmhmo/cm
IN	8/28/81	7.2	14.6	4.2	26						0.4	0.7	1.3	0.8	0.2	0.4	1.0	0.2	0.3	0.3	
IN	9/1/81	-	34.1	-	34						2.0	1.6	2.1	1.6	1.0	1.0	0.9	1.0	0.6	1.2	
IN	9/15/81	138.1	184.8	111.9	435						4.8	10.9	7.3	7.7	4.2	7.0	5.7	1.6	3.9	1.6	
IN	9/23/81	63.0	149.4	86.8	299						2.3	2.2	2.3	2.3	1.8	1.3	1.3	0.5	0.9	1.0	
IN	10/2/81	54.4	113.0	51.3	219						2.5	1.5	4.2	2.7	2.5	1.1	2.5	0.0	0.4	1.7	
IN	10/8/81	24.2	51.8	47.4	123						2.8	2.8	3.2	2.9	2.4	2.4	2.4	0.4	0.4	0.8	
IN	11/6/81	0.0	32.6	23.8	56																
IN	12/17/81	12.5	10.2	0.0	23				0.01	0.03	1.1	1.5	0.4	1.0							
IN	1/20/82	4.9	12.2	0.0	17	1.7	1.7		0.00	0.04	2.4	1.9	1.5	1.9	0.9	0.7	0.7	1.5	1.2	0.8	
IN	2/24/82	13.7	33.4	7.3	54	1.8	1.8		0.01	0.04	1.6	1.6	2.1	1.8	0.9	0.5	0.9	0.7	1.2	1.2	815
IN	3/12/82	23.7	57.4	8.7	90	1.6	1.6		0.01	0.03											880
IN	3/30/82	34.0	77.9	21.2	133	2.0	2.0		0.01	0.04	0.5	0.5	1.3	0.8	0.3	0.3	0.7	0.2	0.2	0.6	700
IN	4/22/82	0.0	137.1	10.3	147	1.8	1.8		0.02	0.05	3.0	2.5	4.3	3.3	1.2	0.7	2.4	1.8	1.8	1.9	585
IN	5/13/82	0.0	60.3	0.0	60	3.0	3.0	<0.02	<0.02	0.07	3.1	3.3	3.0	3.1	1.3	1.6	1.8	1.8	1.7	1.2	645
IN	5/26/82	26.9	24.9	16.1	68	2.4	2.4	0.07	0.03	0.06	2.3	1.9	1.6	1.9	1.6	1.3	0.9	0.7	0.6	0.7	730
IN	7/19/82	497.9	587.3	497.9	1574	2.5	2.5	0.19	<0.02	0.14	1.8	2.0	1.6	1.8	0.8	1.0	0.8	1.0	1.0	0.8	415
IN	8/4/82	681.7	714.8	577.7	1974	2.5	2.5	0.14	<0.02	0.08	3.6	4.3	6.2	4.7	1.3	1.3	2.4	2.3	3.0	3.8	380
IN	8/26/82	540	768	510	1818	1.5	1.5	0.15	0.03	0.13	2.9	3.5	4.0	3.5	0.5	0.5	0.9	2.4	3.0	3.1	340

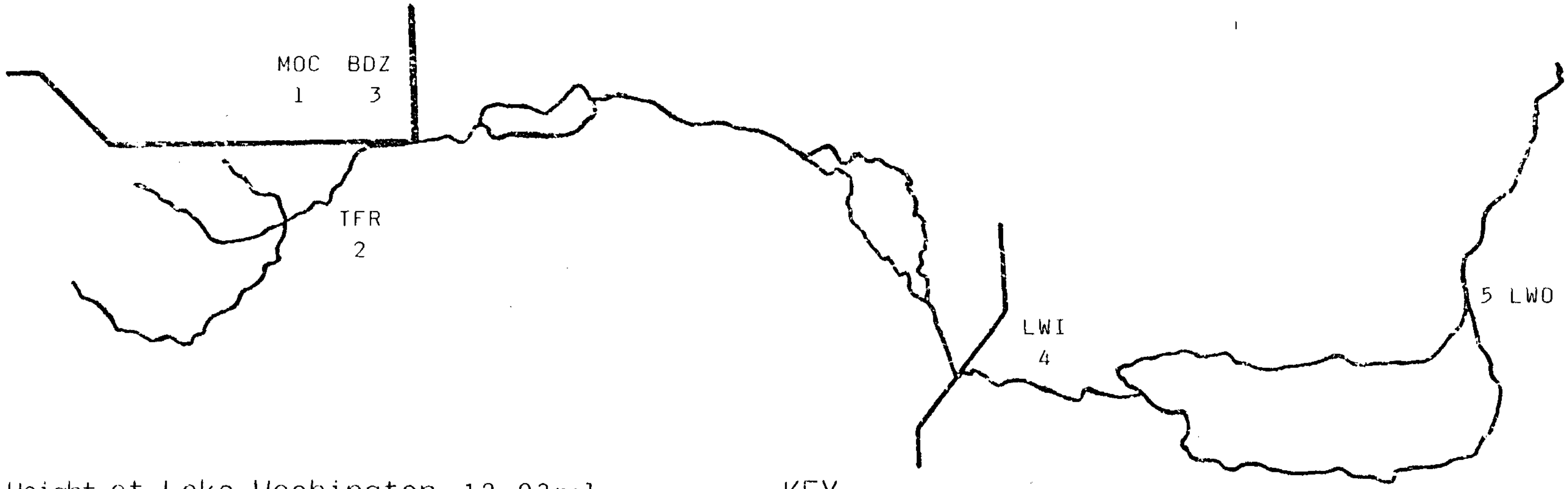
Table B-5. Water Quality and discharge data for Lake Washington Outlet.

SITE	DATE	DISCHARGE ft^3/S				TN	TKN	NH_4-N	NO_3-NO_2 as N	TP	Suspended Solids mg/L				VSS mg/L			FSS mg/L			$\bar{x}$ Cond.
		E	C	W	Total	mg/L	mg/L	mg/L	mg/L	mg/L	E	C	W	$\bar{x}$	E	C	W	E	C	W	µmhmo/cm
OUT	8/28/81				0																
OUT	9/1/81				0																
OUT	9/15/81				0																
OUT	9/23/81				277						3.8	1.6	2.3	2.6	2.2	1.5	1.3	1.6	0.1	1.0	
OUT	10/2/81				239						3.0	2.6	1.9	2.5	1.7	1.4	0.7	1.3	1.2	1.2	
OUT	10/8/81				239						2.1	2.8	2.2	2.4	1.1	1.9	1.2	1.0	0.9	1.0	
OUT	11/6/81				250																
OUT	12/17/81				129				0.23	0.05	1.3	-	1.3	1.3							
OUT	1/20/82				108	2.2	2.0		0.22	0.07	3.4	-	3.7	3.6	2.0	-	1.6	1.4	-	2.1	
OUT	2/24/82				129	2.1	2.0		0.10	0.05	1.6	-	1.7	1.7	0.9	-	0.5	0.7	-	1.2	735
OUT	3/12/82				198	1.4	1.4		0.01	0.03											815
OUT	3/30/82				198	2.0	2.0		0.03	0.06	2.5	-	2.7	2.6	2.3	-	2.5	0.2	-	0.2	805
OUT	4/22/82				376	1.6	1.6		0.02	0.04	3.0	-	3.2	3.1	1.3	-	2.2	1.7	-	1.0	845
OUT	5/13/82				305	3.8	3.8	<0.02	<0.02	0.05	3.3	-	2.5	2.9	1.4	-	1.0	1.9	-	1.5	810
OUT	5/26/82				250	2.3	2.3	0.07	0.03	0.66	2.4	-	2.5	2.5	2.0	-	1.9	0.4	-	0.6	775
OUT	7/19/82				2216	2.3	2.3	0.26	0.02	0.14	2.0	-	2.8	2.4	1.2	-	1.8	0.8	-	1.0	395
OUT	8/4/82				2533	2.6	2.6	0.25	0.03	0.09	4.0	-	3.6	3.8	1.4		0.8	2.6	-	2.8	390
OUT	8/26/82				962	1.6	1.6	0.18	<0.02	0.11	3.0	-	3.2	3.1	0.6	-	0.6	2.4	-	2.6	360

APPENDIX C

Discharge Rates

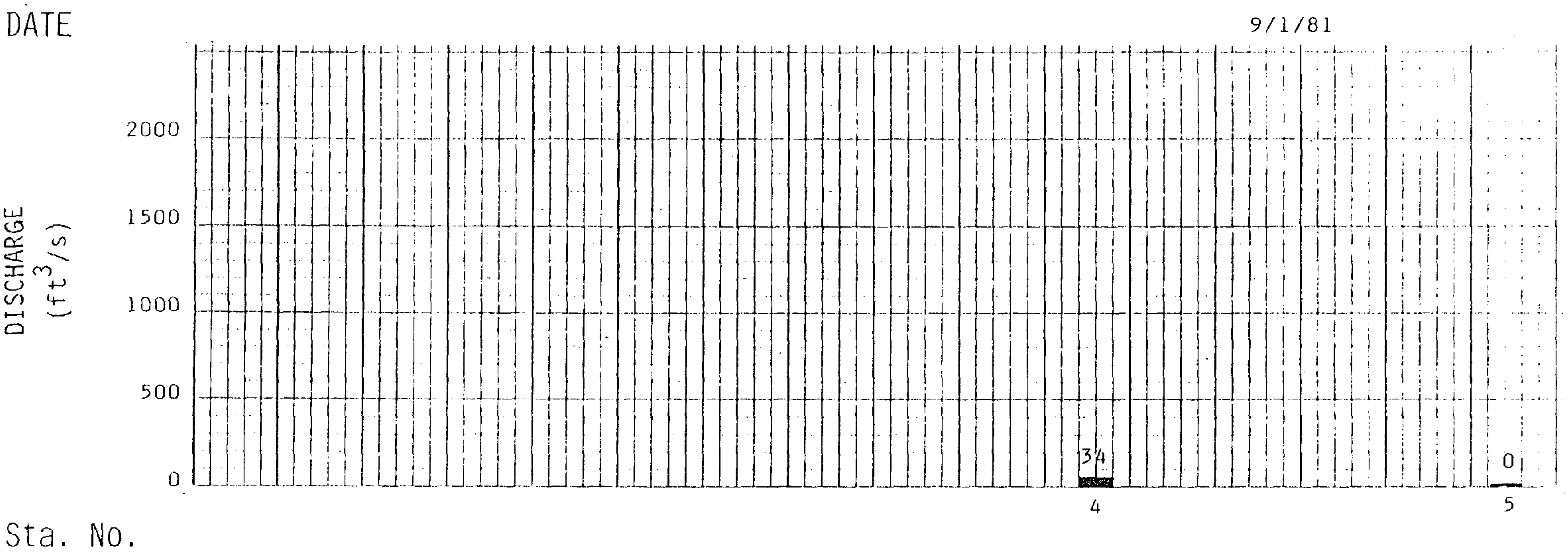


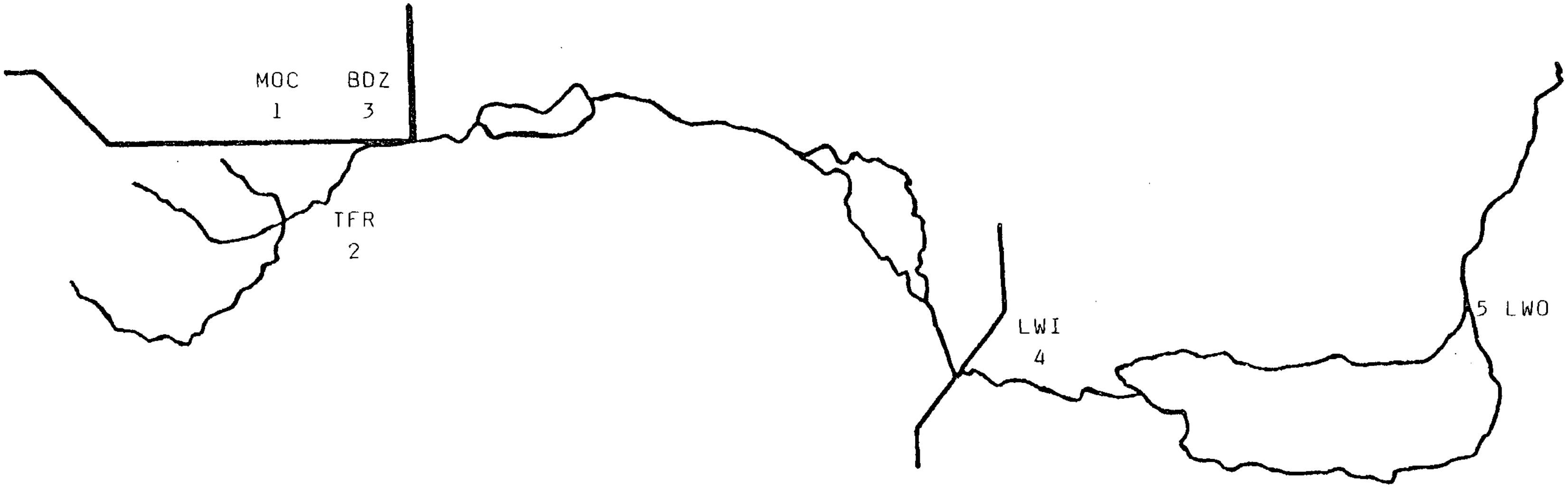


Stage Height at Lake Washington: 12.03msl.

KEY:

MOC = Mormon Outside Canal
TFR = Three Forks Run
BDZ = Bulldozer Canal
LWI = Lake Washington Inlet
LWO = Lake Washington Outlet





<u>Stage</u> <u>Height</u> <u>at</u> <u>Lake</u> <u>Washington</u>: 12.12 msl.

<u>KEY</u>:

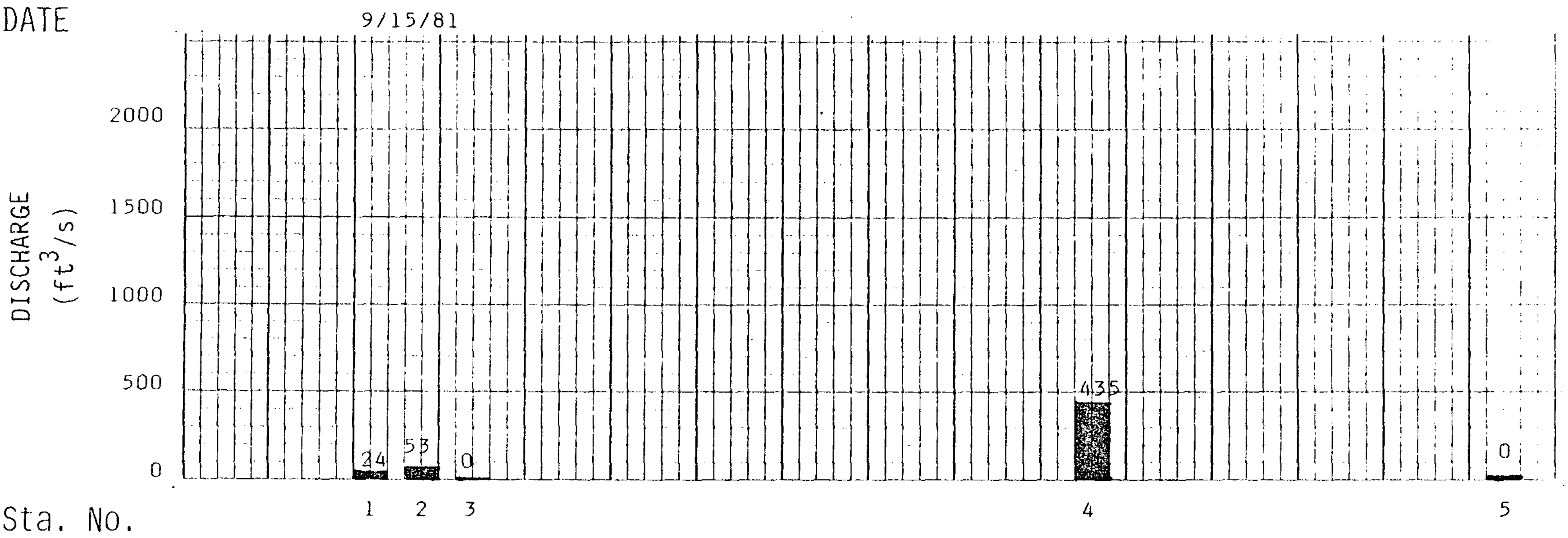
MOC = Morman Outside Canal

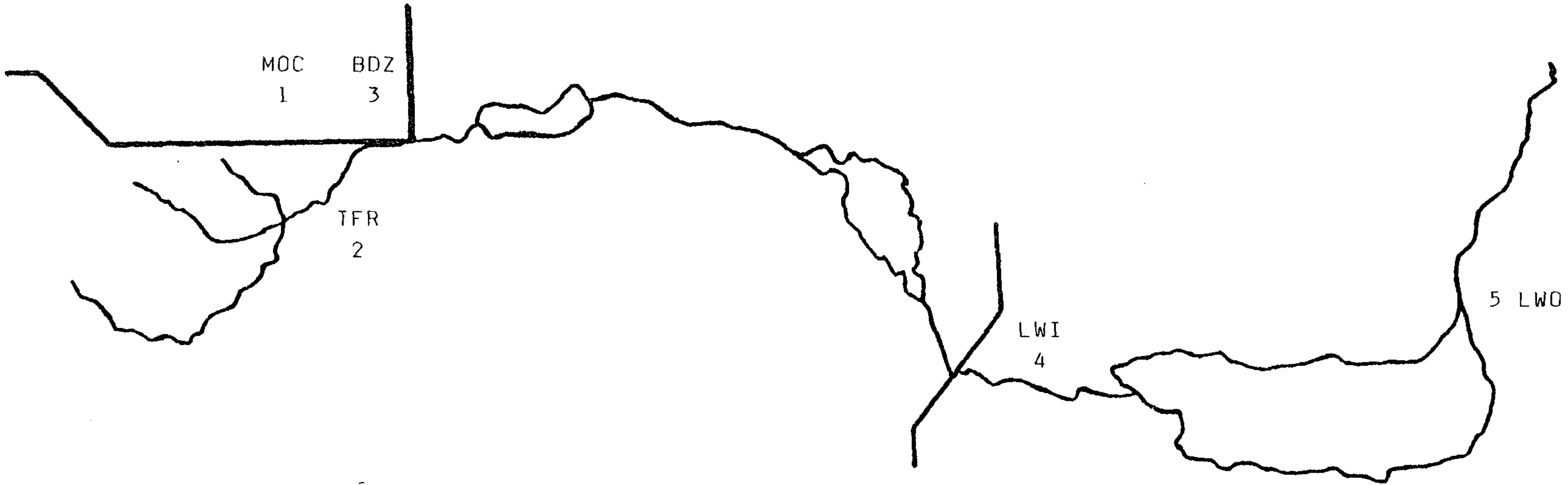
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet





Stage Height at Lake Washington: 12.99 msl.

KEY:

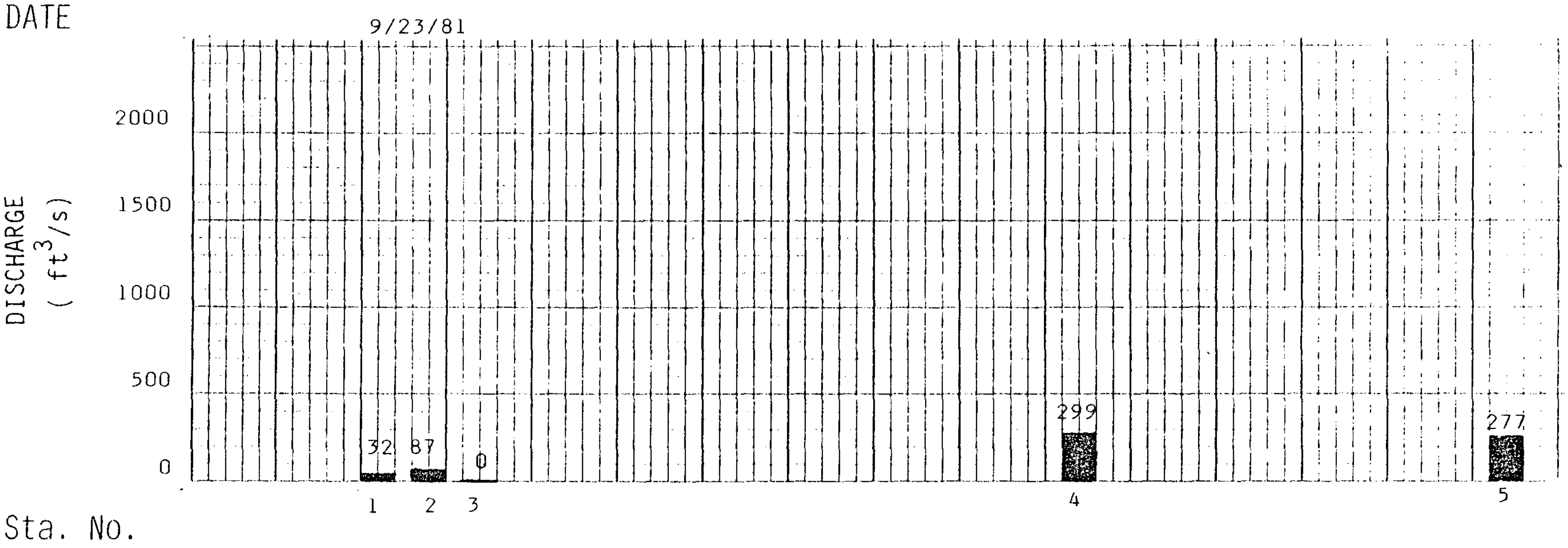
MOC = Mormon Outside Canal

TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake WAshington Outlet



Stage Height at Lake Washington: 14.10 msl.

KEY:

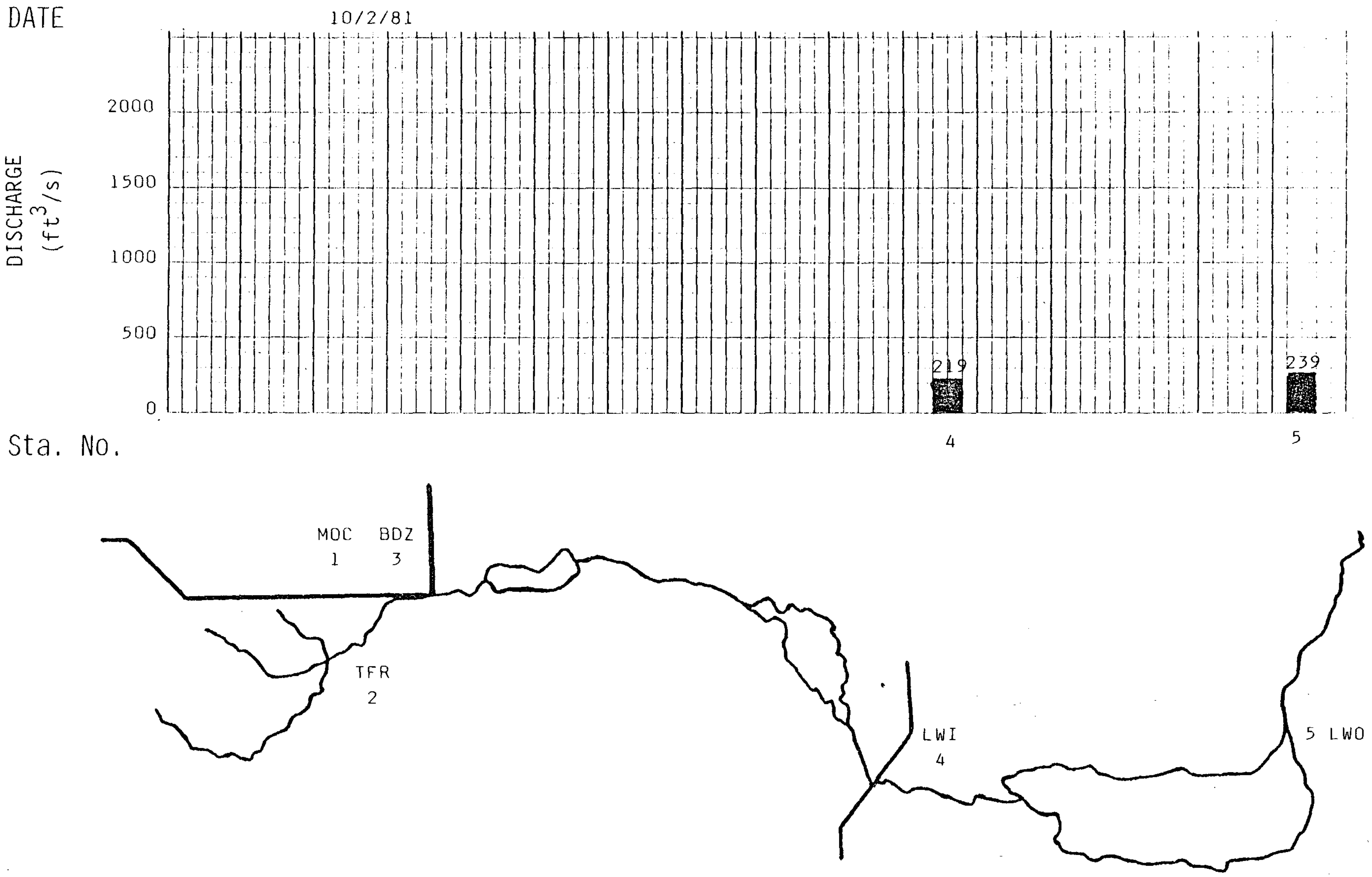
MOC = Mormon Outside Canal

TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet



Stage Height at Lake Washington: 14.13 msl.

KEY:

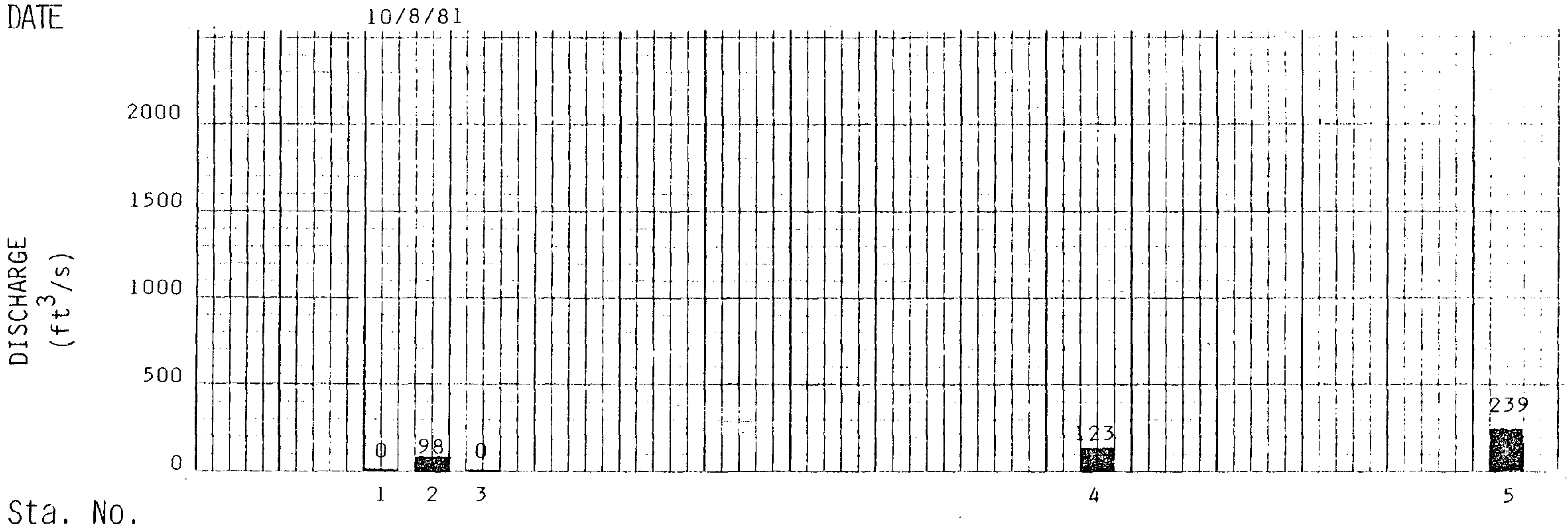
MOC = Mormon Outside Canal

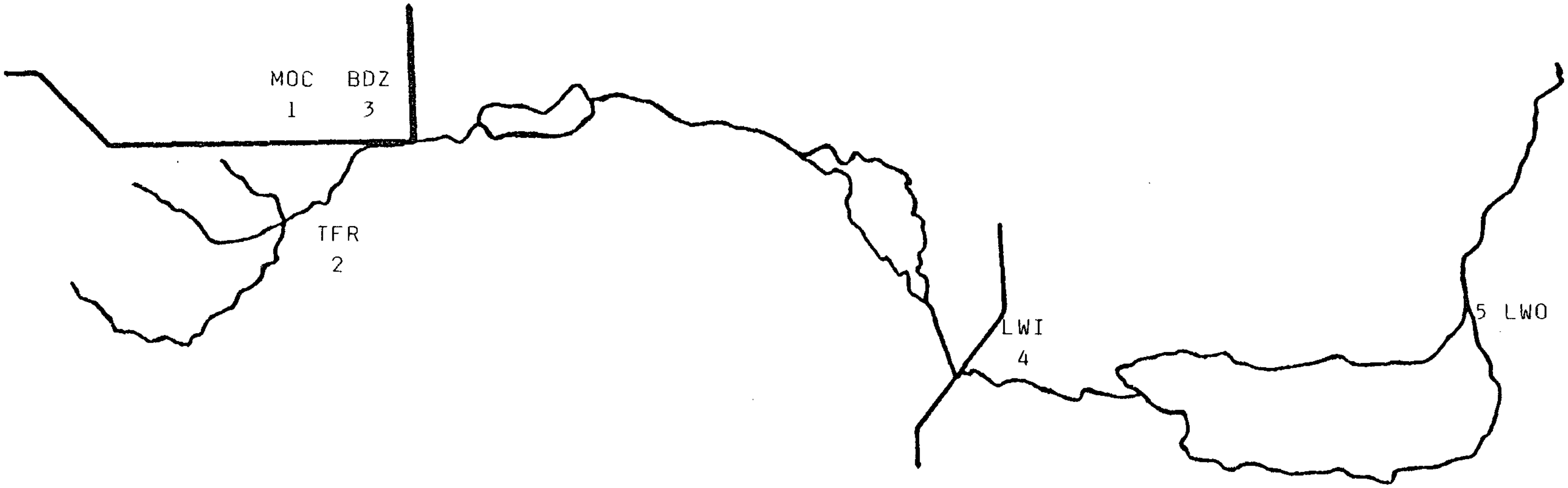
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet





Stage Height at Lake Washington: 14.06 msl.

KEY:

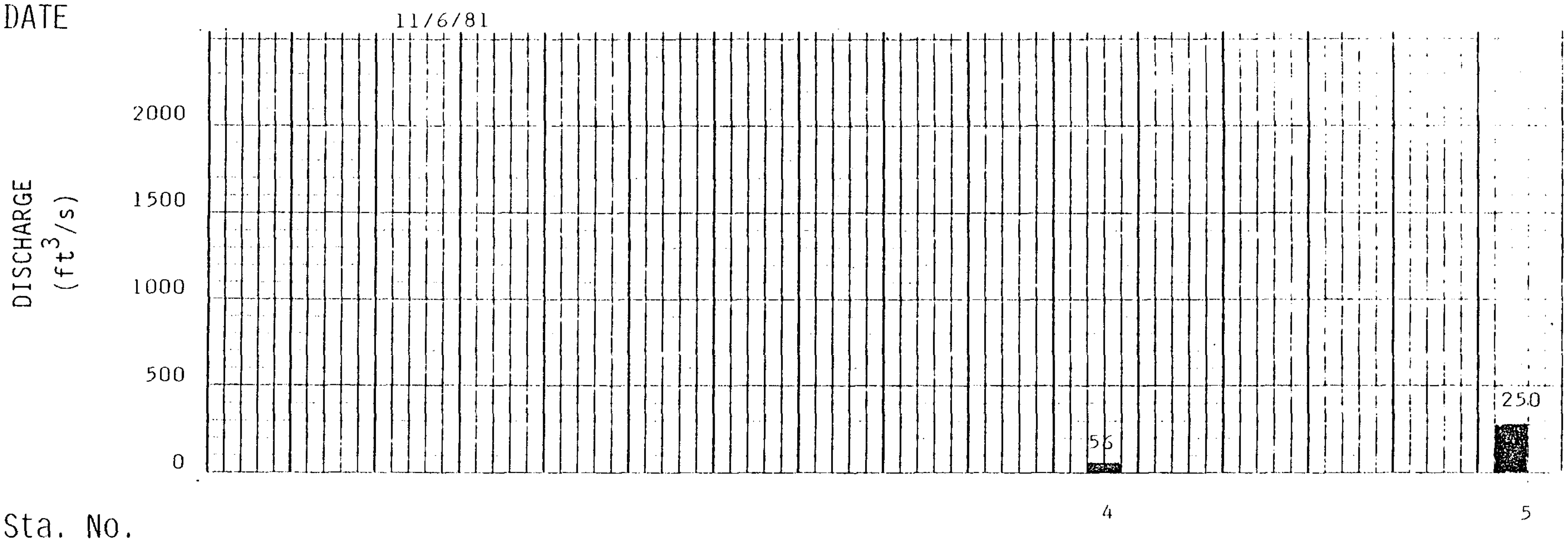
MOC = Mormon Outside Canal

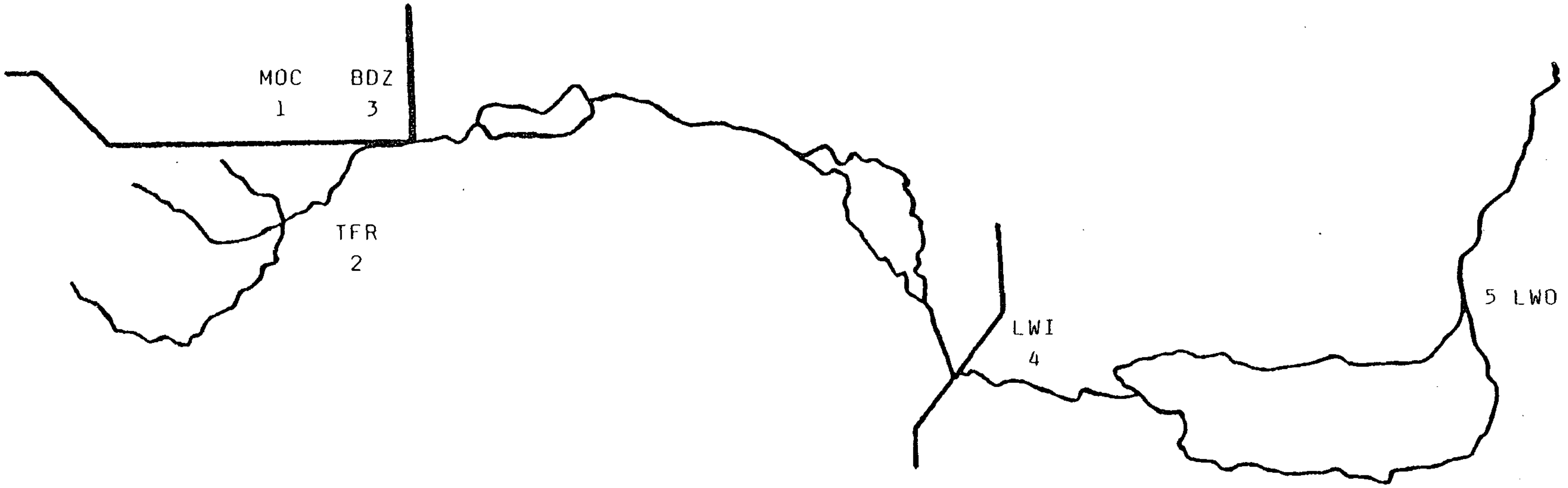
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet





Stage Height at Lake Washington: 14.13 msl.

KEY:

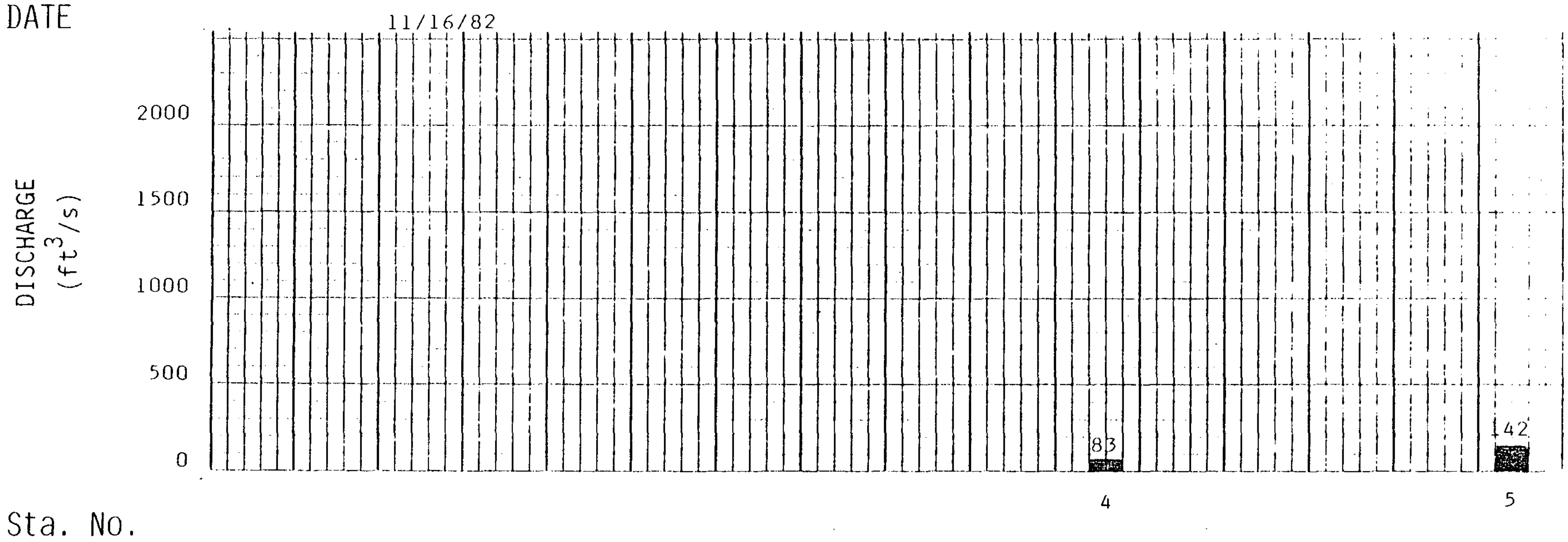
MOC = Mormon Outside Canal

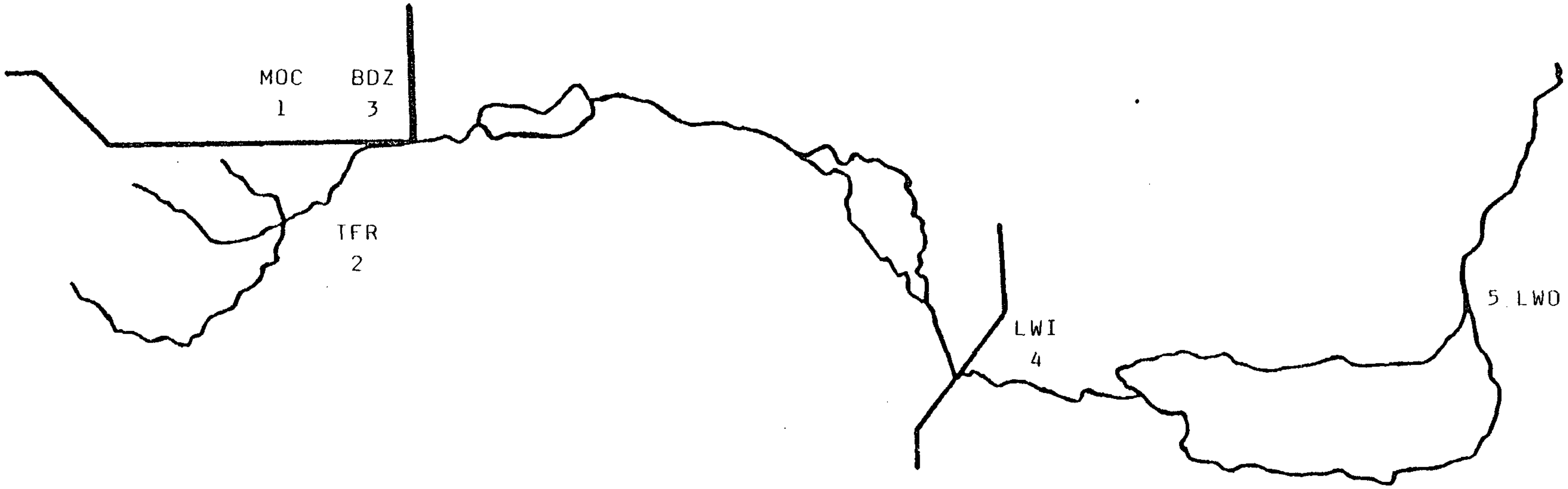
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet

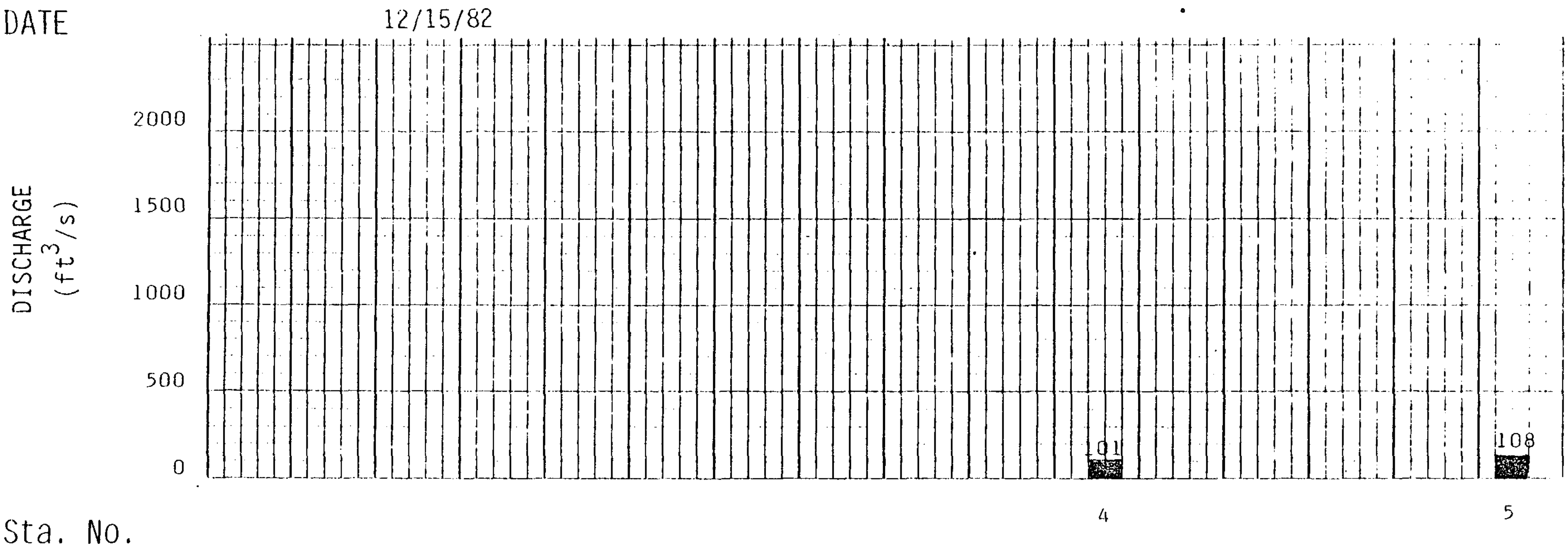


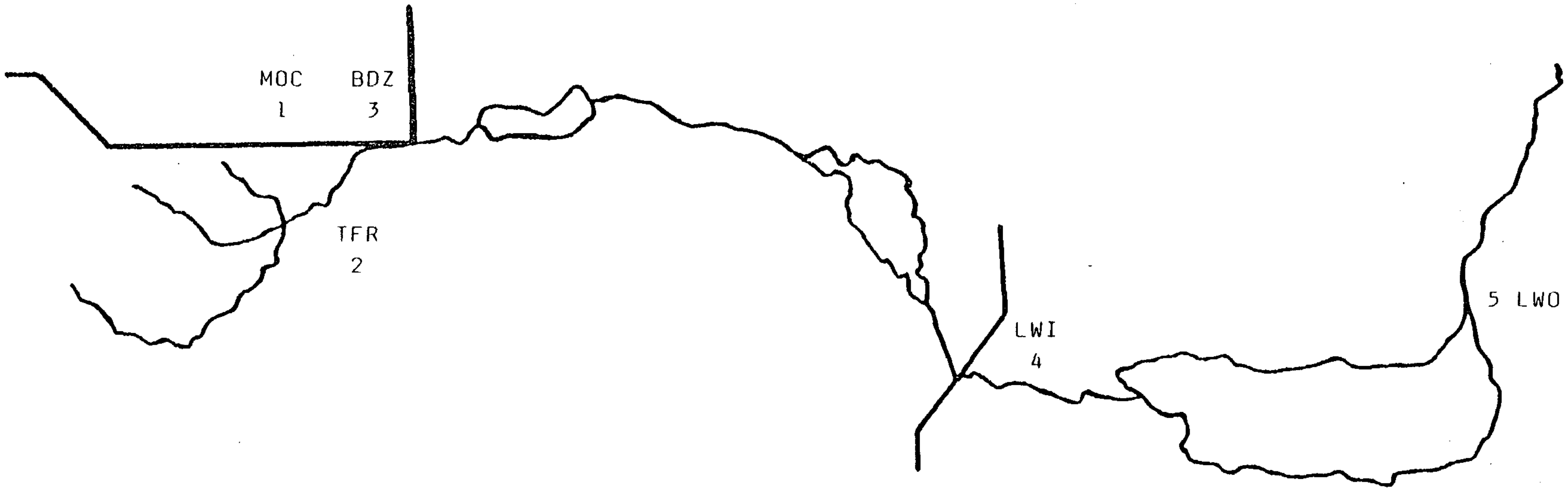


Stage Height at Lake Washington: 13.98 msl.

KEY:

MOC = Mormon Outside Canal
TFR = Three Forks Run
BDZ = Bulldozer Canal
LWI = Lake Washington Inlet
LWO = Lake Washington Outlet





Stage Height at Lake Washington: 13.80 msl.

KEY:

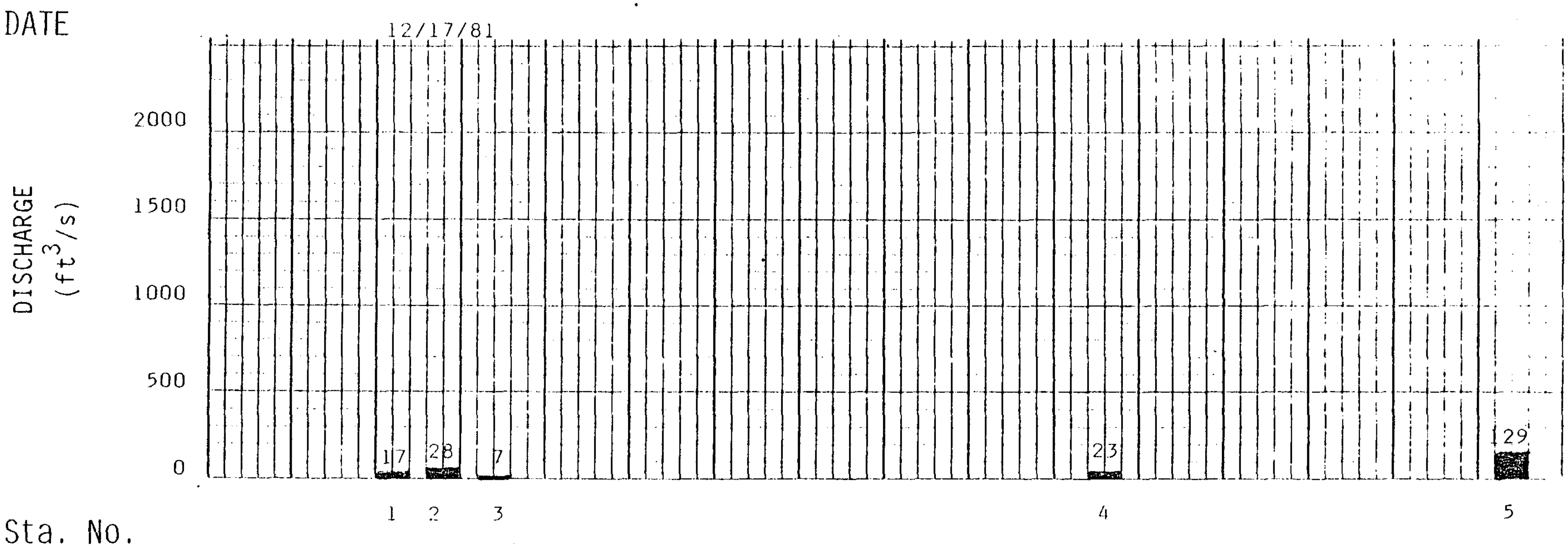
MOC = Mormon Outside Canal

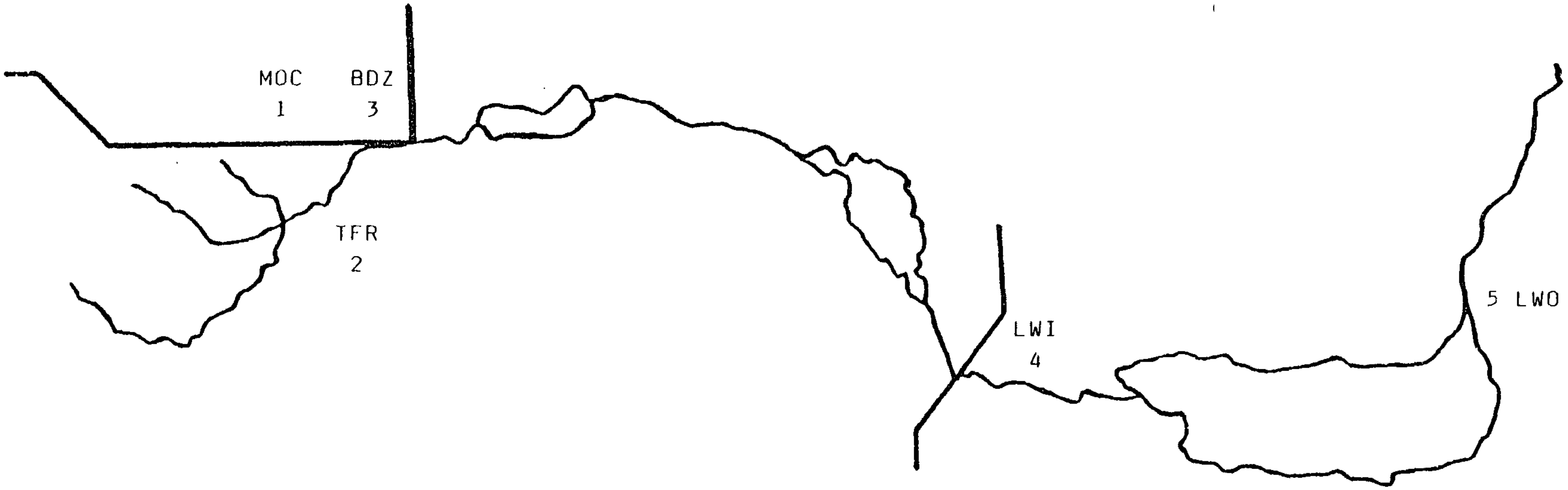
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet

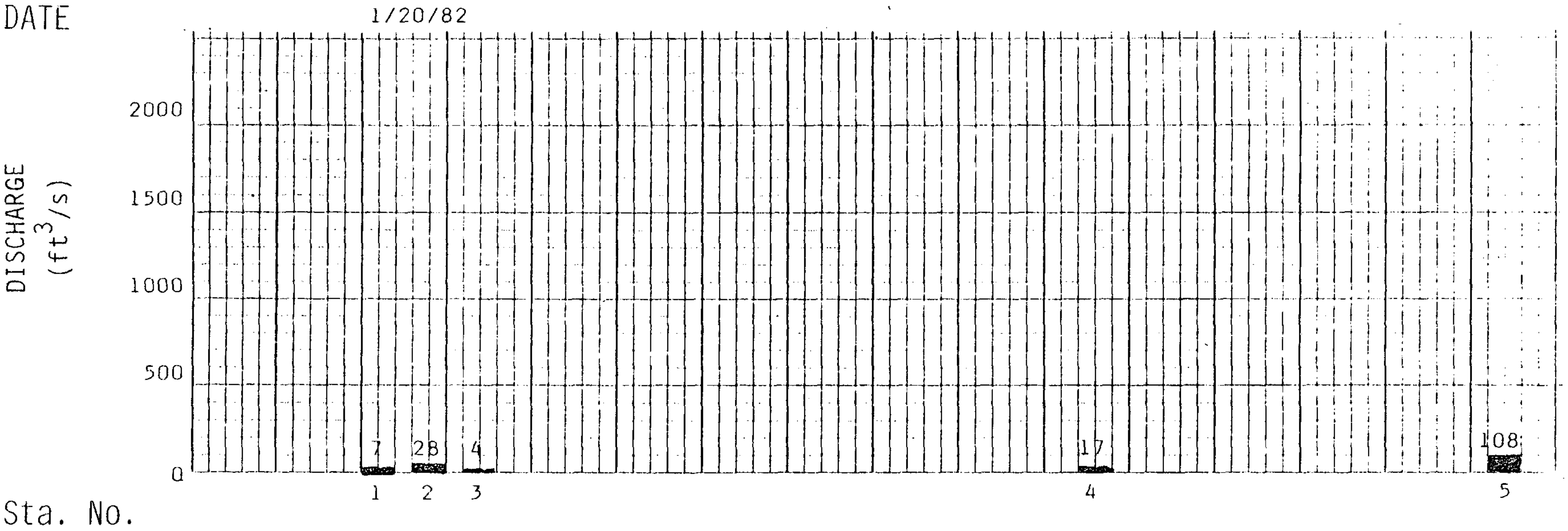


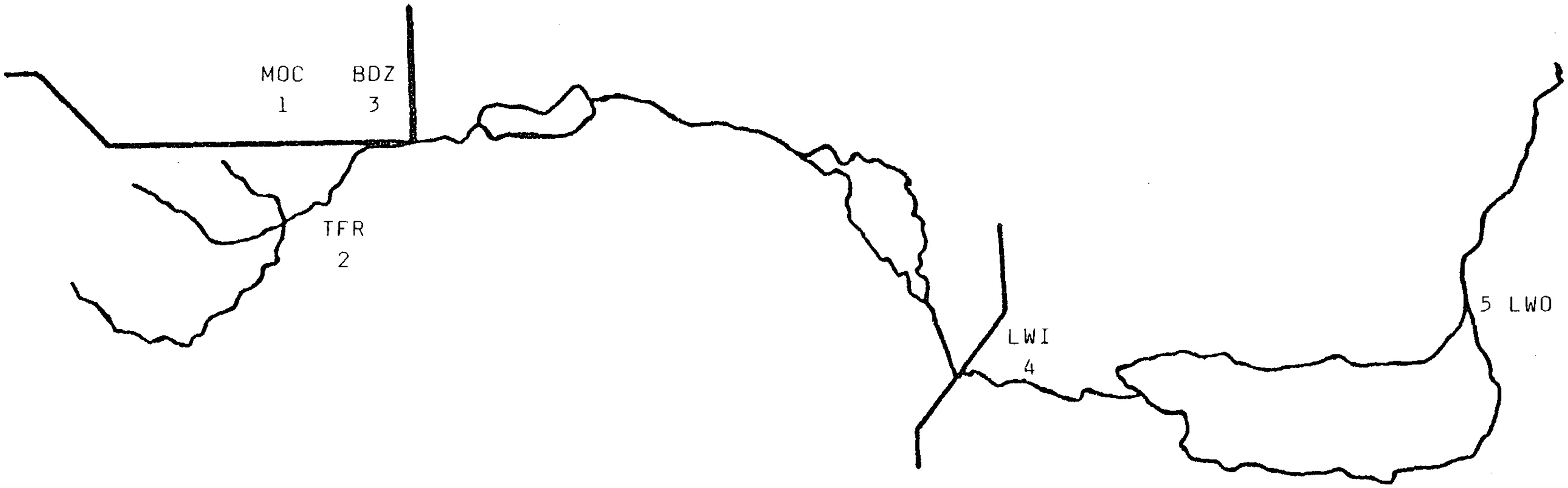


Stage Height at Lake Washington: 13.76 msl.

KEY:

MOC = Mormon Outside Canal
TFR = Three Forks Run
BDZ = Bulldozer Canal
LWI = Lake Washington Inlet
LWO = Lake Washington Outlet





Stage Height at Lake Washington: 13.75 msl.

KEY:

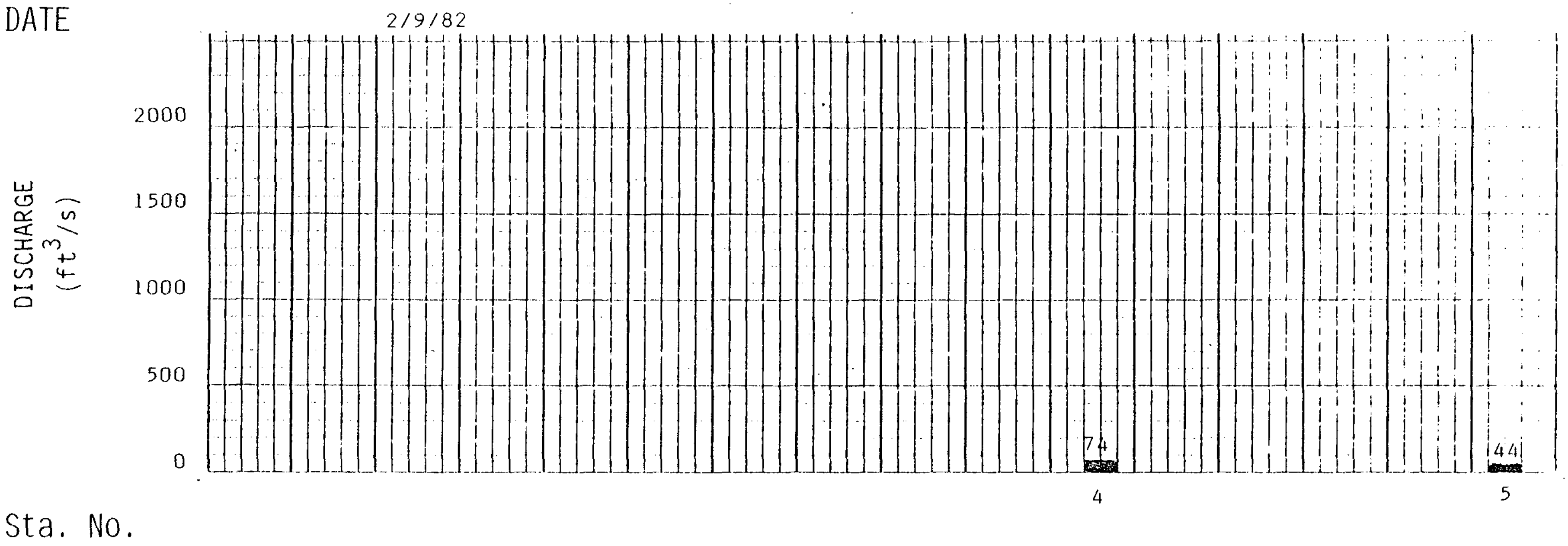
MOC = Mormon Outside Canal

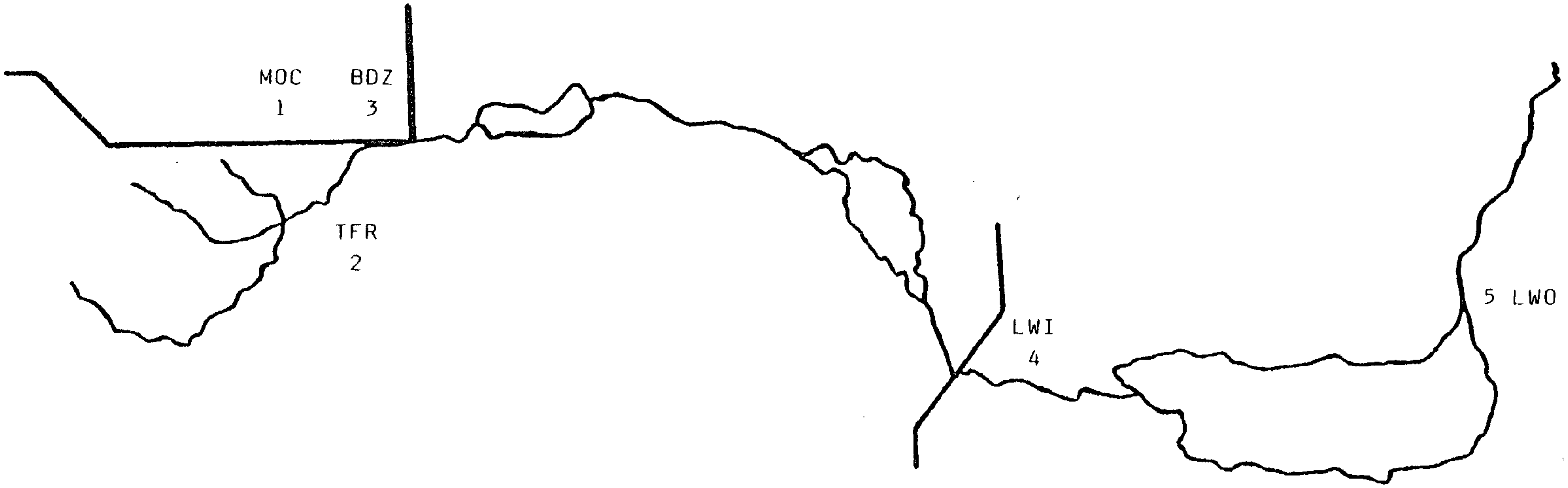
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet





Stage Height at Lake Washington: 13.72 msl.

KEY:

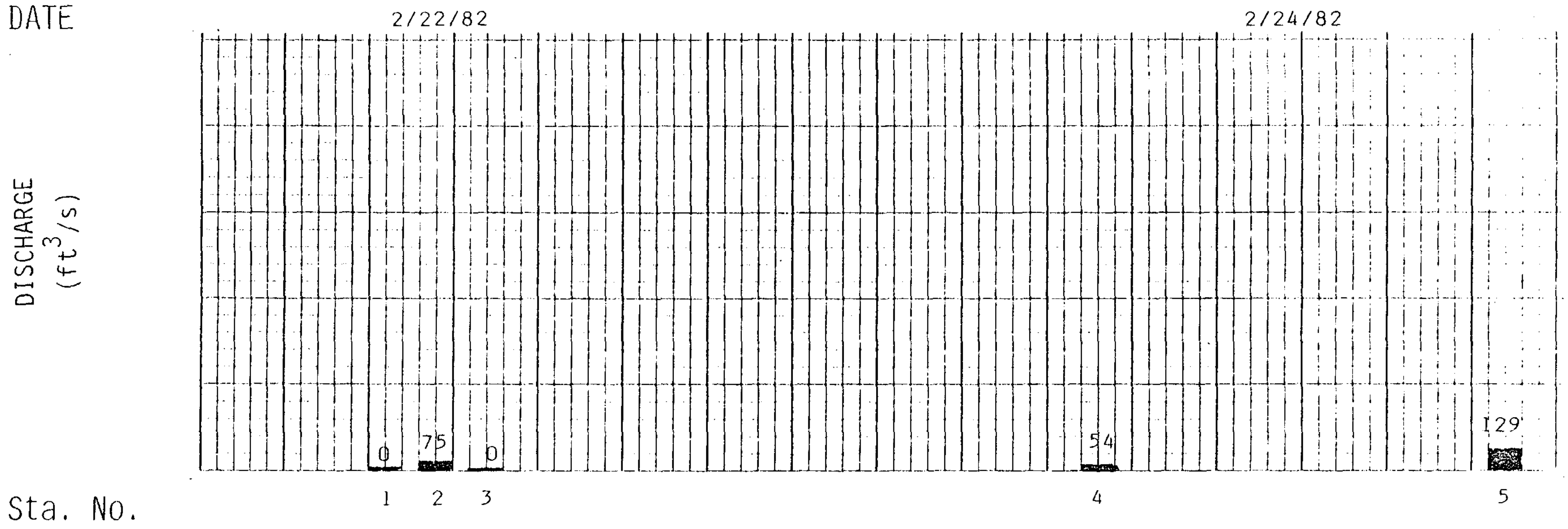
MOC = Mormon Outside Canal

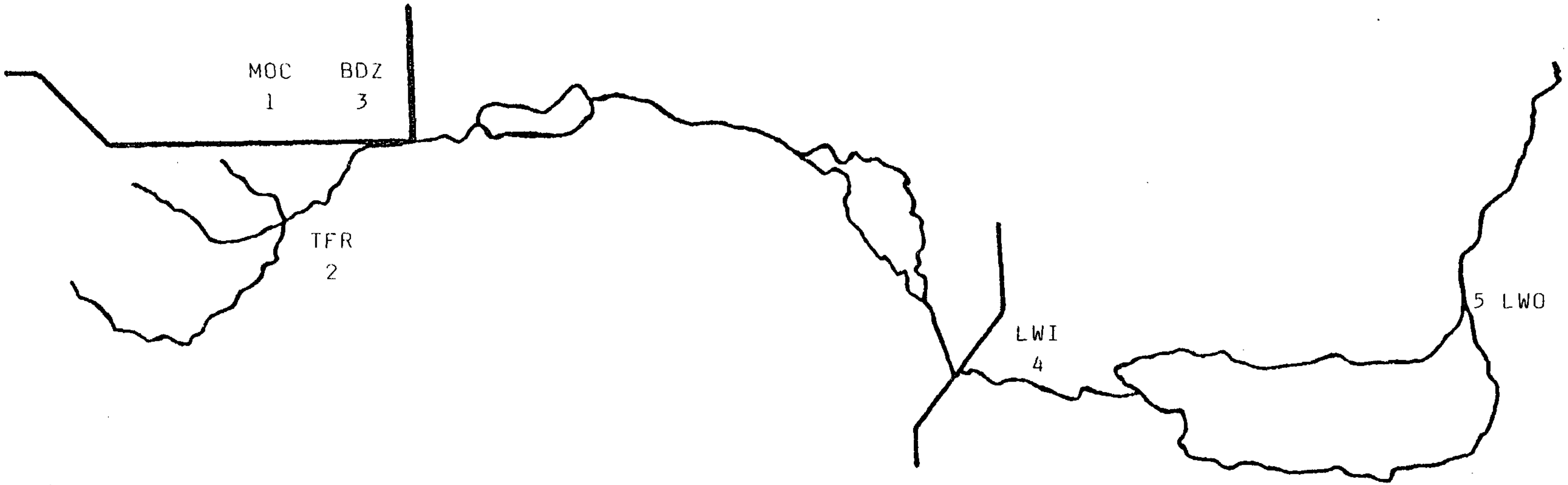
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet

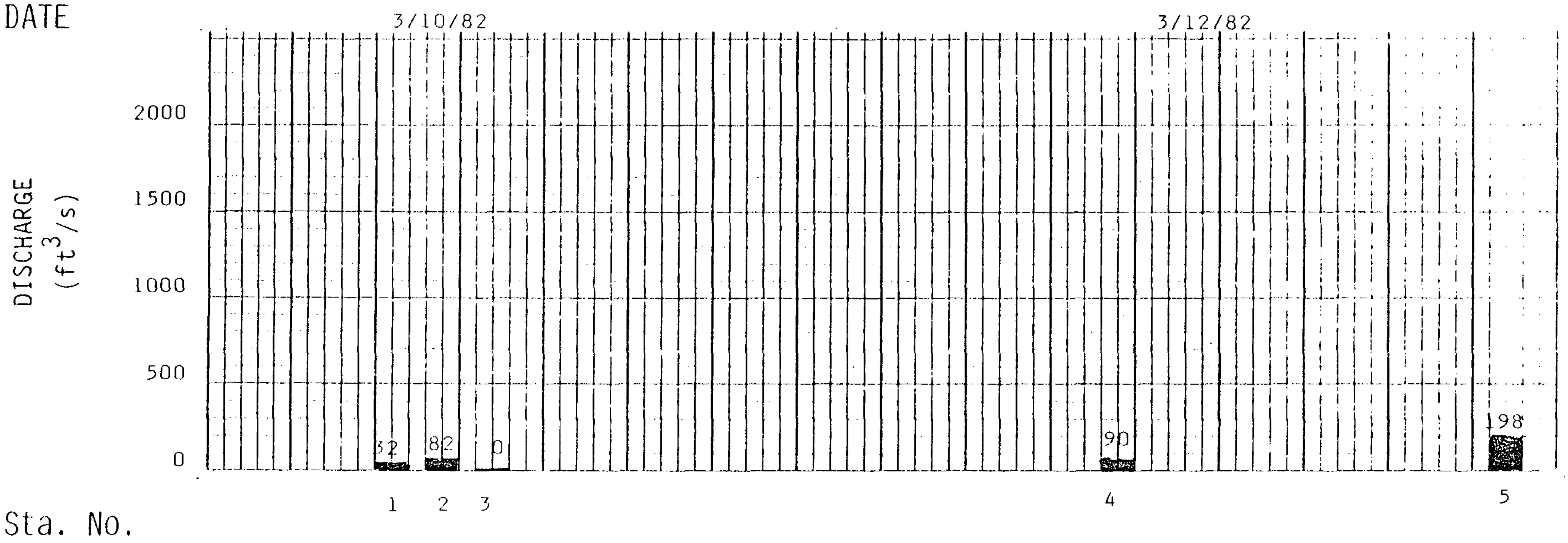


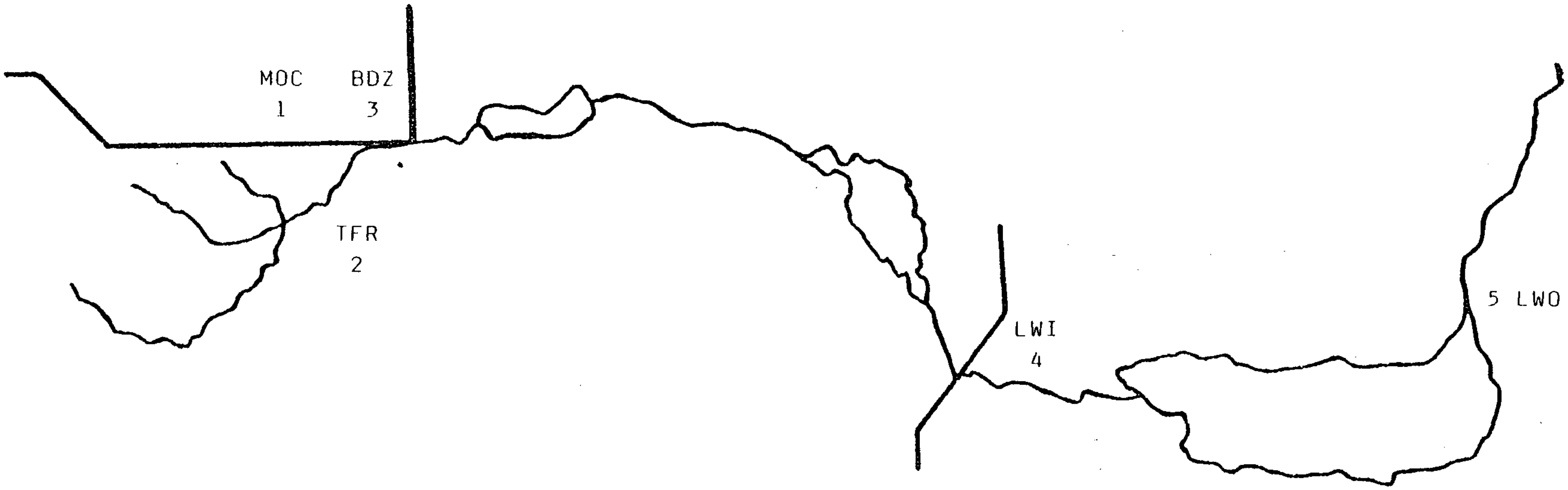


Stage Height at Lake Washington: 13.77 msl.
(2/24/82)

KEY:

MOC = Mormon Outside Canal
TFR = Three Forks Run
BDZ = Bulldozer Canal
LWI = Lake Washington Inlet
LWO = Lake Washington Outlet





Stage Height at Lake Washington: 13.85 msl.
(3/12/82)

KEY:

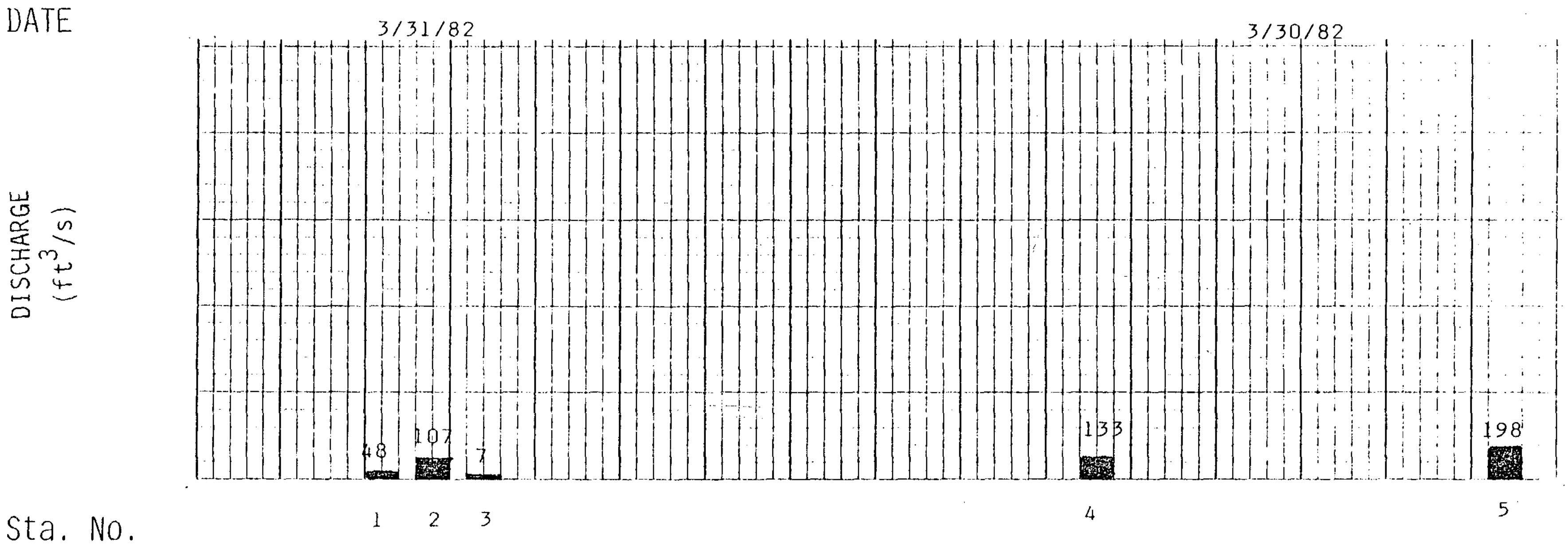
MOC = Mormon Outside Canal

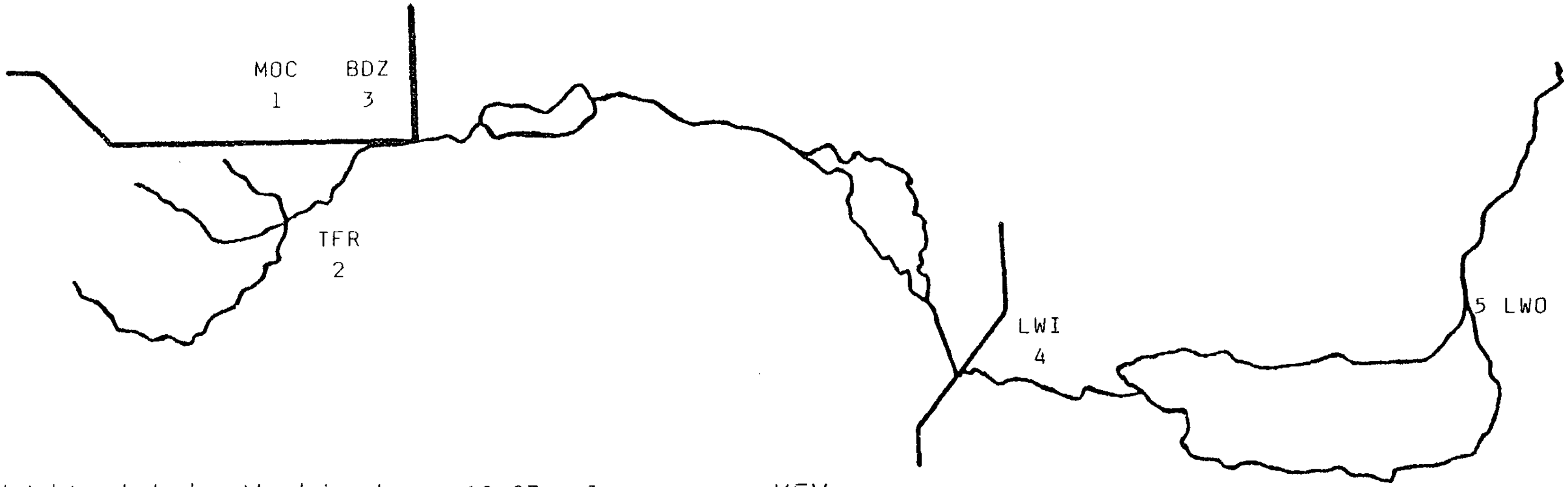
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet





Stage Height at Lake Washington: 13.87 msl
(3/30/82)

KEY:

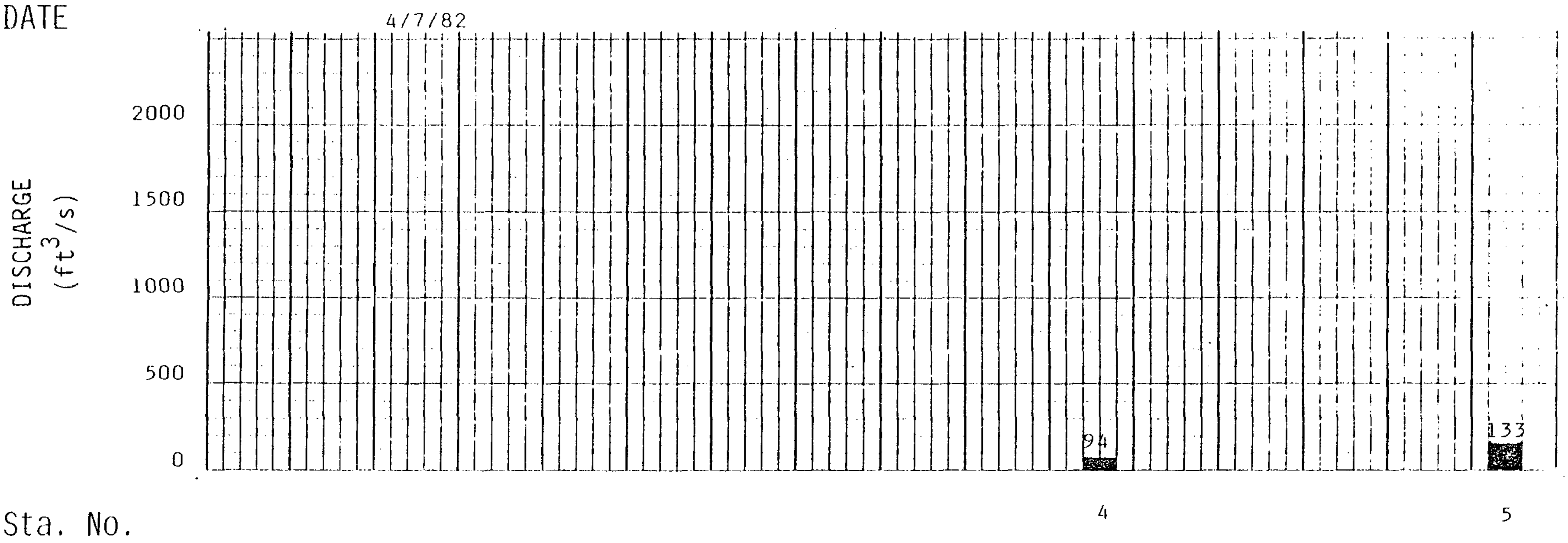
MOC = Mormon Outside Canal

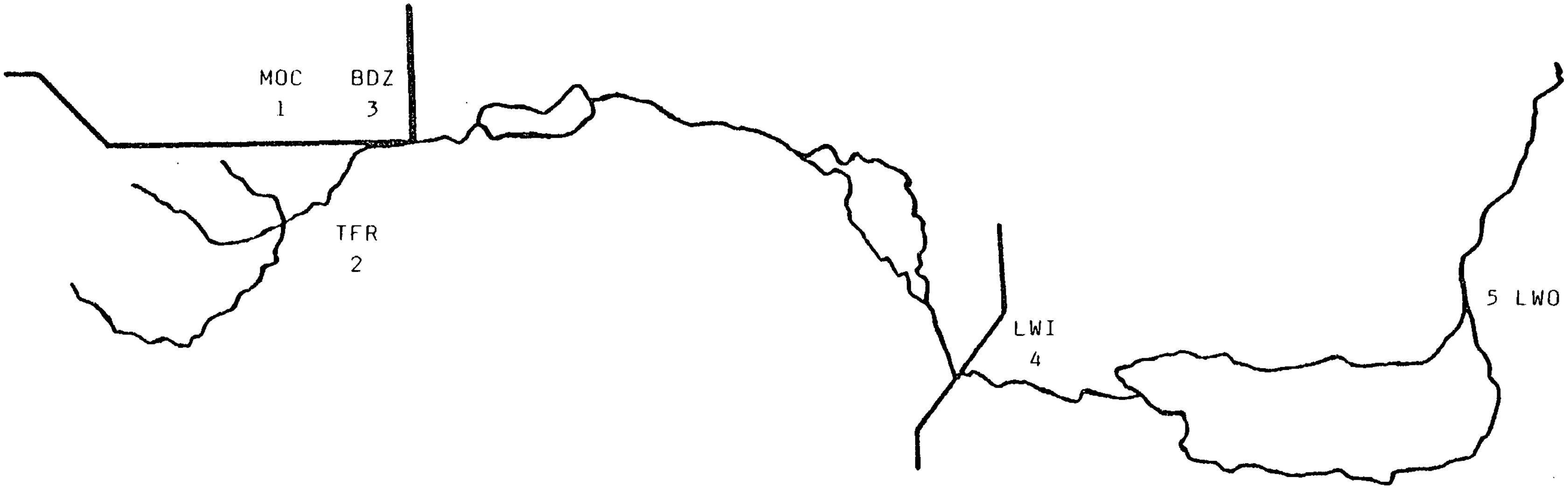
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet





Stage Height at Lake Washington: 13.96 msl.

KEY:

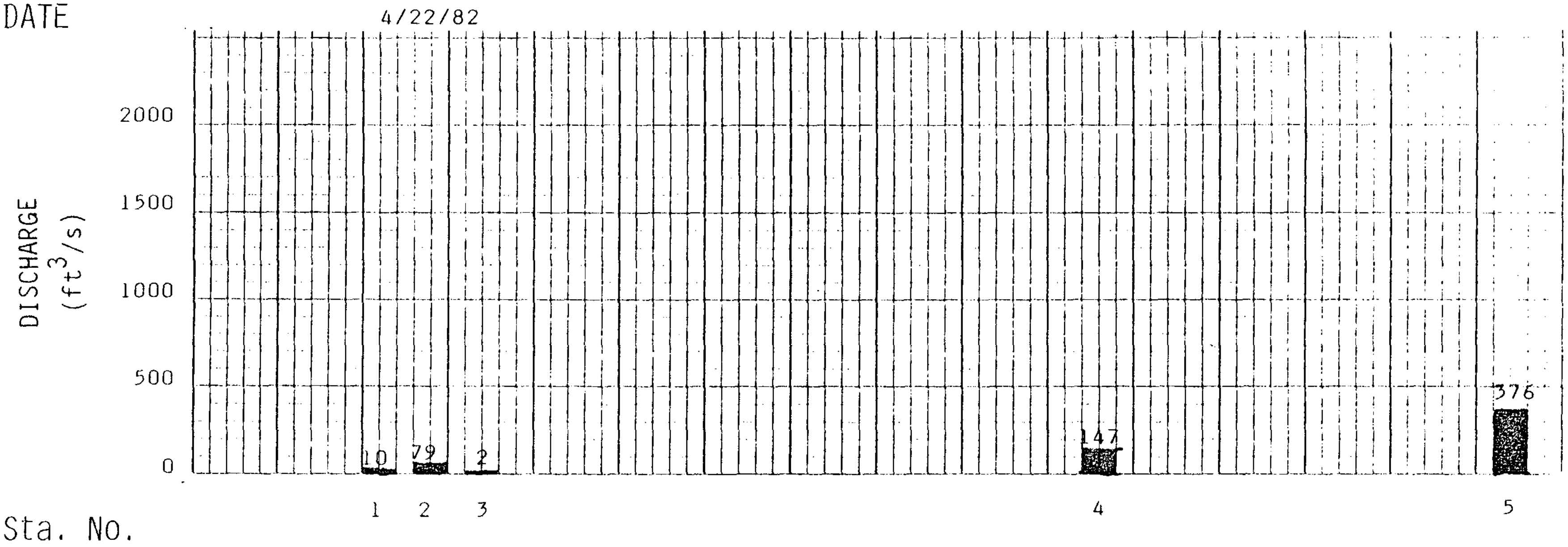
MOC = Mormon Outside Canal

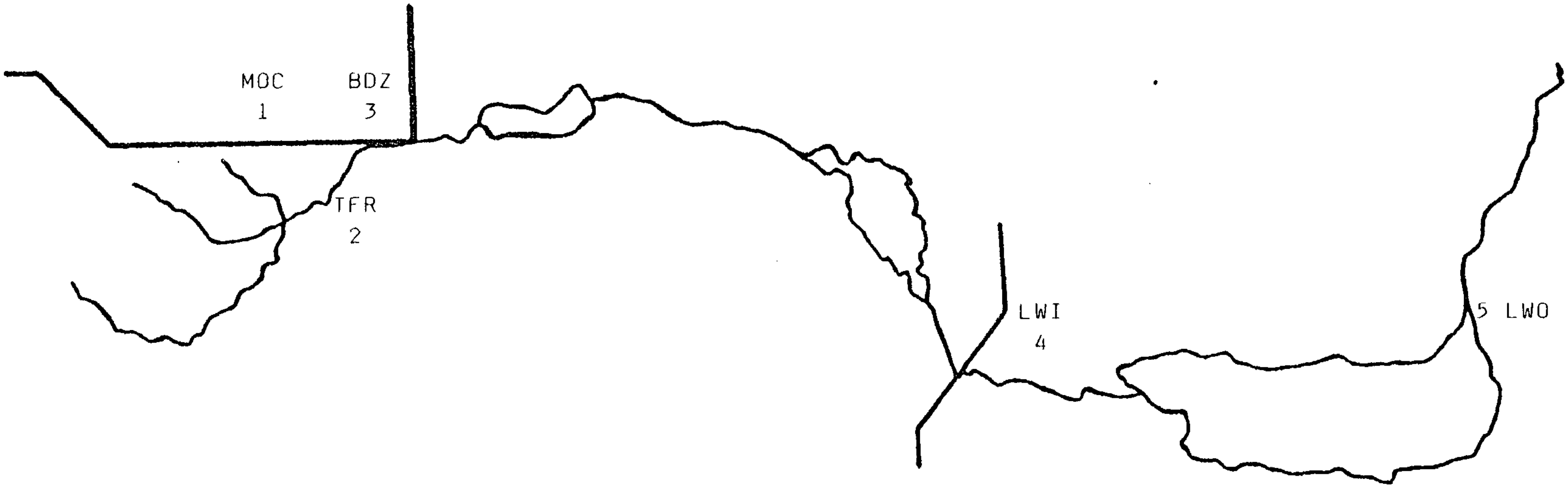
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet





Stage Height at Lake Washington: 14.15 msl.

KEY:

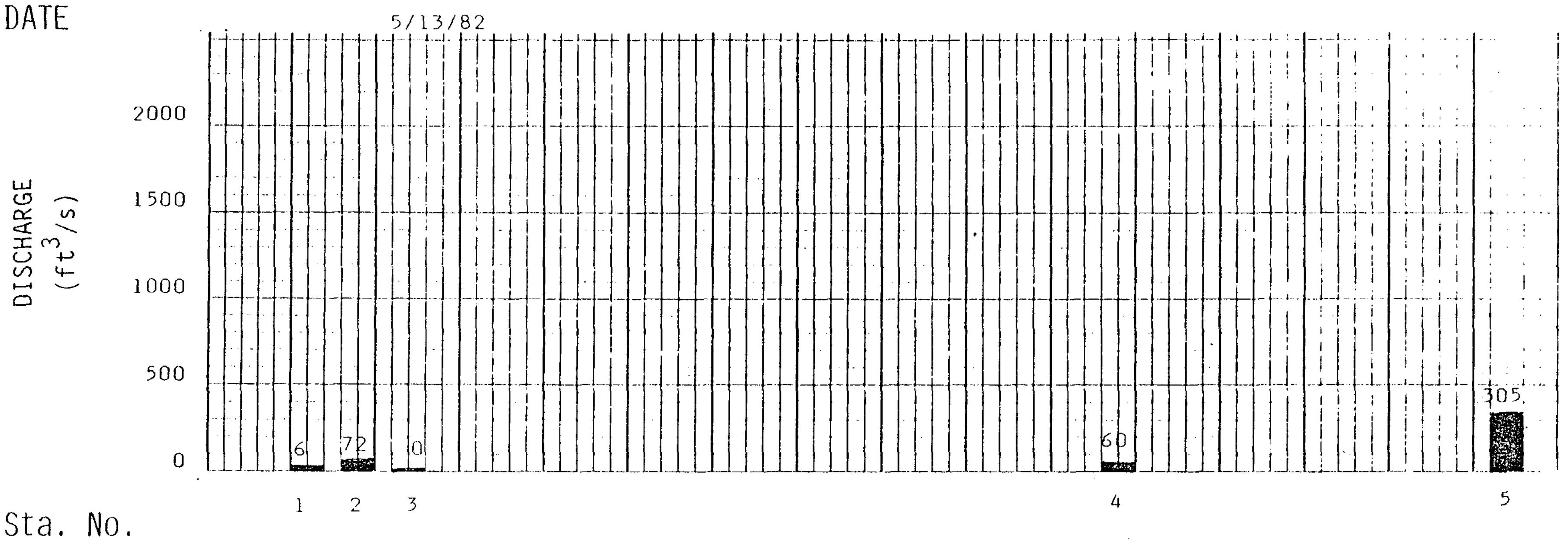
MOC = Mormon Outside Canal

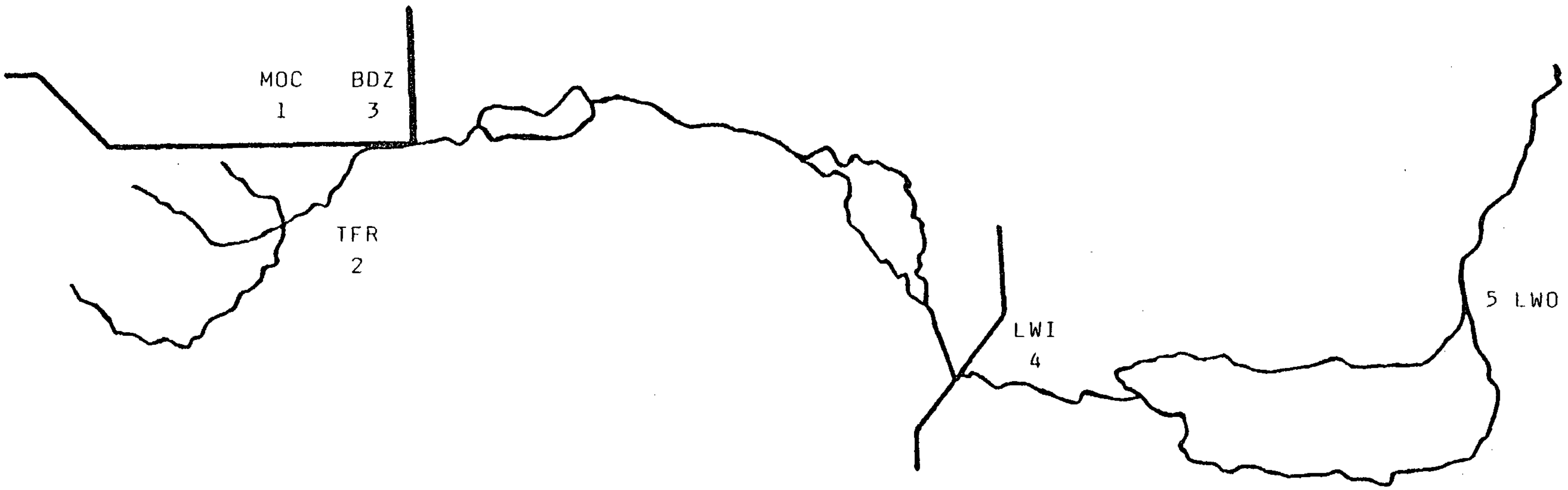
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet





Stage Height at Lake Washington: 14.10 msl.

KEY:

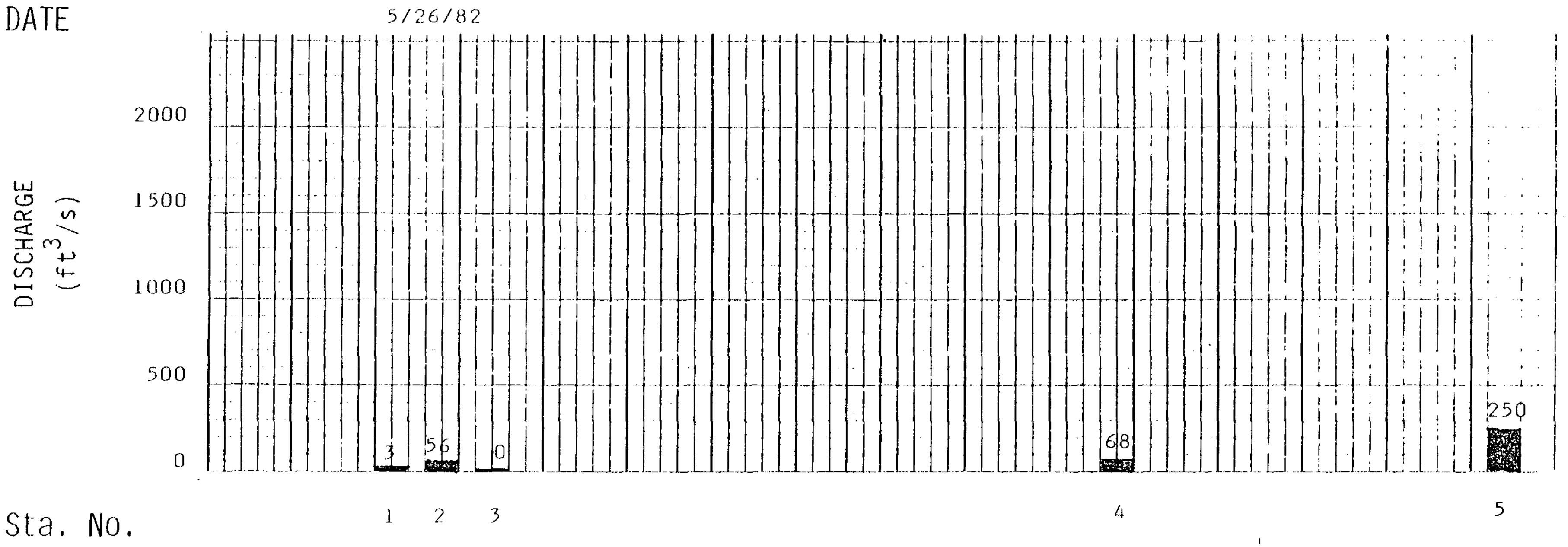
MOC = Mormon Outside Canal

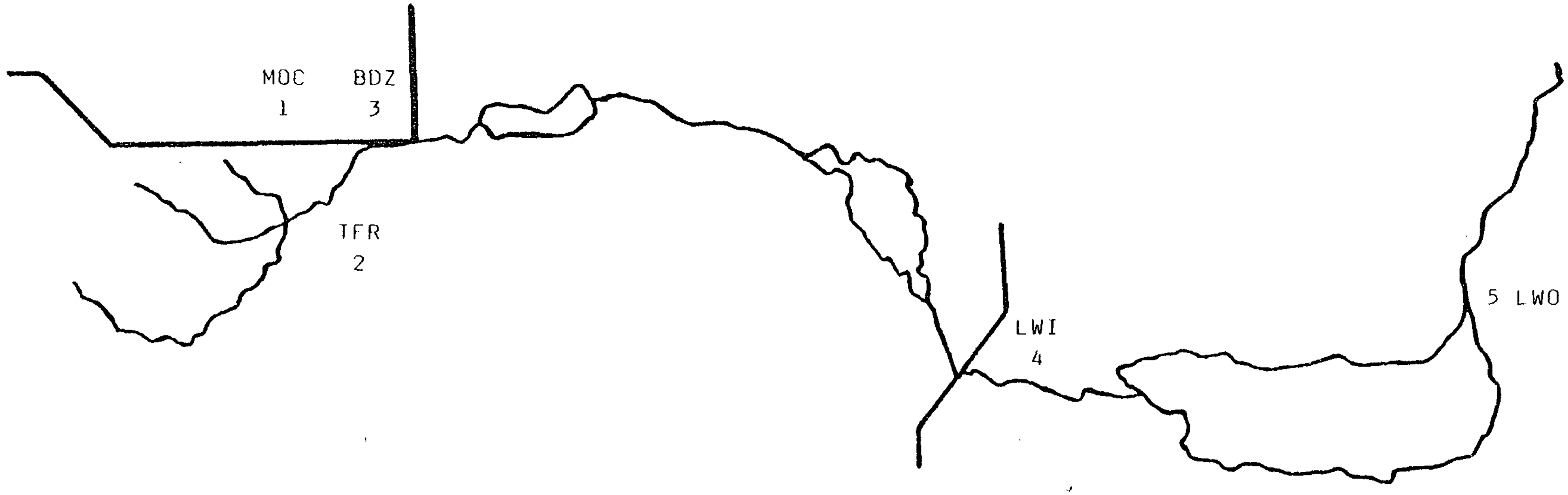
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet

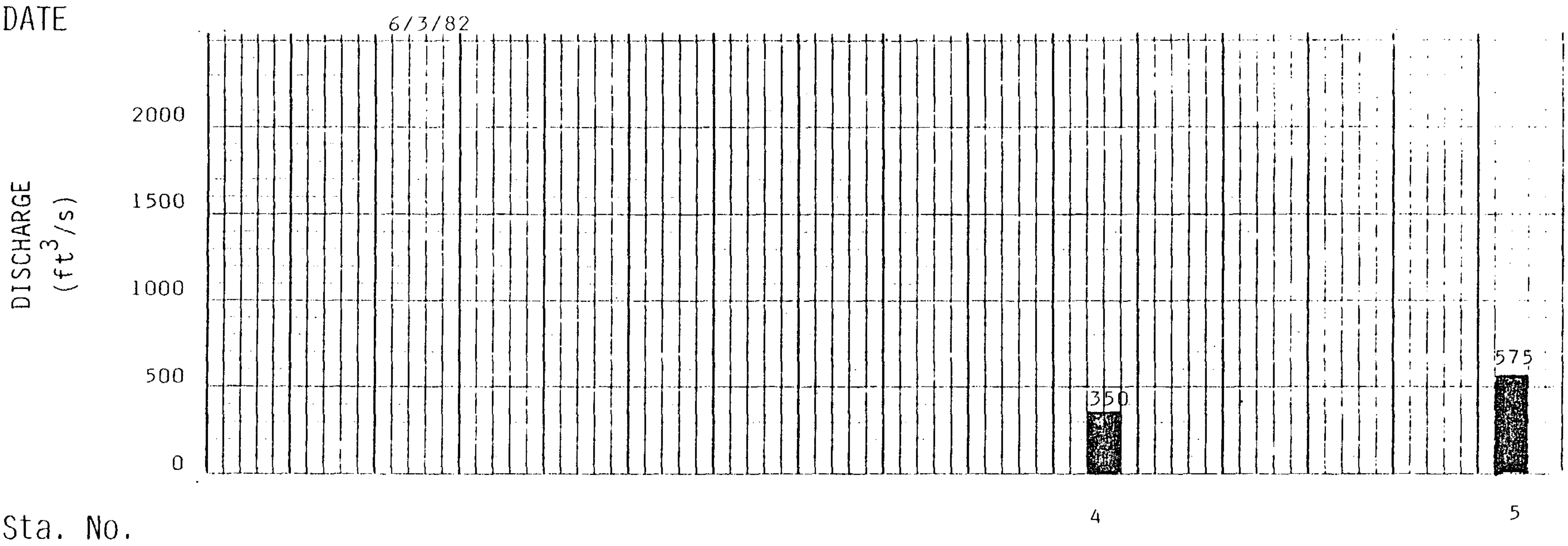


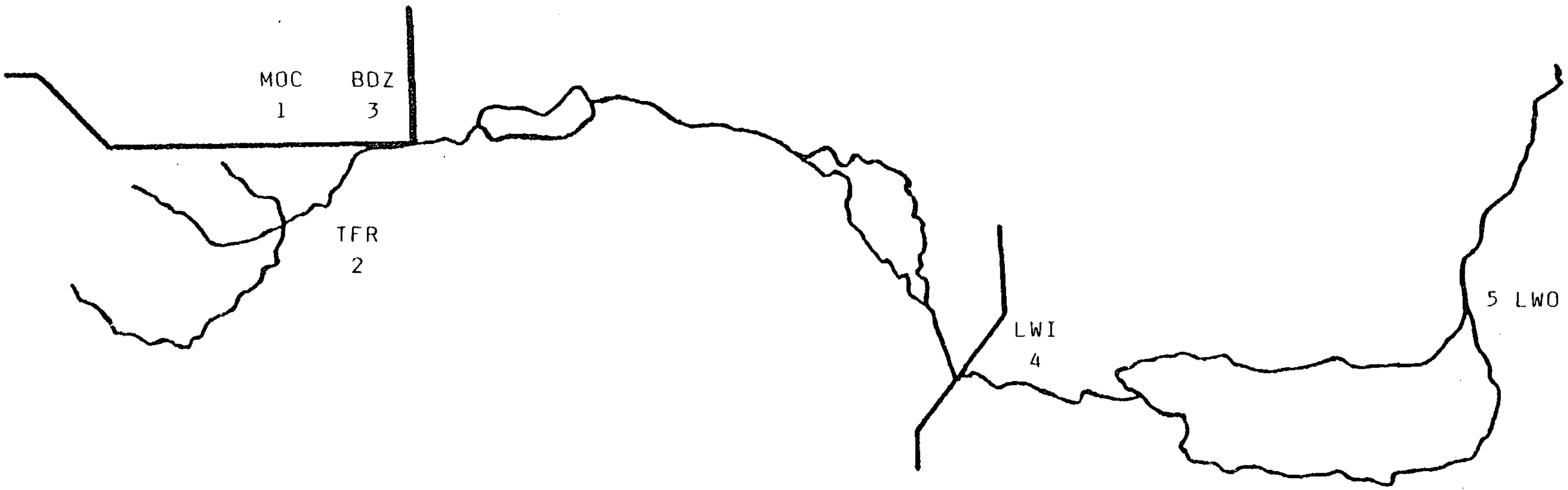


Stage Height at Lake Washington: 14.10 msl.

KEY:

MOC = Mormon Outside Canal
TFR = Three Forks Run
BDZ = Bulldozer Canal
LWI = Lake Washington Inlet
LWO = Lake Washington Outlet





Stage Height at Lake Washington: 14.40 msl.

KEY:

MOC = Mormon Outside Canal

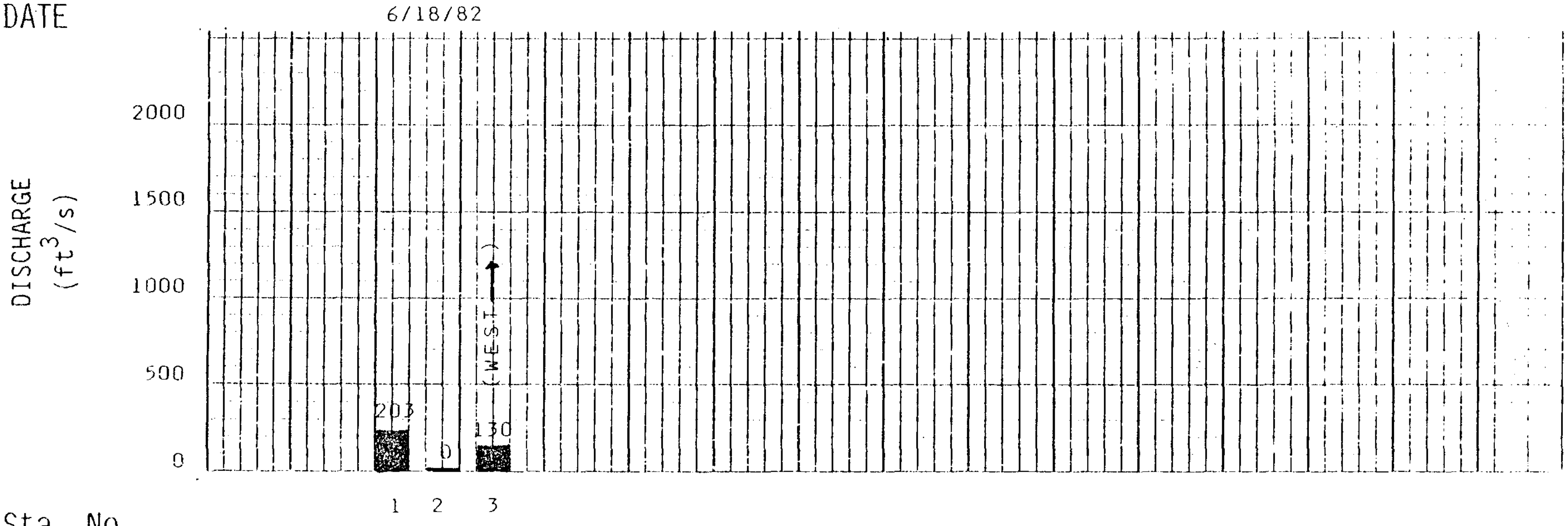
TFR = Three Forks Run

BDZ = Bulldozer Canal

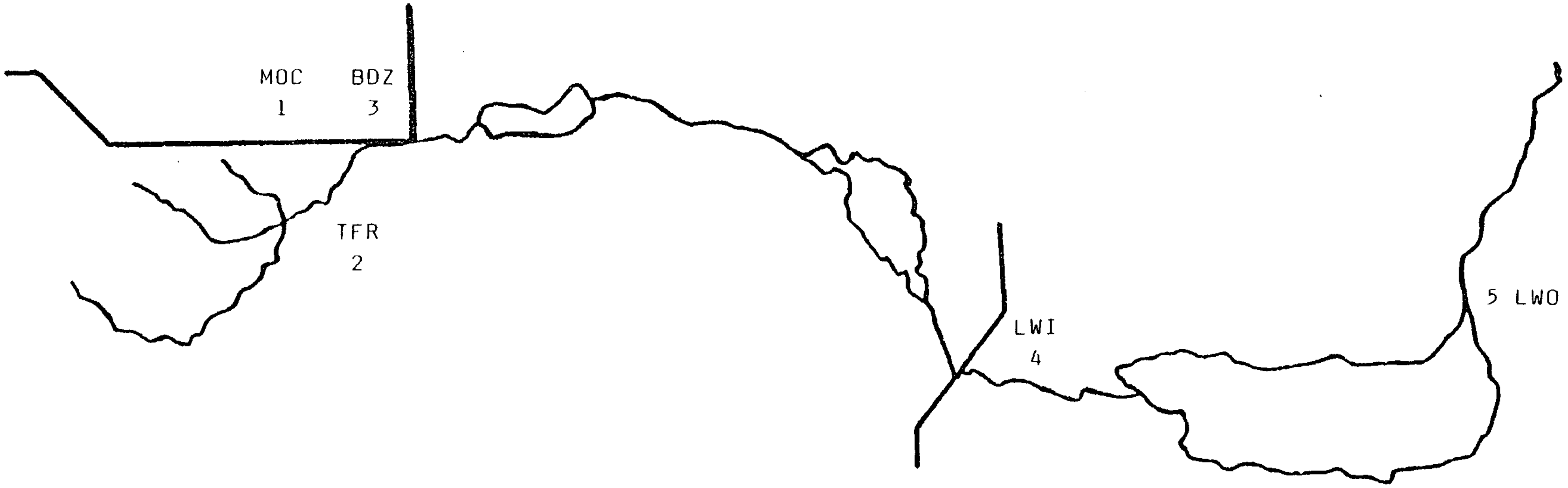
LWI = Lake Washington Inlet

LWO = Lake Washington Outlet

DATE 6/18/82



Sta. No.



Stage Height at Lake Washington: 15.52

KEY:

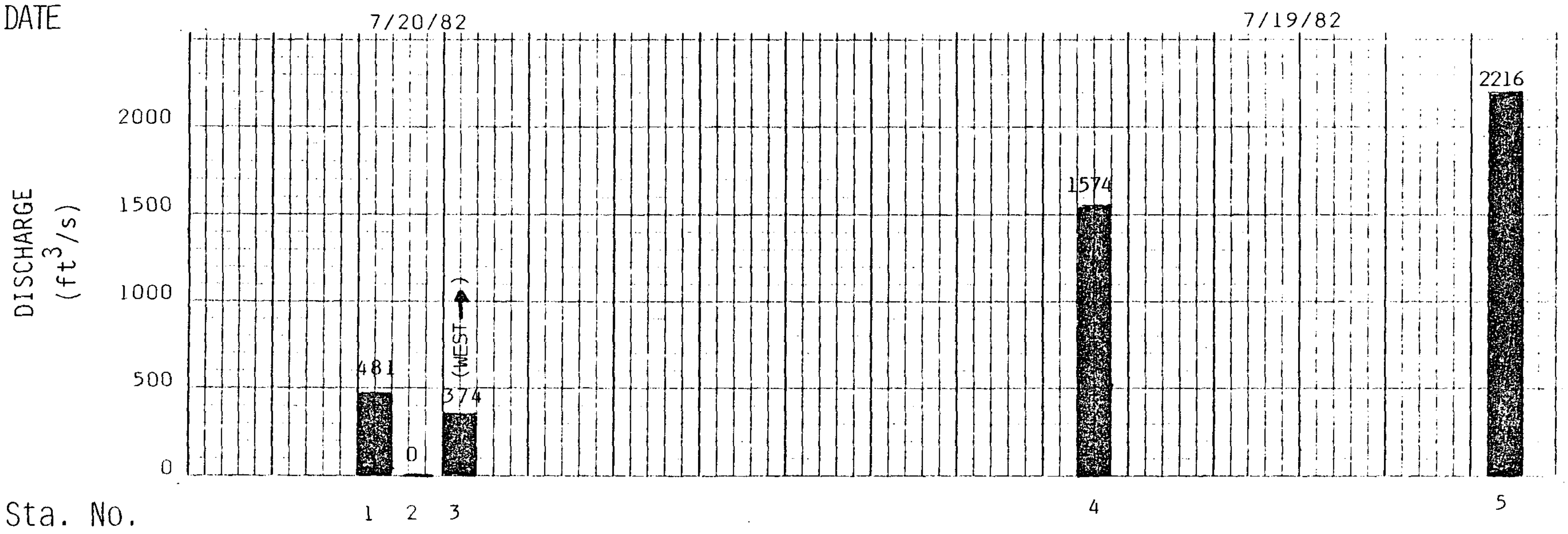
MOC = Mormon Outside Canal

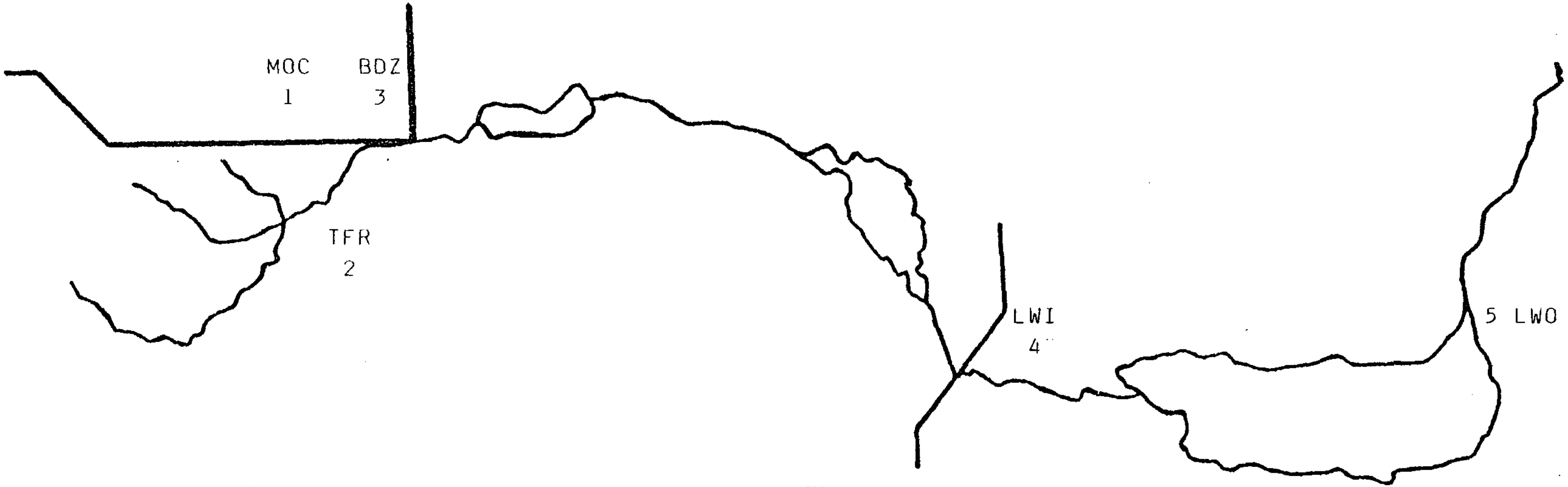
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet

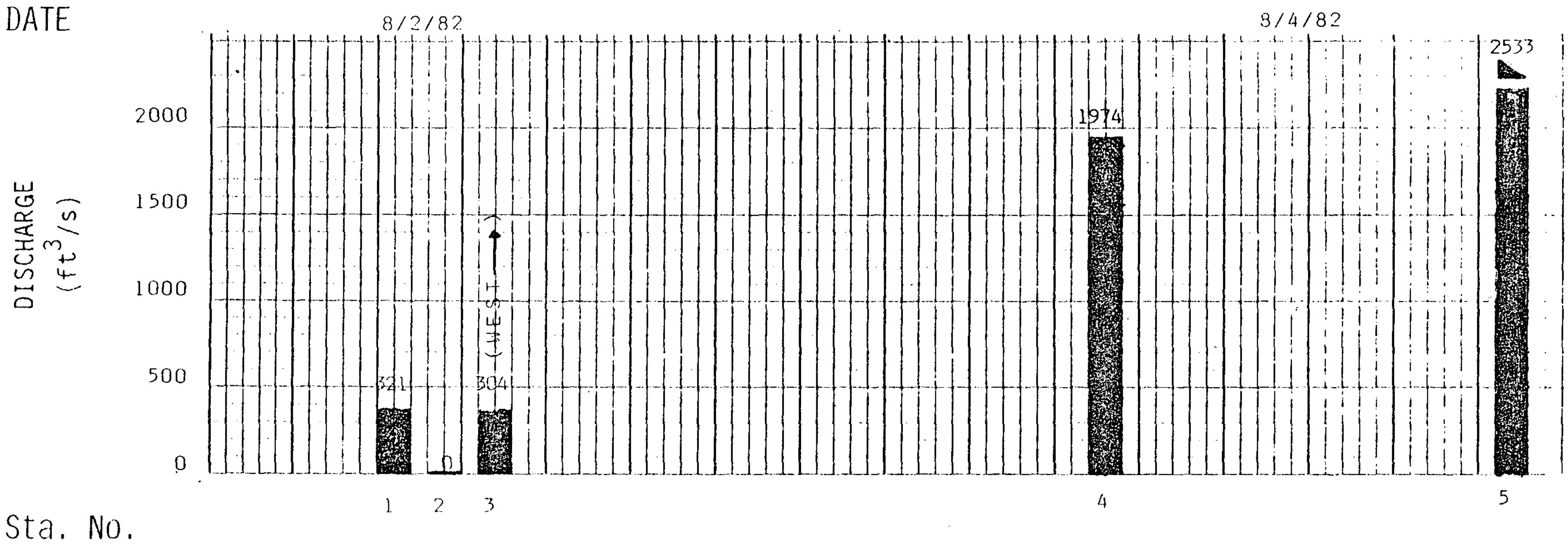


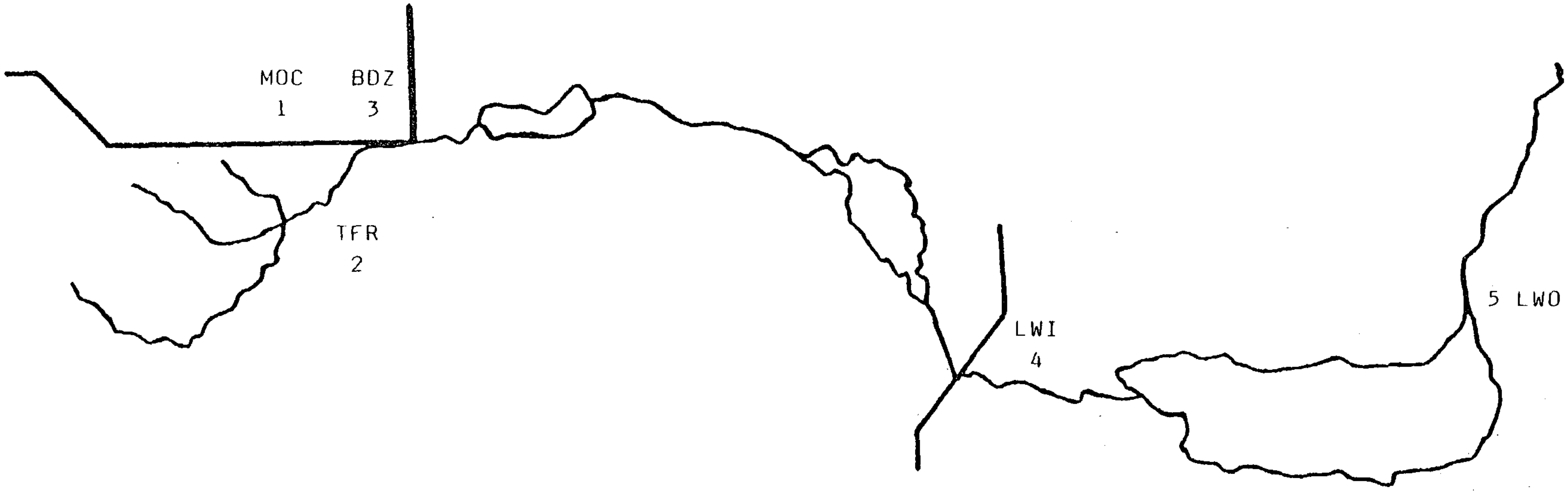


Stage Height at Lake Washington: 16.46 msl.
(7/19/82)

KEY:

MOC = Mormon Outside Canal
TFR = Three Forks Run
BDZ = Bulldozer Canal
LWI = Lake Washington Inlet
LWO = Lake Washington Outlet

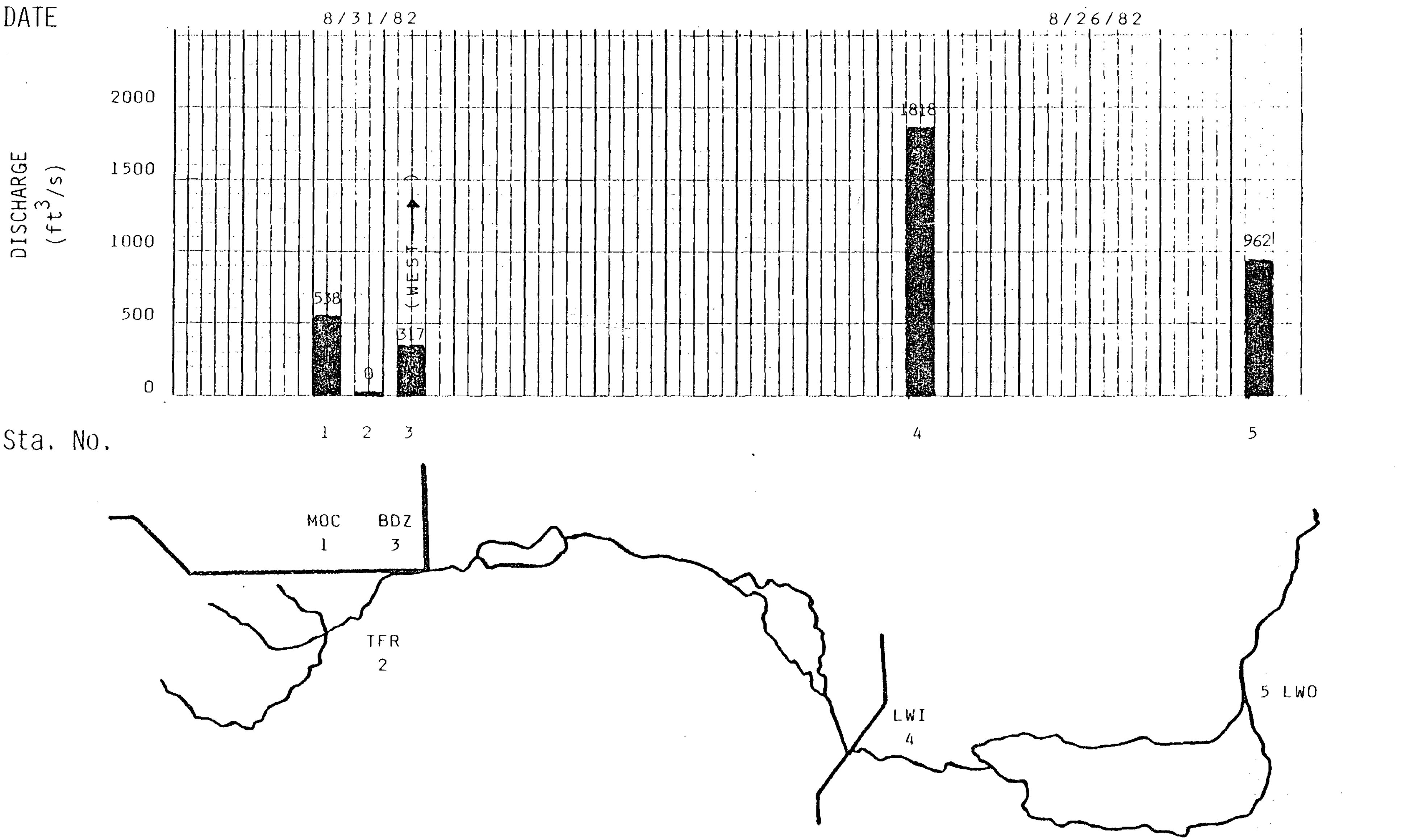




Stage Height at Lake Washington: 16.78 msl.
(8/4/82)

KEY:

MOC = Mormon Outside Canal
TFR = Three Forks Run
BDZ = Bulldozer Canal
LWI = Lake Washington Inlet
LWO = Lake Washington Outlet



Stage Height at Lake Washington: 16.20 msl.
(8/26/82)

KEY:

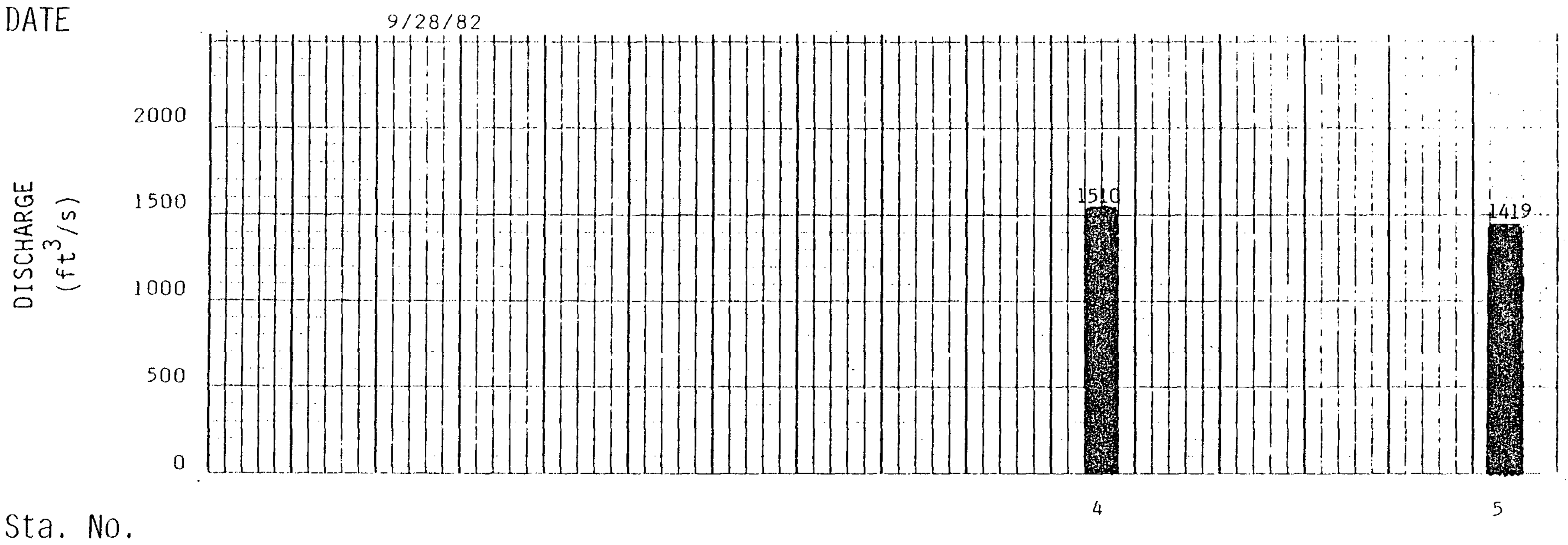
MOC = Mormon Outside Canal

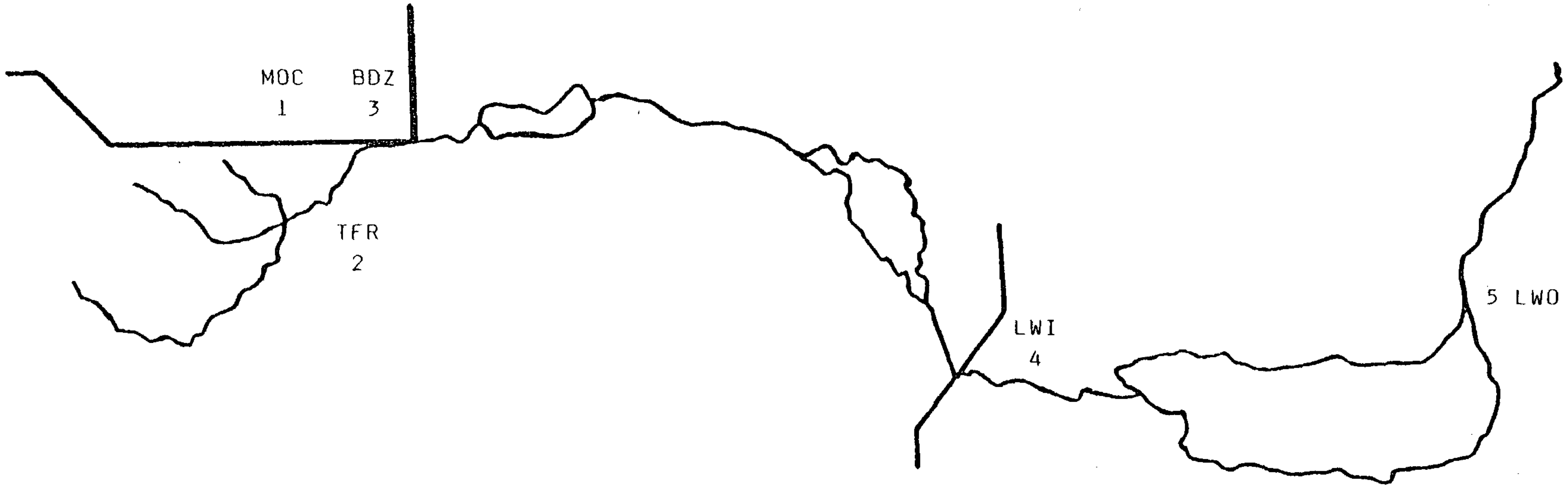
TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet





Stage Height at Lake Washington: 15.73 msl.

KEY:

MOC = Mormon Outside Canal

TFR = Three Forks Run

BDZ = Bulldozer Canal

LWI = Lake Washington Inlet

LWO = Lake Washington Outlet

APPENDIX D

Core Data

SLT = Silt (very fine organic material)

PP = plant detritus (fibrous, woody organic matter)

S = sand

SS = silty sand

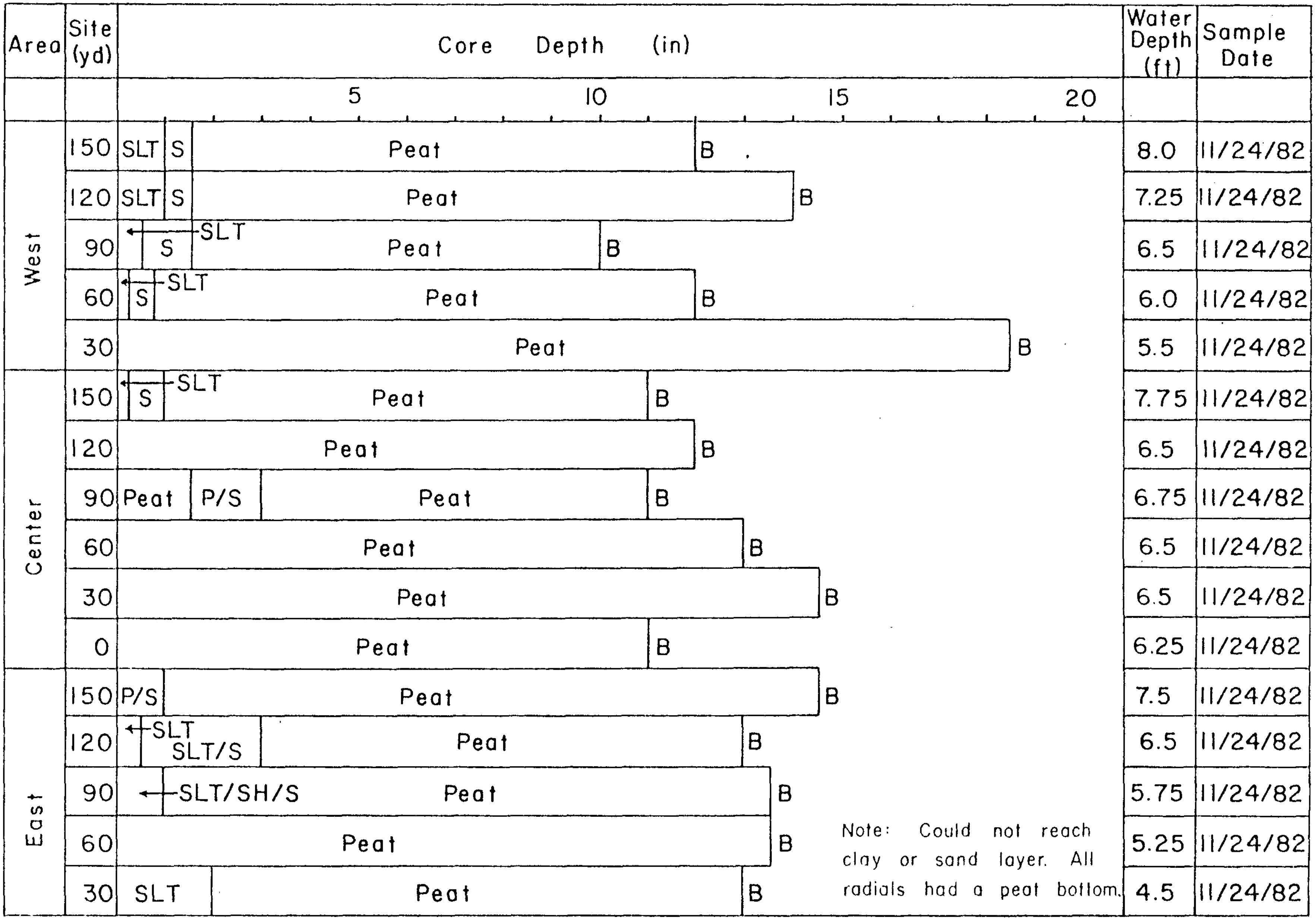
C = clay

BC = black clay

Sh = shells

P = peat

B = (Bottom of core) Did not reach hardpan



Note: Could not reach clay or sand layer. All radials had a peat bottom.

Figure D-1. Blue Cypress Lake – Inlet Radials.

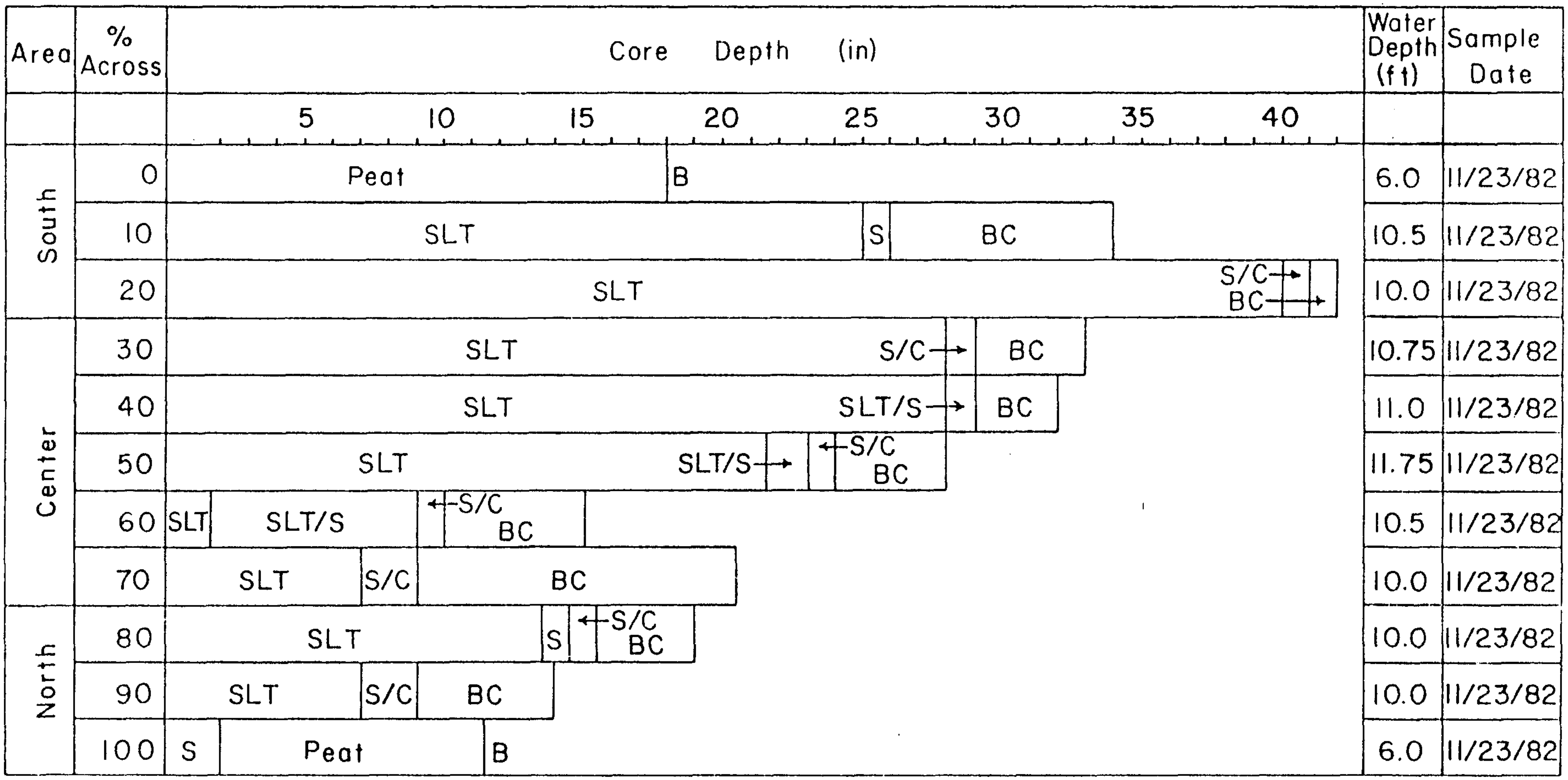


Figure D-2. Blue Cypress Lake – Longitudinal Transect.

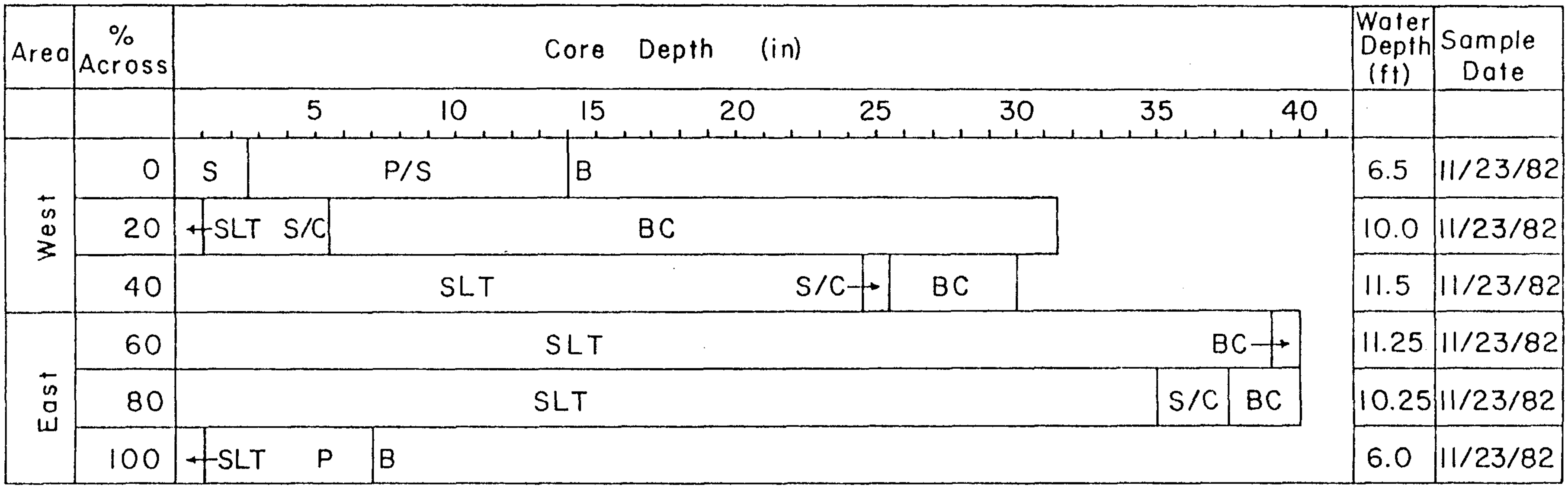


Figure D-3. Blue Cypress Lake - Transverse Transect.

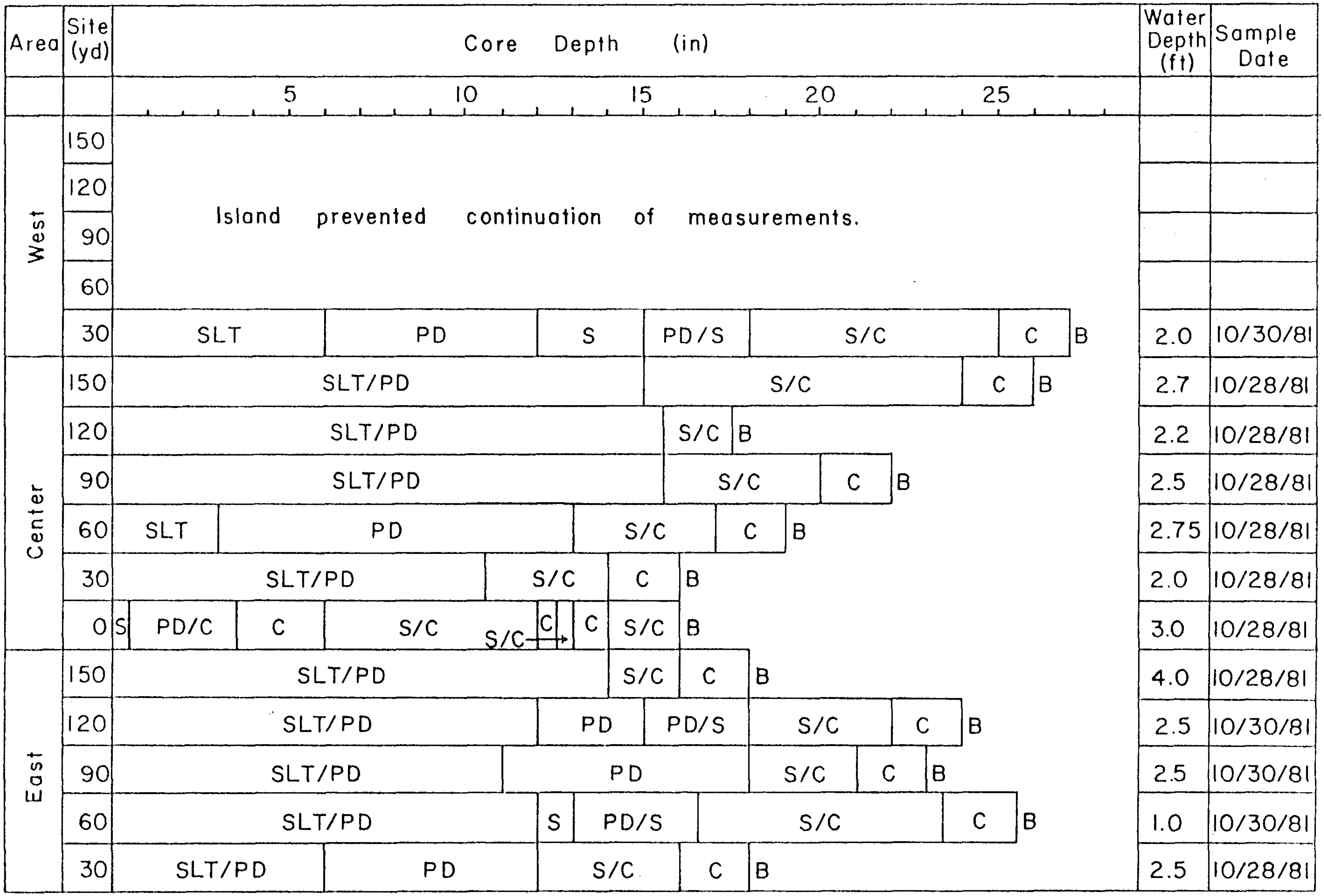


Figure D-4.. Lake Helen Blazes – Inlet Radials.

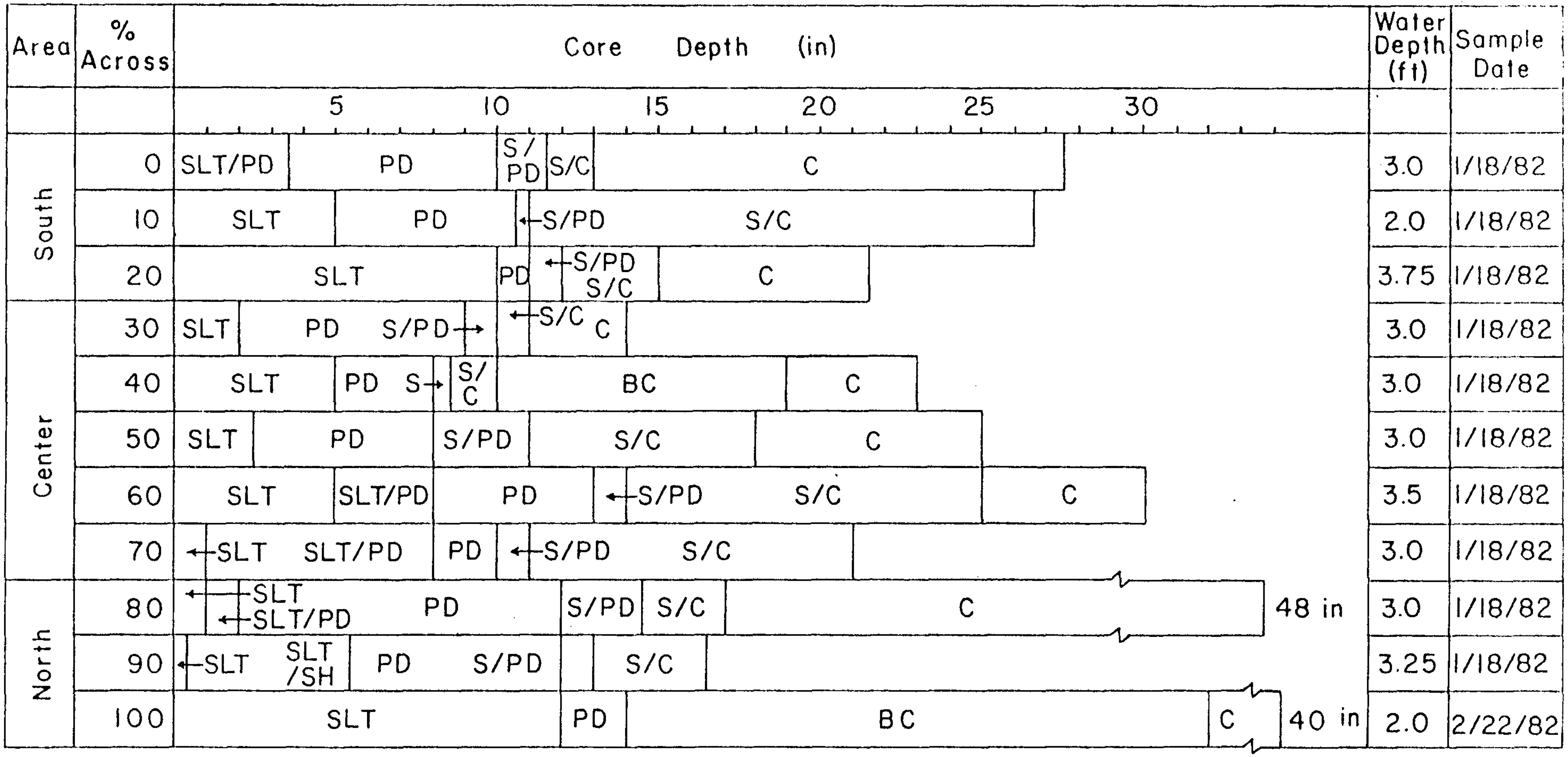


Figure D-5. Lake Helen Blazes – Longitudinal Transect.

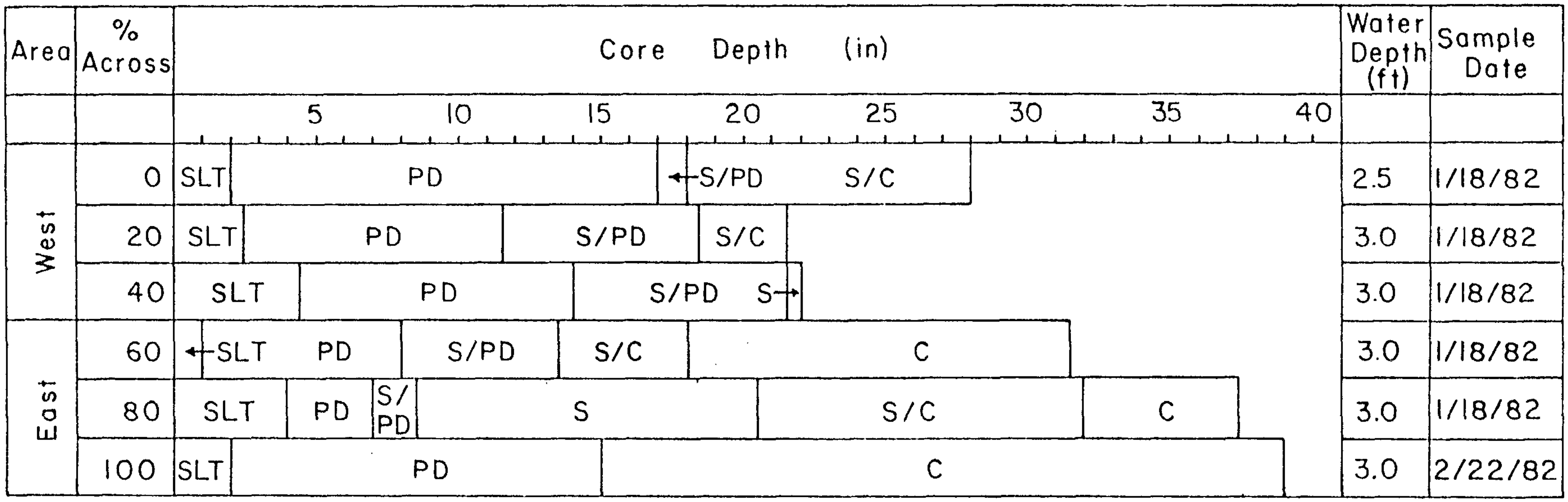
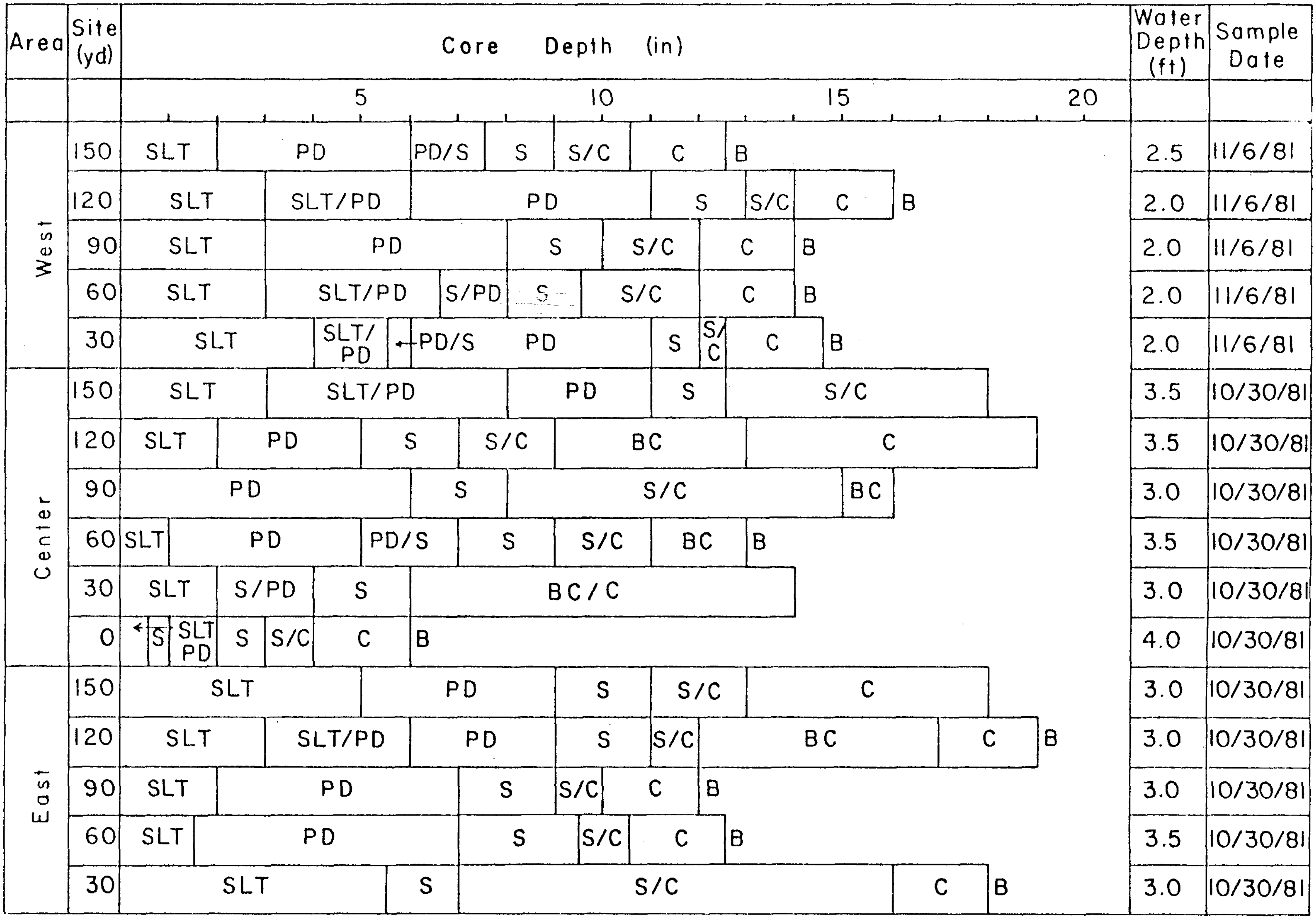
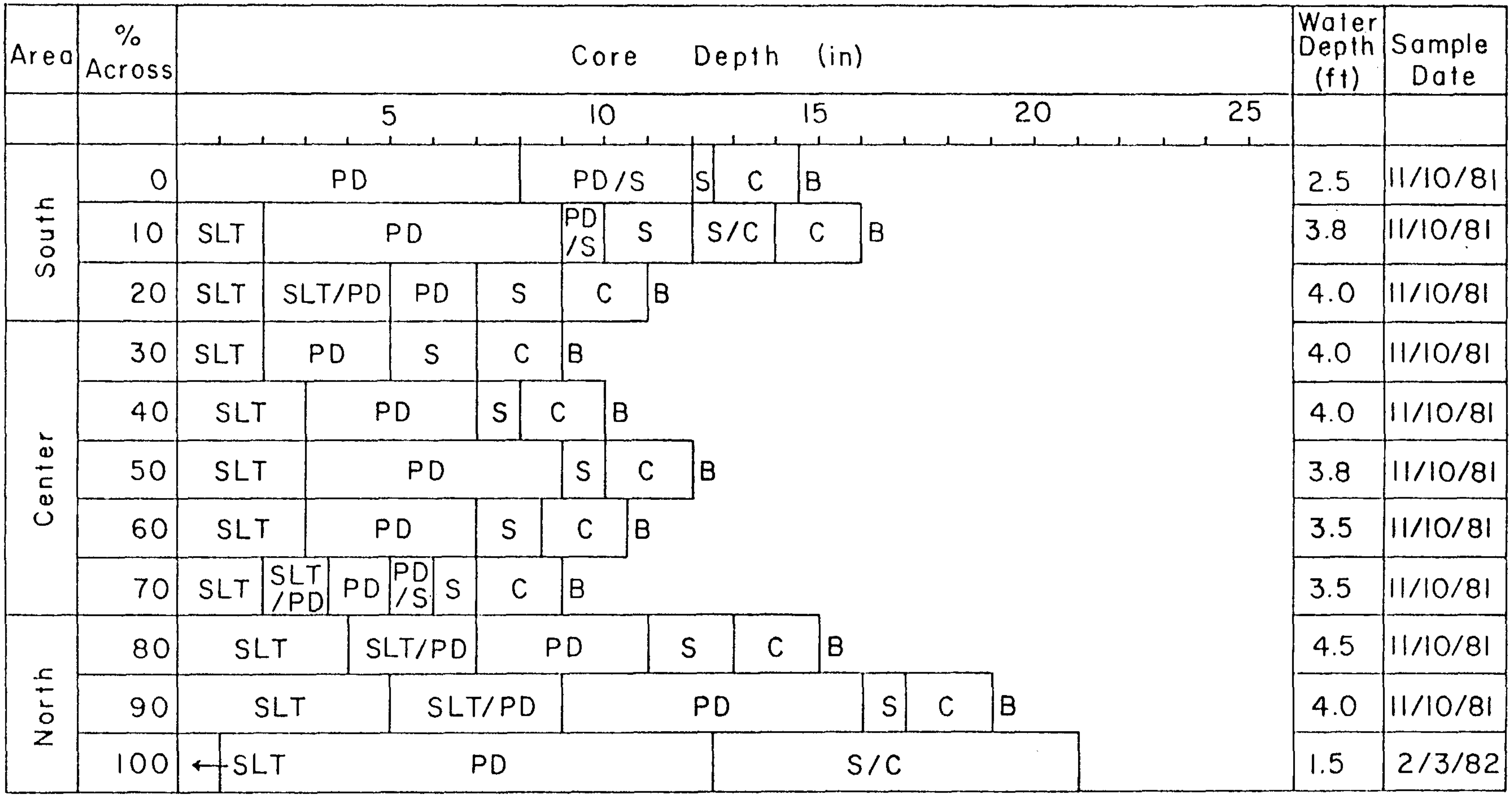


Figure D-6 Lake Helen Blazes - Transverse Transect.





Area	% Across	Core Depth (in)	Water Depth (ft)	Sample Date
		5 10 15 20 25		
South	0	PD PD/S S C B	2.5	11/10/81
	10	SLT PD PD/S S S/C C B	3.8	11/10/81
	20	SLT SLT/PD PD S C B	4.0	11/10/81
Center	30	SLT PD S C B	4.0	11/10/81
	40	SLT PD S C B	4.0	11/10/81
	50	SLT PD S C B	3.8	11/10/81
	60	SLT PD S C B	3.5	11/10/81
	70	SLT SLT/PD PD PD/S S C B	3.5	11/10/81
North	80	SLT SLT/PD PD S C B	4.5	11/10/81
	90	SLT SLT/PD PD S C B	4.0	11/10/81
	100	←SLT PD S/C	1.5	2/3/82

Figure D-8. Lake Sawgrass – Longitudinal Transect.

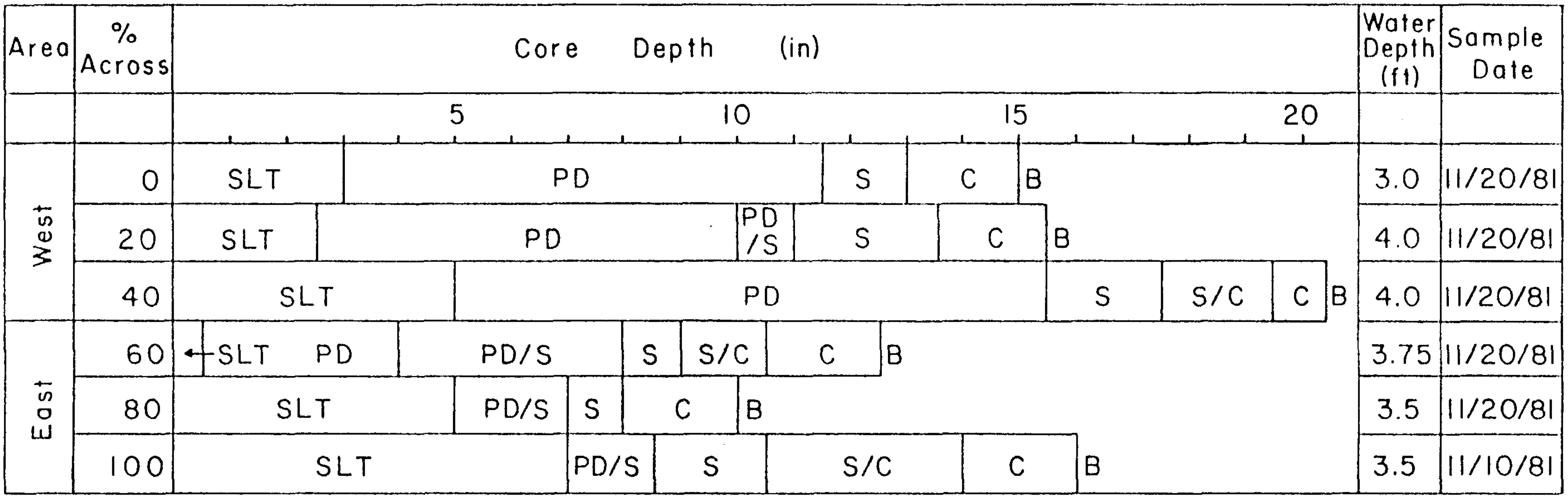


Figure D-9. Lake Sawgrass – Transverse Transect.

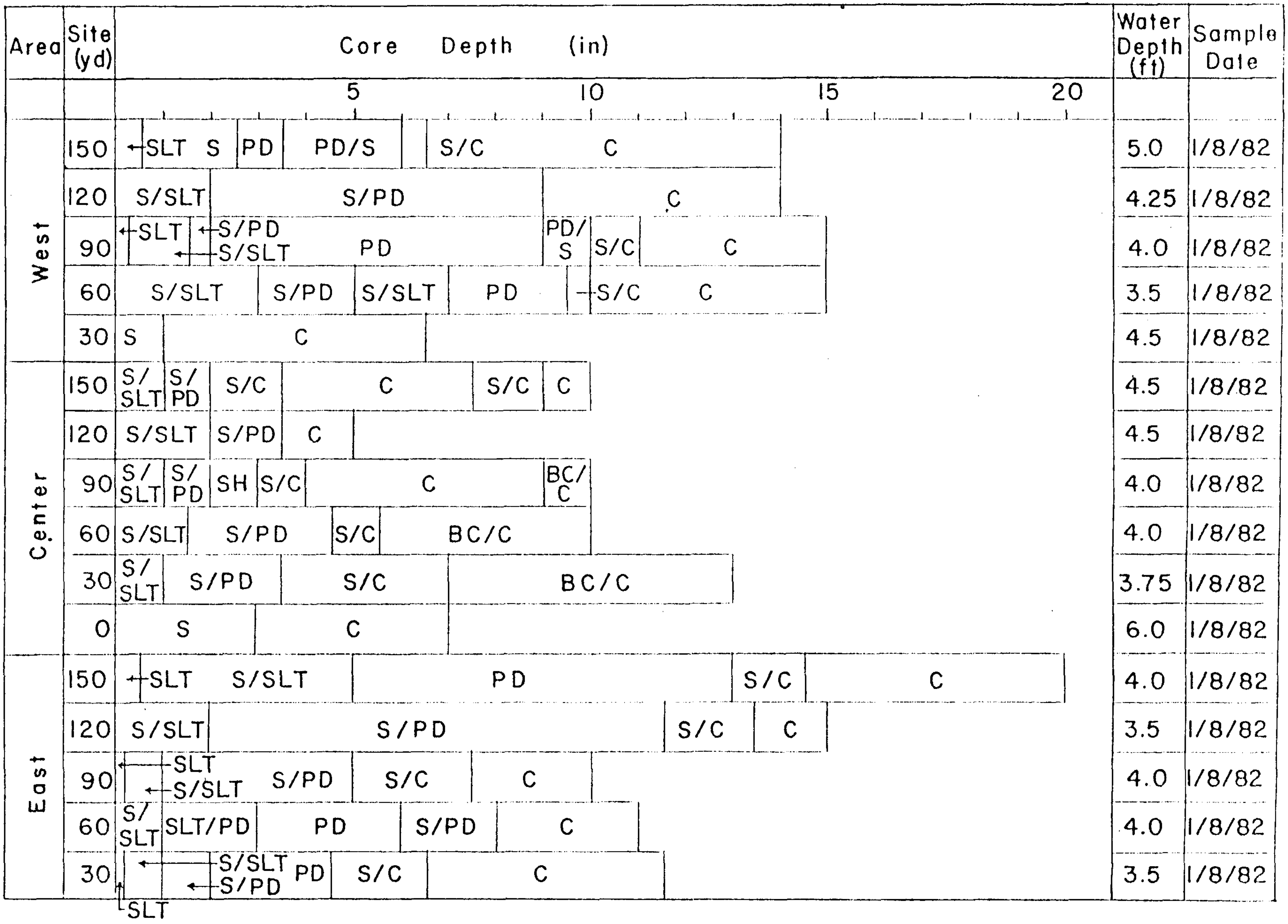


Figure D-10. Lake Washington — Inlet Radials.

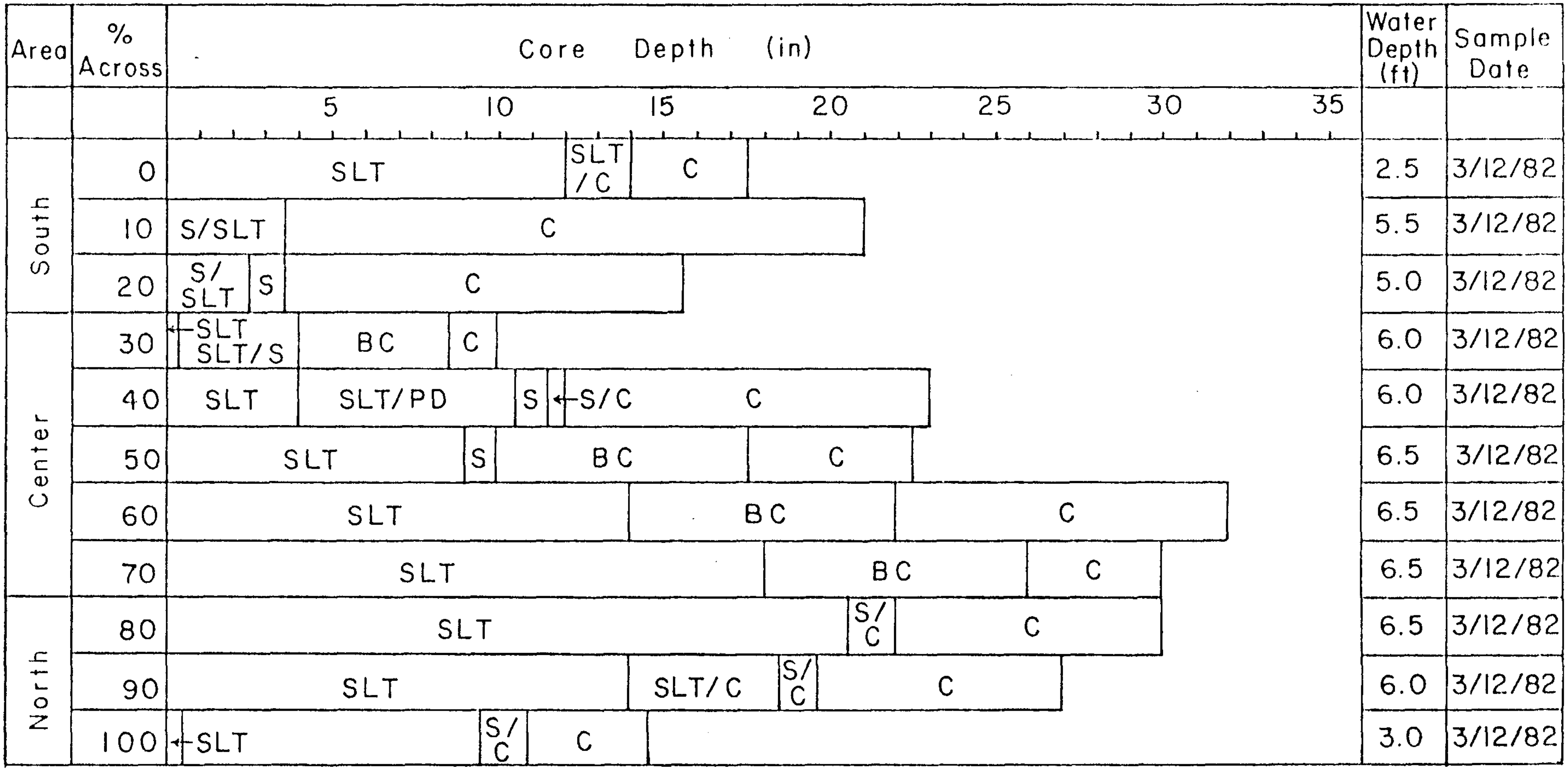
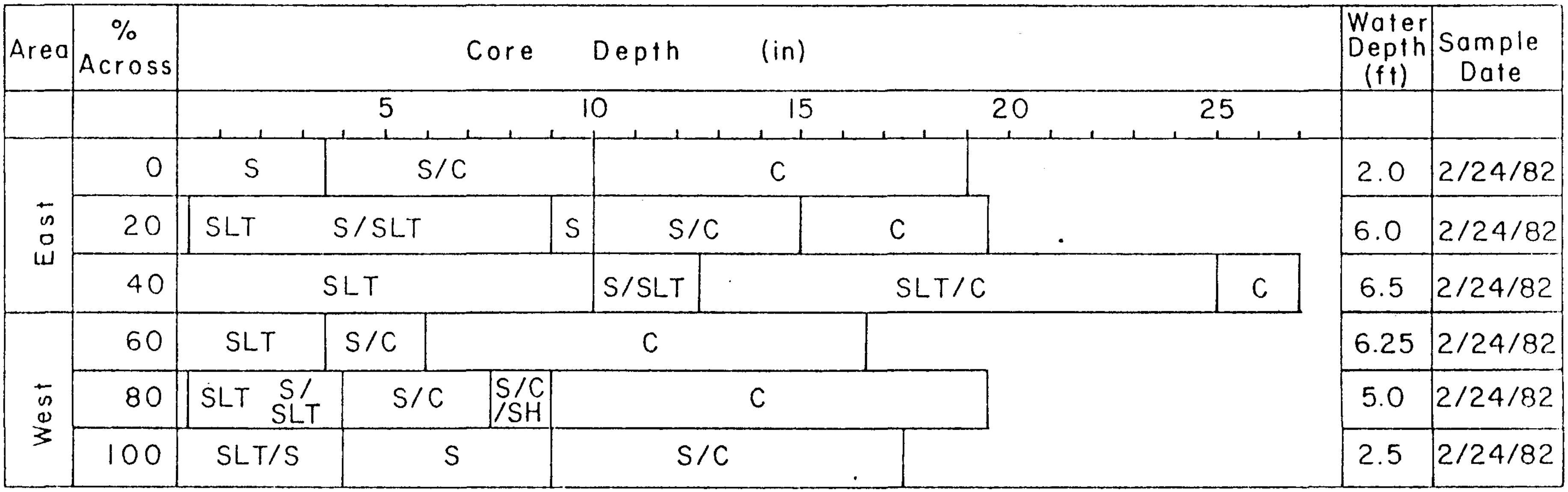


Figure D-11. Lake Washington - Longitudinal Transect.



Area	% Across	Core Depth (in)	Water Depth (ft)	Sample Date
East	0	S S/C C	2.0	2/24/82
	20	SLT S/SLT S S/C C	6.0	2/24/82
	40	SLT S/SLT SLT/C C	6.5	2/24/82
West	60	SLT S/C C	6.25	2/24/82
	80	SLT S/SLT S/C S/C/SH C	5.0	2/24/82
	100	SLT/S S S/C	2.5	2/24/82

Figure D-12. Lake Washington – Transverse Transect.

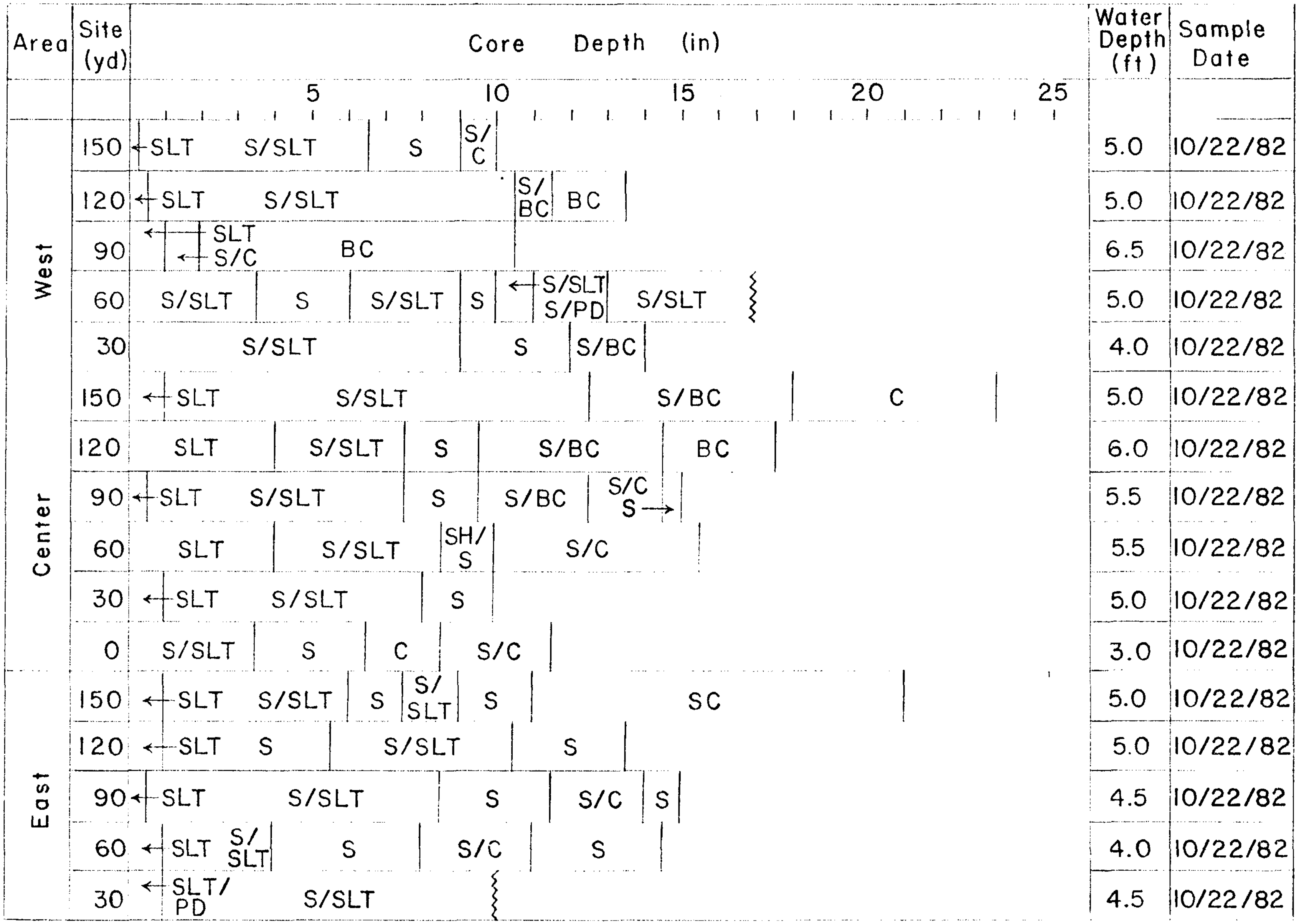
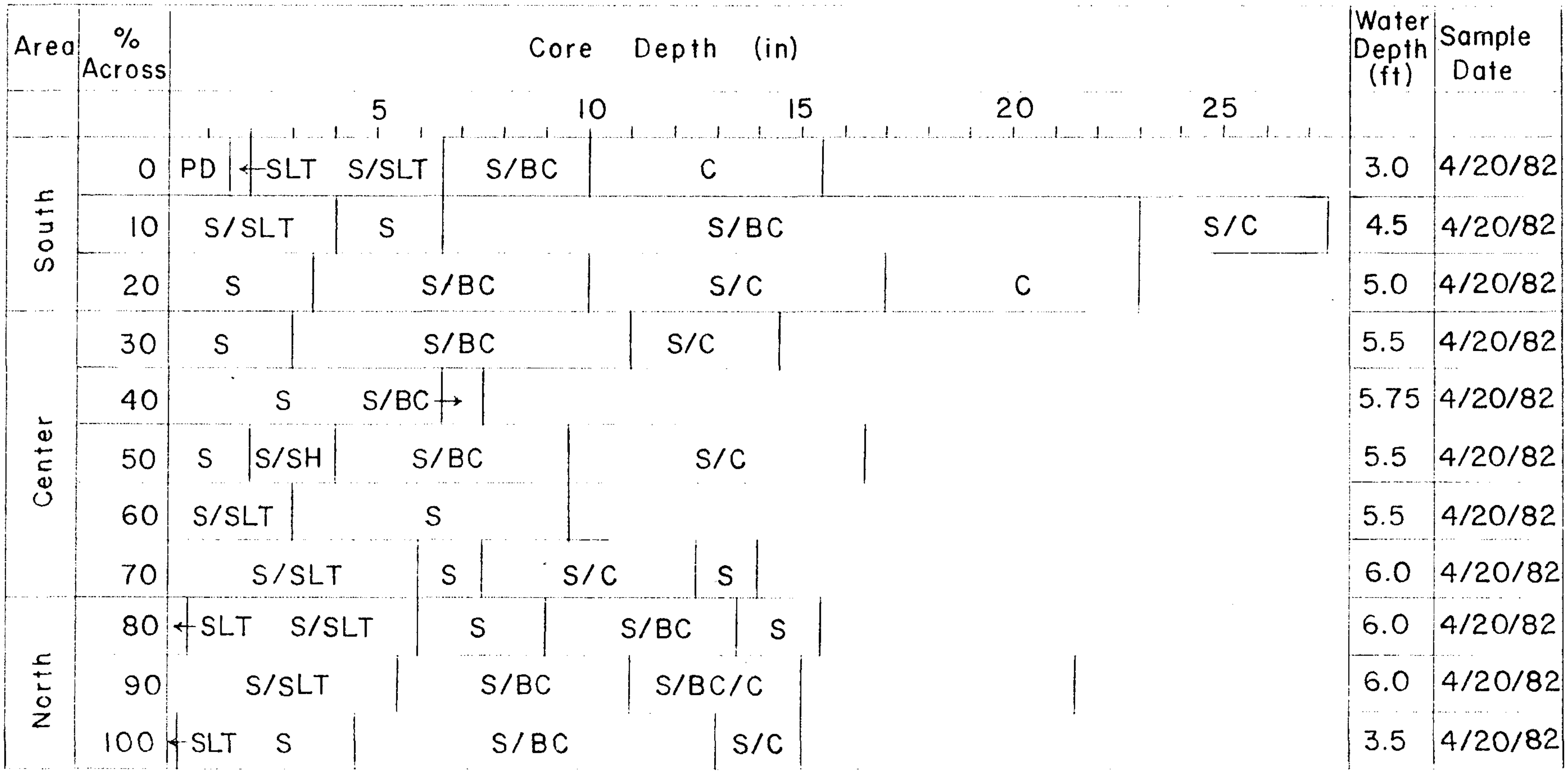


Figure D-13. Lake Winder – Inlet Radials



Area	% Across	Core Depth (in)	Water Depth (ft)	Sample Date
South	0	PD ←SLT S/SLT S/BC C	3.0	4/20/82
	10	S/SLT S S/BC S/C	4.5	4/20/82
	20	S S/BC S/C C	5.0	4/20/82
Center	30	S S/BC S/C	5.5	4/20/82
	40	S S/BC→	5.75	4/20/82
	50	S S/SH S/BC S/C	5.5	4/20/82
	60	S/SLT S	5.5	4/20/82
	70	S/SLT S S/C S	6.0	4/20/82
North	80	←SLT S/SLT S S/BC S	6.0	4/20/82
	90	S/SLT S/BC S/BC/C	6.0	4/20/82
	100	←SLT S S/BC S/C	3.5	4/20/82

Figure D-14. Lake Winder – Longitudinal Transect

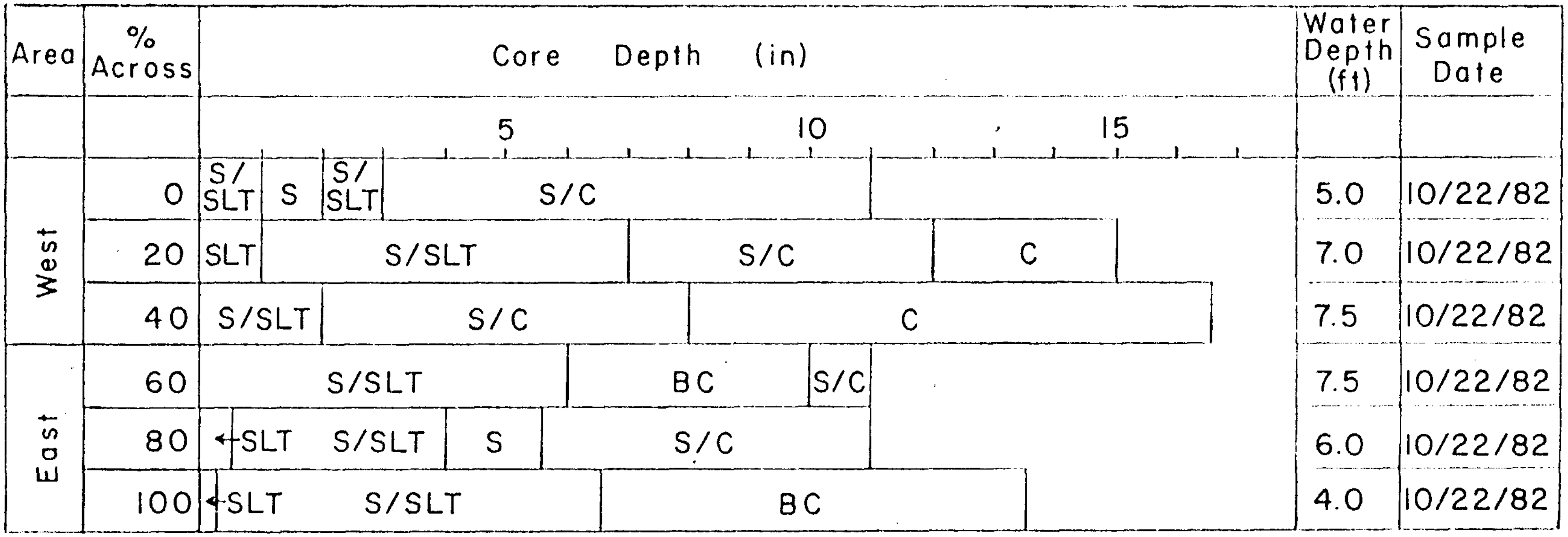


Figure D-15. Lake Winder - Transverse Transect.

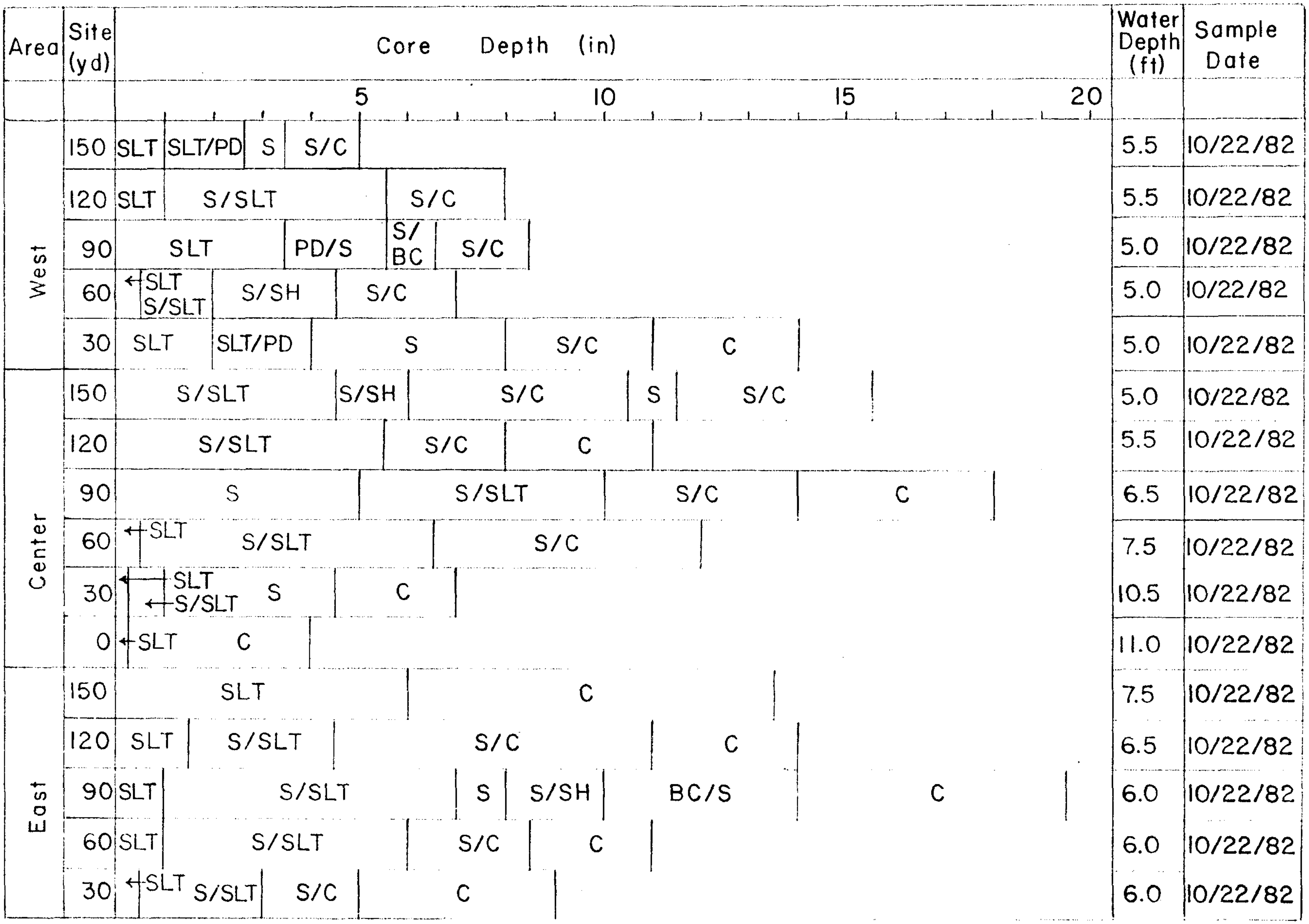


Figure D-16. Lake Poinsett – Inlet Radials

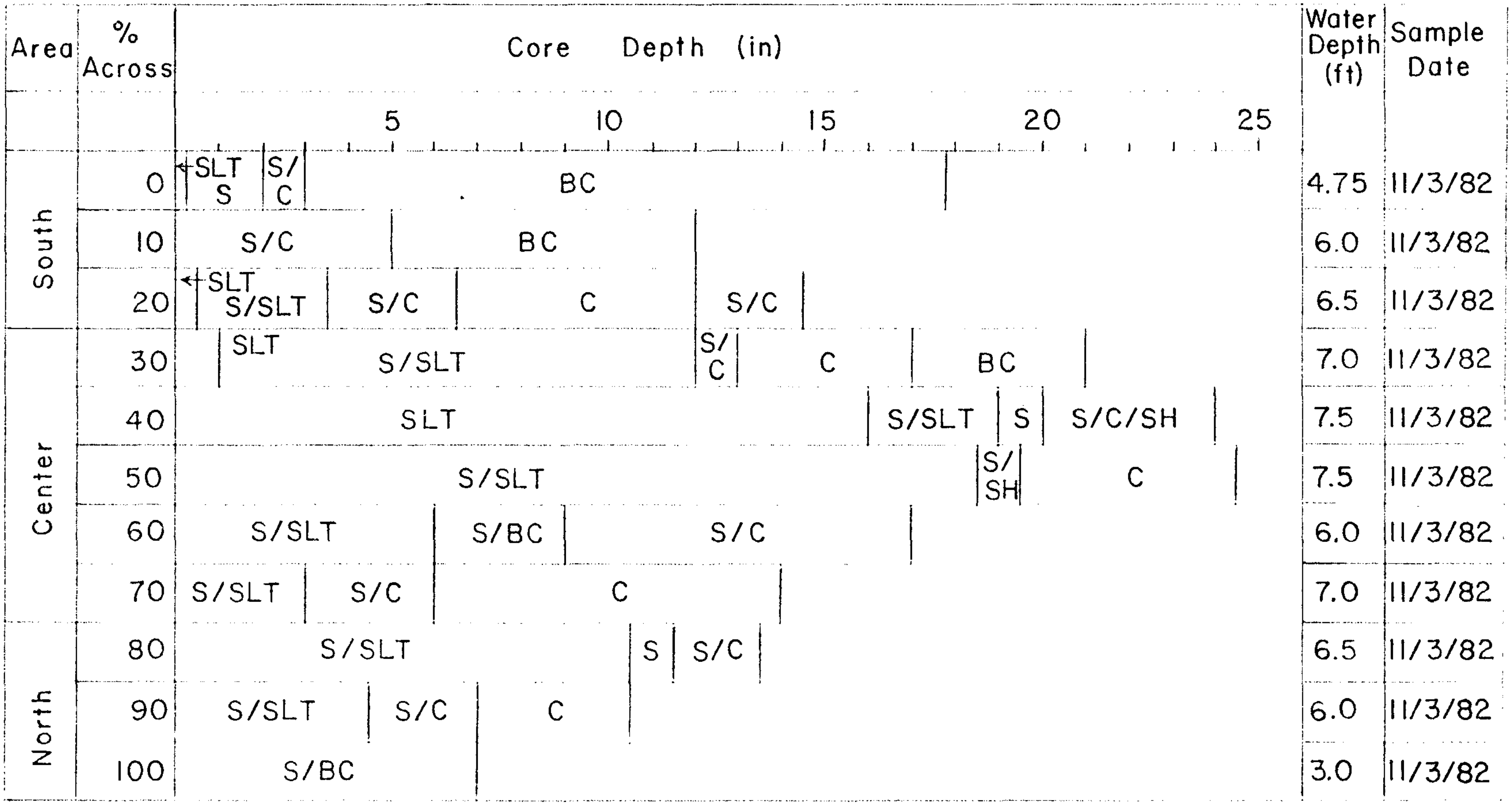


Figure D-17. Lake Poinsett – Longitudinal Transect

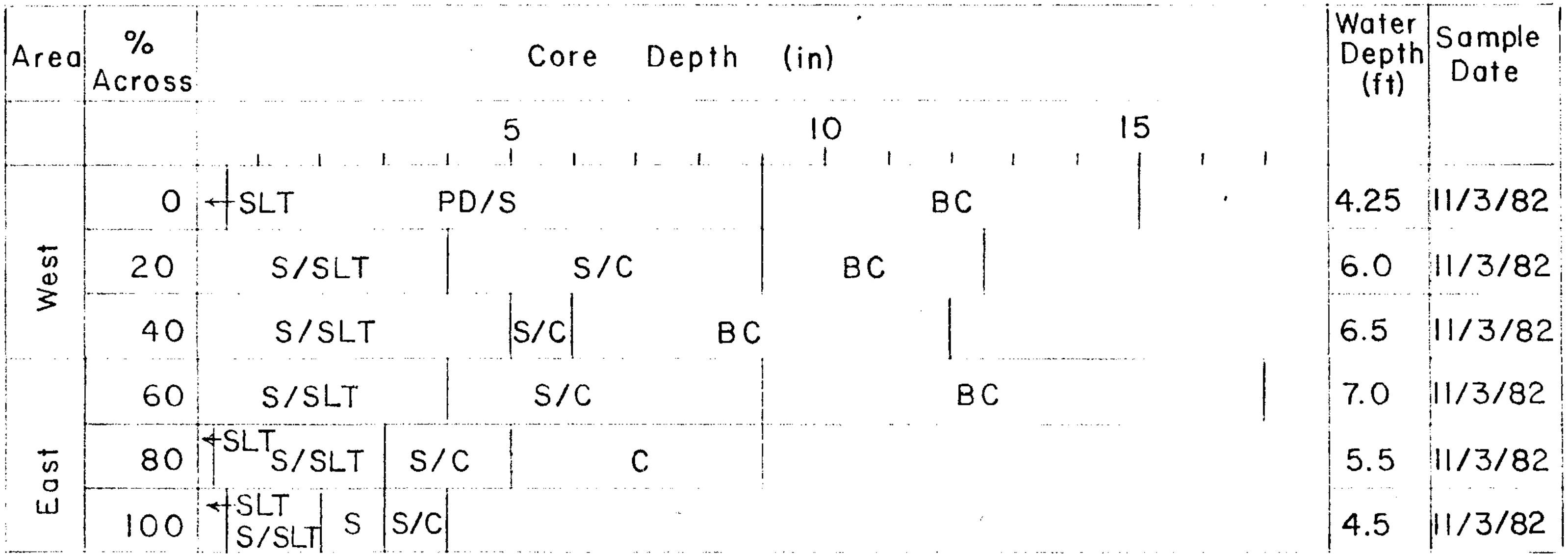
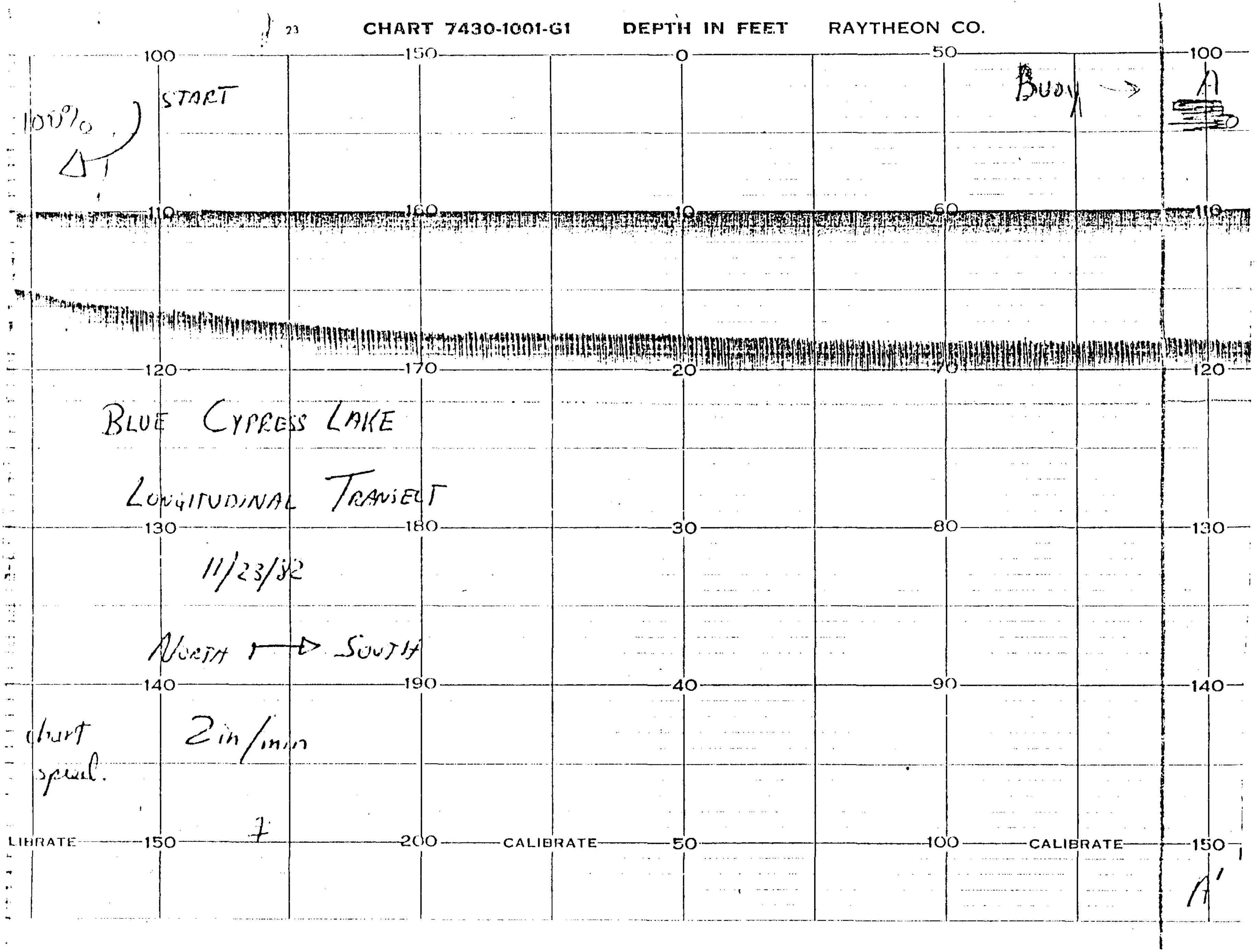


Figure D-18. Lake Poinsett – Transverse Transect

APPENDIX E

Bathymetric Profiles



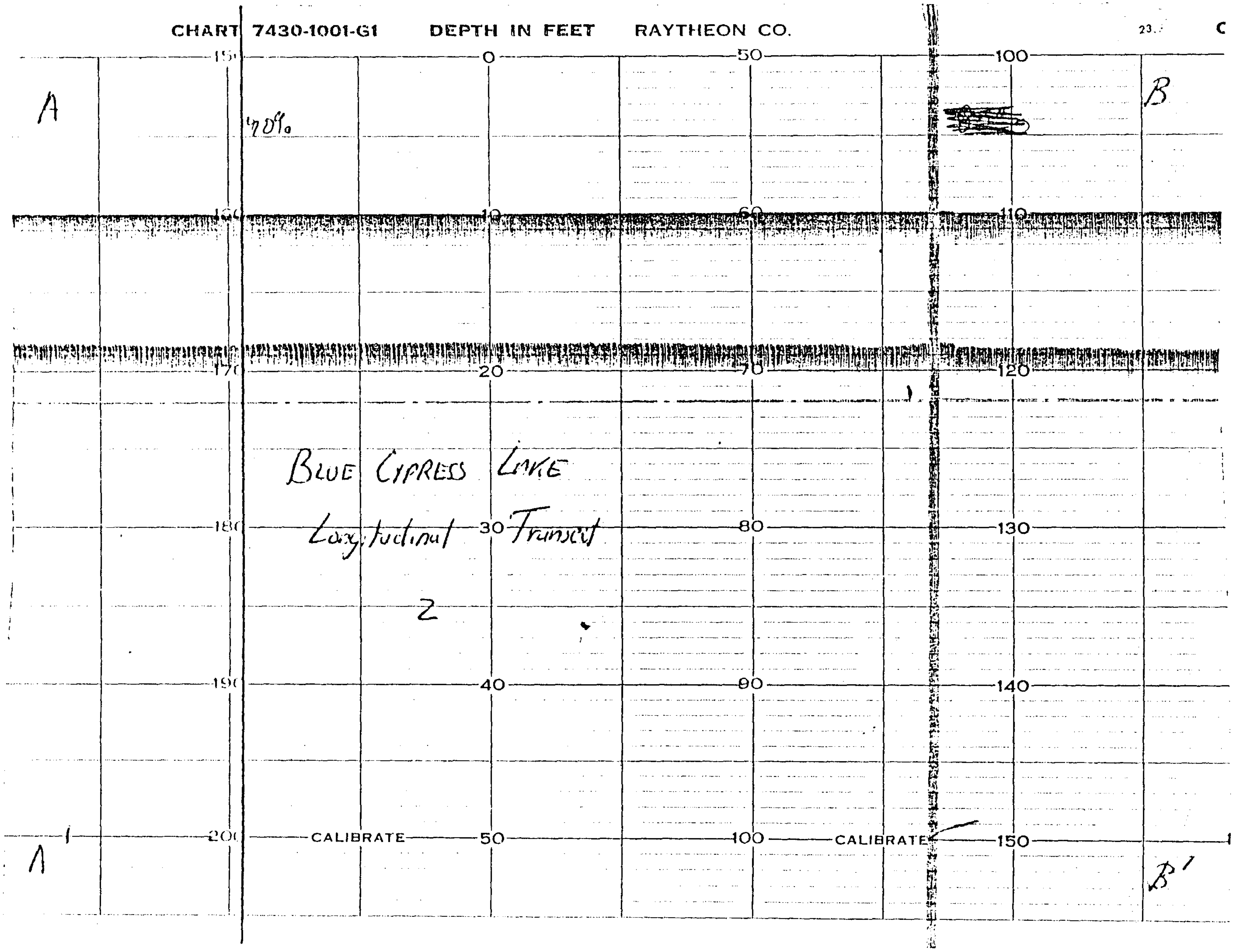
BLUE CYPRESS LAKE

LONGITUDINAL TRANSECT

11/23/82

NORTH → SOUTH

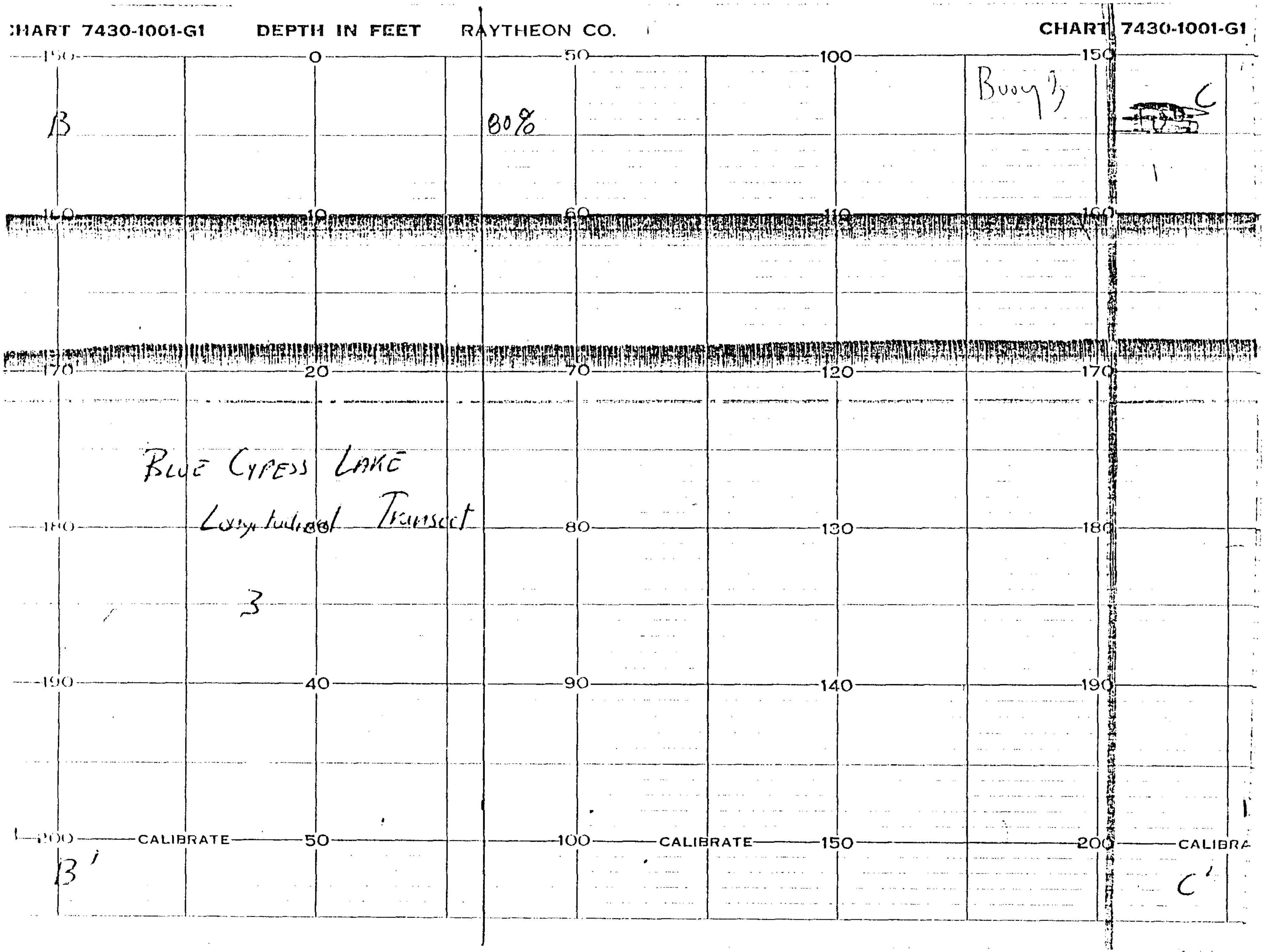
chart speed. 2in/min



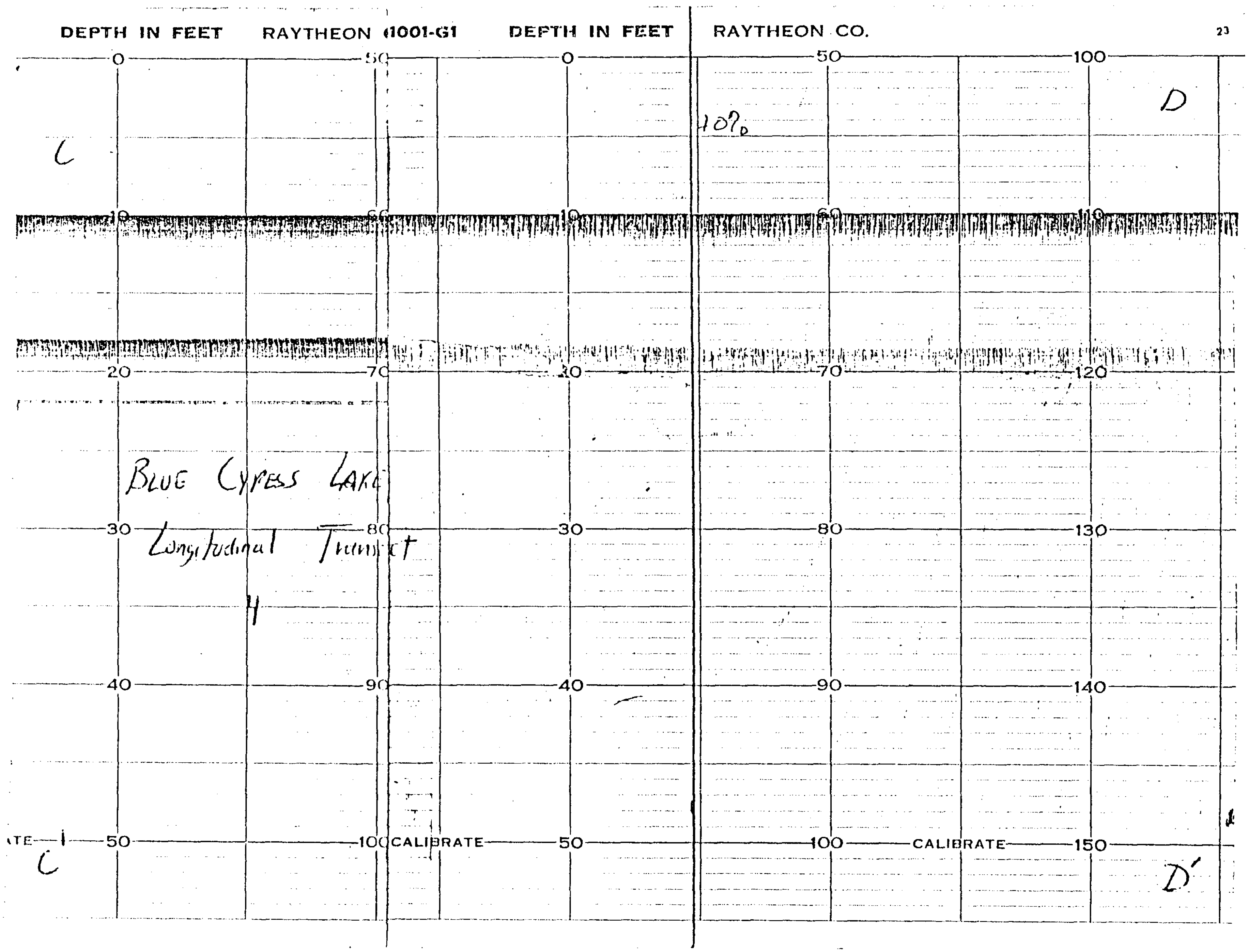
Blue Cypress Lake

Longitudinal Transect

2



Blue Cypress Lake
Longitudinal Transect
3

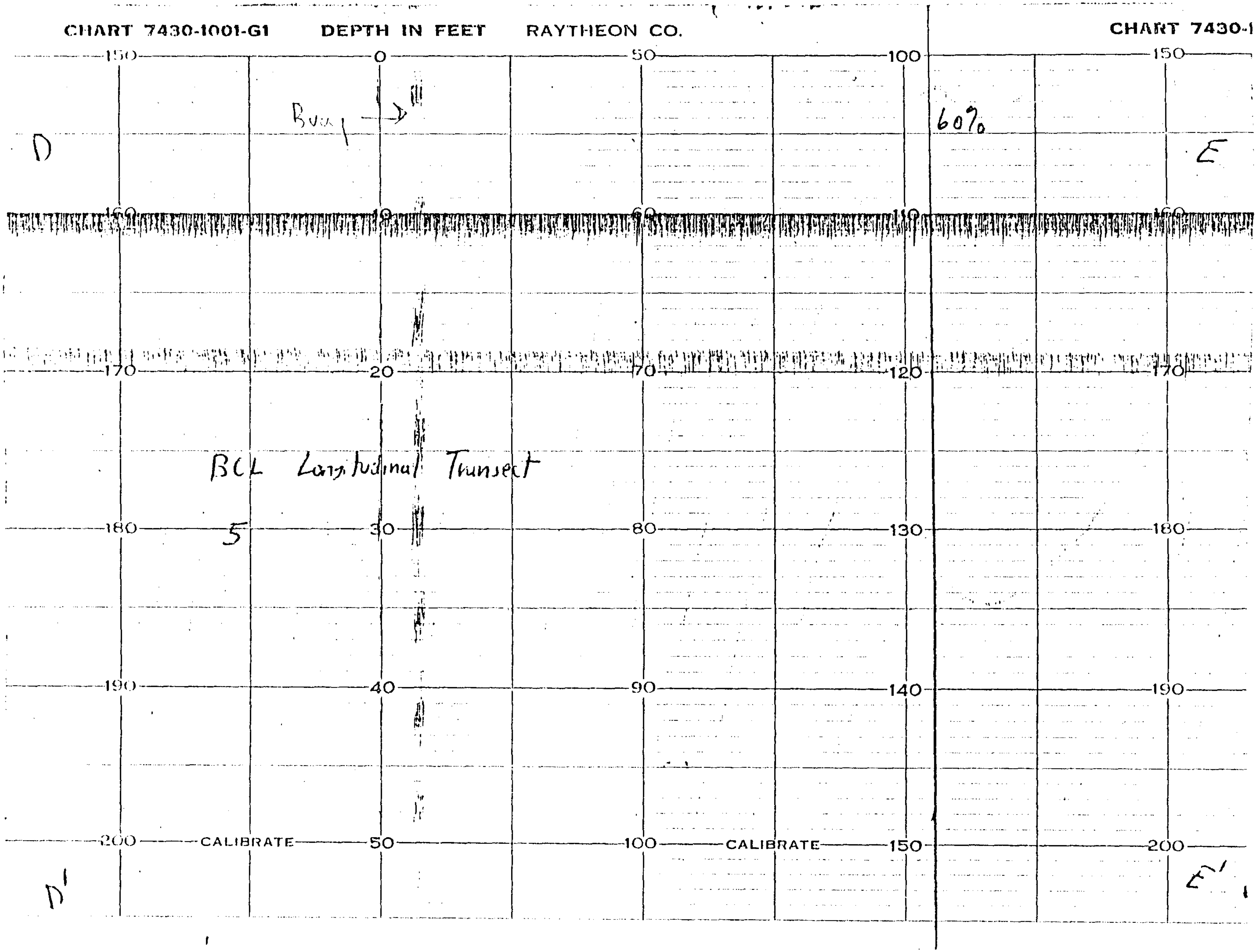


Blue Cypress Lake

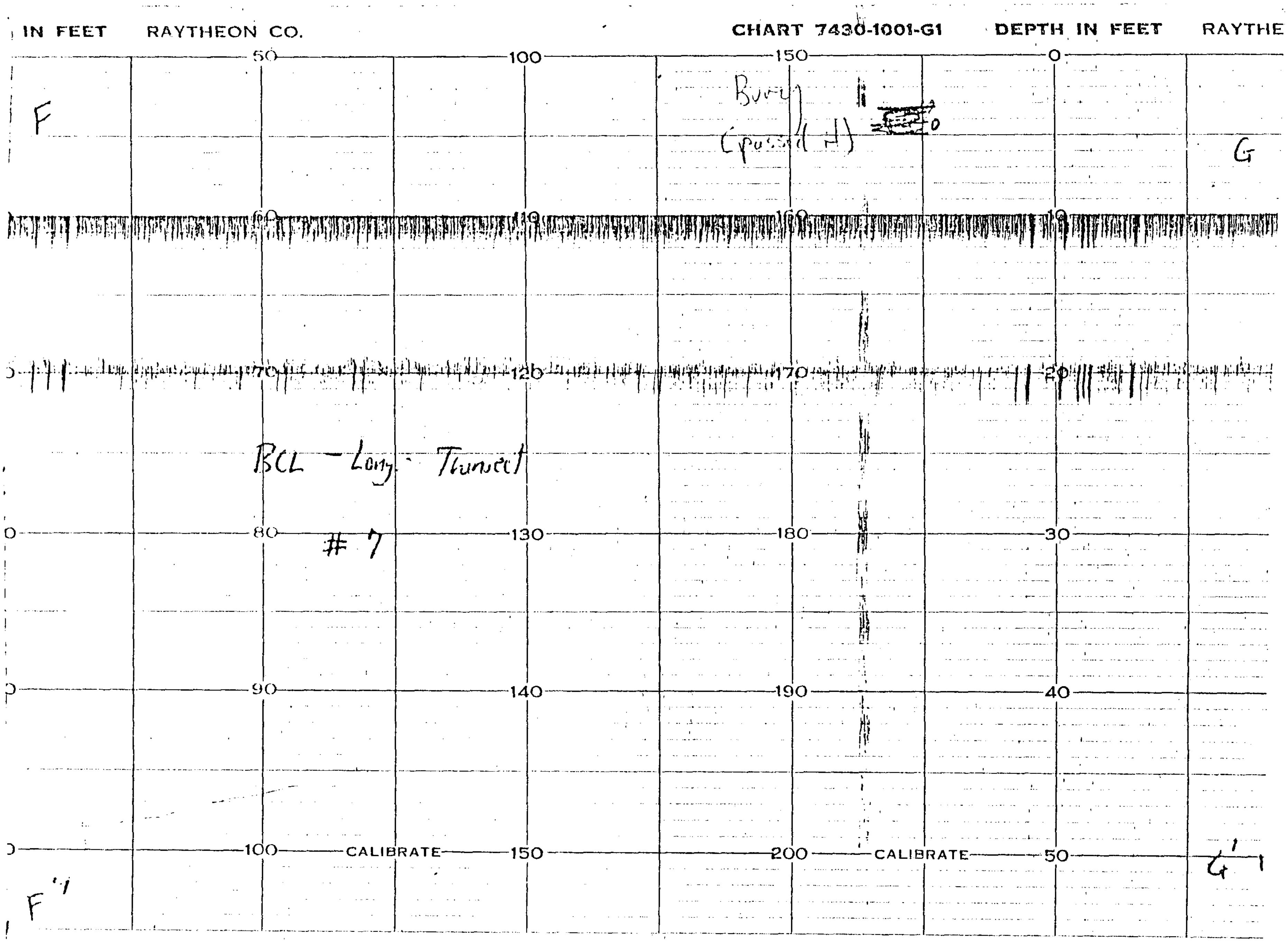
Longitudinal Transect

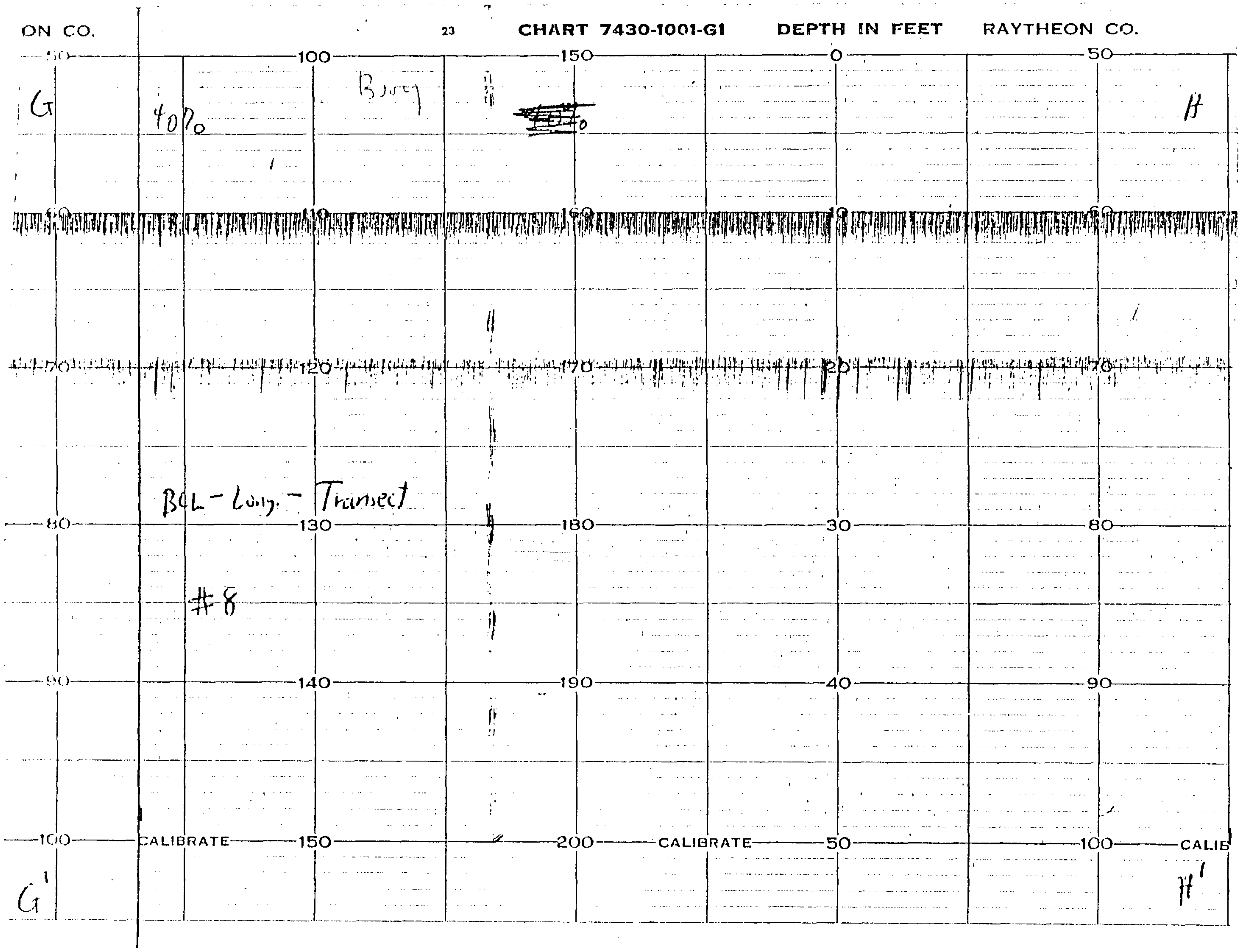
4

CHART 7430-1001-G1 DEPTH IN FEET RAYTHEON CO. CHART 7430-1



BCL Longitudinal Transect


IN FEET RAYTHEON CO.
CHART 7430-1001-G1
DEPTH IN FEET
RAYTHE
F
G
Buoy (passed it)
BCL - Long. Transect
7
F'
G'
50
100
150
0
60
110
160
10
70
120
170
20
80
130
180
30
90
140
190
40
100
CALIBRATE
150
200
CALIBRATE
50



G

40%

Buoy

~~40%~~

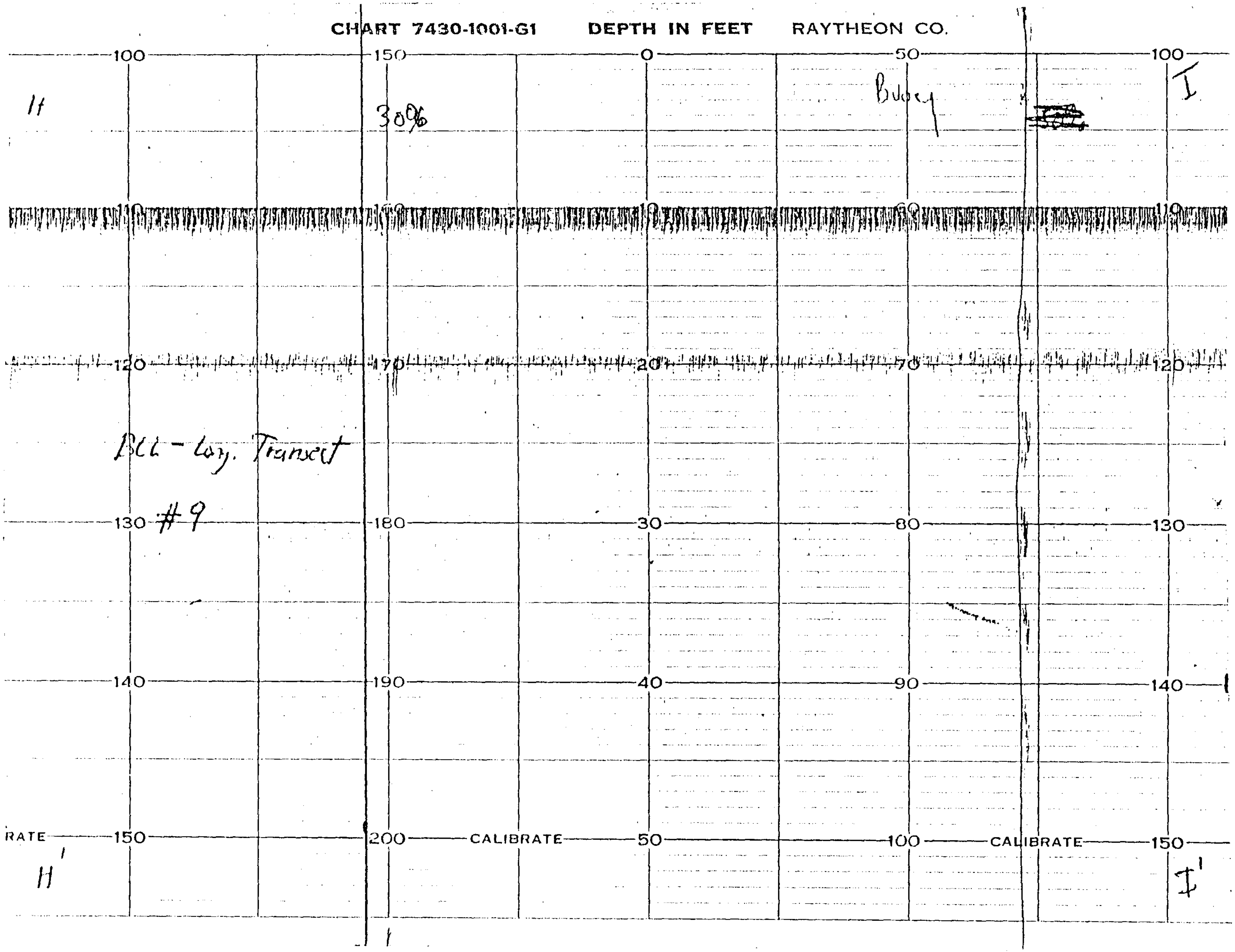
H

BCL - Long. - Transect

#8

G'

H'



H

30%

Buoy

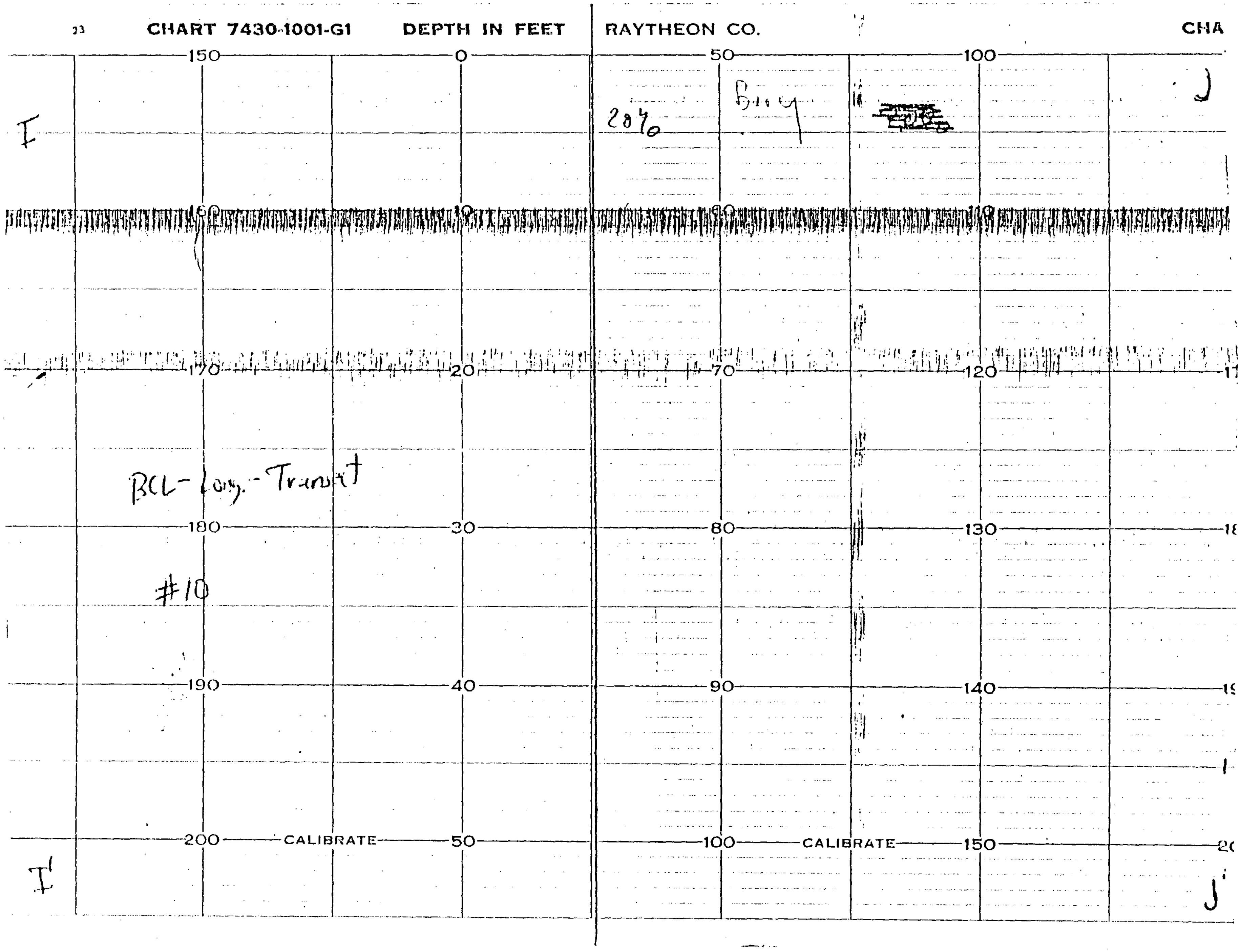
I

BCL - Lay. Transect

#9

H'

I'



I

J

20%

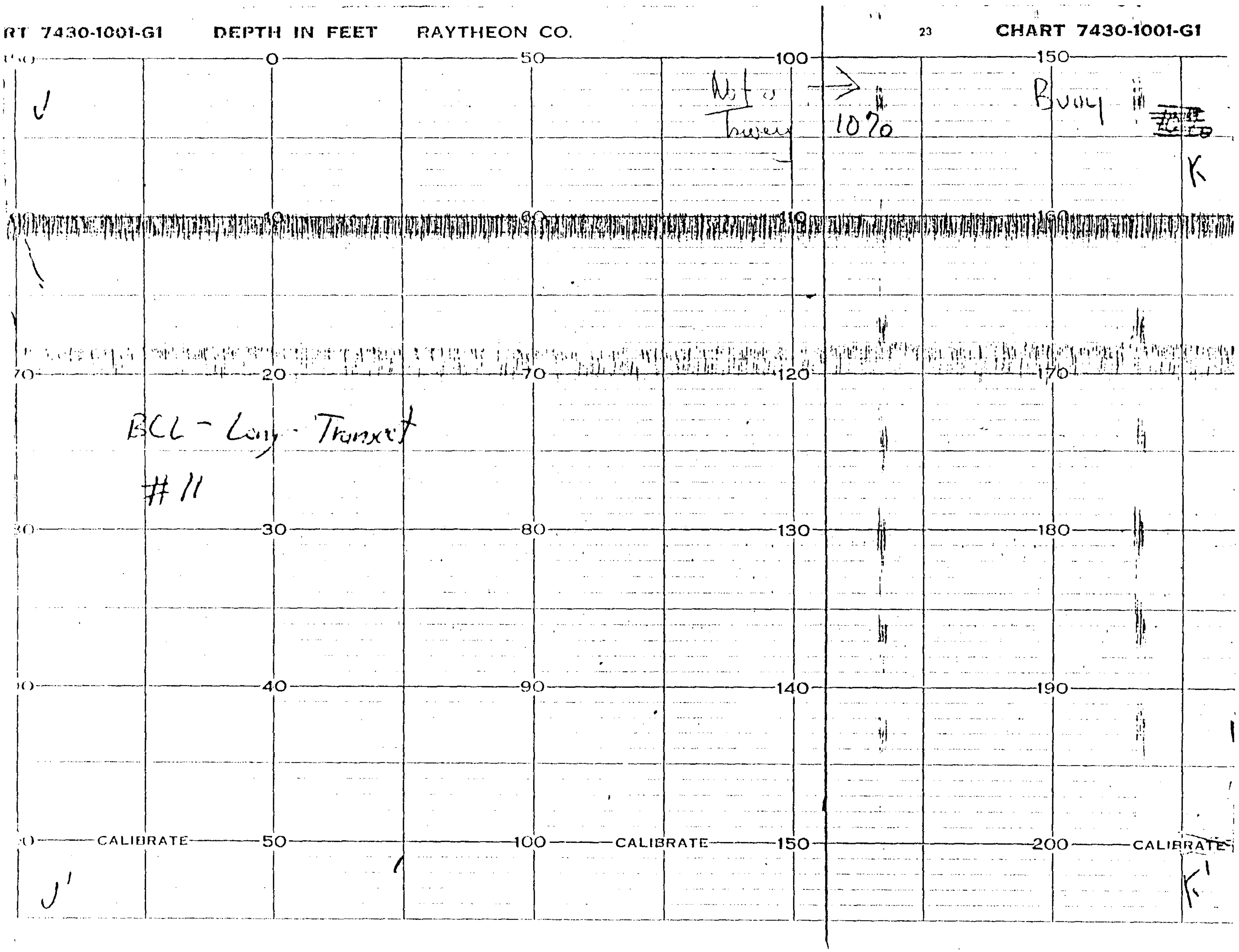
Bay

BCL- Long- Transect

#10

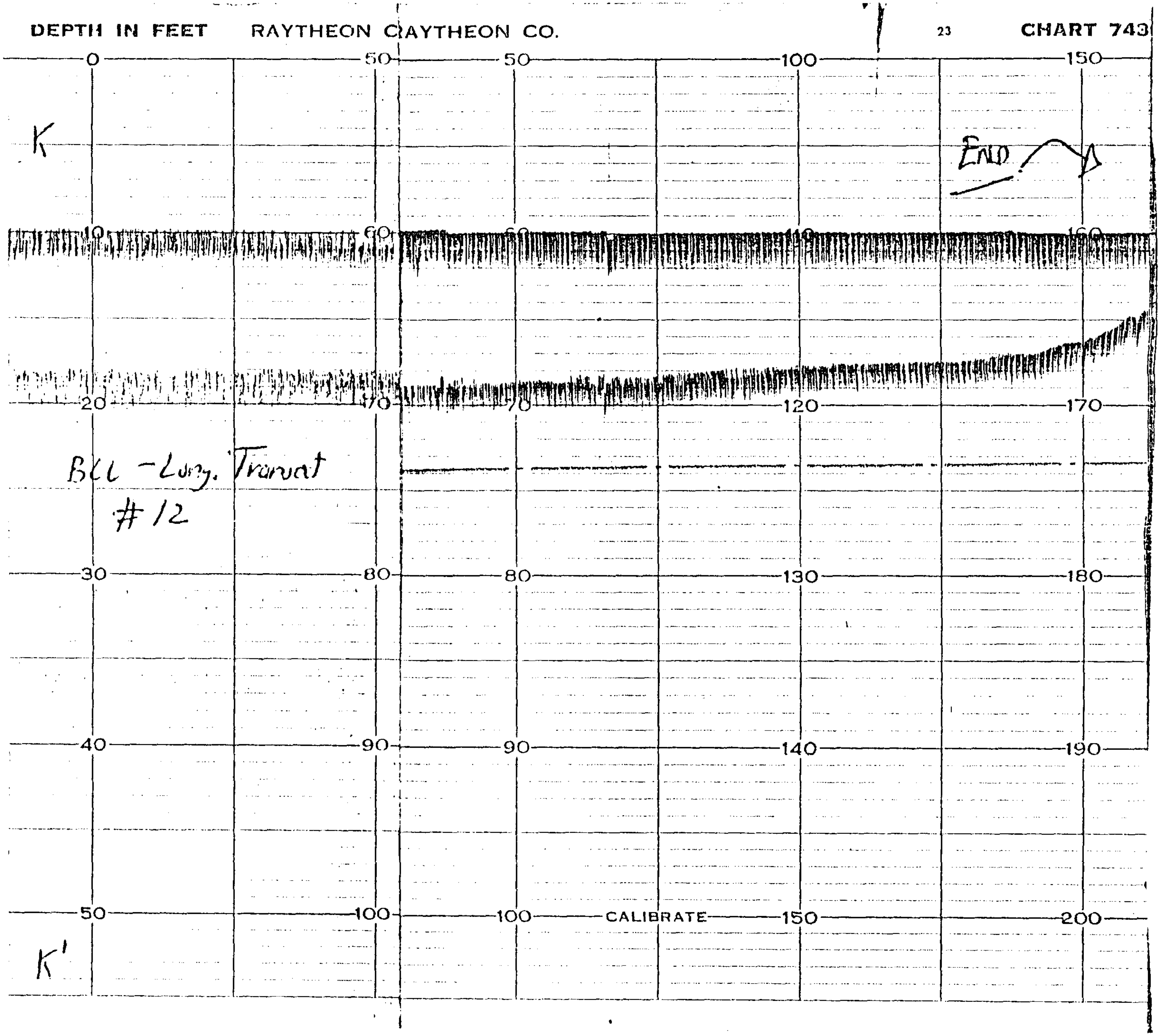
I'

J'



BCL - Long - Transect

#11

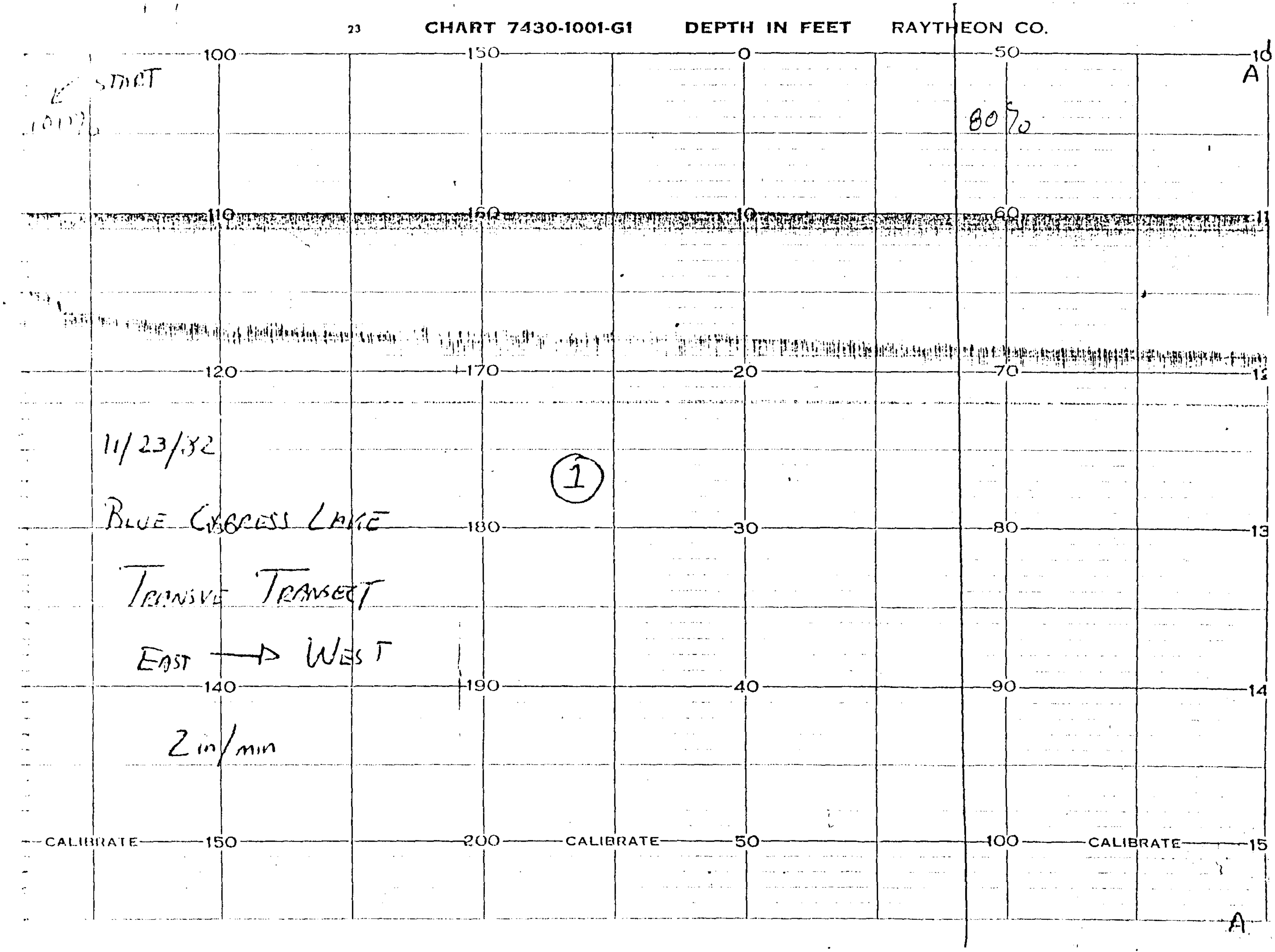


K

END

BLL - Long. Transect
#12

K'



start

100%

80%

11/23/82

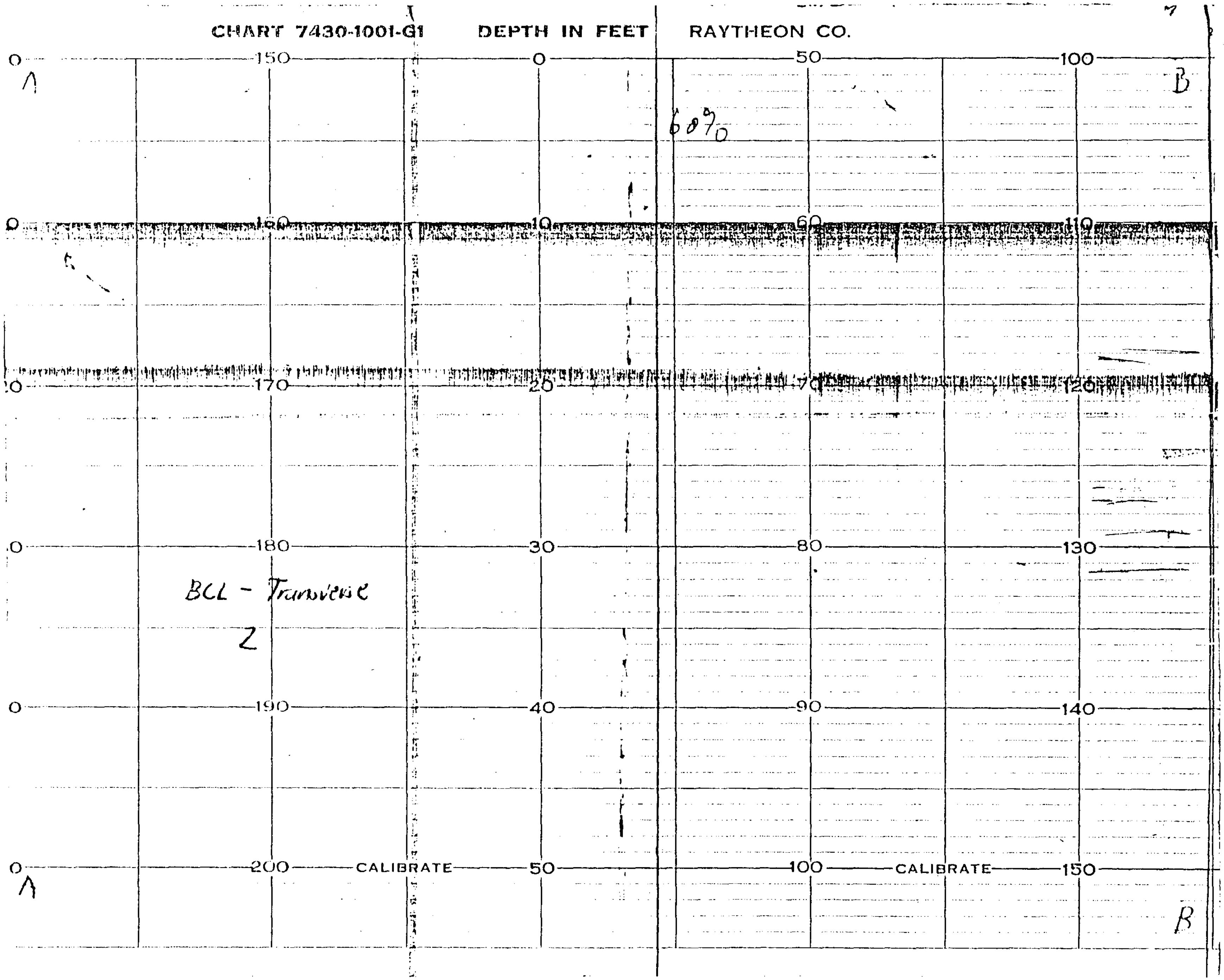
①

Blue Cypress Lake

Transve Transect

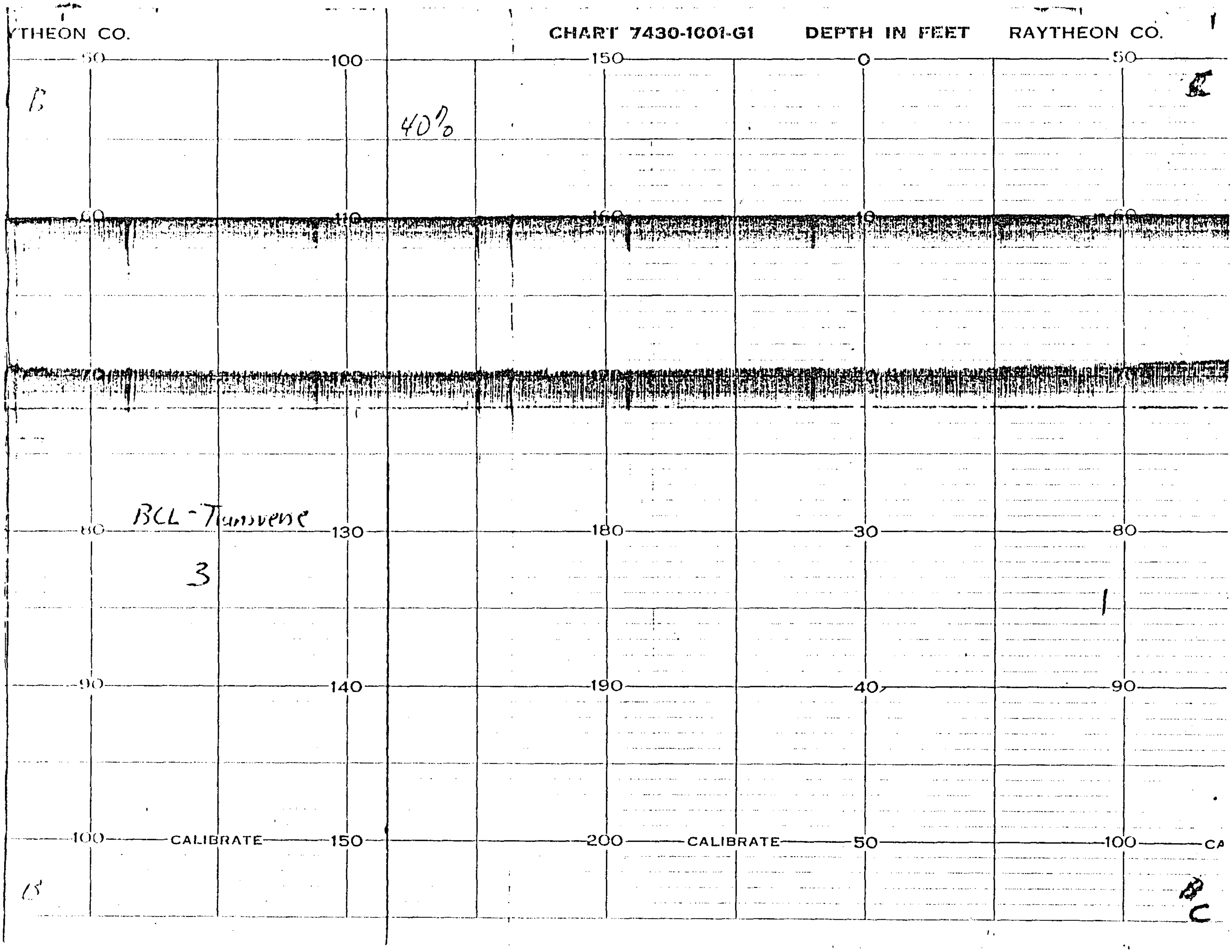
East → West

2 in/min



BCL - Transverse

2



B

40%

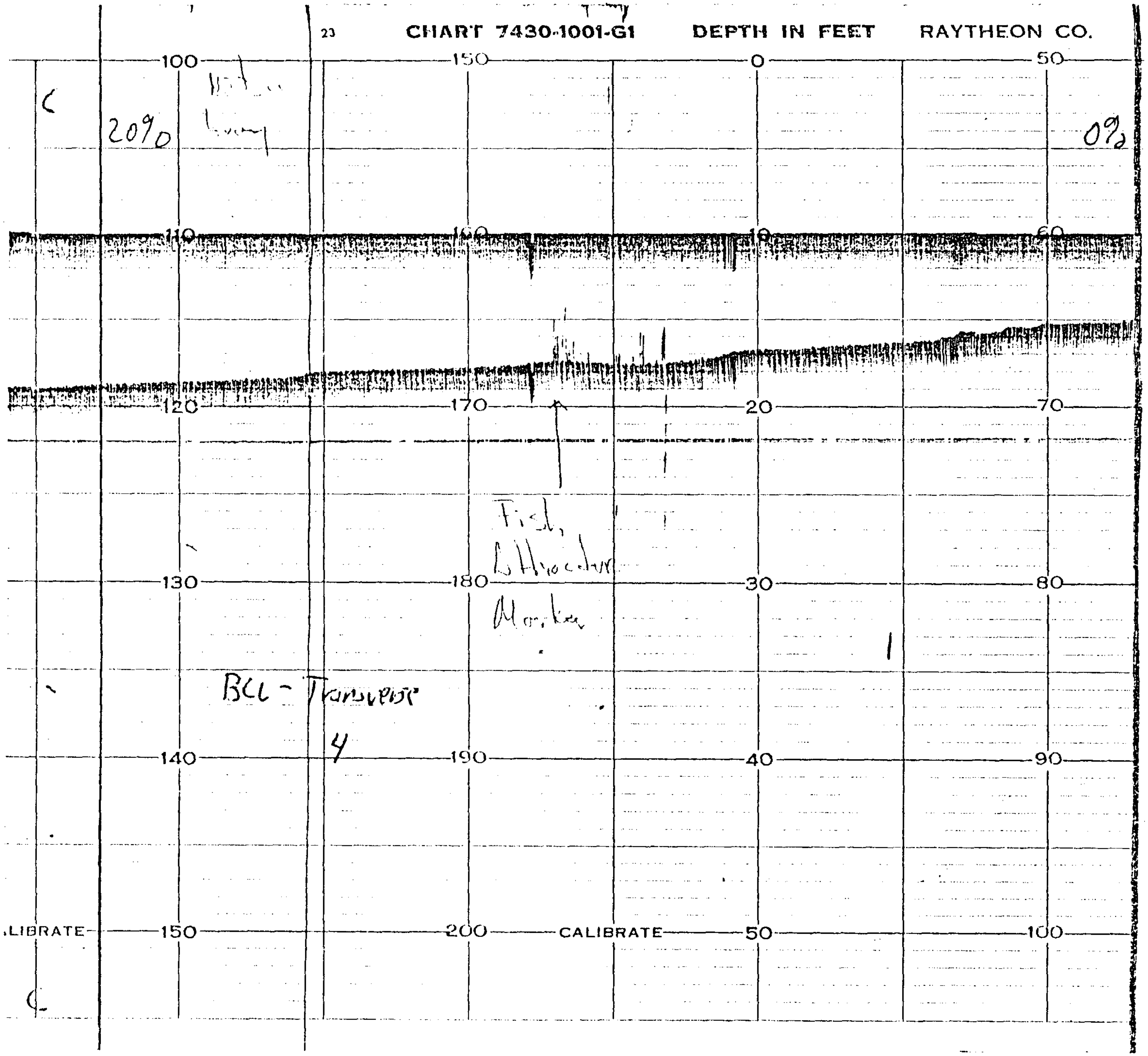
BCL-Transverse

3

1

B

C



C

20%

[illegible]

0%

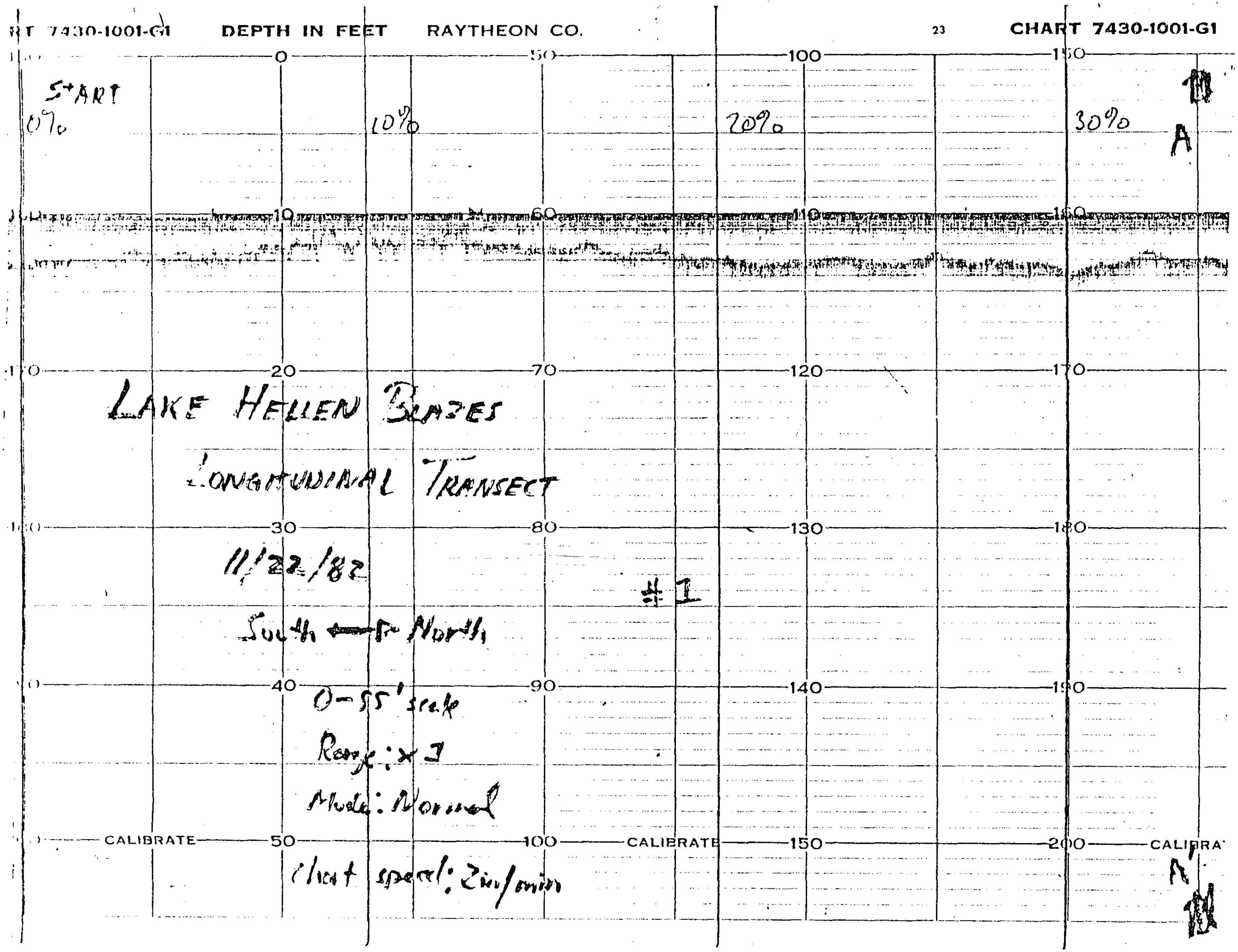
Fish, Whitecedar Marker

BCL - Transverse

4

1

C



START
0%

10%

20%

30%

A

LAKE HELLEN BLAZES

LONGITUDINAL TRANSECT

11/22/82

#I

South ⟵ North

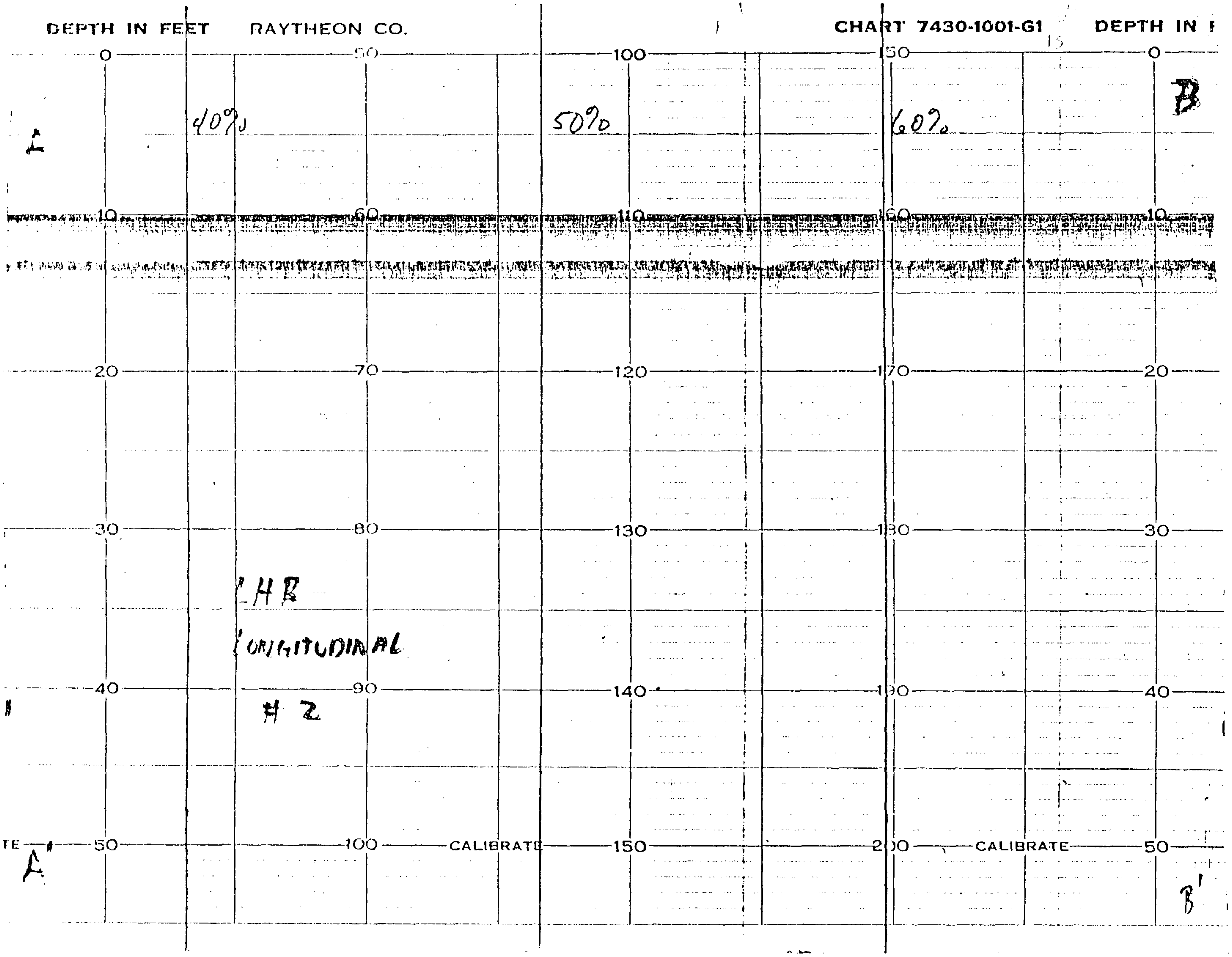
0–55' scale

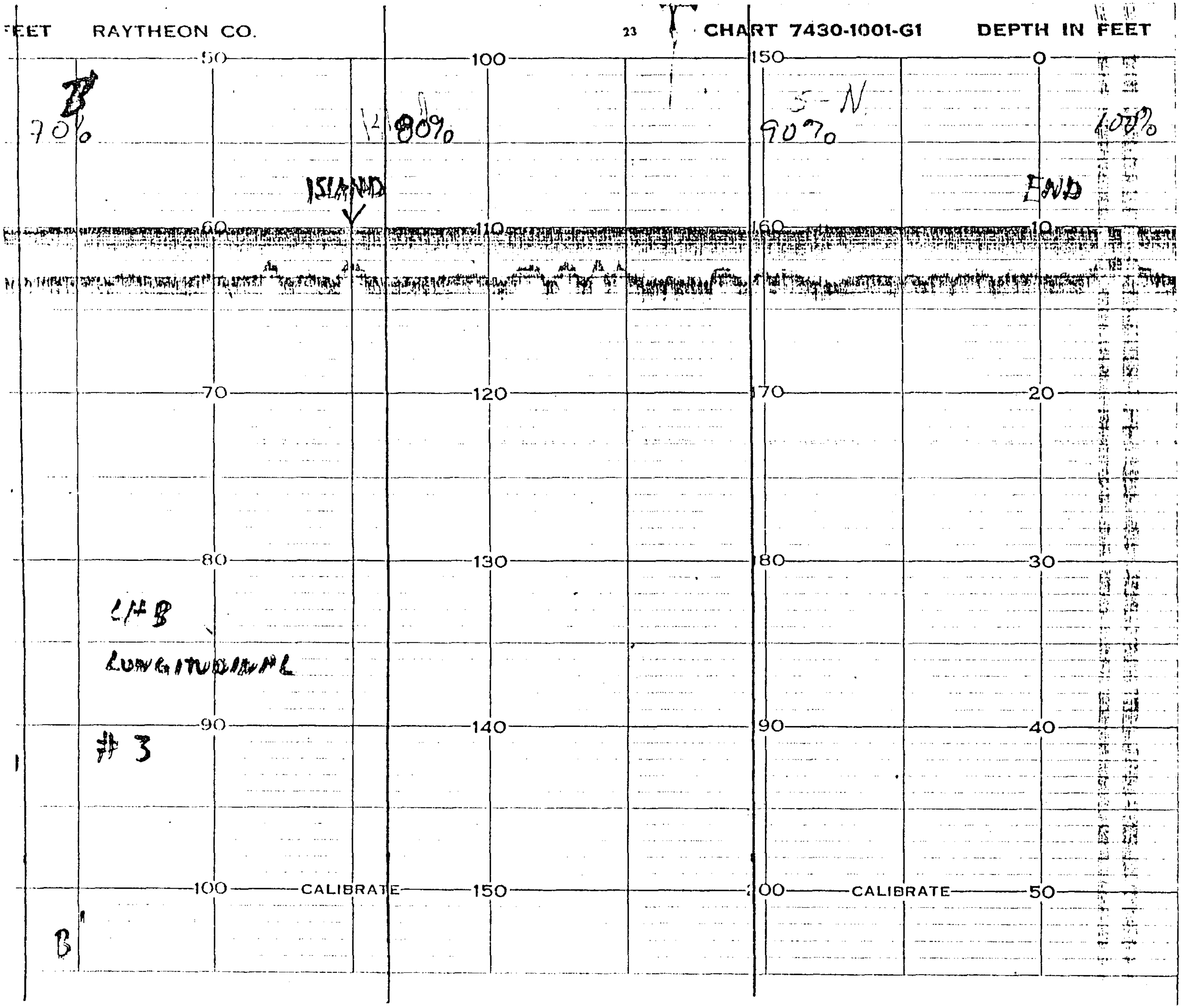
Range: x I

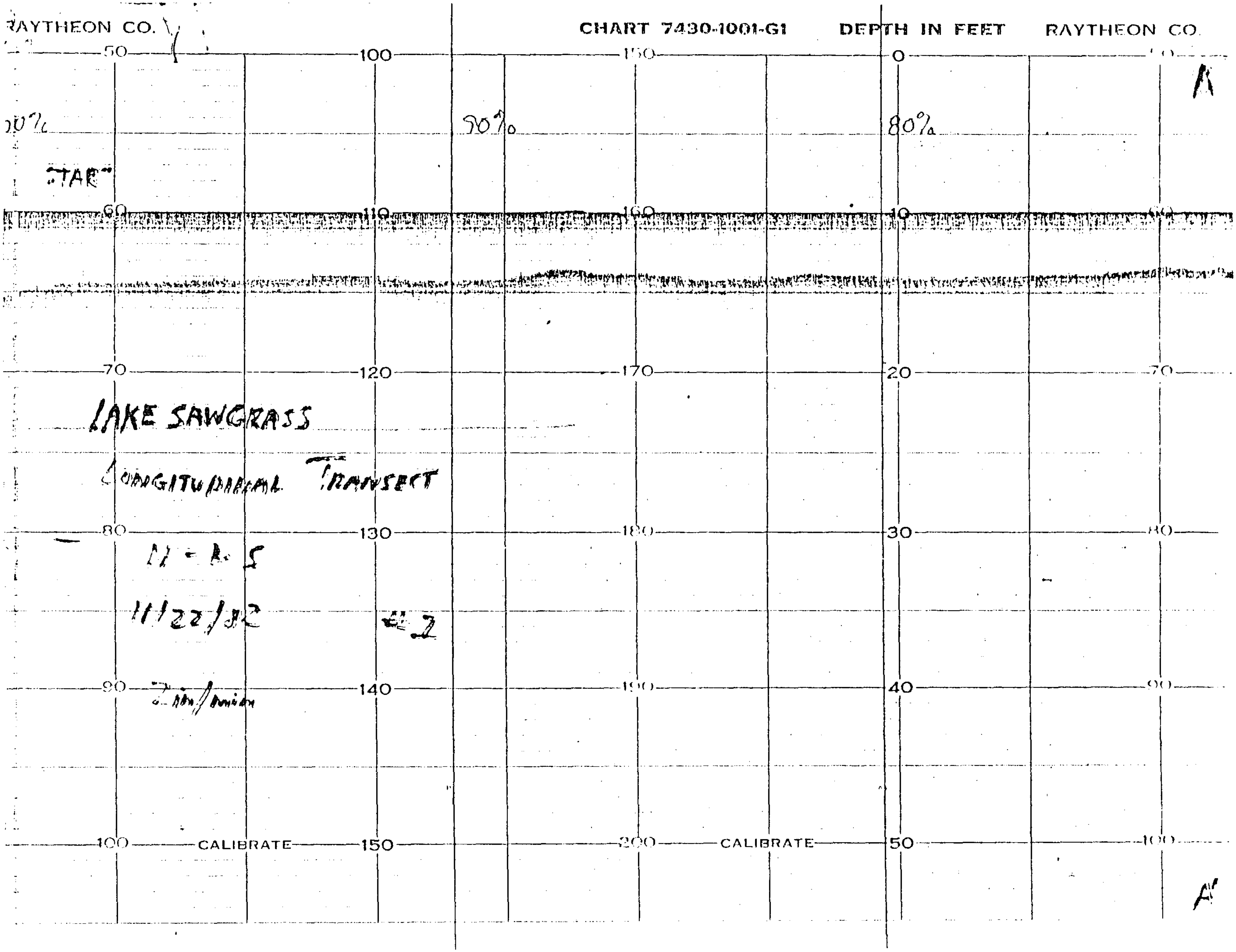
Mode: Normal

Chart speed: 2in/min

A


DEPTH IN FEET
RAYTHEON CO.
CHART 7430-1001-G1
DEPTH IN F
0
50
100
150
0
10
60
110
160
10
20
70
120
170
20
30
80
130
180
30
40
90
140
190
40
50
100
CALIBRATE
150
200
CALIBRATE
50
40%
50%
60%
A
B
CHB
LONGITUDINAL
2
A'
B'


FEET
RAYTHEON CO.
23
CHART 7430-1001-G1
DEPTH IN FEET
50
100
150
0
B
70%
80%
5-N
90%
100%
ISLAND
END
60
110
160
10
70
120
170
20
80
130
180
30
L+B
LONGITUDINAL
90
140
190
40
#3
100
CALIBRATE
150
200
CALIBRATE
50
B'



LAKE SAWGRASS

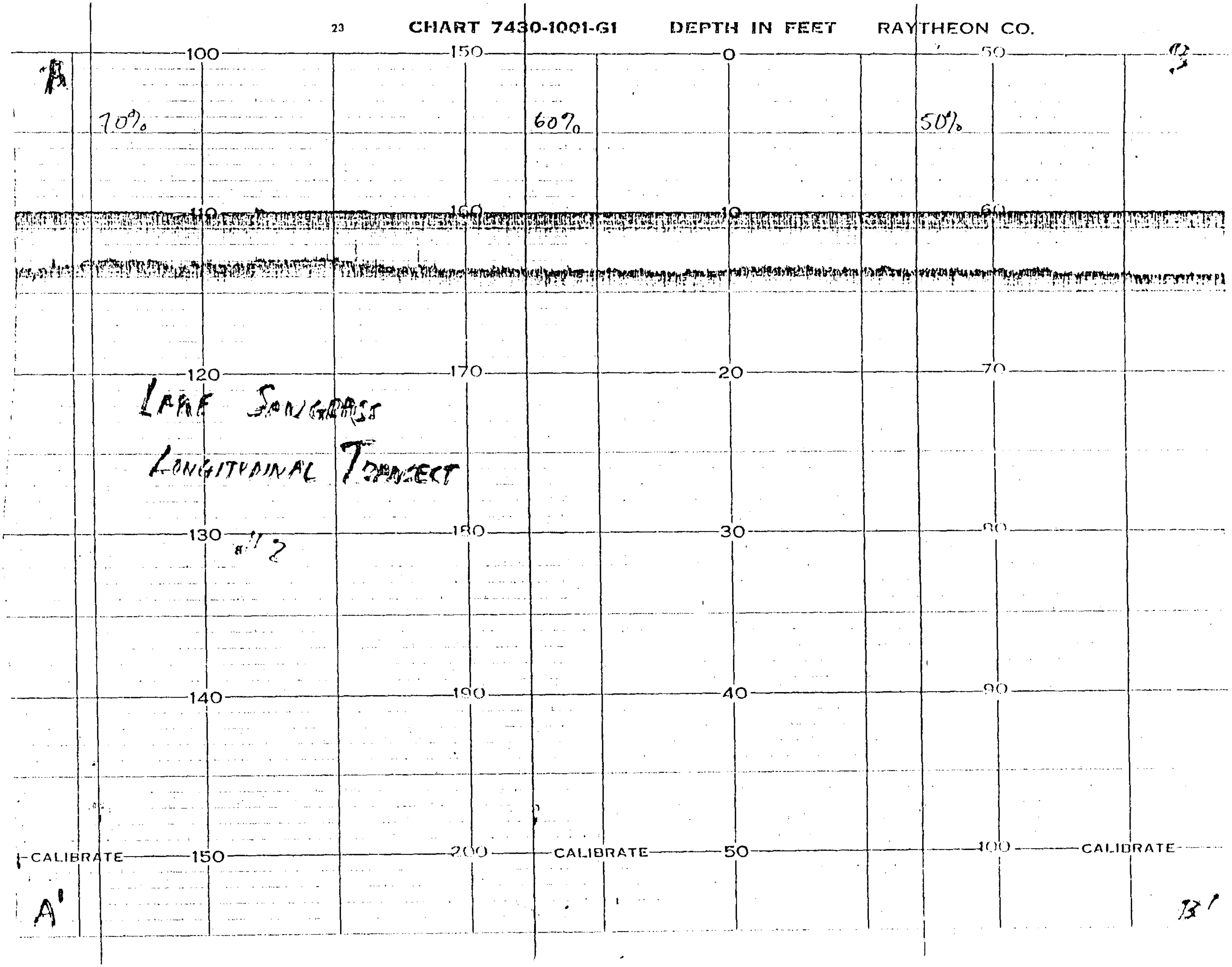
LONGITUDINAL TRANSECT

11 - A 5

11/22/82

#2

2 in/min



LAKE SAWGRASS
LONGITUDINAL TRANSECT
#2

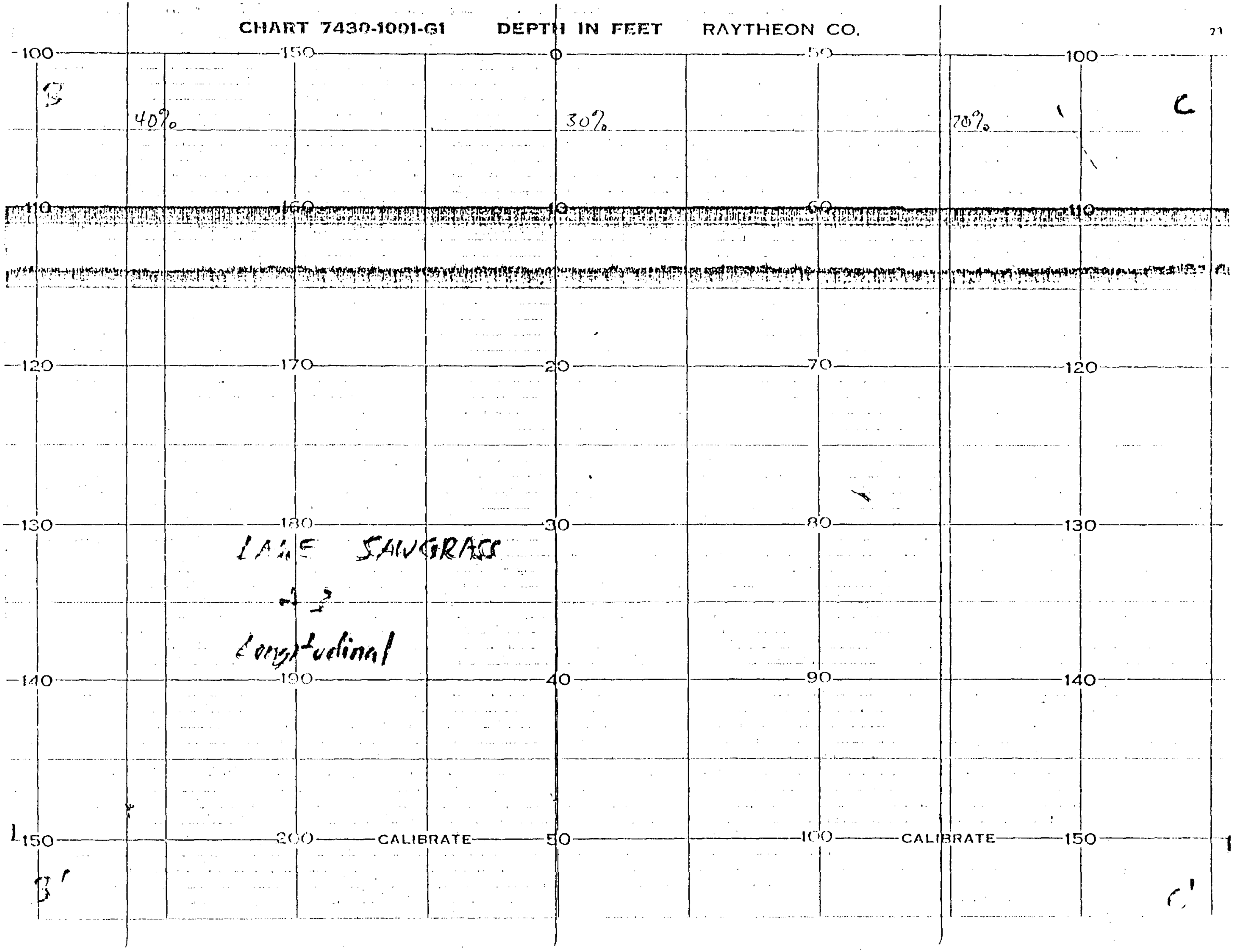
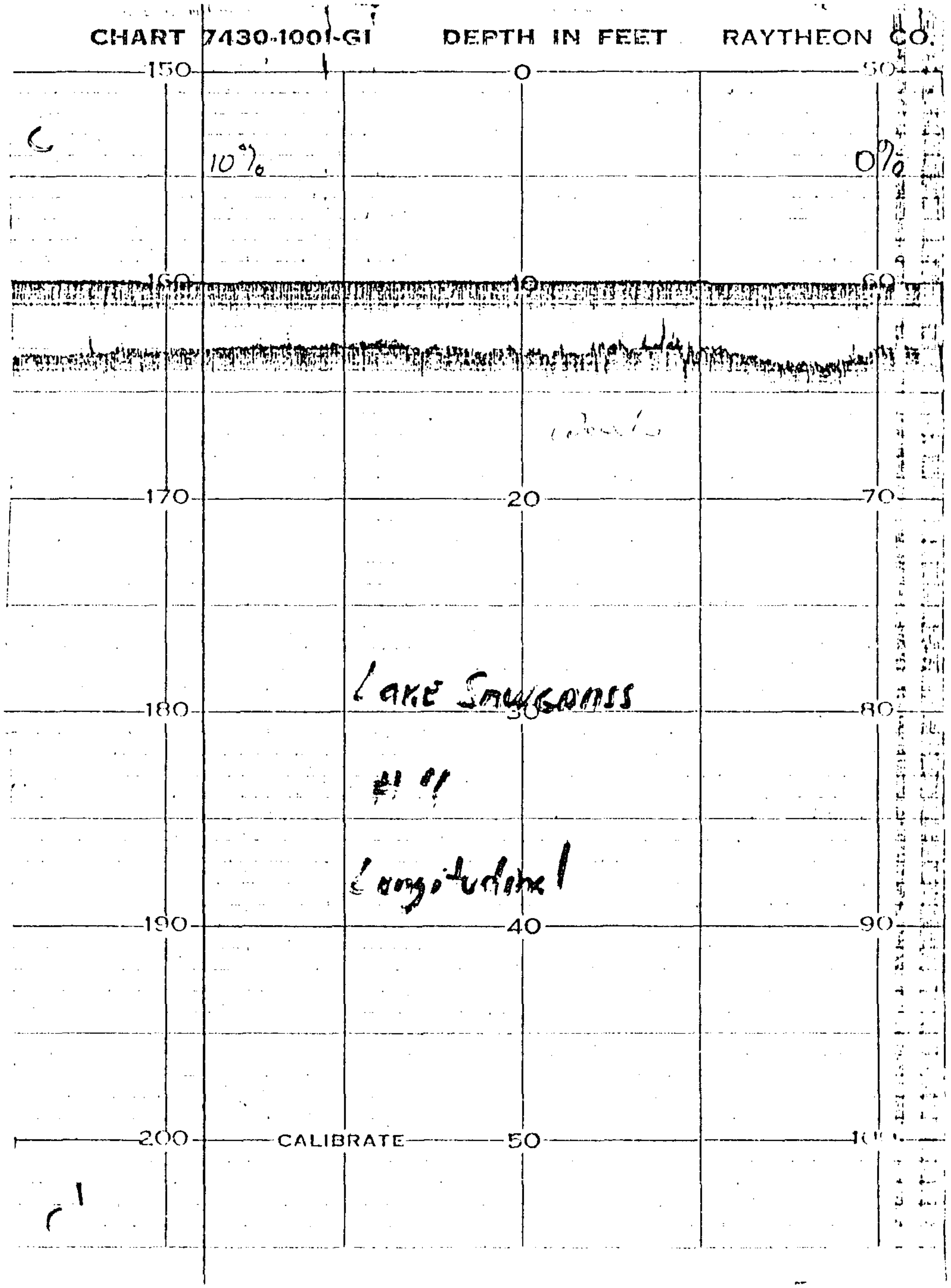


CHART 7430-1001-G1 DEPTH IN FEET RAYTHEON CO.
23
100
150
0
50
100
110
160
10
60
110
120
170
20
70
120
130
180
30
80
130
140
190
40
90
140
150
200
CALIBRATE
50
100
CALIBRATE
150
B
40%
30%
70%
C
B'
C'
LAKE SAWGRASS
←→
Longitudinal



10%

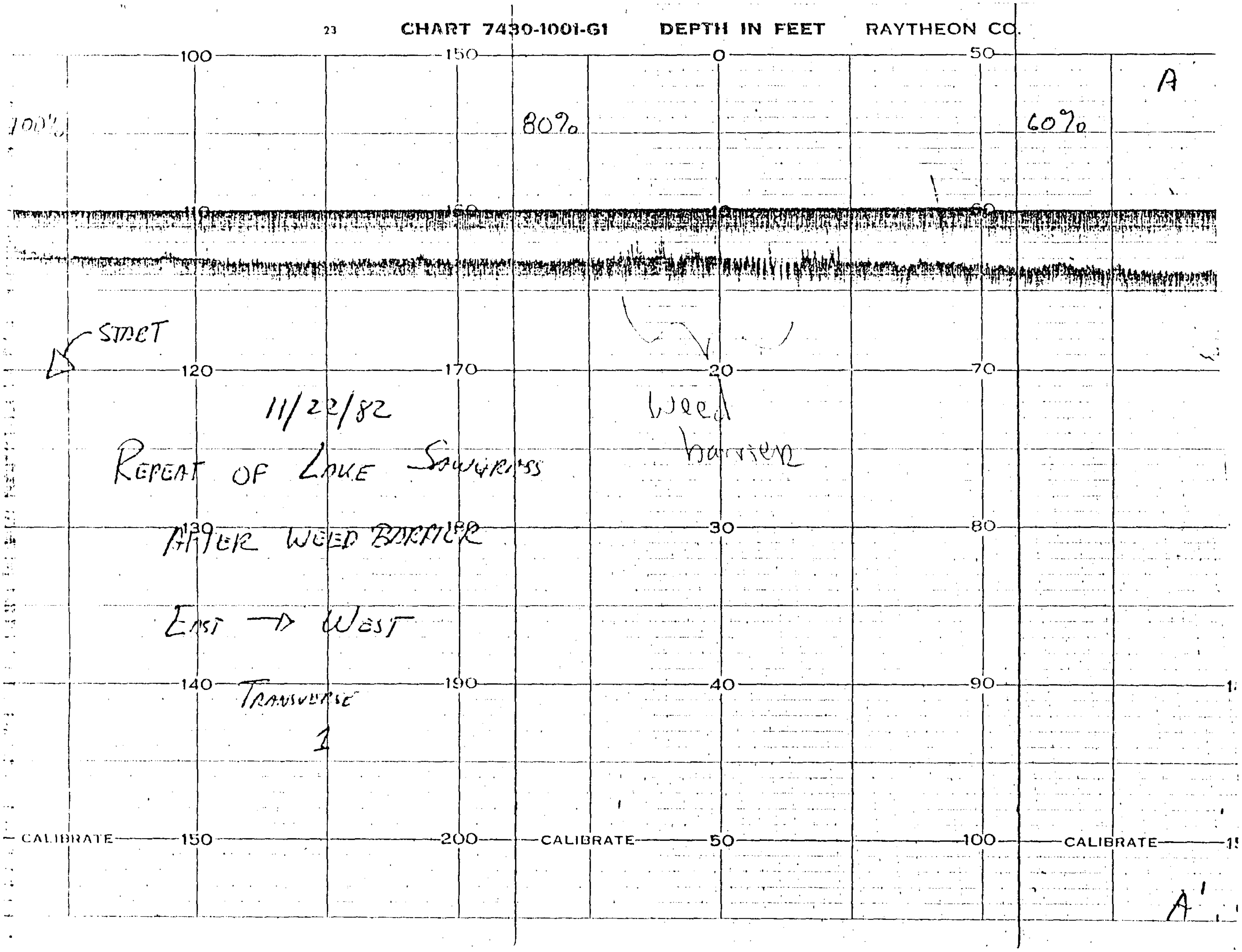
0%

Lake Sawgrass

#4

Longitudinal

23 CHART 7430-1001-G1 DEPTH IN FEET RAYTHEON CO.



11/22/82

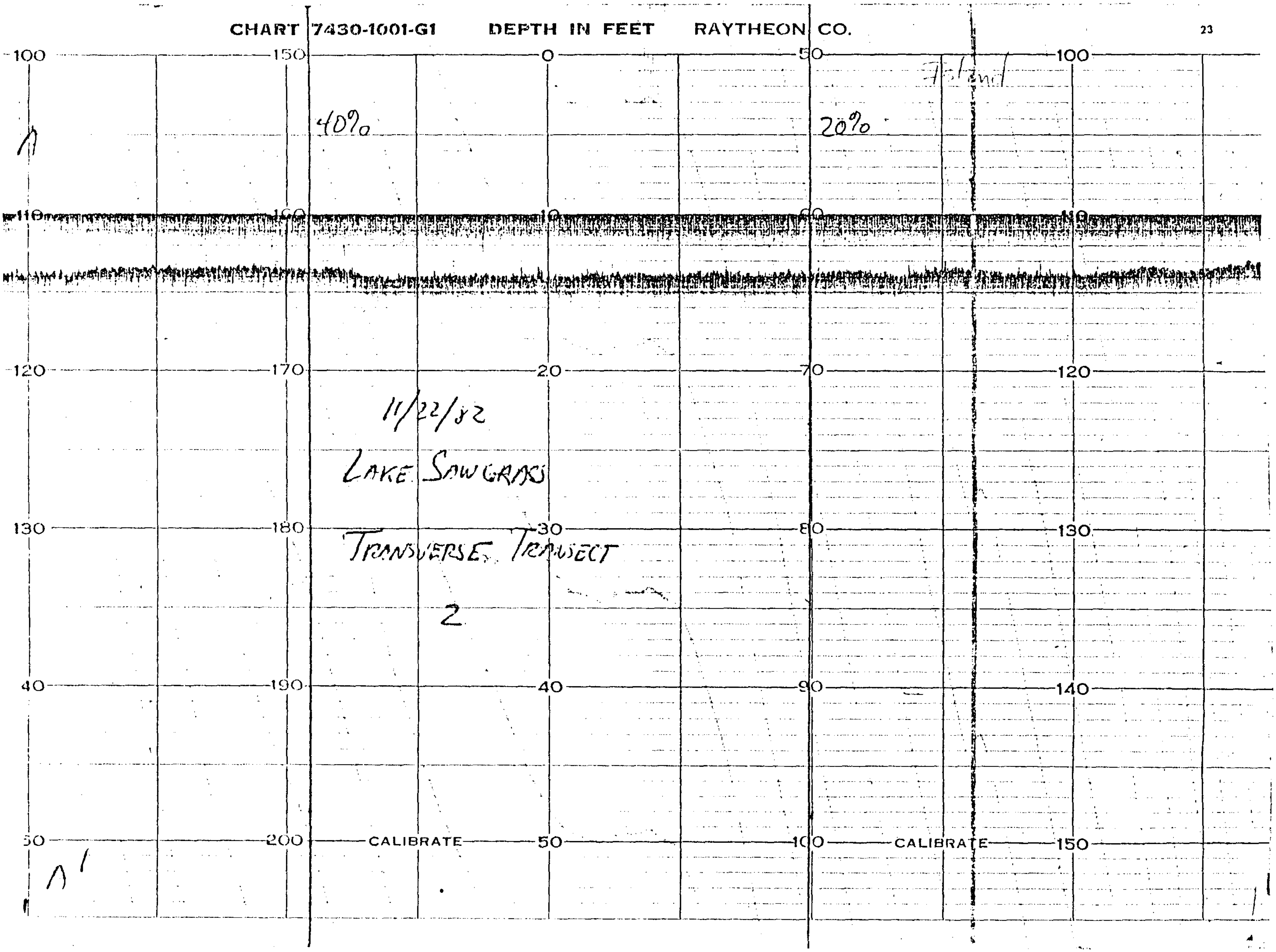
REPEAT OF LAKE SAWGRASS

AFTER WEED BARRIER

EAST → WEST

TRANSVERSE

1

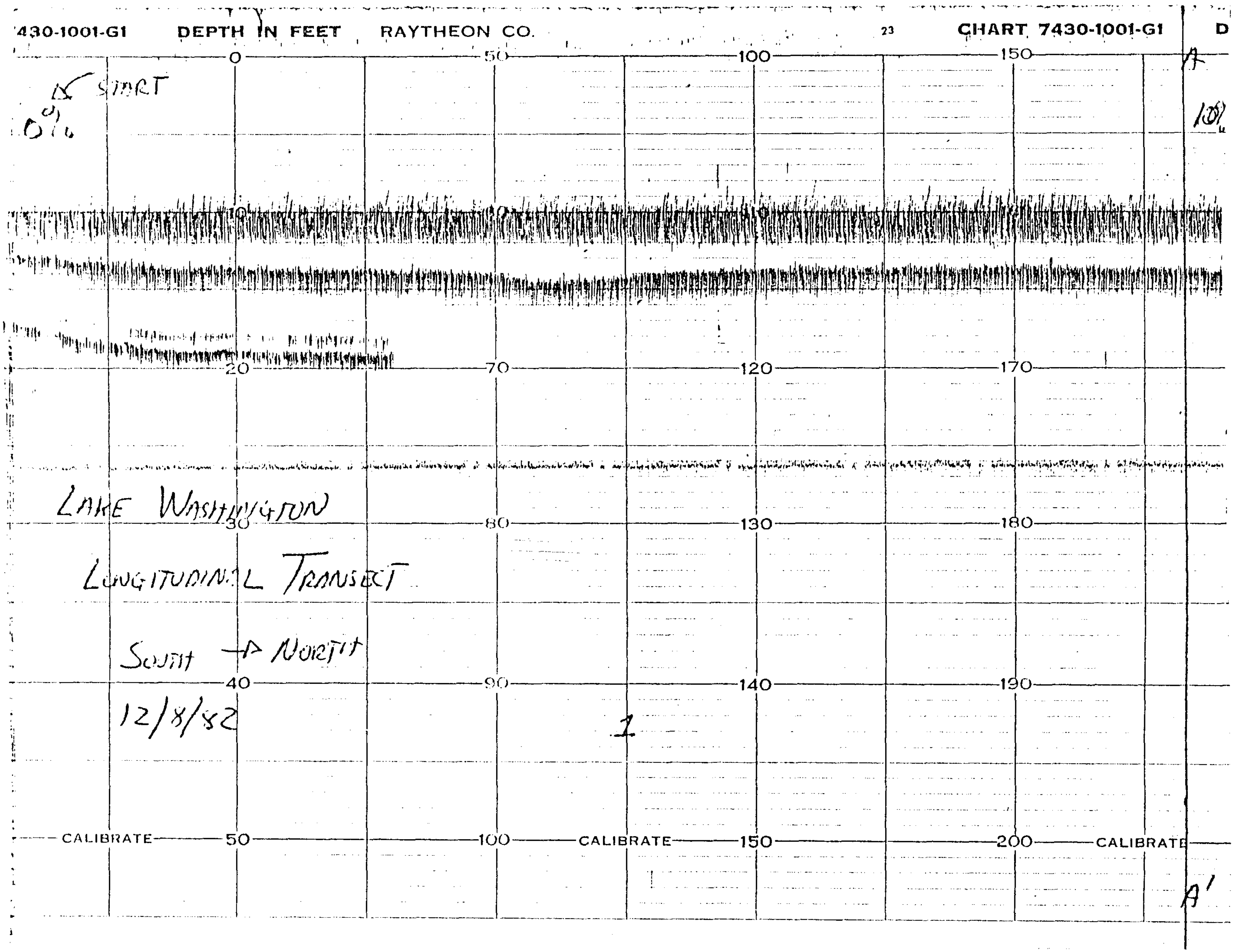


11/22/82

Lake Sawgrass

Transverse Transect

2



START
0%

10%

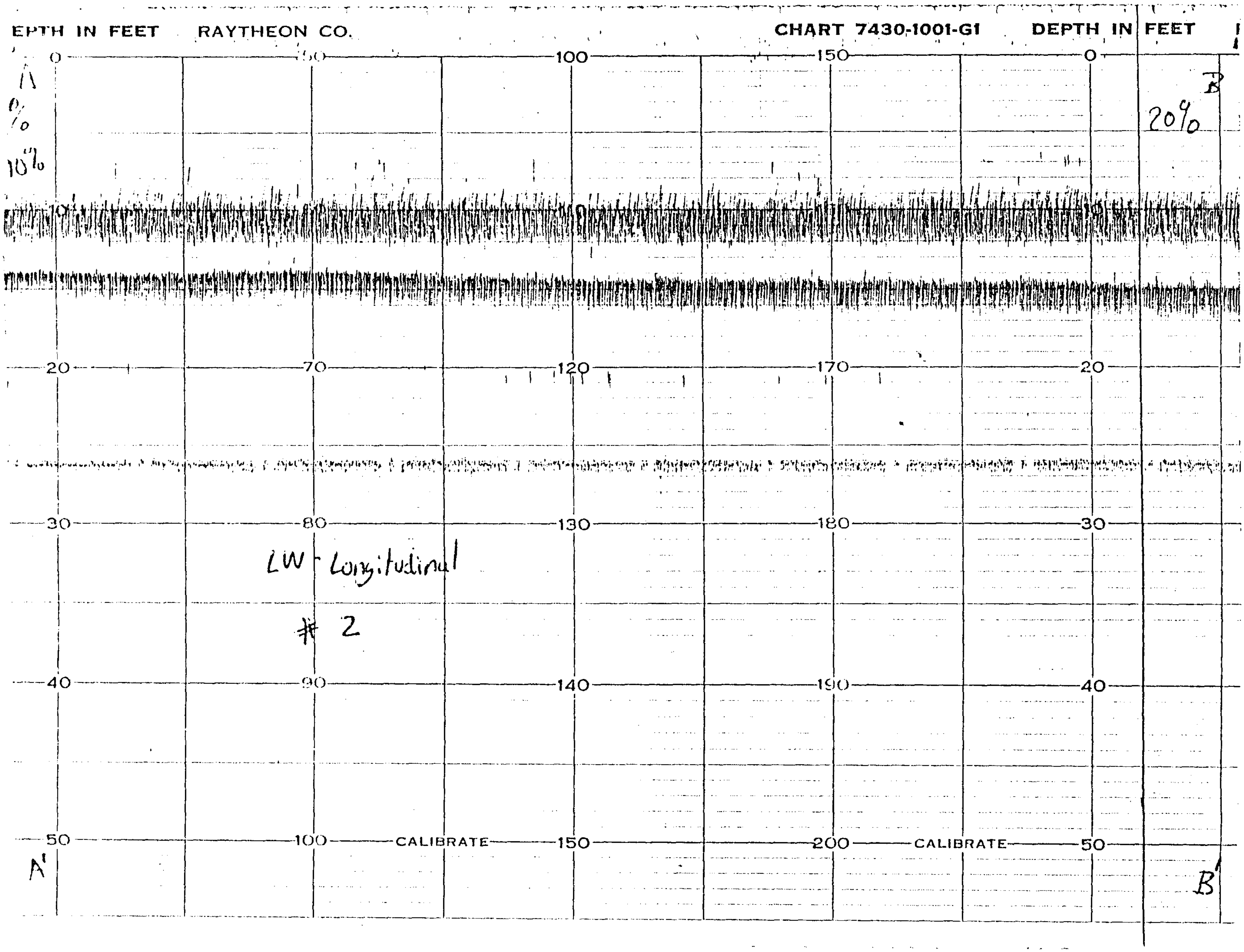
LAKE WASHINGTON

LONGITUDINAL TRANSECT

SOUTH → NORTH

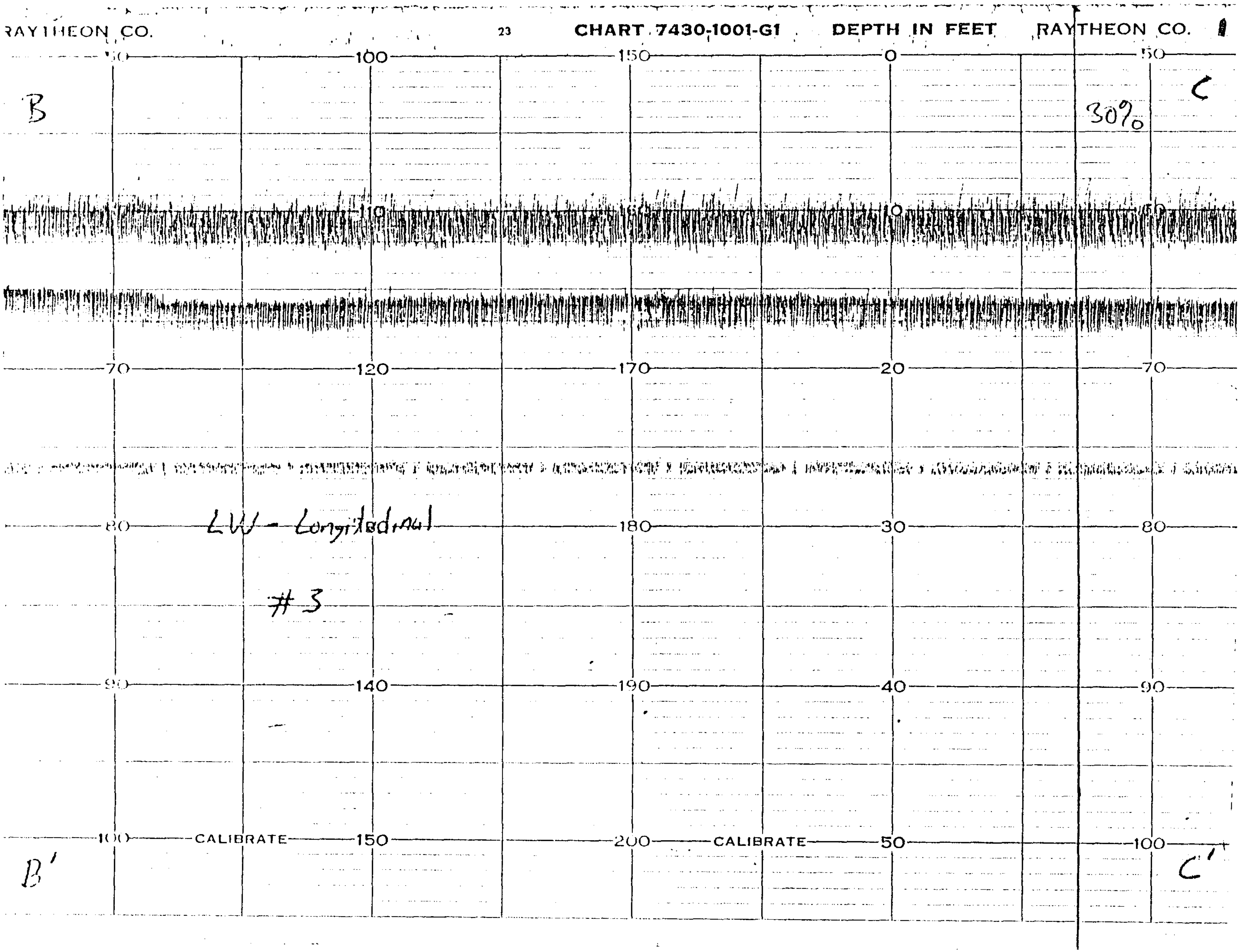
12/8/82

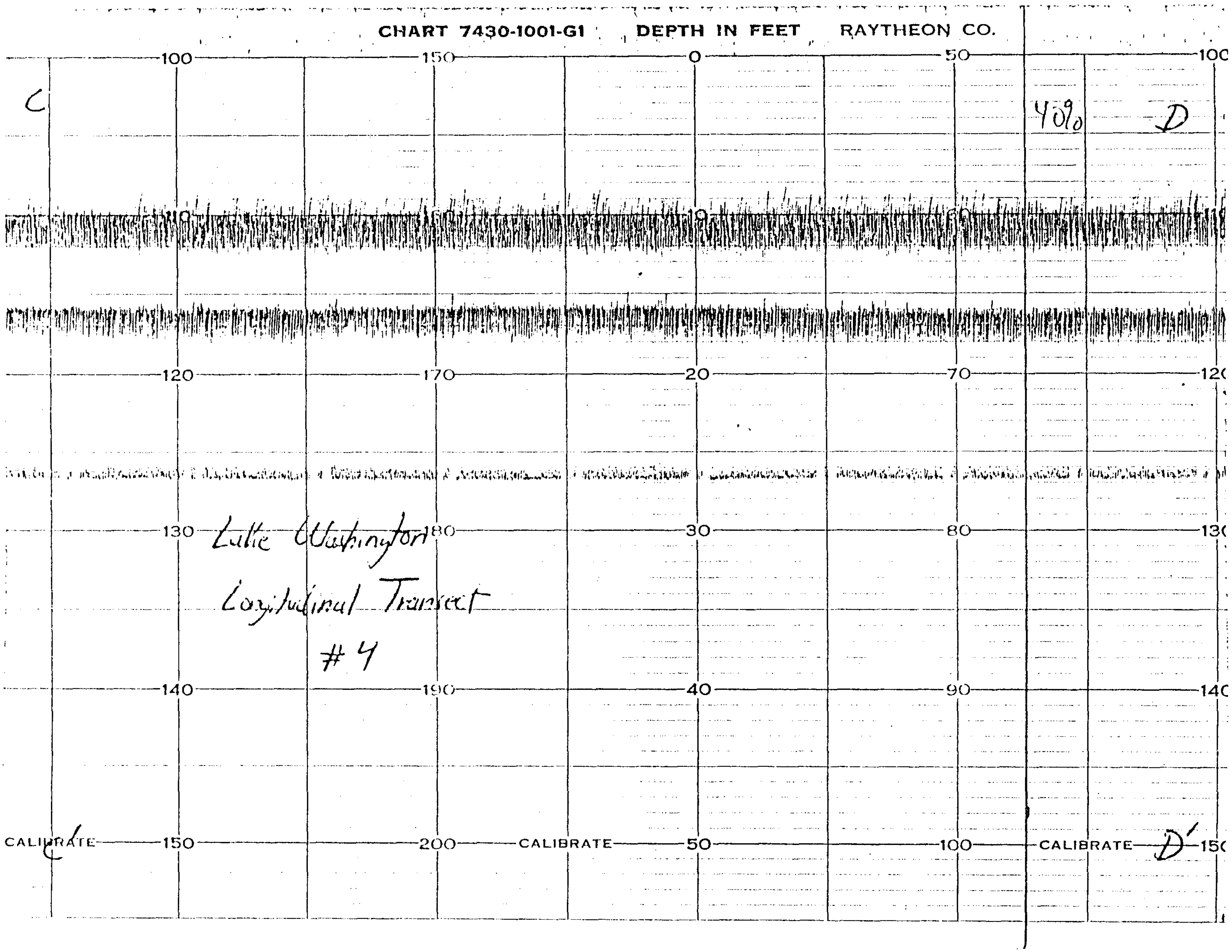
1



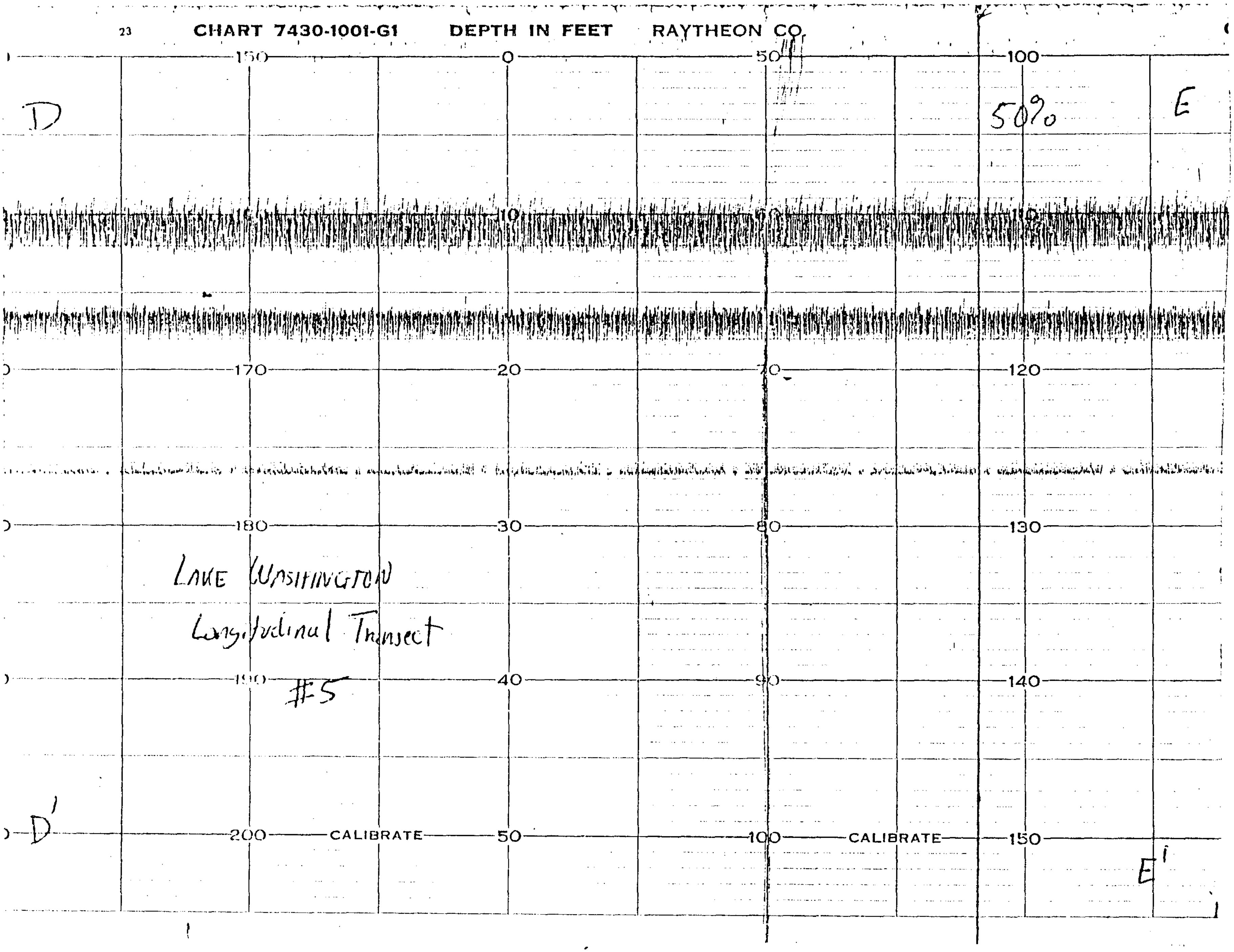
LW - Longitudinal

2

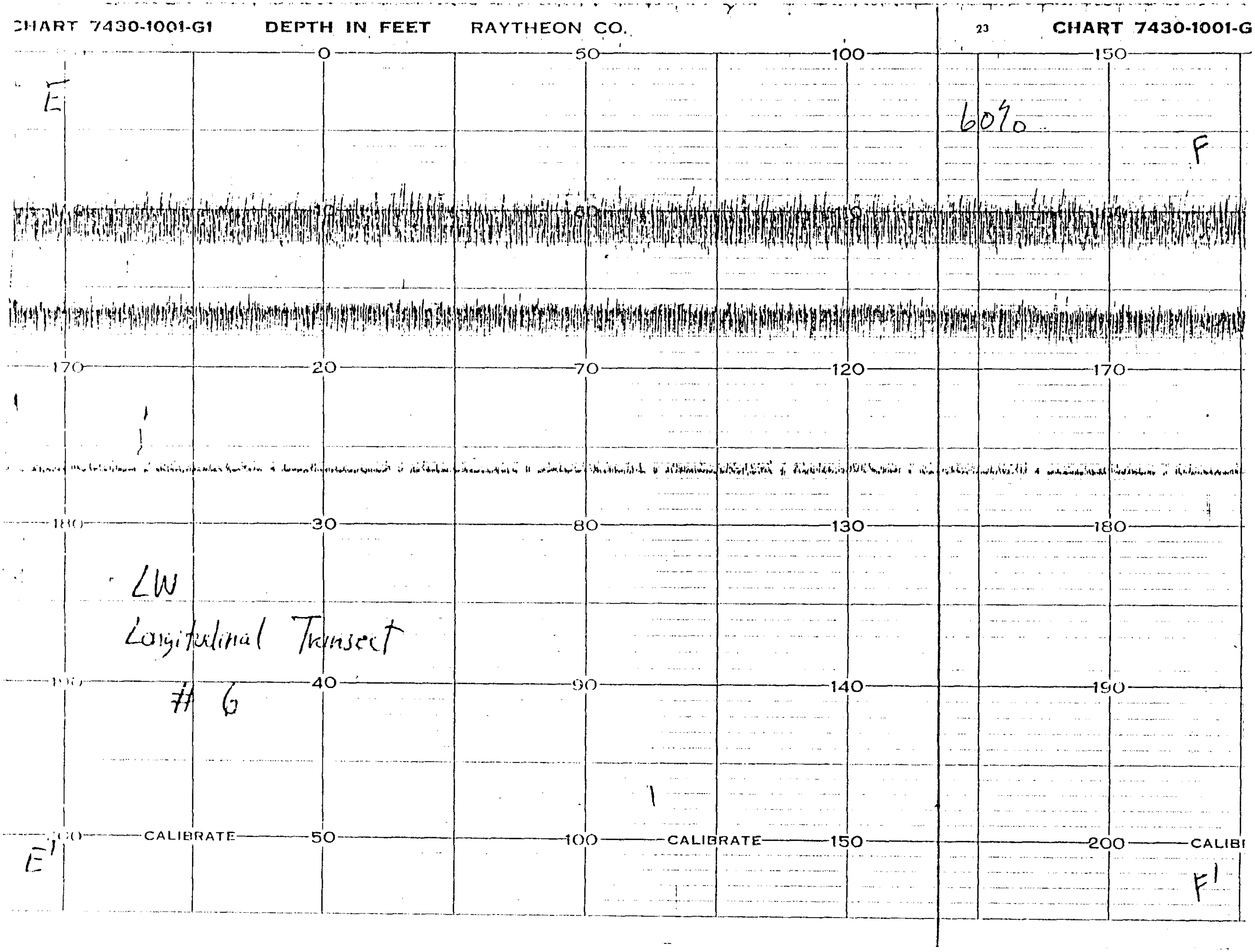

RAYTHEON CO.
23
CHART 7430-1001-G1
DEPTH IN FEET
RAYTHEON CO.
B
C
30%
50
100
150
0
50
60
110
160
10
60
70
120
170
20
70
80
180
30
80
LW - Longitudinal
#3
90
140
190
40
90
100
CALIBRATE
150
200
CALIBRATE
50
100
B'
C'



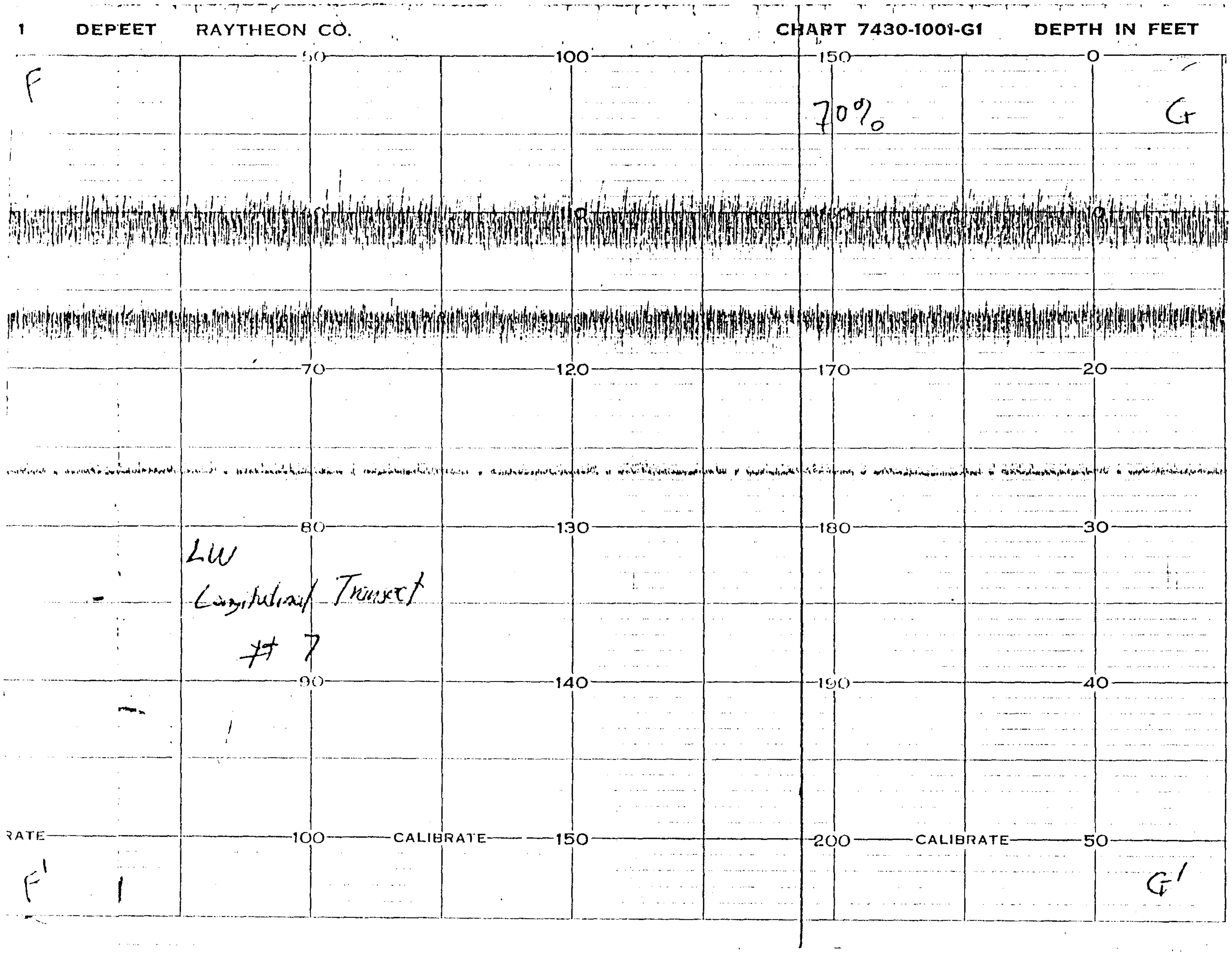
Lake Washington
Longitudinal Transect
#4



Lake Washington
Longitudinal Transect
#5



LW
Longitudinal Transect
6



F

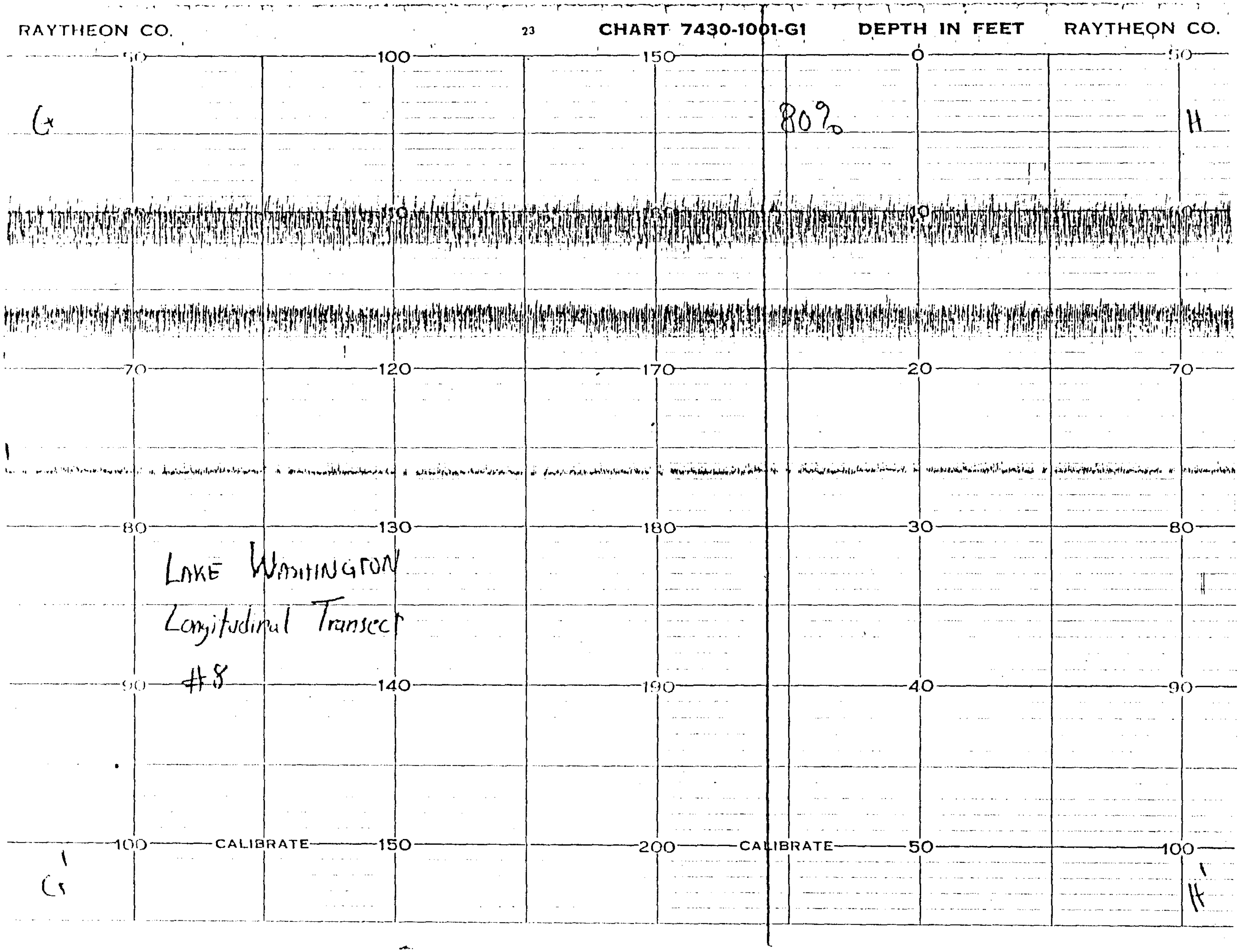
70%

G

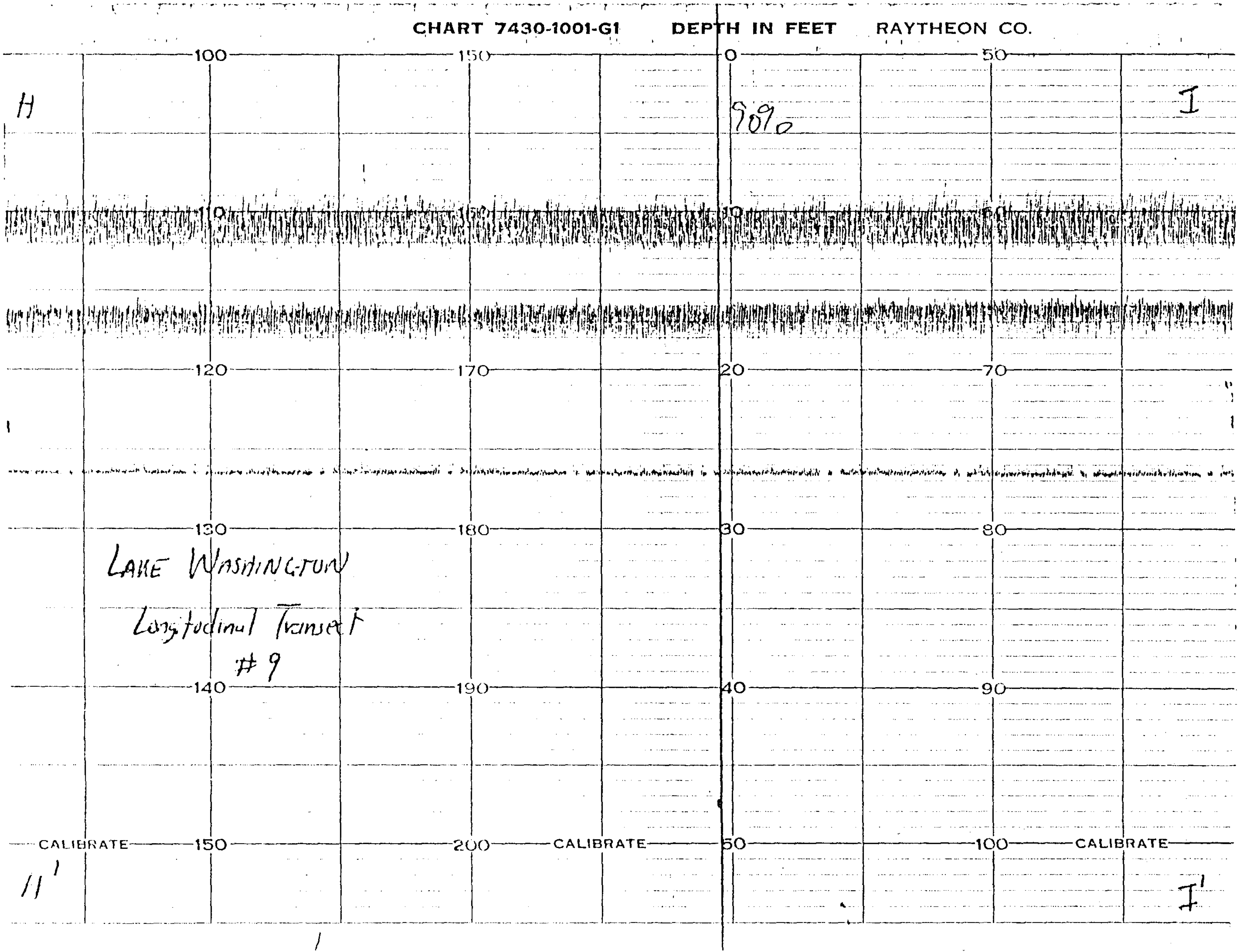
LW
Longitudinal Transect
#7

F'

G'



LAKE WASHINGTON
Longitudinal Transect
#8

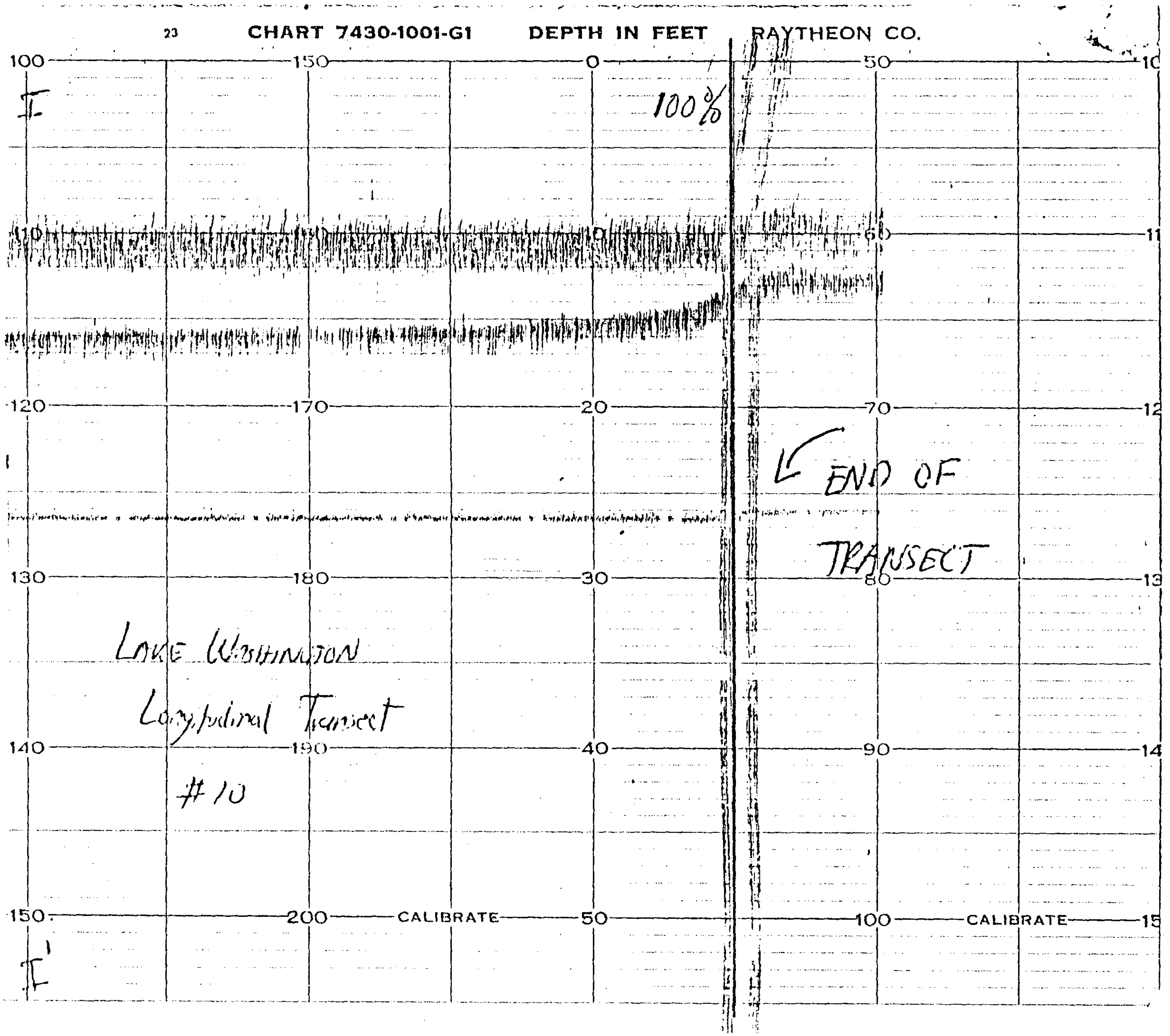


90%

LAKE WASHINGTON

Longitudinal Transect

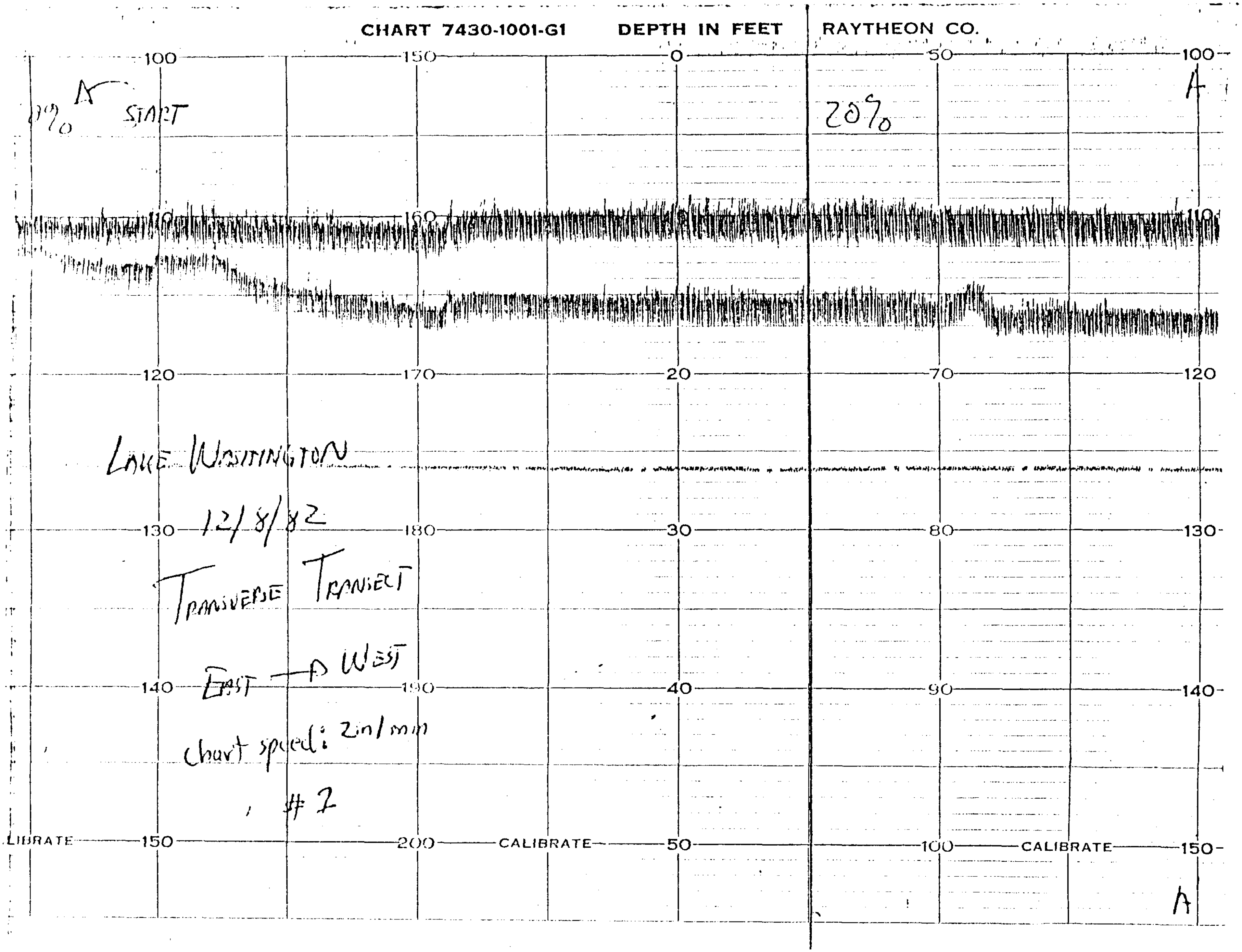
#9



100%

END OF TRANSECT

Lake Washington
Longitudinal Transect
#10



% A START

20%

A

LAKE WASHINGTON

12/8/82

TRANSVERSE TRANSECT

EAST → WEST

Chart speed: 2in/min

#2

A

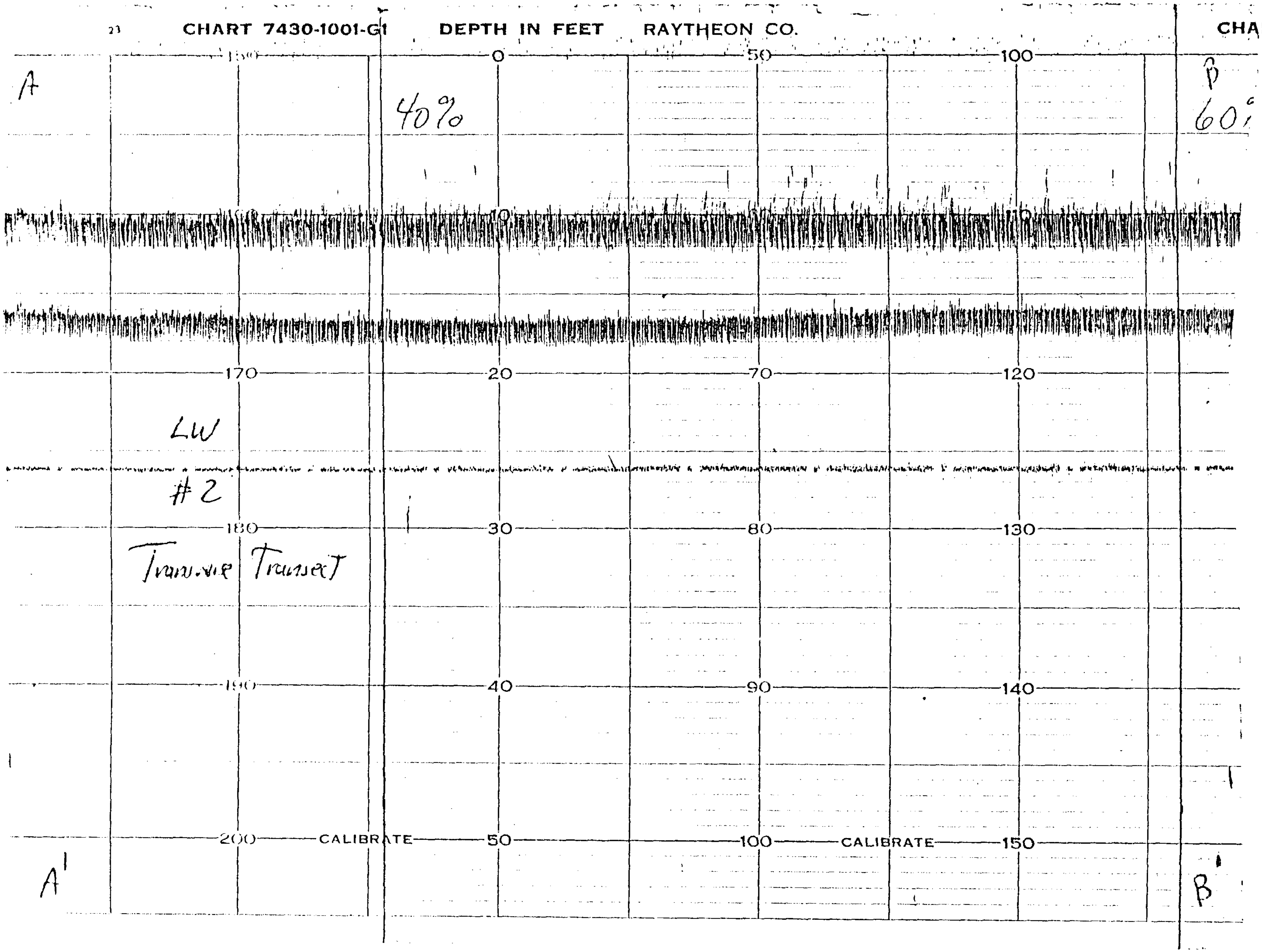
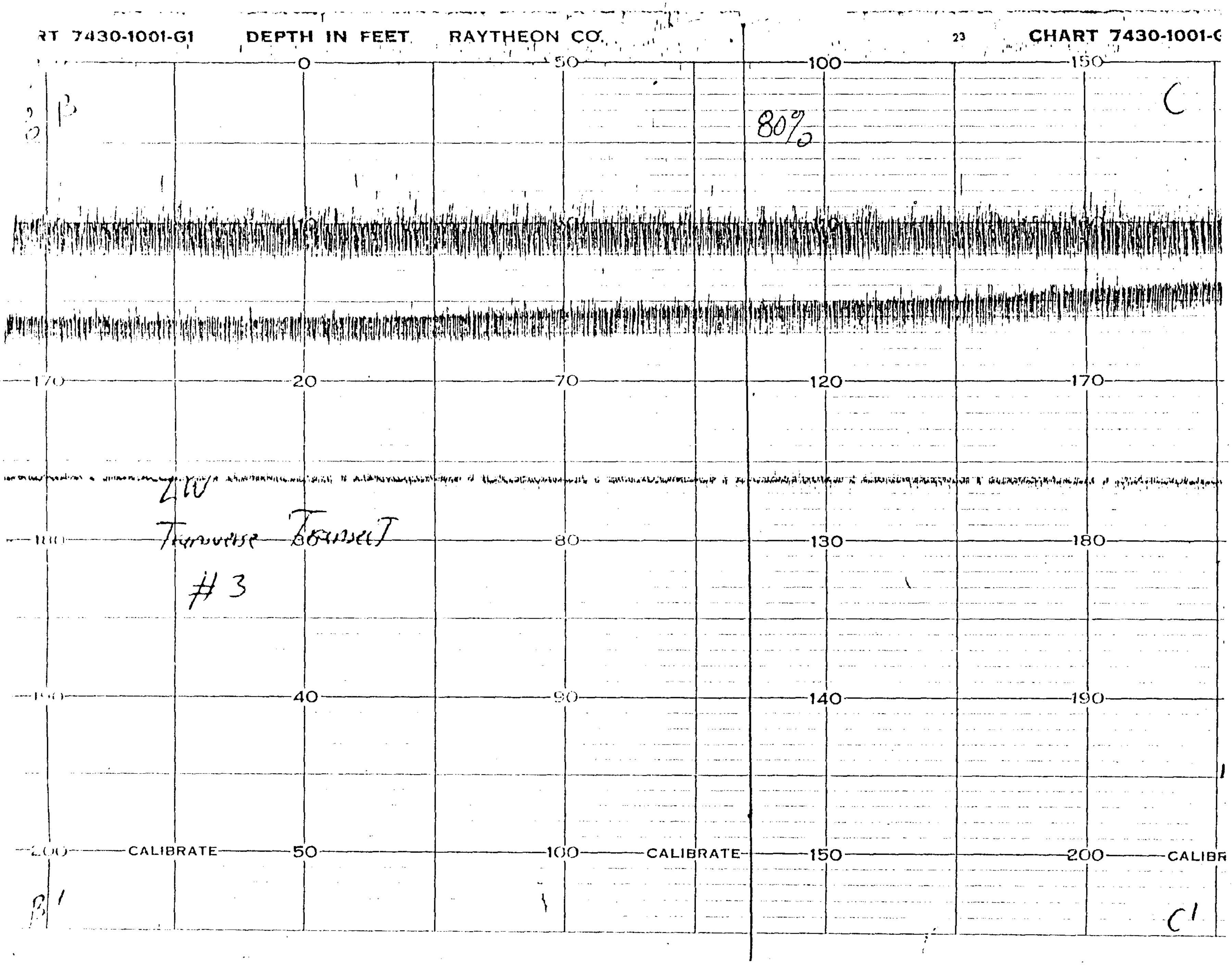
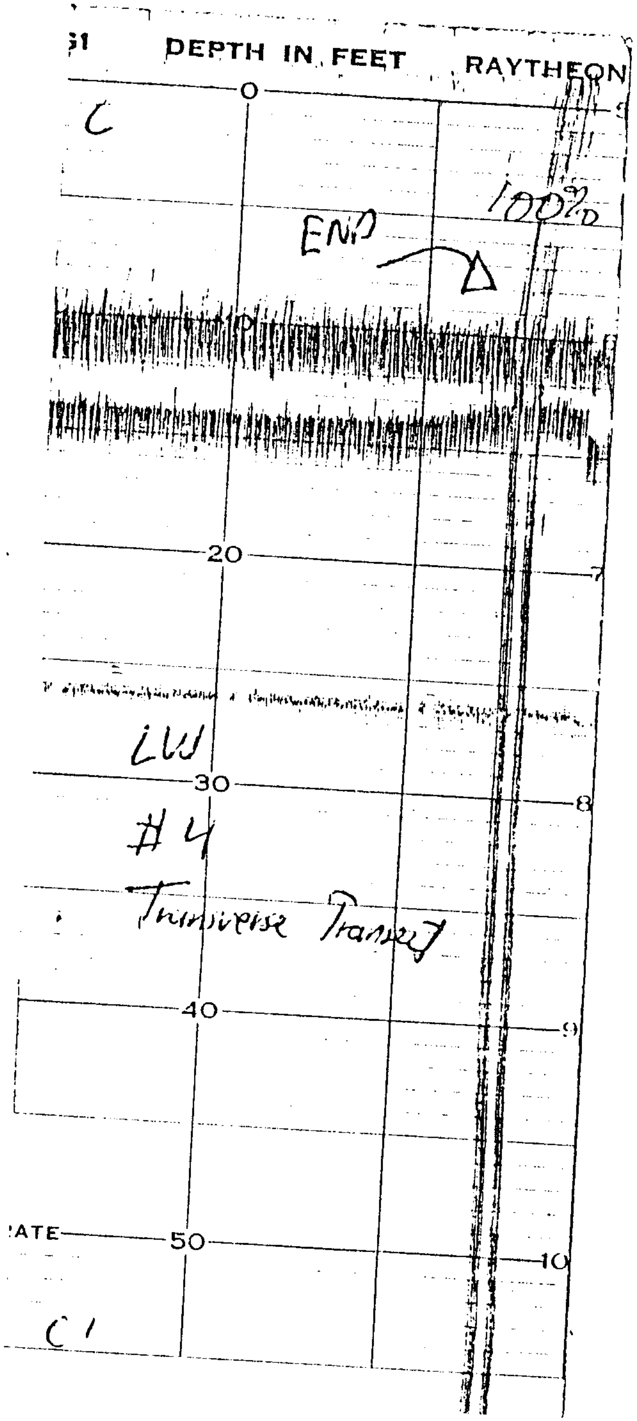


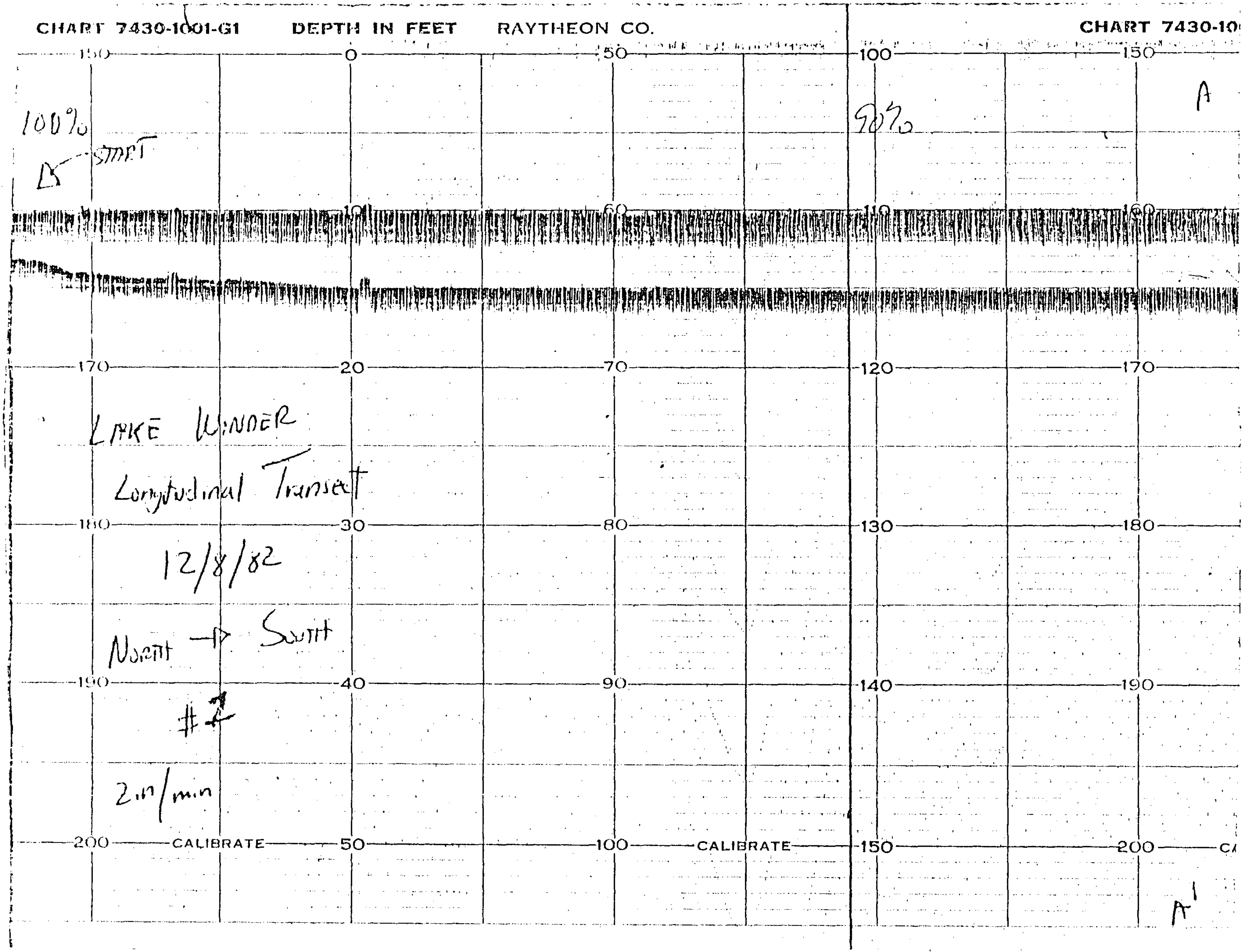
CHART 7430-1001-G1
DEPTH IN FEET
RAYTHEON CO.
CHA
150
0
50
100
A
40%
B
60
170
20
70
120
LW
#2
180
30
80
130
Transverse Transect
190
40
90
140
200
CALIBRATE
50
100
CALIBRATE
150
A'
B'



80%

LW
Transverse Transect
#3


DEPTH IN FEET
RAYTHEON
C
100%
END
0
20
LW
30
#4
Transverse Transect
40
ATE
50
7
8
9
10
C'



100%

START

90%

A

LAKE WINDER

Longitudinal Transect

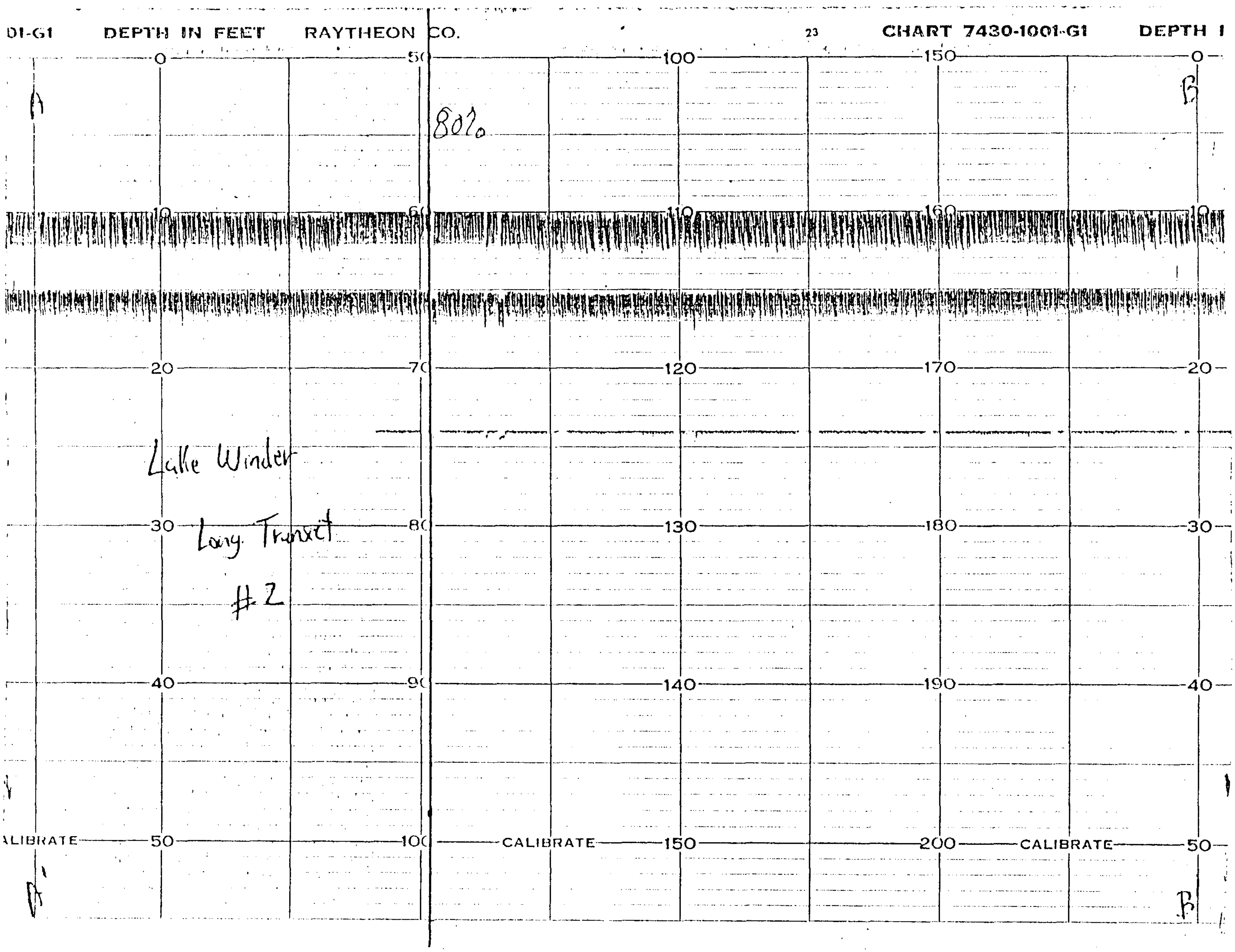
12/8/82

North → South

#2

2in/min

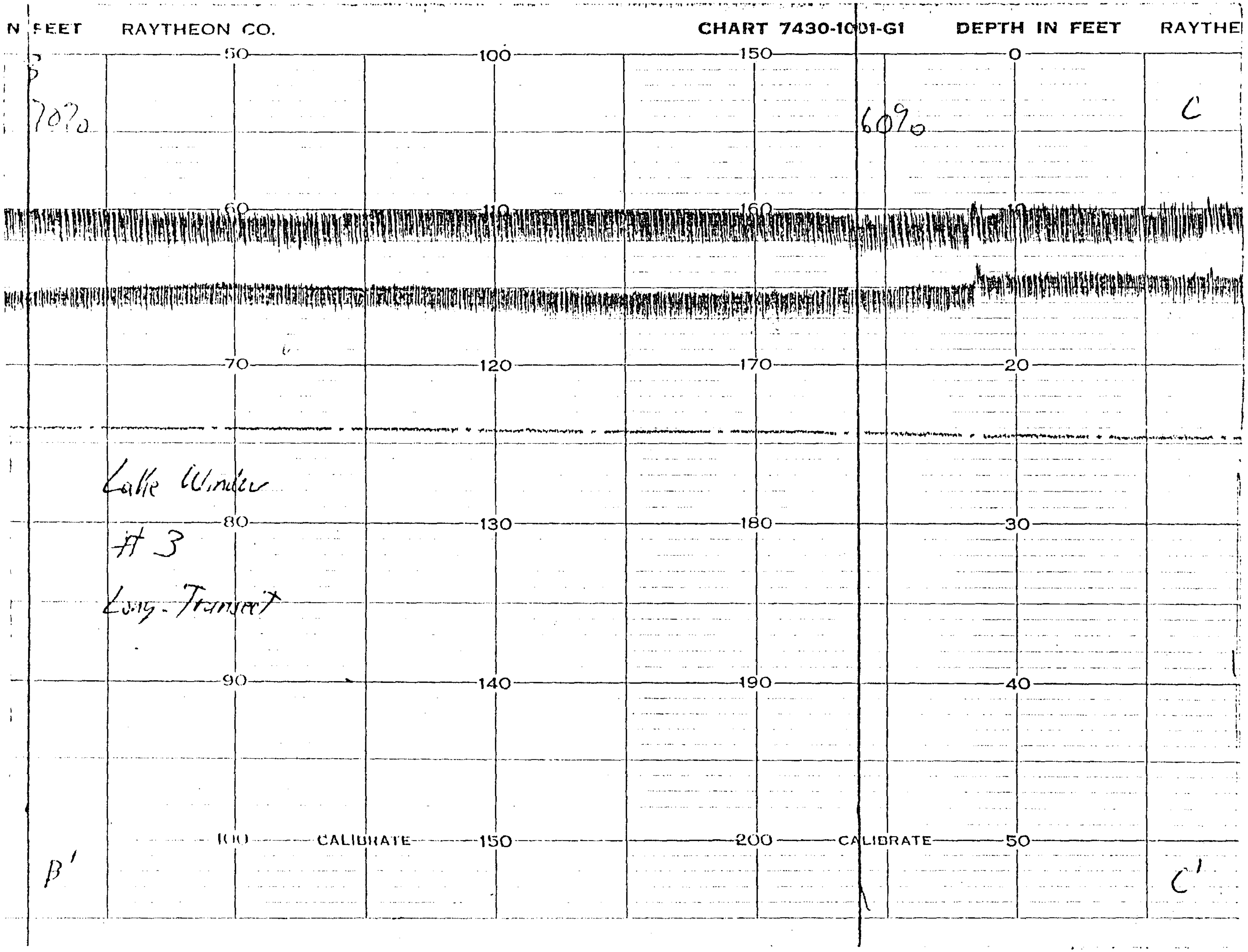
A'



Lake Winder

Long Transect

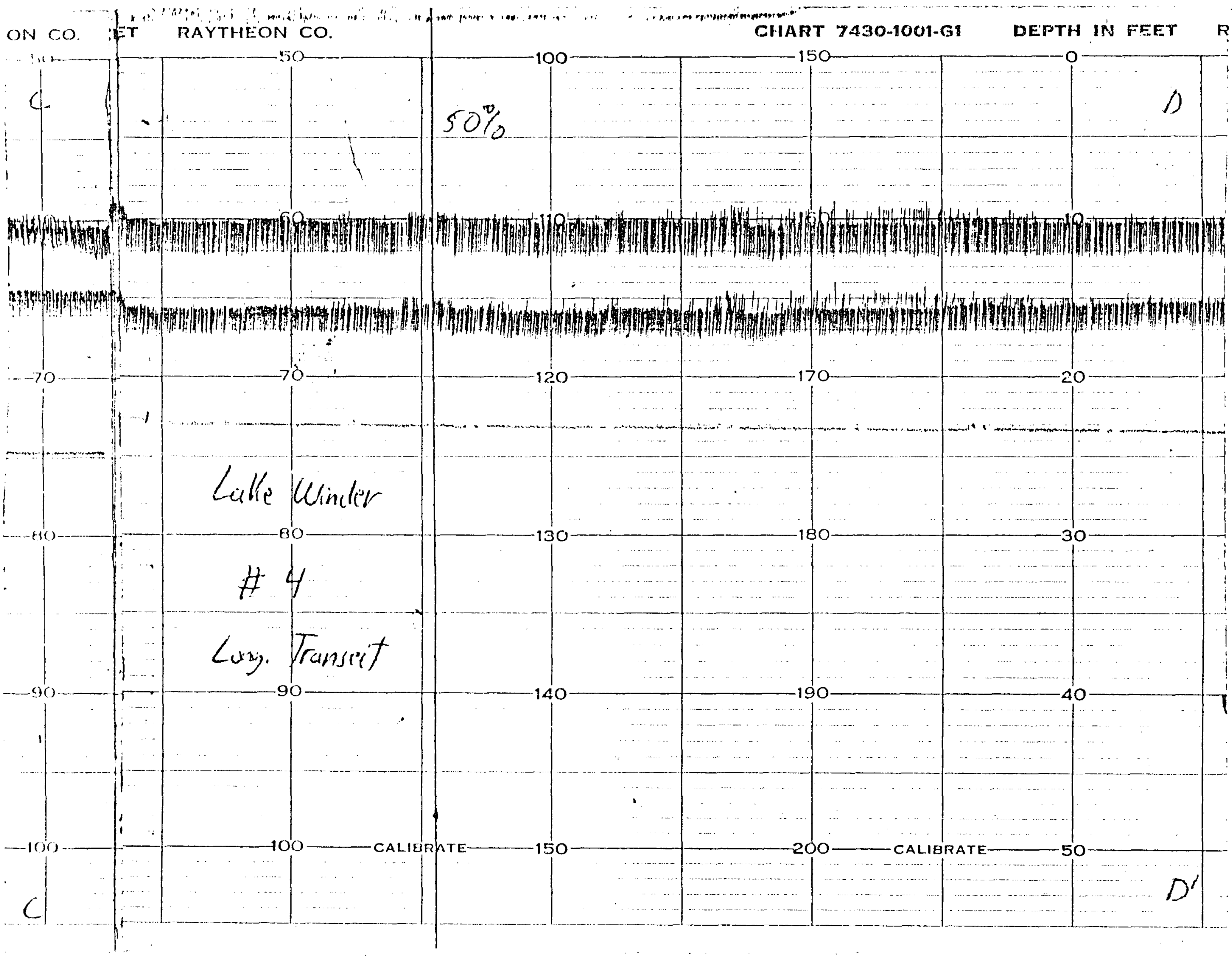
#2

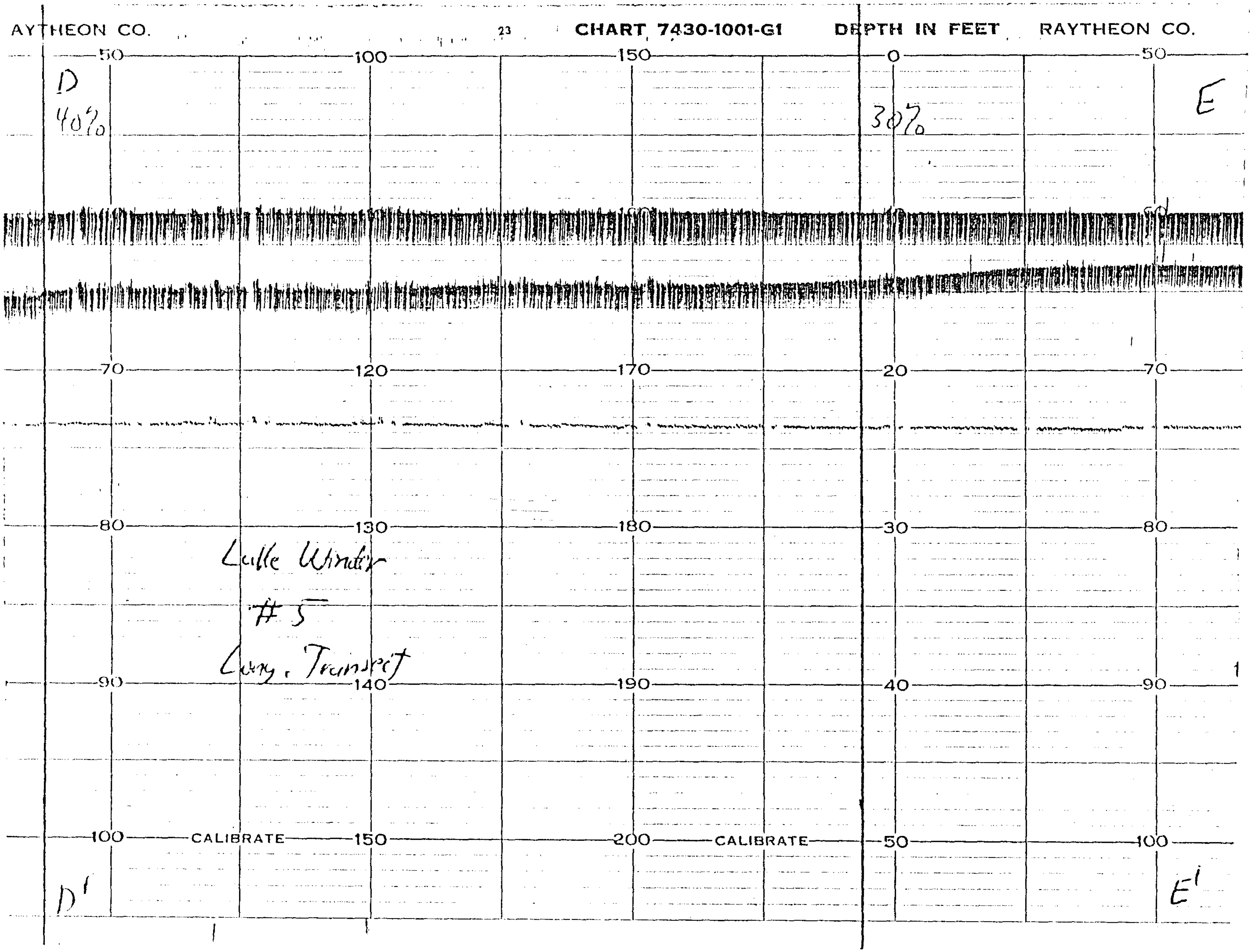


Lake Winder

#3

Long. Transect

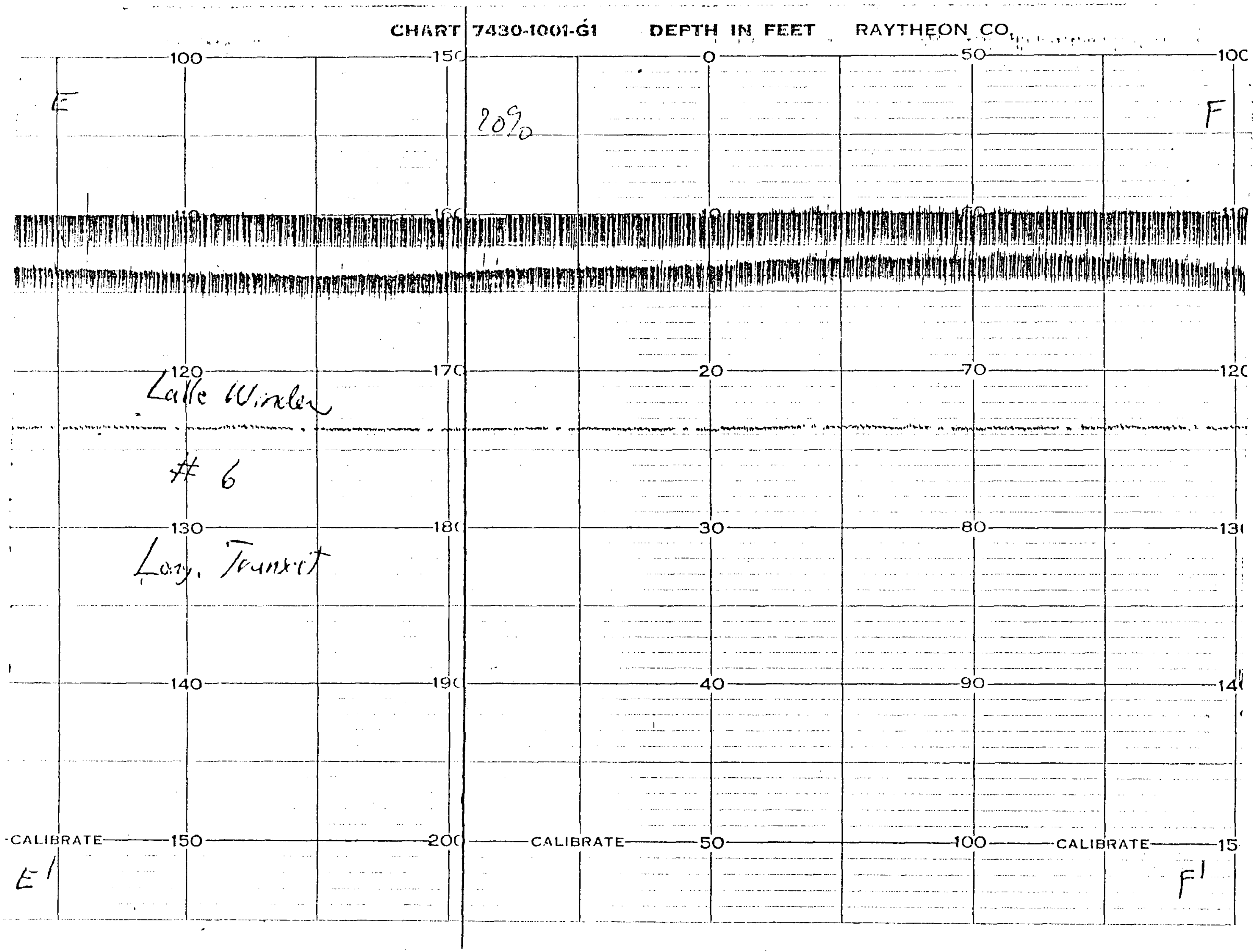

ON CO.
ET
RAYTHEON CO.
CHART 7430-1001-G1
DEPTH IN FEET
R
50
100
150
0
C
D
50%
60
110
160
10
70
120
170
20
Lake Winder
80
130
180
30
4
Long. Transect
90
140
190
40
100
CALIBRATE
150
200
CALIBRATE
50
C
D'



Lake Winder

#5

Long. Transect



E

20%

F

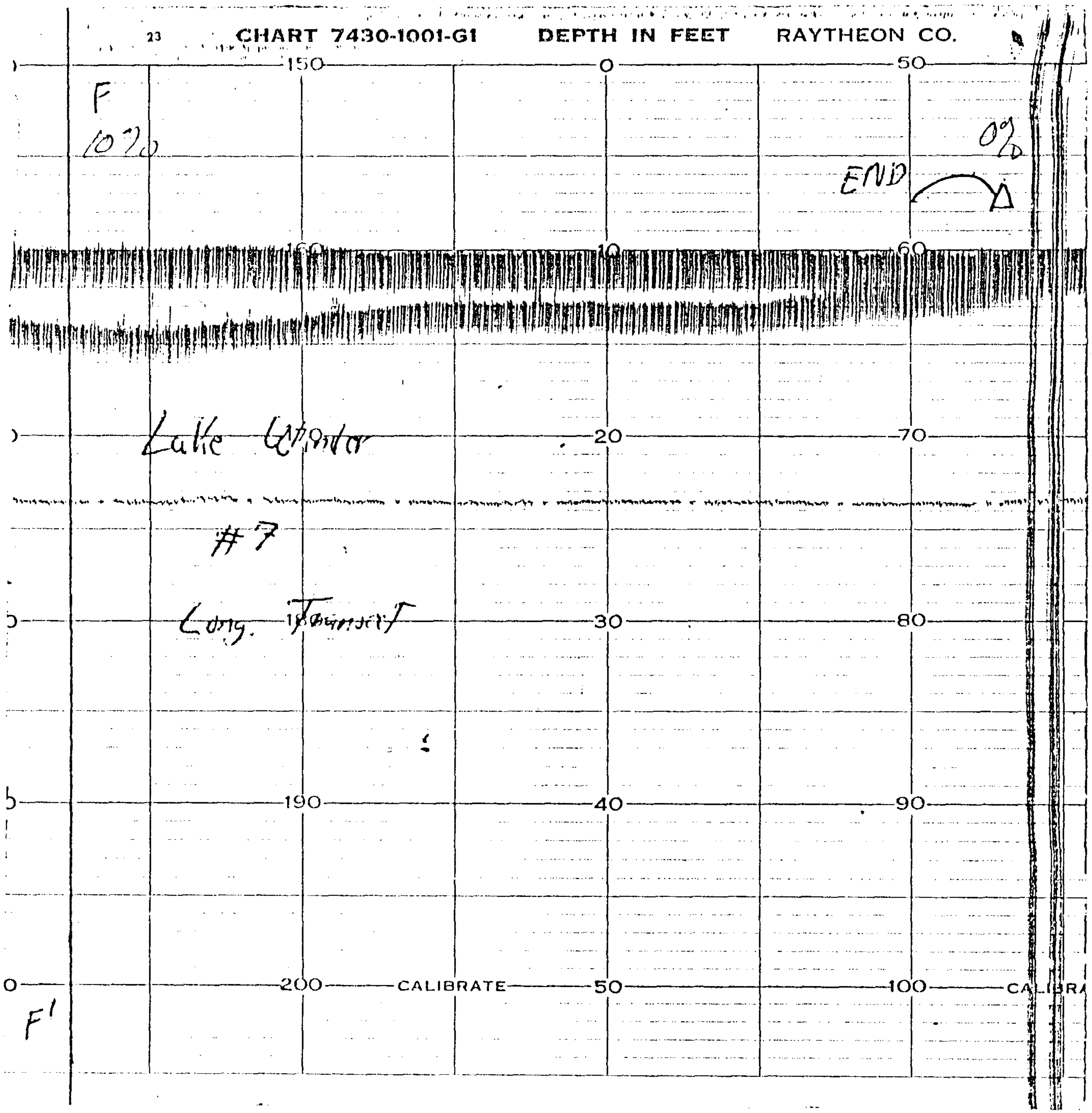
Lake Winder

6

Long. Transit

E'

F'



F
10%

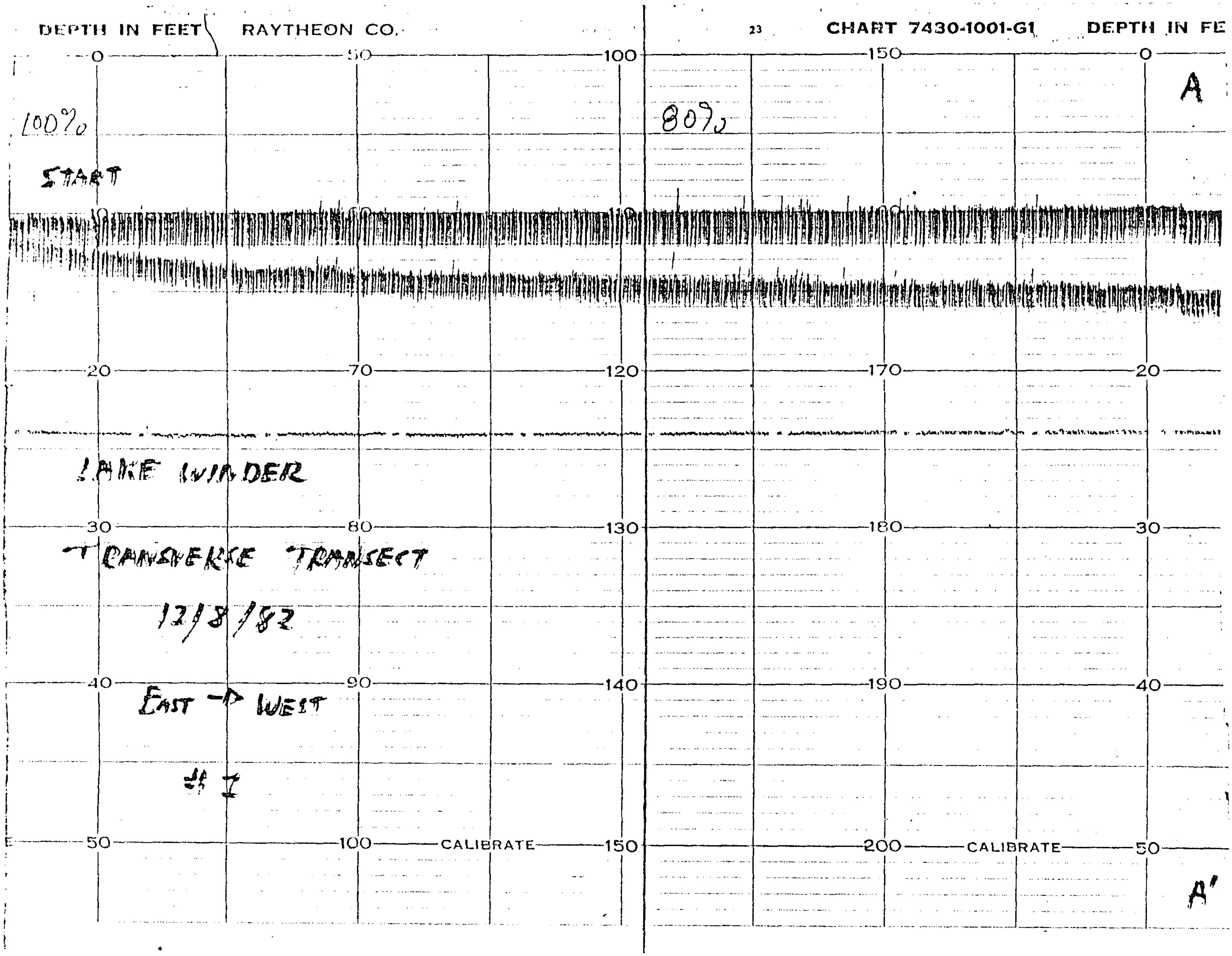
0%
END

Lake Wister

#7

Long. Transect

F'



100%

START

80%

A

LAKE WINDER

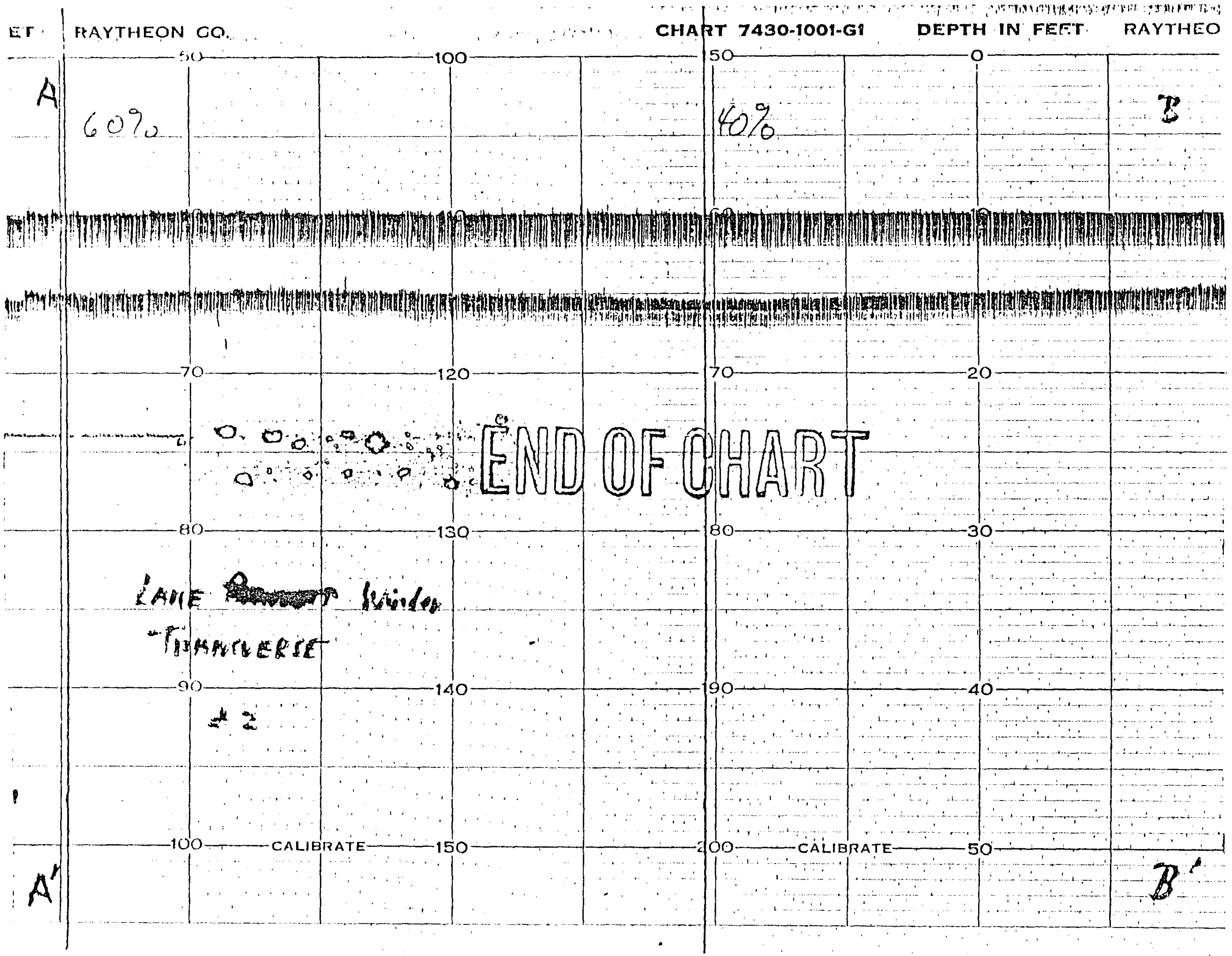
TRANSVERSE TRANSECT

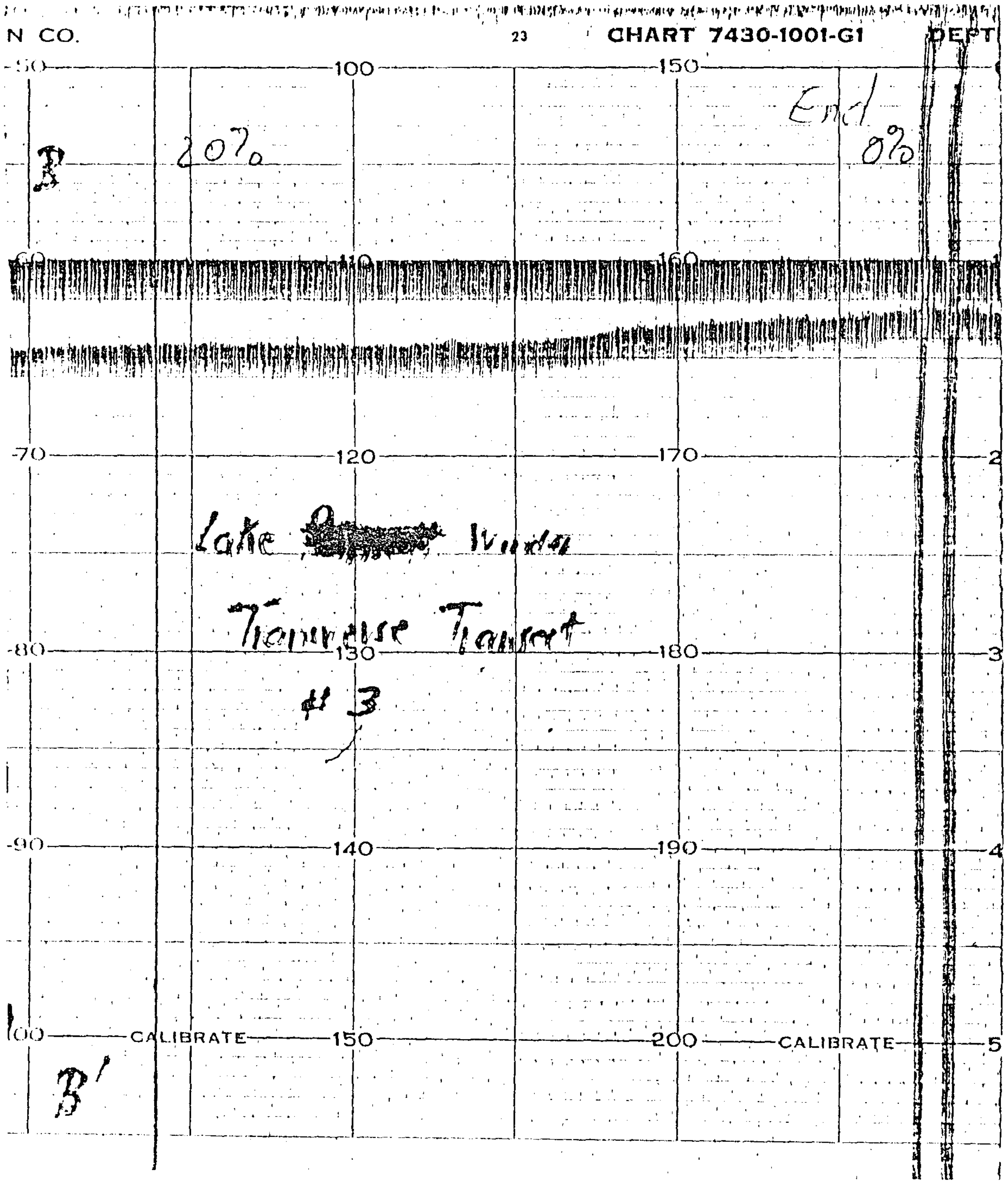
12/8/82

EAST → WEST

I

A'


ET
RAYTHEON CO.
CHART 7430-1001-G1
DEPTH IN FEET
RAYTHEO
A
60%
40%
B
50
100
150
0
60
110
160
10
70
120
170
20
END OF CHART
80
130
180
30
LANE [illegible] Winder
-TRANSVERSE
90
140
190
40
#2
100
CALIBRATE
150
200
CALIBRATE
50
A'
B'



B

20%

End

0%

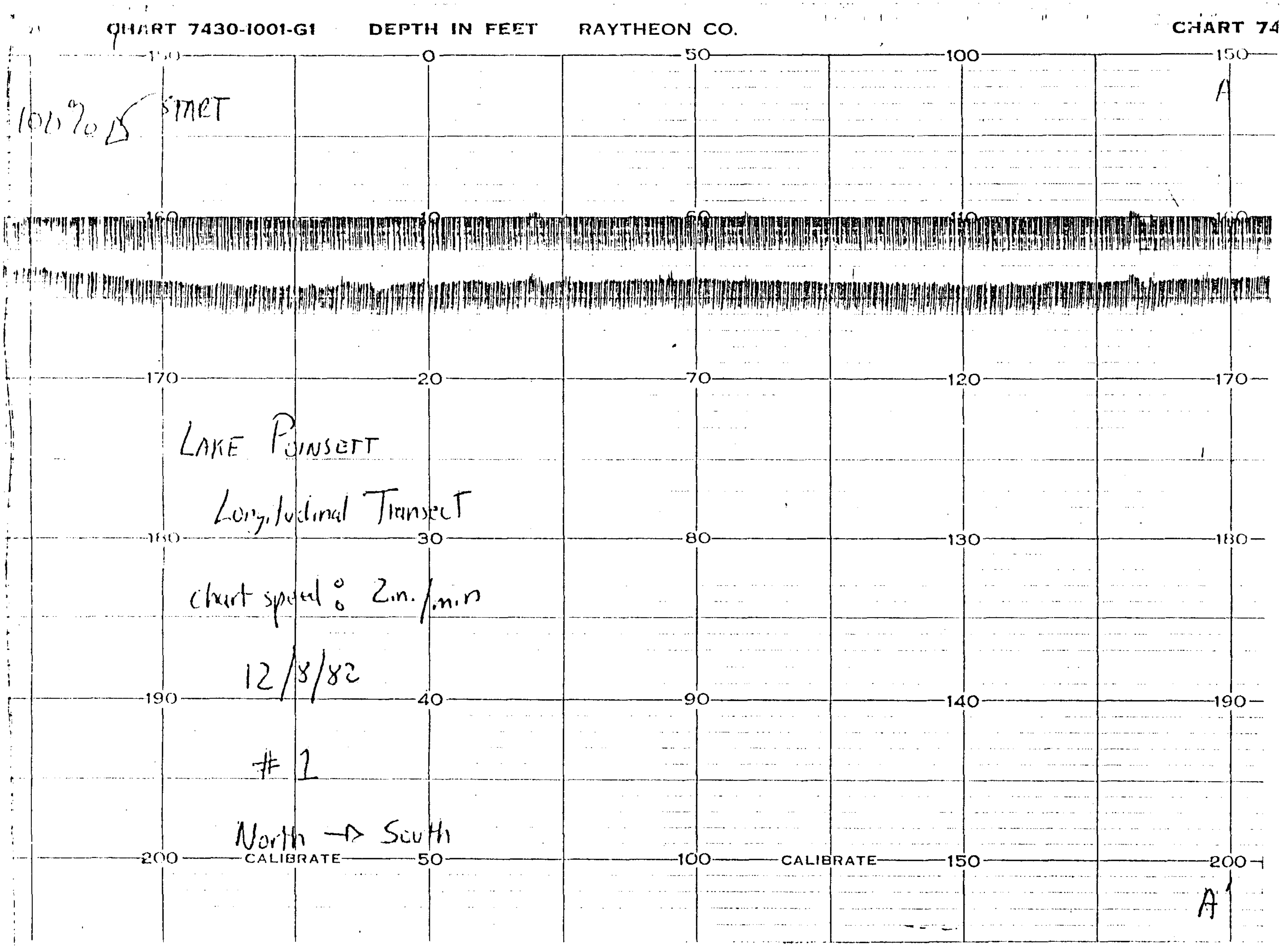
Lake [redacted] Wind

Transverse Transect

#3

B'

CHART 7430-1001-G1 DEPTH IN FEET RAYTHEON CO. CHART 74



100% Δ START

LAKE POINSETT

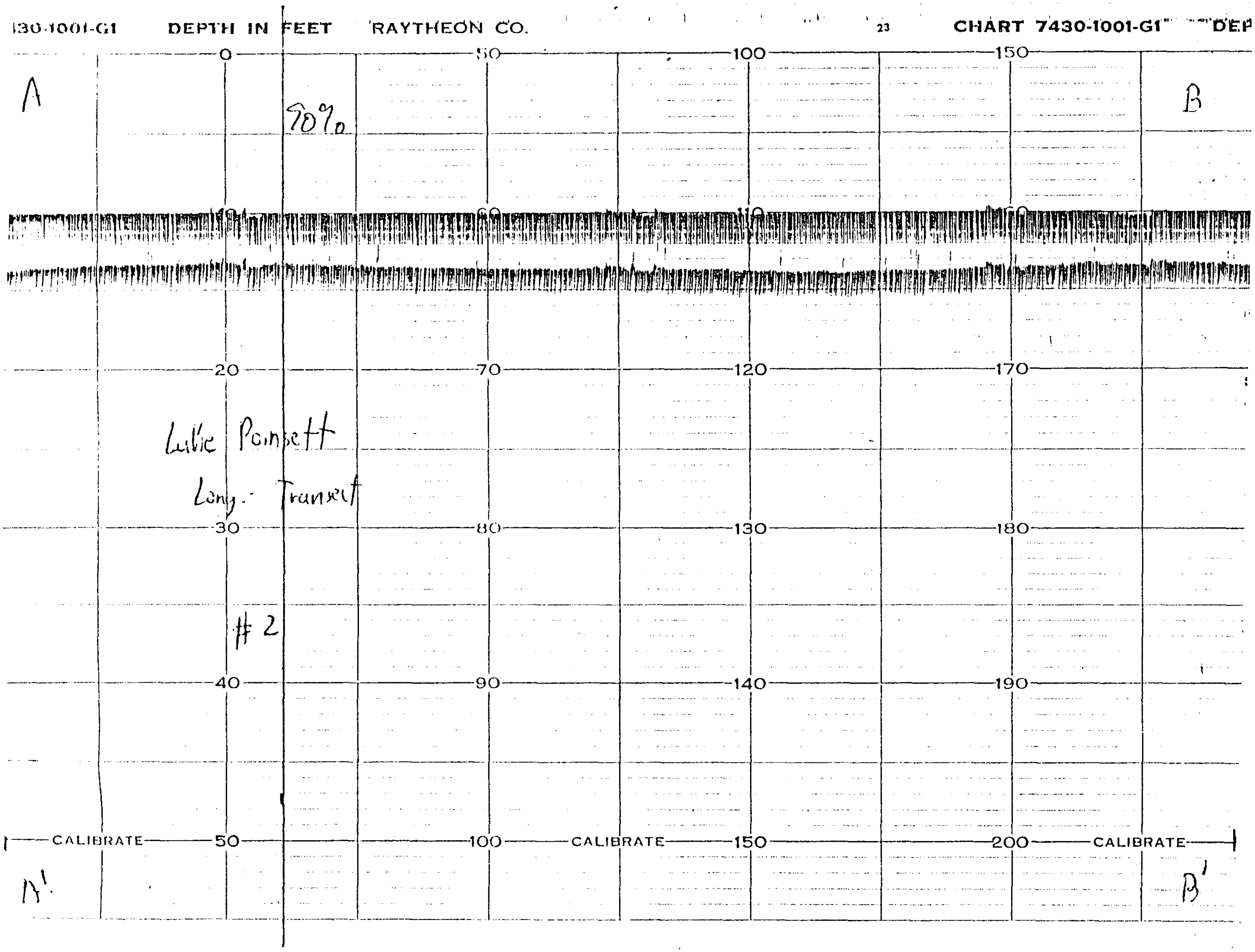
Longitudinal Transect

chart speed: 2in./min

12/8/82

1

North → South



A

B

90%

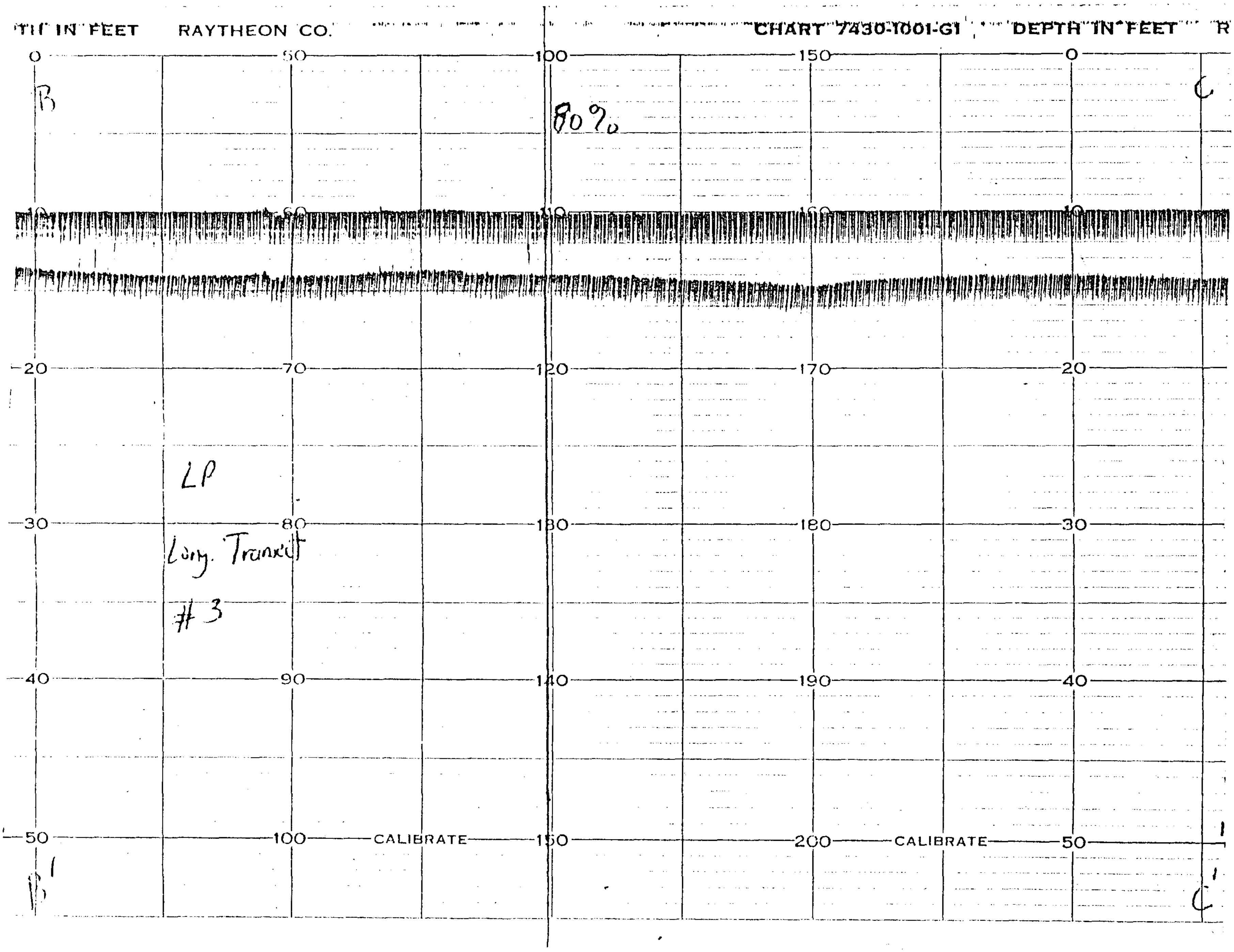
Lake Poinsett

Long. Transect

#2

A'

B'



B

C

80%

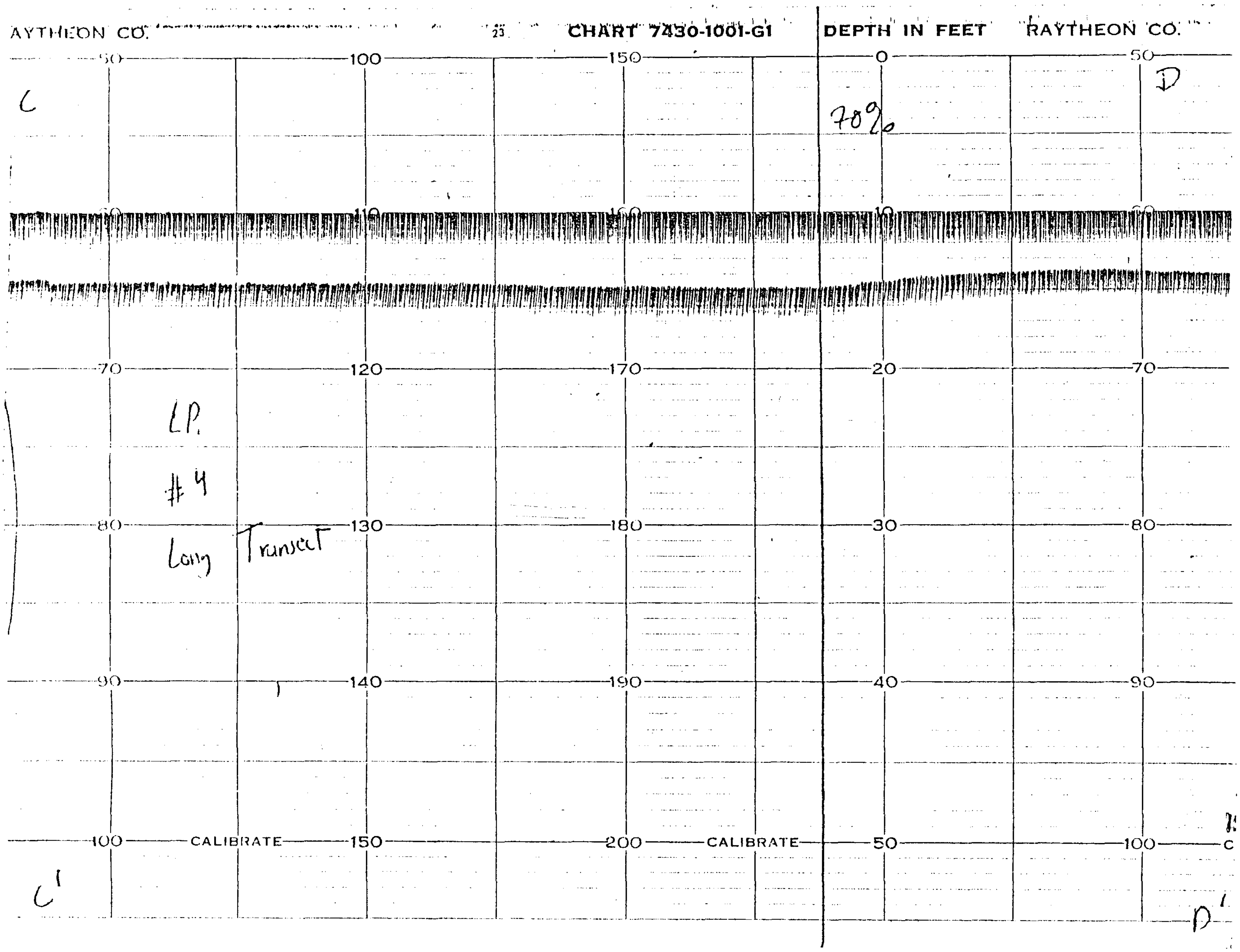
LP

Long. Transect

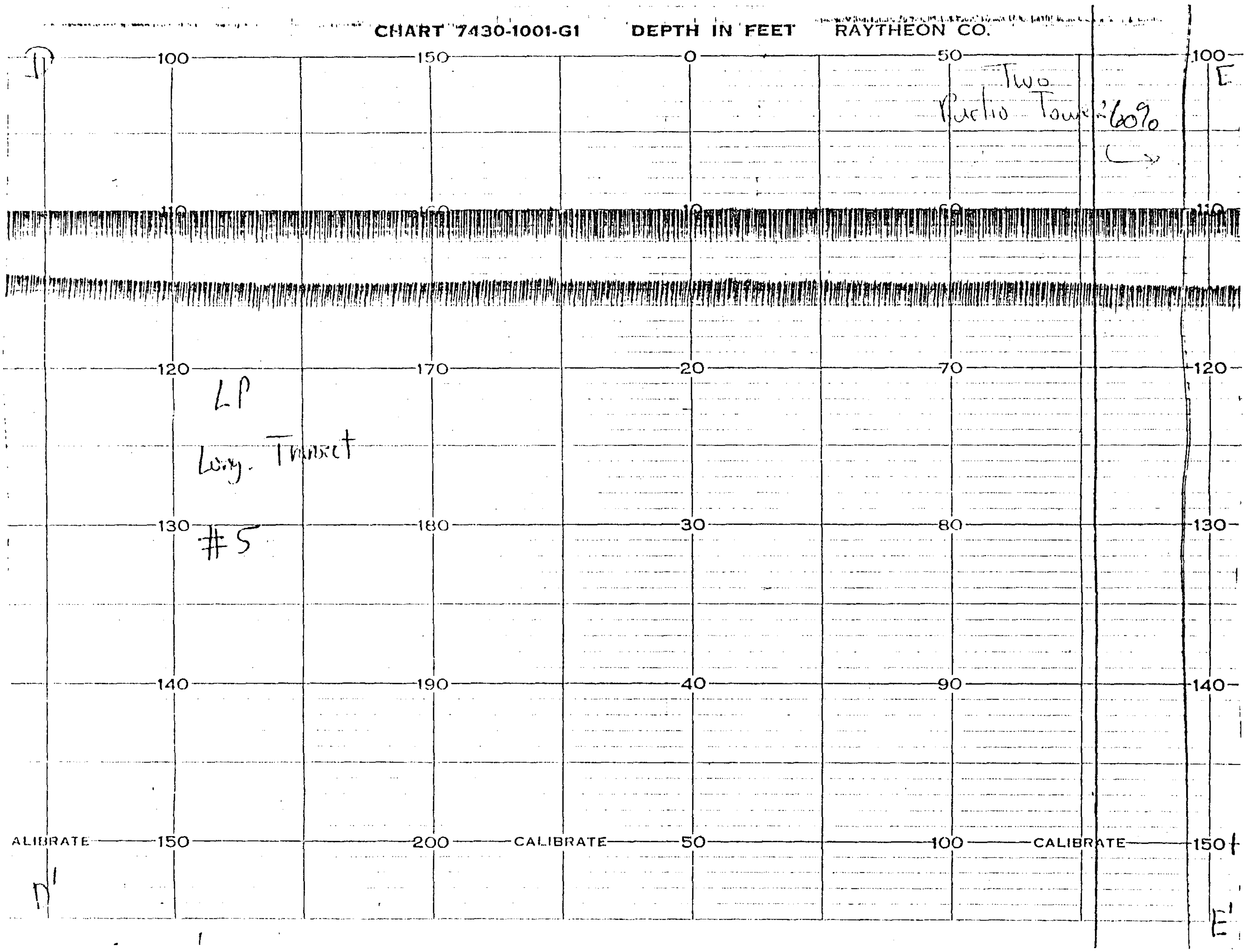
#3

B'

C'



LP.
#4
Long Transect

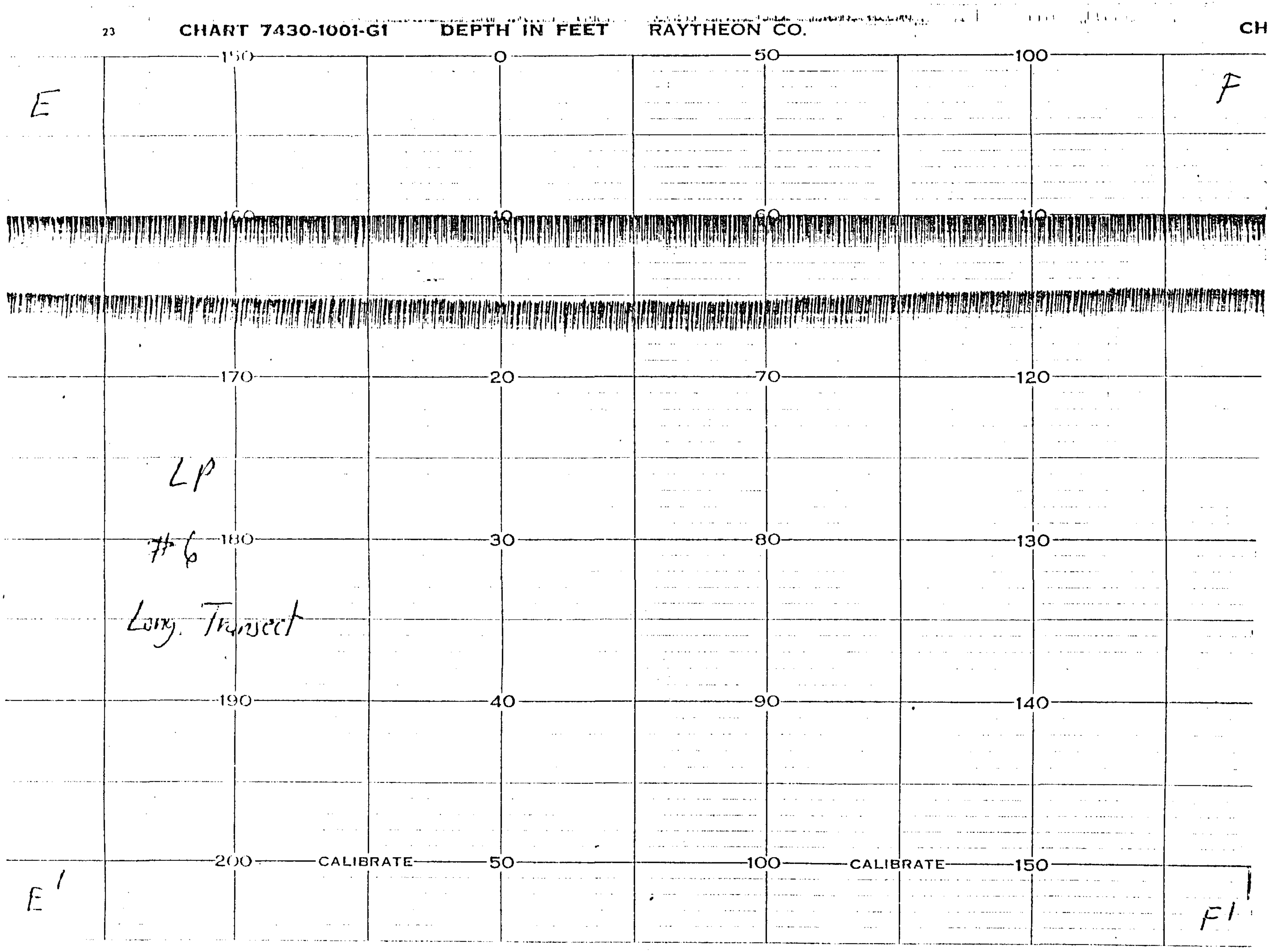


Two Radio Tower 60%

LP

Long. Transect

#5



E

F

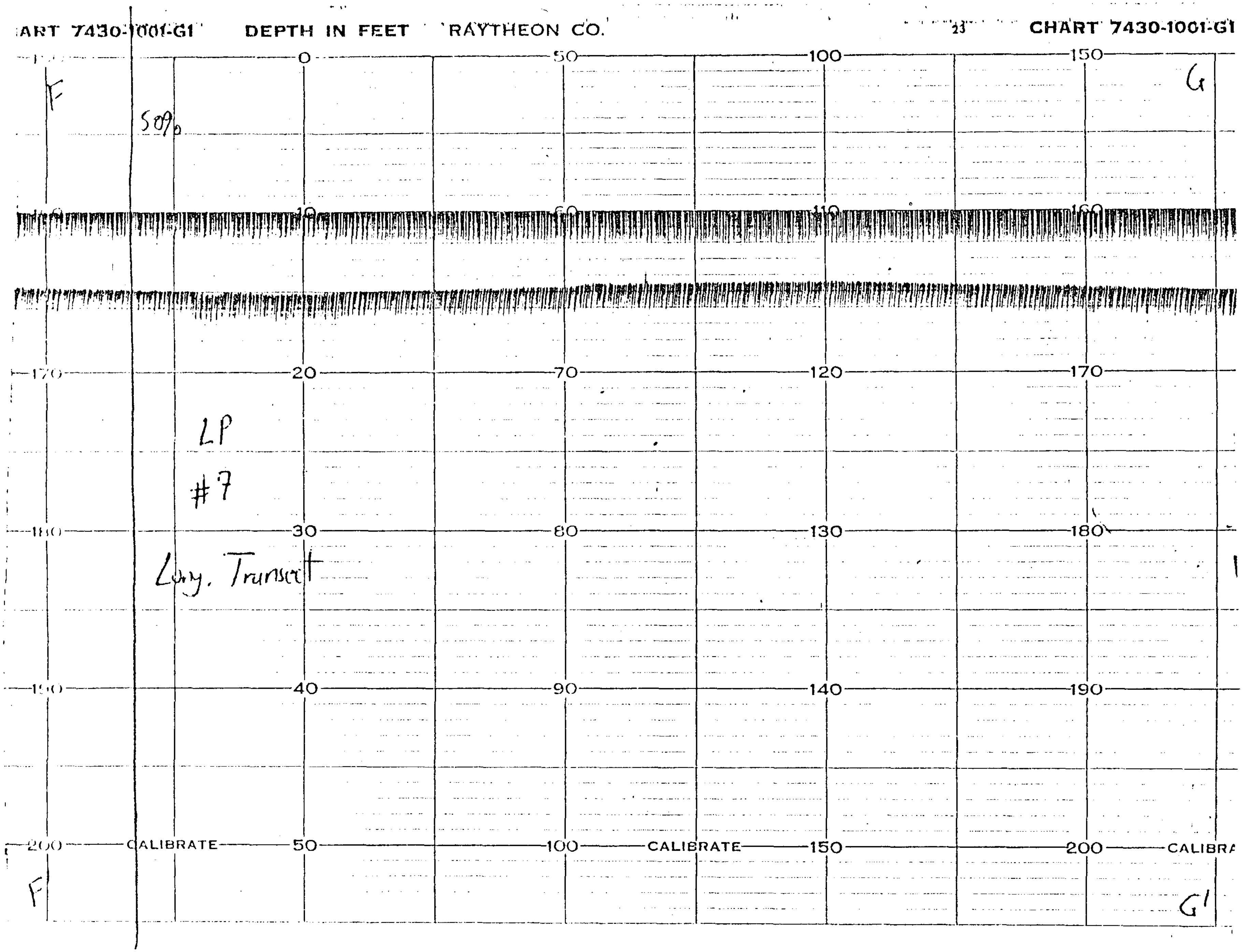
LP

#6

Long. Transect

E'

F'



F

G

50%

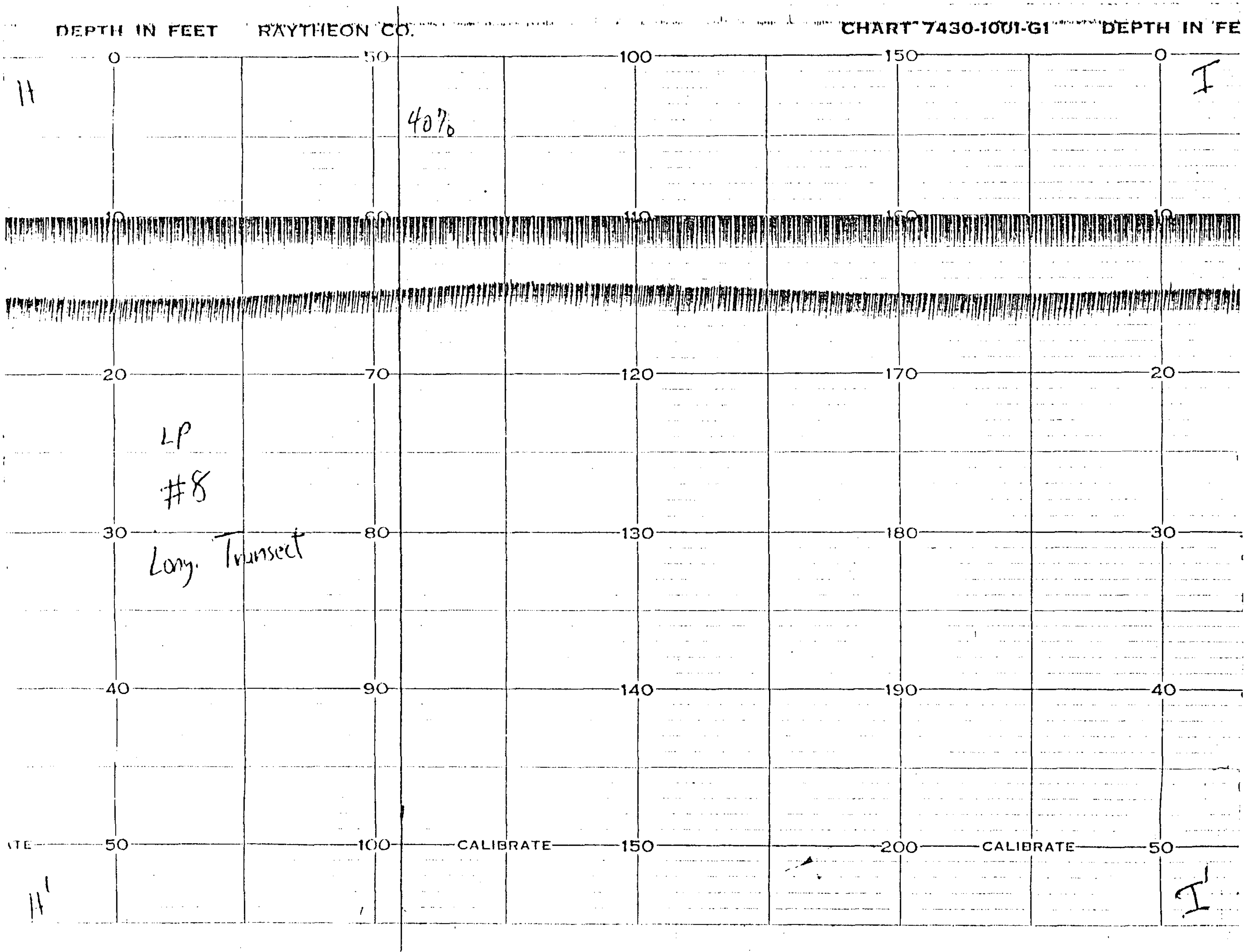
LP

#7

Long. Transect

F'

G'



II

I

40%

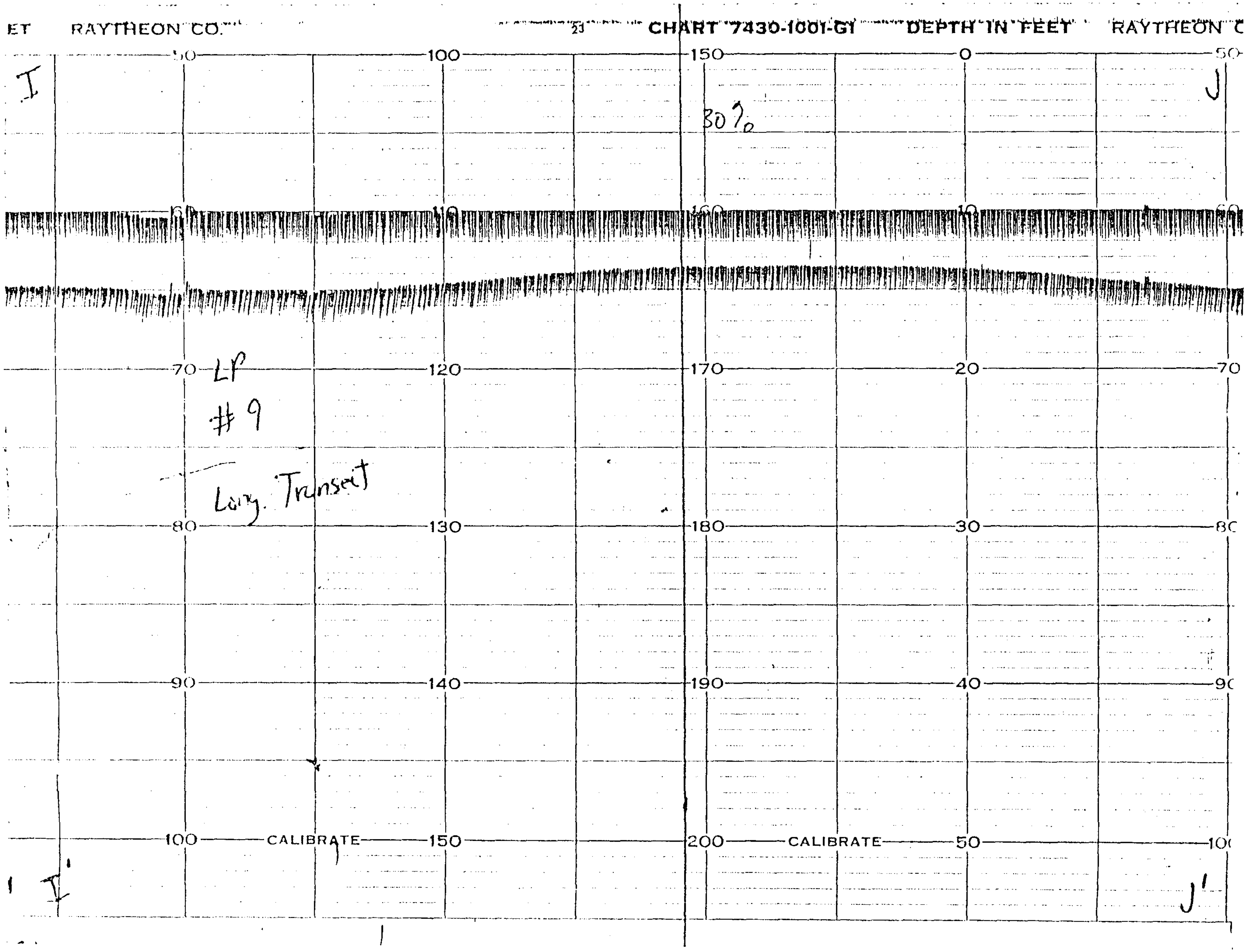
LP

#8

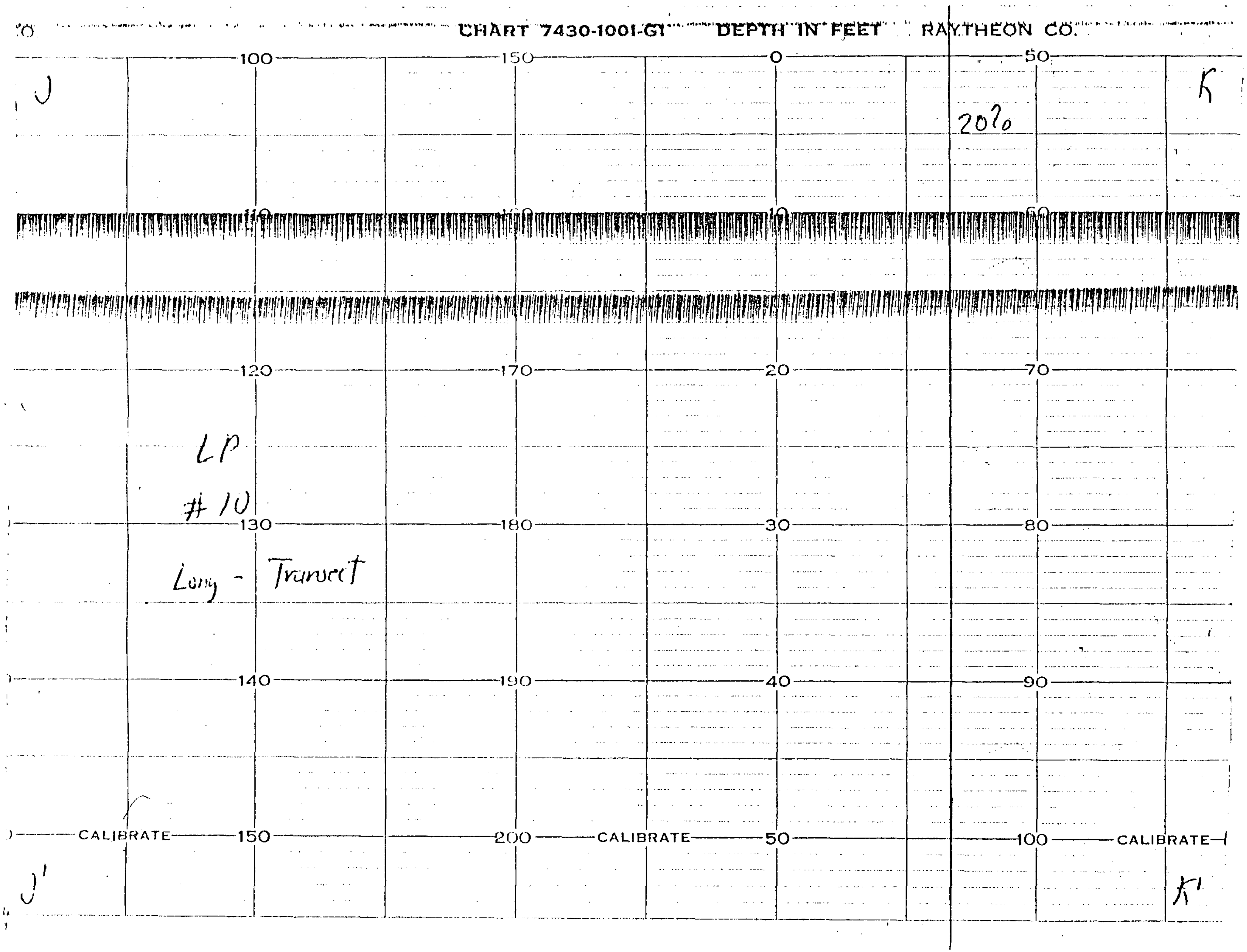
Long. Transect

II'

I'



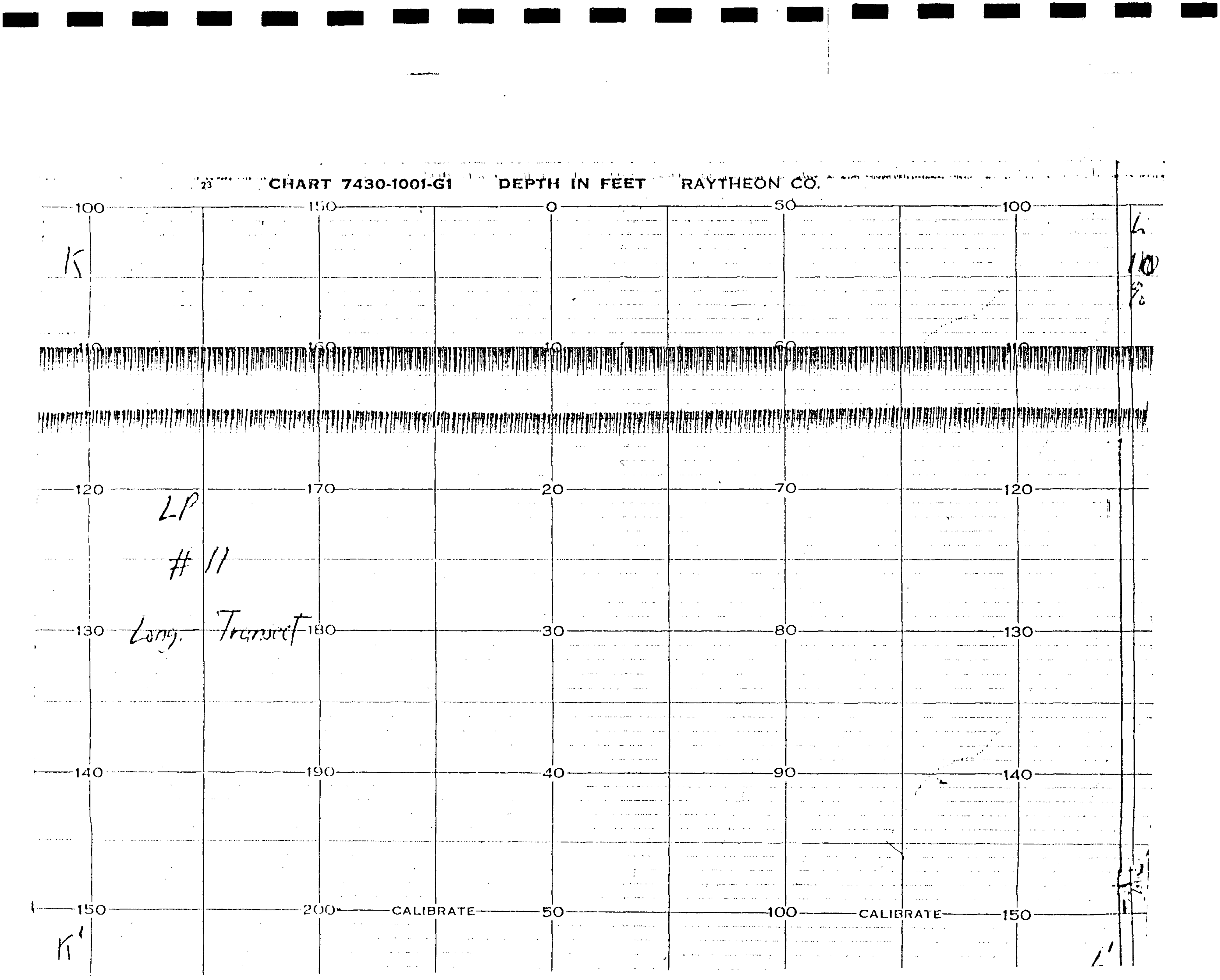
ET
RAYTHEON CO.
CHART 7430-1001-G1
DEPTH IN FEET
RAYTHEON C
I
J
30%
50
100
150
0
60
110
160
10
70
120
170
20
LP
#9
Long. Transect
80
130
180
30
90
140
190
40
100
CALIBRATE
150
200
CALIBRATE
50
I'
J'



LP

#10

Long - Transect



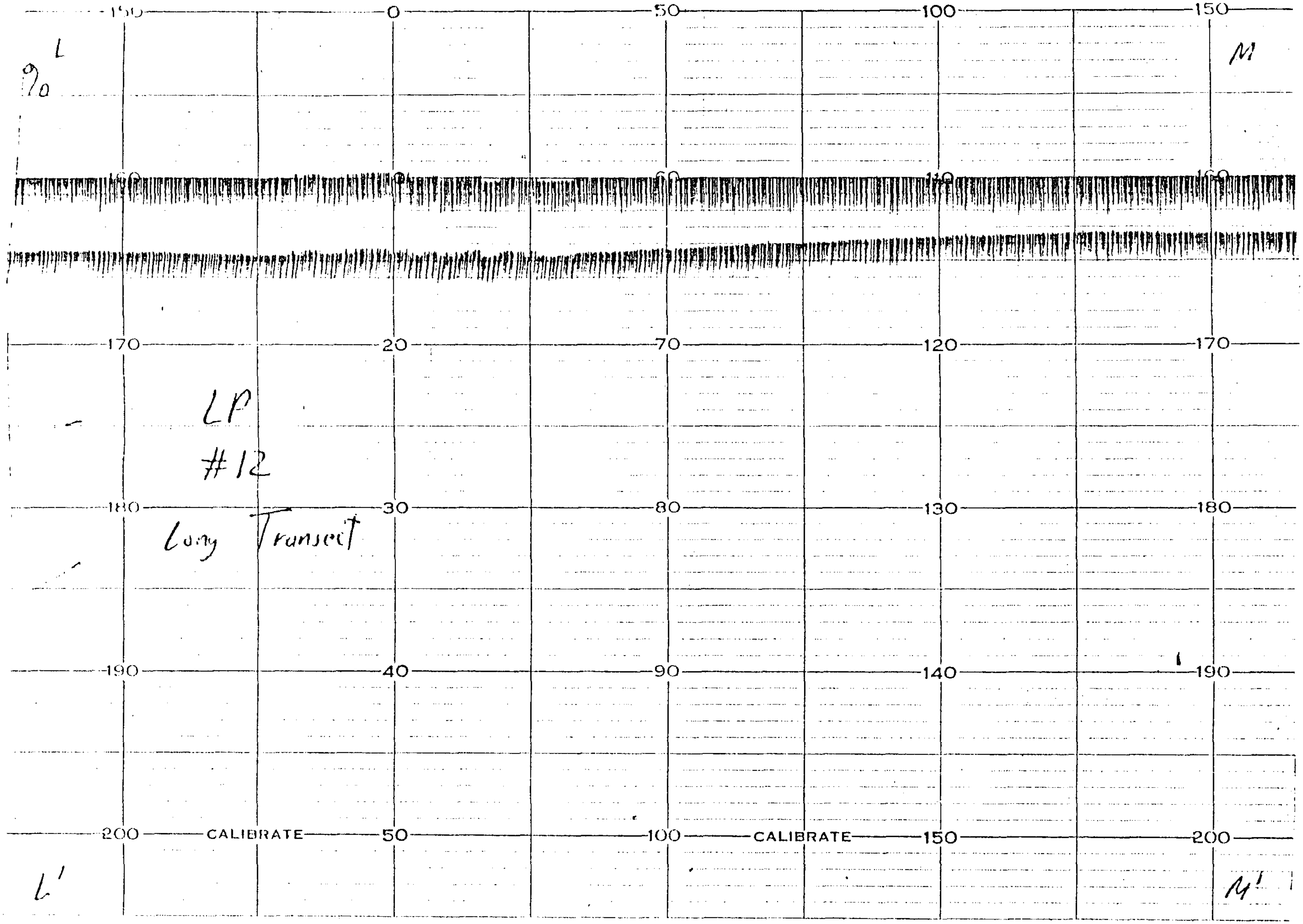
LP

#11

Long. Transect

L 10 %

CHART 7430-1001-G1 DEPTH IN FEET RAYTHEON CO. 23 CHART 7430-



90

L

M

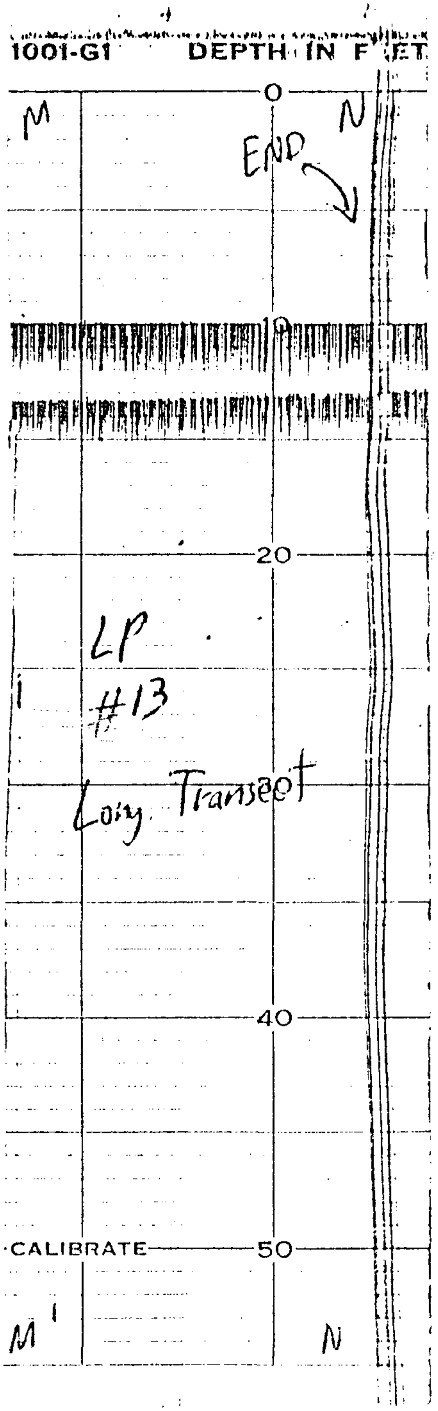
LP

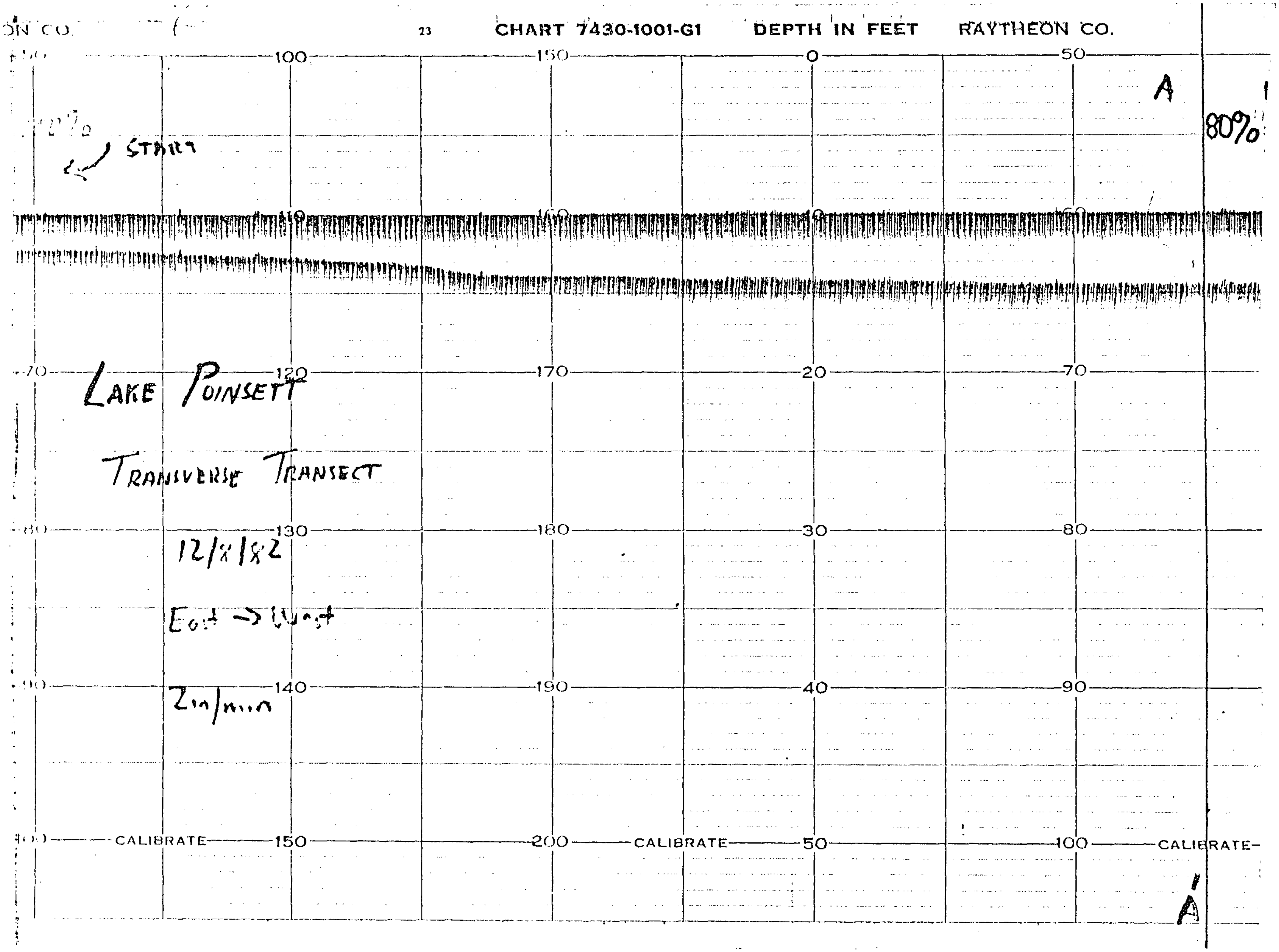
#12

Long Transect

L'

M'


1001-G1
DEPTH IN FEET
0
M
N
END
10
20
LP
#13
Long Transect
40
CALIBRATE
50
M'
N



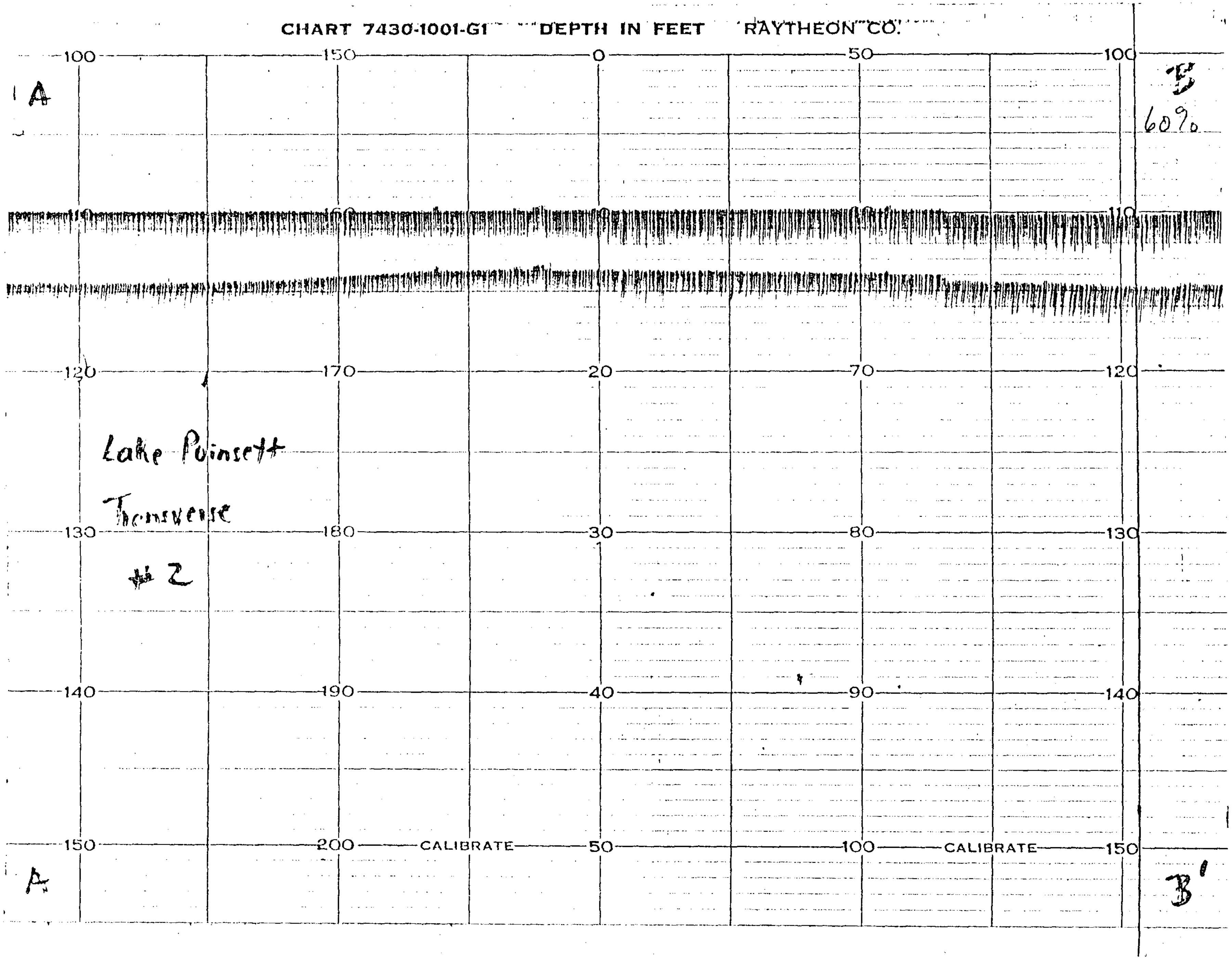
LAKE POINSETT

TRANSVERSE TRANSECT

12/8/82

East -> West

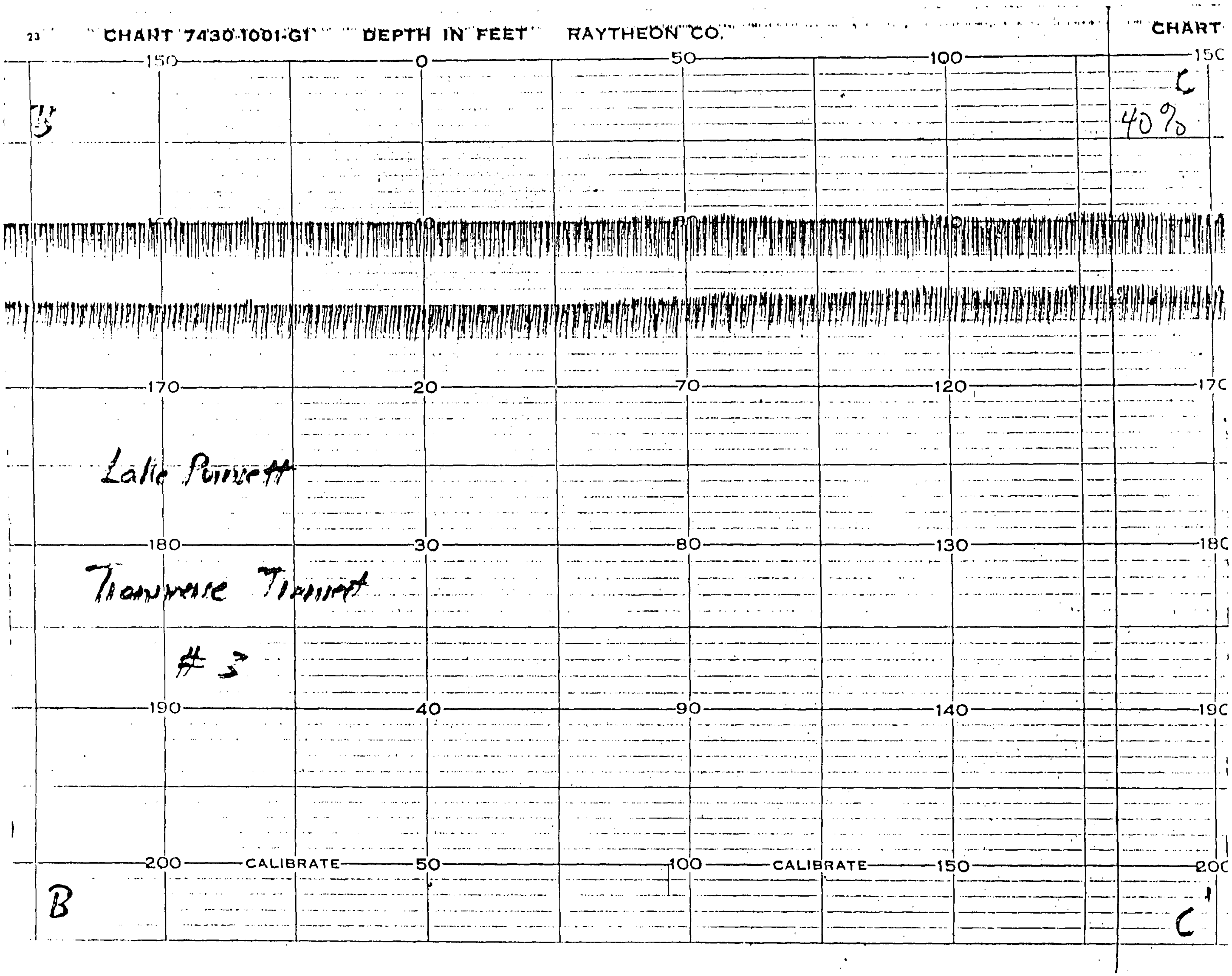
2in/min



Lake Poinsett

Transverse

#2



C

40%

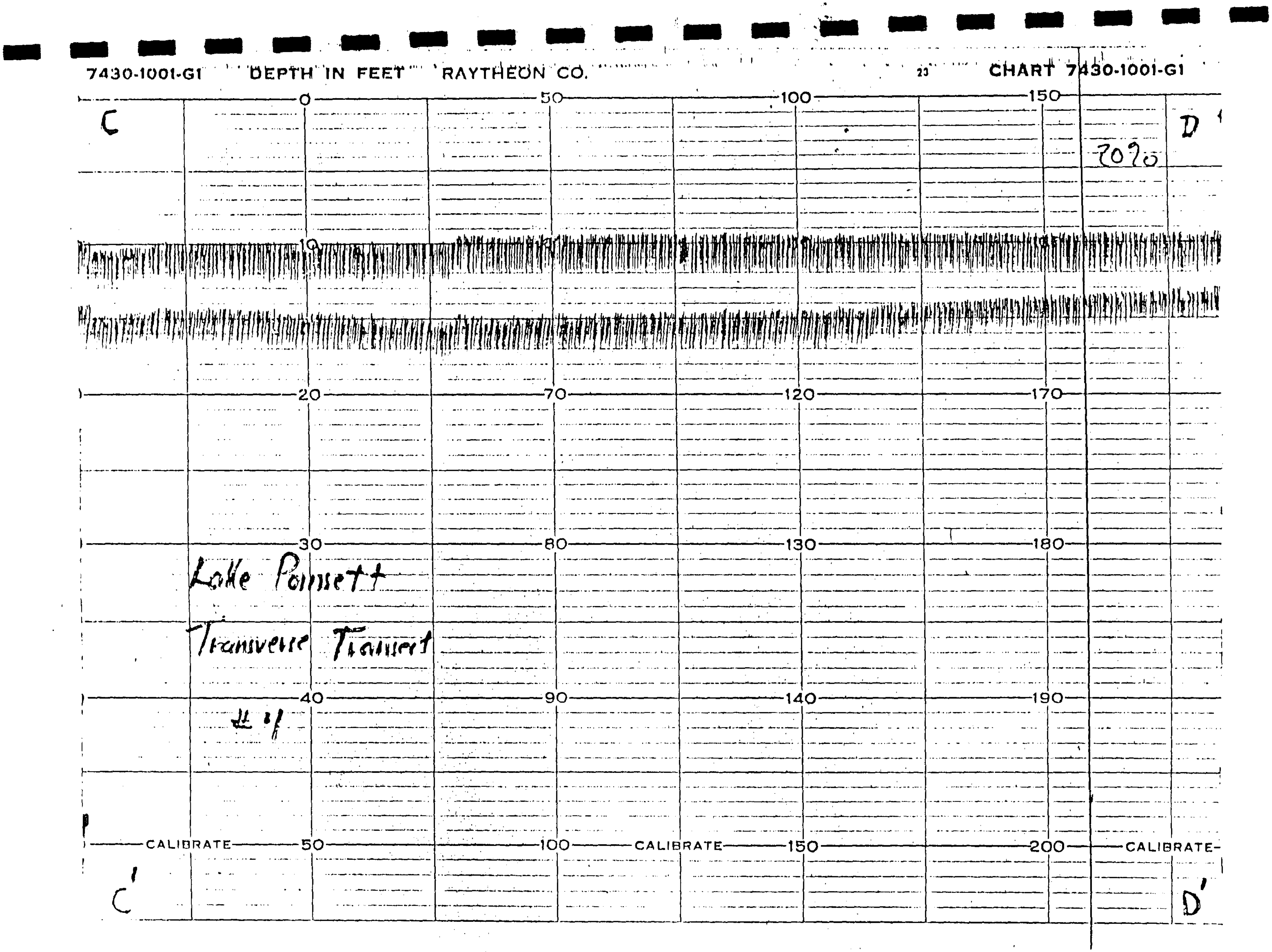
Lake Powell

Transverse Transect

3

B

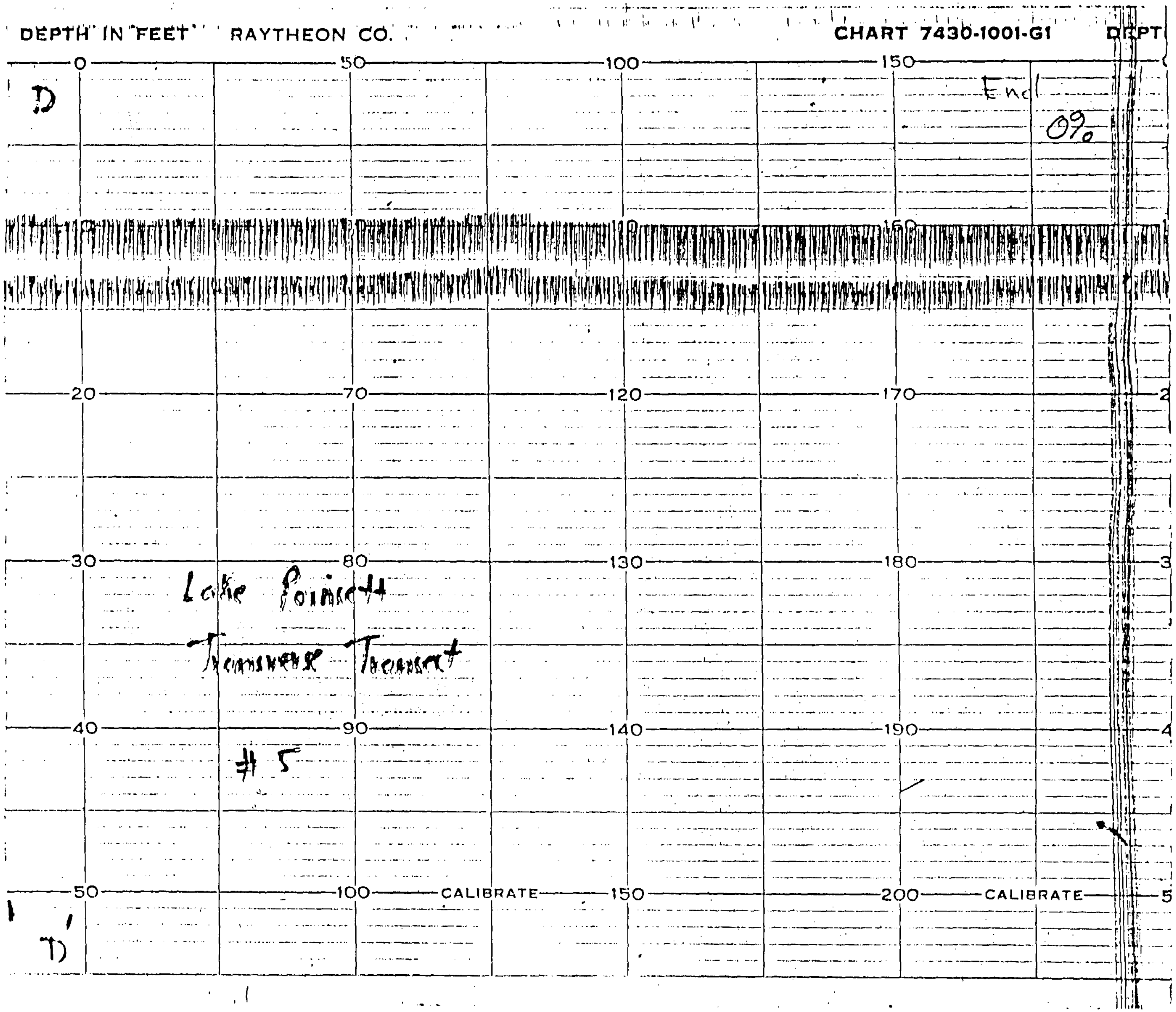
C'



Lake Poinsett

Transverse Transect

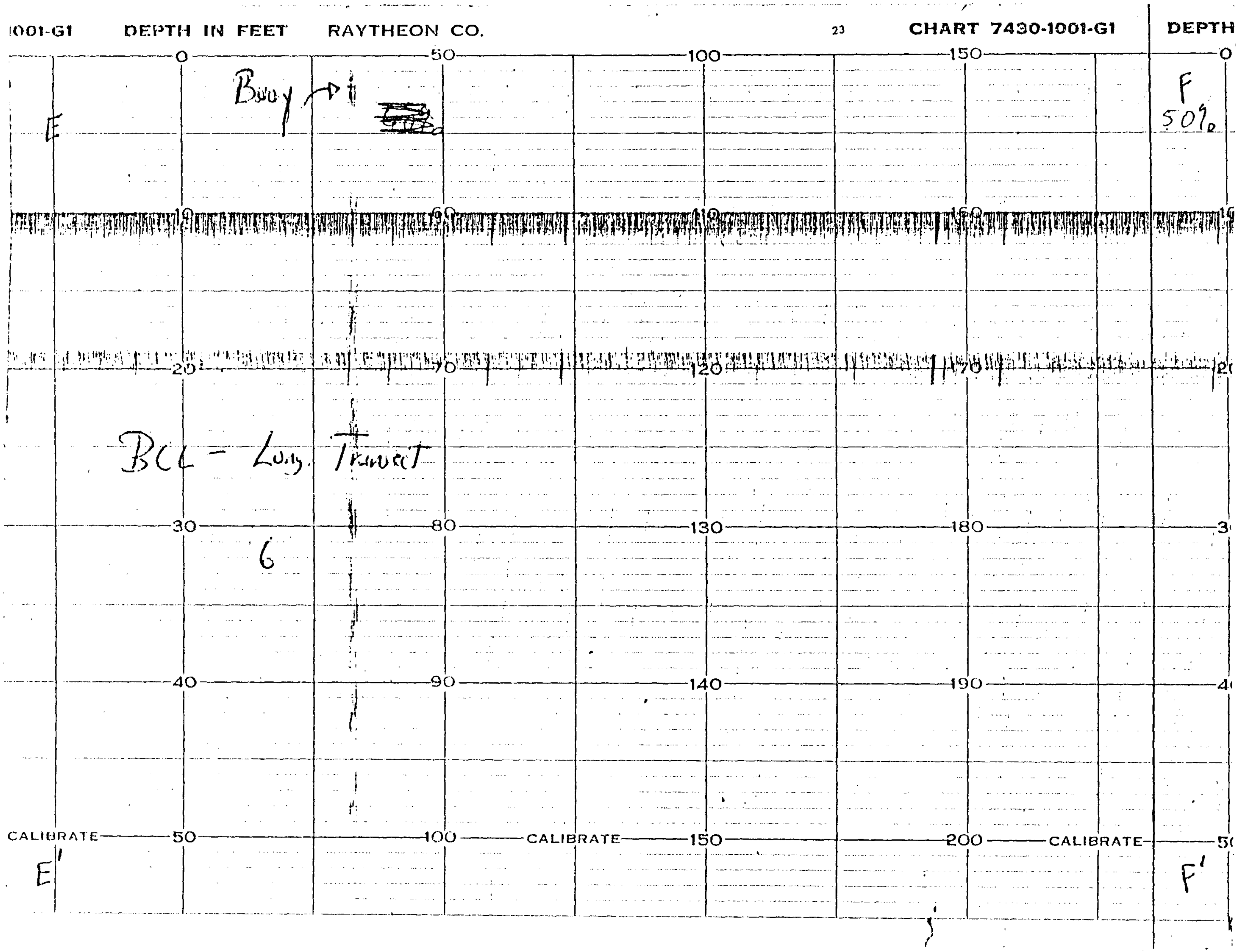
#1



Lake Poinsett

Transverse Transect

#5


1001-G1
DEPTH IN FEET
RAYTHEON CO.
23
CHART 7430-1001-G1
DEPTH
0
50
100
150
10
60
110
160
20
70
120
170
30
80
130
180
40
90
140
190
CALIBRATE
50
100
CALIBRATE
150
200
CALIBRATE
E
Buoy
F
50%
BCL - Long Transect
6
E'
F'