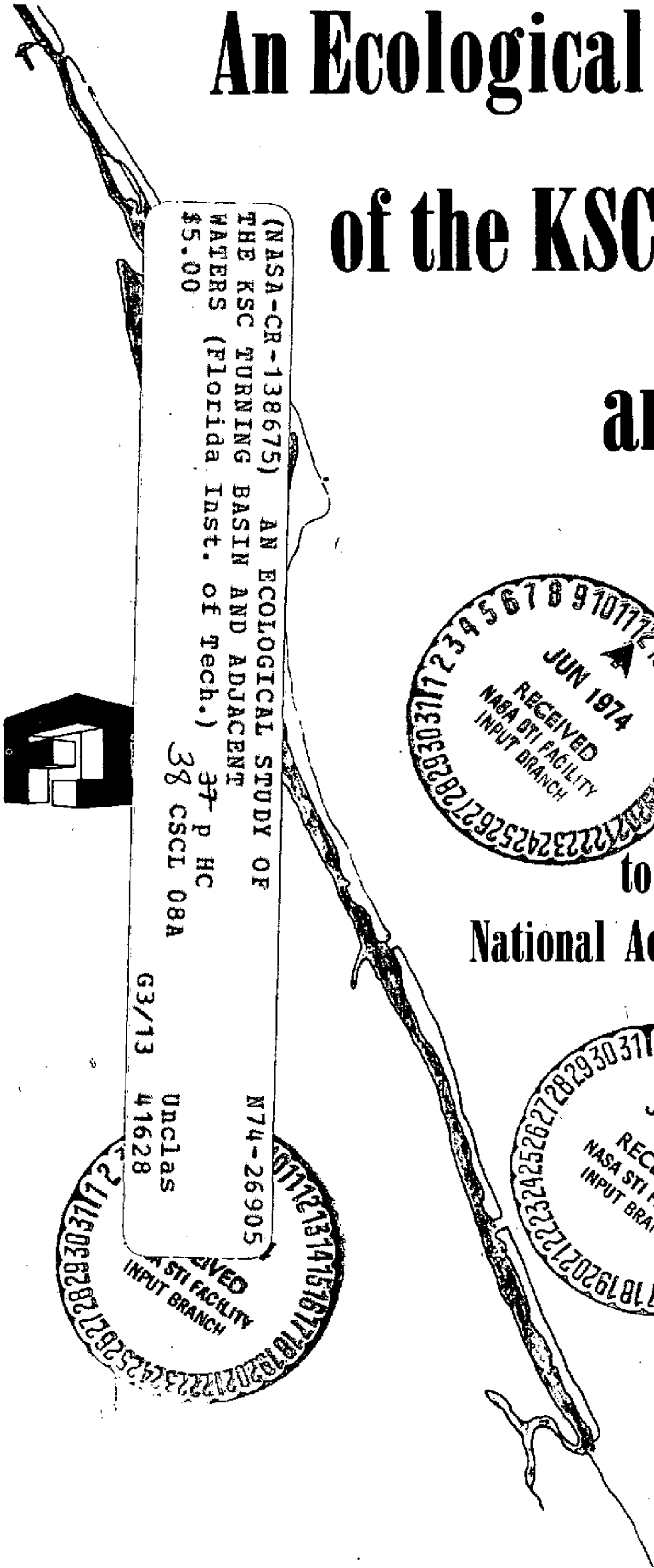
An Ecological Study of the KSC Turning Basin and Adjacent Waters



Special Report Number 6

to the John F. Kennedy Space Center
National Aeronautics and Space Administration
Kennedy Space Center, Florida

by Florida Institute of Technology
Melbourne, Florida 32901

NASA Grant NGR 10-015-008
January 15, 1974

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Introduction

The Florida Institute of Technology, at the request of the Design Engineering Division, John F. Kennedy Space Center, NASA, has conducted a special investigation into the conditions existing in the waters and bottoms of the Turning Basin near the Vertical Assembly Building, the borrow pit near Pad 39A and the Barge Canal connecting them. This investigation was to determine the various parameters of chemical, biological and microbiological significance as they existed prior to the proposed construction of new check-out facilities on the banks of the Turning Basin.

This effort was done as part of the general investigations being conducted for the Florida Institute of Technology under the title "A Study of Lagoonal and Estuarine Ecological Processes in the Area of Merritt Island, Florida, Encompassing the John F. Kennedy Space Center". The general study and the effort reported herein was funded by the John F. Kennedy Space Center, NASA, under NASA Grant number 10-015-008.

1. Purpose

This study was conducted to determine the various parameters of chemical, biological and microbiological significance in the waters and the bottoms of the Turning Basin near the Vertical Assembly Building, the borrow pit at the foot of Pad 39A and the Barge Canal connecting them (see Fig. 1, Site Location Map). The data gathered during the investigation serves also to establish a baseline of the ecological conditions that have developed in these man-made basins during the 8 years that have elapsed since they were constructed.

Site Location Map

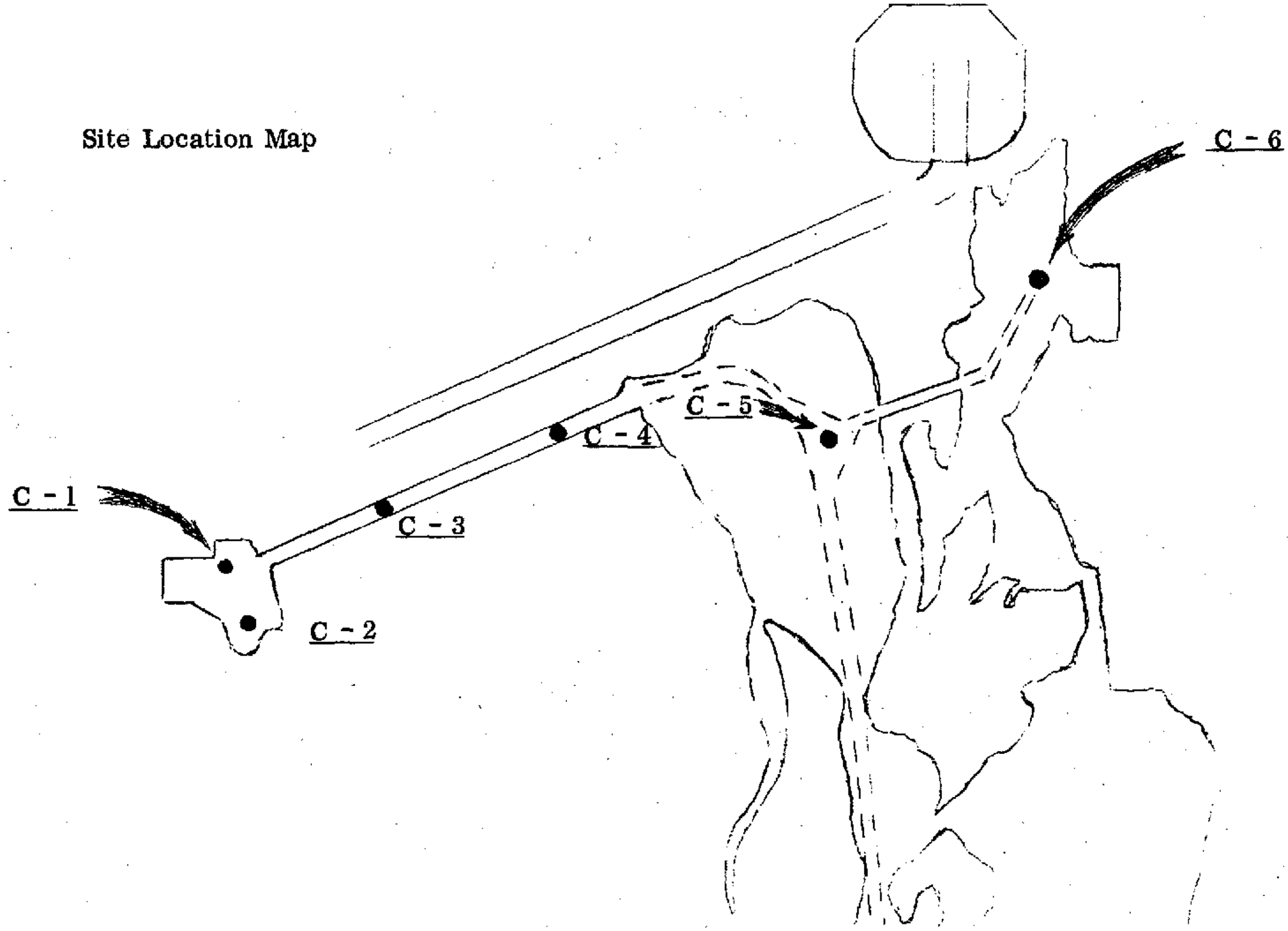


Figure 1

2. Procedure

Samples of water were taken on October 6, November 3, and December 11, 1973. They were analyzed for Temperature, Salinity, pH, Dissolved Oxygen, Nitrate ion, Phosphate ion, and Turbidity. In addition, the October samples were analyzed for the sulfate ion. All tests were performed in accordance with standard methods. The October samples were also analyzed for the heavy metal ions- lead, zinc, iron, chromium and copper, using spot test procedures taken from Fiegel, "Spot Tests in Inorganic Analysis", fifth edition, 1958.

Water samples were taken at 2 foot intervals from top to bottom in October, in order to detect any layering that might be present in the water column. Because no layering was observed in the October data, it was determined that sampling at 4 foot intervals would be sufficient to disclose any significant changes during the November and December samplings.

A 30 inch core was taken from the bottom at each site during the November sampling and examined for structure and surface deposits.

In December, bottom mud samples to determine benthic populations were taken at two sites in the Turning Basin, using a Ponar Grab Sampler operated from the bow of the F.I.T. houseboat laboratory. A total of 5 Grab samples were taken at each site. The five samples were co-mingled and mixed well to secure a sample representative of the general area, overcoming the "patchiness" of benthic populations that had been observed elsewhere in the Indian River and Mosquito Lagoon. A one-fifth aliquot was then taken from the co-mingled samples, washed and fixed and returned to F.I.T. for microscopic identification, separation and counting.

Bacterial samples from both the water columns and the bottom muds were taken at each sampling. The samples were cultured and the bacterial populations determined in accordance with accepted "Most Probable Number" procedures. Cultures were stained to determine the predominant organism.

3. <u>Findings</u>

a. Water Quality

1) Temperature: The water temperatures were found to be remarkably uniform throughout the area at each sampling period. In October, there was less than one degree Centigrade difference from one end of the area to the other or from the top of a water column to the bottom (Figure 2). By November 3rd, the median temperature had dropped 6 1/2^{o}C, from 28.5^{o}C to 22^{o}C and had developed a small but typical decline in temperature from top to bottom (Figure 3). In December, the median had dropped 5 1/2^{o}C further to 16 1/2^{o}C, again with a small decrease from top to bottom. No thermocline was evident (Figure 4).

2) Salinity: The salinity of these waters was uniform throughout the area, within the limits of reading the optical salinometer used, $\pm$1 ^{o}/oo. Further, there did not appear to be any shift in salinity during the 60 day period covered by this study (Figures 5, 6, 7).

3) pH: Again, a very strong uniformity was evident throughout the area. In October, the median was 8.4, with only 0.3 spread from high to low value. In November, the median was 8.0, and the spread only 0.4 unit. The December values were evenly split between 8.0 and 8.1 (see Figures 8, 9, 10).

4) Dissolved Oxygen: The dissolved oxygen, as measured by the Winkler titration method, showed moderate to high values throughout the area. In October and December there was also a uniform distribution from top to bottom, indicative of rapid and thorough wind mixing of the waters. The December sample was taken on a day of moderate winds (10 to 15 mph) following three days of high (15 - 25 mph) winds. The November samples show a typical decrease of oxygen from the top downward, but fair amounts remain even at the deepest places measured. The value

of 0.4 ppm reported at 28 feet at site 2 probably reflects a localized high biological oxygen demand from muck collecting in a pocket in the bottom. (Figures 11, 12, 13).

5) Primary Nutrients: Negligible amounts of Nitrate and Phosphate salts were found, and the variation from site-to-site and from month-to-month was minimal. This distribution parallels the thoroughly-mixed pattern evident from other parameters. The amounts found are typical for the Banana and Indian River waters (Figures 14-19).

6) Sulfate: During the October sampling, the waters were analyzed for the quantity of the sulfate ion present. The amounts of sulfate ion found are typical of sea water of the salinity that was measured, and the variations from point to point are within the expected range. The test was not repeated in November or December (Figure 20).

7) Turbidity: The observed turbidities in this study are approximately the same as those observed elsewhere in the Banana River and Indian River, although the range of values is somewhat less than usually found in the larger areas. In part, this is a result of the wind-mixing previously mentioned, and in part a reflection of the fact that the smaller bodies of water simply have less area in which to develop varied micro-climates (Figures 21, 22, 23).

8) Spot Tests, designed to detect iron, lead, copper and zinc at very low levels of concentration, were made on all water samples in October. No indications of these heavy metals were found in any sample, although the tests are sensitive to their presence in amounts less than one part per million (ppm).

b. Biological Analysis

To assess the effects of dredging activities on the biological component of the turning basin, two benthic samples were collected at sites C-1 and C-2. These samples were collected by Ponar Grab, using a total of five grabs at each site, with counting and sorting performed on a one-fifth aliquot of the pooled sample. A portion of the remaining sample was later analyzed for sediment grain-size analysis and total organic carbon content.

As the Indian River and associated waters form a unique ecosystem, these samples must be compared with other samples from relatively undisturbed portions of the river. Table 1 presents a summary of stations C-1, C-2, TR-13 (from a transectional study of the north Indian River), and a sample from area 4 (borrow pit west of the Titan complex).

In the majority of Indian River benthic stations examined thus far, densities of animal populations have ranged from about 2,000 to 60,000 animals per square meter. The very low densities encountered at stations TR-13 (from the dredged portion of the Intracoastal Waterway) and C-1 and C-2 (turning basin) must therefore be considered as indications of stressed conditions influencing the biological community.

The station from area 4, while having a somewhat higher population count, is still lower than most stations from the Indian River grid and transect studies.

Diversity values, using the Shannon-Weiner diversity index (H), are substantially lower for all four deepwater stations than the mean value for the Indian River transect stations, excluding samples from the Intracoastal Waterway (H=3.58). As environmental stress increases, diversity declines, hence, very low diversity indices would indicate highly stressed environments. Stations C-2, TR-13, and the

TABLE 1

Summary of Data of Deepwater Benthic Samples, Indian and Banana Rivers

Station	C-1	C-2	Borrow pit (area 4)	TR-13
Location	Turning basin	Banana River	Banana River	Indian River
Date	11 December	11 December	25 August	24 July
Depth	12 ft.	28 ft.	22 ft.	10.5 ft.
Temp. (surface)	16.2^{o}C.	17.5^{o}C.	-	-
(bottom)	16.0	17.5	-	28^{o}
D.O. (surface)	7.0 ppm	6.9 ppm	7.04 ppm	4.61 ppm
(bottom)	6.9 ppm	6.5 ppm	2.43 ppm	4.10 ppm
Total Organic Carbon	1.1 %	8.9 %	4.0 %	2.2 %
% Silt & Clay	5.24	59.6	-	31.6
Median Grain Size	150µ	<63µ	-	-
Population Density	1736/m^2	57/m^2	12,698/m^2	94/m^2
Diversity*	3.03	0.86	0.55	1.18

* Shannon-Weiner Index

borrow pit (Area 4) all show this symptom of high stress.

The exact reasons for these lower populations and low diversities are difficult to define without further study. However, several possible reasons were suggested by this study.

Free circulation of water, carrying food and oxygen, and removing metabolites, is essential to maintain healthy benthic communities. The creation of a relatively narrow, deep basin hinders this circulation by allowing formation of a thermocline, and, by increasing the mean depth to surface area ratio, increases the requirement for energy (principally derived from wind and solar heating) necessary to induce turnover of the water mass and re-establish circulation. Higher wind velocities would be required to establish circulation at the bottom of dredged areas than in the Indian River as a whole, which has a very small depth:area ratio.

One symptom of stagnation would be low dissolved oxygen levels, occurring as bacterial and animal metabolism consume available oxygen from the lower levels of stratified water. The December sampling showed little evidence of stratification, but high winds before and during sampling probably eliminated any thermocline. Earlier sampling in November 1973, however, did show thermal stratification and pronounced oxygen depletion.

TABLE 2

Site Number	C-1	C-2
Temperature (surface)	22.8°C	22.8°C
(bottom)	21.8	21.0
D.O. (surface)	7.5 ppm	8.2 ppm
(bottom)	5.1	0.4

Dissolved oxygen values as low as 0.4 ppm, even though temporary, would be quite sufficient to exclude most macrofauna and meiofauna from the benthic community. The effect of this should be to lower both diversity and density, and the effect should be more pronounced with increased depth. This is consistent with the data obtained.

Another detrimental feature of deep basins is that they tend to act as "sinks" in which fine particulate matter collects. This is shown by the increased content of silt and clay and of organic material in the deeper stations. Addition of very fine material is detrimental to bottom organisms in that it may clog feeding and respiratory structures of suspension-feeding animals, common in most benthic communities. High turbidities may also result which may scatter and reflect sufficient light that primary production may be inhibited. It is noteworthy that no living macrophytes were obtained in any of the four stations. Thirdly, fine sediments may not be attractive as substrates for induction of larval metamorphosis. The very small median grain size of station C-2 could, for example, exclude many species of invertebrates which prefer attachment to sand grains.

c. Microbiological Data

The sampling date in October was one of high (20-25 + mph) winds out of the East. The wind induced turbulence and mixing of the water and re-suspension of sediments in the sample area are reflected in the widespread distribution of haloduric bacteria as shows in Figure 24. As was to be expected, the largest numbers were cultivated from the sediments. Coliforms were detected in the deeper waters at sites 1 and 3, during this excursion, however, they were not confirmed as E. coli.

The samples collected during the second excursion in November indicated a more to be anticipated distribution of haloduric bacteria; small numbers in the water columns, larger numbers in the sediments. The data are summarized in Figure 25.

The November pattern was essentially duplicated in the samples collected during December, (Figure 26). In all samples cultured, the predominant organism was a gram positive rod shaped creature, which formed spores. Few gram positive filamentous organisms were also found. No coliforms were detected in samples collected during either of these excursions.

As has been observed previously in studies of Banana Creek, the greatest numbers of cultivatable haloduric bacteria are usually found in the sediments of a body of water. It is of interest, however, that the numbers cultivated from the sediments of the Turning Basin and its access canal are generally smaller by 1 to 2 orders of magnitude than those determined from the sediments of Banana Creek. A probable explanation for the differences noted lies in:

a. The bottom sediments are of fairly recent incidence.

b. The comparatively small amounts of materials transported into the canal and the turning basin from the adjacent land and shallow water areas.

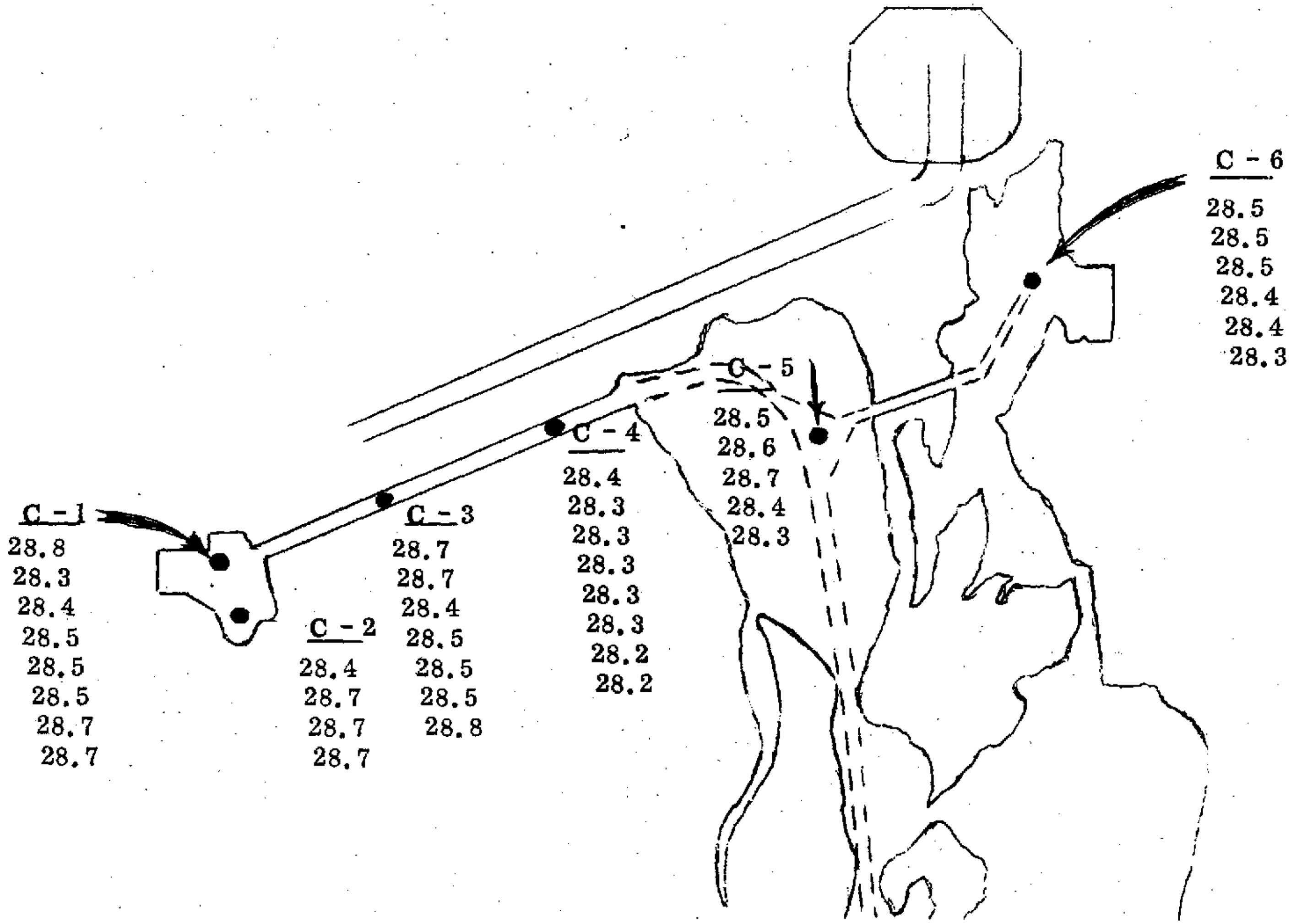
No sulfides were detected chemically in any of the sediment samples tested, although their characteristic odor was noticed in one sample collected at site C-2 during November. The bottom is irregularly deep in this area, and it is entirely possible that the site of the sulfide mud was not located in other samplings.

4. Discussion

On the basis of the results from the analyses performed, the waters of the Turning Basin, barge canal and borrow pit are quite similar to those of the Banana River and Indian River. They are, in general, well mixed and well oxygenated. A few deep pockets in the uneven bottom terrain approach anoxic conditions, and a mud sample from one of these areas had a strong hydrogen sulfide odor, indicating that it was anoxic. Again, this is typical of the open river also. The absence of response in the tests for heavy metal ions is considered to indicate that there was no industrial pollution present. The microbiological tests did not demonstrate E. coli, an indication that there is no waste pollution of these waters.

The low diversity and low total populations of the benthic community are characteristic of the recent origin of these waterways. Many years may be required for establishment of an equilibrium following a severe disturbance of a bottom community. The stations examined may in time develop a large and diverse population, however, our results indicate that such development must be very slow.

Based on the results of our study, we would recommend that future dredging activities be limited in depth and that fill materials should not be removed down to clay strata; if clay/silt layers are fairly shallow, conditions might be improved if the clay were stripped to a larger-grained stratum (e.g. sand). Consideration might also be given to orientation of borrow areas; if the longitudinal axis were oriented in the direction of prevailing winds, more efficient turnover might result, decreasing the effects of stratification.



TEMPERATURE °C
Figure 2

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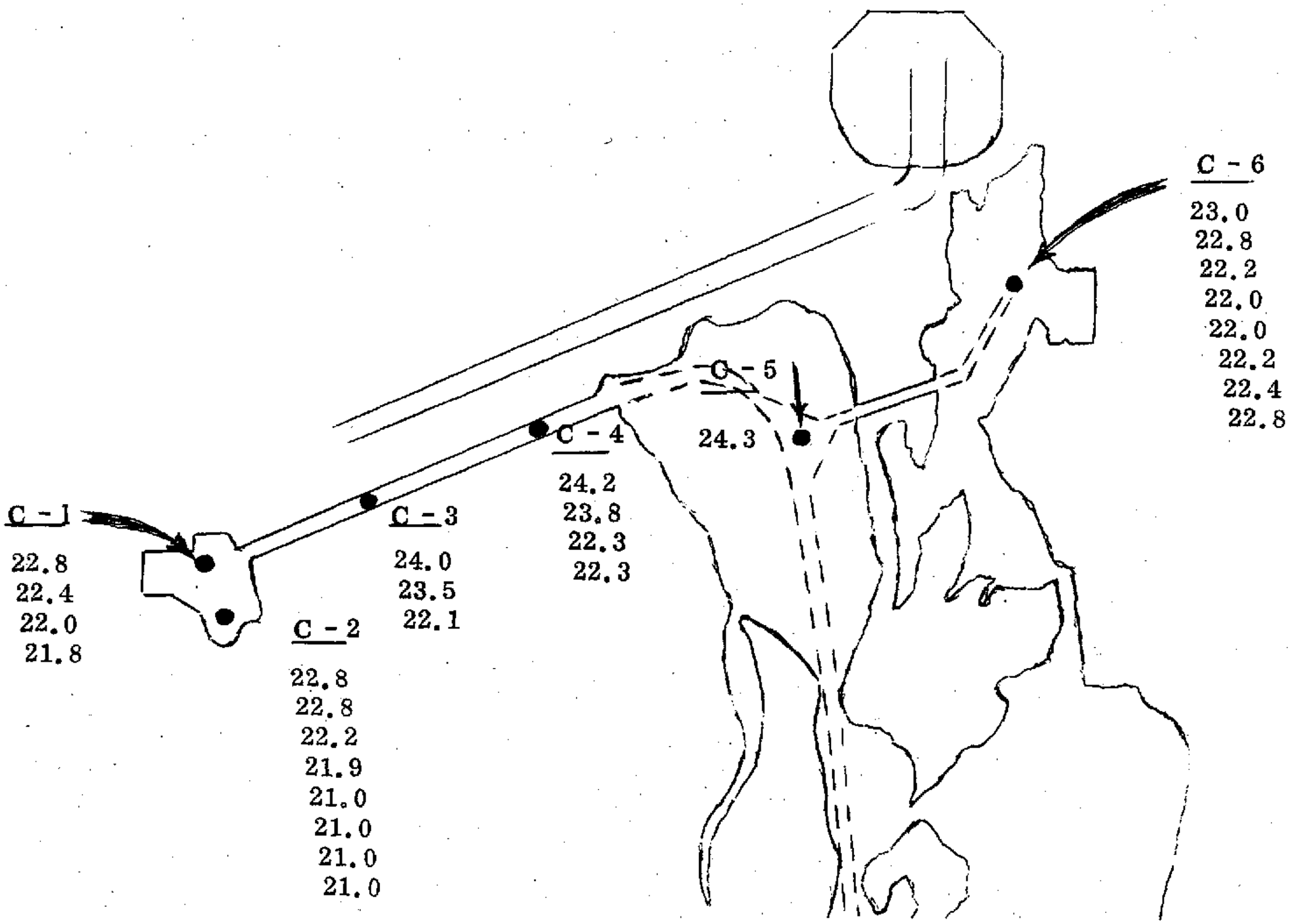
10/6/73



TEMPERATURE ^{o}C
Figure 3

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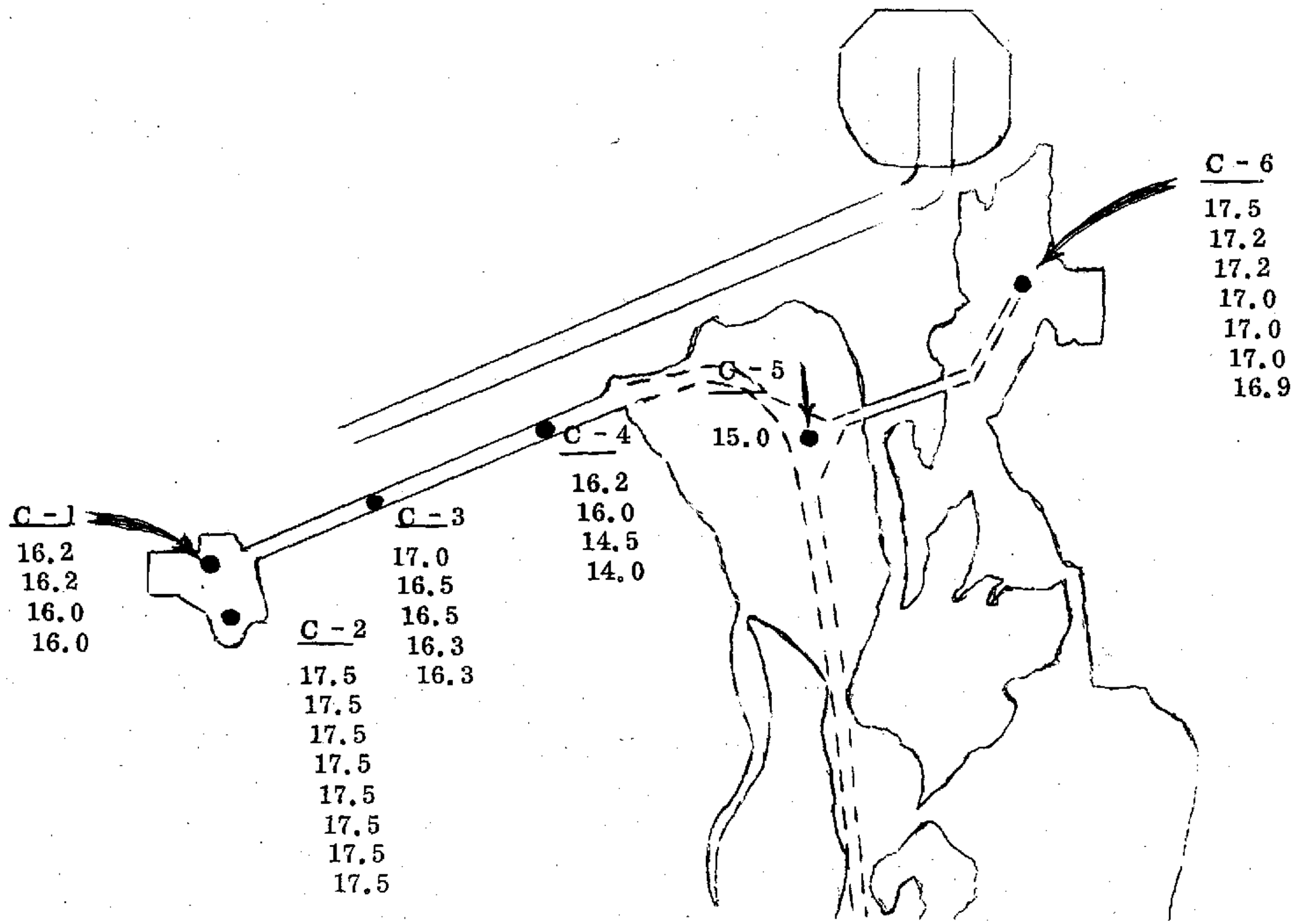

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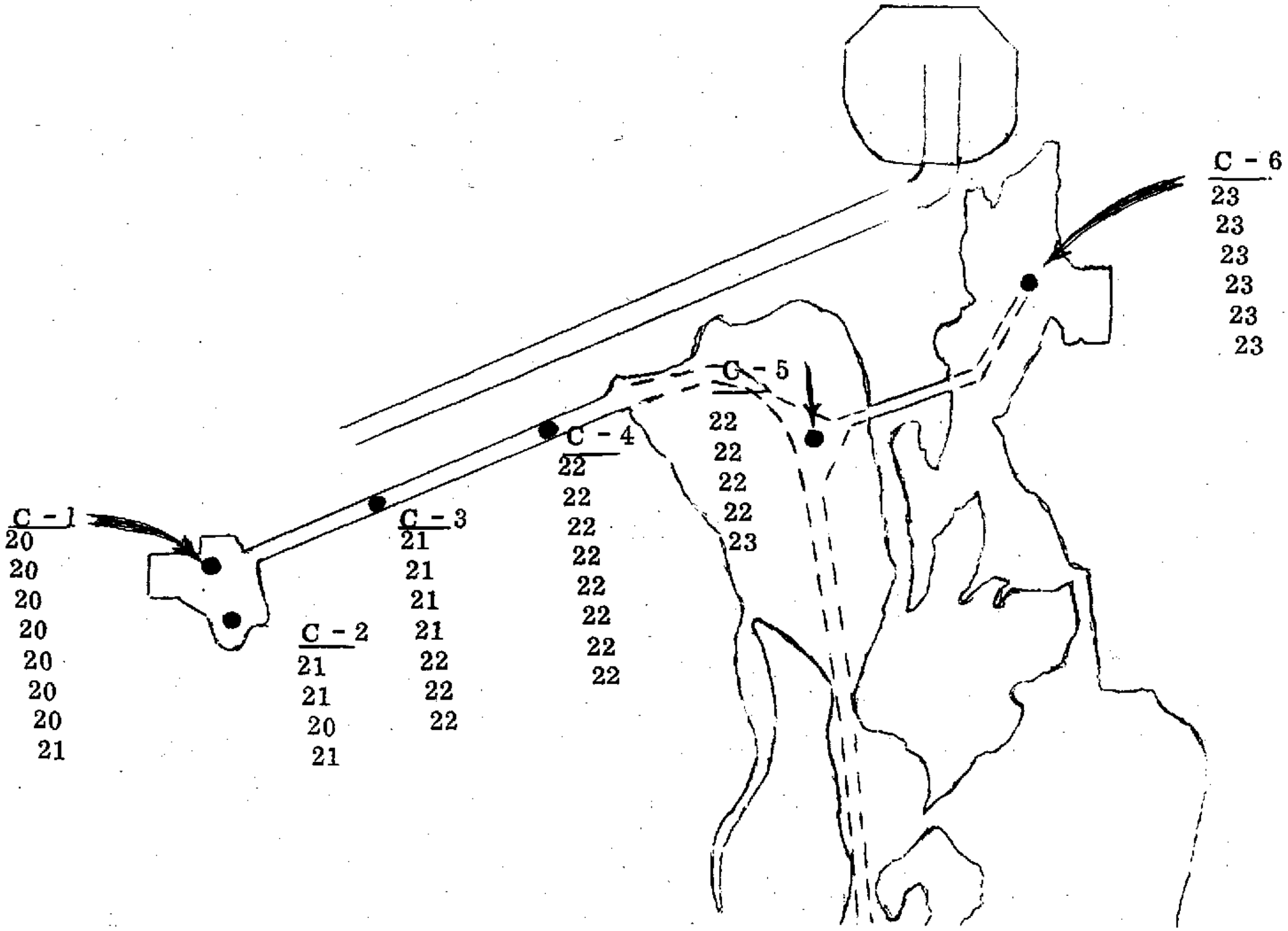
TEMPERATURE °C
Figure 4



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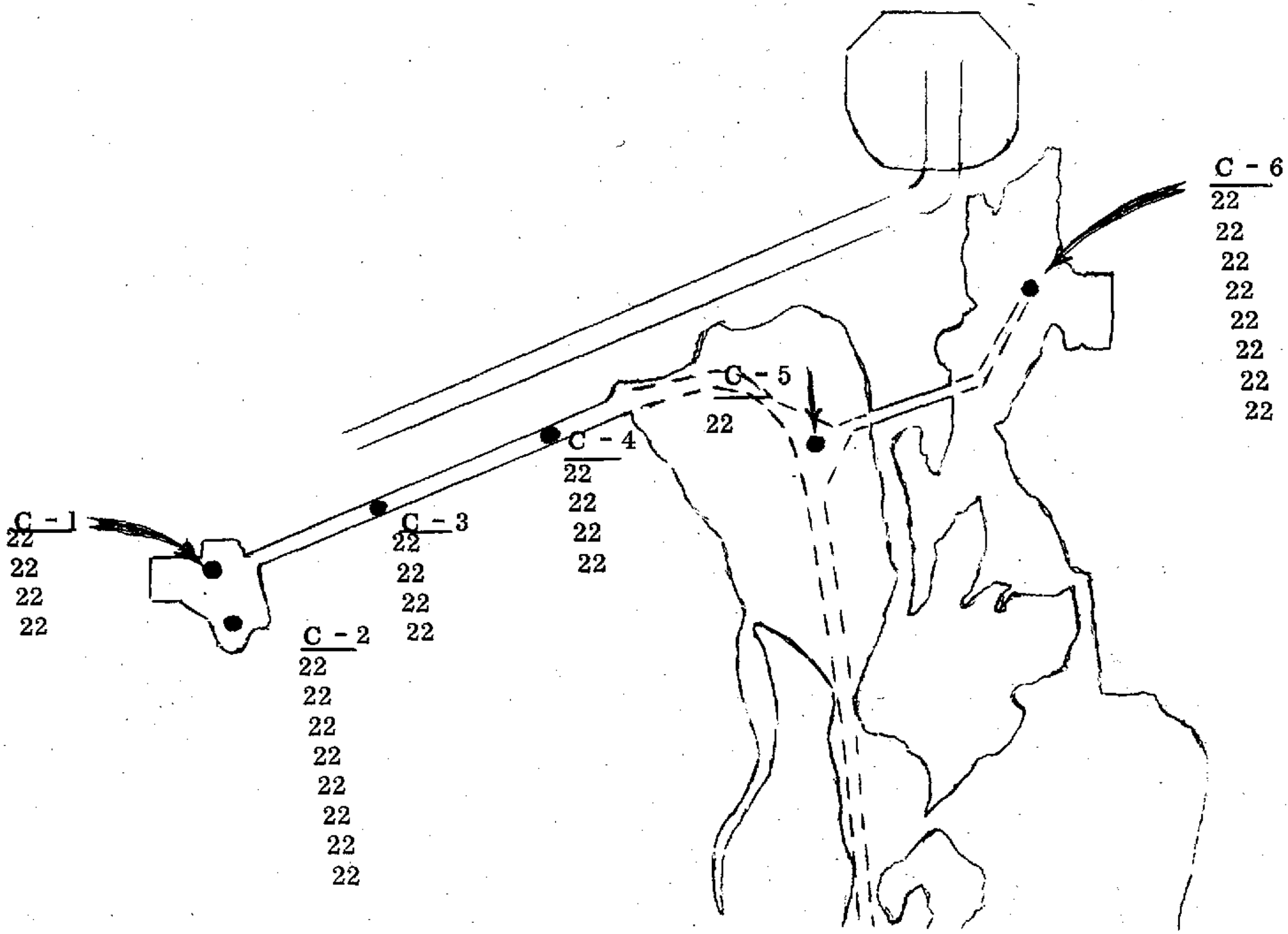
SALINITY $^{0}/oo$

Figure 5



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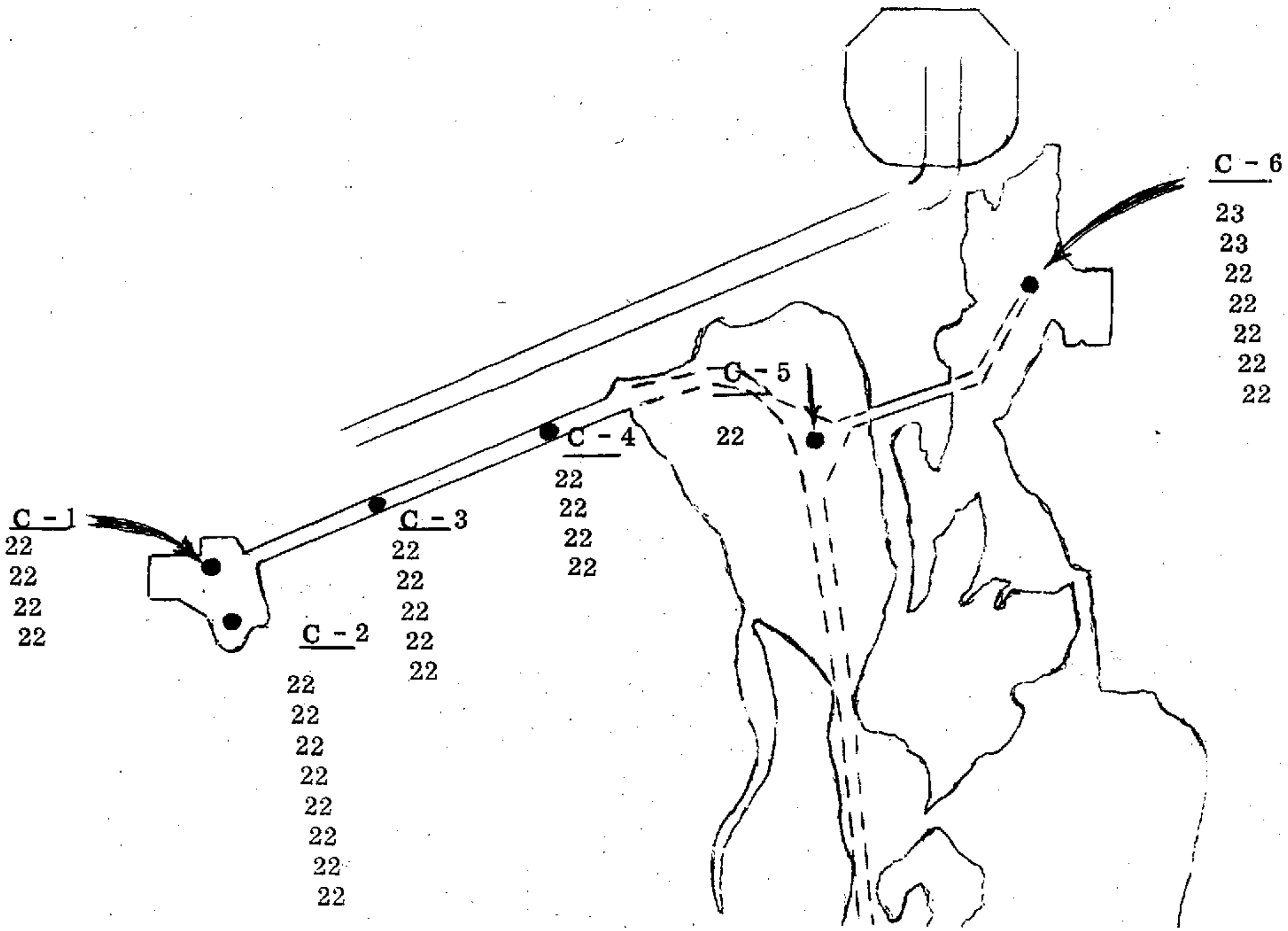
SALINITY $^{o}/oo$
Figure 6



SALINITY $^{o}/_{oo}$
Figure 7

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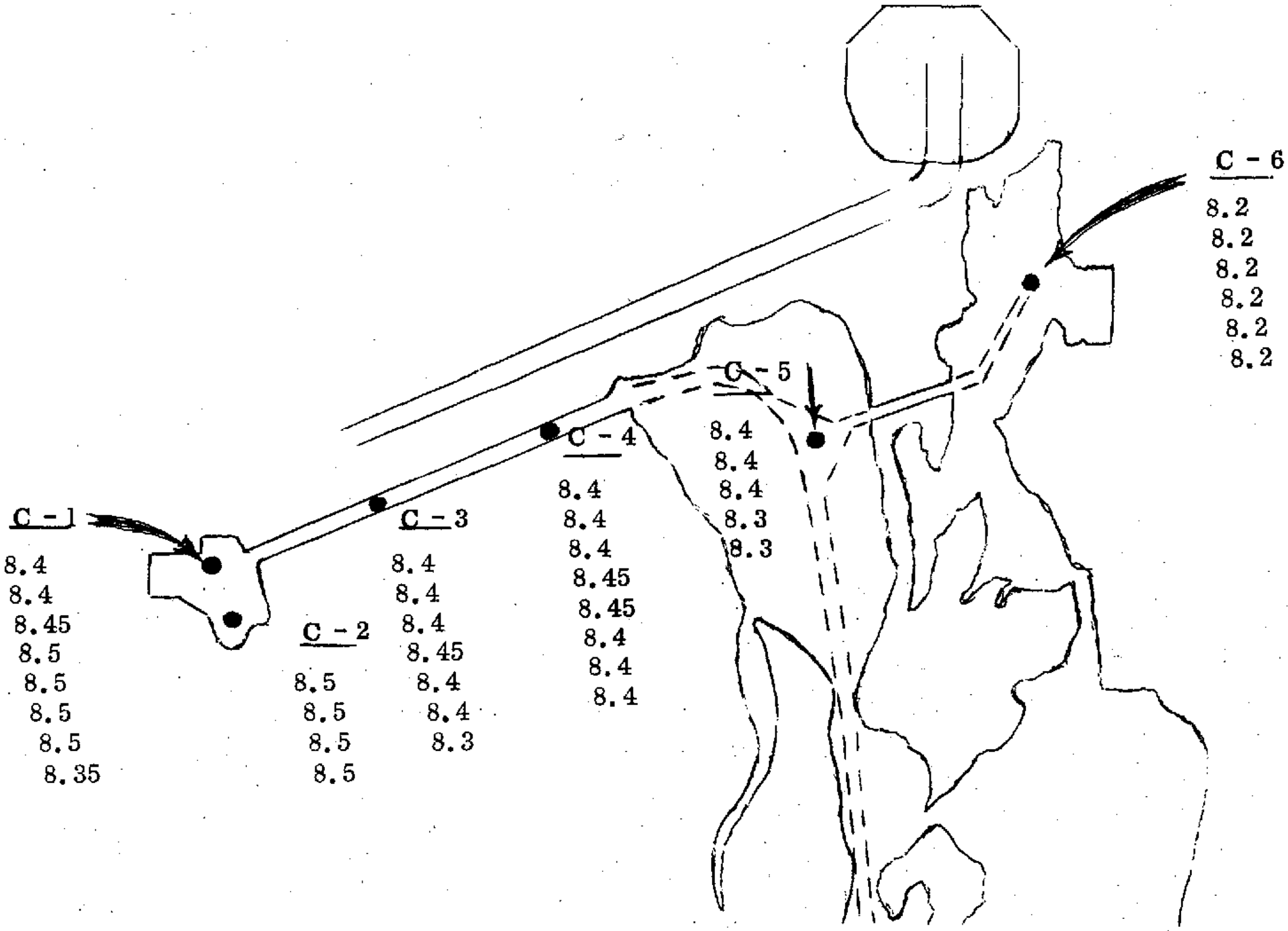

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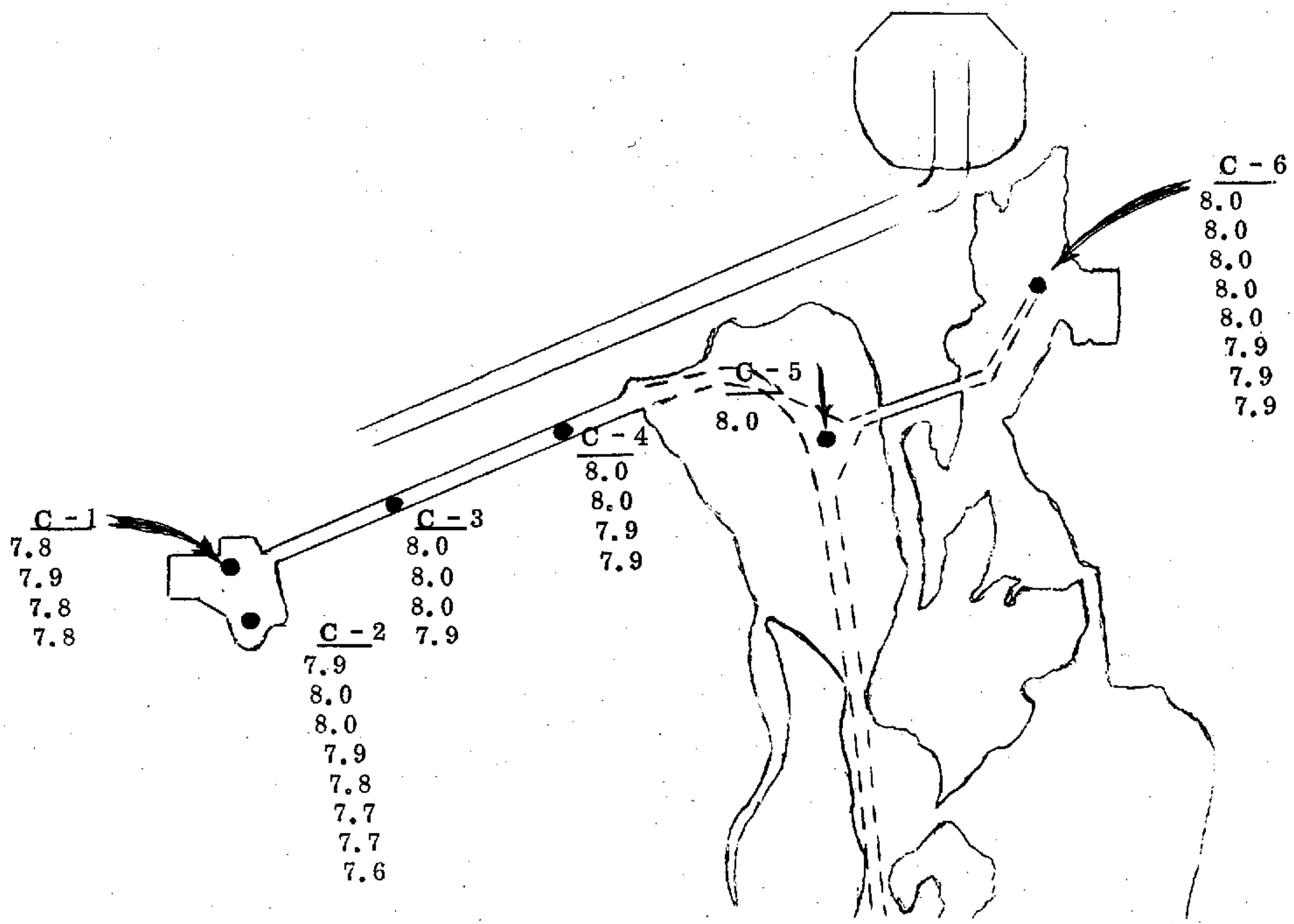
pH

Figure 8



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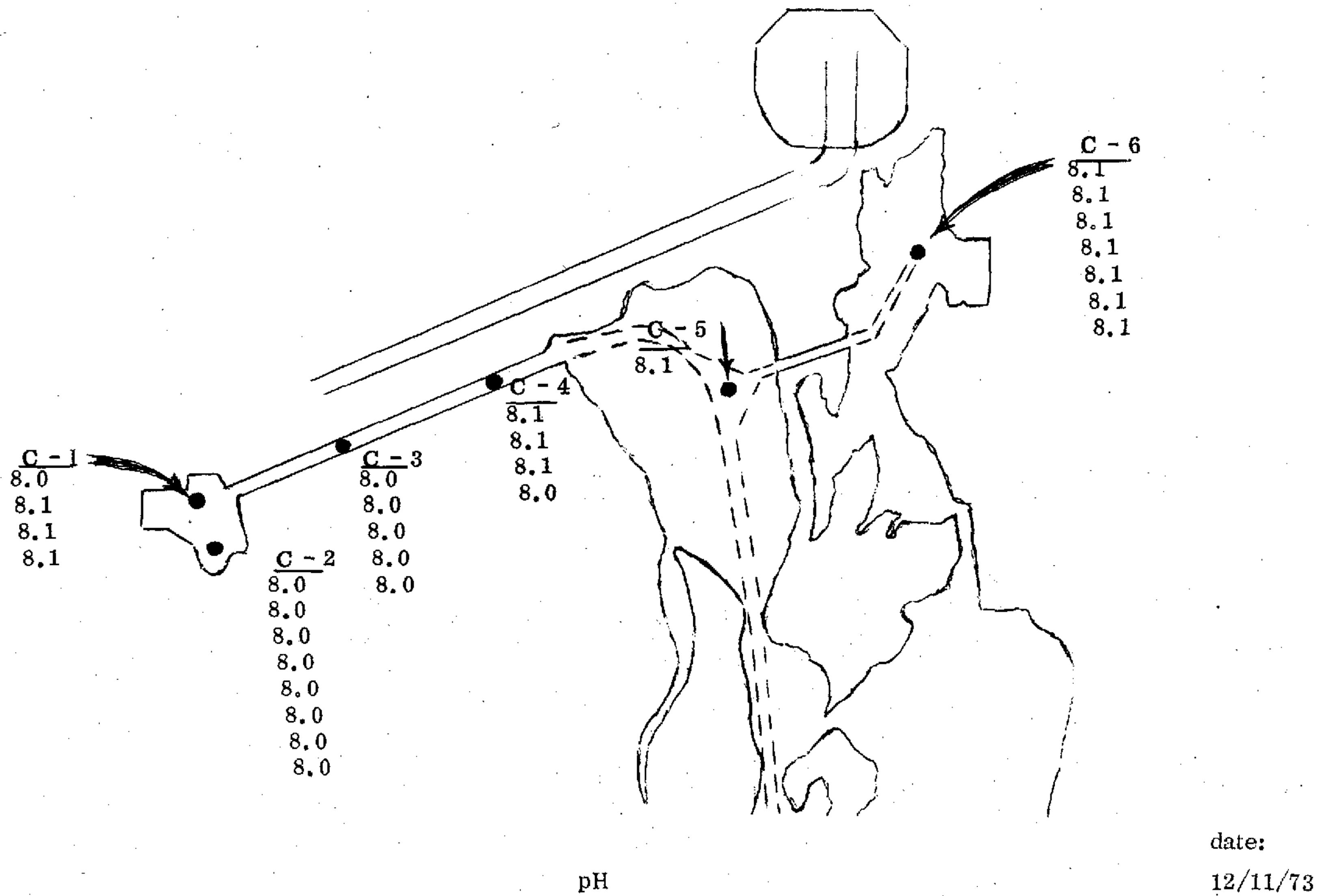
pH

Figure 9


C - 1
8.0
8.1
8.1
8.1
C - 2
8.0
8.0
8.0
8.0
8.0
8.0
8.0
8.0
C - 3
8.0
8.0
8.0
8.0
8.0
C - 4
8.1
8.1
8.1
8.0
C - 5
8.1
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pH
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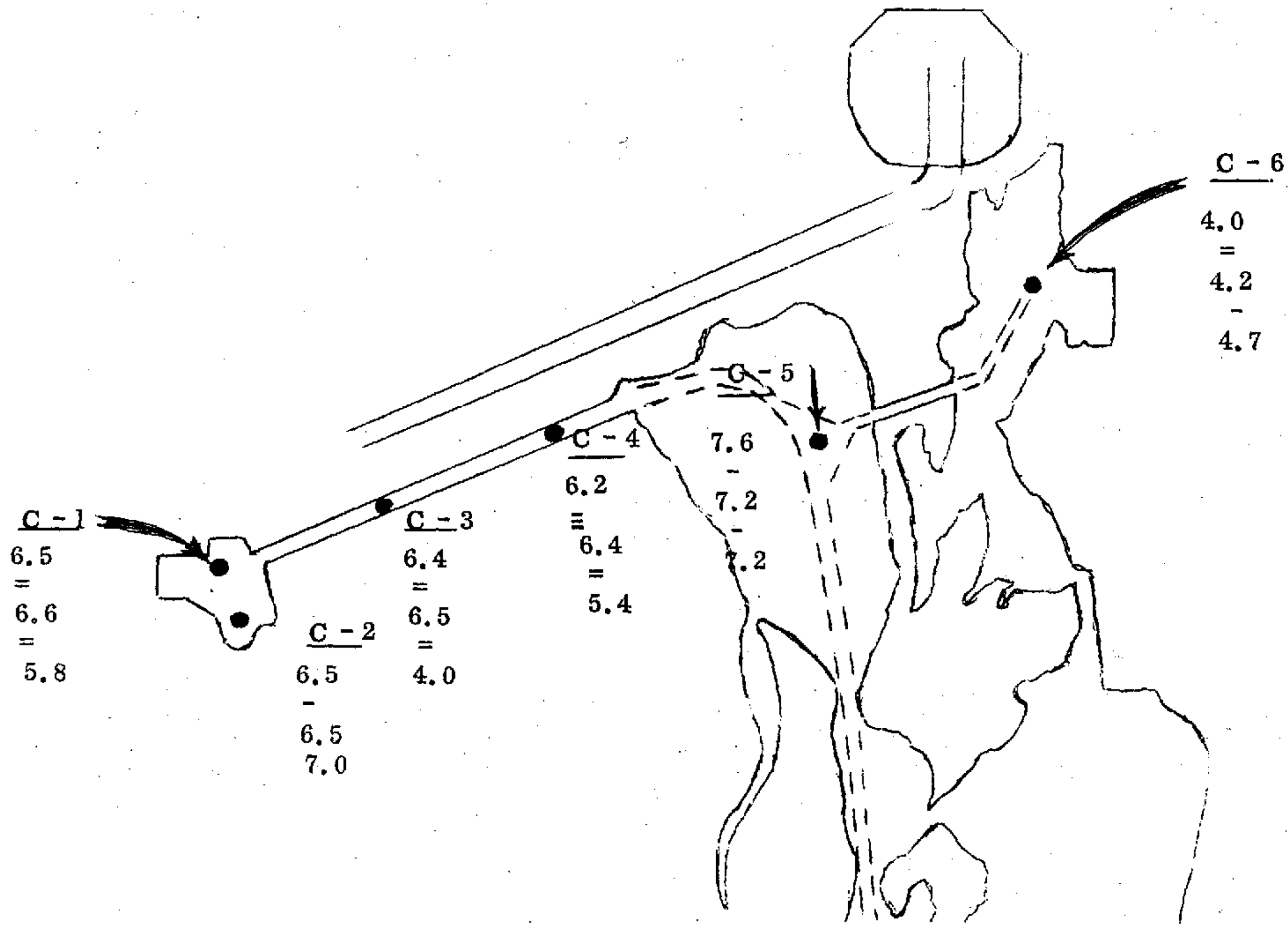
Figure 10



Dissolved Oxygen, ppm

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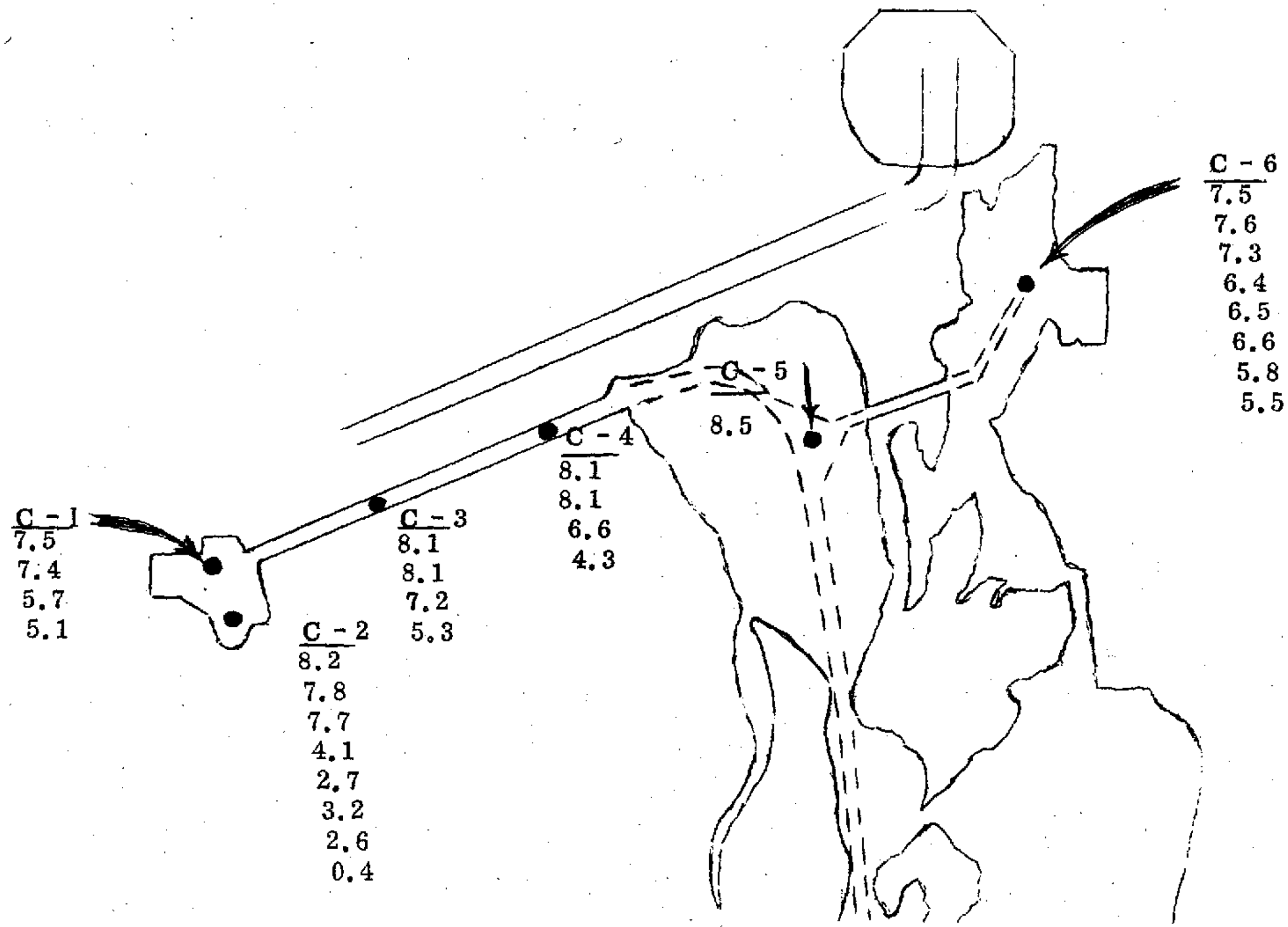
Figure 11



Dissolved Oxygen, ppm

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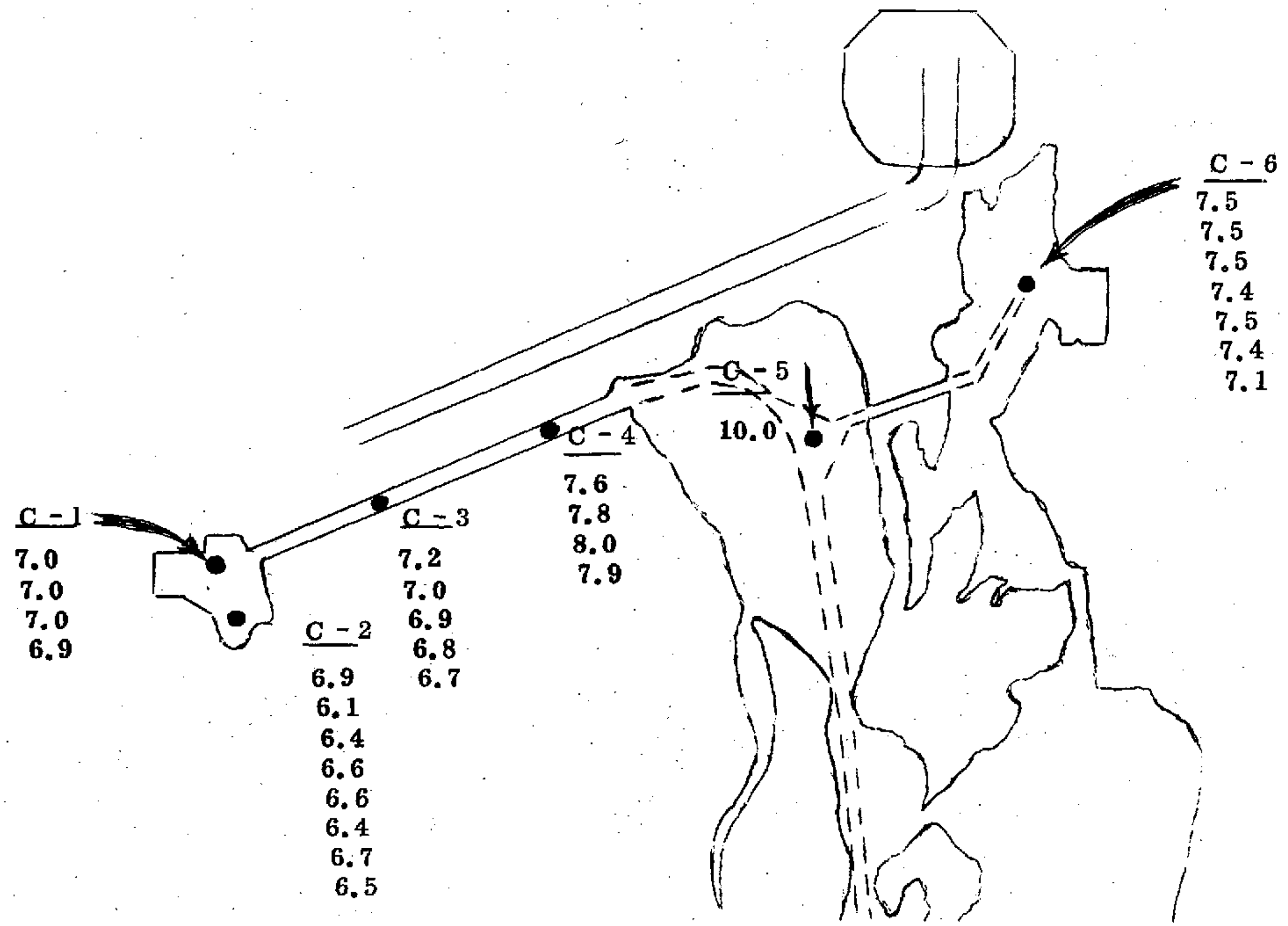
Figure 12



Dissolved Oxygen, ppm

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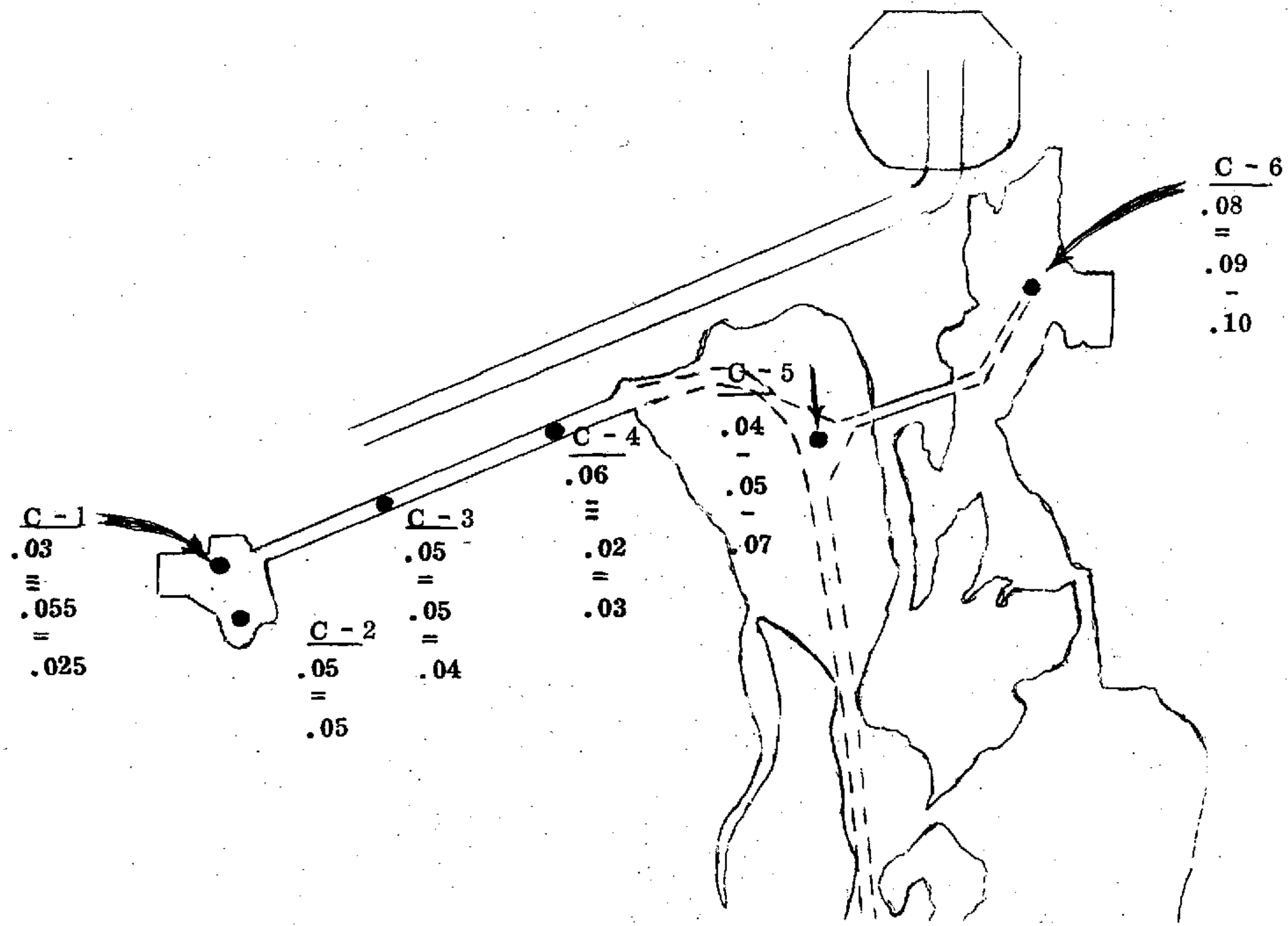
Figure 13



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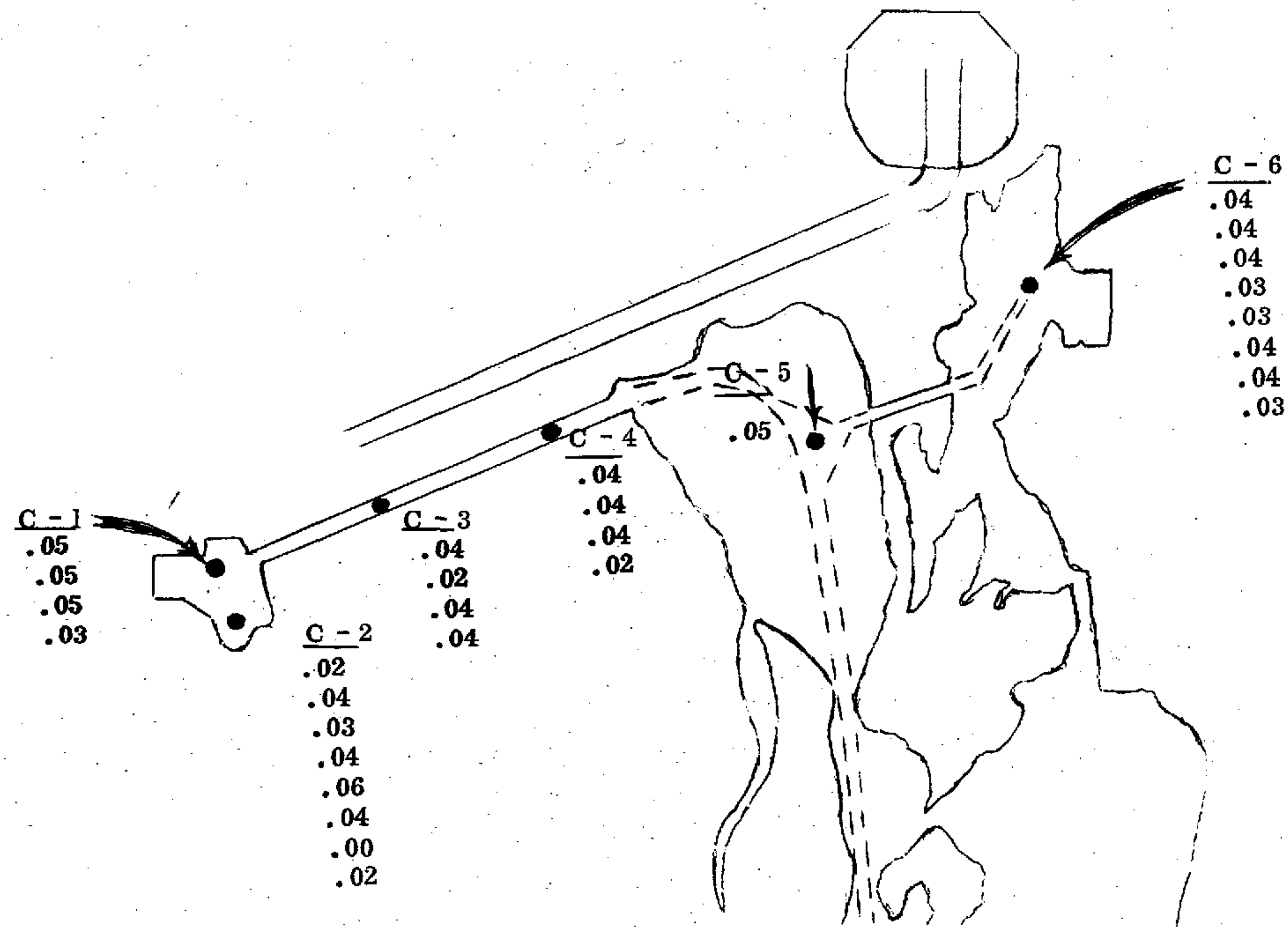
NITRATE ppm

Figure 14



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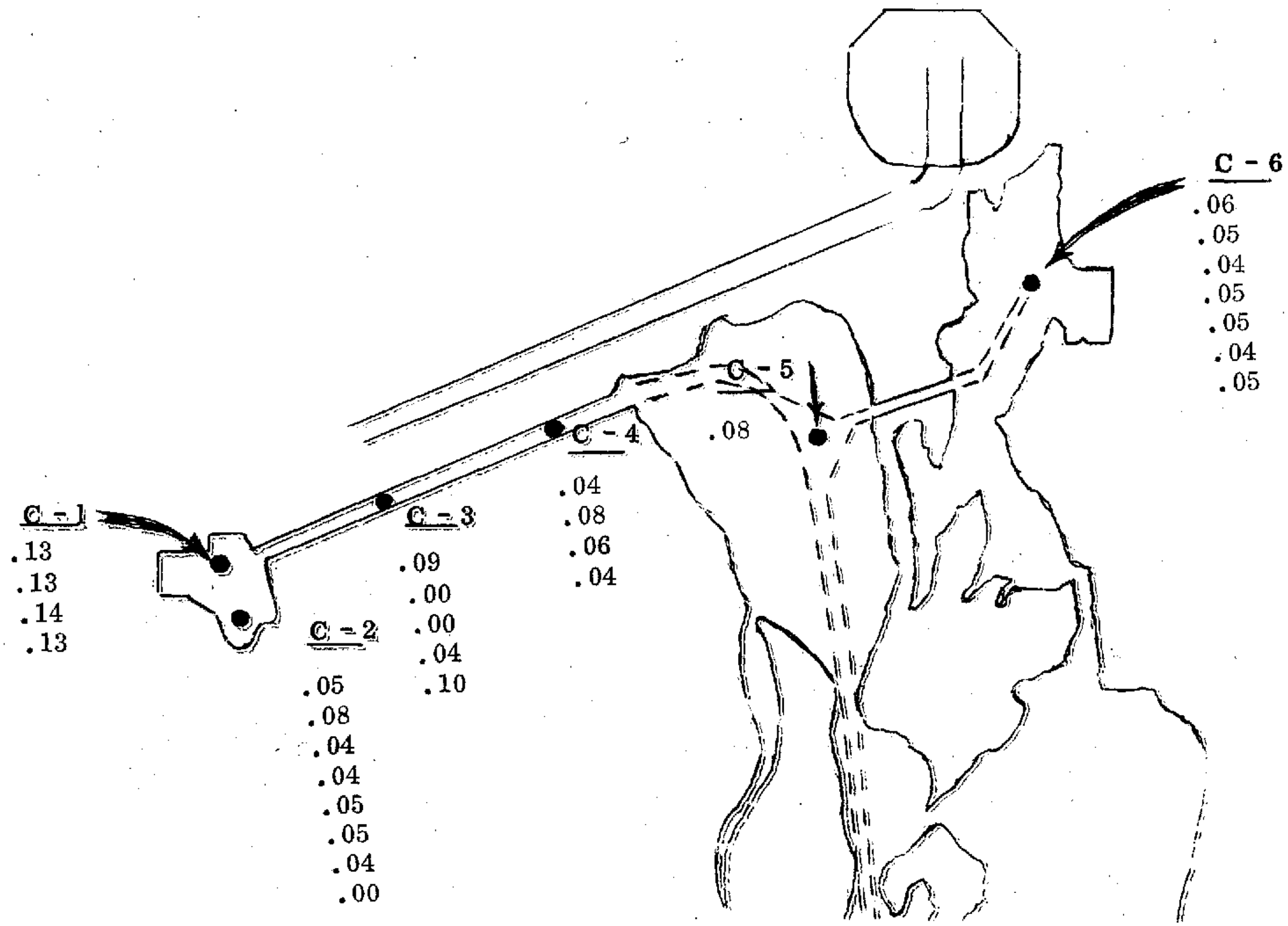
NITRATE ppm

Figure 15



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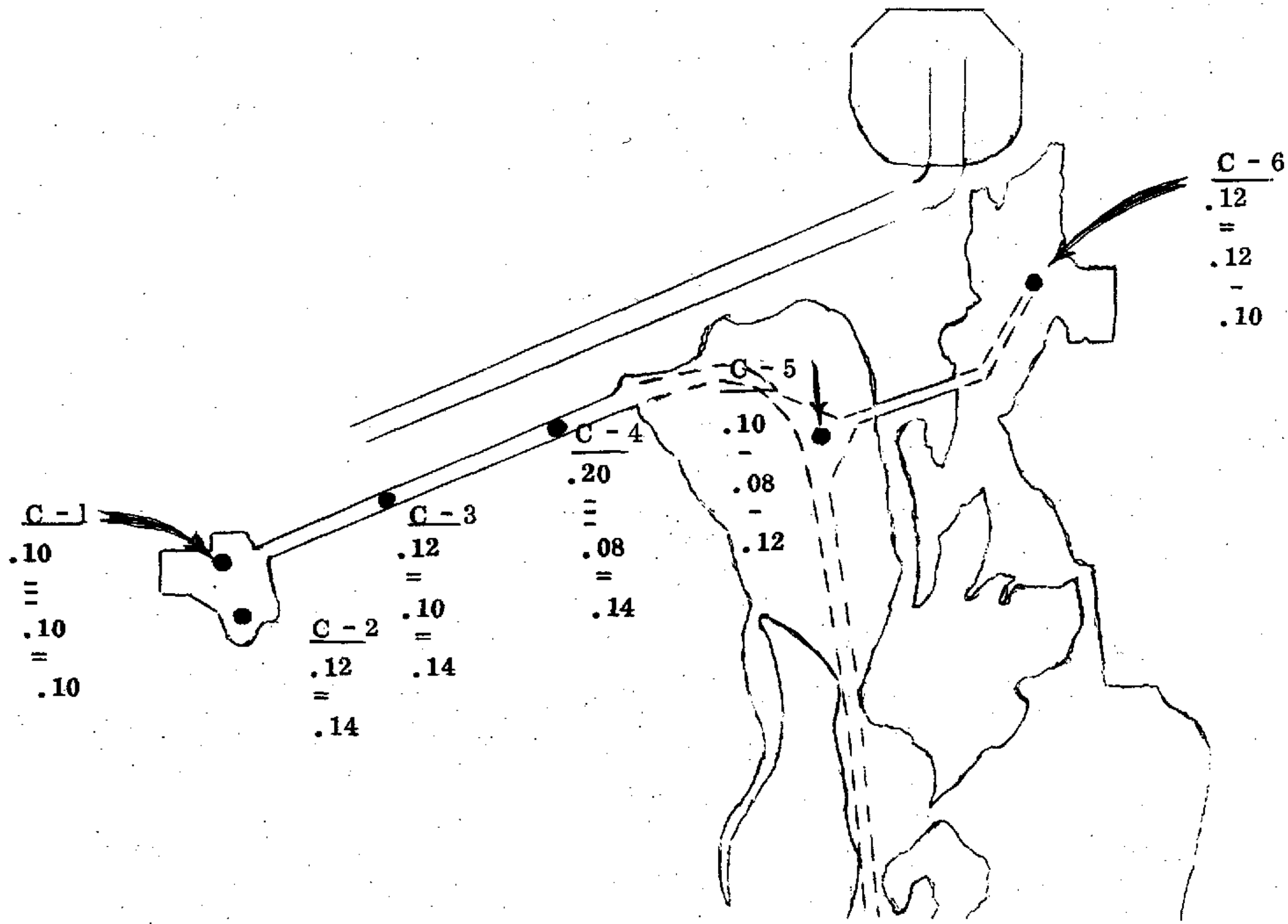
NITRATE ppm

Figure 16



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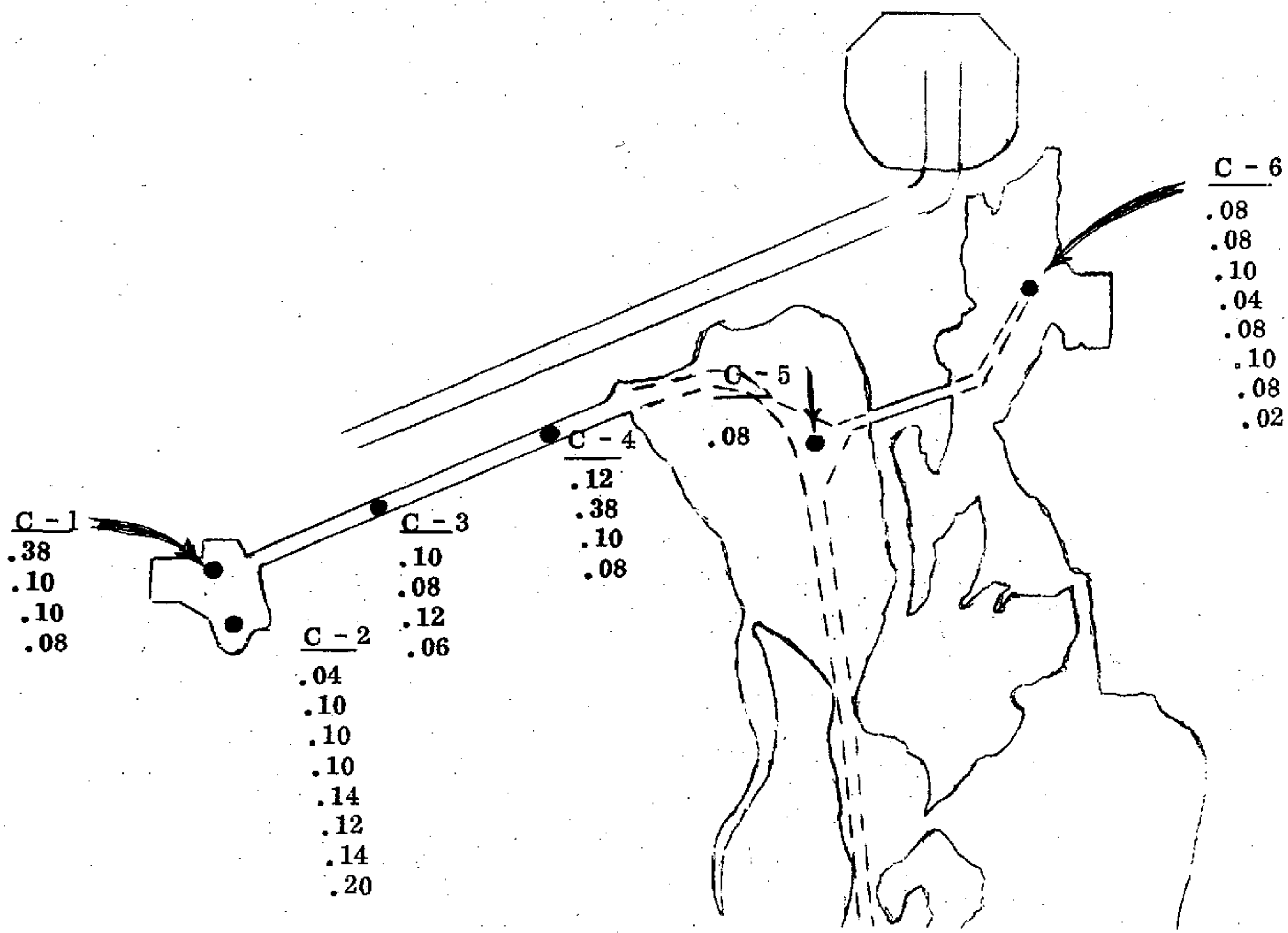
PHOSPHATE ppm

Figure 17



PHOSPHATE ppm

Figure 18

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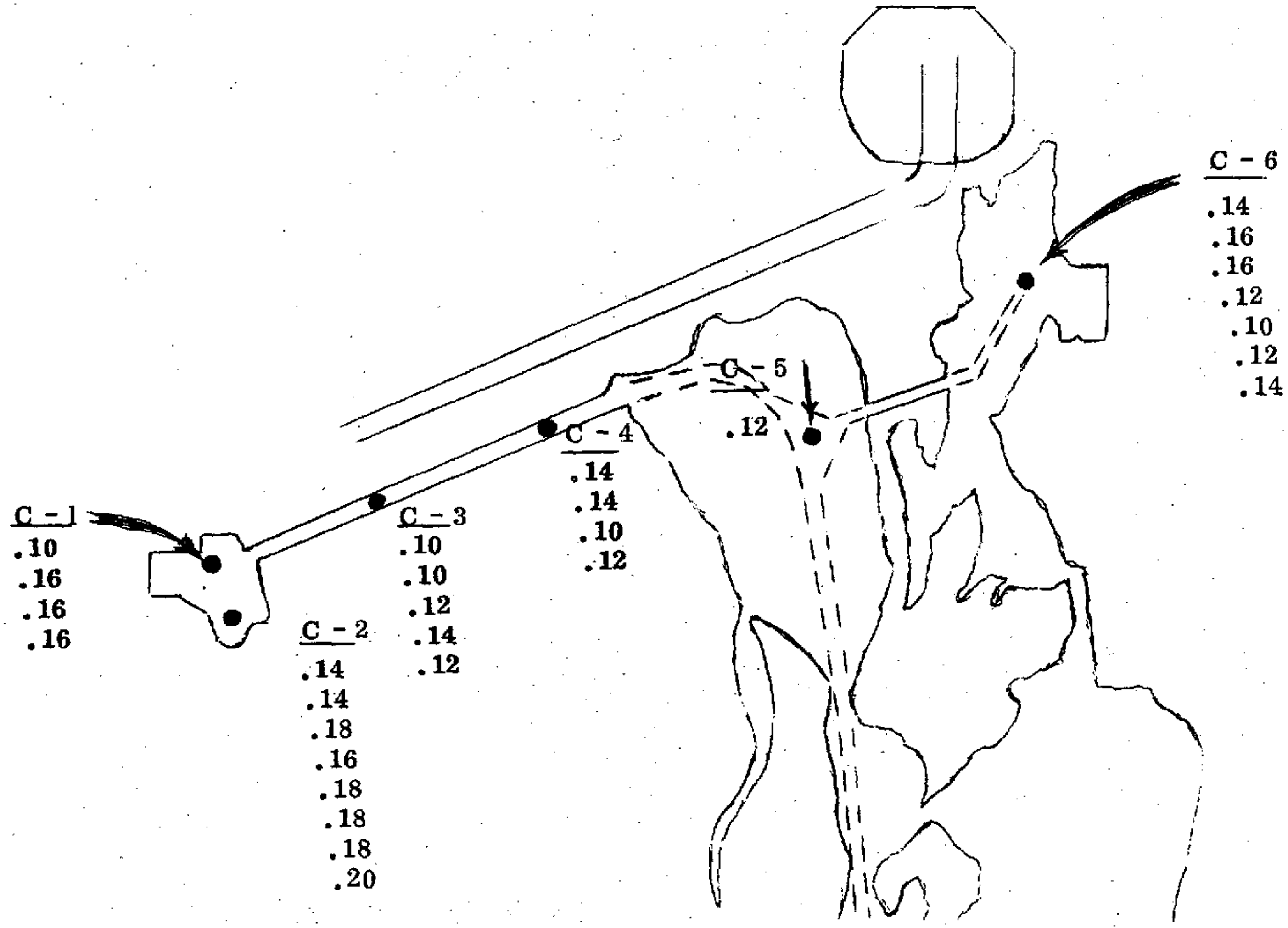

PHOSPHATE ppm

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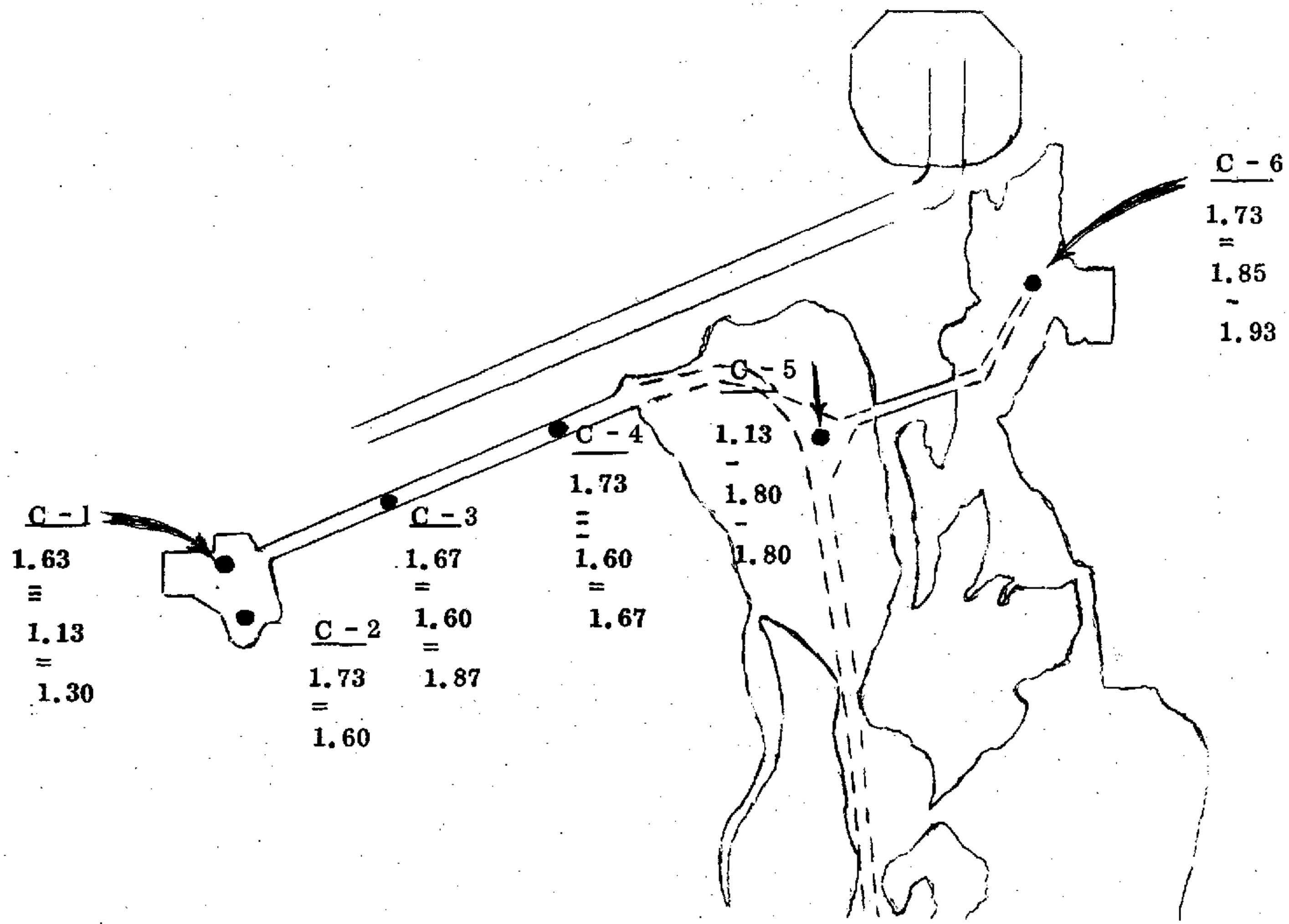
Figure 19



SULFATE mg/l

Figure 20

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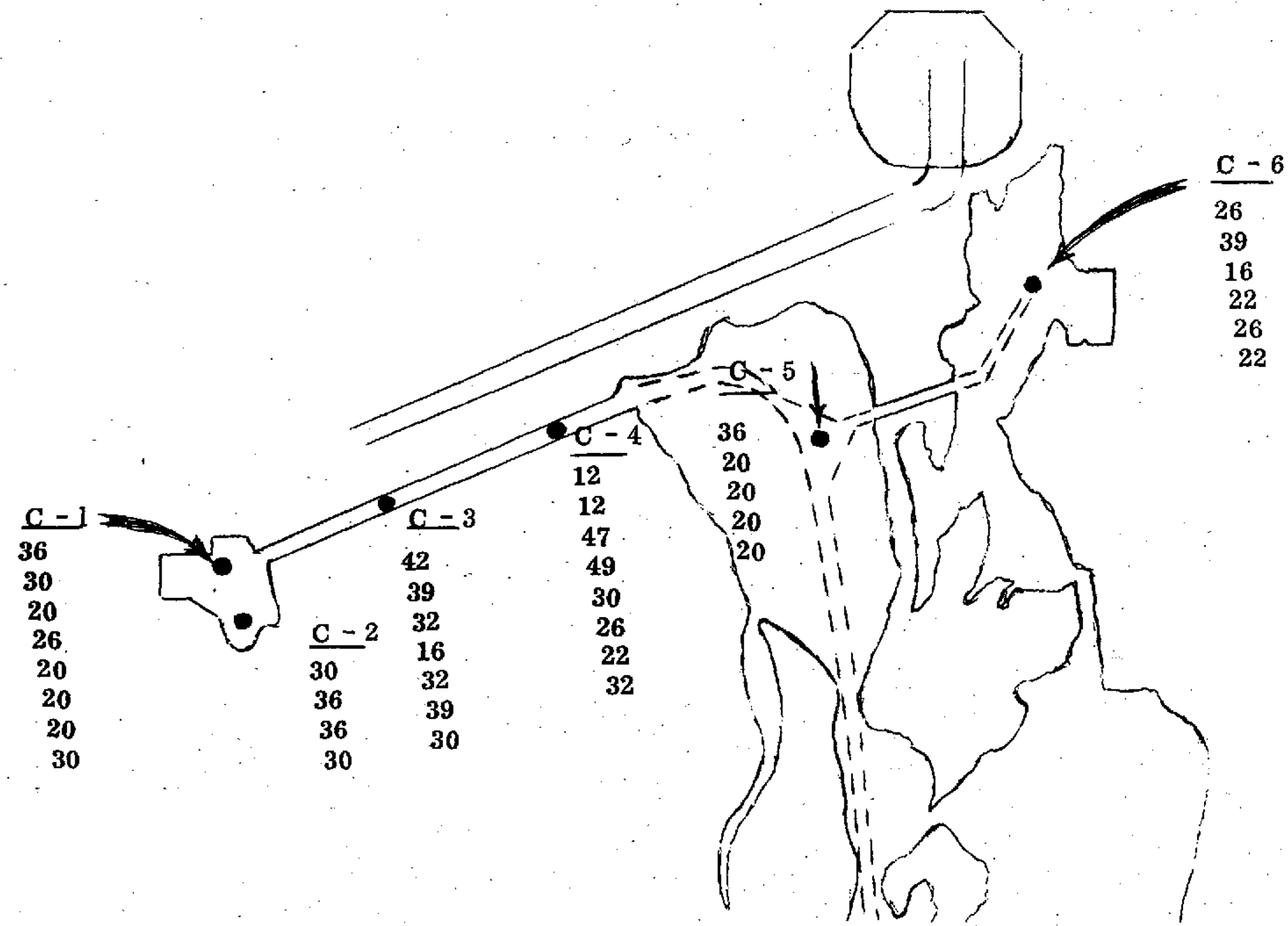

TURBIDITY Jackson Units

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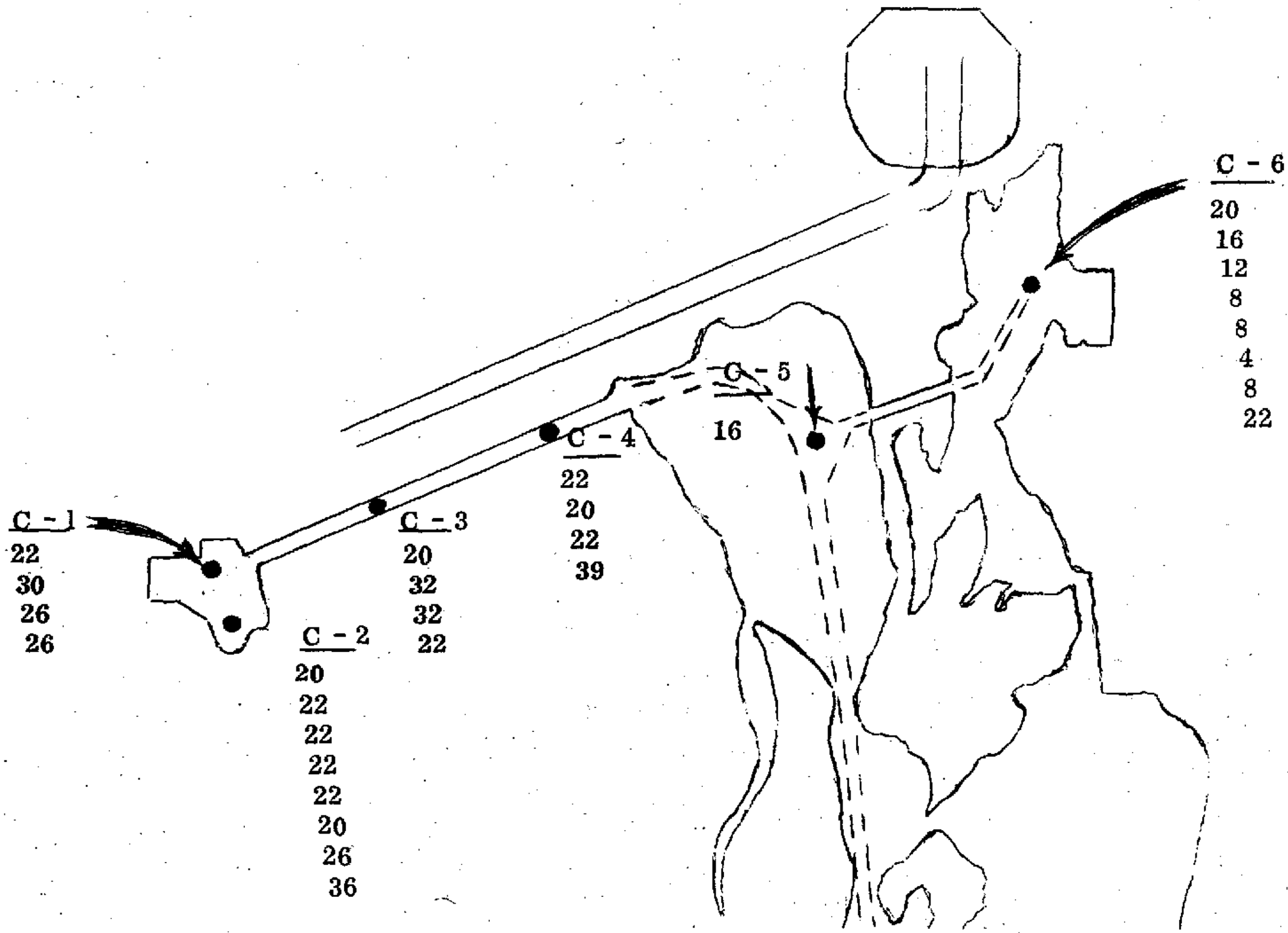
10/6/73

Figure 21



TURBIDITY Jackson Units

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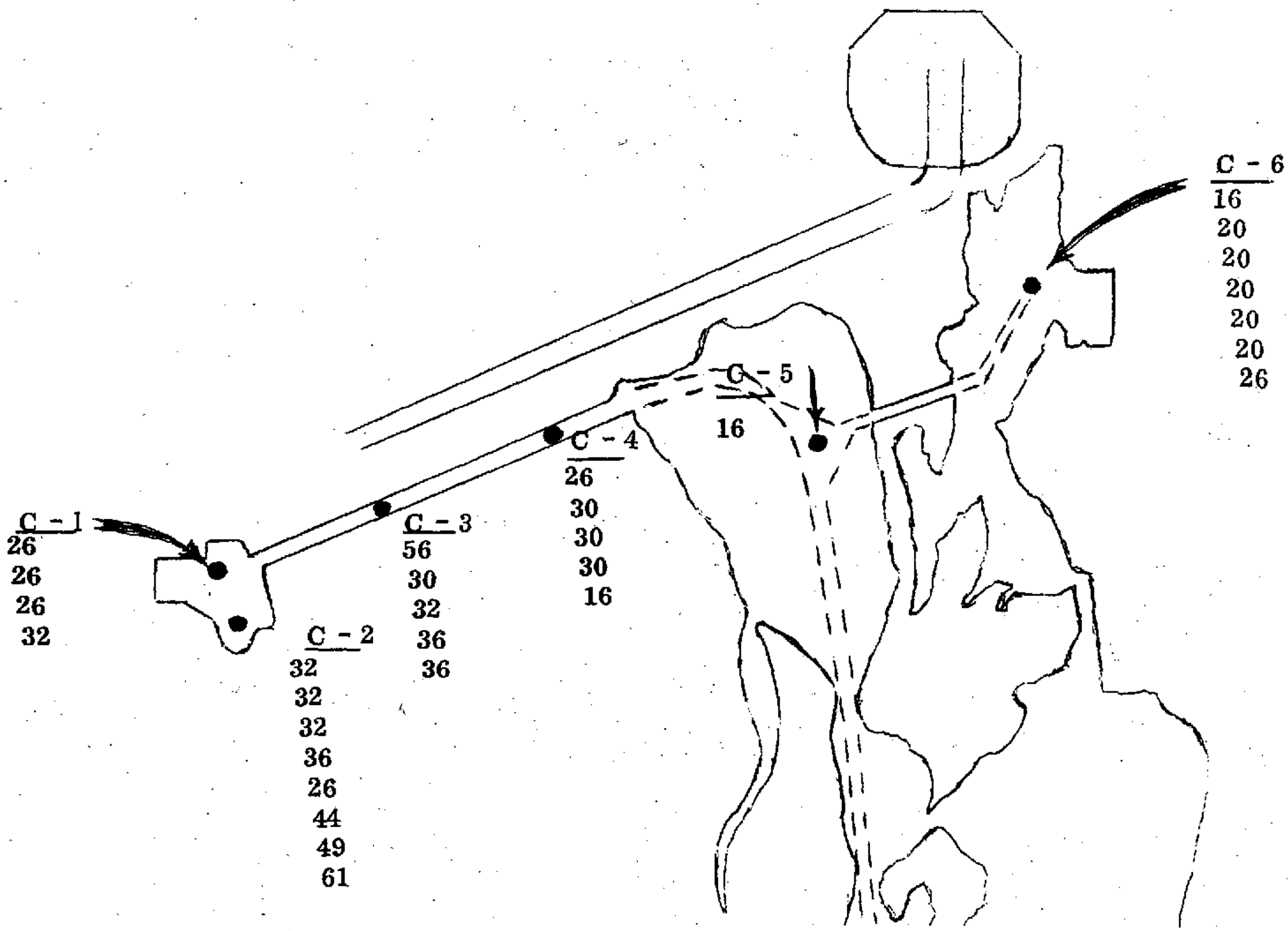
Figure 22



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TURBIDITY Jackson Units

Figure 23