United States Department of Agriculture
Soil Conservation Service

Chester, PA 19013
610-490-6042

**Subject:** GEO - Saluda Lake Project **Date:** 11 May 1994

**To:** Jose J. Acevedo
Acting State Conservationist
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1835 Assembly Street, Room 950
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**Purpose:**
To use ground-penetrating radar (GPR) to assist with a bathymetric and sedimentation survey of Lake Saluda in Greenville and Pickens County, South Carolina.

**Participants:**
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**BACKGROUND**
In the early 1900's, a dam and powerhouse were constructed on the Saluda River creating Saluda Lake. It was reported that the lake had an original surface area of about 110 acres and contained about 1537 acre-feet of water (South Carolina Land Resource Commission, 1979). The South Carolina Land Resource Commission estimated that original water depths ranged from 40 to 50 feet near the dam, to 20 to 25 feet near the Farr Bridge. The Saluda Lake watershed includes an estimated 201,600 acres in Greenville and Pickens Counties.

Deposition of sediment has consumed a significant portion of Lake Saluda's original water storage capacity (USDA - Soil Conservation Service, 1979). During the 1920's and 1930's, rates of sedimentation were excessive and attributed to high rates of soil erosion from the production of cotton. A second major period of sedimentation occurred in the late 1960's and early 1970's with the construction of South Carolina Scenic Highway 11 and U. S. Highway 25. Present sources of sediment include urban constructions and erosion from road banks. Sedimentation has been most severe in the upper reaches of the lake near the Farr Bridge.

Since 1935, the Soil Conservation Service has been conducting sedimentation surveys of reservoirs (Eakin, 1939). Data obtained from these surveys have been used to estimate the capacity and life expectancy of reservoirs, understand sedimentation processes and the

distribution of sediments within reservoirs, and assess the effects of watershed protection measures and conservation practices.

Traditional methods for conducting sedimentation surveys of reservoirs are slow and fatiguing. In most areas, unless the reservoir has been drained, boats are used to conduct sedimentation surveys. A range cable, attached to a line meter, is used to guide a boat across the reservoir, and to locate and measure distances to the sounding points. Field work involves (i) locating ranges, (ii) laying-out, stretching, and securing the range cable, (iii) sounding range cross sections, (iv) measuring and sampling sediment deposits, and (v) releasing, rewinding, and relocating the range cable.

This report documents an attempt by SCS to measure the bathymetry and assess sedimentation in Lake Saluda using state-of-the-art techniques. Several high-tech tools including ground-penetrating radar (GPR), total station survey system, computer models and graphic packages, were used to expedite the survey and to facilitate data collection and presentation.

## MATERIALS AND METHODS

### Equipment

The radar unit used in this study was the Subsurface Interface Radar (SIR) System-8 manufactured by Geophysical Survey Systems, Inc. The system was powered by a 12-volt marine battery. The model 3110 (120 mHz) antenna with a model 705DA transceiver were used in this study.

### Field Methods

The location of ranges was established prior to the survey. Nineteen range lines were extended across the reservoir from major topographic or cultural features. The approximate locations of these range lines are shown in Figure 1.

The control and recording units were mounted on a pontoon boat. The antenna was placed in a rubber raft which was towed beside the pontoon boat. Along each range line, the boat operator maintained course and heading between the designated end points or features.

A total station survey system was used to record distances along range lines. The total station system was set-up at one end of each range line. Range information was recorded and relayed to the GPR operator on the pontoon boat by means of hand-held radio transceivers. An attempt was made to record range and depth information at 50 feet intervals. At each range mark, the radar operator electronically affixed a dashed, vertical line on the radar profile. These lines indicated the location of observation points along the range lines.

At several observation sites, a stadia rod was used to determine the depth of the water. This information was used to scale the radar profiles. The correlation between stadia observations and scaled radar depths was exceptionally high. Based on 45 observations, the coefficient of determination ($r^2$) between the observed stadia and the

interpreted radar depths of water was 0.9847 (see Figure 2). The average difference in depth-of-water measurements between stadia and radar measurements was 0.48 foot. At fifty-eight percent of the observation sites variations between stadia and radar measurements were less than 0.4 foot.

The height of water at the dam was 851.0, 850.7, and 850.0 feet on March 28, 29, and 30, respectively. All calculations of water volume were corrected to the normal pool elevation of 849.0 feet.

**RESULTS**

Ground-penetrating radar techniques were effective in profiling the lake bottom and provide some data on the thickness and distribution of recent bottom sediments. At the time of the survey, the maximum recorded depth of water (35.4 feet) within Lake Saluda was within the observation depth of GPR.

The approximate locations of range lines on Lake Saluda are shown in Figure 1. Each range line has been identified by a number. The ends of each range line have been labelled either "1" or "2," to identify the direction of travel and general locations on the accompanying two-dimensional plots (Figures 3 through 11).

Cross-sectional profiles of each range line are shown in Figures 3 through 11. These profiles show the depths of water along each range line. These profiles have been prepared from radar interpretations. For each profile, the end points shown in Figure 1 have been indicated.

A major sub-bottom interface was recorded on radar profiles from range lines 2 through 9. While the identity of this major sub-bottom interface could not be verified at the time of the survey, it was assumed to represent the contact between the recent sediments and the original lake bottom. The depth to this contrasting, sub-bottom interface was estimated based on a velocity of propagation through saturated silt (dielectric constant of 14). Assuming that this value is appropriate, the maximum thickness of bottom sediments recorded with GPR was about 15.4 feet.

The major sub-bottom interface was not detected on range lines 10 through 18. For range lines 10 through 18, it is conceivable that the bottom sediments became either too thick to be profiled with GPR or became too electrically similar with the underlying deposits and were therefore not detectable.

Basic statistics for each range lines are list in Table 1. Based on the locations of these range lines, the lake was subdivided into 21 segments. The lake was arbitrarily assumed to extend to a point ($34^{o}53'15"N$, $82^{o}29'41"W$) about 2500 feet north of the Farr Bridge. For each segment, a planimeter was used to calculate the surface area of the water. Based on these measurements, the area of Lake Saluda is 331 acres.

The EA RESCAP Reservoir capacity computation program was used to estimate the volume of water within Lake Saluda. To calculate the volume of water within each segment, the EA RESCAP program requires the cross-sectional area of water at each range and the surface area between each range. Volumes were determined using either the Dobson prismoidal equation (if ranges were essentially parallel; within $<15^{o}$) or the average end area method. Based on this program, the volume of water within Lake Saluda was estimated to be 2,761.4 acre-feet.

**Table 1**

**Basic Statistics For Range Lines**

| Range Line | Distance (ft) | Maximum Depth (ft) | Cross-Sectional Volume ($ft^2$) |
|---|---|---|---|
| R2 | 504.9 | 35.4 | 13601 |
| R3 | 493.5 | 35.2 | 10836 |
| R4 | 411.4 | 26.1 | 5916 |
| R5 | 822.3 | 33.8 | 16543 |
| R5A | 531.4 | 33.0 | 10738 |
| R6 | 473.6 | 32.0 | 9587 |
| R7 | 573.2 | 31.4 | 11652 |
| R8 | 859.4 | 29.8 | 15197 |
| R9 | 761.7 | 25.6 | 15617 |
| R10 | 494.3 | 26.6 | 9459 |
| R11 | 488.8 | 21.3 | 7127 |
| R12 | 575.0 | 18.9 | 5795 |
| R13 | 498.4 | 12.2 | 3494 |
| R13A | 315.7 | 10.4 | 2159 |
| R14 | 1175.7 | 13.3 | 12428 |
| R15 | 1235.9 | 9.9 | 3916 |
| R16 | 645.5 | 7.2 | 3443 |
| R17 | 227.2 | 7.1 | 1222 |
| R18 | 188.2 | 8.0 | 960 |

**CONCLUSIONS**

Survey techniques used in this study provided an expeditious and expedient means for conducting a bathymetric survey. The use of GPR provided a general understanding of the depth to and thickness of bottom sediments within Lake Saluda. A close correlation was found between water depths measured with a stadia rod and interpreted from the radar profiles. The use of GPR techniques is recommended for subsequent sedimentation surveys in the Southern Piedmont Land Resource Area. Along some range lines, the thickness of bottom sediments was interpreted based on assumed values of dielectric constant and velocity of propagation listed in published tables. As these results were based on assumption and could not be verified, the thicknesses of bottom sediments reported in this study are interpretative.

In an earlier report (South Carolina Land Resource Commission, 1979), Lake Saluda had been reported as having an area of 110 acres and containing about 1537 acre-feet of water. Measurements conducted as part of this survey indicate an area of 331 acres and a volume of 2,761.4 acre-feet. Though no reference is made in the 1979 report as to the area consider to be "Lake Saluda," the data is suspected of error.

I wish to acknowledge the assistance of Tom Iivari ( National Sedimentation Geologist, NENTC, Chester, PA), who ran the EA RESCAP Reservoir Capacity Computation Program. I would also like to acknowledge Larry Tennity and Doug Barnes (Design Engineer and Draftsman, NENTC, Chester, PA) for their help in preparing Figure 1.

With kind regards

James A. Doolittle
Soil Specialist

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Ben N. Stuckey, Jr., State Soil Scientist, SCS, Columbia, SC

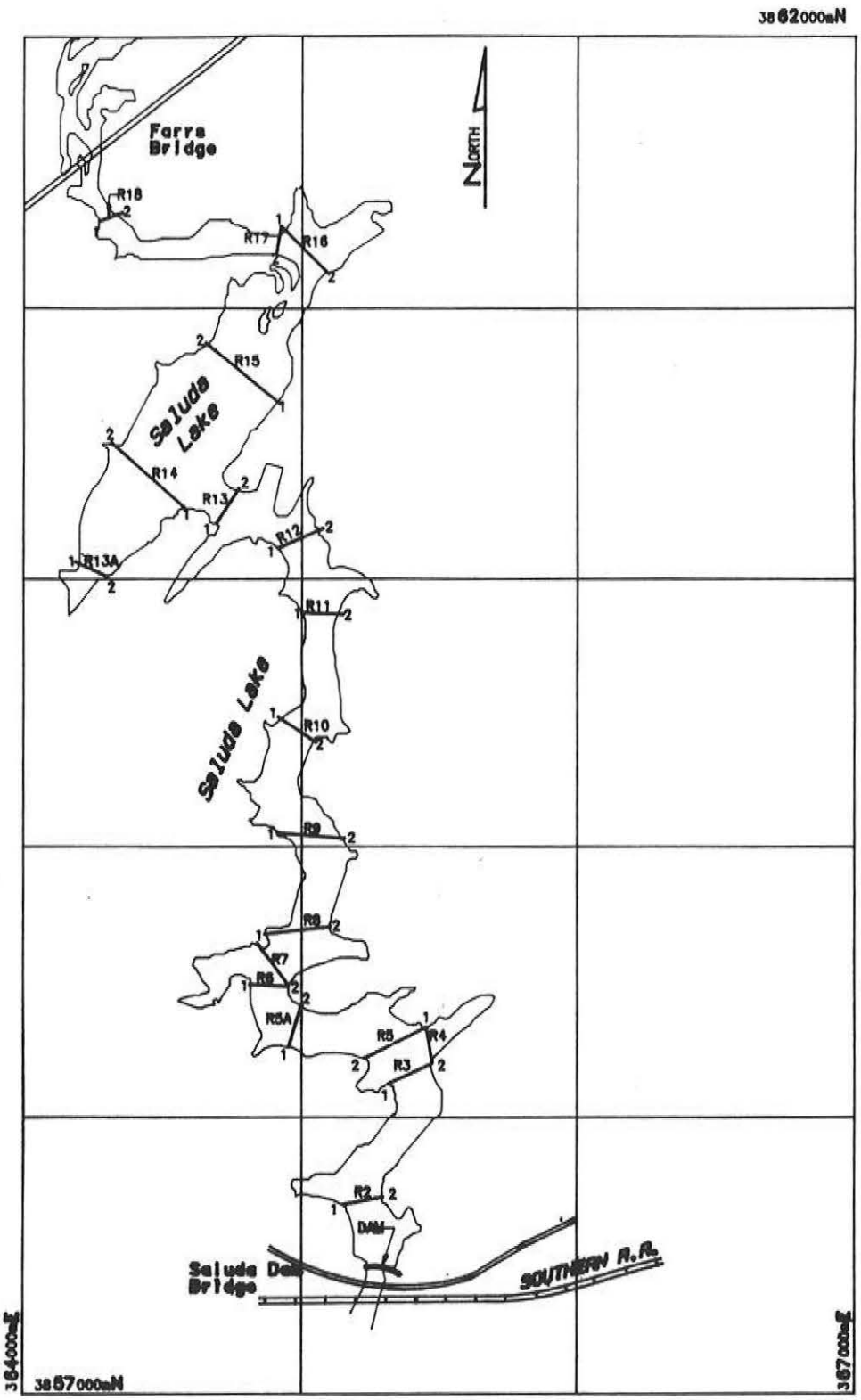
**REFERENCES**

Eakin, H. M. 1939. Silting of reservoir. (Revised by C. W. Brown) USDA Technical Bulletin 524. 168 pp.

South Carolina Land Resources Commission. 1979. Saluda Lake Sedimentation Study. February, 1979. Columbia. 18 pp.

United States Department of Agriculture - Soil Conservation Service. 1979. Preliminary Investigation Report, Saluda Lake Watershed, Greenville and Pickens Counties, South Carolina. Columbia, South Carolina. July 1979, 12 pp.

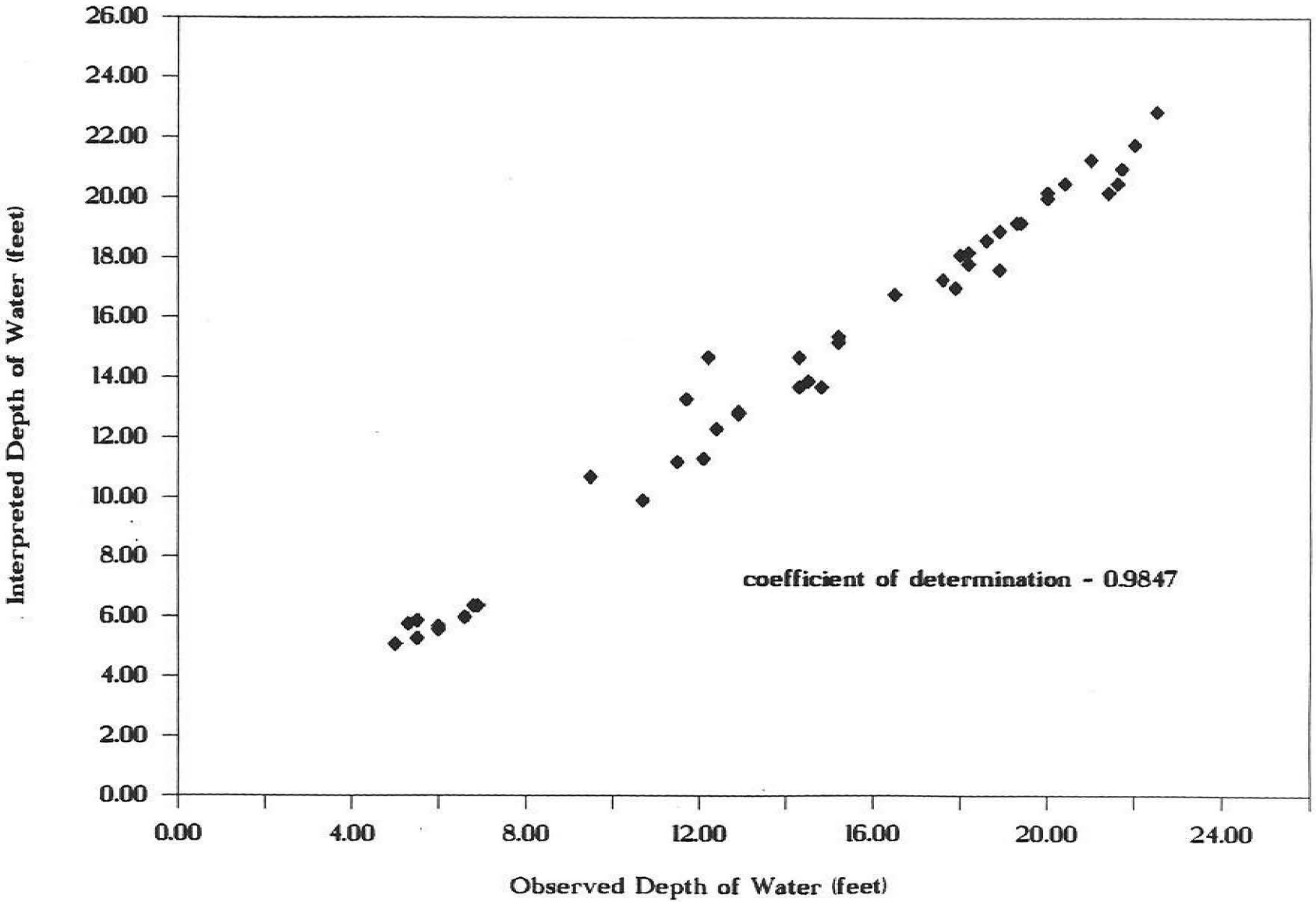
# FIG. 1
# LOCATION OF RANGE LINES FOR SEDIMENTATION SURVEY (MARCH 1994)




0 1000 2000 4000 Ft.

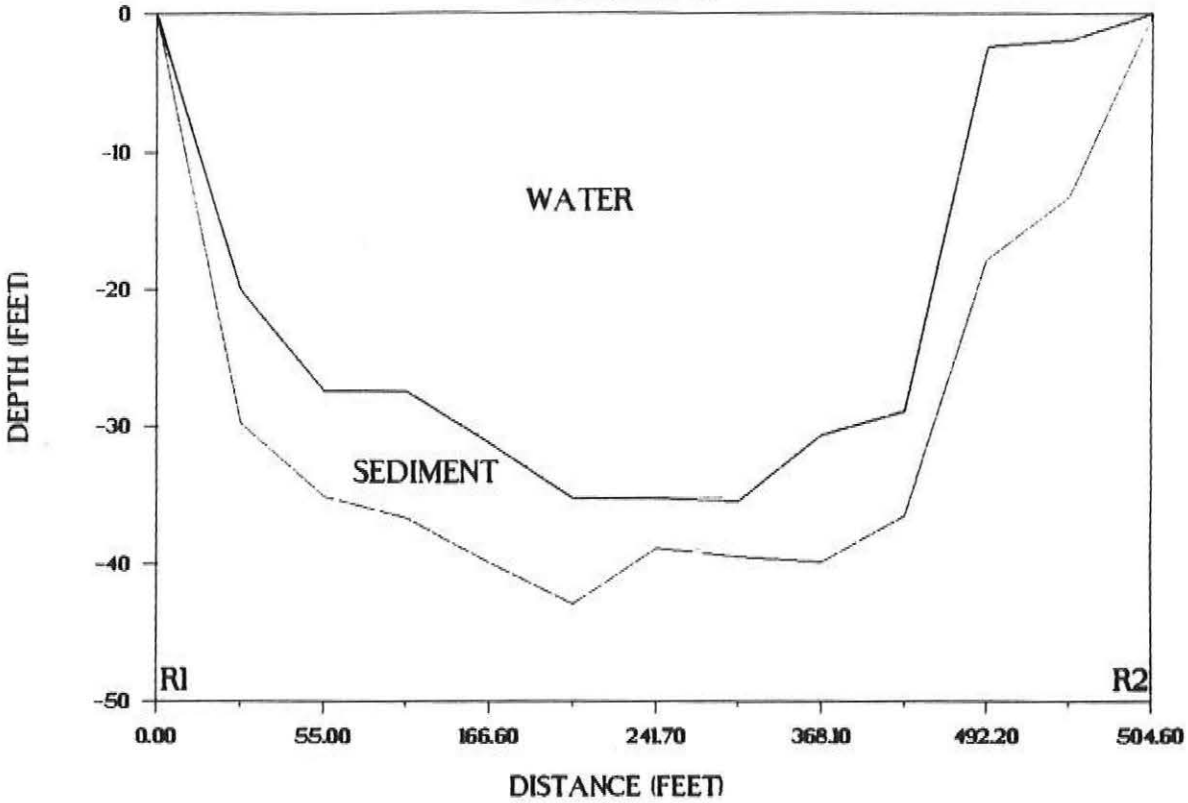
SCALE

FIG. 2


26.00
24.00
22.00
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Interpreted Depth of Water (feet)
0.00
4.00
8.00
12.00
16.00
20.00
24.00
Observed Depth of Water (feet)
coefficient of determination - 0.9847

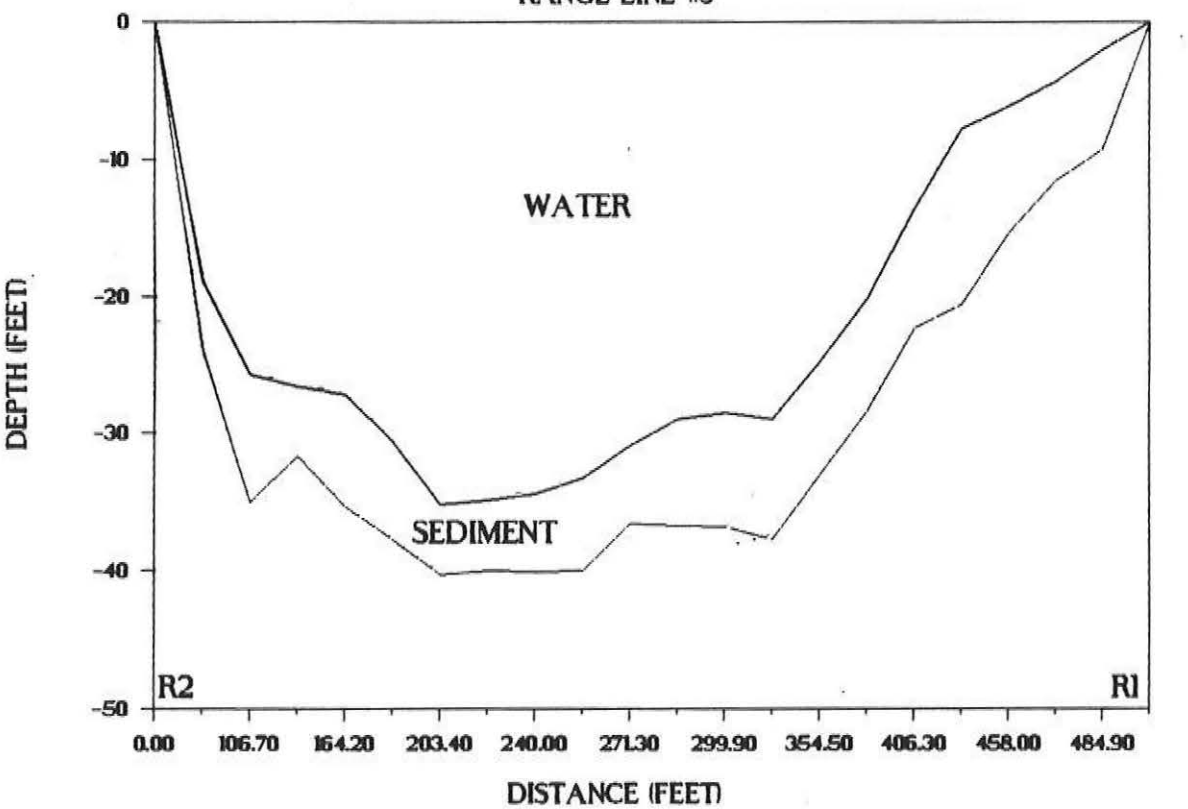
# BATHYMETRIC SURVEY OF SALUDA LAKE

RANGE LINE #2



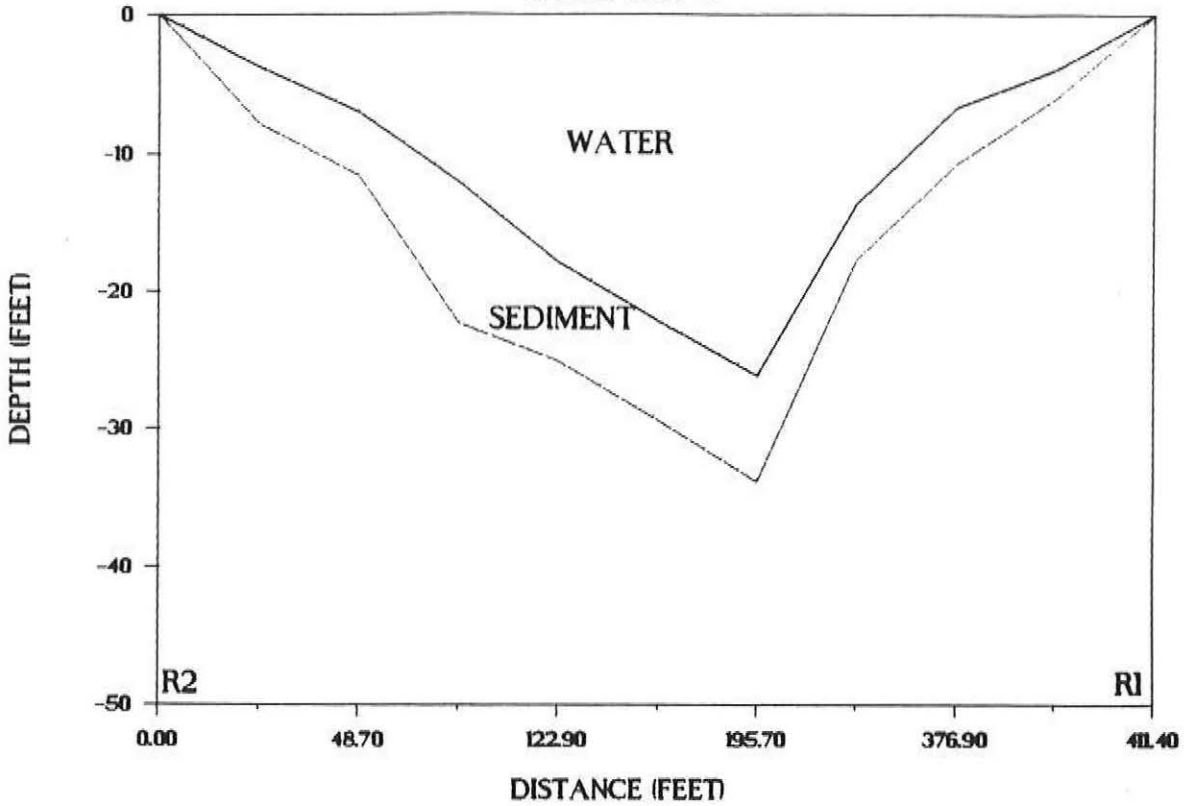

# BATHYMETRIC SURVEY OF SALUDA LAKE

RANGE LINE #3



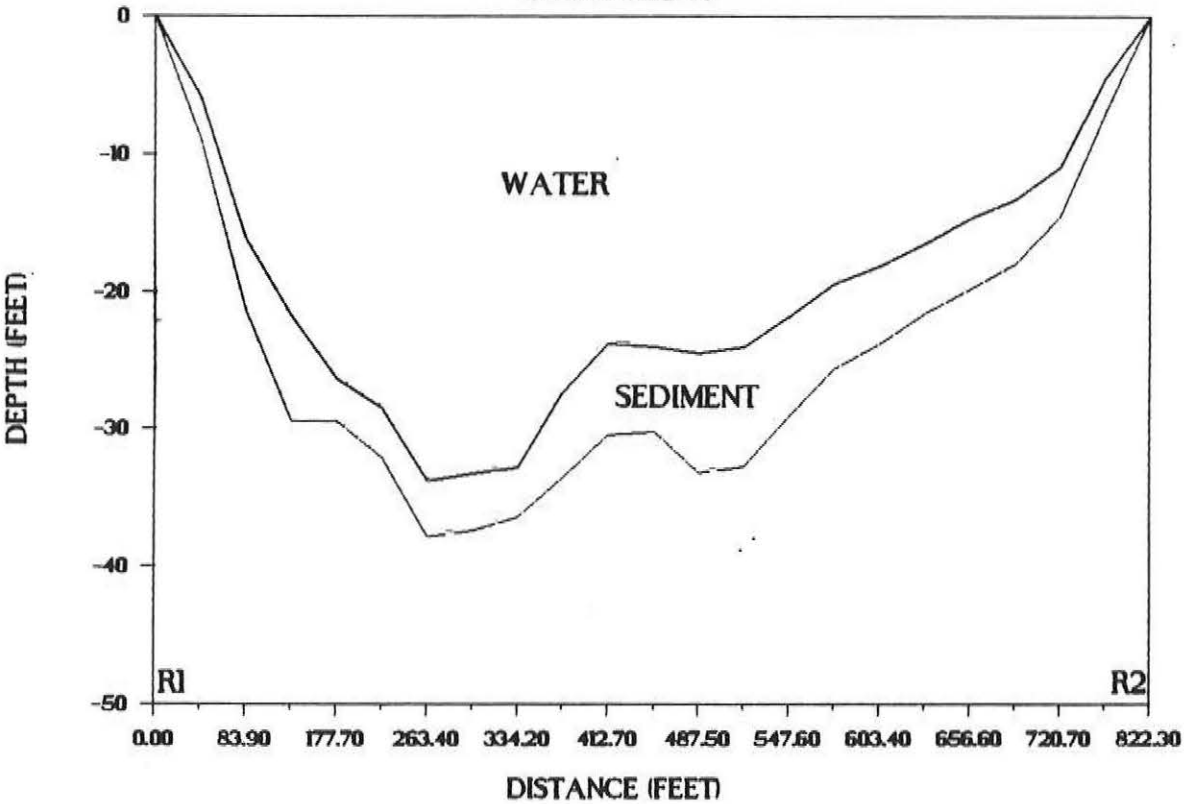
# BATHYMETRIC SURVEY OF SALUDA LAKE

RANGE LINE #4



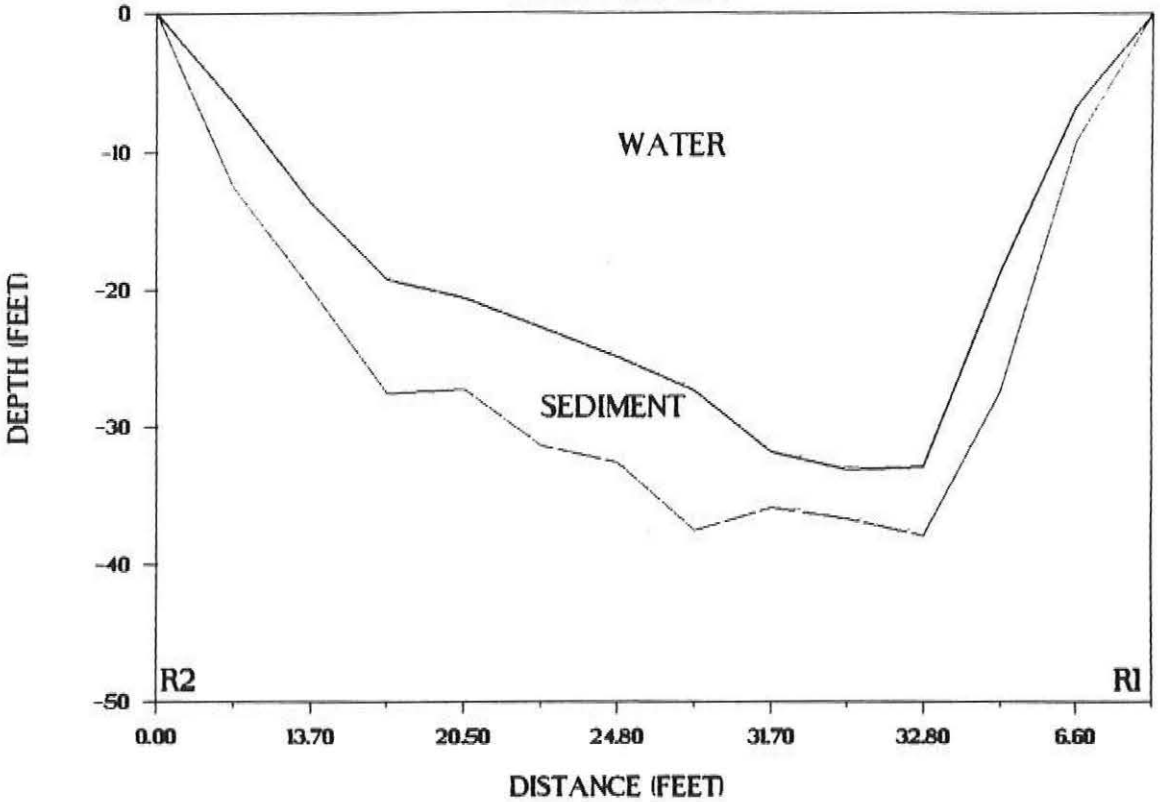

# BATHYMETRIC SURVEY OF SALUDA LAKE

RANGE LINE #5



# BATHYMETRIC SURVEY OF SALUDA LAKE

RANGE LINE #5A

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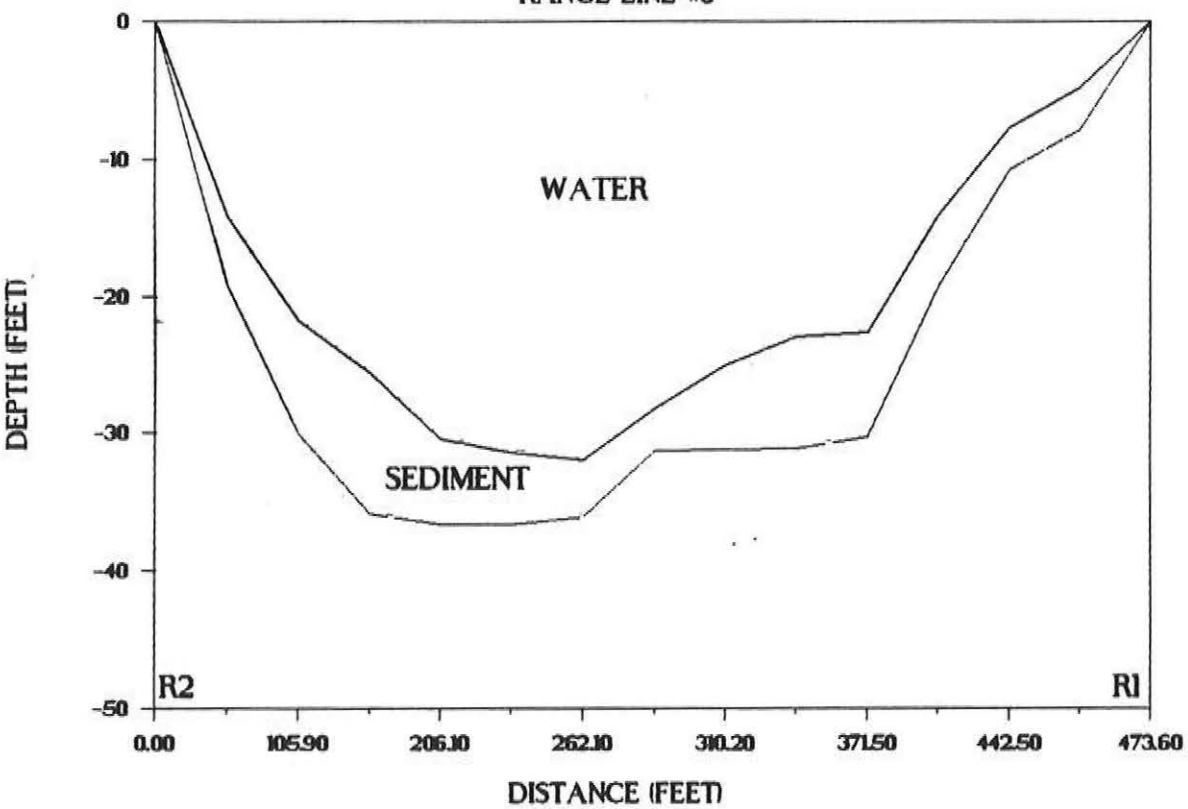
RANGE LINE #6



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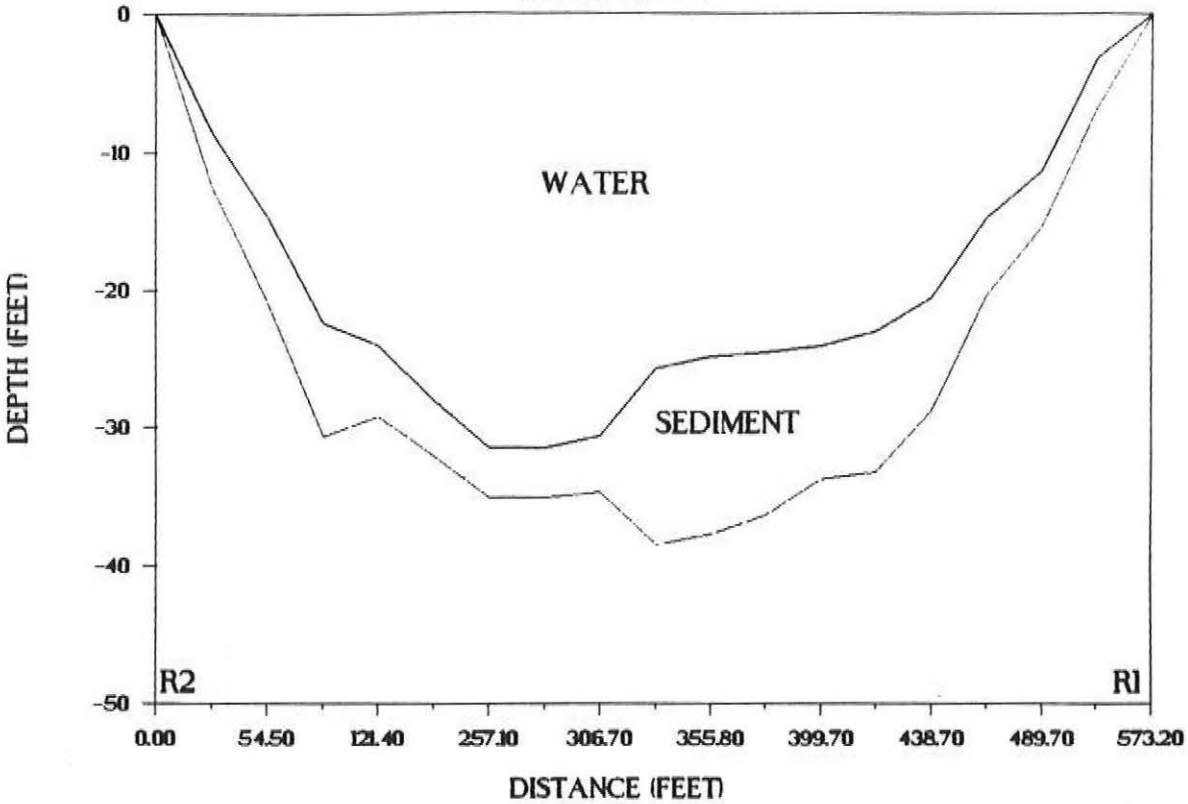
RANGE LINE #7

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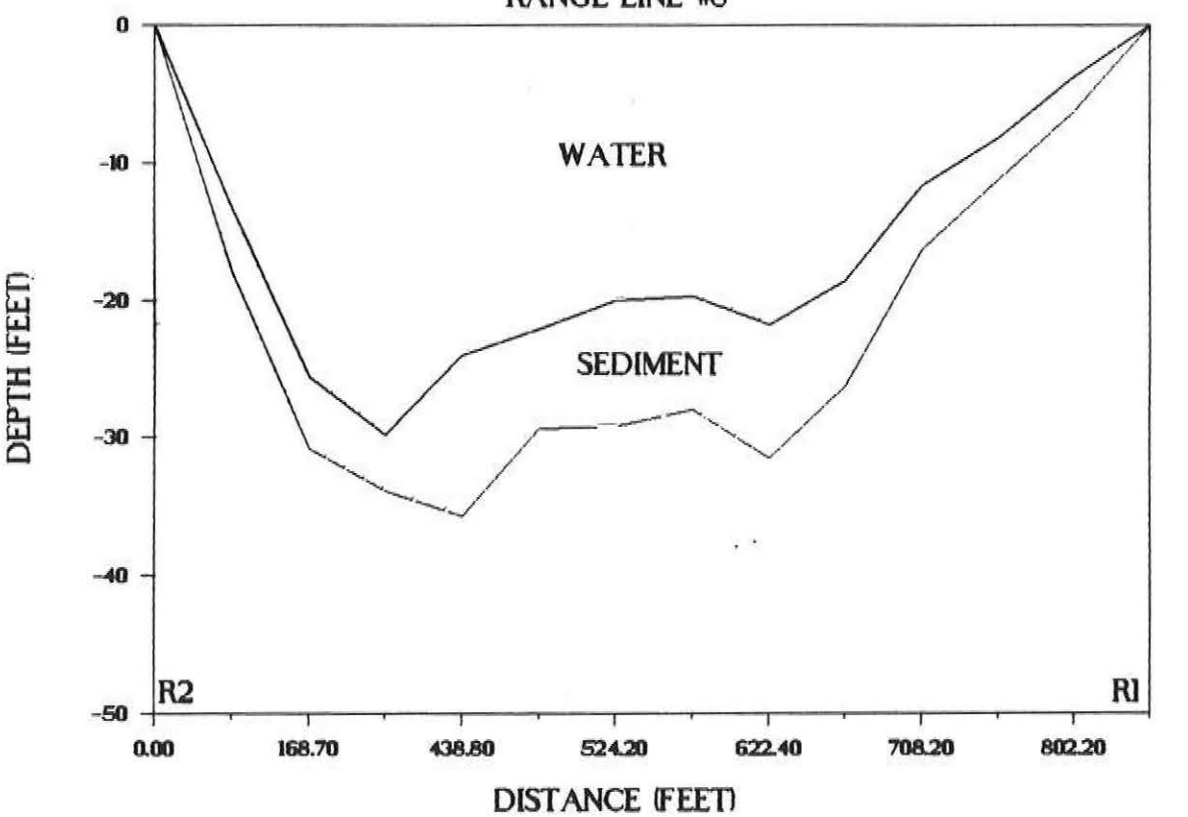
RANGE LINE #8



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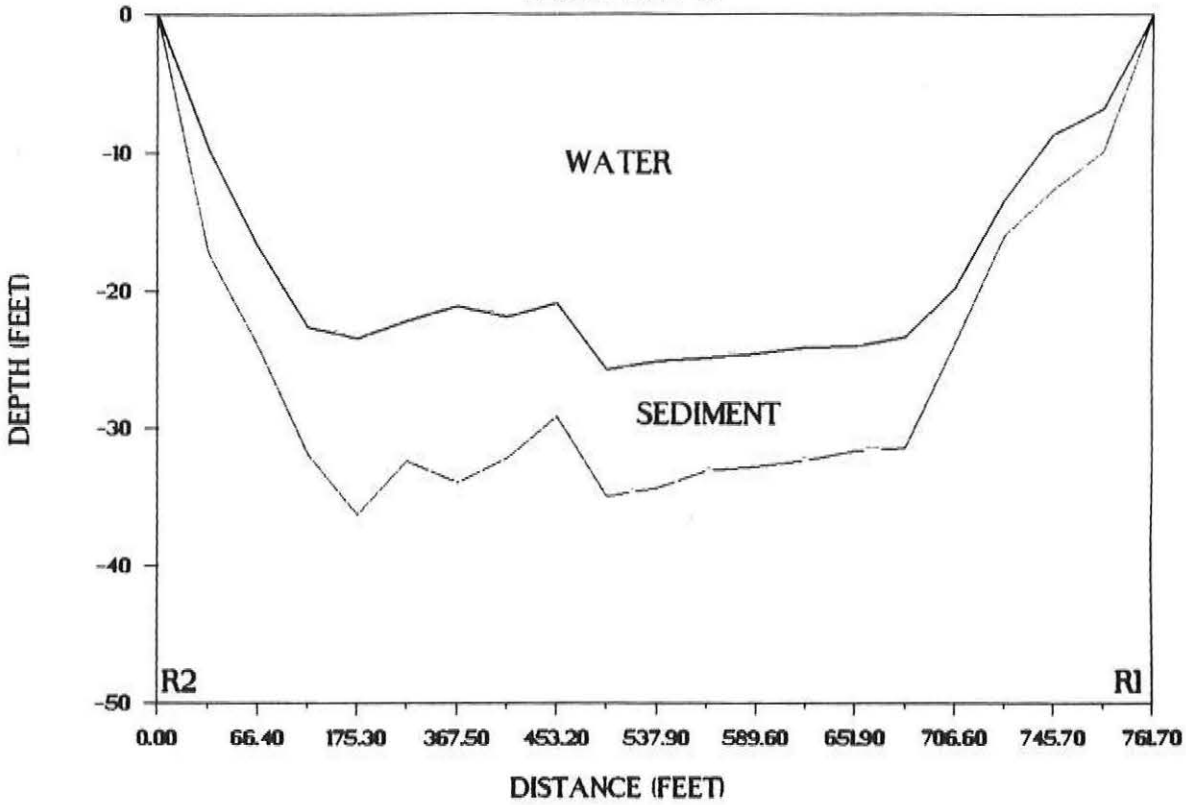
RANGE LINE #9

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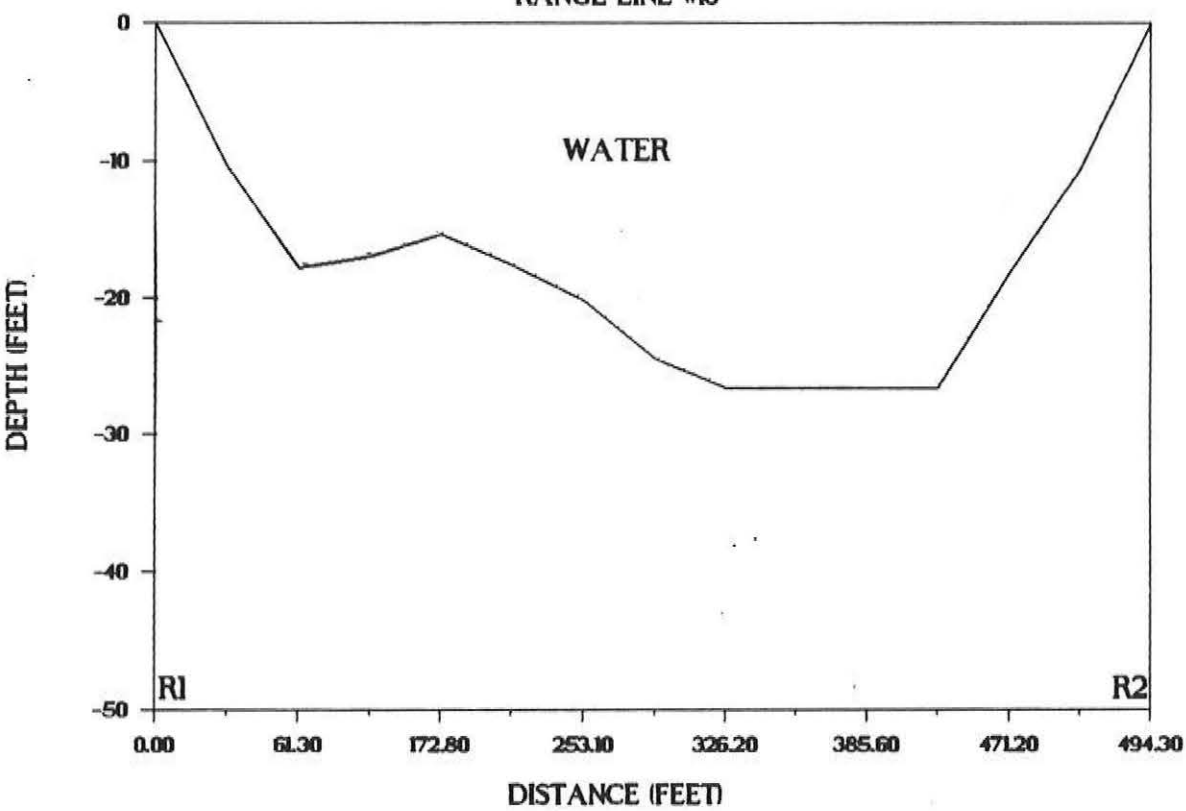
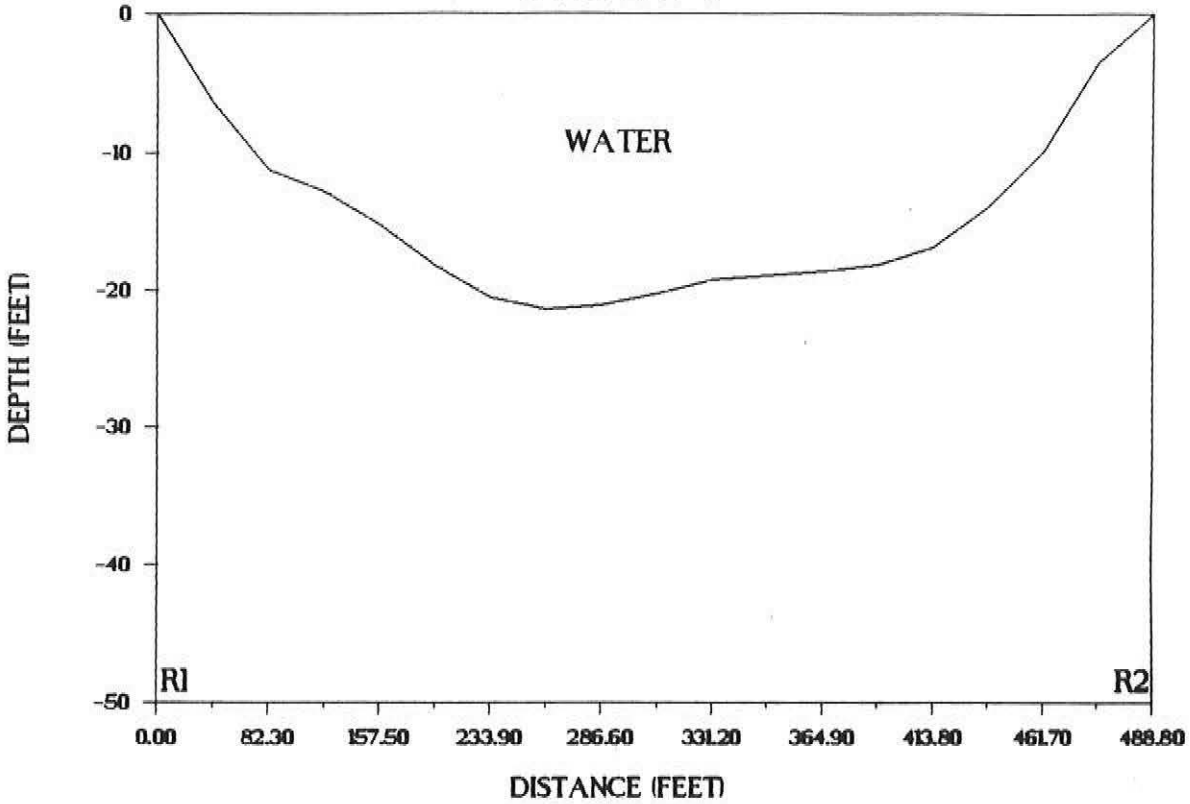
RANGE LINE #10



# BATHYMETRIC SURVEY OF SALUDA LAKE

RANGE LINE #11

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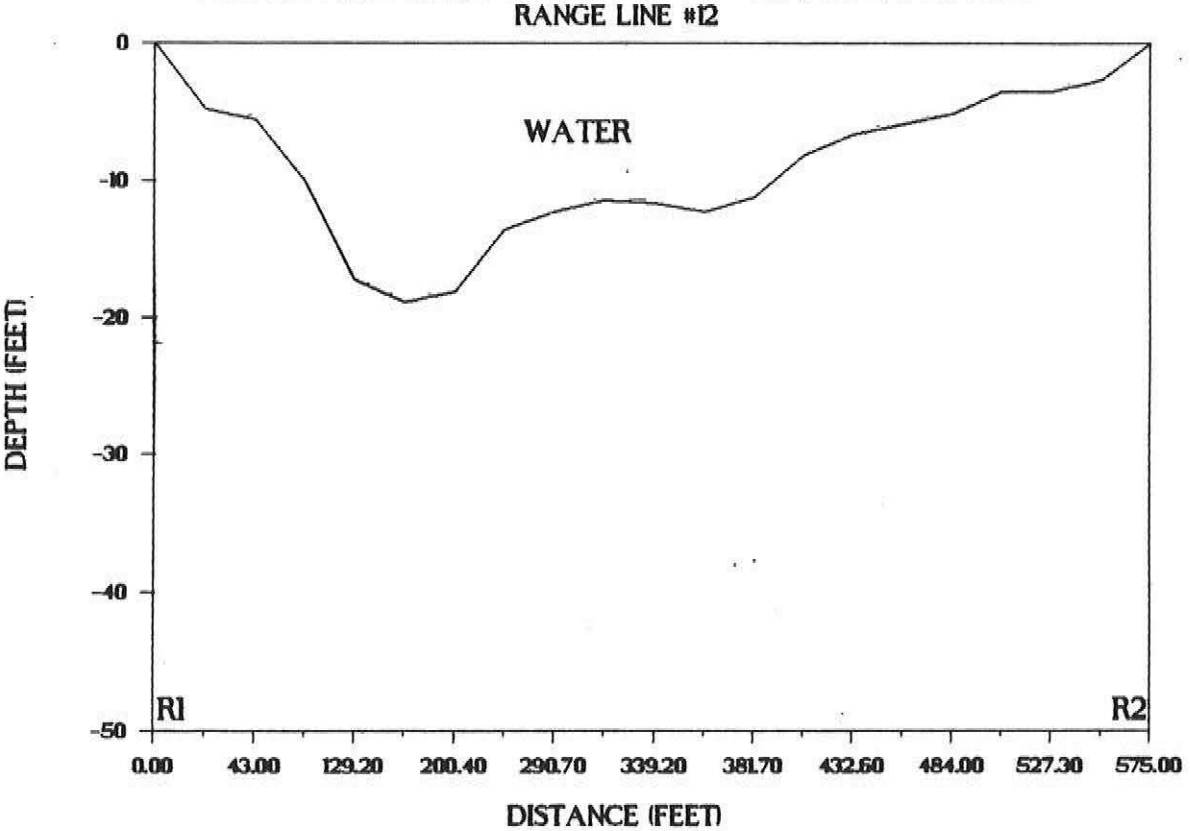
RANGE LINE #12



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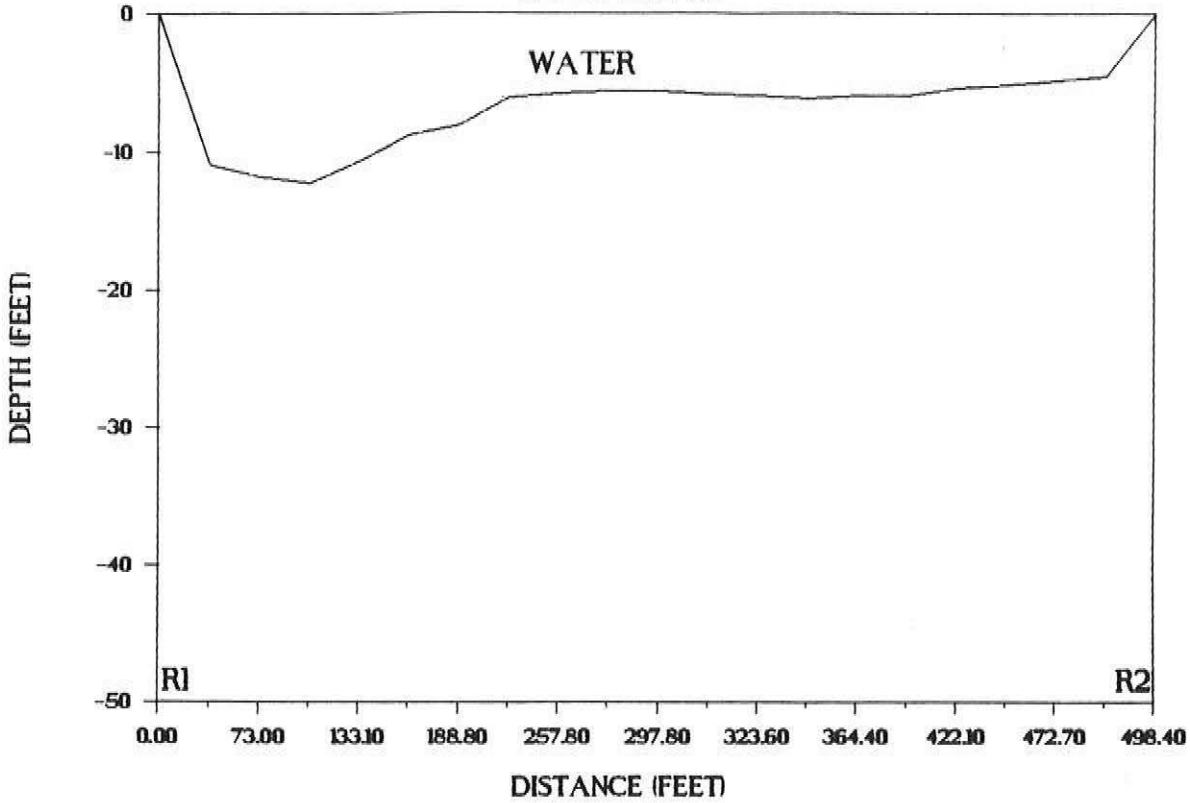
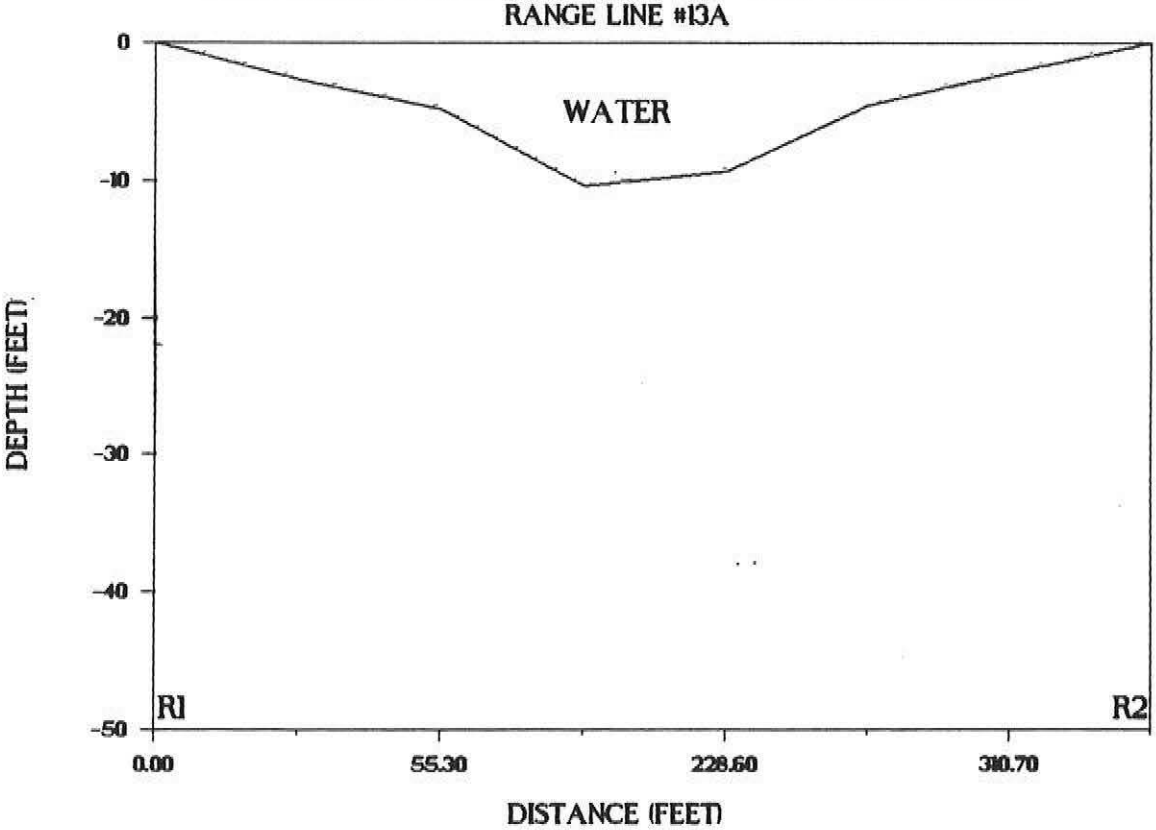
RANGE LINE #13




# BATHYMETRIC SURVEY OF SALUDA LAKE

RANGE LINE #13A



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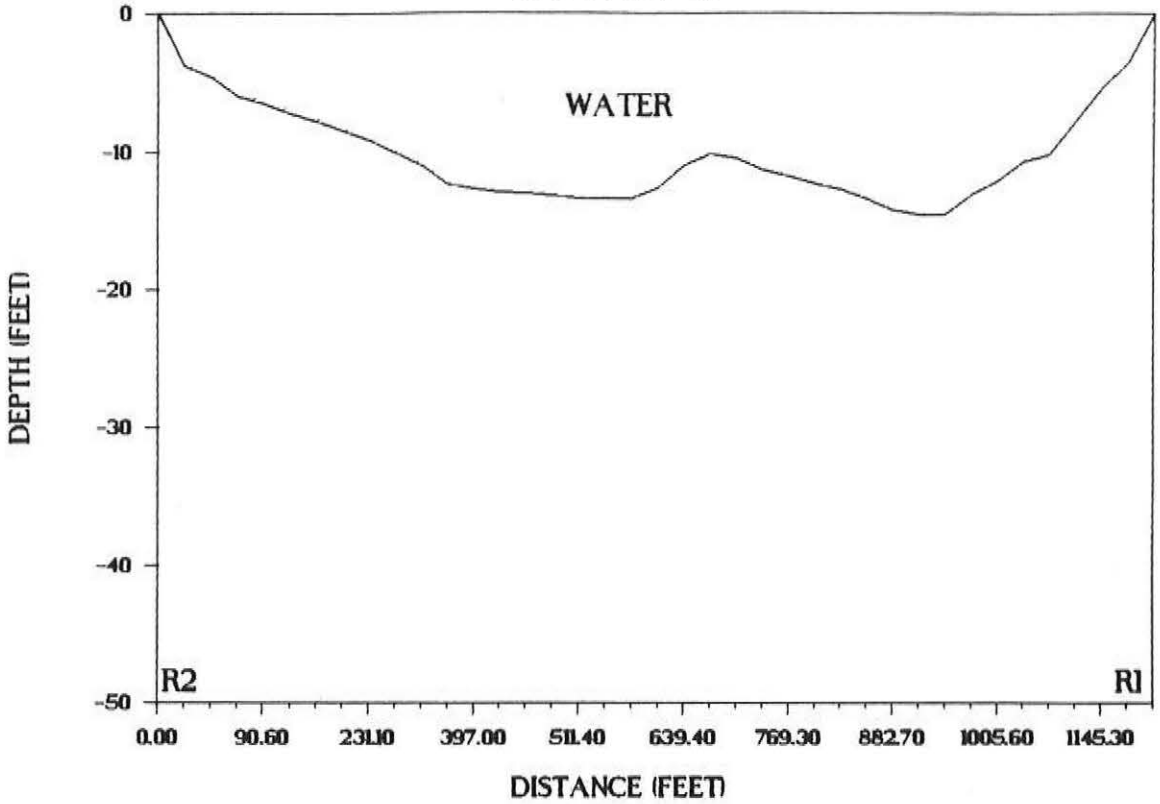
RANGE LINE #14

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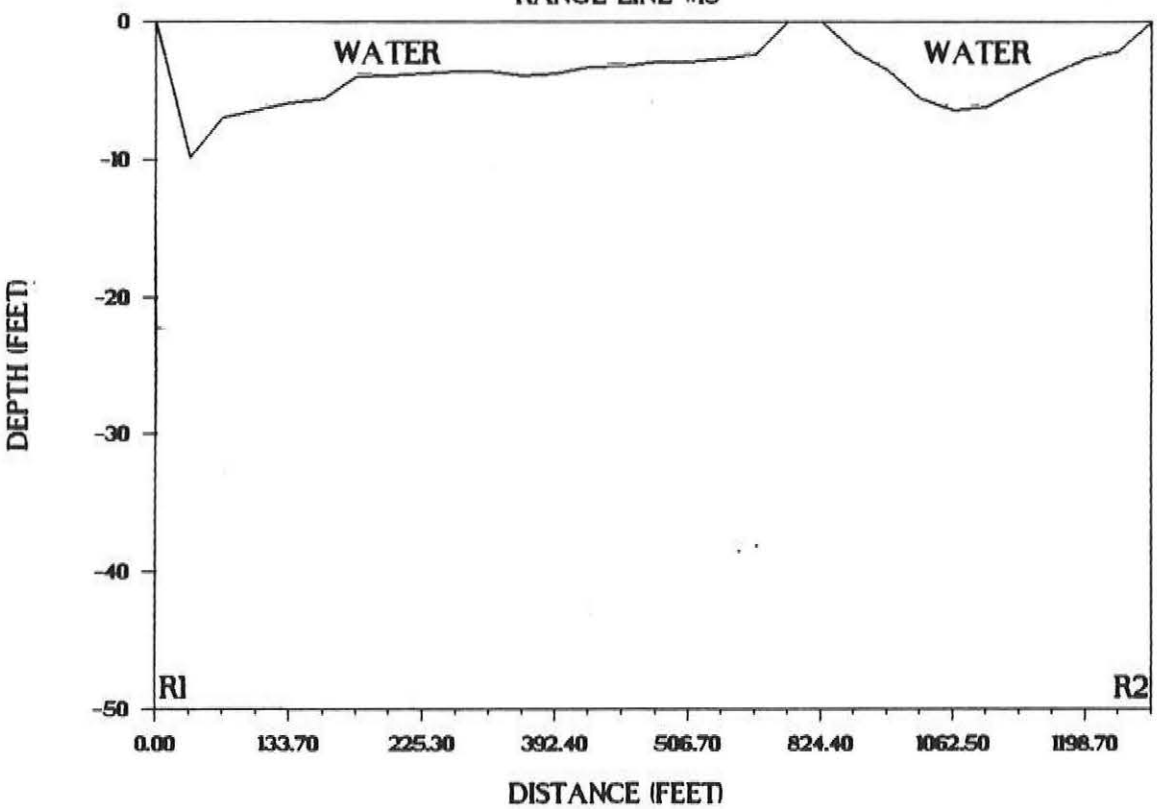
RANGE LINE #15



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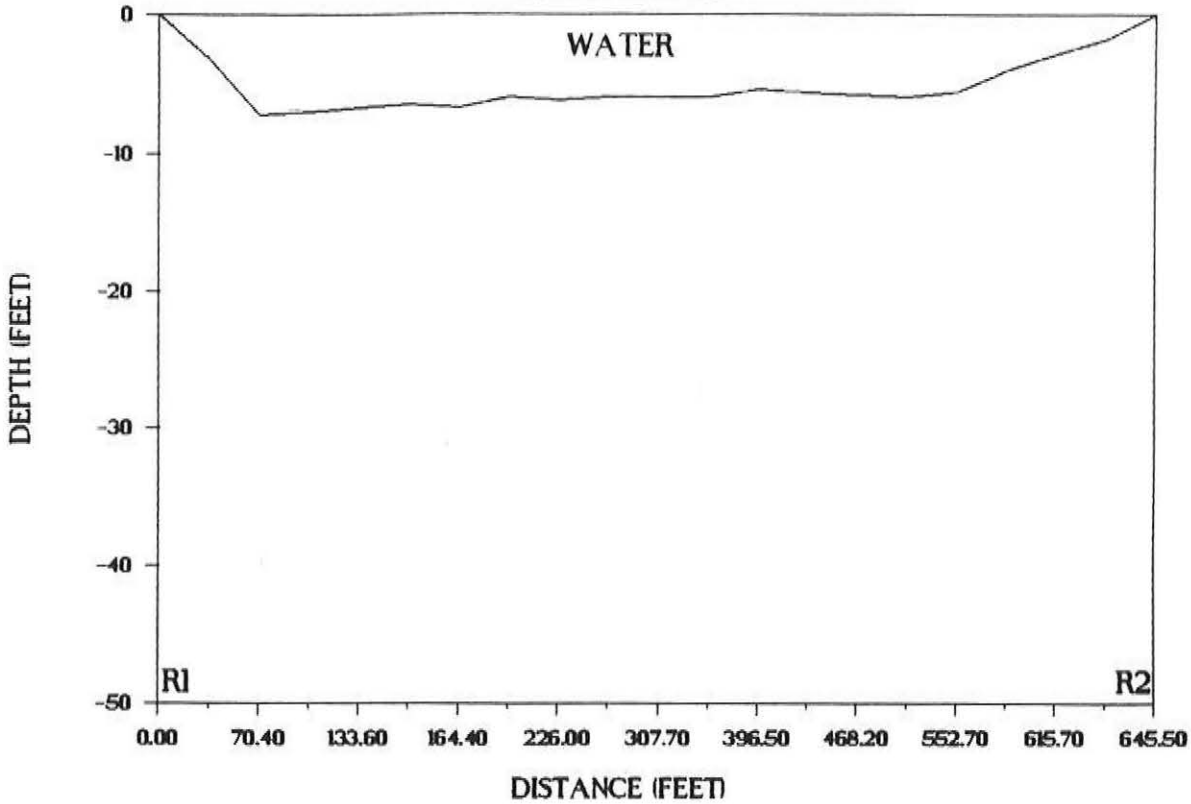
RANGE LINE #16

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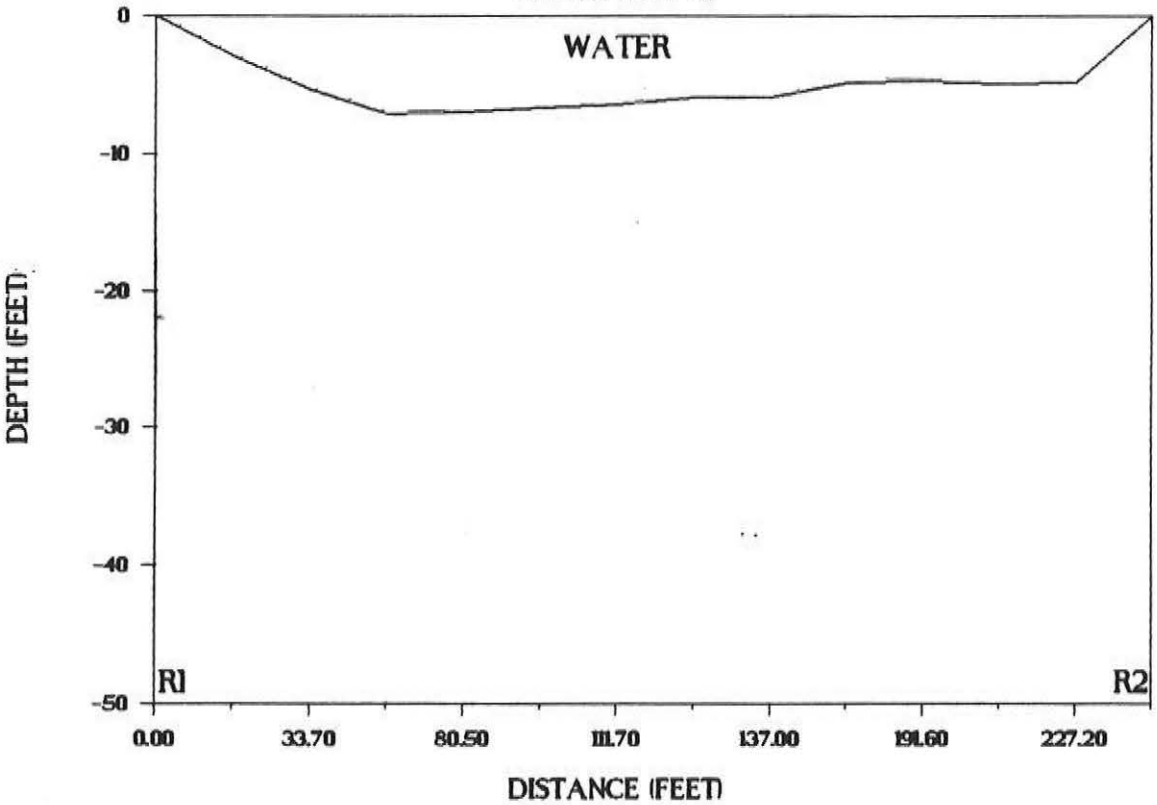
RANGE LINE #17



# BATHYMETRIC SURVEY OF SALUDA LAKE

RANGE LINE #18