BATHYMETRY OF QUARRIES

ON THE

STEARNS COUNTY QUARRY PARK PROPERTY

BY

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December, 1993

ABSTRACT

The bathymetries of 20 water filled quarries in the Stearns County Quarry Park was measured during the summer of 1993 and are presented in this report. More than 6,000 water depth measurements were completed with a maximum depth of 116 feet recorded. The largest quarry is more than 700 feet long and contains more than 6.5 million cubic feet of water. Water depth readings were obtained using a sonar device. These data were plotted on an outline map for each quarry and contour lines were constructed. Maps were throughly field checked and were subsequently digitized to facilitate volume estimation and graphical display. Changes in water level will modify quarry outlines somewhat, but relative differences in depth within a given quarry should be well described by these maps.

INTRODUCTION

This paper is the second in a series of reports describing the results of the investigation of the 100 acres quarry area, a tract of land owned by Stearns county and being developed into a county park. The property is located in eastern Stearns county, in the southwestern quarter of section 20 and the southeastern quarter of section 19, both of which are in T. 124 N. and T. 28 W. The primary focus of the research during the past six months has been to produce a bathymetric map for each of the 20 quarries located on the park property. The field work for this project was completed primarily during the latter part of July and most of August. Field checking and map making have occupied the last several months.

Bathymetric maps have been constructed in order to facilitate planning for the park, to provide some understanding of the physical resources of the area, and to document the activities of the quarry industry in the early part of the century. The geographic placement, orientation and depth of the quarries are largely a result of the geology of the area. The maps of the quarries should provide the user with an accurate underwater picture of the quarry.

DESCRIPTION OF PROCEDURE

The procedure for constructing the bathymetric maps of the 100 acre quarry site requires an accurate outline map upon which data can be plotted. Initially an aerial photo of scale 1" = 200' was used to produce outline maps. This generated a small rather low quality outline which proved to be unsatisfactory. Next, we tried a 1" = 100' aerial photo produced by Mark Hurd Inc. of Minneapolis which was more acceptable. Even though this was the best outline that

could be obtained for the job, it was necessary to make corrections, by hand, based on field observations. After the initial outline map was made, bathymetric readings were taken using a small, portable battery powered sonar device. The procedure included placing a rope marked at one meter intervals across the quarry being studied at specific locations. The sonar was then swam along the rope, with depths being called off and recorded at every meter interval. The tracks were labeled on the outline map showing the direction of data collection and the location of the track. The data were collected onto a recording sheet and later transfered onto the outline map obtained from the aerial photograph. Each transect was lettered, and that letter was marked on the quarry walls at the two ends of the rope with paint. It should be noted that on most quarries water level readings were taken from a fixed paint mark on the day or days of data collection.

The procedure for collecting data was then repeated as many times as necessary to produce the bathymetric map. The largest quarry(number 2) was completed from 18 transects and about 1012 data points. More the 6000 data points were collected to produce the maps of the area. Additional data points were gathered at the time of data collection to formulate a mental image of the quarry to aid in hand contouring. On several of the smaller quarries no tracks were taken. These quarries were of such small magnitude, that we found it was best to simply swim the sonar by hand, and then hand countour it on site. This was done on number 5 and 20.

Data were posted along transect lines for the larger quarries, and a contour map was constructed for each quarry. Initial hand contouring was done in the laboratory and subsequent refinements were made in the field at each quarry site. After these contours were made, they were further field checked by going out to the quarry with the contour map and the sonar. A canoe was utilized to allow the work to be done out on the water. The maps were then checked to make sure they were accurate. Small changes were made to cover areas where insufficient data had been gathered and to correct outline problems.

After the field checking was completed, the map was then digitized utilizing a magnetic digitizing tablet. These data were used to produce a bathymetric grid which is a part of a computer program capable of calculating quarry volumes and other details. This grid was then checked to make sure that the map was similar to the hand contoured map. It should be pointed out that some of the contour lines that the computer constructed had a tendency to become straighter. This only happened to a slight effect on quarry number 2 and number 3.

In keeping with the environmental emphasis of the park, mountain bikes were used to transport our equipment to and from the park. We felt that as little environmental damage

as possible should be done to the park to conduct our survey. All of our equipment was designed so that it could be carried easily to the site of operation by 2 people with backpacks on bikes. Some snorkeling was done to aid in our generation of the maps. This was combined with using a canoe as an effective means of checking the maps. A car was only used on 3 or 4 occasions to transport the canoe to the sites.

One of the biggest problems we had in dealing with this project was that of insects. Due to the unusually large rainfall of the summer the insect population was extremly high. Working in a small area where there was little opportunity to move about was quite aggravating. Field schedules had to be changed occasionally because of adverse weather conditions.

QUARRY DESCRIPTIONS

A commentary on each of the twenty quarries is provided in this section of the report. Maximum depth and volume are summarized in Table 1. The approximate relative locations and numbering systems are shown in Figure 1. Bathymetric maps for each of the 19 quarries are provided at the end of the report. Please note that the scales vary from map to map.

-QUARRY 1

Quarry number 1 is a large quarry reaching just over 400 feet in length. It has a large volume, holding approximately 1,202,000 cubic feet of water. This was the second highest volume at the site. The quarry is also quite deep. There are 2 main depressions in the quarry, the depression in the middle of the quarry is approximately 55 feet deep and covers a large portion of the quarry floor. The other depression sits on the west end and is smaller with a maximum depth of about 65 feet. The east end of the quarry is relatively shallow and does not have steep relief while the south end is close to a vertical wall. There is a bay located on the northwest side which is quite shallow and has cattail growth. There is also a small island that sits on the southeast side of the bay. A spoils pile is located on the northwest end of the quarry.

-QUARRY 2

Quarry number 2 is the largest quarry at the 100 acre quarry site. It is over 700 feet long and 300 feet wide and has a volume of 6.6 million cubic feet. The maximum depth of quarry number 2 is approximately 116 feet. There is a large area near the middle of the quarry that is over 110 feet deep. The quarry is virtually surrounded by spoils piles, as one would expect given its large size and great depth. The west side of the quarry is quite steep especially in the area of the high walls. The north and south ends of the quarry are of more moderate relief and generally fall off in steps towards the main hole. The main

hole of the quarry is quite irregular which would indicate that the bottom is riddled with boulders and other debris.

QUARRY 3

Quarry number 3 is a somewhat long, thin, and relatively shallow quarry. It has a maximum depth of just over 25 feet and a volume of 225,000 cubic feet. Most of the quarry has high walls with the exception of the extreme southeastern corner. There is also a van located just west of the southeast corner along the high wall. The van is submerged in approximately 15 feet of water, and is visible from above. On the eastern side of the quarry near the southern most projection into the quarry there is a small rock island located near the shore. On the north end of the quarry is the deepest depression with a very small hole of 25 feet. The middle of the quarry is relatively shallow. There is also a relatively deep point on the south side where 18 feet is achieved.

-QUARRY 4

Quarry number 4 is a medium sized medium depth quarry. It has a maximum depth of 57 feet, and a volume of 468,000 cubic feet. The deepest portion of the quarry is located on the north side. This is also the area of most extreme relief. The south and east sides of the quarry are surrounded by high walls.

-QUARRY 5

Quarry number 5 is a relatively small and shallow quarry. It has a volume of only 28,000 cubic feet. the maximum depth of quarry number 5 is only 11 feet. This maximum depth is located in the northeast corner of the quarry. There are high walls on the south and west sides of the quarry, while the north and east sides are generally of low relief. A spoils pile sits just east of the quarry.

-Quarry 6

Quarry number 6 a small quarry, that is quite deep. The maximum depth of quarry 6 is 33 feet. It is surrounded by high walls on the north and west sides. The east side is somewhat overgrown with trees making it difficult to obtain a good outline map. The main hole of the quarry lies in the southeastern area. The steepest relief can be found in the southeast corner.

-QUARRY 7

Quarry number 7 is a medium depth, and medium sized quarry. It has a maximum depth of 66 feet, and a volume of 545,500 cubic feet. The south end of the quarry has a rubble pile behind it, and the gradient of the bottom is not as steep as the north side. On the northeast corner there is also a neatly stacked spoils pile. There is a shallow underwater shelf in the southeast corner of the quarry, which drops abruptly to the main hole of 60 or so feet. There is most likely some degree of rubble, or irregularity on the bottom of the main hole.

-QUARRY 8

Quarry number 8 is very deep with a maximum depth around 99 feet. It is of rather small size, and

consequently it's volume is only 261,000 cubic feet. The main 90 foot hole lies on the east side of the quarry. The north, south and east sides of the quarry are all extremely steep, while the west side is slightly less than the others. On the southeast corner of the quarry there is an exposed granite outcrop. Two large spoils piles are located just north and east of the quarry.

-QUARRY 9

Quarry number 9 is a very high walled quarry. It is of medium size and medium depth. The maximum depth of the quarry is 45 feet. On the east side of the quarry is a cleanly built spoils pile. The northwest corner has an obvious notch in it, while part of the west wall has a shelf located just above the water level. The quarry has a volume of approximately 414,000 cubic feet.

-QUARRY 10

Quarry 10 is a small quarry, with an odd and irregular shape. There is a swampy low lying area just east of the quarry. There is also a small rocky island located just east of the middle. The maximum depth of the quarry is 20 feet. The bottom of the quarry, near the main hole is extremely irregular. To the east of the rocky island lies an area with a depth around 3 to 4 feet. The southeast side of the quarry is the site of a large granite outcrop.

QUARRY 11

Quarry number 11 is a large quarry with only a medium depth. The maximum depth of the quarry is just over 50 feet. On the west end of the quarry there is a prominent outcrop which shows clearly on the aerial photograph. There is also an outcrop located on the northern end. The northeastern side of the quarry is also the location of a spoils pile. The eastern shoreline is somewhat irregular in design, with a series of grooves and notches penetrating it. The southern shore is rather straight and flat, with little or no relief between the shore and the land. The maximum depth is located just to the north and east of the prominent knob on the west shore. There is also a canal just over 40 feet deep that runs due south from the maximum depth area.

QUARRY 12

Quarry 12 is a small shallow quarry, located in an area where many quarries are present. The maximum depth of the quarry is approximately 23 feet, and the volume of the quarry is 38,000 cubic feet. The eastern shore of the quarry is an outcrop, while the western shore is a spoils pile. Along the outcrop the relief is steeper, while along the spoils pile the relief is less extreme.

QUARRY 13

Quarry 13 is a long narrow quarry with a moderate depth. The quarry has a volume of 458,000 cubic feet. There are 2 main holes in the quarry. One is located on the west end with a maximum depth of 39 feet. The other one is located on the east end of the quarry with a maximum depth of just over 33 feet. Between the 2 holes is a rocky irregular area with a depth between 1-12 feet formed by

placing debris into the quarry after it was abandoned. Just east of this divider a car is submerged in the water. There is a spoils pile located on the south end of the quarry, as well as a pile on the east side of the quarry. Much of the quarry is surrounded by granitic outcrop.

QUARRY 14

Quarry 14 is slightly smaller than quarry 13, and located directly in line with it to the west. This quarry has a maximum depth of 47 feet, and a volume of 150,000 cubic feet. The main hole is located on the east end of the quarry. The western half of the quarry is relatively shallow with a depth between 10 to 20 feet. This quarry has 2 floating beams in it which are large in diameter, and quite long. On the northeast and south ends of the quarry there is a spoils pile.

QUARRY 15

Quarry number 15 is medium sized, with a maximum depth of about 45 feet, and a volume of 286,000 cubic feet. The quarry has extremely high relief around it, not in the form of walls, but rather spoils piles. The water in this quarry is unusually cold and clear. The main hole of the quarry is located in the northwest corner. There are large spoils piles on the east side, the northeast side, the south side, and further away to the southwest.

QUARRY 16

Quarry 16 is a small, shallow quarry. It has a maximum depth of around 17 feet, and this deep hole is located in about the center of the quarry. The volume of the quarry is 23,000 cubic feet. The north end of the quarry has high walls, while all other sides of the quarry are composed of rubble piles.

QUARRY 17

A survery was not completed on quarry number 17 due to it's small size, and shallow depth. The depth of the quarry is generally only 1 or 2 feet deep.

QUARRY 18

Quarry 18 is a large deep quarry with a volume of 347,000 cubic feet, and a maximum depth of 58 feet. The south side is a high cliff, while the west side and east side are composed of rubble piles. The main hole of the quarry is located in the northern most corner. This is also the area of greatest relief. The west end of the quarry is made up almost entirely of granitic blocks, which separate quarry 18 from quarry 19.

QUARRY 19

Quarry number 19 is located southwest of quarry 18, and the two are separated by a spoils pile. It is generally small and shallow, with a maximum depth of 26 feet, and a volume of 29,000 cubic feet. The south and west ends of the quarry are spoils piles. The main hole is located in the middle of the quarry.

QUARRY 20

Quarry number 20 is a medium sized shallow quarry located on the northen edge of the site. It has a volume of

90,000 cubic feet, and a maximum depth of 26 feet. The deepest portion of the quarry lies in the east corner. This is also the area where the most extreme relief is present. The southwest corner of the quarry is generally quite shallow. The water of quarry number 20 had a murky color to it at the time of examination. The south end of the quarry has a granite outcrop.

EXTENSIONS AND LIMITATIONS

The outlines of each quarry should not be regarded as totally accurate, because they were produced without the aid of a surveryed map. The lack of a totally accurate outline map inhibited our ability to generate a truly accurate bathymetric map. The water depth data which we have generated are reasonably accurate; however, the problem that arises is that one really cannot be sure where the data fit on the outline map. The only way to solve this problem is to have an accurate map of the quarry outline completed immediately before the water depth data are collected. A related complication deals with the nature of the quarry walls. If the quarry margin is one with a very low gradient, as the water level goes up or down the quarry outline will change very rapidly. Quarry outlines were constructed from an older aerial photograph and corrected in the field in 1993. These outlines will not likely be the same as the quarry outlines generated at another time when water levels are higher or lower.

There were also potential problems using the sonar. The sonar produces an elliptical cone of high frequency sound with a maximum angle of 15 degrees. The sound waves returning from the bottom of the quarry are averaged by the device to obtain an average depth. This worked quite well except in those situations where there was a steep cliff beneath the sonar device. The returning sound waves within this 15 degree cone might well be coming from a water depth of a few tens of feet and more than one hundred feet. Hand contouring of the data easily compensated for this potential problem.

Another potential problem was that of securing the rope. This problem was most severe for areas where the rope was to be secured between two high walls.

CONCLUSION

The bathymetric maps presented in this report provide a useful "first look" survey of all the major quarries on the park site. Although absolute depths and quarry outlines may vary with seasonal water level changes, the maps furnish a good picture of relative sizes and depths. It is anticipated that some of the quarries, especially the larger ones, will probably be re-surveyed in the course of planning for the park. The best improvement that can be made on any

of the maps in this report is to accuratley survey the details of the shoreline.

The quarries of this park site are a fundamental element of the environment. They reflect not only the geology and hydrology of the area, but also the human activity involved in developing the building stone resource. Ultimatley it is the quarries which provide much of the appeal in this park. It is appropriate that some of the first work completed for the site deals with characterizing the quarries.

Table 1. Water volumes and maximum depths for the quarries of the Stearns County quarry park.

Quarry number	Water volume cubic feet	Maximum depth feet
1	1,202,000	65
2	6,564,000	116
3	225,000	25
4	468,000	57
5	28,000	11
6	61,000	33
7	545,000	66
8	261,000	99
9	414,000	45
10	69,000	20
11	579,000	50
12	38,000	23
13	458,000	39
14	150,000	47
15	286,000	45
16	23,000	17
18	347,000	58
19	29,000	26
20	90,000	26
Total volume	11,837,000	

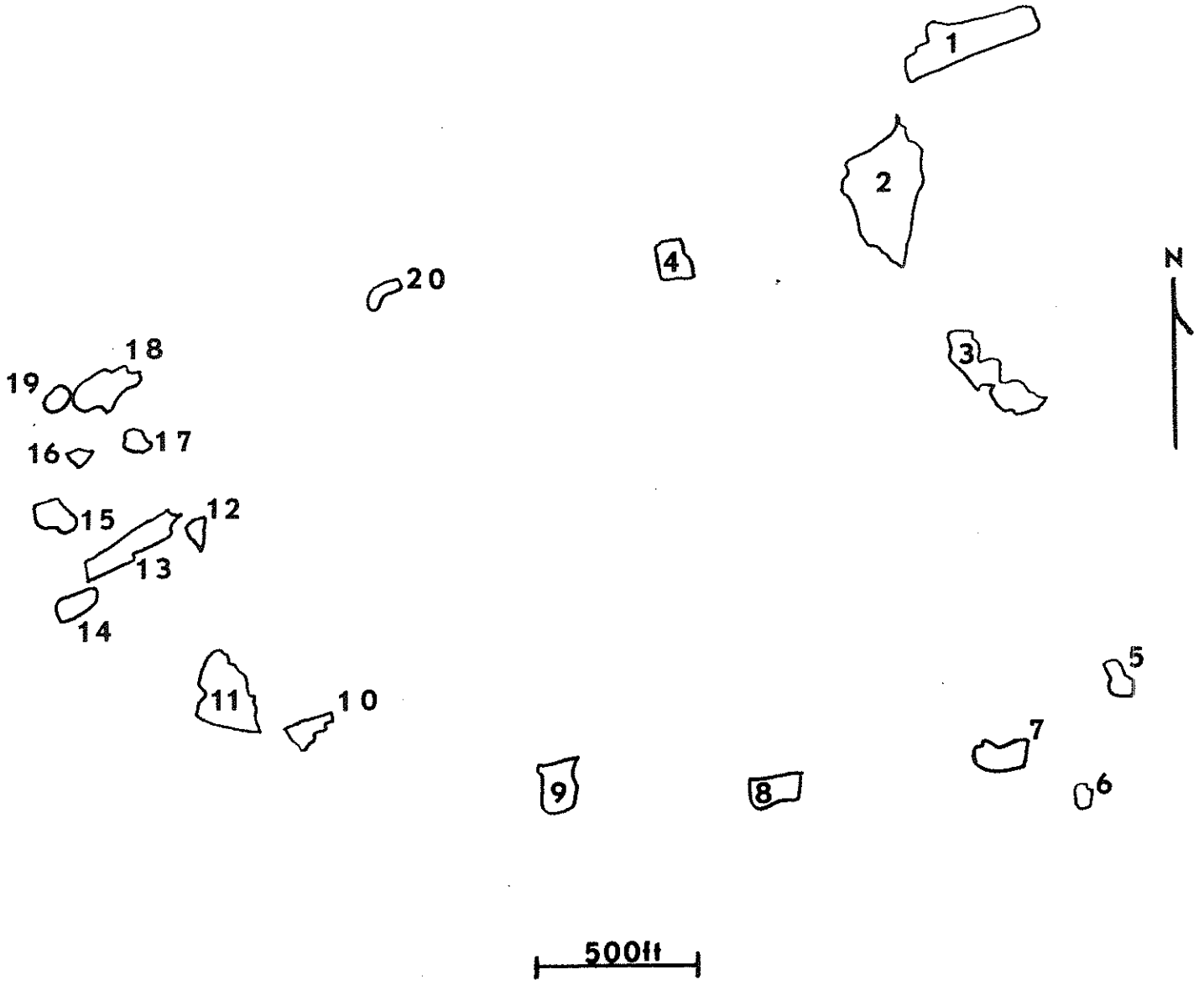

FIGURE 1----Sketch map showing quarry locations.

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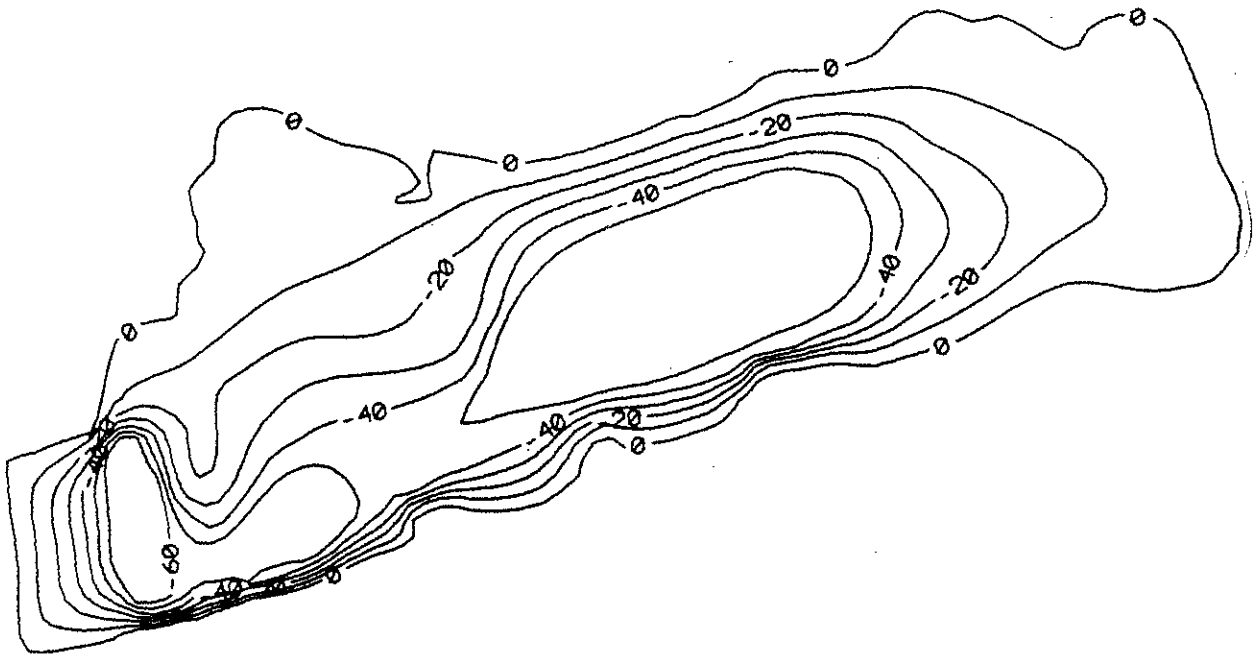

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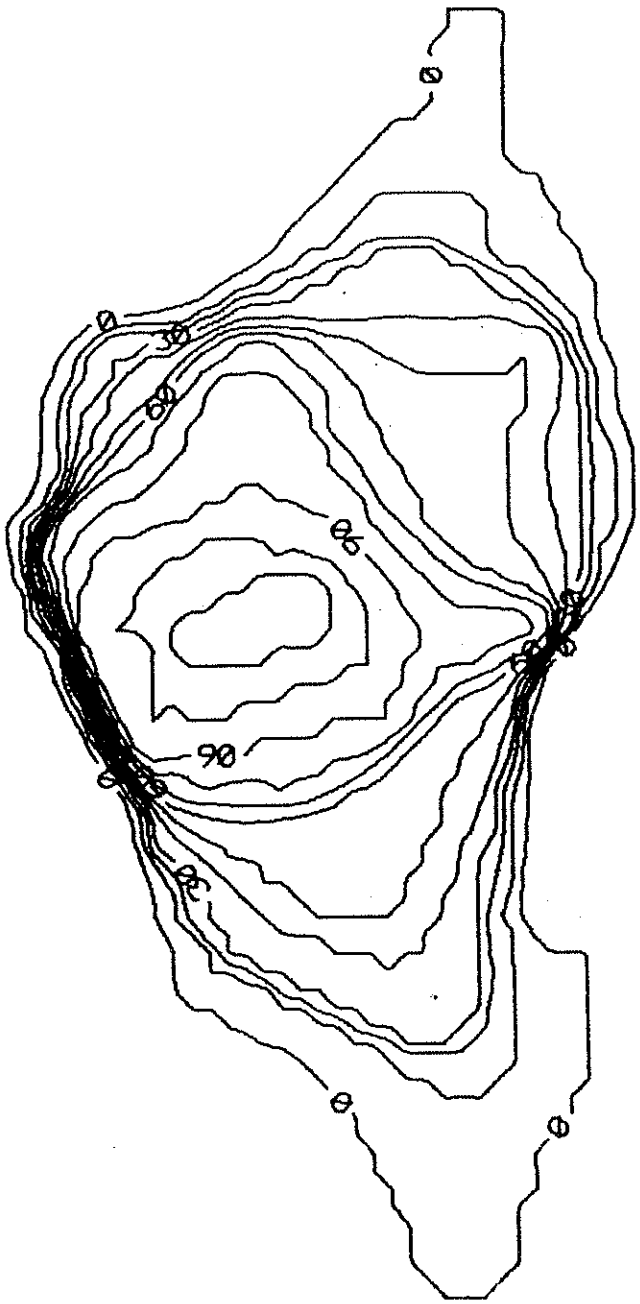

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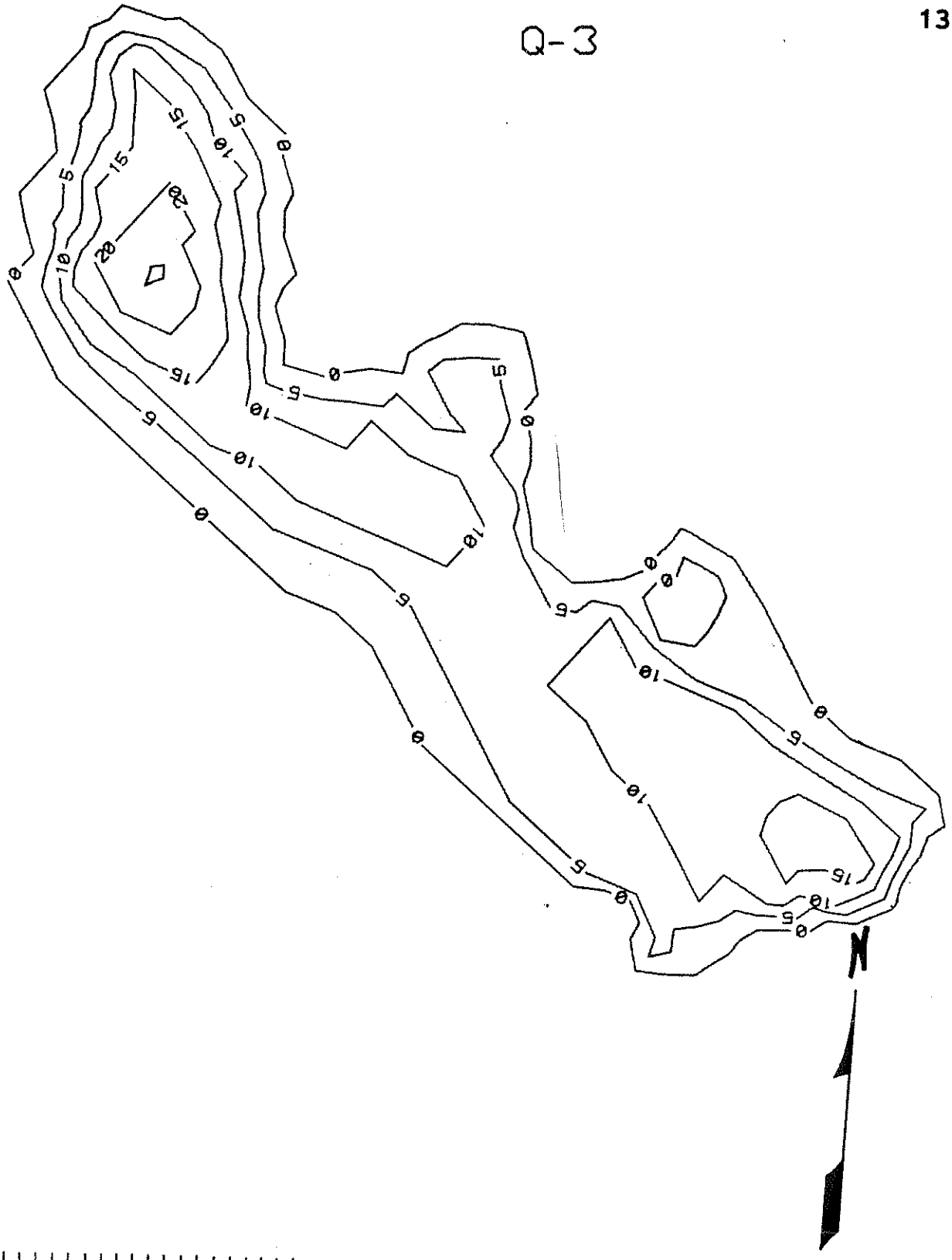

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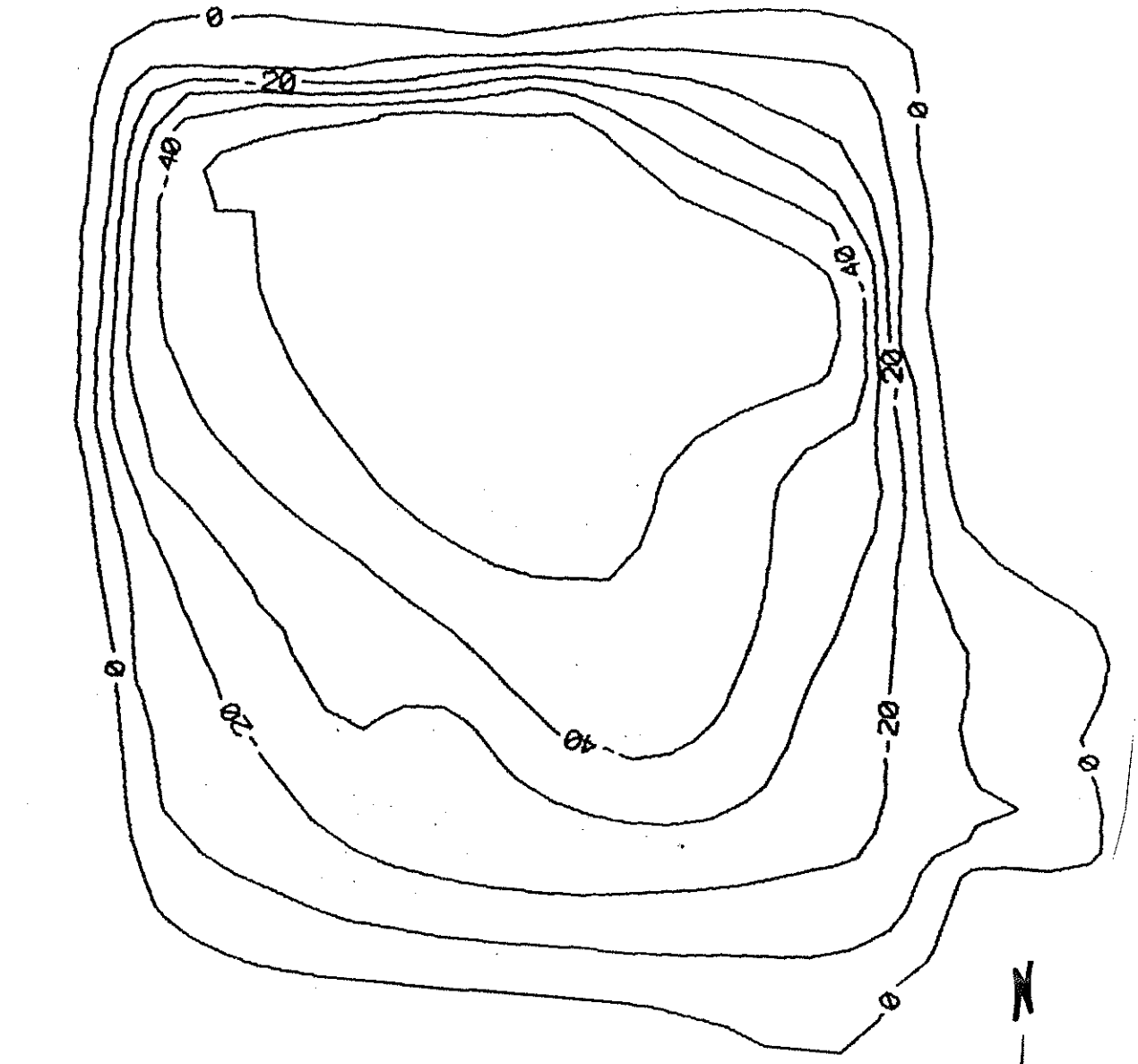

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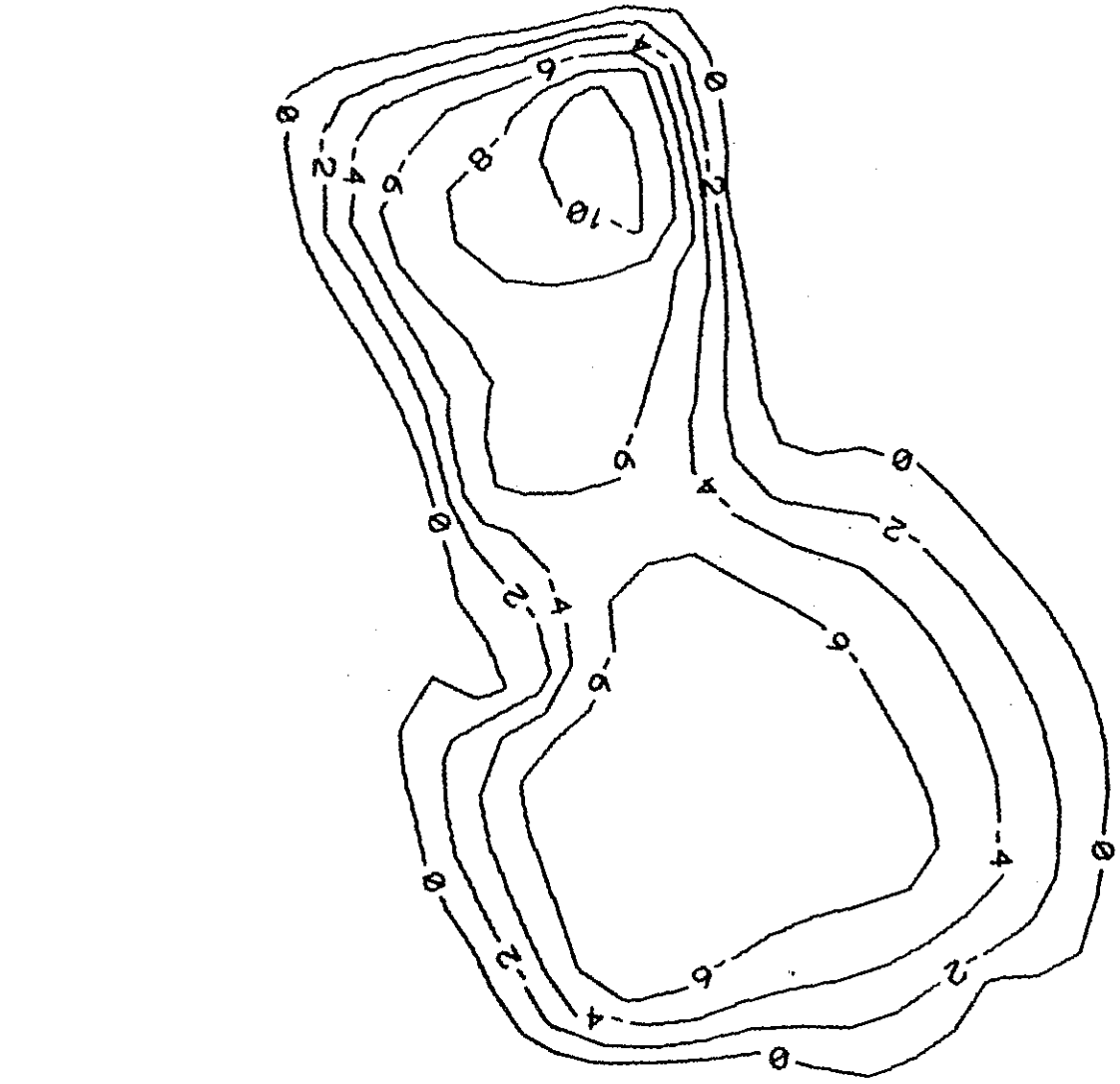

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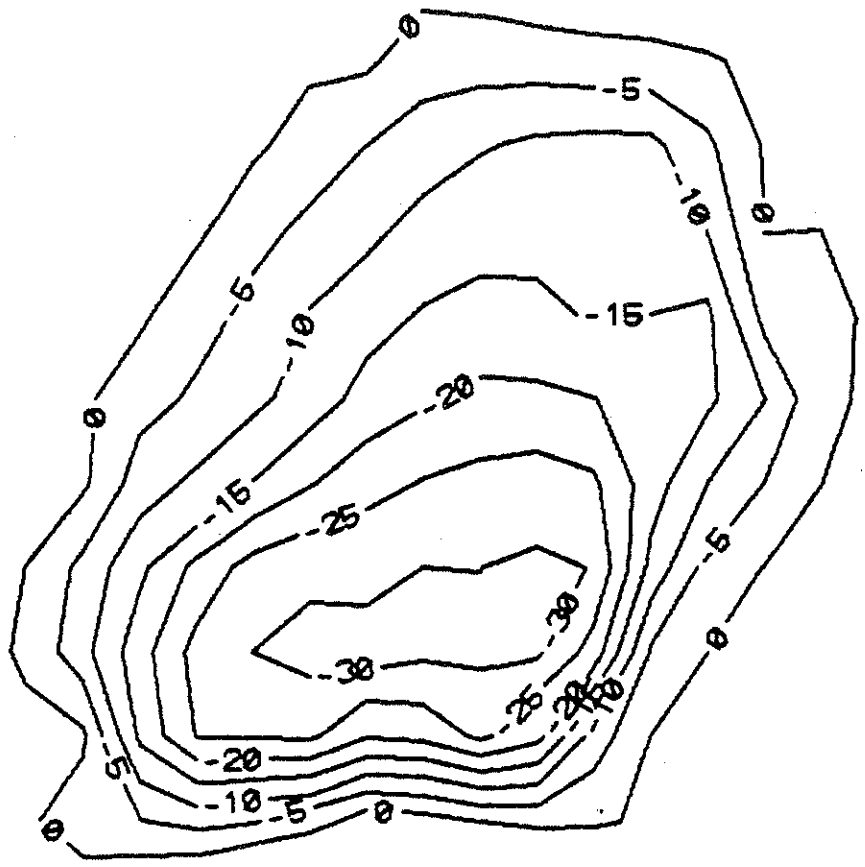
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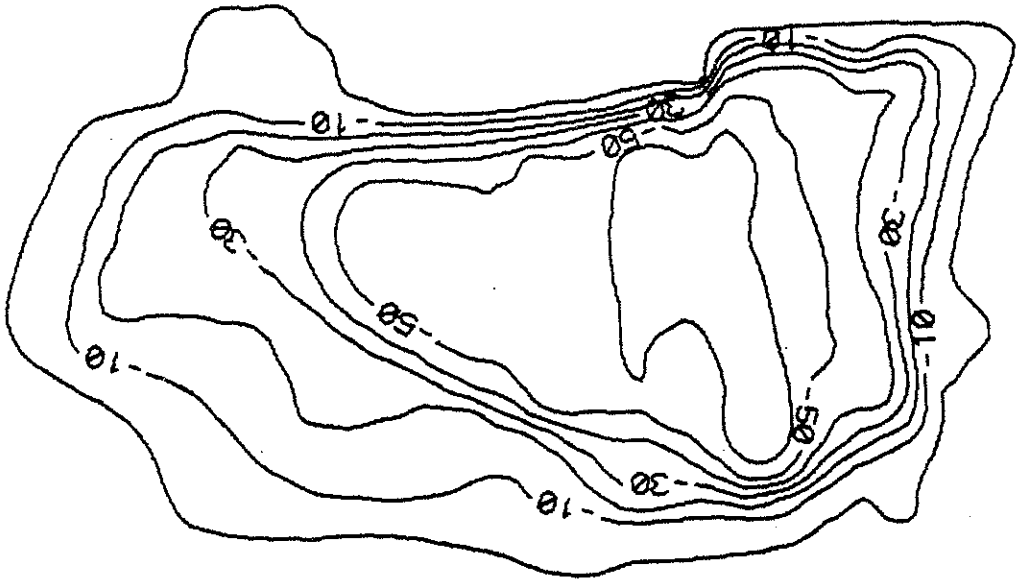

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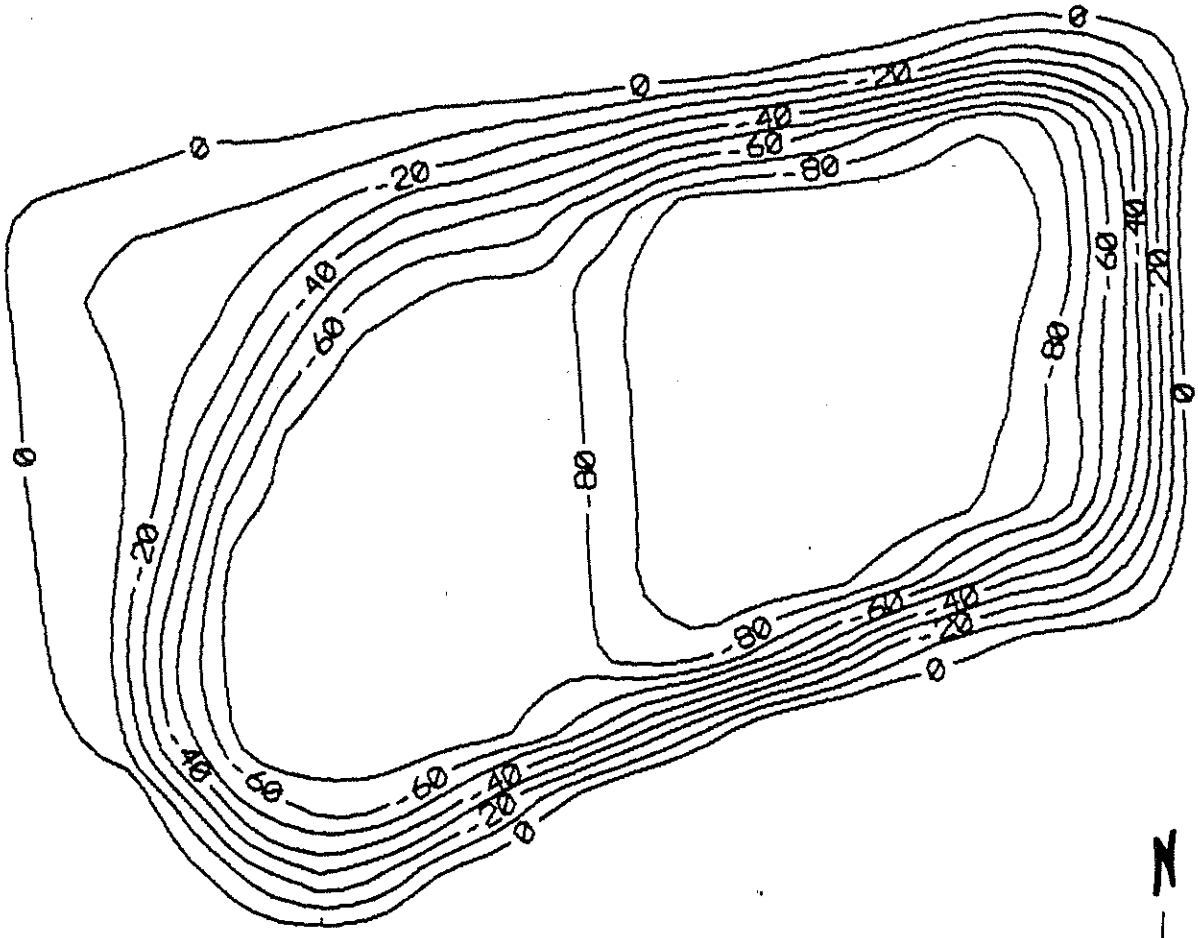

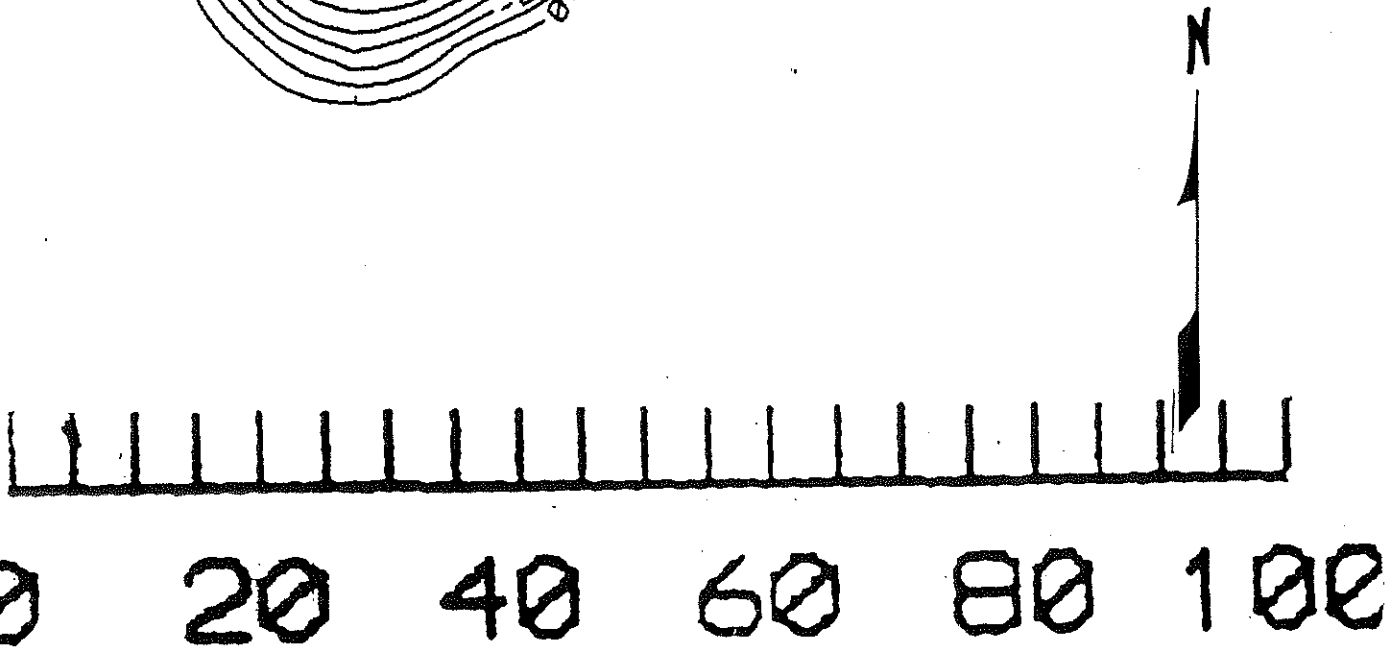

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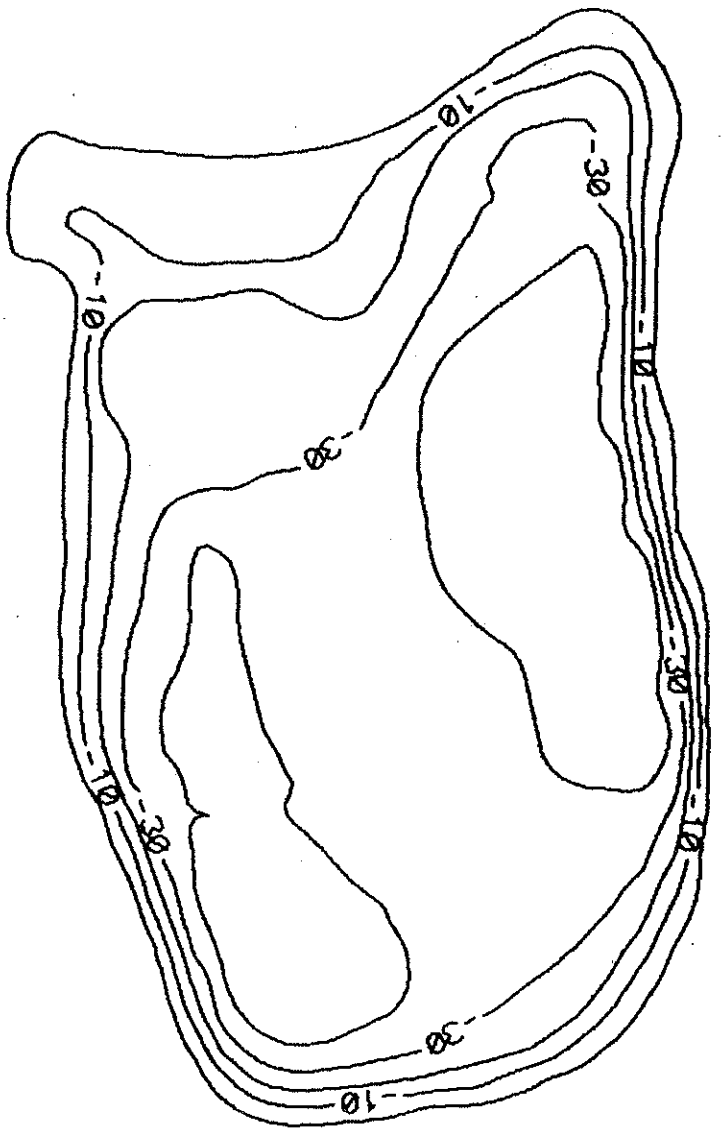

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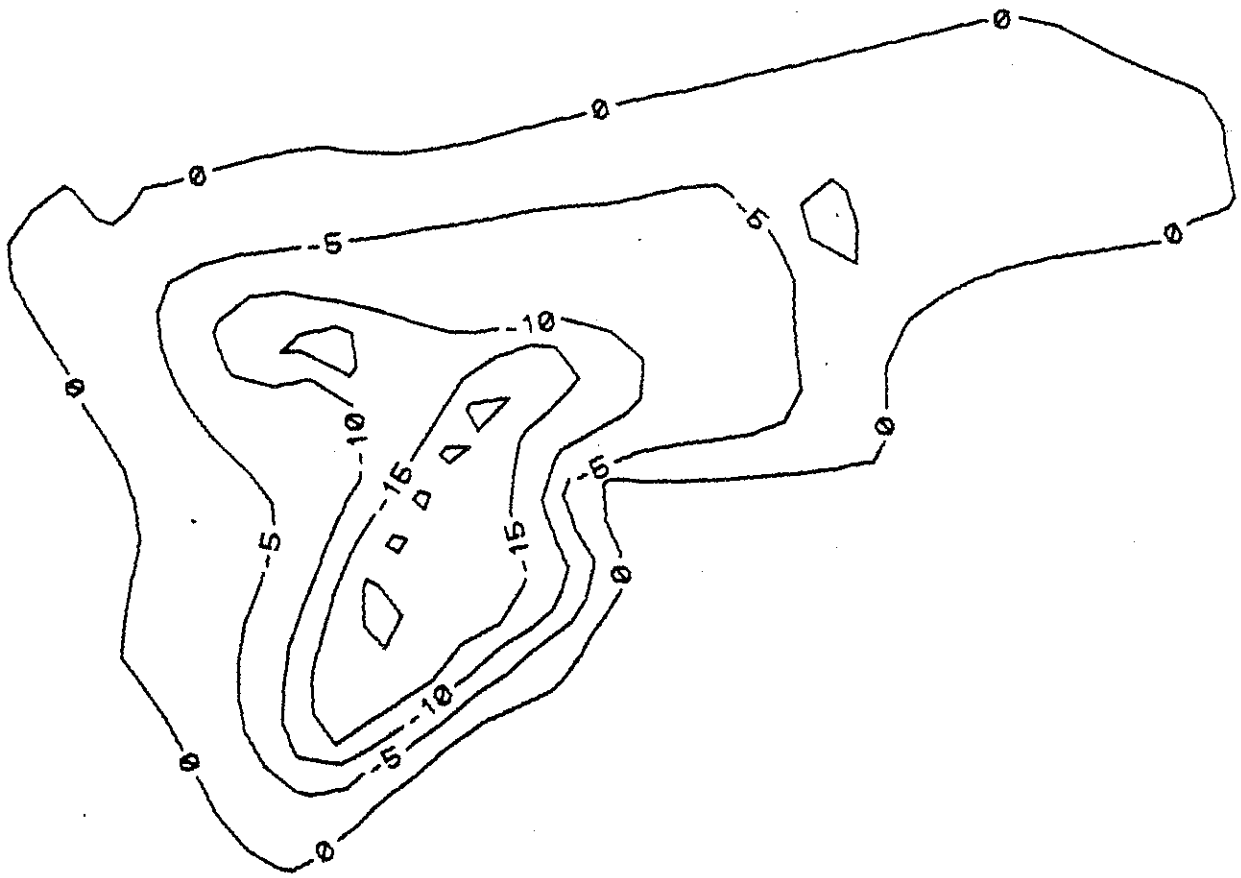

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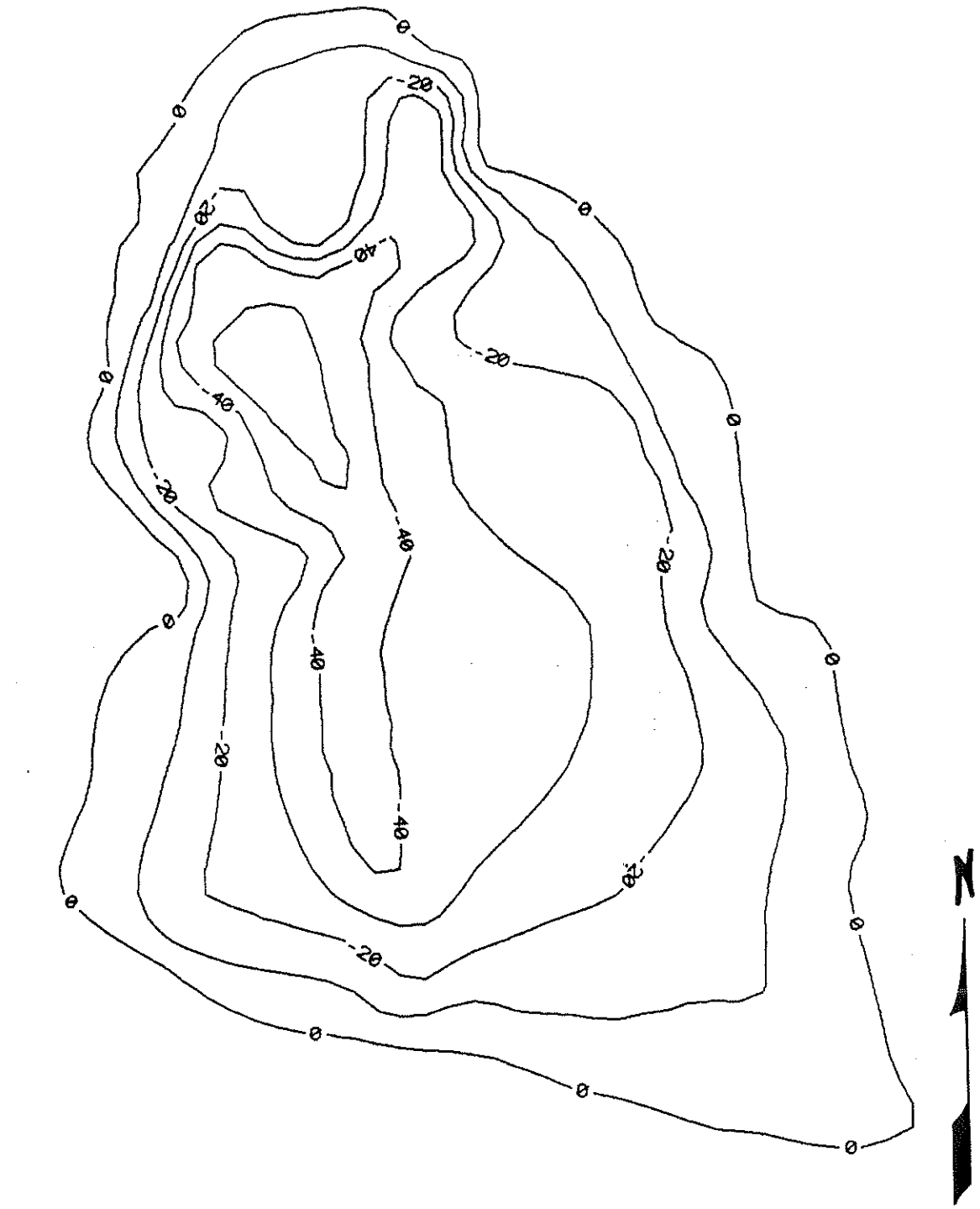

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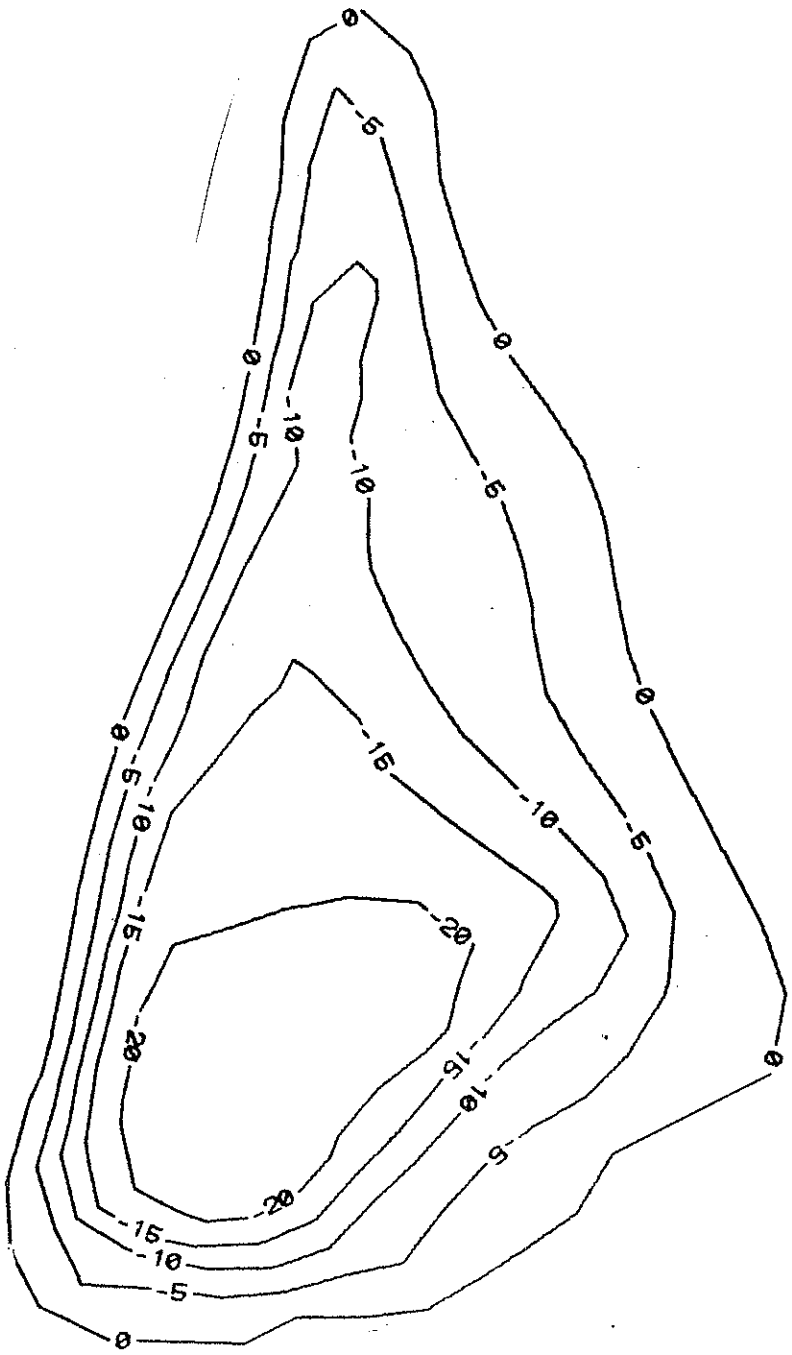

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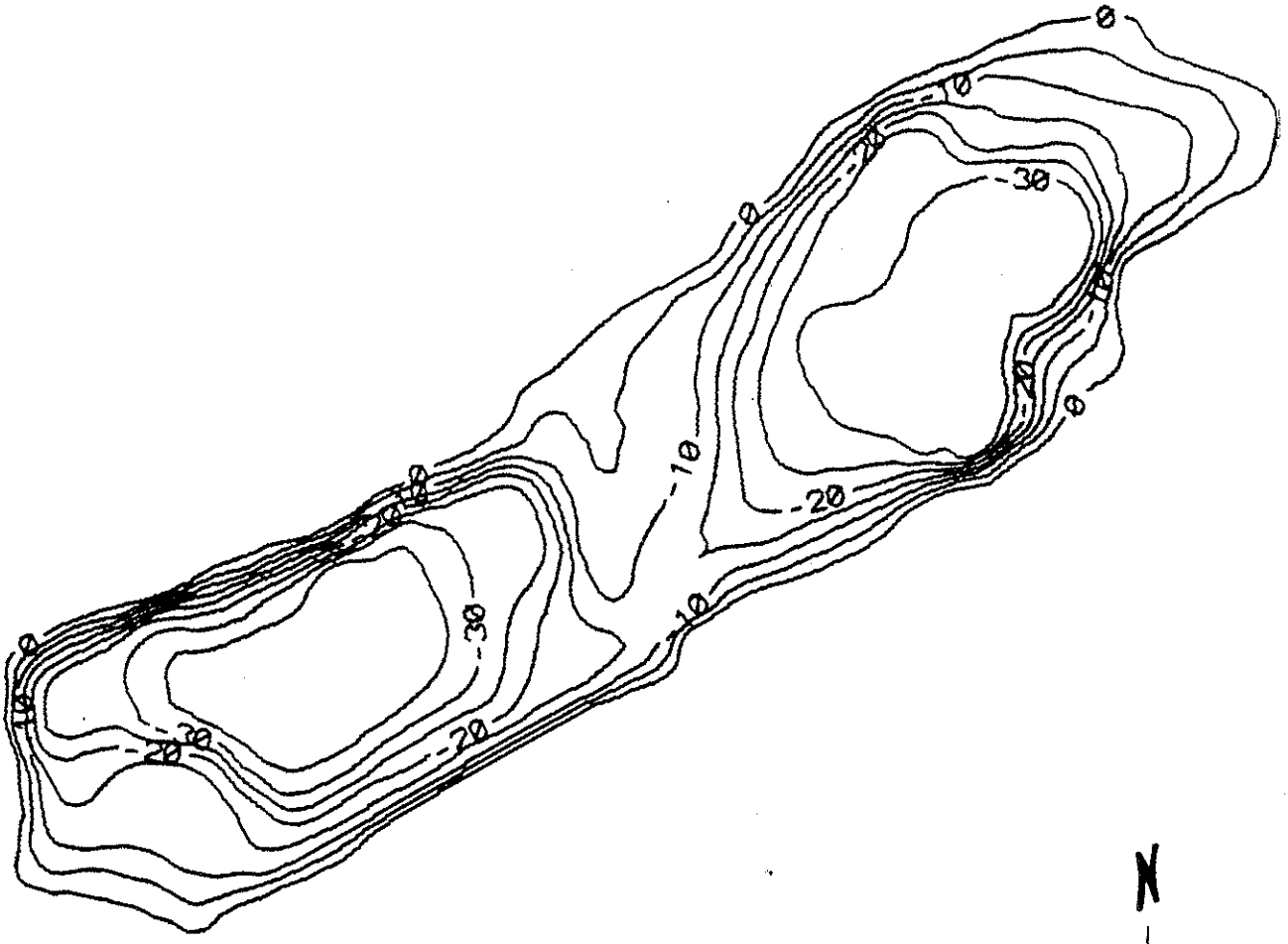
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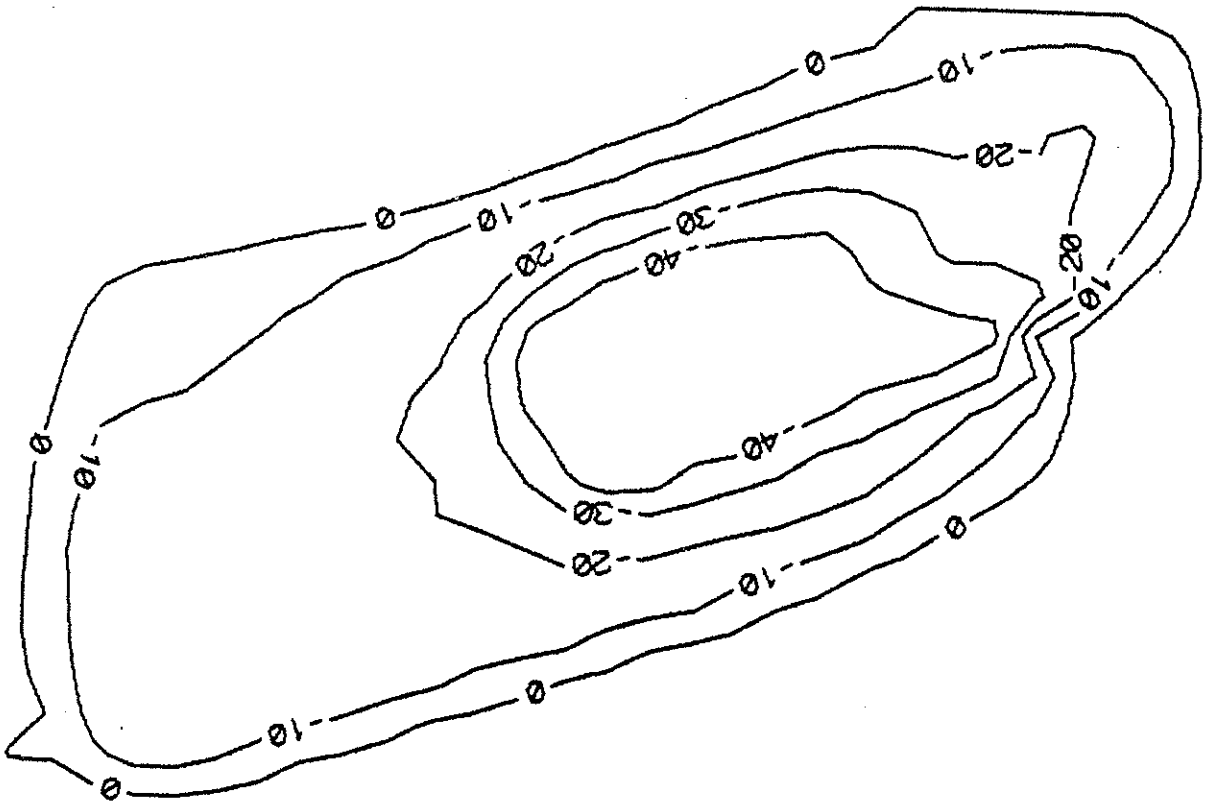
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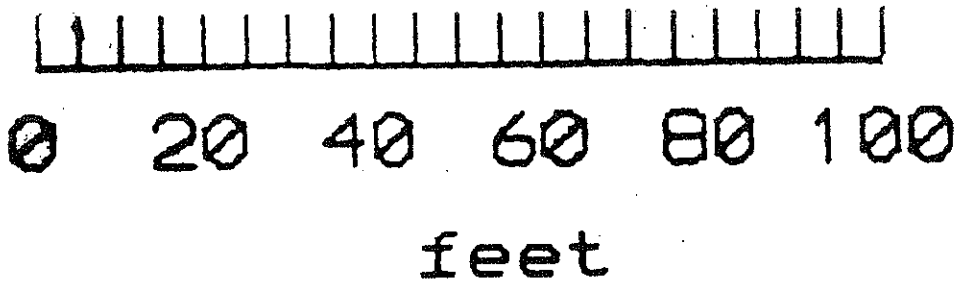
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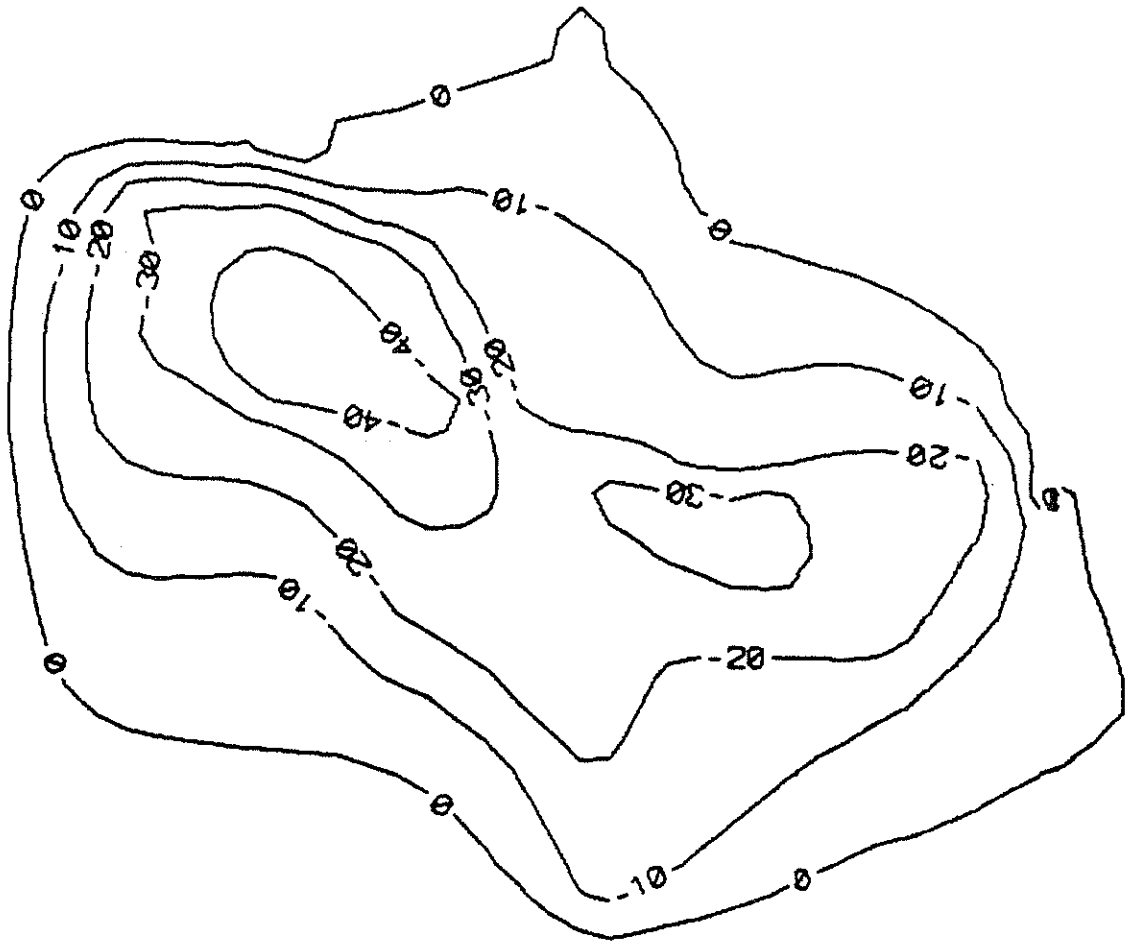

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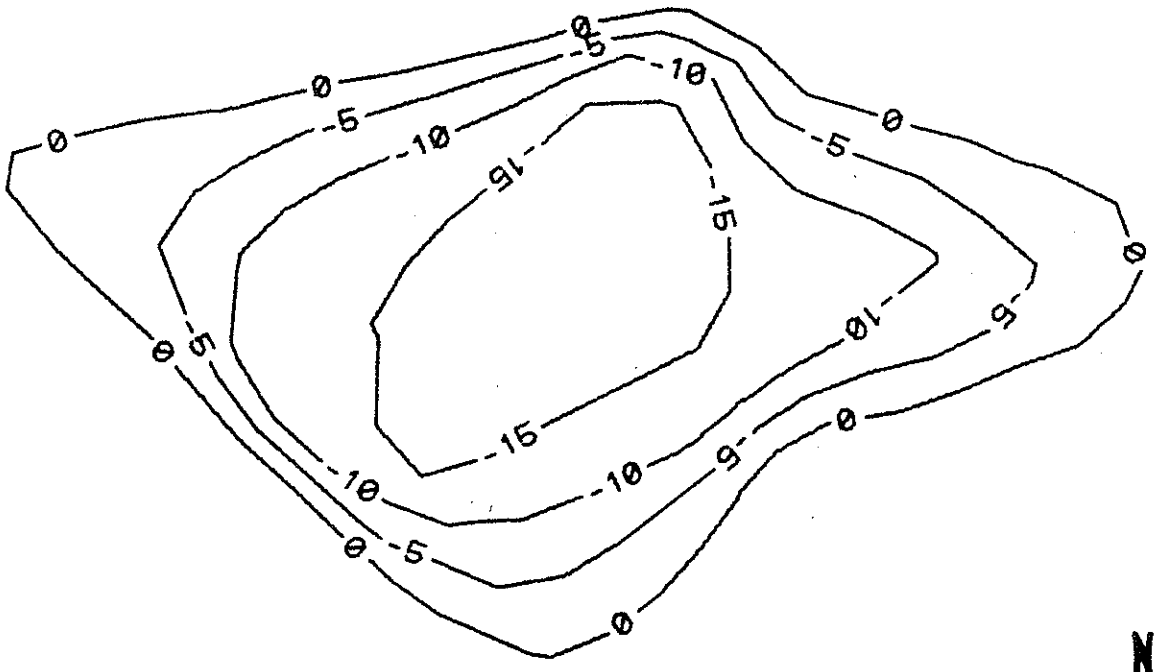

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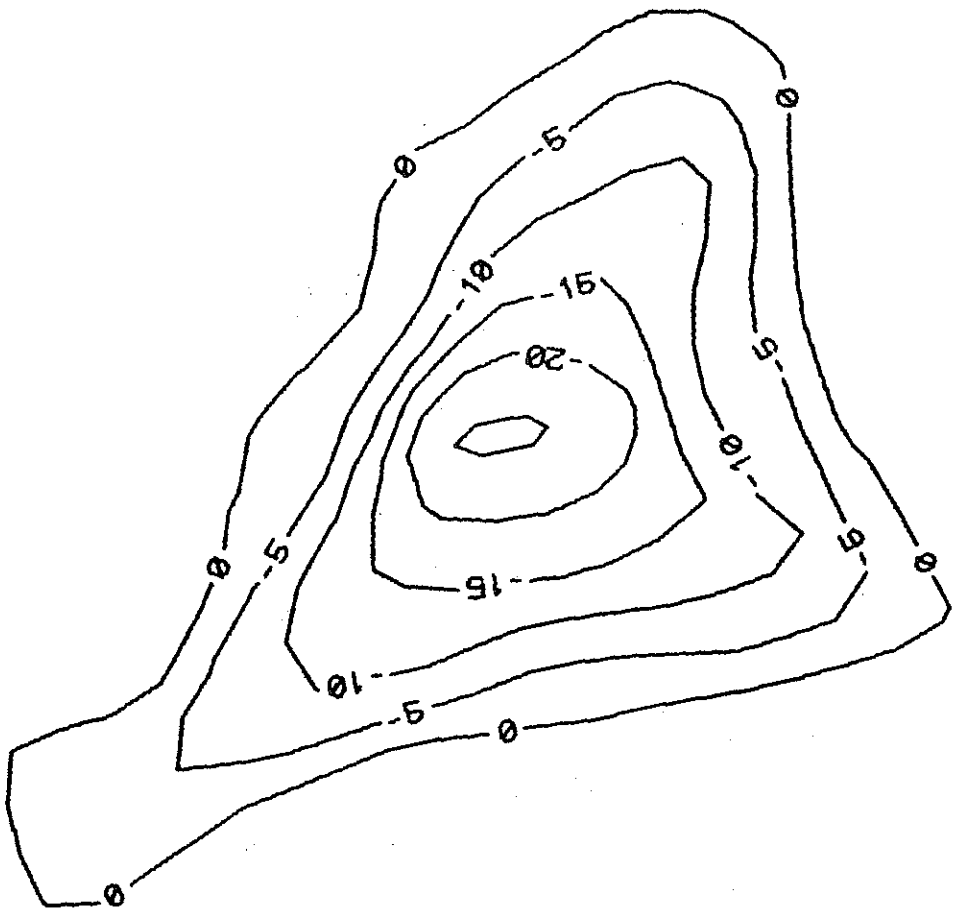

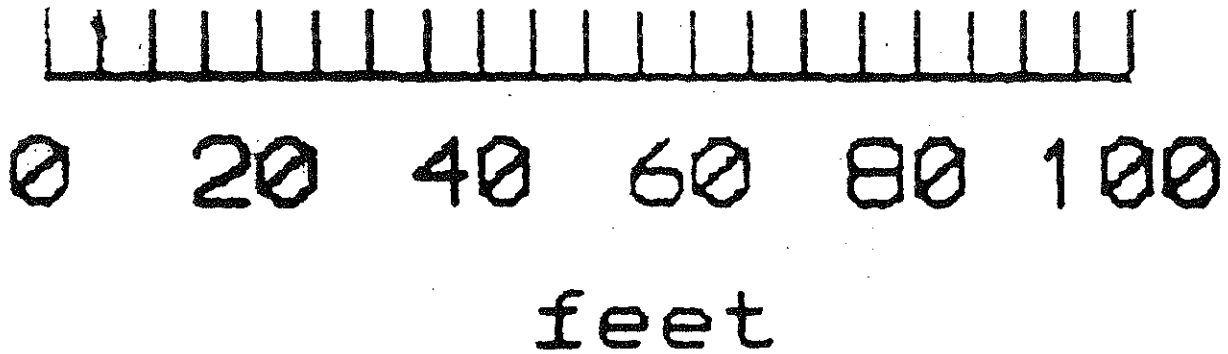

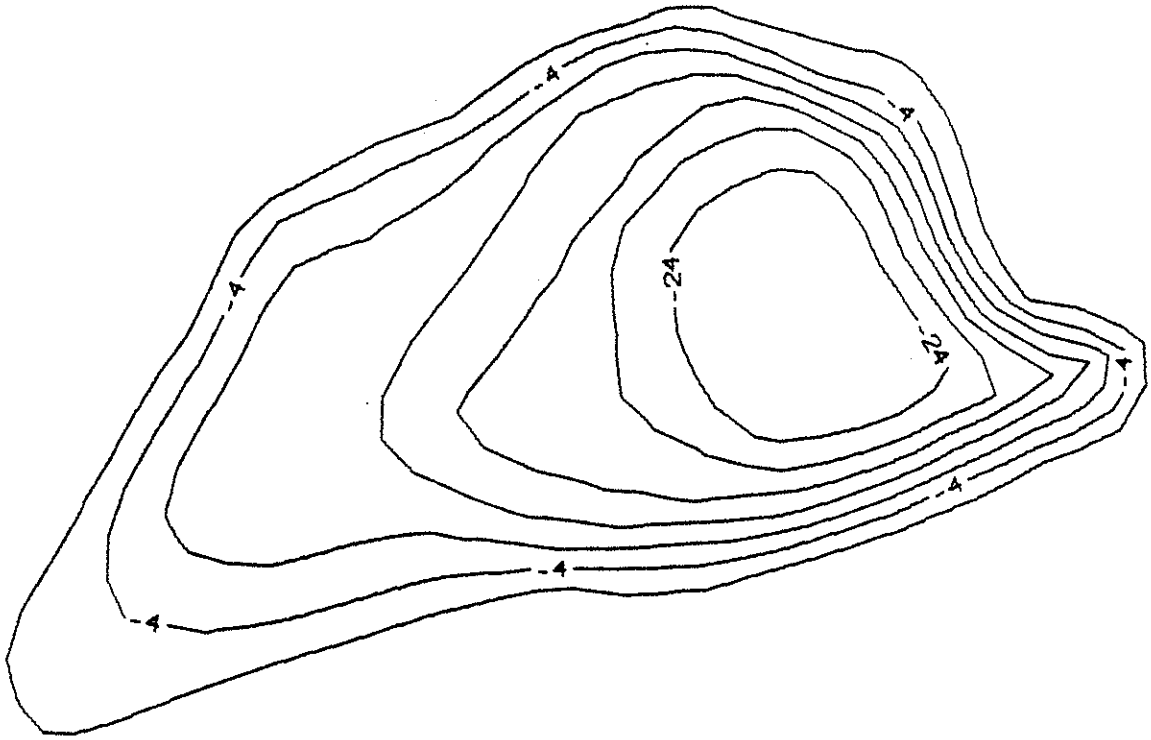

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