Lake Neshonoc Sedimentation Control Study

Prepared for the
Lake Neshonoc Protection and
Rehabilitation District

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I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

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Date 1/7/92 Reg. No. 19950

Summary

Lake Neshonoc is a valuable water resource that is presently being degraded by deposition of sediment or sedimentation. Approximately 11 percent of the lake volume was filled between 1954 and 1985. If nothing is done in the next 30 years there will be severe impacts to the lake. The exposed portion of the delta will extend to about the midpoint of the lake near the campgrounds. This report is a study of the sedimentation problem involving four major steps: 1) data compilation, 2) data analysis, 3) outline of alternatives, and 4) recommendations.

Data compilation included gathering existing data related to Lake Neshonoc sedimentation such as maps, reports, records, photos, and interviews. A field investigation was done to update and add to this information. A list of the available data is contained in this report.

Analysis of the change of the lake bottom elevations shown on the bathymetric maps from 1954 to 1985 shows a clear picture of the growth of the delta at the upstream end of the lake. Volume estimates of the deposited sediment or sedimentation were made despite some discrepancies in the bathymetric data.

Volume estimates of the deposited sediment were also made with established sediment transport equations and methods. These methods produced substantially higher volume estimates of deposited sediment than those estimates from the bathymetric data. The higher rates may be justified by the fact that sediment is being deposited in the floodplain upstream of the lake.

An aerial survey of the watershed was made to investigate the sources of the sediment being transported by the stream. A primary source was identified as cropland. Another may be the erosion of the stream bed and banks along tributary streams as evidenced by deeply incised valleys. It is essential that existing soil conservation plans and plans being established by the local Soil Conservation Service be carried out to reduce the sediment load at the source. It may be helpful to identify and concentrate on critical areas within the watershed.

Dredging and sediment traps were also presented as alternatives to address the sedimentation problem. Budget costs for these alternatives were presented.

A sediment trap located in the delta just upstream of the lake was recommended. Costs depend on the method of construction. Construction cost is expected to be on the order of $500,000.

Introduction

Lake Neshonoc is a 600-acre reservoir formed by a dam on the La Crosse River east of La Crosse, Wisconsin. Deposited sediment or sedimentation has decreased the lake's depth and surface area, with an 11 percent loss in lake volume between 1954 and 1985 (Figure 1). This report to the Lake Neshonoc Protection and Rehabilitation District will review alternatives and make recommendations to control lake sedimentation. This project is important because Lake Neshonoc serves the community in many ways, including recreation, boating, fishing, hydropower, and wildlife habitat.

The work completed for this report includes the following major steps:

1. Data Compilation
2. Data Analysis
3. Outline Alternatives
4. Recommendations

Stream flow naturally moves and carries sediment. The amount of sediment that a stream can move depends on several factors including the stream characteristics, the flow rate, the source of sediment, and the sediment size. Stream flow process tend to balance out the effect of each of these factors. For example, when the rate of sediment entering a stream exceeds what the stream can transport, the excess sediment is deposited, and the stream bed is built up or aggraded. Conversely, when the sediment source is lacking the stream bed is eroded or degraded. At some point an equilibrium is reached.

In the case of a reservoir, the inflow carrying sediment is slowed down and its sediment carrying capacity is reduced. The sediment is deposited creating a delta at the upstream end of the reservoir. This is a typical problem that must be accounted for in the design of dams. Soil conservation plans developed within the watershed address the problem at the source by reducing erosion, but do not eliminate the problem. The stream will continue moving sediment. If a reservoir is intended to last other means in addition to conservation plans are required to control the sediment. These may include direct removal of the sediment by dredging or passing the sediment by the reservoir by pipe or side channel.

Data Compilation

A fair amount of study has already been done on Lake Neshonoc. As a starting place, a very good data source is the Masters degree thesis by Paul Ritter, titled "Nutrient (N,P) Dynamics, Hydrology, and Sedimentation Rates of Lake Neshonoc, La Crosse, Wisconsin", submitted to the University of Wisconsin - La Crosse, dated June, 1986. The thesis primarily covers nutrient dynamics but also includes significant input on hydrology and sedimentation rates of Lake Neshonoc. It also contains a brief historical background and description of the lake and upstream watershed.

Other sources of data used in this study are listed and described below:

Bathymetric Maps

Bathymetric data was obtained for Lake Neshonoc for the years 1954, 1966, and 1985. The most current map is shown in Figure 1. The maps for 1954 and 1966 are contained in the Appendix. The maps show a loss of surface area as well as a loss of depth in the lake.

Sediment Borings

A sediment survey with borings was done in 1984 and 1989. Seven cross sections of the lake were taken, four on the downstream half of the lake in 1984 and three on the upstream half in 1989. These borings were taken through the ice using an auger on a calibrated steel rod. The data included with these borings are:

- the depth to the sediment,
- the depth to the bottom of the sediment, and
- a few descriptive comments.

A sediment survey was also completed during the field investigation for this study, April 26, 1991. This survey focused on the delta of the lake and upstream stream bed. Fifteen samples were taken in the delta and three taken in the upstream stream bed at Highway 162, County Road J, and Highway 27. The samples in the lake were taken primarily with an eggshell sampler. Samples in very shallow locations in the lake and samples in the stream bed were grab samples by a shovel. A grain size distribution analysis was done for each sample. One of the samples of the fine sediments in the lake was analyzed for organic content.

A copy of these data is contained in the Appendix.

Hydraulic Data

Some basic hydraulic data such as stream flows are given in the Ritter thesis previously mentioned. Other hydraulic data were collected during the April 26, 1991 field investigation for the purposes of this study. Three channel cross sections, including the channel bottom and water surface elevations, were taken on the La Crosse River upstream of the lake at Highway 162, County Road J, and Highway 27. The discharge during the investigation was approximately 220 cfs based on the flow rates at the dam.

Sediment Traps on Local Tributaries

According to Marc Schultz of the University of Wisconsin - Extension, La Crosse County experimental sediment traps were constructed on Dutch Creek and Burns Creek. These creeks are shown in Figure 2.

Approximately 425 cubic yards of material was removed from Burns Creek in summer of 1987 to construct a sediment trap. The trap was filled by early fall even though it was a relatively dry year.

The sediment trap on Dutch Creek was permitted for the dimensions of 1000 by 2.5 by 28 feet was located about 2400 feet upstream of the mouth of the creek. Approximately 2000 cubic yards were removed during the construction of the trap in late May, 1989. The trap was filled in about one year. Creek bed degradation was noted in the downstream channel.

Photographs and Video Tape

Several photographs and a video tape were collected for this study. They include:

- two photo copies of 1938 air photos of the lake,
- a photo copy of a 1967 air photo of the lake,
- a photo copy of a 1982 air photo of the lake,
- a color 8 X 10 air photo of a portion of the lake taken in 1989,
- color photos taken during a flight over the watershed and the field investigation done April 26, 1991, and

- a video tape of portions of the lake bottom exposed during the lake draw down for the dam repairs in the fall of 1985. (Obtained from Marc Schultz, County Resource Agent of the University of Wisconsin - Extension, La Crosse County).

<u>Other Data</u>

Other data include general data from the U.S.G.S., and information from discussions with James Leicht, Chairman of the Lake Neshonoc Protection and Rehabilitation District Board; officials from the Wisconsin Department of Natural Resources; Marc Schultz, County Resource Agent of the University of Wisconsin - Extension, La Crosse County; Professor Gary Parker, a sediment transport expert at the University of Minnesota; officials of the local Soil Conservation Service (SCS); Loyal Gakes of North American Hydro; and dredge suppliers.

The U.S.G.S. data includes the standard topographic maps for the area and stream gaging information at the La Crosse River near West Salem, Wisconsin (see Appendix). No U.S.G.S. data relating to stream sediment in the Lake Neshonoc watershed were found.

Some basic land use information is contained in the Ritter thesis. Soil surveys of the area are available from the SCS.

<u>Related Reports</u>

A list of references is given before the Appendix of this study. Of special note are the reports on the Upper Willow Reservoir in Wisconsin, and the Foot and Willmar Lake Improvements in Willmar, Minnesota. No other sedimentation studies were found relating to the Lake Neshonoc watershed.

Data Analysis

The goal in the data analysis is to understand the nature of the lake's sediment problem and how basic sedimentation processes are creating the problem.

During the April 26, 1991 field investigation, a small plane was chartered for aerial views of the lake and watershed. A watershed map is shown in Figure 3. Areas toured and photographed were the Lake Neshonoc delta, Burns Creek watershed, the La Crosse River up to Sparta, the lower portion of the Little La Crosse River, and Sparta. The watershed area upstream of Perch Lake in Sparta is considered a minor source of sediment to Lake Neshonoc. Most of the sediment from this area is trapped in Perch Lake or Angelo Pond a couple miles upstream.

The land use observed during the aerial tour was typically cropland and pastures in the low areas; wooded hills; and several urban areas most notably, Sparta. Ritter's thesis states that the watershed consists of 42 percent cropland, 40 percent woodland, 15 percent pasture or grassland, and 3 percent urban. Judging from the aerial view the primary source of sediment to the streams appears to be the croplands that extend right up to the stream banks. Very few gullies were noted. There were some areas of stream bank erosion. Logging and timber activities occurring in some of the upland areas is also contributing to the sediment load of the streams.

The sediment samples taken for this study show the sediments consists of at least two approximately distinct populations. The coarser population consists of sand ranging from 0.125 mm to 1 mm. The finer population consists mostly of silt finer than 0.05 mm. The finer population is essentially absent from the bed of the La Crosse River. It moves as wash load (suspended sediment) through the system, exchanging with the banks and floodplain. The coarser population is that found on the river bed, and constitutes the source for the bed material load, whether it be moving as bedload or suspended load.

The coarser material constitutes the source for most of the topset deposit in the reservoir, see Figure 4. Some of the finer material is deposited on the top of the delta, but most passes into the reservoir and across the dam. A certain fraction deposits in the reservoir to form the bottomset deposit.

Based on samples taken at Highway 27, County Road J, State Highway 162, the delta surface, and the delta channel, an overall median grain size of 0.30 mm was deduced for the bed material. Between State Highway 27 and the delta, there is no obvious change in median bed material grain size down the river.

The river profile shows a distinct upward concavity in the streamwise direction upstream of the reservoir. This suggests an aggradational environment: that is, river bed elevation is increasing in response to dam-induced backwater.

A bankfull discharge of 2450 cubic feet/second was estimated based on the two-year flood given in the U.S.G.S. flow data for the La Crosse River near West Salem. A flow duration curve was adopted from the U.S.G.S. data at this site.

Estimate of Lake Sedimentation Rate

The primary task in the analysis of the data for sedimentation control study is defining the sedimentation rate; the amount of sediment deposited in the lake over time. This is dependent on several factors including watershed characteristics, land use, sediment size, stream and lake hydraulics, and hydrology. The sediment transport process is very complex. Sediment load rate calculated from several established methods will vary widely. The services of Dr. Gary Parker, sediment transport expert from the University of Minnesota, were employed during the field investigation and for computation of the sediment loads to provide greater confidence in the results. The methods used to estimate the sedimentation rates are described below.

Bathymetric Maps

The bathymetric maps of the lake for the years 1954, 1966, and 1985 were used to estimate the change in lake volume over time. For lack of better information, it was assumed that the lake level at the time of the each survey was approximately the same. The comparison of bathymetric maps for the different years showed that the average annual sediment accumulation ranged from 7,800 to 29,000 cubic yards per year. The large range of values was due different interpretations of the maps. There appears to be inconsistencies with the areas within the contours for depths of four feet or greater. These inconsistencies are probably due to the number and accuracy of the soundings taken and the interpretation of the soundings when the contours were drawn. However, it appears that most of the sedimentation occurred at depths less than four feet.

As stated earlier, the finer material from suspended sediment or wash load settles in the deeper reaches while sands from the bed material load of the LaCrosse River settle in the shallower depths forming the delta (Figure 4). The best estimate for sedimentation at depths 4 feet and less (the bed material load) using the bathymetric maps is approximately 12,000 cubic yards/year.

Brownlie and Engelund-Hansen Methods

The bed material load was calculated by two different methods using the data presented above, specifically the reach of the La Crosse River between Highway 162 and the delta.

The first method is due to Brownlie. The Brownlie relations for hydraulic resistance and bed material load were applied assuming lower-regime conditions. The formula was modified slightly to treat mixtures of sediment. The second method is due to Engelund and Hansen. Their relation for upper-regime resistance was combined with their relation for bed material load.

The computed loads are as follows assuming the bulk density of the deposited sediment is 90 lbs/cubic foot:

- Brownlie: 58,400 cubic yards/year
- Engelund-Hansen: 60,800 cubic yards/year

Based on the bathymetric maps, bed material appears to be depositing in the delta at a rate of 12,000 cubic yards/year. This number is only about one-fifth of the computed bed material loads in the reach immediately upstream of the reservoir.

There are two possible reasons for this. The first concerns the inherent inaccuracy of load calculations in rivers. It is common for calculated values to be one-half to twice observed values. With this in mind, the above values are arbitrarily halved for the sake of estimation, assume the bed material load through the reach in question is 30,000 cubic yards/year.

This value is still considerably higher than the observed rate of deposition in the reservoir. It is likely that the remainder of the sediment is being deposited in the backwater zone between the delta front and the State Highway 162 bridge. Both topographical maps and aerial photographs show anastomosing (branching) channels flowing across a wide marsh, with clear evidence of recent and frequent avulsion. This suggests an environment undergoing rather rapid aggradation (bed deposition).

It is assumed here that part of the sediment supplied to the reach from the delta to State Highway 162 acts to cause the delta to prograde into the lake; the rest causes the bed and floodplain to aggrade upstream of the delta. If 30,000 cubic yards/year bed material load rate is used, the delta moves out at a rate of about 43 feet/year (a volume of approximately 12,000 cubic yards) and about 0.2 inches of material are deposited each year over the upstream floodplain and channel (a volume of approximately 18,000 cubic yards). These numbers do not seem unreasonable in light of the available evidence. For sedimentation in the lake delta 12,000 cubic yards/year will be used.

Wash Load (Fine Suspended Sediment)

The sediment deposited in Lake Neshonoc consists of bed material load and wash load (fine suspended sediment). All the bed material load of the stream which is mostly sand may be considered deposited in the lake. An estimate of the wash load is required to arrive at the total sedimentation rate in the lake.

Ritter measured suspended sediment at various locations and time during 1985. The simple average of the suspended sediment values measured at Highway 162 is 37 mg/l. To be correct, a discharge weighted average should be used. However, no discharge data are available for 1985 so the simple average will be used as a estimate. Ritter estimates that approximately 25 percent of the wash load was retained in the reservoir (use 10 mg/l). Applying 10 mg/l to the average discharge of 288 cfs gives a loading of about 2,800 tons/year or 3,000 cubic yards/year, assuming a density of 70 lbs/cubic foot.

Conclusion

Therefore, if the bed material load deposited in the lake is estimated at 12,000 cubic yards/year and the trapped wash load at about 3,000 cubic yards/year, the total estimated annual sedimentation rate is about 15,000 cubic yards/year using the combined bed material load and wash load estimates. It should be emphasized here that 15,000 cubic yards/year is an average rate, the range may be 4,000 to 60,000 cubic yards/year.

Another method of estimating sediment yield that was not used in this study is to estimate the amount of sheet and rill erosion that occurs in the watershed. Sheet erosion is usually calculated using the Universal Soil Loss Equation (USLE). The USLE calculates the amount of sheet and rill erosion which occurs in an area using data such as land use, type and rotation of crops, management practices, soil types, slope length, and climatic region. The equation only gives an estimate of the annual gross erosion that occurs in a field. It will not directly give an estimate of the sediment arriving at the reservoir. The gross erosion is multiplied by a "delivery ratio" which is a percentage of the gross erosion that will make it to the reservoir. Because of the detailed information needed, USLE becomes very data intensive and will have very questionable results when applied to a large watershed such as Lake Neshonoc's (398 square miles).

The USLE is best used for comparative studies, such as to determine the percent decrease or increase a certain farming practice will have on erosion rates. Direct methods to measure sedimentation rates, as presented above, are preferable to indirect methods such as the USLE, as long as the data are available.

Outline of Alternatives

There are three basic concepts to alleviate the Lake Neshonoc sedimentation problem: 1) limit the sediment entering the river, 2) create a bypass for the sediment through the lake, and/or 3) periodic removal of the sediment. The three alternatives for sediment control presented below are based on the first and the last concepts. There are potential environmental problems with the second one.

A bypass for the sediment could conceivably consist of a pipe placed in the lake to collect the sediment at the inflow to the lake and transport it to the outlet. Very rough calculations show that 10,000 feet of 4-foot diameter pipe would be required to pass 50 cubic feet/second of sediment and water. Using an estimate of $75/foot for the cost of furnishing and installing the pipe, the cost would be approximately $750,000. There are also permitting problems that would have to be considered. The outflow may have to meet waste water treatment standards. This would probably be the first time this procedure would be used in this country. Based on this these factors this concept was ruled out.

Modification of Land Use Practices

Controlling the sediment entering the creek requires land use management within the watershed to limit the sediment erosion at the source. The primary source of sediment in the Lake Neshonoc watershed appears to be from agricultural areas. There is progress in improved farm practices. Conservation plans are currently required to receive federal farm money and state tax credits. These plans include improved crop rotation and tillage practices. Erosion due to logging and timber activities is currently being addressed by La Crosse County regulations.

As an enhancement of the plans currently required, specific areas within the watershed which are contributing the most sediment to the creek should be located. Special conservation plans including such activities as creating buffer strips for these areas could be worked out with local conservation officials.

Dredging

Removing accumulated sediments by dredging is typically done by using mechanical or hydraulic methods. Mechanical dredging may be defined as the process of scooping material from the lake bottom and loading it into a boat or scow to be transported to a nearby disposal area. Hydraulic dredging removes material by pumping a sediment/water slurry through a pipe to a settling basin on land. An advantage of mechanical dredging is that no settling basin is required. With hydraulic dredging, discharge requirements from settling basins may have to meet waste water treatment effluent standards, thus requiring very large basins, especially with the relatively small grain sizes found in the Lake Neshonoc.

If the dredging is limited to the edge of the delta at the upstream end of the lake, there may be a third method to remove the material. During the winter, excavating by standard excavation procedures, such as a dragline or backhoe, may be possible. A cold, dry winter would be preferable to insure solid ice. Drawing the lake down about a foot and some channelization of the inflow may improve the ice conditions. Settling basins would probably not be required and the material could be stockpiled.

A few dredging scenarios were considered for Lake Neshonoc: 1) restoration of the lake by removing all sediment accumulated since a given time; 2) removal the coarser sediments contained in the delta portion of the lake; and 3) concentrating dredging in small portions of the lake to improve fishing habitat, access, or other assets of the lake. These scenarios reflect various levels of dredging. The first requires the most; the second somewhat less; and the third could be "surgical" in nature, dredging in a few selected areas. The third could be combined with either of the other two scenarios.

The first scenario, removal of all the accumulated sediment, would require dredging the entire lake. The earliest available bathymetric map is dated 1954. It is likely that a large amount of sedimentation occurred prior to this time given the land use in the area. However, the lake limits in 1954 will be used as an example for the first scenario.

Since 1954, approximately 450,000 cubic yards of sediment has accumulated in the delta portion of the lake and about 110,000 cubic yards of finer sediments have settled out on the lake bottom. Figure 1 illustrates the accumulation at the delta. The sediment deposited in the delta since 1954 covers an approximate area of 0.5 miles by 0.5 miles. The lake is about 0.5 miles wide at the upstream end. Dredging 450,000 cubic yards would bring the average depth in the delta area to about 3.5 feet. Dredging 110,000 cubic yards off the lake bottom requires removing 0.2 feet over most of the lake bottom assuming the fine sediments have been evenly distributed. A comparison of the bathymetric maps for 1985 and 1954 presented in the Appendix shows the most of the deposition occurring near the outlet of the lake. Concentrating the dredging of 110,000 cubic yards at the outlet would require removing 2 feet over 34 acres.

Dredging the entire lake would have an initial severe impact on the aquatic life within the lake due to the increased turbidity of the water caused by the dredging. The bottom sediments are fine an stay in suspension for long periods of time. The use of the hydraulic dredging method for bottom sediments would require a very large settling basin.

The second scenario has potentially less adverse impacts. The dredging would be localized at the upstream portion of the lake and would remove the coarser sediments. Coarse material settles out faster which requires smaller settling basins if hydraulic dredging is used. It may be feasible to use silt curtains to reduce the impacts of the turbidity since a smaller area is dredged. As stated above, standard excavation methods may be feasible depending on ice conditions in the winter. If work was confined to areas completely iced over impacts due to turbidity could be avoided. Removing 450,000 cubic yards of material would bring the delta back to about the 1954 outline. The depth in the delta area would be about 3.5 feet as stated in the first scenario.

Dredging in the third scenario would be limited to a few selected areas within the lake. The amount of material to be removed would depend on the location to be dredged and the required depth. This could include dredging a few areas along the lake shore to depths and bottom contours that would improve fish habitat. Access to the lake could be improved at the upstream end of the lake where sedimentation is concentrated. Initial impacts of the turbidity may be reduced by dredging in small areas and using silt curtains to confine the suspended sediments. The feasibility of using hydraulic dredging in the fine bottom sediments would have to reviewed.

As an example for the third scenario, three locations could be dredged removing 100,000 cubic yards of material at each location. Two could be for improved fish habitat. The lake depth could be increased an additional 6 feet over two 10 acre areas. One location could be for improved access. Removing 100,000 cubic yards would deepen 0.5 mile of lake shore by 4 feet out to a distance of 250 feet from the shoreline.

Sediment Traps

Sediment traps control sedimentation by catching it at a specific location or locations. The trap size is dependent on the sediment size, the sediment load, and the desired frequency of sediment removal. The grain size analysis of the sediments entering Lake Neshonoc show that most of the sediment falls within the 0.1 to 0.5 mm range, which is fine to medium sand. Relatively large traps are required to remove these sands from the stream flow.

Several locations were considered for the sediment traps: at the outlets of local tributaries, such as Dutch and Burns Creek; on the La Crosse River at Highway 162, and at the delta in Lake Neshonoc. Considering all the factors, locating one large trap within the delta just upstream of the lake is considered to be the most favorable option (Figure 5). All the work is concentrated in one location. The large trap size required for the small sediments easily fits within the delta. Traps located upstream of the wetlands in the area may impact the wetlands by causing channel degradation.

The sediment trap shown in Figure 5 is designed for trapping 120,000 cubic yards of sediment. It is intended to last up to a 10 years depending on the sedimentation rate. The trap requires removal of 250,000 cubic yards of material to account for the required side slopes and expanded width of the trap to insure no circumvention. The dimensions of the trap bottom are approximately 1400 feet wide, 5 feet deeper than the existing channel, and 450 feet long. The upstream and downstream slopes of the trap would by 50:1 and 20:1, respectively, with side slopes of 4:1. The trap may be dredged hydraulically or mechanically. Standard excavation methods (backhoe or dragline) may possibly be used if done during the winter.

Costs

Dredging costs depends primarily on the amount of material to be moved, the dredging face, the transport distance, and elevation of the settling basin relative to the lake. Dredging a small amount of material, less than 100,000 cubic yards, results in higher unit prices since mobilization costs are a higher percentage of the work. The dredging face is the vertical height of the material to be removed. If this is kept around 5 feet the dredge does not have to be moved often resulting in smaller unit costs. With regard to transport distance and relative settling basin elevation, it is best if these factors are limited to less than 6000 feet and less than 25 feet, respectively. This is particularly true for hydraulic dredging. A range of dredging costs are presented below that reflect the majority of conditions for Lake Neshonoc.

Assuming there are disposal/stockpile sites nearby on the south shore of the lake, mechanical dredging may range for \$3 to \$5/cubic yard depending on the mobilization cost. Hydraulic dredging would be as low as \$2/cubic yard not including costs involved with the settling basins.

The possibility of using standard excavation procedures was reviewed by a contractor in St. Paul, Minnesota who estimated the work at \$2 to \$3/cubic yard. A local contractor may be able to bid the work for under \$2/cubic yard.

The option of leasing and purchasing a hydraulic dredge for use on the lake was reviewed. Leasing a dredge only makes sense if the machinery were used for only one year. However, with only one year, contracting the work out is likely more economical. The initial cost of an appropriately sized new dredge would cost about \$500,000. This dredge has a production rate of 18,000 cubic yards/month. Labor and operating costs would be about \$20,000/month.

The Kandiyohi County, Minnesota, Engineer, Gary Danielson, reports dredge costs ranging from \$0.14 to \$0.56/cubic yard for dredging Foot and Willmar Lakes near Willmar, Minnesota. Their dredge was bought used from the U.S. Corps of Engineers and refurbished. 1.5 million cubic yards were dredged between 1981 and 1986.

A used dredge such as the Kandiyohi dredge may cost approximately $150,000 to get it operational at Lake Neshonoc. Given a dredge capacity of 25,000 cubic yards/month, operating and labor costs are estimated to be $25,000/month. The sediment trap shown in Figure 5 could be constructed in two years for a total cost of $400,000 or $1.60/cubic yard. The dredge would then be available in the future years for maintenance of the sediment trap and lake depths with removal costs of approximately $1.00/cubic yard. It should be noted that these costs do not include the costs of the settling basin.

Table 1 is a summarizes of the costs for a few dredging scenarios and the sediment trap previously described. In the first scenario, 560,000 cubic yards are removed throughout the lake, 450,000 cubic yards in the delta and 110,000 cubic yards near the outlet. The second requires removal of 450,000 cubic yards of the delta. In the third, 300,000 cubic yards are removed (100,000 cubic yards in three selected locations). Mechanical dredging was not reviewed for construction of the sediment trap.

Table 1.
Summary of Costs

	Hydraulic Dredging	Mechanical Dredging	Standard Excavation
First Scenario 560,000 CY	$1.0 to $2.2 million[1]	$1.7 to $3.0 million	-
Second Scenario 450,000 CY	$1.0 to $1.8 million[1]	$1.4 to $2.3 million	$0.9 to $1.4 million[2]
Third Scenario 300,000 CY	$0.6 to $1.2 million[1]	$0.9 to $1.5 million	-
Sediment Trap 250,000 CY	$0.5 million[1]	-	$0.5 to $0.75 million[2]

[1] Does not include costs of settling basin(s).
[2] Assumes winter construction.

All costs given above do not consider the value of the excavated material for farming or fill purposes.

Recommendations

It is our opinion that the best alternative to control sedimentation in Lake Neshonoc is the sediment trap located in the delta as illustrated in Figure 5. It is also essential that soil conservation plans be carried out to reduce the sediment load at the source. It may be helpful to identify and concentrate on critical areas within the watershed.

Standard excavation methods done in winter may be the most economical for trap construction. If the hydraulic dredge from Kandiyohi County, Minnesota is purchased, the sediment trap could be economically constructed and the dredge could be used as needed in the lake and for future maintenance of the sediment trap.

If a decision is made to construct the sediment trap further study of the sedimentation rates is warranted. Dr. Parker identified a computer model that could be used to improve the estimates of the sedimentation rates computed in this study and the predict the results of the trap. This would be part of the detailed design of the trap.

A settling basin or basins will be required if hydraulic dredging is selected. Possible sites need to be selected and discussed with the Wisconsin Department of Natural Resources. The design of basin will depend on the regulations of the return water.

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4. Schwab, G.O, et al., Soil and Water Conservation Engineering, John Wiley & Sons, 1966.

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Figures

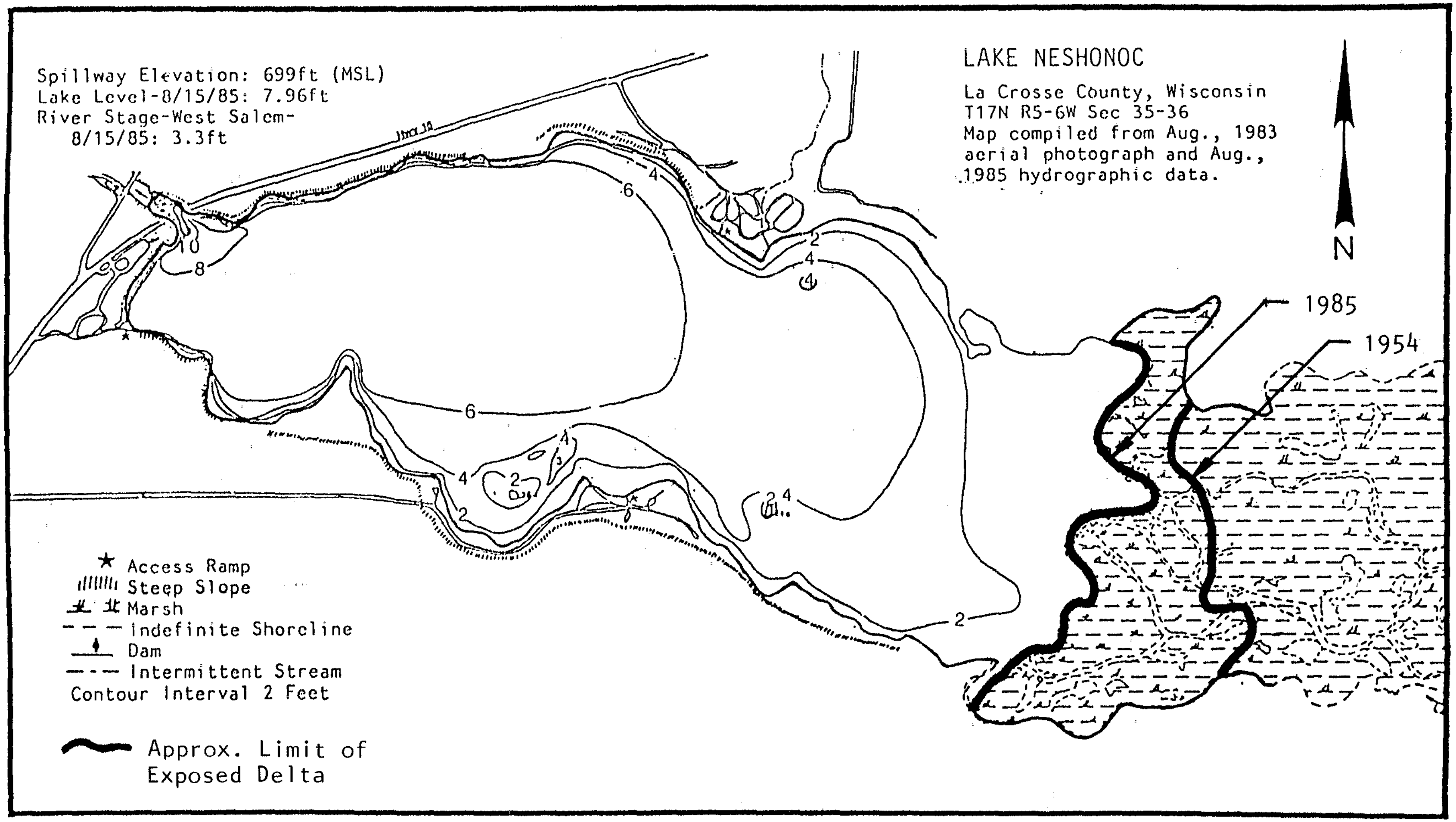


Figure 1

1985 LAKE NESHONOC BATHYMETRIC MAP (COPIED FROM RITTER, 1986)

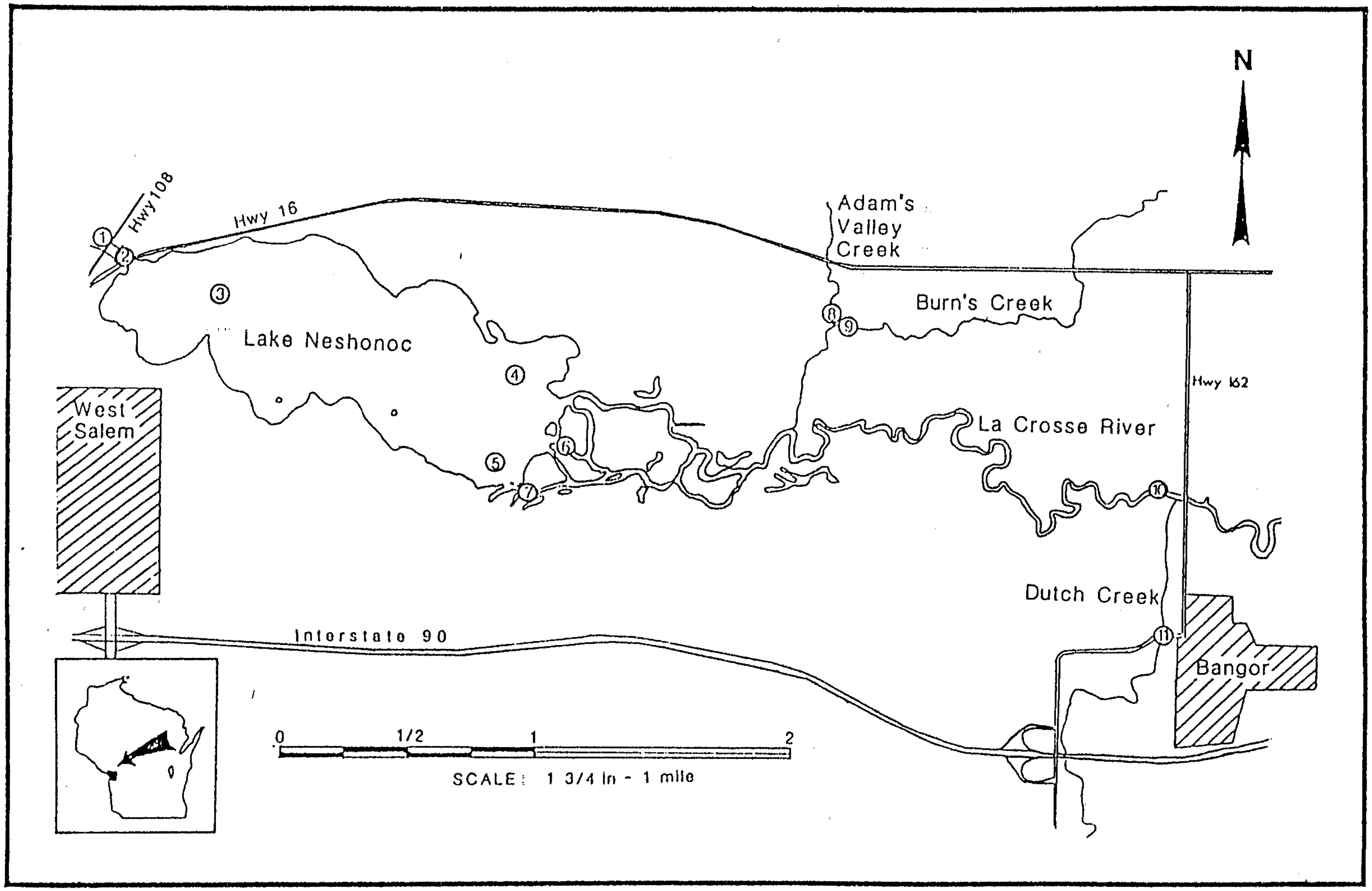


Figure 2

LAKE NESHONOC AND ITS IMMEDIATE TRIBUTARIES
(COPIED FROM RITTER, 1986)

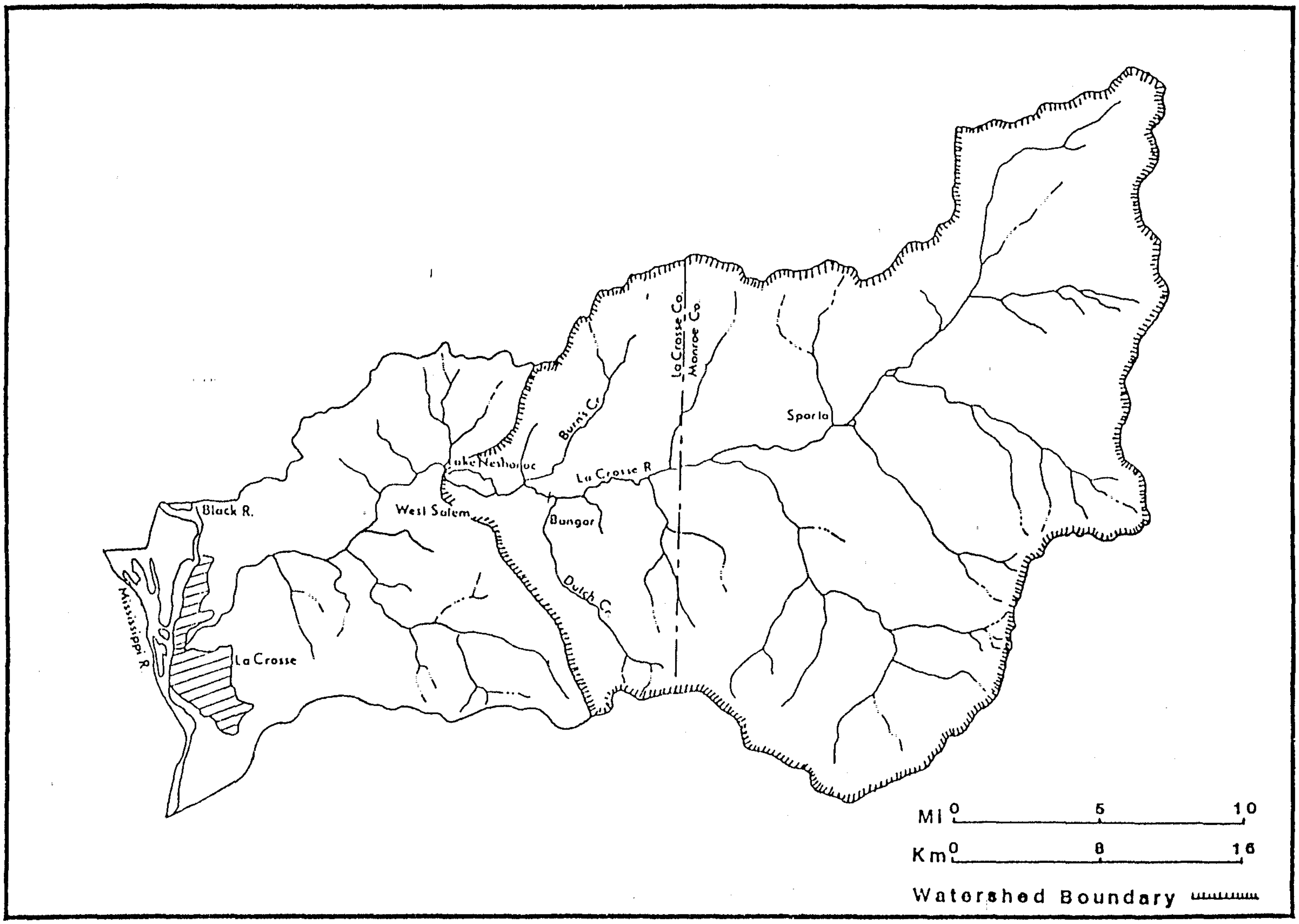


Figure 3

LAKE NESHONOC WATERSHED
(COPIED FROM RITTER, 1986)

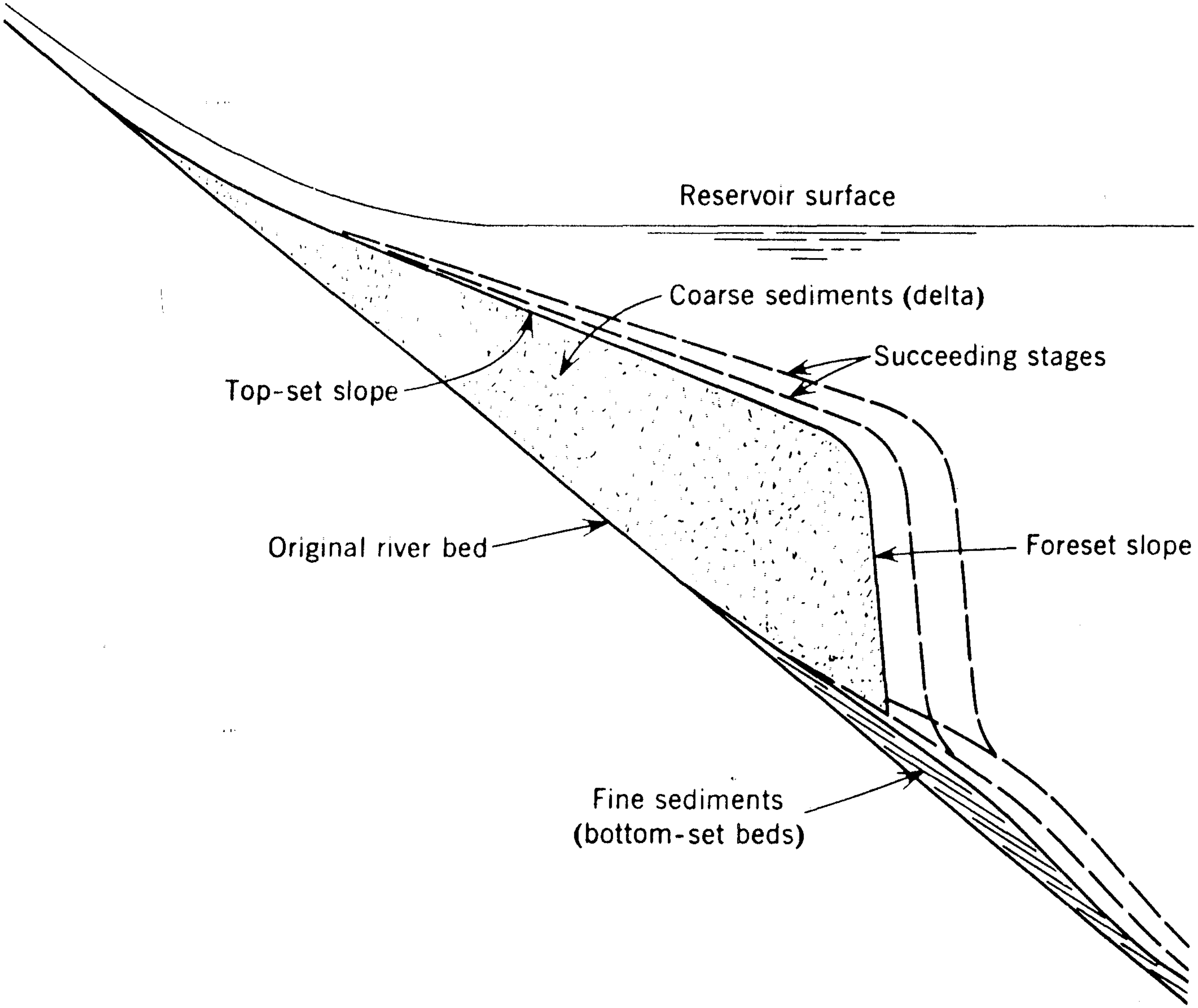


Figure 4

RESERVOIR DELTA FORM
(COPIED FROM REF. 1)

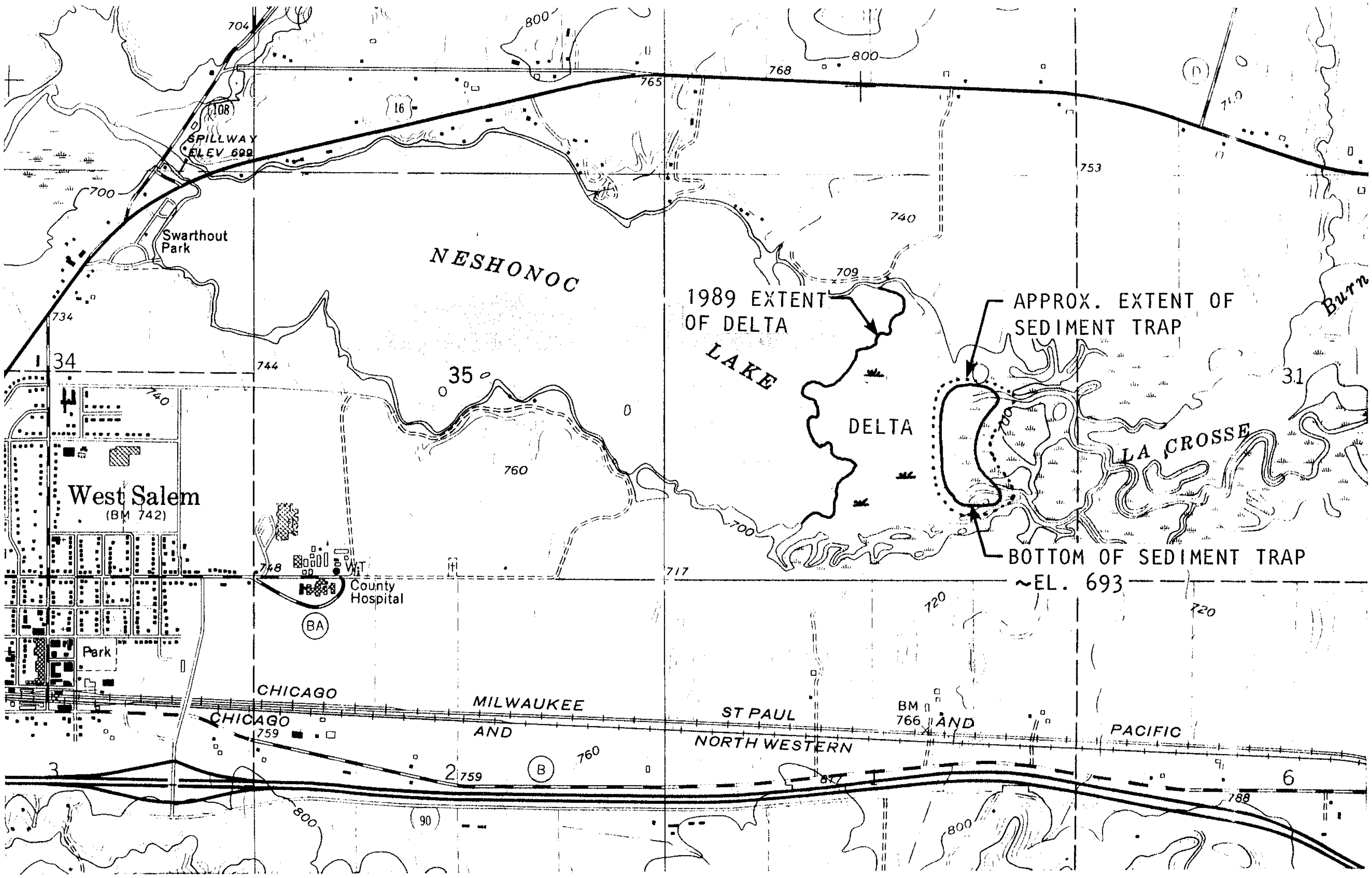


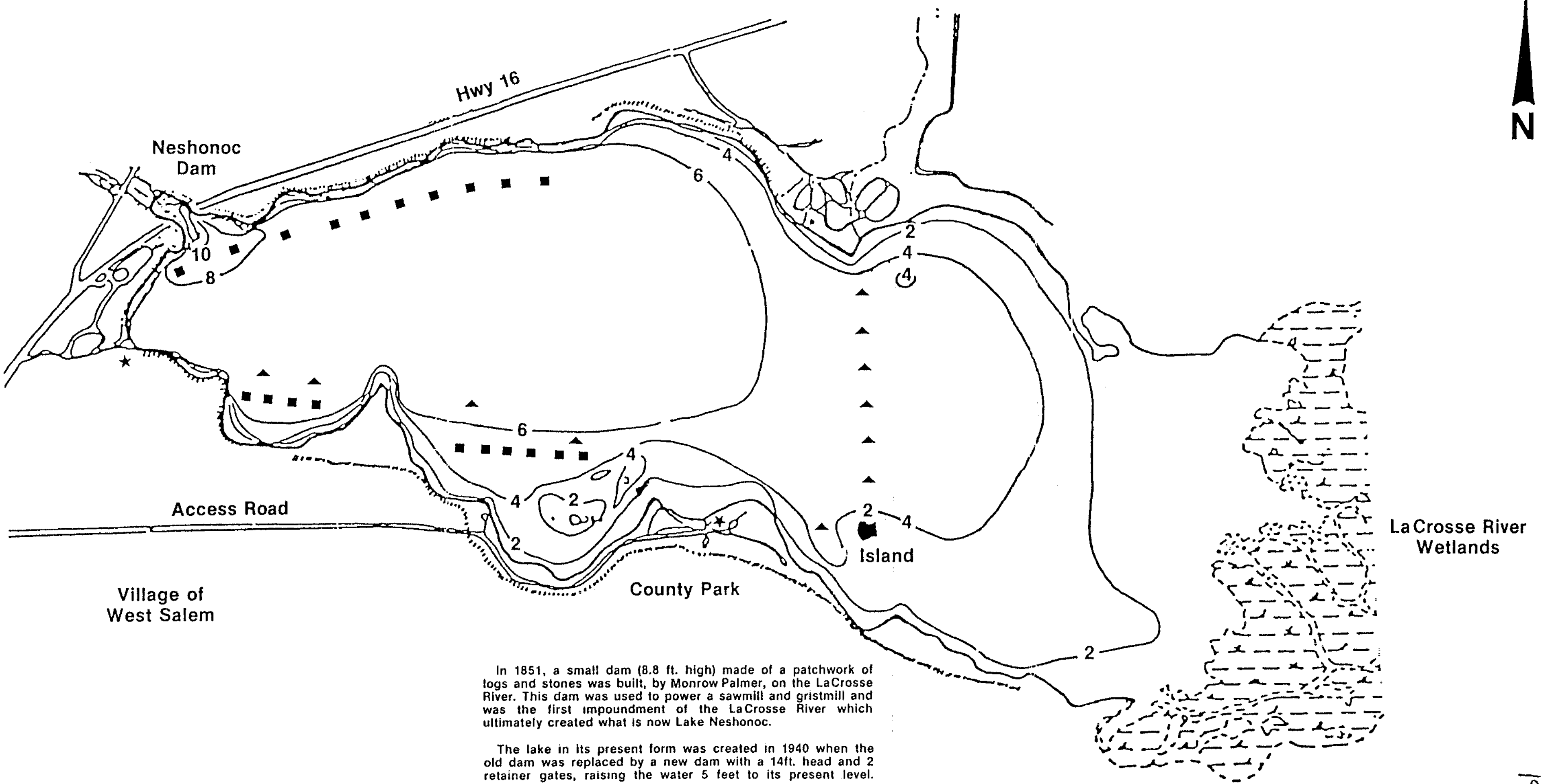
Figure 5

PROPOSED LAKE NESHONOC SEDIMENT TRAP

Appendix

Lake Neshonoc-LaCrosse County

Max. Depth 10 Ft.-Average Depth 4 Ft.



In 1851, a small dam (8.8 ft. high) made of a patchwork of logs and stones was built, by Monrow Palmer, on the LaCrosse River. This dam was used to power a sawmill and gristmill and was the first impoundment of the LaCrosse River which ultimately created what is now Lake Neshonoc.

The lake in its present form was created in 1940 when the old dam was replaced by a new dam with a 14ft. head and 2 retainer gates, raising the water 5 feet to its present level.

From 1940, this approximately 780 acre reservoir has been used as a fishery, for recreational boating, provided valuable habitat for a variety of wildlife, and is the source of hydro-electric power.

This reservoir, like so many others in agricultural regions, is plagued by decreasing water depth and area due to the sediments trapped in the lake. Increasing siltation will cause detrimental lack of depth and further loss of surface area in the years to come.

The Lake Neshonoc Protection and Rehabilitation District, along with the support of local residents and organizations want to preserve this natural resource for future generations. Continuing long term programs and policies are directed towards protection and eventual rehabilitation of Lake Neshonoc and the LaCrosse River watershed area.

We ask that everyone enjoy this scenic lake and help us all with this effort.

The Lake Neshonoc Protection & Rehabilitation
Board of Commissioners

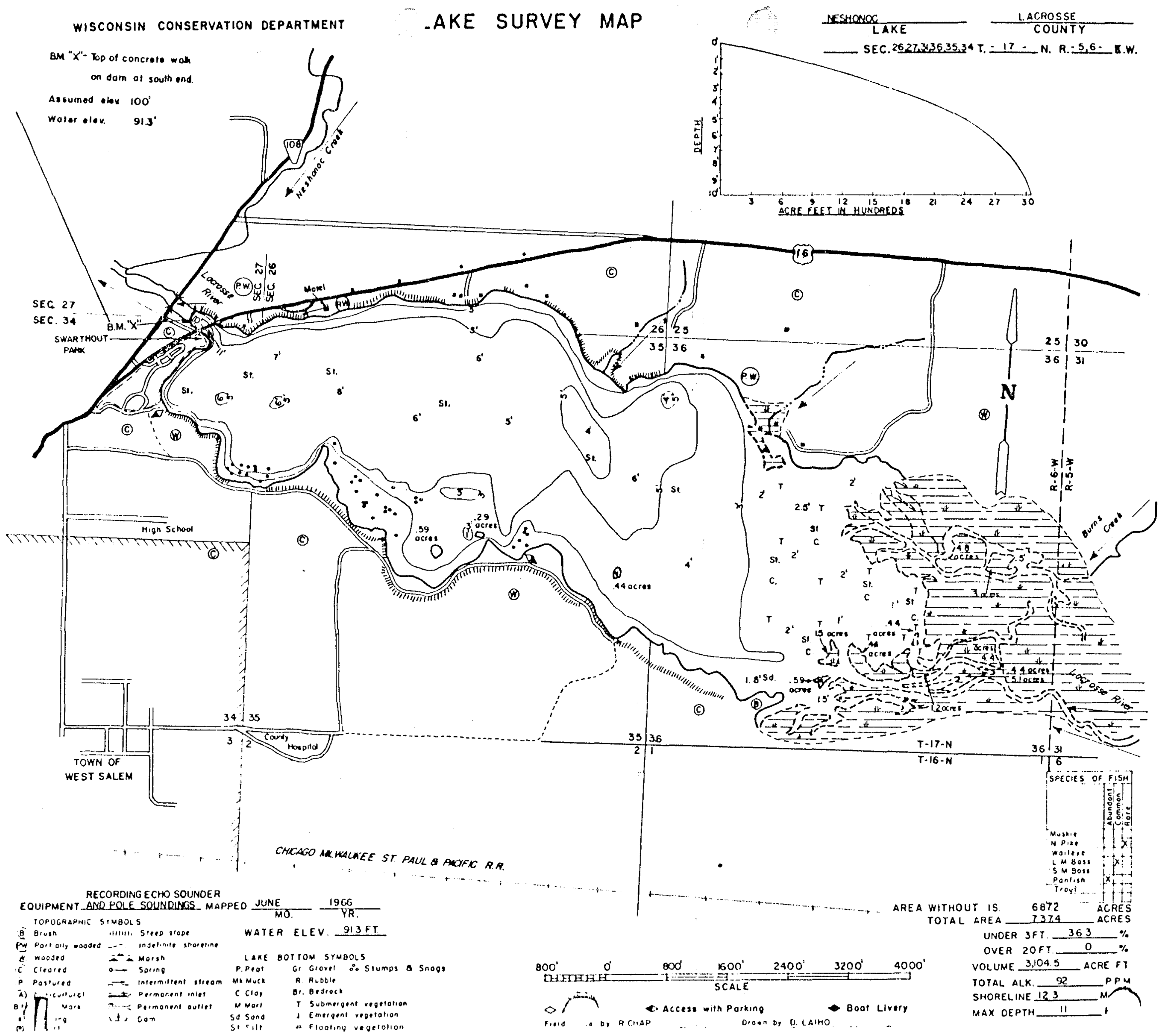
■ Fish Cribs

▲ Informational Buoys

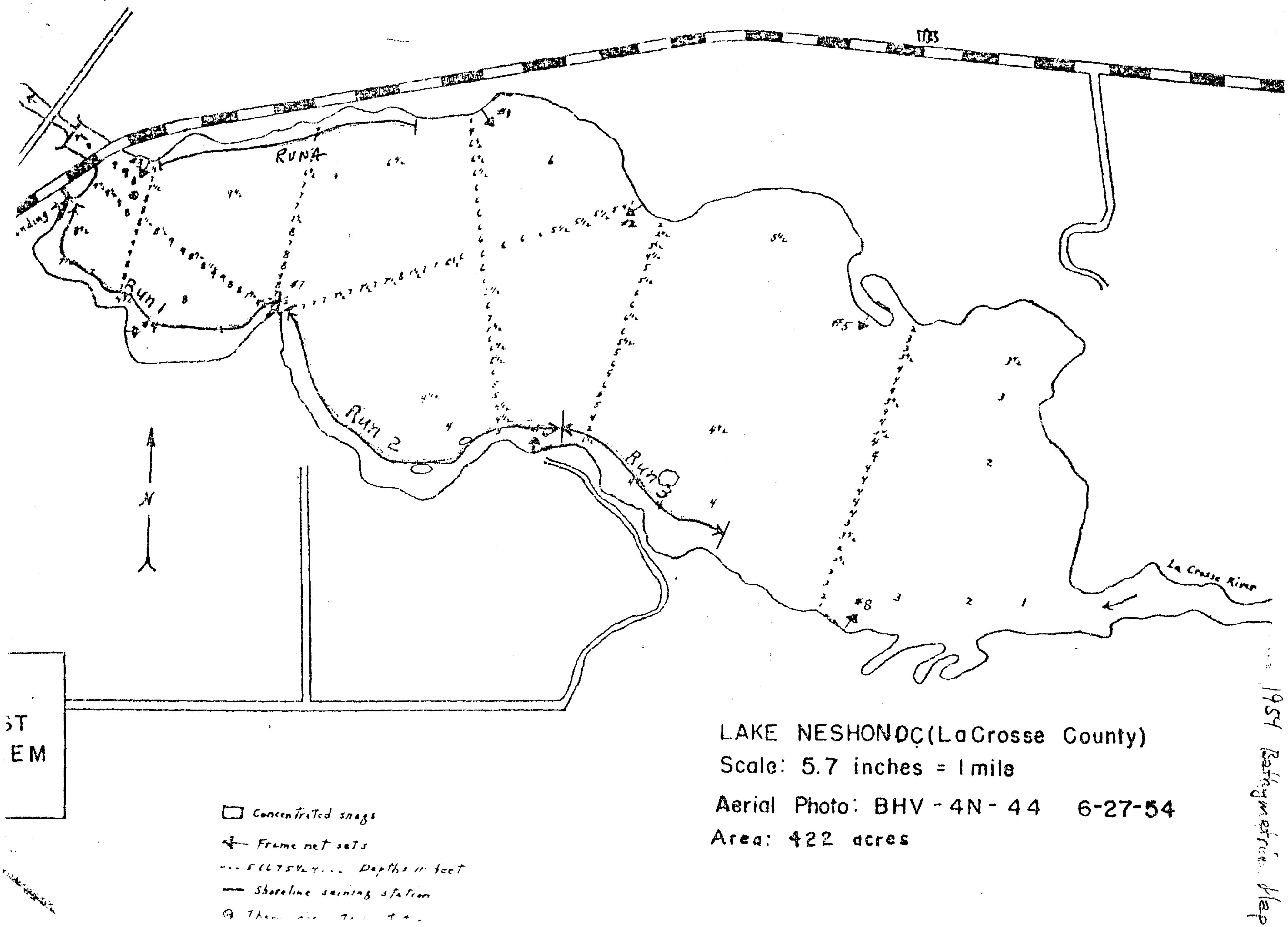
★ Boat Landings

[- - -] Marsh Wetlands

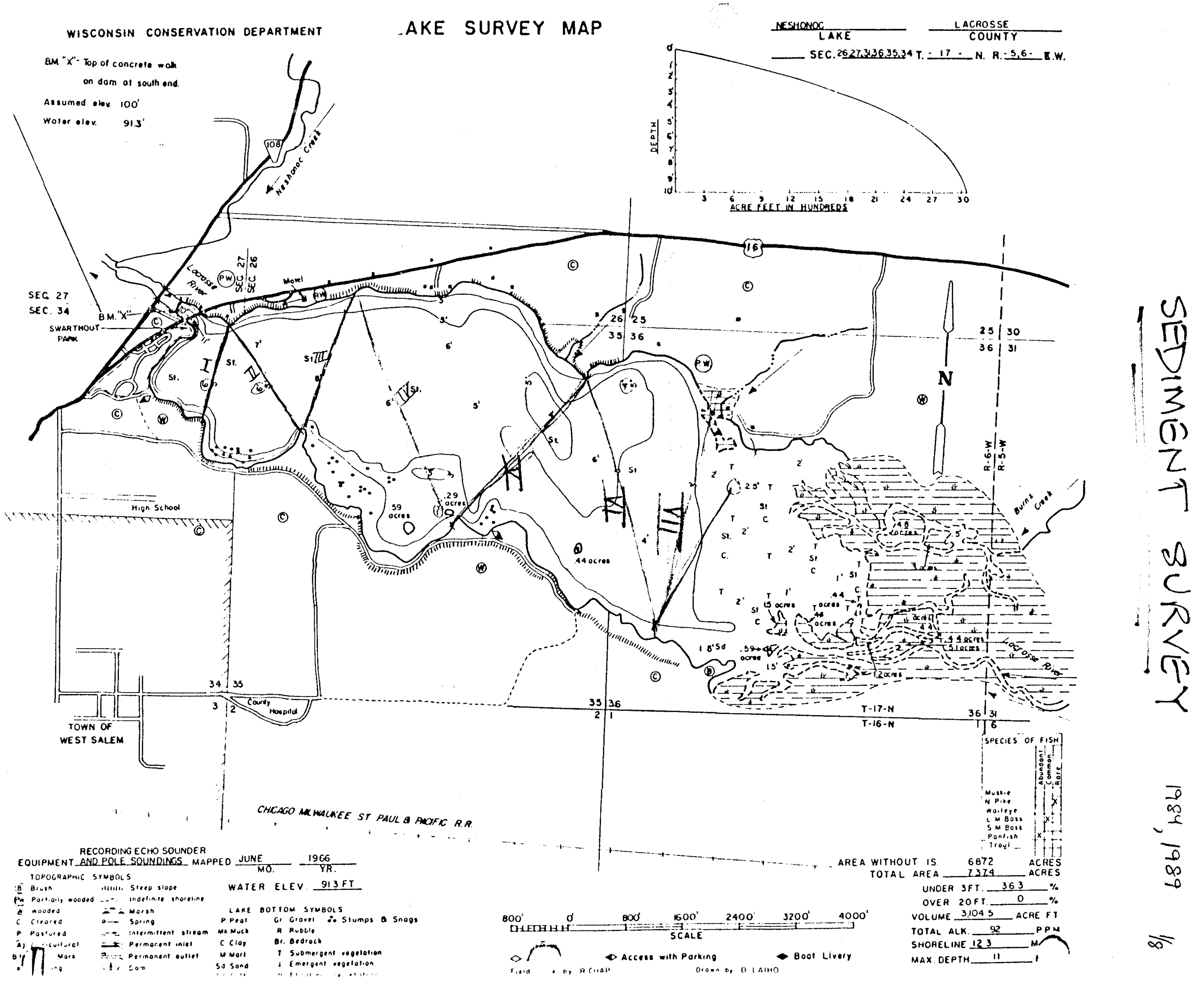
1985 Bathymetric Map



1966 Bathymetric Map



Run A
Run 1
Run 2
Run 3
N
La Crosse River
LAKE NESHONOC (LaCrosse County)
Scale: 5.7 inches = 1 mile
Aerial Photo: BHV - 4N - 44 6-27-54
Area: 422 acres
Concentrated snags
Frame net sets
Depths in feet
Shoreline seining station
1954 Bathymetric Map


WISCONSIN CONSERVATION DEPARTMENT
LAKE SURVEY MAP
NESHONOC LAKE
LACROSSE COUNTY
SEC. 26,27,34,36,35,34 T. 17 N. R. 5,6 E.W.
BM "X" - Top of concrete walk on dam at south end.
Assumed elev. 100'
Water elev. 91.3'
DEPTH
ACRE FEET IN HUNDREDS
Neshonoc Creek
Lacrosse River
Motel
SEC. 27
SEC. 26
SEC. 27
SEC. 34
B.M. "X"
SWARTHOUT PARK
High School
County Hospital
TOWN OF WEST SALEM
Burns Creek
T-17-N
T-16-N
R-6-W
R-5-W
N
CHICAGO MILWAUKEE ST PAUL & PACIFIC R.R.
SPECIES OF FISH
Abundant
Common
Rare
Muskie
N Pike
Walleye
L M Bass
S M Bass
Panfish
Trout
RECORDING ECHO SOUNDER
EQUIPMENT AND POLE SOUNDINGS MAPPED JUNE MO. 1966 YR.
WATER ELEV. 91.3 FT
TOPOGRAPHIC SYMBOLS
Brush
Partially wooded
Wooded
Cleared
Pastured
Steep slope
Indefinite shoreline
Marsh
Spring
Intermittent stream
Permanent inlet
Permanent outlet
Dam
LAKE BOTTOM SYMBOLS
P Peat
Mk Muck
C Clay
M Marl
Sd Sand
Gr Gravel
R Rubble
Br. Bedrock
Stumps & Snags
T Submergent vegetation
Emergent vegetation
SCALE
Access with Parking
Boat Livery
Drawn by D. LAIHO
AREA WITHOUT IS. 687.2 ACRES
TOTAL AREA 737.4 ACRES
UNDER 3 FT. 36.3 %
OVER 20 FT. 0 %
VOLUME 3104.5 ACRE FT
TOTAL ALK. 92 PPM
SHORELINE 12.3 M
MAX. DEPTH 11 F
SEDIMENT SURVEY
1984, 1989
1/8

LAKE NESHONOC SEDIMENT SURVEY February , 1984

Guage Height_____

X - Section I

Measurement	Depth to Top of Sediment	Depth to Bottom of Sediment
100 North Shore Pt.	8	11½
200	8	12+
300	8	13+
400	8	13+
500	8½	13+
600	8	13+
700	8 sediment seems more solid here	11+
800	8½	12+
900	8	13+
1000	7½	12+
1100	7	12+
1200	6 3/4	10
1300 Point	6	30′ to shore fine sand, no sediment

LAKE NESHONOC SEDIMENT SURVEY February , 1984

Guage Height_____

X - Section II

Measurement	Depth to Top of Sediment	Depth to Bottom of Sediment
100 Point	8	No reading-close to 100' hole of X-Section I
200	7½	12+
300	7 3/4	12+
400	8 very loose sediment	13+
500	8	13+
600	7½	13 to solid, bottom a little sand
700	7½	12 sand
800	7¼	9 sand
900	7½	10+
1000	7½	13+
1100	7¼	13+ soft, shakes off easily
1200	7 3/4	13+ very loose
1300	7 3/4	13+ old marsh grass
1400	7½	12
1500	7½	12+ solid organic
1600	6	13+ old marsh grass
1700 100' to shore	5 3/4 sand at 5 3/4, 1' organic sand	9 to bottom sand, sand over organic

LAKE NESHONOC SEDIMENT SURVEY February , 1984

Guage Height_____

X - Section III

Measurement	Depth to Top of Sediment	Depth to Bottom of Sediment
100 North Shore	6'	6' sand little bit organic
200	7'	7' sand
300	7½'	10 3/4 muck, grass root
400	7½'	13+
500	7 1/4'	13+
600	7'	9½ old marsh, solid organic
700	7'	12+
800	6 3/4'	9 3/4 sand
900	6½'	11 sand
1000	6½'	11½ sand
1100	6½'	9½' some sand
1200	6 3/4'	9½
1300	6½'	10
1400	6¼'	9+
1500	6¼'	8 sand
1600	6¼'	10 muck
1700	6¼'	10
1800	6¼'	12+ muck
1900 South Shore	1' to sand; 12' to shore	

LAKE NESHONOC SEDIMENT SURVEY February , 1984

Guage Height_____

X - Section IV

Measurement	Depth to Top of Sediment	Depth to Bottom of Sediment
100 South Shore	6 3/4	12
200	6	9 organic kind of clay
300	6	10 sand
400	6	9½
500	6	10 to sand, layers of sand and muck
600	6	11+
700	6¼	11+
800	6	9
900	6	13+ old marsh
1000	6¼	11
1100	6¼	9½ appears to be clay size
1200	6¼	11 sand
1300	6	9 3/4 sand
1400	6	12 sand
1500	6	9½ organic
1600	6	12
1700	6¼	
1800	6 3/4	8+
1900	6¼	8+
2000	6½	12 black organic
2100	6½	12+
2200	6½	11½ black organic
2300	6¼	10 sand
2400	6¼	10½ black organic
2500	6 upper layer organics not as well decomposed as previous	9
2600	6	8½
2700	4	4 sand
2800	3½	3½ sand
2900	3¼	3¼ sand
3000	3	3 sand
3100	3½	3½
3200 North Shore Pt.	3	3

250' to shore-less than 3' depth

LAKE NESHONIC SEDIMENT SURVEY March 1989

V Measurement	Depth to top of Sediment	Depth to bottom of Sediment
50	3 ft.	Sand
100	5 ft.	10 ft. muck to peat
200	5 ft.	6 ft. muck over peat
300	5 ft.	6 ft. muck over peat
400	5' 6"	6 ft. muck over peat
500	6 ft.	7 ft. muck over peat
600	6 ft.	7' 6" muck over more decomposed peat
700	6 ft.	7 ft. muck over clay with some fibers
800	6 ft.	7' 6" muck over peaty muck
900	6' 6"	12 ft. & muck (stump)
1000	6' 6"	10' 6" muck
1100	6' 6"	9' 6" muck over peat
1200	6' 6"	7' muck over mucky sand
1300	6' 6"	7' muck over peaty muck
1400	6 ft.	6' 6" muck over peaty muck with large fibers
1500	6 ft.	9' muck to hard bottom
1600	6 ft.	7' muck over clay muck
1700	6 ft.	10' 6" muck
1800	6 ft.	7' muck over clay muck
1900	6' 6"	8' 6" muck over clay muck
2000	6' 6"	8' 6" muck over clay muck
2100	6 ft.	7' 6" muck over clay muck
2200	6' 6"	7' 6" muck over peaty muck with some fibers
2300	6 ft.	7 ft. muck over clay muck
2400	5' 6"	5' 8" muck over sandy muck
2500	2 ft.	sand -- 50 ft. from North Shore

VI

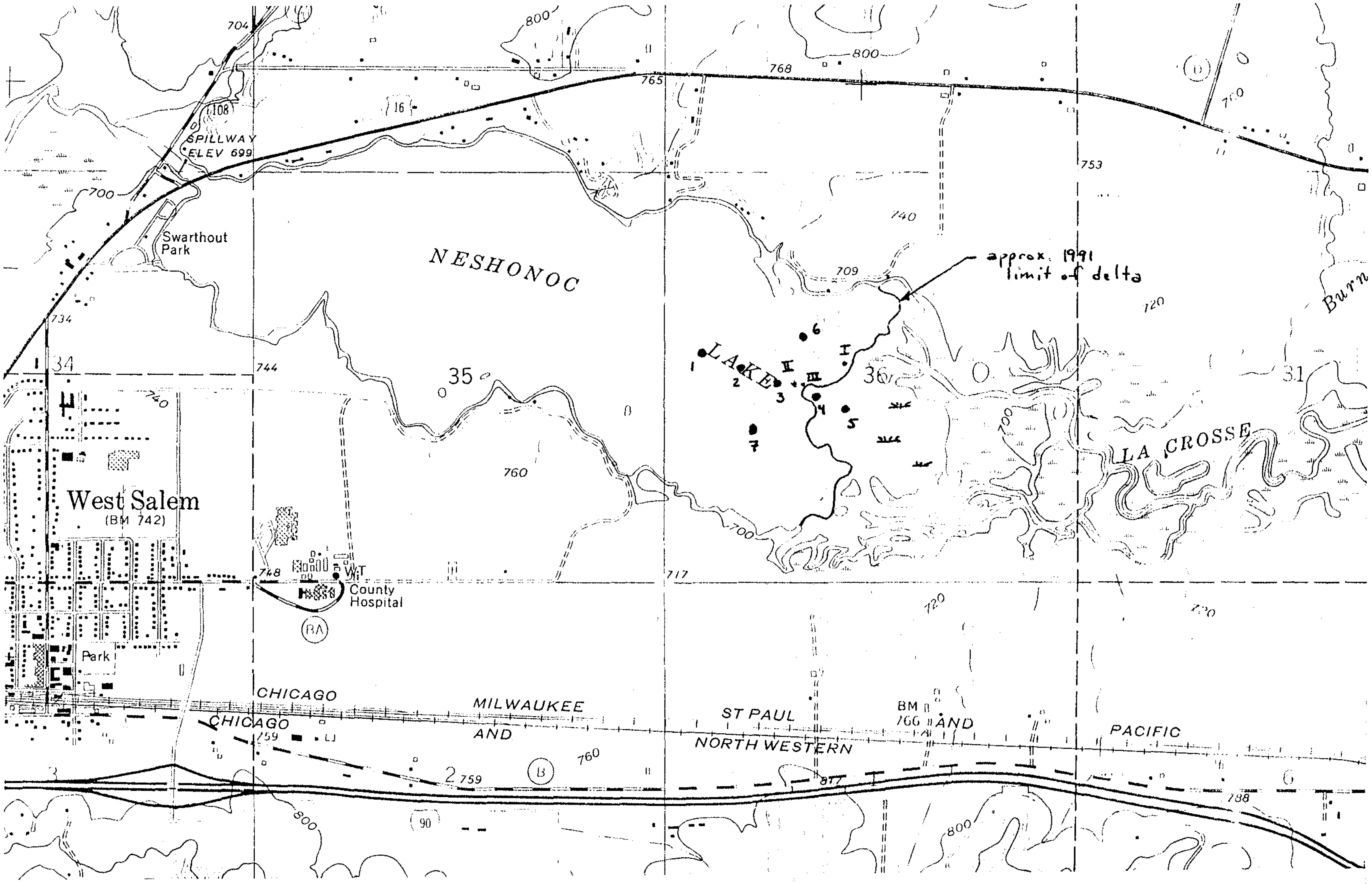
Measurement	Depth to top of Sediment	Depth to bottom of Sediment
100	3 ft.	Sand
200	6 ft.	7 ft. muck over clay muck
300	6' 6"	12 ft. and muck
400	6 ft.	12 ft. and muck
500	6 ft.	11 ft. muck
600	6 ft.	11 ft. muck
700	6 ft.	6' 6" muck over peaty muck (stumps)
800	5' 6"	10 ft. muck
900	5' 6"	9 ft. muck
1000	5' 6"	10 ft. muck
1100	6 ft.	10 ft. muck
1200	5' 6"	8 ft. peaty muck
1300	5' 6"	8 ft. muck over sand
1400	5' 6"	9 ft. muck over sand
1500	5' 6"	8' 6" muck over sand
1600	5' 3"	5' 9" muck over sand
1700	5' 8"	7 ft. muck over sandy clay
1800	5' 3"	7 ft. muck over sandy clay
1900	5' 6"	7' 6" muck over peaty muck
2000	5' 3"	7' 6" muck over peat
2100	5 ft.	7 ft. muck over clay (stump)
2200	5' 3"	7' 3" muck over sandy muck
2300	4' 8"	8 ft. muck over peat
2400	4' 6"	5 ft. sand
2500	4' 6"	5' 6" muck over sand
2600	4' 6"	5' 8" sand
2700	4' 3"	6' 8" muck (fibers) over sand
2800	4' 3"	6' 6" muck over mucky sand
2900	3' 3"	4 ft. to sand
3000	4 ft.	6' 3" muck over peat
3100	3' 6"	5' 6" muck over mucky sand
3200	3 ft.	3' 6" muck over sandy muck

*100 ft. from South Shore

VII

Measurement	Depth to top of Sediment	Depth to bottom of sediment
100	3 ft.	3' 6" muck over sandy muck
200	3' 6"	6 ft. muck over peat
300	3' 8"	6' 6" muck over peat
400	3' 8"	5' 6" muck over mucky clay
500	4' 3"	6 ft. muck over mucky peat
600	4' 3"	6 ft. muck over peat muck
700	4 ft.	6' 6" muck over sand
800	4 ft.	7 ft. muck over clay muck
900	4' 6"	9 ft. muck over peat
1000	4 ft.	5' 3" muck over mucky sand
1100	4 ft.	9 ft. muck-fibers (plants)
1200	4 ft.	9' 3" muck
1300	3' 6"	6 ft. muck over clay muck
1400	3' 8"	7' 6" muck over clay muck
1500	3' 6"	8 ft. muck over clay muck
1600	3' 3"	9 ft. muck
1700	3 ft.	9 ft. sand over mucky sand
1800	3' 6"	8 ft. sand

MAS/dm/0021x



Scale ≈ 1" = 2000'

Sediment Sample Locations
(See also annotated color photo)

4/26/91 Sediment Survey

1/25

Laboratory Test Summary

Project: LAKE NESHONOC REHABILITATION - #49/32-007 JWT 01 Date: 5-9-91

Reported To: BARR ENGINEERING COMPANY Job No.: 1401

Boring No.	NORTH MOUTH SAND BAR	~1400' D.S. SOUTH MOUTH	SOUTH MOUTH	SOUTH MOUTH	~800' D.S. SOUTH MOUTH
Sample No.	I	1	II A	II B	2
Depth (Ft)	0 - 4"	3.5' water depth	SURFACE	8" BELOW SURFACE	2.7' water depth
Type of Sample	JAR	LINER	JAR	JAR	LINER
Soil Classification (ASTM: D2487/2488	SAND W/ SILT & A LITTLE ORGANICS (SP-SM)	LEAN CLAY W/ ORGANICS (CL/OH)	SILTY SAND W/ ORGANICS (SM)	SILTY SAND W/ ORGANICS (SM/SC-SM	LEAN CLAY W/ ORGANICS (CL/OH)
Mechanical Analysis					
Dry Weight (Grams)	476	278	297	314	284
Percent Passing					
Gravel 3"					
2"					
1"					
3/4"					
#4					
Sand #10	100	100	100	100	100
#40	89.9	98.7	92.7	96.4	99.9
#100	24.1	93.1	44.6	78.7	98.1
#200	10.3	90.9	25.1	64.9	95.9
Atterberg Limits					
Liquid Limit					
Plastic Limit					
Plasticity Index					
Moisture - Density					
Water Content (%)					
Dry Density (PCF)					
Unconfined Compression					
Maximum Load (psf)					
Hand Penetrometer (tsf)					
Organic Content (%)		7.3			
Ph (Meter Method)					
Specific Gravity					
Resistivity (ohm-cm)					

note: if type of sample lists "liner" then a tube sample of the material 0 to ~1.5' below the lake bottom was taken JWT

3016 West 56th St SOIL ENGINEERING TESTING, INC. Minneapolis Mn 55420

Laboratory Test Summary

Project: LAKE NESHONOC REHABILITATION - #49/32-007 JWT 01 Date: 5-9-91

Reported To: BARR ENGINEERING COMPANY Job No.: 1401

Boring No.		SOUTH MOUTH ON SAND BAR	SOUTH MOUTH ON SAND BAR	SOUTH MOUTH ON SAND BAR	FIRST IN DELTA	FIRST IN DELTA
Sample No.		III	3A	3B	4	4B
Depth (Ft)		@ SURFACE	1.3' water depth	1.3' water depth	@ SURFACE	TOP 5"
Type of Sample		JAR	metal egg shell LINER	plastic egg shell LINER	LINER	JAR
Soil Classification (ASTM: D2487/2488		SAND, FINE GRAINED (SP)	SILTY SAND W/ SOME ORGANICS (SM)	SILTY SAND W/ SOME ORGANICS (SM)	SILTY SAND W/ SOME ORGANICS (SM/SC-SM)	SANDY SILTY CLAY W/ORGANICS (CL-ML/OL)
Mechanical Analysis Dry Weight (Grams)		337	288	293	266	220
Percent Passing Gravel	3"					
	2"					
	1"					
	3/4"					
	#4					
Sand	#10	100	100	100	100	100
	#40	86.8	89.2	95.6	91.5	98.5
	#100	3.9	30.9	44.9	51.5	73.8
	#200	1.2	25.0	32.8	37.6	57.2
Atterberg Limits Liquid Limit						
Plastic Limit						
Plasticity Index						
Moisture - Density Water Content (%)						
Dry Density (PCF)						
Unconfined Compression Maximum Load (psf)						
Hand Penetrometer (tsf)						
Organic Content (%)						
Ph (Meter Method)						
Specific Gravity						
Resistivity (ohm-cm)						

Laboratory Test Summary

4/25

Project: LAKE NESHONOC REHABILITATION - #49/32-007 JWT 01 Date: 5-9-91

Reported To: BARR ENGINEERING COMPANY Job No.: 1401

Boring No.	FIRST IN DELTA	300' UPSTREAM IN DELTA	300' UPSTREAM IN DELTA	SOUTH BRANCH DELTA CHANNEL	IN LAKE, DOWNSTREAM OF NORTH MOUTH
Sample No.	4C	5A	5B	5C	6
Depth (Ft)	5"-9"	@ SURFACE	@ 6"	@ SURFACE	1.1' water depth
Type of Sample	BAG	BAG	BAG	JAR	LINER
Soil Classification (ASTM: D2487/2488	SILTY SAND W/ SOME ORGANICS (SM/SP-SM)	NO TEST	SAND, FINE GRAINED (SP)	SAND, FINE GRAINED (SP	SILTY, CLAYEY SAND W/ ORGANICS (SC-SM/SM)
Mechanical Analysis Dry Weight (Grams)	358		351	213	477
Percent Passing Gravel 3"					
2"					
1"					
3/4"					
#4	100		100		
Sand #10	99.9		99.9	100	100
#40	93.1		74.7	79.3	96.9
#100	24.6		6.0	3.8	45.9
#200	13.1		2.1	0.6	33.8
Atterberg Limits Liquid Limit					
Plastic Limit					
Plasticity Index					
Moisture - Density Water Content (%)					
Dry Density (PCF)					
Unconfined Compression Maximum Load (psf)					
Hand Penetrometer (tsf)					
Organic Content (%)					
Ph (Meter Method)					
Specific Gravity					
Resistivity (ohm-cm)					

Laboratory Test Summary

5/25

Project: LAKE NESHONOC REHABILITATION - #49/32-007 JWT 01 Date: 5-9-91

Reported To: BARR ENGINEERING COMPANY Job No.: 1401

Boring No.	IN LAKE, SOUTH & DOWNSTREAM OF SOUTH MOUTH				
Sample No.	7				
Depth (Ft)	~1' water depth				
Type of Sample	LINER				
Soil Classification (ASTM: D2487/2488	LEAN CLAY w/ORGANICS (CL/OH)				
Mechanical Analysis Dry Weight (Grams)	310				
Percent Passing Gravel 3"					
2"					
1"					
3/4"					
#4					
Sand #10	100				
#40	99.2				
#100	95.2				
#200	91.4				
Atterberg Limits Liquid Limit					
Plastic Limit					
Plasticity Index					
Moisture - Density Water Content (%)					
Dry Density (PCF)					
Unconfined Compression Maximum Load (psf)					
Hand Penetrometer (tsf)					
Organic Content (%)					
Ph (Meter Method)					
Specific Gravity					
Resistivity (ohm-cm)					

Laboratory Test Summary

6/25

Project: LAKE NESHONOC REHABILITATION - #49/32-007 JWT 01   Date: 5-9-91

Reported To: BARR ENGINEERING COMPANY   Job No.: 1401

Boring No.	LACROSSE RIVER @ #162	LACROSSE RIVER @ COUNTY RD. J	LACROSSE RIVER HWY 27, NEAR SPARTA		
Sample No.	A	B	C		
Depth (Ft)	@ SURFACE	@ SURFACE	@ SURFACE		
Type of Sample	JAR	JAR	JAR		
Soil Classification (ASTM: D2487/2488	SAND, FINE GRAINED (SP)	SAND, FINE TO MEDIUM GRAINED (SP)	SAND, FINE GRAINED (SP/SP-SM)		
Mechanical Analysis					
Dry Weight (Grams)	458	257	224		
Percent Passing					
Gravel 3"					
2"					
1"					
3/4"					
#4	100	100			
Sand #10	99.9	99.9	100		
#40	93.6	59.6	74.4		
#100	4.1	0.9	5.3		
#200	0.4	0.6	5.0		
Atterberg Limits					
Liquid Limit					
Plastic Limit					
Plasticity Index					
Moisture - Density					
Water Content (%)					
Dry Density (PCF)					
Unconfined Compression					
Maximum Load (psf)					
Hand Penetrometer (tsf)					
Organic Content (%)					
Ph (Meter Method)					
Specific Gravity					
Resistivity (ohm-cm)					

Grain Size Distribution

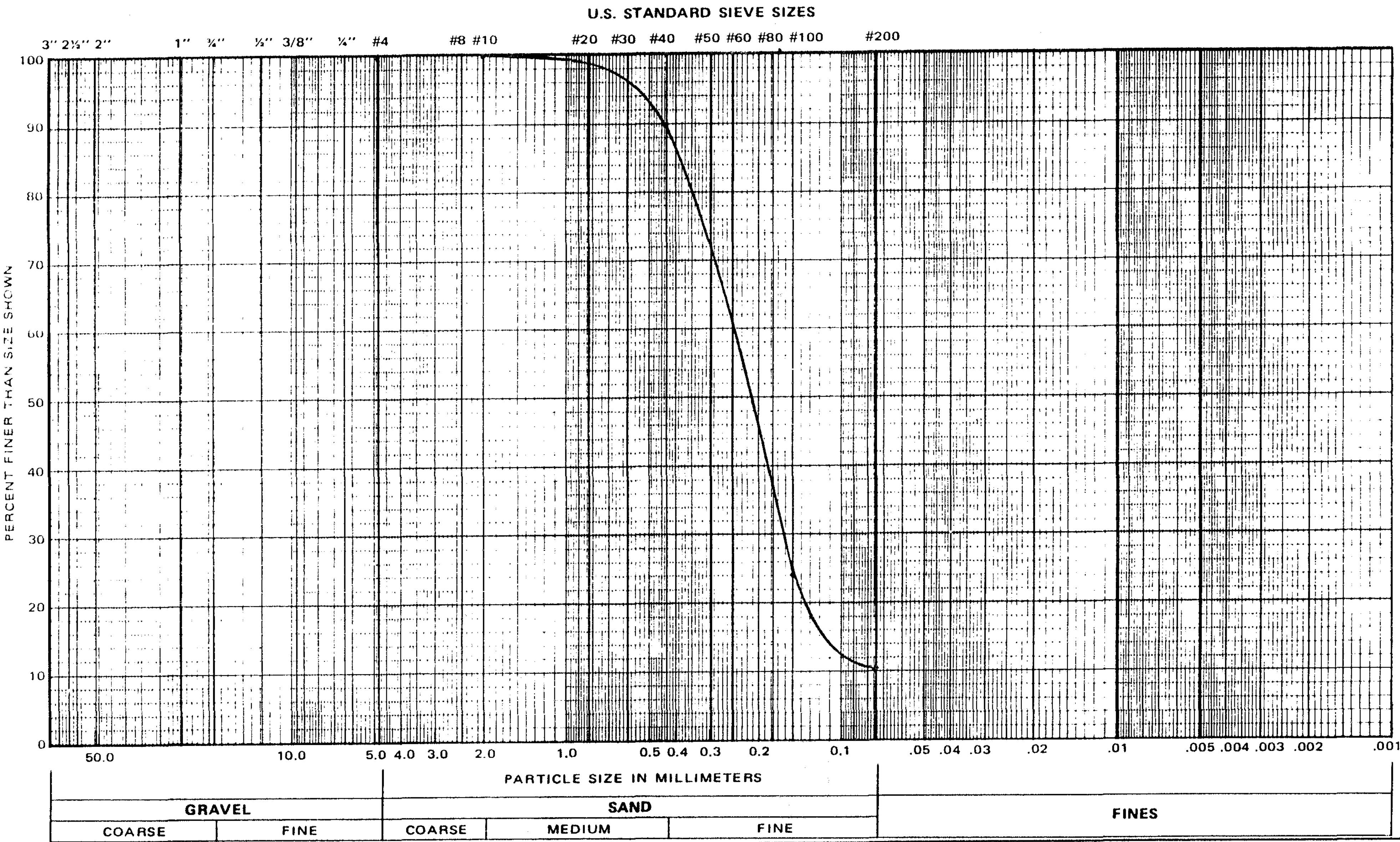
Boring No.	Sample No.	Depth (ft)	Soil Classification
*	I	0 – 4"	SAND w/SILT & A LITTLE ORGANICS (SP-SM)
* NORTH MOUTH ~~#~~ SAND BAR			

Job No: 1401 Date: 5-9-91

Project: LAKE NESHONOC REHABILITATION

#49/32-007 JWT 01

Reported To: BARR ENGINEERING COMPANY



7/25

3016 West 56th St. SOIL ENGINEERING TESTING, INC. Minneapolis, MN 55410

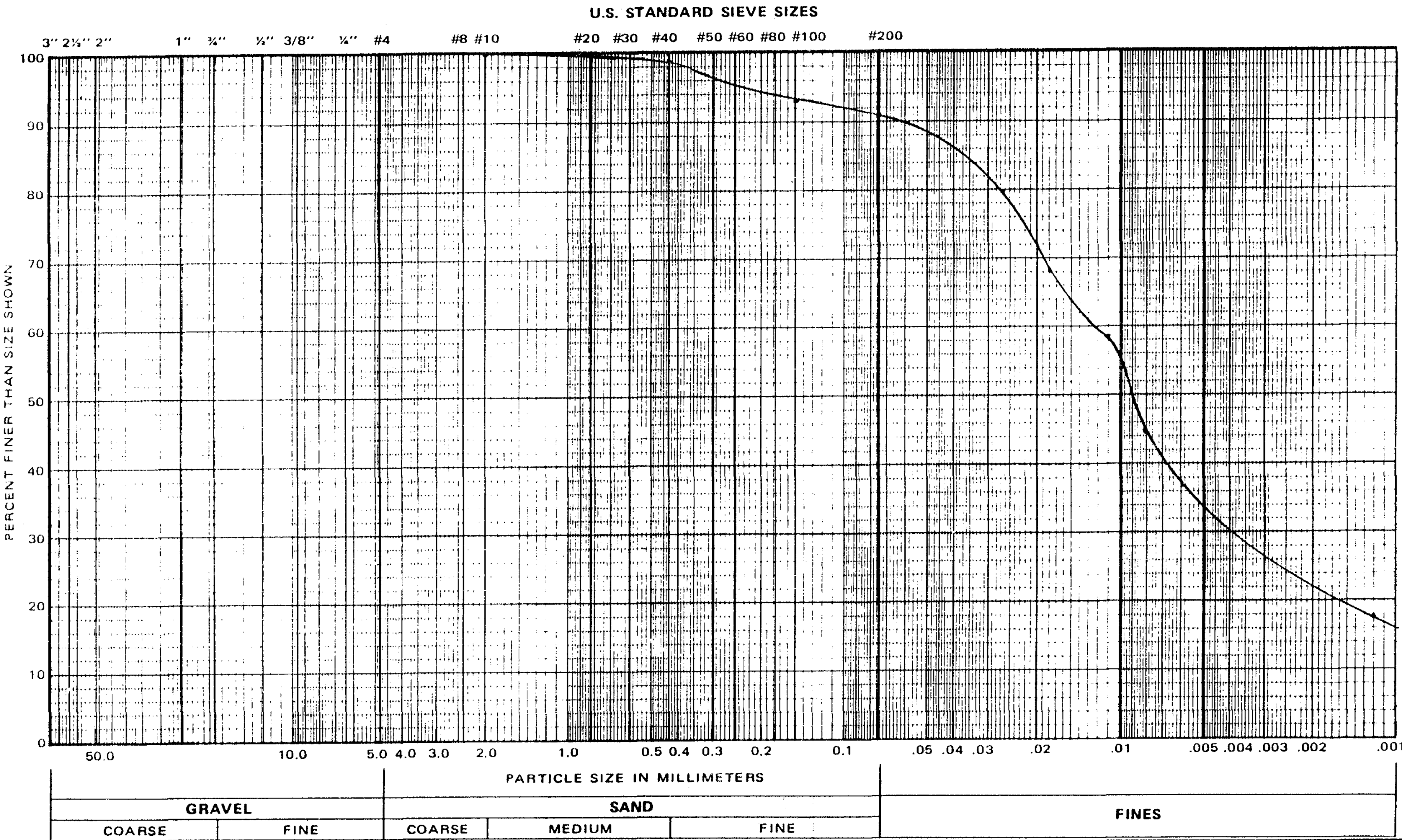
SET R3

Grain Size Distribution

Boring No.	Sample No.	Depth (ft)	Soil Classification
~~*~~	1	~~@~~3.5' water depth	LEAN CLAY w/ORGANICS (CL/OH)

~~→ NORTH MOUTH OF SAND BAR~~
~1400' D.S. SOUTH MOUTH & LAKE

Job No: 1401 Date: 5-9-91
Project: LAKE NESHONOC REHABILITATION #49/32-007 JWT 01
Reported To: BARR ENGINEERING COMPANY



8/25

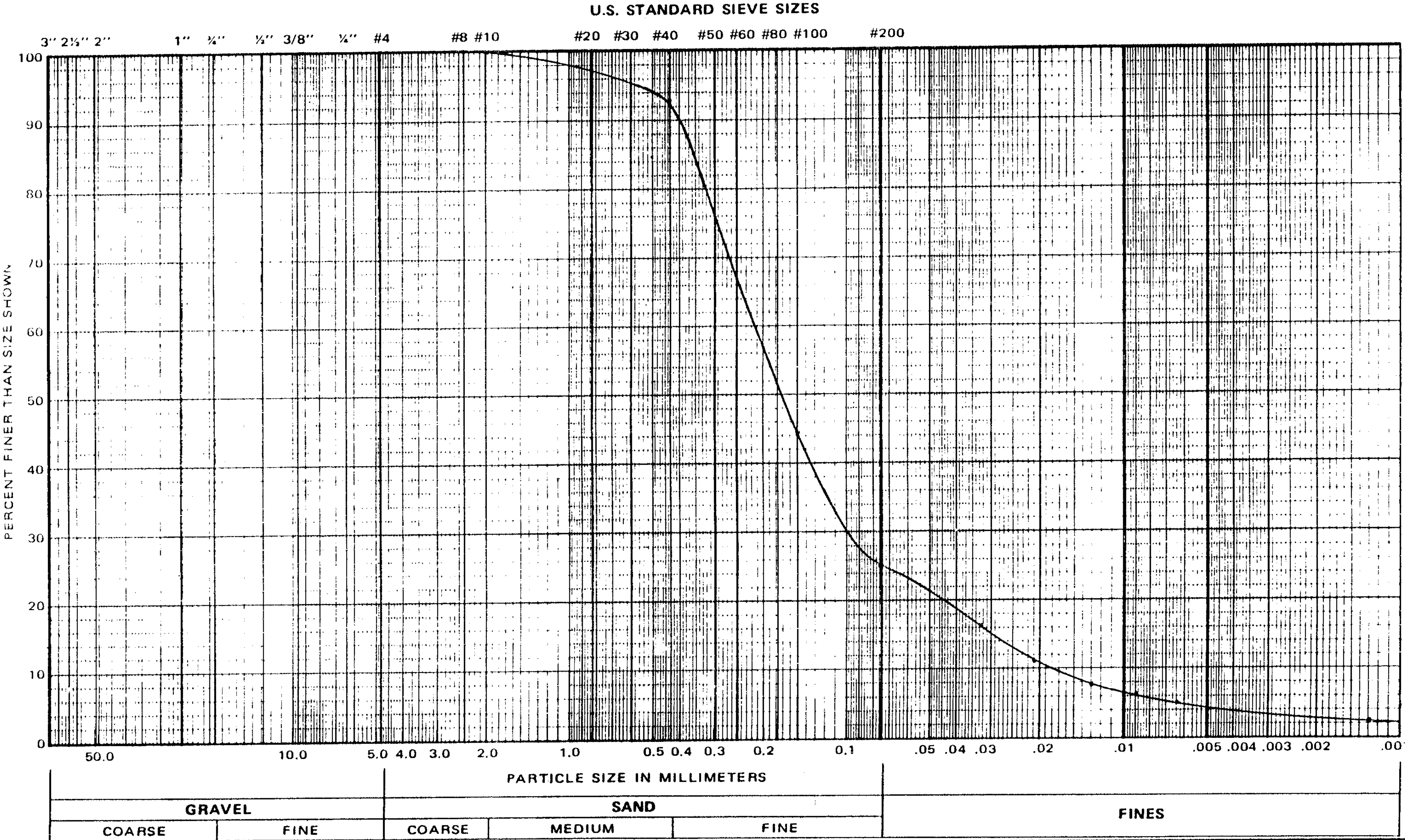
Grain Size Distribution

Boring No.	Sample No.	Depth (ft)	Soil Classification
*	II A	SURFACE	Silty Sand w/organics (SM)
* South Mouth			

Job No: 1401 Date: 5-9-91

Project: Lake Neshonoc Rehabilitation #49/32-007 JWT 01

Reported To: Barr Engineering Company



3016 West 56th St. SOIL ENGINEERING TESTING, INC. Minneapolis, MN 55410

9/25

ET R3

Grain Size Distribution

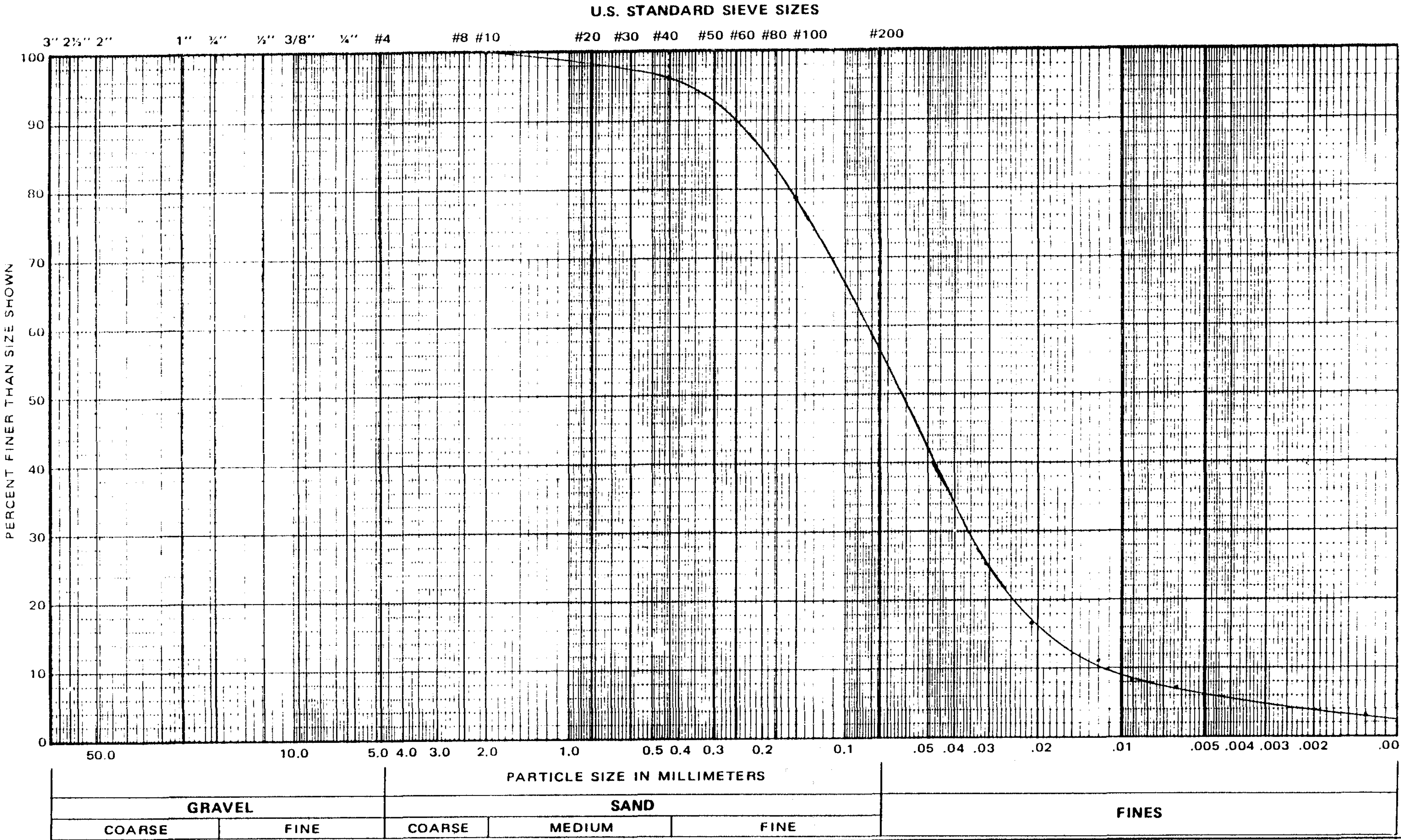
Boring No.	Sample No.	Depth (ft)	Soil Classification
*	II B	8" Below Surface	Silty Sand w/organics (SM/SC-SM)

* South Mouth

Job No: 1401 Date: 5 9 91

Project: Lake Neshonoc Rehabilitation #49/32-007 JWT 01

Reported To: Barr Engineering Company



10/25

3016 West 56th St. SOIL ENGINEERING TESTING, INC. Minneapolis, MN 55410

SET R3

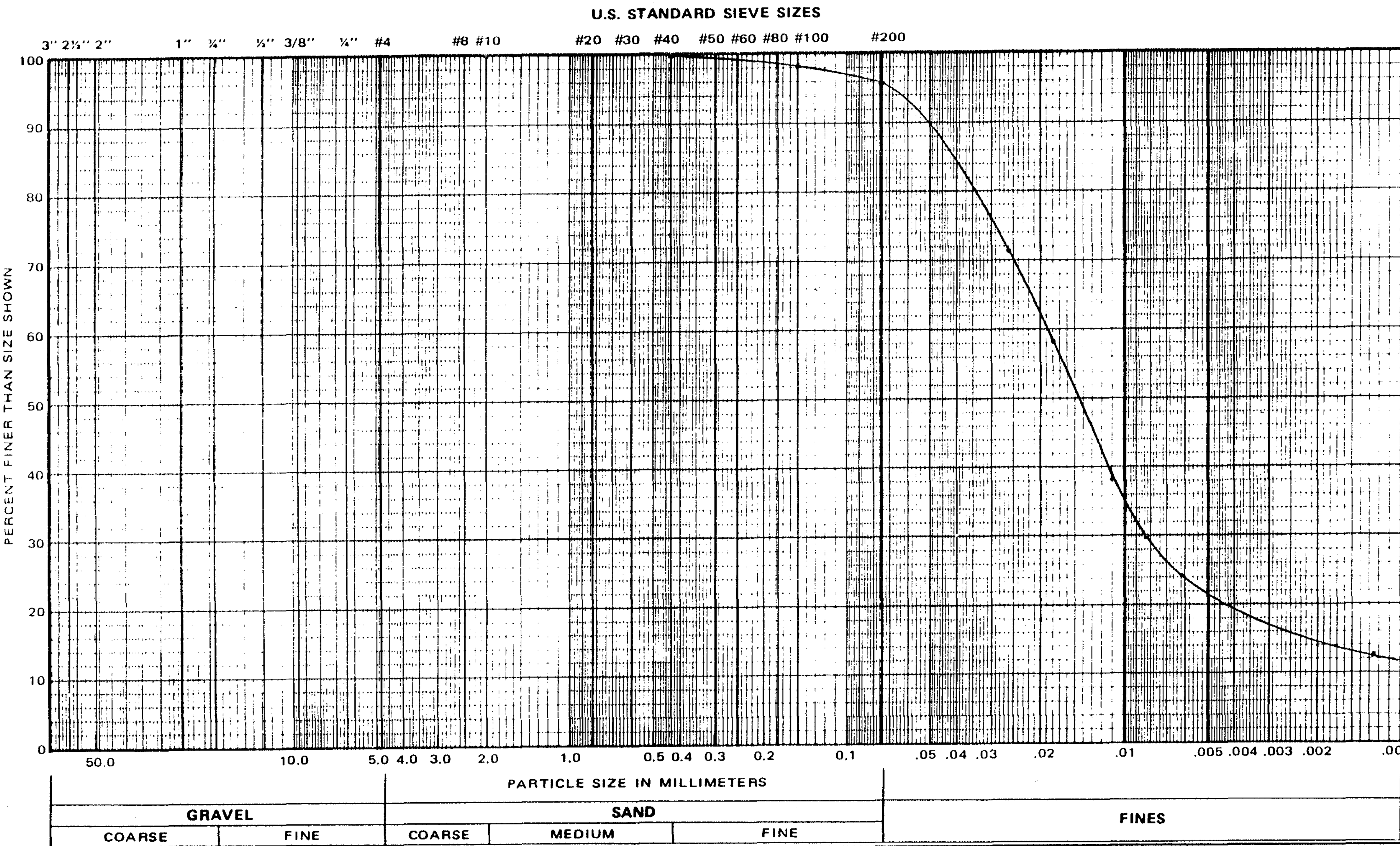
Grain Size Distribution

Boring No.	Sample No.	Depth (ft)	Soil Classification
*	2	@2.7' water depth	Lean Clay w/organics (CL/OH)
~800' D.S.			
* South Mouth			

Job No: 1401 Date: 5-9-91

Project: Lake Neshonoc Rehabilitation
49/32-007JWT01

Reported To: Barr Engineering Company



11/25

Grain Size Distribution

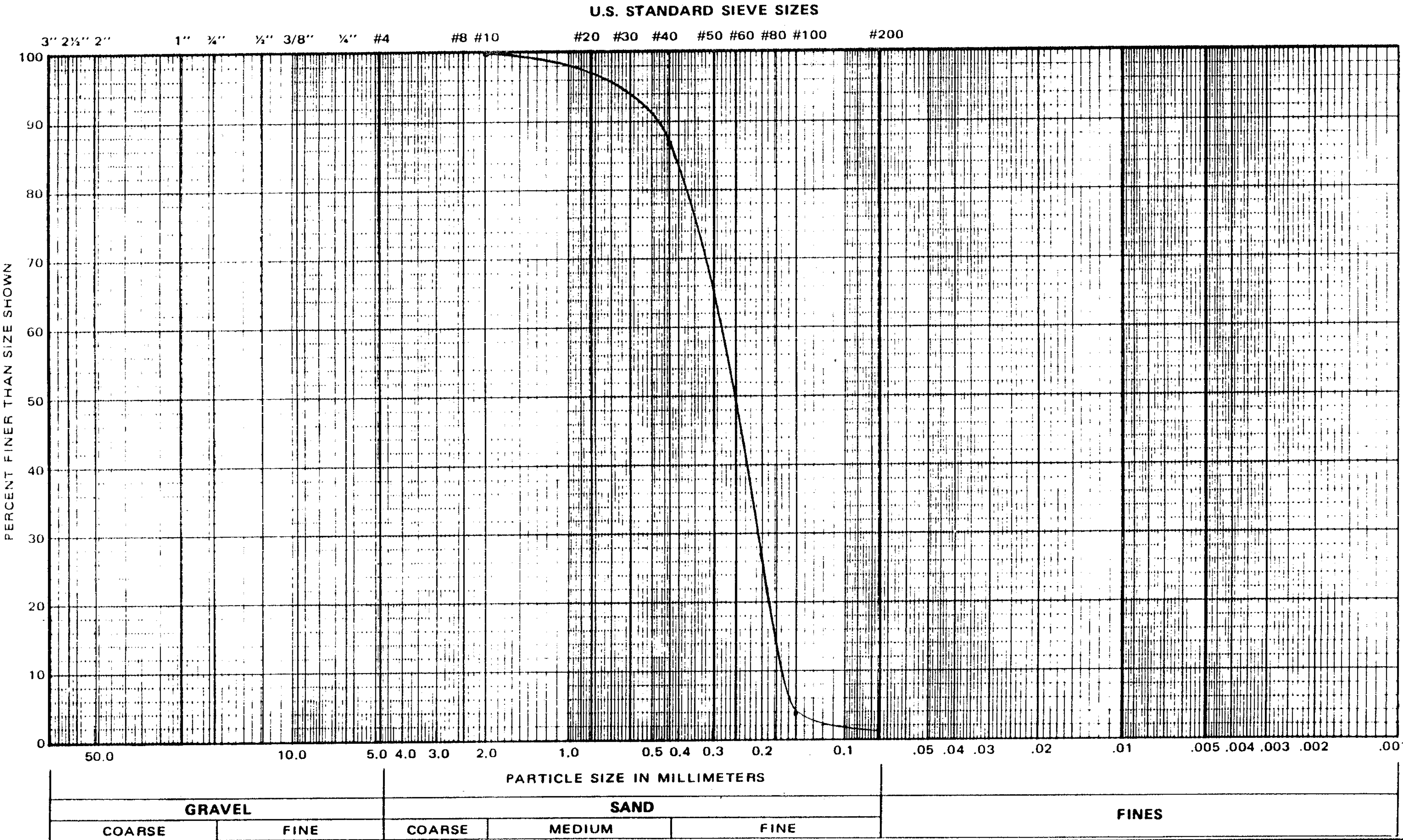
Boring No.	Sample No.	Depth (ft)	Soil Classification
*	III	@ Surface	Sand, Fine Grained (SP)

* South Mouth on Sand Bar

Job No: 1401 Date: 5-9-91

Project: Lake Neshonoc Rehabilitation
\# 49/32-007 4WT 01

Reported To: Barr Engineering Company



3016 West 56th St. Soil Engineering Testing, Inc. Minneapolis, MN 55410

Grain Size Distribution

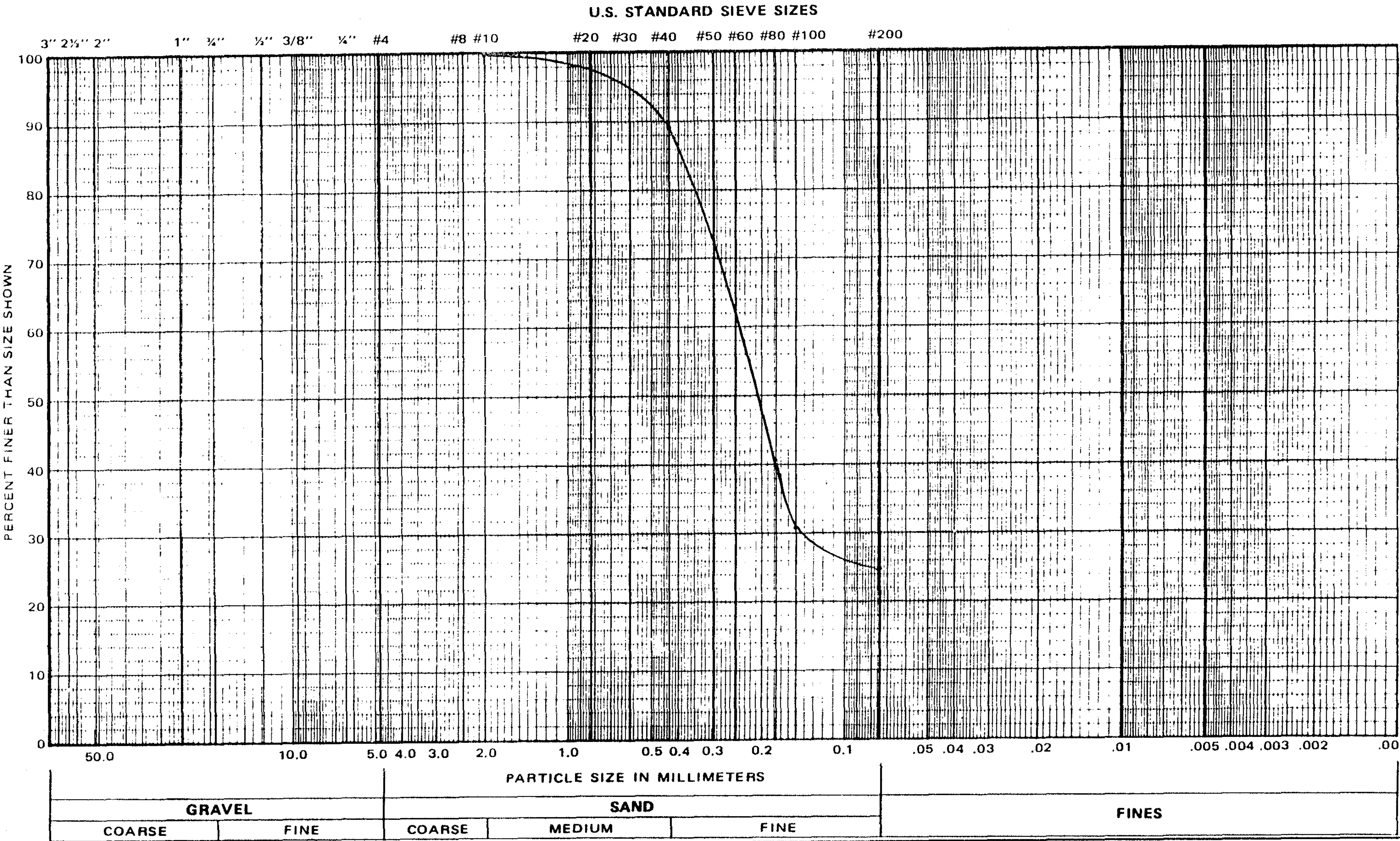
Boring No.	Sample No.	Depth (ft)	water depth Soil Classification
*	3A	1.3'	Silty Sand w/some Organics (SM)
			metal (brass) egg shell
* South mouth on sand bar			

Job No: 1401 Date: 5-9-91

Project: Lake Neshonoc Rehabilitation

#49/32-007 JWT01

Reported To: Barr Engineering Company



13/25

Grain Size Distribution

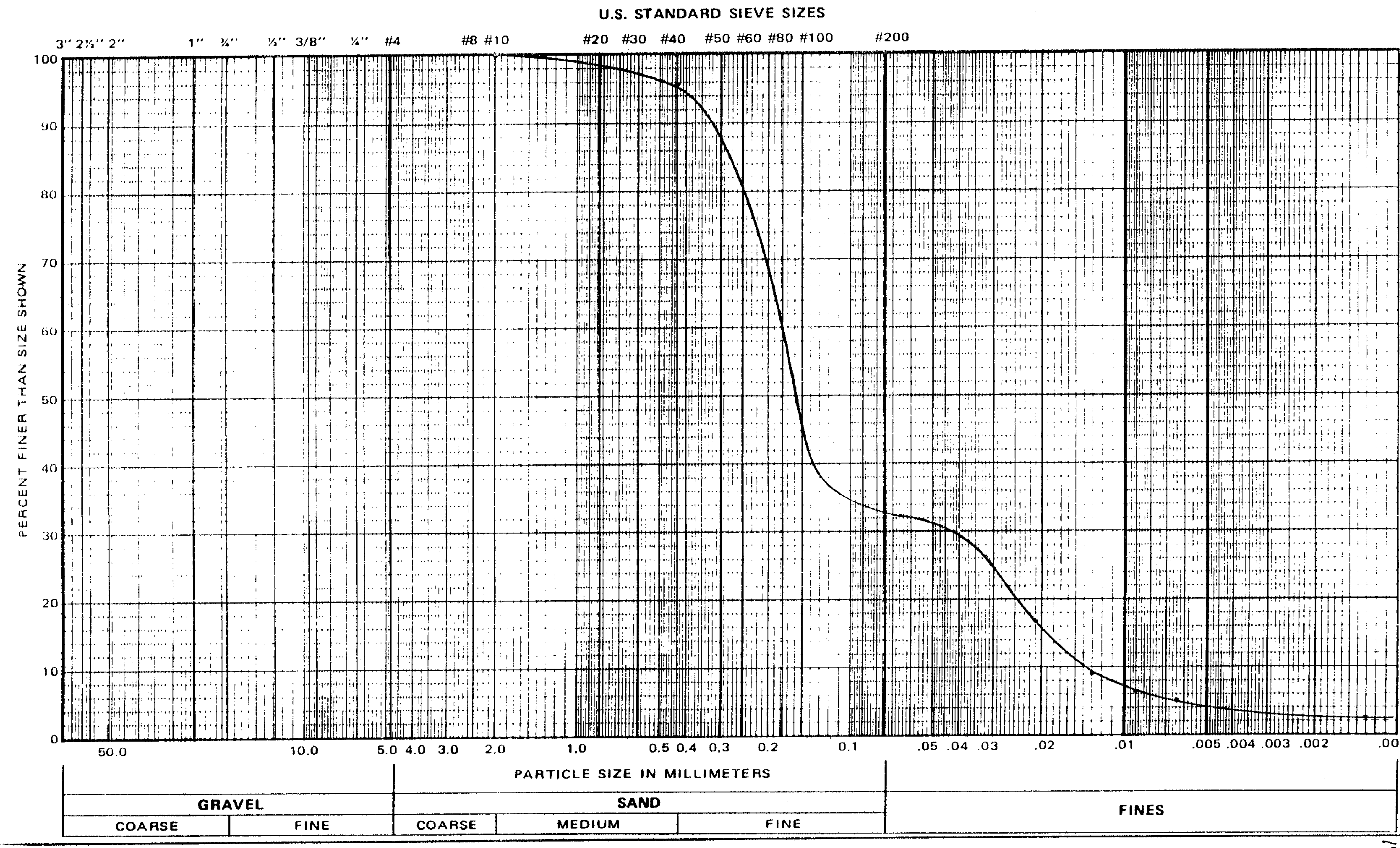
Boring No.	Sample No.	Depth (ft)	Soil Classification
*	3B	1.3 water depth	Silty Sand w/ Some Organics (Sm)
	plastic egg shell		

* South Mouth on Sand Bar

Job No: 1401 Date: 5-9-91

Project: Lake Neshonoc Rehabilitation # 49/32-027 JWT 01

Reported To: Barr Engineering Company



14/25

F R3

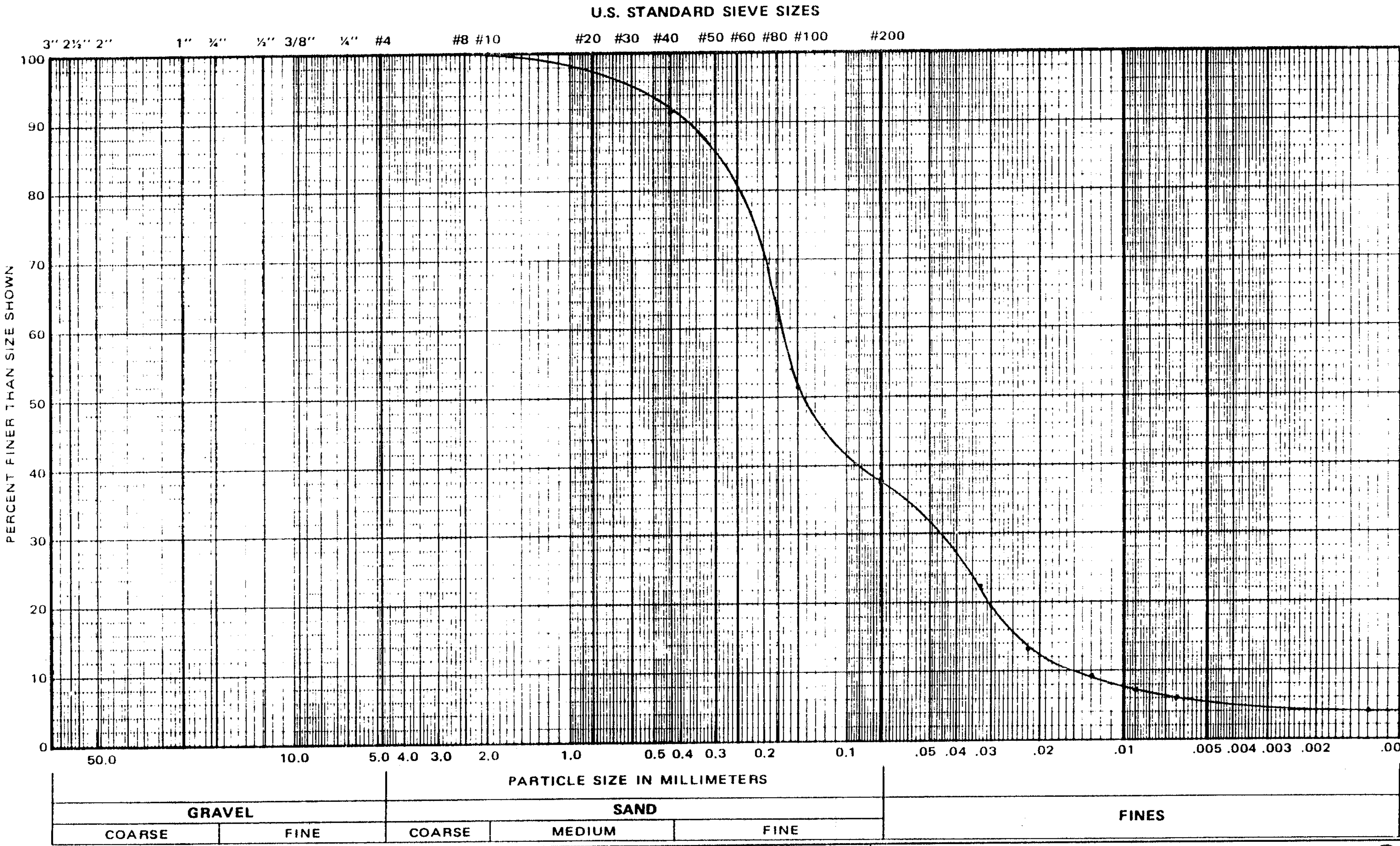
Grain Size Distribution

Boring No.	Sample No.	Depth (ft)	Soil Classification
*	4	@ SURFACE	SILTY SAND W/SOME ORGANICS (SM/SC-SM)
* FIRST IN DELTA			

Job No: 1401 Date: 5-9-91

Project: LAKE NESHONOC REHABILITATION #49/32-007 JWT 01

Reported To: BARR ENGINEERING COMPANY



15/25

3016 West 56th St. SOIL ENGINEERING TESTING, INC. Minneapolis, MN 55410

B3

Grain Size Distribution

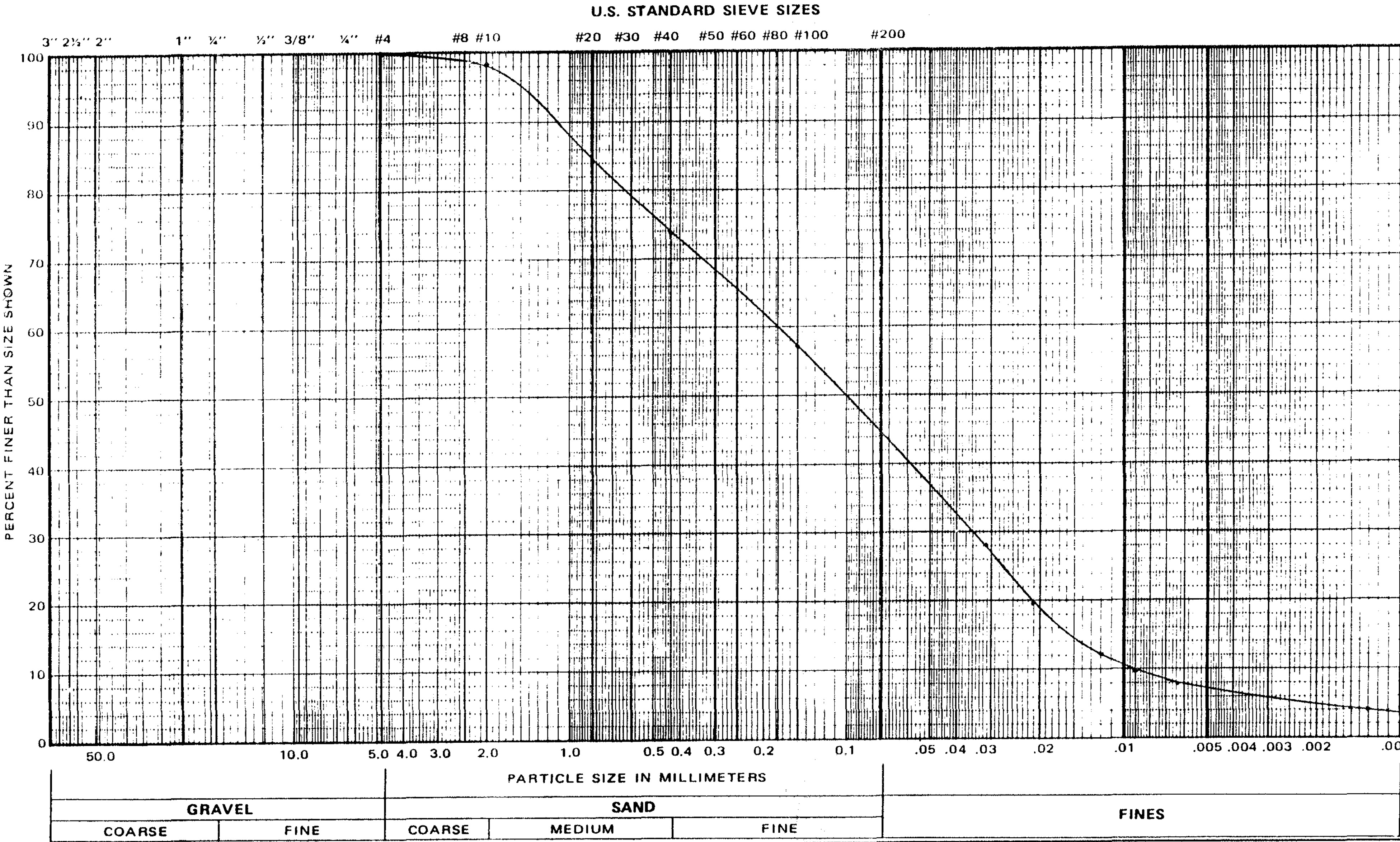
Boring No.	Sample No.	Depth (ft)	Soil Classification
*	4B	TOP 5"	SANDY SILT [illegible] ORGANICS (CL-ML/OL)

* FIRST IN DELTA

Job No: 1401 Date: 5-9-91

Project: LAKE NESHONOC REHABILITATION #49/32-007 JWT 01

Reported To: BARR ENGINEERING COMPANY



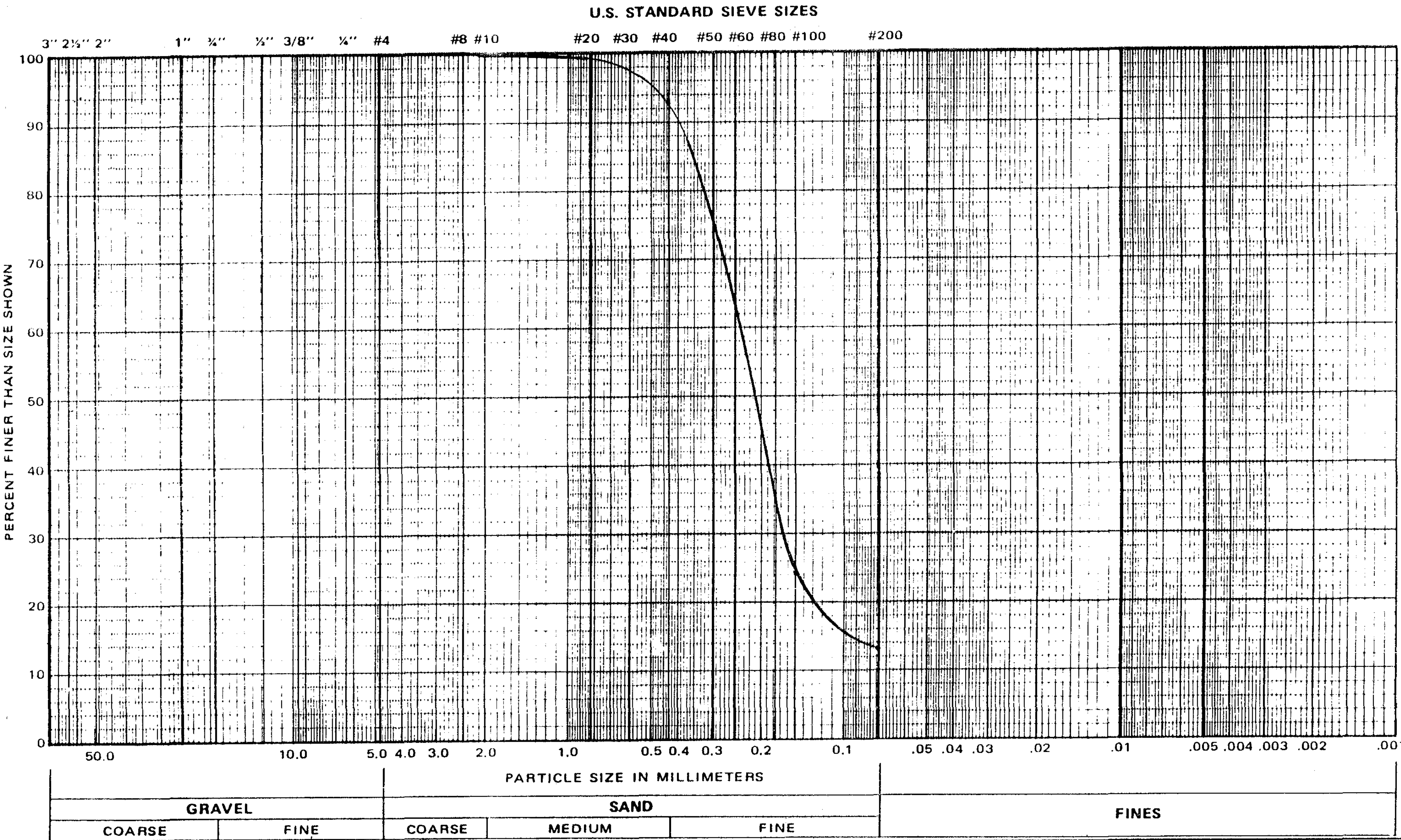
Grain Size Distribution

Boring No.	Sample No.	Depth (ft)	Soil Classification
*	4C	5"-9"	Silty Sand w/Some Organics (SM/SP-SM)
*	First in Delta		

Job No: 1401 Date: 5-9-91

Project: Lake Neshonoc Rehabilitation
49/32-007 JWT 01

Reported To: Barr Engineering Company



Grain Size Distribution

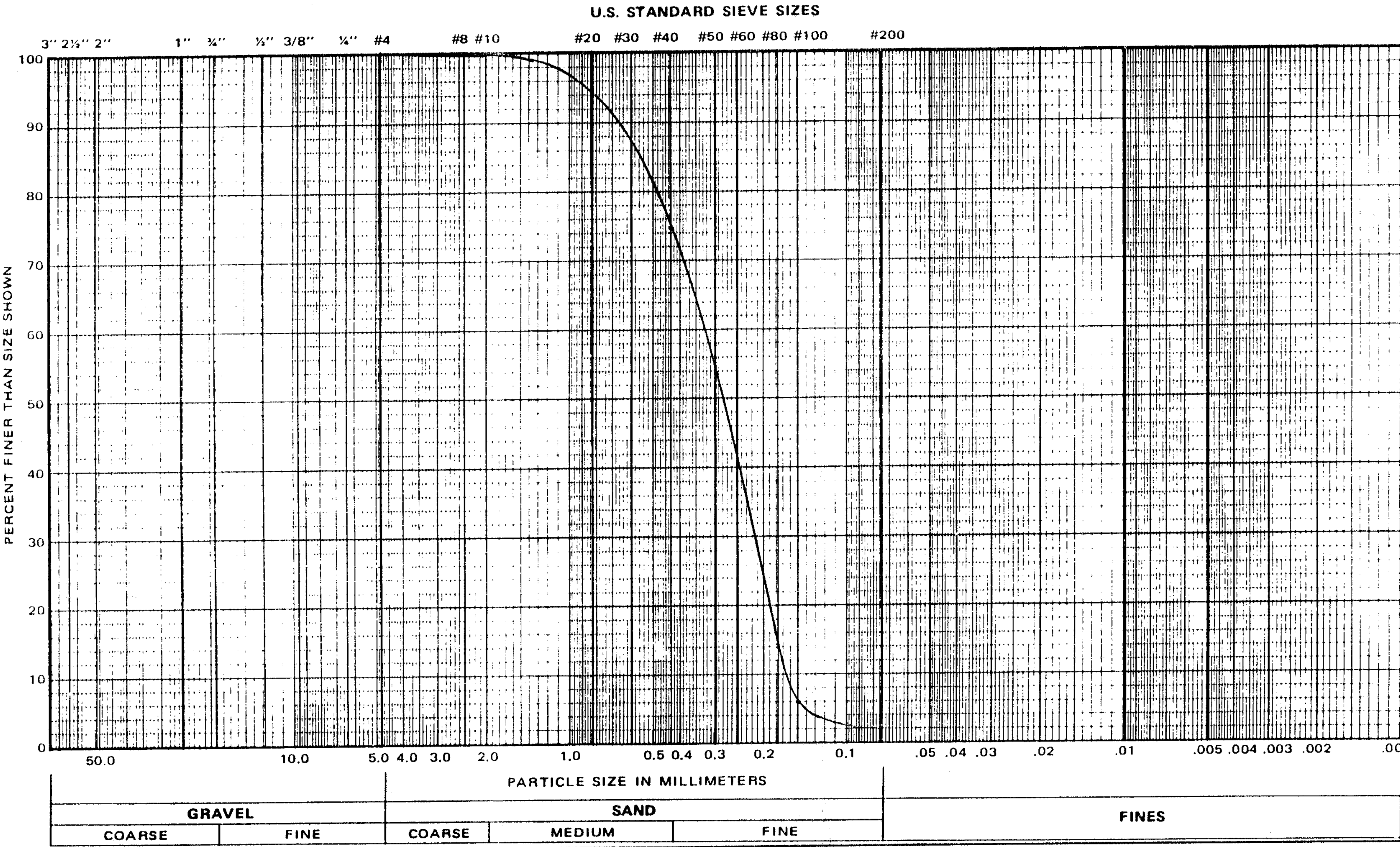
Boring No.	Sample No.	Depth (ft)	Soil Classification
*	5B	@6"	Sand, Fine Grained (SP)

* 300' Upstream in Delta

Job No: 1401 Date: 5-9-91

Project: Lake Neshonoc Rehabilitation #49/32-007 JWT01

Reported To: Barr Engineering Company



52/81

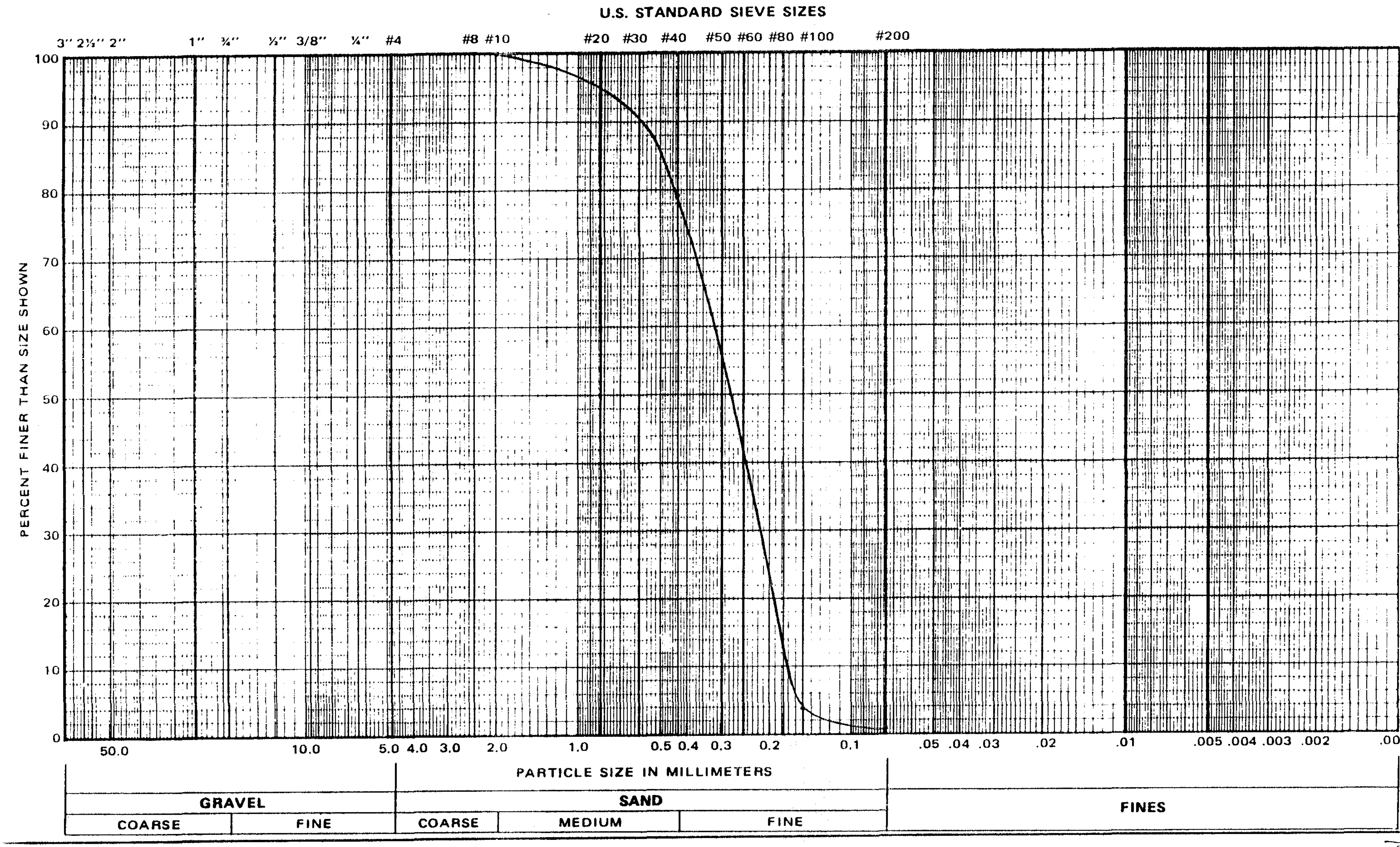
Grain Size Distribution

Boring No.	Sample No.	Depth (ft)	Soil Classification
*	5C	@ Surface	Sand, Fine Grained (SP)
* South Branch, Delta Channel			

Job No: 1401 Date: 5-9-91

Project: Lake Neshonoc Rehabilitation #49/32-007 NWT 01

Reported To: Barr Engineering Company



5/91

Grain Size Distribution

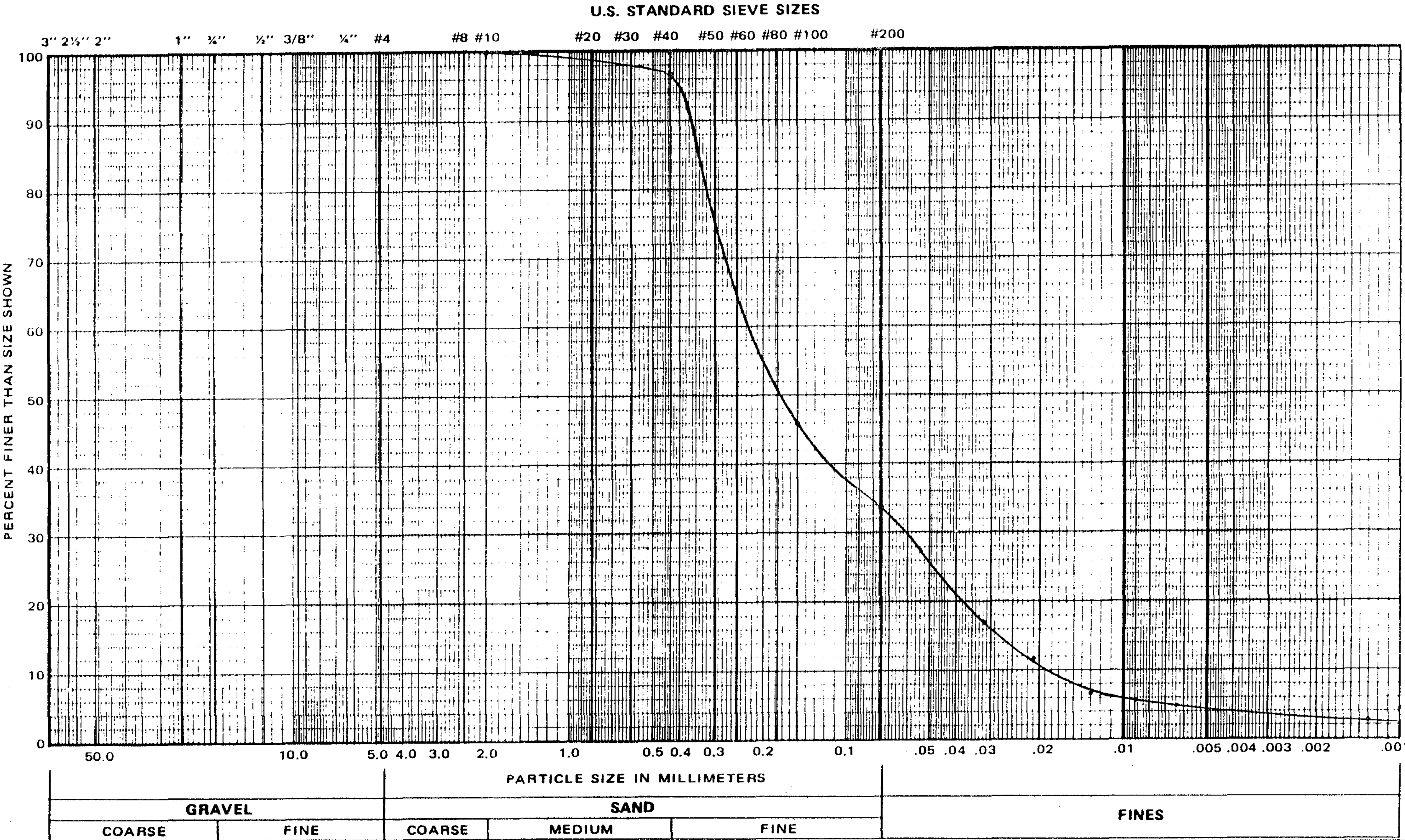
Boring No.	Sample No.	Depth (ft)	Soil Classification
*	6	@1.1'	Silty, Clayey Sand w/organics (SC-SM/SM)

* In Lake, Downstream of North Mouth

Job No: 1401 Date: 5-9-91

Project: Lake Neshonoc Rehabilitation #49/32-007 JWT01

Reported To: Barr Engineering Company



28/25

Grain Size Distribution

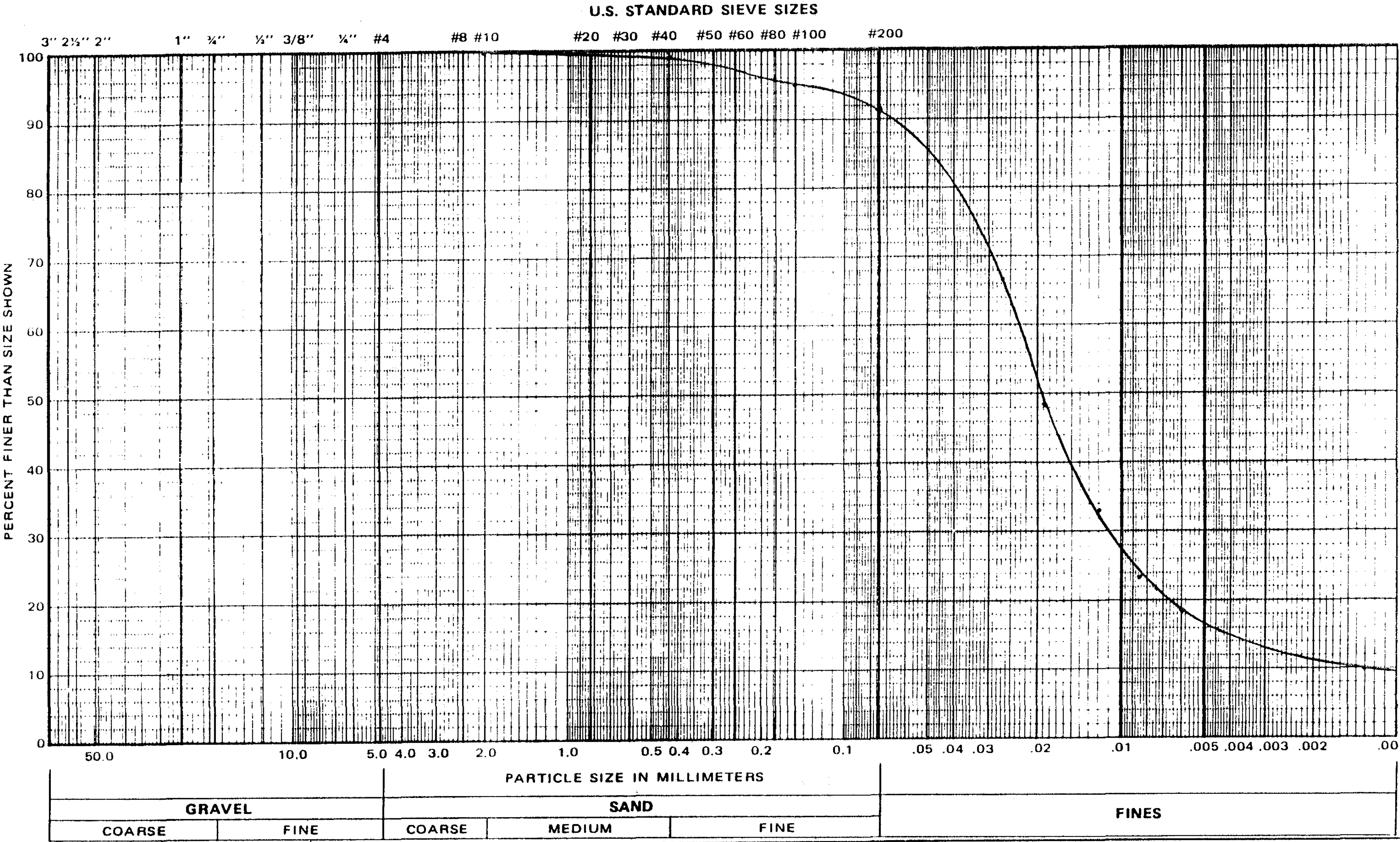
Boring No.	Sample No.	Depth (ft)	Soil Classification
*	7	~~6"-15"~~ 1' water depth	LEAN CLAY W/ORGANICS (CL/OH)

* IN LAKE, SOUTH & DOWNSTREAM OF SOUTH MOUTH

Job No: 1401 Date: 5-9-91

Project: LAKE NESHONOC REHABILITATION #49/32-007 JWT 01

Reported To: BARR ENGINEERING COMPANY



3016 West 56th St. SOIL ENGINEERING TESTING, INC. Minneapolis, MN 55410

T-R3

52/12

Grain Size Distribution

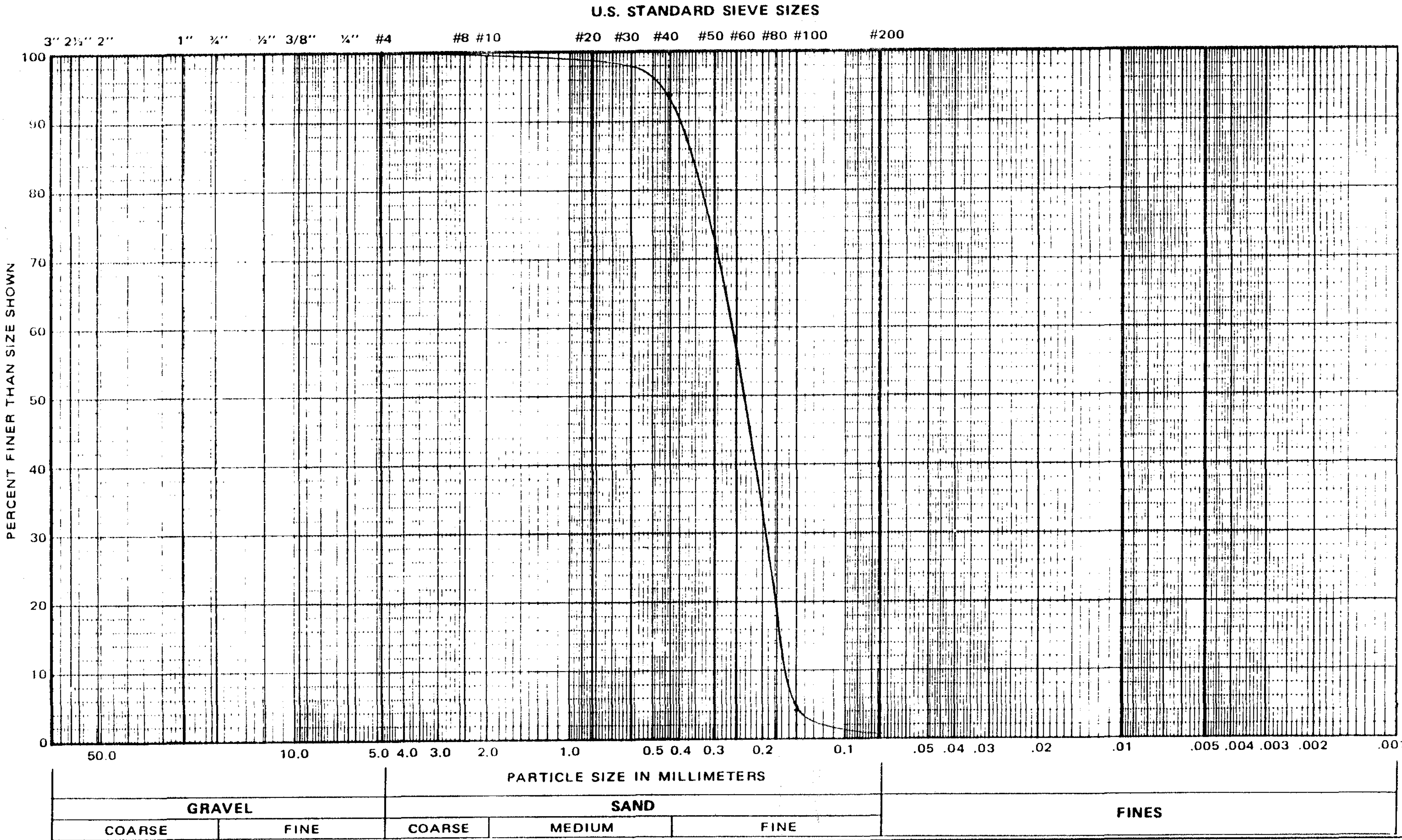
Boring No.	Sample No.	Depth (ft)	Soil Classification
*	A	@ Surface	Sand, Fine Graded (SP)

* LaCrosse River at #162

Job No: 1401 Date: 5 9 97

Project: Lake Neshonoc Rehabilitation #49/32-007 JWT 01

Reported To: Barr Engineering Company



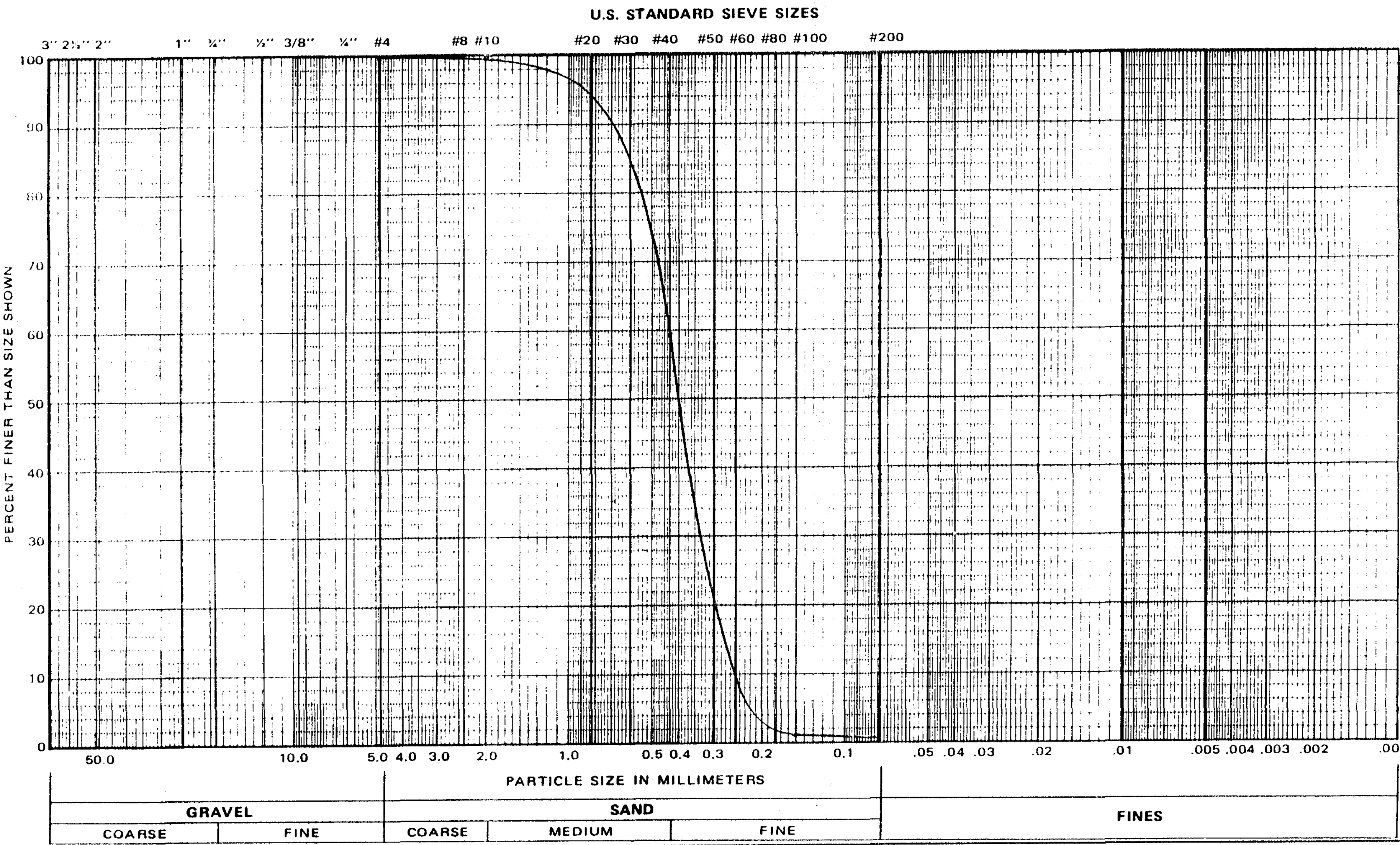
Grain Size Distribution

Boring No.	Sample No.	Depth (ft)	Soil Classification
*	B	@ Surface	Sand, Fine to Medium Grained (SP)
* At	County	Road J	

Job No: 1401 Date: 5 9 91

Project: Lake Neshonoc Rehabilitation #49/32-007JWT01

Reported To: Barr Engineering Company



23/25

3016 West 56th St. SOIL ENGINEERING TESTING, INC. Minneapolis, MN 55410

1-R3

Grain Size Distribution

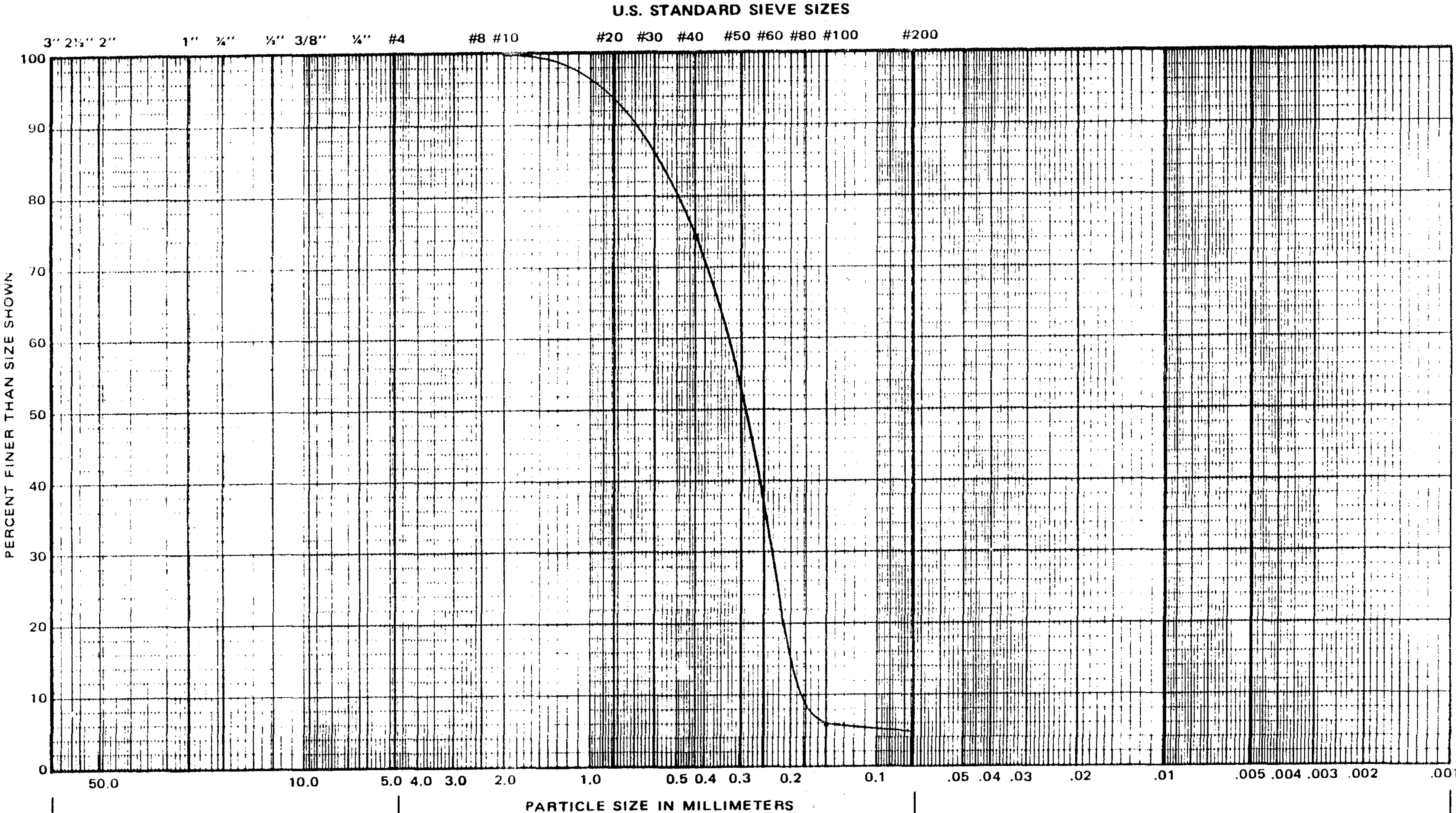
Boring No.	Sample No.	Depth (ft)	Soil Classification
*	C	@SURFACE	SAND, FINE GRAINED (SP/SP-SM)

* AT HIGHWAY 27, NEAR SPARTA

Job No: 1401 Date: 5-9-91

Project: LAKE NESHONOC REHABILITATION #49/32-007 SWT01

Reported To: BARR ENGINEERING COMPANY



GRAVEL		SAND			FINES
COARSE	FINE	COARSE	MEDIUM	FINE	

24/125

Classification of Soils For Engineering Purposes

ASTM:D 2487-85

25/25

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay[K,L,M,N]; Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[K,L,M,P]; Organic silt[K,L,M,Q]
Highly organic soils		Primarily organic matter, dark in color, and organic odor		PT	Peat

Fibric Peat >67% Fibers — Hemic Peat 33%-67% Fibers — Sapric Peat <33% Fibers

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥30% plus No. 200, predominantly sand, add "sandy" to group name.

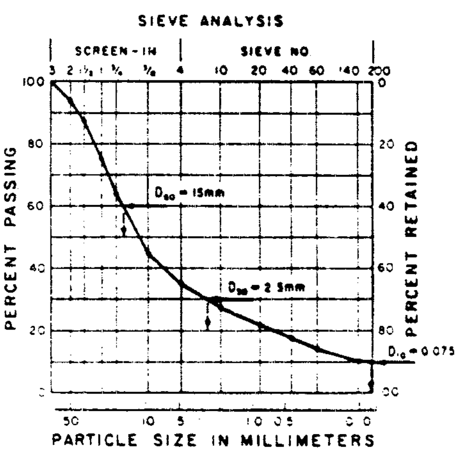
[M] If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI≥4 and plots on or above "A" line.

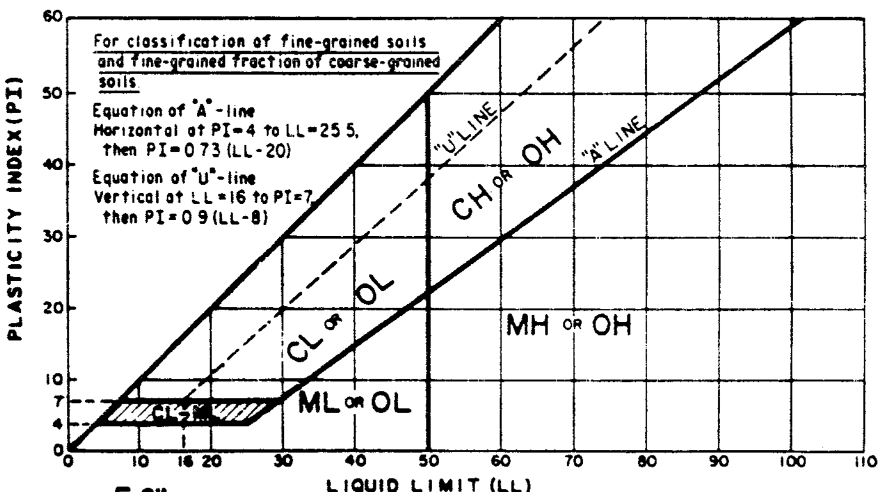
[O] PI<4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.



$C_u = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200 \qquad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$



Surveyed Cross Sections on the La Crosse River
Upstream of Lake Neshonoc (4/26/91)

Section 1: 300' downstream of Hwy 162
Distances measured from left bank looking downstream
Section 2: 300' downstream of County Road J
Distances measured from right bank looking downstream
Section 3: 250' downstream of Highway 27
Distances measured from left bank looking downstream

All depths are measured relative to the water surface elevation.
A negative depth is a distance above the water surface.
See the water surface profile for elevation information.

Section 1
D.S. Hwy 162

DISTANCE (Feet)	DEPTH (Feet)
-3.0	-2.3
8.0	0.0
14.0	1.3
25.0	1.8
37.0	1.9
48.0	2.1
59.0	2.3
66.0	2.6
75.0	3.1
82.0	3.6
86.0	3.3
90.0	3.0
92.5	2.0
94.5	0.0
98.0	-3.5

Section 2
D.S. County Rd. J

DISTANCE (Feet)	DEPTH (Feet)
0.0	-2.30
10.0	-0.90
29.0	-0.90
31.0	0.00
32.0	1.00
40.0	1.25
50.0	1.25
60.0	1.05
70.0	1.15
80.0	1.30
90.0	1.95
100.0	2.00
110.0	3.05
115.0	2.10
116.5	0.00
120.0	-3.90

Section 3
D.S. Hwy 27

DISTANCE (Feet)	DEPTH (Feet)
0.0	-4.00
3.5	0.00
4.0	0.50
8.0	0.80
12.0	0.90
15.0	1.50
20.0	1.90
22.0	2.40
25.0	2.50
30.0	2.70
35.0	2.60
40.0	2.40
45.0	2.10
50.0	1.90
55.0	1.90
60.0	1.80
63.0	0.00
65.0	-2.30

Stream Profile of the La Crosse River Upstream of Lake Neshonoc

LOCATION	DISTANCE FROM DAM (Feet)	WATER SURFACE ELEVATION	DEPTH (Feet)	CHANNEL BOTTOM ELEVATION
Dam	0	697.80	(9)	(688.8)
Delta	10000	697.80	(1)	(696.8)
700 Contour (1)	16000	(704)	(4)	700.0
Hwy 162	31800	709.50	3.6	705.9
720 Contour (1)	49000	(723.3)	(3.3)	720.0
County Road J	60000	728.00	3.1	725.5
730 Contour (1)	63000	(733)	(3)	730.0
5th Avenue (2)	72500			
740 Contour (1)	78000	(743)	(3)	740.0
6th Drive (2)	82000			
Hwy 27	88000	756.40	2.7	753.7

Survey data was taken 4/26/91. Information at the dam was received from North American Hydro.

(1) Elevations taken from the U.S.G.S. topographic maps for the area.
(2) Water surface elevations were taken relative to the bridge decks, but the bridge deck elevations were not available.

DVSTAT - DAILY VALUES STATISTICAL PROGRAM

STATION ID - 05383000
LA CROSSE RIVER NEAR WEST SALEM, WI
PARAMETER CODE - 00060 DISCHARGE
STATISTIC CODE - 00003 MEAN

DURATION TABLE OF DAILY VALUES
FOR PERIOD OCT TO SEP

NUMBER OF DAYS IN CLASS

CLASS / WATER YEAR RANGE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1914 1914										16	45	70	50	26	22	9	19	1	5	5	1	1	1	1		1									
1915 1915									21	25	50	94	18	36	32	17	39	6	10	3	5	1	8												
1916 1916										7	46	30	39	87	59	30	30	5	7	5	5	10	1	1	1	2	1								
1917 1917								1	7	34	31	26	61	72	50	23	27	5	5	7	4	2	2	2	1	1	1	1	1	1					
1918 1918							1	2	10	8	13	47	93	67	45	16	12	10	9	5	3	6	3	7	3		2		2	1					
1919 1919									1	9	40	46	96	67	38	26	16	13	3	2	1	2	1	1	1					2					
1920 1920						2	7	14	28	34	35	59	37	36	28	23	16	9	8	8	14	2		1	2		1		1	1					
1921 1921							2	8	12	31	76	60	62	50	30	9	11	4	1	3	2	2	2												
1922 1922						1	7	12	32	59	74	37	23	30	19	12	14	11	4	3	6	8	2	5		1	2	1		1	1				
1923 1923						2	4	22	30	83	93	36	18	22	10	7	6	2	5	11	4	3	2	1	2			1	1						
1924 1924					2	2	6	33	34	56	32	20	33	31	29	23	18	12	4	8	5	5	3	3	2	3			2						
1925 1925							1	3	14	36	57	46	47	60	29	18	14	3	7	7	9	4	3	2	2	1	1	1							
1926 1926							3	3	4	18	21	51	49	85	46	32	17	14	6	4	1	6	2		2		1								
1927 1927		1	3	2	7	10	9	11	24	35	27	31	43	64	30	27	18	6	7	3	4	1		1	1										
1928 1928					2	4	15	18	12	25	15	60	61	37	23	23	21	14	7	4	10	3	3	1	1	2		2		2					1
1929 1929												14	83	112	61	37	28	10	8	6	3	2	1												
1930 1930							1	1	6	14	42	73	112	83	6	9	7	3	1	1	2		1		1		1					1			
1931 1931				1		1	4	10	34	31	78	109	53	34	5	2	1	2																	
1932 1932						1		1	8	13	36	73	98	46	23	23	13	3	6	3	5	6		3	4				1						
1933 1933							2	7	25	57	49	60	50	44	27	10	8	14	1	4	1	2	1				1		1				1		
1934 1934						1	12	19	36	99	55	82	22	15	9	4	1	3	1	3		1				1			1						
1935 1935									2	22	40	50	61	55	33	24	26	13	17	3	7	3	4	1	2								2		
1936 1936							5	5	20	65	51	74	65	16	27	11	4	5	2		1		3	3	6	1	1	1							
1937 1937								11	14	74	60	51	58	23	38	13	7	2	6	4	4														
1938 1938								3	7	30	29	96	40	47	16	28	24	10	8	10	4	3	3	1	2		1		2		1				
1939 1939									4	48	73	72	41	64	27	14	4	4	4	1		2	2	2	3										
1940 1940								1	14	114	105	68	19	15	7	6	5	6	5	1															
1941 1941									1	18	111	89	47	31	14	15	11	6	4	8	4	2	2				1	1							
1942 1942										3	16	44	87	105	37	23	15	10	9	5	5	1	2	1				1	1						
1943 1943												102	124	63	42	9	4	6	5	2	2	1	3		1			1							
1944 1944										5	25	89	126	48	27	10	12	6	3	5		3	1	3	2		1								
1945 1945									33	27	19	51	107	45	32	16	9	3	5	5	2	3	2	2		2		2							
1946 1946											2	82	149	52	29	17	9	8	3	3	2	3		1		1	3	1							
1947 1947												26	105	97	76	28	9	6	5	5	3	1	2	1					1						
1948 1948									10	41	38	59	97	63	31	11	3	1	1	2	2		1	1		4	1								

DVSTAT - DAILY VALUES STATISTICAL PROGRAM

ATION ID - 05383000
CROSSE RIVER NEAR WEST SALEM, WI
AMETER CODE - 00060 DISCHARGE
ATISTIC CODE - 00003 MEAN

DURATION TABLE OF DAILY VALUES

NUMBER OF DAYS IN CLASS

ASS / IER YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1949							1	3	14	49	118	52	30	66	13	5	3	3	2	2	1	2	1												
1950					4	2	1	7	15	118	36	23	57	62	15	2	3	5	3			1	3	4	1				2	1					
1951								5	14	85	30	54	41	67	28	8	3	8	7	4	7	2	1	1											
1952										12	60	18	58	149	19	6	11	9	9	3	1	4	1	1	3		1	1							
1953									1	9	75	96	23	84	28	12	5	10	5	11	5		1												
1954										12	69	144	40	61	7	7	4	4	9	4	1	2			1										
1955									10	33	64	41	69	83	24	9	6	13	5	5				1				2							
1956			1	2		5	7	17	38	66	96	32	39	31	12	2	6	2	3	2		1		1	1						1			1	
1957							5	8	35	140	90	25	33	23	5		1																		
1958		1	1	1	1	2	15	35	75	117	67	16	20	6	4	1		1		1			1												
1959						2	8	75	79	42	42	25	22	19	16	7	3	1	4	3	1	3		2	4	1	2	1	1	2					
1960								1	3	42	66	27	74	63	40	15	3	7	7	7	6		3	1		1									
1961								1	21	81	73	47	45	42	24	13	3	3	2		1	1	3	1				1	1				2		
1962									1	7	59	111	75	79	12	3	2	2	3	2	3	2	1		1	1	1								
1963		1		1	6		2	3	7	75	79	72	45	38	11	7	5	4		1	1		4	2		1									
1964							1	1	33	78	99	49	71	20	10	1	1		1	1															
1965								1	2	80	121	19	35	40	10	10	5	5	6	1	1	4	4	5	4	5	1	3	2	1					
1966				1				1	4	13	60	27	54	74	60	16	17	16	9	3	5	1		1		1								1	1
1967									2	26	112	65	59	47	13	11	8	1	3	2	4	2	1	2	2		2		2		1				
1968								11	7	48	68	47	68	32	36	19	6	4	4	6		4	3	1	1	1									
1969									2	2	60	39	81	86	39	26	5	4	7	4	3	2	2	2	1										
1970			5			2		2	3	24	65	66	78	52	33	11	5	9	4		3	1			2										

DVSTAT - DAILY VALUES STATISTICAL PROGRAM

ATION ID - 05383000
A CROSSE RIVER NEAR WEST SALEM, WI
RAMETER CODE - 00060 DISCHARGE
ATISTIC CODE - 00003 MEAN

ASS	VALUE	TOTAL	ACCUM	PERCT
1	0.0	0	20727	100.00
2	57.0	3	20727	100.00
3	65.0	10	20724	99.99
4	74.0	8	20714	99.94
5	85.0	22	20706	99.90
6	97.0	37	20684	99.79
7	110.0	119	20647	99.61
8	126.0	356	20528	99.04
9	144.0	809	20172	97.32
10	164.0	2296	19363	93.42
11	187.0	3093	17067	82.34
12	213.0	3172	13974	67.42

CLASS	VALUE	TOTAL	ACCUM	PERCT
13	244.0	3391	10802	52.12
14	278.0	3052	7411	35.76
15	317.0	1516	4359	21.03
16	362.0	796	2843	13.72
17	413.0	583	2047	9.88
18	471.0	347	1464	7.06
19	538.0	275	1117	5.39
20	614.0	211	842	4.06
21	701.0	164	631	3.04
22	800.0	121	467	2.25
23	912.0	90	346	1.67
24	1040.0	70	256	1.24

CLASS	VALUE	TOTAL	ACCUM	PERCT
25	1190.0	60	186	0.90
26	1360.0	31	126	0.61
27	1550.0	26	95	0.46
28	1770.0	21	69	0.33
29	2010.0	22	48	0.23
30	2300.0	12	26	0.13
31	2620.0	4	14	0.07
32	2990.0	1	10	0.05
33	3420.0	5	9	0.04
34	3900.0	2	4	0.02
35	4450.0	2	2	0.01

UE EXCEEDED 'P' PERCENT OF TIME

[illegible] = 155.9
[illegible] = 171.1
[illegible] = 199.8
[illegible] = 248.4
[illegible] = 306.5
[illegible] = 411.4
[illegible] = 560.3

RATION CURVE STATISTICAL CHARACTERISTICS FOR ...
ATION ID: 05383000   LA CROSSE RIVER NEAR WEST SALEM, WI
RAMETER CODE = 00060

RATION DATA VALUES ARE INTERPOLATED FROM DURATION TABLE:
DATA ARE NOT ANALYTICALLY FITTED TO A PARTICULAR STATISTICAL DISTRIBUTION,
AND THE USER IS RESPONSIBLE FOR ASSESSMENT AND INTERPRETATION.

DITIONAL CONDITIONS FOR THIS RUN ARE:
ATISTICS ARE BASED ON LOGARITHMS (BASE 10).
MBER OF VALUES IS REDUCED FOR EACH NEAR-ZERO OR ZERO VALUE.

UMBER OF VALUES = 19 (NUMBER OF NEAR-ZERO VALUES = 0)
ISTING OF DATA FOLLOWS:

RCENT OF TIME VALUE UALED OR EXCEEDED	DATA VALUE	
95.0	155.9	(LOG = 2.19285)
90.0	171.1	(LOG = 2.23325)
85.0	181.5	(LOG = 2.25883)
80.0	191.1	(LOG = 2.28122)
75.0	199.8	(LOG = 2.30058)
70.0	208.5	(LOG = 2.31911)
65.0	217.9	(LOG = 2.33826)
60.0	228.0	(LOG = 2.35799)
55.0	238.2	(LOG = 2.37686)
50.0	248.4	(LOG = 2.39515)
45.0	258.8	(LOG = 2.41294)
40.0	269.2	(LOG = 2.43004)
35.0	280.0	(LOG = 2.44716)
30.0	293.2	(LOG = 2.46723)
25.0	306.5	(LOG = 2.48641)
20.0	323.3	(LOG = 2.50966)
15.0	354.1	(LOG = 2.54913)
10.0	411.4	(LOG = 2.61421)
5.0	560.3	(LOG = 2.74841)

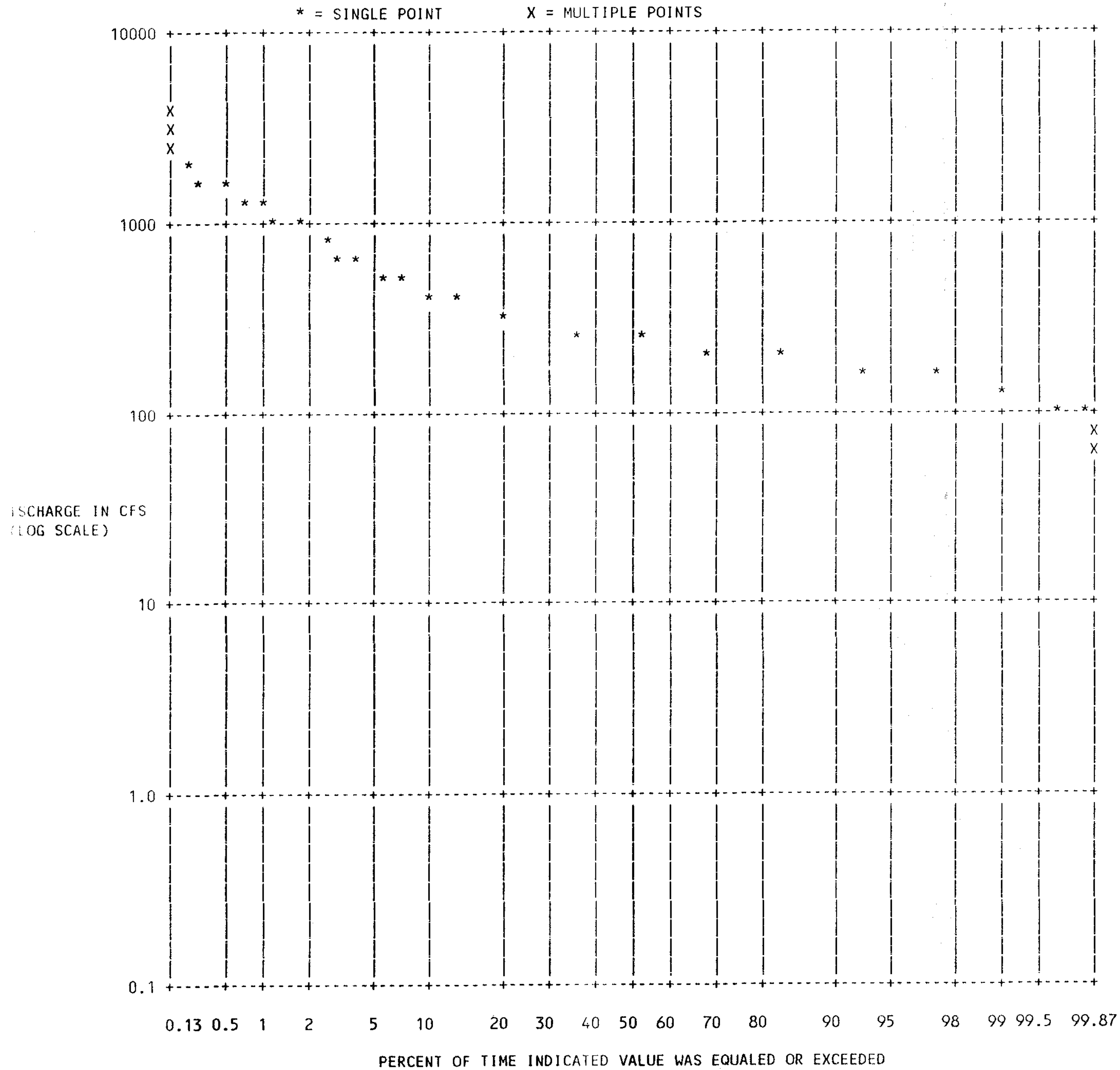
AN OF LOGS = 2.40628

ANDARD DEVIATION OF LOGS = 0.13812 (VARIABILITY INDEX - SEE USGS WSP 1542-A)

EFFICIENT OF VARIATION = 0.05740

EFFICIENT OF SKEW = 0.74280

G-NORMAL DURATION PLOT FOR PERIOD OCT TO SEP (YEARS 1914 - 1970)
ATION ID: 05383000 LA CROSSE RIVER NEAR WEST SALEM, WI DRAINAGE AREA = 398.00 SQ. MI.



PGM J407 VER 3.7
(REV 11/5/81)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.

LOG PEARSON FOR ALL WISCONSIN PEAK DATA
RUN-DATE 10/26/89 AT 1758 SEQ 1.0181

STATION - 05383000 /USGS LA CROSSE RIVER NEAR WEST SALEM, WI 1914-1978 05383000 /USGS

********* NOTICE -- PRELIMINARY MACHINE COMPUTATIONS. *********
********* USER RESPONSIBLE FOR ASSESSMENT AND INTERPRETATION. *********

INPUT DATA LISTING — EMPIRICAL FREQUENCY CURVES — WEIBULL PLOTTING POSITIONS

WATER YEAR	DISCHARGE	CODES	WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	W R C ESTIMATE
1914	1800.0		1935	8200.0	0.0169	0.0169
1915	1800.0		1978	7600.0	0.0339	0.0339
1916	1850.0		1966	5940.0	0.0508	0.0508
1917	2990.0		1956	5720.0	0.0678	0.0678
1918	3130.0		1928	5160.0	0.0847	0.0847
1919	3900.0		1945	4590.0	0.1017	0.1017
1920	2600.0		1961	4490.0	0.1186	0.1186
1921	1150.0		1933	4310.0	0.1356	0.1356
1922	2920.0		1942	4170.0	0.1525	0.1525
1923	2480.0		1946	4170.0	0.1695	0.1695
1924	2600.0		1919	3900.0	0.1864	0.1864
1925	2120.0		1934	3890.0	0.2034	0.2034
1926	1920.0		1955	3650.0	0.2203	0.2203
1927	1370.0		1967	3620.0	0.2373	0.2373
1928	5160.0		1938	3490.0	0.2542	0.2542
1929	1170.0		1930	3270.0	0.2712	0.2712
1930	3270.0		1959	3270.0	0.2881	0.2881
1931	635.0		1918	3130.0	0.3051	0.3051
1932	2380.0		1936	3020.0	0.3220	0.3220
1933	4310.0		1941	3020.0	0.3390	0.3390
1934	3890.0		1917	2990.0	0.3559	0.3559
1935	8200.0		1922	2920.0	0.3729	0.3729
1936	3020.0		1947	2900.0	0.3898	0.3898
1937	1100.0		1950	2900.0	0.4068	0.4068
1938	3490.0		1943	2790.0	0.4237	0.4237
1939	1510.0		1965	2610.0	0.4407	0.4407
1940	1140.0		1920	2600.0	0.4576	0.4576
1941	3020.0		1924	2600.0	0.4746	0.4746
1942	4170.0		1923	2480.0	0.4915	0.4915
1943	2790.0		1952	2470.0	0.5085	0.5085
1944	2150.0		1932	2380.0	0.5254	0.5254
1945	4590.0		1968	2360.0	0.5424	0.5424
1946	4170.0		1948	2300.0	0.5593	0.5593
1947	2900.0		1944	2150.0	0.5763	0.5763
1948	2300.0		1962	2150.0	0.5932	0.5932
1949	2020.0		1925	2120.0	0.6102	0.6102
1950	2900.0		1963	2060.0	0.6271	0.6271
1951	1630.0		1949	2020.0	0.6441	0.6441
1952	2470.0		1926	1920.0	0.6610	0.6610
1953	1320.0		1916	1850.0	0.6780	0.6780

-- CONTINUED --

PGM J407 VER 3.7
(REV 11/5/81)

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.

LOG PEARSON FOR ALL WISCONSIN PEAK DATA
RUN-DATE 10/26/89 AT 1758 SEQ 1.0181

STATION - 05383000 /USGS LA CROSSE RIVER NEAR WEST SALEM, WI 1914-1978 05383000 /USGS

********* NOTICE -- PRELIMINARY MACHINE COMPUTATIONS. *********
********* USER RESPONSIBLE FOR ASSESSMENT AND INTERPRETATION. *********

INPUT DATA LISTING — EMPIRICAL FREQUENCY CURVES — WEIBULL PLOTTING POSITIONS

-- CONTINUED --

WATER YEAR	DISCHARGE	CODES	WATER YEAR	RANKED DISCHARGE	SYSTEMATIC RECORD	W R C ESTIMATE
1954	1730.0		1914	1800.0	0.6949	0.6949
1955	3650.0		1915	1800.0	0.7119	0.7119
1956	5720.0		1970	1800.0	0.7288	0.7288
1957	984.0		1960	1780.0	0.7458	0.7458
1958	1310.0		1969	1750.0	0.7627	0.7627
1959	3270.0		1954	1730.0	0.7797	0.7797
1960	1780.0		1951	1630.0	0.7966	0.7966
1961	4490.0		1939	1510.0	0.8136	0.8136
1962	2150.0		1927	1370.0	0.8305	0.8305
1963	2060.0		1953	1320.0	0.8475	0.8475
1964	1020.0		1958	1310.0	0.8644	0.8644
1965	2610.0		1929	1170.0	0.8814	0.8814
1966	5940.0		1921	1150.0	0.8983	0.8983
1967	3620.0		1940	1140.0	0.9153	0.9153
1968	2360.0		1937	1100.0	0.9322	0.9322
1969	1750.0		1964	1020.0	0.9492	0.9492
1970	1800.0		1957	984.0	0.9661	0.9661
1978	7600.0		1931	635.0	0.9831	0.9831

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PGM J407 VER 3.7                     U. S. GEOLOGICAL SURVEY
(REV 11/5/81)                 ANNUAL PEAK FLOW FREQUENCY ANALYSIS        LOG PEARSON FOR ALL WISCONSIN PEAK DATA
                              FOLLOWING WRC GUIDELINES BULL. 17-B.         RUN-DATE 10/26/89 AT 1758   SEQ 1.0181

 STATION   05383000      USGS    LA CROSSE RIVER NEAR WEST SALEM  WI          1914-1978              05383000     /USGS
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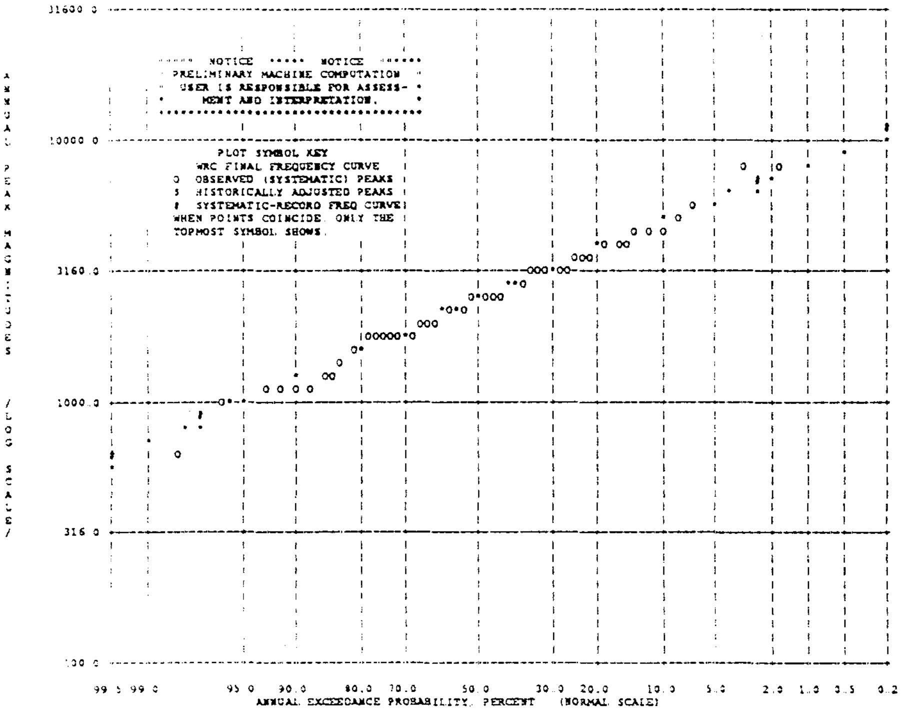


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PGM J407 VER 3.7                     U. S. GEOLOGICAL SURVEY
(REV 11/5/81)                 ANNUAL PEAK FLOW FREQUENCY ANALYSIS        LOG PEARSON FOR ALL WISCONSIN PEAK DATA
                              FOLLOWING WRC GUIDELINES BULL. 17-B.         RUN-DATE 10/26/89 AT 1758   SEQ 1.0182

OPTIONS IN EFFECT --   PLOT  NOBC  LGPT  NODB  PPOS  NORS  EXPR  CLIM

 STATION - 05386300     /USGS    NORMAN CREEK NEAR LA CROSSE, WI            1961-1988             05386300     /USGS
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I N P U T   D A T A   S U M M A R Y

YEARS OF RECORD SYSTEMATIC	YEARS OF RECORD HISTORIC	HISTORIC PEAKS	GENERALIZED SKEW	STD. ERROR OF GENERAL SKEW	SKEW OPTION	GAGE BASE DISCHARGE	USER-SET OUTLIER CRITERIA HIGH OUTLIER	USER-SET OUTLIER CRITERIA LOW OUTLIER
8	0	0	-0.400	--	WRC WEIGHTED	400.0	--	--

```
*********   NOTICE -- PRELIMINARY MACHINE COMPUTATIONS.          *********
*********   USER RESPONSIBLE FOR ASSESSMENT AND INTERPRETATION.   *********

  WCF133I-SYSTEMATIC PEAKS BELOW GAGE BASE WERE NOTED.       11    400.0
  WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION.           208.1
**WCF199W-NUMBER OF PEAKS BELOW FLOOD BASE EXCEEDS WRC SPEC.  11    400.0   7
  WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE.     8813.9
  WCF002J-CALCS COMPLETED.  RETURN CODE = 2
```

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE DISCHARGE	FLOOD BASE EXCEEDANCE PROBABILITY	LOGARITHMIC MEAN	LOGARITHMIC STANDARD DEVIATION	LOGARITHMIC SKEW
SYSTEMATIC RECORD	400.0	0.6071	2.7555	0.5916	-0.437
W R C ESTIMATE	400.0	0.6071	2.7555	0.5916	-0.422

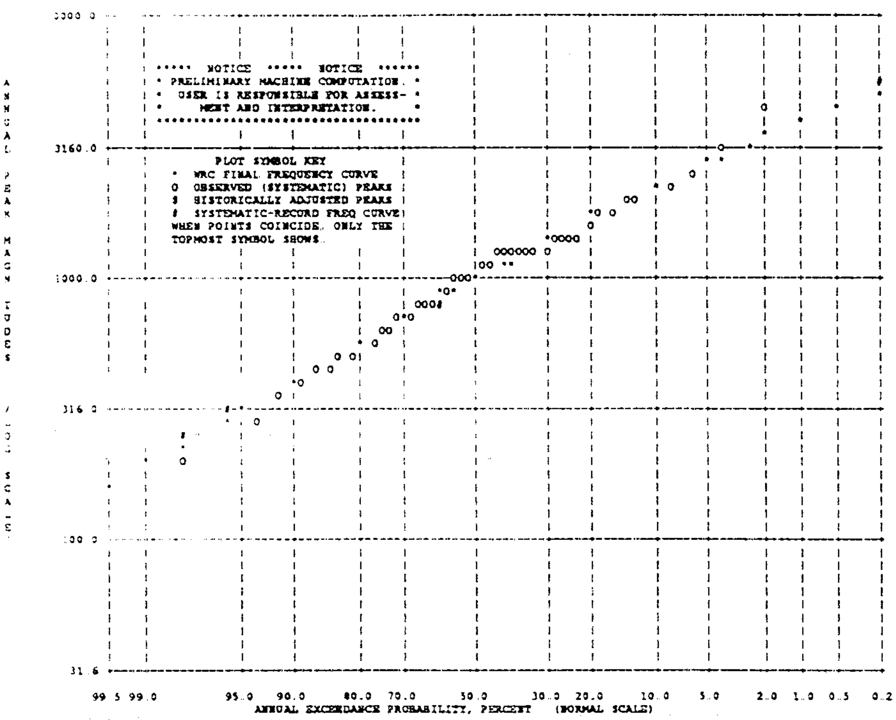
ANNUAL FREQUENCY CURVE ORDINATES -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	W R C ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR W R C ESTIMATES LOWER	UPPER
0.9950	--	--	--	--	--
0.9900	--	--	--	--	--
0.9500	--	--	--	--	--
0.9000	--	--	--	--	--
0.8000	--	--	--	--	--
0.5000	626.6	628.8	626.6	407.5	973.1
0.2000	1826.6	1827.2	1901.1	1161.6	3248.1
0.1000	3034.0	3024.5	3267.1	1842.9	5959.4
0.0400	5019.1	4978.5	5618.4	2874.3	11027.3
0.0200	6809.1	6728.0	7958.7	3745.6	16083.9
0.0100	8841.4	8702.2	10652.7	4689.2	22265.9
0.0050	11109.1	10892.0	13957.0	5699.7	29625.4
0.0020	14455.0	14100.9	19091.4	7129.6	41228.7

U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.

LOG PEARSON FOR ALL WISCONSIN PEAK DATA
RUN-DATE 10/26/89 AT 1758 SEQ 1.0180

STATION - 05382500 /USGS LITTLE LA CROSSE RIVER NEAR LEON, WI 1934-1981 05382500 /USGS



U. S. GEOLOGICAL SURVEY
ANNUAL PEAK FLOW FREQUENCY ANALYSIS
FOLLOWING WRC GUIDELINES BULL. 17-B.

LOG PEARSON FOR ALL WISCONSIN PEAK DATA
RUN-DATE 10/26/89 AT 1758 SEQ 1.0181

OPTIONS IN EFFECT -- PLOT NOBC LGPT NODB PPOS NORS EXPR CLIM

STATION - 05383000 /USGS LA CROSSE RIVER NEAR WEST SALEM, WI 1914-1978 05383000 /USGS

I N P U T D A T A S U M M A R Y

-- YEARS OF RECORD --		HISTORIC	GENERALIZED	STD. ERROR OF	SKEW	GAGE BASE	USER-SET OUTLIER CRITERIA	
SYSTEMATIC	HISTORIC	PEAKS	SKEW	GENERAL SKEW	OPTION	DISCHARGE	HIGH OUTLIER	LOW OUTLIER
58	0	0	-0.400	--	WRC WEIGHTED	0.0	--	--

********* NOTICE -- PRELIMINARY MACHINE COMPUTATIONS. *********
********* USER RESPONSIBLE FOR ASSESSMENT AND INTERPRETATION. *********

WCF134I-NO SYSTEMATIC PEAKS WERE BELOW GAGE BASE. 0.0
WCF195I-NO LOW OUTLIERS WERE DETECTED BELOW CRITERION. 547.8
WCF163I-NO HIGH OUTLIERS OR HISTORIC PEAKS EXCEEDED HHBASE. 10867.7

ANNUAL FREQUENCY CURVE PARAMETERS -- LOG-PEARSON TYPE III

	FLOOD BASE DISCHARGE	FLOOD BASE EXCEEDANCE PROBABILITY	LOGARITHMIC MEAN	LOGARITHMIC STANDARD DEVIATION	LOGARITHMIC SKEW
SYSTEMATIC RECORD	0.0	1.0000	3.3874	0.2297	-0.032
W R C ESTIMATE	0.0	1.0000	3.3874	0.2297	-0.117

ANNUAL FREQUENCY CURVE ORDINATES -- DISCHARGES AT SELECTED EXCEEDANCE PROBABILITIES

ANNUAL EXCEEDANCE PROBABILITY	W R C ESTIMATE	SYSTEMATIC RECORD	'EXPECTED PROBABILITY' ESTIMATE	95-PCT CONFIDENCE LIMITS FOR W R C ESTIMATES LOWER	UPPER
0.9950	589.4	614.9	542.4	442.4	732.8
0.9900	681.2	704.1	640.6	523.5	833.0
0.9500	1004.7	1017.4	980.0	819.9	1179.1
0.9000	1231.0	1236.6	1208.5	1033.5	1418.2
0.8000	1568.4	1564.6	1554.3	1355.7	1776.1
0.5000	2465.2	2446.8	2465.2	2196.5	2768.2
0.2000	3818.8	3811.3	3850.8	3371.2	4421.0
0.1000	4772.7	4797.4	4852.0	4147.2	5674.8
0.0400	6027.8	6124.3	6192.0	5127.7	7404.6
0.0200	6992.6	7166.2	7276.1	5859.1	8783.9
0.0100	7979.1	8250.3	8394.5	6591.4	10232.1
0.0050	8991.8	9382.3	9616.7	7329.5	11753.7
0.0020	10375.7	10959.1	11190.5	8319.5	13883.9