[Editor's Note: This partial report was written by Metropolitan Engineering circa 1993]

1. INTRODUCTION

HISTORY OF THE LAKE

Lake Tishomingo, a 120 acre man made recreational lake located in north central Jefferson County, represents a high quality residential and ecological asset to the county. The lake was laid out and platted in 1948. Shortly thereafter, construction commenced and the dam was impounding water by 1950.

The dam is 900 feet long and 55 feet high. A concrete spillway is located at the south end of the dam. The dam was built using regular construction procedures and presents no significant leakage problems. A few years ago, part of the downstream face of the dam, near the south end, developed cracks and began to slide. Stiff, impervious clay was hauled in to rebuild the area that had failed. The cracking and sliding subsided and no known problems exist at the dam.

The lake is approximately 6500 feet long, oriented in an east-west direction. A lake road, terminating at each end of the dam encircles the lake. Both lake side and second tier lots exist on each side of the lake. There are 530 lot owners holding title to 860 lots. The original developer still owns approximately 65 lots.

There are 93 families living year-round and 100 other weekend, seasonal and vacation homes at the lake. Neither public water or sewer service is available at this time, although previous attempts have been made to secure both. The lake is within the boundary of Public Water Supply District No. 11, which has been formed but has no facilities in the ground. A recent attempt to establish a sewer district at the lake was defeated.

NATURE OF THE PROBLEMS

The problems at Lake Tishomingo include the build up of silt, accumulation of sediment and the overabundance of aquatic weeds in the lake. The siltation exists primarily at the head end of the lake where water depths have been decreased by as much as 4, 5 and 6 feet. The coves, to a lesser extent, have the same problem. Because of the reduced depth, aquatic weeds have been growing in overabundance the past few years near the shore lines, in the shallow cove areas and at the head end of the lake. There are no ,trees or cat tails growing in the silted areas although grass has sprouted on an island that has been formed by the deposition of I suspended clay and sand.

STUDY OBJECTIVES

The objectives of this study are to recommend, through an in-depth study of the watershed, environmental considerations and lake characteristics, the following:

1. Methods of removing and disposition of silt from the lake.
2. Methods to control future sedimentation.
3. Methods to reduce and control aquatic growth.
4. Alternatives
5. Estimates of Cost and Financing

In arriving at objectives, the development and formulation of land reclamation and disposal evolved. Methods of sediment control examined were upstream silting basins, upstream channel control controlled sedimentation in the lake with periodic maintenance and the consideration of a high velocity channel in the creek to sweep depositions to deeper parts of the lake.

Inputs from the Home Owners Association were considered as well as those from local residents who have lived on the lake for many years and have seen the change in lake character.

The recommendations contained within this report are based upon the results of field investigations, soil and water sampling and analysis and hydrologic investigations. In addition, preliminary designs and cost estimates are based upon reasonable benefits to be achieved by and returned to the lot owners.

PREVIOUS RENOVATION ATTEMPTS

Each year the Home Owners Association draws down the lake by excavating out a plug at the spillway. The lake is lowered 4.5 to 5 feet from October thru December to give property owners the opportunity to work on their docks, sea walls and do other lake maintenance. In the past, during these drawdowns, home owners within a cove have hired an excavator to remove as much silt as possible within their cove. Two or three coves on the south shore are relatively free of silt and aquatic growth due, in part, to the efforts of those residents within the immediate vicinity.

Several attempts have been made to remove silt from the main channel at the head end of the lake. These efforts have all failed to make meaningful progress in removing the silt either because of bad weather conditions, inadequate preparation or the wrong type of equipment used by the contractor.

Previous efforts to remove aquatic growth have had only limited success. The growth is due in part to the shallow water created by the sediment and bank erosion. There has been no coordinated, sustained, long range program to attack the weed problem. At different times the Home Owners Association has contracted for lake treatment, at other times it has encouraged individual lot owners to apply a given treatment. As a result, no noticeable gains have been made in the battle against the weeds. In most areas the aquatic weed growth is greater than it has ever been.

COORDINATION WITH OTHER AGENCIES

During the preparation and development of this lake study, efforts have been made to keep the various federal, state and local agencies informed as to what we are attempting to do and to invite their cooperation. On site meetings or consultation was established with the following agencies or departments of the government.

U. S. Army Corps of Engineers
U. S. Environmental Protection Agency
Department of Housing and Urban Development
Soil Conservation Service, USDA
Missouri Department of Conservation
Missouri Department of Natural Resources

2. EXISTING CONDITIONS

LOCATION AND DESCRIPTION OF WATERSHED

Lake Tishomingo is located in central Jefferson County, Missouri, in part of Sections 4, 5, 8, and 9 in Township 41 North, Range 4 East. The lake is shown on the Belew Creek USGS topographic map. The watershed feeding the lake is rectangular in shape and is approximately 15,000 feet long and 5,500 feet wide. Water shed area is 1900 acres. See Figure 1.

The lake is approximately 6500 feet long by 750 feet wide and has 120 acres of water surface at the normal pool. The Tishomingo dam is located upstream 5000 feet on a tributary to Belew Creek. Belew Creek flows northward from the juncture point of the tributary, one mile to the Big River.

Several small tributaries forming coves on the Lake enter from the north and south although the majority of the watershed lies to the east of the Lake.

The Lake is located two miles east of Missouri Highway 21 near the AT&T transmission tower, approximately seven miles north of Hillsboro.

TOPOGRAPHY

The Tishomingo watershed varies from a lake level of 545 feet, MSL, to the high point in the eastern part of the watershed of 800 feet, MSL. The basin is rolling in the eastern parts but is quite hilly immediately north and even more so to the south of the Lake. The average slope of the main channel from the east is 1.4%. The slope of the cove watersheds on the north and south are 6.5% and 15% respectively. See Figure 5.

Close to 50% of the gentler slopes in the watershed are under cultivation or are used for pasture. The remainder, and virtually all the steeper slopes, remain wooded. An eight acre private lake is located upstream on a smaller tributary to the main creek flowing into Lake Tishomingo.

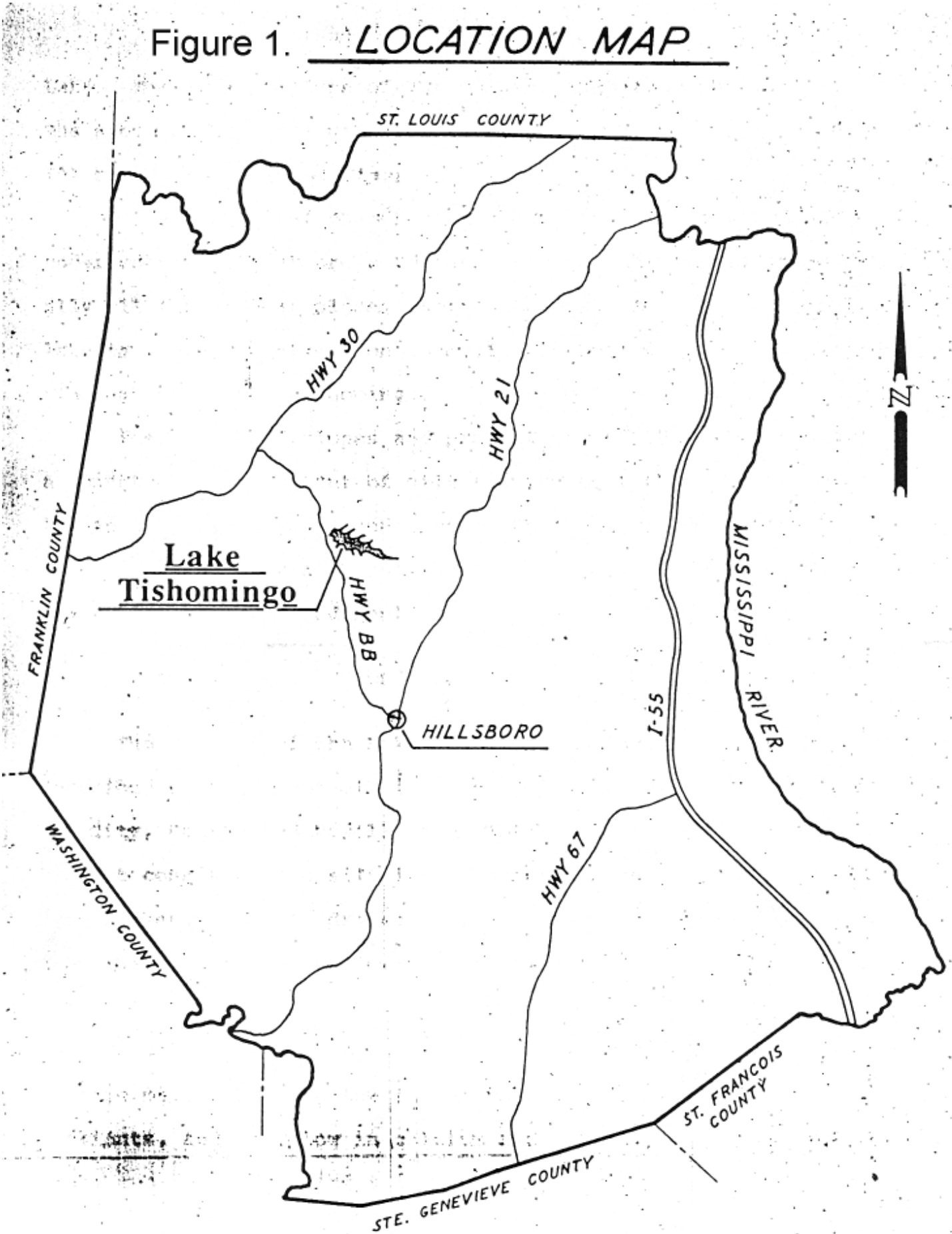
The degree of slopes and present use of the watershed are a function of the amount of silt and sediment that can be expected in the main channel and coves. Definite relationships can be recognized and accurate predictions can be made regarding runoff and the accumulation of sediment in the lake.

GEOLOGY AND SOILS

The geology of the Lake Tishomingo watershed can beat be described as a blanket of clay overlaying limestone of the Jefferson City, Cotter and Powell Formations. The generally thin clay blanket consists of a silt loam having a high sand content underlain by heavy, poorly drained clays. The clay varies from 0 to 8 feet thick with the shallower depths occurring on the slopes to the south of the lake.

“The majority of the soils are a silt loam (Plate 9) low in organic material, very low in phosphate, low in capacity to hold nutrients, and very low in calcium and hydrogen. In general, the upper two feet resembles a limestone derivation, while the lower subsoils contain more sandstone. The ridges and valleys have a deep soil mantle, but the steeper slopes are stony with frequent rock outcrops.”

Figure 1. LOCATION MAP



“The soil-geologic combinations have particular characteristics affecting construction of buildings, highways, dam , and other structures. Some areas are favorable for residential development, while others have underlying rock and soil which are more suitable for industrial construction. Certain regions have soils which swell when wet, causing pavement and foundation cracking unless safeguards such as underdrains have been installed. The clay deposits in areas of steep topography sometimes become unstable due to excess moisture causing landslides and settlement. Underlying rock strata frequently carries water from distant sources to the toe of these hills, placing moisture in soils that are not stable under moist conditions.”

“Other soils high in sand, silt, or limestone will not hold water, causing sewage lagoons and lakes to leak. Several areas developed for lake-resort development have experienced severe loss of water due to collapse of the upper soil and rock layer into caves and crevices not determined prior to construction.” (1)

(1) Comprehensive Water and Sewer Plan - Jefferson County, Missouri, Harland Bartholomew and Associates, 1970.

WEATHER CONDITIONS

Weather conditions, including the amount of precipitation, in the Lake Tishomingo basin is typical of that found in northern Jefferson and St. Louis Counties area.

Precipitation in the area occurs mostly in the spring, summer and fall seasons. Normal annual precipitation based on a thirty year average is slightly over 35 inches. As much as 68 inches has been recorded, and as little as 20.6 inches fell in 1953. April thru June traditionally bring close to 12 inches annually. Spring and summer rain usually are the result of thunderstorm activity of limited duration but high intensity, however low intensity rains or even periods of drought are not uncommon.

Rainfall intensity and frequency curves for the area are platted on Figure 2. Rainfall data for the area was obtained from the U. S. Weather Service.

WATERSHED DEVELOPMENT

At present, Lake Tishomingo watershed to the east of the lake, with the exception of the area around Lake Bo No Del, is used for agricultural purposes. Homes are scattered and there are no known developments under consideration.

A General Land Use Plan 1985, prepared for Jefferson County by Harland Bartholomew and Associates indicates the area within the watershed is designated Suburban Residential. This classification defines those areas that are some what remote from major commercial centers but are well oriented to transportation routes. Residential development, when it does occur will generate a density of one dwelling unit per 2 to 4 acres, with an ultimate population of 800 to 1000 persons per square mile of developable ground.

Should public water or sewers become a reality within the watershed, the ultimate density would remain the same and only the time period to reach it would occur sooner.

A check with the Missouri Highway Department revealed that the present Highway 21 relocation will not effect the upper watershed of Lake Tishomingo.

3. INVESTIGATIONS AND ANALYSIS

Our field investigations, observations and analysis were based upon determining the type and character of the sediment to be removed, the watershed run off and its relationship to erosion and analyzing water quality. In addition, soil test holes were made, soundings were performed and visual observations were noted.

CHARACTERISTIC OF SEDIMENT

Sediment built up in the main channel at the head end of the lake consists of a very sandy material mixed with fine clay. Thickness varies from a few inches near the shore to five and six feet in mid channel. The material appears to be well layered with 1 to 1.5 inches of fine clay mixed with organics overlaying 3 inches of much sandier clay. These alternate layers appear to go down three or four feet leaving one to believe that the sandier accumulation develops under normal water level conditions while the thinner clay and organics layer is the result of the annual draw down. The main channel silt possesses good drainage characteristics.

In the cove areas the silt material is not nearly so deep, the maximum about 18 inches, and it is an entirely different type of material. The cove silt is more of a fine yellow clay with very little sand. The cove silt exhibits poor drainage characteristics and -is very cohesive. The cove silt is much more representative of Jefferson County soil than the main channel silt.

Silt that had accumulated in the creek bed just east of the bridge was composed almost entirely of sand. An accumulation of 3 to 3.5 feet of the material had been deposited over the past year in a make shift silting channel that is working amazingly well.

The volume and extent of the siltation was determined by probing and soundings, at the head end of the lake it is estimated there is an average silt build up of 2 feet over a 20 acre water surface area. The coves are estimated at 9 inches of build up over a 5 acre surface area. Total material to be moved in a dry condition is estimated to be 71,000 cubic yards or 44 acre feet. In a wet or hydro soil condition the volume is estimated to be 143,000 cubic yards.

Assuming the material has been accumulating over a period of 25 years, the rate of build up has been nearly 2 acre feet per year.

WATERSHED CHARACTERISTICS

The relative percentages of forested lands to agricultural lands and the degree of development and construction activity in the upper parts of the Lake Tishomingo water shed appreciably affect the runoff, water quality and sediment content of the lake. As forested lands are converted to agricultural lands and further developed to residential areas the amount of runoff increases. Unless specific measures are considered and incorporated into any land use change, an increase in sediment will occur as runoff increases.

For a number of years, the Soil Conservation Service has tried -to establish districts in Jefferson County to combat the same problems the lake residents are fighting — that is the curbing of erosion and the establishment of soil conservation practices. Each time the local citizenry cast their ballots against the formation of a district, soil erosion continues unabated. The cheapest and most effective method to reduce upstream runoff and to slow down erosion is to seed all open fields and construct small silting basins. Both practices are advocated by the Soil Conservation Service.

Good design ratio between a contributing watershed and a downstream impoundment in this area should be in the realm of 10:1 to 15:1. This ratio has proven to minimize dam failures due to wash outs, provide a large enough impoundment to absorb expected rains and to provide the proper-amount of water changes to maintain a desirable level of fish life. Lake Tishomingo has been well designed in this respect, its 1900 acre water shed and 120 acre water surface yield a 15:1 ratio.

Annual rainfall and the accompanying runoff affect the ability of the lake to maintain a stable surface elevation. Average precipitation, as discussed earlier is 35 inches per year. The yield or long term runoff from a normal year of rain, snow, transpiration and evaporation for the watershed is approximately 8 inches, which is equivalent to 1200 acre feet. If an average water depth of 10 feet is assumed, the lake volume would be 1200 acre feet. Therefore should the lake need be drained an average precipitation year would be required to refill it. During the initial filling of the lake, troubles arose due to the reason that years 1952, 1953 and 1954 all had below average rains. Weather bureau records indicate that in 1953 only 20.6 inches of precipitation fell, the lowest recorded in 40 years.

The Tishomingo water shed is free of flooding both from a backwater flood from the Big River and from a headwater flood from upstream.

FIELD TESTS AND OBSERVATION

Field tests made at the lake include test holes at selected locations, steel rod probings, water samplings and bottom soundings. Test holes were made with a conventional post hole digger in the parking area and on the dewatered silt that was exposed when the lake was drawn down 4.5 feet. Test holes on the filled parking area provided information relative to the type of soil, its compaction and, the depth of ground water. Test holes in the exposed silt provided information relative to the composition and layering effect exhibited and to the ability, of the material to drain.

Steel rod probings were made in the exposed silt areas in the coves as well as at the head end of the lake. Average depths of the accumulated material were obtained to help determine the volume of silt.

Soundings were made from a boat across the eastern end of the lake. The lake was cross sectioned at 200 foot intervals and soundings were taken at the quarter points on each cross section. Sounding information was used to determine the approximate contour of the lake bottom as well as to help determine the volume of silt to be removed.

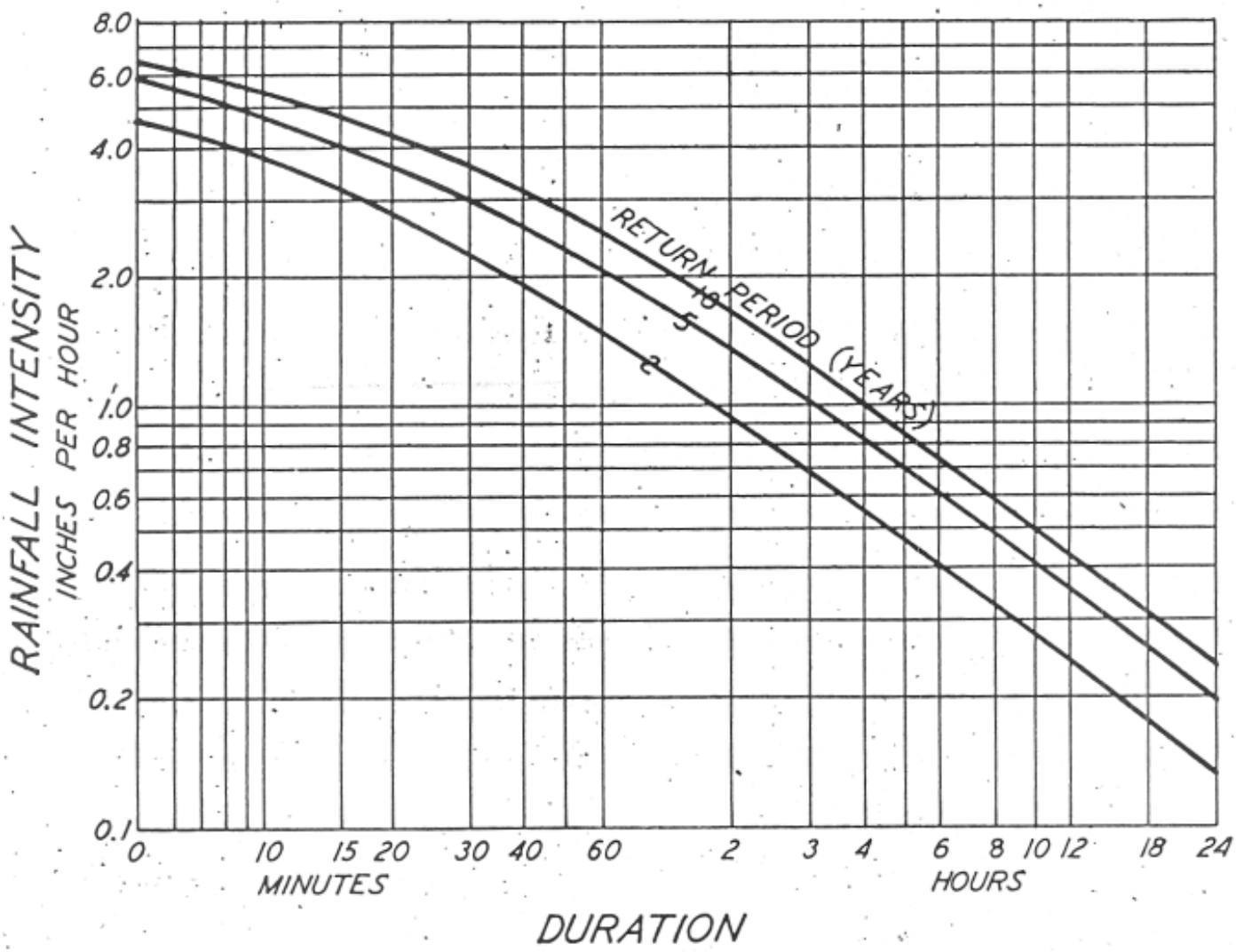
Gallon samples of water were taken from the “head end”, “center”, and “near dam” areas of the lake. The samples were delivered to Analyst Consulting Laboratories at Festus, Missouri, for chemical and bacteriological analysis. The test results, as well as the laboratory’s interpretation thereof, are in the APPENDIX.

The water analysis indicated a high degree of pollution in the lake. Although the study of and possible need for sewers were not a part of this report, we would be remiss in not pointing out that regular lake water monitoring should be a high priority item.

AQUATIC WEEDS

Aquatic weeds flourish wherever the water remains relatively still and wherever surface runoff increases the nutrient level to create a desirable environment. The runoff from roadways, roofs, lawns and agricultural-areas are all contributing causes to a change in water chemistry and the level of nutrients in the lake. Aquatic weeds foul pumps, wrap around boat propellers, clog docks detract from the beaches and seriously restrict boating, fishing and lake enjoyment.

Figure 2. *RAINFALL INTENSITY AND FREQUENCY CURVES FOR JEFFERSON COUNTY, MISSOURI*



Removing the lake silt will go a long way in combating the weed problem. Mechanical harvest would in effect be taking place in addition to deepening the shallow water areas. Weeds experience difficulty in growing and spreading in water over 4 feet deep.

With the assistance of W. G. Malone from Marine Biochemists Inc., the aquatic weeds were identified as being primarily Chara, an attached algae type weed and Coontail, a rooted submersed weed. In addition to Chara and Coontail there are smaller amounts of pondweed and duckweed present in the cove areas. Chara, being an algae, must be treated differently from the higher order type plants and weeds that are present. Long term affective abatement of Chara must include nutrient removal and regular application of the proper chemical treatment.

The higher order aquatic weeds are more easier controlled. A combination of lake deepening, weed harvest and chemical treatment will effectively control these types of weeds.

Considerations that have been made with respect to chemical weed control include:
1. Toxicity to human and fish life.
2. Wave action and dispersal.
3. Required set or waiting period.
4. Frequency of application.
5. Undesirable after effects:
 a. Swimmer's itch
 b. Depletion of dissolved oxygen
 c. Nuisance floating debris

A proposal to chemically treat the lake has been submitted by Marine Biologists and is included in the APPENDIX.

FISH LIFE

There are many fishermen within the 530 lot owners at the lake. Any lake renovation project must take into consideration their interests in preserving Lake Tishomingo as a desirable place for fishing.

Mr. Kenneth R. Perry, a fishery biologist from the Missouri Department of Conservation, has indicated that the lake population is made up primarily of bass, channel cat, blue gill and green sunfish. He further indicated that should the lake be lowered for renovation purposes, one year of fish reproduction would probably be lost. This loss would not materially effect the fishing conditions and the long-range benefits of lake renovation to the fish population would far outweigh the loss of one year of fish production.

Mr. Perry further indicated that should the lake be lowered 15 feet for lake renovation, enough food would exist in the remaining pool to support the current population. Oxygen depletion will not create any fishing problems in the lake.

4. SEDIMENT REMOVAL AND ESTIMATED COSTS

Two methods of silt removal were considered and evaluated as a part of the lake study. The material can be removed either by a floating suction dredge or by conventional earthmoving equipment using dozers and scrapers. A drag line operation was briefly considered but was dropped due to the nature of the shore line, and the width of the lake.

FLOATING SUCTION DREDGE

The use of a floating suction dredge represents the cleanest, and from an esthetic point of view, the most desirable method to remove lake bottom deposits. The lake need not be lowered, practically full use of the lake is available for recreation and fish are not greatly affected by the operation. The lake bottom is free of tree stumps, large rock formations and refuse which are important factors for a successful dredging project.

Two types of floating dredges were considered. The horizontal mounted auger type manufactured by Mud Cat and the more conventional hydraulic cutterhead dredge which is presently being used to dredge Creve Coeur Lake in St. Louis County.

The Mud Cat can operate in 27 inches of water and cuts a path 8 feet wide as it pulls itself along a guide cable anchored on the opposite bank. The Mud Cat does not cut into the original lake bottom but only removes the silt and underwater sediment that has accumulated. The Mud Cat will remove material from a depth of 10.5 feet. Should greater depths be encountered, either the lake can be lowered or bigger models are available. Mud Cat leaves bottom contours even and ridge free without danger of breaking the bottom seal. A high powered centrifugal pump feeds the bottom material thru an 8 inch discharge line to a spoil area. In addition to the machine operator, a helper would be required for guide cable and discharge line moves, repair and general maintenance both on the equipment and at the spoil area.

The hydraulic cutterhead type dredge has been used successfully in many lakes and ponds. It is usually bigger, takes greater skill and manpower to operate and has a much higher production rate than the Mud Cat machine., A cutterhead dredge maneuvers by the use of spuds and usually requires a work boat on the site. A cutterhead dredge would not give the uniform and ridge free bottom that a Mud Cat would produce.

Close, convenient disposal sites are a must for either type of dredge. At the very least a 10 acre site is the minimum that could be considered. Mr. Leo Kley, the owner of 120 acres immediately east of the Lake has several sites that would provide good spoil areas. The owner has indicated the land is neither for sale nor lease and furthermore, he would not consider the use of his land for a spoil site. Due to the topography of the lake's watershed, the next best disposal sites would be below the dam on property owned by Horn Real Estate Company. Mr. Horn has been contacted and has expressed an interest in leasing the property for a spoil site. Mr. Horn's proposals to lease the land were:
1a. Horn be given title to Lot K-55 or K-56 which is contiguous to the 120 acres that he owns.
1b. All fences that are disturbed due to the hydraulic fill operation must be replaced.
2a. Horn be reimbursed for a years loss of a cash crop that could have been produced from the spoil area. Horn's estimate was from $3,000 to $4,000.
2b. Same as 1b.

Because the distance of the Horn tract from the upper reaches of the lake is 6300 feet, a booster pump would be required for a Mud Cat. The cutterhead would not require a booster. However, both units would require 6500 lineal feet of floating discharge pipe.

CONVENTIONAL EXCAVATION

Opposed to the dredging of wet material from the lake bottom, the lake can be lowered to expose the material, and remove it with conventional excavating equipment. The lake would need to be lowered 15 feet and permitted to dry for several months prior to attempting to remove the silt. A combination of dozers, high-lifts, trucks and scrapers could be used to remove the material.

Again, spoil sites must be made available. In this case the spoil area would be the parking area at the east end of the lake and a peninsula that would protrude into the lake from the parking area. See Figure 3. Using conventional excavating equipment and constructing a peninsula, fewer cubic yards of material would be moved a much shorter distance than that required by the suction dredge. Figure 4 shows a typical cross section through the peninsula.

After thoroughly draining and compacting, the fill area could again be used for parking. Slope protection would extend on all three sides of the peninsula extending from one foot above normal water level to two feet below. Side slopes would be 1:4 with 3 feet of freeboard.

Based upon experience at another lake project in Jefferson County, the lake would have to be lowered for at least a nine month period to permit the material to drain. From soundings of the lake bottom, lowering the water level 15 feet should expose most of the silt. That which is at a deeper level in some of the coves and in the deeper parts of the original channel will have to be left undisturbed should this method of silt removal be considered.

Should the level be lowered 15 feet, a normal year of precipitation should easily refill the lake to normal level. Both rainfall intensity and frequency curves and information from the Weather Bureau confirm this point.

To dry excavate the lake bottom the lake must be drawn down 15 feet and permitted to dry out. The lake level can be lowered either by cutting down the spillway to the required level or by installing a siphon. Due to the presence of rock, the depth of cut necessary and the inherent risk when breaching and repairing a 15 foot cut in any dam, a siphon should be used to lower the lake. The siphon should be erected as a permanent structure to permit future lake drawdowns without the need to breach the spillway.

ESTIMATED COSTS

Estimated costs were derived from equipment suppliers, local excavators and from the dredging operation underway at Creve Coeur Lake. To hold down costs it was assumed, for estimating purposes, that the lake would purchase their own suction dredge, hire the necessary help and carry out the project over a 2 year period. At the end of the project the equipment would be sold. In the case of the conventional excavation method it was assumed that the entire project would be contracted out to the low bidder.

MUD CAT METHOD

Dredge	$75,000
Booster Pump	18,000
6500 L.P. Discharge Piping cable, fittings, etc.	55,000
Spoil Site Lease	6,000
Operator 65 weeks	26,000
Helper 40 weeks	11,200
Dozer 10 weeks	12,000
Spoil Area Spillway	4,000
Fuel	6,000
Sub-total	$213,200
Contingency 15%	30,000
Sub-total	$243,200
Equipment Resale 50%	71,200
TOTAL ESTIMATED COSTS	$172,000

Cost per Cubic Yard $172,000 / 142,000 cu.yd. = $1.21

5. SEDIMENT CONTROL

To only remove sediment from the lake is half the job. The remaining half is to try in some manner to control or retain the inflow of additional sediment from upstream in the major watershed to the east and to a lesser extent to do the same at the smaller watersheds at each cove along the north and south shore.

The large boulders that have been placed in the incoming creek immediately upstream of the bridge are providing an extremely effective sediment drop out structure. The boulders are loosely placed to permit the flow of water through them at a reduced velocity to enhance the settling out of sand and silt. Material as deep as 3 feet has been excavated from the upstream side of the boulders that would have been carried on into the lake.

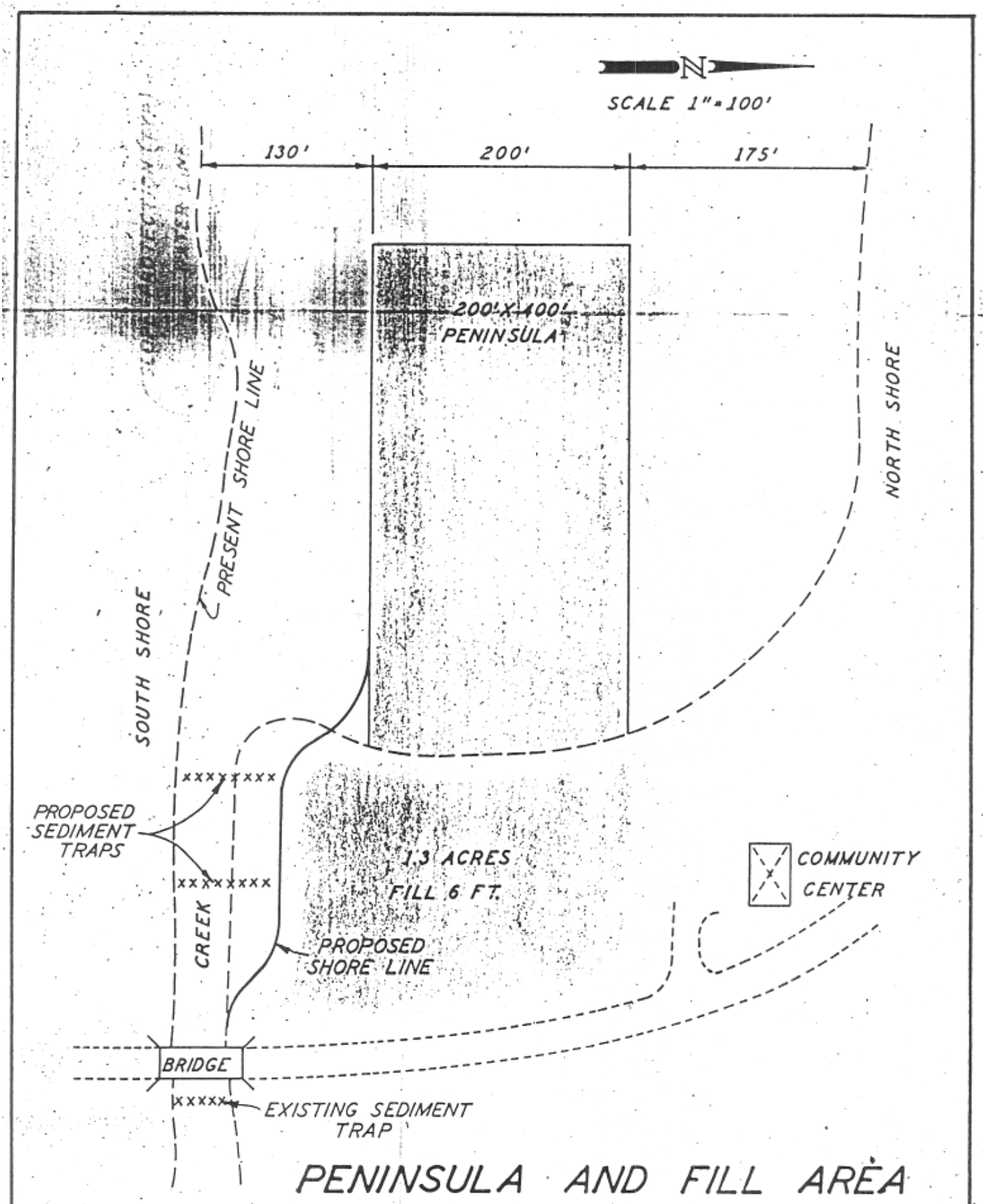
Widening the creek bed west of the bridge and placing two similar sized rock barriers across the channel should improve even more the settling out capacity of the inlet creek. See Figure 3.

Ideally sediment should be controlled in the upper reaches of the water shed by a combination of proper land use management and retention basins. This is what the Soil Conservation Service attempts to establish. Unfortunately, the S.C.S. has not been permitted to exercise conservation measures in Jefferson County. The track of land directly east of the bridge would make an ideal site for a settling or retention basin. Several small contributing watersheds along the north and south shore line possess the capability to construct a small retention or silt basin within the platted limits of the lake property. These smaller basins would tend to keep the cove areas from silting up as rapidly as they do.

6. RECOMMENDATIONS

After extensive investigation of the many facets of the lake renovation and having many interviews with various lot owners, contractors, government offices and outside consultants the following recommendations are herein made:

1. Lower the water level 15 feet from normal level with a 24 inch siphon.
2. Contract for silt removal by the use of conventional excavating equipment.
3. Widen the inlet creek and erect rock barriers for a silt trap.
4. Construct settling basins within those coves on second tier lots that have the Lot Owner’s consent.
5. Purchase land immediately east of the lake whenever it comes on the market.
6. After silt removal has been complete, chemically treat the lake on a regular basis for weed control.
7. Obtain water samples from selected coves and locations on the lake for laboratory analysis on a regular 6 month basis.
8. Work closely with Department of Conservation personnel regarding the lowered lake level and any unforeseen effects it may have on fish life.
9. Submit an Environmental Protection Agency application kit for a construction grant.



PENINSULA AND FILL AREA
LAKE TISHOMINGO

Figure 3.

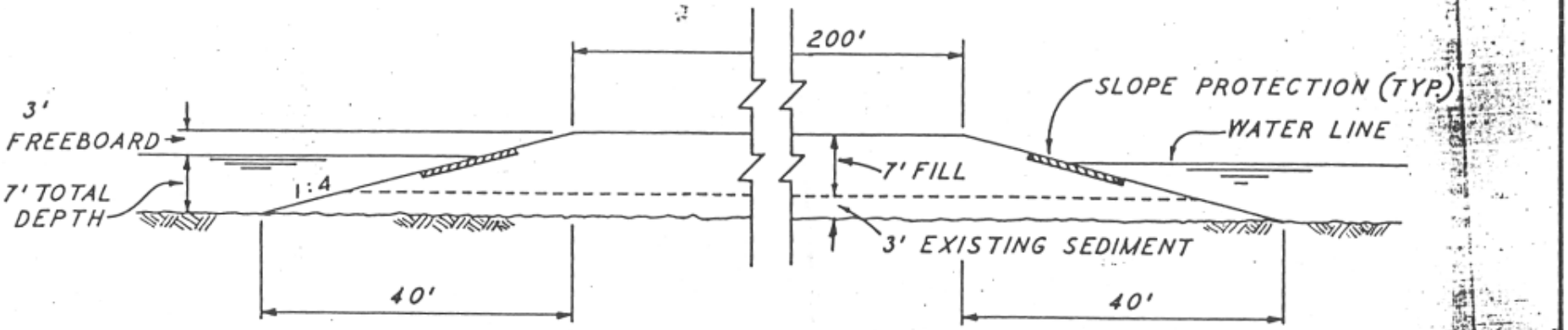


Figure 4. *TYPICAL SECTION THRU PENINSULA*

LAKE TISHOMINGO