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REPORT ON INVESTIGATIONS FOR

IMPROVEMENT PROGRAM FOR WHITE ROCK LAKE PARK

1971

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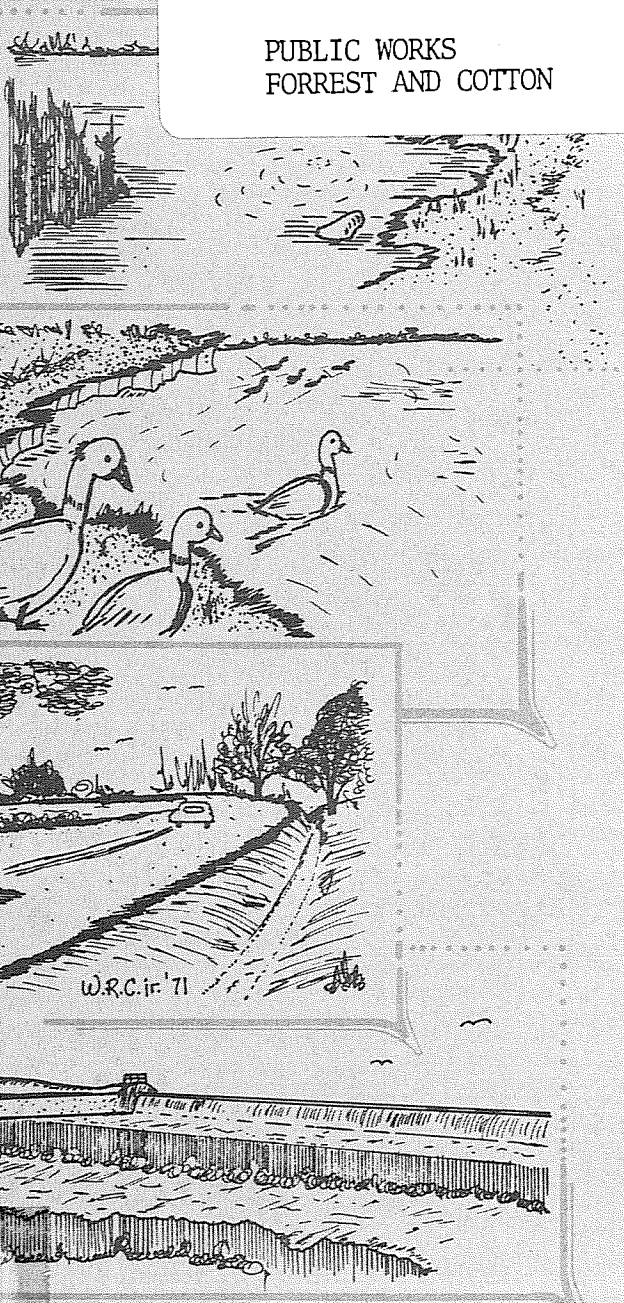

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AUGUST 1971

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August 18, 1971

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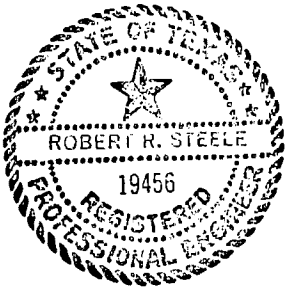
Mr. L. B. Houston, Director
Park and Recreation Department
City of Dallas
406 City Hall
Dallas, Texas 75201

Mr. H. H. Stirman
Director of Public Works
City of Dallas
512 South Akard
Dallas, Texas 75202

Gentlemen:

Attached is our report on "Investigations for Improvement Program for White Rock Lake Park," which has been prepared in accordance with our contract dated August 31, 1970. The report presents the results of our investigations and studies, including alternative improvement plans, and contains recommendations for improvements required for optimum utilization of the park in future years. Our investigations included analyses of the interrelationship of the existing ecological system, sediment accumulation in the lake, the use of the lake for water supply, pollution of the lake, the future water and sanitary sewer lines in the area, the movement of traffic in and around the park, and drainage and flood control problems.

The estimated construction costs of the recommended improvements, which vary from a minimum of $2,897,000 to $5,243,000, are based on 1971 price levels. Consequently, allowances should be made for the continuing escalation of costs in accordance with the schedule adopted by the City for the construction planned.



Very truly yours,

Robert R. Steele

Robert R. Steele, P.E.
Project Manager

George M. Parker

George M. Parker, P.E.
Chairman of the Board

REPORT ON INVESTIGATIONS FOR

IMPROVEMENT PROGRAM FOR
WHITE ROCK LAKE PARK

PARK AND RECREATION BOARD

DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

FORREST AND COTTON, INC.
CONSULTING ENGINEERS
DALLAS, TEXAS

AUGUST 1971

REPORT ON
INVESTIGATIONS FOR IMPROVEMENT
PROGRAM FOR WHITE ROCK LAKE PARK

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D	Soils and Foundation Investigation, Proposed Improvements, White Rock Lake Spillway, by National Soil Services, Inc.

WHITE ROCK LAKE AND DAM

CITY OF DALLAS, TEXAS

PERTINENT DATA

1. LOCATION

The White Rock Lake Dam site is located on White Rock Creek about 10 miles above the confluence of the stream with the Trinity River. The dam and reservoir are entirely within Dallas County, about five miles northeast of Dallas City Hall.

2. PURPOSE

Water supply and recreation.

3. DRAINAGE AREA

100 square miles at the dam site.

4. ESTIMATED ANNUAL RUNOFF AT DAM SITE, 1949 TO 1969

	Ac-Ft.	Inches
Maximum (1957)	118,888	22.28
Minimum (1956)	6,124	1.15
Average (21 years)	48,024	9.00

5. ESTIMATED ANNUAL NET LAKE EVAPORATION, 1949 TO 1969

Maximum (1956)	5.06 ft.
Minimum (1957)	1.11 ft.
Average (21 years)	2.76 ft.

6. SERVICE SPILLWAY

Length	450 feet
Crest Elevation	458.0
Type	Uncontrolled Weir

7. RESERVOIR

Top of Dam Elevation	467-468 feet (msl)
Lake Bottom Elevation	434 feet (msl)
Storage Capacity at Spillway Level	10,743 acre-feet
Surface Area at Spillway Level	1,119 acres

REPORT ON
INVESTIGATIONS FOR IMPROVEMENT
PROGRAM FOR WHITE ROCK LAKE PARK

I - INTRODUCTION

1-01. General. This report has been prepared in accordance with a contract dated August 31, 1970, between the City of Dallas and Forrest and Cotton, Inc. (Resolution No. 70-3708) covering investigations, studies and recommended improvements for White Rock Lake Park.

1-02. White Rock Lake was used as the primary source for water supply for the City after it was completed in 1911 until Lake Dallas was placed in service in 1930, but then lost its importance as a water supply because of the much larger supply available from Lake Dallas. Since 1930, the lake has been used primarily for recreation but during the severe drought of the fifties equipment was reinstalled at the water plant at the lake and water was used from this source. After the drought, which ended in early 1957, use of the lake for water supply was continued during the summer months of each year until 1964. Although the lake is used now primarily for recreation, it provides a reserve water supply for use during unforeseen emergencies. The lake is also effective in the reduction of peak flows downstream from the dam during floods.

1-03. Roads around the lake provide a scenic drive for sightseers, and park facilities are provided for various recreational activities. The eastern shore of the lake provides the greatest area for recreational use with boating facilities operated by sailing clubs, picnic areas, fishing spots and playground facilities. The public areas along the western shoreline are more limited in size but are also used extensively by the public. The park land north of Mockingbird Lane is largely wooded with heavy undergrowth and swampy areas which provide a natural habitat for birds and small animals. Private property adjacent to the City-owned property is highly developed and is used extensively for residential purposes. Many of the existing park improvements were provided by the Civilian Conservation Corps program during the 1935-42 period during which time privately owned camp houses, boat houses and other facilities were removed and public shelters, community buildings and roadway improvements were constructed. A dredging program from 1937 to 1941 removed silt from swamps, restored beaches, and created additional park lands.

1-04. White Rock Lake Park is a popular attraction with about 8,000,000 people having visited the area in 1970. The lake and park have proven to be of economic value in maintaining property values of surrounding neighborhoods and are an integral part of the City's planned open space program. The public's use of the park can be expected to increase in future years, and additional park area and general park improvements, including facilities for the safe movement of vehicular traffic, bicycle paths, hiking trails, boat docking and fishing piers are needed to help meet the public's demands.

1-05. In view of the many public benefits attributable to the lake and park, there is no uncertainty in concluding that expenditures of public funds in maintaining and improving these facilities are justified. However, the high degree of development and continuing urbanization in the upstream watershed and outlying areas require the construction of new facilities for public and private use and the operation and maintenance of facilities that affect and are affected by the lake and its maintenance. Consequently, the wise expenditure of public funds requires that these problems be recognized and that a coordinated, balanced approach be taken to the operation and maintenance of the existing facilities and the construction of new facilities to serve the area by the City of Dallas and/or other governmental agencies.

1-06. It is anticipated that the public will be concerned over possible detrimental effects to the environment and/or ecologic systems by any maintenance and improvement activities proposed, and reasonable answers must be provided if worthwhile programs are to be completed without undue delay. The deposition of sediment is decreasing the life of the lake and is also aggravating the drainage and flood problems in areas adjacent to the lake, particularly at the Northwest Highway Crossing over White Rock Creek, the Buckner Boulevard-Northwest Highway intersection, and the Buckner Boulevard Crossing over Dixon Branch. The flood problem is aggravated further by the continuing urbanization of the upstream watershed which causes a greater volume of flood runoff and higher peak flows. The increased flood flows result in higher lake levels, a more frequent flooding of road crossings and blocking of drainage facilities, and decrease the structural safety of the dam and spillway. The upstream urbanization also results in a pollution problem caused by waste discharges and storm runoff which must be recognized in connection with the future utilization of the lake.

1-07. The lake has influenced the location of traffic arteries serving the area and vehicular traffic between downtown Dallas and the area northeast of the lake is routed around the lake. While the extra distance travelled is not of major consequence, traffic on Garland Road and Northwest Highway is greater because of the location of the lake and is expected to increase as time passes. Consequently, the question arises as to the need for an additional

roadway and bridge across the lake and possible alternatives and the effect such construction would have on plans for the park. The location of the lake has also controlled the alignment of water and sewer lines and other utilities which serve the area and in over-all planning, the future requirements for these facilities should be considered.

1-08. Scope of Report. This report presents the results of investigations and studies made to develop a plan for improvement for White Rock Lake Park and other public facilities directly related to such development. The investigations and studies included:

a. An ecological study by Dr. J. K. G. Silvey of North Texas State University to determine the effect that sediment removal from the lake would have on the ecology of the lake;

b. A sediment survey by the U. S. Soil Conservation Service to determine the amount of sediment that has been deposited in the lake;

c. Analysis of sediment to determine its physical properties and foundation investigations at the dam by National Soil Services, Inc.;

d. Flood control and drainage investigations to determine the flood potential of the watershed and the effect that the lake level has on drainage of areas adjacent to the lake and tirbutary streams;

e. Conferences with the City Planning Department and the Traffic Control Division to determine the possible need for an additional road crossing over White Rock Lake and/or the probable need for an additional thoroughfare on park land;

f. Future requirements for additional sanitary sewer and water lines that might affect or be affected by White Rock Lake Park improvements;

g. A determination of the water supply potential of the lake;

h. A pollution survey to determine locations of upstream waste water discharges and the present water quality of the stream; and

i. The development of preliminary plans for sediment removal from the lake; spillway and dam improvements; drainage improvements for Dixon and Jackson Branches; and general improvements for the park.

1-09. Source of Data and Acknowledgments. Previous reports and data utilized included:

a. Sediment Survey, July 1928, by T. U. Taylor and Major W. J. Powell;

b. U. S. Soil Conservation Service Sediment Surveys of 1935 and 1956 and its 1950 report, "Flood Control Work Plan, White Rock Creek Watershed";

c. Report on siltation of White Rock Lake in 1936 by Mr. A. P. Rollins, Director of Public Works, City of Dallas;

d. Report on Drainage Improvement Studies, Lower White Rock Creek, 1965 - prepared for the Department of Public Works, City of Dallas, by Forrest and Cotton, Inc.

e. Report on Drainage Improvement Studies, Upper White Rock Creek, 1965 - prepared for the Department of Public Works, City of Dallas, by Forrest and Cotton, Inc.

f. Stream flow records and miscellaneous flood data furnished by the U. S. Geological Survey;

g. Rainfall records from the U. S. Weather Bureau;

h. Master Plan Committee for the City of Dallas 1957 and 1965 reports on "Thoroughfares" and its 1959 report on "Parks and Open Spaces";

i. U. S. Geological Survey topographic maps and topographic maps furnished by the Dallas Park Department and the Department of Public Works.

Plans of existing improvements were furnished by the Department of Public Works, the Water Utilities Department, and the Park Department. The City Health Department obtained water samples from 13 upstream locations on White Rock Creek and tributaries, and furnished results of tests of the samples taken over a five month period. The City Planning Department and the Traffic Control Department were most helpful in discussions concerning the traffic problems of the area.

1-10. We wish to express our sincere appreciation for the fine cooperation extended by representatives of the various City Departments and others in furnishing information for these studies.

II - ECOLOGICAL STUDY

2-01. General. White Rock Lake Park affords a fish and wildlife habit that is enjoyed by tens of thousands of visitors to the park each year. A stable, well-balanced fish population exists in the reservoir, particularly in the south end where the water is deepest. The open-water areas of the lake are used by gulls, terns, and numerous resting waterfowl. The marsh area at the north end harbors significant numbers of puddle ducks and shore birds, and, although semi-aquatic mammals are uncommon, there have been sightings of such animals as swamp rabbit, nutria and beaver.

2-02. The effect that a silt removal program at the lake might have on the ecological system has been a matter of great concern and can be a major factor in determining the feasibility of such a program. To establish a basis for predictions on pertinent effects of a silt removal program, an ecological study of White Rock Lake was made in February 1971. This study was made by the Institute for Environmental Studies, North Texas State University, and was under the direction of Dr. J. K. G. Silvey, Director of the Institute and Chairman of Biology at North Texas State University. The report made on the study is included in the back of this report as Appendix A. A condensation of the major topics of the report, together with conclusions and recommendations, are presented in the ensuing paragraphs. Supplemental information to the ecological study regarding the projected effects of dredging on fish production is presented in paragraph 2-26.

2-03. Hydrographic Survey. In order to obtain a comprehensive picture of bottom contours and sedimentation patterns, a number of strategically located transects of the lake were run by boat. Bottom depths were monitored with a depth sounder. Results of these measurements have been combined and are presented as an estimation of the lake bottom morphology on Figure 1. As indicated by the map, the mid-regions of the lake are relatively flat with a gradual increase in depth from north to south. Expansive shallow "shelves" have been deposited in the areas where White Rock Creek and Dixon Branch enter the lake.

2-04. Lake Sampling and Analysis. Shown on the map on Figure 1 are ten circled numbers. The numbers indicate the depth of water, and the circles indicate the locations of sampling stations where samples were taken of lake water and bottom sediments for

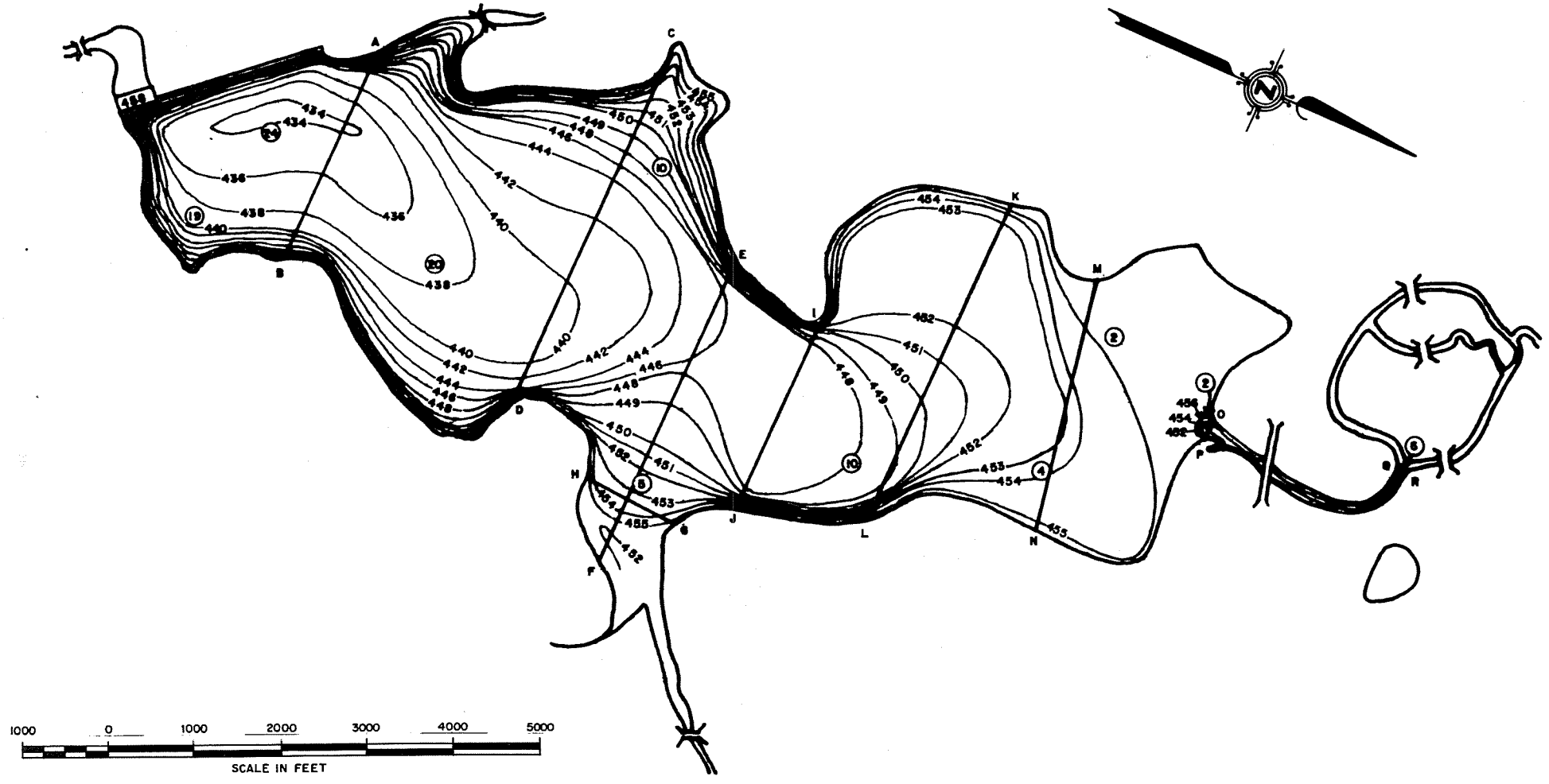


Figure 1. *Bottom Morphology and Station Depth Measurements*

The transect positions are indicated by straight lines lettered at the ends. The circled numbers are station depths. Contours by Institute for Environmental Studies.

analysis. Physical and chemical analyses made included dissolved oxygen, temperature, alkalinity, pH, total hardness, phosphorous, nitrates, iron, manganese, inorganic and organic carbon, and turbidity. Biological analyses included sediment oxygen demand, plankton identification and enumeration, and a potential algae growth assay.

2-05. Results of the physio-chemical analysis of the sediments indicate that although the sediments are rich in potential nutrients, most of these ionic constituents are firmly bound. Thus, the sediments evidently act as a nutrient *sink* for the lake. This is further exemplified by the results of the nutrient exchange analysis. Phosphates and nitrates are apparently adsorbed from the water by the sediments.

2-06. The nutrient sink phenomenon is further evidenced by the high nitrate and phosphate content of White Rock Creek water entering the lake and the much lower content of the nutrients in lakewater. It appears that although the White Rock Creek water is rich in algal nutrients, these nutrients are closely associated with the suspended solids either biologically or electrostatically. As these suspended particles settle out they carry the majority of nutrients entering White Rock Lake to the bottom.

2-07. Results of the potential growth assay indicate that a large increase in algae following dredging is unlikely. In disturbing the sediments it appears there will be very little increase in soluble nutrients and subsequent increase in algal populations.

2-08. The plankton analysis of the lake water samples shows a relatively good population density. From the plankton analysis and the results of several of the previously mentioned investigations it appears unlikely that dredging operations will be detrimental to the algal community structure or productivity of the lake.

2-09. Fisheries Analysis. White Rock Lake sustains an important, urban recreational fishery. The typical fisherman uses bait, fishes from shore, and is either a local resident unable to travel great distances to enjoy his sport, or fishes incidentally in conjunction with other park activities. Many families, for example, picnic in the afternoon and then fish for a short while in the evening before returning home. The principal species sought are white crappie, yellow bass, channel catfish, and sunfish.

2-10. Creel census data supplied by the Texas Parks and Wildlife Department indicated that 49,343 fishermen harvested 19,511 pounds of fish from the lake in 1970. Catch rates were highest in April (1.49 fish/hour) and lowest in November (.09 fish/hour). A commercial fisherman harvested 11,000 pounds of rough fish (principally smallmouth buffalo) from the lake in November 1970.

2-11. Results of a seining and netting operation conducted to determine resident fish populations, age, growth, condition and balance, indicate that a stable, well-balanced fish population exists in the reservoir, particularly in the deep southern end of the lake. White crappie and channel catfish are the most abundant sport fish. The northern end of the lake is populated primarily by rough fishes. Detailed results of the seining operation are tabulated in Appendix A.

2-12. Aquatic Vegetation. White Rock Lake supports only a few common varieties of vascular plants. A few specimens of frogbit and American lotus were collected. Filimentous green algae cover the bottom in water less than 2 - 3 feet deep at the north end of the lake. Scattered patches of *Chara* were also found in this area.

2-13. Emergent vegetation is also rather sparsely distributed about the margin of the lake. On the east, west, and south shores of the lake only scattered clumps of the great bulrush are found. The marshy areas at the north end of the lake have more extensive growths of bulrush as well as moderately dense stands of 1 - 4 feet high willow shoots. Several species of smartweed are also found growing in the marsh area.

2-14. Several long-time residents of the area and employees at White Rock Park recalled that during the 1950's and early 1960's there were extensive growths of bulrushes all around the lake. Park employees believe the bulrushes began disappearing at about the same time that nutria began invading the lake. After exhausting the emergent vegetation the nutria population declined.

2-15. Vertebrates of the Shore and Marshes. The open areas of the lake serve as resting and feeding areas for several species of migrating diving ducks (canvasbacks, scaup, etc.), ring-billed gulls, and terns. The edges of the lake and the marsh areas harbor a greater variety of aquatic and semi-aquatic vertebrates.

2-16. Vertebrates observed during investigations included cotton rats, nutria, and swamp rabbits at the north end of the lake. Park employees reported sighting an occasional beaver in the area within the last year. None of these are present in large numbers, but the opportunity to view the animals in their natural habitat is available to park visitors. The beaver should probably not be encouraged since they would destroy many small trees in the vicinity of White Rock Creek. The nutria can be expected to increase when and if the amount of emergent vegetation increases.

2-17. Waterfowl and other aquatic birds make up the most impressive group of resident vertebrates in the shallow water areas. During investigations, large numbers of mallards,

green-winged teal, blue-winged teal, shovelers, coots, and pintails were sighted. These puddle ducks were resting and feeding in the marsh areas. Also seen were many killdeer, a few snipe, and one woodcock.

2-18. Park employees reported that in the summer the marsh is visited by grebes, sandpipers, great blue herons, green herons, and wood ducks. Wood ducks nest in the trees along White Rock Creek and feed in the marsh areas. Three local bird-watchers were interviewed, and each related stories of many hours spent birding along the north end of the lake.

2-19. Benthos. The word benthos is a noun defining the whole assemblage of plants or animals living on the lake (sea) bottom. As used in this study, it relates primarily to those small organisms living in the bottom of the lake on which fish feed. Examples of benthos are worms, larvae, midges, clams, leeches, etc.

2-20. Generally speaking, a wide variety of species of benthos indicates a healthy environment, and the greater the number of different species, the healthier the environment. The thirty dredge samples taken from the 10 sampling stations in the lake, however, indicated a relatively poor benthos community diversity. Only 5 different organisms, Chironomus (midges), Oligochaete worms, Chaoborus (phantom midges), Sphaerid clams, and a few leeches were present. The complete absence of mayfly naiads of the genus Hexagenia and relatively high populations of the more tolerant midges and worms at deeper sampling points indicate a lack of available nutrients such as sessile algae.

2-21. The occurrence of good populations of Chironomus, Chaoborus and Oligochaete worms at the 3 deepest stations, and poor standing crops in the upper shallow areas suggest that dredging of shallow areas of the lake, at least to depths of 20 to 25 feet, would promote an increase in the overall benthos production.

2-22. It is considered that even in areas dredged down to mineral substrate, enough organic detritus would settle back in to promote recolonization within 6 months. The overlapping nature of midge populations, and consequent emergence and reproduction the year around by adults, would lead to a constant "reseeding" of eggs over dredged areas. Oligochaetes would migrate into the areas from adjacent undredged ones as initial resedimentation occurred.

2-23. It is possible that sufficient toxic sediments might be removed by dredging to promote colonization by highly desirable Hexagenia (mayfly) populations. Temporary reductions in midges and Oligochaetes by dredging might affect the channel catfish

production of perhaps one season, but retention of piscivorous brood adults in good condition would promote renewed production the following year under conditions of higher carrying capacity of the lake.

2-24. Conclusions and Recommendations. The ecological survey of White Rock Lake has resulted in the accumulation of data that demonstrates that the lake is in good balance at the south end and in poor condition at the north end. It also shows that the sediments available do not stimulate the production of algae even though they are rich in both inorganic and organic materials that would stimulate plant growth provided the sediments were dried and available for use on lawns, pastures and other areas where rich loam is desirable. The chemical analyses of the lake water and the sediments are presented which indicate adsorption of nutrients from the creek water as it enters the lake.

2-25. The other data shown in the report are relevant when one considers whether dredging should occur or not, what type of dredging should be used and if certain areas of the lake should be preserved while others are used as fill. Thus, from the ecological information contained in the report, the following recommendations are made:

1. It is mandatory to preserve a part of the swamp areas and the deltas at the north end of the lake in order to maintain a region for wildlife and to promote the growth of additional plants such as bulrushes and willows as well as to preserve the park areas that are enjoyed by many individuals. The northwest section of the lake that is very shallow due to siltation and sedimentation could be used partly as a site for filling since there are no marshy areas in that immediate region. The water is very shallow, highly unproductive and a fill would result in additional marsh land that would offer cover for wildlife and would not decrease the area of the lake by too great a proportion.

2. It is apparent from this survey that hydraulic dredging should improve the ecological balance of White Rock Lake. Removal of the present sediments along with increasing depths would allow an increase in both species diversity and production of the benthos. Our studies indicate that rough fish predominate in the north end of the lake where the dredging would mainly occur. Thus, a deeper area would improve the ecological conditions and would provide additional area and food for the yellow bass, crappie and catfish. An increase in depth, especially along shore areas, would increase temperature stability in the lake and provide more desirable habitats for game fishes, and, in addition, permit suitable fishing areas on the bank.

Special recognition should be taken of the Dixon Branch area and the north end where the contours show the depth to be less than six feet.

acres surface area, or to clear, infertile waters. Fertilization of a lake results in an accelerated rate of eutrophication or ageing of the lake. I believe that fertilization of White Rock Lake is unnecessary because:

1) The lake is already in an advanced stage of eutrophication with abundant nutrients (although some of the nutrients are bound into the sediment layers).

2) The expense of fertilizing (at 20 lbs. of 10-40-0 commercial fertilizer/acre, 2-3 times per year) would be excessive.

3) Fertilization would certainly produce a bloom of green algae in the lake, and this might be objectionable to boaters on esthetic grounds.

4) Fertilization might increase the standing crop of fish present in the lake but would probably benefit the rough fish in much greater proportion than the gamefish.

With regard to your description of the channels to be dredged between Mockingbird Lane and Northwest Highway, we agree that this would aid in preventing excess deposition of silt in the northern marsh areas, and that the operation could be carried out without serious disruption of the adjacent marsh areas.

3. If the equipment used for dredging is of the hydraulic type, it is suggested that due to the high biochemical oxygen demand of the bottom sediments, that most of the dredging should perhaps occur during the fall, winter and spring. The reason for this suggestion is that dredging in the summertime would agitate the bottom sediments and would likely result in a depletion of the oxygen. This would result in a fairly extensive fish-kill in the north end of the lake. While it is apparent from our survey that mainly rough fish are in the area, a fish-kill is rather disastrous to any ecological improvement program.

4. The larger the proportion of sediment removed from the lake, the greater will be the ecological improvement. While our laboratory results demonstrate that the sediments precipitate in a period of three days, these samples were agitated initially and permitted to remain undisturbed for 72 hours. Therefore, whenever wind action occurs on White Rock Lake, the flocculant sediments will be suspended resulting in turbidity which reduces the productivity of the water. Since the original basin of the lake is hard and not subject to being disturbed by currents, the greater proportion of sediments that is removed, the clearer the waters of the lake will become and consequently more productive and particularly improved from an esthetic viewpoint.

5. Our studies do not indicate that the biochemical oxygen demand of the sediment is produced by substances that would give rise to highly obnoxious odors. The sulphur components are extremely low in these sediments. Obviously, there is an odor but one would describe it as swampy rather than obnoxious or offensive. Therefore the materials removed from the lake bottom would be very useful for lawns and pastures, particularly if they were dried somewhat prior to the time they were hauled to a new site.

6. The wildlife area around the north end of the lake should be preserved. It might be practical in using hydraulic fill to pump thin layers into the regions adjacent to White Rock Creek where it is desirable to have a better view from the bridge on Mockingbird Lane. A deposition of such sediments would result in death to trees for a short period of time and then a new growth would occur.

7. It is quite obvious that the ecology of the lake could be more greatly improved by draining and removing of silt by heavy earth moving equipment. This type of dredging would result in the basin of the lake being more suitably contoured and dry sediments could more feasibly be deposited on land areas not adjacent to the lake. However, it is not our recommendation that such practice be followed since it would be our impression that the temporary disturbance of fish populations, of bottom organisms, of boating, picnicking and similar types of activities would persist for a period of time after completion

of dredging operations. Equipment would have to wait for complete drying before it could move in and do the proper type of job. The marsh region would be lost, the wildlife would be lost, and parts of the basin would grow up in weeds and other types of vegetation. To summarize briefly, it would be a very unpopular practice and detrimental to the best interests of the Park Department.

2-26. Projected Effects of Dredging on Fish Production. Supplemental information regarding the effects that a sediment removal program might have on fish production at the lake was requested from the Institute of Environmental Studies. The following letter, dated July 8, 1971, from William D. Pearson, Ph.D., Assistant Professor, Department of Biological Sciences, North Texas State University, was received in that regard.

> Dr. J. K. G. Silvey has referred your letter of June 21, 1971 concerning the projected effects of dredging White Rock Lake on fish production to me. We have examined the results of a comprehensive creel survey conducted on the lake in 1970 by Mr. Ed Bonn of the Texas Parks and Wildlife Department. This study indicates that 49,343 anglers fished for 71,389 hours on White Rock Lake in 1970. These anglers harvested a total of 49,600 fish weighing 19,511 pounds. This represents a catch/unit of effort of 0.69 fish (0.27 lbs.) per angler-hour. The principal species sought were white crappie, yellow bass, and channel catfish.
>
> In our initial report we indicated that dredging in the north end of the lake should favor the spread of gamefish into that area. The area to be dredged appears to represent about one-third of the total area of the lake. Consequently, we might estimate that the standing crop of fish in the lake would increase by 10-20% as a result of dredging new habitat. Yield of fish to the fisherman (and catch rates) are dependent, in part, on the standing crop of fish present in the lake, but another very important factor influencing yield is the actual availability or "catchability" of those fish.
>
> Much of the fish population in White Rock Lake is not readily available to the shore angler because larger gamefish do not venture into very shallow waters during the most popular daytime fishing hours. If, in the dredging operation, the areas within casting distance of the shoreline could be deepened to 6-8' it would increase the availability of fish to the angler. In this case we might predict an increase in yield of 10-30% (an increase in annual yield of 2-6000 lbs.). I would point out that this approach does not create more fish in the lake, rather it substitutes fishing mortality for some of the natural causes of mortality in the fish population.
>
> You also mentioned the possibility of improving the yield of fish from the lake through cultural practices - primarily fertilization. The fertilization of impounded waters has usually been limited to ponds of less than 10

III - SEDIMENTATION

3-01. General. At the time of the construction of White Rock Dam in 1910, the 100 square miles of watershed above the dam was a rural area, much of which was under cultivation. Runoff from rainfall on the watershed carried with it large quantities of soil from the plowed fields and eroding hillsides, and deposited it in the newly formed lake as sediment. This process of sedimentation has continued over the years, although at a somewhat reduced rate in the last 30 years due to soil conservation practices and changes in land use, and has gradually diminished the storage capacity of the reservoir. Recent surveys indicate that about 41 percent of the original capacity has been lost to sedimentation. Large deltas of sediment have built up at the headwaters of the lake at White Rock Creek and on the east side of the lake at the mouth of Dixon Branch. In the main body of the lake, sediment has been deposited more uniformly over the bottom.

3-02. Previous Sedimentation Studies and Dredging Programs. There has been considerable interest in the sedimentation of White Rock Lake for many years, and several studies have been made in this regard. There has also been a major hydraulic dredging program on the lake. Brief descriptions of some of the studies and the dredging project are given in the following paragraphs. The sources of information include the studies themselves and files of the City Park and Recreation Department.

3-03. 1923 Survey. In 1923 the City of Dallas had a survey made of White Rock Lake, and from this information a contour map was prepared. (This contour map, scale 1" = 200', is presently on file in the Survey Section of the Department of Public Works.) The storage capacity of the reservoir at that time was calculated to be 16,896 acre-feet. An effort to determine sedimentation rates gave inconclusive answers due to insufficiency of original survey data. It was determined, however, that there was a build-up of sediment in the upper end of the lake due apparently to the growth of cattails, willows, and other growth which retarded the flow and caused sediment to drop out.

3-04. 1928 Sediment Survey. In July 1928 a sediment survey of the lake was made by T. U. Taylor and Major W. J. Powell. A report on their findings was published in a University of Texas Bulletin No. 3025, dated July 1, 1930. In that study a comparison was made with soundings taken in the 1923 survey. Additional accumulations of sediment in the upper end of the lake were noted, but no evidence was found of any sediment in the lower two miles of the lake.

3-05. 1935 SCS Survey. In April 1935 the Soil Conservation Service of the U. S. Department of Agriculture made an extensive survey of the lake. They established and monumented new range lines, sounded and spudded the ranges, and extended the mapping done by the City in 1923 to include more detail in the upper end of the lake. Details from their report show that the original capacity of the lake was 18,158 acre-feet. By 1935 it had reduced to 14,276 acre-feet, which was a loss due to sedimentation of 3,882 acre-feet, or 6,262,960 cubic yards. This represents an average annual loss of about 155 acre-feet. Much of the sediment was found to be located in the main body of the lake, which was contrary to the findings of previous surveys which had shown no evidence of sediment in the main body of the lake. It was concluded that the volume of sediment could not be measured with any reasonable accuracy when the original contour map was not available and when direct penetrations of the sediment were not made.

3-06. 1936 Report by A. P. Rollins. A report on siltation of White Rock Lake was made in October 1936 by A. P. Rollins, Director of Public Works for the City of Dallas. The report concluded that it was not feasible to remove the accumulated sediment, since more would continue to enter the lake, and that more permanent relief from sedimentation would be obtained through the development of a soil conservation project. The report recommended that efforts be put forth toward this latter alternative. It also recommended "that the water level of the lake be kept as high as practicable (by raising the spillway crest), creating still water far up the lake causing the sediment to be deposited in the upper or shallow areas . . . and . . . that the dense growth on the silted areas be protected and that steps be taken to make it more effective."

3-07. Hydraulic Dredging Program of 1937 to 1941. Pursuant to instructions from the City Council in November 1936, a hydraulic dredge was constructed and placed in operation on White Rock Lake. During about three years' operation, 583,320 cubic yards of sediment were moved. The United States Department of Agriculture in 1943 printed its Miscellaneous Publication No. 521 - "The Control of Reservoir Silting." Included therein is the following reference to this dredging program:

> The most extensive reservoir suction-dredging operation undertaken in the past few years is that on White Rock Lake in Dallas, Texas. The use of this reservoir as a source of water supply was discontinued in 1928, partly because a larger reservoir had been built to meet the increased demands of a growing city, and partly because silting had reduced the capacity of White Rock Lake by more than 15 percent in 18 years. After 1928, White Rock Lake rapidly became a popular recreational spot and has enhanced the value of nearby property by an estimated $10,000,000. By 1937, silting and unhealthful swamping had become so pronounced in a large area in the upper part of the lake that an 8-inch suction dredge (Figure 39) was

constructed to cut channels through the reservoir delta and dump the sediment on islands that could be beautified for recreational use. A 3/4-yard dragline was used to a lesser extent. According to records of the Dallas Director of Parks, approximately 86 acres were reclaimed in the lake and 583,320 cubic yards of sediment were removed. The original cost of the dredge was $33,656.34; the cost of its operation for about three years was $74,940.96; the cost of the dragline was $6,913.90; and the cost of its operation was $7,489.23; making a total cost of $123,000.43. Deducting $5,000 received by resale of the dragline and allowing $5,000 for the resale value of the dredge, the total cost of the project was $113,000. The cost per cubic yard moved was $0.1937, or approximately $312.50 per acre-foot. It should be noted, moreover, that sediment was not moved out of the reservoir, but was moved only a few hundred feet, on an average, to the man-made islands within the lake.

In most of the reclaimed areas the surface was raised to an elevation approximately 6 feet above spillway level. After silt had been raised to this level, a time delay varying from 12 to 24 months was necessary before machinery could be placed on the surface for final grading because the fill had not dried sufficiently to sustain this weight.

3-08. Miscellaneous Disposal Projects. City records show that from 1939 to 1941 sediment was offered loaded onto individuals' trucks at the rate of 25¢ per cubic yard. The project grossed $1,315.00, which represents about 5,000 cubic yards of sediment. In a six-month period from late 1955 to early 1956, 15,360 cubic yards were removed by dragline from the lake. In the summer of 1970, the lake was low and sediment was offered free for the taking. It is reported that a total of 41 cubic yards was removed that year.

3-09. 1950 SCS Report. In 1950, the Soil Conservation Service published a report entitled "Flood Control Work Plan, White Rock Creek Watershed." The report recommended the construction of nine flood control reservoirs in the watershed, as well as the adoption of land treatment measures such as grass seeding, terracing, fencing, construction of farm ponds, improvement in crop rotations, and improved range and pasture management. Much of the land treatment has since been accomplished, but the flood control structures were never built because of the rapidly expanding urbanization of the watershed.

3-10. 1956 SCS Survey. In 1956, at the request of the City of Dallas, the Soil Conservation Service made its second sedimentation survey of White Rock Lake. Primary purposes were to determine the capacity of the reservoir and the rate of loss by sedimentation, and to evaluate the effectiveness of the conservation program in reducing

the volume of sediment delivered to the lake. A description of the conservation program and the results of the survey are included in the following excerpts from the 1956 Report:

> Since the 1935 sedimentation survey of White Rock Lake, farmer and rancher cooperators with soil conservation districts, with the Soil Conservation Service assisting, have established in the White Rock Lake watershed 112 miles of terraces, 94 waterways and 1,924 acres of pasture. There have also been over 12,000 acres of cover crops planted. More than 1,400 acres of pasture have been improved. Other conservation practices have been useful. These include contour farming, fertilizing, brush control, wildlife improvement and pond construction. These conservation practices, along with other land use changes such as the urban area adjacent to and east of the reservoir, have been a factor in reducing the rate of sediment yield to White Rock Lake . . . .
>
> White Rock Lake originally had a surface area of 1,254 acres. The 1935 survey showed a surface area of 1,150 acres. Sediment had reduced the area of the lake in the upper reaches by 104 acres. One delta was formed by sediment at the mouth of Dixon Branch. The other delta extended out into the lake from the mouth of White Rock Creek.
>
> The 1956 survey showed a surface area of 1,095 acres, or a total reduction since 1910 of 159 acres . . . .
>
> The original capacity of the lake was 18,158 acre-feet. This capacity had been reduced to 14,276 acre-feet according to the 1935 survey. The 1956 survey showed that an additional 1,955 acre-feet of sediment had been trapped by the reservoir, leaving a capacity of 12,321 acre-feet. This represents a loss to date of 32.15 percent of the original lake capacity. The 1935 survey showed an average annual capacity loss of 0.89 percent. The 1956 survey showed an average annual capacity loss for the entire life of the lake (45.9 years) to be 0.70 percent annually. The average annual rate at which sediment was being trapped by the reservoir for the period 1910-1935 was 1.60 acre-feet per square mile of drainage area. This rate was reduced 30 percent during the period 1935-1956, to 0.97 acre-foot per square mile annually. As previously explained in "History of the Watershed," this reduced rate is the result of conservation practices established in the watershed during the period 1935-1956, and the land use changes such as the urban development adjacent to and east of the reservoir.
>
> Volume weight and particle size analysis as determined by the Soil Conservation Service Soil Mechanics Laboratory at Lincoln, Nebraska, showed the five sediment samples had an average dry volume weight of 35.3 pounds per cubic foot and were composed of no sand, an average of 14.2 percent silt, and 85.8 percent clay. Sample No. 1A taken near the dam was composed of no sand, 13 percent silt, and 87 percent clay,

while sample No. 5A taken near the head of the lake contained no sand, 20 percent silt, and 80 percent clay. The dry volume weight of sample No. 1A was 30.6 pounds per cubic foot. Sample No. 5A had a dry volume weight of 41.3 pounds per cubic foot.

The sediment is quite evenly distributed across the submerged valley flat. Channels are almost completely obliterated. The average thickness of sediment along the range parallel to and nearest the dam is 6.70 feet, while the average thickness along range 012-013 near the head of the main body is 6.90 feet.

3-11. Soil Conservation Service Sedimentation Survey of 1970. In conjunction with the engineering studies covered by this report, the City of Dallas in August 1970 requested the Soil Conservation Service (SCS) to provide an updated sedimentation study on White Rock Lake. The sedimentation survey was performed in October 1970 by Robert H. Zodin, Geologist, SCS Sedimentation Survey Party. The published report on the survey is expected to be available in August 1971. The SCS was very cooperative in furnishing advanced pertinent information from the survey, and in discussing the findings of the survey. Pertinent data furnished directly by the SCS and reprinted herein include the following three exhibits:

Table 1	Reservoir Sediment Data Summary
Table 2	Segment Data, White Rock Lake
Figure 2	Map of Sedimentation Resurvey 1970

Information on sediment range profiles was also furnished by the SCS. This information was plotted and/or redrawn and is presented herein on Plates 1, 2, 3, and 4.

3-12. Rate of Sedimentation. The data on Table 1 indicate that the lake has gradually decreased in storage capacity from 18,158 acre-feet in 1910 to 10,743 acre-feet in 1970, with intermediate capacities of 14,276 acre-feet in 1935 and 12,321 acre-feet in 1956. (1 acre-foot = 325,851 gallons = 1,613 cubic yards). Since its construction in 1910, the lake has lost 7,415 acre-feet (nearly 12,000,000 cubic yards) to sedimentation. This represents an average loss over sixty years of about 122 acre-feet per year. During the first twenty-five years after construction began (1910-1935) sediment accumulated in the lake at the average rate of 155 acre-feet per year. During the next 21 years (1935-1956) the average rate had reduced to 94 acre-feet per year, and the overall 46-year average annual rate of loss had decreased to 127 acre-feet. The reduction in rate was attributed by the SCS in their 1956 survey report to ". . . conservation practices established in the watershed during the period 1935-1956, and the land use changes such as urban development adjacent to and east of the reservoir."

RESERVOIR SEDIMENT
DATA SUMMARY
SCS-34 Rev. 6-66

TABLE 1

WHITE ROCK LAKE
NAME OF RESERVOIR

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DATA SHEET NO.

DAM

1. OWNER City of Dallas	2. STREAM White Rock Creek	3. STATE Texas
4. SEC. TWP. RANGE	5. NEAREST P.O. Dallas	6. COUNTY Dallas
7. LAT. 32° 49'00" LONG. 96° 43' 45"	8. TOP OF DAM ELEVATION 468.5	9. SPILLWAY CREST ELEV. 458.0

RESERVOIR

10. STORAGE ALLOCATION	11. ELEVATION TOP OF POOL	12. ORIGINAL SURFACE AREA, ACRES	13. ORIGINAL CAPACITY, ACRE-FEET	14. GROSS STORAGE, ACRE-FEET	15. DATE STORAGE BEGAN
a. FLOOD CONTROL					April 1910
b. MULTIPLE USE	458.0	1254	18,158	18,158	
c. POWER					16. DATE NORMAL OPER. BEGAN
d. WATER SUPPLY					
e. IRRIGATION					1910
f. CONSERVATION					
g. INACTIVE					

WATERSHED

17. LENGTH OF RESERVOIR 2.80 MILES		AV. WIDTH OF RESERVOIR 0.61 MILES	
18. TOTAL DRAINAGE AREA 99.1 SQ. MI.		22. MEAN ANNUAL PRECIPITATION 34.55 (85) INCHES	
19. NET SEDIMENT CONTRIBUTING AREA 97.4 SQ. MI.		23. MEAN ANNUAL RUNOFF 4.29 INCHES	
20. LENGTH 22.9 MILES	AV. WIDTH 4.35 MILES	24. MEAN ANNUAL RUNOFF 22,673 AC.-FT.	
21. MAX. ELEV. 700	MIN. ELEV. 434	25. ANNUAL TEMP: MEAN 66°F RANGE 46°F - 86°F	

SURVEY DATA

26. DATE OF SURVEY	27. PERIOD YEARS	28. ACCL. YEARS	29. TYPE OF SURVEY	30. NO. OF RANGES OR CONTOUR INT.	31. SURFACE AREA, ACRES	32. CAPACITY, ACRE-FEET	33. C/I. RATIO, AC.-FT. PER AC.-FT.
April, 1910	--	--			1,254	18,158	0.80
April, 1935	25	25	Range	13	1,150	14,276	0.63
March, 1956	20.9	45.9	Detail	9	1,095	12,321	0.54
Oct., 1970	14.6	60.5		9	1,119	10,743	0.47

26. DATE OF SURVEY	34. PERIOD ANNUAL PRECIPITATION	35. PERIOD WATER INFLOW, ACRE-FEET			36. WATER INFL. TO DATE, AC.-FT.	
		a. MEAN ANNUAL	b. MAX. ANNUAL	c. PERIOD TOTAL	a. MEAN ANNUAL	b. TOTAL TO DATE

26. DATE OF SURVEY	37. PERIOD CAPACITY LOSS, ACRE-FEET			38. TOTAL SED. DEPOSITS TO DATE, ACRE-FEET		
	a. PERIOD TOTAL	b. AV. ANNUAL	c. PER SQ. MI.-YEAR	a. TOTAL TO DATE	b. AV. ANNUAL	c. PER SQ. MI.-YEAR
March 1935	3,882	155	1.60	3,882	155	1.60
March 1956	1,955	94	0.97	5,837	127	1.30
Oct. 1970	1,578	108	1.11	7,415	122	1.25

26. DATE OF SURVEY	39. AV. DRY WGT., LBS. PER CU. FT.	40. SED. DEP., TONS PER SQ. MI.-YR.		41. STORAGE LOSS, PCT.		42. SED. INFLOW, PPM	
		a. PERIOD	b. TOTAL TO DATE	a. AV. ANN.	b. TOT. TO DATE	a. PERIOD	b. TOT. TO DATE
March 1935	49 (8)	1,708	1,708	0.89	21.38	--	--
March 1956	35 (5)	1,297	991	0.70	32.15	--	--
Oct. 1970	32 (6)	505	871	0.67	40.83	--	--

3-13. The average annual loss rate for the period 1956-1970 was 108 acre-feet, which is an increase of about 15 percent over the previous period rate of 94 acre-feet annually. This increase in rate, although contrary to the general belief that lake sedimentation should be decreasing along with anticipated reductions in watershed sediment yields, does not necessarily prove either hypothesis to be in error. The total sediment yield of the watershed is either deposited in the backwater reaches upstream from the lake or within the lake itself with an insignificant amount passing over the spillway. All sediment measurements made in the past have been limited to deposits beneath the normal pool level (approximate elevation 458.0) while it is known that large quantities of sediment have been deposited at higher elevations. Depositions at these higher levels have been caused by the natural backwater effects of the reservoir, and retardation of flow velocities by the dense vegetation growing there. This situation was recognized as desirable in the 1936 study by Mr. A. P. Rollins (see paragraph 3-06) who recommended that ". . . the dense growth on the silted areas be protected and that steps be taken to make it more effective." The aggradation of the floodplain in these reaches has produced higher banks for the existing natural channels. With higher banks on the channels, it is expected that their hydraulic efficiencies would have been improved, hence a larger percentage of the total flood flows along with sediment loads are now conveyed into the lake at higher velocities than in the past. A corresponding reduction in overbank flooding would be expected which would, in turn, reduce the rate of sediment deposition there. Unfortunately, it is not feasible to obtain factual data for evaluation of the changes that have occurred in the regimen of this portion of the stream. It is believed, however, that land management and urban development in the watershed have substantially reduced its sediment yield, and that some further reduction can be expected in the future. It might be many years before benefits of this reduction are apparent at the lake because of the sediment accumulations in the floodplain above the head of the reservoir.

3-14. Acreages that once may have been plowed fields or eroding hillsides are now covered with large buildings, paved parking areas, streets, driveways, sidewalks, houses, and grassed lawns. However, during the construction phase of urbanization, the work areas are often more susceptible to erosion than under agricultural or natural conditions. An area planned for development may be stripped of vegetation at the beginning of construction and then stand in this denuded condition for a period of months, or even years, before the project is actually completed. New and improved drainageways, even though they may be finished with concrete lining or sodded sideslopes, will, during construction, be vulnerable to bank erosion as well as provide a quantity of loosened soil, whether in the bottom of the channel or on the adjacent banks, that is readily available to be picked up by runoff waters and transported downstream. Finally, the erosion potential of the waterways is heightened by the increase in volume and rate of rainfall runoff which follows urbanization.

3-15. There is as yet insufficient information available to place a value on the net effect of the urbanization process on sedimentation. In the case of the White Rock Lake watershed, however, about half of the watershed has undergone urbanization, and its effects are indicated by the amount of sediment found in the lake. Most of the remaining undeveloped areas are located in the upper half of the watershed. As urbanization moves upstream, its effect on lake sedimentation is expected to become less and less as its distance from the lake increases. It is believed that the peak effects of the urbanization process have already passed, as far as White Rock Lake is concerned, and that in the future the rate of sedimentation in the lake will gradually trend toward rates expected from the end result of urbanization rather than those experienced in the process of urbanization.

3-16. Distribution of Sediment in the Lake. The map on Figure 2 shows the location and the numbering system of the range lines along which the SCS took soundings to determine lake bottom elevations. The range line profiles of 1970 are shown on Plates 1, 2, 3, and 4. Where information was available on bottom elevations for previous years, this information is shown also. For two ranges, 01-02 in the lower end of the reservoir and 012-013 in the upper portion of the reservoir, profiles are shown for 1970, 1956, 1935, and 1910. The 1956 profiles were also available for four other ranges. When comparing 1970 and 1956 profiles it will be noted that on some of the profiles there is an apparent discrepancy in length and elevation near the ends of the sections. This is attributed to the inability to reestablish exactly the original range line monument locations, and to the filling around the edge of the lake. Filling along the shoreline to gain additional recreational area, combined with routine maintenance operations, has resulted in the obliteration of essentially all of the range line monuments that were established in 1935. Since the accumulation of sediment is so uniform transversely across the bottom of the lake, however, the discrepancies at the ends of some ranges were not considered to have any important effect on the calculations of sediment volume.

3-17. The sediment in the lake has completely filled in the old creek channel and other depressions in the lake bottom and has developed a uniform bottom shape, as indicated by the range profiles on Plates 1, 2, 3, and 4. The profiles of ranges 01-02 and 012-013 on Plate 1 show that there are heavy deposits of sediment in the lower part of the lake as well as the upper part. Sediment depths as great as 19 feet are indicated at range 01-02, which is near the dam. The presence of large quantities of sediment in the lower (downstream) part of the lake is attributed to the fact that the sediment is primarily a fine colloidal clay which requires a long settling time. Only the heaviest particles settle out in the upper end of the lake, while the lighter particles remain in suspension long enough to be distributed throughout the remainder of the lake. The uniform depth of deposit from 1956 to 1970 of about one and one-half to two feet of sediment at ranges

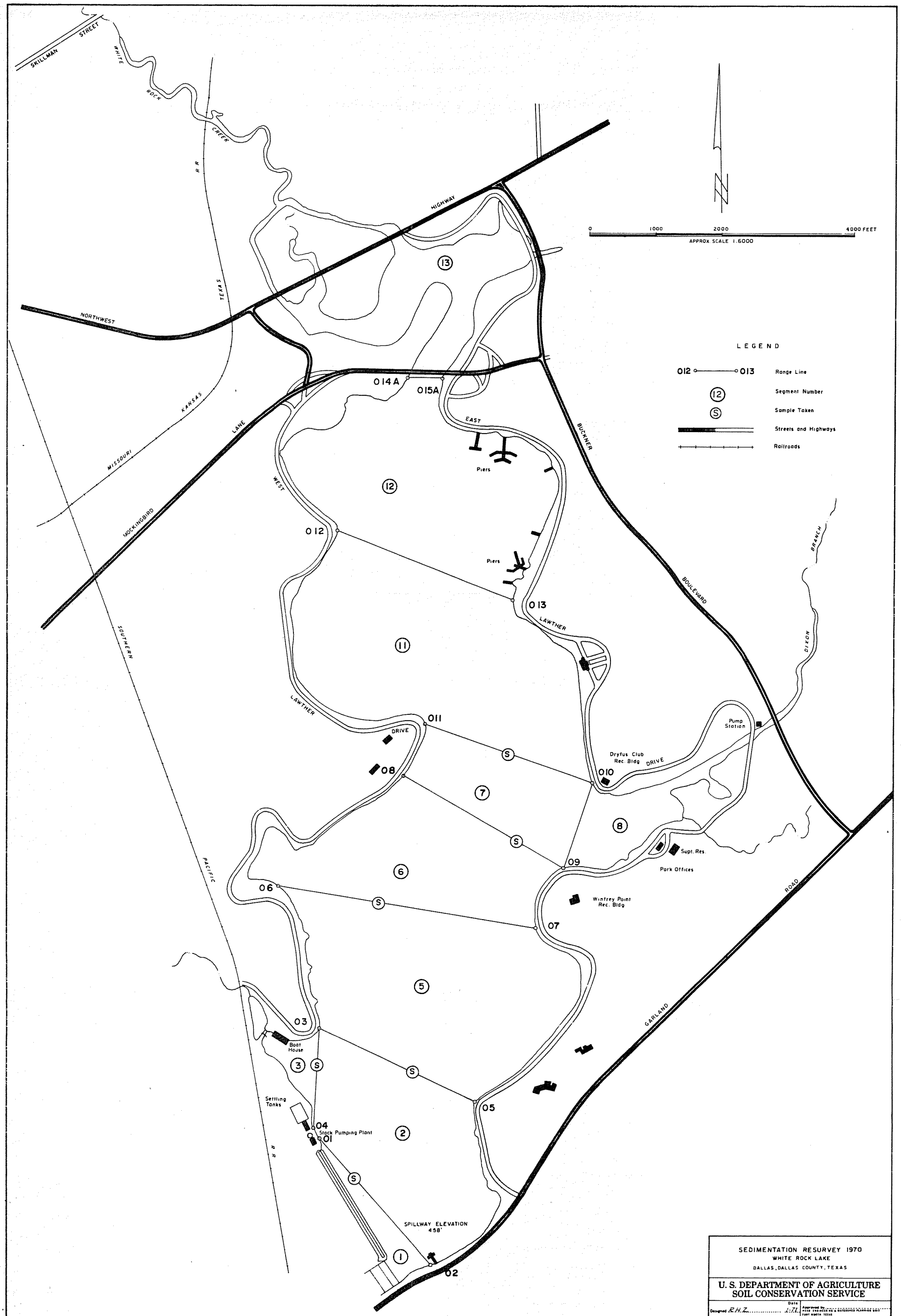

SKILLMAN STREET
WHITE ROCK CREEK
R R
HIGHWAY
NORTHWEST
TEXAS
KANSAS
MISSOURI
LANE
MOCKINGBIRD
SOUTHERN
PACIFIC
014A
015A
EAST
WEST
012
013
011
010
09
08
07
06
05
04
03
02
01
Piers
Piers
LAWTHER
LAWTHER
DRIVE
Dryfus Club Rec. Bldg
DRIVE
Pump Station
Supt. Res.
Park Offices
Wintrey Point Rec. Bldg
Boat House
Settling Tanks
Stock Pumping Plant
SPILLWAY ELEVATION 458'
BUCKNER
BOULEVARD
DIXON
BRANCH
GARLAND
ROAD
12
11
7
8
6
5
3
2
1
S
0
1000
2000
4000 FEET
APPROX SCALE 1:6000
LEGEND
012 013 Range Line
12 Segment Number
S Sample Taken
Streets and Highways
Railroads
SEDIMENTATION RESURVEY 1970
WHITE ROCK LAKE
DALLAS, DALLAS COUNTY, TEXAS
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Designed R.H.Z. 1-71
Drawn R.H.Z. 1-71
Traced B.P. 2-71
Checked
Drawing No. 4-E-30119

Figure 2

05-03, 07-06, 09-08, and 010-011 is further evidence of a fairly uniform rate of deposit in the main body of the lake. The average total depth of deposit over the entire reservoir is 6.6 feet.

3-18. As indicated on the map on Figure 2, the range lines have been used to divide the lake into ten segments. The segments are numbered 1, 2, 3, 5, 6, 7, 8, 11, 12, and 13 on the map. Table 2 shows pertinent data for each segment for present surface area; orginal capacity; and capacity, sediment volume and percent of capacity loss for 1935, 1956, and 1970. The 1970 data are based on range line profiles, plane table surveys, and previous survey data.

3-19. As indicated on Table 2, the lake has lost 41 percent of its original capacity. The most serious loss is taking place in the upper end of the lake in segments 12 and 13. By 1935 segment 12 had lost 62 percent of its original capacity and segment 13 had lost 80 percent. The hydraulic dredging program of 1937 and the change in 1956 of the location of sediment range 015-014 make it difficult to establish a correlation between 1910 and 1970 conditions for the two segments individually. However, the two segments combined presently have less than 25 percent of their original capacity remaining. Segment numbers 3 and 8, both at the mouths of small creeks which flow into the lake, have also shown heavy sedimentation. The map on Figure 3 has been prepared to show the percent of original storage capacity remaining in each of the segments. Overall, segments 3, 8, 11, 12, and 13 all have less than 50 percent remaining. These segments account for almost 50 percent of the lake surface. Segments 1, 2, 5, 6, and 7 are generally in the deeper part of the lake where the volume of sediment has a lesser effect on the percent of capacity. Their present capacities range from a low of 58 percent of original in segment 7 to a high of 76 percent in segment 5.

3-20. The average depth of water for each of the segments is also shown on Figure 3. These depths are based on surface area and capacity data shown in Table 2. Present average water depths at spillway level range from 0.8 feet in segment 13, which is above Mockingbird Lane, to 18.9 feet in segment 2 in the lower end of the lake.

3-21. Probable Life of the Lake. Within the past 14 years, the lake has accumulated sediment at the average rate of 108 acre-feet per year. As discussed in paragraphs 3-12 through 3-15, this rate is believed to be decreasing somewhat. For the purpose of estimating future sediment accumulation in the lake, a deposit rate of 100 acre-feet per year has been adopted. Based on this rate, it would take something over 100 years for the present storage capacity of 10,743 acre-feet to become completely filled with sediment. It is difficult to imagine, however, that such a condition could or ever would be allowed to

TABLE 2

SEGMENT DATA

WHITE ROCK LAKE

SEGMENTS	PRESENT SURFACE AREA (Acres)	ORIGINAL CAPACITY (Ac.Ft.)	CAPACITY (Ac.Ft.) 1935	CAPACITY (Ac.Ft.) 1956	CAPACITY (Ac.Ft.) 1970	SEDIMENT VOLUME (Ac.Ft.) 1935	SEDIMENT VOLUME (Ac.Ft.) 1956	SEDIMENT VOLUME (Ac.Ft.) 1970	CAPACITY LOSS (PERCENT) 1935	CAPACITY LOSS (PERCENT) 1956	CAPACITY LOSS (PERCENT) 1970
1	15.69	420.42	383.44	311.43	278.81	36.98	108.99	141.61	9	26	34
2	133.00	3,500.01	3,210.31	2,719.46	2,510.45	281.70	780.55	989.56	8	22	28
3	11.50	218.43	178.92	103.52	102.40	39.51	114.91	116.03	18	53	53
5	196.81	4,060.26	3,768.42	3,212.54	3,148.43	291.84	847.72	911.83	7	21	24
6	142.26	2,610.41	2,295.10	1,922.45	1,678.37	314.80	687.96	932.04	12	26	36
7	71.74	1,431.03	1,165.99	917.65	823.13	265.04	513.38	607.90	19	36	42
8[1]	42.09	401.92	206.06	145.35	167.60	195.86	256.57	234.32	48	64	58
11	233.20	3,070.09	2,392.55	1,775.75	1,459.08	677.54	1,294.34	1,611.01	22	42	53
12	183.40	990.87	389.14	969.70	507.56	610.73	--[2]	483.31[3]	62	--[2]	49[3]
13[4]	89.50	1,454.06	286.07	243.58	67.44	1,167.99	--[2]	1,386.62[3]	80	--[2]	95[3]
TOTALS	1,119.19	18,157.50	14,276.00	12,321.43	10,743.27	3,881.99	--[2]	7,414.83	79	--[2]	41

1/ Segments 8, 9 & 10 from 1935 survey combined into segment 8 during 1956 survey.
2/ Capacity loss and sediment volume not applicable due to relocation of Range 014, 015.
3/ Capacity loss and sediment volume compared to 1956 survey data due to relocation of R 014, 015.
4/ Segments 13, 14, 15, & 16 from 1935 survey combined into segment 13 during 1956 survey.

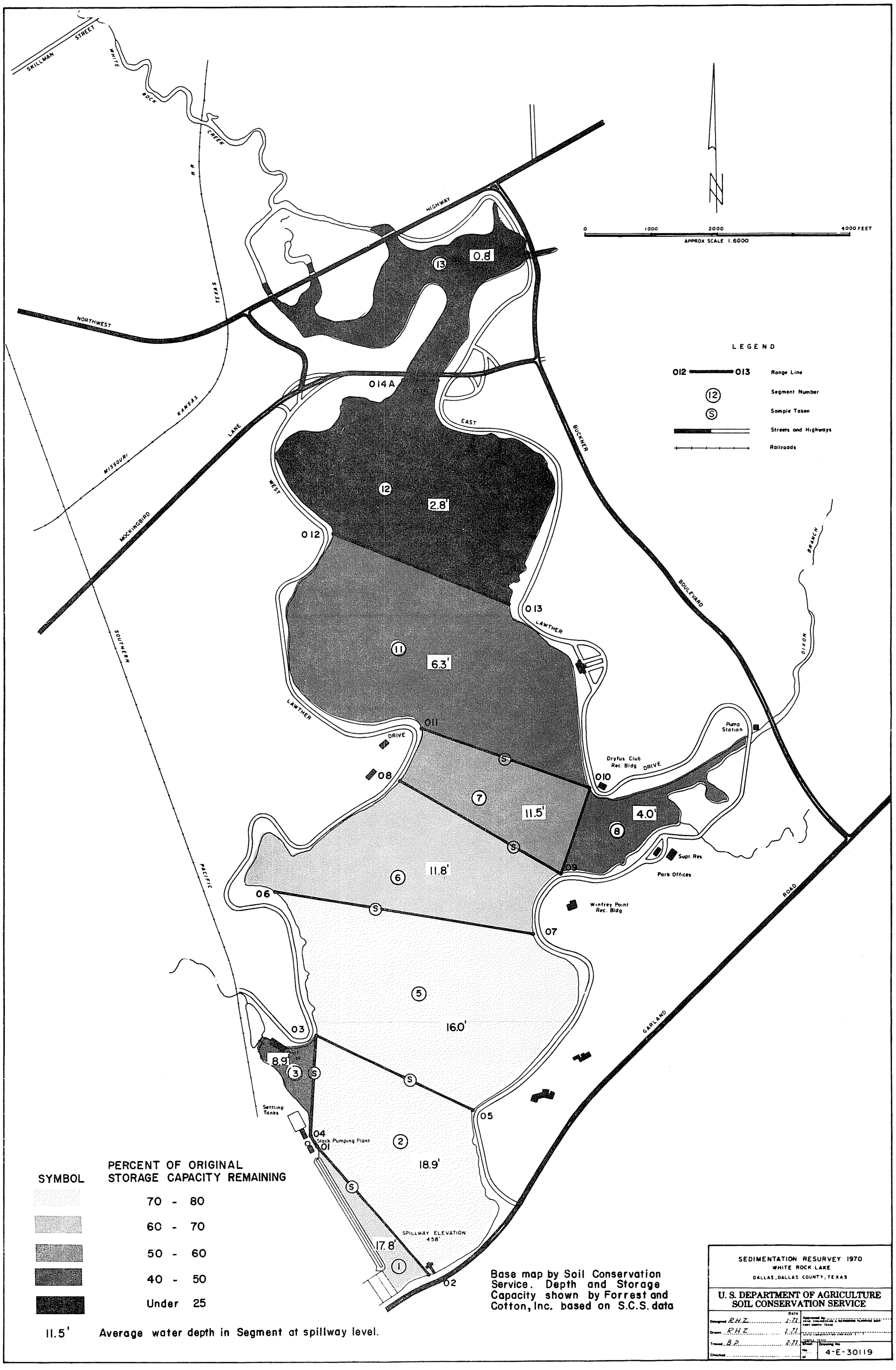


Figure 3

LAKE DEPTHS AND STORAGE CAPACITY

occur. The lake would have long since become completely useless for the recreational activities for which it is so popular. It is apparent that at some point in time it will be necessary to initiate a sediment removal program if the lake is to continue to be used for recreational purposes. An estimate has been made of the condition of the lake that may be expected at each decennium between 1970 and 2000 if a sediment removal program is *not* initiated. This estimate is shown on Table 3 and includes surface area, storage capacity, and average water depth for each segment. Distribution of the sediment within the reservoir is based on data found in Table 2. Information from this table indicates that the average depth of sediment deposit over the reservoir from 1956 to 1970 was 1.41 feet. In the upper end (segments 12 and 13), the average depth of deposit was 2.35 feet, or about 66 percent greater than the overall lake average. Using a deposit rate of 100 acre-feet per year, the average depth of deposit over the entire reservoir would be 0.09 feet per year initially, and increase to 0.12 feet per year by the year 2000 as the surface area reduced due to sediment accumulation. To arrive at the data in Table 3 these values were prorated, using uniform distribution of sediment in the main body of the reservoir, and a rate 66 percent greater than average for the upper segments. As a segment was filled with sediment, the next segment downstream was then considered as the upper part of the reservoir, and rates were adjusted accordingly.

3-22. Need for Sediment Removal Program. The original surface area of White Rock Lake was 1,254 acres. By 1970 this area had been reduced to 1,119 acres or a loss of 135 acres. Segment 13, which contains 89.5 acres, has been essentially lost to active recreation, although it does provide a wildlife habitat and a source for nature appreciation. Its average depth is only 0.8 feet. About one-half of segment 12 is less than 2 feet deep and the average depth of this 183-acre area is only 2.8 feet, with a maximum depth of 7 feet at the lower end. Recent drawdowns of the lake of about 2 feet for repair work on the dam exposed a large area of barren sediment in this area. The three boat clubs on the lake, White Rock Boat Club, White Rock Sailing Club, and Corinthian Sailing Club, as well as the public boat launching ramps, are all located in segment 12. Because of the shallow depths around the boat docks and ramps, boaters have difficulty in getting their boats into open water. This is particularly true when the lake is drawn down to any extent. At the southern end of the segment in the vicinity of the Corinthian Club the problem is not as severe.

3-23. Segment 8, which is the Dixon Branch area on the east side of the lake, also has heavy deposits of sediment. This one-time open water inlet has given way to an ever-encroaching delta of sediment. The fishing dock on the south side of the inlet was left high and dry by the recent lake drawdown. Segment 11 is also showing signs of heavy sediment accumulations, particularly on the west side. Depths along the southern

TABLE 3

ESTIMATED FUTURE SEGMENT DATA
(NO SEDIMENT REMOVAL)

Segment No.	1970 Surface Area (Acres)	1970 Capacity (Ac-Ft)	Estimated Future Capacity (Ac-Ft)			1970 Avg. Water Depth (Ft.)	Estimated Future Avg. Water Depth		
			1980	1990	2000		1980	1990	2000
1	15.69	279	268	255	241	17.8	17.1	16.3	15.4
2	133.00	2,511	2,418	2,308	2,190	18.9	18.2	17.4	16.5
3	11.50	102	94	84	74	8.9	8.2	7.3	6.4
5	196.81	3,148	3,011	2,848	2,674	16.0	15.3	14.5	13.6
6	142.26	1,678	1,578	1,461	1,335	11.8	11.1	10.3	9.4
7	71.74	823	773	714	650	11.5	10.8	10.0	9.1
8	42.09	168	139	103	66	4.0	3.3	2.4	1.5
11	233.20	1,459	1,229	970	513	6.3	5.3	4.2	2.2
12	183.40	508	233	0	0	2.8	1.3	0	0
13	89.50	67	0	0	0	0.8	0	0	0
TOTALS	**1,119.19**	**10,743**	**9,743**	**8,743**	**7,743**				

Surface Areas used in calculations:

1970 - 1980 : 1119 Ac.
1980 - 1990 : 1029 Ac.
1990 - 2000 : 846 Ac.

edge of this segment range up to about eleven feet but the overall depth of the segment averages only 6.3 feet. Other segments of the reservoir appear to have adequate depths for general recreation.

3-24. On the basis of the estimate shown on Table 3, there will continue to be a decrease in surface area, capacity, and water depth in the lake until such time as a sediment removal program is initiated. If delayed until 1980, segment 13 will have been lost completely to sediment and the depth of segment 12 will have been reduced to an average of about 1.3 feet, which would essentially amount to a loss of this 183-acre segment to general recreational use. By the year 2000 segment 8 will have been essentially lost also, and segment 11 will have been reduced to an average depth of 2.2 feet which is somewhat shallower than the present condition of segment 12.

3-25. If White Rock Lake is to be maintained as a recreational reservoir, there is a need now for the initiation of a sediment removal program. Postponement will only result in additional accumulation of sediment within the lake and a further deterioration of this valuable property.

3-26. Methods of Sediment Removal Considered. In determining the most feasible method of removing sediment from the lake, an evaulation was made of two basic methods of removal - hydraulic dredging and excavating and hauling. A hydraulic dredge usually consists of a floating barge equipped with a motor-driven cutter head, a pump, and suction and discharge lines. The size of unit depends upon the rate and distance the sediment must be pumped. Discharge piping lengths can vary from a few feet to several miles. One or more booster pumps may be required for long distances. Piping over water is usually floated on pontoons, and over land is usually laid on top of the ground and anchored.

3-27. Under the excavation and hauling method, it would be necessary to drain the lake down below desired sediment removal levels. This could be accomplished by one of a number of different methods, such as installation of a controlled drainage outlet at a low elevation in the dam, or by installing a battery of pipes over the spillway to be used to siphon water from the lake. Excavation of sediments would begin at the edge of the lake and proceed inward as the bottom dried sufficiently to support equipment. Sediment removal would be accomplished either by self-propelled scrapers or by excavating with draglines and hauling by trucks.

3-28. The excavation and hauling method would have several advantages over hydraulic dredging, such as handling and placing a much drier material, and the ability to excavate to a definite grade line. On the other hand, there would be a number of drawbacks

to this method, not the least of which would be the unpopularity of low lake levels. The installation of facilities to draw the lake down would be a major project in itself. The facilities would have to be sized not only to draw the lake down but also to handle normal reservoir inflow as well. Weather conditions would present uncertainties to this method, particularly in view of the relatively long drying time of the sediments. If the sediments were to be hauled to areas remote from the lake, the City streets would have to be used for hauling. There would doubtless be continual spillage of sediments on the streets as well as inestimable amounts of damage to the streets themselves.

3-29. Preliminary cost estimates, based on moving about 2,000,000 cubic yards of sediment, indicate that the movement of sediments for short distances in and around the lake could be accomplished for a per cubic yard cost of $0.26 by hydraulic dredging and $0.60 by excavating and hauling. For long distance transportaiton, such as six or eight miles to the downstream floodplain, the cost per cubic yard for hydraulic dredging would be about $1.20 as compared to $1.77 for excavating and hauling. The excavation and hauling costs are exclusive of the cost of installing lake drawdown facilities. On the basis of these estimates and the other factors mentioned previously, it was concluded that hydraulic dredging would be the most practical method of disposal.

3-30. Water Requirements. Water supply is a controlling factor in dredging operations, and a determination was made of the amount of water that would be required and also the amount of water that can be expected to be available on the basis of past flows. It is estimated that water requirements for hydraulic dredging amount to four or five times the volume of dredged material to be moved. Consequently, for each 1,000,000 cubic yards of solid material to be dredged, from 2,500 acre-feet to 3,100 acre-feet of water would be required. If material were deposited along the lake shore or as islands in the lake, the water would return to the lake and little or no water loss would occur, but if the material were moved downstream, the water used would be lost.

3-31. Water would be available from about the top five feet of the lake, which has a capacity of 4,500 acre-feet, and also from inflows into the reservoir. Average inflows for the period 1949 to 1969 are shown in Table 4.

TABLE 4

Average Monthly Lake Inflows
Acre-Feet (1949 to 1969)

January	3,135	July	1,828
February	4,041	August	821
March	3,799	September	4,131
April	8,364	October	1,797
May	11,575	November	2,522
June	4,172	December	1,838

Total Average Annual Inflow **48,023 Acre-Feet**

3-32. The time element enters into the water supply problem and dredging computations herein are based on moving 1,000 cubic yards of dredged material each hour or a maximum of about 2,000,000 cubic yards per year. Should 4,000,000 cubic yards be dredged, a two-year program would be suggested. A comparison of the average inflows shown in Table 4 with the maximum requirements for a one-year dredging water requirement indicates that unless a severe drought should occur during the dredging operations, water supply would not be a problem.

3-33. Characteristics of Sediment. Evaluation of the characteristics of the sediment in the lake is necessary from a construction viewpoint in order that the procedures for placing material in fills and probable time of consolidation can be determined. A soils consulting firm obtained samples of sediment deposits and the underlying parent material from six locations in the lake. It was felt that the lower original bottom material would probably provide a more suitable fill material. The cutter head on the dredge could be effectively lowered to obtain this material if found advantageous. The results of the investigations are presented in a report entitled "Soils Investigation, Lake Sediments, White Rock Lake," prepared by National Soil Services, Inc., and attached as Appendix B to this report.

3-34. The results of the investigations indicate that material deposited as lake sediments are considered as highly plastic clays, and the original ground or bed of the lake consists of medium plastic clays. The lake sediments in the Dixon Branch area are not as plastic as the sediment elsewhere in the lake. These high moisture content materials will require considerable time for the soil to lose its moisture and consolidate. Atmospheric conditions and depth of placement would be major factors in the time of consolidation. Time of consolidation could vary from several months to several years, depending on factors stated

above. It would appear desirable to place the fill in shallow lifts rather than placing the material to the full depth desired at one time. This would permit a quicker loss of moisture and settlement. Settlement of the material could be as much as 50% - 60% of the original depth to which the fill is placed. The tests also indicate that the dredged material would assume very flat slopes if unconfined during filling operations and that levees, sheet piling, or other methods of confinement would be required.

3-35. Use of Sediment. The results of the tests shown in Appendix B indicate that the sediments in the upper White Rock Lake area are not ideally suited for usual type of construction fill or as top soil; however, with proper processing and quality control during placement, the clays could be utilized for ordinary embankments, dikes and the reclamation of miscellaneous areas. These dredged materials are not recommended for use in the upper portions of roadway fills or as foundations for buildings, due to the high plasticity and shrinkage characteristics.

3-36. The soils may be used agriculturally, based on results of tests performed by soils laboratory at Texas A & M. However, they are not considered suitable for areas which require continuous tilling, such as flower beds. The soils are slightly saline but except during periods when seeds germinate, this condition would be of no major concern and could be overcome by providing adequate soil moisture during the germinating period. No offensive odors were observed in any of the sediment samples. Generally it can be assumed that the material will be suitable for reclaimed areas and will consolidate after several years. However, the consolidation period could be accelerated by proper placement. Materials forming the original bed of the lake would provide a more suitable fill material; however, it would be more difficult and costly to remove since intermixing would result and an increase in quantities of material would be required to be moved.

3-37. Areas for Sediment Removal. The removal of all of the sediment deposited in the lake is neither economically feasible nor particularly desirable from the viewpoint of expected usage of the lake. Adequate water depths for recreation are still available in the southern half of the lake and the primary areas considered for sediment removal are the shallower parts in the northern half of the lake, including parts of segments 7, 8, 11, 12, and 13 (see Figure 3). Proposed removal work in segment 13 in the area between Mockingbird Lane and Northwest Highway includes a 200-foot bottom width channel on White Rock Creek and a 100-foot bottom width channel into the lagoon areas both east and west of the main channel. This channel work is planned to improve hydraulic flow conditions to allow better passage of flood water through these shallow areas. An added benefit would be an improved vista of the lake from Mockingbird Lane. In the Dixon Branch area (segment 8) it is proposed that the delta of sediment protruding into the inlet be removed for a distance of about 400 feet upstream from its exposed lower end,

and that the inlet be dredged up into the mouth of Reinhardt Branch, a tributary of Dixon Branch which drains Casa Linda Shopping Center. The widening of Dixon Branch channel to a 100-foot bottom width as far upstream as Buckner Boulevard is also proposed under drainage improvement plans discussed in Section IV, paragraphs 4-20 through 4-23.

3-38. In the southern end of the lake dredging is proposed in part of segment 3 to provide deeper fishing waters at the mouth of McCommas Branch, and in part of segment 1 to remove the sediment from the spillway approach channel to improve the hydraulic efficiency of the spillway. Proposed sediment removal areas in the lake are shown on the map on Plate 5.

3-39. The dredging program should provide a minimum water depth in the main body of the lake of between 6 and 8 feet below spillway level if the dredging program is to be worthwhile. Consideration is given in this regard to providing a reasonable period of time before a repeat dredging program is required, as well as providing adequate water depths during periods when the lake is drawn down either by evaporation loss or for maintenance or construction purposes. A comparison of the amounts of sediment that would need to be excavated from the various segments to provide water depths of 6, 8, 10, and 12 feet is shown in Table 5.

TABLE 5

Sediment Volume by Segments for Minimum Water Depths

	Sediment in Cubic Yards for Depths Shown			
	6 Feet	8 Feet	10 Feet	12 Feet
Segment 3	33,500	56,000	82,000	112,000
Segment 8	135,000	205,000	290,000	370,000
Segment 7	32,000	60,000	100,000	235,000
Segment 11	550,000	1,045,000	1,730,000	2,570,000
Segment 12	1,055,000	1,660,000	2,310,000	2,950,000
Segment 13	204,000	233,000	233,000	233,000
Total	**2,009,500**	**3,259,000**	**4,745,000**	**6,470,000**

The quantities to be removed can be varied by varying the depth in designated areas if this should be found desirable; however, it was assumed for study purposes that a uniform minimum water depth would be selected. The final depth of removal would be controlled by areas of disposal and by economics.

3-40. Land Reclamation Areas. One of the major problems in a sediment removal project is finding a suitable location to dispose of the sediment at a reasonable cost. Generally speaking, the more distant the disposal area, the greater the cost. Potential disposal areas were selected in and around the reservoir as well as in the downstream floodplain so that the relative benefits of each could be weighed. Sites were selected that could be put to a beneficial use, and could be considered as land reclamation areas.

3-41. Reclamation Around White Rock Lake. Several plans for local placement of sediment and reclamation of areas around the lake shore were considered. Four potential areas which could be reclaimed for recreational use are shown on Plate 5, as areas A, B, D, and E. These areas could accommodate approximately 2,500,000 cubic yards of compacted fill to elevation 464.0, which is about 6 feet above spillway level. Assuming an eventual shrinkage in sediment volume of 50 percent, these areas could accommodate about 5,000,000 cubic yards of sediment. A breakdown of pertinent information on the areas is given in Table 6.

TABLE 6

Pertinent Data on Potential Reclamation Areas Around White Rock Lake

Area	Consolidated Volume - (Cubic Yards)	Loose Sediment Volume - (Cubic Yards)	Surface Area (Acres)
A	700,000	1,400,000	59
B	600,000	1,200,000	41
D	650,000	1,300,000	37
E	550,000	1,100,000	44
Totals	**2,500,000**	**5,000,000**	**181**

Data based on filling to elevation 464.0.

Reclamation of any or all of these areas would reduce the quantities shown in Table 5, since the sediment under a reclamation area would not be excavated. The sediment volumes under each of the areas at various water depths are shown in Table 7.

TABLE 7

Sediment Volume Under Potential Reclamation Areas
(Cubic Yards)

Area	6 Foot Depth	8 Foot Depth	10 Foot Depth	12 Foot Depth
A	380,000	570,000	760,000	950,000
B	335,000	350,000	480,000	615,000
D	100,000	170,000	260,000	380,000
E	300,000	440,000	580,000	725,000
Total	**1,115,000**	**1,530,000**	**2,080,000**	**2,670,000**

3-42. In order that the filling of the areas shown can be reasonably controlled, confining the sediment placement would be required. Use of steel sheet piling and compacted heavy clay fill dikes were considered as construction material in the lake area. Using steel sheeting would require the use of a floating plant in the lake and would necessitate the need for some minor dredging to permit access to the proposed new lake shore limit of the reclaimed area due to the present limited depth of water available for floating heavy equipment. Construction of the dikes would require a source of selected borrow material from outside of the reservoir area. Relatively flat slopes on the dikes would be required to provide resistance to sliding, and slope protection against erosion by wave action would also be necessary. It is expected that clays suitable for dike construction would be available along the White Rock Creek floodplain below the dam. It is proposed to end dump this material into the lake from the shore. The heavy clay would move the softer material and consolidation of the dike would be performed by the hauling and spreading equipment.

3-43. An examination of the values in Tables 6 and 7 indicates that there is ample room in the four areas to deposit all or any part of the sediments in 6 to 12 foot water depths shown in Table 5. For example, if a minimum of 6-foot depth were desired and area A were selected for filling, 1,400,000 cubic yards of the total 2,009,500 cubic yards could be deposited on the area. Another 380,000 cubic yards of the total would not have to be excavated from under area A, leaving a net of only 229,500 cubic yards to be deposited in another area. The size of any of the areas could of course be reduced or enlarged as desired. If areas A and B were both filled, the excavation of 2,600,000 cubic yards would provide a net minimum water depth of over 8 feet.

3-44. Of the four areas along the lake shore selected as possible reclamation sites, area A is probably the most practical. It is very shallow, little used, and sometimes unsightly. The filling of area E would necessitate the relocation of two boating clubs and other facilities along the shore. There are also drawbacks to filling areas B and D. In summary, there is adequate room in and along the shore of the lake to deposit sediment, and the reclaimed land acquired by providing deeper lake depths could be advantageously used for recreational purposes.

3-45. Other areas immediately adjacent to or in the lake that were considered for land reclamation areas include the marsh area in the north end of the lake between Mockingbird Lane and Northwest Highway, and the old fish hatchery area below the dam. The marsh area was one of the primary objects of the ecological study discussed in Section II, and that study concluded that it would be more beneficial to leave the marsh as a wildlife habitat than to fill it and reclaim the land. The land adjacent to the marsh area, however, could be used for disposal of sediment from the proposed channel excavation through that area without any long-lasting detrimental effects. The old fish hatchery below the dam has been abandoned, and the area is no longer used for any productive purposes. The site provides about 23 acres of low land that could be beneficially used for sediment disposal and land reclamation. However, the site has been selected as a potential storm water pollution control station, and the Water Utilities Department has verbally requested that the area be reserved for that purpose. The proposed storm water pollution control station is discussed in Section VI under paragraphs 6-12 through 6-14.

3-46. Downstream Floodplains. Consideration was also given to the transportation of the sediment from the upper lake areas to disposal or reclamation areas below Garland Road. There are several of these areas along the floodplain of White Rock Creek which can be considered as possible sites for disposal. One area containing about 34 acres is about 3,000 to 4,000 feet below the White Rock dam and is indicated as area C on Plate 5. This area could accommodate approximately 575,000 cubic yards of consolidated fill (about 1,150,000 cubic yards of sediment). This area could possibly be used in conjunction with filling around the lake shore. Other areas considered as possible locations for reclamation and sediment deposition are located about 6 to 8 miles below White Rock Lake as indicated on Plate 6. The locations of these areas have been coordinated with the Corps of Engineers plan of future channel improvement along the Trinity River and White Rock Creek floodplain. No specific attempt has been made to designate a definite site since these areas are potentially capable of containing much more than the quantity of sediment proposed for removal. For example, 2,500,000 cubic yards of sediment could be deposited on 78 acres of land and consolidated to a 10-foot depth. Selection of a site will depend upon availability of land, and can be made after adoption of a definite

sediment removal program. In view of the economic benefit to a landowner of having his land raised above flooding levels, consideration should be given to negotiating with landowners who may be willing to pay all or part of the cost of the dredging operation in exchange for having their lands raised.

3-47. Confining of Sediments. In paragraph 3-42, the confining of sediments within the lake area by clay dikes and steel sheeting was discussed. A typical section of the clay dike would have a top width of 10 feet and four to one side slopes, with 18 inches of protective riprap and 9 inches of filter blanket on the lake side of the dike extending from the top of the fill to about 3 feet below normal water line. It was assumed that underwater placement of part of the riprap would be required. The dike would be overbuilt to allow for settlement. Steel sheet piling used for confinement of sediments would be driven vertically and anchored where necessary. The top of the sheeting would be finished with a concrete cap. The estimated cost of sheet piling as compared with clay dikes for confining sediments within the four lake areas is as follows:

	Steel Sheet Piling	Riprapped Clay Dike
Area A	$287,000	$289,000
Area B	420,000	417,100
Area D	455,000	492,700
Area E	455,000	492,700

The above estimates include the cost of weirs for controlling water releases from the areas. As indicated in the tabulation, steel sheet piling is the more economical of the two in all areas except Area B, and the difference in cost for that area is relatively minor. In view of the potential use that sheet piling affords for fishing and boat docking, and the flexibility it provides for meandering the shore line, it is considered to be the more practical and beneficial type of confining structure.

3-48. Construction of confining dikes at areas below the dam along the White Rock Creek floodplain would not present a problem and could be accomplished much more economically than in the reservoir. It is estimated that a confining dike for Area C would cost about $20,000, including control weir. A confining dike, which would permit placement of about 10 feet depth of fill in the lower White Rock Creek floodplain, estimated to contain approximately 1,250,000 cubic yards of compacted fill, is estimated at about $72,000. This is an average value and assumes that approximately 12,000 feet of dike would be required of approximately 10 foot height.

3-49. Cost of Hydraulic Dredging. Discussions were held with contractors competent in the dredging field in order to obtain realistic costs for dredging. Consideration was given to the purchase or lease of equipment for dredging and placing of sediment within the park area and also for the placing of materials six to eight miles downstream from the reservoir. The cost of dredging depends upon the rate of removal and the distance the material must be transported, and estimates presented herein are based on equipment capable of moving 1,000 cubic yards in one hour. The cost of the equipment would be about $315,000 to $346,000, and an operating crew for the dredge would consist of one operator, one engineer, and a helper deckhand. Three additional men would be required to handle pontoons, pipe, workboat barge, etc. The estimated cost and size of equipment are based on the assumptions that work would be completed in about one year. The use of a longer period of time would reduce the cost of equipment, but would increase the cost of operating personnel. The cost of leasing the equipment without operating personnel was quoted at $24,000 per month and the use of the equipment for about twelve months would amount to about $288,000, which is about the cost of purchasing the equipment. The cost of equipment required for transporting sediment to the disposal or reclamation areas below the dam for a distance of six to eight miles is estimated to be $1,371,000, which includes the required booster pumps. Due to the high cost of equipment, further consideration was not given to the purchase or lease of such equipment.

3-50. It was considered that competitive bidding would unquestionably result in lesser cost for removing sediment from White Rock Lake and placing sediments in disposal areas. An internationally known dredging contractor was contacted, and he volunteered to provide preliminary unit costs for removing the sediment. It was assumed initially that about 2,000,000 cubic yards of material would be removed from the lake bottom and deposited around the lake shore in various areas, and that work would be completed within one year. It was also assumed, in the interest of economy, the contractor would be permitted to work the equipment on an around the clock basis. Based on the foregoing, the cost of sediment removal was estimated at $0.22 per cubic yard which does not include the cost of mobilization of equipment. It was estimated that the cost of mobilization would add an additional $0.04 to the above cost, making the total cost of removal and placing approximately $0.26. It is pointed out that removing substantially lesser amounts of sediments or greater amounts could affect the unit cost quoted.

3-51. Assuming that areas A and B as shown on Plate 5 were to be used as reclamation areas, approximately 2,600,000 cubic yards of sediment would be required. Due to the larger volume of sediment proposed than previously contemplated, a longer time for completion would be recommended. Relative mobilization cost would also reduce. The

cost of dredging is estimated at $0.25 per cubic yard. To this cost must be added the cost of a confining structure (assumed to be steel sheet piling), as well as the cost of clearing trees and stumps in the upper end of the lake and at Dixon Branch, sufficient to allow dredging operations. About 40 acres of clearing at an estimated cost of $500 per acre would be required. The total cost of raising areas A and B is estimated to be about $1,377,000 as broken down below:

	Area A	Area B	Total
Dredging: 2,600,000 cu. yds. @ 25¢	$350,000	$300,000	$ 650,000
Sheet Piling	287,000	420,000	707,000
Clearing	10,000	10,000	20,000
Totals	**$647,000**	**$730,000**	**$1,377,000**

The reclaiming of both areas would ultimately provide about 100 acres of land at elevation 464.0, but would reduce the surface area of the lake accordingly. As an offsetting feature, however, to the loss of lake surface, some 278 acres of lake area would be dredged to a minimum depth of about 8 feet.

3-52. Transporting sediments to reclamation areas in the downstream floodplain is considered practical. If a comparable yardage of 2,600,000 cubic yards were transported 6 or 8 miles downstream to the areas indicated on Plate 6, the estimated cost would be $3,212,000. This includes sediment at $1.20 per cubic yard plus a containing dike and clearing. The reclaimed land would consist of some 80 to 90 acres about 10 feet high. Minimum depth in the reservoir would be about 7 feet and about 350 acres of lake area would be dredged.

3-53. Investigations indicate that area C could also be used as a disposal or reclamation area. It would accommodate about 1,150,000 cubic yards of sediment at an estimated cost of $0.90 per cubic yard. The cost of reclaiming this 34 acres is estimated to be about $1,055,000 which includes a containing dike.

3-54. Future Sediment Removal Program. The amount of sediment suggested for removal at this time is about 2,600,000 cubic yards. At an estimated continuous rate of sedimentation of 100 acre-feet per year, this represents about 16 years' accumulation of sediment. This does not mean, however, that if 2,600,000 cubic yards were excavated today that in 16 years the lake would be back in exactly the same condition it is today. As discussed previously, the sediment distributes over the entire reservoir, with somewhat heavier deposits in the upper end. Average accumulation depth over the entire reservoir would be about 0.9 feet every 10 years. Prorated in the same manner as discussed in

paragraph 3-13, the average depth of accumulation in the main body of the reservoir would be about 0.7 feet in 10 years and in the upper end about 1.5 feet.

3-55. Long range planning for future sediment removal should anticipate a repeat dredging operation every 15 to 20 years, depending on the rate of sedimentation. In this regard, sedimentation re-surveys should be made about every 10 years to determine lake depths and sedimentation rates. Future sediment could be used to build additional park land around the lake; however, consideration should be given to alternative sites for land reclamation which may require long distance pumping.

3-56. Summary and Conclusion. Sediment accumulation has reduced the storage capacity of White Rock Lake by about 41 percent in its 60 years of life. About 135 acres of the lake have been filled completely by sedimentation, and another 269 acres presently have depths of less than 3 feet. Sedimentation is expected to continue at a rate of about 100 acre-feet per year, and to avoid further deterioration of the lake from this process a sediment removal program should be initiated. Such a program would be of benefit from the standpoint of fishing, boating, aesthetics, general recreation and flood control.

3-57. The most practical means of sediment removal is by hydraulic dredging. The sediment deposits can be pumped almost any reasonable distance desired and can be put to beneficial use in reclaiming land. Potential reclamation areas given most serious consideration include (1) floodplain lands about 6 to 8 miles downstream from White Rock Lake and (2) shallow areas along the shoreline in the upper reaches of the lake. Of these two alternatives the latter is much more economical overall due to the short pumping distance, even though the cost of confining sediments in areas around the lake shore is expensive. This alternative also has the added benefit of providing additional recreation land around the lake, particularly on the west side where the only park land along much of the shore line is a narrow strip of land between the edge of the lake and private property.

3-58. The dredging program should provide a minimum of 6 to 8 feet of water depth in the main body of the lake and should include channel dredging between Mockingbird Lane and Northwest Highway and dredging in the Dixon Branch inlet and other selected areas. The minimum volume of dredging required would range between 2.0 and 3.2 million cubic yards. A sample sediment removal - land reclamation plan would involve the dredging of 2.6 million cubic yards of sediment and the reclamation of 100 acres of land on the west side of the lake (Areas A and B). The plan would provide a minimum lake depth of about 8 feet and is estimated to cost $1,377,000.

IV - DRAINAGE AND FLOOD CONTROL

4-01. General. White Rock Lake as it exists today is both an asset and a liability insofar as flood flows and drainage of storm waters are concerned. The construction of the reservoir effectively reduces the flood flows downstream from the dam that would have occurred without the dam; for example, a 100-year frequency flood discharge over the spillway would amount to 26,200 cubic feet per second but would have been about 34,900 cubic feet per second without the dam. This reduction in downstream flow is accomplished as a result of flood waters being stored temporarily in the reservoir which results in a rise in the water surface level of the lake. The experienced increases in water levels in the lake have caused flooding of Northwest Highway, Lawther Drive, Buckner Boulevard and other streets, and also impede drainage from some areas immediately adjacent to the lake. The existence of the lake, in addition, has caused sediment carried by flood waters to be deposited in the lake to the extent that, in some cases, higher water levels are experienced in streams flowing into the lake because of the sediment deposition and the growth of trees and underbrush in delta areas. Flooding of houses has been experienced in some areas along Dixon and Jackson Branches and detailed investigations were made to determine the effect, if any, that the high lake levels and sedimentation have on high water elevations in the flooded areas.

4-02. The White Rock Lake Dam consists of an earthen embankment about 2,100 feet long and an uncontrolled concrete spillway 450 feet long. The embankment has a maximum height of about 40 feet, a crown width of 20 feet and was constructed with 1 on 2 side slopes, and intermediate berms. Field surveys indicate the upstream slope to be 1 on 2, while the downstream slope varies from 1 on 2 to 1 on 2.85. A typical section of the embankment is shown on Plate 20. The upstream face of the embankment is protected from wave action by concrete paving to about elevation 467.5, which is 2.4 feet below the original design elevation for the top of the embankment. The spillway is at the south end of the embankment and consists of a broad-crested concrete weir with a crest which varies from elevation 457.9 to 458.4. Two notches in the concrete weir are located near the center of the spillway. The notches which are 10 feet long by 2.6 feet deep, are normally kept closed by stop-logs and the normal pool of the lake is kept near the spillway crest level. The south abutment of the spillway and approach wall are at elevation 466.3. Garland Road is immediately south of the spillway and if water levels in the lake should exceed elevation 466.3, water would overtop the approach wall and spill along and across Garland Road into White Rock Creek downstream from

the dam. The spillway rating curve shown on Plate 20 includes the water that would spill over the approach wall. The embankment of the dam has settled, with the passage of time, and a field survey made in May 1971 shows that the top of the earthen embankment is between elevations 467.0 and 468.0 over most of its length. The profile of the dam and spillway is shown on Plate 20.

4-03. 1965 Drainage Improvement Studies. A report entitled, "Drainage Improvement Studies, Lower White Rock Creek," was prepared in March 1965 by Forrest and Cotton, Inc. for the City of Dallas Department of Public Works. This report was followed in October 1965 by a similar report on "Upper White Rock Creek," and in January 1967 by a report on "Additional Hydraulic and Hydrologic Studies on Upper White Rock Creek," prepared by the same firm. These reports dealt primarily with bridge and channel improvements to alleviate flooding problems along White Rock Creek. The Lower White Rock Creek report also dealt with improvements for uncontrolled regulation of the normal lake level at about three feet below present normal level and for controlled releases to rapidly lower the lake level for future maintenance and construction purposes in the upstream lake area. The plan of improvement at the spillway included the removal of all obstructions to flow over the weir, including the catwalk, concrete piers, and steel stop-log supports; the removal of the stop-logs in the two existing 10-foot notches; lowering of the spillway approach channel; and facilities for lowering the lake levels, consisting of a 14-foot diameter drop inlet with crest at elevation 455.0, and a 7-foot diameter tunnel under Garland Road. The report also pointed out that based on present-day and future urbanization the spillway capacity is such that the embankment would be overtopped if the watershed were subject to a flood of the magnitude of the "Standard Project Flood" as defined by the Corps of Engineers. The report further pointed out that while the improvements recommended therein would improve the situation with respect to floods of record, the spillway would still be inadequate when evaluated by present standards for spillway design.

4-04. Rainfall and Streamflow Records. The U. S. Geological Survey, under a cooperative agreement with the City of Dallas, has been collecting rainfall and streamflow data in the White Rock Creek watershed since 1961. Included in the watershed is a network of fifteen recording rain gages, four recording stream gaging stations, five crest-stage stations, and thirty-nine flood-profile stations on which information has been published. Locations and pertinent data for these gages are shown on Plate 7. In recent months, the U. S. Geological Survey has installed a number of additional flood-profile stations within the watershed on which pertinent data have not yet been published. Five of these stations are on Dixon Branch and five are on Jackson Branch at major road crossings. The locations of the stations are listed on the following page.

Dixon Branch	Jackson Branch
Peavy Road	Merriman Road
Easton Road	Skillman Street
Fernald Drive	Fair Oaks
Kingsley Road	IH 635 (East Fork)
IH 635	IH 635 (West Fork)

Valuable flood profile information will be provided by these gages in the future.

4-05. Four reports have been issued by the U. S. Geological Survey on White Rock Creek floods under the cooperative program. These reports are: *Floods on White Rock Creek Above White Rock Lake at Dallas, Texas,* Open File No. 66, dated July 1963; *Frequency and Extent of Flooding on Lower White Rock Creek at Dallas, Texas,* Open File No. 69, dated April 1964; *Floods on White Rock Creek at Dallas, Texas in 1962 and 1964;* and *Floods of April 28, 1966 in the Northern Part of Dallas, Texas,* Open File No. 96, dated December 1966.

4-06. Flood History. White Rock Creek has experienced severe floods throughout the period of settlement and development of the area. Although specific flood data are available only for recent years, a reliable general flood history has been developed from various sources by the U. S. Geological Survey. The maximum flood experienced since the 1880's was that of September 20-21, 1964, while the second greatest flood occurred April 19-20, 1942. Other major floods were experienced in June 1949, July and October 1962, April 1966, and May 1969, and floods of sufficient importance to be newsworthy occurred in April 1922, May 1946, August 1947, May 1957, November 1964, and February 1965. Peak discharges for floods in 1962, 1964, 1966, and 1969 recorded at the four recording gages are given in Table 8.

TABLE 8

FLOOD PEAK DISCHARGES IN C.F.S. AT U.S.G.S.
RECORDING STREAMFLOW STATIONS
ON WHITE ROCK CREEK

	Sept. 20 & 21 1964*	July 27 & 28 1962	Oct. 8 1962	April 28 1966	May 7 1969
Keller Springs Road	37,900**	9,410	2,360	9,020	8,300
Greenville Avenue	38,100	20,000	29,000	27,000	19,600
White Rock Lake Spillway	28,300	13,700	10,200	18,800	12,300
Scyene Road	30,200	17,400	9,300	21,500	13,500

* Maximum flood experienced since 1880's

** Discharge value is almost equal to Greenville Avenue discharge, although the drainage area at Keller Springs Road is 29.4 square miles compared with 66.4 square miles at Greenville Avenue. However, this value has been re-checked with U.S.G.S. which is confident that figure is reasonably accurate. Water was from 10 to 12 feet deep over roadway and resulted from about 12 inches of rainfall.

4-07. Hydrologic Studies for White Rock Creek and Tributary Streams. The 1965 report on Lower White Rock Creek contains a detailed discussion of the hydrology of the White Rock Creek watershed including flood history, effects of urbanization, unit hydrograph determinations, design storm rainfall and runoff, and the development of flood hydrographs for storms of various frequencies of occurrence. The hydrological data developed in the 1965 report were used as the basis for flood studies on White Rock Creek and White Rock Lake made for this report, with appropriate consideration being given to the additional records now available. For ease of reference, the hydrology of the 1965 report is attached as Appendix C.

4-08. Dixon Branch and Jackson Branch are much smaller watersheds than White Rock Creek, with different watershed characteristics. Detailed backwater computations for these streams for this report are based on recent hydrological data reported by the U.S. Geological Survey for small watersheds in the Dallas vicinity with supplemental data from the previous reports.

4-09. Hydrology of Tributary Streams. Hydrological computations were made to determine the effect of varying lake levels on major storm drainage facilities on Dixon Branch and Jackson Branch, and to determine the water surface elevations that would result from flood flows under various conditions. Streamflow records are not available on these streams, so in their absence, flood peak discharges were derived by developing unit hydrographs for the separate watersheds and applying rainfall-excess values for various frequency storms. Backwater computations, based on these discharges, were then made to determine water surface elevations.

4-10. Unit Hydrograph Determinations. Analyses to develop unit hydrograph characteristics were based on Snyder's empirical relationships for synthetic unit hydrographs. The following equations were used:

$$t_p = C_t(LL_{ca})^{0.3}$$

$$t_r = \frac{t_p}{5.5}$$

$$t_{pR} = t_p + 0.25\ (t_R - t_r)$$

$$q_{pR} = \frac{C_p 640}{t_{pR}}$$

$$Q_p = q_p A$$

t_p = lag time from midpoint of unit duration, t_r, to peak of unit hydrograph in hours.

t_r = unit rainfall duration, general, hours.

t_R = unit rainfall duration, adopted for a given study, hours.

t_{pR} = lag time from midpoint of unit duration, t_R, hours.

q_{pR} = peak discharge of unit hydrograph for unit duration t_r, cfs per square mile.

Q_p = peak discharge of unit hydrograph for unit duration, t_R, cfs.

L = stream miles from a given point to the upstream divide of the drainage area, miles.

L_{ca} = stream miles from a given point to the center of gravity of the drainage area, miles.

A = drainage area above a given point, square miles.

C_t and C_p640 = coefficients that depend on the characteristics of the watershed and its drainage system.

C_t and C_p640 values used in this study were based on recorded storm flow records on Bachman Creek, a small watershed immediately west of the White Rock Creek drainage divide. The Bachman Creek watershed above Midway Road bears a strong resemblance to both the Dixon Branch and the Jackson Branch watersheds as is indicated in the comparison in Table 9.

TABLE 9

COMPARISON OF WATERSHED CHARACTERISTICS

Characteristic	Bachman Creek (Above Midway Road)	Dixon Branch (Above Buckner Blvd.)	Jackson Branch
Relief Ratio Ft./Ft.	0.007	0.006	0.006
Drainage Area Square Miles	10.0	6.90	8.81
Average Width Miles	1 1/2 to 2	1 1/2	2
Length - Miles	5	5	5
State of Urban Development			
Percentage Developed	80-90	70-80	10-20
Directional Alignment	North-South	North-South	North-South

The only existing dissimilarity of significance consists of the low degree of urban development of the Jackson Branch watershed. However, the Jackson Branch watershed is developing rapidly and for the purpose of future design flows is considered to be fully developed. Investigation of U.S.G.S. data on eleven historical floods on Bachman Creek between 1964 and 1969 resulted in the selection of 0.70 and 650 for C_t and C_p640 values, respectively. These coefficients were considered representative of both the Dixon Branch and the Jackson Branch watersheds. Pertinent unit hydrograph data for the two branches are shown in Table 10. This table also shows data developed for the portion of Jackson Branch which lies above an unnamed tributary which drains the vicinity of White Rock Trail and Spring Branch Drive.

TABLE 10

1/2-HOUR UNIT HYDROGRAPH DATA

Watershed	A (Sq.Mi.)	L (Miles)	L_{ca} (Miles)	t_{pr} (Hours)	C_t	C_p640	Q_p (cfs)
Dixon Branch	6.90	6.0	2.2	1.57	0.70	650	2860
Jackson Branch	8.81	5.8	3.3	1.73	0.70	650	3310
Jackson Branch*	7.18	5.6	3.1	1.70	0.70	650	2740

*Above unnamed tributary.

4-11. Flood Hydrograph Development. Rainfall values for a 12-hour duration storm of 5-, 25-, and 100-year frequencies for the watersheds of interest were estimated from data in U.S. Weather Bureau Technical Paper No. 40, "Rainfall Frequency Atlas of the United States," dated May 1961 and reprinted January 1963. In this report, as in the 1965 reports to the City of Dallas, a given frequency rainfall is assumed to cause a flood of the identical frequency. Initial infiltration losses for these urban watersheds were assumed to be 0.35 inch, with an ensuing loss at the rate of 0.12 inch per hour. Table 11 gives the distribution of the 12-hour rainfall, the infiltration losses, and the resulting rainfall excess values for the 5-, 25-, and 100-year storms. These excess rainfall values were then applied to the unit hydrographs to yield the flood hydrographs. Flood discharge peaks for 5-, 25-, and 100-year frequency storms for Dixon and Jackson Branches are tabulated below.

Watershed	Flood Discharge Peaks (cfs.) 5-Yr.	25-Yr.	100-Yr.
Dixon Branch	4280	6200	8100
Jackson Branch	5200	7540	9860
Jackson Branch Above Unnamed Tributary	4300	6220	8140

4-12. Backwater Computations. Backwater computations were made utilizing an IBM 1130 digital computer with a program initially written by the United States Corps of Engineers, since revised. Representative channel cross-sections were surveyed in the field and this information was supplemented with 1-foot contour maps provided by the City of Dallas. Accurate descriptions of bridges which cross the streams were determined from

TABLE 11

DIXON BRANCH AND JACKSON BRANCH WATERSHEDS
RAINFALL, LOSSES, AND RAINFALL EXCESS
5-, 25-, and 100-YEAR STORMS OF 12-HOUR DURATION

1/2-Hour Period	5-YEAR STORM Rainfall inch	5-YEAR STORM Infiltration Loss inch	5-YEAR STORM Rainfall Excess inch	25-YEAR STORM Rainfall inch	25-YEAR STORM Infiltration Loss inch	25-YEAR STORM Rainfall Excess inch	100-YEAR STORM Rainfall inch	100-YEAR STORM Infiltration Loss inch	100-YEAR STORM Rainfall Excess inch
1	0.07	0.07	0.00	0.09	0.09	0.00	0.12	0.12	0.00
2	0.07	0.07	0.00	0.09	0.09	0.00	0.12	0.12	0.00
3	0.08	0.08	0.00	0.10	0.10	0.00	0.13	0.13	0.00
4	0.08	0.08	0.00	0.11	0.11	0.00	0.14	0.06	0.08
5	0.08	0.08	0.00	0.12	0.06	0.06	0.15	0.06	0.09
6	0.10	0.06	0.04	0.12	0.06	0.06	0.16	0.06	0.10
7	0.11	0.06	0.05	0.16	0.06	0.10	0.20	0.06	0.14
8	0.15	0.06	0.09	0.21	0.06	0.15	0.27	0.06	0.21
9	0.22	0.06	0.16	0.30	0.06	0.24	0.39	0.06	0.33
10	0.22	0.06	0.16	0.30	0.06	0.24	0.39	0.06	0.33
11	0.22	0.06	0.16	0.31	0.06	0.25	0.40	0.06	0.34
12	0.23	0.06	0.17	0.33	0.06	0.27	0.42	0.06	0.36
13	0.56	0.06	0.50	0.79	0.06	0.73	1.01	0.06	0.95
14	0.71	0.06	0.65	0.99	0.06	0.93	1.27	0.06	1.21
15	0.69	0.06	0.63	0.96	0.06	0.90	1.23	0.06	1.17
16	0.42	0.06	0.36	0.59	0.06	0.53	0.76	0.06	0.70
17	0.30	0.06	0.24	0.42	0.06	0.36	0.54	0.06	0.48
18	0.21	0.06	0.15	0.29	0.06	0.23	0.37	0.06	0.31
19	0.06	0.06	0.00	0.09	0.06	0.03	0.11	0.06	0.05
20	0.01	0.01	0.00	0.02	0.02	0.00	0.02	0.02	0.00
21	0.01	0.01	0.00	0.02	0.02	0.00	0.02	0.02	0.00
22	0.01	0.01	0.00	0.02	0.02	0.00	0.02	0.02	0.00
23	0.01	0.01	0.00	0.02	0.02	0.00	0.02	0.02	0.00
24	0.01	0.01	0.00	0.02	0.02	0.00	0.02	0.02	0.00
TOTALS	**4.63**	**1.27**	**3.36**	**6.47**	**1.39**	**5.08**	**8.28**	**1.43**	**6.85**

field surveys and construction plans. Field inspections of the channel, immediate overbank, and flood plain, aided in selection of appropriate Manning's "n" values, the friction coefficient used in Manning's equation describing uniform flow in open channels. The adopted "n" values are as follows:

ADOPTED MANNING'S "n" VALUES

Existing Conditions:	Channel	-	0.040-0.150
	Overbank	-	0.050-0.125
Improved Conditions:	Paved Channel	-	0.018
	Earth Channel	-	0.035
	Overbank	-	0.050-0.125

4-13. Dixon Branch. Dixon Branch is a tree-lined channel about six miles long which drains into the east side of White Rock Lake. Its drainage area above Buckner Boulevard, which is essentially at the eastern headwaters of the lake, is 6.9 square miles. The reach of the channel considered in this study is from the mouth of Dixon Branch at White Rock Lake to Easton Road, nearly two miles upstream. This reach is shown on the map on Plate 9. Near the mouth of Dixon Branch a large delta of sediment has gradually built up over the years and it continues to encroach on the open waters of the Dixon Branch inlet. The delta is overgrown with underbrush and large trees, primarily willows, which tend to slow down incoming floodwaters, allowing additional sediment to drop out, and continuing the build-up of the delta. Although this process is effective in preventing sediment from being carried farther into the lake, it also fills in the inlet and channel and reduces the hydraulic efficiency of Dixon Branch, causing higher water levels upstream. Sediment has accumulated in the bottom of the channel from the mouth to Buckner Boulevard and has reduced the channel depth to about 5 feet. Above Buckner Boulevard the sediment accumulation tapers out in a few hundred feet, and from there on upstream to Easton Road channel depths range from 10 to 15 feet.

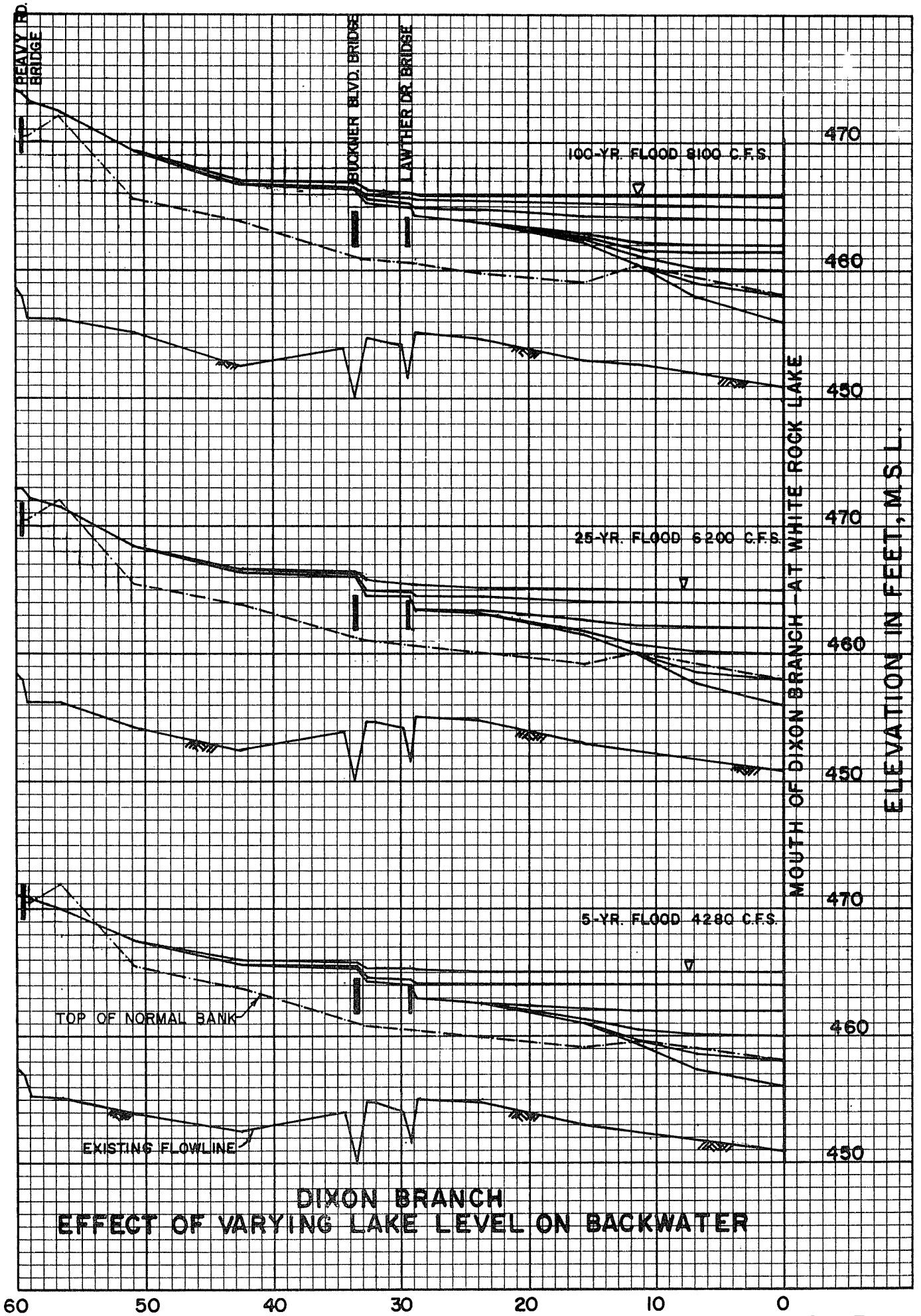
4-14. Extent and Effect of Flooding. There have been reports of flooding of several houses along Dixon Branch in the vicinity of Vinemont and Creekmere Drives (Floods of July 1962, April 1966, and May 1969). This area is on the east side of the creek just upstream from Peavy Road. Peavy Road, Buckner Boulevard, and Lawther Drive have also been flooded from heavy rainfall on the Dixon Branch watershed. In order to determine water surface profiles for various frequency floods on Dixon Branch, a series of backwater computations were made for 5-, 25-, and 100-year floods. These profiles for the reach from White Rock Lake to Easton Road are shown on Plate 8. Also shown

on Plate 8 are historical high water elevations at road crossings which were furnished by the Department of Public Works.

4-15. The water surface profiles indicate that out-of-bank flooding occurs generally throughout the reach from the lake to Easton Road for frequencies as low as 5 years. Buckner Boulevard and Lawther Drive bridges are overtopped by the 5-year flood. Peavy Road and Easton Road bridges are adequate to pass the 5-year flood, but would be overtopped by the 25- and 100-year floods. Plate 9 shows the approximate limits of flooding for the 100-year frequency flood. This flood limit delineation is based on 1-foot contour maps furnished by the Department of Public Works for areas in which such maps are available, and supplemented with City of Dallas 5-foot contour maps and field survey data in other areas. The 100-year flood delineation indicates that a number of homes would have floodwaters in the yards, but not necessarily in the house, depending upon the floor elevation of the individual house. Spot field survey checks of floor elevations in the area subject to flooding upstream from Peavy Road indicate that about 60 houses would be flooded by the 100-year flood on Dixon Branch.

4-16. Effect of Lake Levels on Flooding. The possibility of a 100-year frequency lake stage occurring at the same time as the 100-year flood on Dixon Branch is extremely remote. During general storms over the White Rock Creek watershed, the peak flow on Dixon Branch usually occurs before the peak stage is reached on White Rock Lake because of the longer travel time for flood waters on White Rock Creek. To determine the effect that various lake levels might have on flooding on Dixon Branch, a series of backwater computations were made for 5-, 25-, and 100-year floods for various lake levels ranging from elevation 456.0 (2 feet below spillway level) to elevation 465.9, which is the approximate 100-year frequency lake level under fully developed watershed conditions. The results of these computations, which are shown graphically on Figure 4, indicate that for each frequency flood, the water surface profiles for each of the various starting elevations coincide at some point between Buckner Boulevard and Peavy Road. Based on these computations, it is concluded that under present conditions, the level of White Rock Lake for a 100-year flood stage or less has no effect on flood water elevations further upstream than a point 1,600 feet upstream from Buckner Boulevard.

4-17. Drainage Improvements Considered for Dixon Branch. Maximum water levels in White Rock Lake will flood areas upstream from Buckner Boulevard for a distance of about 1,600 feet. However, even without the lake being in existence, the natural flows from Dixon Branch would flood this 1,600-foot reach to some extent and the lake levels do not have any effect on the high water levels further upstream. The existing Dixon Branch channel has a discharge capacity of about 600 cfs between the lake and Buckner



DIXON BRANCH
EFFECT OF VARYING LAKE LEVEL ON BACKWATER

FIGURE 4

Boulevard; about 1,600 cfs from Buckner Boulevard to Peavy Road; and, about 4,000 cfs at a point 1,500 feet upstream from Peavy Road. It is anticipated that the Dixon Branch watershed will be completely urbanized within the next few years and that flows may be expected to be 4,280 cfs for a 5-year flood; 6,200 cfs for a 25-year flood, and 8,100 cfs for a 100-year flood. In view of the foregoing, the existing channel capacities would have to be increased substantially if overbank flooding is to be prevented or reduced appreciably.

4-18. It is recognized in considering the possibilities of channel improvements, that objections may be voiced to the straightening of meandering natural channels, the cutting of trees, and the paving of excavated channels with concrete. However, if it is desired that flooding be reduced in the Dixon Branch area such improvements are required and the following generalized information is presented in order to point out some of the economic problems involved. It has been found that the most effective and least costly method of lowering flood heights in channels where underbrush and trees have grown is by the clearing out of such growth. Such clearing can easily double or triple the carrying capacity of the stream depending upon the density of the growth. Where additional capacity is needed and sufficient space is available, excavated channels and/or levees may be constructed to provide the desired degree of protection. Concrete lined channels will carry about two times the flow of unlined channels and where there is insufficient space to use unlined channels and/or levees, concrete lined channels and floodwalls may be utilized effectively. It is not necessary to follow an absolutely straight alignment in channel enlargement projects when right-of-way is available, but if a meandering alignment should be adopted, the construction cost would be increased by the added length of channel and the hydraulic requirement that the channel be enlarged to compensate for the reduced velocity of the flowing water attributed to the added length. For example, if a 40-foot bottom width straight channel with a 10-foot depth and 1 on 2 side slopes were to be increased in length by 30 percent by a meandering alignment, it is apparent that the quantities of excavation and paving would be increased by 30 percent. However, the capacity of the meandering channel would be reduced about 12 percent and in order to provide the same capacity as the straight channel, the bottom width would have to be increased to 46.5 feet which would increase the excavation quantitites an additional 11 percent and the paving quantities by about 7.5 percent.

4-19. There are numerous combinations of lined and unlined channels, levees and/or floodwalls, and pumping stations that might be utilized to reduce flooding from Dixon Branch and in order to evaluate the costs of such improvements, several preliminary plans were investigated and are discussed in the following paragraphs. A summary of the features and estimated costs of the various plans is shown in Table 12, which follows the description of Improvement Plan 4.

4-20. Drainage Improvement Plan 1. Channels of various bottom widths were studied for the reach of Dixon Branch between Buckner Boulevard and the mouth of the creek and it was found that an unlined channel with a bottom width of 100 feet and 1 on 3 side slopes, or the provision of multiple channels with an equivalent hydraulic capacity, would provide the desired reduction in water levels at Buckner Boulevard. At Buckner Boulevard the channel would transition into the existing bridge. The existing structure would remain in place, but the bridge opening would be enlarged as much as practical and the channel deepened to provide a 35-foot bottom width opening. This channel would be lined with concrete and would extend under Buckner Boulevard and about 200 feet upstream where it would transition into the natural channel. As an alternative to the downstream 100-foot bottom width channel, two smaller, gently meandering channels with equivalent capacity could be utilized if such an alternative would be more compatible with the park beautification. In connection with the channel enlargement, a portion of the delta at the mouth of Dixon Branch formed by sediment deposition would be excavated to the line shown on Plate 9. The Lawther Drive bridge over the channel would be lengthened by 50 feet in order to accommodate the enlarged channel, but it would remain at its present grade. Details of the lengthening of this bridge are shown on Plate 14. Under Plan 1, flooding of the existing Buckner Boulevard bridge would be eliminated for floods of 5-year frequency or less. The estimated cost of Plan 1 is $189,000.

4-21. Drainage Improvement Plan 2. Plan 2 would include the improvements described under Plan 1 and would also include the replacement of the existing Buckner Boulevard bridge, the widening of the concrete channel under the bridge to 49 feet, and appropriate roadway grade changes so that Buckner Boulevard would not be inundated from an occurrence of the 100-year flood. A minimum of 2 feet of freeboard above the 100-year lake level of elevation 465.9 would be provided for the bridge. Details for enlarging the bridge and raising the roadway are shown on Plate 14. The estimated cost of Plan 2 is $580,000.

4-22. Drainage Improvement Plan 3. Plan 3 would consist of an extension of channel improvements upstream from the Plan 2 improvements with a 49-foot bottom width concrete lined channel from Buckner Boulevard upstream to about 200 feet above Peavy Road, where the channel would transition into a 48-foot bottom width earth channel. This section would be continued upstream for 1,700 feet to station 78+00 where a transition into the natural channel would be made. From this point to Easton Road the existing channel would be cleared of underbrush and small trees to improve its efficiency. Plate 10 shows the alignment for Plan 3 which would follow very closely the course of the existing channel. The channel would carry the 100-year flood of 8,100 cfs within bank throughout most of its length, and where out-of-bank flow would occur

there would be no flood damage. In the reach immediately upstream from Buckner Boulevard, overbank flow could occur under high lake stages. The Peavy Road and Easton Road bridges would remain in place. A profile of the improved channel with typical channel sections is shown on Plate 11. The estimated cost of Plan 3 is $1,408,000.

4-23. Drainage Improvement Plan 4. Plan 4 has been considered briefly as an alternative to Plan 3. It would be an extension of Plan 2 and upstream from Buckner Boulevard the existing channel would remain in its natural state. A series of levees and /or walls along the floodplain would be utilized to contain the design flood of 8,100 cfs with White Rock Lake at elevation 465.9. Levees would be constructed with flat slopes to blend into the natural terrain. Where construction room would be limited, stone or concrete walls would be constructed. The Peavy Road bridge and adjacent roadway would be raised. Plan 4 would require that pumping facilities be provided to discharge storm waters that would collect behind the levees and floodwalls. The locations of these pumping stations are shown on Plate 12. The water surface profile with the improvements in operation and top of levee for the design 100-year flood are shown on Plate 13. The estimated cost of Plan 4 is $3,667,000.

TABLE 12

Summary of Alternative Improvement Plans
Dixon Branch

Improvement Plan No.	Features	Flood Frequency Protection	Cost
1	100' B-W channel from lake to Buckner. Lengthen Lawther Drive bridge. 35' B-W concrete channel under existing Buckner bridge.	5-Year @ Buckner	$ 189,000
2	Same as Plan 1, except 49' B-W concrete channel under Buckner, new Buckner bridge, and raise Buckner Boulevard.	100-Year @ Buckner	$ 580,000
3	Same as Plan 2, plus 49' B-W concrete channel Buckner to Peavy, 1700' of 48' B-W earth channel and 1500' of cleared natural channel Peavy to Easton.	100-Year Overall	$ 1,408,000
4	Same as Plan 2, plus levees, walls and pump stations upstream to Easton.	100-Year Overall	$3,667,000

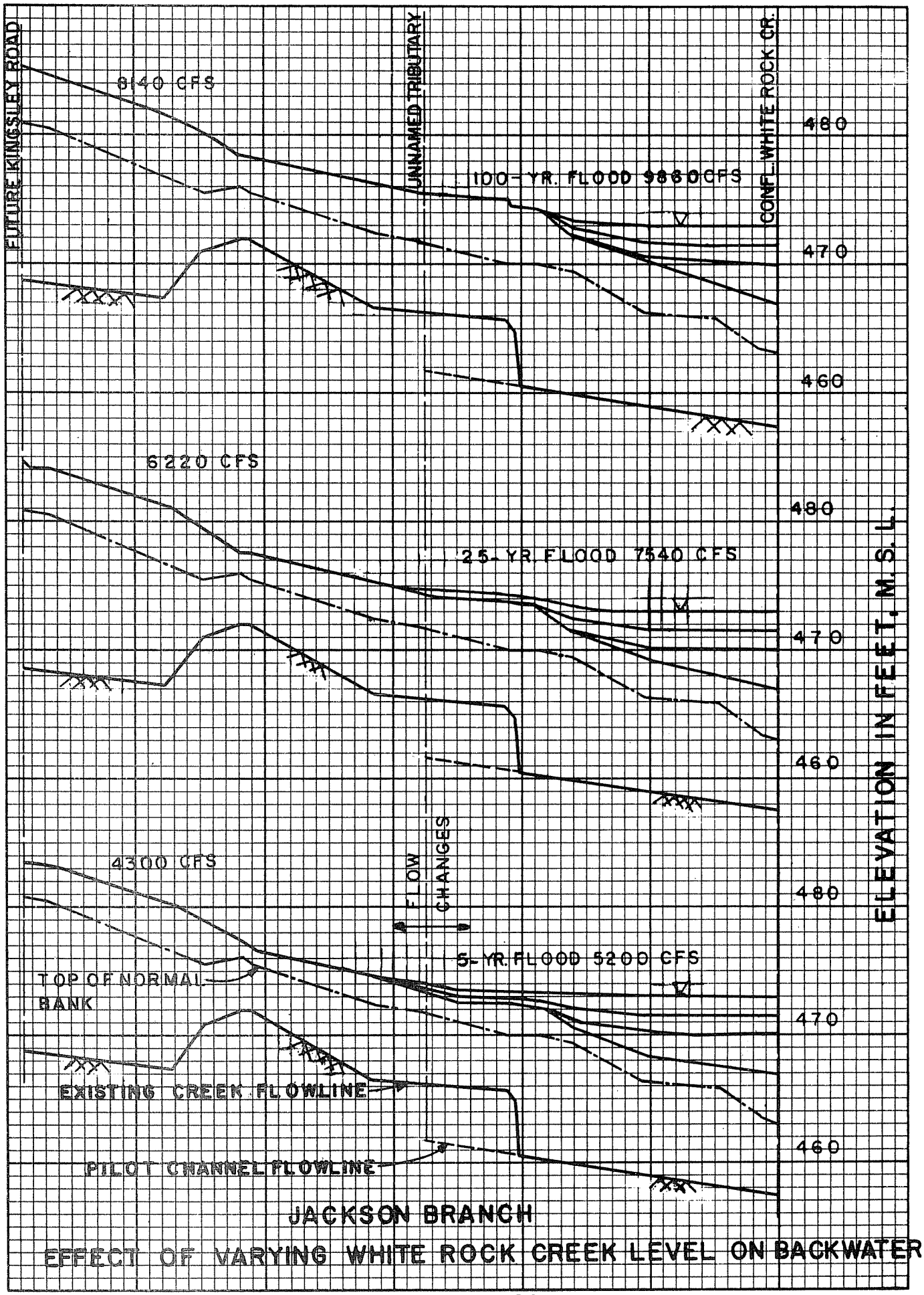
4-24. Jackson Branch. Jackson Branch is a tributary of White Rock Creek, with the confluence of the streams located about 0.6 miles upstream from Northwest Highway. The creek has a length of about 5 miles and a drainage area of 8.8 square miles. The channel reach studied is slightly less than two miles in length, extending from the mouth of the creek to Church Road. Although there are no road crossings in this reach of the stream at present, Kingsley Road is to be extended across the creek in the future at a point about 6,000 feet upstream from the creek's confluence with White Rock Creek. With the exception of a tributary channel on the east side, the creek and floodplain are confined generally within a strip of land about 1,000 feet wide, bounded by Skillman Street on the west and the M.K.T. Railroad on the east. Plate 15 shows the reach of Jackson Branch studied.

4-25. Much of the floodplain is in its natural state, and the only major development is an apartment complex built on an embankment adjacent to Skillman Street. The natural channel in the lower floodplain is a small, sharply meandering stream with poor hydraulic characteristics. At a point about 4,000 feet upstream from the mouth, the channel has been completely obscured by a construction haul road. Above this point for about 1,000 feet upstream, the channel has been filled with cut trees and limbs, and has a very limited discharge capacity. However, the channel is deeper and more efficient further upstream. In the lower floodplain, a new 15-foot bottom width pilot channel has recently been constructed to improve flow conditions, with particular consideration given to providing an improved outlet for floodwaters originating in the previously mentioned unnamed tributary. The pilot channel and unnamed tributary can be identified on Plate 15. The present discharge capacity of the pilot channel is about 1,800 cfs and the Jackson Branch channel at Church Road has a capacity of about 5,000 cfs.

4-26. Extent and Effects of Flooding. Reported flooding problems on the Jackson Branch watershed have been limited primarily to the unnamed tributary in the area above White Rock Trail. During the flood of April 1966, three houses in the 9300 block of Clearhurst Drive reported flooding within the houses. House floor elevations in these three houses range from 476.1 to 476.6. High water elevation reported by the Department of Public Works was 476.9. This high water was reportedly caused by a combination of high water on Jackson Branch and the inability of an M.K.T. Railroad culvert to pass the flood waters originating on the unnamed tributary. However, subsequent to the April 1966 flood, the 15-foot bottom width pilot channel was constructed from White Rock Creek to the mouth of the tributary and flow under the M.K.T. Railroad embankment has been improved by the installation of four 6- x 10-foot culverts in addition to the two 8- x 8-foot concrete culverts already existing. In addition, a 38-foot wide channel with paved bottom has been constructed from the railroad upstream to the flooded area.

4-27. In order to determine water surface profiles for various frequency floods on Jackson Branch, a series of backwater computations were made for the 5-, 25-, and 100-year floods, which have peak flows of 5,200 cfs; 7,540 cfs; and 9,860 cfs, respectively. The profiles for the reach from White Rock Creek to Church Road are shown on Plate 16. Also shown on Plate 16 are historical high water marks at the mouth of Jackson Branch and at Church Road. Generally, out-of-bank flows occur over this entire reach for the floods studied, although neither Church Road nor the proposed Kingsley Road Bridge would be overtopped by the 100-year flood. The embankment at the apartment complex on Skillman Street has adequate freeboard, with a top of bank elevation of 479.0 versus an adjacent 100-year water surface elevation of 475.0. At the mouth of the unnamed tributary on the west side of the M.K.T. Railroad, the water surface elevation is approximately 475.5 for the 100-year flood. This is nearly 8 feet higher than the 100-year design water surface level of elevation 467.63 shown on the construction plans for the new concrete bottom tributary channel on the east side of the railroad culvert. The new channel's design gradient provides a freeboard of about 4 feet opposite the lowest houses. The possibility of a 100-year frequency flood occurring on both of these streams simultaneously is remote; however, with a 100-year flood on Jackson Branch and no flow at all in the tributary, there would be only 0.6-foot to 1.1 feet of freeboard on the three houses previously flooded on Clearhurst Drive (floor elevations 476.1 to 476.6). From a spot field survey check, most other houses in the area were found to have floor elevations of 478.0 or greater. The 100-year flood line resulting solely from backwater on Jackson Branch is delineated on Plate 15. This delineation is based on 1-foot contour maps furnished by the Department of Public Works for areas in which such maps were available, and supplemented with City of Dallas 5-foot contour maps and spot field survey checks in other areas.

4-28. Effect of Lake Levels on Flooding. During the greatest flood of record (September 1964) on White Rock Creek, the water surface at the mouth of Jackson Branch reached elevation 471.6 which is the highest water surface expected to occur at this location for frequencies of 100 years or less. To determine the effect of this and lesser White Rock Creek flood stages on flooding on Jackson Branch, a series of backwater computations were made for 5-, 25-, and 100-year floods for various White Rock Creek stages. The results of these computations, which are shown graphically on Figure 5, indicate that for the 100-year flood, the water surface profiles for each of the various starting elevations converge before reaching station 27+50 (the mouth of the unnamed tributary), which is the area of primary concern insofar as flooding is concerned. The profiles for the 25-year and 5-year floods also converge to within less than one foot before reaching station 27+50, and this difference would be caused only by the maximum flood of record occurring in White Rock Creek at the same time as the peak discharge in Jackson Branch. Based



JACKSON BRANCH

EFFECT OF VARYING WHITE ROCK CREEK LEVEL ON BACKWATER

FIGURE 5

K+E 10 X 10 TO THE INCH 46 0703
7 X 10 INCHES MADE IN U.S.A.
KEUFFEL & ESSER CO.

on the foregoing, it is concluded that the level of White Rock Lake would have no appreciable effect on flooding of present improvements on Jackson Branch.

4-29. Drainage Improvements Considered for Jackson Branch. Since the possibility of flooding exists for some houses upstream from White Rock Trail, a study was made to determine what improvements could be made to reduce the possibility of flooding. From a review of the construction plans for the tributary channel, it was concluded that a considerable improvement would be effected if the water surface profile at the mouth of the tributary (station 27+50 on Jackson Branch drainage ditch) could be lowered to elevation 473.5. This would reduce the effect of Jackson Branch backwater on the tributary channel sufficiently to avoid flooding of houses. Backwater computations showed that it would be possible to lower the 100-year flood level at station 27+50 to elevation 473.5 by widening the existing 15-foot bottom width pilot channel to 80 feet and extending it about 300 feet up Jackson Branch. A transition from the end of the excavated channel would be made with the natural channel of Jackson Branch. The plan of improvement is shown on Plate 17 and the water surface profile for the enlarged channel is shown on Plate 18. The total improvement would consist of about 2,800 feet of 80-foot bottom width channel with 1 on 3 side slopes or equivalent, a junction structure at the mouth of the tributary, and a transition structure at the upper end of the improvement. The estimated cost of this improvement is $162,000.

4-30. White Rock Lake Dam and Spillway. The highest flood level of record on White Rock Lake was that of September 1964 which reached elevation 465.6 at the dam. Other floods of significant magnitude with recorded or estimated flood heights follow:

Date	Flood Height
April 20, 1942	465.2
June 14, 1949	464.0
July 27, 1962	463.7
October 8, 1962	461.9
April 28, 1966	463.8
May 7, 1969	462.4

Subsequent to the 1964 flood the pedestrian bridge and supporting piers were removed from the existing spillway which has improved the efficiency of the spillway, and the occurrence of a flood of like size would result in slightly lower lake levels under present conditions. However, as urbanization of the watershed continues, runoff into the lake increases in both volume and rate and under fully developed watershed conditions, it is

estimated that a 100-year flood would cause the water surface in the lake to rise to elevation 465.9. Peak inflow from such a flood would amount to 46,720 cfs and the peak outflow would amount to 35,260 cfs over the existing spillway.

4-31. The dam and spillway were designed and constructed during the 1910-11 period at which time the upstream watershed was largely in farms, and it was estimated that high water would be about 3.5 feet over the spillway crest. The top of the dam was designed to be 12.2 feet above the spillway crest or 8.7 feet above the probable highwater level as shown on the original plans for the structure. With a flow of 3.5 feet over the spillway, the discharge would be about 10,000 cfs; however, the spillway would have safely passed about 40,000 cfs with 3.5 feet of freeboard on the embankment.

4-32. The determination of the required spillway capacity to insure the safety of a dam is not an exact science and while a number of methods have been developed over the years, no one method yet devised can be said to be absolutely accurate. In the final analysis or selection of the design discharge, the judgment of experienced hydrologists and engineers must be utilized.

4-33. The Corps of Engineers and some other governmental agencies base their spillway design computations on a flood designated as the Maximum Probable Flood which has been developed by the Federal Agencies. The Maximum Probable Flood is the greatest flood to be expected, assuming complete coincidence of all factors that would produce the heaviest rainfall and maximum runoff. It would result from the maximum probable rainfall as determined from maximum observed rainfall adjusted for differences between observed and potential moisture changes. The spillways for Grapevine, Garza-Little Elm, Lavon, and Forney Dams are designed to pass the Maximum Probable Flood. A lesser flood designated as the Standard Project Flood has also been developed by the Federal Agencies and the existing Dallas Floodway Levees and new levees proposed for construction in the Dallas area by the Corps of Engineers are based on passing the Standard Project Flood with about four feet of freeboard between the maximum water surface and the top of the levees. The Standard Project Flood is the greatest flood that may reasonably be expected, taking into account all pertinent conditions of location, meteorology, hydrology, and terrain. Such floods have been observed in some areas, and there is a reasonable chance of its occurrence in any area in any year. In view of the very remote possibility of occurrence of the Maximum Probable Flood, Forrest and Cotton, Inc., has utilized, on several projects, the Standard Project Flood as a basis for spillway design to the extent that the spillway would pass the Standard Project Flood discharge without damage to the structure. However, utilization of the Standard Project Flood has been predicated on constructing the earthen embankment to a sufficient height that the

Maximum Probable Flood could be passed through the spillway without overtopping the embankment. It would be expected that some damage would occur but that the structures would safely withstand such a flood.

4-34. In order to evaluate the adequacy of the existing spillway structure, the estimated 100-year frequency flood based on complete urbanization of the upstream watershed was routed through the existing spillway. The peak inflow for this flood amounted to 46,720 cfs, the routed outflow amounted to 35,260 cfs, and the maximum lake level reached elevation 465.9. A Standard Project Flood hydrograph was computed for similar watershed conditions. This flood would result from 13.4 inches of rainfall excess during a 12-hour period and would have a peak flow of 101,000 cfs. Based on the assumption that flows through the lake would be confined to the spillway and that the embankment would not be overtopped, the lake level would rise to elevation 471.2 and the peak outflow would be 79,580 cfs.

4-35. The calculated minimum freeboard requirement, which is based on a sustained wind velocity of 50 miles per hour and a maximum fetch of 1.36 miles, is 3.5 feet. The existing embankment crown is between elevations 467.0 and 468.0 over most of its length which provides about 1.4 feet of freeboard above the maximum water level of record (September 1964) and about one foot of freeboard above the estimated water level that would result from the 100-year flood. The Standard Project Flood water level would be about 4 feet higher than the present embankment and about one foot higher than the embankment as originally designed.

4-36. Modifications Considered for Dam and Spillway. Several discussions have been held with representatives of the Public Works and Park Departments of the City concerning alterations or modifications to dam and spillway and while some of the methods discussed would not be seriously considered because of excessive costs or other factors, brief discussions are included concerning some of these methods in order to provide answers to other interested parties. In considering possible modifications or major repairs to the existing structure, it should be borne in mind that the Texas Water Rights Commission must approve the construction plans and specifications for such work.

4-37. Basically five methods have been considered for the modification of flow conditions through the reservoir and while there are numerous combinations that could be used, the methods discussed are illustrative of the approximate costs that would be incurred and other factors involved. The five methods discussed are:

Method No.	Description
1	By-Pass Channel Around Lake
2	Tunnel under Garland Road
3	Gated Spillway Addition
4	Raising Dam to Elevation 475.0
5	Parapet Wall Construction

A summary of the features and estimated costs of the various methods studied is shown in Table 13, which follows the discussion of Method 5.

4-38. Based on a review of the flood history and urbanization of the White Rock Creek watershed, it appears that it would be wise to adopt the Standard Project Flood for the design of modifications contemplated for the dam and/or spillway. In this regard, it is doubtful that a lesser flood would be approved by the Texas Water Rights Commission and the improvements discussed hereinafter are based on this criterion. Inflow-outflow hydrographs for routings of the Standard Project Flood through various types of spillways considered are shown on Plate 20.

4-39. Method 1 - Lake By-Pass Channel. The possibility of constructing a diversion channel around the lake to by-pass flood waters with the attendant silt load was discussed on several occasions with the representatives of the City, and the following comments relate to this method of improvement. Although not a frequent practice, this method can be effective and economical if suitable conditions of terrain are present. An investigation of such a channel was made with its primary purpose being to provide adequate capacity, when combined with the capacity of the existing spillway, to safely pass the Standard Project Flood. Required channel capacity would be approximately 50,000 cfs, and with the available grade, a bottom width of about 180 feet, with 1 on 2 side slopes, would be required. The channel would be about 3.65 miles long, and a location was selected along the west side of the lake as shown on Plate 19. A typical channel section is also shown on that drawing.

4-40. The channel would lie in and along the west edge of the lake for as much of its length as practical, and then would head inland to conserve length and grade and to allow flows to be discharged on the downstream side of White Rock Dam. At the upper end of the lake above Northwest Highway a diversion dam or weir with appropriate gate controls would be constructed. Where the channel is along the edge of the lake a dike would be provided to maintain water within the lake. Through the overland section, cuts as deep as 40 feet would be encountered. About 2.5 million cubic yards of earth

and rock would have to be excavated; numerous road and utility line relocations and/or bridge construction would be required; and much beautiful and valuable property would be converted to a drainage channel. The estimated cost of this by-pass channel is $15,212,000, which includes $74,000 for raising the existing dam to elevation 471.0, but does not include right-of-way through private property.

4-41. Variations in the foregoing method could be used whereby lesser flows would be diverted. However, if the flow to be diverted were to be reduced to 10,000 cfs, a channel bottom width of 76 feet would still be required and it is believed the detrimental effects on the beauty of the park and adjacent property would preclude such construction even if cost were not a factor.

4-42. Method 2 - Drop Inlet with Tunnel under Garland Road. The 1965 report on Drainage Improvement Studies, Lower White Rock Creek, proposed the construction of a 14-foot diameter drop inlet and 7-foot diameter conduit under Garland Road which would have maintained the lake level at elevation 455.0 or about 3.0 feet below the existing spillway. A sluice gate was to be provided in the drop inlet structure so that the lake could be drawn down to elevation 431.0 and sediment excavated in selected areas. At the maximum experienced lake level of elevation 465.6, the 7-foot conduit would discharge about 1,100 cfs or about 3 percent of the flow over the spillway. Since the preparation of the 1965 report, it has become apparent that the lake should not be permanently lowered, and current studies indicate that if a large quantity of sediment is to be removed from the lake, it can be accomplished most economically and with least adverse effect on the ecology by hydraulic dredging. Consequently, the facility as originally conceived is no longer appropriate.

4-43. An adequately sized conduit under Garland Road would reduce the high water level in the lake and would have the advantage of discharging flood flows downstream from the Garland Road bridge. Several schemes were investigated for such a structure utilizing various sizes of conduits with flows regulated by radial gates. Major problems involved in utilizing this method for the discharge of flood flows are the large size of conduit required to discharge a sufficient quantity of water to lower the high water level in the lake and the design and construction of an appropriate intake structure that would not be esthetically unpleasant. In this regard, the type gates required to utilize the maximum hydraulic capacity of the conduits, while holding the lake level to the desired maximum elevation, and the intake gate structure would be very large and would be plainly visible from Garland Road.

4-44. Flood routings indicate that a conduit in the range of a 22-foot to a 32-foot horseshoe about 930 feet long would be required under Garland Road in order to provide a sufficient discharge capacity to pass the Standard Project Flood flows. The structure would be constructed with a gate controlled intake in the lake located sufficiently upstream from the existing spillway so that it would not affect the flow over the existing spillway. The radial gates at the intake structure would be capable of lowering the lake to 10 feet below normal if found necessary. A stilling basin capable of eliminating the erosive effects of the flowing water would be provided at the discharge end of the conduit. The hydraulic studies show that a 32-foot horseshoe conduit would control the lake level to elevation 467.7 and that a 22-foot conduit would control the lake level to elevation 469.3. Consequently, the 32-foot conduit or equivalent would be required to provide the supplemental spillway capacity needed. However, the 22-foot conduit could be used in combination with some modification of the dam embankment. The 100-year flood level in the lake would be reduced to about elevation 461.4 by the 32-foot conduit and elevation 463.2 by the 22-foot conduit. A typical section of the conduit is shown on Plate 19. The intake to this structure would require nine 20 x 10-foot radial gates or equivalent.

4-45. Two core-holes were drilled in order to determine foundation conditions for the conduit. Data from this investigation are contained in a report entitled "Soils and Foundation Investigation, Proposed Improvements White Rock Lake Spillway," prepared by the National Soil Services, Inc., which is attached as Appendix D. These data indicate that part of the tunnel structure would be founded on hard limestone and part on stiff clay. While tunneling would be proposed under Garland Road, the lower portions could be constructed by open-cut methods. The estimated cost of the 32-foot conduit and appurtenances amounts to $9,968,000. The estimated cost of the 22-foot conduit amounts to $7,293,000. The foregoing cost includes the cost of required modification to the dam for the 22-foot conduit scheme.

4-46. Method 3 - Gated Spillway. Several schemes were studied for the modification of the existing spillway that would provide more flexibility in controlling flood discharges. The possibility of extending the spillway to the north at its present crest elevation was investigated, but lengths of from 500 feet to 750 feet were required and foundation conditions for a concrete structure were questionable for these additional lengths. However, the addition of a gated section appears to be feasible and more detailed investigations were made for this modification. Experience has shown that where radial gates can be used this type of gate and supporting structure have been found to be more economical than other types and several combinations utilizing this type gate were analyzed. The flood routings showed that if two 40 x 20-foot radial gates with gate sill at elevation 440.0 were provided in addition to the existing spillway, that the Standard Project Flood

could be passed with a maximum lake level of elevation 466.9 and that the 100-year flood could be passed with a lake level of elevation 461.5.

4-47. Two core holes were drilled through the existing embankment at the north end of the spillway where the auxiliary spillway would be located to determine the foundation conditions. The logs of the drilled holes, which are shown on Plate 9, Appendix D, indicate that a suitable foundation is available at the location investigated for the spillway studied. The structure would have its gate sill at elevation 440.0, a chute type spillway with horizontal stilling basin, baffle blocks, and an end sill. The estimated cost for the spillway described amounts to $2,774,000, which includes raising the dam to elevation 471.0. A typical section of the gated spillway is shown on Plate 19. The construction of this improvement would afford maximum flexibility in the operation of the lake.

4-48. Method 4 - Raising Existing Dam. The flood routings showed that if flows were confined to the existing spillway area that the passage of the Standard Project Flood and the 100-year flood would result in maximum lake levels of elevations 471.2 and 465.9, respectively. This could be accomplished by raising the embankment to elevation 475.0 and minor grading and drainage in the vicinity of the water plant. The existing embankment would be raised by placing fill on the downstream slope and extending the upstream slope in its present location. Slope paving would be provided for the extended portion of the upstream slope and the right abutment for the existing spillway would be raised. The borings made for the gated spillway did not indicate any unusual condition in the existing embankment and Appendix D includes information regarding the embankment. The estimated cost of raising the dam as discussed amounts to $436,000. A typical section of the raised dam is shown on Plate 19.

4-49. Method 5 - Parapet Wall Construction. As an alternative to Method 4, a parapet wall could be constructed on top of the embankment. The embankment grade would be raised to elevation 471.0 and the parapet wall would have a top elevation of 474.5. The right abutment of the existing spillway would be raised and the wall would extend from the spillway to the north end of the dam, a distance of about 2,100 feet. Minor grading and drainage alterations would be required in the vicinity of the water plant. Based on the two borings through the embankment, no unusual problems would be anticipated with the wall construction. A typical section of the wall is shown on Plate 19, and the estimated cost of this improvement amounts to $364,000.

TABLE 13

Alternative Methods for Modifications to Dam and Spillway

Method No.		Lake Level 100-Yr. Flood	Lake Level Std. Proj. Flood	Top of Dam Elev.	Cost
1	By-Pass Channel	- -	467.5	471.0	$15,212,000
2	32' Tunnel under Garland Road	461.4	467.7	471.0	$ 9,968,000
2a	22' Tunnel under Garland Road and raise dam	463.2	469.3	473.0	$ 7,293,000
3	Gated Spillway 2 - 40' x 20' tainter gates	461.5	466.9	471.0	$ 2,774,000
4	Raising Dam to elevation 475.0	465.9	471.2	475.0	$ 436,000
5	Parapet Wall	465.9	471.2	474.5	$ 364,000

4-50. Effect of Lake Levels on Storm Sewer Systems Adjacent to the Lake. An investigation was made to determine the effect that lake levels would have on the operation of the storm sewers in the immediate vicinity of the lake. The locations of the storm sewers investigated are shown on Plate 21 and the numbers shown correspond to the numbering system in Table 14 which presents pertinent information regarding the storm sewers and appropriate remarks regarding flooding.

4-51. In making the study two lake levels were used, elevation 461.5 which is 3.5 feet above the normal pool level and elevation 465.9 which is 7.9 feet above the normal pool level. The higher elevation is the lake level that would obtain from an occurrence of the 100-year flood with the existing spillway structure and the lower elevation would obtain from an occurrence of a 5-year flood with the existing structure or the 100-year flood with the modifications investigated under Method 3 - Gated Spillway (paragraph 4-46). The runoff into the storm sewer system was based on a 100-year storm with the 100-year water level at the storm sewer outlet and total head losses computed to obtain the inlet water level required to pass the discharge. From this water surface level, the extent of flooding was determined according to whether or not there was overload and above-curb relief away from yards and residences in the area.

4-52. As would be expected, the 100-year storm would result in flooding at most storm sewer inlets since the storm sewers, in general, are designed for less critical storms. However, this situation in the White Rock area is no different from what would be experienced throughout the City during the occurrence of such a storm and does not represent a critical problem. The difference in lake levels (elevations 461.5 and 465.9) results in a greater depth of flooding at 13 of the storm sewer locations investigated and pertinent information in this regard follows in Table 15. It will be noted from Table 15 that most of the flooding occurs in streets and yards but in two locations (#4 and #5), the possibility of flood damage from a 100-year storm exists. At both locations water would be about 0.4 foot higher with the lake at the higher level of elevation 465.9. However, the high water levels would be at elevation 469.5 (#4) and 471.6 (#5) and additional storm sewer capacity would be effective in reducing the high water levels. It will also be noted that while the difference in lake levels at the remaining eleven locations result in increased depths of flooding from 0.4 to 4.4 feet, flooding is over streets and yards and does not cause the flooding of buildings.

4-53. Effect of Lake Levels on Tributary Streams. As discussed in paragraphs 4-16 and 4-28, variation in lake levels below elevation 465.9 has no effect on the flooding of houses on Dixon Branch and Jackson Branch. Studies were also made of other named tributaries to the lake, including Reinhardt Branch (drainage area 372 acres), McCommas Branch

TABLE 14

EFFECT OF LAKE LEVELS ON HIGH WATER AT STORM SEWER INLETS FOR 100-YEAR STORM

Storm Sewer Location	100-Year Inflow (cfs)	Inlet Elev. (Ft.)	Sewer Dia. (In.)	Drains to	H.W. Elevation at Inlet Lake Elev. 461.5	H.W. Elevation at Inlet Lake Elev. 465.9	Remarks
(1) Buckner at Lake Highlands	100	469.0	42	Dixon Br.	470.1	471.3	Some street flooding.
(2) Lake Highlands N.E. of Buckner	16.6	466.5	24	Dixon Br.	471.3	471.7	Proposed - Yards N.W. of Lake Highlands from Buckner to Harter Road flooded.
(3) Lake Highlands at Harter Road	55.5	Top Hd. Wall 470.5	36	Dixon Br.	471.6	472.0	Proposed - Yards N.W. of Lake Highlands from Buckner to Harter Road flooded.
(4) Waterford Dr. at Tranquilla	45	469.5	27	Dixon Br.	472.9	473.3	Intersection flooded, also homes at 1009 and 1019 Waterford could be flooded.
(5) Waterford Dr. at Tralee Dr.	45	471.6	30	Dixon Br.	476.2	476.6	Possibility of flooding house at intersection.
(6) Athlone at Waterford and Buckner		500±	48	Reinhardt Br.	Not Affected		
(7) Knob Oak Dr.	33.5	478.5	24	Reinhardt Br.	Not Affected		
(8) Emerald Isle		505±	24	Tributary of W. R. Lake	Not Affected		
(9) Timplemore Dr.	43.9	465.8±	Double 24	W. R. Lake	463.1 Not Affected	469.1	Street flooded and yard at 1108 Timplemore flooded by higher lake level only.

Storm Sewer Location	100-Year Inflow (cfs)	Inlet Elev. (Ft.)	Sewer Dia. (In.)	Drains to	H.W. Elevation at Inlet Lake Elev. 461.5	H.W. Elevation at Inlet Lake Elev. 465.9	Remarks
(10) Garland Rd. at Lawther Dr.	148.5	High Inlet Elev. 514	42	W. R. Lake	518.8	523	Inlets from Lakeland Dr. to E. Lawther will surcharge and produce flooding on Garland Rd. Higher than curb flow will return to W. R. Lake.
(11) Garland Rd. North of Oakwood Intersection 2 inlets	5.25	468.5	15	W. R. Lake	463.2	467.6 Not Affected	Not affected.
(12) Garland Rd. at Oakwood	32		24	W. R. Lake		Not Affected	Has capacity for 100-Yr. Q but street flooding occurs due to surrounding sewers.
(13) Garland Rd. at White Rock Dr.	38.7	472.5	24	W. R. Lake	469.8	474.2	
(14) Tokalon		485+		W. R. Creek		Not Affected	High and drains below dam. F.L. approximately 485.
(15) Westlake Ave. at Lawther Dr.	47.6	466.5	30	McCommas Br.	465.0 Not Affected	469.5	S.W. corner flooding to top of curb - No problem.
(16) Alexander Dr. at Merrilee Lane		Sewer Flow Line = 471±	24	McCommas Br.		Not Affected	Storm sewers not affected by lake level, but creek channel is inadequate for large discharges regardless of lake level and backs up through storm sewers. Yard flooding often takes place at 7218 and 7206 Alexander and homes would be endangered by 100-Yr. flood on McCommas Br.
(17) Bob-O-Links at Williamson Rd.				Williamson Br.		Not Affected	

Storm Sewer Location	100-Year Inflow (cfs)	Inlet Elev. (Ft.)	Sewer Dia. (In.)	Drains to	H.W. Elevation at Inlet Lake Elev. 461.5	Lake Elev. 465.9	Remarks
(18) Lyre Lane at Carrousel Cr.	61	467±	21	Williamson Br.	Not Affected	467.5	Lower inlets could have surcharging with W. R. Lake at 465.9.
(19) Branchfield Dr. at alley south of Westbay Circle	20.8	464	24	Rush Br.	Not Affected	467.6	General street flooding along Branchfield will occur with W. R. Lake Elev. = 465.9 with no homes endangered.
(20) Branchfield Dr. near Fisher Rd.	24.9	465	24	Rush Br.	Not Affected	467.6	General street flooding along Branchfield will occur with W. R. Lake Elev. = 465.9 with no homes endangered.
(21) Cathedral Drive	16	479	18	Drainage ditch to White Rock	469.6	474	Not affected.
(22) Axminster Ct.	7.1	488.5	18	Drainage ditch to White Rock	481.8	481.8	Storm sewer not affected - Backwater taken into account
(23) Benedict Dr.	18.6	464.0	18	White Rock Lake	468.6	473.0	For W. R. Lake = Elev. 465.9, street and yard flooding will occur.
(24) Chapel Hill Dr. to W. Lawther	15	466.5	18	White Rock Lake	466.1 Not Affected	470.5	For higher lake level street and yard flooding will occur - no homes endangered.
(25) Lawther Dr. at Mockingbird - Line "E" 3 inlets	9.27	470.5	18	White Rock Lake	462.6	467.0 Not Affected	Not affected.
(26) Lawther Dr. at Mockingbird - Line "F" 3 inlets	11.1	470.5	15	White Rock Lake	466.1 Not Affected	470.5	With W. R. Lake at 465.9, all inlets will be affected.

Storm Sewer Location	100-Year Inflow (cfs)	Inlet Elev. (Ft.)	Sewer Dia. (In.)	Drains to	H.W. Elevation at Inlet Lake Elev. 461.5	H.W. Elevation at Inlet Lake Elev. 465.9	Remarks
(27) Lawther Dr. at Mockingbird - Line "G" 4 inlets	13.4	470	24	White Rock Lake	462	466.4 Not Affected	Storm sewers along Mockingbird not affected beyond this storm sewer to the east.
(28) Walling Circle at MKT R.R.		500+	15	White Rock Creek		Not Affected	High enough not to be affected.
(29) Walling Ln. at Fenton		505+	30	White Rock Creek		Not Affected	F.L. at 468.9 - therefore out of lake influence - steep gradient.
(30) Goforth North of Eagle Trail			18	White Rock Creek		Not Affected	F.L. at 465.0 - design included overflow from other sewers' drainage areas upstream.
(31) Audelia Road North of N.W. Hwy.	872	472	3-72	Box Culvert to White Rock Lake	473.6	478.0	Slight street flooding with W. R. Lake at 461.5. Extensive flooding with W. R. Lake at 465.9.

TABLE 15

INCREASES IN DEPTHS OF FLOODING AT STORM SEWER INLETS ATTRIBUTABLE TO THE LEVEL OF WHITE ROCK LAKE AT ELEVATION 465.9 VS. ELEVATION 461.5

	Location of Storm Sewer	Increased Flood Depth at Inlet in Feet From	To	Description of Flooding
(1)	Buckner at Lake Highlands	1.1	2.3	Street Flooding.
(2)	Lake Highlands Northeast of Buckner (Proposed)	4.8	5.2	Streets and yards flooded from Buckner Blvd. to Harter Road.
(3)	Lake Highlands at Harter Road (Proposed)	1.1	1.5	Streets and yards flooded from Buckner Blvd. to Harter Road.
(4)	Waterford Drive at Tranquilla	3.4	3.8	Streets flooded. Houses at 1009 & 1019 Waterford could be flooded.
(5)	Waterford Drive at Tralee	4.6	5.0	Streets flooded. Possibility of house being flooded.
(9)	Timplemore Drive	0	3.3	Streets flooded. Yard flooded at 1108 Timplemore Drive.
(13)	Garland Road at White Rock Drive	0	1.7	Streets flooded.
(15)	Westlake Avenue at Lawther Drive	0	3.0	Street flooded.
(19)	Branchfield Drive at Alley South of Westbay Circle	0	3.6	Streets flooded.
(20)	Branchfield Drive near Fisher Road	0	2.6	Streets flooded.
(23)	Benedict Drive	4.6	9.0	Street and yards flooded.
(24)	Chapel Hill Drive at West Lawther	0	4.0	Street and yards flooded.
(31)	Audelia Road North of Northwest Highway	1.6	6.0	Street flooded.

(806 acres), Williamson Branch (914 acres), and Rush Branch (777 acres). These tributaries are shown on Plates 7 and 21. The possibility of the occurrence of a 100-year lake stage at the same time as a 100-year flood on these tributaries is extremely remote because of their relatively small size and short runoff time. Field investigations and available topographic data indicate that by virtue of the relatively steep gradients on these streams, the effect of backwater from a 100-year lake level would generally play out within the limits of park property, and the lake level would not affect the flooding of houses from local runoff. In a particular location near the park on McCommas Branch near the intersection of Alexander Drive and Merrilee Lane, yard flooding takes place from floods of lesser frequency and houses would be endangered by the 100-year flood. This flooding is attributed, however, to the limited capacity of McCommas Branch rather than lake backwater. The primary difference in flooding on tributaries around the lake from lake elevations of 461.5 and 465.9 is the greater depth of flooding of Lawther Drive and other residential streets at the higher lake level.

4-54. Northwest Highway Crossing over White Rock Creek. This crossing, which is used by 39,000 vehicles per day, is located in the upper part of the lake where a large amount of sediment deposition has taken place. The crossing consists of separate roadways with three bridge structures for east and west-bound traffic. Flooding begins when water exceeds elevation 465.0 and ordinary floods overtop the crossing for a distance of about 2,700 feet. While minor flooding would have been caused by the lake levels that occurred from the 1942 and 1964 floods (the two greatest of record), flooding is generally caused by the flow from the creek entering the lake. The sediment deposition in the area is continuing to occur with the capacity of the channels and bridges being decreased and when this is combined with increased runoff resulting from urbanization of the watershed, more frequent flooding may be expected. Flooding from flows entering the lake can be reduced by dredging channels from the Northwest Highway bridges through the Mockingbird Lane bridge to the main body of the lake and clearing out of the sediment that now blocks flow through the bridges. Plate 5 shows a tentative alignment of such channels which would be a part of the over-all sediment removal program. Modifications of the alignment shown could be tolerated in the interest of overall beautification of the park.

4-55. Discussion and Conclusions. The primary drainage and flood problems related to White Rock Lake are: (1) flooding from Dixon and Jackson Branches; (2) flooding of traffic arteries and developed areas immediately adjacent to the lake; and (3) the adequacy of the spillway insofar as the structural safety of the dam is concerned. As mentioned in paragraph 3-37, the dredging program should include the excavation of sediment now partially blocking flow into the lake from White Rock Creek at Northwest Highway and from Dixon Branch at Buckner Boulevard.

4-56. Flooding from Dixon Branch has been experienced at the Peavy Road crossing and in the Vinemont-Creekmere Drive area where about 60 houses are subject to being flooded from an occurrence of the 100-year flood, with yard and street flooding resulting from floods with a frequency of one occurrence in five years. In addition, Buckner Boulevard and Lawther Drive crossings over Dixon Branch are overtopped by floods with a frequency of occurrence of 2 to 5 years. Field surveys and hydraulic studies showed that White Rock Lake highwater levels affect the frequency of flooding of Lawther Drive and Buckner Boulevard but that the effects of water levels in the lake do not extend beyond a point about 1,600 feet upstream from Buckner Boulevard. Consequently, the construction of drainage improvements upstream from Buckner Boulevard will be required for the purpose of providing protection to the Vinemont-Creekmere Drive area if flooding is to be reduced.

4-57. It was found that flooding of Buckner Boulevard from the 100-year flood could be eliminated and traffic maintained during the occurrence of such a flood by the excavation of a 100-foot channel in the lake area downstream from Buckner Boulevard, lengthening the Lawther Drive bridge, raising about 1,800 feet of Buckner Boulevard and enlarging the Buckner Boulevard bridge in accordance with Plan 2 (paragraph 4-21) at a cost of about $580,000. If protection from the 100-year flood is desired for the Vinemont-Creekmere Drive area, Plan 3 (paragraph 4-22), could be used to include work upstream from Buckner Boulevard. Essentially, this plan would consist of the Plan 2 work plus about 3,000 feet of paved channel, 1,700 feet of unlined channel, and 1,500 feet of channel clearing from Buckner Boulevard to Easton Road and would cost about $828,000 more than Plan 2. However, the construction of the drainage improvements upstream from Buckner Boulevard would place an excessive financial burden on the City for the limited benefits that would accrue and would also detract from the appearance of the area. Therefore, construction upstream from Buckner Boulevard is not recommended at this time. However, as an alternative to the channel work described under Plan 3, it is recommended that underbrush, fallen trees and other impediments to flow in the natural channel of Dixon Branch and its tributaries be removed. The estimated initial cost of this work is $44,000. Continuing maintenance of the channels could be done as a part of the Park Department's regular maintenance program. In this connection, it was found that the drainage ditch discharging into a natural channel at Peavy Road about 600 feet east of the main Dixon Branch channel is adequately designed but that impediments in the natural channels cause flooding from backwater.

4-58. Investigations made in connection with drainage improvements for Jackson Branch showed that three houses in the 9300 block of Clearhurst Drive reported flooding from the April 1966 flood. It was found that the critical flood point on Jackson Branch is

about 2,750 feet upstream from its junction with White Rock Creek and that the level of water in White Rock Creek has only a very minor effect on the 5-year flood at the critical point and no effect for the 25- and 100-year floods. It was also found that 100-year flood protection could be afforded the area by providing an 80-foot bottom width channel about 2,800 feet long at a cost of $162,000. However, in view of the very limited benefits that would be derived from such construction, it cannot be justified from an economic viewpoint.

4-59. The structural safety of the dam could be improved by increasing the height of the embankment as discussed in paragraph 4-48 or by the construction of the parapet wall discussed in paragraph 4-49. The construction of the parapet wall would cost about $364,000, which would be $72,000 less costly than increasing the embankment height, and would be the method recommended as the choice between these two methods. However, the parapet wall construction would be for the sole purpose of increasing the structural safety of the dam and would not reduce the flooding of traffic arteries or developed areas adjacent to the lake.

4-60. Lake levels of elevation 464.0 and 465.0 flood Buckner Boulevard at Dixon Branch and Northwest Highway at White Rock Creek, respectively, and based on the plan of improvement for Buckner Boulevard recommended herein and the plan of improvement suggested in the "Report on Upper White Rock Creek" in 1965 for Northwest Highway, the cost of improvements required to eliminate flooding of these thoroughfares would be $2,610,000 (1971 price level).

4-61. In considering solutions to the flood problems, it is apparent that if the maximum flood level in the lake could be reduced appreciably, the structural safety of the dam would be increased. In addition, the lowering of the lake coupled with the channel dredging, proposed as a part of the sediment removal program, would reduce flooding of Northwest Highway over White Rock Creek, Buckner Boulevard over Dixon Branch, the storm sewer inlets shown in Table 15, and other areas adjacent to the lake. The reduction of the lake levels during flood periods could be accomplished best by providing additional spillway capacity under Method 3 (paragraph 4-46) whereby the lake level resulting from a 100-year flood would be reduced from elevation 465.9 to elevation 461.5 and from the Standard Project Flood would be reduced from elevation 471.2 to elevation 466.9. The lowering of the lake level combined with the proposed dredging program would provide protection from flooding of Northwest Highway from a 50-year flood and, with the lengthening of Lawther Drive bridge over Dixon Branch (Drainage Improvement Plan 1, paragraph 4-20), would reduce the frequency of flooding to about once in five years at Buckner Boulevard. If protection from the 100-year flood were to be provided

for Buckner Boulevard as proposed under Plan 2 (paragraph 4-22), the cost of Plan 2 would be reduced by $64,000 to $516,000. Plan 1 would have a cost of about $189,000.

4-62. The estimated cost of providing additional spillway capacity under Method 3 is $2,774,000 but would reduce or eliminate costs as shown below:

Item	Without Gated Spillway	With Gated Spillway
Northwest Highway	$2,030,000	$ 0
Buckner Boulevard (Plan 2)	580,000	516,000
Parapet Wall on Dam	364,000	0
Gated Spillway	0	2,774,000
Totals	**$2,974,000**	**$3,290,000**

It will be noted that with the gated spillway, costs would be $316,000 higher than they would be without the gated spillway for the improvements shown. However, the structural safety of the dam would be greatly improved by the reduction in lake levels effected by the addition of the gated spillway; high water levels at storm sewer inlets would be reduced as shown in Table 15 for the 100-year flood and eliminated for the more frequent floods; and the cost of future drainage improvements immediately adjacent to the lake would be reduced. In addition, the problem of handling Northwest Highway traffic during construction of modifications to that facility would be eliminated.

4-63. It is recommended that the structural safety of the dam be increased by restoring the embankment to its original level and constructing additional spillway capacity (Method 3) or a concrete parapet wall along the upstream edge of the embankment (Method 5). If the additional spillway capacity is provided, it is recommended also that Plan 2 be adopted for Dixon Branch with modifications to reflect the lower lake levels. If the additional spillway capacity is not provided, it is recommended that Plan 2 be followed in its entirety. The estimated cost of the drainage and flood control improvements recommended herein amounts to $988,000 if the parapet wall is used to provide the required safety for the embankment and $3,334,000 if the additional spillway capacity is provided.

V - POLLUTION

5-01. General. The waters of the White Rock Creek Watershed, which include White Rock Lake, White Rock Creek, and tributary streams, are used for a variety of purposes, including irrigation, water supply, boating, propagation of fish and wildlife, fishing, and aesthetics.

5-02. To protect and enhance the usability of the waters for these purposes as well as other potential uses, it is important that water pollution within the watershed be controlled. This section discusses sources of pollution and existing water quality, and makes recommendations for water pollution control measures.

5-03. Sources of Pollution. The drainage basin of White Rock Lake lies in a well-populated urban area which includes the usual features of residential, institutional, commercial, and industrial development as well as transportation arteries and park areas. Each category of development generates possible sources of pollution to White Rock Creek, but most wastewaters in the drainage basin are treated before being discharged into the stream or are diverted through sewers to other wastewater treatment facilities.

5-04. A field survey of eight known wastewater discharge points along White Rock Creek and its tributaries was made. The locations of these discharge points are indicated on Plate 22 and each discharge is discussed in the following paragraphs in downstream order, i.e., from the headwaters of White Rock Creek to White Rock Lake. Only two of the eight known wastewater dischargers have received waste discharge orders from the Texas Water Quality Board (TWQB).

5-05. Lambert Landscape Company, Inc., is located north of the LBJ Freeway and east of White Rock Creek. According to the Water Quality Surveillance Section of the Dallas Health Department, Lambert Landscape Co. is one of many nurseries which discharge fertilizer- and pesticide-rich waters into State watercourses. Due to the greater awareness of the detrimental effects of pesticides on water quality, most nurseries have been decreasing pesticide discharges. A discharge has been observed from Lambert Landscape, but no visual evidence of pollution was apparent. This discharge is shown as Waste Discharge No. 1 on Plate 22.

5-06. Republic Aluminum Company (REALCO), a manufacturing company, is located at 100 West Spring Valley Road. A portion of REALCO property apparently has been used for disposal of process wastes. Although no discharges were observed, the area contained various oily substances and a white powdery and crusty substance. No direct discharge to White Rock Creek or its tributaries was noted; however, these pollutants could be carried to nearby Floyd Branch as part of surface runoff from rainfall. The Republic Aluminum Company location is shown as Waste Discharge No. 2 on Plate 22.

5-07. City of Richardson, Floyd Branch Wastewater Treatment plant is located immediately south of Spring Valley Road. The facility is reported to be operating well within the limits of its wastewater discharge order issued by the TWQB. Some of the treatment plant effluent is used for irrigation. A study is in progress by the City of Richardson to develop information required to expand the plant from its present capacity of 1.54 MGD to 5.19 MGD to treat wastewater from the Cottonwood Creek watershed, and to add advanced waste treatment capability to the plant. This high degree of treatment will provide a high quality water suitable for a number of uses. Reuse of this water could significantly reduce the volume of discharge from the treatment plant. This discharge is shown as Waste Discharge No. 3 on Plate 22.

5-08. National Cylinder Gas Company is located at 13140 Floyd Road. Wastewater discharge from this plant includes cooling tower blowdown, compressor condensate, and boiler blowdown. According to TWQB records, the company is operating within the limits of its discharge permit except for a slightly excessive biochemical oxygen demand (BOD). National Cylinder Gas Company has made application to TWQB to increase its flow from 10,000 to 100,000 gallons per day without any other changes. A hearing was held on this application several months ago, but no Board Order had yet been issued as of the latter part of June 1971. This discharge is shown as Waste Discharge No. 4 on Plate 22.

5-09. Restland Memorial Park is located between Greenville Avenue and the Southern Pacific Railroad, north of Valley View Lane. Water described as having an emerald green appearance has been observed to flow from this area and discharge to Floyd Branch. Restland Memorial Park is shown as Waste Discharge No. 5 on Plate 22.

5-10. Texas Instruments, Inc. is located immediately northeast of the intersection of U.S. 75 and I.H. 635 (North Central Expressway and Lyndon B. Johnson Freeway, respectively). At the time of the field survey, discharges were observed from the industrial complex to a ditch draining into a tributary to Cottonwood Creek. These discharges appeared to cause a light greenish-blue sediment in Cottonwood Creek. The Industrial Wastes Division of the City of Dallas reports that Texas Instruments has a water treatment

process which produces a very high quality water. The system consists of flocculation, sedimentation, filtration, and ion exchange units, but once or twice a year the system is flushed with formaldehyde. This waste discharge and some aluminum sulfate and fibrous filter wastes reach Cottonwood Creek. The Water Quality Surveillance Section of the City of Dallas reports that corrective action is being taken on Texas Instruments' filter backwash operation.

5-11. Another pollutional problem from Texas Instruments involves sanitary sewage. Texas Instruments has rights to discharge 120 million gallons per month into the municipal sewer, but at times surcharging causes raw sewage to enter Cottonwood Creek. An 18-inch corrugated surface-laid sewer was installed to prevent such bypassing. This temporary line is repaired after each rain. A new trunk sewer on the east bank of White Rock Creek is under construction to eliminate this surcharge condition and will be completed in Fall 1972.

5-12. The Surveillance Section indicates that Texas Instruments is tying into the City sewerage system in three phases which will almost eliminate discharges to Cottonwood Creek. First phase was to have been completed by May 31, 1971, second phase by June 20, and third phase by mid-July. Thenceforth, the only discharge to Cottonwood Creek will be small quantities of condensate and drinking fountain water. The Texas Instruments location is shown as Waste Discharge No. 6 on Plate 22.

5-13. Dixon Branch Sewage Pump Station is located between Lawther Drive and Buckner Boulevard, on the north side of Dixon Branch and on the east side of White Rock Lake. It is not the policy of the City to bypass sewage into the lake, although bypassing does sometimes occur under extreme conditions of heavy rains and accompanying high sewer infiltration. Normally, flow to the facilities ranges from one to four million gallons per day, but during wet periods, the flow reaches ten to twelve million gallons per day. The normal flow is discharged from the pump station in a 16-inch and a 24-inch force main. Funds were included in the 1967 Crossroads Bond Program for increasing the capacity of these facilities, and the Water Utilities Department has plans to add more pumping capacity and possibly more line capacity in 1972-73. The Dixon Branch Sewage Pump Station is shown as Waste Discharge No. 7 on Plate 22.

5-14. Collins-Denison Ford, Inc. is located at 9407 Garland Road. A discharge described as a foul-smelling, oily black material had been observed along the banks of the stream. However, the company has made efforts to control the discharges through proper operation

of grease traps and sand filters, and indications are that this discharge has been stopped. Collins-Denison Ford is shown as Waste Discharge No. 8 on Plate 22.

5-15. A field reconnaissance of the watershed revealed other sources, or potential sources of pollution such as washdown water from service stations, litter and silt in shopping centers and industrial areas which rain will wash into storm sewers and streams, trash dumping along creek banks, barn lots, septic tanks and surcharged sewer lines.

5-16. Water Quality Sampling Program. In the early part of 1971 the Dallas Health Department initiated a water quality sampling program on streams in the White Rock Creek watershed. For the purposes of this report it was requested through the Park Department that sampling be done at seven locations on the streams in addition to the six stations already being sampled. The Health Department cooperated in this request and furnished analysis data for grab samples at all thirteen stations.

A description of these locations and the duration of sampling at each location are reported in Table 16. Plate 22 shows these locations in the watershed. As indicated on Plate 22, locations 1-5 are on White Rock Creek; locations 6-10 are on tributaries to White Rock Lake; and locations 11-13 are on tributaries to White Rock Creek above White Rock Lake.

TABLE 16

WATER QUALITY SAMPLING STATIONS

Station Number	Location	Sampling Period
1	White Rock Creek at Hawn Freeway	1/27/71 to 4/17/71
2	White Rock Creek at Garland Road	3/17/71 to 5/26/71
3	White Rock Creek at Greenville Ave.	5/06/71 to 4/13/71
4	White Rock Creek at Forest Lane	1/26/71 to 4/13/71
5	White Rock Creek at Frankford Rd.	5/06/71 to 5/27/71
6	Williamson Branch at Williamson Rd.	5/06/71 to 5/27/71
7	McCommas Branch above W. Lawther Dr.	5/06/71 to 5/27/71
8	Rush Branch at Fisher Road	5/06/71 to 5/27/71
9	Reinhardt Branch near Knob Oak Dr.	5/06/71 to 5/27/71
10	Dixon Branch above Peavy Road	5/16/71 to 5/27/71
11	Jackson Branch at Skillman	1/18/71 to 4/13/71
12	Floyd Branch at Forest Lane	1/18/71 to 5/25/71
13	Cottonwood Creek at Forest Lane	1/18/71 to 4/13/71

5-17. Water samples were taken weekly during daylight hours. The parameters analyzed included: pH, BOD (Biochemical Oxygen Demand), COD (Chemical Oxygen Demand), sodium chloride, DO (Dissolved Oxygen), linear alkyl sulfonate, total alkalinity, ortho-phosphate, percent light transmittance, total coliforms, fecal coliforms, and water temperature. These data have been reduced to the statistical form presented in Table 17.

5-18. Present Water Quality. The Texas Water Quality Board has formulated a specific set of standards of water quality for each section of the Trinity River Basin. The stream standards for White Rock Creek are included in "Other Waters" of the Trinity River Basin and described in *Water Quality Requirements, Volume 1, Inland Waters*, by the TWQB. Table 18 indicates the allowable concentrations for water quality parameters in White Rock Creek and in the Trinity River at its confluence with White Rock Creek. These standards are included herein for comparison with the existing water quality data shown in Table 17. An analysis of that data indicates the following:

a. An average of the BOD values obtained on samples taken near the headwaters is 3.0 mg/l and for a location just above the confluence with Floyd Branch is 2.0 mg/l but the average increases to 5.5 mg/l below the confluence. All tributaries exhibited relatively high maximum BOD values, but only Floyd Branch exhibited a consistently high BOD resulting in an average value of 9.5 mg/l. The five tributaries discharging directly to White Rock Lake exhibited BOD average values ranging from 2.0 mg/l to 3.0 mg/l. The samples taken of the discharge from the lake and of the creek above its confluence with the Trinity River had average BOD values of 6.0 mg/l. All stations exhibited BOD values lower than the standard allowable of 15 mg/l set for the Trinity River near its confluence with White Rock Creek.

b. Dissolved oxygen levels were greater than the Trinity River standard of 4.0 mg/l except at stations 6, 7, 8, and 9. The minimum levels observed at these stations were 3.4 mg/l, 2.0 mg/l, 1.8 mg/l, and 0.0 mg/1, respectively. Samples taken at stations 7 and 9 exhibited consistently low dissolved oxygen concentrations.

c. The average ortho-phosphate levels observed throughout the watershed are higher than the values usually cited as capable of supporting an algal bloom. The sampling and testing program indicates that a considerable amount of phosphorus is being introduced into the lake. The samples of the discharge from the lake indicate an average ortho-phosphate level of 0.7 mg/l which is less than the concentrations in White Rock Creek of 1.1 mg/l entering the lake. This indicates that the lake is a phosphate sink which concurs with the findings of Dr. Silvey as presented in Appendix A.

TABLE 17

OBSERVED WATER QUALITY

Station No.	pH			BOD mg/l			COD mg/l			NaCl mg/l			DO mg/l			Total Alkalinity As $CaCO_3$ mg/l			Ortho PO_4 mg/l			% Transmittance			Total Coliforms		Fecal Coliforms		Station No.
	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Av.	Max.	Min.	Max.	Min.	Max.	
1	8.0	8.3	8.8	2.0	6.0	9.0	16	39	56	70	115	170	7.3	9.2	11.0	115	180	225	0.7	1.9	3.2	57	82	93	340	920,000	100	210	1
2	7.9	8.4	9.2	4.0	6.0	9.0	0	31	41	60	70	90	6.6	8.7	11.3	140	185	235	0.0	0.7	1.5	68	86	100	300	49,000	0	210	2
3	7.9	8.1	8.2	3.0	5.5	9.0	16	36	56	50	65	100	5.8	6.7	7.4	170	189	205	0.0	1.1	2.5	14	71	94	2,300	2,800	80	290	3
4	7.3	7.9	8.7	0.0	2.0	3.0	0	19	40	50	85	110	6.0	7.7	10.4	150	222	260	0.0	0.2	1.0	96	99	100	200	22,000	0	650	4
5	7.8	8.2	8.4	2.0	3.0	4.0	16	28	56	30	40	50	5.8	6.8	8.6	185	195	210	0.0	0.3	0.9	97	99	100	300	700	20	260	5
6	7.7	8.1	8.3	2.0	4.0	7.0	24	42	48	40	45	50	3.4	5.3	7.2	120	150	165	0.0	0.7	1.7	96	99	100	1,200	160,000	190	15,000	6
7	7.6	7.9	8.1	2.0	4.5	7.0	24	40	64	30	55	70	2.0	3.4	5.4	115	156	200	0.0	0.2	0.5	93	98	100	500	160,000	50	2,200	7
8	7.8	8.0	8.3	2.0	3.5	7.0	24	36	48	40	80	110	1.8	4.0	7.2	100	176	230	0.0	0.4	0.6	79	95	100	1,000	410,000	230	16,000	8
9	7.8	7.9	8.0	2.0	4.0	8.0	24	44	63	20	45	60	0.0	2.5	7.0	120	175	200	0.4	1.4	3.2	93	94	99	150	500,000	310	20,000	9
10	7.8	8.0	8.2	2.0	3.0	8.0	8	14	32	30	50	70	4.8	6.2	7.0	180	211	230	0.0	0.4	1.1	34	83	100	1,700	170,000	480	20,000	10
11	7.9	8.3	8.5	1.0	3.0	9.0	0	20	55	40	75	180	8.4	10.0	11.4	155	180	230	0.0	1.3	3.9	85	98	100	490	58,000	400	4,600	11
12	7.8	8.2	8.8	6.0	9.5	15.0	16	52	72	60	135	220	6.6	9.9	12.8	120	155	195	0.0	6.1	25.0	43	95	100	100	1,600,000	400	5,900	12
13	7.7	8.4	9.9	2.0	4.5	8.0	0	27.9	63.0	80	150	620	8.2	8.6	12.2	130	167	250	0.0	0.5	2.2	80	95	100	400	490,000	30	6,100	13

d. The pH levels observed in the samples were slightly on the basic side of neutral with average values ranging from 7.9 to 8.4. The highest value of 9.9 was found at Station 13. It appears that these slightly high values are due to natural runoff rather than to waste discharges into the stream.

e. Maximum total coliform counts are consistently high throughout the basin. Samples from all stations except those in the uppermost reaches of White Rock Creek have exhibited counts of greater than 20,000/100 ml, while samples from all stations exhibited counts of greater than 100/100 ml (See Table 18 - Footnote b).

f. Fecal coliforms are high on all tributaries of White Rock Creek. It appears that the geometric means of counts at all stations are greater than 200/100 ml which is the recommended maximum value for water contact sports. Additional data values are required to provide sufficient information for a statistically reliable analysis.

g. The chloride concentrations are generally low throughout the watershed with the average sodium chloride values for the various stations ranging from 40 mg/l to 150 mg/l. The chloride concentration can be calculated by multiplying the sodium chloride concentrations by 0.607. Chloride concentration averages are all less than the Trinity River standard of 100 mg/l and are significantly less than the U.S. Public Health standard of 250 mg/l. The maximum chloride concentrations measured at Stations 1, 11, 12, and 13 exceed the Trinity River standard and the sodium chloride value of 620 mg/l observed at station 13 exceeds the U.S. Public Health recommendations.

TABLE 18

WATER QUALITY STANDARDS

Parameter	White Rock Creek	Trinity River at White Rock Creek
Chloride, average not to exceed	a	100 mg/l
Sulfate, average not to exceed	a	100 mg/l
Filterable Residue, average not to exceed	a	500 mg/l
B.O.D., average not to exceed	a	15.0 mg/l
D.O., not less than	a	4.0 mg/l
pH	a	6.5 - 8.5
MPN (Coliforms)	b	b
Temperature	c	d
Toxicity	c	e
Free or Floating Oil	f	f
Foaming or Frothing Material	g	g

Footnotes to Table 18

a. These requirements shall be the native quality of the zone water (insofar as the native quality of the water can be determined) as it may be altered or affected by receipt of legally permitted waste discharges, or other wastes not presently controllable. It is recognized that waters in this zone range from undiluted waste discharges and storm sewer flows through waters of high quality and significant local use.

Footnotes to Table 18 (continued)

b. Water orientated recreation, including water contact sports, is a desirable use of the waters of the state everywhere. Water contact activities in natural waters are not opposed by the state health agency where routine sanitary surveys support such activities, and where, in addition, as a flexible guide-line to be used in the light of conditions disclosed by the sanitary survey, the geometric means of the number of fecal coliform bacteria is less than 200 per hundred milliliters and not more than 10% of the samples during any thirty (30) day period exceed 400 fecal coliform bacteria per hundred milliliters. This policy is advisory only and in no way limits the responsibilities and authorities of local health agencies. It is highly desirable for waters comprising the raw water supply to a public surface water treating plant that the total coliform bacteria should not exceed 100 per 100 milliliters and the fecal coliform bacteria should not exceed 20 per 100 milliliters. Nevertheless, raw water supplies to surface water treating plants shall not be deemed unsatisfactory where the total coliform organisms do not exceed 20,000 per 100 milliliters and the fecal coliform organisms do not exceed 2,000 per 100 milliliters. The evaluation of raw water supplies cannot be reduced to the simple counting of bacteria of any kind and the foregoing must be used with judgment and discretion and this paragraph is not intended to limit the responsibilities and authorities of responsible local governments or local health agencies.

c. As controlled by permits for legal waste discharges into the zone waters.

d. Upper limit of the representative temperature - 96 degrees Fahrenheit, and not to exceed a 5 degree Fahrenheit rise in the representative temperature above natural conditions. This temperature requirement is a requirement of the Federal Water Pollution Control Administration.

e. These waters shall not exhibit either acute or chronic toxicity (or other harmful effect) to human, animal, or aquatic life to such an extent as to interfere with uses of the waters.

f. Substantially free from oil.

g. None of a persistent nature.

5-19. In order to supplement the water quality data obtained by the City of Dallas, a field reconnaissance of streams in the White Rock Creek watershed was conducted, and visual observations of water quality were made. In general, the field investigations have revealed good water quality throughout most of the drainage basin. Although a great deal of algal growth was encountered in local areas, the water in these areas is often clear and gives evidence of supporting fish life. Most problems are localized, are not serious, and do not persist very far in the streams.

5-20. Conclusions. The above data allow some limited conclusions to be drawn. The entire watershed is subject to various magnitudes of organic pollution. The highest organic pollutional load as indicated by an average BOD of 9.5 mg/l is carried by Floyd Branch, a stream on which four sources of pollution have been identified. Floyd Branch also contains the highest average concentration of ortho-phosphate with a level of 6.1 mg/l. The relatively high dissolved oxygen values observed at a number of stations in the watershed indicate reasonably extensive algal growth. This conclusion is enforced by the observation of levels of ortho-phosphate sufficient for algal growth. The high levels of coliforms observed, even in streams in which no sources of pollution have been identified, indicate that surface runoff contributes substantially to pollution in the tributaries. These high levels of fecal coliforms found in the watershed indicate that the usability of the lake for contact sports is marginal, and it would be inadvisable to allow swimming or water skiing in the lake. In general it can be concluded that the condition of surface waters in the watershed upstream of White Rock Dam is of fair to good quality. This conclusion is supported by the finding of Dr. Silvey (See Appendix A) that a stable, well-balanced fish population exists in White Rock Lake.

5-21. Recommendations for Corrective Measures. In order to preserve the aesthetic and recreational attributes of White Rock Lake and the stream system of the watershed, and to preserve a quality in the lake suitable for its use as a reserve water supply, it is recommended that a program of water quality management and pollution abatement be implemented. Of primary importance to such a program would be the regulation of unpermitted waste discharges in the watershed. Discharges not presently regulated by a waste control order are being inventoried by the City Health Department Water Quality Surveillance Section. Such action as the City deems prudent should be taken to insure that these discharges are either eliminated or brought under a waste control order by the State.

5-22. The Texas Water Quality Board is entrusted to protect the quality of waters within the State of Texas. Pursuant to this end, the Board has established water quality standards and has instituted a policy of requiring cities or other organizations discharging wastes into or adjacent to waters of the State to obtain waste control orders. Additionally,

the Board periodically passes Board Orders to deal with subjects of widespread importance, such as the Orders regulating the discharge of heavy metals and the Order concerning regulation of wastes from swine-feeding operations.

5-23. Before granting a waste control order, the Board must ascertain that the wastewater permitted by that order will not violate the water quality standards of the receiving stream. Since standards designating specific parameter concentrations have not been established for streams of the White Rock Creek Watershed, the criteria for the granting or denial of a waste control order cannot be the effect of the discharge on specific parameters as they relate to stream standards. It would seem, therefore, that the criteria for granting or denial should be the effect of the discharge on the beneficial uses of waters in the White Rock Creek Watershed. It is recommended that the City of Dallas adopt this criteria as a guideline for evaluating and adopting a stand on each waste control order proposed in the watershed.

5-24. To implement this recommendation, the present and future beneficial uses of White Rock Creek waters must be agreed upon. The proposed major uses of this water appear to be non-contact water sports, fishing, and public water supply. Each proposed waste control order should then be reviewed to ascertain the effect of the discharge on these uses of White Rock Creek waters. Only those discharges which do not adversely affect water usability should be allowed to go uncontested.

5-25. A portion of the pollution present in the White Rock Creek watershed is from sources which can not be regulated by a waste control order. The pollution referred to results from storm runoff from surface areas on which pollutants have accumulated. This type problem should be attacked by eliminating pollution constituents at their source.

5-26. Efforts should be made to curtail unauthorized stream side dumping and to remove refuse already deposited along the banks of watershed streams.

5-27. To assess whether pollution programs are succeeding and whether further programs are necessary, a water quality sampling program should be continued. The program should involve sampling of White Rock Lake, White Rock Creek, and selected tributaries. The parameters presently used by the City of Dallas Health Department in the sampling program cited earlier appear generally adequate. However, consideration should be given to adding the monitoring of algal growth.

VI - SANITARY SEWERS AND WATER LINES

6-01. General. The network of sanitary sewers and water lines in the White Rock area has evolved from long range planning by the Dallas Water Utilities Department. Construction of local collection and distribution lines served by the major networks has progressed on a parallel with urbanization of the area, and since essentially all of the developable property in the immediate vicinity of the lake has been, or is being developed, the future extensions of existing systems are expected to be minimal. Major trunk sewers and water transmission lines have been planned around the lake, thus avoiding the need for lake crossings. Locations of the existing major lines, as well as anticipated future improvements, are shown on the map on Plate 23.

6-02. Included in the improvements planned by the Water Utilities Department are the White Rock Relief Sewer, a storm water pollution control station below White Rock Dam, increased capacity of Dixon Branch Sewage Pump Station, and two water lines near the south end of the lake. Investigations were made of the effect, if any, the planned sewer and water facilities would have on park improvements proposed in this report, and conversely, the effect of the proposed park improvement on existing and planned sewer and water utilities. An investigation was also made of the possibility of utilizing the proposed White Rock Relief Sewer initially as a sediment disposal line.

6-03. White Rock Relief Sewer. According to a preliminary report entitled *A Master Plan for Water Pollution Control for Dallas, Texas*, prepared by Black and Veatch, Consulting Engineers, in October 1970, the existing White Rock Trunk Sewer on the west side of the lake between the MKT Railroad and Winstead Drive (about 21,800 feet) is planned to be paralleled during the period 1973-1975 by the construction of the White Rock Relief Sewer. Construction staging for the relief sewer downstream from this point is designated as Long Range (probably after 1985). The general alignment of the proposed relief sewer is indicated on the map on Plate 6.

6-04. In the reach between Mockingbird Lane and the old fish hatchery below the dam, a distance of about 12,150 feet, the existing sewer is installed in a tunnel. This reach is indicated on the map on Plate 23 by Point A near Mockingbird Lane and Point B near the old fish hatchery. The proposed relief sewer in this reach is planned to be 66-inch and 54-inch diameter, essentially the same size as the existing sewer. Although no definite alignment for the relief sewer has been selected, it is indicated to follow

generally parallel to the existing sewer. In consideration of the high cost of tunnelling and of the potential advantage of having the relief sewer out in the lake for possible initial use for transporting sediment to the downstream floodplain, a cost comparison was made between (1) installing the relief sewer by tunnelling immediately parallel to the existing sewer, and (2) installing it in the lake bottom. The cost comparison included the reach between Points A and B as indicated on Plate 23.

6-05. For the line in the lake, no estimate was made of the cost of draining the lake and laying the sewer to grade by open cut. From investigations discussed previously in this report it was concluded that adverse effects on the ecology, undesirability and inconvenience to the public, and the uncertainties of sufficient drying time to allow suitable working conditions in the lake bottom would preclude this alternative. Instead, estimates were made for sub-aqueous installation of the line, with consideration given to using concrete pipe or ductile iron pipe. Dredging of a trench about 20 feet deep below the present lake bottom would be required to assure installation below the design hydraulic gradient of the sewer, although the pipe would not necessarily be laid to a true straight grade. Water-proof joints would be an absolute necessity to eliminate the possibility of infiltration of lake water or the exfiltration of sewer water. For the 66-inch concrete pipe it was assumed that divers would be used and that jointing would be done under water. For ductile iron pipe it was assumed that ball joints would be used for every other joint, and that the pipe would be laid by barge without the use of divers. In the case of ductile iron pipe the largest standard size manufactured is 54-inches. The nearest equivalent double sewer line to a 66-inch is 48-inch, and this size double line was used for estimating purposes.

6-06. For the tunnelling plan, estimates were made for both precast 66-inch reinforced concrete cylinder pipe and for a 66-inch cast in place conduit. Listed below is a summary of the estimated costs of the various alternates for a relief sewer between Points A and B:

Sub-aqueous	66" RCCP	$6,807,000
Sub-aqueous	Double 48" Ductile Iron	$5,646,000
Tunnel	66" RCCP	$5,542,000
Tunnel	66" Dia. Cast In Place	$5,412,000

As shown in the tabulation, there is little difference percentage-wise between the tunnelling and sub-aqueous construction costs, with the tunnelling being slightly less expensive. However, it is believed that maintenance costs would be considerably less for the tunnelling alternative which would make this method of construction the most economical on an annual basis.

6-07. The White Rock Relief Sewer downstream from Winstead Drive to Second Avenue, according to the Black and Veatch report, is planned to parallel the existing trunk sewer and to range in size from 66-inch to 78-inch diameter. Construction staging for this reach of some 24,000 feet is designated as Long Range. Its present-day construction cost is estimated to be about $2,000,000. Downstream from Second Avenue a major portion of the future sewage flow from the White Rock Creek watershed is planned to be diverted at sometime in the future to the Southside Wastewater Treatment Plant and to limit flows to the Dallas/White Rock Plant to about 125 MGD. The general alignment and staging of the trunk sewers involved are indicated on Plate 6.

6-08. Dual Purpose Sediment Removal and Sanitary Sewer Line. As discussed in Section III of this report, one of the alternatives for disposing of sediment from White Rock Lake would be by hydraulic dredging, and pumping the sediment by pipeline several miles downstream to a land reclamation site in the floodplain somewhere in the general vicinity of Second Avenue. It has been suggested that possibly the portion of the proposed White Rock Relief Sewer extending downstream to this location, even though it is scheduled for long range construction, could be constructed at an early date for initial use as a sediment transportation line, and then be converted at such time as needed to a sanitary sewer line. An evaluation of this possibility must take into consideration the physical capability of transporting a sediment solution in such a large pipe, as well as the economics involved.

6-09. The equipment suggested as being most suitable for use in dredging White Rock Lake would be capable of discharging about 1,000 cubic yards of sediment per hour in a 20 percent solution of sediment and lake water. This discharge is at an approximate rate of 24 million gallons per day. If the sediment were to be pumped downstream to a land reclamation site, a pipeline 18 inches to 24 inches in diameter laid on top of the ground would normally be used. If a much larger pipeline, such as the planned 66-inch to 78-inch diameter White Rock Relief Sewer, were to be used to transport sediment, serious problems could be encountered with sediment settling out in the pipeline.

6-10. The minimum permissible velocity for transporting the sediment solution considered in this study is 7.6 feet per second. Lesser velocities will allow settling of the sediment and clogging of the pipeline. Calculation of this velocity is based on the following formula derived by the French hydraulics engineer, R. Durand.

$$V = C\sqrt{2gD\,\frac{s.g.' - s.g.}{s.g.}}$$

where:

V = Minimum non-silting velocity
C = Coefficient depending on particle size
g = Acceleration constant of gravity
D = Inside diameter of pipe
s.g. = Specific gravity of water
s.g'. = Specific gravity of sediment

The approximate slope of the ground from Winstead Drive to Second Avenue is 1.4 feet per 1,000 feet. A 66-inch pipeline laid on this grade would carry a flow of 24 MGD, which is the rate of the proposed sediment solution discharge, at a velocity of 4.6 feet per second, which is too slow to avoid settlement. In order to obtain the necessary velocity of 7.6 feet per second in a 66-inch pipeline, the line would require surcharging to a hydraulic gradient slope of 2.6 feet per 1,000 feet. This would necessitate a continuous input to the pipe of about 120 MGD, which is about five times as great as the disposal rate considered to be most practical. At this slope, the required hydraulic gradient would exceed the normal lake level, elevation 458.0, at some point near the lower end of the lake, which is remote from the primary sediment removal area.

6-11. From the above factors it is concluded that it is impractical to try to use the proposed relief sewer as a sediment disposal line. In addition, consideration of an investment of $2,000,000 for construction of the portion of the relief sewer planned for construction after 1985 within the immediate future indicates that such a scheme could not be justified economically. Consequently, it is recommended that no further consideration be given to the construction of the relief sewer for the purpose of sediment disposal from the lake.

6-12. Storm Water Pollution Control Station. Storm water, as discussed herein, relates to the water that enters sanitary sewer lines during and after periods of rainfall, due to faulty pipe joints, cracked pipe, submerged manholes, faulty house connections, and other means. These extraneous flows, combined with domestic and industrial sewage flows, result in the overloading of sewer lines and treatment facilities, and localized overflowing of manholes and backing up of sewage into service lines. Efforts are being made through such methods as improved pipe and joint materials, and modifications to plumbing codes, to reduce the amount of storm water flow, although it still persists in large quantities, particularly in older parts of the City.

6-13. In the previously referenced Black and Veatch report an economic evaluation was made of two basic methods for properly handling the storm water flows: (1) Construct

trunk sewers and main wastewater treatment plants of adequate size to handle the total combined storm water and domestic and industrial sewage flows, or (2) construct smaller trunk sewers and treatment plants, and handle the excess sewage by construction of storm water pollution control stations. The latter alternative was concluded to be economical. At the storm water stations, "storm flow would receive effective sedimentation and chlorination treatment comparable to the treatment such flows would receive at the main wastewater treatment plant. If necessary, this treatment could later be supplemented by addition of chemicals to further increase BOD and solids removal." The treated water would be discharged to the stream and settled solids would be returned to the trunk sewer after passage of peak flows.

6-14. The area of the old fish hatchery below White Rock Dam has been selected as a potential storm water pollution control station, and the Water Utilities Department of the City of Dallas has verbally requested that this area be reserved for that purpose. It is noted that dumping of refuse is taking place in the northern end of the fish hatchery area, and consideration should be given to halting this operation until specific plans for the pollution control station are developed, lest foundation problems be needlessly created. Construction of the station is scheduled for the period 1973-1975. It is anticipated that by that time much valuable information on the effectiveness of such a station can be obtained from experience at a similar station scheduled to be opened this summer at Harry Hines Boulevard at Shorecrest Drive.

6-15. Dixon Branch Sewage Pump Station. The Dixon Branch Pump Station is located near Buckner Boulevard on the east side of the lake as indicated on Plate 23. Sewage from the Dixon Branch watershed flows to this point, from which it is pumped through 16-inch and 24-inch force mains into a 36-inch gravity sewer. These pipelines follow generally along Lawther Drive along the east side of the lake. As discussed in paragraph 5-13, the Water Utilities Department has plans to increase the capacity of the pump station in 1972-73. Additional pumping capacity will be installed and possibly additional pipelines. Should additional pipelines be needed, their location should be coordinated with bicycle trails and roadway work recommended in this report.

6-16. Water Lines. According to preliminary information from Pitometer Associates Design Study for 1985 Water System Operation for Dallas, only two new major water lines are planned for the White Rock Lake area. They include (1) a 16-inch and 30-inch main east along Lakeland Drive from Garland Road, and (2) a 30-inch main along Highland Drive and below White Rock Dam. The location of each is shown on Plate 23.

6-17. The line along Lakeland Drive is outside of the area of improvements considered in this report and would not be affected by such improvements. However, the line

downstream from the dam could be affected by improvements to the dam or spillway discussed in Section IV. If either of Methods 2, 3, or 4 (tunnel under Garland Road, gated spillway, or raising the dam to elevation 475.0, respectively) should be adopted, modification or relocation would be required of the proposed water line below the dam as well as the existing 12-inch and 24-inch water lines below the dam. Under Methods 1 or 5 (by-pass channel or parapet wall) no modification would be necessary.

6-18. Conclusions. From an evaluation of the sanitary sewer and water lines planned for future construction in the White Rock Lake area, the following conclusions have been drawn.

1. It is impractical to use the proposed White Rock Relief Sewer for transporting sediment because of the inability to maintain non-settling velocities in this size pipeline with the planned sediment discharge rates, and the early construction of the relief sewer for such purpose cannot be justified from the viewpoint of economics.

2. Disadvantages, particularly in regard to maintenance, would outweigh the advantages realized from installing the proposed White Rock Relief Sewer in the lake as compared to dry-land installation in the reach between Mockingbird Lane and the old fish hatchery as planned.

3. The storm water pollution control station concept appears to be a practical solution to handling excess storm water flow carried in the sanitary sewer. However, before construction of the proposed station at the old fish hatchery site, additional information will be available on the effectiveness of such treatment from the station now being completed at Harry Hines Boulevard and Shorecrest Drive.

4. Planning for locations of possible additional sanitary sewer lines from the Dixon Branch Pump Station should be coordinated with planning for possible roadways and bicycle trails on the east side of the lake.

5. The proposed water main construction below White Rock Dam should be coordinated with future dam and spillway improvements in order to avoid possible conflicts in the overall planning for the area.

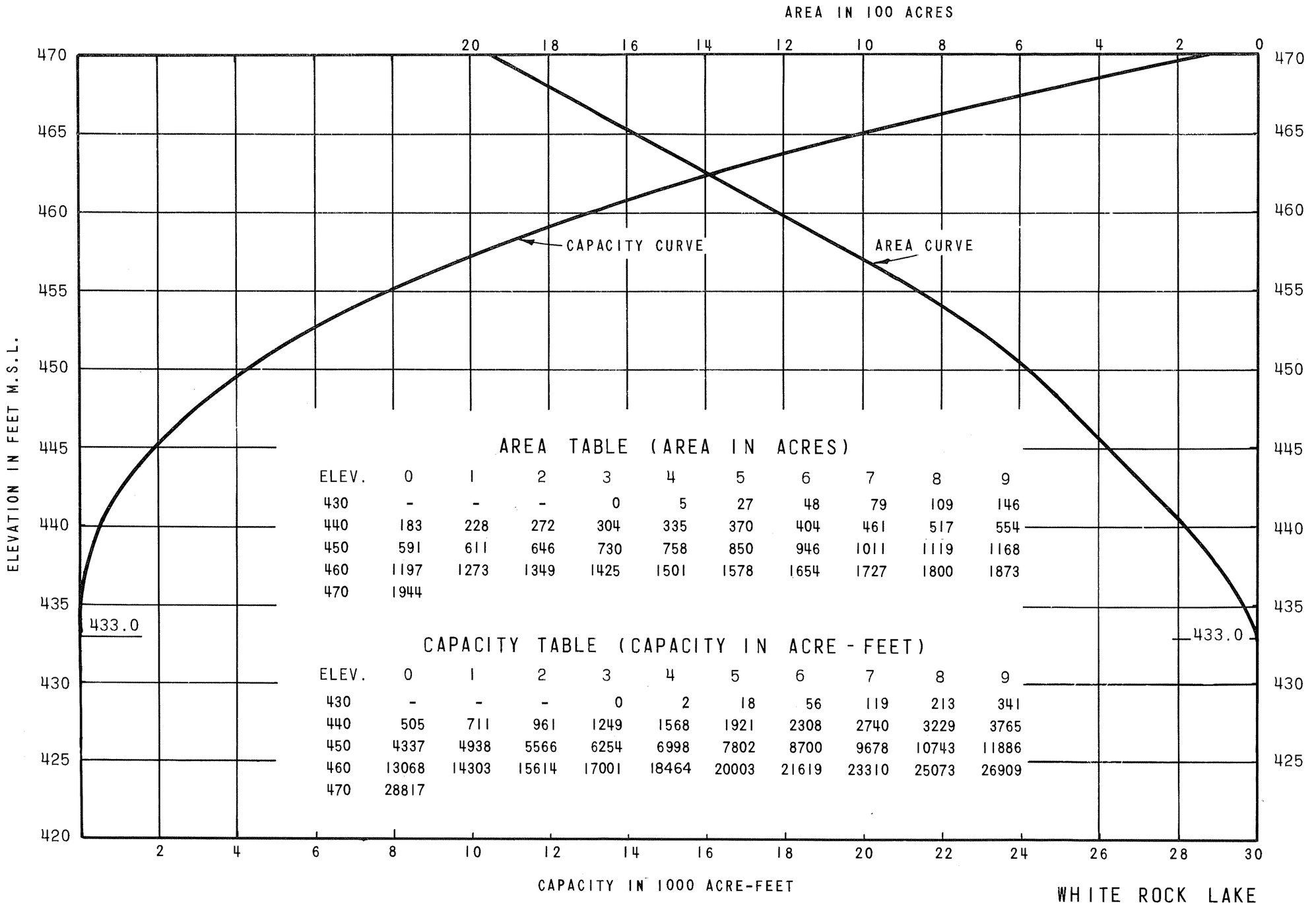
VII - WATER SUPPLY

7-01. General. White Rock Lake was designed and constructed during the 1910-11 period as a primary source of municipal water supply for the City of Dallas. However, after the completion of Lake Dallas and the Bachman Treatment Plant in 1930, the lake was used almost exclusively for recreational purposes until May 1953 when it was again placed in service to help supply the City's needs for water during a drought which lasted into early 1957. After the drought, use of the lake for water supply was continued during the summer months of each year until 1964. While the lake's primary use is for recreation, it provides a readily available reserve water supply in the event of an unforeseen emergency.

7-02. Existing Water Rights. The City of Dallas holds water rights in White Rock Lake under Certified Filing No. 75, filed with the State Board of Water Engineers April 29, 1914. This permit authorizes the City to divert water for municipal purposes at the maximum rate of 1,128 cubic feet per second (about 817,000 acre-feet per year) from Elm Fork of Trinity River, Bachman Creek, and White Rock Creek. One of the authorized impoundments is White Rock Lake and Dam with 929,836,580 cubic feet of storage.

7-03. Area and Capacity Data. According to the results of the October 1970 sedimentation survey of White Rock Lake made by the Soil Conservation Survey, the lake has a surface area of 1,119 acres at spillway level (Elev. 458.0), and a storage capacity of 10,743 acre-feet. Area and capacity data for each one foot increment of elevation were developed from data furnished by the Soil Conservation Service. These data are shown both graphically and in tabular form on Figure 6.

7-04. Reservoir Inflow. Three U.S.G.S. streamflow gages lying near the White Rock Lake Watershed provided data relevant to determining inflow to the lake. The historical streamflows at these gages were adjusted on a drainage area basis to yield a reasonable approximation of runoff from the 100-square mile drainage area above White Rock Dam. Table 19 lists the three gages, including their locations, their drainage areas, and their respective periods of record used in determining White Rock Lake inflow for the period 1949-1969.



AREA TABLE (AREA IN ACRES)

ELEV.	0	1	2	3	4	5	6	7	8	9
430	-	-	-	0	5	27	48	79	109	146
440	183	228	272	304	335	370	404	461	517	554
450	591	611	646	730	758	850	946	1011	1119	1168
460	1197	1273	1349	1425	1501	1578	1654	1727	1800	1873
470	1944									

CAPACITY TABLE (CAPACITY IN ACRE-FEET)

ELEV.	0	1	2	3	4	5	6	7	8	9
430	-	-	-	0	2	18	56	119	213	341
440	505	711	961	1249	1568	1921	2308	2740	3229	3765
450	4337	4938	5566	6254	6998	7802	8700	9678	10743	11886
460	13068	14303	15614	17001	18464	20003	21619	23310	25073	26909
470	28817									

WHITE ROCK LAKE

AREA AND CAPACITY CURVES

BASED ON DATA FROM OCTOBER 1970 SEDIMENTATION SURVEY BY S.C.S.

FIG. 6

TABLE 19

U.S.G.S. Streamflow Gages
Used to Estimate Inflow to White Rock Lake

USGS Gage No.	Location	Drainage Area Sq. Mi.	Period of Record Used From	To
-	East Fork Trinity River near Rockwall, Texas	840	Jan. 1949	Aug. 1949
8-595	Sister Grove Creek near Princeton, Texas	113	Sept. 1949	Sept. 1961
8-572	White Rock Creek at Greenville Avenue, Dallas, Texas	66	Oct. 1961	Dec. 1969

The period from 1949 to 1969 is significant in that it includes two severe droughts for the North Central Texas area. The first drought during this period occurred during the early and mid 1950's, and the second during the early and mid 1960's. A tabulation of the estimated monthly values of inflow to White Rock Lake for the 21-year study period is shown on Table 20. As indicated by the table, inflow has averaged 48,024 acre-feet per year, with a maximum in 1957 of 118,888 acre-feet and a minimum in 1956 of 6,124 acre-feet.

7-05. Evaporation. For the period from January 1949 through December 1965, net lake evaporation was extracted from data published in Texas Water Development Board Report 64, using weighted values of quadrangles E-11 and D-10. For the period from January 1966 through December 1969, net lake evaporation data were estimated on the basis of evaporation data taken from U.S. Weather Bureau Stations at Lake Lavon and Grapevine Reservoir, and correlated with rainfall data at Dallas Love Field Airport.

Table 21 summarizes the monthly net lake evaporation data for the study period. It indicates an average annual loss to evaporation of 2.76 feet, with a maximum of 5.06 feet in 1956 and a minimum of 1.11 feet in 1957.

7-06. White Rock Lake Yield. For the purposes of this report, lake yield is defined as the maximum continuous rate of withdrawal from the lake that could be sustained during the period of record. Using the values of surface area, storage capacity, inflow,

TABLE 20

WHITE ROCK LAKE INFLOW
in Acre-Feet

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1949	12379.	10160.	6904.	3080.	6735.	3444.	76.	6.	0.	1912.	473.	314.	45483.
1950	8850.	17045.	2982.	6257.	20656.	4903.	3230.	4221.	9248.	1354.	537.	453.	79736.
1951	395.	2212.	1204.	700.	1929.	24134.	1655.	83.	0.	0.	0.	0.	32312.
1952	0.	61.	217.	5682.	2664.	472.	0.	0.	0.	0.	220.	335.	9651.
1953	362.	320.	1469.	12903.	10956.	881.	140.	0.	0.	132.	920.	837.	28920.
1954	2018.	1460.	662.	2531.	7177.	1850.	42.	0.	0.	894.	179.	131.	16944.
1955	290.	1487.	2505.	2221.	1186.	259.	662.	0.	0.	112.	0.	0.	8722.
1956	0.	1841.	378.	632.	3248.	7.	0.	0.	0.	0.	18.	0.	6124.
1957	0.	0.	1584.	32648.	51082.	12275.	476.	12.	315.	97.	15275.	5124.	118888.
1958	7558.	3841.	7266.	10036.	25700.	2221.	530.	137.	1646.	82.	14.	61.	59092.
1959	81.	190.	343.	196.	60.	1664.	344.	45.	59.	1434.	1743.	8107.	14266.
1960	8505.	5452.	2575.	1195.	529.	281.	379.	314.	243.	224.	96.	4230.	24023.
1961	6735.	4053.	4938.	2637.	2487.	735.	513.	3.	247.	1312.	2620.	3385.	29665.
1962	1881.	2212.	2062.	7345.	2000.	16426.	23275.	3628.	8717.	15841.	5664.	3805.	92856.
1963	1894.	1097.	1309.	3549.	3097.	1313.	1956.	118.	82.	77.	265.	403.	15160.
1964	606.	796.	2469.	2274.	3929.	748.	73.	697.	55755.	3354.	14939.	2451.	88091.
1965	2478.	21169.	2859.	2035.	27081.	4336.	673.	253.	2000.	796.	1487.	929.	66096.
1966	1140.	2407.	2274.	61773.	16266.	4213.	1867.	3921.	2797.	2301.	653.	973.	100585.
1967	615.	518.	1867.	4912.	9204.	1991.	832.	189.	3451.	3381.	1885.	3487.	32332.
1968	6655.	3974.	24824.	7434.	8496.	4124.	1487.	3186.	1363.	938.	2257.	1476.	66214.
1969	3398.	4575.	9080.	5602.	38586.	1327.	187.	435.	831.	3496.	3717.	2106.	73340.
TOTAL	65840.	84870.	79771.	175642.	243068.	87604.	38397.	17248.	86754.	37737.	52962.	38607.	1008500.
AVG.	3135.	4041.	3799.	8364.	11575.	4172.	1828.	821.	4131.	1797.	2522.	1838.	48024.

TABLE 21

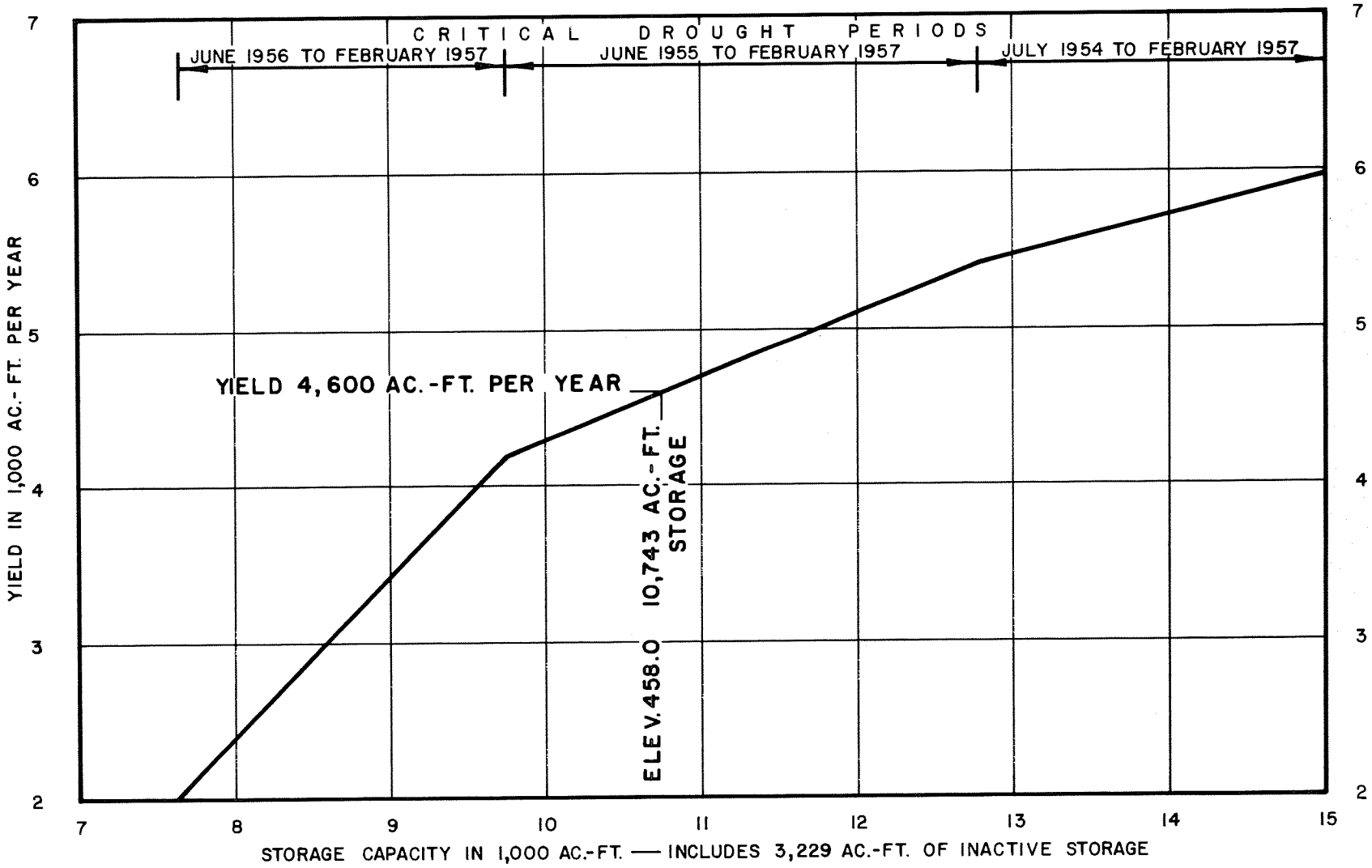
WHITE ROCK LAKE NET EVAPORATION
in Feet

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1949	-0.23	-0.05	0.10	0.10	0.07	0.31	0.51	0.53	0.46	-0.07	0.33	0.11	2.17
1950	-0.06	-0.15	0.31	-0.03	0.00	0.27	0.18	0.46	0.17	0.42	0.40	0.26	2.23
1951	0.14	-0.04	0.28	0.27	0.20	0.10	0.64	0.82	0.23	0.29	0.27	0.22	3.42
1952	0.18	0.10	0.11	-0.05	0.02	0.52	0.65	0.92	0.78	0.67	0.01	-0.06	3.85
1953	0.18	0.10	0.03	0.03	0.05	0.64	0.43	0.55	0.52	0.22	0.13	0.10	2.98
1954	-0.03	0.27	0.31	0.09	0.04	0.48	0.92	0.98	0.78	0.24	0.24	0.23	4.55
1955	0.09	-0.01	0.16	0.16	0.14	0.24	0.43	0.37	0.30	0.56	0.44	0.24	3.12
1956	0.09	0.01	0.37	0.29	0.20	0.52	0.95	0.95	0.86	0.42	0.25	0.15	5.06
1957	0.09	0.01	0.00	-0.64	-0.29	0.26	0.61	0.59	0.32	0.12	-0.13	0.17	1.11
1958	0.07	0.14	-0.02	-0.14	0.10	0.49	0.49	0.48	0.11	0.30	0.23	0.18	2.43
1959	0.25	0.03	0.29	0.12	0.02	-0.02	0.27	0.50	0.39	-0.05	0.36	0.00	2.16
1960	-0.02	0.06	0.19	0.23	0.27	0.30	0.36	0.33	0.47	0.15	0.28	-0.25	2.37
1961	-0.08	-0.02	0.01	0.31	0.21	0.00	0.40	0.57	0.26	0.27	0.05	0.11	2.09
1962	0.11	0.09	0.19	-0.08	0.34	0.00	0.27	0.58	-0.03	0.11	0.12	0.20	1.90
1963	0.17	0.21	0.19	-0.12	0.11	0.31	0.52	0.70	0.50	0.58	0.28	0.13	3.58
1964	0.10	0.11	0.04	0.07	0.07	0.42	0.80	0.57	0.08	0.46	0.00	0.17	2.89
1965	0.06	-0.10	0.11	0.16	-0.28	0.27	0.62	0.48	0.17	0.29	0.11	0.10	1.99
1966	0.02	-0.06	0.19	-0.65	0.26	0.30	0.59	0.22	0.25	0.33	0.33	0.13	1.91
1967	0.24	0.19	0.31	0.10	0.26	0.48	0.48	0.77	0.15	0.20	0.17	0.02	3.37
1968	-0.13	0.05	-0.12	0.15	0.15	0.22	0.51	0.52	0.40	0.25	0.00	0.22	2.22
1969	0.07	0.03	0.02	0.16	-0.21	0.65	0.88	0.53	0.22	-0.03	0.20	-0.03	2.49
TOTAL	1.31	0.97	3.07	0.53	1.73	6.76	11.51	12.42	7.39	5.73	4.07	2.40	57.89
AVG.	0.06	0.05	0.15	0.03	0.08	0.32	0.55	0.59	0.35	0.27	0.19	0.11	2.76

and evaporation presented in preceding paragraphs the yield of White Rock Lake was calculated to be 4,600 acre-feet per year, or about 4.1 million gallons per day. This yield is based on the assumption that the 3,229 acre-feet of storage below elevation 448.0 would be inactive, and that the lake would not be drawn down below that level. This minimum content level was estimated on the basis of pump station intake information furnished by the Water Utilities Department, and on a correlation of present storage data with inactive storage data published in the Texas Water Report.

7-07. Additional Yield from Sediment Removal Program. In the event that a sediment removal program from the lake is adopted, more water storage space will be provided, thus permitting an increase in the reservoir yield. On Figure 7 is plotted a curve of yield versus total reservoir storage, which can be used in estimating the increase in yield resulting from a sediment removal program. For example, if 2 million cubic yards (1,240 acre-feet) of sediment were removed, the reservoir storage capacity would increase to 11,983 acre-feet (10,743 + 1,240). From Figure 7 the corresponding yield would be 5,100 acre-feet per year, or about 4.5 MGD.

7-08. Conclusion. The estimated yield of White Rock Lake is about 4.1 MGD, which is about 2 percent of the City's present water usage. A small increase in yield could be realized from a sediment removal program, although the increase would be relatively insignificant. The lake is too small to fully equalize the runoff it receives; but, if it were used during the low rainfall period of each year, it would decrease slightly the demand on other reservoirs in the Dallas water supply system. This practice would result in fluctuating lake levels, however, which would be extremely undesirable to recreational interests. It is believed that from a water supply standpoint, the most practical use of the lake is its present use as a source of supply in event of unforeseen emergency.



YIELD CURVE - WHITE ROCK LAKE

FIG. 7

VIII - TRAFFIC CIRCULATION SYSTEMS

8-01. Park Roadways. Primary access points to the park are from Garland Road at East Lawther Drive, from Mockingbird Lane at East and West Lawther Drives, and from Northwest Highway on both sides of the lake. The existing roadway system at the park consists of East Lawther Drive, West Lawther Drive, both of which are two-lane, several residential streets intersecting with East and West Lawther Drives, and a few internal paved and unpaved park roads. Traffic counts by the Park Department show that in the last three years about 8,000,000 people per year visited White Rock Lake Park with peak day traffic for the July 4 and Labor Day holidays of 100,000 people in 25,000 vehicles. Northwest Highway across the upper end of the lake has a count of about 39,000 cars per day, Mockingbird Lane 14,000 cars per day, and Garland Road at the spillway 37,000 cars per day. Park traffic must intermingle with through traffic at Garland Road and Northwest Highway but Mockingbird Lane has overpasses at both East and West Lawther Drives which allow through traffic to move without interruption by park traffic.

8-02. The present park road system is overloaded on weekends and holidays and to better accommodate the large amount of Sunday traffic the Park Department temporarily designates East Lawther Drive as a one-way road from Garland Road north to Northwest Highway. This arrangement helps the movement of traffic but does require the regular placing and removal of one-way signs and some difficulties are experienced by drivers unfamiliar with the road system and the available means of ingress and egress.

8-03. It is believed that use of the park facilities will increase as the City grows and that some improvements to the roadways are justified in order that traffic may flow more evenly and that congestion may be minimized. Alternatives considered for improvements ranged from minimum alterations of the existing roadway to constructing a four-lane divided thoroughfare. It is generally agreed that high speed traffic should not be encouraged to use Lawther Drive and the construction of a thoroughfare type roadway might actually encourage higher speeds. An additional adverse effect of such construction would be the loss of trees resulting from the widening of the roadway.

8-04. Based on our investigations, it appears that off-street parking facilities coupled with left turn lanes would permit two-way traffic at moderate speeds to utilize the existing roadways. Such improvements could be constructed for a cost of about $388,000 and without a major loss of trees or natural beauty. The location of the left turn lanes and

parking areas would be selected on the ground with full consideration given to saving trees. Prior to the preparation of construction plans a detailed evaluation would be made of each proposed left turn lane to determine its priority of need. The proposed left turn lane and parking improvement locations are shown on Plate 24, and typical sections and details are shown on Plate 25. The construction of the parking improvements would greatly increase the lane capacity by altering the present operational procedure whereby traffic must come to a stop to allow parked cars to back into the street before proceeding with the traffic flow.

8-05. Studies were made for comparative purposes for four-lane roadways on both sides of the lake as shown on Plate 26. The existing two-lane roadway would be utilized to the greatest extent practical. On the east side of the lake the roadway would be divided, and where right-of-way and terrain permit, the two new lanes would be constructed on high ground to provide a scenic overlook of the lake. The roadway on the west side of the lake would not be divided because of the relatively small amount of park land on that side. Typical sections and details for this alternate four-lane roadway plan are shown on Plate 27. The construction cost of this plan would amount to about $976,000, exclusive of right-of-way costs. As indicated in the sections on Plate 27, asphalt pavement would be used in this construction, and road ditches and culverts would be provided for drainage. This type drainage is considered more practical for the park than concrete curb and gutters since the existing roadway would be utilized to a great extent, and its grade is generally too flat to adapt practicably to curb and gutter construction. Should the four-lane roadway alternate be adopted, curb and gutter could be used on the new portion of the divided roadway on the east side of the lake if desired, since it would be relatively independent of the existing roadway. The estimated additional cost for providing curb and gutter on that 4.2-mile portion is $132,000.

8-06. The Park Department presently has plans for relocating in 1972 a portion of the existing roadway on the west side of the lake in the vicinity of the concession area. The road is to be relocated high on the hill to provide a scenic overlook as well as to provide for development of the hillside for recreational activities. This relocation is compatible with either the two-lane or four-lane roadway plan presented herein.

8-07. Bicycle and Hiking Trails. In recent years, bicycling has become a popular activity for pleasure and exercise by young and old alike. This increase in cycling activity has resulted in the development of a bike trail plan in the White Rock area by the City of Dallas to help provide for safe and enjoyable riding on City streets. The White Rock area plan is a pilot study from which evaluations can be made which will eventually lead to a City-wide bike trail plan.

8-08. Lawther Drive is the basic loop of the White Rock bicycle trail plan. In order for cyclists to be able to ride safely in the park, facilities are needed to separate them from the automobile traffic using the park roads. This can best be accomplished by a paved trail that would generally follow Lawther Drive around the lake, staying on the lake side of the road where possible. Occasional digression from Lawther Drive would provide a desirable variety of terrain and scenery. A typical section of the proposed trail is shown on Plate 25 and a possible location is shown on Plates 24 and 26. The latter two plates also indicate residential streets connecting to Lawther Drive which have been suggested in the White Rock pilot study for use as bicycle trails. An alternative to separate bicycle trails would be the widening of the existing lakeside shoulder with asphalt to provide for bicycle traffic. Such an arrangement would be especially practical in areas where available space between the roadway and the lake is insufficient for the construction of a separate bicycle trail. It is estimated that about 46,000 feet of trails would be constructed if the alignments shown on Plates 24 and 26 were used and that such construction would cost about $144,000.

8-09. Bicycling should not be restricted to the trails but should be allowed throughout the park except where such use would interfere with other park activities. The paved bicycle trails should be used only for bicycles and walking. Provisions should be made for the exclusion of motorbikes, motorcycles, small cars, and horses from the trails. An aid in the development of the bicycle trail system within the park would be the use of the standard bicycle trail symbol, which is used to mark the bicycle trail system in other areas of the City. This symbol provides guidance to the cyclist and a caution signal to motorists.

8-10. Where the bicycle trails are separated from automobile traffic, the use of the trails by both hikers and bicyclists is compatible. However, hiking trails would be needed at both the north and south ends of the lake to connect to the trails proposed in the City's Green Belt Plan, and where bicycle trails are on the shoulder of the road, separate trails for hikers should be provided.

8-11. Bridle Paths. Saddle horses are kept by boarding stables in the vicinity of White Rock Lake and by some owners who maintain their own stables and use the park grounds for riding. In addition, riding clubs and individuals bring their own horses into the park from other areas. A recently passed City of Dallas ordinance sets forth the specific requirements that must be met in order to keep horses within the City but it is not believed that the passage of this ordinance will cause any appreciable decrease in the number of riders using the park.

8-12. Most of the horseback riding occurs in the northern half of the park but riders may be encountered in all parts of the park. Since riders prefer to roam freely to enjoy the park, the need for formalized paths is not indicated. However, restrictions should be placed on the areas where horseback riding would conflict with other uses and the following are recommended as restricted areas:

a. All paved bicycle trails.
b. All designated picnic areas.
c. The area south of the museum of the east side of the lake.
d. The strip of land between the shore and East Lawther Drive in the boat dock area on the east side of the lake.

8-13. The only major roads which require crossing by horseback riders are Mockingbird Lane and Northwest Highway. Since both East and West Lawther Drives pass under Mockingbird Lane, no major crossing problems exist at Mockingbird Lane. However, at Northwest Highway, grade crossings at the signalized intersections with West Lawther Drive and with Buckner Boulevard provide the best crossings under existing conditions. Investigations have been made of the possibility of crossing under the existing Northwest Highway bridges at White Rock Creek; however, insufficient head room is available between the underside of the bridges and the normal lake level. Other possibilities considered include a tunnel under the roadway in the vicinity of Flag Pole Hill or an equestrian bridge over the roadway. Both of these are major construction projects, however, and would be difficult to justify from an economic standpoint. There are no immediate plans for the construction of roadway grade separations at the intersections of Northwest Highway with either Buckner Boulevard or Lawther Drive; however, should this be done at any time in the future, consideration should be given to including provisions for equestrian crossings. In the meantime, as a matter of safety, these intersections should be clearly marked for both approaching motorists and riders as equestrian crossings, and riders should be alerted by signs to follow pedestrian crossing procedures.

8-14. The range of horseback riding in the area could be extended by selective clearing of underbrush in the floodplain area north of Northwest Highway. Although no bridle paths are recommended within the park, it is recommended that short trails be developed and marked in this northern area for the use of children and inexperienced riders. In addition, an educational program should be carried out to instruct horseback riders in safe and courteous procedures to follow in using the park for such purpose.

8-15. **Signing.** Roadside signing, whether regulatory, informational, or interpretive, is an integral part of the visitor experience, as well as road design. Care should be exercised

to insure that the quality and design of all signing enhances the visitor experience. The residential streets which provide access to East Lawther and West Lawther Drives should be signed at their intersections with major streets to indicate access routes to the park. Streets within the park serving as existing routes to major surrounding streets should also be marked with the streets identified. In conjunction with roadside signing, the use of maps and literature describing activities within the park would be helpful.

8-16. Thoroughfares. Traffic between downtown Dallas and the areas northeast of White Rock Lake, if traveling the most direct routes, uses Garland Road, Mockingbird Lane, or Northwest Highway, which have daily traffic counts of 37,000; 14,000; and 39,000, respectively, at the lake. The traffic counts have decreased somewhat since the construction of Interstate Highway 635 but are expected to increase as the area continues to develop.

8-17. The Dallas Thoroughfare Plan calls for the construction of a north-south secondary thoroughfare between Plano and Jupiter Roads south from Kingsley Road that would connect with Garland Road and thereby relieve Buckner Boulevard traffic. However, there is considerable concern that such construction will not be approved by residents in the area and that an alternative solution must be developed. The Planning Department and the Traffic Control Division have suggested alternative plans for consideration but the final selection will depend upon detailed studies and the desires of the residents in the affected areas.

8-18. Dallas City Planning Department has tentatively proposed that as a part of the major thoroughfare plan, Lake Highlands Drive be extended in a southwesterly direction from its intersection with Buckner Boulevard across the Dixon Branch arm of White Rock Lake to a connection with Lakeland Drive at Garland Road, as shown on Plate 24. The primary purpose for this thoroughfare would be to divert some of the traffic away from the heavily used Buckner Boulevard and Garland Road intersection and to provide a more direct corridor from the northern part of the City toward downtown. This construction would also provide additional access to White Rock Lake Park. Approximately 80 percent of the 1.4 miles of thoroughfare would be across either park lands or private property.

8-19. Discussions were held with Traffic Control Division representatives concerning alternatives to the Lake Highlands Drive-Lakeland Drive connection and one alternative would be to extend Lake Highlands Drive southwestward across the main body of the lake to a connection with Westshore Drive and an extension to the downtown area via the Santa Fe Railroad right-of-way and Columbia Avenue. This route would relieve both Garland and Ferguson Roads from some traffic to and from the Central Business District. However, it is anticipated this route would be unpopular both from the standpoint of

penetration of the Lakewood residential area and the esthetic detriment of a major lake crossing. This construction would also be very costly.

8-20. A second alternative considered would be the construction of Van Dyke Road as a major thoroughfare from Mockingbird Lane to Northwest Highway at Easton Road. This would provide a downtown route via Mockingbird and several north-south streets. Construction cost of this alternate would not be as great as other plans considered, and much less private property would be involved.

8-21. In connection with the foregoing alternatives, it appears that utilization of Van Dyke Road connection from Northwest Highway to Mockingbird Lane or some slight modification of this alternative as a major thoroughfare would provide the needed relief at minimum cost and with minimum modification to existing facilities. Consequently, further studies should be made by the Planning Department of this alternative before a final decision is reached. Due consideration should also be given to provisions of an Act passed in 1969 by the 61st State Legislature (Art. 5421q, Vernon's Annotated Civil Statutes) providing that taking of park and recreation lands for other uses requires a public hearing and a determination that there is no feasible and prudent alternative to the taking. In the event it is decided to construct the Lake Highlands Drive-Lakeland Drive connection, consideration should be given to an alignment that would not cross Lawther Drive, and close coordination of planning for this improvement should be effected with the Park Department.

IX - DISCUSSION AND RECOMMENDATIONS

9-01. Discussion. White Rock Lake Park with an area of 2,343 acres, including 1,119 acres of lake area, serves the public as a recreational center, a reserve water supply, and a scenic attraction which enhances the City both economically and esthetically. The lake also reduces the height of downstream flooding by temporarily storing a portion of flood flows. There is no question as to the value and continuing need for White Rock Lake Park, but optimum utilization of this facility without undue cost will require a balanced program for future public service improvements and a coordinated operation and maintenance program by the various City departments with facilities in the area or responsibilities for public health and safety. Proper evaluation of the numerous problems involved in furnishing the public services required for the area will aid in minimizing costs and prevent undue delay in the implementation of the White Rock Lake Park improvement program adopted by the City.

9-02. The studies and investigations described in the foregoing sections of this report were made in order to evaluate the problems critical to the development of a balanced improvement program for White Rock Lake Park and to provide a guide for the development of such a program by the City. The studies included investigations for improvements and/or alterations of existing facilities to compensate for the adverse effects of urbanization of the watershed, which include: (1) the continuing deposition of sediment in the lake; (2) increased flood runoff; and (3) pollution from storm runoff and wastewater. The studies also included investigations of the ecological impact of a sediment removal program and the need for: (1) additional water and sanitary sewer lines in the park area; (2) roadways, bicycle trails, and bridle paths in the park; (3) drainage improvements for Dixon and Jackson Branches and minor tributaries discharging into the lake (4) dam and/or spillway improvements to increase the structural safety of the dam; and (5) possible solutions to the location of additional traffic arteries which may require rights-of-way needed for park purposes.

9-03. The investigations showed that:

a. Sedimentation, which has reduced the lake capacity by 41 percent (18,158 acre-feet in 1910 vs. 10,743 acre-feet in 1970), is continuing at a rate of about 100 acre-feet (161,300 cubic yards) annually and that the surface area at spillway level has been reduced by 135 acres to 1,119 acres which includes 269 acres of lake with less than 3 feet of depth.

b. A sediment removal program is needed in order to: (1) preserve the life of the lake; (2) increase the acreage of park land available for public use; (3) improve the lake for boating and fishing; and (4) help reduce the flooding of Buckner Boulevard from Dixon Branch and the flooding of Northwest Highway from White Rock Creek.

c. Hydraulic dredging would provide the most economical procedure for the removal of sediment from the lake and should improve the ecological balance of the lake.

d. Increased urbanization is resulting in greater volumes of flood runoff entering the lake at higher rates than prior to urbanization which reduces the structural safety of the dam to the extent that corrective work is needed. The required structural safety could be provided by providing additional spillway discharge capacity or by raising the earthen embankment. The most desirable method of increasing the spillway capacity would be by the addition of two 40- by 20-foot radial gates at the north end of the existing spillway (paragraph 4-46), which would permit the passage of the Standard Project Flood with a maximum lake level of elevation 466.9 and would reduce the maximum lake level from an occurrence of the 100-year flood from elevation 465.9 to 461.5. This modification in combination with the channel dredging in the lake of White Rock Creek from Mockingbird Lane to Northwest Highway and of Dixon Branch from the lake to Buckner Boulevard would reduce the frequency of flooding of Northwest Highway and Buckner Boulevard and also would reduce the depth of flooding from major floods at storm sewer inlets and streets adjacent to the lake. In lieu of increasing the spillway capacity, the embankment could be raised (paragraph 4-48) and/or a concrete parapet wall (paragraph 4-49) constructed along the upstream edge of the embankment with sufficient height to prevent excessive damage from an occurrence of the Standard Project Flood.

e. The reduction of the 100-year flood lake level from elevation 465.9 to elevation 461.5 would not affect flood water heights on Dixon Branch upstream from a point 1,600 feet upstream from Buckner Boulevard nor would it have any effect on flooding in developed areas on Jackson Branch.

f. Flooding from a 100-year flood on Dixon Branch upstream from Peavy Road could be reduced to a non-damaging stage and traffic maintained on Buckner Boulevard by: (1) excavation of an earthen channel from the lake to Buckner Boulevard; (2) bridge modifications at East Lawther Drive and Buckner Boulevard; (3) raising 1,800 feet of Buckner Boulevard; (4) the construction of 3,000 feet of paved channel from Buckner Boulevard through Peavy Road; (5) 1,700 feet of excavated earth channel from Peavy Road upstream; and (6) 1,500 feet of channel clearing from the end of the excavated channel to Easton Road.

g. Potential flooding of the White Rock Trail area on Jackson Branch from an occurrence of a 100-year flood could be eliminated by widening the 2,500 feet of existing drainage ditch from White Rock Creek up Jackson Branch from 15 feet to 80 feet and excavating the ditch for a distance of 300 feet upstream beyond the end of the existing ditch.

h. While flooding is a problem to property owners in the Vinemont-Creekmere Drive area on Dixon Branch, the White Rock Trail area on Jackson Branch, and some areas drained by Reinhardt, McCommas, Williamson, and Rush Branches, the stream gradients are steep enough that flooding in these locations is not affected by White Rock Lake water levels. Consequently, justification for drainage improvements in these areas should be considered on an individual basis whether based on economics or City drainage policy.

i. While White Rock Lake water is of good quality, as evidenced by the fish found in the lake, pollution loads from upstream waste discharges and storm runoff are possible sources of future trouble and should be watched closely and water quality permit standards enforced.

j. Construction of future water and sanitary sewer lines in the park area should not create any problem but that planning for such construction should be closely coordinated between the Water Utilities, Park, and Public Works Departments.

k. White Rock Lake provides a reserve water supply of about 4.1 million gallons per day for unforeseen emergencies, and the quality and quantity of water stored in the lake should be preserved to the extent practicable.

l. While streets in the park are generally adequate for park traffic, circulation of traffic could be improved by the construction of additional parking facilities and left turn lanes at appropriate locations.

m. Tentative consideration is being given to the construction of a thoroughfare connection across park land from Lake Highlands Drive to Garland Road over the Dixon Branch arm of the lake although alternative routes will be studied before a final route selection for a future thoroughfare is made. In this regard, serious consideration should be given to an improved connection from Northwest Highway to Mockingbird Lane via Van Dyke Road in lieu of the Lake Highlands Drive-Garland Road connection.

n. Increased use of the park, which had 8,000,000 visitors in 1970, justifies the construction of bicycle trails through the park; the construction of connecting hiking trails at the north and south ends of the park with other hiking trails proposed by the Park Department in its open space program; and the exclusion of specific areas from horseback and motor-bike riding.

9-04. Recommendations. Numerous investigations have been made and alternative plans studied in connection with problems which should be considered in developing a plan of improvement for White Rock Lake Park and, in general, conclusions and/or recommendations relating to the subjects covered are contained in the appropriate sections of this report. However, the following general recommendations are made in connection with future activities and improvements related to the park.

9-05. It is recommended that the City of Dallas:

a. Adopt a water quality monitoring plan as an aid in the preservation and improvement of the quality of water stored in the lake. Periodic monitoring of inflows into the lake and effluents at upstream wastewater discharge points should be accomplished in order to effect the enforcement or upgrading of the water quality permit standards (see paragraphs 5-21 through 5-27).

b. Continue to utilize White Rock Lake as a reserve water supply.

c. Give serious consideration to the development of an alternative thoroughfare location as a substitute for the tentatively proposed Lake Highlands Drive-Garland Road connection across Dixon Branch in order to preserve the use of park lands for park purposes to the maximum practicable extent.

d. Adopt both an initial and a long range program for sediment removal from White Rock Lake, utilizing hydraulic dredging for excavation in the main body of the lake and taking into consideration the comments and recommendations furnished by Dr. J. K. G. Silvey in Appendix A. The initial program should consist of the removal of a minimum of 2,000,000 cubic yards of sediment in order to obtain lowest unit prices, and should include the excavation of channels in the White Rock Creek-Northwest Highway area and in the Dixon Branch-East Lawther Drive area to help relieve upstream flooding and also the excavation of sediment in the approach area of the existing spillway. Other areas selected for lake excavation should be located where maximum benefits would be provided for boating and fishing and the excavated material placed in designated lakeshore areas where additional park land is needed. Permanent bulkheads should be used to confine

the dredged material within the selected areas and also to provide for shoreline fishing. The long range plan for repeat dredging should be based on a 15- or 20-year cycle depending upon future rates of sedimentation. In this regard, sedimentation re-surveys should be made every 10 years to determine lake depths and sedimentation rates. Future sediment could be used to build additional park land; however, long range planning should consider alternative sites for sediment deposition.

e. Improve the structural safety of the embankment of the dam by restoring the embankment to its original level and constructing additional spillway capacity or a concrete parapet wall along the upstream edge of the embankment to prevent possible erosion from wave action or overtopping of the embankment (see paragraphs 4-56 through 4-60).

f. Construct drainage improvements on Dixon Branch from the lake through Buckner Boulevard in general accordance with Plan 2 (paragraph 4-21) and clear the natural channels from Buckner Boulevard to Easton Road of underbrush, fallen trees and other debris which block or impede the discharge of storm water. If it is necessary to implement the present policy of providing 100-year flood protection as far upstream as Easton Road, then Plan 3 (paragraph 4-22) should be utilized.

g. Construct additional off-street parking facilities and left turn lanes at appropriate locations on East and West Lawther Drives to aid in minimizing traffic congestion (see Plate 24).

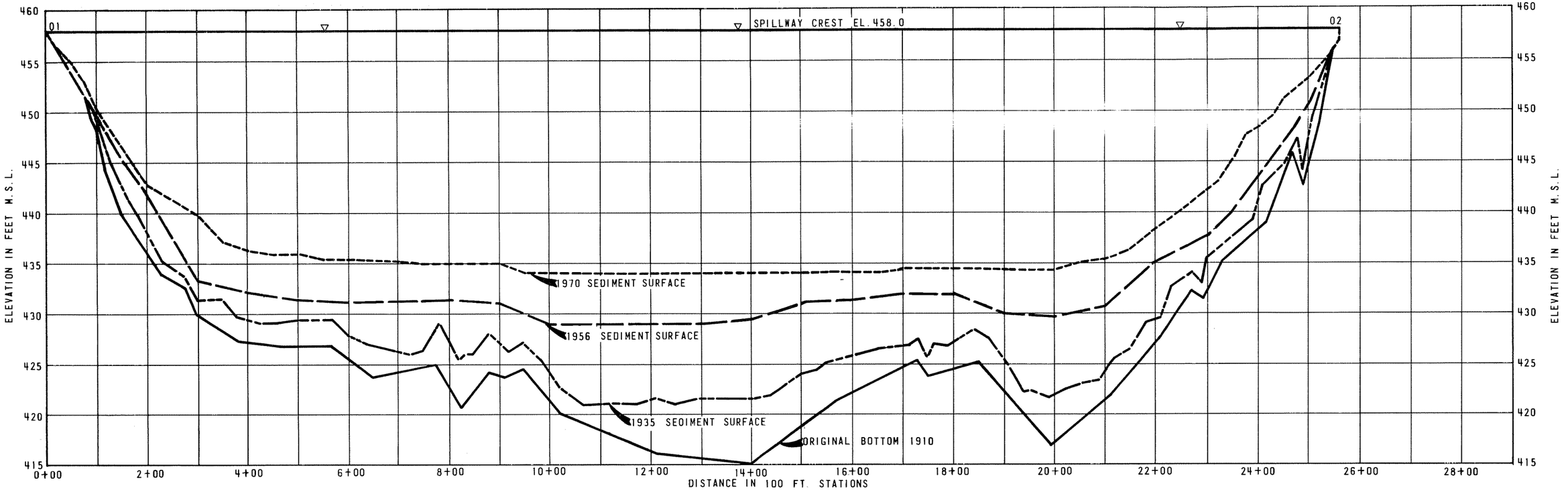
h. Provide bicycle trails around the park and hiking trails at the north end and south end of the park to connect with other hiking trails proposed in the City's open space program.

The estimated total construction cost of the minimum improvements recommended is $2,897,000 which would be increased to $5,243,000 if the gated spillway improvement were constructed. Table 22 shows a breakdown of these costs, which are based on 1971 construction prices.

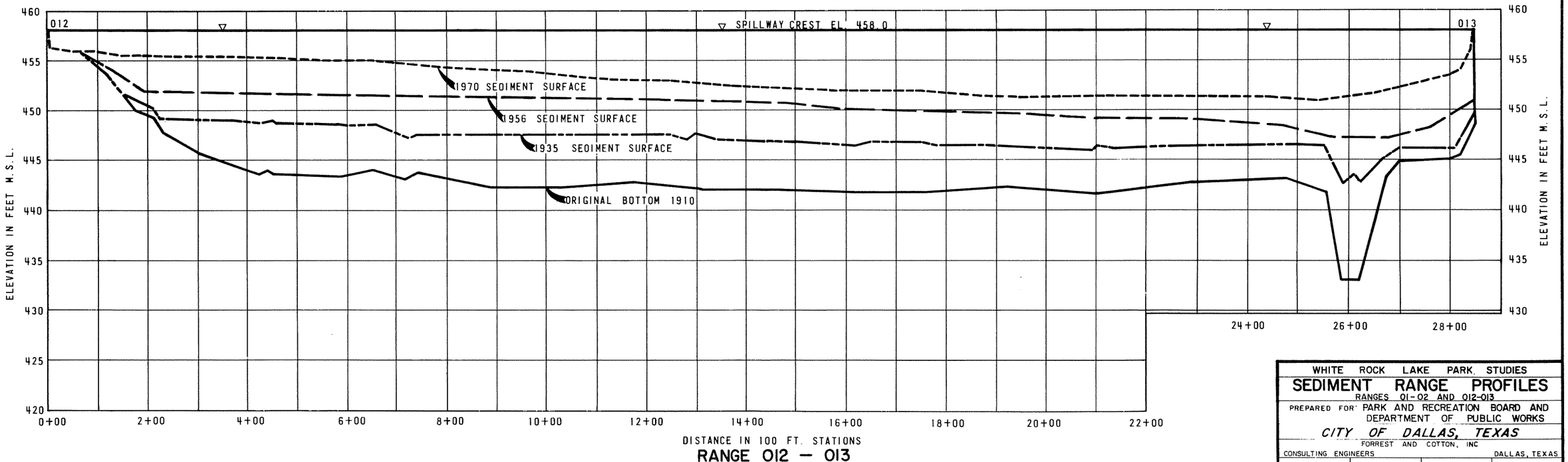
TABLE 22

COST SUMMARY - RECOMMENDED IMPROVEMENTS
(1971 Price Levels)

Item	Feature	Cost with Parapet Wall	Cost with Gated Spillway
Hydraulic Dredging of Sediment	Dredge 2,600,000 cubic yards and reclaim 100 acres of land on west side of lake.	$1,377,000	$1,377,000
White Rock Dam	Method 3 - Gated Spillway.	-	2,774,000
White Rock Dam	Method 5 - Parapet Wall.	364,000	-
Dixon Branch	Improvement Plan 2	580,000	516,000
Dixon Branch	Cleaning channel upstream from Buckner Boulevard to Easton Road	44,000	44,000
Park Roadways	Left turn lanes and parking areas.	388,000	388,000
Bicycle Trails	8-foot wide (paved).	144,000	144,000
	Total	**$2,897,000**	**$5,243,000**



RANGE 01 – 02



RANGE 012 – 013

WHITE ROCK LAKE PARK STUDIES

SEDIMENT RANGE PROFILES

RANGES 01-02 AND 012-013

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

CONSULTING ENGINEERS: FORREST AND COTTON, INC, DALLAS, TEXAS

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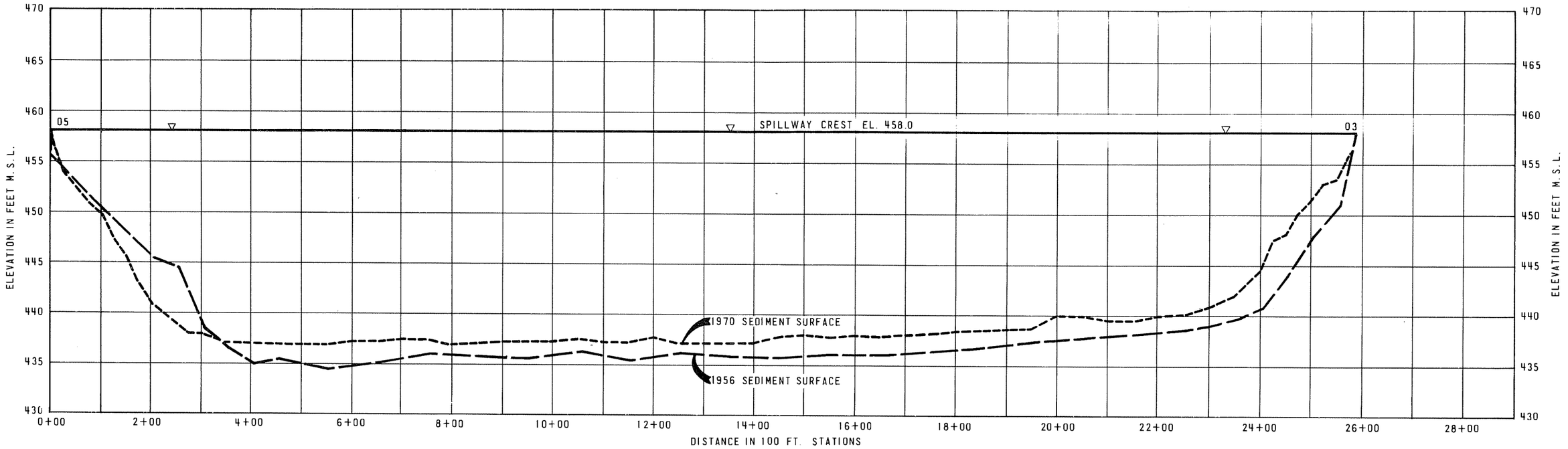
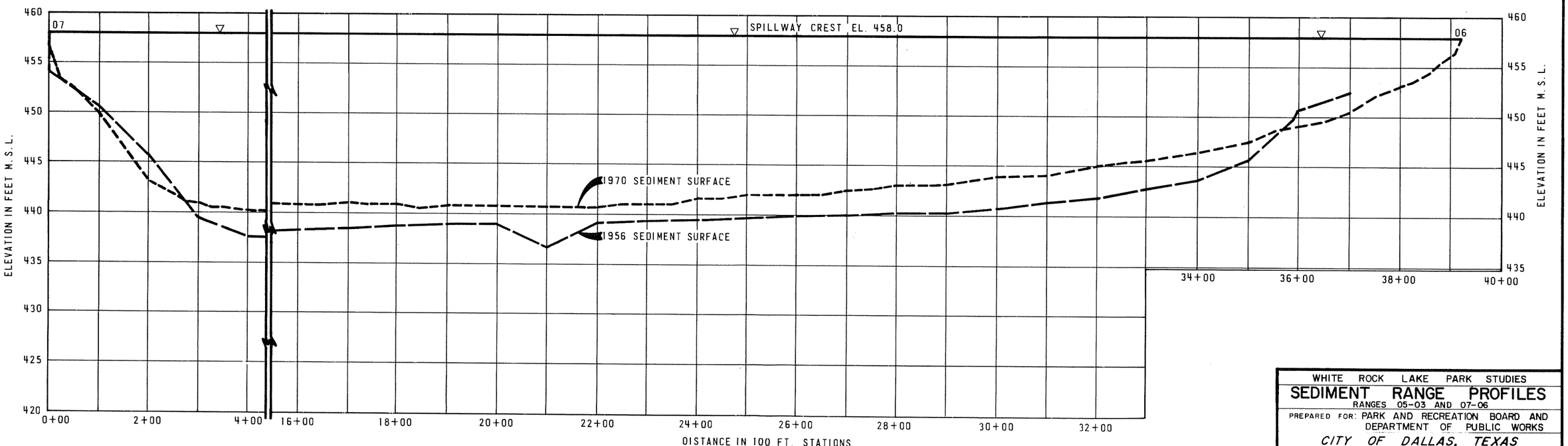


RANGE 05 – 03



RANGE 07 – 06

WHITE ROCK LAKE PARK STUDIES

SEDIMENT RANGE PROFILES

RANGES 05-03 AND 07-06

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

FORREST AND COTTON, INC

CONSULTING ENGINEERS DALLAS, TEXAS

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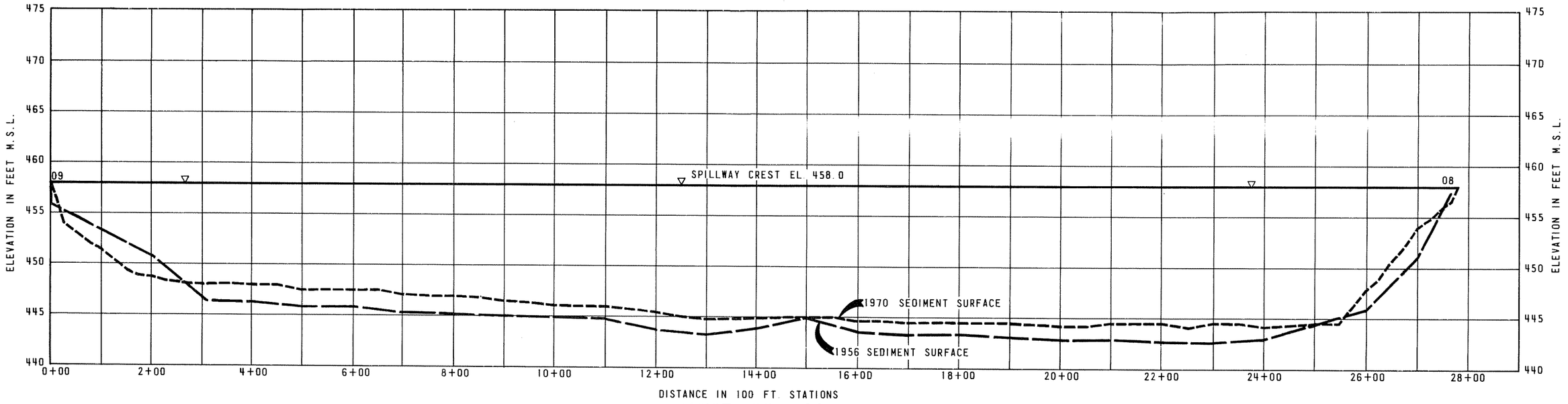
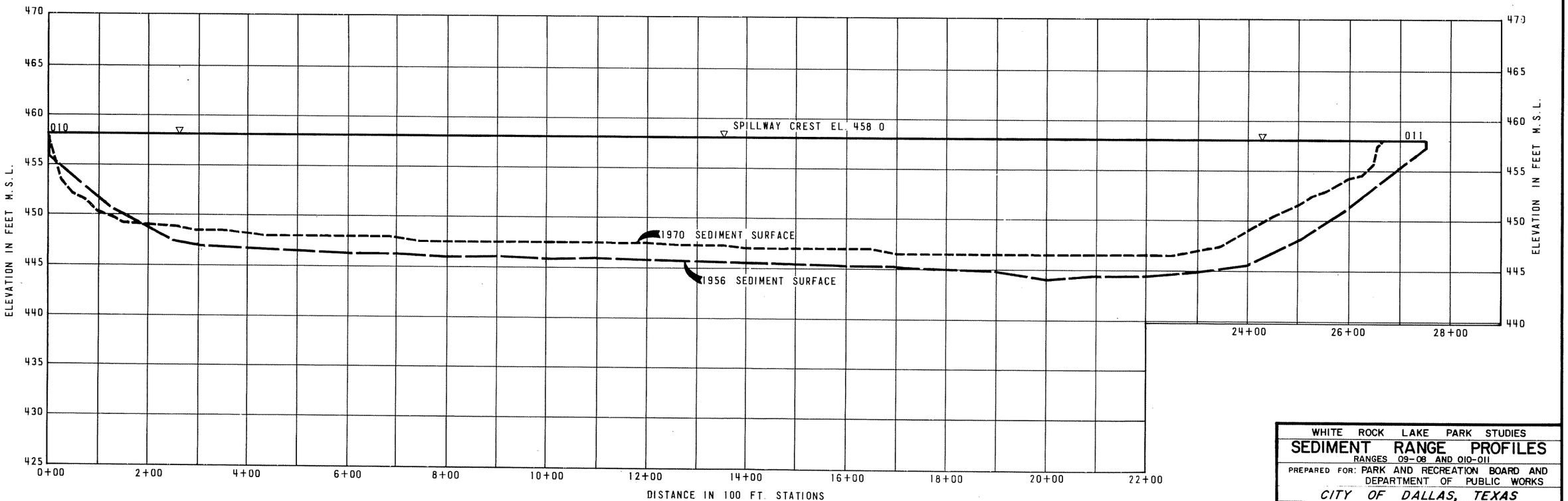


RANGE 09 – 08



RANGE 010 – 011

WHITE ROCK LAKE PARK STUDIES

SEDIMENT RANGE PROFILES

RANGES 09-08 AND 010-011

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

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CONSULTING ENGINEERS DALLAS, TEXAS

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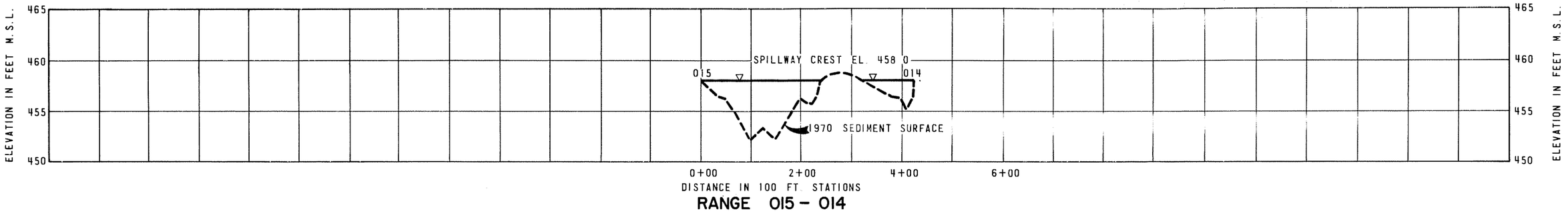
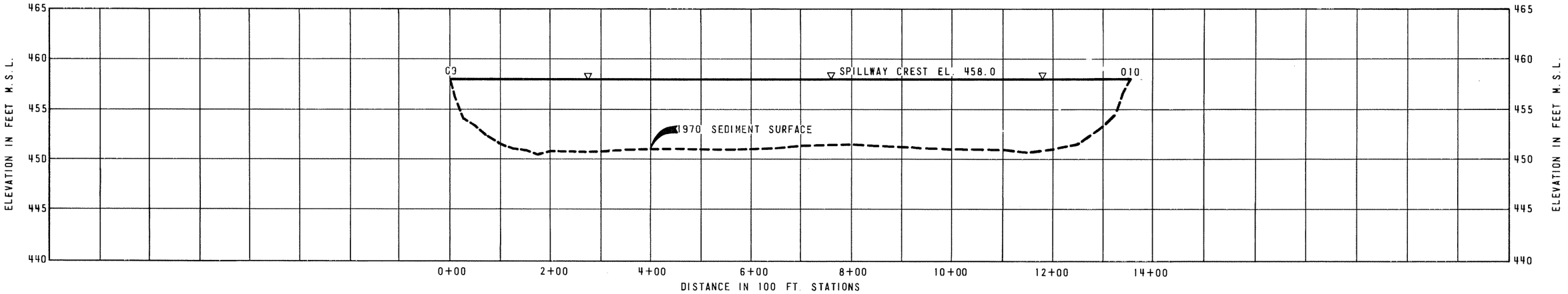
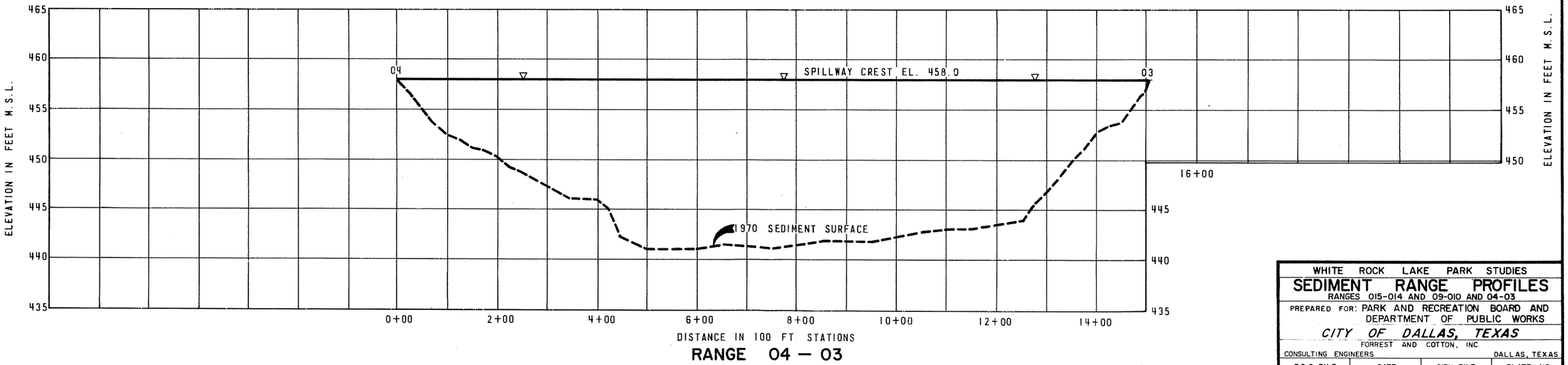


RANGE 015 – 014



RANGE 09 – 010



RANGE 04 – 03

WHITE ROCK LAKE PARK STUDIES

SEDIMENT RANGE PROFILES

RANGES 015-014 AND 09-010 AND 04-03

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

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WHITE ROCK LAKE PARK STUDIES

PROPOSED SEDIMENT REMOVAL AREAS & POTENTIAL LAND RECLAMATION AREAS

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

FORREST AND COTTON, INC.
CONSULTING ENGINEERS
DALLAS, TEXAS

F&C FILE	DATE	CITY FILE	PLATE NO.
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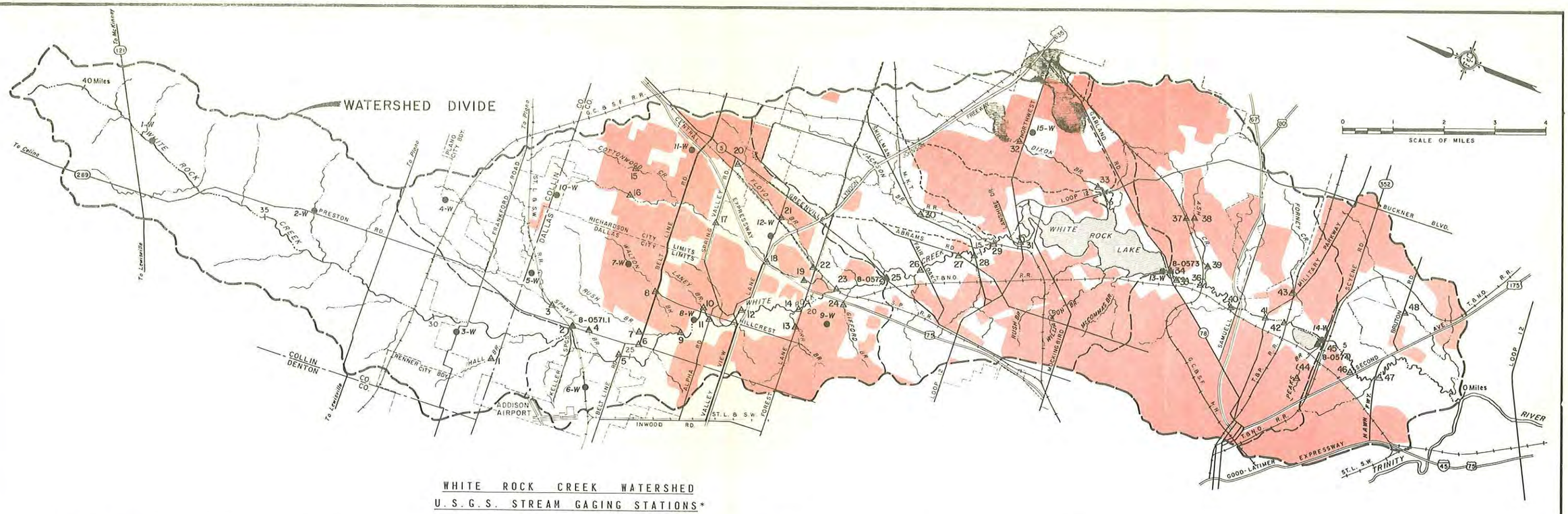

WHITE ROCK CREEK WATERSHED
U.S.G.S. STREAM GAGING STATIONS*

MAP NO.	STATION NO.	STATION NAME	DRAINAGE AREA (SQ MI)	DISTANCE ABOVE MOUTH (MILES)
		WHITE ROCK CREEK BASIN		
1		HALL BRANCH NEAR OLD FRANKFORD CEMETERY		
2	8-0571.0[a]	WHITE ROCK CREEK AT KELLER SPRINGS ROAD	29.4	26.1
3		SPANKY BRANCH AT DAVENPORT ROAD		
4	8-0571.2[b]	SPANKY BRANCH AT McCALLUM LANE	6.77	
5		WHITE ROCK CREEK AT BELT LINE ROAD	38.7	24.5
6		WHITE ROCK CREEK AT PRESTON ROAD	40.2	23.6
7		RUSH BRANCH AT BELT LINE ROAD		
8		WALTON BRANCH AT BELT LINE ROAD		
9		WALTON BRANCH AT WEST END SPRING VALLEY ROAD	1.42	
10		LANEY BRANCH AT HILLCREST ROAD		
11		WHITE ROCK CREEK AT ALPHA ROAD	45.8	22.0
12		WHITE ROCK CREEK AT VALLEY VIEW ROAD	47.2	21.3
13		ORR BRANCH AT FOREST LANE		
14		WHITE ROCK CREEK AT FOREST LANE	50.6	19.6
15		COTTONWOOD CREEK AT ARAPAHO ROAD		
16		ARMSTRONG BRANCH AT ARAPAHO ROAD		
17		COTTONWOOD CREEK AT SPRING VALLEY ROAD		
18		COTTONWOOD CREEK AT VALLEY VIEW ROAD		
19	8-0571.4[b]	COTTONWOOD CREEK AT FOREST LANE	8.50	
20		FLOYD BRANCH AT SPRING VALLEY ROAD		
21		FLOYD BRANCH AT VALLEY VIEW ROAD	3.18	
22	8-0571.6[b]	FLOYD BRANCH AT FOREST LANE	4.17	
23		WHITE ROCK CREEK AT T & NO RR	64.1	18.7
24		GIFFORD BRANCH AT U. S. HIGHWAY 75		

MAP NO.	STATION NO.	STATION NAME	DRAINAGE AREA (SQ MI)	DISTANCE ABOVE MOUTH (MILES)
		WHITE ROCK CREEK BASIN		
25	8-0572.0[a]	WHITE ROCK CREEK AT GREENVILLE AVENUE	66.4	17.7
26		WHITE ROCK CREEK AT FAIR OAKS AVENUE	70.0	16.4
27		WHITE ROCK CREEK AT ABRAMS ROAD		15.4
28		WHITE ROCK CREEK AT SKILLMAN STREET	73.1	14.9
29		WHITE ROCK CREEK AT M K T RR		14.3
30		JACKSON BRANCH AT CHURCH ROAD		
31		WHITE ROCK CREEK AT LOOP 12	83.0	13.5
32		DIXON BRANCH AT NORTHWEST HIGHWAY		
33		DIXON BRANCH AT BUCKNER BLVD.		
34	8-0573.0[a]	WHITE ROCK CREEK AT WHITE ROCK LAKE	100	10.3
35		WHITE ROCK CREEK AT GARLAND ROAD	101	10.1
36		WHITE ROCK CREEK AT GC & SF RR	101	9.2
37		NORTH BRANCH ASH CREEK AT LAKELAND DRIVE		
38		SOUTH BRANCH ASH CREEK AT LAKELAND DRIVE		
39	8-0573.2[c]	ASH CREEK AT HIGHLAND ROAD	6.92	7.8
40		WHITE ROCK CREEK AT SAMUEL BLVD.	111	7.8
41		WHITE ROCK CREEK AT MILITARY PARKWAY	113	7.1
42		WHITE ROCK CREEK AT T & P RR	114	6.6
43	8-0573.4[b]	FORNEY CREEK AT LAWNVIEW AVENUE	1.84	6.6
44		PEAKS BRANCH AT LAGOW STREET		
45	8-0574.0[a]	WHITE ROCK CREEK AT SCYENE ROAD	125	5.8
46		WHITE ROCK CREEK AT SECOND AVENUE	132	4.6
47		WHITE ROCK CREEK AT U. S. HIGHWAY 175		
48		WHITE ROCK CREEK TRIBUTARY AT NEW BRUTON ROAD		

(a) STREAM-GAGING STATION.
(b) CREST-STAGE PARTIAL-RECORD STATION EQUIPPED WITH STAGE-RAINFALL (SR) RECORDER.
(c) CREST-STAGE PARTIAL-RECORD STATION.
* FLOOD-PROFILE PARTIAL-RECORD STATIONS, EXCEPT AS NOTED.

LEGEND

- URBANIZED AREAS
- 7-W ● U.S.G.S. RECORDING RAIN GAGE
- ▲ U.S.G.S. RECORDING STREAM GAGE AND STATION NUMBER
- △ U.S.G.S. CREST-STAGE PARTIAL RECORD STATION
- △ FLOOD-PROFILE PARTIAL RECORD STATION

WHITE ROCK LAKE PARK STUDIES

RAINFALL AND STREAM GAGING STATIONS

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

FORREST AND COTTON, INC.
CONSULTING ENGINEERS DALLAS, TEXAS

F&C FILE	DATE	CITY FILE	PLATE NO.
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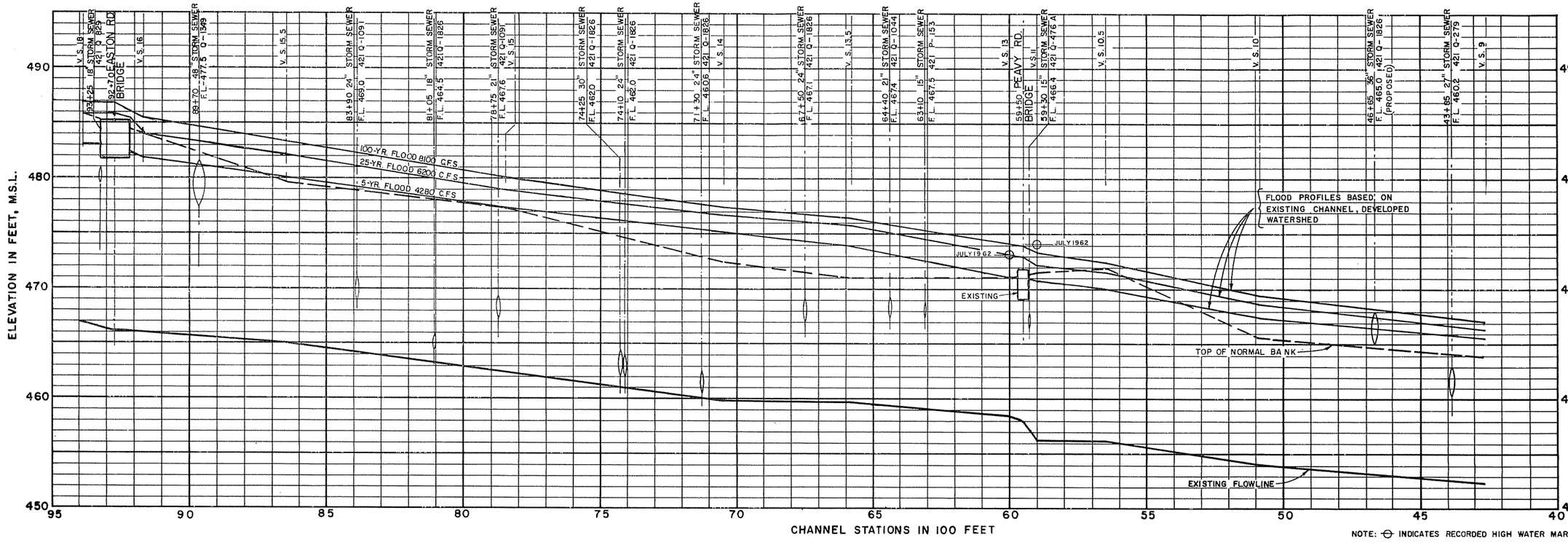

WHITE ROCK LAKE PARK STUDIES			
DIXON BRANCH EXISTING CHANNEL PROFILES			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
FORREST AND COTTON, INC. CONSULTING ENGINEERS			DALLAS, TEXAS
F & C FILE	DATE	CITY FILE	PLATE NO.
427-03-08	AUG. 1971		8

EASTON ROAD

VINEMONT DR.

CREEKMERE CIR.

PEAVY ROAD

BLVD.

BUCKNER

LAKE

IMPROVED CONCRETE LINING

LAWTHER DR.

DIXON BRANCH

HIGHLANDS

DRIVE

WHITE ROCK LAKE

90 80 70 60 50 40 30 20 10

LEGEND

30 EXISTING CHANNEL & STATIONS-100'

IMPROVED BRIDGE.

APPROXIMATE LIMIT 100-YR. FLOOD, IMPROVED CHANNEL, DEVELOPED - WATERSHED

IMPROVED EARTHEN CHANNEL

0 600 1200 1800

SCALE IN FEET

WHITE ROCK LAKE PARK STUDIES			
DIXON BRANCH - IMPROVEMENT PLAN I			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
FORREST AND COTTON, INC. CONSULTING ENGINEERS			DALLAS, TEXAS
F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-09	AUG. 1971		9

EASTON ROAD

VINEMONT DR.

PEAVY ROAD

CREEKMERE CIR.

BLVD.

BUCKNER

LAKE

HIGHLANDS

DRIVE

LAWTHER DR.

DIXON BRANCH

90

80

70

60

50

40

30

20

10

WHITE ROCK LAKE

LEGEND

- IMPROVED CONCRETE CHANNEL
- IMPROVED BRIDGE & ROADWAY
- APPROXIMATE LIMIT 100-YR. FLOOD, IMPROVED CHANNEL, DEVELOPED - WATERSHED
- IMPROVED EARTHEN CHANNEL

0 600 1200 1800

SCALE IN FEET

WHITE ROCK LAKE PARK STUDIES

DIXON BRANCH - IMPROVEMENT PLAN 3

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

CONSULTING ENGINEERS FORREST AND COTTON, INC. DALLAS, TEXAS

F&C FILE	DATE	CITY FILE	PLATE NO.
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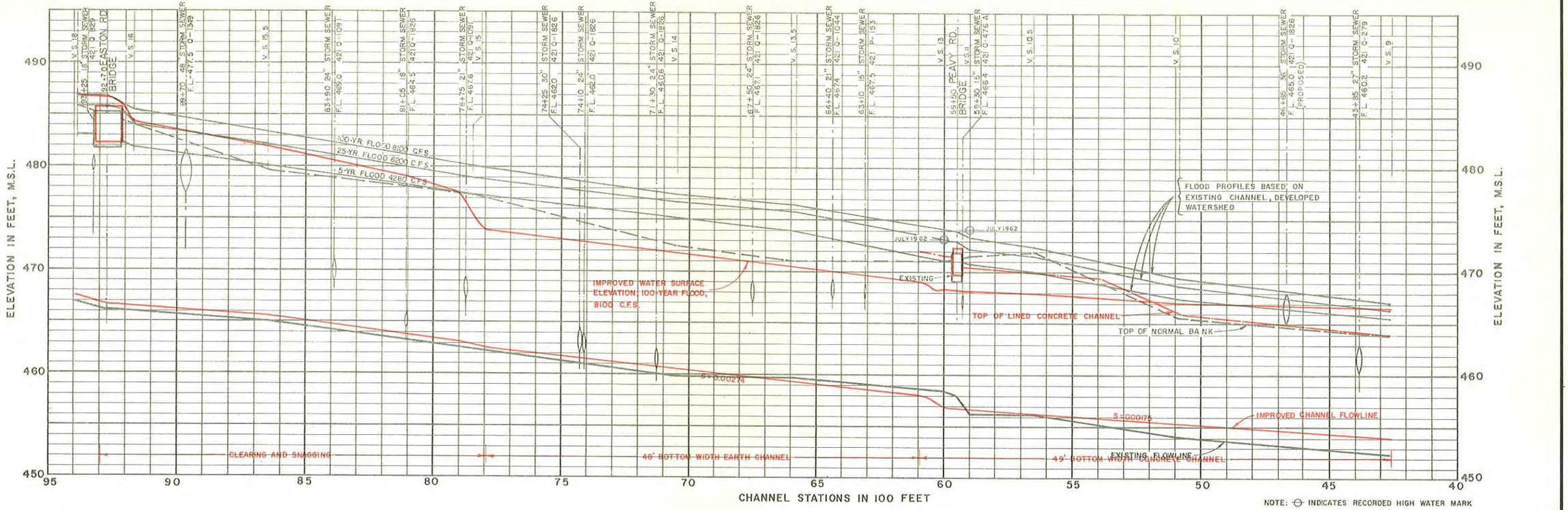

WHITE ROCK LAKE PARK STUDIES			
DIXON BRANCH IMPROVEMENT PLAN 3 CHANNEL PROFILES			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
FORREST AND COTTON, INC. CONSULTING ENGINEERS			DALLAS, TEXAS
F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-11	AUG. 1971		11

EASTON ROAD

VINEMONT DR.

PEAVY ROAD

CREEKMERE CIR.

BLVD.

90

80

70

60

50

40

30

20

10

BUCKNER

LAWTHER DR.

LAKE

IMPROVED CONCRETE CHANNEL

DIXON BRANCH

HIGHLANDS

DRIVE

WHITE ROCK LAKE

LEGEND — **IMPROVEMENTS**

- IMPROVED EARTHEN CHANNEL
- IMPROVED BRIDGE & ROADWAY
- LEVEE
- WALL
- PUMP STATION
- APPROXIMATE LIMIT 100-YR. FLOOD, IMPROVED CHANNEL, DEVELOPED WATERSHED

0 600 1200 1800

SCALE IN FEET

WHITE ROCK LAKE PARK STUDIES

DIXON BRANCH - IMPROVEMENT PLAN 4

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

FORREST AND COTTON, INC

CONSULTING ENGINEERS DALLAS, TEXAS

F&C FILE	DATE	CITY FILE	PLATE NO.
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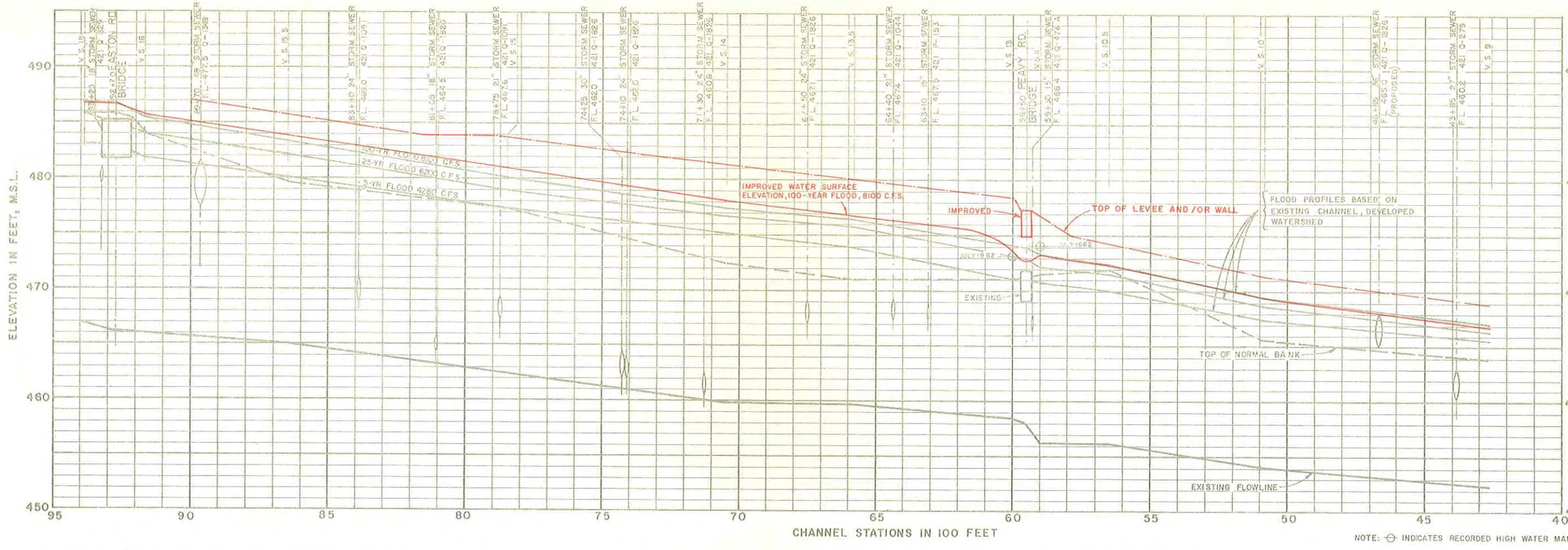
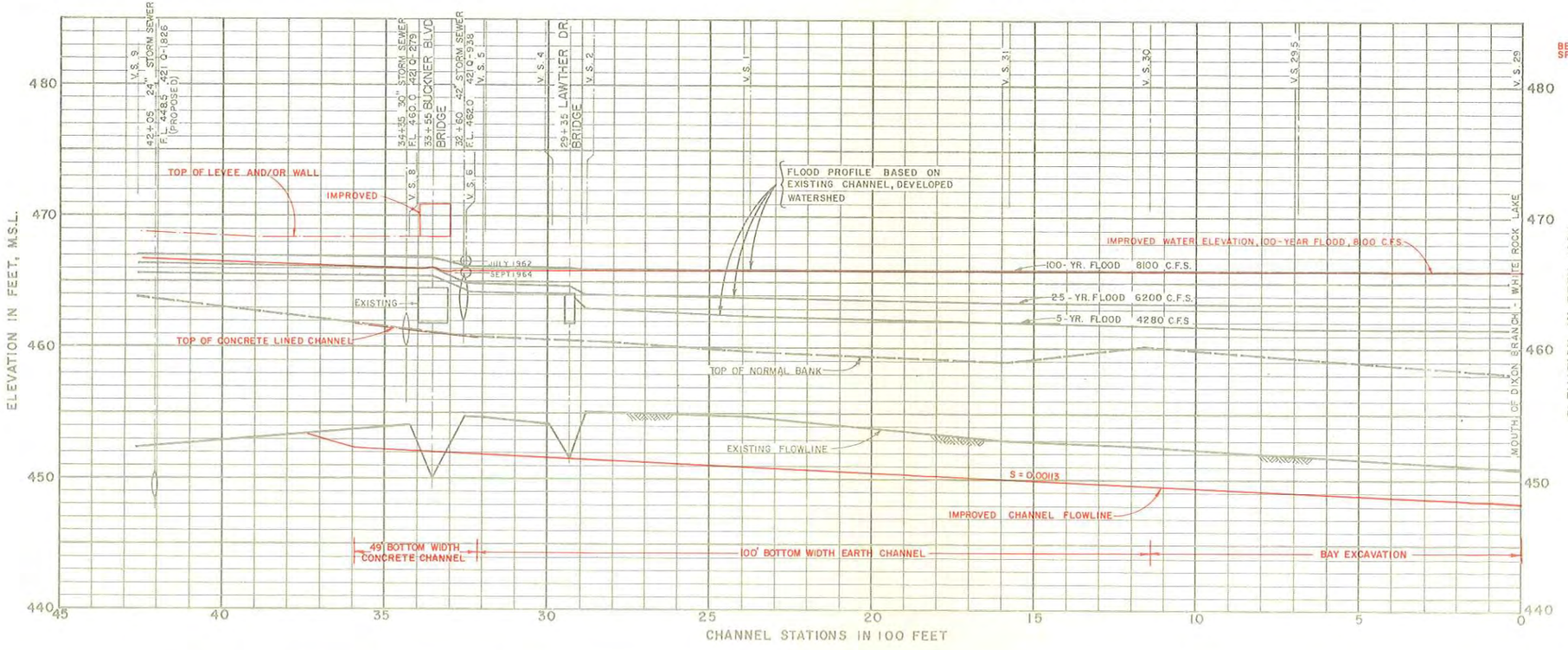
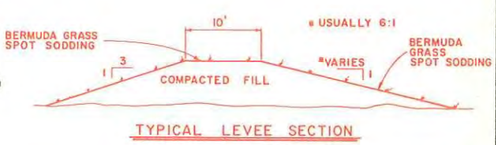
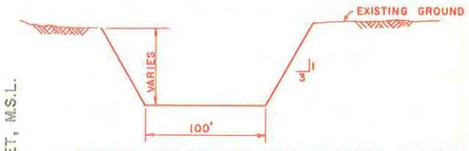


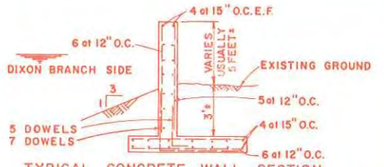




TYPICAL LEVEE SECTION



TYPICAL SECTION IMPROVED EARTHEN CHANNEL



TYPICAL CONCRETE WALL SECTION

WHITE ROCK LAKE PARK STUDIES			
DIXON BRANCH IMPROVEMENT PLAN & CHANNEL PROFILES			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
FORREST AND COTTON, INC. CONSULTING ENGINEERS DALLAS, TEXAS			
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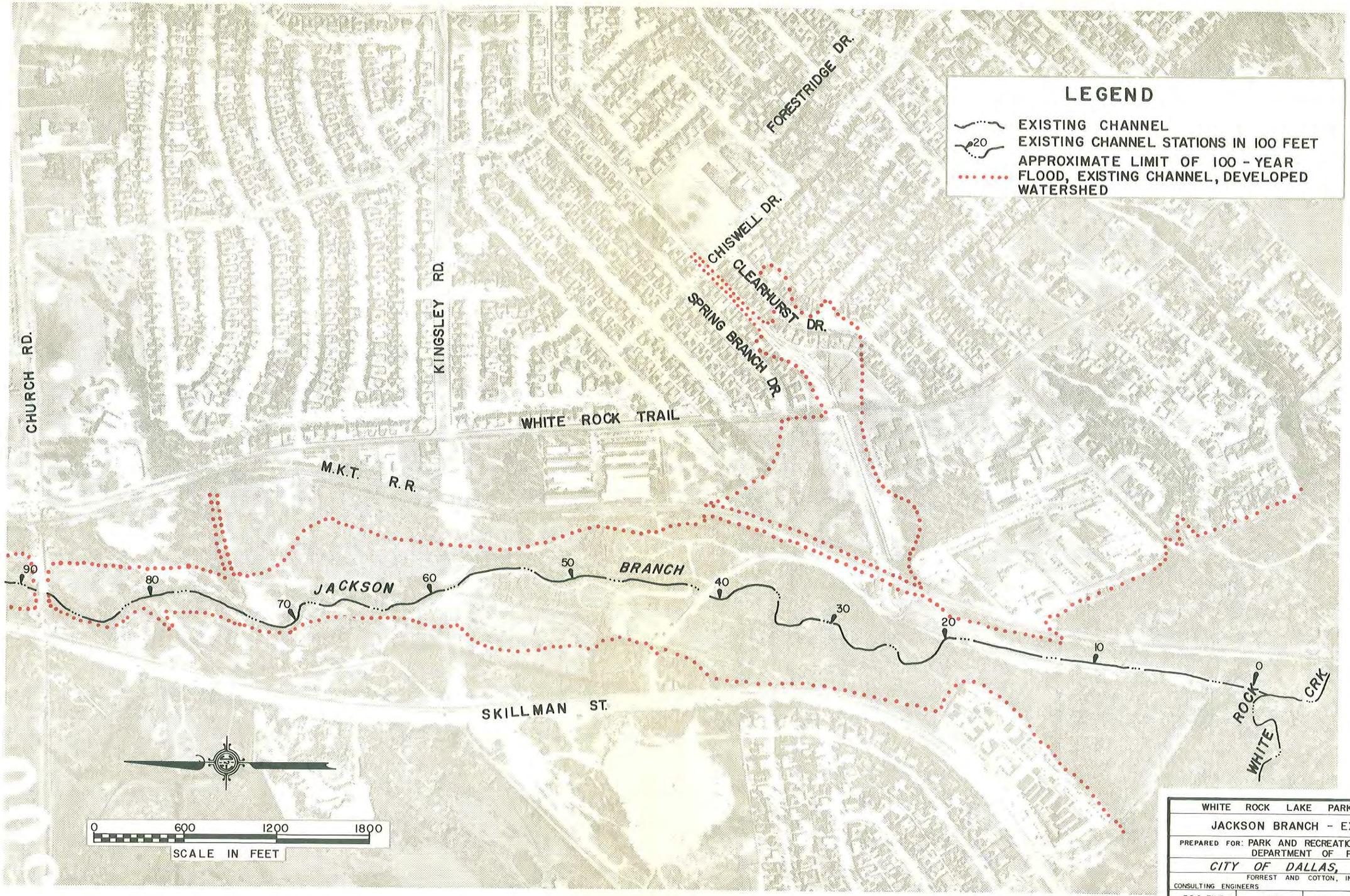

WHITE ROCK LAKE PARK STUDIES			
JACKSON BRANCH - EXISTING			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
CONSULTING ENGINEERS: FORREST AND COTTON, INC. DALLAS, TEXAS			
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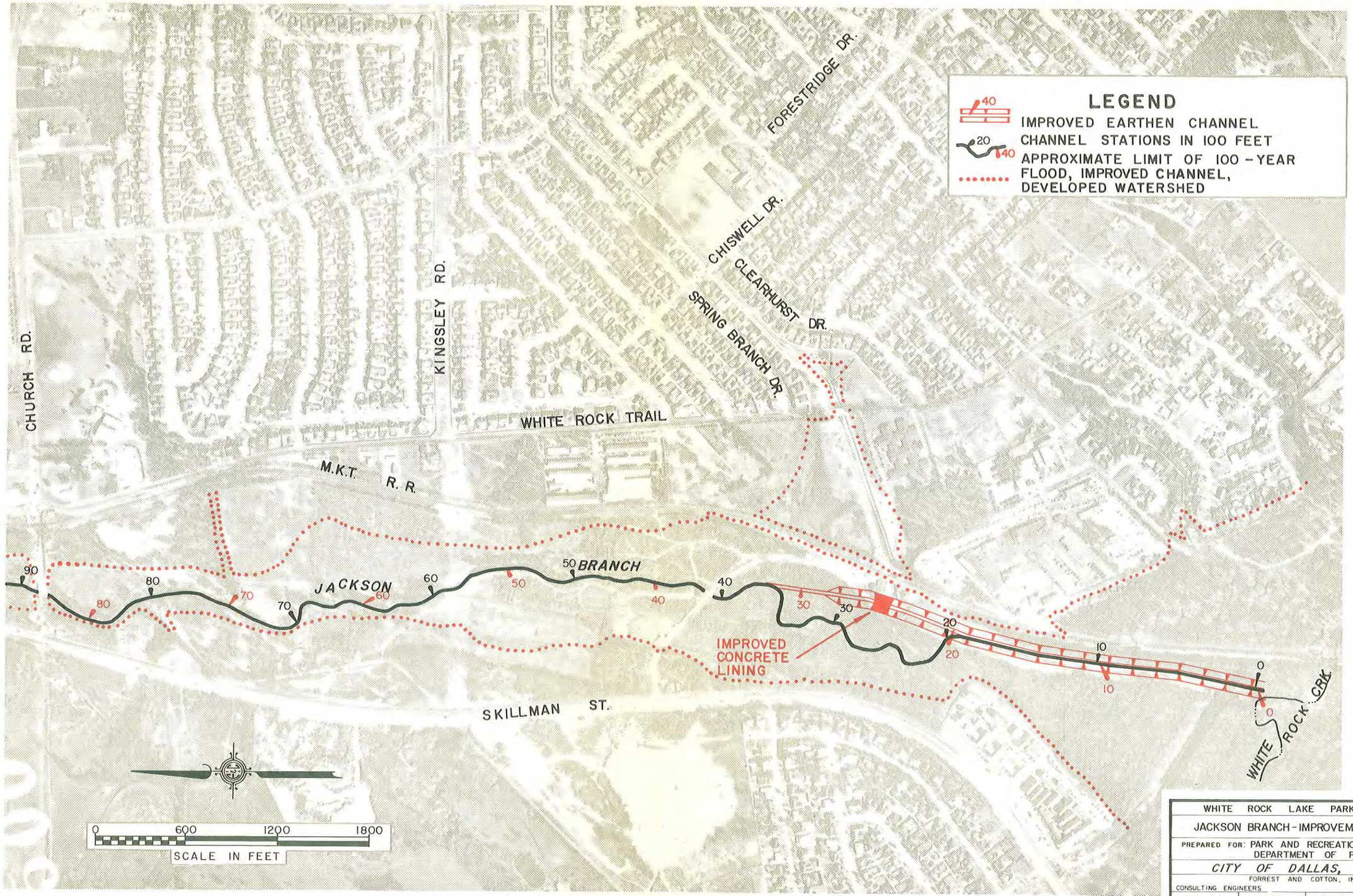

WHITE ROCK LAKE PARK STUDIES			
JACKSON BRANCH - IMPROVEMENT PLAN			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
CONSULTING ENGINEERS FORREST AND COTTON, INC.			DALLAS, TEXAS
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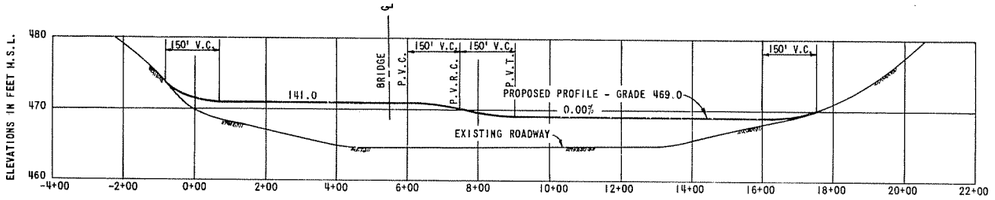
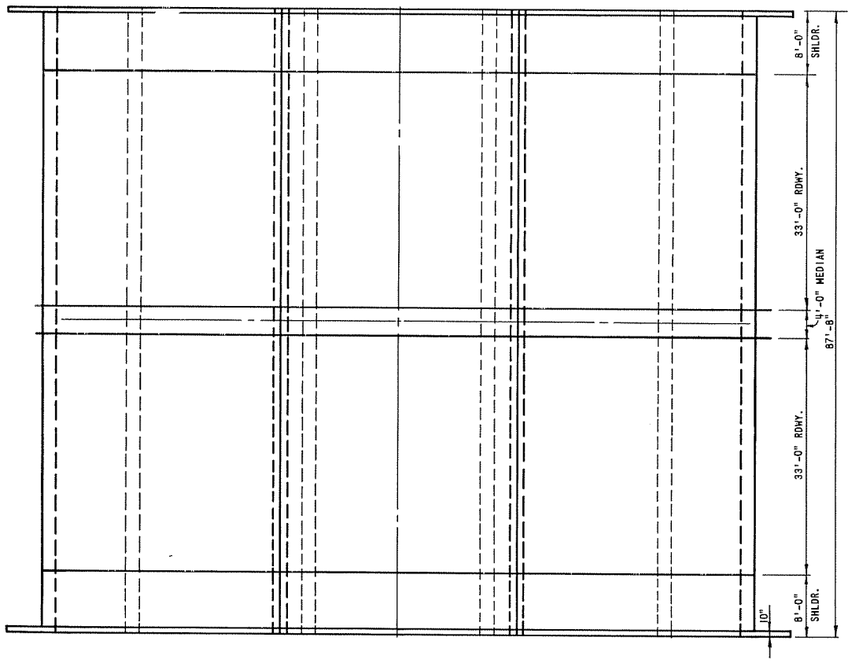


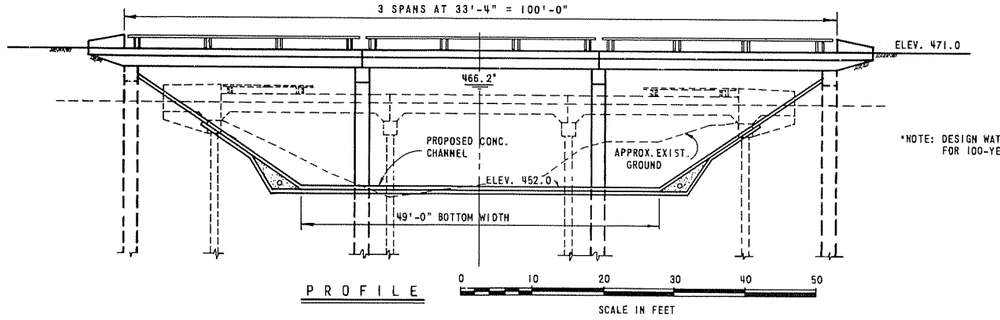
PROFILE - BUCKNER BLVD.



PLAN

0 10 20 30 40 50

SCALE IN FEET



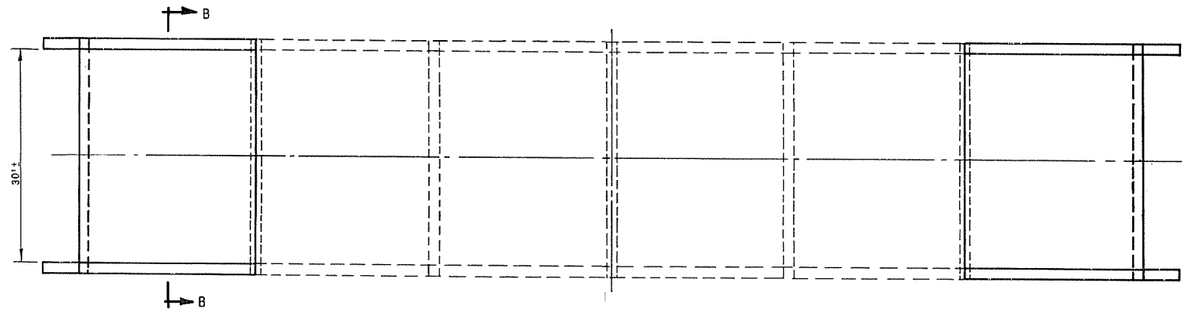
*NOTE: DESIGN WATER SURFACE ELEVATION FOR 100-YEAR FLOOD, 8100 C.F.S.

PROFILE

0 10 20 30 40 50

SCALE IN FEET

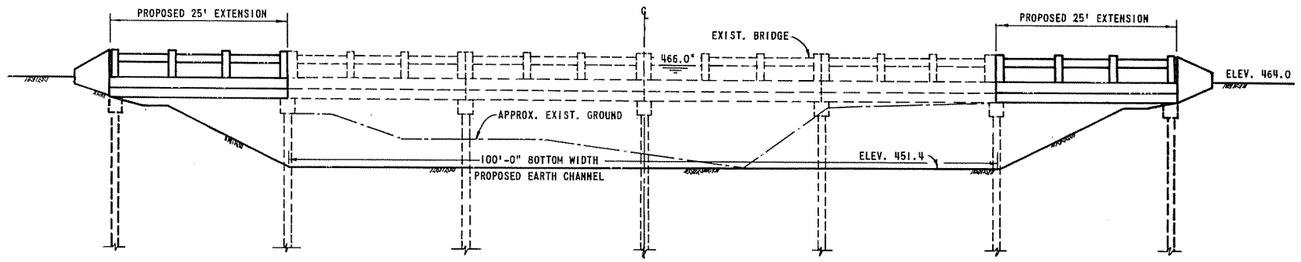
BUCKNER BLVD. BRIDGE



PLAN

0 10 20 30 40 50

SCALE IN FEET

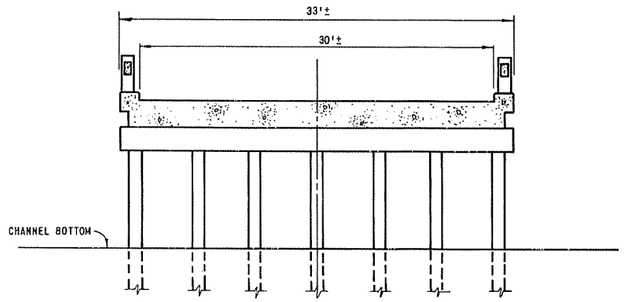


PROFILE

0 10 20 30 40 50

SCALE IN FEET

*NOTE: DESIGN WATER SURFACE ELEVATION FOR 100-YEAR FLOOD, 8100 C.F.S.



TYPICAL SECTION B-B

0 6 12 18 24 30

SCALE IN FEET

LAWTHER DR. BRIDGE

WHITE ROCK LAKE PARK STUDIES

BUCKNER BOULEVARD AND LAWTHER DRIVE BRIDGES AT DIXON BRANCH

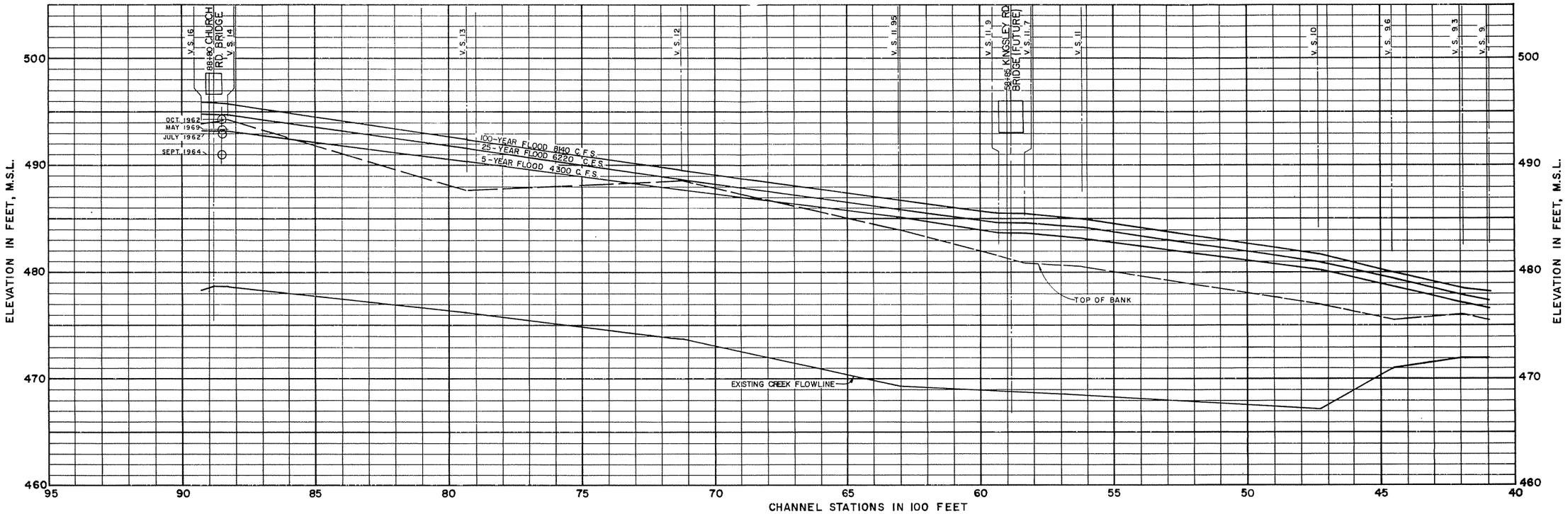
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

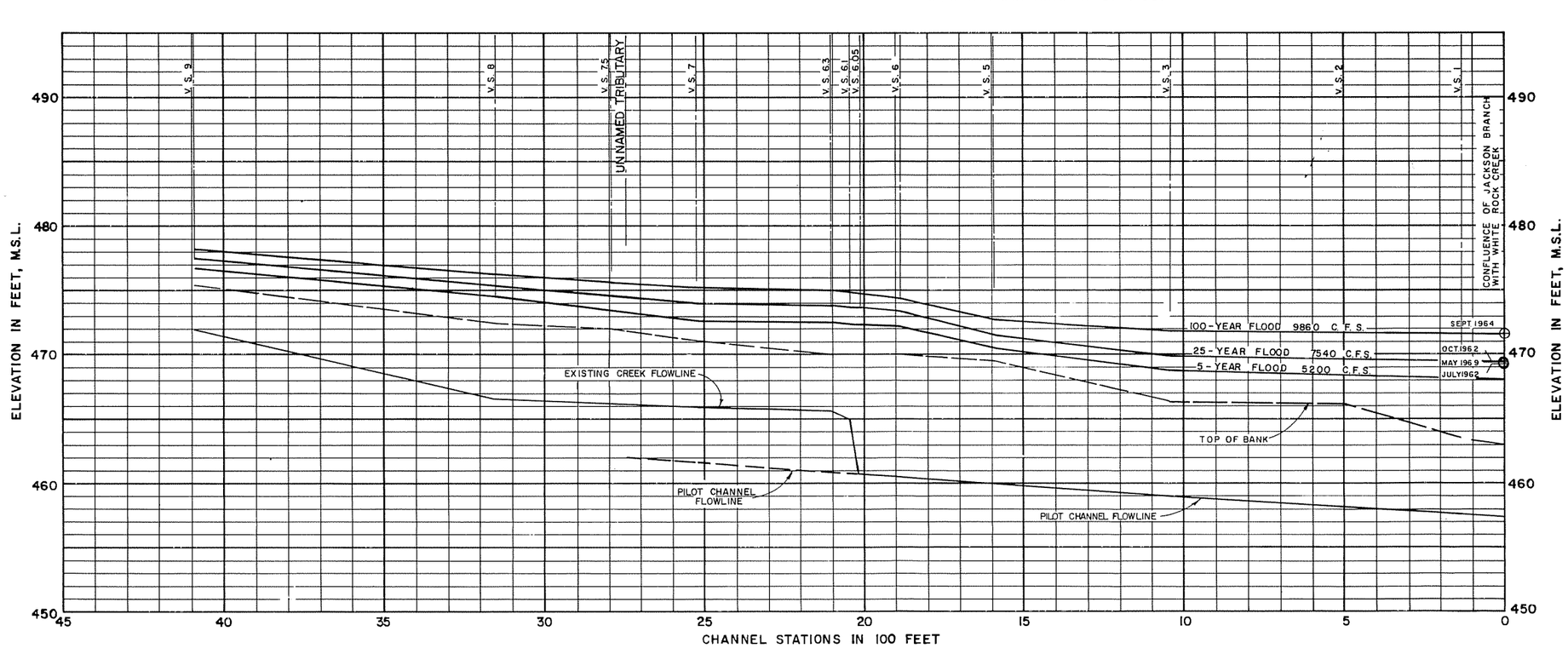
CITY OF DALLAS, TEXAS

FORREST AND COTTON, INC.

CONSULTING ENGINEERS DALLAS, TEXAS

F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-14	AUG. 1971		14





NOTE: FLOOD PROFILES ARE BASED ON EXISTING CHANNEL, DEVELOPED-WATERSHED

CHANNEL STATIONS APPLY TO NATURAL CHANNEL ABOVE STATION 20+00

FLOW CHANGES AT STATION 27+50 DUE TO INFLOW FROM UNNAMED TRIBUTARY.

⊖ INDICATES RECORDED HIGH WATER MARK

WHITE ROCK LAKE PARK STUDIES

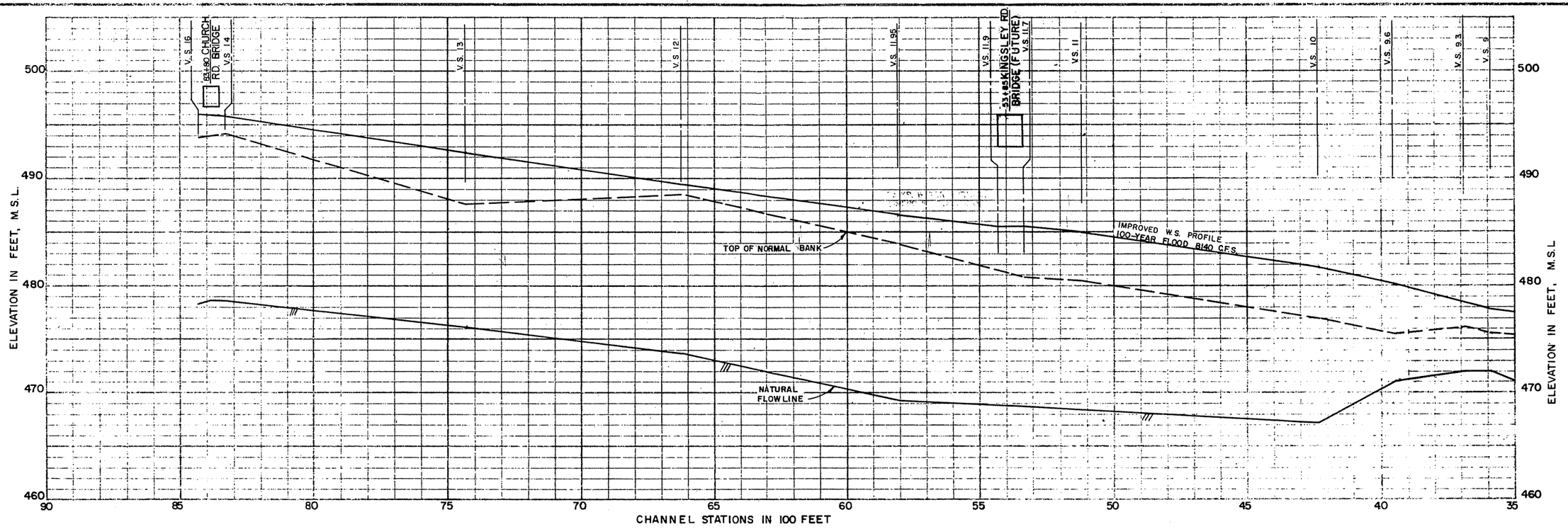
JACKSON BRANCH
EXISTING CHANNEL PROFILES

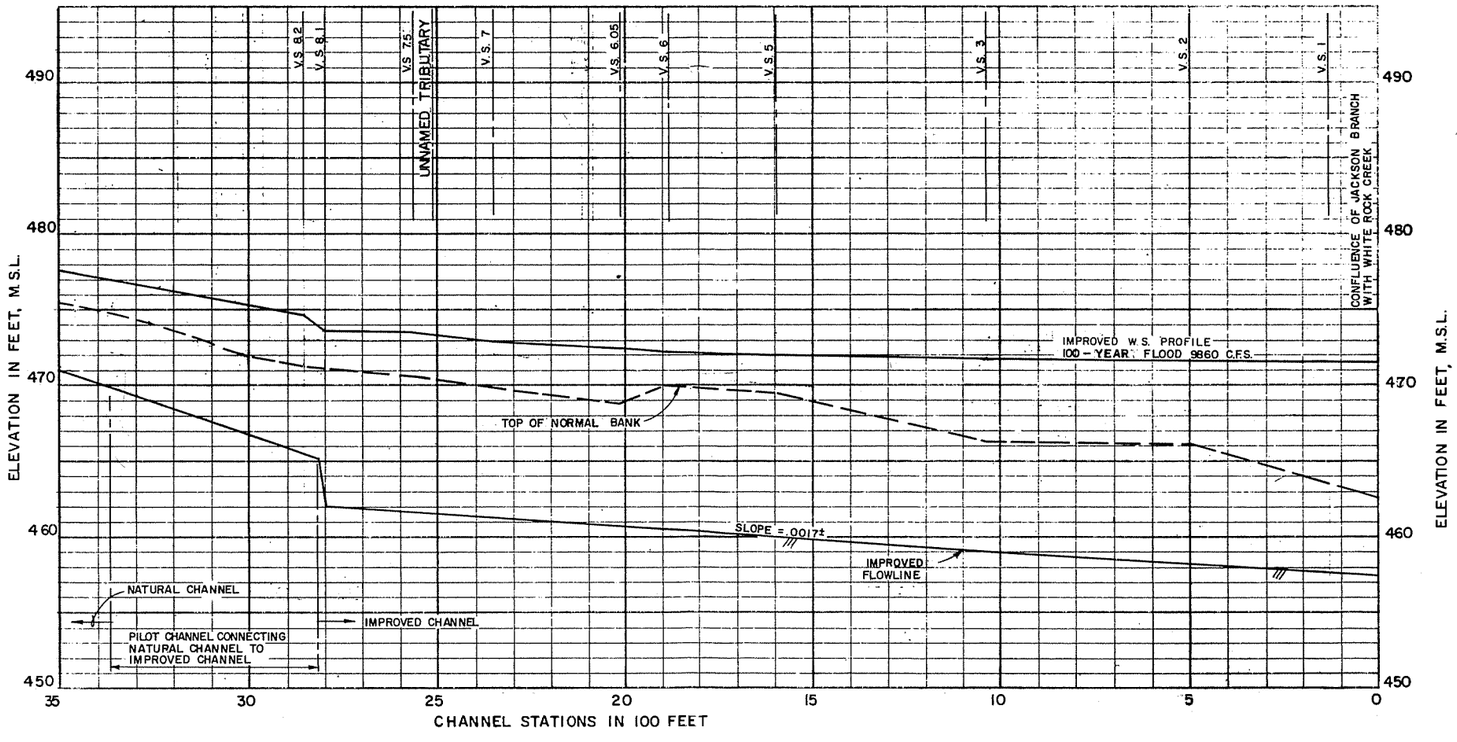
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

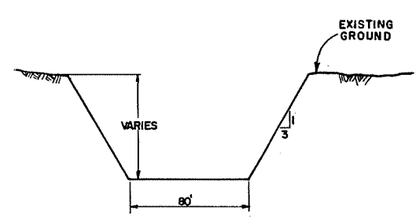
CITY OF DALLAS, TEXAS

FORREST AND COTTON, INC
CONSULTING ENGINEERS — DALLAS, TEXAS

F&C FILE	DATE	CITY FILE	PLATE NO
427-03-16	AUG. 1971		16







TYPICAL SECTION
IMPROVED CHANNEL
N.T.S.

NOTES: CHANNEL STATIONING BASED ON IMPROVED CHANNEL

FLOW CHANGES AT STATION 25+10 DUE TO INFLOW FROM UNNAMED TRIBUTARY.

WHITE ROCK LAKE PARK STUDIES

JACKSON BRANCH
IMPROVED CHANNEL PROFILES

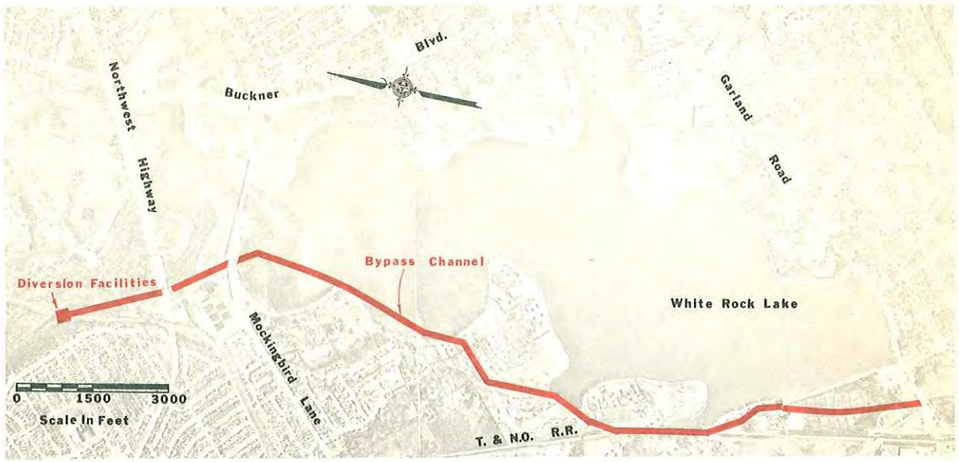
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

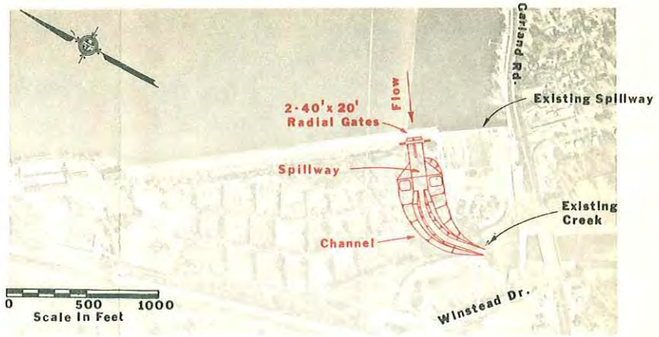
CONSULTING ENGINEERS: FORREST AND COTTON, INC., DALLAS, TEXAS

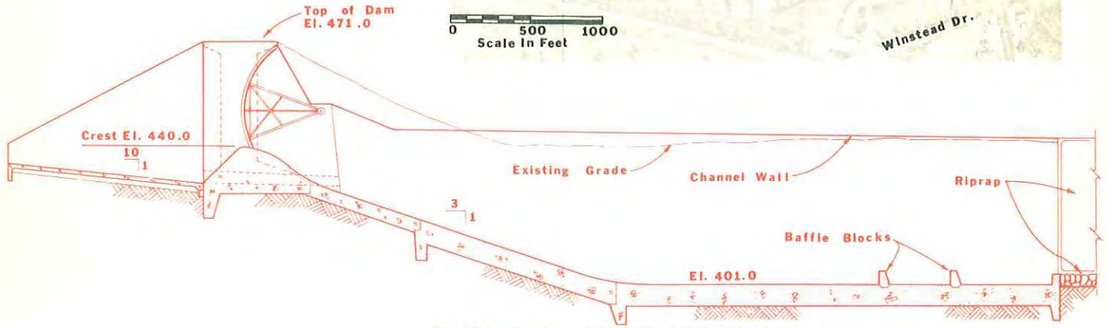
F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-18	AUG. 1971		18

Typical Channel Section

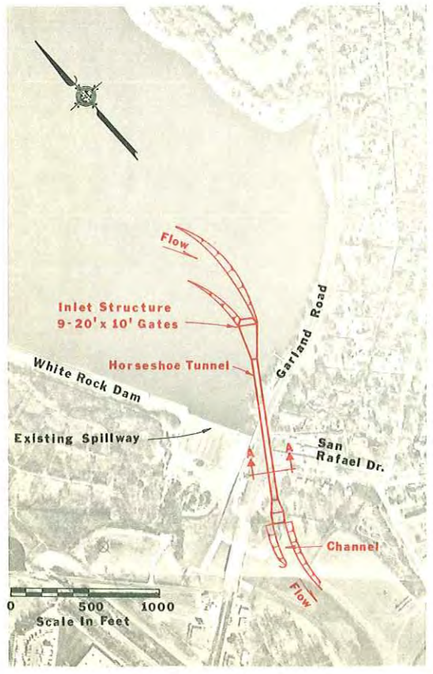


METHOD·1 BYPASS CHANNEL

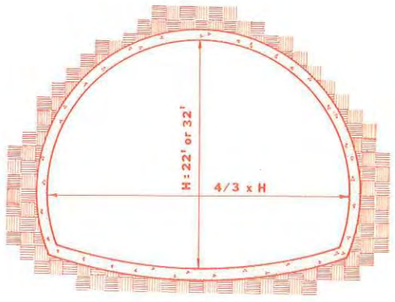




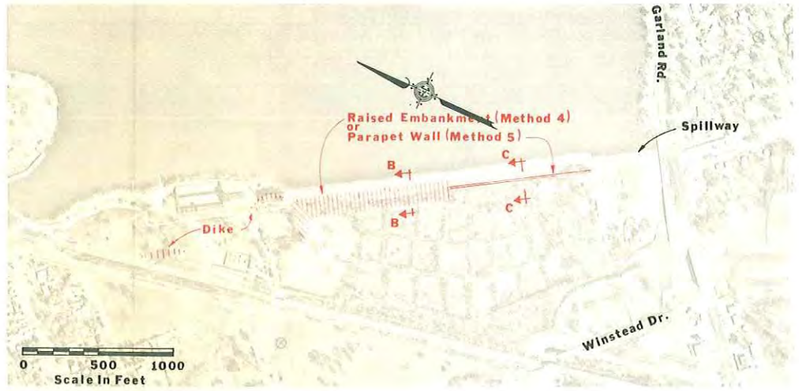
METHOD·3 GATED SPILLWAY

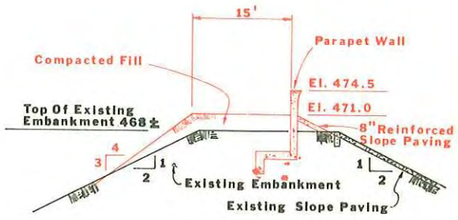


METHOD·2 TUNNEL UNDER GARLAND ROAD



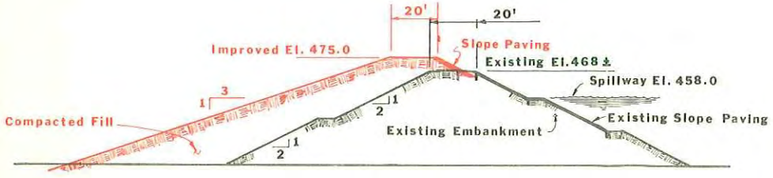
SECTION A-A





SECTION C-C

METHOD·5 PARAPET WALL

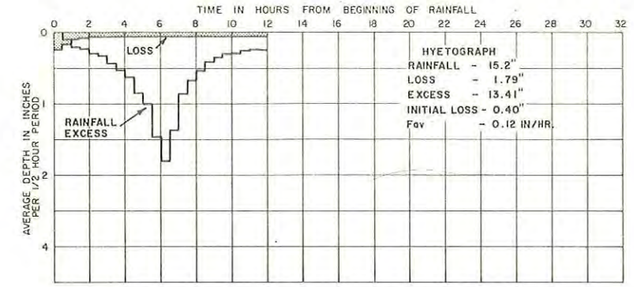


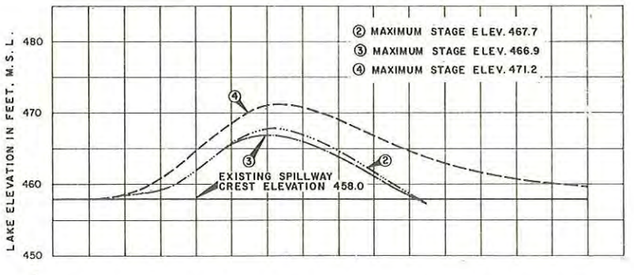
SECTION B-B

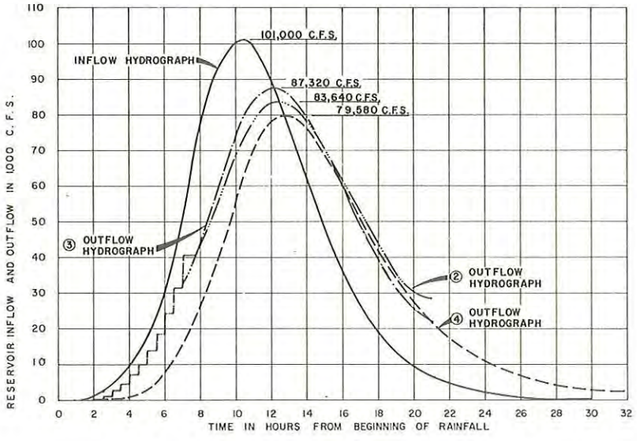
METHOD·4 RAISING WHITE ROCK DAM

NOTE: Data shown in red indicates proposed improvements under the various methods.

WHITE ROCK LAKE PARK STUDIES			
MODIFICATIONS CONSIDERED TO DAM AND SPILLWAY			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
FORREST AND COTTON, INC. CONSULTING ENGINEERS			DALLAS, TEXAS
F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-19	AUG. 1971		19







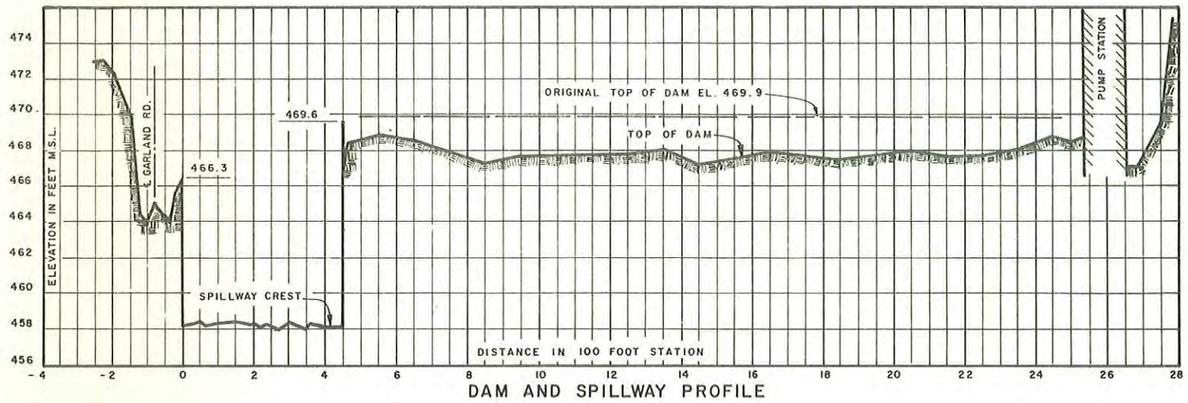
STANDARD PROJECT FLOOD
HYETOGRAPH
LAKE STAGE GRAPH
INFLOW AND OUTFLOW HYDROGRAPHS

ALTERNATES

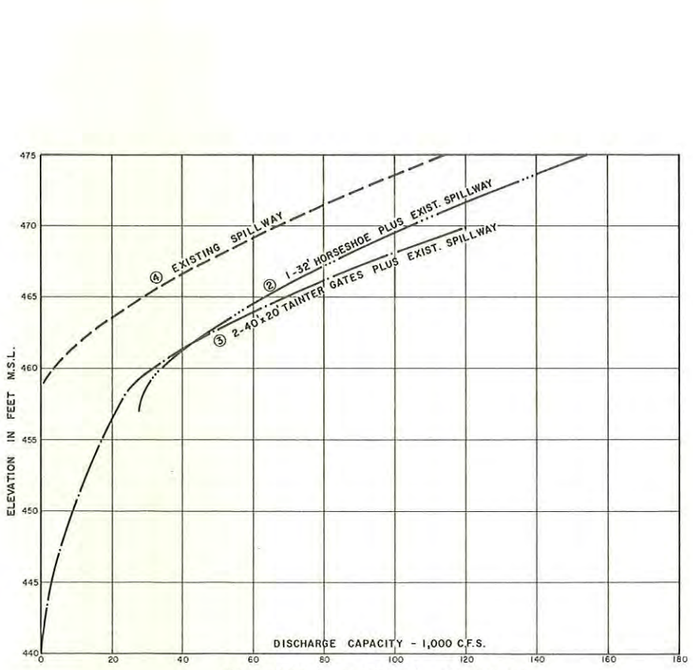
② ONE 32' MODIFIED HORSESHOE PLUS EXISTING 450' SPILLWAY

③ TWO 40'x20' TAINTER GATES, CREST ELEV. 440.0 PLUS EXISTING 450' SPILLWAY

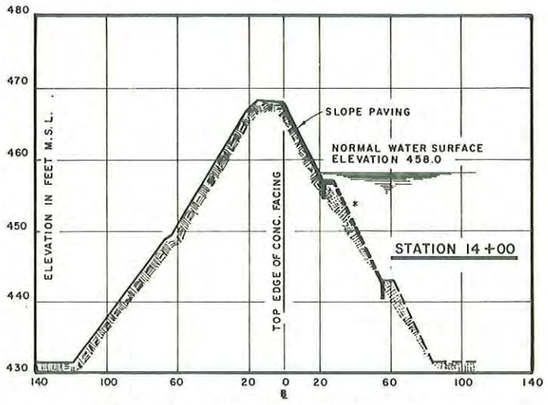
④ EXISTING 450' SPILLWAY, CREST ELEV. 458.0



DAM AND SPILLWAY PROFILE



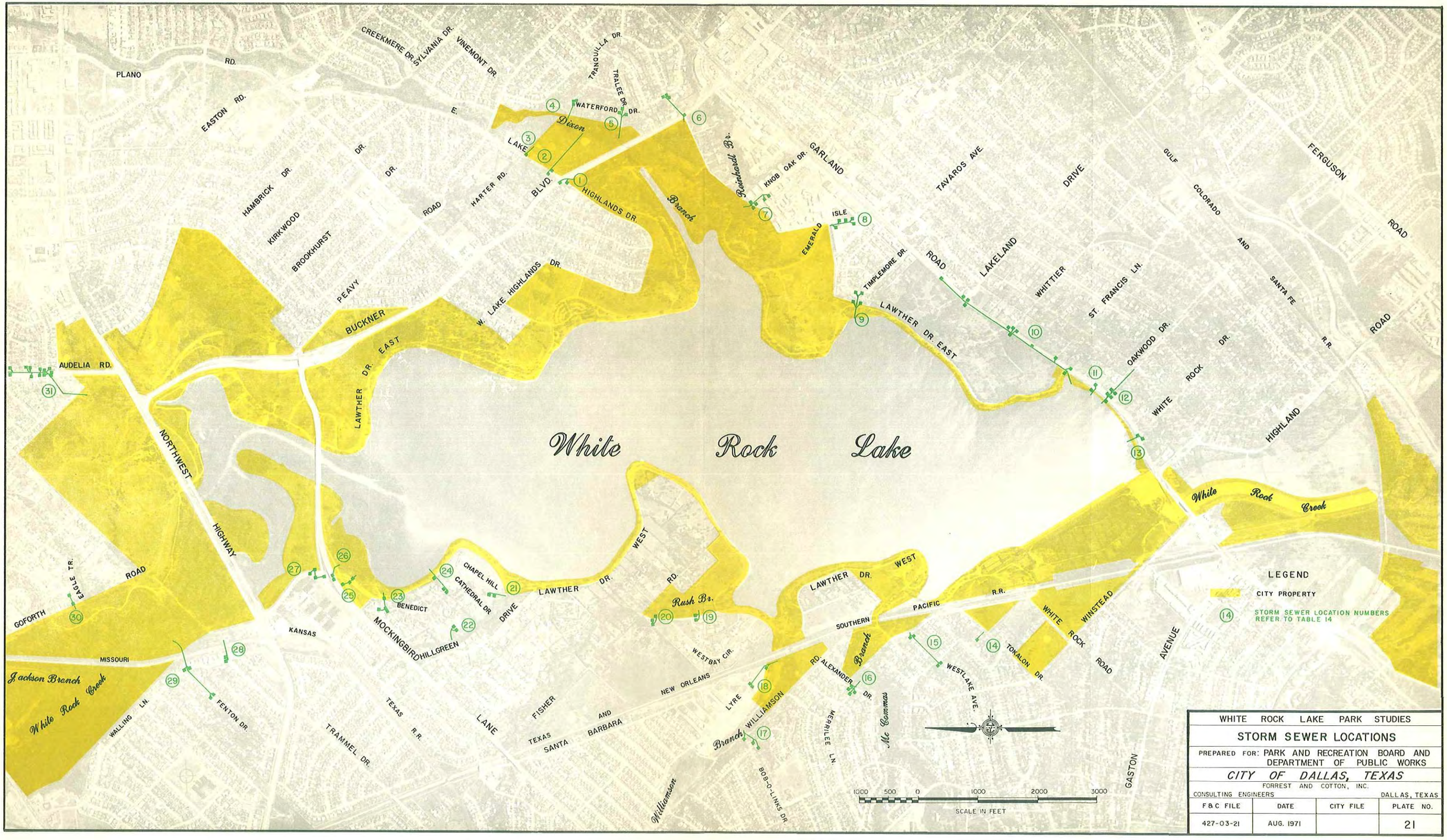
SPILLWAY RATING CURVES



TYPICAL SURVEYED SECTION OF EXISTING DAM

*NOTE: AREA BELOW WATER SURFACE NOT SURVEYED.

WHITE ROCK LAKE PARK STUDIES			
HYDROLOGIC EXHIBITS, DAM AND SPILLWAY			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
FORREST AND COTTON, INC.			
CONSULTING ENGINEERS			DALLAS, TEXAS
F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-20	AUG. 1971		20



WHITE ROCK LAKE PARK STUDIES

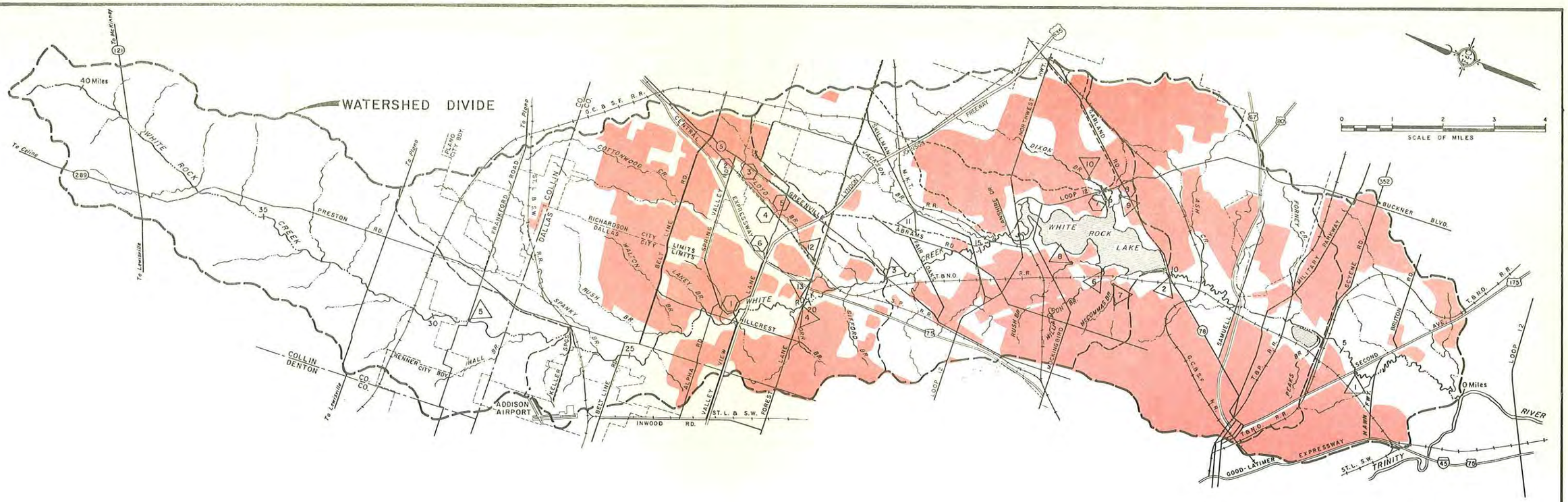
STORM SEWER LOCATIONS

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

FORREST AND COTTON, INC.
CONSULTING ENGINEERS — DALLAS, TEXAS

F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-21	AUG. 1971		21



WATER QUALITY SAMPLING STATIONS

STATION NUMBER	LOCATION
1	WHITE ROCK CREEK AT HAWN FREEWAY
2	WHITE ROCK CREEK AT GARLAND ROAD
3	WHITE ROCK CREEK AT GREENVILLE AVE.
4	WHITE ROCK CREEK AT FOREST LANE
5	WHITE ROCK CREEK AT FRANKFORD RD.
6	WILLIAMSON BRANCH AT WILLIAMSON RD.
7	McCOMMAS BRANCH ABOVE W. LAWTHER DR.
8	RUSH BRANCH AT FISHER ROAD
9	REINHARDT BRANCH NEAR KNOB OAK DR.
10	DIXON BRANCH ABOVE PEAVY ROAD
11	JACKSON BRANCH AT SKILLMAN
12	FLOYD BRANCH AT FOREST LANE
13	COTTONWOOD CREEK AT FOREST LANE

KNOWN WASTE DISCHARGES

DISCHARGE NO.	DISCHARGER
1	LAMBERT LANDSCAPE COMPANY. INC.
2	REPUBLIC ALUMINUM COMPANY (REALCO)
3	CITY OF RICHARDSON. FLOYD BRANCH WASTEWATER TREATMENT PLANT
4	NATIONAL CYLINDER GAS COMPANY
5	RESTLAND MEMORIAL PARK
6	TEXAS INSTRUMENTS. INC.
7	DIXON BRANCH SEWAGE PUMP STATION
8	COLLINS-DENISON FORD. INC.

LEGEND

- WATER QUALITY SAMPLING STATION
- KNOWN WASTE DISCHARGE
- URBANIZED AREAS

WHITE ROCK LAKE PARK STUDIES

WATER QUALITY SAMPLING STATIONS AND WASTE DISCHARGES

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

CONSULTING ENGINEERS: FORREST AND COTTON, INC. DALLAS, TEXAS

F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-22	AUG. 1971		22

White Rock Lake

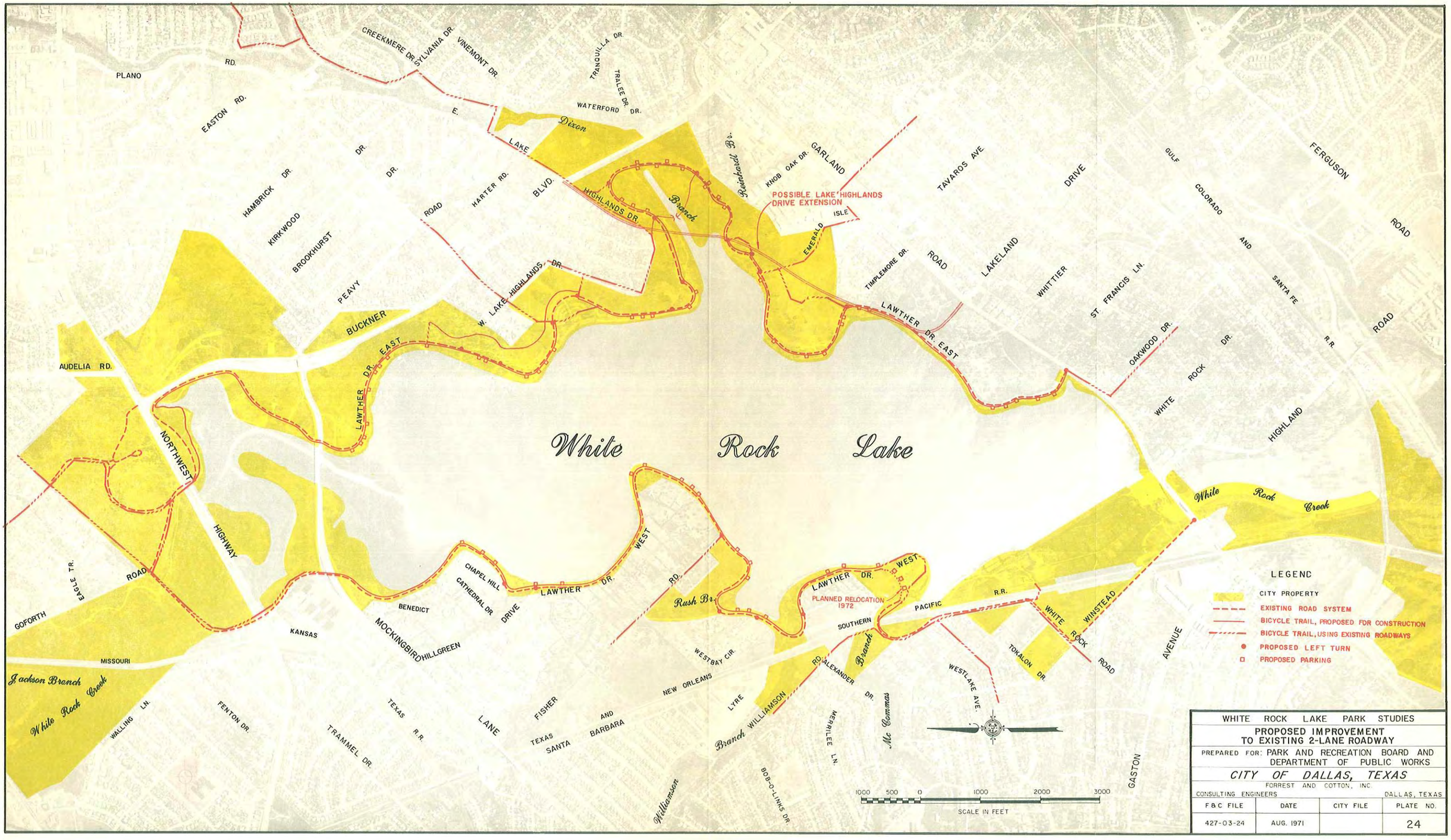
LEGEND
- PROPOSED RELIEF SEWER
- ALTERNATE RELIEF SEWER
- PROPOSED WATER LINES
- EXISTING WATER LINES
- EXISTING SAN. SEW. LINES

PLANO
EASTON RD.
HAMBRICK DR.
KIRKWOOD DR.
BROOKHURST DR.
PEAVY ROAD
BUCKNER BLVD.
AUDELIA RD.
NORTHWEST HIGHWAY
CREEKMERE DR.
SYLVANIA DR.
VINEMONT DR.
TRANQUILLA DR.
TRALEE DR.
WATERFORD DR.
LAKE HIGHLANDS DR.
W. LAKE HIGHLANDS DR.
HARTER RD.
LAWTHER DR. EAST
Dixon Branch
DIXON BRANCH PUMP STATION
Reinhardt Br.
FM 24"
FM 16"
KNOB OAK DR.
GARLAND ROAD
TAVAROS AVE
EMERALD ISLE
TIMPLEMORE DR.
LAWTHER DR. EAST
LAKELAND DRIVE
PROPOSED 16"w
PROPOSED 30"w
WHITTIER
ST. FRANCIS LN.
GULF COLORADO AND SANTA FE R.R.
FERGUSON ROAD
OAKWOOD DR.
WHITE ROCK DR.
HIGHLAND ROAD
ALTERNATE ALIGNMENT WHITE ROCK RELIEF SEWER
POINT-A
POINT-B
PROPOSED STORMWATER POLLUTION CONTROL STATION
WHITE ROCK PUMP STATION STANDBY BOOSTER
PROPOSED 30"w
White Rock Creek
54"
CITY PROPERTY
WINSTEAD AVENUE
WHITE ROCK ROAD
TOKALON DR.
WESTLAKE AVE.
PACIFIC R.R.
SOUTHERN
LAWTHER DR. WEST
CHAPEL HILL CATHEDRAL DR.
DRIVE
BENEDICT
MOCKINGBIRD LANE
HILLGREEN
66" PROPOSED WHITE ROCK RELIEF SEWER
66" EXISTING WHITE ROCK TRUNK SEWER
WESTBAY CIR.
NEW ORLEANS
LYRE
ALEXANDER RD.
Brands Br.
McCommas Br.
Williamson Branch
MERRILEE LN.
BOB-O-LINKS DR.
GASTON
RUSH Br.
TEXAS AND SANTA BARBARA R.R.
FISHER
TRAMMEL DR.
FENTON DR.
WALLING LN.
EAGLE TR.
GOFORTH ROAD
HIGHWAY
KANSAS
MISSOURI
Jackson Branch
White Rock Creek

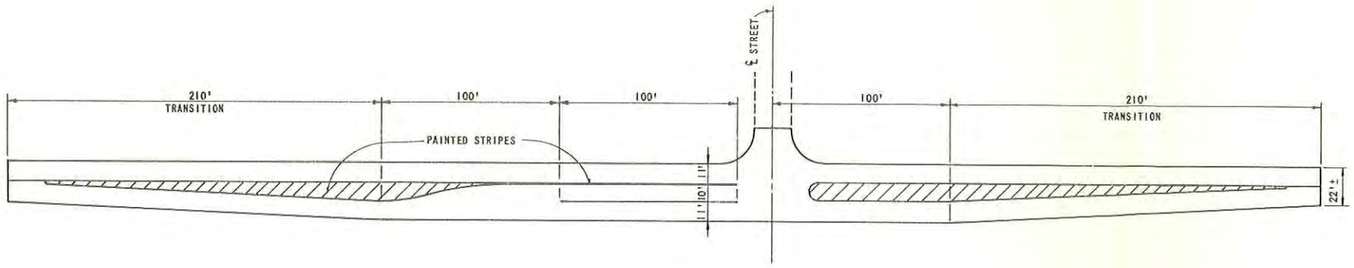
SCALE IN FEET: 1000 500 0 1000 2000 3000

WHITE ROCK LAKE PARK STUDIES	
SANITARY SEWERS AND WATER LINES	
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS	
CITY OF DALLAS, TEXAS	
CONSULTING ENGINEERS: FORREST AND COTTON, INC.	DALLAS, TEXAS

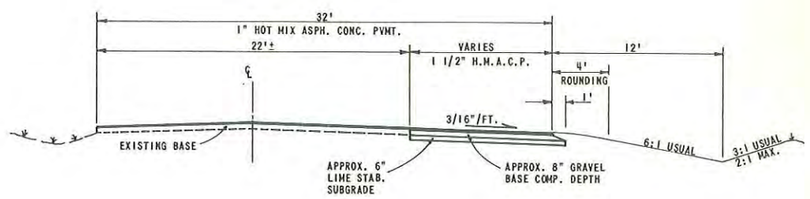
F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-23	AUG. 1971		23



WHITE ROCK LAKE PARK STUDIES			
PROPOSED IMPROVEMENT TO EXISTING 2-LANE ROADWAY			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
FORREST AND COTTON, INC. CONSULTING ENGINEERS			DALLAS, TEXAS
F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-24	AUG. 1971		24

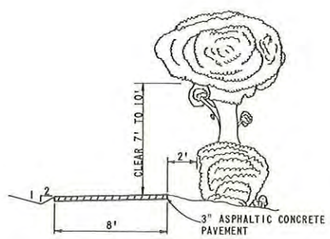


PLAN



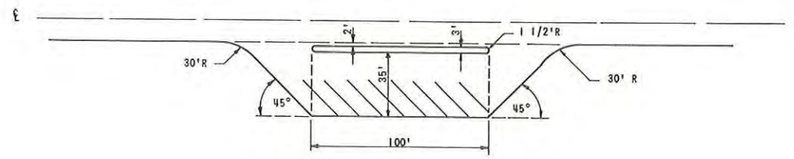
TYPICAL SECTION

EXISTING PAVEMENT WIDENING FOR LEFT TURN LANE

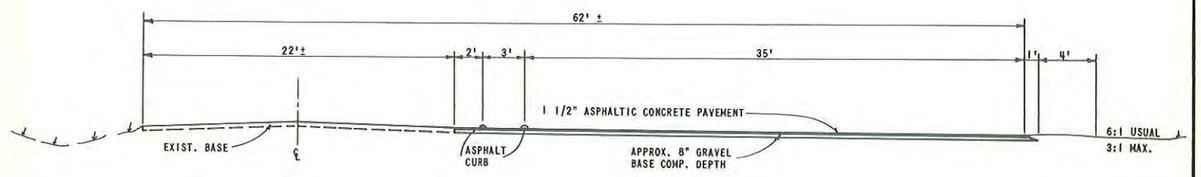


TYPICAL SECTION

BICYCLE TRAIL



PLAN



TYPICAL SECTION

OFF STREET PARKING

WHITE ROCK LAKE PARK STUDIES			
LEFT TURN LANE, PARKING, AND BICYCLE TRAIL DETAIL			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
CONSULTING ENGINEERS: FORREST AND COTTON, INC. DALLAS, TEXAS			
F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-25	AUG. 1971		25

White Rock Lake

PLANO RD.
EASTON RD.
CREEKMERE DR.
SYLVANIA DR.
VINEMONT DR.
TRANQUILLA DR.
TRALEE DR.
WATERFORD DR.
E. LAKE BLVD.
Dixon Branch
Reinhardt Br.
KNOB OAK DR.
GARLAND ROAD
TAVAROS AVE
GULF COLORADO AND SANTA FE R.R.
FERGUSON ROAD
HAMBRICK DR.
KIRKWOOD DR.
BROOKHURST DR.
HARTER ROAD
HIGHLANDS DR.
EMERALD ISLE
TIMPLEMORE DR.
LAKELAND DRIVE
WHITTIER ROAD
ST. FRANCIS LN.
PEAVY BUCKNER
W. LAKE HIGHLANDS DR.
LAWTHER DR. EAST
OAKWOOD DR.
WHITE ROCK DR.
HIGHLAND ROAD
AUDELIA RD.
NORTHWEST HIGHWAY
White Rock Creek
EAGLE TR. ROAD
GOFORTH
MISSOURI
KANSAS
BENEDICT
MOCKINGBIRD HILLGREEN
CHAPEL HILL CATHEDRAL DR.
DRIVE
LAWTHER DR. WEST
RD.
Rush Br.
LAWTHER DR. WEST
SOUTHERN PACIFIC R.R.
WHITE ROCK ROAD
WINSTEAD AVENUE
TOKALON DR.
WESTLAKE AVE.
WESTBAY CIR
NEW ORLEANS
LYRE
ALEXANDER RD.
Brand
WILLIAMSON
Branch
MERRILEE LN.
Mc Commas DR.
GASTON
Jackson Branch
White Rock Creek
WALLING LN.
FENTON DR.
TRAMMEL DR.
TEXAS R.R.
LANE
FISHER
TEXAS SANTA AND BARBARA
Williamson
BOB-O-LINKS DR.

LEGEND

- CITY PROPERTY
- 4-LANE UNDIVIDED
- 4-LANE DIVIDED
- LEFT TURN
- PARKING
- BICYCLE TRAIL, PROPOSED FOR CONSTRUCTION
- BICYCLE TRAIL, USING EXISTING ROADWAYS

NOTE: ALTERNATE PLAN OF ROADWAY IMPROVEMENT SHOWN IN RED

1000 500 0 1000 2000 3000
SCALE IN FEET

WHITE ROCK LAKE PARK STUDIES

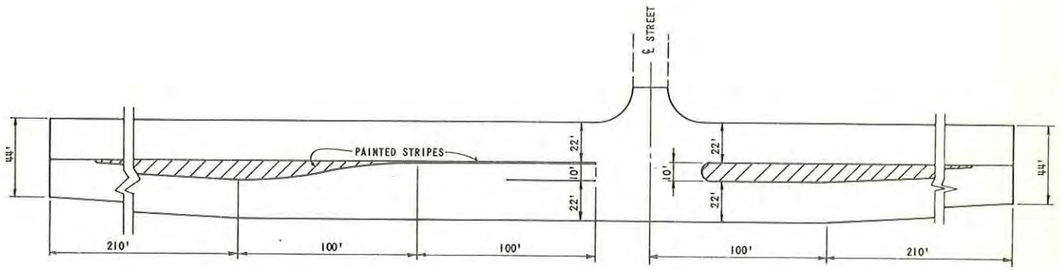
ALTERNATE PLAN OF IMPROVEMENT, 4-LANE ROADWAY

PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS

CITY OF DALLAS, TEXAS

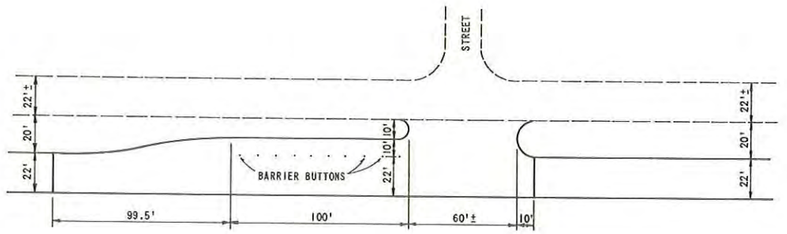
FORREST AND COTTON, INC.
CONSULTING ENGINEERS — DALLAS, TEXAS

F&C FILE	DATE	CITY FILE	PLATE NO.
427-03-26	AUG. 1971		26



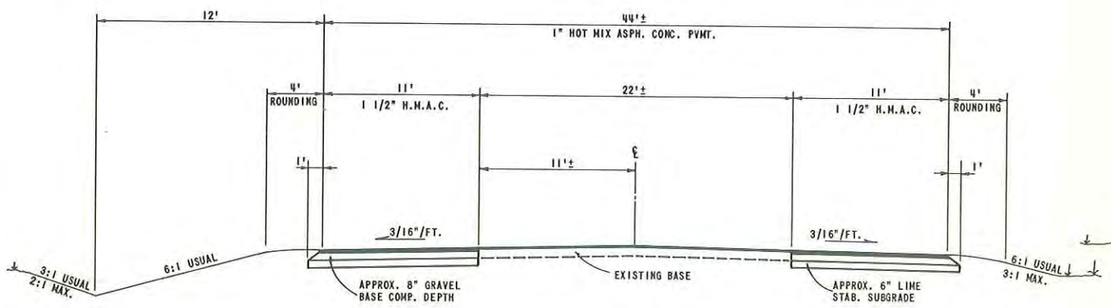
PLAN

LEFT TURN LANE



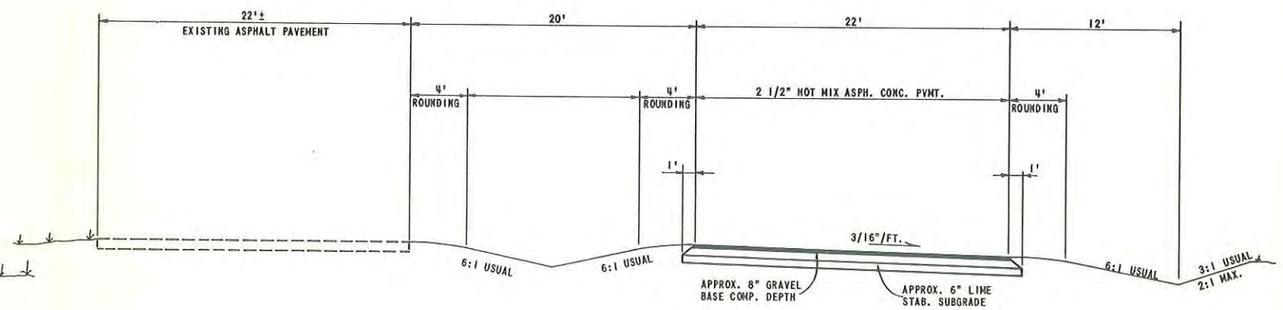
PLAN

LEFT TURN LANE



TYPICAL SECTION

WIDENING BOTH SIDES - 4 LANE UNDIVIDED



TYPICAL SECTION

CONSTRUCTION 2 LANES SEPARATE FROM EXISTING

WHITE ROCK LAKE PARK STUDIES			
4-LANE ROADWAY DETAILS			
PREPARED FOR: PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS			
CITY OF DALLAS, TEXAS			
CONSULTING ENGINEERS: FORREST AND COTTON, INC.			DALLAS, TEXAS
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REPORT ON

INVESTIGATIONS FOR IMPROVEMENT

PROGRAM FOR WHITE ROCK LAKE PARK

APPENDIX A

Ecological Study of White Rock Lake
by Institute for Environmental Studies

APPENDIX A

ECOLOGICAL STUDY OF

WHITE ROCK LAKE

By

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March 5, 1971

APPENDIX A

ECOLOGICAL STUDY OF WHITE ROCK LAKE

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ECOLOGICAL STUDY OF WHITE ROCK LAKE

I - INTRODUCTION

GENERAL

The White Rock Lake study was begun on February 5 in order to complete a survey that would result in ecological data that will be used for recommendations concerning dredging of the lake area. In order to obtain a complete picture of the situation in White Rock Lake it was necessary that a hydrographic survey be accomplished with accurate plotting of contours so that the areas of greatest siltation could be determined. Next, it was felt by our group that at least ten sampling stations should be established on the lake, including those areas that are relatively deep and biologically stable and the others that are questionable as regards their present ecological condition.

As soon as the hydrographic map with contours was completed, samples were taken at ten different stations with concentration in the region of Dixon's Branch and White Rock Creek. Comparative samples were also taken at other stations so as to obtain information concerning any ecological differences. Complete water analyses were performed as well as detailed studies of the sediment which was necessary in order to predict the effects of dredging on lake ecology.

Fisheries analyses including the study of resident fish populations, age, growth, condition and balance were made in the survey, as well as a detailed benthos analysis. A member of our group who is a swamp ecologist made studies of the aquatic vascular plants and shore ecology including the resident vertebrates.

The report includes various parameters that were taken into consideration in this ecological investigation. In each instance the methods employed are described, the results are presented in tabular and graphic form, and some discussion of the findings is included in each section of the report.

It is the purpose of this report to answer the questions that were posed by Forrest and Cotton, Inc., in their communication of December 29, 1970. The answers will be based on the ecological findings and comments will be made concerning the decisions that must

be made by the engineers who are in charge of the dredging procedures. While it is obvious that various conclusions may be drawn from ecological surveys, it is the feeling of our group that we have carefully scrutinized all parameters that we could study in the time available. Consequently we have entered the consensus of opinion of our group regarding the effects of dredging on White Rock Lake, the deposition of the dredge materials and other items that will be useful to the engineers.

II - HYDROGRAPHIC SURVEY, LAKE SAMPLING AND ANALYSIS

METHODS

Hydrographic

In order to obtain a more comprehensive picture of bottom contours and sedimentation patterns, a number of strategically located transects were run. Bottom depths were monitored with a Heath Kit depth sounder and locations computed from compass bearings on fixed points and trigonometric functions. Depth measurements were also made at each sampling station.

Physical and Chemical Analyses

Sediment samples were collected with a Ponar dredge at each sampling station. These were refrigerated upon return to the laboratory in order to retard biological activity prior to analysis. Water samples were collected by Kemmerer bottle at each station. A large sample (5 gallons) was collected from the surface at station 3 to use in determinations requiring large quantities of lake water.

Field analyses included dissolved oxygen, temperature, and alkalinity. These were run following standard procedures. A Rustrak recording DO and temperature meter was employed in determining temperature and DO profiles at the deeper stations.

Immediately upon return to the laboratory, water samples were analyzed for pH, total hardness and specific conductance. These three determinations were made following standard methods (A.P.H.A., 1965).

Chemical analyses of the water and sediment included phosphorous, nitrates, iron, manganese, and inorganic and organic carbon. Phosphorous was determined by the modified orthophosphate test of Edwards, Molof, and Schneeman (1965). Iron was determined by the ferrozine reagent method (Stookey, 1970). Nitrates and manganese were determined by the phenodisulfonic acid and periodate oxidation methods respectively (A.P.H.A., 1965). Inorganic and organic carbon were measured with a Beckman carbon

analyzer. Intense UV photocombustion was employed to facilitate total phosphorous, iron, and manganese determinations of the water and sediment (Strickland and Parsons, 1968; Henriksen, 1970).

Turbidity generation and settling time were determined by placing one cm^3 of sediment from each of the sampling stations into 200 ml of lakewater in 250 ml Erlenmeyer flasks. The flasks were then stoppered and shaken. Initial turbidity measurements (Klett - Summerson Colorimeter) were made on the lakewater alone and the well-shaken lakewater and sediment samples. The samples were allowed to settle and turbidity measurements made again at 24 and 72 hours.

Biological Analysis

Biological analyses included sediment oxygen demand, plankton identification and enumeration, and a potential algal growth assay.

Sediment oxygen demand was determined by placing 1 cm^3 of fresh sediment from each of the ten sampling stations into 300 ml BOD bottles. The bottles were then filled with lakewater and an initial DO determination was made (Weston Oxygen Analyzer with BOD probe). Measurements were made periodically thereafter. The bottles were incubated in darkness at 20 degrees Centigrade during the test.

The plankton analysis was conducted by concentrating the plankton in 250 ml of lakewater to 25 ml by centrifugation followed by identification and enumeration with a haemocytometer.

The potential algal growth assay was conducted by inoculating filtered samples of lakewater and lakewater-sediment mixtures with *Selenastrum* (a common green alga) and *Microcystis* (a common blue-green alga). The cultures were then incubated at 24 degrees Centigrade and 300 foot-candles illumination on a shaker for five days. At the end of this period, algal growth was measured turbidimetrically with a Klett-Summerson colorimeter.

RESULTS AND DISCUSSION

General

Results of the depth transects and station depth measurements have been combined and are presented as an estimation of the lake bottom morphology in Figure No. 1. Locations

of sampling stations (Figure No. 2) indicate that all major portions of the lake and the influences of its tributaries were adequately represented. It appears that the mid-regions of the lake are relatively flat with a gradual increase in depth from north to south. Expansive shallow "shelves" have been deposited in the areas of stations 6, 7 and 9 by White Rock Creek and Dixon Branch.

Sediment samples from stations 1, 2 and 3 were of high clay and organic content with the consistency of axle grease. Sediments from stations 4, 9, and 10 were similar to the lower stations but with a less greasy consistency. Station 6 sediment was comprised of a great deal of sand and allochthonous plant debris overlain with a thin layer of silt. (It is interesting that sediment samples analyzed by the Soil Conservation Service in 1956 were composed of no sand.) Sediment from station 5 was intermediate between stations 6 and 10. Sediments from stations 7 and 8 were primarily a gray clay, with station 7 being overlain with a fine layer of silt. None of the sediment samples offered strong odors.

Physio-Chemical Analysis

Results of the physio-chemical analyses of the sediments are presented in Table I. These data indicate that although the sediments are rich in potential nutrients, most of these ionic constitutents are firmly bound. Thus, the sediments evidently act as a nutrient *sink* for the lake. This is further exemplified by the results of the nutrient exchange analysis (Table II). Phosphates and nitrates were apparently adsorbed from the water by the sediments. Iron was initially released into the water by stirred sediments but after a period of time was readsorbed to original levels. Manganese behaved much as iron for the stations exhibiting manganese content.

The nutrient sink phenomena is further evidenced by the high nitrate and phosphate content of White Rock Creek water entering the lake (station 8) and the much lower content of the nutrients in lakewater. (Table III). This cannot be attributed entirely to dilution effects. It appears that although the White Rock Creek water is rich in algal nutrients, these nutrients are closely associated with the suspended solids either biologically or electrostatically. As these suspended particles settle out they carry the majority of nutrients entering White Rock Lake to the bottom.

Results of the turbidity generation and settling time of the sediments are presented in Table IV. These data indicate a rapid settling of disturbed sediments under reduced turbulence and clarification of the turbidity beyond that of the original lakewater within three days.

Biological Analysis

Sediment oxygen demand data further illustrate the high organic and inorganic nutrient content of the sediments. One and five-day BOD (biochemical oxygen demand) values are presented in Table V. The reason for the one-day BOD at station 1 being higher than the five-day BOD is in the method of calculation and the high initial uptake exemplified by that sediment (Figure No. 3). From the data presented in Figure Nos. 3, 4, and 5, a general trend in sediments from a more geologic origin to a more biologic origin from upper to lower reaches of the lake can be recognized.

Results of the potential algal growth assay indicate that a large increase in algae following dredging is unlikely. There was no significant increase in growth in the sediment exchange water as compared to the lakewater. This indication can be further substantiated with the nutrient exchange data presented earlier. In disturbing the sediments it appears there will be very little increase in soluble nutrients and subsequent increase in algal populations.

The plankton analysis of the lakewater samples shows a relatively good population density (Table VI). The low densities at stations 8 and 9 as compared to the other stations are indicative of phytoplankton of flowing water as compared to open lake phytoplankton. The sample from station 8 contained a large amount of clay particles which due to shading may have also limited the plankton population there. A listing of species of algae and relative abundance of each is given in Table VII. From the plankton analysis and the results of several of the previously mentioned investigations it appears unlikely that dredging operations will be detrimental to the algal community structure or productivity of the lake.

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WHITE ROCK LAKE
February 13, 1971

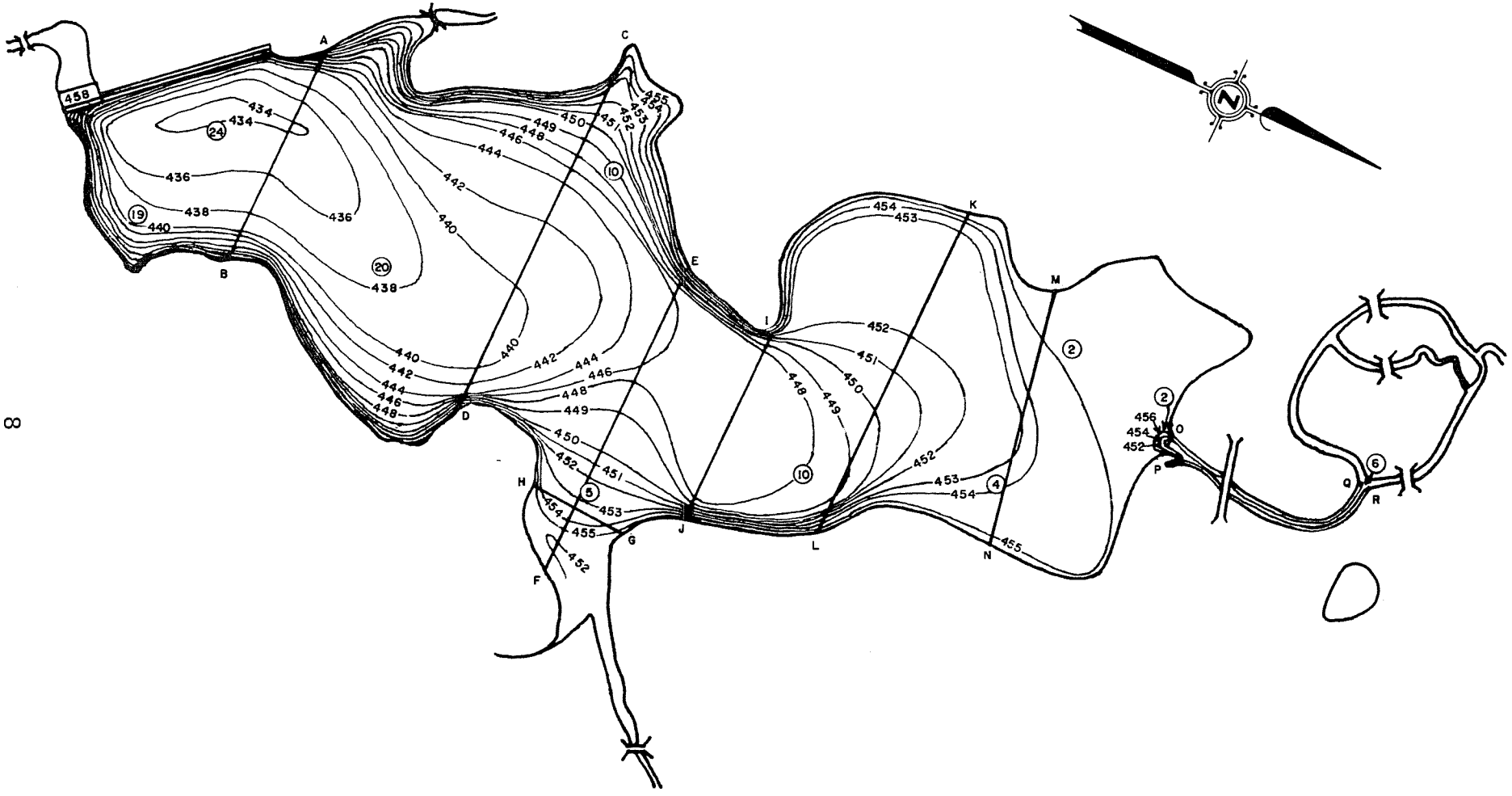

Figure No. 1. *Bottom Morphology and Station Depth Measurements*

The transect positions are indicated by straight lines lettered at the ends. The circled numbers are station depths. Refer to Figure No. 2 for station numbers.

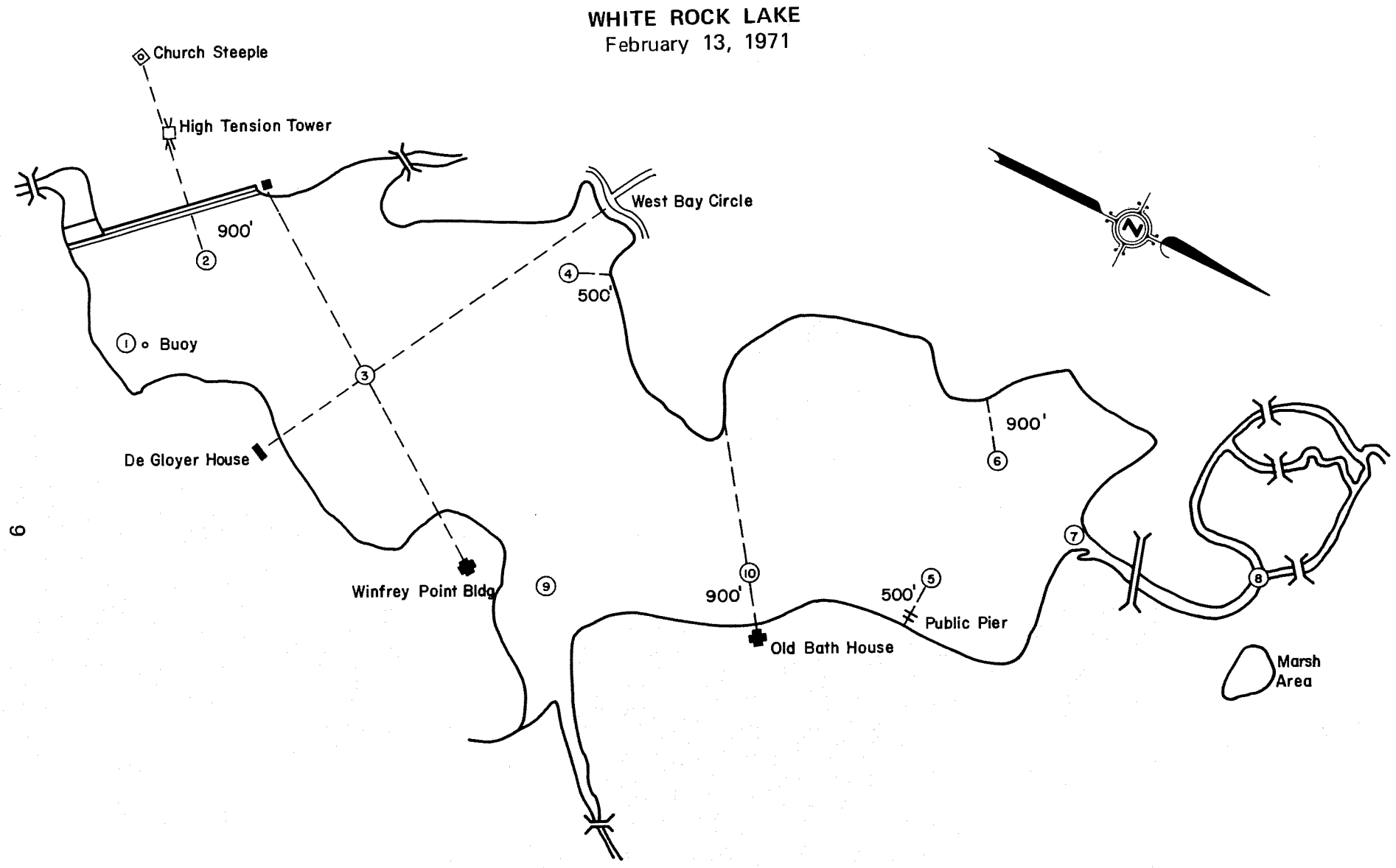

Figure No. 2. *Shoreline Map Indicating the Positions of Sampling Stations*

Refer to Figure No. 1 for depths. Distances and landmarks are indicated.

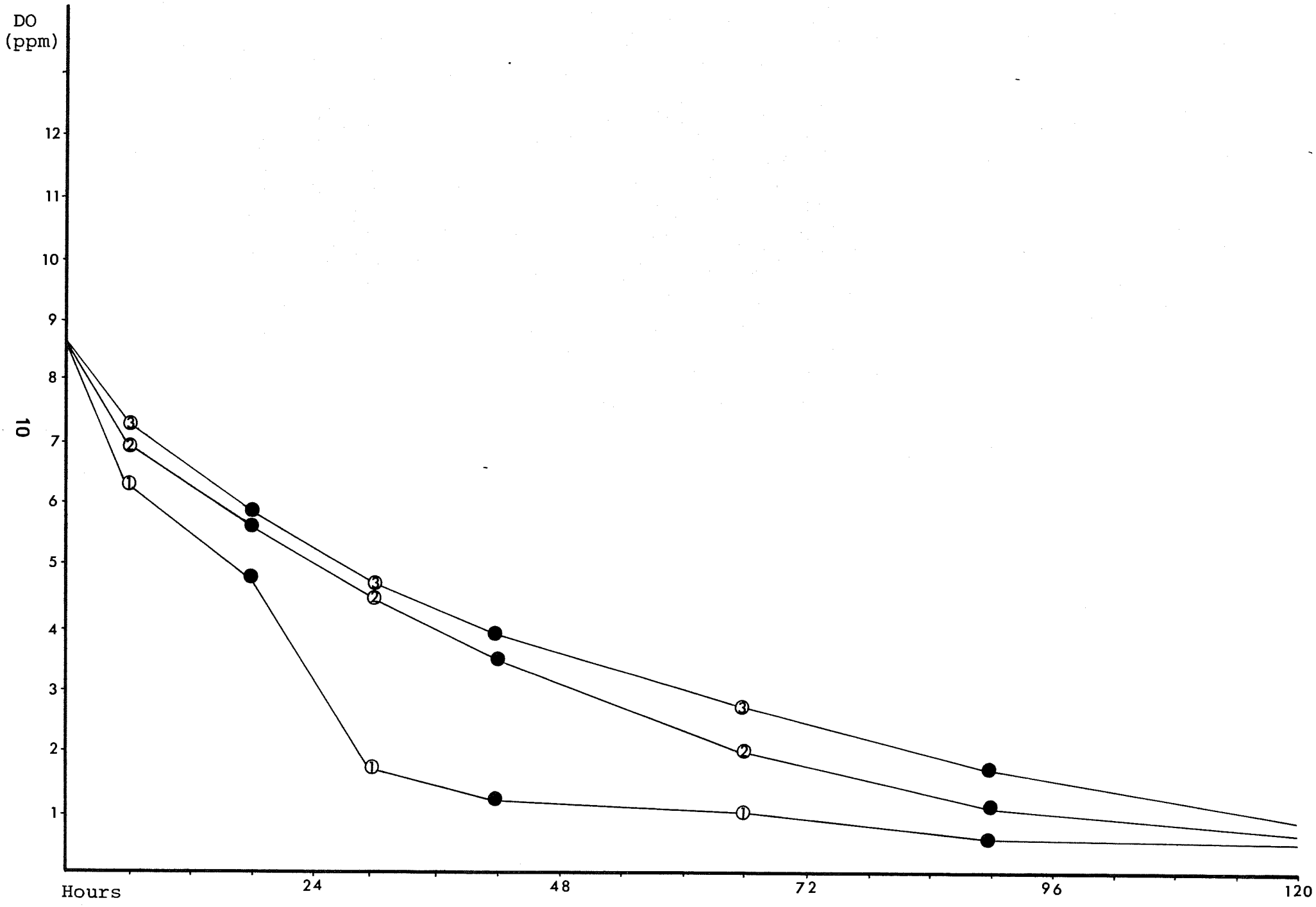

Figure No. 3. Sediment Oxygen Uptake - Stations 1, 2, and 3.

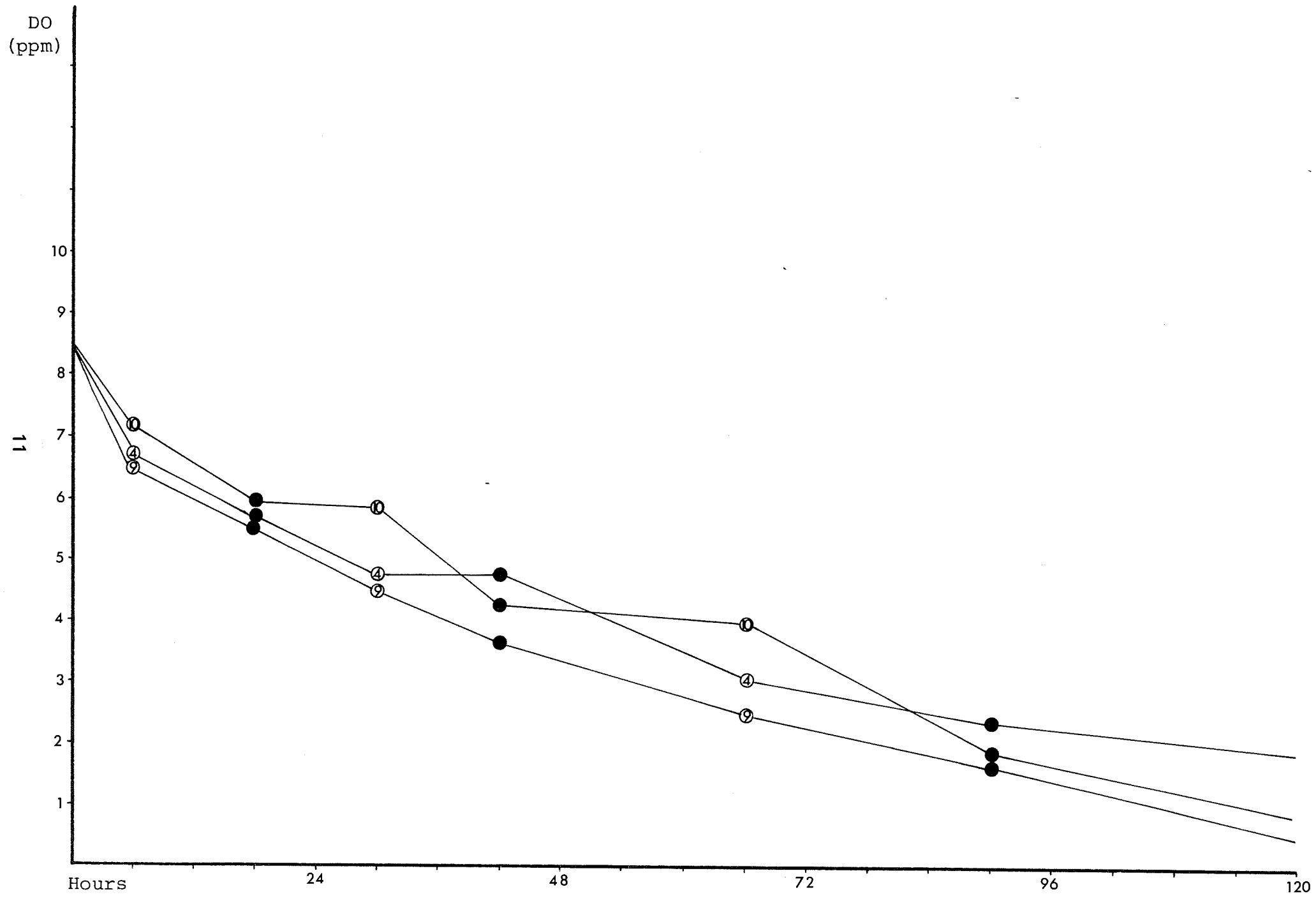

Figure No. 4. Sediment Oxygen Uptake - Stations 4, 9, and 10.

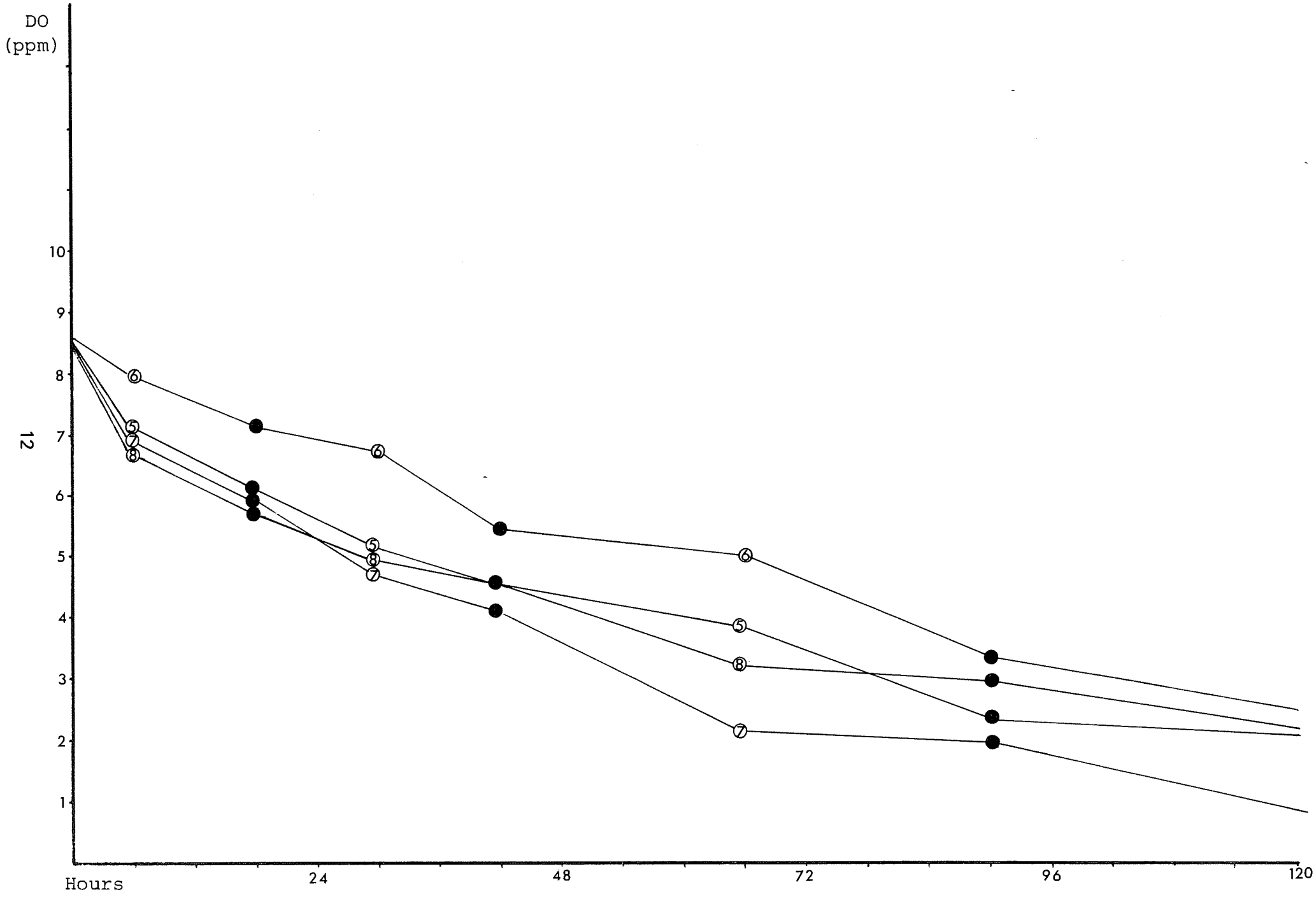

Figure No. 5. Sediment Oxygen Uptake - Stations 5, 6, 7, and 8.

TABLE I

SEDIMENT ANALYSES*

Station	PO_4 Total	PO_4 Sol.	Fe Total	Fe Sol.	NO_3 Total	NO_3 Sol.	Mn Total	Mn Sol.	Carbon Inorg.	Carbon Org.	Dry Weight	Specific Gravity
1	0.51	0.18	7.26	0.43	0.40	0.04	0.70	0.02	26.0	5.0	15	1.19
2	0.40	0.18	4.86	0.54	0.35	0.04	0.40	0.01	16.0	6.0	10	1.08
3	0.39	0.17	4.86	0.44	0.36	0.06	0.35	0.01	17.0	6.0	16	1.14
4	0.50	0.16	5.37	0.41	0.41	0.04	0.48	0.01	20.0	9.0	12	1.27
5	0.41	0.19	5.88	0.41	0.37	0.06	0.50	0.01	24.0	7.0	5	1.19
6	0.39	0.20	3.06	0.40	0.42	0.06	0.48	0.02	32.0	6.5	18	1.69
7	0.39	0.15	4.78	0.71	0.44	0.10	0.76	0	35.0	7.0	28	1.47
8	0.49	0.09	6.05	0.75	3.00	0.04	0.55	0	20.0	8.0	35	1.29
9	0.49	0.16	6.36	0.50	0.40	0.06	0.48	0	28.0	3.0	15	1.29
10	0.39	0.18	4.38	0.51	0.38	0.06	0.38	0.01	21.0	7.5	11	1.26

* All values as mg/cm^3 of sediment (grams/1000 cm^3)

TABLE II

NUTRIENT EXCHANGE ANALYSES

Station	PO_4 ppm	change	Fe ppm	change	NO_3 ppm	change	Mn ppm	change
1	0.05	0	0.20	+0.12	0.10	-0.41	0.64	+0.64
2	0.05	0	0.08	+0.04	0.10	-0.30	0.01	+0.10
3	0.05	0	0.45	+0.40	0.15	-0.35	0	0
4	0.05	0	0.34	+0.32	0.10	-0.30	0	0
5	0.05	0	0.06	+0.04	0.24	-0.28	0	0
6	0.05	0	0.05	+0.03	0.43	-0.18	0	0
7	0.05	0	0.08	+0.03	0.30	-0.65	0	0
8	0.05	0	0.52	+0.47	0.30	-2.69	0	0
9	0.05	0	0.20	+0.18	0.19	-0.34	0	0
10	0.05	0	0.08	+0.06	0.10	-0.41	0	0

(1 ml sediment material in 300 ml lakewater.)

TABLE III

PHYSICO-CHEMISTRY OF WHITE ROCK LAKE WATER

Station	Depth (ft.)	Temp. (°C)	DO (ppm)	% Sat.	pH	Alkalinity CO_3	Alkalinity HCO_3	Hardness (ppm)	Spec. Cond. μ mhos/cm	Phosphorous Sol.	Phosphorous Total	NO_3	Iron Sol.	Iron Total
1	19.0	7.0	12.1	98	8.4	0	105	124	350	.05	0.06	0.51	0.08	0.34
2	23.5	7.0	12.1	98	8.3	0	106	130	345	.05	0.06	0.40	0.05	1.40
3	20.5	6.9	12.1	98	8.5	6	101	134	350	.05	0.10	0.50	0.06	0.55
4	10.5	8.9	12.7	108	8.5	4	104	100	340	.05	0.06	0.40	0.05	0.41
5	4.5	9.0	13.2	112	8.6	8	103	84	343	.05	0.06	0.52	0.05	0.56
6	2.5	9.3	13.6	116	8.5	4	106	140	310	.05	0.10	0.61	0.02	1.26
7	2.5	10.9	12.5	112	8.5	4	120	146	375	.05	0.10	0.95	0.02	0.40
8	6.0	9.8	8.5	74	7.9	0	184	210	550	0.94	0.95	3.00	0.02	0.40
9	5.0	7.0	12.5	102	8.4	8	103	140	338	0.07	0.19	0.75	0.05	0.71
10	10.0	8.9	12.6	108	8.6	4	105	140	345	.05	0.08	0.53	0.05	0.52

TABLE IV

TURBIDITY GENERATION

Station	Turbidity	Lakewater - Sediment Mixture 0 hr. Turbidity	After 24 hr. Turbidity	After 24 hr. %Reduction	After 72 hr. Turbidity	After 72 hr. %Reduction
1	23	336	80	68	15	95
2	20	333	68	74	10	97
3	18	240	56	70	23	90
4	10	170	42	68	15	91
5	25	250	58	70	23	90
6	42	272	58	72	25	90
7	30	333	58	78	18	95
8	18	408	40	90	13	97
9	25	204	49	70	10	95
10	30	410	44	88	20	95

(% Reductions are relative to zero time turbidity.
Turbidities are in terms of Jackson Turbidity Units, JTU.)

TABLE V

SEDIMENT OXYGEN DEMAND*

Station	1 Day BOD	5 Day BOD
1	1410	1170
2	855	1122
3	795	1098
4	860	1203
5	645	720
6	330	645
7	690	1020
8	705	660
9	750	720
10	600	1059

*All values expressed as mg O_2/1000cc sediment.

TABLE VI

PHYTOPLANKTON DENSITIES OF WHITE ROCK LAKE
(Org./ml.)

Station	Chlorophyta and Chrysophyta	Chanophyta (Anacystis)	Total Organisms
1	1.98×10^4	5.14×10^4	7.12×10^4
2	2.18×10^4	1.14×10^4	3.32×10^4
3	2.58×10^4	3.72×10^4	6.30×10^4
4	3.12×10^4	5.92×10^4	9.04×10^4
5	3.94×10^4	13.00×10^4	16.94×10^4
6	3.52×10^4	7.18×10^4	10.70×10^4
7	2.00×10^4	3.12×10^4	5.12×10^4
8	0.14×10^4	0.92×10^4	1.06×10^4
9	1.80×10^4	4.36×10^4	6.16×10^4
10	3.08×10^4	4.38×10^4	7.46×10^4

TABLE VII

WHITE ROCK LAKE PHYTOPLANKTON LISTED IN ORDER OF RELATIVE ABUNDANCE

Alga	Average No./ml
Anacystis	52880
Ankistrodesmus	8580
Chlorella	6040
Pseudotetraedron	3700
Tetrastrum	2400
Stephanodiscus	1280
Kirschneriella	1100
Langerheimia	440
Dictyosphaerium	360
Nitzschia	200
Scenedesmus	160
Synedra	140
Selenastrum	100
Cyclotella	80
Lepocinclis	60
Chroococcus	60
Closteriopsis	40
Closterium	20
Chlamydomonas	20
Nauicula	20
Tetraedron	20

III - FISHERIES, VASCULAR PLANTS AND AQUATIC VERTEBRATES

METHODS

Fisheries Analysis

On the morning of February 12, 1971 three experimental gill nets (150 feet long with five meshes of .75 to 2.00 inches) were set in White Rock Lake, Dallas County, Texas. The nets were pulled the following morning and the fish were counted, weighed, and measured. One of the nets was set 300 meters above the dam and 100 meters from the east shore (station 1). A second net was set 100 meters from Winfrey Point (station 3), and a third net was set 100 meters off the Corinthian Sailing Club pier (station 5).

On the afternoon of February 13, 1971 six seine hauls were made at the north and east edges of the lake. Fish captured in the seine were identified and counted. The catch statistics, including condition coefficients (K) calculated for the fish were tabulated.

We also discussed the condition of the White Rock Lake fisheries with Mr. Ed Bonn, Fishery Biologist III, of the Texas Parks and Wildlife Department. Mr. Bonn supplies information on both the sport and commercial fisheries in the lake.

Vascular Plants and Aquatic Vertebrates

Surveys of the vascular plants, waterfowl, shorebirds, and mammals were made on February 12, 13, and 20, 1971. Specimens of plants were collected and returned to the North Texas State University Herbarium for identification Observations of birds and mammals were made at the lake. We also discussed past conditions of vascular plants and wildlife study opportunities with local residents, park visitors, and park employees.

Distribution of Fishes in the Lake

The gill nets set at stations 1 and 3 caught 43 and 76 fish per net respectively (Table No. 8). White crappie, channel catfish, and gizzard shad were the most abundant species in the nets. At station 5, in the north end of the lake, only 20 fish per net were taken

TABLE VIII. Total number of fish caught in experimental gill nets at three stations, White Rock Lake, Texas, February 12-13, 1971.

Location	Fish	Number
Near Dam:		
	white crappie	16
	channel catfish	15
	drum	6
	river carpsucker	3
	redhorse	1
	gizzard shad	1
	smallmouth buffalo	1
Winfrey Point:		
	white crappie	12
	channel catfish	24
	largemouth bass	1
	bluegill sunfish	5
	redear sunfish	1
	drum	3
	river carpsucker	5
	redhorse	2
	gizzard shad	18
	log perch	1
	golden shiner	2
Corinthian Club Pier:		
	white crappie	1
	channel catfish	8
	drum	1
	river carpsucker	2
	gizzard shad	8

and shad, catfish, and carpsuckers were the most abundant species. It appears that the gamefishes are concentrated in the deep southern end of the lake, and that the northern end of the lake is populated primarily by roughfishes.

The results of the seine hauls (Table No. 9) indicate that golden shiners are distributed in both ends of the lake. Mosquito-fish, however, are found in numbers only at the upper end of the lake, and particularly in the marsh areas. We saw many dense schools of mosquito-fishes in shallow water at the north end of the lake.

RESULTS

Fisheries Analysis

White Rock Lake sustains an important, urban recreational fishery. The typical fisherman uses bait, fishes from shore, and is either a local resident unable to travel great distances to enjoy his sport, or fishes incidentally in conjunction with other park activities. Many families, for example, picnic in the afternoon and then fish for a short while in the evening before returning home. The principal species sought are white crappie, yellow bass, channel catfish, and sunfish. The results of our survey indicate that good numbers of crappie and catfish are present in the lake.

Creel census data (supplied by the Texas Parks and Wildlife Department) indicated that 49,343 fishermen harvested 19,511 pounds of fish from the lake in 1970. Catch rates were highest in April (1.49 fish/hour) and lowest in November (.09 fish/hour). A commercial fisherman harvested 11,000 pounds of roughfish (principally smallmouth buffalo) from the lake in November, 1970.

The condition of the catfish (mean K value = .95; Table No. 10) is very good compared to values reported from other areas within the state. Examination of the stomachs of several catfish revealed that they were feeding on young-of-the-year gizzard shad. The white crappies are of slightly less than average body proportions and robustness for the state of Texas. Only small samples of yellow bass and sunfishes were collected, but the specimens were all in a robust condition.

Several white crappies were aged by examining the annuli on body scales. A representative sample of size classes showed ages of I to IV years. Growth rates of both catfish and crappies are judged to be adequate when compared to populations examined in other parts of the Southwest.

TABLE IX. **Total number of fish caught in seine hauls at two stations, White Rock Lake, Texas, February 13, 1971.**

Location	Fish	Number
North End of Lake:		
	bluegill sunfish	3
	mosquitofish	116
	golden shiner	37
	topminnow	2
Mouth of Dixon Creek:		
	bluegill sunfish	5
	yellow bass	1
	redear sunfish	1
	golden shiner	40
	bluntnose minnow	2
	brook silversides	2

TABLE X. Length, weight, and condition factor (K) of fish caught in gill nets and seines, White Rock Lake, February 12-13, 1971.

Fish	Length (cm)	Weight (g)	K
White crappie	27.0	286	1.45
	26.5	303	1.63
	25.0	278	1.78
	26.5	322	1.73
	27.0	354	1.80
	27.0	328	1.67
	25.0	250	1.60
	24.0	268	1.94
	26.5	353	1.90
	25.5	304	1.83
	25.0	300	1.92
	25.0	284	1.82
	27.0	337	1.71
	24.5	271	1.84
	27.5	338	1.63
	28.5	385	1.66
	21.0	128	1.38
	31.0	380	1.64
	8.5	7	1.14
	22.0	185	1.74
	21.5	151	1.52
	18.5	80	1.26
	17.5	64	1.19
	21.5	158	1.59
	26.0	290	1.65
	20.0	115	1.44
	26.0	295	1.68
	8.5	6	.98
	8.5	6	.98
Channel catfish	35.0	368	.86
	32.5	320	.93
	34.5	417	1.02
	34.0	380	.97
	19.5	62	.84
	33.0	388	1.08
	33.5	391	1.04
	34.0	384	.98
	37.0	449	.89
	35.9	420	.94
	41.5	454	.64
	42.0	454	.61
	37.0	488	.96
	31.0	272	.91
	28.0	251	.94

TABLE X. (contd.)

	Length (cm)	Weight (g)	K
Channel catfish (contd.)	29.5	245	.95
	23.9	110	.85
	22.9	100	.88
	28.5	170	.77
	27.0	162	.82
	33.0	322	.90
	21.0	64	.69
	23.0	90	.74
	21.0	84	.91
	22.0	78	.73
	22.0	88	.83
	19.5	66	.89
	21.0	94	1.02
	32.5	292	.85
	34.5	417	1.02
	32.0	310	.95
	35.0	433	1.01
	34.0	299	.76
	31.5	303	.97
	33.0	332	.92
	36.0	479	1.03
	35.0	410	.96
	29.5	208	.81
	32.0	328	1.00
	34.0	345	.88
	38.0	448	.82
	24.0	114	.82
	30.0	240	.89
	30.0	252	.93
	34.0	366	.93
	34.0	375	.95
	35.0	420	.98
Bluegill sunfish	8.1	8	1.56
	7.1	7	2.10
	4.6	1	1.23
	5.8	3	1.43
	6.0	3	1.34
	11.0	27	2.03
	11.5	27	1.78
	13.0	42	1.91
	13.0	47	2.14
	11.5	32	2.10
Redear sunfish	12.0	39	2.26
	19.5	162	2.18
Yellow bass	8.9	66	.94
Largemouth bass	19.5	110	1.48

TABLE X. (contd.)

	Length (cm)	Weight (g)	K
Drum	30.5	412	1.45
	13.5	25	1.00
	13.5	30	1.22
	15.0	39	1.16
	31.0	410	1.38
	28.0	293	1.33
	34.0	474	1.21
	29.5	310	1.21
	30.5	386	1.36
	28.0	287	1.31
Gizzard shad	17.0	45	.92
	13.0	20	.93
	16.5	42	.81
	17.0	40	.81
	26.0	163	.93
	26.0	158	.90
	25.0	158	1.01
	24.0	140	1.01
	16.5	42	.93
	25.5	170	1.03
	13.5	30	1.22
	20.0	70	.88
	26.0	152	.86
	14.0	25	.91
	16.5	38	.85
	12.5	18	.92
	13.0	23	1.05
	16.5	37	.82
	20.0	72	.90
	13.0	24	1.09
	20.5	75	.87
	8.0	3	.59
	17.0	39	.75
	13.0	32	.94
	17.0	43	.98
	14.5	30	.98
	30.0	269	1.00
River carpsucker	30.0	385	1.43
	28.5	426	1.84
	32.5	492	1.43
	30.5	432	1.52
	33.0		
	31.0	410	1.38
	16.0	55	1.34
	32.0	430	1.31
	34.0	454	1.16
	31.0	455	1.53
Smallmouth buffalo	27.0	283	1.43

Aquatic Vegetation

White Rock Lake supports only a few common varieties of vascular plants. A few specimens of frogbit *(Limnobium)* and American lotus *(Nelumbium Pentaplatum)* were collected. Filimentous green algae covers the bottom in water less than 2 - 3 feet deep at the north end of the lake. Scattered patches of *Chara* were also found in this area.

Emergent vegetation is also rather sparsely distributed about the margin of the lake. On the east, west, and south shores of the lake only scattered clumps of the great bulrush *(Scirpus Validus)* are found. The marshy areas at the north end of the lake have more extensive growths of *Scirpus Validus* as well as moderately dense stands of 1 - 4 feet high willow *(Salix)* shoots. Several species of smartweed (*Polygonum Spp.*) are also found growing in the marsh areas.

Several long-time residents of the area and employees at White Rock Park recalled that during the 1950's and early 1960's there were extensive growths of bulrushes all around the lake. Park employees believe the bulrushes began disappearing at about the same time that nutria began invading the lake. After exhausting the emergent vegetation the nutria population declined.

It is also possible that the bulrushes have not spread around the lake because of unfavorable conditions for seed germination. The bulrush, unlike the cattail, does not usually propagate itself by floating rootstocks. Rather, colonization is achieved by the dissemination of the achenes or seeds. Germination of the seeds can occur only on recently exposed mud flats. Germination cannot occur underwater or on dry soil. Therefore, a period of relatively stable water levels would inhibit the spread of bulrushes. A water level fluctuation regime which exposes mud flats in the early summer and refloods the mud flats in fall would encourage the spread of bulrushes.

Vertebrates of the Shore and Marshes

The open areas of the lake serve as resting and feeding areas for several species of migrating diving ducks (canvasbacks, scaup, etc.), ring-billed gulls, and terns. The edges of the lake and the marsh areas harbor a greater variety of aquatic and semi-aquatic vertebrates.

During our investigations we observed cotton rats (*Sigmodon*), nutria (*Coypu*), and swamp rabbits (*Sylvilagus aquaticus*) at the north end of the lake. Park employees reported sighting an occasional beaver (*Castor canadensis*) in the area within the last year. None of these

animals are present in large numbers, but the opportunity to view the animals in their natural habitat is available to park visitors. The beaver should probably not be encouraged since they would destroy many small trees in the vicinity of White Rock Creek. The nutria can be expected to increase when and if the amount of emergent vegetation increases.

Waterfowl and other aquatic birds make up the most impressive group of resident vertebrates in the shallow water areas. During our investigations we saw large numbers of mallards, green-winged teal, blue-winged teal, shovelers, coots, and pintails. These puddle ducks were resting and feeding in the marsh areas. We also saw many killdeer, a few snipe, and one woodcock.

Park employees reported that in the summer the marsh is visited by grebes, sandpipers, great blue herons, green herons, and wood ducks. Wood ducks nest in the trees along White Rock Creek and feed in the marsh areas. Three local bird-watchers were interviewed, and each related stories of many hours spent birding along the north end of the lake.

GENERAL DISCUSSION

Ecological Systems

1. A stable, well-balanced fish population exists in this old reservoir, particularly in the south end of the lake. White crappies and channel catfish are the most abundant sport fishes.

2. Emergent vegetation (bulrush, *Scirpus validus*) is distributed in very small, scattered clumps around the south, east, and west edges of the lake. The only extensive stands of this plant were found in the marsh area between Mockingbird Lane and the Northwest Highway at the north end of the lake. Other aquatic vascular plants are rare.

3. The open-water areas of the lake are used by gulls, terns, and resting waterfowl (canvasbacks, scaup, etc.). The marsh area at the north end harbors significant numbers of puddle ducks and shore birds. Semi-aquatic mammals are uncommon in the marsh area (swamp rabbit, nutria, and beaver).

IV - BENTHOS

METHODS

On February 13, 1971, one Ponar Dredge sample was taken at each of the 10 established stations; on February 23, two additional samples per station were taken with a Tall Ekman Dredge. Samples were washed through a Wildco Wash Bucket, preserved in 70% Isopropanol and returned to the laboratory. On days following sampling, organisms were sorted, counted and identified.

RESULTS

The thirty dredge samples taken from the 10 stations indicated a relatively poor benthos community diversity. Only 5 different organisms, *Chironomus* sp. (midges), Oligochaete worms, *Chaoborus* (phantom midges), Sphaerid clams, and a few leeches were present. The complete absence of mayfly naiads of the genus *Hexagenia* and relatively high populations of the more tolerant midges and worms at deeper sampling points indicates a lack of available nutrients such as sessile algae.

The midges and Oligochaete worms probably serve as major items in the diet of channel catfish fingerlings and other fishes in the lake. Smaller *Ictalurus* and other bottom feeding fishes take *Chironomus* and *Chaoborus* larvae and worms the year around. *Chaoborus* larvae migrate into the limnetic and surface littoral zones during the scotophase, thus becoming available to other fishes. *Chironomus* is most available during the pupal stage when they swim up to the surface and transform into adults.

The wide range of larval instars of *Chironomus* present in the lake in February, and the presence of pupae and emerging adults, indicates over-lapping generations and year around emergence. Peak emergence occurs during warm months.

The highest populations of these 3 important benthic food organisms are generally sustained in the deeper (southern and central) areas of the basin at 5-24 ft. (Table XI). Poor benthos production is indicated in the northern reaches of the lake, encompassed by stations 6, 7, and 8.

TABLE XI

BENTHOS STANDING CROP[1]
WHITE ROCK LAKE 2/23/71

Station	Depth	Chironomus	Oligochaete Worms	Chaoborus	Sub. Tots.	Sphaerid Clams	Leeches
			Mean No. Organisms/m^2				
1	19.0'	744	1288	68	(2100)	20	-
2	23.5'	586	1689	136	(2411)	-	-
3	20.5'	270	385	121	(776)	10	-
4	20.5'	755	20	98	(873)	36	-
5	4.5'	630	125	16	(771)	-	-
6	2.3'	113	73	-	(186)	11	-
7	2.5'	31	28	7	(66)	7	11
8	6.0'	-	35	-	(35)	-	-
9	5.0'	617	76	14	(707)	-	-
10	10.0'	470	787	100	(1357)	32	7

[1]Based on one Ponar Dredge Sample and 2 Tall Ekman Dredge Samples per station

GENERAL DISCUSSION

The occurrence of good populations of *Chironomus, Chaoborus* and Oligochaete worms at the 3 deepest stations, and poor standing crops in the upper shallow areas (Table XI), suggest that dredging of shallow areas of the lake, at least to depths of 20 to 25 feet, would promote an increase in the overall benthos production.

It is considered that even in areas dredged down to mineral substrate, enough organic detritus would settle back in to promote recolonization within 6 months. The overlapping nature of midge populations, and consequent emergence and reproduction the year around by adults, would lead to a constant "reseeding" of eggs over dredged areas. Oligochaetes would migrate into the areas from adjacent undredged ones as initial resedimentation occurred.

It is possible that sufficient toxic sediments might be removed by dredging to promote colonization by highly desirable *Hexagenia* (mayfly) populations. Adult Hexagenia disperse across land barriers from other ponds and lakes in the general area during April-October. The sediments of Garza Reservoir and Lake Texoma, at depths analagous to those of many stations in White Rock Lake, support good populations of these important food organisms.

Temporary reductions in midges and Oligochaetes by dredging might affect the channel catfish production of perhaps one season, but retention of piscivorous brood adults in good condition would promote renewed production the following year under conditions of higher carrying capacity of the lake.

V - RECOMMENDATIONS FOR DREDGING PROCEDURES

GENERAL

The ecological survey of White Rock Lake has resulted in the accumulation of data that demonstrates that the lake is in good balance at the south end and in poor condition at the north end. It also shows that the sediments available do not stimulate the production of algae even though they are rich in both inorganic and organic materials that would stimulate plant growth provided the sediments were dried and available for use on lawns, pastures and other areas where rich loam is desirable. The chemical analyses of the lake water and the sediments are presented which indicate adsorption of nutrients from the creek water as it enters the lake.

The other data shown in the report are relevant when one considers whether dredging should occur or not, what type of dredging should be used and if certain areas of the lake should be preserved while others are used as fill. Thus, from the ecological information contained in the report, the following recommendations are made:

1. It is mandatory to preserve a part of the swamp areas and the deltas at the north end of the lake in order to maintain a region for wildlife and to promote the growth of additional plants such as bulrushes and willows as well as to preserve the park areas that are enjoyed by many individuals. The northwest section of the lake that is very shallow due to siltation and sedimentation could be used partly as a site for filling since there are no marshy areas in that immediate region. The water is very shallow, highly unproductive and a fill would result in additional marsh land that would offer cover for wildlife and would not decrease the area of the lake by too great a proportion.

2. It is apparent from this survey that hydraulic dredging should improve the ecological balance of White Rock Lake. Removal of the present sediments along with increasing depths would allow an increase in both species diversity and production of the benthos. Our studies indicate that rough fish predominate in the north end of the lake where the dredging would mainly occur. Thus, a deeper area would improve the ecological conditions and would provide additional area and food for the yellow bass, crappie and catfish. An increase in depth, especially along shore areas, would increase temperature stability in the lake and provide more desirable habitats for game fishes; and, in addition, permit suitable fishing areas on the bank.

Special recognition should be taken of Dixon's Branch area and the north end where the contours show the depth to be less than six feet.

3. If the equipment used for dredging is of the hydraulic type, it is suggested that due to the high biochemical oxygen demand of the bottom sediments, that most of the dredging should perhaps occur during the fall, winter and spring. The reason for this suggestion is that dredging in the summertime would agitate the bottom sediments and would likely result in a depletion of the oxygen. This would result in a fairly extensive fish-kill in the north end of the lake. While it is apparent from our survey that mainly rough fish are in the area, a fish-kill is rather disastrous to any ecological improvement program.

4. The larger the proportion of sediment removed from the lake, the greater will be the ecological improvement. While our laboratory results demonstrate that the sediments precipitate in a period of three days, these samples were agitated initially and permitted to remain undisturbed for 72 hours. Therefore, whenever wind action occurs on White Rock Lake, the flocculant sediments will be suspended resulting in turbidity which reduces the productivity of the water. Since the original basin of the lake is hard and not subject to being disturbed by currents, the greater proportion of sediments that are removed, the clearer the waters of the lake will become and consequently more productive and particularly improved from an esthetic viewpoint.

5. Our studies do not indicate that the biochemical oxygen demand of the sediment is produced by substances that would give rise to highly obnoxious odors. The sulphur components are extremely low in these sediments. Obviously, there is an odor but one would describe it as swampy rather than obnoxious or offensive. Therefore the materials removed from the lake bottom would be very useful for lawns and pastures, particularly if they were dried somewhat prior to the time they were hauled to a new site.

6. The wildlife area around the north end of the lake should be preserved. It might be practical in using hydraulic fill to pump thin layers into the regions adjacent to White Rock Creek where it is desirable to have a better view from the bridge on Mockingbird Lane. A deposition of such sediments would result in death to trees for a short period of time and then a new growth would occur.

7. Our recommendation is that the most desirable method of handling dredging is to remove as much sediment as available park department funds will allow, to place it on the rock banks on the east side of the lake in relatively large piles, permit it to partially dry, and to haul it by truck down to the lower reaches of White Rock Creek.

The area referred to is bound on the northeast by Garland Road, on the southeast by a railroad and by White Rock Creek on the west and north. It is observed that this land is owned by the City of Dallas. Mr. Cooke described it as a swampland that was not presently being used. Although it may not belong to the park department, perhaps permission could be obtained to do a land fill using the dredged material. This would get it away from the lake, would provide a fertile region for the growth of vegetation, and would have accomplished the task of making the lake deeper and ecologically more stable.

8. It is quite obvious that the ecology of the lake could be more greatly improved by draining and removing of silt by heavy earth moving equipment. This type of dredging would result in the basin of the lake being more suitably contoured and dry sediments could more feasibly be deposited on land areas not adjacent to the lake. However, it is not our recommendation that such practice be followed since it would be our impression that the temporary disturbance of fish populations, of bottom organisms, of boating, picnicking and similar types of activities would persist for a period of time after completion of dredging operations. Equipment would have to wait for complete drying before it could move in and do the proper type of job. The marsh region would be lost, the wildlife would be lost, and parts of the basin would grow up in weeds and other types of vegetation. To summarize briefly, it would be a very unpopular practice and detrimental to the best interests of the Park Department.

REPORT ON

INVESTIGATIONS FOR IMPROVEMENT

PROGRAM FOR WHITE ROCK LAKE PARK

APPENDIX B

Soils Investigation, Lake Sediments, White Rock Lake
by National Soil Services, Inc.

SOILS INVESTIGATION

LAKE SEDIMENTS

WHITE ROCK LAKE

Report to

CITY OF DALLAS
Department of Public Works

&

FORREST AND COTTON, INC.
Consulting Engineers
Dallas, Texas

By

NATIONAL SOIL SERVICES, INC.
Consulting Engineers
Dallas, Texas

May, 1971

NATIONAL SOIL SERVICES, INC. *CONSULTING ENGINEERS*
214-330-0455
P. O. BOX 24596
4087 SHILLING WAY
DALLAS, TEXAS 75224

May 14, 1971
Report No. 7197

Parks and Recreation Department
Department of Public Works
City of Dallas, Texas 75201

THRU:

Forrest and Cotton, Inc.
Consulting Engineers
600 Mercantile Continental Building
Dallas, Texas 75201

Attention: Mr. A. Martelli, P. E.
Mr. Robert Steele, P. E.

SOILS INVESTIGATION
LAKE SEDIMENTS
WHITE ROCK LAKE

Gentlemen:

Submitted here are the results of our preliminary investigation of surficial deposits in White Rock Lake. This study was performed in accordance with our proposal dated February 26, 1971 and was authorized by resolution of the City Council on April 5, 1971.

We trust that the results of this study provide sufficient information for preliminary design analyses. If you have any questions or if we may be of further service, please call us.

Very truly yours,

NATIONAL SOIL SERVICES, INC.

Tillman A. Riewe, P. E.

TAR:gt
Copies submitted: 10

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INTRODUCTION

These studies were made in areas of extensive sedimentation in White Rock Lake, Dallas, Texas. Specifically, the investigation was performed

(1) to determine types and classification of soil sediments in the reservoir;

(2) to determine the general engineering characteristics of these soil deposits;

(3) to develop recommendations for disposing of the deposits; and,

(4) to evaluate potential usages of the soils.

FIELD INVESTIGATION

Subsurface conditions were defined by six undisturbed sample borings (CB-5 through CB-10) located as shown on Plate 1 in the report's illustrations. Continuous undisturbed samples were obtained from the mudline through the lake sediments and thereafter at five-foot intervals to the completion depths of the borings. Borings CB-5 through CB-9 were made using a rotary drilling rig mounted on a barge. Boring CB-10 was made from a small boat using thin-wall tubing which was pushed into the sediments by hand. In essence, two soundings were made at each of the deeper boring locations. First, a vane shear boring was made to accurately determine the consistency of the lake sediments and depth to the underlying natural soil deposits. The barge was then moved to an adjacent location for the undisturbed sample boring. The results of the vane shear and the undisturbed

sample borings are presented on a common boring log, Plates 2 through 7. A key to terms and symbols used on the logs is presented on Plate 11.

The shear strength of the lake sediments was determined by the standard vane shear test. In this test, a three-inch diameter by five-inch long vane is rotated in undisturbed soil below the bottom of the borehole. The ultimate stress at failure is recorded. The vane is then rotated sufficiently to completely shear or remold the soil. The resistance to rotation is again recorded. Shear strengths determined by the vane procedure are shown in the strength plot on the boring logs and tabulated on Plates 8, 9, and 10. A plot of shear strength in pounds per square inch versus depth below mudline in feet is presented on Plate 19.

The shear strength of samples obtained from the undisturbed sample borings was evaluated by the hand penetrometer and torvane shearing devices. These apparatuses have been correlated with the laboratory unconfined compression test, and provide a reliable estimate of soil consistency. The results of these tests are expressed as "tons per square foot" in the shear strength plot on the logs and on Plates 8, 9 and 10.

LABORATORY TESTS

Classification of soils was verified by eight natural moisture content determinations; 17 moisture density determinations; 17 liquid, plastic, and shrinkage limit determinations; ten hydrometer analyses; and eight organic content determinations. The results of these tests are presented at respective sample depths on the logs and tabulated on Plates 12 through 16.

Samples of sediments encountered from the mudline to three feet and from three feet below the mudline to six feet below the mudline were combined respectively for use in standard Proctor (ASTM D-698) compaction tests. The results of these tests, along with shear strength as determined by the hand penetrometer tests, are presented on Plates 17 and 18.

Representative specimens from each boring were submitted to the Soils Testing Laboratory, Agricultural Extension Service, Texas A & M University, College Station, Texas, for evaluation of the sediments for use as top soil. These tests included salinity hazard determinations. The results are presented on Plate 20.

GENERAL SOIL CONDITIONS

Water depths in the area of these studies varied from one to nine feet and averaged 5.6 feet. The thickness of lake sediments, which consist mainly of highly plastic clays, varied from six to 14.5 feet and averaged 8.8 feet. The lake sediments in the Dixon's Branch drainage area consist of highly plastic clays with liquid limits varying from 53 to 61. Highly plastic clays with liquid limits varying from 66 to 84 predominate in other areas of the lake. In general, lake sediments from the White Rock Creek area are of considerably higher plasticity than those from Dixon's Branch. Based on the results of the hydrometer analyses, the sediments from the White Rock Creek drainage area are considerably finer than sediments in the Dixon's Branch drainage area. None of the sediments encountered had a particularly offensive odor.

The lake sediments are underlain by soft to very stiff calcareous clay to below the completion depth of the borings. Natural soil deposits in the lake area consist primarily of medium plastic clays with liquid limits less than 50.

ANALYSIS OF RESULTS AND RECOMMENDATIONS

Method of Excavation

The very soft consistency of the recent sediments would necessitate excavation by dredge if the lake is to be cleaned in a reasonable length of time. The use of a dredge would necessitate pumping the sediments to a disposal area where they could consolidate and lose moisture. Moisture contents will be high and a considerable length of time will be required for the soil to lose its moisture. Due to the high plasticity of the deposits, the time required would be relatively lengthy and will be influenced by atmospheric conditions and thickness of the redeposited sediments. It is anticipated that several years would be required for the soil to lose sufficient moisture to use it economically. It is recommended that the soils be deposited in thin lifts to expedite drying.

Excavation slopes in the sediments cannot be accurately defined; however, it is anticipated that 10:1 slopes in the sediments and 2:1 slopes in the natural deposits will perform satisfactorily. Containment of sediment in disposal areas could be accomplished by dikes.

Utilization of Lake Sediments

Based on the results of these tests, the sediments in White Rock Lake basin are not ideally suited for either engineered construction or top soil. However, with proper processing and quality control during construction, the clay could be utilized for embankments, dikes, and miscellaneous fills. The soils are not recommended for use in the upper portion of roadway fills or under buildings due to their high plasticity.

The soils may be used agriculturally based on the results of tests performed by the soils laboratory at Texas A & M University. They are not considered suitable for areas which require continued tilling, such as flower beds. The soils have a slight salinity hazard which would be of no major consequence other than during periods when seeds germinate. Adequate soil moisture during the germination period will dilute the salt content, thus reducing the effect to a negligible value.

ILLUSTRATIONS

OVER
SIZE

LOG OF BORING NO. CB-5

LAKE SEDIMENTS
WHITE ROCK LAKE
DALLAS, TEXAS

TYPE BORING: Undisturbed Sample LOCATION: See Plan of Borings

ELEVATION: 456.33

DEPTH, FT.	SOIL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	UNIT DRY WT. LBS./CU. FT.
	Water				
5	Soft medium gray clay w/vegetation (CH)				
	Soft tan to gray clay w/silt laminations	53	16	50 54 58	68
10		61	19	63 66 55	59
	-roots on bottom (CH)				
	Soft tan calcareous clay	41	15	28	72
15	-calcareous gravel (CL)				
	Firm brown calcareous clay w/shell fragments	45	16	26	98
20	(CL)				
	Stiff light gray and tan calcareous clay			18	
25	(CL)				

SHEAR STRENGTH IN TONS/SQ FT. (0.5, 1.0, 1.5)

Natural Vane Shear

Remolded Vane Shear

Torvane Shear

Hand Penetrometer

COMPLETION DEPTH: 25.0'
DATE: 4/13/71

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

PLATE 2

LOG OF BORING NO. CB-6

LAKE SEDIMENTS
WHITE ROCK LAKE
DALLAS, TEXAS

TYPE BORING: Undisturbed Sample LOCATION: See Plan of Borings

DEPTH, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	SHEAR STRENGTH IN TONS/SQ FT. (0.5 1.0 1.5)	UNIT DRY WT. LBS./CU. FT.
			ELEVATION: 456.33					
			Water					
5								
10			Soft dark gray clay w/organic material	78	25	125		31
				84	27	125		39
			-tan and gray in color					
15			(CH)					
			Stiff tan to brown calcareous clay w/ roots at top of sample			31		
20			-shell fragments			29		93
			(CL)					
			Very stiff tan and light gray calcareous clay			19		
25			(CL)					

COMPLETION DEPTH: 25.0'
DATE: 4/15/71

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

PLATE 3

LOG OF BORING NO. CB-7

LAKE SEDIMENTS
WHITE ROCK LAKE
DALLAS, TEXAS

TYPE BORING: Undisturbed Sample LOCATION: See Plan of Borings

ELEVATION: 456.33

DEPTH, FT.	SOIL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	UNIT DRY WT. LBS./CU. FT.
	Water				
5	Soft dark gray clay	76	20	109	39
	-lighter gray in color				
10	-tan and gray in color	77	34	98	47
15	(CH)	79	23	97	53
20	Firm dark brown calcareous clay w/ calcareous silt seams -tan calcareous clay	65	21	41	77
25	(CH)				
	Stiff tan and gray clay				
30	(CH)				

SHEAR STRENGTH IN TONS/SQ FT.
0.5 1.0 1.5

COMPLETION DEPTH: 30.0'
DATE: 4/13/71

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

PLATE 4

LOG OF BORING NO. CB-8

LAKE SEDIMENTS
WHITE ROCK LAKE
DALLAS, TEXAS

TYPE BORING: Undisturbed Sample **LOCATION:** See Plan of Borings

DEPTH, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	SHEAR STRENGTH IN TONS/SQ FT. (0.5 1.0 1.5)	UNIT DRY WT. LBS./CU. FT.
			ELEVATION: 456.33					
			Water					
			Soft dark gray clay w/vegetation (CH)	66	18	100		42
5			Soft tan-gray clay w/calcareous silt layers -stiff brown clay seam 4.0-4.5' (CH)	70	18	77		34
10			Firm dark brown clay, calcareous -trace organic material and shell -becoming stiff (CH)	59	17	28		89
15			Stiff tan and light gray calcareous clay (CL)	43	13	19		
20								

COMPLETION DEPTH: 20.0'
DATE:

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

PLATE 5

LOG OF BORING NO. CB-9

LAKE SEDIMENTS
WHITE ROCK LAKE
DALLAS, TEXAS

TYPE BORING: Undisturbed Sample LOCATION: See Plan of Borings

ELEVATION: 456.33

DEPTH, FT.	SOIL DESCRIPTION	BLOWS PER FT.	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	SHEAR STRENGTH IN TONS/SQ FT. (0.5 1.0 1.5)	UNIT DRY WT. LBS./CU. FT.
	Water						
	Soft medium gray clay (CH)						
5	Soft tan to gray clay -thin calcareous gravel zone		74	20	85		43
	-thin calcareous gravel zone (CH)						
10	Firm tan and gray calcareous clay -stiff		50	15	27		72
15							
20	(CL-CH)						

COMPLETION DEPTH: 20.0'
DATE: 4/13/71

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

PLATE 6

D-105-69
7197 CB-9

LOG OF BORING NO. CB-10

LAKE SEDIMENTS
WHITE ROCK LAKE
DALLAS, TEXAS

TYPE BORING: Undisturbed Sample LOCATION: See Plan of Borings

DEPTH. FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	BLOWS PER FT.	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	SHEAR STRENGTH IN TONS/SQ FT. 0.5 1.0 1.5	UNIT DRY WT. LBS./CU. FT.
			ELEVATION: 456.33						
			Water						
			Soft dark gray clay (CH)		64	22	63 70		59 61
5			Note: boring was made by pushing 2" plastic pipe by hand from the side of small boat.						

COMPLETION DEPTH: 4.0'
DATE:

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

PLATE 7

D-105-69 08-10 7197

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

SUMMARY OF RESULTS

HAND PENETROMETER, TORVANE, AND IN-PLACE VANE SHEAR STRENGTH TESTS

Boring	Depth (ft)	Hand Penetrometer Strength (tsf)	Torvane Strength (tsf)	In-Place Vane Shear Strengths	
				Natural (tsf)	Remolded (tsf)
CB-5	4.0-5.0	0	0	0.111	0.070
	5.0-6.0	0	0	0.140	0.070
	6.0-7.0	0	0	0.140	0.070
	7.0-8.0	0	0	0.170	0.084
	8.0-9.0	0	0	0.127	0.057
	9.0-10.0	0	0	0.127	0.070
	10.0-11.0	0.03	0	0.127	0.099
	11.0-12.0	0.16	0	0.487	0.084
	12.0-13.0	0.33	0.25	0.560	0.210
	18.0-19.5	0.83	0.50		
	24.0-25.0	1.08	0.75		
CB-6	9.0-10.0	0	0	0	0
	10.0-11.0	0	0	0	0
	11.0-12.0	0	0	0	0
	12.0-13.0	0	0	0.029	0
	13.0-14.0	0	0	0.070	0.029
	14.0-15.0	0	0	0.070	0.029
	15.0-16.0			0.307	0.140
	16.0-16.5			0.530	0.111
	19.5-20.0	0.83	0.80		
	23.5-25.0	1.08	1.0+		

PLATE 8

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

SUMMARY OF RESULTS (Cont'd.)

HAND PENETROMETER, TORVANE, AND IN-PLACE VANE SHEAR STRENGTH TESTS

Boring	Depth (ft)	Hand Penetrometer Strength (tsf)	Torvane Strength (tsf)	In-Place Vane Shear Strengths Natural (tsf)	Remolded (tsf)
CB-7	4.5-5.5	0	0	0	0
	5.5-6.5	0	0	0	0
	6.5-7.5	0	0	0	0
	7.5-8.5	0	0	0.042	0
	8.5-9.5	0	0	0.042	0.029
	9.5-10.5	0	0	0.070	0
	10.5-11.5	0	0	0.099	0.070
	11.5-12.5	0	0	0.111	0.070
	12.5-13.5	0	0	0.111	0.084
	13.5-14.5	0	0	0.140	0.111
	14.5-15.5	0	0	0.170	0.140
	15.5-16.5	0	0	0.223	0.155
	16.5-17.5	0	0	0.252	0.197
	17.5-18.5	0	0	0.281	0.223
	18.5-19.5	0.10	0	0.281	0.111
	19.5-20.5			0.350	0.170
	20.5-21.5			0.770	0.325
	24.0-25.0	0.58	0.40		
	28.5-30.0	0.83	0.90		
CB-8	2.0-3.0	0	0	0	0
	3.0-4.0	0	0	0.111	0.057
	4.0-5.0	0	0	0.170	0.084
	5.0-6.0	0	0	0.182	0.127
	6.0-7.0	0	0	0.210	0.155

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS

SUMMARY OF RESULTS (Cont'd.)

HAND PENETROMETER, TORVANE, AND IN-PLACE VANE SHEAR STRENGTH TESTS

Boring	Depth (ft)	Hand Penetrometer Strength (tsf)	Torvane Strength (tsf)	In-Place Vane Shear Strengths Natural (tsf)	Remolded (tsf)
CB-8	7.0-8.0	0	0	0.281	0.155
(Cont'd)	8.0-9.0	0	0	0.252	0.210
	9.0-10.0	0	0	0.140 (disturbed)	0.070
	10.0-11.0			0.855	0.239
	12.0-14.0	0.58	0.50		
	14.0-15.0	0.63	0.65		
	18.5-20.0	0.83	0.90		
CB-9	2.0-3.0	0	0	0.042	0
	3.0-4.0	0	0	0.042	0
	4.0-5.0	0	0	0.239	0.084
	5.0-6.0	0	0	0.155	0.070
	6.0-7.0	0	0	0.070	0.029
	7.0-8.0	0	0	0.099	0.042
	8.0-9.0	0.33	0.30	0.450	0.070
	9.0-10.0			0.867	0.420
	11.0-12.0	0.66	0.55		
	18.0-20.0	0.58	0.45		

PLATE 10

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

SUMMARY OF RESULTS

LIQUID AND PLASTIC LIMIT, LINEAR SHRINKAGE, ORGANIC CONTENT, MOISTURE AND DENSITY TESTS

Boring No.	Depth (Ft.)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Linear Shrinkage (%)	Organic Content (%)	Moisture Content (%)	Unit Dry Weight (pcf)
CB-5	5.0-5.5						49.9	
	5.5-6.0	53.4	15.9	37.5	17.5		54.1	68.3
	7.0-7.5						57.8	
	8.0-9.0						62.9	
	9.5-11.0	60.5	18.5	42.0	21.5	26.1	65.9	58.7
	11.0-12.5						55.5	
	13.5-15.0	40.5	14.9	25.6	14.4		28.2	71.6
	19.0-19.5	45.3	16.1	29.2	16.2		26.4	97.5
	24.0-24.5						18.3	
CB-6	9.0-11.0	77.8	25.0	52.8	28.8		125.0	31.3
	11.0-13.0	84.4	26.9	57.5	27.5	31.1	124.7	39.4
	16.5-17.0						30.6	
	19.5-20.0						28.7	93.3
	23.5-24.0						18.6	
CB-7	5.0-7.0	75.7	20.2	55.5	23.5	32.3	109.0	38.9
	9.0-11.0	77.3	23.4	53.9	24.4		98.1	47.0
	15.0-17.0	79.2	22.8	56.4	25.0		97.5	53.0
	22.5-23.0	65.4	21.3	44.1	21.5		41.0	76.6
CB-8	2.0-4.0	66.4	18.2	48.2	21.5	34.4	100.0	42.2
	6.0-8.0	69.5	17.5	52.0	23.5	29.3		
	13.5-14.0	58.7	16.6	42.1			27.5	88.9
	18.5-19.0	42.8	13.1	29.7			18.8	

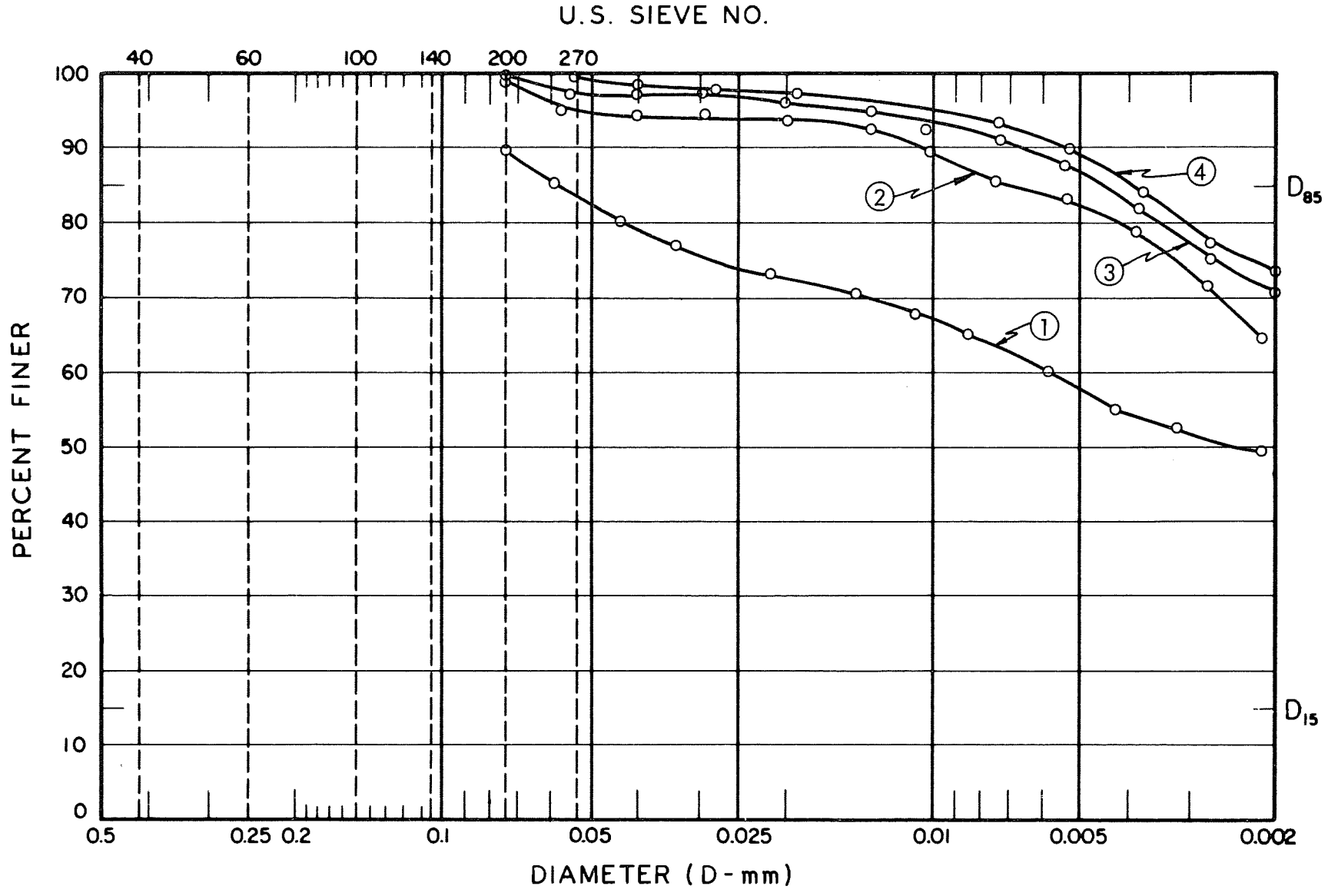
SUMMARY OF RESULTS (Cont'd.)

LIQUID AND PLASTIC LIMIT, LINEAR SHRINKAGE, ORGANIC CONTENT, MOISTURE AND DENSITY TESTS

Boring No.	Depth (Ft.)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Linear Shrinkage (%)	Organic Content (%)	Moisture Content (%)	Unit Dry Weight (pcf)
CB-9	4.0-6.0	74.0	19.6	54.4	24.4	30.3	85.4	43.0
	11.0-12.0	49.8	14.7	35.1	16.9	38.8	27.4	72.3
CB-10		63.7	21.7	42.0	22.5	36.8	71.25	59.7
Composite	mudline to -3'	74.9	23.5	51.4	25.0	31.8		
Composite	-3 to -6'	76.8	25.6	51.2	25.6	31.0		

NATIONAL SOIL SERVICES
CONSULTING ENGINEERS

GRADATION TEST

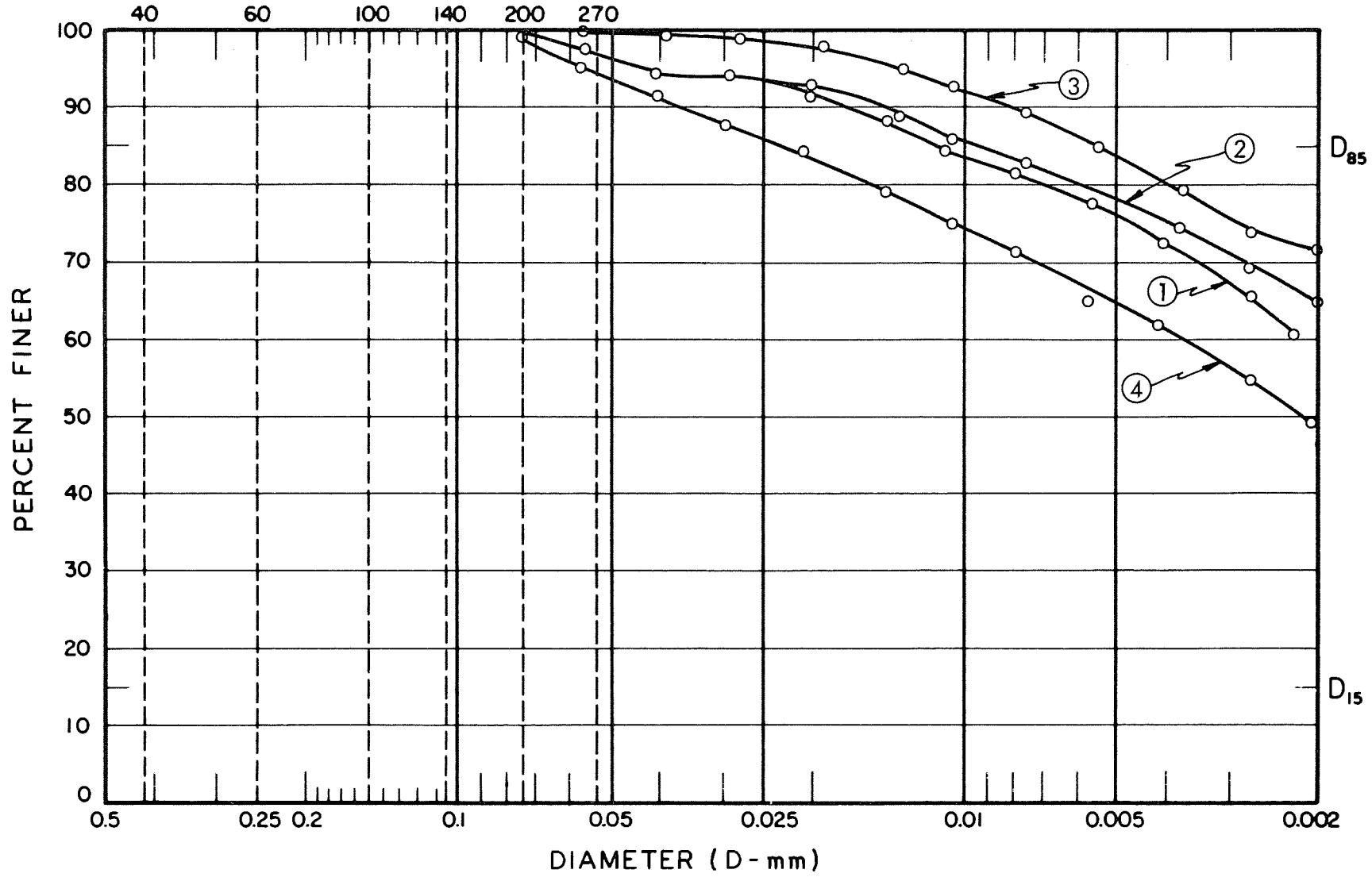


FINE SAND			SILT OR CLAY		
BORING	DEPTH	CURVE	BORING	DEPTH	CURVE
CB-5	5.5-6.0'	1	CB-7	5.0-7.0'	3
CB-6	9.0-11.0'	2	CB-7	9.0-11.0'	4

PLATE 14

NATIONAL SOIL SERVICES
CONSULTING ENGINEERS

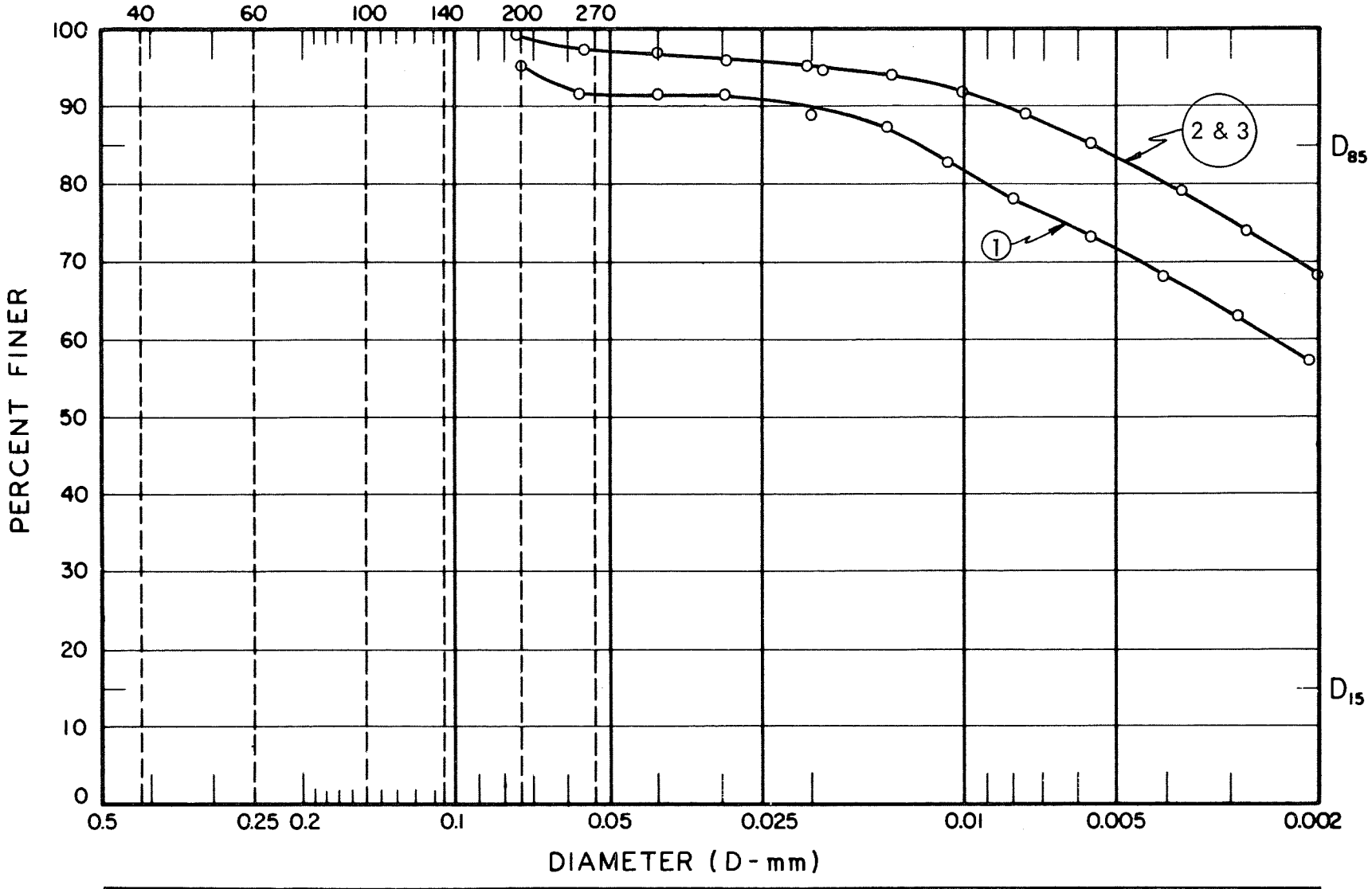
GRADATION TEST



FINE SAND			SILT OR CLAY		
BORING	DEPTH	CURVE	BORING	DEPTH	CURVE
CB-8	2.0-4.0'	1	CB-9	4.0-6.0'	3
CB-8	6.0-8.0'	2	CB-9	11.0-12.0'	4

NATIONAL SOIL SERVICES
CONSULTING ENGINEERS

GRADATION TEST



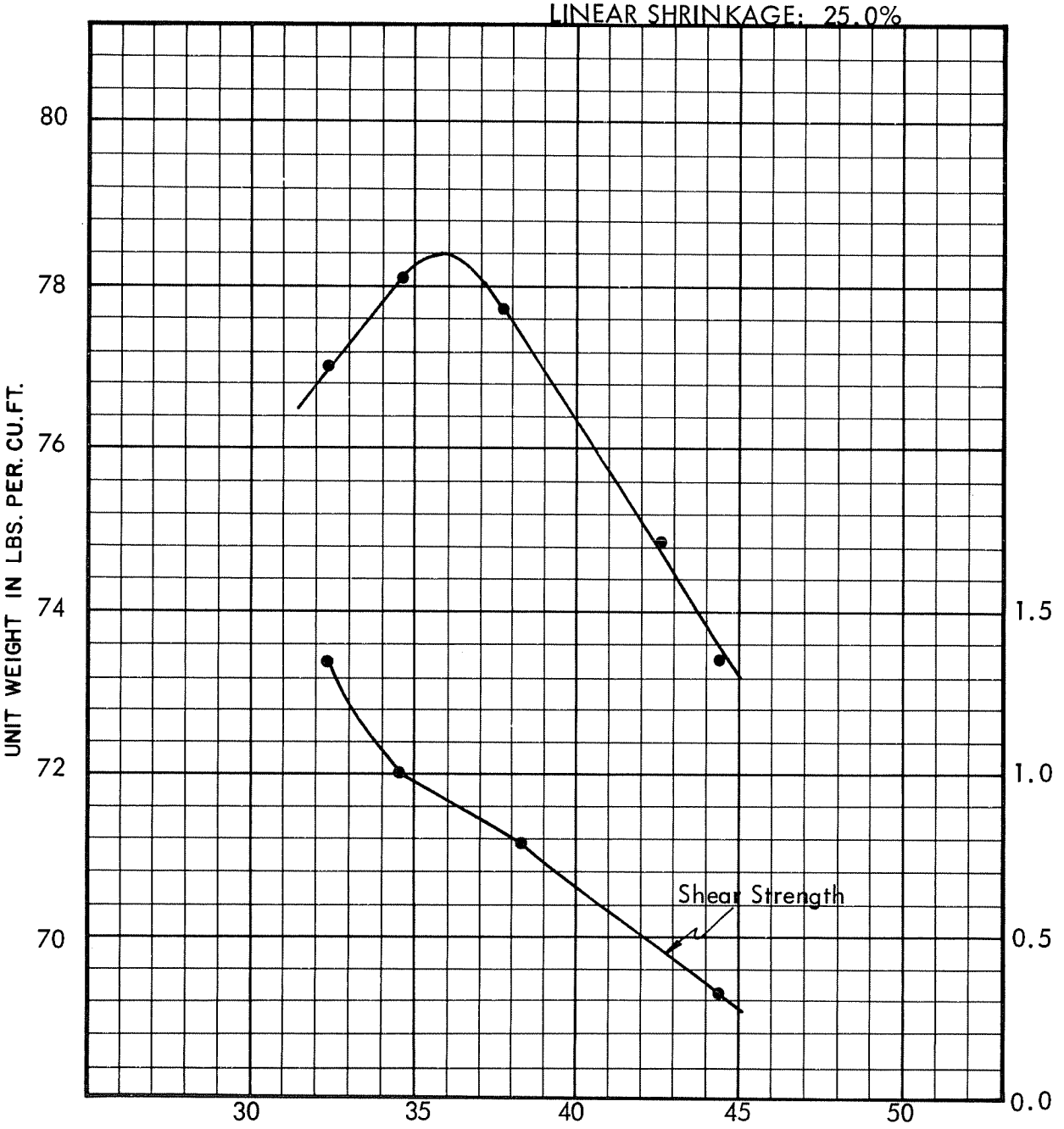
FINE SAND			SILT OR CLAY		
BORING	DEPTH	CURVE	BORING	DEPTH	CURVE
CB-10	Mudline to -3'	1	Composite	-3' to -6.0'	3
Composite	Mudline to -3'	2			

PLATE 16

PROJECT: 7197
TEST METHOD: ASTM D-698
MOLD: 1/30 cu. ft.
HAMMER: 5.5#
DROP: 12"
BLOWS: 25
LAYERS: 3

SAMPLE: Composite, mudline to -3 feet
DESCRIPTION: Dark gray clay

LIQUID LIMIT: 74.9
PLASTICITY INDEX: 51.4
OPTIMUM MOISTURE: 35.9 %
MAX. UNIT DRY WT: 78.4 LBS./CU.FT.
ORGANIC CONTENT: 31.8%
LINEAR SHRINKAGE: 25.0%



OPTIMUM MOISTURE TEST

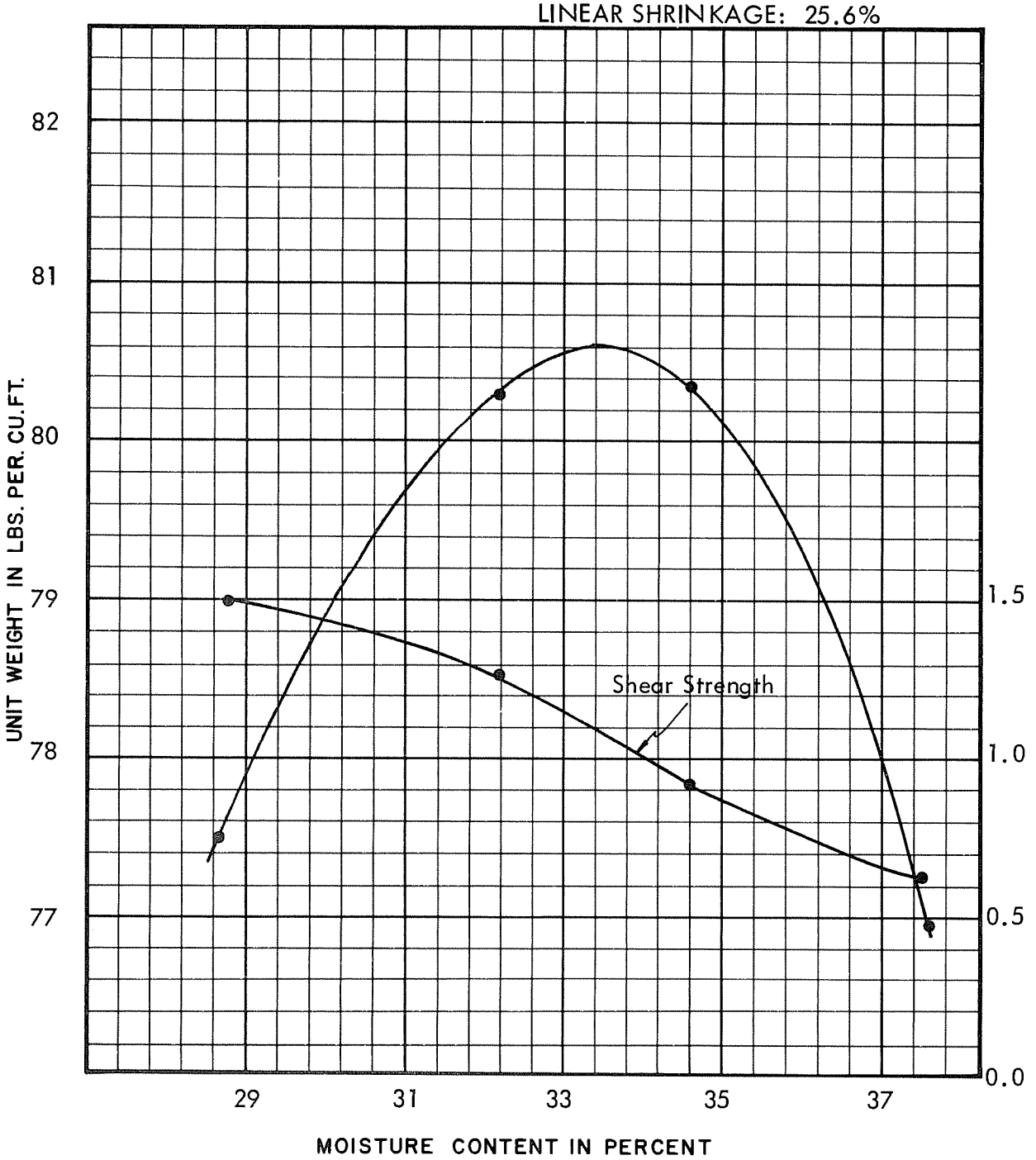
NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

PLATE 17

PROJECT: 7197
TEST METHOD: ASTM D-698
MOLD: 1/30 cu. ft.
HAMMER: 5.5#
DROP: 12"
BLOWS: 25
LAYERS: 3

SAMPLE: Composite -3.0 to -6.0
DESCRIPTION: Dark gray clay

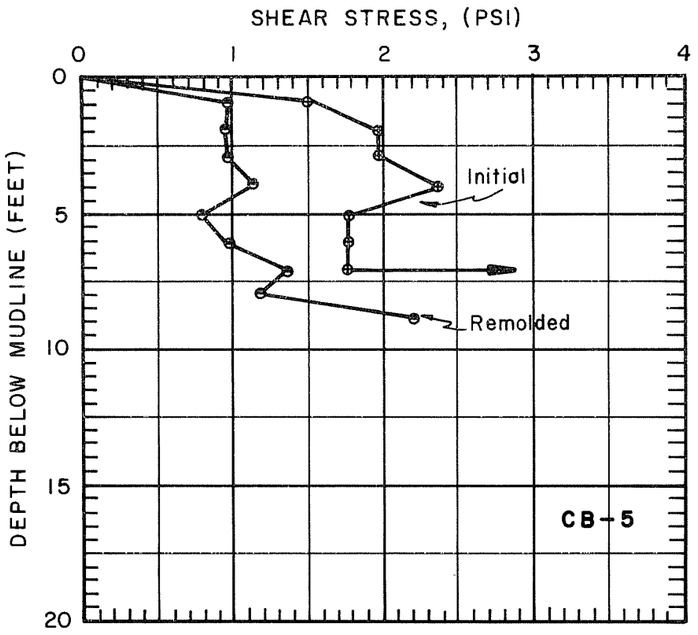
LIQUID LIMIT: 76.8
PLASTICITY INDEX: 51.2
OPTIMUM MOISTURE: 33.4 %
MAX. UNIT DRY WT: 80.6 LBS./CU.FT.
ORGANIC CONTENT: 31.0%
LINEAR SHRINKAGE: 25.6%

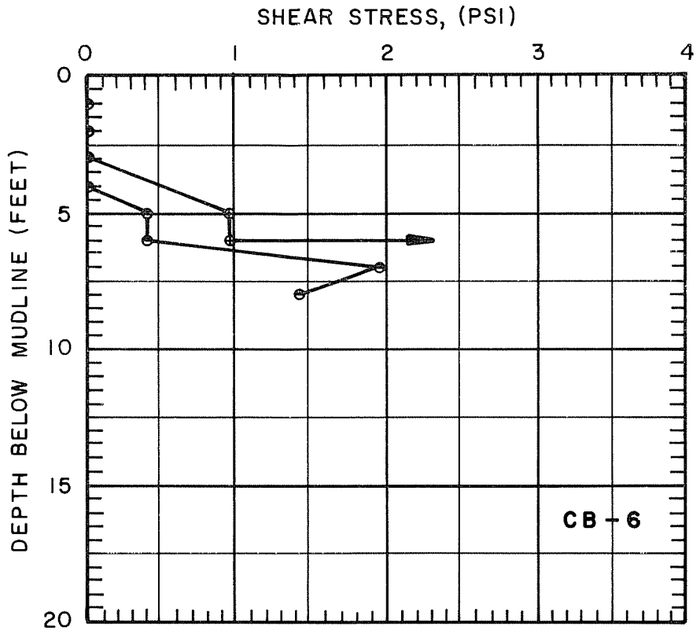


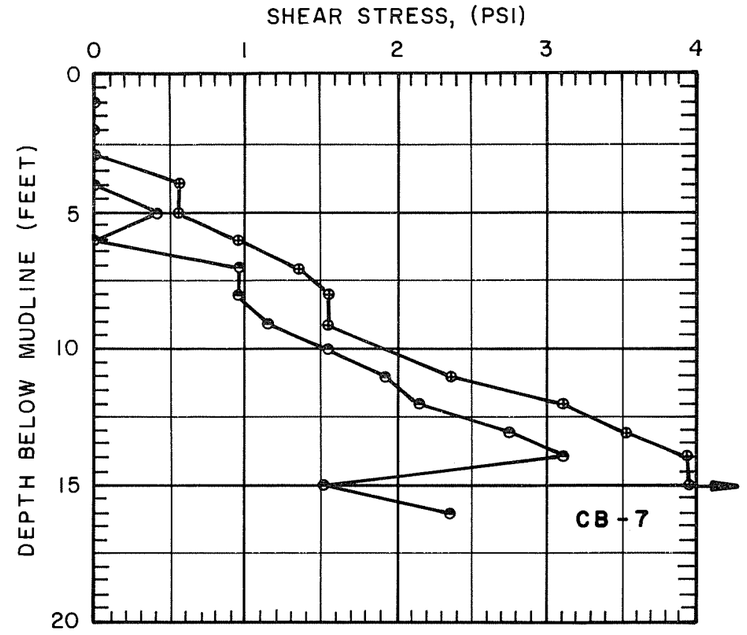
OPTIMUM MOISTURE TEST

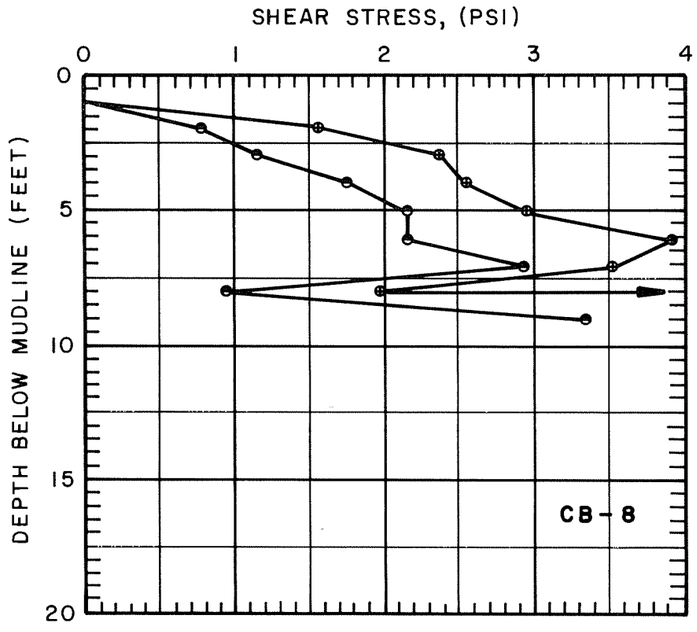
NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

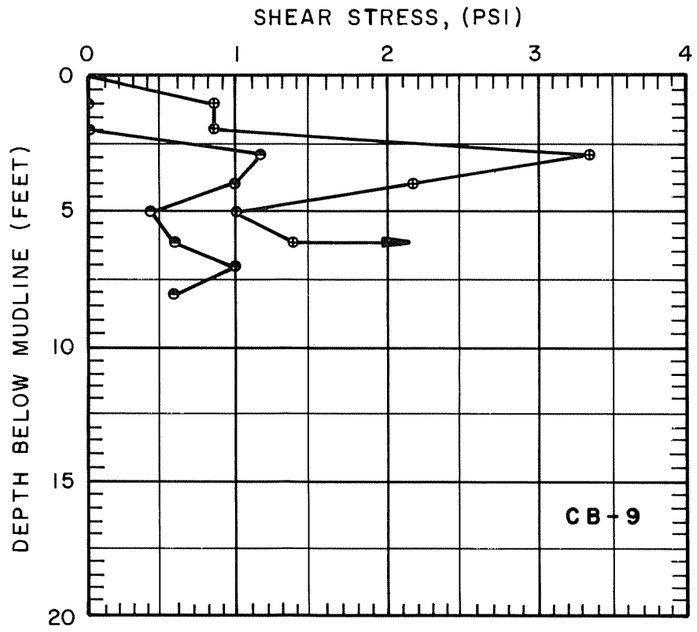
PLATE 18











SUMMARY OF RESULTS
VANE SHEAR TESTS

PLATE 19

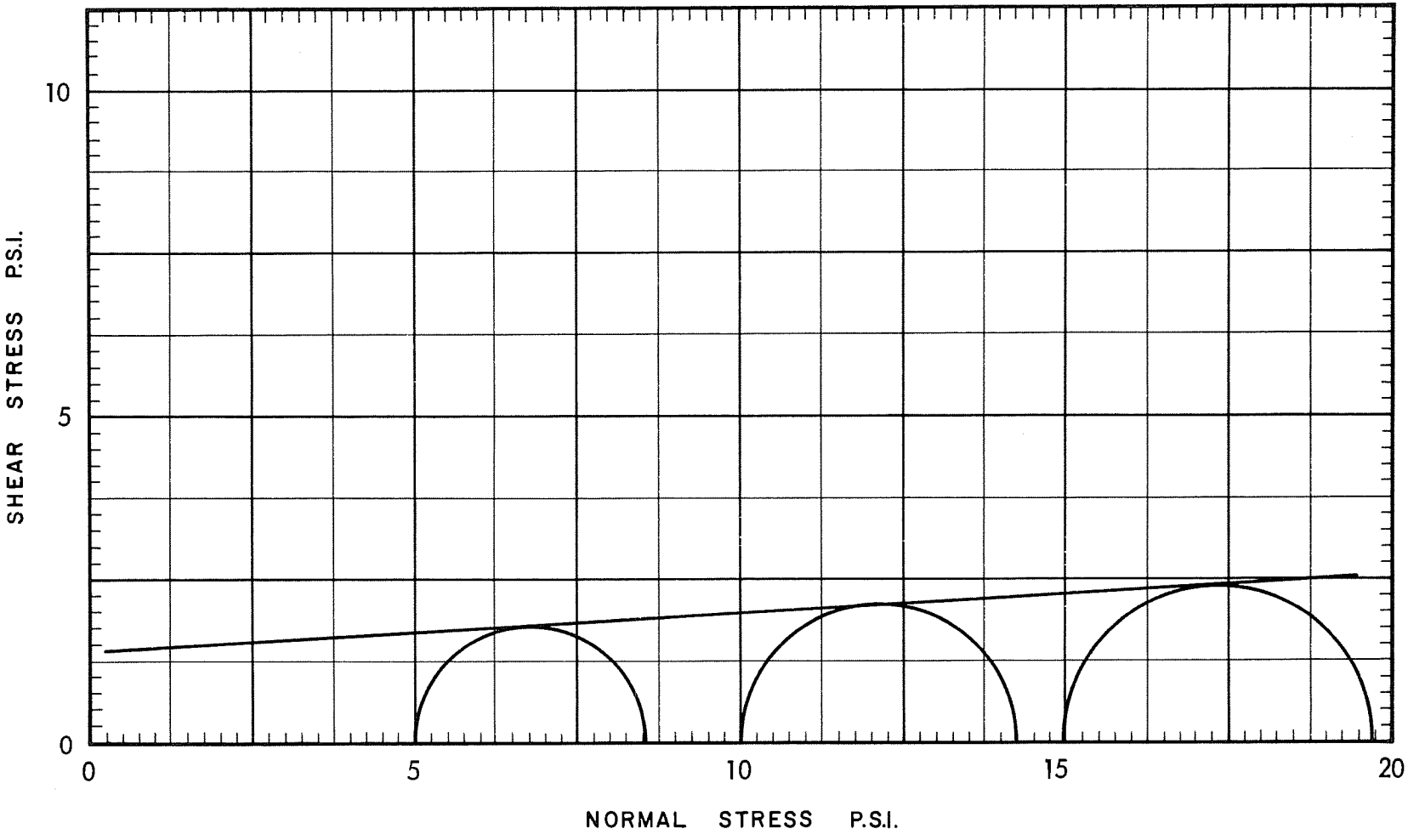
C-101-69

NATIONAL SOIL SERVICES, INC
CONSULTING ENGINEERS

BORING NO: CB-7 DEPTH: 19.0-19.5'
DESCRIPTION: Dark brown calcareous clay

ANGLE OF SHEAR: 3.0°
COHESION: c = 1.4 psi = 0.10 tsf

MOISTURE CONTENT:
BEFORE: 48.0 %, AFTER: %
UNIT DRY WT: 69.5 LBS./CU.FT.
LIQUID LIMIT:
PLASTICITY INDEX:



UNCONSOLIDATED-UNDRAINED
SHEAR TEST RESULTS

PLATE 20

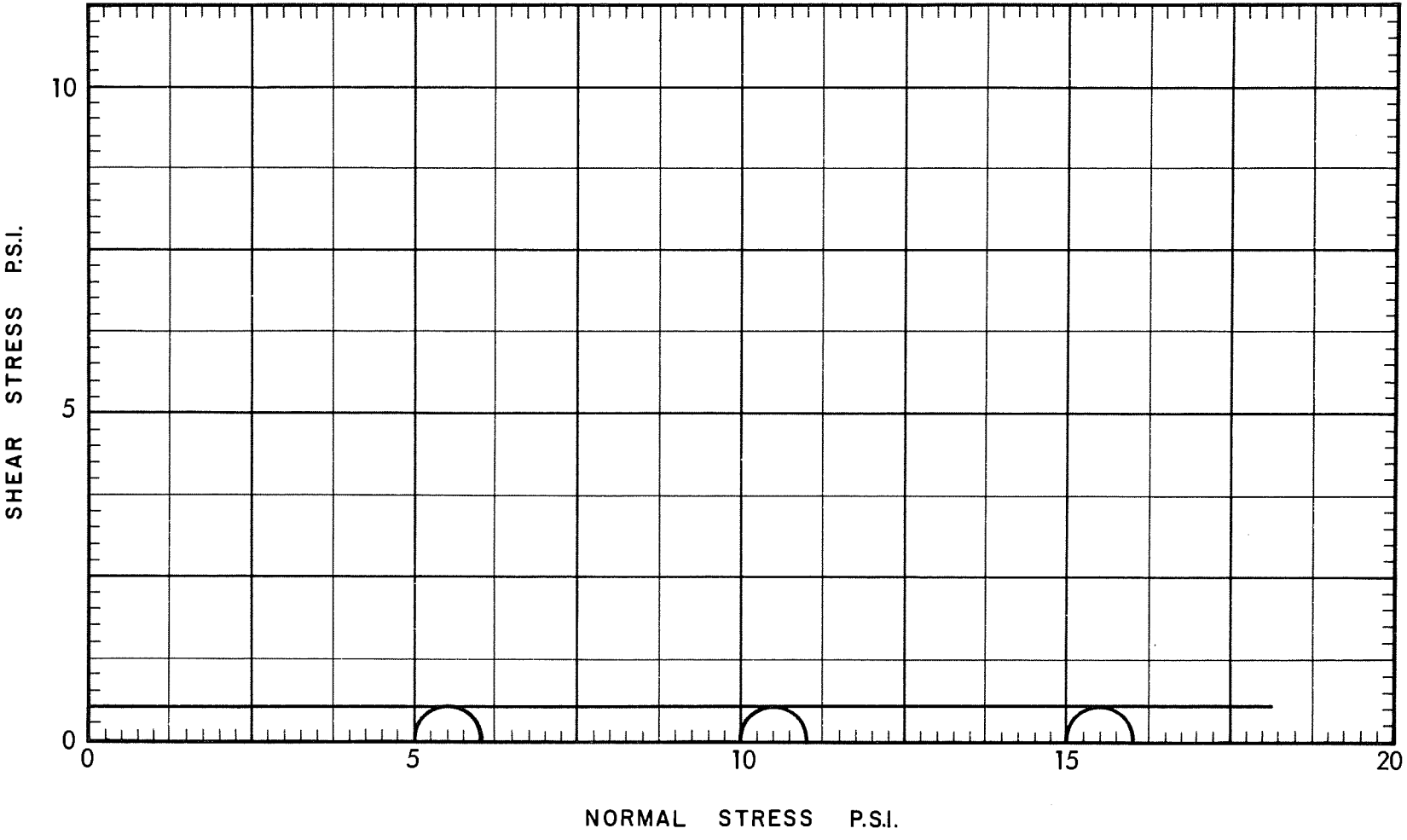
D-101-69

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

BORING NO: CB-8 DEPTH: 10.0-12.0'
DESCRIPTION: Gray clay (Remolded)

ANGLE OF SHEAR: 0.0°
COHESION: c = 0.5 psi = 0.036 psi

MOISTURE CONTENT:
BEFORE: 88.7 %, AFTER: %
UNIT DRY WT: 48.8 LBS./CU.FT.
LIQUID LIMIT:
PLASTICITY INDEX:



UNCONSOLIDATED-UNDRAINED
SHEAR TEST RESULTS

PLATE 21

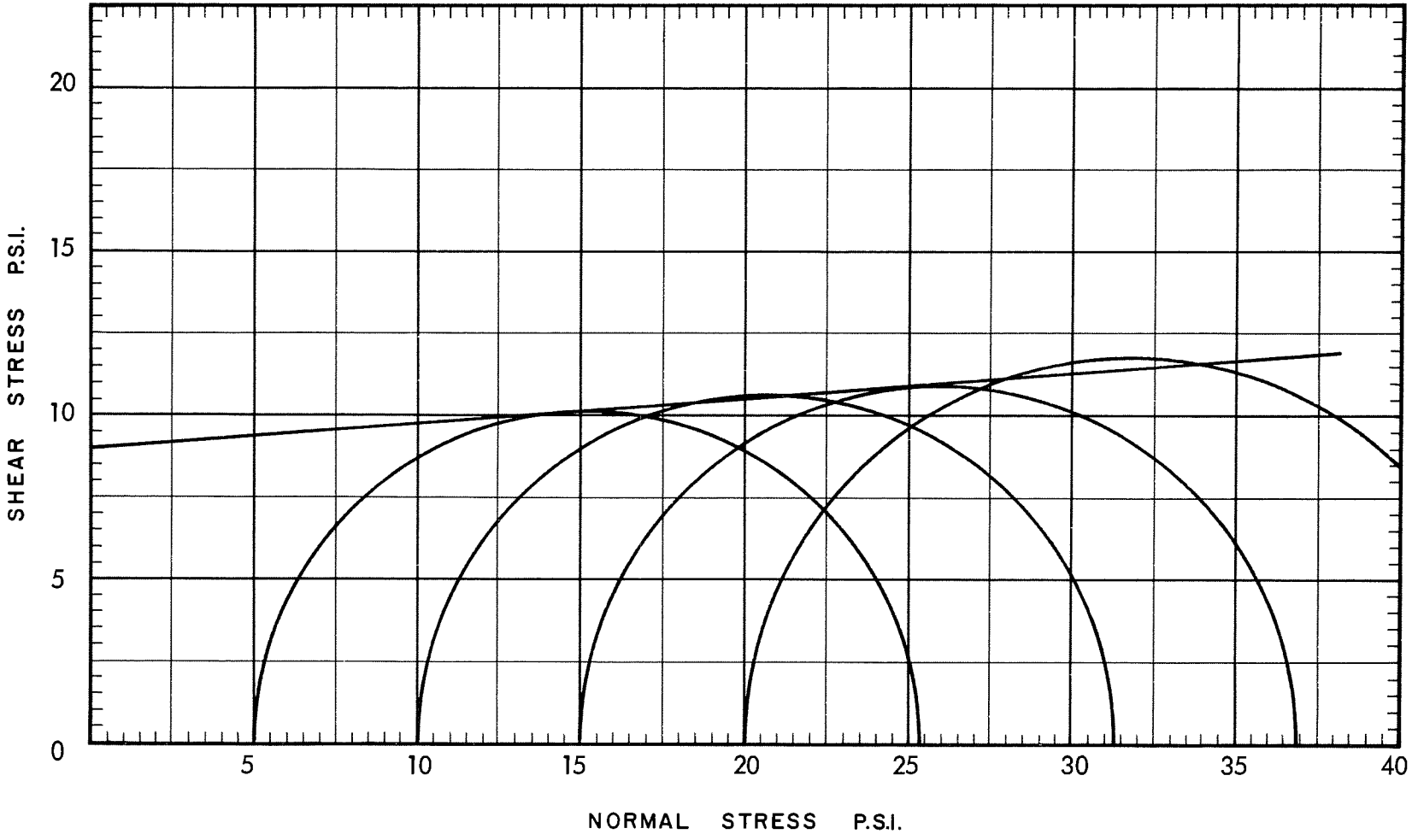
D-101-69

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

BORING NO: CB-8 DEPTH: 14.5-15.0'
DESCRIPTION: Brown clay

ANGLE OF SHEAR: 4.5°
COHESION: c = 9.0 psi = 0.648 tsf

MOISTURE CONTENT:
BEFORE: 26.4 %, AFTER: %
UNIT DRY WT: 97.8 LBS./CU.FT.
LIQUID LIMIT:
PLASTICITY INDEX:



UNCONSOLIDATED-UNDRAINED
SHEAR TEST RESULTS

PLATE 22

SUMMARY OF RESULTS
SOIL TEST REPORT
TEXAS A&M UNIVERSITY - AGRICULTURAL EXTENSION SERVICE

Boring No.	Depth	Soil Reaction (pH)	Calcium CaO #/A*	Calcium CaO Level	Organic Matter %	Organic Matter Level	Predicted Nitrogen Level	Phosphorus P_2O_5 #/A*	Phosphorus P_2O_5 Level	Potassium K_2O #/A*	Potassium K_2O Level	Magnesium Mg. #/A*	Magnesium Mg. Level	Salinity Hazard	Zinc
CB-5	Mudline to 3'	7.8	8400	VH	2.6	H	LM	7	VL	790	VH	315	H	None	H
CB-5	3-6'	7.6	8400	VH	2.7	H	LM	7	VL	810	VH	315	H	None	H
CB-6	Mudline to 3'	7.8	8400	VH	2.7	H	LM	17	VL	1040	VH	230	M	Slight	H
CB-6	3-6'	7.8	8400	VH	3.0	H	LM	5	VL	1200	VH	320	H	Slight	H
CB-7	Mudline to 3'	7.7	8400	VH	3.0	H	LM	31	VL	620	VH	240	M	Slight	H
CB-7	3-6'	7.8	8400	VH	3.2	H	LM	5	VL	1160	VH	335	H	Slight	H
CB-8	Mudline to 3'	7.9	8400	VH	3.0	H	LM	17	VL	810	VH	250	M	Slight	H
CB-8	3-6'	7.6	8400	VH	2.9	H	LM	2	VL	970	VH	325	H	Slight	H
CB-9	Mudline to 3'	7.7	8400	VH	3.1	H	LM	2	VL	850	VH	265	H	Slight	H
Composite of all Borings	Mudline to 3'	7.7	8400	VH	3.3	H	LM	7	VL	900	VH	295	H	None	H
Composite of all Borings	3-6'	7.2	8400	VH	3.4	H	LM	8	VL	900	VH	315	H	Slight	H

*The values for pounds per acre are based on testing procedures used at Texas A&M soil testing laboratories and may differ from results obtained by other procedures. The level of very low, low, etc., is more important than pounds per acre, since these levels indicate the probability of response to added plant nutrients.

REPORT ON

INVESTIGATIONS FOR IMPROVEMENT

PROGRAM FOR WHITE ROCK LAKE PARK

APPENDIX C

Excerpt, Section III - Hydrology
from 1965 Report on Drainage
Improvements Studies, Lower White Rock Creek
by Forrest and Cotton, Inc.

III - HYDROLOGY

3-01. General. The White Rock Creek watershed is within an area of relatively high intensity storm rainfall, which extends from the Gulf of Mexico through eastern Texas and western Louisiana into the Mid-Continental and High Plains states, and is subject to flood producing storms during all months of the year. However, intense storms that produce the higher peak discharges from areas the size of the White Rock Creek watershed have a greater probability of occurrence during the period from April through October.

3-02. Rainfall and Streamflow Records. Rainfall and stream flow data in the watershed are being obtained by the U. S. Geological Survey under a cooperative agreement with the City of Dallas. This program was initiated in 1961. The gaging operations include a network of 12 recording rain gages in the drainage area upstream from Greenville Avenue, four stream flow stations equipped with automatic stage recorders on White Rock Creek, and five crest-stage gages on tributary streams. Locations of these gages are shown on Plate 1, and Table 4 gives pertinent data relating to the stream gages.

3-03. Two reports have been issued by the U. S. Geological Survey on White Rock Creek floods under the cooperative program. These reports are: "Floods on White Rock Creek above White Rock Lake at Dallas, Texas," Open File No. 66, dated July 1963 and "Frequency and Extent of Flooding on Lower White Rock Creek at Dallas, Texas," Open File No. 69, dated April 1964.

TABLE 4

STREAM GAGE INFORMATION

Stream and Location	USGS Station No.	Type Gage	Drainage Area Sq. Mi.
White Rock Cr., Keller Springs Rd.	8-571	Recorder	29.4
White Rock Cr., Greenville Avenue	8-572	Recorder	66.4
White Rock Cr., White Rock Lake	8-573	Recorder	100.0
White Rock Cr., Scyene Road	8-574	Recorder	123.05
Spanky Branch, McCallum Lane	8-571.2	Crest	6.77
Cottonwood Creek, Forest Lane	8-571.4	Crest	8.50
Floyd Branch, Forest Lane	8-571.6	Crest	4.17
Ash Creek, Highland Road	8-573.2	Crest	6.92
Forney Creek, Lawnview Avenue	8-573.4	Crest	1.84

3-04. Flood History. White Rock Creek has experienced severe floods throughout the period of settlement and development of the area. Although specific flood data are available only for recent years, a reliable general flood history has been developed from various sources by the U. S. Geological Survey. The maximum flood experienced since the 1880's was that of September 20-21, 1964, while the second greatest flood occurred April 19-20, 1942. Other major floods were experienced in June 1949, July and October 1962, and floods of sufficient importance to be newsworthy occurred in April 1922, May 1946, August 1947, May 1957, November 1964 and February 1965.

3-04a. Flood of September 1964. During the latter half of September, most sections of Texas received flood-producing amounts of rainfall. On the 16th, during a period of 8 to 12 hours, the twelve rain gages in White Rock Creek above Greenville Avenue recorded rainfall ranging from 1.60 to 4.75 inches. This rain, since it fell on a relatively dry watershed, produced only minor runoff but it "primed" the watershed for high runoff yield from subsequent rainfall. Between 10 P.M., September 20 and 7 A.M., September 21, an intense storm was centered over the upper White Rock Creek watershed in Collin County. This rain, when added to the earlier catch at some of the gages, exceeded the weighing gage capacity, which required that the total rainfall at these gages be estimated. Estimated average rainfall for the 9-hour period on the drainage area above Keller Springs Road was 12.95 inches and on the area above Greenville Avenue 9.80 inches. The 100-year frequency, 9-hour rainfalls, as computed from

data included in U. S. Weather Bureau, Technical Paper No. 40, "Rainfall Frequency Atlas of the United States," for areas of equal size in the same vicinity are 7.4 and 7.2 inches, respectively. The flood produced by this intense storm inundated the USGS stage recording equipment at Keller Springs Road and caused extensive flooding throughout the drainage system. Peak discharges are listed in Table 5 and the flood profile along Lower White Rock Creek is shown on Plate 2.

3-04b. Flood of April 1942. Rainfall recorded at Weather Bureau stations in the vicinity of the watershed for April 19 and 20, 1942, is as follows: Love Field, 3.44 inches; Fort Worth, 5.19 inches; Carrollton, 7.73 inches. These are not extraordinary amounts of storm rainfall for the locality but there were unofficial reports of depths up to 12 inches in the upstream areas of White Rock Creek watershed. Two days of general thunderstorm activity preceded the main storm and established the conditions favorable for high runoff. One life was lost by drowning at the Forest Lane crossing. Newspaper accounts stated that water stages in the White Rock Creek area were reported by old-time residents as the highest in over 50 years. The elevations of high water marks for this flood in Lower White Rock Creek are shown on Plate 2.

3-04c. Flood of June 1949. The flood of June 14, 1949 was serious but is described by the USGS as having stages from 1 to 3 feet lower than those for the 1942 flood from White Rock Lake upstream. The storm that produced this flood was centered over the eastern portion of the watershed. A rainfall of 11.5 inches was reported by the City of Richardson.

3-04d. Floods of July and October, 1962. These floods have occurred since gaging operations were started in the watershed. On July 27, 1962 the area above Greenville Avenue received an average rainfall of 6.2 inches after almost 2 inches had fallen on the 26th. This storm caused flooding comparable to that experienced in June 1949. During the early morning of October 8, 1962, an intense, short duration storm occurred in the upper watershed. Rainfall averaged 4.5 inches in about 3 hours, and caused more severe flooding downstream from Forest Lane than was experienced in July 1962. Peak discharges for these floods are listed in Table 5 and the profile along Lower White Rock Creek is shown on Plate 2.

TABLE 5

FLOOD PEAK DISCHARGES
AT USGS RECORDING STREAMFLOW STATIONS
WHITE ROCK CREEK

Location	Flood Peak Discharges in c.f.s.		
	Sept. 20-21 1964	July 27-28 1962	Oct. 8 1962
	1/		
Keller Springs Road	37,900	9,410	2,360
Greenville Avenue	37,700	20,000	29,000
White Rock Lake Spillway	28,200	13,700	10,200
Scyene Road	30,200	17,400	9,300

1/ Maximum flood experienced since 1880's.

3-05. Area Flooded. Major floods inundate most of the natural floodplain of Lower White Rock Creek and overflow some streets and highways crossing the stream. Moderate to major floods overtop Garland Road and only minor floods cause inundation of properties upstream from Garland Road in the vicinity of the Loving-Winsted Drive intersection.

Between Garland Road and Samuell Boulevard, the area inundated during major floods is nearly 5,000 feet wide in the vicinity of Tenison Park and the Ash Creek confluence with White Rock Creek. From Samuell Boulevard to Scyene Road, the flooded area ranges in width from about 1,500 feet in the vicinity of the T. & P. Railroad to 4,000 feet upstream from Military Parkway. Minor to moderate floods overflow Military Parkway and Samuell Boulevard. The common floodplain of White Rock Creek and the Trinity River extends upstream to the vicinity of Scyene Road. Flooding in this area may be produced by flood flows in White Rock Creek, backwater from the Trinity River or by coincident floods on both streams. Of the total area flooded, amounting to about 4,410 acres, Dallas owns 740 acres, or about 17 percent. Above Scyene Road, Dallas owns 404 acres out of a total flooded area of 1,058 acres, or about 38 percent. The limits of flooding from an estimated 100-year flood under existing conditions, which is discussed in paragraph 3-15, is shown in red on Plates 5 thru 26. The profile for this flood is shown on Plate 2. The following table gives the area flooded in selected reaches, broken down between property owned by the City of Dallas and by others.

AREA FLOODED, WHITE ROCK CREEK
DOWNSTREAM FROM WHITE ROCK DAM

Stream Reach	Area Flooded in Acres		
	City of Dallas	Owned by Others	Total Area
1. White Rock Dam to Garland Rd.	59	27	86
2. Garland Rd. to G. C. & S. F. R.R.	49	67	116
3. G. C. & S. F. R.R. to Samuell Blvd.	245	70	315
4. Samuell Blvd. to Mil. Parkway	0	234	234
5. Mil. Parkway to T. & P. R.R.	3	98	101
6. T. & P. R.R. to Scyene Rd.	48	158*	206
7. Scyene Rd. to Second Ave.	0	1,668	1,668
8. Second Ave. to Hawn Fwy.	14	367	381
9. Hawn Fwy. to Trinity River	322±	981±	1,303±
	740	3,670	4,410

*Most of area owned by Dallas Power and Light Co.

3-06. Effects of Urbanization on Flood Hydrology. It is generally recognized that a watershed will produce higher flood discharges under urban development than under natural conditions. This increase will vary with conditions and types of watersheds and reliable evaluation requires adequate data. The investigation of rainfall and runoff now in progress may, within a few years, provide such data for White Rock Creek conditions. The principal hydrologic factors that are modified by urban development are watershed infiltration and hydraulic efficiency of the overall drainage system.

3-06a. Infiltration. Urban development converts significant portions of the land area into impervious surfaces such as streets, driveways, roofs and parking areas. This results in decreased watershed infiltration which increases runoff during storm periods.

3-06b. Hydraulic Effects. When an area is developed, the channels comprising the drainage system are usually modified and in some cases the modifications result in a more dense drainage network. Hydraulic efficiency of the upland portions of the drainage system are normally improved by storm sewers and by other changes. Improvements may also be made in the primary and secondary channels. Such changes improve hydraulic efficiency of the overall drainage system and speed up the movement of runoff to various points in the system.

3-07. Unit Hydrograph Determinations. Analyses to develop unit hydrograph characteristics were based on Snyder's empirical relationships for synthetic unit hydrographs. The following equations were used:

$$t_p = C_t (LL_{ca})^{0.3}$$

$$t_r = \frac{t_p}{5.5}$$

$$t_{pR} = t_p + 0.25 (t_R - t_r)$$

$$q_{pR} = \frac{640 C_p}{t_{pR}}$$

$$Q_p = q_p A$$

t_p = lag time from midpoint of unit duration, t_r, to peak of unit hydrograph in hours.
t_r = unit rainfall duration, general, hours.
t_R = unit rainfall duration, adopted for a given study, hours.
t_{pR} = lag time from midpoint of unit duration, t_R, hours.
q_{pR} = peak discharge of unit, hydrograph for unit duration t_R, cfs per sq. mi.
Q_p = peak discharge of unit hydrograph for unit duration, t_R, cfs.

L = stream miles from a given point to the upstream divide of the drainage area, miles.
L_{cg} = stream miles from a given point to the center of gravity of the drainage area, miles.
A = drainage area above a given point, sq. mi.
C_t and C_p = coefficients that depend on the characteristics of the watershed and its drainage system.

Rainfall and runoff data at the Keller Spring Road and Greenville Avenue gaging stations were used in the unit hydrograph analyses. Close inspection of the recorded flood hydrographs and the storm rainfall data led to the selection of 0.5 hr. as the unit duration, t_R, for use in the analyses at each station.

3-08. Records at the Keller Springs Road gage include data for two flood periods for which the runoff-producing rainfall was fairly uniform over the watershed and of relatively short duration. Since the limits of both the rainfall and stage recorders were exceeded by the September 20-21, 1964 flood event, reliable unit hydrograph analyses could not be made for that flood. Floods analysed were those of September 27, 1964 and July 27, 1962. Each of these hydrographs has a single peak and consistent rising and falling limbs. On September 27, 1964, rainfall on the watershed amounted to 1.8 inches from 4 A.M. to 10 A.M., producing an excess of 0.77 inch during the two-hour period from 6 A.M. to 8 A.M. On July 27, 1962, rainfall on the watershed amounted to 5.95 inches between 4 A.M. and 2 P.M., which produced excess rainfall of 2.36 inches during the two-hour period from 5 A.M. to 7 A.M. The unit hydrograph developed from the analyses of these floods is shown on Figure 2, Plate 3. Derived values of C_t and 640 Cp

are 0.71 and 443, respectively. A comparison between the September 27, 1964 recorded hydrograph and the hydrograph produced from the derived unit hydrograph and recorded rainfall is shown on Figure 1, Plate 3.

3-09. Attempts to derive unit hydrographs with consistent characteristics from available storm and flood flow data at the Greenville Avenue gage were unsuccessful. This gage records stages at the downstream side of the main channel bridge. Minor floods overflow the road across the wide floodplain on the left and several hundred feet north of the bridge when the stage at the gage is relatively low. It is doubtful that there is a consistent or reliable relationship between stage at the gage and total discharge when the road is overtopped.

3-10. Another factor having a bearing on unit hydrograph analyses of hydrographs recorded at the Greenville Avenue gage is Cottonwood Creek which enters White Rock Creek about one mile upstream. It has a drainage area of 12.8 square miles which represents almost 20 percent of the total area above the gage. Flood flows originating on Cottonwood Creek often peak at Greenville Avenue sooner than flows from the main stem, causing some hydrographs at the Greenville Avenue gage to have dual peaks. Therefore, unit hydrographs derived at this gage from different floods can be expected to vary and have characteristics that depend more on the timing and areal distribution of rainfall than on watershed characteristics. The derived value of C_t=0.84 at this station is considered valid. However, of the flood hydrographs analysed, that of September 27, 1964 was single crested and that of July 27, 1962 was double crested.

3-11. Adopted Unit Hydrograph Characteristics. Preparation of the improvement plan for White Rock Creek required flood discharge determinations at various locations for both existing and urban developed conditions. In order to meet this requirement, the basic unit hydrograph dimensions have been defined so as to facilitate the computation of a unit hydrograph at any desired location and for either of the specified watershed conditions.

3-11a. Lag. Values of Snyder's term, $(LLca)^{0.3}$ for selected locations on White Rock Creek were measured from topographic maps. The relationship between these values and contributing drainage area is shown graphically on Figure 4, Plate 3. The relationship between Snyder's constant, C_t, and drainage area, based on the previously discussed C_t values at Keller Springs Road and Greenville Avenue of 0.71 and 0.84, respectively, is also shown on Figure 4, Plate 3. By use of values of C_t and $(LLca)^{0.3}$ scaled from Figure 4 for various drainage areas, lag (tp) values, representing existing channel and watershed conditions, were computed to produce the curve of tp versus drainage area shown on Figure 4. Factual material is not available at this time covering the effect that watershed urbanization of a watershed will have on flood peak discharges, or on lag time (tp). The curve for lag (tp) under developed watershed conditions, shown on Figure 4, Plate 3, was based on the judged decision that future lag will vary from 0.80 of present lag in the vicinity of Keller Springs Road to 0.75 of present lag at Northwest Highway. For tributary streams, C_t=0.5 was adopted, based on studies made on Turtle Creek in Dallas by the Corps of Engineers. Figure 5, Plate 3 shows the relationship between $(LLca)^{0.3}$, lag (tp) and drainage area that was developed for tributary streams.

3-11b. Peak Discharge. The coefficient C_p, under Snyder's method, is used to empirically relate peak discharge of a unit hydrograph to watershed characteristics. Hydrograph analyses at Keller Springs Road established the value of $640C_p=443$, which is considered reliable. Further gagings are necessary to define C_p at the Greenville Avenue station, but presently available data indicate a $640C_p$ value in the range from 450 to 500. In view of these findings, Snyder's equation is modified to express Q_p in terms of $(t_{pR}+0.25)$, time to peak of the unit hydrograph, and to provide for variation in C_p, as follows:

$$Q_p = \frac{640\ C_pA}{t_{pR}} = \frac{KA}{(t_{pR}+0.25)}$$

The constant, K = 484, is evaluated on the basis of $t_{pR}= 2.75$ and $640\ C_p=443$ at Keller Springs Road, and maintains Snyder's general, empirical relationship. Thus, the peak discharge of the adopted unit hydrograph is:

$$Q_p = \frac{484A}{(t_{pR}+0.25)}$$

The features of the adopted unit hydrograph are shown graphically on Figure 3, Plate 3. The range of variation of $640\ C_p$ along White Rock Creek that results from use of the above equation for Q_p is illustrated by the following table in which the lag, t_{pR}, is for existing watershed conditions.

Location	Drainage Area Sq. Mi.	Lag t_{pR} hrs.	$640C_p$	Q_p cfs
Keller Springs Road	29.4	2.75	443	4740
Greenville Avenue	66.4	4.25	457	7140
Northwest Highway (Loop 12)	83.0	5.00	461	7650

3-11c. Shape. The adopted unit hydrograph, plotted in dimensionless coordinates, is shown on Figure 3, Plate 3. This hydrograph is identical in shape to the 0.5 hr. unit hydrograph developed from data at the Keller Springs Road gage. At discharges of 50 and 75 percent of the peak discharge the widths of the hydrograph are 0.72 (t_{pR} +0.25) and 1.14 (t_{pR} +0.25).

3-12. Rainfall and Runoff. To establish a consistent basis for flood computations at various locations and for existing and urban developed conditions, runoff estimates have been based on watershed rainfall for selected frequencies.

3-13. Depths of rainfall on the 136-square mile watershed for a 12-hour duration and 25- 50-and 100-year frequencies were estimated from data in U. S. Weather Bureau, Technical Paper No. 40, "Rainfall Frequency Atlas of the United States," dated May 1961. These amounts of rainfall, distributed so as to place the higher rates of rainfall near the central portion of the 12-hour duration, which is typical of short and medium duration storms, are listed in Table 6, and histograms for these storms are shown in Figure 6, Plate 3.

3-14. General knowledge and experience relating to Blackland soils under agricultural use indicates watershed infiltration rates in the order of 0.10 inches per hour with field moisture at capacity levels and 0.15 to 0.20 inches per hour with average field moisture. Rainfall and runoff measurements on White Rock Creek have not covered a wide enough range of conditions to permit firm estimates of water-

TABLE 6

WHITE ROCK CREEK WATERSHED
RAINFALL, LOSSES AND RAINFALL-EXCESS
25-,50-,100-YEAR STORMS, 12-HOUR DURATION

1/2-Hr. Period	Rainfall			Losses		Rainfall Excess Existing Condition			Rainfall Excess Urban Condition		
	25yr. in.	50yr. in.	100yr. in.	Existing Condition in. 1/	Urban Condition in. 2/	25yr. in.	50yr. in.	100yr. in.	25yr. in.	50yr. in.	100yr. in.
1	0.09	0.11	0.12	0.38	0.24	0	0	0	0	0	0
2	0.11	0.11	0.13	0.21	0.16	0	0	0	0	0	0
3	0.11	0.13	0.16	0.16	0.10	0	0	0	0	0	0
4	0.13	0.14	0.16	0.12	0.08	0	0	0	0	0	0
5	0.14	0.16	0.18	0.11	0.07	0	0	0	0	0	0.10
6	0.16	0.17	0.20	0.10	0.06	0	0	0	0.03	0.11	0.14
7	0.19	0.22	0.24	0.09	0.06	0	0	0.02	0.13	0.16	0.18
8	0.23	0.26	0.30	0.08	0.06	0	0.05	0.22	0.17	0.20	0.24
9	0.26	0.30	0.35	0.08	0.06	0.09	0.22	0.27	0.20	0.24	0.29
10	0.36	0.40	0.46	0.08	0.06	0.28	0.32	0.38	0.30	0.34	0.40
11	0.41	0.46	0.53	0.08	0.06	0.33	0.38	0.45	0.35	0.40	0.47
12	0.60	0.67	0.77	0.08	0.06	0.52	0.59	0.69	0.54	0.61	0.71
13	0.72	0.81	0.93	0.08	0.06	0.64	0.73	0.85	0.66	0.75	0.87
14	0.56	0.62	0.72	0.08	0.06	0.48	0.54	0.64	0.50	0.56	0.66
15	0.36	0.41	0.47	0.08	0.06	0.28	0.33	0.39	0.30	0.35	0.41
16	0.28	0.32	0.37	0.08	0.06	0.20	0.24	0.29	0.22	0.26	0.31
17	0.24	0.26	0.30	0.08	0.06	0.16	0.18	0.22	0.18	0.20	0.24
18	0.18	0.20	0.24	0.08	0.06	0.10	0.12	0.16	0.12	0.14	0.18
19	0.16	0.18	0.20	0.08	0.06	0.08	0.10	0.12	0.10	0.12	0.14
20	0.14	0.16	0.19	0.08	0.06	0.06	0.08	0.11	0.08	0.10	0.13
21	0.14	0.16	0.18	0.08	0.06	0.06	0.08	0.10	0.08	0.10	0.12
22	0.12	0.14	0.16	0.08	0.06	0.05	0.06	0.08	0.06	0.08	0.10
23	0.12	0.13	0.15	0.08	0.06	0.04	0.06	0.08	0.06	0.07	0.09
24	0.12	0.13	0.15	0.08	0.06	0.04	0.05	0.07	0.06	0.07	0.09
TOTALS	5.93	6.65	7.66	2.52	1.79	3.41	4.13	5.14	4.14	4.86	5.87

1/ Initial Retention 0.6 in., infiltration 0.16 in./hr.
2/ Initial Retention 0.35 in., infiltration 0.12 in./hr.

shed infiltration rates. During the September 27, 1964 runoff period, when field moisture level is considered to have been about average, the approximate infiltration rates were 0.14 and 0.17 inches per hour above Greenville Avenue and Keller Springs Road, respectively. Runoff estimates for this investigation have been based on the following:

Watershed	Initial Retention	Average Infiltration
Existing Condition	0.60 in.	0.16 in. per hr.
Urban Developed	0.35 in.	0.12 in. per hr.

Losses for existing and urban conditions, and estimated rainfall excess by 0.5 hr. unit duration periods for the 25 - 50-and 100-year storms are listed in Table 6.

3-15. Flood Peak Discharge-Frequency Determinations. Synthetic ½-hour unit hydrographs for conditions of both existing and urbanized watersheds were constructed in the manner described in paragraph 3-11 for flow at the head of White Rock Lake, for tributary lake inflow, and for incremental runoff from the area between White Rock Dam and Samuell Boulevard, the T. & P. Railroad, and Scyene Road. Rainfall-excess values given in Table 6 were applied to the synthetic unit hydrographs to produce flood hydrographs for each of the selected areas. The total inflow to White Rock Lake was computed by adding the ordinates of the flood hydrographs at head of the lake to the tributary inflow and the rainfall on the lake surface. The flood hydrographs were then routed through the White Rock Spillway, as appropriate, with spillway in either existing condition or modified as described in the Project Plan, to produce hydrographs at the Garland Road bridge. These hydrographs were

then adjusted for time of travel downstream and combined with hydrographs developed for the downstream areas to produce hydrographs at the selected locations. Flood peaks indicated by this series of computations are given in Table 7. The 100-year flood, existing condition watershed, was used as the basis for delineation of the area subject to flooding under existing conditions shown on the Project Plan drawings.

3-16. Peak inflows and outflows for White Rock Lake given in Table 7 show that the lake materially reduces the peak discharges of floods. Reduction downstream from the lake is due to two factors. First, spillway storage acts to make peak outflow considerably less than peak inflow and delays outflow in relation to inflow. Second, the reduced and delayed outflow hydrograph reaches downstream locations after local inflows to the stream have started to recede. As a result of these actions, peak discharges at downstream locations, shown in Table 7, are less than peak inflows to the lake and are not appreciably greater than peak outflows from the lake.

3-17. Design Discharges. Channel improvements proposed for Lower White Rock Creek are discussed in Section V. The design discharges in the different reaches are listed in Table 8. Conditions in the two lower reaches, which are discussed in paragraph 5-02, cause the design to be based on considerations other than specific discharge capacity.

TABLE 7

LOWER WHITE ROCK CREEK
PEAK DISCHARGES FOR SELECTED STORM RAINFALL FREQUENCIES

Rainfall Frequency	Watershed Condition 3/	White Rock Lake Peak Inflow cfs	White Rock Lake Peak Outflow cfs	Flood Peak Discharges in cfs Samuell Blvd.	T. & P. R.R.	Scyene Rd.
100	Developed	46,720	2/35,430	36,920	37,370	38,500
50	Developed	39,370	2/29,030	30,450	30,800	31,710
25	Developed	34,120	2/24,540	25,910	26,200	26,950
100	Existing	34,900	1/26,190	26,710	26,830	27,100

1/ Existing spillway
2/ Spillway improved, see Section IV
3/ Distinguishes between existing channel and watershed conditions, and urban developed watershed conditions with modified channels.

TABLE 8

DESIGN DISCHARGES 1/

Reach	Channel 2/ cfs	Floodway 3/ cfs
Garland Road-Samuell Boulevard	25,910	36,920
Samuell Boulevard-T. & P. Railroad	26,200	37,370
T. & P. Railroad-Scyene Road	4/	38,500
Scyene Road-Trinity River	5/	5/

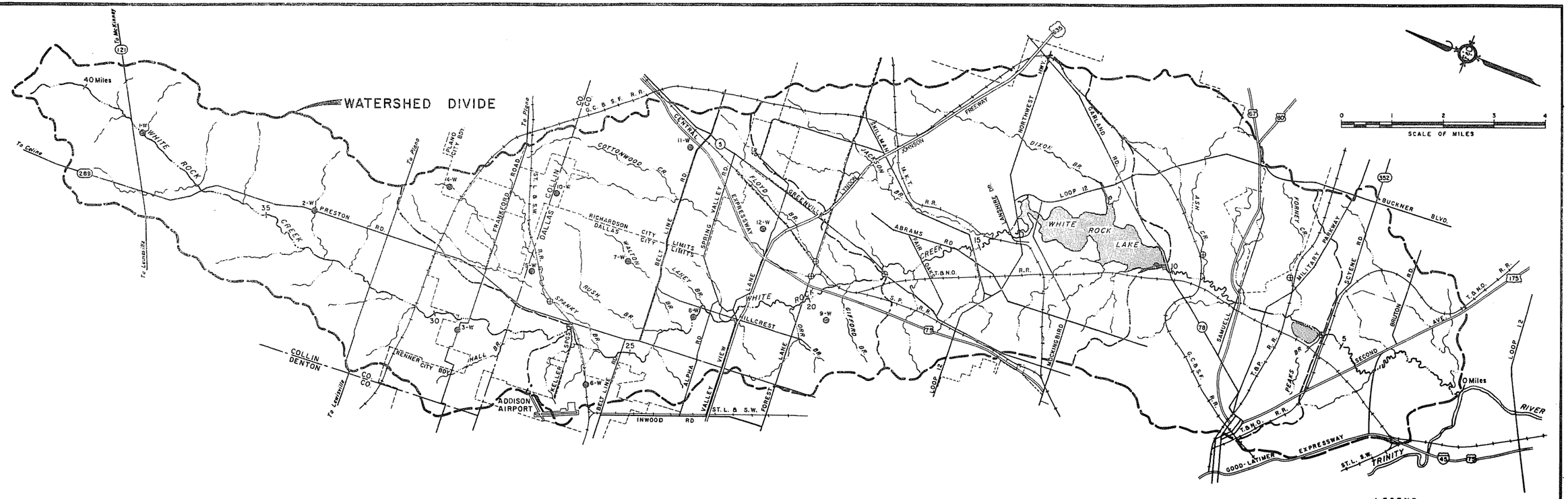
1/ Estimated for urban developed watershed conditions and improved channels.

2/ Flood produced by 12-hour, 25-year rainfall.

3/ Flood produced by 12-hour, 100-year rainfall.

4/ Channel capacity varies and depends on Trinity River stage.

5/ Flooding and flood stages in this reach depend primarily on Trinity River conditions.



DRAINAGE AREAS
WHITE ROCK CREEK
DALLAS, TEXAS

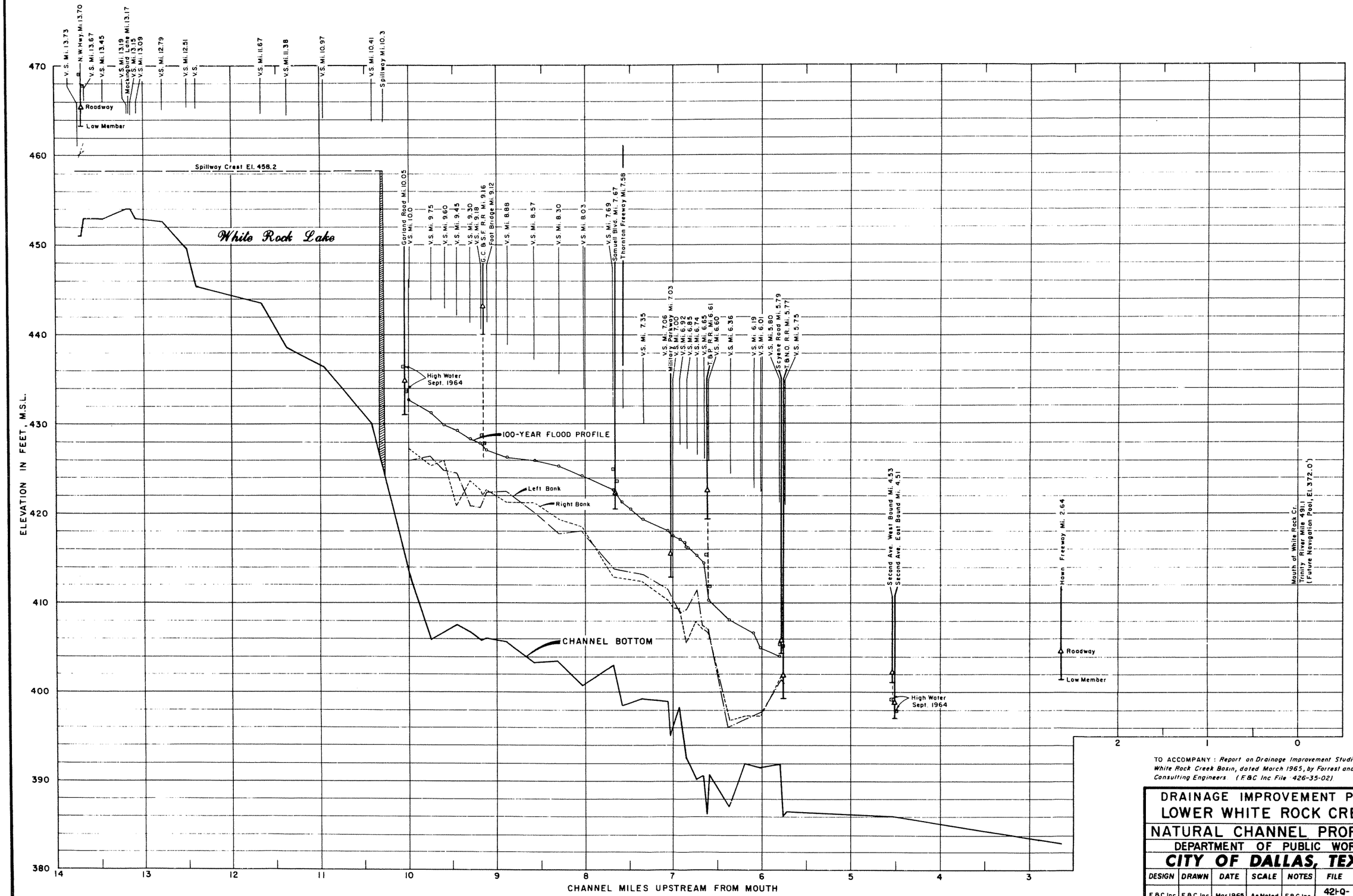
POINT OF MEASUREMENT	DRAINAGE AREA IN SQ.MI. COMPONENT	DRAINAGE AREA IN SQ.MI. TOTAL	CHANNEL MILE ABOVE MOUTH
SOURCE		0	41.22
FRANKFORD ROAD BRIDGE	25.50	25.50	29.29
DALLAS - COLLIN CO. LINE	1.10	26.60	28.27
DALLAS CITY BOUNDARY	0	26.60	28.27
ABOVE MOUTH OF HALL BRANCH	.20	26.80	27.82
BELOW MOUTH OF HALL BRANCH	2.20	29.00	27.82
KELLER SPRINGS RD. BR. (USGS GAGE B-571)	.40	29.40	26.72
ST. LOUIS & S.W. RAILROAD BRIDGE	1.10	30.50	26.18
ABOVE MOUTH OF SPANKY BRANCH	.50	31.00	25.77
BELOW MOUTH OF SPANKY BRANCH	7.00	38.00	25.77
BELT LINE ROAD BRIDGE	.70	38.70	25.17
PRESTON ROAD BRIDGE	1.50	40.20	24.28
ABOVE MOUTH OF RUSH BRANCH	.20	40.40	23.90
BELOW MOUTH OF RUSH BRANCH	2.61	43.01	23.90
ABOVE MOUTH OF WALTON BRANCH	.17	43.18	23.52
BELOW MOUTH OF WALTON BRANCH	1.42	44.60	23.52
ABOVE MOUTH OF LANEY BRANCH	.50	45.10	22.75
BELOW MOUTH OF LANEY BRANCH	.44	45.54	22.75
ALPHA ROAD	.26	45.80	22.59
VALLEY VIEW ROAD BRIDGE	1.40	47.20	21.91
ABOVE MOUTH OF ORR BRANCH	1.10	48.30	20.33
BELOW MOUTH OF ORR BRANCH	2.01	50.31	20.33
FOREST LANE BRIDGE	.29	50.60	20.16
NORTH CENTRAL EXPRESSWAY BRIDGE	.40	51.00	19.60
ABOVE MOUTH OF COTTONWOOD CREEK	.25	51.25	19.25
BELOW MOUTH OF COTTONWOOD CREEK	12.80	64.05	19.25
T. AND N.O. RAILROAD BRIDGE	.05	64.10	19.17
ABOVE MOUTH OF GIFFORD BRANCH	.11	64.21	18.90
BELOW MOUTH OF GIFFORD BRANCH	1.29	65.50	18.90
GREENVILLE AVENUE BRIDGE (USGS GAGE B-572)	.90	66.40	18.07
FAIR OAKS AVENUE BRIDGE	3.60	70.00	16.72
ABRAMS ROAD BRIDGE	2.87	72.87	15.74
SKILLMAN ROAD BRIDGE	.23	73.10	15.15
M.K. AND T. RAILROAD BRIDGE	.00	82.30	14.56
ABOVE MOUTH OF JACKSON BRANCH	.38	73.48	14.53
BELOW MOUTH OF JACKSON BRANCH	8.82	82.30	14.53
NORTHWEST HIGHWAY (LOOP 12) BRIDGE	.70	83.00	13.70
HEADWATERS WHITE ROCK LAKE	0	83.00	13.70

DRAINAGE AREAS (CONTINUED)

POINT OF MEASUREMENT		DRAINAGE AREA IN SQ. MI. COMPONENT	DRAINAGE AREA IN SQ. MI. TOTAL	CHANNEL MILE ABOVE MOUTH
WHITE ROCK LAKE:				
DIXON BRANCH	6.90			
TRIBUTARY TO LAKE	8.44			
LAKE SURFACE	1.66			
	17.00			
WHITE ROCK LAKE DAM		17.00	100.00	10.3
GARLAND ROAD BRIDGE		0.64	100.64	10.05
A.T. AND S.F. RAILROAD BRIDGE		0.55	101.19	9.15
ABOVE MOUTH OF ASH CREEK		.01	101.20	9.06
BELOW MOUTH OF ASH CREEK		7.00	108.20	9.06
SAMUELL BLVD. BRIDGE		2.13	110.33	7.67
ABOVE MOUTH OF TRIBUTARY FROM EAST		.09	110.42	7.51
BELOW MOUTH OF TRIBUTARY FROM EAST		1.76	112.18	7.51
MILITARY PARKWAY BRIDGE		.77	112.95	7.30
T. & P. RAILROAD BRIDGE		.25	113.20	6.61
ABOVE MOUTH OF FORNEY BRANCH		.64	113.84	6.44
BELOW MOUTH OF FORNEY BRANCH		2.05	115.89	6.44
ABOVE MOUTH OF PEAKS BRANCH		.84	116.73	5.80
BELOW MOUTH OF PEAKS BRANCH		6.30	123.03	5.80
SCYENE ROAD BRIDGE		.02	123.05	5.79
T. & N. O. RAILROAD BRIDGE		.20	123.25	5.77
SECOND AVENUE BRIDGE		7.70	130.95	4.50
CONFLUENCE, WHITE ROCK CREEK WITH TRINITY RIVER @ MILE 493.0		5.05	136.00	0

TO ACCOMPANY: *Report on Drainage Improvement Studies, Lower White Rock Creek Basin, dated March 1965, by Forrest and Cotton, Inc., Consulting Engineers.* (F.B.C. Inc File 426-35-01)

DRAINAGE IMPROVEMENT PLAN LOWER WHITE ROCK CREEK						
WATERSHED MAP						
DEPARTMENT OF PUBLIC WORKS						
CITY OF DALLAS, TEXAS						
DESIGN	DRAWN	DATE	SCALE	NOTES	FILE	PLATE NUMBER
F.B.C. Inc	F.B.C. Inc.	Mar. 1965	As Noted	F.B.C. Inc	426-1500	1



TO ACCOMPANY : *Report on Drainage Improvement Studies, Lower White Rock Creek Basin, dated March 1965, by Forrest and Cotton, Inc., Consulting Engineers (F.&C. Inc. File 426-35-02)*

DRAINAGE IMPROVEMENT PLAN
LOWER WHITE ROCK CREEK
NATURAL CHANNEL PROFILES
DEPARTMENT OF PUBLIC WORKS
CITY OF DALLAS, TEXAS

DESIGN	DRAWN	DATE	SCALE	NOTES	FILE	PLATE NUMBER
F.&C. Inc	F.&C. Inc	Mar. 1965	As Noted	F.&C. Inc	426-1500	2

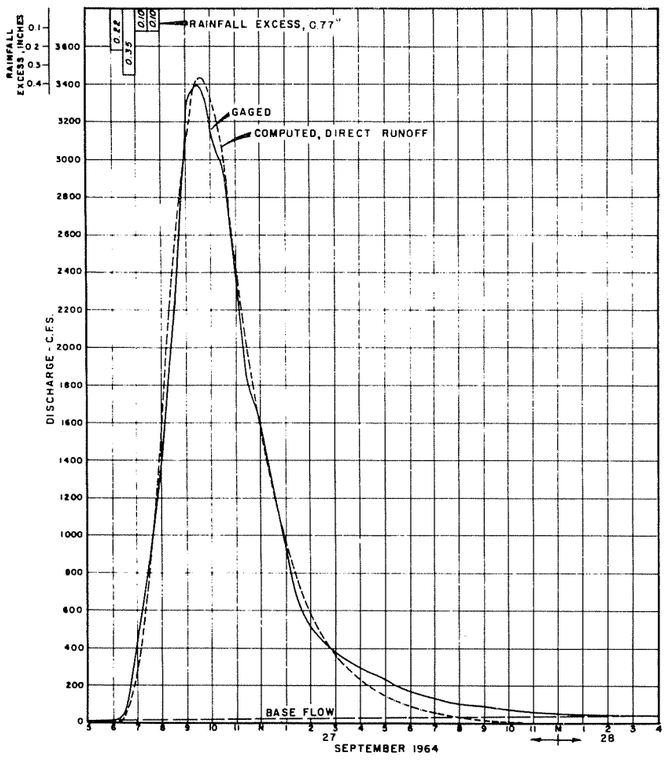


FIG. 1 GAGED AND COMPUTED HYDROGRAPHS, SEPTEMBER 27, 1964 KELLER SPRINGS ROAD.

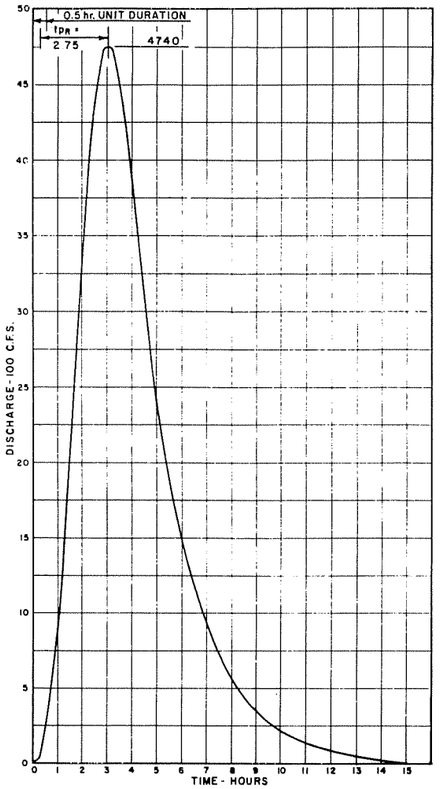


FIG. 2 UNIT HYDROGRAPH, KELLER SPRINGS ROAD

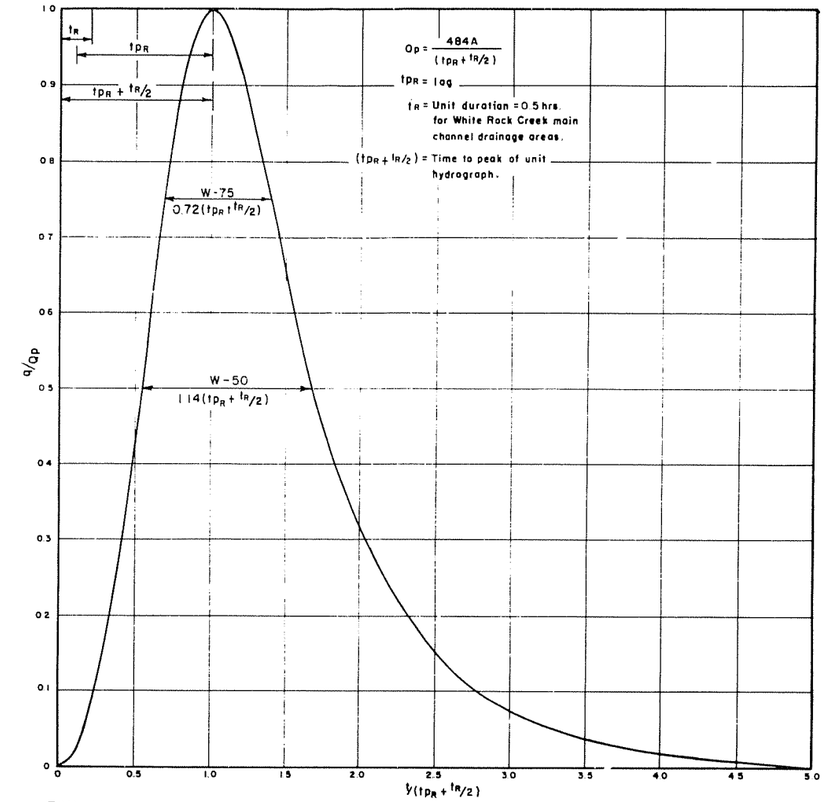


FIG. 3 DIMENSIONLESS UNIT HYDROGRAPH

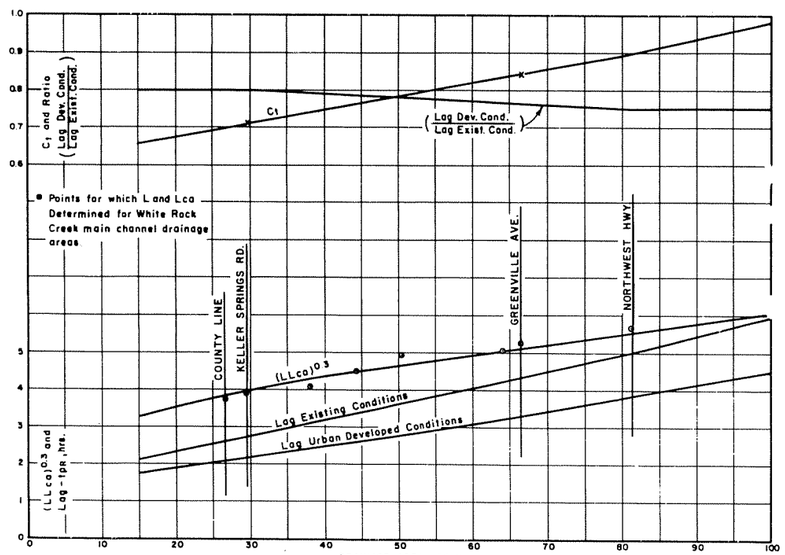


FIG. 4 LAG AND OTHER UNIT HYDROGRAPHS RELATIONSHIPS, MAIN CHANNEL DRAINAGE AREAS, WHITE ROCK CREEK.

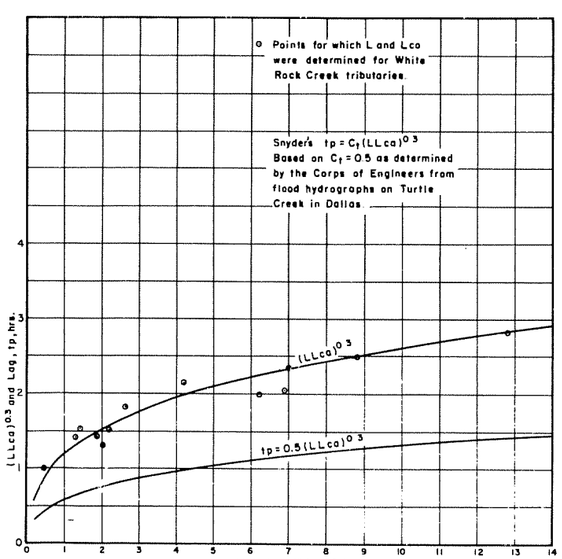


FIG.5 LAG FOR UNIT HYDROGRAPHS WHITE ROCK CREEK TRIBUTARIES

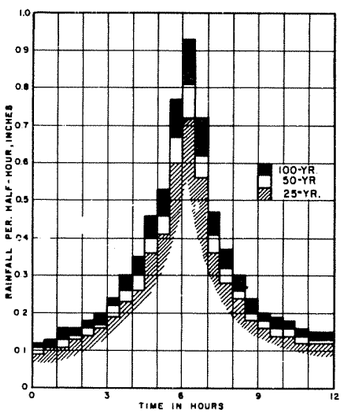


FIG.6 HISTOGRAMS, 12-HR RAINFALLS ON WHITE ROCK CREEK WATERSHED

DRAINAGE IMPROVEMENT PLAN LOWER WHITE ROCK CREEK HYDROLOGIC EXHIBITS						
DEPARTMENT OF PUBLIC WORKS CITY OF DALLAS, TEXAS						
DESIGN	DRAWN	DATE	SCALE	NOTES	FILE	PLATE NUMBER
F&C Inc.	F&C Inc.	Mar. 1965	As Noted	F&C Inc.	421-0-1500	3

REPORT ON

INVESTIGATIONS FOR IMPROVEMENT

PROGRAM FOR WHITE ROCK LAKE PARK

APPENDIX D

Soils and Foundation Investigation
White Rock Lake Spillway
by National Soil Services, Inc.

SOILS AND FOUNDATION INVESTIGATION

PROPOSED IMPROVEMENTS

WHITE ROCK LAKE SPILLWAY

Report to

CITY OF DALLAS
Department of Public Works

&

FORREST AND COTTON, INC.
Consulting Engineers
Dallas, Texas

By

NATIONAL SOIL SERVICES, INC.
Consulting Engineers
Dallas, Texas

May, 1971

NATIONAL SOIL SERVICES, INC. *CONSULTING ENGINEERS*
214-330-0455
P. O. BOX 24596
4087 SHILLING WAY
DALLAS, TEXAS 75224

May 21, 1971
Report No. 7196

Parks and Recreation Department
Department of Public Works
City of Dallas, Texas 75201

THRU:

Forrest and Cotton, Inc.
Consulting Engineers
600 Mercantile Continental Building
Dallas, Texas 75201

Attention: Mr. A. Martelli, P. E.
Mr. Robert Steele, P. E.

SOILS AND FOUNDATION INVESTIGATION
PROPOSED IMPROVEMENTS
WHITE ROCK LAKE SPILLWAY

Gentlemen:

Submitted here are the results of preliminary studies made at the site of the above improvements. This study was performed in accordance with our proposal dated February 26, 1971 and was authorized by resolution of the City Council on April 5, 1971.

We trust that the results of this study are in sufficient detail to provide data for preliminary design and evaluation of the proposed structures. If you have any questions or if we may be of further service, please call us.

Very truly yours,

NATIONAL SOIL SERVICES, INC.

Tillman A. Riewe, P. E.

TAR/sb
Copies submitted: 10

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LABORATORY TESTS	2
GENERAL SOIL CONDITIONS	2
Spillway	2
Conduit Area	3
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Underseepage Control	4
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INTRODUCTION

These studies were made at the proposed location for a gated spillway structure and discharge conduit, one of which is required to provide additional discharge capacity from White Rock Lake, Dallas, Texas. Specifically, these studies were performed to:

(1) determine pertinent soil types and classifications;

(2) develop generalized soil and rock profiles;

(3) assist in the determination of foundation types and allowable loading for the gated spillway structure;

(4) define foundation type and preliminary design parameters for the discharge conduit intake structure; and

(5) define foundation type and establish preliminary design parameters for the discharge conduit stilling basin.

FIELD INVESTIGATION

Subsurface conditions were defined by four undisturbed sample borings located as shown on Plate 1 in the report's illustrations. In borings CB-1 and CB-2, continuous undisturbed samples were obtained through the existing embankment. Natural soil deposits underlying the embankment were sampled at five-foot intervals. In borings CB-3 and CB-4, continuous undisturbed samples were obtained from the surface to a depth of 10 feet and thereafter at five-foot intervals to the underlying limestone formation. The limestone was cored continuously in each boring to the completion depths. Soil and rock formations encountered are shown on the logs of borings, Plates 2 through 6. Keys to classification terms and symbols are presented on Plates 7 and 8.

The consistency of clay samples was measured in the field using a hand penetrometer. This device has been correlated with laboratory unconfined compression tests and provides a reliable estimate of soil consistency. Strength values defined by the hand penetrometer are tabulated at respective depths on the boring logs.

The limestone formations were cored continuously with an NX size double tube core barrel. Core recovery, expressed as a percentage of core recovered to depths cored, is tabulated at respective depths on the logs.

Water level observations were made in all borings within a few days after completion. This data is tabulated in the lower right of the logs.

LABORATORY TESTS

Classification of soils was verified by six natural moisture content, nine liquid and plastic limit, and six moisture-density determinations. The results of these tests are presented at respective sample depths on the boring logs.

GENERAL SOIL CONDITIONS

Spillway

The soils data have been combined to develop the generalized profile shown on Plate 9. Correlation was established based on color, consistency, and classification. In general, stiff to very stiff, tan and brown clay (fill) with limestone and gravel fragments was encountered from the surface to the underlying natural soils (28 feet in boring CB-1 and 13 feet in boring CB-2). Firm to stiff, dark gray clay

was encountered at the base of the embankment. The thickness of this clay stratum varies from 3.5 to 6.5 feet. The soil deposits are underlain by limestone to below the completion depths of the borings. The upper 4.5 to 5.5 feet of the limestone is weathered.

Conduit Area

Subsurface conditions existing in the conduit area are shown on the generalized soil profile, Plate 10. In the area of the intake structure (boring CB-3), very stiff to hard, dark gray and tan to tan clay with calcareous nodules and concrete (fill) was encountered from the surface to Elev 452. These fills are underlain by stiff, light tan calcareous clay with calcium nodules to Elev 446. Limestone was encountered from this depth to below the completion depth of the boring. The upper two feet of the limestone is soft and highly weathered. Vertical fractures and shale seams were encountered within the underlying moderately hard, gray limestone.

In the area of the stilling basin (boring CB-4), firm, dark tan and gray clay (slightly organic) was encountered from the surface to Elev 426. This surface layer is underlain by stiff to very stiff, dark tan and tan and gray clay to Elev 416. Stiff, tan calcareous clay is present to Elev 392 and is underlain by firm, gray and tan sandy clay to Elev 381. These soil deposits are underlain by limestone to below the completion depths of the borings. The upper two feet of the limestone is weathered. The underlying moderately hard, limestone contains thin clay or weathered seams with angle fractures varying from 20 to 50 degrees.

ANALYSIS OF RESULTS AND RECOMMENDATIONS

Foundation Type

Foundation support for all structures should be derived from the gray limestone. If economic considerations necessitate basing structures at a higher grade, then foundation support may be provided by drilled footings penetrating into or by piles driven to the underlying limestone.

Allowable Loadings

Based on the results of borings and previous design experience, foundations at the surface of the gray limestone may be proportioned for an allowable bearing pressure of 15,000 pounds per square foot. Foundations penetrating into the gray limestone to a minimum depth of five feet may be proportioned for an allowable bearing value of 40,000 pounds per square foot.

Piles driven to refusal on the limestone may be used for foundation support. For preliminary analysis, maximum design loads equivalent to the structural capacity of the piles may be assumed.

Underseepage Control

Deposits in this area have variable permeability characteristics. Underseepage control can be provided by vertical sand drains penetrating the limestone and soil formations. Drains beneath the stilling basin and behind the walls should also be provided to effectively relief hydrostatic pressures.

Uplift Resistance

Resistance to uplift may be provided by drilled anchors extending into the rock formation. Preliminary anchor capacities should be based on conservative values in the order of 200 pounds per square foot for clay soils and 1,000 pounds per square foot of contact area in the moderately hard, gray limestone.

Horizontal Loads and Resistance to Sliding

Horizontal loads for preliminary analysis should approximate pressures produced by an equivalent fluid weighing 60 pounds per cubic foot above the water table and 90 pounds per cubic foot below the water table. The spillway should be provided with an upstream key to develop adequate resistance to horizontal sliding. The coefficient of horizontal shear resistance for preliminary analysis may be based on an angle of internal friction (Ø) of 30 degrees. The value is based on the assumption that clay seams may be encountered below the base of the key.

Excavation Stability

Based on the results of this study, it is anticipated that slopes for required excavations in soil may be made in the order of 2 horizontal to 1 vertical. Excavations within the limestone formations may generally be made on near vertical slopes; however, slopes in the order of 1 vertical to 1 horizontal should be assumed for excavations penetrating the limestone greater than 10 feet.

It is anticipated that dewatering may be accomplished by sumps and pumps. Major sand and gravel strata requiring dewatering by well-points were not encountered.

Future Studies

Field studies for final design analyses should include a sufficient number of borings in the spillway or conduit area to adequately define stratigraphy and elevation of the various strata. Laboratory testing should include classification, strength, and permeability tests. Design studies to define bearing capacities, seepage control, uplift resistance of anchors, resistance to horizontal sliding, and excavation stability will be required.

ILLUSTRATIONS

LOG OF BORING NO. CB-1

PROPOSED SPILLWAY WIDENING
WHITE ROCK LAKE
DALLAS, TEXAS

TYPE BORING: Undisturbed Sample **LOCATION**: See Plan of Borings

DEPTH, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION ELEVATION: 468.5	PEN SHEAR STRENGTH, T.S.F.	CORE RECOVERY %	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	SHEAR STRENGTH, T.S.F.	ANGLE OF SHEAR	UNIT DRY WT. LBS./CU. FT.
			Hard brown clay w/limestone fragments (fill) (CL)	1.5+							
			Very stiff tan and brown clay (fill)	1.1 1.5 1.5+		46	17	17			109
5				1.1							
			-stiff	0.8		44	18	23			103
10			-very stiff light tan and light gray	1.2 0.7 1.1 0.7 0.6							
			-tan and dark gray	1.5+		39	15	20			111
15			-gray w/large soft limestone fragments -dark gray and tan	0.7							
			-very stiff dark gray w/soft limestone nodules (CL)	0.6 1.5+							
20			Stiff dark gray clay (fill) (CH)	0.8		59	19	28			81
25			Hard tan calcareous clay w/weathered limestone nodules and gravel (CL)								
30			Stiff dark gray clay (CH)	1.0 1.3							
35			Soft light gray and tan limestone w/horizontal fractures -60° angle fracture 36.5-37.0' -vertical fracture, 38.5'								
40			Moderately hard gray limestone -2" tan seam 40.0' -1" tan seam 40.5' -1/2" tan seam 41.5'		100						
45			-15° angle fracture 43.5'								
			Note: Boring advanced by dry auger methods between sample intervals to a depth of 20.0'								
50											

COMPLETION DEPTH: 45.0' DEPTH TO WATER: 16.4' Caved at 33.0'
DATE: 4/7/71 DATE: 4/8/71

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

PLATE 2

LOG OF BORING NO. CB-2

PROPOSED SPILLWAY WIDENING
WHITE ROCK LAKE
DALLAS, TEXAS

TYPE BORING: Undisturbed Sample LOCATION: See Plan of Borings

ELEVATION: 468.5

DEPTH, FT.	SOIL DESCRIPTION	PEN SHEAR STRENGTH, T.S.F.	CORE RECOVERY %	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	SHEAR STRENGTH, T.S.F.	ANGLE OF SHEAR	UNIT DRY WT. LBS./CU. FT.
0	Stiff dark brown clay w/limestone fragments and some inbedded gravel (fill)	0.9							
		1.1							
		1.0							
		1.2							
5	-tan and brown at 5.0'	1.3							
	-some imbedded pea gravel at 7.0'								
	-tan at 7.5'								
10	-calcareous pockets below 11.0'	1.0							
		0.7							
	(CL-CH)								
15	Firm dark gray clay -moist at 15.0'								
	(CL)								
20	Soft tan weathered limestone w/gray seams -60° angle fracture at 18.0' -25° angle fracture at 18.5'								
	Moderately hard gray limestone w/tan weathered seams -25° angle fracture at 20.5' -fracture at 22.0'		100						
25	Moderately hard gray limestone w/shell fragments -4" shale seam								
30			100						
35			100						
40									
45	Note: Bore hole advanced by dry auger methods to a depth of 16.5 feet.								
50									

COMPLETION DEPTH: 40.0'
DATE: 4/6/71

DEPTH TO WATER: 14.2' Caved at 26.2'
DATE: 4/7/71

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CONSULTING ENGINEERS.

PLATE 3

LOG OF BORING NO. CB-3

PROPOSED CONDUIT
WHITE ROCK LAKE
DALLAS, TEXAS

TYPE BORING: Undisturbed Sample **LOCATION:** See Plan of Borings

DEPTH, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	PEN SHEAR STRENGTH, TSF	CORE RECOVERY %	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	SHEAR STRENGTH, TSF	ANGLE OF SHEAR	UNIT DRY WT. LBS./CU. FT.
			ELEVATION: 462.1								
0			Hard dark gray and tan clay w/calcareous nodules (fill)	1.5+							
			-very stiff and dark gray	1.5+							
5				1.5+							
			-concrete (Grout)	1.5+							
			-stiff tan w/concrete fragments (CL)	1.5+							
10			Stiff light tan calcareous clay	0.8							
			-w/weathered limestone fragments (CL)								
15			Soft tan weathered limestone								
20			Moderately hard gray limestone w/shell fragments		100						
					100						
25					95						
			-vertical fracture 47.5-48.5'								
30					100						
35											
					100						
40											
45			-6" shale seam 44.5-45.0'								
			-2" shale seam 45.8'		100						
50											

COMPLETION DEPTH: 50.0' DEPTH TO WATER: 8.5'
DATE: 4/9/71 DATE: 4/10/71

NATIONAL SOIL SERVICES, INC.
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PLATE 4

LOG OF BORING NO. CB-4

PROPOSED CONDUIT
WHITE ROCK LAKE
DALLAS, TEXAS

TYPE BORING: Undisturbed Sample LOCATION: See Plan of Borings

DEPTH, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	PEN SHEAR STRENGTH, TSF	CORE RECOVERY %	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	SHEAR STRENGTH, TSF	ANGLE OF SHEAR	UNIT DRY WT. LBS./CU. FT.
			ELEVATION: 430.8								
			Firm dark tan and gray clay, slightly organic (CH)	0.5 0.4 0.4				26			
5			Stiff dark tan clay -very stiff -tan -stiff tan and gray	0.6 1.0 1.2 1.2 1.2 0.8		48	17	20			
10			(CL-CH)	0.9							
15			Stiff tan calcareous clay	0.7 0.6		44	16	21			
20				0.6 0.6							
25				0.6		42	15	23			104
30				0.9				23			
35			(CL)	0.5 1.0				28			
40			Firm gray and tan sandy clay w/occasional very coarse sand pockets	0.3		39	15	25			
45			(CL)	0.3		35	16	24			103
50			Moderately hard light gray and tan weathered limestone								

(Continued)

NATIONAL SOIL SERVICES, INC.
CONSULTING ENGINEERS.

PLATE 5

LOG OF BORING NO. CB-4 (Cont'd.)

PROPOSED CONDUIT
WHITE ROCK LAKE
DALLAS, TEXAS

DEPTH, FT.	SYMBOL	SAMPLES	SOIL DESCRIPTION	PEN SHEAR STRENGTH, TSF	CORE RECOVERY %	LIQUID LIMIT	PLASTIC LIMIT	MOISTURE CONTENT, %	SHEAR STRENGTH, TSF	ANGLE OF SHEAR	UNIT DRY WT. LBS./CU. FT.
55			Moderately hard gray limestone -1" tan clay seam at 50.25' -20° angle fractures at 50.5' -2" tan weathered seam at 54.0' -50° angle fracture at 55.0'		100						
60											
65											
70											
75											
80											
85											
90											
95											
100											

COMPLETION DEPTH: 60.0'
DATE: 4/8/71

DEPTH TO WATER: 8.3' Caved at 51.8'
DATE: 4/9/71

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CONSULTING ENGINEERS.

PLATE 6

KEY TO ROCK CLASSIFICATIONS AND SYMBOLS

ROCK TYPE

Limestone

Dolomite

Chalk

Marl

Shale

Sandstone

Conglomerate

Granite

Quartz

Anhydrite

SAMPLE TYPE

Undisturbed

Rock Core

Split Spoon

No Recovery

TERMS CHARACTERIZING PHYSICAL PROPERTIES OF ROCK

Bedding Characteristics:

Massive	-	occurring in thick beds, free from minor joints and laminations, more than 100 mm. in thickness
Thin to med.	-	occurring in relatively thin layers or laminae, 2 mm. to 100 mm. bedding planes
Fissile	-	bedding which consists of laminae less than 2 mm. in thickness, splits easily along closely spaced parallel planes
Cross-bedded	-	arrangement of laminations of strata transverse or oblique to the main planes of stratification of the strata concerned
Foliated	-	the laminated structure resulting from segregation of granular and fine minerals into layers parallel to the schistosity (result of the parallel arrangement of platy and ellipsoidal mineral grains)
Platy	-	parallel arrangement of broad or flat minerals (giving a foliation) by slablike inclusions, by schlieren, or by bonds of different mineralogy or texture
Fragmental	-	consisting of broken material, particularly that which has been moved from its place of origin

Lithologic Characteristics:

Clayey, Shaly, Calcareous (limy) Siliceous Sandy, Silty, Plastic Seams Carbonaceous	-	The lithology is used describing the parent rock such as a shaly limestone or carbonaceous shale

Hardness and Degree of Cementation:

Very soft or plastic	-	can be remolded in hand, corresponds in consistency up to very stiff in soils
Soft	-	can be scratched with fingernail
Moderately hard	-	can be scratched easily with knife; cannot be scratched with fingernail
Hard	-	difficult to scratch with knife
Very hard	-	cannot be scratched with knife
Poorly cemented or friable	-	easily crumbled
Cemented	-	bound together by chemically precipitated material occurring in the interstices between allogenic particles of rock - quartz, calcite, dolomite, siderite and iron oxide are common cementing materials

Swelling Properties:

Swelling and Non-Swelling

Slaking Properties:

Non-Slaking

Slakes slowly on exposure

Slakes readily on exposure

Texture:

Dense	-	fine-grained aphanitic rocks in which the grain size generally averages less than 0.05 to 0.1 mm.
Fine	-	more than 50% by weight smaller than 0.074 mm. in diameter (seen only with a strong hand lens or a microscope)
Medium	-	majority of grain sizes between 0.074 mm. and 0.5 mm.
Coarse	-	grain sizes range from 0.5 mm. to 1.0 mm. (crystals are visible to the unaided eye)

Structure:

Bedding	-	Flat (0° to 15°); Gently dipping (15° to 30°) Steeply dipping (30° to vertical)
Fractures, scattered or open	-	broken surface of minerals or rock which does not exhibit cleavage or bedding planes
Fractures, closely spaced	-	shows signs of broken minerals but now is cemented
Brecciated (sheared & frogmented)	-	rock made up of highly angular coarse fragments - may be sedimentary or formed by crushing or grinding along faults
Joints	-	fractures in rock, generally more or less vertical or transverse to bedding, along which no appreciable movement has occurred.
Faulted	-	fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture - the displacement may be a few inches or many miles
Slickensides	-	polished and striated (scratched) surface that results from friction along a fault plane

Degree of Weathering:

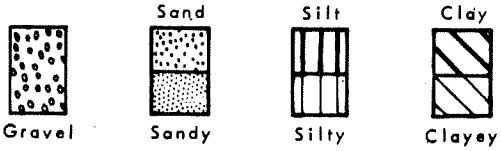
Unweathered	-	rock in its natural state before being exposed to atmospheric agents
Slightly weathered	-	noted predominantly by color change with no disintegrated zones
Weathered	-	complete color change with zones of slightly decomposed rock
Extremely weathered	-	complete color change with consistency, texture, and general appearance approaching soil

Solution and Void Conditions:

Solid	-	contains no voids
Vuggy (pitted)	-	cavities in rock
Vesicular	-	containing many small cavities
Porous	-	containing voids, pores, interstices, or other openings which may or may not interconnect
Cavities	-	solutional concavity in limestone caves, the outline of which is determined by a joint or joints - also applied to small hollows in cavernous lava
Cavernous	-	containing cavities or caverns, sometimes quite large - most frequent in limestones and dolomites

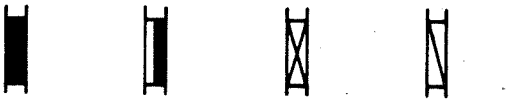
KEY TO SOIL CLASSIFICATIONS AND SYMBOLS

SOIL TYPE



Predominant type shown heavy

SAMPLE TYPE



TERMS DESCRIBING CONSISTENCY OR CONDITION

COARSE GRAINED SOILS
(Major portion retained on No. 200 sieve)

Includes (1) clean gravels and sands described as fine, medium or coarse, depending on distribution of grain sizes and (2) silty or clayey gravels and sands. Condition is rated according to relative density, as determined by laboratory tests or estimated from resistance to sampler penetration.

Penetration Resistance Blows/Foot **	Descriptive Term	Relative Density *
0 - 10	Loose	0 to 40%
10 - 30	Medium dense	40 to 70%
30 - 50	Dense	70 to 90%
Over 50	Very dense	90 to 100%

* From tests on undisturbed sand sample
** 140# hammer, 30-inch drop

Relative density is also used to describe condition of low plasticity (P I $<$10) fine grained soils such as sandy silts.

FINE GRAINED SOILS
(Major portion passing No. 200 sieve)

Includes (1) inorganic and organic silts and clays, (2) gravelly, sandy, or silty clays, and (3) clayey silts. Consistency is rated according to shearing strength, as indicated by penetrometer readings or by unconfined compression tests for soils with plasticity indices $\geq$ 10.

Descriptive Term	Compressive Strength Tons/Sq. Ft.
Very soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very stiff	2.00 to 4.00
Hard	4.00 and higher

Note: Slickensided and fissured clays may have lower unconfined compressive strengths than shown above, because of planes of weakness or shrinkage cracks in the soil. The consistency ratings of such soils are based on penetrometer readings.

TERMS CHARACTERIZING SOIL STRUCTURE

Fissured - containing shrinkage cracks, frequently filled with fine sand or silt; usually more or less vertical

Sensitive - pertaining to cohesive soils that are subject to appreciable loss of strength when remolded

Laminated - composed of thin layers of varying color and texture

Interbedded - composed of alternate layers of different soil types

Calcareous - containing appreciable quantities of calcium carbonate

Well graded - having wide range in grain sizes and substantial amounts of all intermediate particle sizes

Poorly graded - predominately of one grain size, or having a range of sizes with some intermediate size missing

Slickensided - having inclined planes of weakness that are slick and glossy in appearance.

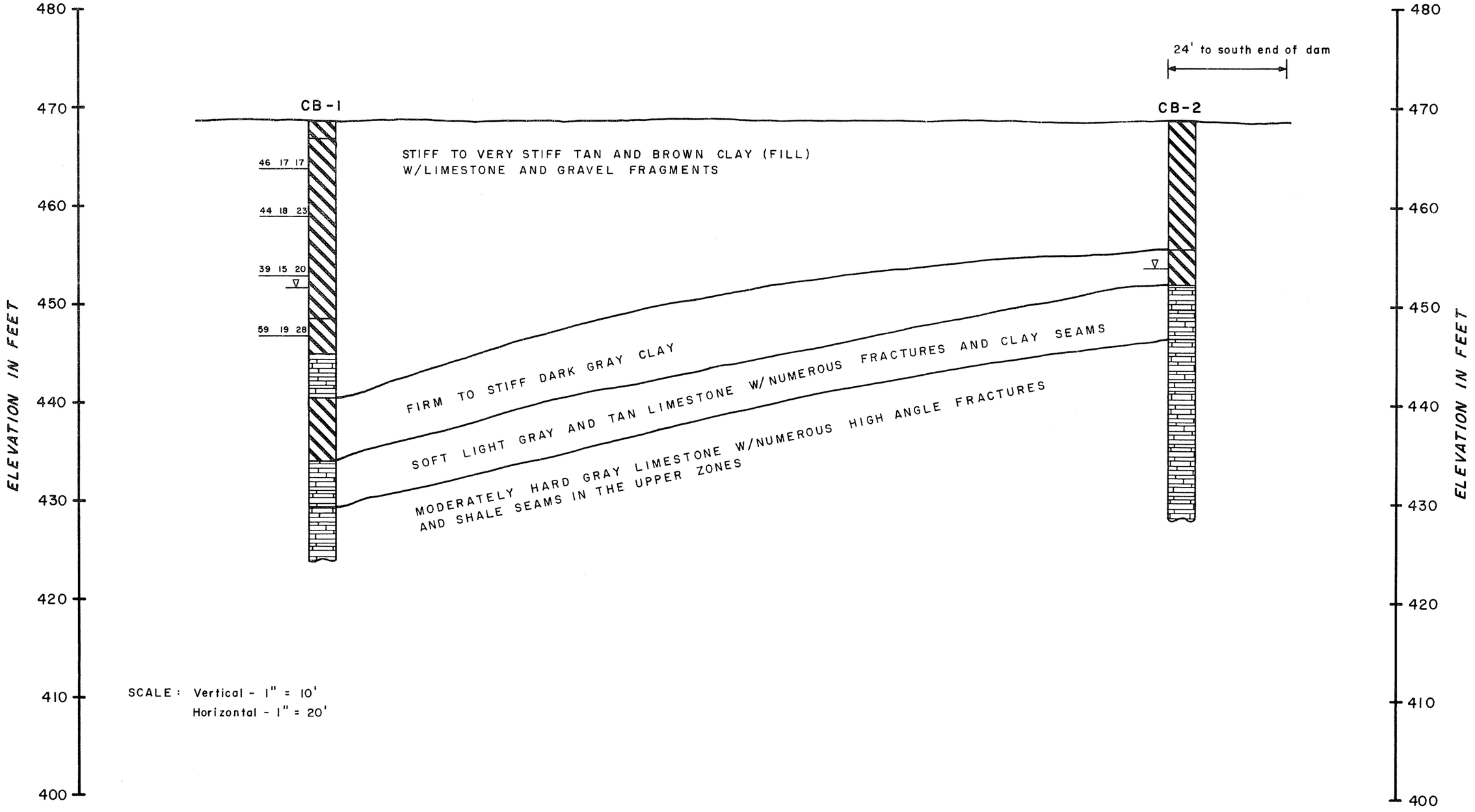
Degree of slickenside development:

Slightly slickensided - slickensides are present at intervals of 1-2 feet and soil does not easily break along these planes.

Moderately slickensided - slickensides are spaced at intervals of 1-2 feet and soil breaks easily along these planes.

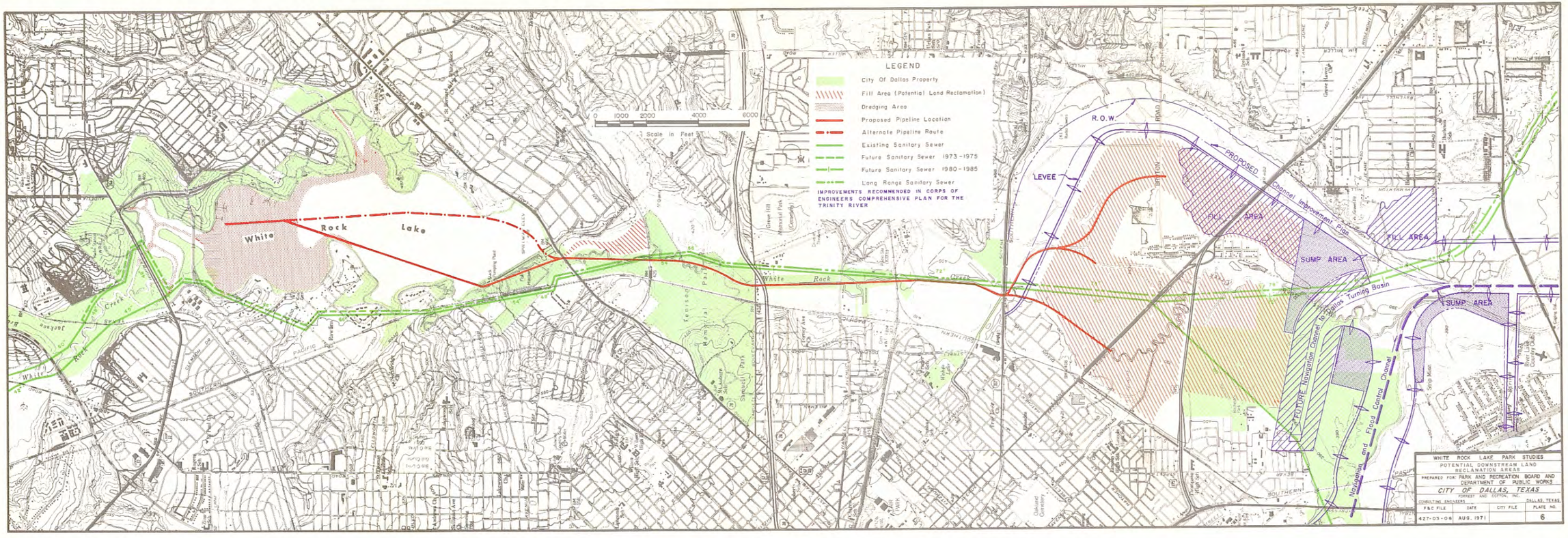
Extremely slickensided - slickensides are spaced at intervals 4-12 inches, are continuous and interconnected. Soil breaks easily along the slickensides. Resulting size of broken pieces three to six inches.

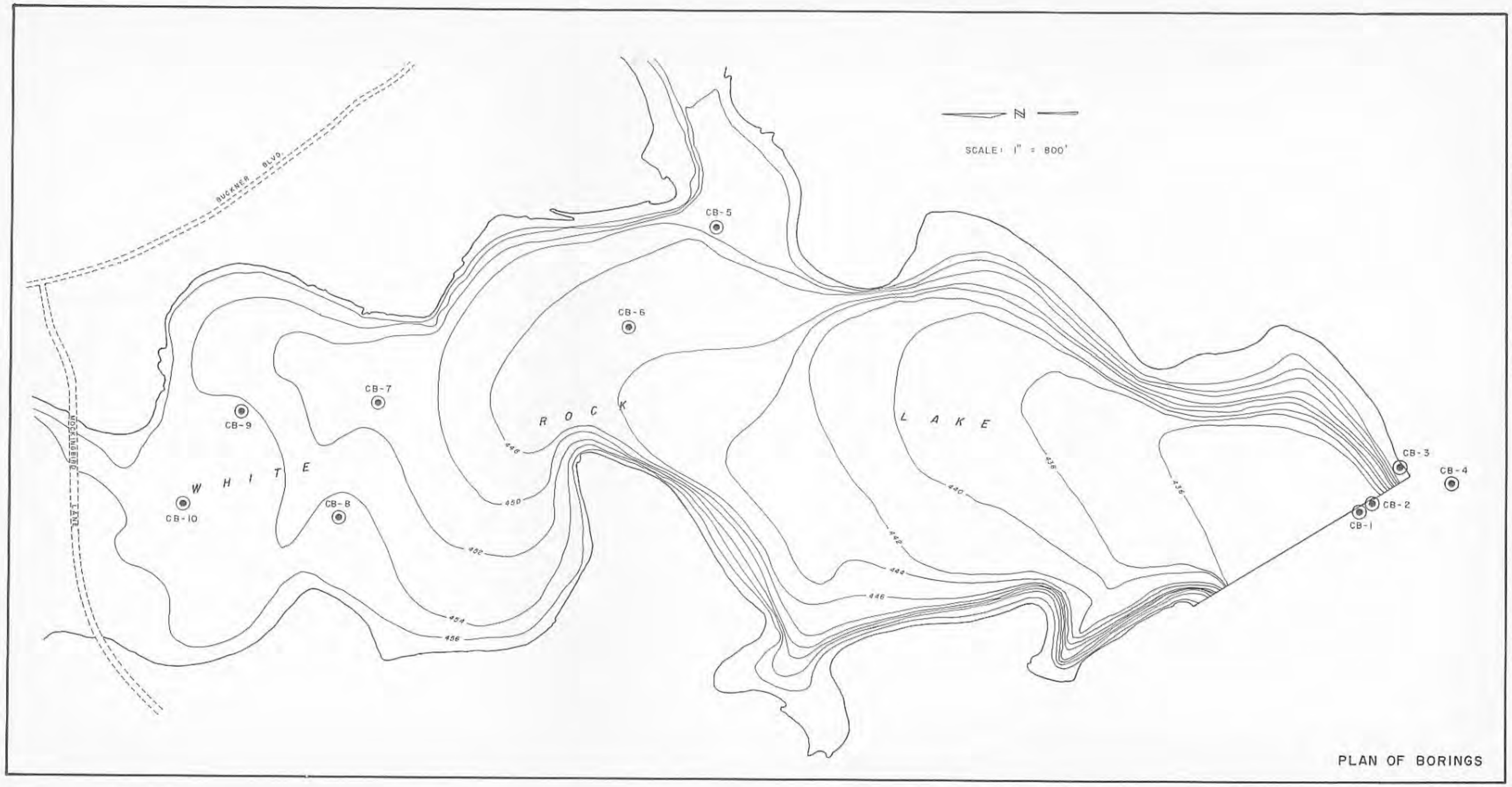
Intensely slickensided - slickensides are spaced at intervals of less than four inches and are continuous in all directions. Soil breaks down along planes into nodules 1/4 - 2 inch in size.



GENERALIZED SOILS PROFILE

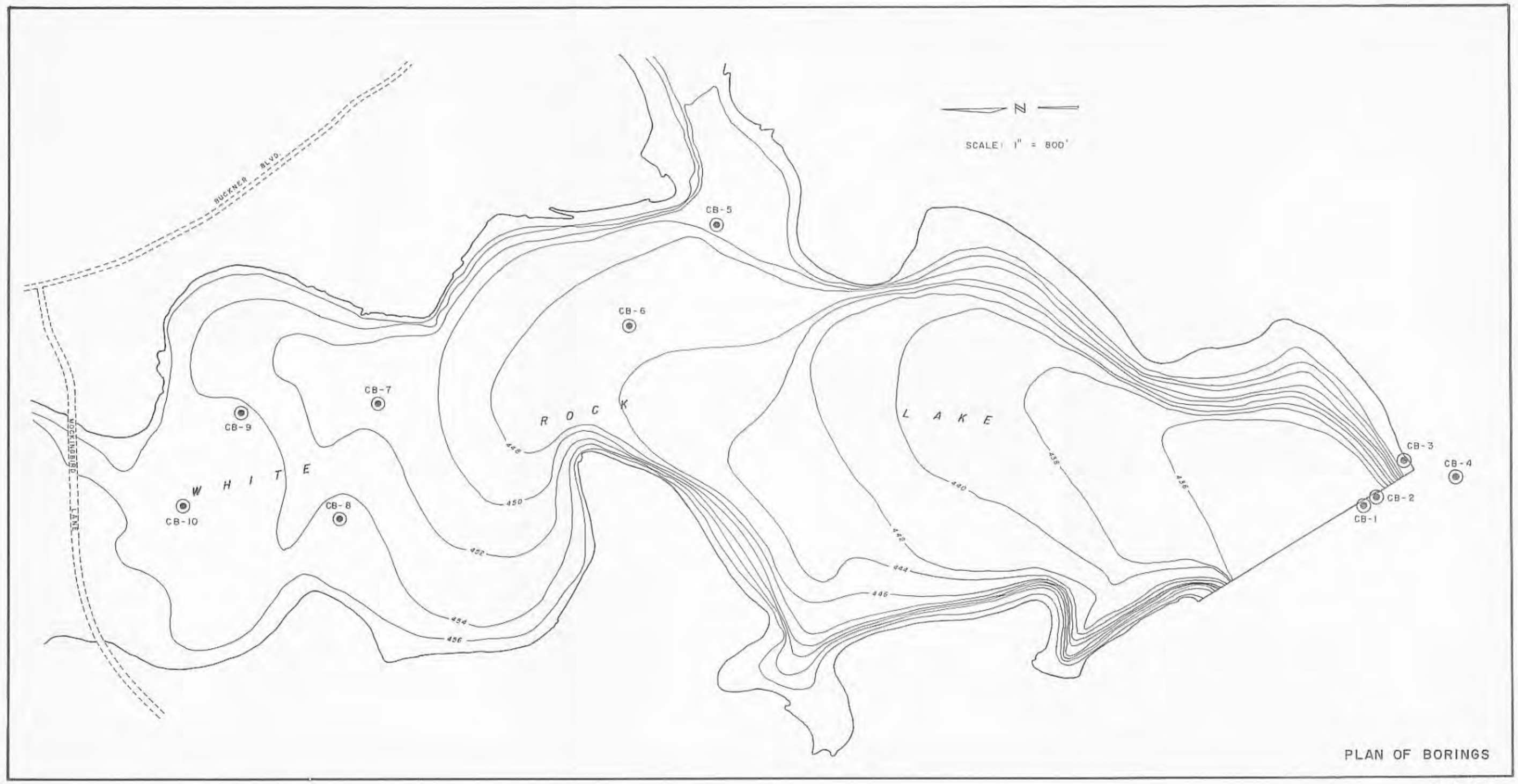
PLATE 9


LEGEND
City Of Dallas Property
Fill Area (Potential Land Reclamation)
Dredging Area
Proposed Pipeline Location
Alternate Pipeline Route
Existing Sanitary Sewer
Future Sanitary Sewer 1973-1975
Future Sanitary Sewer 1980-1985
Long Range Sanitary Sewer
IMPROVEMENTS RECOMMENDED IN CORPS OF ENGINEERS COMPREHENSIVE PLAN FOR THE TRINITY RIVER
0 1000 2000 4000 6000
Scale in Feet
White Rock Lake
R.O.W.
LEVEE
PROPOSED
Channel Improvement Plan
FILL AREA
SUMP AREA
FUTURE Navigation Channel to Dallas Turning Basin
Woodall Rodgers Freeway
Stemmons Freeway
Trinity River
Sump Main
Oakland Cemetery
Oak Cliff
Dallas
WHITE ROCK LAKE PARK STUDIES
POTENTIAL DOWNSTREAM LAND RECLAMATION AREAS
PREPARED FOR PARK AND RECREATION BOARD AND DEPARTMENT OF PUBLIC WORKS
CITY OF DALLAS, TEXAS
FORREST AND COTTON, INC.
DALLAS, TEXAS
CONSULTING ENGINEERS
F&C FILE 427-03-06
DATE AUG. 1971
CITY FILE
PLATE NO. 6



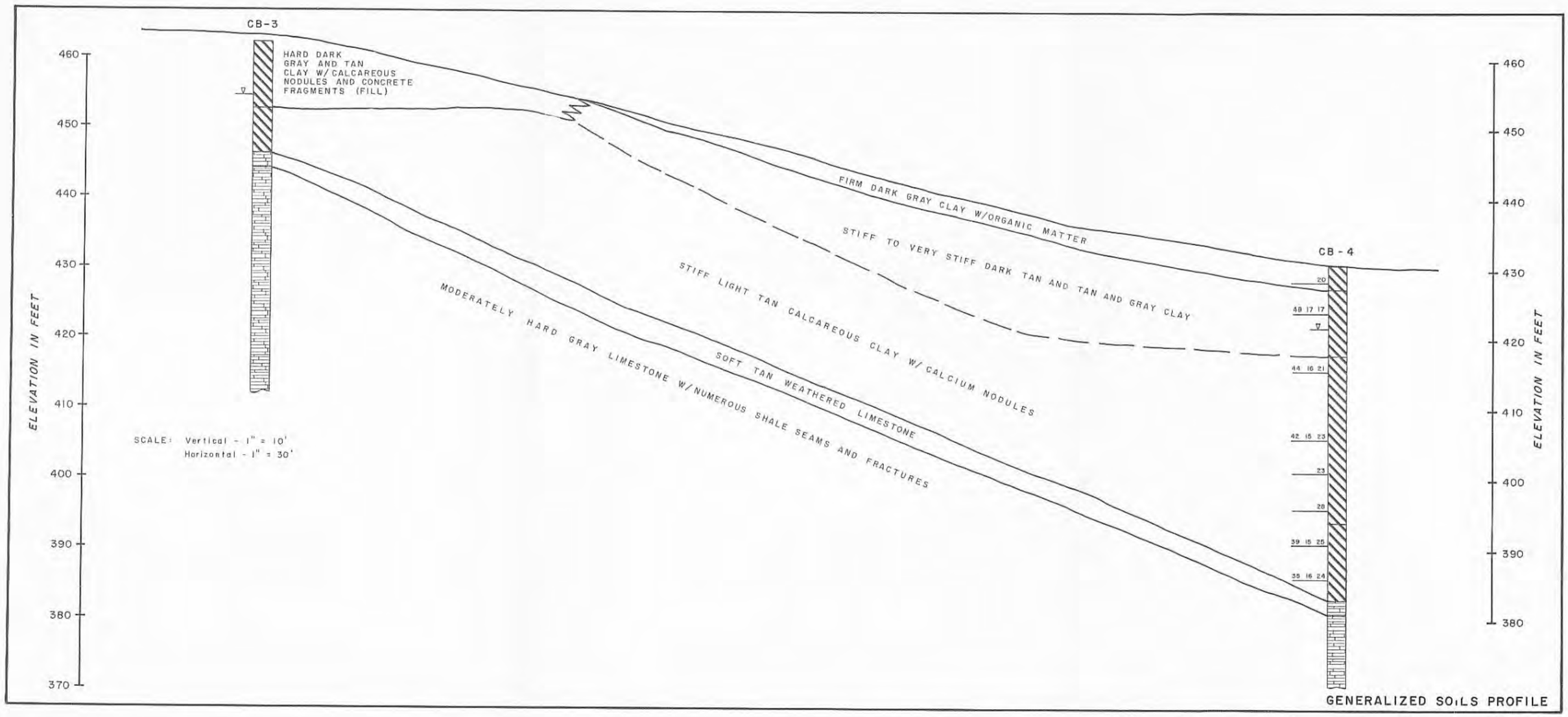
PLAN OF BORINGS

PLATE I



PLAN OF BORINGS

PLATE I



GENERALIZED SOILS PROFILE

PLATE 10

TEXAS WATER COMMISSION

B. J. Wynne, III, Chairman
John E. Birdwell, Commissioner
Cliff Johnson, Commissioner

John J. Vay, General Counsel
Michael E. Field, Chief Hearings Examiner
Gloria A. Vasquez, Chief Clerk

Allen Beinke, Executive Director

April 11, 1991

The Honorable John J. Carona
House of Representative
P.O. Box 2910
Austin, Texas 78768-2910

Re: Your letter of March 26, 1991 concerning the silting of White Rock Lake, Dallas County, Trinity River Basin, Certificate of Adjudication No. 08-2461

Dear Representative Carona:

Thank you for your letter of March 26, 1991 regarding silting of White Rock Lake. In response to your request, we are pleased to provide you the following information.

As you are probably aware, White Rock Lake belongs to the City of Dallas, and as owner of Certificate of Adjudication No. 08-2461, the city is authorized to impound 21,345 acre-feet of water in the lake. The certificate authorizes the city to use the impounded water for municipal, irrigation and recreation purposes. As the owner of White Rock Lake, the City of Dallas is also responsible for operation and maintenance of the facility.

Concerning the possibility of State assistance to correct this problem, the only State program which may apply is a loan from the Texas Water Development Board (TWDB). However, the Board staff advises, however, that no loans have ever been made for the purpose of removing silt from a reservoir, and in addition, potential environmental problems such as disposal of the sediment, and the economics of reservoir dredging would not likely be favorable. If Mr. Hibbs would like more information on the TWDB loan program, he should contact Ms. Suzanne Schwartz at 512/463-7981.

I also suggest that Mr. Hibbs consult with City of Dallas representatives concerning any plans the city might be considering regarding the siltation of White Rock Lake.

I hope this information is useful to you and Mr. Hibbs. If I can provide additional assistance in this or any other matter, please let me know.

Sincerely,

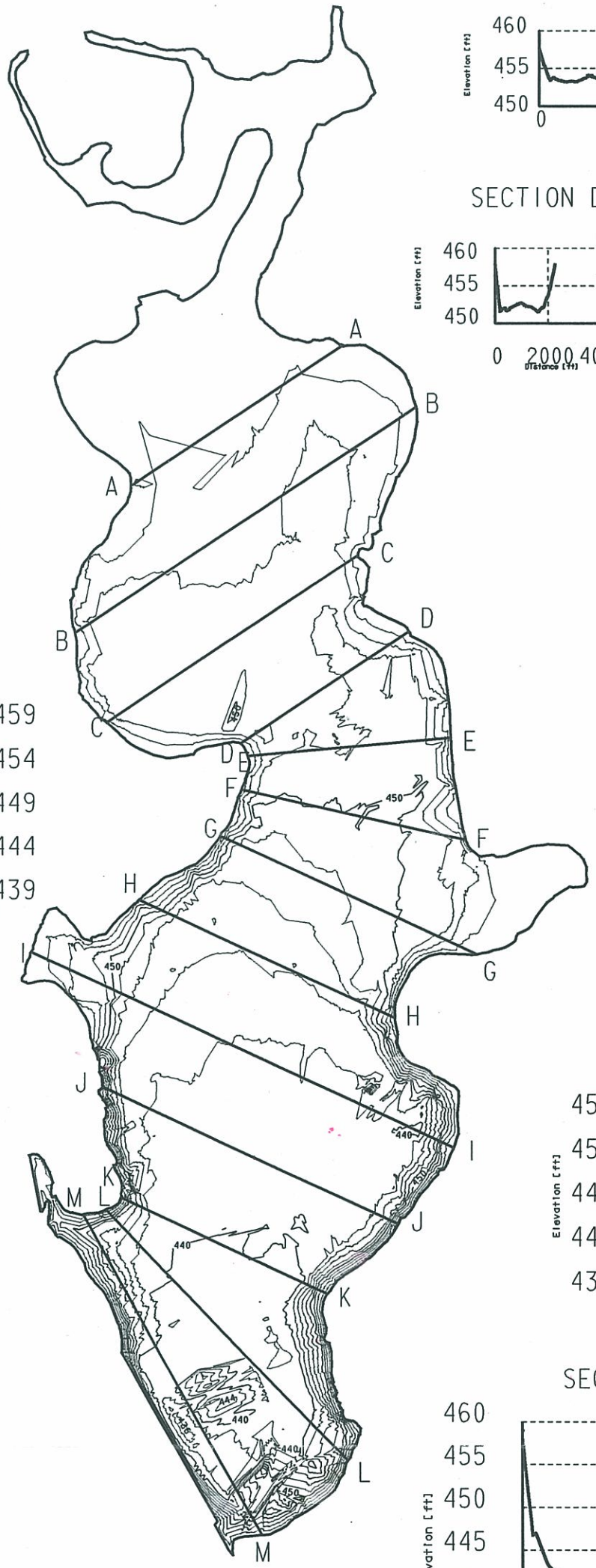
Allen Beinke

Allen Beinke
Executive Director

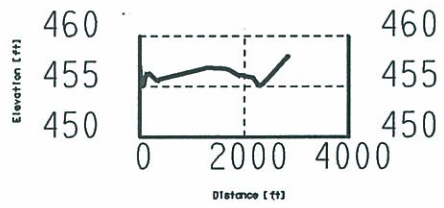
ccs: Larry Brown, City of Dallas, Dallas
Max Hibbs, Dallas, Texas
Suzanne Schwartz, Texas Water Development Board, Austin

WHITE ROCK LAKE

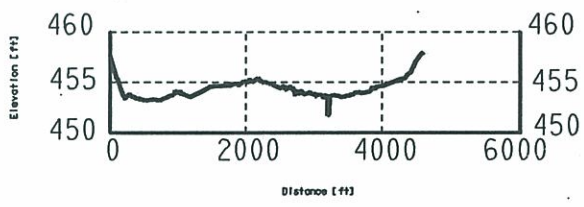
CONTOUR MAP



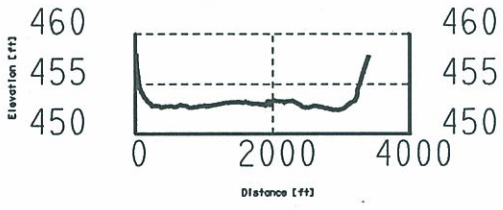
SECTION A-A



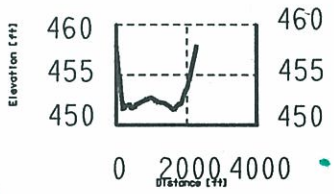
SECTION B-B



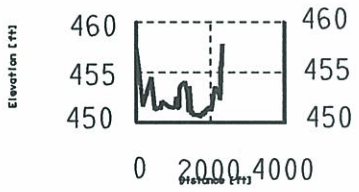
SECTION C-C



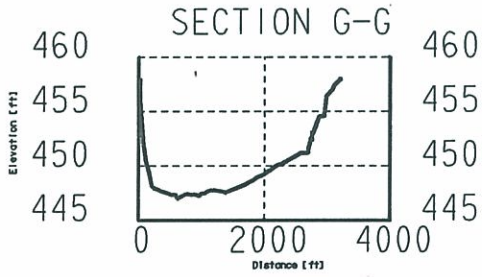
SECTION D-D



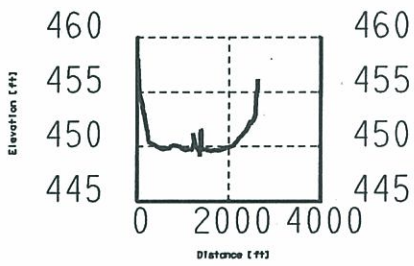
SECTION E-E



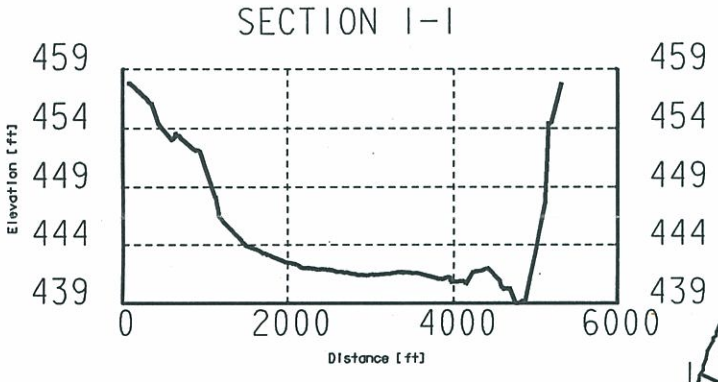
SECTION G-G



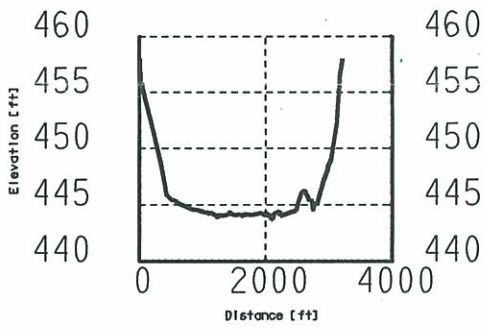
SECTION F-F



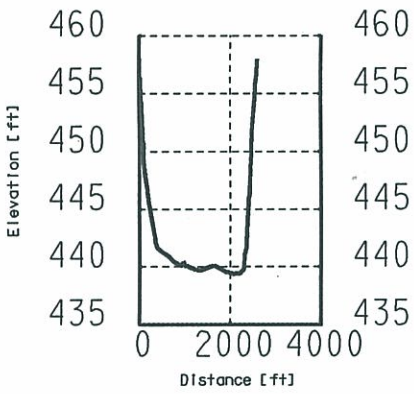
SECTION I-I



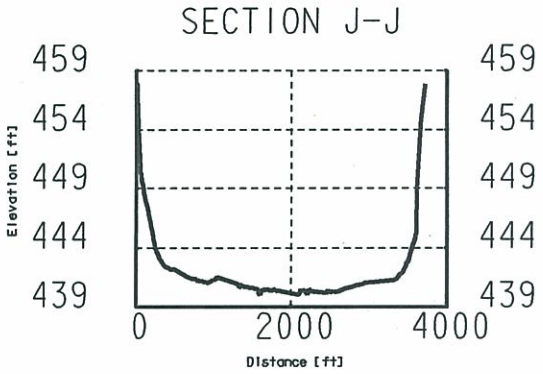
SECTION H-H



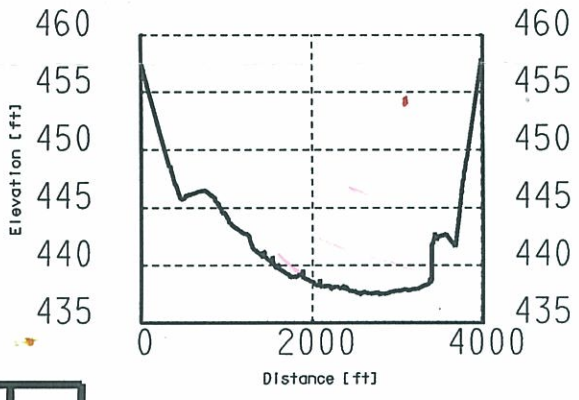
SECTION K-K



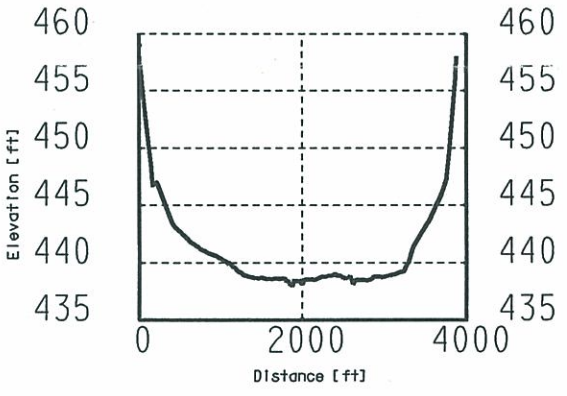
SECTION J-J



SECTION M-M



SECTION L-L



PREPARED BY:

THE TEXAS WATER DEVELOPMENT BOARD

JULY 1993

LEGEND

- 10' CONTOUR LINE
- 2' CONTOUR LINE
- -000- CONTOUR ELEVATION
- CROSS-SECTION LOCATION
- BOUNDARY

This map is the product of a hydrographic survey conducted to determine the capacity of the reservoir. The Texas Water Development Board makes no representations or assumes any liability if this information is used for other purposes, such as boating maps.

EXHIBIT 1-1

WHITE ROCK LAKE
CONTOUR MAP

ADDENDUM ITEM # 16

CATEGORY: **ITEMS FOR INDIVIDUAL CONSIDERATION**

AGENDA DATE: April 9, 1997

CITY SERVICE AREA(S): All

COUNCIL DISTRICT(S): All

DEPARTMENT: Public Works & Transportation

CMO: Ryan S. Evans, 670-3314

MAPSCO: 78M

SUBJECT

Authorize the City Manager to execute a temporary easement agreement with The Stephens Group, L. P., landowner of the area known as the Gravel Pit site in South Dallas County, for discharge of the dredged material from White Rock Lake to their property - $2,388,078 - Financing: 1995 Bond Funds

BACKGROUND

The City has completed negotiation for a temporary easement with the owners of a sand/gravel mining operation who has agreed to accept the dredged material from White Rock Lake. The purpose of the easement is to allow the City's contractor to discharge the dredged material to the landowner and for the landowner to accept and manage the material. In consideration for accepting the material, the City agrees to make payments to the landowner for constructing and maintaining the site for the duration of the project. Payments will be made concurrent with work completed at the site which is referred to in the agreement as Initial Preparation phase, Final Preparation phase and Maintenance and Operation phase. Initial Preparation includes site clearing, road building, engineering, surveying and other miscellaneous items necessary to prepare for Final Preparation. Final Preparation includes levee construction, excavation, hauling, pipeline installation, fencing, construction surveying and other miscellaneous items necessary to construct the holding ponds for the dredged material. Operation and Maintenance includes manpower, equipment, fuel, supplies, materials, and other miscellaneous items necessary to operate and maintain the holding ponds for the duration of the project. Also included is a small contingency fund for work that may be required, but not provided for in the Initial Preparation, Final Preparation or Operation and Maintenance phases.

ITEM: WHITE ROCK LAKE DREDGING PROJECT

ESTIMATED SCHEDULE OF PROJECT

Begin Construction	August 1997
Complete Construction	August 1999

PRIOR ACTION/REVIEW (COUNCIL, BOARDS, COMMISSIONS)

Authorized City Manager to negotiate easement for reclamation site	October 23, 1996
Council Briefed	October 16, 1996
Authorized Professional Services Contract	December 1995

FISCAL INFORMATION

Site Selection, Surveying, Engineering, Permitting	$ 1,307,812
Dredging Construction	
Reclamation Site Agreement ($2,228,078 w/$160,000 contingency)	$ 2,388,078
Dredging and Pipeline	$14,304,110 (Est.)
	$18,000,000 (Est.)

LANDOWNER

The Stephens Group, L.P.
Gary Ben Stephens, General Partner
James Mark Murphy, M.D., Limited Partner

MAP

Attached

April 9, 1997

WHEREAS, it is the desire of the City of Dallas to enter in a temporary easement agreement with the owners of the site chosen as the final site for the placement of the dredged material from White Rock Lake, referred to as the Gravel Pit Site, located in an unincorporated area of South Dallas County, and

WHEREAS, the temporary easement agreement will allow the City's contractor to discharge the dredged material onto the property known as the Gravel Pit Site, owned by The Stephens Group, L.P., and in turn, The Stephens Group, L.P., agrees to construct, operate and maintain the site to accept the dredged material; and

WHEREAS, the City agrees to make payments not to exceed $2,388,078 as prescribed in the temporary easement agreement for consideration of the use of the site and for the construction, operation and maintenance of the site for the duration of the project.

Now, Therefore,

BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF DALLAS:

Section 1. That the City Manager is authorized to execute the temporary easement agreement with The Stephens Group, L.P., which allows the City's contractor to discharge the dredged material from White Rock Lake onto their property.

Section 2. That the temporary easement agreement special terms and conditions are:

(a) The City will obtain an individual section 404 permit from the U. S. Army Corps of Engineers and the Landowner will maintain the site as an active mining area.

(b) The Landowner agrees to accept an amount of material up to 3,000,000 cubic yards at a rate of up to 15,000 gallons per minute. Discharge will occur on a 24 hour per day basis.

(c) The Landowner agrees to allow the City or its contractor or any State or Federal agency access to the easement area for inspections. Landowner agrees to allow the City access to its property to perform on-site analytical testing anytime during the course of the project and written one (1) year after completion of the project.

(d) The Landowner agrees to grant an additional easement to accommodate an additional booster pump if necessary.

(e) The Landowner agrees to pay liquidated damages of $10,000 per day for each day the Landowner fails to accept or wrongfully blocks the discharge of the dredged material.

(f) The City agrees to make payments to the Landowner an amount not to exceed $2,195,000 for performance of its obligations under the easement which will be paid concurrently with work performed.

(g) The City agrees to make payment to the Landowner from a contingency fund an amount not to exceed $160,000 for work not included in the agreement work plan but may be required. Contingency work must be agreed upon by both the City and the Landowner.

(h) The City agrees to make one lump sum payment of $33,078 to the Landowner in the event the time from completion of the site preparation to the commencement of material discharge through the pipeline exceeds 30 days.

(i) The easement term shall extend, unless sooner terminated, until the City certifies in writing that the project is complete. The City may extend the term of the easement by notice in writing to the Landowner for six months for additional inspection of the property.

(j) The City may terminate the easement for any reason upon 10 days written notice to the Landowner at any time before commencement of the City's dredging project.

Section 3. That the City Controller is hereby authorized to pay for this agreement out of:

White Rock Lake Improvement Fund
Fund M08, Agency PBW, Org. L910, Act. PBW3
Obj. 4250, Job # PB95L910, PD PBW95L910G1
Vendor # 351926-A in an amount not to exceed $2,388,078

Section 4. That this resolution shall take effect immediately from and after its passage in accordance with the provisions of the Charter of the City of Dallas and it is accordingly so resolved.

Distribution: Public Works & Transportation, Pam Rickman
320 E. Jefferson, Room 102
City Attorney
City Controller
Budget and Management Services

Memorandum

CITY OF DALLAS

DATE August 6, 1997

TO Robert Sloan
City Secretary

SUBJECT Original Documents
City Secretary File No. 97-1232 Council Date: April 9, 1997
Property Management Log No. AP/19300

The attached original document(s) are forwarded to the City Secretary's office for permanent record.

Ruby Anthony
Real Estate Manager

RECEIVED
AUG 13 1997
PUBLIC WORKS AND TRANSPORTATION
SURVEY SECTION

SD03358

DISTRIBUTION
Chief City Surveyor
City Property File
City Controller - Egbert Hood
Budget & Management Services -Tommy Duncan (ordinances & resolutions only)
Plat Records (Darrell Green - 6/B/S)
PW&T Private Development Activities - Tom Rasco
PW&T Engineering
PW&T Assessments
DWU Engineering
revised 1/10/94

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Distribution:
Public Works & Transportation, Pam Rickman
320 E. Jefferson, Room 102
City Attorney
City Controller
Budget and Management Services

APPROVED BY
CITY COUNCIL

APR 09 1997

City Secretary

APPROVED HEAD OF DEPARTMENT

APPROVED CITY CONTROLLER

APPROVED CITY MANAGER

97R025 20 -W1

97-1232
4-9-97

HP/17300

TEMPORARY PIPELINE EASEMENT

1300469

07/07/97 573108 $29.00
Deed

STATE OF TEXAS §
§ KNOW ALL MEN BY THESE PRESENTS:
COUNTY OF DALLAS §

That THE STEPHENS GROUP, L.P., a Texas limited partnership (hereinafter called "Grantor" whether one or more natural persons or legal entities) of the County of Dallas, State of Texas, for and in consideration of the sum of TEN AND NO/100 DOLLARS ($10.00) (the receipt of which is hereby acknowledged) and other good and valuable consideration, as recited in the special provisions below, to Grantor in hand paid by the City of Dallas, Texas a municipal corporation, and in consideration of the further benefits to be derived by Grantor's remaining property as a result of the grant of this easement, has granted, sold and conveyed and does hereby grant, sell and convey unto said City of Dallas, 1500 Marilla Street, Dallas, Texas 75201, of the County of Dallas, State of Texas (hereinafter called "Grantee"), its successors and assigns, an easement for the purpose of installing, operating and maintaining a pipeline and related appurtenances, and such additional appurtenances as are needed in the future, for the disposal of sand, silt, water and other material (hereinafter called the "dredge material") recovered in connection with the dredging of White Rock Lake (hereinafter called the "Project") in, under, through, across and along all that certain lot, tract, or parcel of land situated in the County of Dallas, State of Texas and described as follows:

Refer to Exhibit A, attached to and made a part of this easement

Should Grantor herein consist of one or more natural persons not joined by their respective spouse, it is conclusively presumed that the land herein conveyed is not the residence or business homestead of such person or persons. Should Grantor consist of one or more legal entities other than a natural person, it shall be conclusively presumed that the person signing on behalf of such a party has been duly and legally authorized to so sign and there shall be no necessity for a seal or attestation.

The City shall have all other rights and benefits necessary or convenient for the full enjoyment or use of the rights herein granted, including, but without limiting the same to, the right of ingress and egress over and across said property to and from said easement for the purpose of constructing, reconstructing, maintaining, inspecting or repairing the pipeline.

Grantee shall have the right to remove and keep removed from the easement herein granted any and all structures, fences trees, shrubs, growths or other obstructions which may endanger or interfere with the construction, reconstruction maintenance, repair or operation of the pipeline. Grantor, its successors or assigns, for the duration of this easement, shall not place or store any material upon, or cover, bury or pave over, the pipeline or any related appurtenance located within the herein described easement.

SPECIAL PROVISIONS:

In further consideration of the grant of this easement, and in consideration of the mutual promises and covenants contained herein, Grantor and Grantee agree to the following special provisions as a part of the grant:

(1) Grantee's pipeline shall be located above the natural ground surface within the area of real property described in Exhibit A (hereinafter called the "easement area"), attached to and made a part of this easement. The pipeline will be owned and operated by Grantee or its designated contractor. The points of entry and termination within the easement area are also described in Exhibit A; provided, however, that Grantee reserves the right to change the points of entry or termination prior to commencement of the pipeline construction, with the consent of Grantor. Once construction of the pipeline is commenced, Grantee's contractor will only place the pipeline one time from White Rock Lake to the termination point; no relocations of the pipeline will be allowed thereafter without the payment of additional compensation to Grantor. Grantee will provide the necessary piping tie-downs to eliminate any movement of the connection to Grantor's pipeline. Grantor agrees that its connecting pipeline will match Grantee's pipeline in size, not to exceed 20 inches in diameter. The dimension used to measure whether the sizes match will be the inside pipe diameter. Grantor will likewise secure the attachment to Grantee's pipeline in a manner to eliminate movement and not impose forces upon Grantee's pipeline. Grantor and Grantee will each provide a flange on each party's respective side of the connection point of both pipelines. The dredge material will be at sufficient pressure on Grantee's side of the connection point to Grantor's pipeline to allow Grantor to distribute the dredge material to any point on Grantor's property without further pumping. Grantor's pipeline shall be limited to a maximum length of 14,000 linear feet of steel or high density polyethylene (plastic) pipe.

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(2) Grantee will obtain an individual Section 404 permit from the U.S. Army Corps of Engineers for discharge of the dredge material onto Grantor's property. Grantor represents that since the easement area and Grantor's property is an active mining area, no navigable waters of the United States or wetlands are located on the property. Therefore, no mitigation for impacts to navigable waters or wetlands are required on the easement area or Grantor's property as a condition of any permit. Grantor shall maintain the status of its property as an active mining area and shall provide mitigation for any environmental impacts caused by Grantor to Grantor's property and adjacent property after conveyance of this easement.

(3) Grantor agrees to accept from Grantee's pipeline, until final completion of the Project, a discharge of dredge material from the Project in an amount of up to 3,000,000 cubic yards (with a reasonable margin of error in determining this quantity of 2.5%) of lake in situ material and rate of up to 15,000 gallons per minute. Grantor agrees that if the amount and rate limit is increased, these Special Provisions may be supplemented to accommodate the change in Project scope. Grantor further agrees that if the Project amount is increased, a request for change in scope of the Special Provisions is valid only if the increase in amount of cubic yards of dredge material exceeds a reasonable margin of error in the estimated dredged quantity or causes an increase in dredging time beyond the 18 months scheduled after the initial date of delivery from Grantee's pipeline. Discharge will occur on a twenty-four (24) hour per day basis. Once discharged beyond the termination point of Grantee's pipeline, the dredge material becomes the property of Grantor and Grantor is solely responsible for transferring the material to any other part of its property as it sees fit, subject to applicable state, federal and local laws, regulations and ordinances. Grantor may use the dredge material for any lawful purpose it deems appropriate; provided, however, that dredge material shall be held on Grantor's property for a minimum of forty-eight (48) hours before it is discharged or transferred onto adjacent properties. Grantor is solely responsible for obtaining consent from other property owners to discharge or transfer dredge material onto adjacent properties.

(4) Grantor agrees to take all actions necessary to prepare its property to properly accept and use the dredge material upon its discharge from the termination point. Grantor shall be responsible for constructing all improvements, appurtenances and other features on its property, including but not limited to road crossings, fences culverts, pipelines, berms, dams or outlet structures. Grantor shall also be responsible for maintaining the condition of all existing roads, fences, culverts, pipelines, utilities and other features and services on, over, under or within Grantor's property that are related and necessary to the performance of the special provisions of this easement. Grantee shall make no repairs or improvements to the easement area or Grantor's property beyond any specifically required of Grantee under this easement, with the sole exception that Grantee may erect a temporary on-site foundation, building, parking area and fencing should a pumping station be required.Grantee will have sole responsibility for upkeep of and liability for such facility if constructed and, if necessary, will clean up any fluid spills onto or over Grantor's or other adjacent owners' properties.

(5) **GRANTEE MAKES NO WARRANTIES OR REPRESENTATIONS CONCERNING THE FITNESS, SUITABILITY, CONDITION OR MATERIAL PROPERTIES OF THE DREDGE MATERIAL FOR ANY PURPOSE; CITY DOES NOT REPRESENT THAT THE DREDGE MATERIAL WILL FILL THE PROPERTY IN AN EQUAL MANNER, AND DOES NOT REPRESENT THAT IT WILL COMPACT TO ANY DENSITY OR DRY OUT WITHIN ANY SPECIFIED TIME FRAME.**

(6) Grantor shall allow representatives of Grantee, Grantee's contractor and any state or federal agency access to the easement area and the entry and termination points of the pipeline to perform any necessary inspections or operations. Grantor shall also allow Grantee access to Grantor's property to perform on-site analytical testing of the dredge material received from the pipeline at any time during the course of the Project and within one year after the completion of the Project.

(7) If Grantee's contractor requires a booster pump to be placed on Grantor's property, Grantor agrees that it will grant an easement to Grantee's contractor immediately upon request from Grantee for the purpose of installing the booster pump facilities, for access to operate the booster pump site and to provide for a power supply to the booster pump facilities. Grantee's contractor shall be responsible for the operation and maintenance of the booster pump, engines and other equipment associated with the facility.

(8) During the course of the Project, Grantor shall not alter or impede the natural offsite drainage from adjacent properties onto Grantor's property.

(9) Subject to Special Provisions (11) and (17)(a) below, Grantor shall be solely responsible for the operation, construction and maintenance of operations to accept dredge material

discharged and for all other activities conducted on its property during the course of the Project, and shall be responsible for obtaining any and all permits required in regard to the Grantor's own activities, the use of the dredge material, the discharge of excess water or dredge material and any other related operations. During the course of the Project, Grantor shall conduct its operations for receiving the dredge material in a manner compatible with the Project and shall do nothing to hinder, interfere with or prevent the flow of dredge material through the pipeline onto Grantor's property. **IF GRANTOR FAILS TO ACCEPT OR WRONGFULLY BLOCKS THE DISCHARGE OF DREDGE MATERIAL FROM GRANTEE'S PIPELINE IN BREACH OF THE TERMS OF THIS EASEMENT, GRANTOR AGREES TO PAY, AS LIQUIDATED DAMAGES, THE SUM OF $10,000 PER DAY FOR EACH DAY THAT GRANTOR FAILS TO ACCEPT OR WRONGFULLY BLOCKS THE DISCHARGE IN BREACH OF THE TERMS OF THIS EASEMENT. GRANTOR AND GRANTEE AGREE THAT THIS SUM IS NOT A PENALTY, BUT IS REASONABLE LIQUIDATED DAMAGES DUE TO THE IMPRACTICALITY AND DIFFICULTY OF CALCULATING ACTUAL DAMAGES IN THIS INSTANCE.**

(10) Grantor agrees to comply with the conditions of any state or federal permit relating to the discharge of water, dredge material or other material from Grantor's property. If any of the conditions are not met, Grantor shall change the operations on the property until the conditions of the permit are met. Grantor shall be responsible for the cleanup, remediation or restitution of any contamination or adverse impacts to adjacent or other properties (including Grantor's own property) resulting from the discharge of dredge material, water or any other material from Grantor's property. **GRANTEE OR ANY STATE OR FEDERAL REGULATORY AGENCY SHALL HAVE THE RIGHT TO ENTER GRANTOR'S PROPERTY FOR THE PURPOSE OF MONITORING THE DISCHARGE OF DREDGE MATERIAL, WATER OR OTHER MATERIAL FROM GRANTOR'S PROPERTY.**

(11) (a) In consideration of the grant of this easement and the performance by Grantor of its obligations under this easement regarding the acceptance of the dredge material, Grantee agrees to make payments, not to exceed $2,388,078 (unless additional funding is agreed upon and approved as described in subsection (e) below), to Grantor for the cost of construction, maintenance and management of operations to accept the dredge material discharged. The payments made by Grantee under this Special Provision are based upon receipt of the dredge material at Grantee's pipeline termination point indicated in Exhibit A. Payments shall be made in the manner described in subsections (b), (c), (d) and (e) below, concurrently with the phases of Initial Preparation, Final Preparation, Operation, Maintenance and Contingency. Initial Preparation includes site clearing, road building, engineering, surveying and other miscellaneous items necessary to prepare for the Final Preparation phase. Final Preparation includes levee, berm, excavation, hauling, pipeline, fencing, surveying and other miscellaneous items necessary to construct the holding ponds for the dredge material. Operation and Maintenance includes manpower, equipment, fuel, supplies, materials and other miscellaneous items necessary to operate and maintain the holding ponds for the duration of the Project. Contingency includes the manpower, equipment, fuel, supplies, material and other miscellaneous items necessary to make major repairs to the holding ponds, and specifically includes work required to construct culvert improvements under Fulghum Road and maintenance to the berm roads not included in the Operation and Maintenance phase. Contingency also includes a contingency to pay Grantor for up to 10% additional dirt work (estimated to be 9,600 cubic yards) required to complete the holding ponds in the Final Preparation phase, and materials density testing for the holding pond levees as deemed necessary by Grantee. The purpose of the Contingency phase is to provide payment to Grantor for a major repair of the holding ponds, culvert improvements under Fulghum Road and maintenance grading of the berm roads which cannot be completed with the manpower, equipment, materials, supplies and other items estimated to be necessary in the Operation and Maintenance phase. The Contingency phase will be used only on an as needed basis as determined and agreed upon by Grantor and Grantee.

(b) Grantor will initiate all payments under this Special Provision 11 by making a written pay request to Grantee five (5) working days before the payment is due. The pay request must include a written invoice for the amount to be paid and documentation supporting the pay request such as copies of equipment lease agreements, invoices for purchased materials or equipment, surveyed measurements of dirt work, invoices for contract work, and other similar reasonable items. Subject to receipt of the properly documented invoices as provided above, payments by Grantee will begin 15 days before the scheduled date of award for the Project contract. One lump sum payment of $61,126 will be made upon execution of this easement and one lump sum payment of $202,634 will be made one day after the scheduled date of award of the Project contract for work to complete the Initial Preparation phase.

(c) After completion of the Initial Preparation phase, Grantor agrees to begin the Final Preparation phase upon Grantee's issuance of a notice to proceed to its Project contractor. Grantee agrees to make payment for Final Preparation work in an amount not to exceed $1,355,836, which payment will be paid in lump sum increments of 50%, 30% and 20% of the total not to exceed amount stated in this subparagraph (c). Each payment will be made when each one-third of dirt work is completed during the Final Preparation phase as certified by Grantor. It is agreed by Grantor and Grantee that an amount not to exceed 96,000 cubic yards of dirt work shall be the total amount of Final Preparation dirt work upon which the payment amount is based.

(d) After completion of the Final Preparation phase, Grantee agrees to make payments for Operation and Maintenance in an amount not to exceed $595,404, which sum is payable in eighteen regular lump sum monthly payments of $33,078 during the course of the Project. The first payment will be made within ten (10) calendar days after discharge of the dredge material through the pipeline begins. Each subsequent payment will be made on or before the 30th day of each calendar month thereafter. If the time from completion of the Final Preparation phase to commencement of discharge of the dredge material through the pipeline exceeds 30 days, Grantee agrees to make one additional lump sum payment of $33,078 to Grantor. Further, if Grantee makes the additional lump sum payment described above and the Project contractor completes the discharge of the dredge material through the pipeline before the eighteenth regular payment is made, Grantor agrees to forfeit and waive any right to the eighteenth regular payment.

(e) If, during the course of the Operation and Maintenance phase, a major repair to the holding ponds, culvert improvements under Fulghum Road or maintenance grading of the berm roads is required, which major repair Grantor and Grantee agree cannot be corrected with the manpower, equipment, materials, supplies and other items estimated to be necessary and available in the Operation and Maintenance phase, Grantee agrees to make payments to Grantor from the Contingency fund for the work completed to make the repair. For purposes of this Special Provision, the term "major repair" means a breach to a containment levee which would require equipment and manpower necessary to haul, place, work in or rework levee material to repair the breached area not used for day-to-day operation and maintenance. A major repair does not include increasing the height, top width, width or length of the containment levee for the convenience of Grantor, nor does it include a repair of any erosion to, rutting of or intentional breaching of a containment levee. Also, if during the course of the Final Preparation phase additional dirt work is needed to complete the holding ponds, or if materials density testing to the holding pond levees is directed by Grantee, Grantee agrees to make payment to Grantor from the Contingency fund for up to an additional 10%, or 9,600 cubic yards, of dirt work, or in the case of the materials density testing, the cost of the test. In this instance, Grantee must be notified in writing immediately of a problem that might require the Contingency. **GRANTOR MUST OBTAIN WRITTEN APPROVAL FROM THE GRANTEE BEFORE THE GRANTOR ORDERS OR PERFORMS ANY MAJOR REPAIR WORK FOR WHICH GRANTOR SEEKS REIMBURSEMENT FROM GRANTEE'S CONTINGENCY FUND.** Grantee shall respond to a written request within 24 hours after receipt; approval of the request shall not be unreasonably withheld. Requests or responses that are facsimiled or electronically mailed are acceptable formats under this subparagraph. Grantor must also provide a written pay request including sufficient documentation of the work completed before a payment is made. The Contingency fund will be an amount not to exceed $160,000. If, for any reason, the Contingency fund is insufficient to pay for a major repair, Grantor and Grantee agree to negotiate the necessity of the major repair and possible additional compensation for the major repair, subject to approval of additional funding by the Dallas City Council. This provision shall not be construed to bind Grantee to provide additional funding until such is agreed upon and approved by the Dallas City Council.

(12) **GRANTOR AGREES TO DEFEND, INDEMNIFY AND HOLD GRANTEE, ITS OFFICERS, AGENTS AND EMPLOYEES, HARMLESS AGAINST ANY AND ALL CLAIMS, LAWSUITS, JUDGMENTS, FINES, PENALTIES, COSTS AND EXPENSES FOR REGULATORY VIOLATIONS, OR FOR ANY PERSONAL INJURY (INCLUDING DEATH), PROPERTY DAMAGE OR OTHER HARM FOR WHICH RECOVERY OF DAMAGES IS SOUGHT, SUFFERED BY ANY PERSON OR PERSONS, THAT MAY ARISE OUT OF OR BE OCCASIONED BY GRANTOR'S BREACH OF ANY OF THE TERMS OR PROVISIONS OF THIS EASEMENT, VIOLATION OF ANY FEDERAL, STATE OR LOCAL ENVIRONMENTAL LAWS, RULES OR REGULATIONS GOVERNING PERFORMANCE OF THE TERMS OF THIS EASEMENT (INCLUDING BUT NOT LIMITED TO ANY RULES GOVERNING USE, HANDLING OR DISPOSAL OF THE DREDGE MATERIAL RECEIVED FROM GRANTEE), OR FROM ANY NEGLIGENT OR STRICTLY LIABLE ACT OR OMISSION OF GRANTOR, ITS OFFICERS, AGENTS, EMPLOYEES OR**

SUBCONTRACTORS, IN THE PERFORMANCE OF OPERATIONS TO RECEIVE THE DREDGE MATERIAL OR IN THE PERFORMANCE OF ANY OTHER OBLIGATION OF GRANTOR UNDER THE TERMS OF THIS EASEMENT; EXCEPT THAT THE INDEMNITY PROVIDED FOR IN THIS PARAGRAPH SHALL NOT APPLY TO ANY LIABILITY CAUSED SOLELY BY THE NEGLIGENCE OR FAULT OF GRANTEE, ITS OFFICERS, AGENTS, EMPLOYEES OR SEPARATE CONTRACTORS, AND SHALL NOT APPLY TO ANY LIABILITY CAUSED IN WHOLE OR IN PART BY CONTAMINATION OF THE DREDGE MATERIAL CAUSED BY GRANTEE OR ORIGINATING FROM GRANTEE'S PIPELINE OR PROJECT OPERATIONS; AND IN THE EVENT OF JOINT AND CONCURRING RESPONSIBILITY OF GRANTOR AND GRANTEE, RESPONSIBILITY AND INDEMNITY, IF ANY, SHALL BE APPORTIONED PROPORTIONATELY IN ACCORDANCE WITH THE LAW OF THE STATE OF TEXAS, WITHOUT WAIVING ANY GOVERNMENTAL IMMUNITY AVAILABLE TO GRANTEE UNDER TEXAS LAW AND WITHOUT WAIVING ANY DEFENSES OF THE PARTIES UNDER TEXAS LAW. THE PROVISIONS OF THIS PARAGRAPH ARE SOLELY FOR THE BENEFIT OF GRANTOR AND GRANTEE AND ARE NOT INTENDED TO CREATE OR GRANT ANY RIGHTS, CONTRACTUAL OR OTHERWISE, TO ANY OTHER PERSON OR ENTITY.

(13) This easement is a temporary easement; the term of this easement shall extend, unless sooner terminated as provided below, until the Grantee certifies in writing that the Project is finally complete and makes final payment to its contractor. Grantee reserves the right, at its sole option, to automatically extend the term of this easement, by notice to Grantor in writing, for a period of six months after Project completion to allow solely for additional inspection of the effects of the discharge on Grantor's property and cleanup of the easement area. Upon termination of this easement for any reason, Grantee agrees to clean up any surplus excavation, remove the pipeline and any appurtenances thereto, and remove any construction or other debris, trash, litter or other material resulting from Grantee's use of the easement area and to restore the easement area as nearly as possible to its original contour and condition.

(14) This easement is subject to termination by Grantee for any reason, including Grantee's convenience, upon ten (10) days prior written notice to Grantor. Grantee agrees, in the event of termination, to pay Grantor reasonable termination costs, not to exceed the cost of any construction, maintenance and management operations to receive the dredge material performed prior to the date of termination, less any payments previously made by Grantee. Grantee agrees to take whatever steps are necessary upon termination under this paragraph to promptly authorize and record a release of this easement so as to remove any encumbrance upon Grantor's title to the underlying property.

(15) This easement and the special provisions herein are subject to the Charter and ordinances of the City of Dallas, and all applicable state and federal laws and regulations. This easement and the special provisions herein shall be construed in accordance with the laws and court decisions of the State of Texas.

(16) **NO JOINT VENTURE, PARTNERSHIP OR OTHER COMMON ECONOMIC ENTERPRISE IS CREATED BY THIS EASEMENT, AND NOTHING IN THIS EASEMENT AND THE SPECIAL PROVISIONS HEREIN SHALL BE CONSTRUED TO CREATE A JOINT VENTURE, PARTNERSHIP OR COMMON ECONOMIC ENTERPRISE BETWEEN GRANTOR AND GRANTEE. EACH PARTY IS ONLY RESPONSIBLE FOR CONTROLLING AND DIRECTING ITS OWN OPERATIONS AND PERSONNEL, SUBJECT ONLY TO THE TERMS OF THIS EASEMENT.**

(17) (a) The obligations of Grantor to perform under the special provisions of this easement shall be extended or excused for reasons of force majeure, including but not limited to acts of God, acts of war, strikes, abnormal weather conditions, riot, fire, unusual or unforeseeable delay in transportation, cessation of any work or construction required under these special provisions by court order or an order of any public authority through no act or fault of Grantor, or any other cause beyond Grantor's control.

(b) The obligations of Grantee to perform under the special provisions of this easement shall be extended or excused for reasons of force majeure, including but not limited to acts of God, acts of war, strikes, abnormal weather conditions, riot, fire, unusual or unforeseeable delay in transportation, cessation of any work or construction required under these special provisions by court order or an order of any public authority through no act or fault of Grantee, or any other cause beyond Grantee's control.

(18) If it is necessary to enforce any of the provisions of this easement, exclusive venue for any legal action to enforce this easement and its provisions shall lie exclusively in Dallas County, Texas.

(19) This easement and the special provisions herein shall be binding upon Grantor and Grantee and their respective successors and assigns, including but not limited to Grantor's successors in title to Grantor's property, if any.

(20) This easement and the special provisions herein shall constitute the entire agreement between Grantor and Grantee, superseding any previous or contemporary oral or written agreements relating to the subject matter of this easement and the special provisions herein. The terms of this easement may be amended only by written agreement signed by duly authorized representatives of both Grantor and Grantee.

The grant of this easement is made by Grantor and accepted by Grantee subject to: (i) all encumbrances, restrictions and other matters of record affecting the easement area, recorded in the real property records of Dallas County, Texas, which encumbrances, restrictions and other matters of record are as shown in Exhibit B, attached to and made a part of this easement; and (ii) all zoning laws, regulations and ordinances of municipal or governmental authorities, if any, affecting the easement area.

TO HAVE AND TO HOLD the above-described easement, together with all and singular the rights and appurtenances thereto in anywise belonging unto the City of Dallas, its successors and assigns forever, and Grantor is hereby bound, together with all heirs, successors or assigns, to warrant and forever defend, all and singular, the said easement unto the City of Dallas, its successors and assigns, against every person whomsoever lawfully claiming, or to claim the same or any part thereof. It is intended by these presents to convey a right-of-way to the City of Dallas to construct, maintain and operate the above-mentioned pipeline and appurtenances thereto, with the usual rights of ingress and egress in the necessary use of such right-of-way in and along said easement.

EXECUTED this 5 day of 23, 1997.

ATTEST:

BY _____

GRANTOR:
THE STEPHENS GROUP, L.P., a Texas limited partnership

BY _____
GARY BEN STEPHENS
General Partner

APPROVED AS TO FORM:
SAM A. LINDSAY, City Attorney

BY _____
Assistant City Attorney
Submitted to City Attorney

ACCEPTED:
CITY OF DALLAS
JOHN L. WARE, City Manager

BY _____
Assistant City Manager

PROPERTY MANAGEMENT DIRECTOR
_____

97130 02428

THE STATE OF TEXAS)
)
COUNTY OF DALLAS)

BEFORE ME, the undersigned, a Notary Public in and for said County and State, on this day personally appeared Ryan S. Evans, the Assistant City Manager of the City of Dallas, known to me to be the person and officer whose name is subscribed to the foregoing instrument, and he acknowledged to me that the same was the act and deed of the City of Dallas, Texas for the purposes and consideration therein expressed, and in the capacity therein stated.

GIVEN UNDER MY HAND AND SEAL OF OFFICE this the 15th May day of _____, 1997.

LAURIETTA STEWART
Notary Public, State of Texas
My Commission Expires
10/09/2000

NOTARY PUBLIC, STATE OF TEXAS

Laurietta Stewart
PRINTED NAME OF NOTARY

MY COMMISSION EXPIRES: 10-9-2000

THE STATE OF TEXAS)
)
COUNTY OF DALLAS)

This instrument was acknowledged before me on May 23, 1997 by Gary Ben Stephens, general partner of The Stephens Group, L.P., a Texas limited partnership, on behalf of said limited partnership.

TONYA IVY ORTEGA
Notary Public
State of Texas
My Comm. Exp. Sept. 13, 1997

NOTARY PUBLIC, STATE OF TEXAS

Tonya Ivy Ortega
PRINTED NAME OF NOTARY

MY COMMISSION EXPIRES: 9/13/97

97130 02429

Easement From The Stephens Group L.P. In The Robert Sloan Survey
Abstract No. 1271, Dallas County, Texas

REVIEWED BY 4-23-97

BEING situated in The Robert Sloan Survey Abstract No. 1271, Dallas County, Texas and being part of that land conveyed to The Stephens Group L.P. by substitute trustee's deed recorded in Volume 92017, Page 2206 of the Deed Records of said County and containing approximately 2.716 acres of land and being more particularly described as follows:

BEGINNING at a 1/2" iron rod set at the intersection of the common line of said Sloan Survey and the John Goar Survey Abstract No. 510 Dallas County, Texas with the South line of the P. Sampson Survey Abstract No. 1274, Dallas County, Texas and lying in the approximate center of Post Oak Road;

THENCE South 29°10'43" East along said common line and said approximate centerline a distance of 80.00 feet to a point;

THENCE South 61°28'43" West a distance of 1479.50 feet to a point;

THENCE North 28°31'17" West 80.09 feet to a 1/2" iron rod set in the north line of said Sloan Survey;

THENCE North 61°43'57" East along said north line a distance of 21.22 feet to a 1/2" iron rod set in the approximate center of Post oak Road;

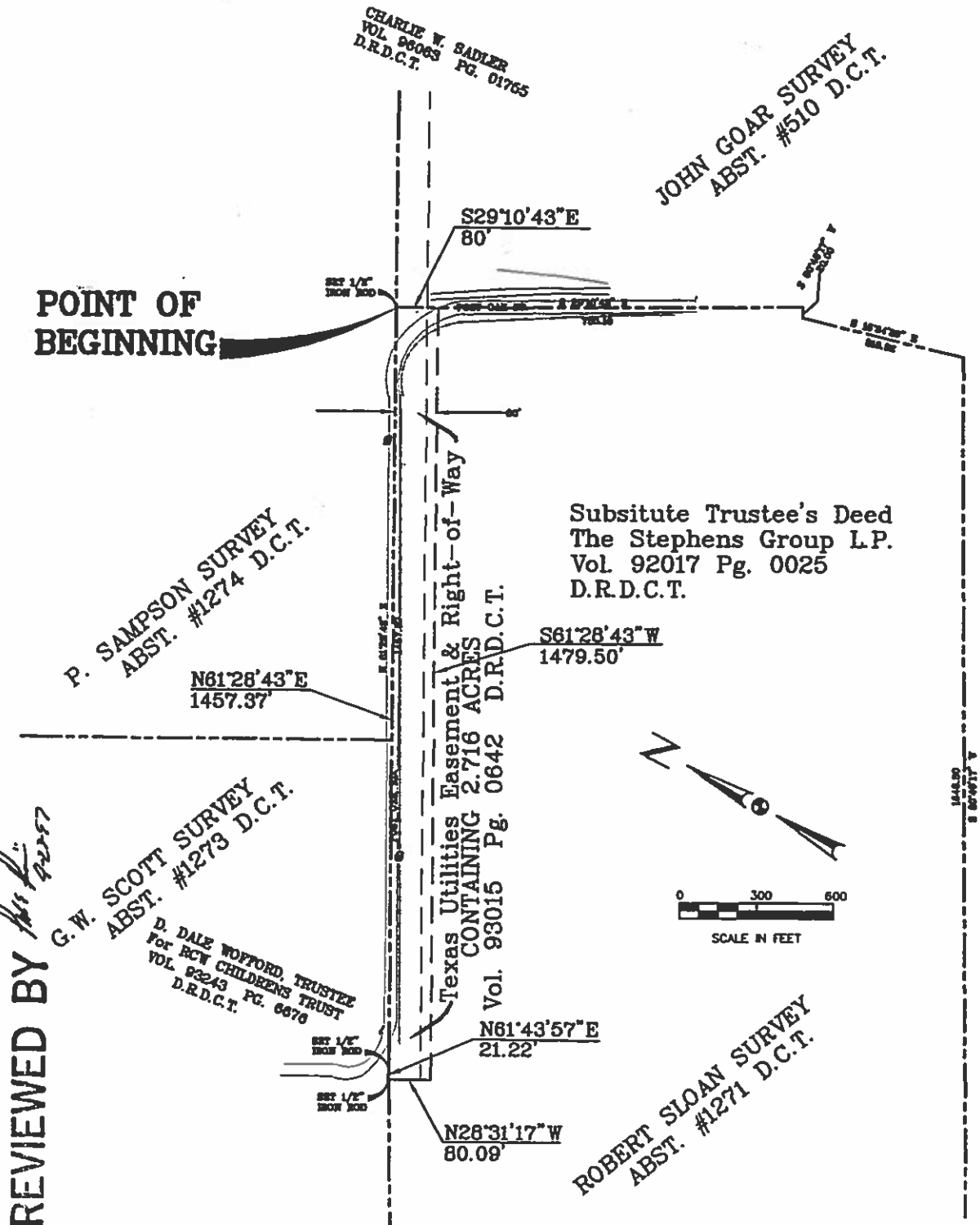
THENCE North 61°28'43" East along the approximate center of Post Oak Road and along said north line a distance of 1457.37 feet to the place of beginning and containing approximately 118,317 square feet or 2.716 acres, more or less and being subject to an easement to Texas Utilities Electric Company recorded in Volume 93015, Page 0642 of said Deed Records and the portion of said land lying in the presently used roadway.

BASIS OF BEARINGS: Bearings are State Plane Bearings on the North Central Texas Zone.

STATE OF TEXAS
REGISTERED
WALTER D. THOMAS
1984
PROFESSIONAL
LAND SURVEYOR

4/23/97

97130 02430



REVIEWED BY

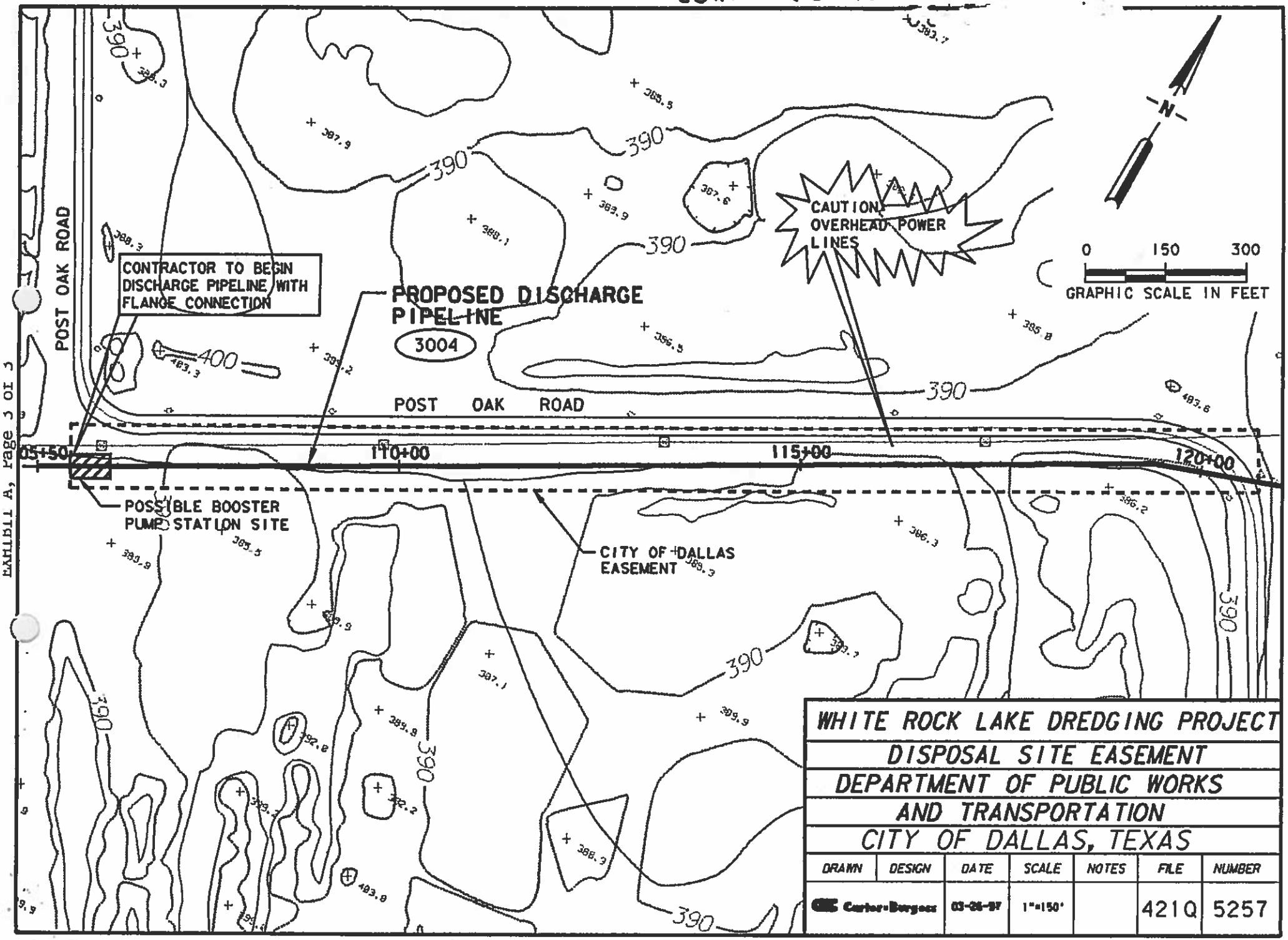
STATE OF TEXAS
REGISTERED
WALTER D. THOMAS
1984
PROFESSIONAL
LAND SURVEYOR

4/23/97

NOTE:
BASIS OF BEARINGS are State Plane Bearings on the North Central Texas Zone.

97130 02431

91130 0243Z



WHITE ROCK LAKE DREDGING PROJECT						
DISPOSAL SITE EASEMENT						
DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION						
CITY OF DALLAS, TEXAS						
DRAWN	DESIGN	DATE	SCALE	NOTES	FILE	NUMBER
Carter-Burgess		03-26-97	1"=150'		421Q	5257

EXHIBIT B

The temporary pipeline easement is subject to the following listed matters of record affecting the easement area:

(1) Easement granted by Gifford-Hill & Company, Inc. to Dallas Power & Light Company, filed March 16, 1977, recorded in Volume 77052, Pages 1452-1453, Deed Records of Dallas County, Texas.

(2) Easement granted by The Stephens Group, L.P. To Texas Utilities Electric Company, filed January 22, 1993, recorded in Volume 93015, Pages 0642-0646, Deed Records of Dallas County, Texas.

(3) Mineral estate and interest described in subparagraph (9) of Special Warranty Deed With Vendor's Lien from Gifford-Hill & Company, Inc. to Jones and Wahle Joint Venture #2, filed July 23, 1987, recorded in Volume 87141, Pages 5866-5869, Deed Records of Dallas County, Texas.

Memorandum

CITY OF DALLAS

DATE August 4, 1997

TO Robert Sloan
City Secretary

SUBJECT Original Documents
City Secretary File No. 97-0011 Council Date: July 8, 1997
Property Management Log No. AP/19678

The attached original document(s) are forwarded to the City Secretary's office for permanent record.

Ruby Anthony
Real Estate Manager

RECEIVED
AUG 13 1997
PUBLIC WORKS AND TRANSPORTATION
SURVEY SECTION

S103356

DISTRIBUTION
Chief City Surveyor
City Property File
City Controller - Egbert Hood
Budget & Management Services -Tommy Duncan (ordinances & resolutions only)
Plat Records (Darrell Green - 6/B/S)
PW&T Private Development Activities - Tom Rasco
PW&T Engineering
PW&T Assessments
DWU Engineering
revised 1/10/94

Memorandum

97-0011
7-8-97

CITY OF DALLAS

DATE July 8, 1997

TO
City Secretary through
City Manager through City Controller

SUBJECT
Project Name and Number: White Rock Lake Dredging Project

Property Description: N/A

Location: Texas Utilities Electric Company right-of-way from Lawther Dr. to Hawn Freeway

Grantor(s): Texas Utilities Electric Company

As authorized by Section 2-11.2, 1960 Revised Dallas Code, the attached instrument is accepted and forwarded to be filed for record.

CONSIDERATION: $ None (Commercial License Agreement)

RECEIVED
JUL 22 1997
PROPERTY MANAGEMENT

SPECIAL PROVISIONS: None

RECOMMENDED:

for Ruby Anthony
GAY DeHOFF
Property Management
Director

DISTRIBUTION:
(complete packet)
City Controller-Egbert Hood
Budget and Research (Resolution Only)
Chief City Surveyor
City Property File
Planning/Maps & Plats-Darrell Green(6/B/S)
Public Works-Walter Hart
Public Works Assessments
~~Water Engineering~~
~~Water Accounting Water(S/A/P) (Resolution Only)~~

AP / 19678
0129F.WPF/2

APPROVED:
JOHN L. WARE, CITY MANAGER

By _____
Assistant City Manager

Approved as to form:
SAM LINDSAY, CITY ATTORNEY

By _____
Assistant City Attorney

Contact: Ruby Anthony
Supervisor
948-4089

REVISED 05/01/94

LC 4389

PARKDALE - CEDAR CREST
NEEDS: C-8.0, H-7.0, D-6.2, T-20.0
P-12.0, R-12.0, B-23.0, F-3.0, M-41.0
P-15.0, L-1.0, L-1.1, B-2.0, W-11.0,
R-13.0, M-28.0, L-1.2, J-12.0, T-11.0
C-9.6, V-1.0

97-0011
7-8-97

COMMERCIAL LICENSE AGREEMENT

STATE OF TEXAS §
§ KNOW ALL MEN BY THESE PRESENTS:
COUNTY OF DALLAS §

This license agreement made this 1st day of August, 1997, by and between Texas Utilities Electric Company, a Texas Corporation, hereinafter called Licensor and **The City of Dallas**, Texas, a Texas Municipal Corporation located primarily in Dallas County, Texas hereinafter called Licensee. In consideration of the mutual covenants and agreements set forth herein, and other good and valuable consideration, Licensor does hereby grant to Licensee, a revocable nonexclusive license to use the following described property:

On **EXHIBIT "A"** attached hereto and made a part hereof for all intent and purposes.

1. LICENSE TERM: The term of this license shall be for Two (2) Years commencing on August 1, 1997 and ending on August 1, 1999, and shall continue thereafter on a Year to Year basis until terminated by either party with thirty days written notice.

2. PERMITTED USE: Licensee may use the premises for a 36" discharge pipe and booster pump stations. Licensee may not use the premises for any other purpose without the written consent of Licensor.

3. LIABILITY INSURANCE: During the license term Licensee shall maintain a policy of public liability insurance at Licensee's expense insuring Licensee against liability assumed by Licensee hereunder and insuring Licensee and Licensor against liability arising out of or in any way incident to ownership, use, occupancy or maintenance of the property made the subject of this license. Such policy or policies shall also provide that the policy is primary and shall apply without regard to other policies separately carried. The initial amount of required insurance shall be at least $1,000,000 Combined Single Limit for Personal Injury, Bodily Injury including death and Property Damage and shall be subject to periodic increase based upon inflation, recommendation of professional insurance advisors, and other relevant factors. Licensor shall give Licensee ninety days notice of any change in insurance requirements Licensee agrees to obtain and provide proof of such required insurance.

In lieu of the above provision, the Licensee may self-insure and upon request will provide the Licensor a letter of self-insurance evidencing adequate reserves in accordance with sound accounting practices.

4. INDEMNITY: Licensee agrees to defend, indemnify and hold Licensor, its officers, directors, agents, and employees harmless against any and all claims, lawsuits, judgments, costs, and expenses for personal injury (including death), property damage or other harm for which recovery of damages is sought, suffered by any person or persons that may arise out of or be occasioned by any negligent act or omission of Licensee, its officers, agents, associates, employees, or subconsultants; except that the indemnity provided for in this paragraph shall not apply to any liability resulting from the sole negligence of Licensor, its officers, agents, or employees or separate contractors, and in the event of joint and concurrent negligence of both the Licensee and Licensor, responsibility and indemnity, if any, shall be apportioned comparatively in accordance with the laws of the State of Texas, without, however, waiving any governmental immunity or other defenses available to the parties under Texas law. The provisions of this paragraph are solely for the benefit of the parties hereto and not intended to create or grant any rights, contractual or otherwise, to any other person or entity.

5. COMPLIANCE WITH LAW: Licensee shall, at its own cost and expense, comply with all applicable laws, including but not limited to existing zoning ordinances, governmental rules and regulations enacted or promulgated by any governmental authority and shall promptly execute and fulfill all orders and requirements imposed by such governmental authorities for the correction, prevention and abatement of nuisances in or upon or connected with said premises because of Licensee's use thereof.

6. LICENSOR'S ACCESS: Licensor and its authorized agents shall have the right to enter the property at any time for any purpose. It being understood that from time to time entry will be necessary for general inspections of Licensor's facilities. This license is nonexclusive, and Licensor, its employees, agents, representatives, and others whom it may license, may go upon, make improvements upon, use and traverse the above described premises and make changes in the location of or additions to Licensor's transmission and distribution facilities located thereon without payment of compensation to Licensee, without liability for any damage or interruption resulting to Licensee of its activities or business.

7. ACCEPTANCE OF PREMISES: Licensee acknowledges that it has fully inspected the property and accepts the property in its present condition as suitable for the purposes for which it is licensed. Licensee shall not make or cause to be made any improvements to the licensed property including but not limited to, any buildings, light standards, fences, shrubs, trees or signs, except as approved in writing by Licensor and then only at the sole cost and expense of Licensee.

8. CONDITION UPON TERMINATION: Upon termination of this agreement, Licensee shall surrender the property to Licensor in the same condition as received except for ordinary wear and tear. In addition, Licensor may require Licensee to remove any improvements made to the property by Licensee prior to the termination of this agreement and to restore the property to its original condition, at Licensee's expense. All improvements not removed at Licensor's request, shall become Licensor's property at no

cost or expense to Licensor.

9. ASSIGNMENT AND SUBLETTING: This agreement is personal to Licensee and may not be sold, transferred, assigned or sublet but may be used by Licensee, and with Licensee's permission, by its employees, agents and those with whom it does business.

10. BOOM-TYPE EQUIPMENT: Use of draglines or other boom-type equipment in connection with any work to be performed on Licensor's property by the Licensee, its employees, agents, representatives or contractors must comply with Chapter 752, Texas Health and Safety Code, the National Electric Safety Code and any other clearance requirements. Notwithstanding anything to the contrary herein, in no event shall any equipment be within fifteen feet of Licensor's power lines situated on the aforesaid property. Licensee must notify the Supervisor of Dallas Region Transmission, 721-6281, 48 hours prior to the use of any boom-type equipment on Licensor's property. Licensor reserves the right to refuse Licensee permission to use boom type equipment.

11. LIEN ON PROPERTY: During the period of construction and at all times while this agreement is in effect, Licensee shall take whatever steps are necessary to prevent any liens, including but not limited to, mechanics liens and materialmen's liens, from attaching to Licensor's property. Licensee shall immediately pay such sums as may be necessary to dispatch liens and encumbrances filed with respect to all or any portion of the Licensor's property resulting from the construction, maintenance or presence of any of Licensee's improvements.

12. MAINTENANCE OF PROPERTY: Licensee, at its own cost and expense at all times during the term of this agreement, agrees to keep clean and maintain or cause to be kept clean and maintained, the premises and all improvements which may be placed or erected on the premises by Licensee with Licensor's consent in a good state of appearance and repair.

13. NOTICES: All written notices required under this License must be hand delivered or sent by certified mail addressed to the proper party at the following addresses:

LICENSOR	LICENSEE
Texas Utilities Electric Company	City of Dallas
Right of Way Manager	Director of Property Management
1601 Bryan Street	320 E. Jefferson Blvd., Room 203
Dallas, Texas 75201	Dallas, Texas 75203

Each party may change the address to which notices are to be sent by giving the other party notice, within ten (10) days, of the new address in the manner provided by this paragraph.

14. DEFAULT: It is understood and agreed that, in case of default by Licensee in any of the terms and conditions herein stated and such default continues for a period of ten

(10) days after Licensor notifies Licensee of such default, Licensor may at its election forthwith terminate this agreement and upon such termination all rights of the Licensee hereunder shall cease and come to an end. If such termination results from Licensee's default there shall be no prorata refund to Licensee of the unearned portion of the rental fee for the then current term, however, in the event that termination of this agreement is for the convenience of either or both parties hereto, Licensor shall refund to Licensee the prorated portion of the rental fee for the then current term.

15. PRIOR AGREEMENTS: This agreement constitutes the sole and only agreement of the parties to the license and supersedes any prior understandings or written or oral agreements between the parties respecting the subject matter of this license.

16. TEXAS LAW: This agreement shall be construed under, and in accordance with, the laws of the State of Texas.

17. AMENDMENT: No amendment, modification, or alteration of the terms of this license shall be binding unless it is in writing, dated subsequent to this lease, and duly executed by the parties to this license.

EXECUTED in triplicate as of the 1st day of August, 1997.

LICENSOR

TEXAS UTILITIES ELECTRIC COMPANY

BY: M Thomason

Mark Thomason
Manager of Dallas Region Transmission

LICENSEE

CITY OF DALLAS

BY: Ryan S. Evans

Ryan S. Evans
Assistant City Manager

ATTEST:

Barry Davis

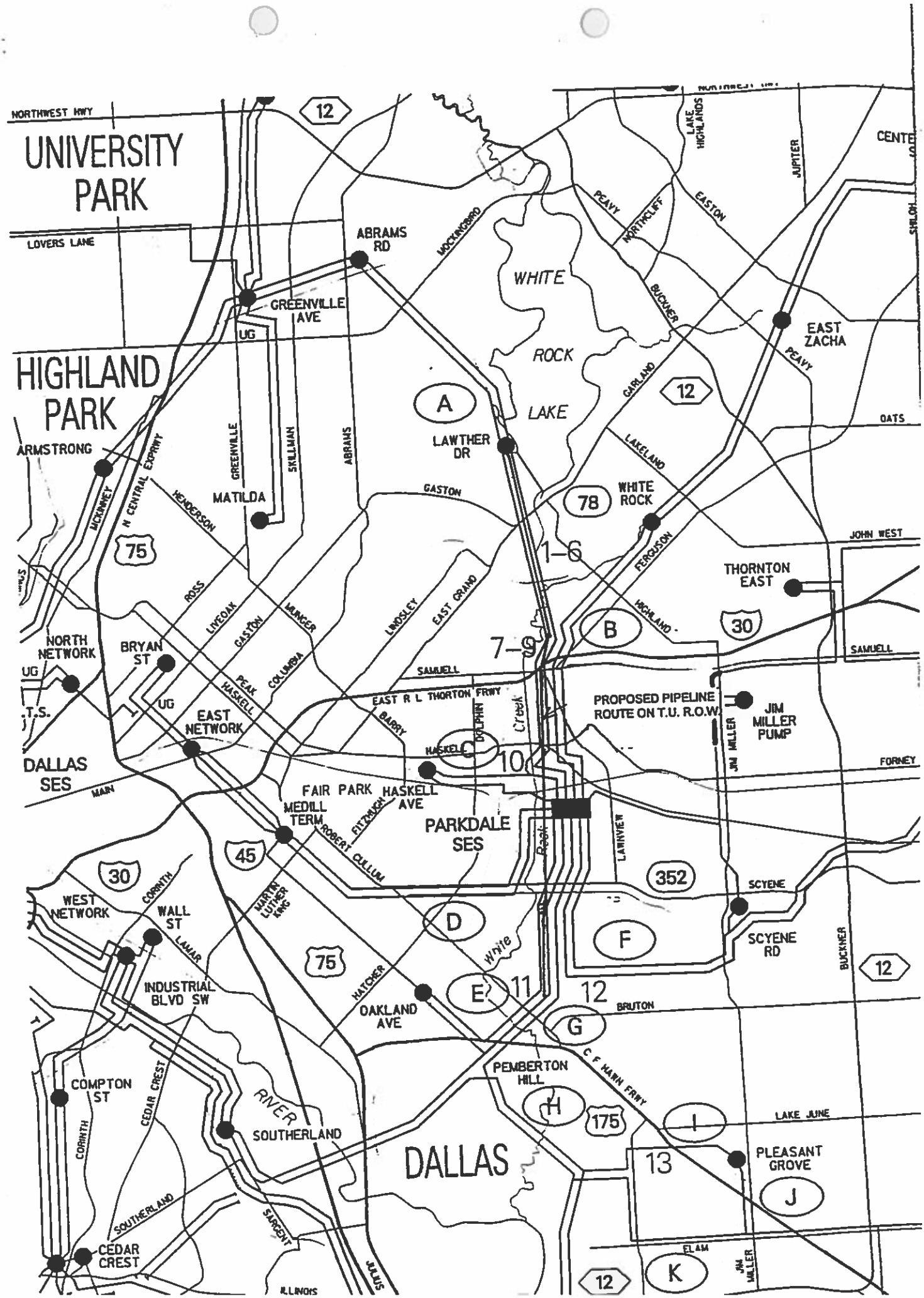
City Secretary:

APPROVED AS TO FORM: CITY ATTORNEY

BY: Lawrence J. Sahl

Assistant City Attorney

Submitted to City Attorney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DALLAS
NORTHWEST HWY
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PEAVY
NORTHCLIFF
EASTON
JUPITER
LAKE HIGHLANDS
BUCKNER
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GARLAND
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LAKELAND
ARMSTRONG
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N CENTRAL EXPRWY
GREENVILLE
SKILLMAN
ABRAMS
MATILDA
HENDERSON
GASTON
LAWTHER DR
WHITE ROCK
JOHN WEST
FERGUSON
THORNTON EAST
ROSS
LIVEOAK
MUNGER
LINDSLEY
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SAMUELL
NORTH NETWORK
BRYAN ST
PEAK
COLUMBIA
HASKELL
BARRY
EAST R L THORTON FRWY
DOLPHIN
Creek
PROPOSED PIPELINE ROUTE ON T.U. R.O.W.
JIM MILLER PUMP
JIM MILLER
FORNEY
EAST NETWORK
DALLAS SES
MAIN
FAIR PARK
HASKELL AVE
MEDILL TERM
ROBERT CULLUM
FITZHUGH
PARKDALE SES
LAWNVIEW
SCYENE
WEST NETWORK
CORINTH
WALL ST
LAMAR
MARTIN LUTHER KING
INDUSTRIAL BLVD SW
HATCHER
OAKLAND AVE
White
SCYENE RD
BUCKNER
BRUTON
C F HAWN FRWY
PEMBERTON HILL
COMPTON ST
CEDAR CREST
RIVER
SOUTHERLAND
LAKE JUNE
PLEASANT GROVE
SARGENT
ELAM
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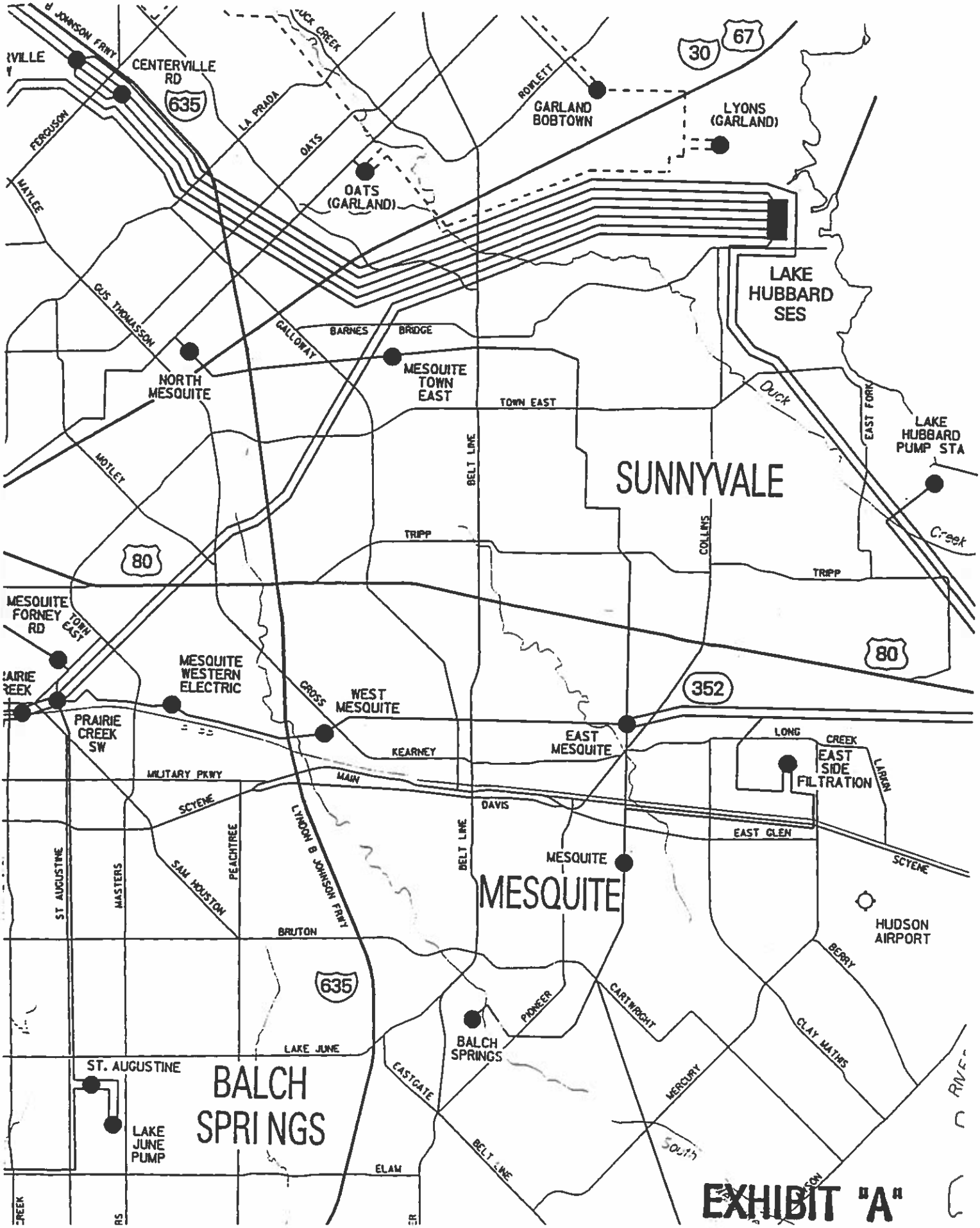
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OATS (GARLAND)
ROWLETT
GARLAND BOBTOWN
30
67
LYONS (GARLAND)
LAKE HUBBARD SES
GUS THOMASSON
GALLOWAY
BARNES BRIDGE
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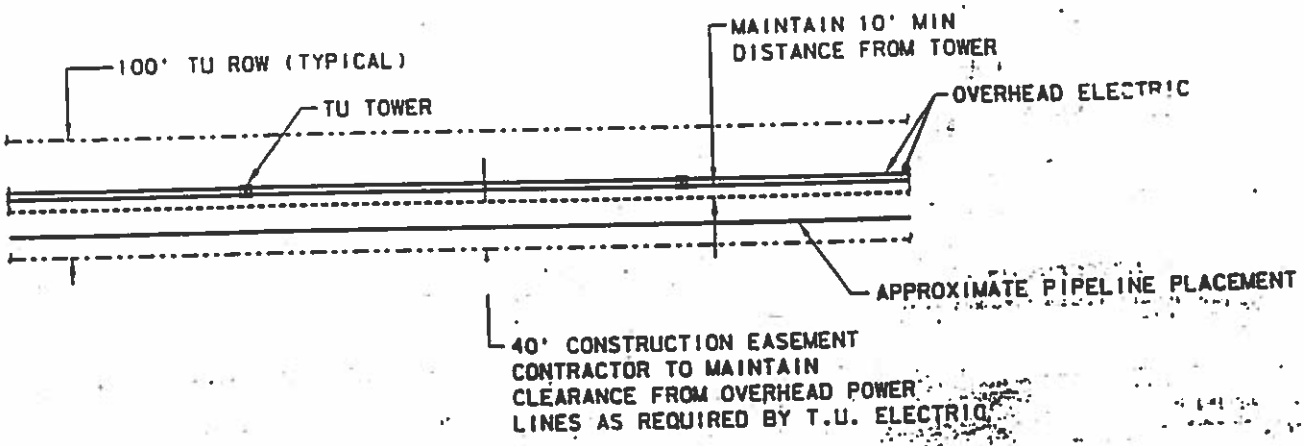
MESQUITE TOWN EAST
TOWN EAST
Duck
EAST FORK
LAKE HUBBARD PUMP STA
MOTLEY
BELT LINE
SUNNYVALE
COLLINS
TRIPP
Creek
80
MESQUITE FORNEY RD
MESQUITE WESTERN ELECTRIC
CROSS
WEST MESQUITE
352
PRAIRIE CREEK SW
KEARNEY
EAST MESQUITE
LONG CREEK
EAST SIDE FILTRATION
LARKIN
MILITARY PKWY
MAIN
SCYENE
DAVIS
EAST GLEN
ST AUGUSTINE
MASTERS
PEACHTREE
SAM HOUSTON
LYNDON B JOHNSON FRWY
MESQUITE
HUDSON AIRPORT
BRUTON
BERRY
635
PIONEER
CARTWRIGHT
BALCH SPRINGS
CLAY MATHIS
LAKE JUNE
ST. AUGUSTINE
EASTGATE
MERCURY
BALCH SPRINGS
LAKE JUNE PUMP
ELAM
BELT LINE
South

EXHIBIT "A"



TYPICAL TU RIGHT-OF-WAY
PIPELINE PLACEMENT

Memorandum

~~97-0[illegible]~~

97-0011
7-8-97

CITY OF DALLAS

DATE July 8, 1997

TO
City Secretary through
City Manager through City Controller

SUBJECT
Project Name and Number: White Rock Lake Dredging Project

Property Description: N/A

Location: Texas Utilities Electric Company right-of-way from Lawther Dr. to south of Scyene Road

Grantor(s): Texas Utilities Electric Company

As authorized by Section 2-11.2, 1960 Revised Dallas Code, the attached instrument is accepted and forwarded to be filed for record.

CONSIDERATION: $ None (Encroachment on Easements)

SPECIAL PROVISIONS: None

RECOMMENDED:

for Ruby Anthony
GAY DeHOFF
Property Management
Director

APPROVED:
JOHN L. WARE, CITY MANAGER

By _____
Assistant City Manager

DISTRIBUTION:
(complete packet)
City Controller-Egbert Hood
Budget and Research (Resolution Only)
Chief City Surveyor
City Property File
Planning/Maps & Plats-Darrell Green(6/B/S)
Public Works-Walter Hart
Public Works Assessments
~~Water Engineering~~
~~Water Accounting Water(S/A/D)(Resolution Only)~~

Approved as to form:
SAM LINDSAY, CITY ATTORNEY

By Lawrence G. Scaff
Assistant City Attorney

Contact: Ruby Anthony
Supervisor
948-4089

AP / 19678
0129F.WPF/2

REVISED 05/01/94

97-0011
7-8-97

TUSERVICES
ENCROACHMENT ON EASEMENTS

June 25, 1997

Re: Parkdale - Cedar Crest Transmission Line
White Rock Dredging Project
Encroachment on Easements, 5375-A, 717-E,
4625-E, 855-E, 814-J, 738-E, & 739-J

City of Dallas
Director of Property Management
320 E. Jefferson, Rm. 203
Dallas, Texas 75203

Dear Sir:

The City of Dallas (hereinafter referred to as User) has requested permission to construct a 36 inch discharge pipe and the associated booster pumps within the area or boundaries of Texas Utilities Electric Company's (TU Electric), successor to Dallas Power & Light Company's, easements recorded in Volume 4897, Page 0512, Volume 1697, Page 0140, Volume 2025, Page 0217, Volume 1784, Page 0014, Volume 0018, Page 0355, Volume 1703 Page 0126, and Volume 0028, Page 0215, Deed Records of Dallas County, Texas.

TU Electric is agreeable to the construction of the 36 inch discharge pipe and booster pumps, hereinafter referred to as the "encroaching facility", for a period not to exceed two (2) years, if the encroaching facility is located and described as shown on the attached drawing, marked **Exhibit "A"** and incorporated herein, and subject to the following terms and conditions:

1. It is understood and agreed that TU Electric holds easement rights on the property involved; therefore, User will be required to obtain whatever rights and permission, other than TU Electric's, that are necessary. This letter agreement shall extend to and be binding upon User and its heirs, successors, and assigns, and is not to be interpreted as a waiver of any rights held by TU Electric under its easement.

2. User agrees to defend, indemnify and hold Grantor, its officers, agents and employees, harmless against any and all claims, lawsuits, judgements, costs, and

expenses for personal injury (including death), property damage or other harm for which recovery of damages is sought, suffered by any person or persons that may arise out or be occasioned by any negligent act or omission of User, its officers, agents, associates, employees, or subconsultants; except that the indemnity provided for in this paragraph shall not apply to any liability resulting from the sole negligence of Grantor, its officers, agents or employees or separate contractors and in the event of joint and concurrent negligence of both User and Grantor, responsibility and indemnity, if any, shall be apportioned comparatively in accordance with the laws of the State of Texas, without, however, waiving any governmental immunity or other defenses available to the parties under Texas law. The provisions of this paragraph are solely for the benefit of the parties hereto and not intended to create or grant any rights, contractual or otherwise, to any other person or entity.

3. Use of draglines or other boom-type equipment in connection with any work to be performed on the TU Electric easement by User, its employees, agents, representatives or contractors must comply with Texas Statute (3TexCiv.St. 1436c), the National Electric Safety Code and any other applicable safety or clearance requirements. Notwithstanding anything to the contrary herein, in no event shall any equipment be within fifteen feet of the TU Electric power lines situated on the aforesaid property. User must notify the Supervisor of Dallas Region Transmission Operations, (214) 721-7321, 48 hours prior to the use of any boom-type equipment on the TU Electric easement.

4. Whenever by reason of Grantors use of its hereinabove described property, for any purpose whatsoever, it shall be deemed necessary by Grantor to remove alter, change, adapt, or conform the facilities of User, such alterations or changes shall be made as soon as practicable by User when ordered in writing by Grantor, without claim for reimbursement or damages against Grantor, provided, however, if said requirements impose a material financial hardship upon User, the User shall have the right to present alternative proposals for Grantor's consideration. Grantor shall not require User to remove its facilities entirely from the hereinabove described easement unless suitable alternatives are available for relocation at reasonable cost, but in any event User shall be required to relocate such facilities with the the herinabove described easement so that such facilities do not impair the use of such property by Grantor in the operation of its business.

5. It is expressly understood and agreed that if the property has transmission or distribution facilities located thereon, User shall not place upon the premises, any improvements including but not limited to, buildings, light standards, fences, shrubs, trees or signs unless approved in writing by TU Electric.

6. It is agreed that no trash dumpsters, toxic substances or flammable material will be

allowed on the easement.

7. TU Electric will not be responsible for any costs of construction, operation and maintenance of User's encroaching facility. It is further agreed that TU Electric shall not be liable for any damage to the encroaching facility herein agreed to as a result of TU Electric's use pursuant to its easement. Any TU Electric property damaged or destroyed by User or its agents shall be repaired or replaced by TU Electric at User's expense and payment is due upon User's receipt of an invoice from TU Electric.

8. General construction limitations on encroachments are described and listed in **Exhibit "B"** attached hereto and by reference made a part hereof.

9. It is understood and agreed that, in case of default by User or its agents in any of the terms and conditions herein stated and such default continues for a period of ten (10) days after TU Electric notifies User of such default, TU Electric may at its election forthwith terminate this agreement and upon such termination all of User's rights hereunder shall cease and come to an end. This agreement shall also terminate upon the abandonment of the encroaching facility.

If the foregoing terms and conditions are acceptable to the City of Dallas, please have the original and a copy of this letter agreement signed and returned to me at, 1601 Bryan Street, EP 34128, Dallas, Texas 75201-3411, within 30 days for final approval by TU Electric. This letter agreement shall be effective only after final approval by TU Electric.

Yours very truly,

Jerry Rider

Jerry Rider
Real Estate Analyst, Sr.

ACCEPTED:

THE CITY OF DALLAS

By: Ryan S. Evans
Ryan S. Evans
Assistant City Manager
Date 7-17-97

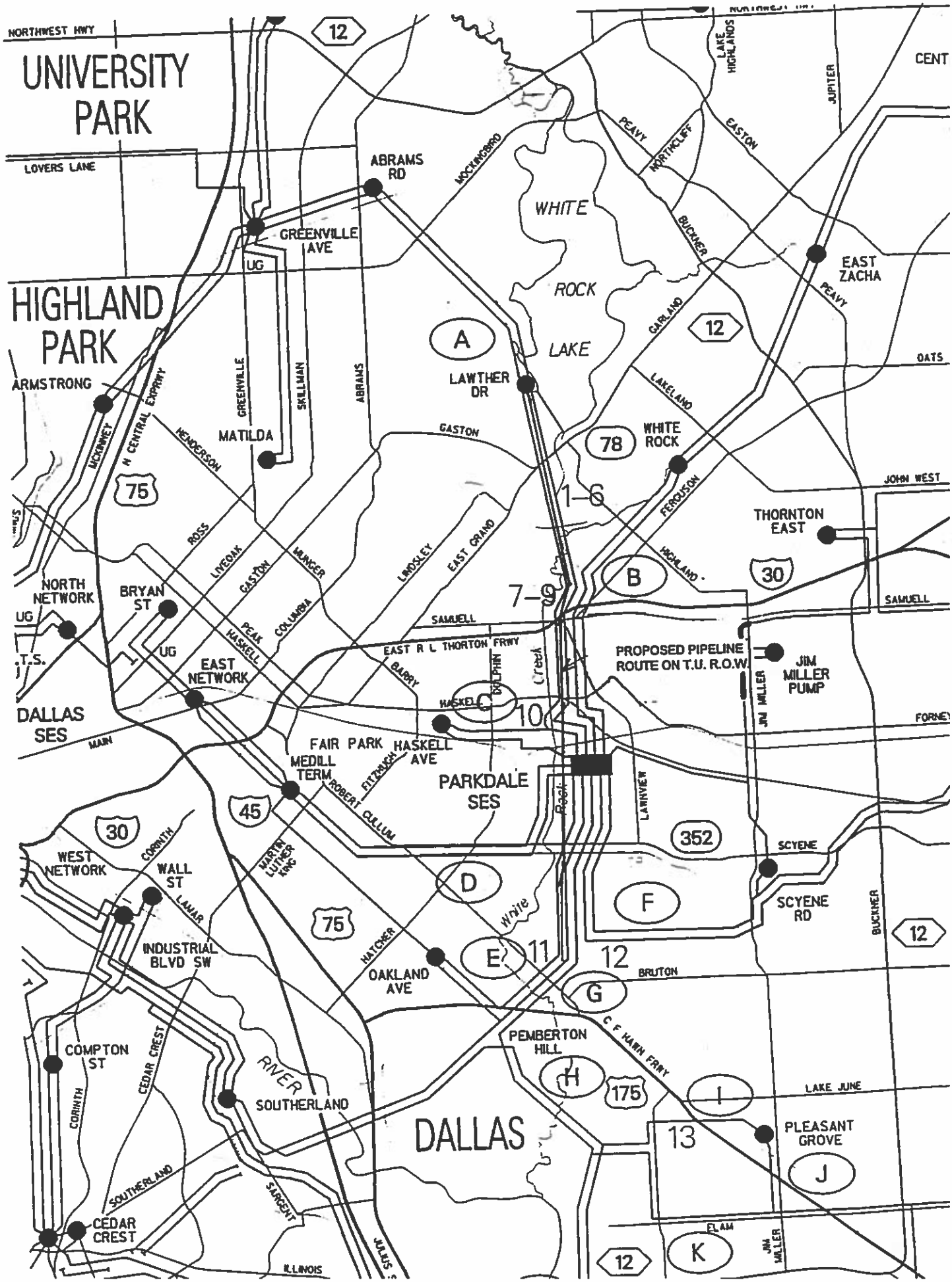
APPROVED:

TEXAS UTILITIES ELECTRIC COMPANY

By: B. N. Norris
B.N. Norris
Attorney-In-Fact
Date 7-28-97

Approved as to form:
SAM LINDSAY, City Attorney
By Thomas P. Schaffer
Assistant City Attorney

Submitted to City Attorney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HIGHLAND PARK
DALLAS
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ABRAMS RD
GREENVILLE AVE
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NORTHCLIFF
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JUPITER
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BUCKNER
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GARLAND
OATS
LAKELAND
ARMSTRONG
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N CENTRAL EXPWY
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SKILLMAN
ABRAMS
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HENDERSON
GASTON
LAWTHER DR
WHITE ROCK
FERGUSON
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PROPOSED PIPELINE ROUTE ON T.U. R.O.W.
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FORNEY
MAIN
FAIR PARK
HASKELL AVE
MEDILL TERM
ROBERT CULLUM
FITZHUGH
PARKDALE SES
LAMNVIEW
SCYENE
SCYENE RD
WEST NETWORK
CORINTH
WALL ST
LAMAR
MARTIN LUTHER KING
INDUSTRIAL BLVD SW
HATCHER
OAKLAND AVE
White
BRUTON
C F HAWN FRWY
PEMBERTON HILL
COMPTON ST
CEDAR CREST
RIVER
SOUTHERLAND
LAKE JUNE
PLEASANT GROVE
SARGENT
ELAM
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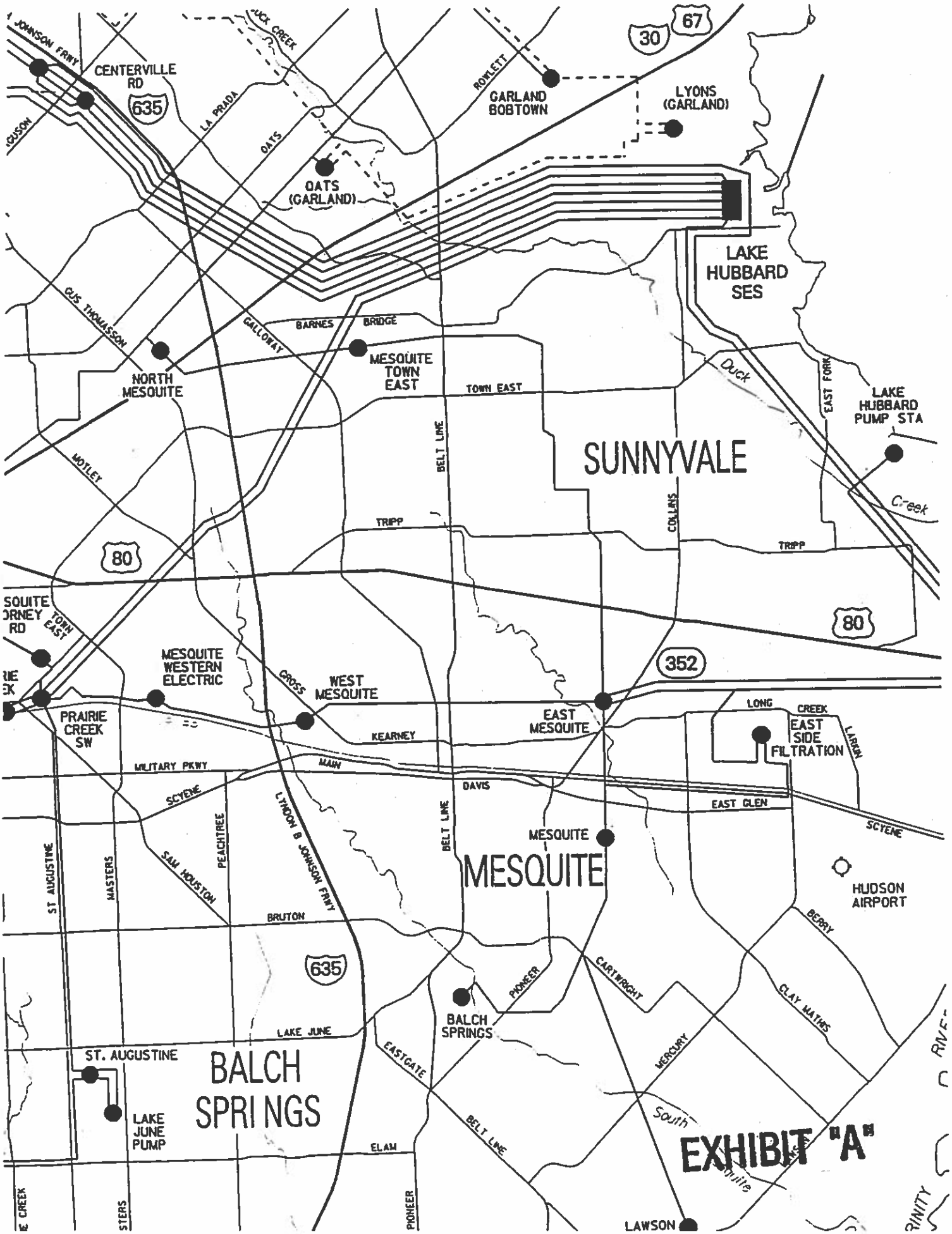
CENTERVILLE RD
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GALLOWAY
BARNES BRIDGE
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NORTH MESQUITE
TOWN EAST
Duck
EAST FORK
LAKE HUBBARD PUMP STA
Creek
SUNNYVALE
BELT LINE
COLLINS
MOTLEY
TRIPP
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MESQUITE WESTERN ELECTRIC
CROSS
WEST MESQUITE
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EAST MESQUITE
LONG
CREEK
EAST SIDE FILTRATION
LARKIN
PRAIRIE CREEK SW
KEARNEY
MILITARY PKWY
MAIN
DAVIS
EAST GLEN
SCYENE
MESQUITE
MESQUITE
HUDSON AIRPORT
ST AUGUSTINE
MASTERS
SAM HOUSTON
PEACHTREE
LYNDON B JOHNSON FRWY
BRUTON
635
BERRY
PIONEER
CARTWRIGHT
CLAY MATHIS
BALCH SPRINGS
LAKE JUNE
EASTGATE
MERCURY
ST. AUGUSTINE
BALCH SPRINGS
LAKE JUNE PUMP
BELT LINE
South
ELAM
EXHIBIT "A"
LAWSON

CONSTRUCTION LIMITATIONS ON TU ELECTRIC TRANSMISSION RIGHT OF WAY

You are notified, and should advise your employees, representatives, agents, and contractors, who enter the property that they will be working in the vicinity of high voltage electrical facilities and should take proper precautions, included but not limited to the following stipulations and in compliance, at all times, with Chapter 752, V.T.C.A., Health & Safety Code.

Blasting is not to be permitted on Company right-of-way or under Company lines.

Grading will be done in order to leave the right-of-way as near as possible to present condition. Spoil dirt will be removed from the right-of-way and no trash is to be left on right-of-way. Slopes shall be graded so that trucks can go down the right-of-way when required and such that they can be mechanically maintained.

No signs, lights or guard lights will be permitted on the right-of- way.

Equipment will not exceed 15 feet in height when operated under the electrical lines.

Fencing will not exceed 8 feet in height and will be grounded with an appropriate driven ground.

Drag lines will not be used under the line or on Texas Utilities Electric Company right-of-way.

Shoring will be required where excavation is within 10 feet of a structure and will extend 20 feet each side of the centerline of the structure. Shoring will be sufficient to withstand the added load of the structure and its footing. Shoring shall not be left open for extended periods of time, except when pipe or underground facilities are installed, shoring shall be removed and properly backfilled as soon as practical. Backfill will be thoroughly tamped. Water tamping will not be permitted within the area.

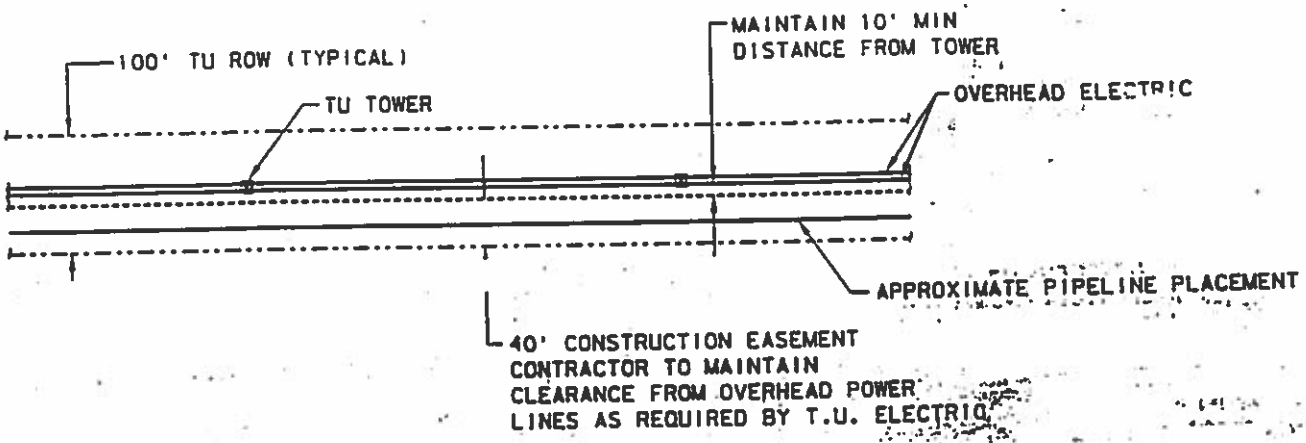
Right-of-way will be protected from washing and erosion by the method approved before crossing permits are granted.

No obstruction shall be installed on the right-of-way that would interfere with access to Texas Utilities Electric Company structures or prevent mechanical maintenance.

Before any work is done under Texas Utilities Electric Company lines or by Texas Utilities Electric Company structures notify the Supervisor of Regional Transmission, as noted in the document.

Brush and cut timber will not be piled or stacked on Texas Utilities Electric Company right-of-way or not be burned upon or in close proximity to the conductors or towers.

EXHIBIT "B"



TYPICAL TU RIGHT-OF-WAY
PIPELINE PLACEMENT

ADDENDUM ITEM # 1

CATEGORY: **ITEMS FOR INDIVIDUAL CONSIDERATION**

AGENDA DATE: October 8, 1997

CITY SERVICE AREA(S): All

COUNCIL DISTRICT(S): All

DEPARTMENT: Public Works & Transportation

CMO: Ryan S. Evans, 670-3314

MAPSCO: N/A

SUBJECT

Authorize execution of a license agreement with Dallas County for the use of County property needed for the installation of the White Rock Lake Dredging Project pipeline - $1,825 - Financing: 1995 Bond Funds

BACKGROUND

The Dallas County Commissioners Court has requested that the City Council authorize a license agreement for permission to use County property and cross three County roads. This type of license agreement may be handled administratively; however, the Commissioners Court specifically requested authorization by the City Council. The license will allow the City to place the pipeline over and across County property at the McCommas Bluff Park Preserve in the City of Dallas and the Goat Island Park Preserve in the unincorporated pasture of Dallas County. The pipeline is within the limits of an existing Dallas Water Utilities sanitary sewer easement through the McCommas Bluff Park and within the limits of an existing Texas Utilities easement through the Goat Island Park Preserve. The license will also grant permission for the City's contractor to cross three County roads by boring.

The major points of the agreement are as follows: The term of the license is for three years and can be extended by agreement of both parties. The consideration for the license is $1,825. The County reserves the right to use the property for any purpose and may, at its determination, require the relocation of the pipeline. The City must notify the County in the event of any leaks or spills. The County may request pipeline operations to cease in the event of a significant leak. The City agrees to lake sediment testing and periodic testing of the dredge discharge material at the disposal site. The City agrees to cross the County roads by method of boring under the road. The City's contractor must sign a right-of-entry agreement with the County and agree to indemnify the County and provide a $25,000 maintenance bond for the work at the road crossings. The City's contractor agrees to name the County as additional insured on its

insurance policies. The City agrees to remove the pipeline from County property within

BACKGROUND Cont'd

60 days of project completion. The City agrees to purchase environmental pollution insurance to cover hazards and mitigation arising from conditions that may be caused by the discharged dredge material both during and after the project.

ESTIMATED SCHEDULE OF PROJECT

Began Construction	September 15, 1997
Complete Construction	August 1999

PRIOR ACTION/REVIEW (COUNCIL, BOARDS, COMMISSIONS)

Authorized Engineering Services Contract Resolution 95-4069	December 13, 1995
City Council Briefing on Reclamation Site	October 16, 1996
Authorized City Manager to Negotiate Easement Agreement for Reclamation Site Resolution 96-3494	October 23, 1996
Authorized City Manager to Execute Easement Agreement for Reclamation Site Resolution 97-1232	April 9, 1997
Authorized Rejection of Bids Resolution 97-1614	May 14, 1997
Award Construction Contract Resolution 97-2419	August 13, 1997

FISCAL INFORMATION

Funding for this item is budgeted in the current fiscal year.

1995 Bond Funds - $1,825

MAP

Attached.

October 8, 1997

WHEREAS, the City of Dallas seeks permission to use Dallas County property and cross three County roads for installation of the White Rock Lake Project pipeline, and;

WHEREAS, the City Manager is allowed by the City Code to execute this type of agreement without Council authorization, and;

WHEREAS, the Dallas County Commissioners Court has requested the authorization of a license agreement for use of the County property by the City Council.

Now, Therefore,

BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF DALLAS:

Section 1. That the City Manager is authorized to execute a license agreement with Dallas County for permission to use Dallas County property and cross three County roads for the purpose of installing the White Rock Lake Dredging Project pipeline.

Section 2. That the City Controller is hereby authorized to disburse funds in accordance with the term and conditions of the contract from:

White Rock Lake Improvements Fund
Fund M08, Agency PBW, Org. L910, Act. PBW3
Obj. 4250, Job #PB95L910, PD PBW95L910A1
Vendor #267865, in an amount not to exceed $1,825

Section 3. That this resolution shall take effect immediately from and after its passage in accordance with the provisions of the Charter of the City of Dallas, and it is accordingly so resolved.

Distribution: Public Works & Transportation, Sandra Williams, OCMC, Room 101
City Attorney
City Controller
Budget and Management Services

APPROVED _____ HEAD OF DEPARTMENT
APPROVED _____ CITY CONTROLLER
APPROVED _____ CITY MANAGER

REVISED AGENDA ITEM # 19

CATEGORY: CONTRACT AMENDMENTS

AGENDA DATE:	October 14, 1998
CITY SERVICE AREA(S):	Northeast
COUNCIL DISTRICT(S):	9
DEPARTMENT:	Public Works & Transportation
CMO:	Ryan S. Evans, 670-3314
MAPSCO:	37B, C, F, G, K, L, M, P, Q

SUBJECT

Authorize (1) an increase in the contract with Oscar Renda Contracting, Inc. for additional dredging work (not included in the original contract) for the White Rock Lake Dredging Project to enhance recreation use in sections of Sunset Bay on the east side of the lake and Lily Pad Bay on the west side of the lake in the amount of $375,000, from $13,590,720 to $13,965,720 and (2) increase appropriations in the White Rock Lake Improvement Fund in the amount of $230,000 - Financing: 1995 Bond Funds

BACKGROUND

On August 13, 1997, Resolution 97-2419 authorized a construction contract with Oscar Renda Contracting, Inc. for the dredging improvements to White Rock Lake.

The Park and Recreation Department has requested that additional dredging work be added to the contract to enhance recreation use in these areas. Parks has asked that sections of Sunset Bay on the east side of the lake and Lily Pad Bay on the west side of the lake be added and completed under the current contract. These areas were not included in the scope of the current contract. The need for additional dredging in these areas was identified during the recent low stage of the lake that exposed sediment in the Bays. Citizens raised concern that in the area of the two Bays, shoreline access was restricted. The current project is near completion. Utilizing the current dredge contractor is an advantage due to his familiarity with the lake and his ability to provide the best price to perform the extra work.

ESTIMATED SCHEDULE OF PROJECT

Began Construction	September 1997
Complete Construction	August 1999

ITEM: Authorize an increase in contract for White Rock Lake Dredging Project

PRIOR ACTION/REVIEW (COUNCIL, BOARDS, COMMISSIONS)

Authorized Engineering Services Contract Resolution 95-4069	December 13, 1995
City Council Briefing on Reclamation Site	October 16, 1996
Authorized City Manager to Negotiate Easement Agreement for Reclamation Site Resolution 96-3494	October 23, 1996
Authorized City Manager to Execute Easement Agreement for Reclamation Site Resolution 97-1232	April 9, 1997
Authorized Rejection of Bids Resolution 97-1614	May 14, 1997
Authorized Construction Contract Resolution 97-2419	August 13, 1997
Authorized License Agreement with Dallas County Resolution 97-3262	October 8, 1997
Authorized Supplemental Agreement No. 1 to Engineering Services Contract Resolution 97-3615	November 12, 1997
Authorized Change Order to Construction Contract Resolution 98-0887	March 25, 1998

FISCAL INFORMATION

Funding for this item is budgeted in the current fiscal year.

1995 Bond Funds - $375,500

Site Selection, Surveying Engineering, Permitting		$ 1,307,812
Dredging Construction		
Reclamation Site Agreement		
($2,228,078 w/$160,000 contingency)		$ 2,388,078
Dredging and Pipeline	PWT	$ 4,510,220
	WTR	$ 9,000,000
Construction Management Services		$ 325,496
Change Order No. 1		$ 65,500
Change Order No. 2	PKR	$ 15,000
Change Order No. 3		$ 375,000
Total Project Cost		$17,987,106

ITEM: Authorize an increase in contract for White Rock Lake Dredging Project

M/WBE INFORMATION

See attached.

ETHNIC COMPOSITION

Oscar Renda Contracting, Inc.

Hispanic Female	1	Hispanic Male	109
African-American Female	0	African-American Male	4
Other Female	0	Other Male	2
White Female	8	White Male	48

OWNER(S)

Oscar Renda Contracting, Inc.

Oscar Renda, President

MAP

Attached.

CATEGORY: LAND MISCELLANEOUS

AGENDA DATE:	December 9, 1998
CITY SERVICE AREA(S):	All
COUNCIL DISTRICT(S):	All
DEPARTMENT:	Public Works & Transportation
CMO:	Ryan S. Evans, 670-3314
MAPSCO:	N/A

SUBJECT

Authorize the release of a temporary easement granted to the City by the Stephens Group for the White Rock Lake Dredging Project Reclamation Site - Financing: No cost consideration to the City

BACKGROUND

On April 9, 1997, Resolution 97-1232 authorized an easement agreement with the Stephens Group for the purpose of allowing the pipeline from the White Rock Lake Dredging Project to discharge the dredge material onto their property.

Dredge material discharge through the pipeline is now complete and the pipeline removed from the property. The City desires to release the easement.

PRIOR ACTION/REVIEW (COUNCIL, BOARDS, COMMISSIONS)

Authorized Professional Services Contract Resolution 95-4069	December 13, 1995
City Council Briefing on Reclamation Site	October 16, 1996
Authorized City Manager to negotiate Easement Agreement for Reclamation Site Resolution 96-3494	October 23, 1996
Authorized City Manager to Execute Easement Agreement for Reclamation Site Resolution 97-1232	April 9, 1997
Authorized Rejection of Bids Resolution 97-1614	May 14, 1997
Authorized Construction Contract Resolution 97-2419	August 13, 1997

PRIOR ACTION/REVIEW (COUNCIL, BOARDS, COMMISSIONS) (Continued)

Authorized License Agreement with Dallas County Resolution 97-3262	October 8, 1997
Authorized Supplemental Agreement No. 1 Resolution 97-3615	November 12, 1997
Authorized Change Order No. 1 Resolution 98-0887	March 25, 1998
Authorized Change Order No. 3 Resolution 98-2911	October 14, 1998

FISCAL INFORMATION

No cost consideration to the City.

MAP

Attached.

December 9, 1998

WHEREAS, on April 9, 1997, Resolution 97-1232 authorized an Easement Agreement with the Stephens Group, property owners of the reclamation site for the dredged material from the White Rock Lake Dredging Project; and,

WHEREAS, discharge through the pipeline to the Stephens Group property is complete and the pipeline has been removed from the easement; and,

WHEREAS, it is now desired and necessary to authorize release of the easement.

Now, Therefore,

BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF DALLAS:

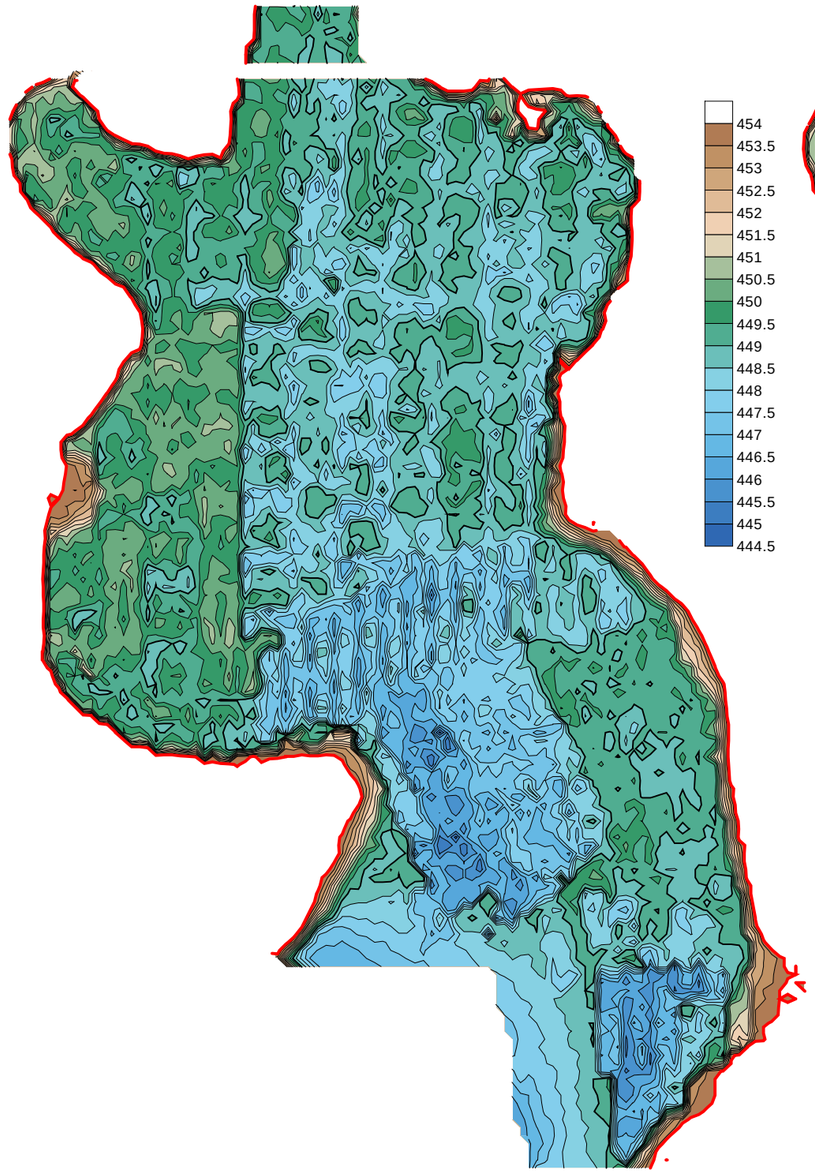
Section 1. That the City Manager is hereby authorized to execute the release of easement document after it has been approved as to form by the City Attorney.

Section 2. That this resolution shall take effect immediately from and after its passage in accordance with the provisions of the Charter of the City of Dallas and it is accordingly so resolved.

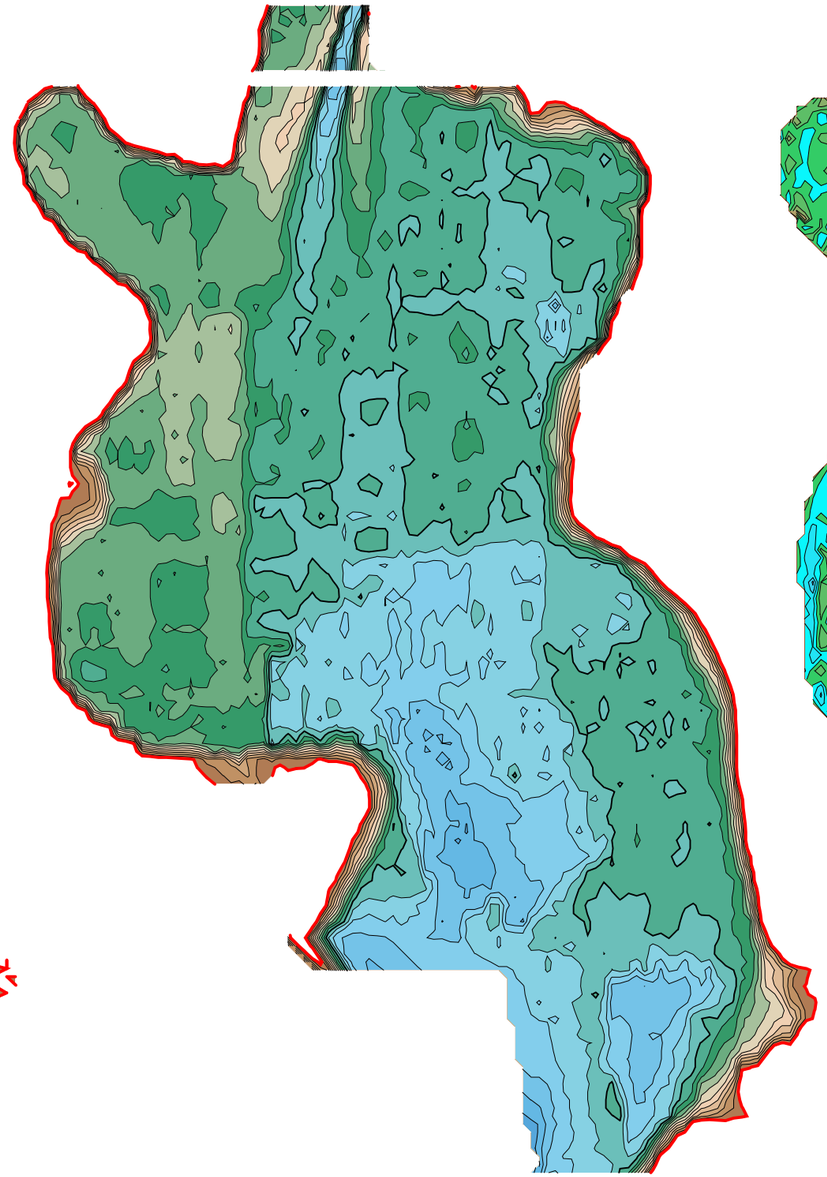
Distribution: Public Works and Transportation, Sandra Williams, OCMC, Room 101
Budget and Management Services
City Controller, Jerry McWhorter
City Attorney

APPROVED _____ HEAD OF DEPARTMENT
APPROVED _____ CITY CONTROLLER
APPROVED _____ CITY MANAGER

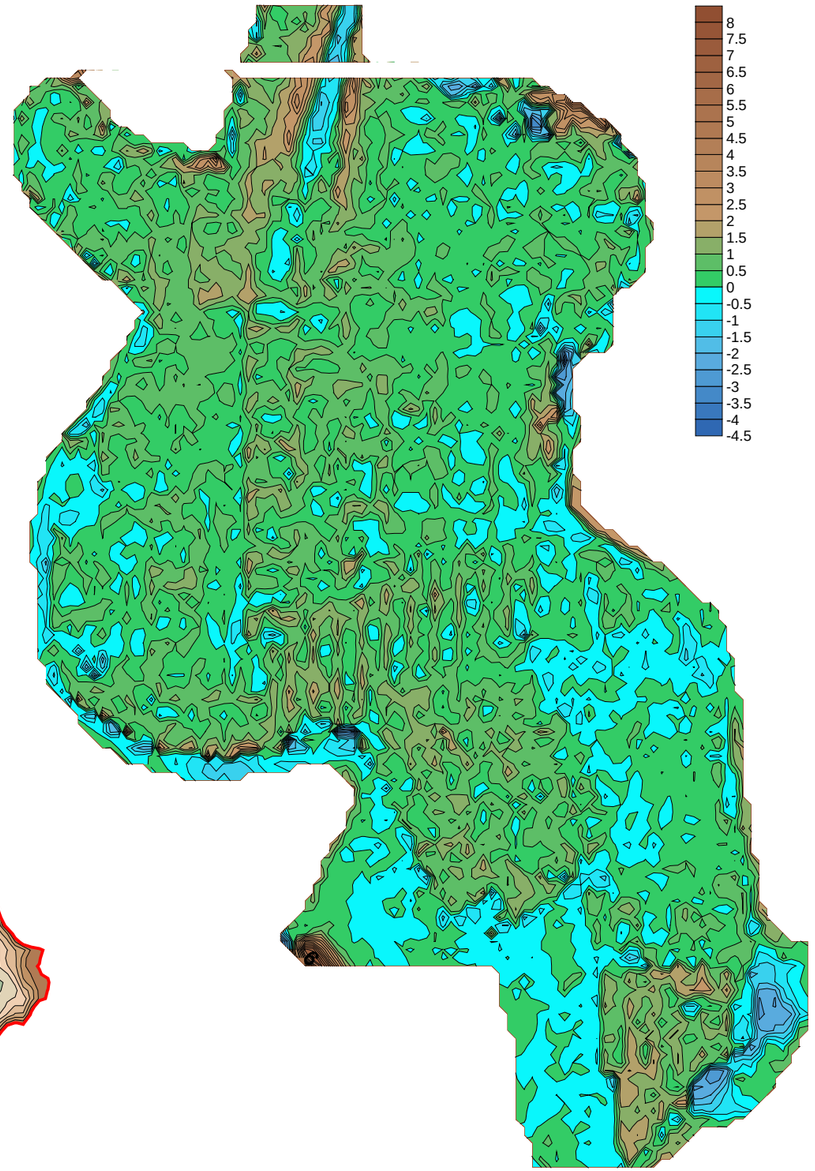
WHITE ROCK LAKE



After 1999 Dredging Project



January 2004



Difference

CATEGORY: CONTRACT AMENDMENTS

AGENDA DATE:	January 19, 2000
CITY SERVICE AREA(S):	Northeast
COUNCIL DISTRICT(S):	9
DEPARTMENT:	Public Works & Transportation
CMO:	Jill A. Jordan, P.E., 670-5299
MAPSCO:	37B C F G K L M P Q

SUBJECT

Authorize **(1)** an increase in the contract with Oscar Renda Contracting, Inc. for removal of trash and debris in Sunset Bay for the White Rock Lake Dredging Project in the amount of $262,000, from $13,965,720 to $14,227,720 and **(2)** increase appropriations in the White Rock Lake Improvement Fund in the amount of $262,000 - Financing: 1995 Bond Funds

BACKGROUND

On August 13, 1997, Resolution 97-2419 authorized a construction contract with Oscar Renda Contracting, Inc. for the dredging improvements to White Rock Lake.

Near the completion of the originally planned dredging project, Park and Recreation Department requested additional dredging work be added to the contract to enhance recreation use in these areas. Parks asked that sections of Sunset Bay on the east side of the lake and Lily Pad Bay on the west side of the lake be added and completed under the original contract. These areas were not included in the scope of the current contract. The need for additional dredging in these areas was identified during the low stage of the lake in the summer of 1998 that exposed sediment in the Bays. Citizens raised concern that in the area of the two Bays, shoreline access was restricted.

During dredging of Sunset Bay a large amount of trash and debris was encountered on the bottom of the lake. The hydraulic dredge was unable to function efficiently and was experiencing an unacceptable amount of downtime due to trash clogging the pump. An area of the bay that was proposed to be dredged was not completed due to the fact that the remaining volume of material to be dredged was made up of trash rather than silt.

BACKGROUND (Continued)

In the area where the trash was encountered, an alternative to the hydraulic dredging operation is needed to complete the planned restoration of Sunset Bay to the desired depth. This change order will provide for equipment and operations to remove the trash from the lake bottom.

The work associated with this change order will require floating barges capable of handling excavation equipment, work boats, and excavation equipment with special attachments for removing the trash from the lake bottom. This work will be completed with the general contractor's own work forces.

ESTIMATED SCHEDULE OF PROJECT

Began Dredging	September 1997
Completed Dredging	September 1998
Began Sunset and Lily Pad Bay Dredging	June 1999
Completed Sunset and Lily Pad Bay Dredging	August 1999
Begin Sunset Bay Trash Removal	January 2000
Complete Sunset Bay Trash Removal	March 2000

PRIOR ACTION/REVIEW (COUNCIL, BOARDS, COMMISSIONS)

Authorized Engineering Services Contract Resolution 95-4069	December 13, 1995
City Council Briefing on Reclamation Site	October 16, 1996
Authorized City Manager to Negotiate Easement Agreement for Reclamation Site Resolution 96-3494	October 23, 1996
Authorized City Manager to Execute Easement Agreement for Reclamation Site Resolution 97-1232	April 9, 1997
Authorized Rejection of Bids Resolution 97-1614	May 14, 1997
Authorized Construction Contract Resolution 97-2419	August 13, 1997
Authorized License Agreement with Dallas County Resolution 97-3262	October 8, 1997
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Authorized Change Order to Construction Contract Resolution 98-0887	March 25, 1998
Authorized Change Order to Construction Contract Resolution 98-2911	October 14, 1998

ITEM: Authorize an increase in contract for White Rock Lake Dredging Project

FISCAL INFORMATION

1995 Bond Funds - $262,000

Site Selection, Surveying Engineering, Permitting		$ 1,307,812
Dredging Construction		
Reclamation Site Agreement		
($2,228,078 w/$160,000 contingency)		$ 2,388,078
Dredging and Pipeline	PWT	$ 4,510,220
	WTR	$ 9,000,000
Construction Management Services		$ 325,496
Change Order No. 1		$ 65,500
Change Order No. 2	PKR	$ 15,000
Change Order No. 3		$ 375,000
Change Order No. 4		$ 262,000
Total Project Cost		$18,249,106

M/WBE INFORMATION

See attached.

ETHNIC COMPOSITION

Oscar Renda Contracting, Inc.

Hispanic Female	0	Hispanic Male	104
African-American Female	0	African-American Male	3
Other Female	0	Other Male	2
White Female	7	White Male	42

OWNER(S)

Oscar Renda Contracting, Inc.

Oscar Renda, President

MAP

Attached.

VOLUMETRIC SURVEY OF WHITE ROCK LAKE

Prepared for:

THE CITY OF DALLAS

Prepared by:

The Texas Water Development Board

March 10, 2003

Texas Water Development Board

Craig D. Pedersen, Executive Administrator

Texas Water Development Board

Charles W. Jenness, Chairman *Wesley E. Pittman, Vice Chairman*
William B. Madden *Noe Fernandez*
Diane E. Umstead *Othon Medina, Jr.*

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This report was prepared by the Hydrographic Survey group:

Carol R. Hearn, P.E., R.P.L.S.
Duane Thomas
Randall Burns

For more information, please call (512) 445-1471

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WHITE ROCK LAKE
HYDROGRAPHIC SURVEY REPORT

INTRODUCTION

Staff of the Hydrologic Survey Unit of the Texas Water Development Board (TWDB) conducted a hydrographic survey on White Rock Lake in March, 1993. The purpose of the survey was to determine the capacity of the lake at the normal pool elevation and to establish baseline information for future surveys. From this information, future surveys will be able to determine sediment deposition locations and rates over time. Survey results are presented in the following pages in both graphical and tabular form.

HISTORY AND GENERAL INFORMATION OF THE RESERVOIR

White Rock Lake, owned by the City of Dallas, is located within the city limits, northeast of the central business district. White Rock Dam is located on White Rock Creek, a tributary of the Trinity River. Dam construction commenced in March, 1910, was completed in September of 1911, and the reservoir filled in August, 1912.

Certified Filing No. 75 authorized the City of Dallas to impound 21,345 acre-feet of water in White Rock Lake and to divert and use a maximum of 8,696.8 acre-feet of water annually for municipal purposes with a priority date of April 22, 1914. An Amendment To Certified Filing No. 75 was granted by the Texas Water Commission on November 8, 1982, and authorized a change in use of 3,000 acre-feet from municipal to irrigation.

Certificate of Adjudication No. 2461 was issued July 22, 1983 by the Texas Water Commission. Consistent with the Amendment to Certified Filing, it authorized the City of Dallas to divert and use a maximum of 5,696.8 acre-feet for municipal purposes and 3,000 acre-feet for irrigation purposes. It also authorized the City of Dallas to divert and use a maximum of 6.35

acre-feet of water per annum for recreational purposes.

White Rock Dam is an earthfill structure approximately 2,100 feet in length and 40 feet in height. The elevation of the top of the dam is 468.5 feet above mean sea level based on the National Geodetic Vertical Datum of 1929 (NGVD '29). All elevations presented in this report are reported in NGVD '29 unless noted otherwise. Results of a 1970 survey indicate the conservation storage to be 10,740 acre-feet with a surface area of 1,119 acres. The service/emergency spillway is a concrete, broad-crested, uncontrolled weir 450 feet in length at elevation 458.0 feet.

HYDROGRAPHIC SURVEYING TECHNOLOGY

GPS Information

The following is a brief and simple description of Global Positioning System (GPS) technology. GPS is a new technology that uses a network of satellites, maintained in precise orbits around the earth, to determine locations on the surface of the earth. GPS receivers monitor the broadcasts from the satellites over time to determine the position of the receiver. With only one satellite being monitored, the point in question could be located anywhere on a sphere surrounding the satellite with a radius of the distance measured. Additional satellite readings would also produce a possible location on a sphere surrounding that satellite with a radius of the distance measured. The observation of two satellites from an unknown point decreases the possible location to a finite number of points on a circle where the two spheres intersect. With a third satellite observation, the unknown location is reduced to two points where all three spheres intersect. One of these points is obviously in error because its location is in space, and it is ignored. Although three satellite measurements can fairly accurately locate a point on the earth, the minimum number of satellites required to determine a three dimensional position within the required accuracy is four. The fourth measurement compensates for any time discrepancies between the clock on board the satellites and the clock within the GPS receiver.

GPS technology was first put into use on February 22, 1978, when the first satellite was launched. The NAVSTAR (NAVigation System with Time And Ranging) satellite constellation will consist of 24 satellites when fully implemented. At the time of the survey, 21 satellites of the constellation were fully functional. The United States Department of Defense (DOD) is responsible for implementing and maintaining the satellite constellation. In an attempt to discourage the use of these survey units as a guidance tool by hostile forces, the DOD has implemented means of false signal projection called Selective Availability (S/A). Positions determined by a single receiver when S/A is active result in errors to the actual position of up to 100 meters. These errors can be reduced to centimeters by performing a static survey with two GPS receivers, one of which is set over a point with known coordinates. The errors induced by S/A are time-constant. By monitoring the movements of the satellites over time (1 to 3 hours), the errors can be minimized during post processing of the collected data and the unknown position computed accurately.

Differential GPS (DGPS) can determine positions of moving objects in real-time or "on-the-fly" and was used during the survey of White Rock Lake. One GPS receiver was set up over a benchmark with known coordinates established by the hydrographic survey crew. This receiver remained stationary during the survey and monitored the movements of the satellites overhead. Position corrections were determined and transmitted via a radio link once per second to a second GPS receiver located on the moving boat. The boat receiver used these corrections, or differences, in combination with the satellite information it received to determine its differential location. Positional accuracies can be produced within 3 meters for the moving receiver. DGPS was used to determine horizontal position only. Vertical information was supplied by the depth sounder.

As the boat traveled across the lake surface, the depth sounder gathered approximately ten readings of the lake bottom each second. The depth readings were averaged over the one-second interval and stored with the positional data to an on-board computer. After the survey, the average depths were corrected to elevation using the daily lake elevation. The set of data points logged during the survey were used to calculate the lake volume. Accurate estimates of the lake volume can be quickly determined using these methods, to produce an affordable survey. The level of

accuracy is equivalent to or better than other methods previously used to determine lake volumes.

TWDB staff verified the horizontal accuracy of the DGPS used in the White Rock Lake survey to within the specified accuracy of three meters. The shore station was set up over a known United States Geological Service (USGS) first order monument and placed in differential mode. The second receiver was set up over another known USGS first order monument. Based on the differentially-corrected coordinates received and the published coordinates for these points, the results compared within 2.8 meters.

Equipment

The equipment used in the hydrographic survey of White Rock Lake consisted of a 23 foot aluminum tri-hull SeaArk craft with cabin, equipped with twin 90 Horsepower Johnson outboard motors. Installed within the enclosed cabin are an Innerspace Helmsman Display (for navigation), an Innerspace Technology Depth Sounder and Velocity Profiler, a Trimble Navigation, Inc. 4000SE GPS receiver, a Motorola Radius radio with an Advanced Electronic Applications, Inc. packet modem, and an on-board computer. The computer is supported by a dot matrix printer and a B-size plotter. Power is provided by a water-cooled generator through an in-line uninterruptible power supply. References to brand names does not imply endorsement by the TWDB.

The shore station included a second Trimble 4000SE GPS receiver, Motorola Radius radio and Advanced Electronic Applications, Inc. packet modem, and an omni-directional antenna mounted on a modular aluminum tower to a total height of 30 feet. The combination of this equipment provided a data link with a reported range of 25 miles over level to rolling terrain that does not require that line-of-sight be maintained with the survey vessel in most conditions, thereby reducing the time required to conduct the survey.

Survey Methods

The Hydrographic Survey crew set a benchmark at the top of the hill at Winfrey Point in November of 1992 that would serve as control for the shore station site. A brass cap marked TWDB #004 was embedded into the sidewalk approximately forty feet west of the southwest corner of the building. This location was chosen because of its close proximity to the lake, the unobstructed view of the lake, and relative security of the area.

A static survey using the two Trimble 4000SE GPS receivers was performed to obtain coordinates for TWDB #004. One GPS receiver was positioned over a Corps of Engineers first-order monument named RESERVOIR, located approximately three miles west of the lake. RESERVOIR was established in 1947. Satellite data were gathered from this station for almost two hours, with up to seven satellites visible to the receiver. During the same time period, data were gathered from the second receiver positioned over TWDB #004.

Once data collection ended, the data were retrieved from the two receivers using Trimble Trimvec software, and processed to determine coordinates for the shore station benchmark. The NAVSTAR satellites use the World Geodetic System (WGS '84) datum. The WGS' 84 coordinates for TWDB #004 were determined to be North latitude 32° 29' 50.19", West longitude 96° 42' 57.68", and ellipsoid height of 125.80 meters. The approximate NGVD '29 elevation is 499.5 feet. Those coordinates were then entered into the shore station receiver located over TWDB #004 to fix its location and allow calculation and broadcasting of corrections through the radio and modem to the roving receiver located on the boat.

The reservoir's surface area was determined by digitizing the lake boundary from 1958 USGS quad sheets that were photo-revised in 1968 and 1973. Intergraph Microstation CADD software was used to determine the boundary based on the North American Datum of 1927 (NAD '27) used for this map. The information was then transformed to the North American Datum of 1983 (NAD '83) using Microstation Projection Manager. NAD '83, a flat projected representation of the curved earth surface, was chosen to calculate areas and volumes. The data points obtained by DGPS were also transformed from WGS '84 to NAD '83. The resulting shape was modified slightly to match information gathered in the field, resulting in 1,088 acres at the normal pool

elevation.

The survey layout was pre-planned, using approximately twenty-four survey lines at a spacing of 500 feet. Additional random data were collected lengthwise along the lake. Additional data were entered into the data set utilizing the DGPS horizontal position and manually poling the depth in shallow areas where the depth was less than the minimum recordable depth of the depth sounder. Figure 2 presents the actual location of the data collection sites. Data were not collected in areas that were inaccessible due to shallow water or obstructions. The data set included approximately 10,400 data points.

Depths were transformed to elevations based on a water surface elevation of 458.57 feet. The data points were used to create a digital terrain model (DTM) of the lake's bottom surface using the Terrain Modeler product. The product uses Delauney's criteria for triangulation to produce a DTM, or a numerical representation of the actual bottom surface. From this dry lake bottom representation, the Modeler product calculates the surface area and volume of the entire lake at the specified elevations. Figure 3 is a graphical representation of a grided version of the three-dimensional DTM. Areas that were too shallow for data collection or obstructed by vegetation were estimated by the Modeler product, using a straight-line interpolation. The difference between the estimated volume and the actual volume is believed to be minor because the shallow areas do not contain significant amounts of water. Figure 4 presents a two-dimensional version of the same map, using bands of color increasing in intensity from shallow to deep water.

The DTM was then smoothed and linear smoothing algorithms were applied to the smoothed model to produce smooth contours. The following smoothing options were chosen for this model: Douglas-Peucker option with a tolerance of 0 feet, to eliminate redundant points, and Round Corners with a delta of 50 feet. Figure 5 presents a contour map and typical cross sections of the lake.

DATA

White Rock Lake is a finger-shaped lake approximately fifteen thousand feet in length. The deepest portions of the lake are found within the area immediately adjacent to the dam. The cross sections reflect a wide, flat bottom with relatively steep side slopes throughout the lake.

White Rock Lake was estimated by this survey to encompass 1,088 acres and to contain a volume of 9,004 acre-feet at the normal pool elevation of 458.0 feet. The reservoir volume table is presented in Appendix A, and the area table in Appendix B. An elevation-area-volume graph is presented in Appendix C. Normally the boat can negotiate in approximately 1.8 feet of water. Since the surface elevation of the lake was actually above the normal pool elevation on the date of the survey, only the upper 1.2 feet are estimated, based on a straight-line interpolation from the last data points collected to the normal pool elevation boundary as digitized. The positional data collected in the field corresponds with the boundary obtained from the photo-revised USGS map. The Board does not represent the boundary, as depicted in this report, to be a detailed actual boundary. It is an approximation of the actual boundary used to compute the volume and area within the upper elevations.

The storage volume calculated by this survey is approximately fifty-eight percent less than the original permit for the lake, and approximately sixteen percent less than the 1970 survey. The estimated surface area at normal pool elevation is approximately three percent less than the 1970 survey.

SUMMARY

The lowest elevation encountered during this survey was 435.3 feet, or 22.7 feet of depth. Based on the March 1993 survey, the conservation storage was calculated to be 9,004 acre-feet. In comparison to the 1970 survey, the estimated reduction in storage capacity is 1,736 acre-feet, or sixteen percent. It is assumed that the reduction in estimated storage is due to both a combination of sedimentation, and improved data and calculation methods, but the majority of the reduction is attributed to sedimentation. It is obvious that deposition is occurring at the point where White

Rock Creek enters the lake. Repeating this survey with the same calculation methodology in five to ten years or after major flood events should remove any noticeable error due to improved calculation techniques and will help isolate the storage loss due to sedimentation.

FIGURE 1

WHITE ROCK LAKE

LOCATION MAP

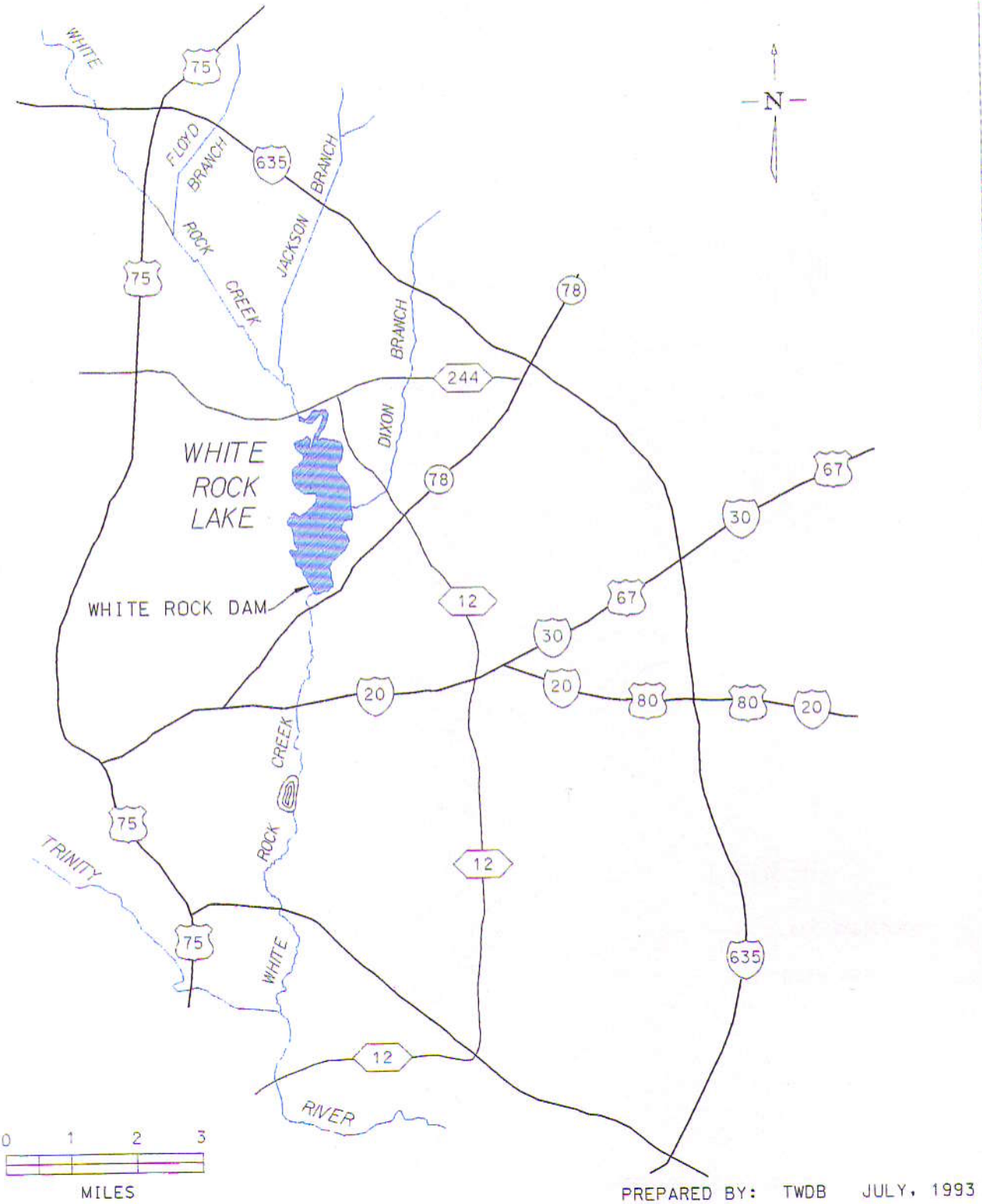


FIGURE 2

WHITE ROCK LAKE

LOCATION OF SURVEY DATA

N

1"=2000'

LEGEND

LAKE BOUNDARY

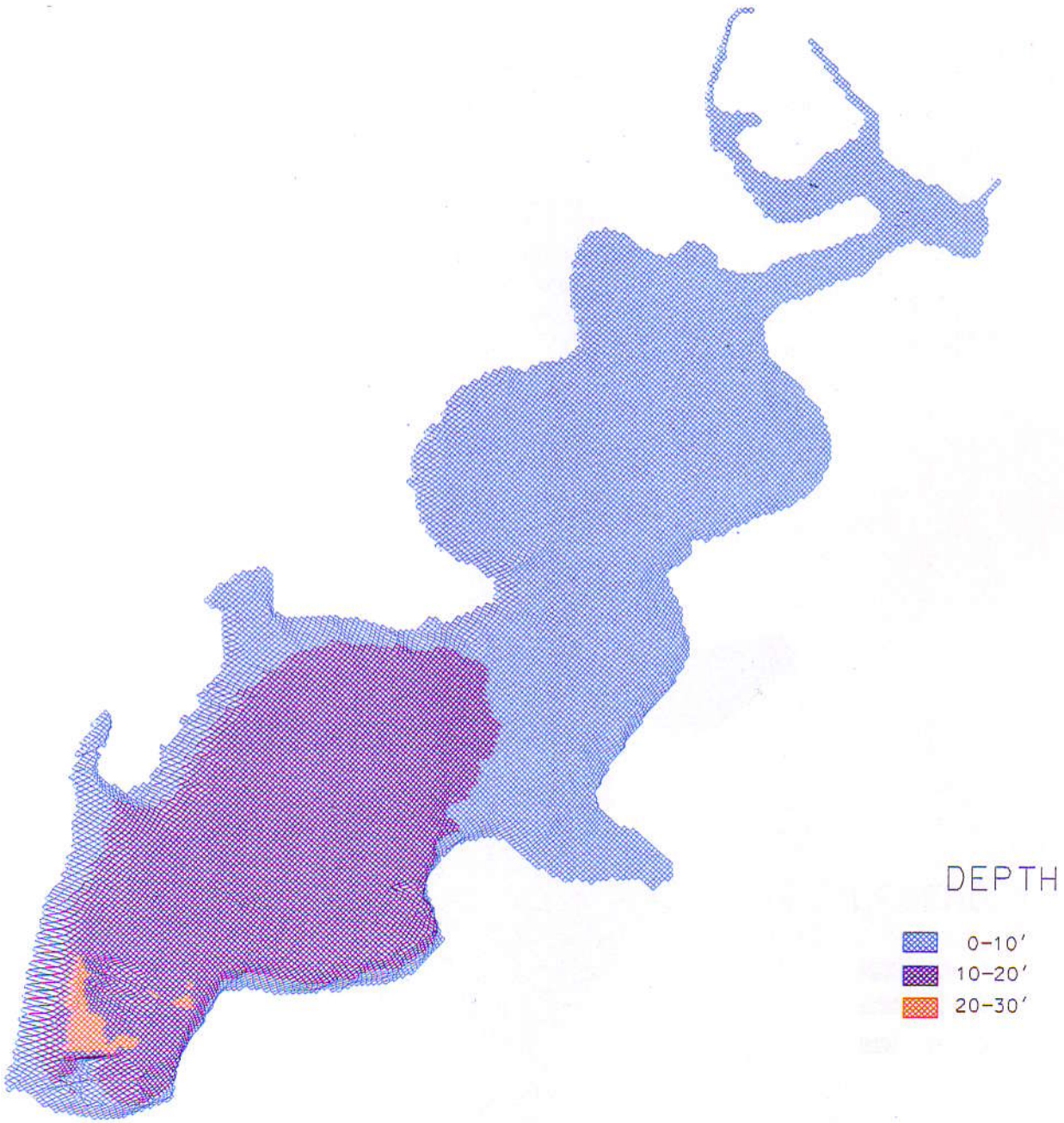
DATA POINTS

PREPARED BY: TWDB JULY, 1993

FIGURE 3

WHITE ROCK LAKE

3-D BOTTOM SURFACE

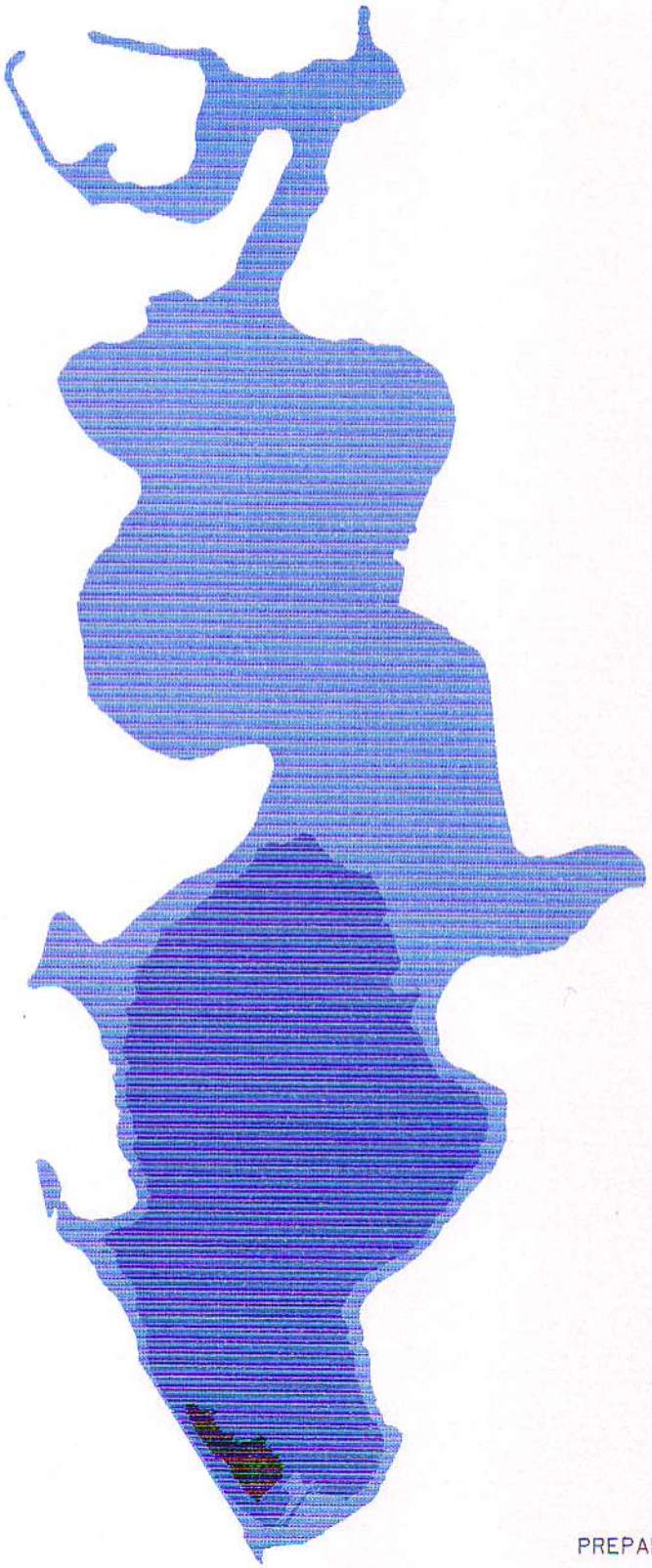


PREPARED BY: TWDB JULY, 1993

FIGURE 4

WHITE ROCK LAKE

DEPTH RANGES



N

1"=2000'

LEGEND

0-10'

10-20'

20-30'

PREPARED BY: TWDB JULY, 1993

Volumetric and Sedimentation Survey of WHITE ROCK LAKE

March 2015 Survey

Texas Water Development Board

February 2016

Texas Water Development Board

Bech Bruun, Chairman | Kathleen Jackson, Member | Peter Lake, Member

Kevin Patteson, Executive Administrator

Prepared for:

City of Dallas

With Support Provided by:

U.S. Army Corps of Engineers, Fort Worth District

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Executive summary

In September 2014, the Texas Water Development Board (TWDB) entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, to perform a volumetric and sedimentation survey of White Rock Lake. The City of Dallas provided 50% of the funding for this survey, while the U.S. Army Corps of Engineers, Fort Worth District, provided the remaining 50% of the funding through their Planning Assistance to States Program. Surveying was performed using a multi-frequency (208 kHz, 50 kHz, and 24 kHz), sub-bottom profiling depth sounder. In addition, sediment core samples were collected in select locations and correlated with the multi-frequency depth sounder signal returns to estimate sediment accumulation thicknesses and sedimentation rates.

White Rock Dam and White Rock Lake are located on White Rock Creek, a tributary of the Trinity River, in Dallas County, within the city limits of Dallas, Texas. The conservation pool elevation of White Rock Lake is 457.9 feet above mean sea level (NGVD29). TWDB collected bathymetric data for White Rock Lake on March 19, 2015, March 25, 2015, and March 27, 2015. The daily average water surface elevations during the survey measured 458.3, 458.7, and 458.4 feet above mean sea level (NGVD29), respectively.

The 2015 TWDB volumetric survey indicates that White Rock Lake has a total reservoir capacity of 10,230 acre-feet and encompasses 995 acres at conservation pool elevation (457.9 feet above mean sea level, NGVD29). Previous capacity estimates according to the Soil Conservation Service Reservoir Sediment Data Summary sheet, calculated at spillway elevation 458.0 feet above mean sea level, include the original design estimate of 18,160 acre-feet, a 1935 estimate of 14,276 acre-feet, a 1956 estimate of 12,321 acre-feet, a 1970 estimate of 10,743 acre-feet, and a 1977 estimate of 10,721 acre-feet. A 1993 TWDB survey estimated a capacity of 9,004 acre-feet. The 2015 TWDB survey indicates White Rock Lake has a total reservoir capacity of 10,329 acre-feet at spillway elevation 458.0 feet above mean sea level.

The 2015 TWDB sedimentation survey measured 3,550 acre-feet of sediment below conservation pool elevation (457.9 feet NGVD29). Sediment accumulation is greatest in the area where the reservoir narrows northwest of the Dallas Arboretum and in pockets throughout the reservoir. TWDB recommends that a similar methodology be used to resurvey White Rock Lake in 10 years or after a major flood event.

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Appendix B: White Rock Lake 2015 area table
Appendix C: White Rock Lake 2015 capacity curve
Appendix D: White Rock Lake 2015 area curve

Note: References to brand names throughout this report do not imply endorsement by the Texas Water Development Board

Introduction

The Hydrographic Survey Program of the Texas Water Development Board (TWDB) was authorized by the 72nd Texas State Legislature in 1991. Section 15.804 of the Texas Water Code authorizes TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In September 2014, the Texas Water Development Board (TWDB) entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, to perform a volumetric and sedimentation survey of White Rock Lake. The City of Dallas provided 50% of the funding for this survey, while the U.S. Army Corps of Engineers, Fort Worth District, provided the remaining 50% of the funding through their Planning Assistance to States Program (TWDB, 2014). This report describes the methods used to conduct the volumetric and sedimentation survey, including data collection and processing techniques. This report serves as the final contract deliverable from TWDB to the City of Dallas and the U.S. Army Corps of Engineers, Fort Worth District, and contains as deliverables: (1) a shaded relief plot of the reservoir bottom [Figure 4], (2) a bottom contour map [Figure 6], (3) an estimate of sediment accumulation and location [Figure 10], and (4) an elevation-area-capacity table of the reservoir acceptable to the Texas Commission on Environmental Quality [Appendix A, B].

White Rock Lake general information

White Rock Dam and White Rock Lake are located on White Rock Creek a tributary of the Trinity River, in Dallas County, within the city limits of Dallas, Texas (Figure 1). White Rock Dam and White Rock Lake are owned and operated by the City of Dallas. Construction on White Rock Dam and deliberate impoundment began in 1910 (TWDB, 1973, SCS, 1978). White Rock Dam was completed on June 24, 1911 (Visser, 2011). White Rock Dam and White Rock Lake were built primarily for water supply storage for the City of Dallas. White Rock Lake was expected to serve as the city's major water source for 100 years, however, by 1926, the city had outgrown it. When Dallas Lake (now part of Lewisville Lake) was completed in 1929, White Rock Lake became a recreational destination (Butler, 2011). During the drought of the 1950's, White Rock Lake was briefly used for supplemental water supply in 1953 (WRLC, 2014, Butler, 2016). The lake is still operational as an emergency water supply for the City of Dallas and for direct

use by Dallas Power and Light for a steam-electric generating plant as a standby service (Freese and Nichols, 2008).

Water rights for White Rock Lake have been appropriated to the City of Dallas through Certificate of Adjudication No. 08-2461 and Amendments to Certificate of Adjudication Nos. 08-2461A, and 08-2461B. The complete certificate is on file in the Information Resources Division of the Texas Commission on Environmental Quality.

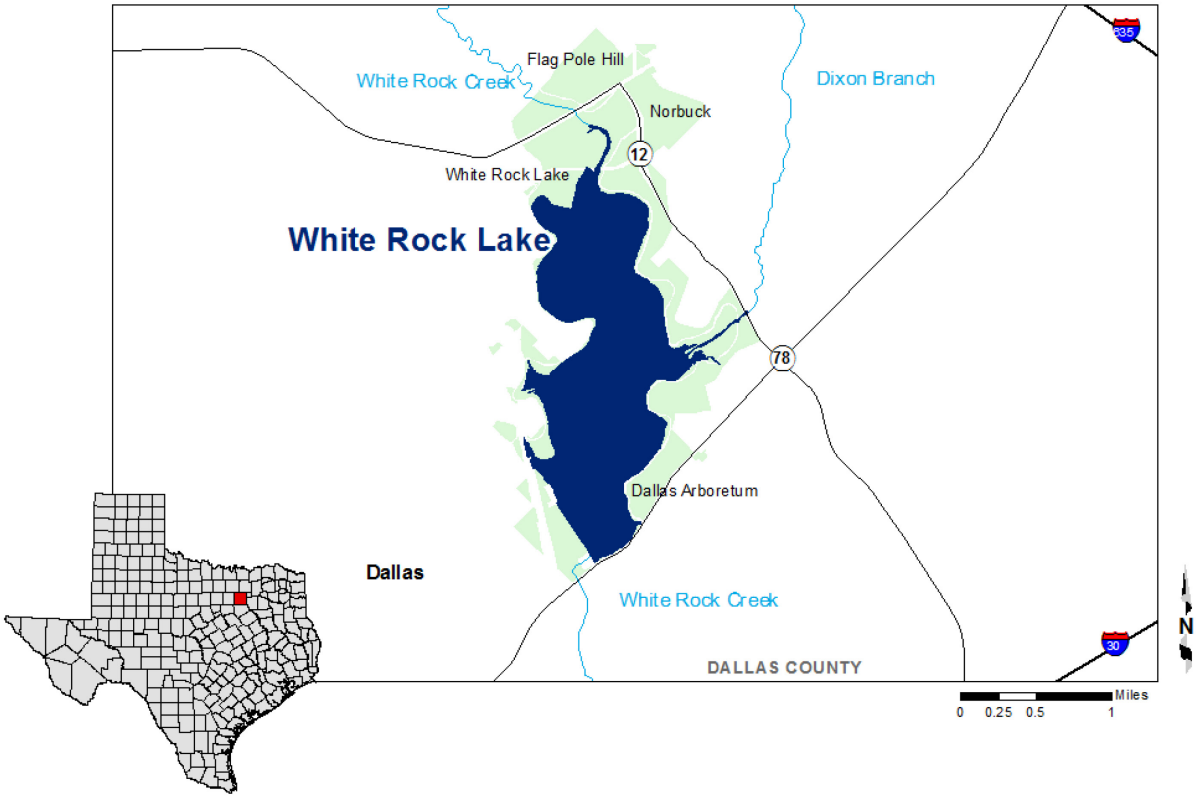


Figure 1. Location of White Rock Lake

Table 1. Pertinent data for White Rock Dam and White Rock Lake

Owner
City of Dallas

Design Engineer
Forrest and Cotton, Inc. are consultants on maintenance of the present dam

Location of dam
On White Rock Creek in Dallas County, within the city limits of Dallas

Drainage area
100 square miles

Dam

Type	Earthfill
Length	2,100 feet
Height	40 feet
Top width	20 feet

Spillway

Location	Left end of the dam
Type	Broad-crested (uncontrolled)
Control	2 weir type notches about 2.5 feet deep by 10 feet long, normally sealed with flash boards
Crest length	450 feet
Crest elevation	458.0 feet above mean sea level

Reservoir data (Based on 2015 TWDB survey)

Feature	Elevation (feet NGVD29[a])	Capacity (acre-feet)	Area (acres)
Top of dam*	475.0	N/A	N/A
Spillway crest	458.0	10,329	998
Conservation pool[b]	457.9	10,230	995

Source: (TWDB, 1973, SCS, 1978) *Note: In 1978, a parapet wall was constructed along the crest of the dam raising the top elevation to 475.0 feet from 468.5 feet (Freese and Nichols, 2008).
[a] NGVD29 = National Geodetic Vertical Datum 1929
[b] C. Sanchez, personal communication, June 5, 2015

Volumetric and sedimentation survey of White Rock Lake

Datum

The vertical datum used during this survey is unknown. It is assumed to be equivalent to the National Geodetic Vertical Datum 1929 (NGVD29). Volume and area calculations in this report are referenced to water levels provided by the City of Dallas in feet above mean sea level. The horizontal datum used for this report is North American Datum 1983 (NAD83), and the horizontal coordinate system is State Plane Texas North Central Zone (feet).

TWDB bathymetric and sedimentation data collection

TWDB collected bathymetric data for White Rock Lake on March 19, 2015, March 25, 2015, and March 27, 2015. The daily average water surface elevations during the survey measured 458.3, 458.7, and 458.4 feet above mean sea level (NGVD29), respectively (C. Sanchez, personal communication, May 4, 2015). For data collection, TWDB used a Specialty Devices, Inc. (SDI), single-beam, multi-frequency (208 kHz, 50 kHz, and 24

kHz) sub-bottom profiling depth sounder integrated with differential global positioning system (DGPS) equipment. Data was collected along pre-planned survey lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 250 feet apart. The depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. Figure 2 shows where data collection occurred during the 2015 TWDB survey.

All sounding data was collected and reviewed before sediment core sampling sites were selected. Sediment core samples are collected at regularly spaced intervals within the reservoir, or at locations where interpretation of the acoustic display would be difficult without site-specific sediment core data. After analyzing the sounding data, TWDB selected four locations to collect sediment core samples (Figure 2). The sediment core samples were collected on May 20, 2015, with a custom-coring boat and SDI VibeCore system.

Sediment cores are collected in 3-inch diameter aluminum and/or clear acrylic tubes. Analysis of the acoustic data collected during the bathymetric survey assists in determining the depth of penetration the tube must be driven during sediment sampling. The goal is to collect a sediment core sample extending from the current reservoir-bottom surface, through the accumulated sediment, and to the pre-impoundment surface. After retrieving the sample, a stadia rod is inserted into the top of the aluminum tubes to assist in locating the top of the sediment in the tube. This identifies the location of the layer corresponding to the current reservoir-bottom surface. The aluminum tube is cut to this level, capped, and transported back to TWDB headquarters for further analysis. Sediment levels in the clear acrylic tubes were measured before transport back to TWDB headquarters. During this time, some settling of the upper layer can occur.

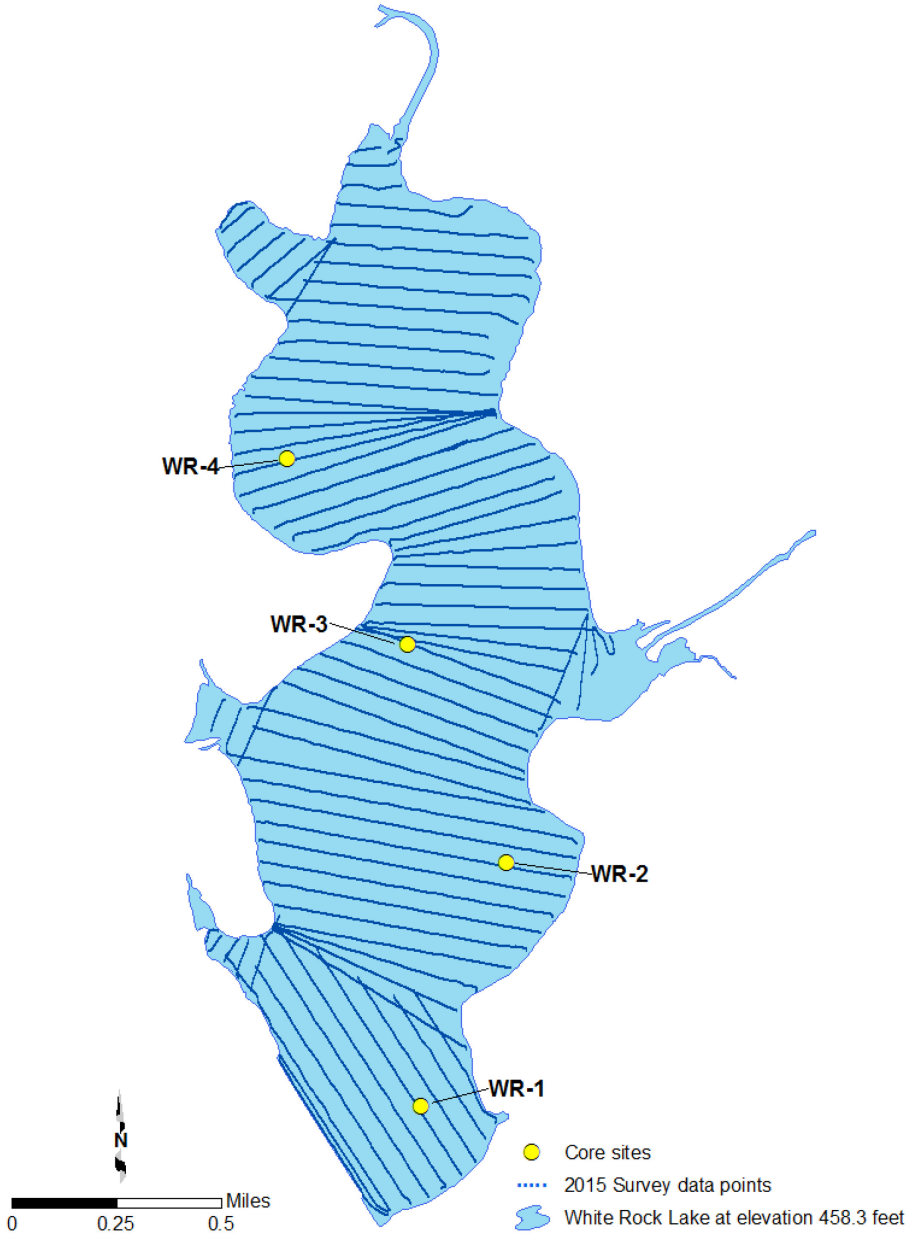


Figure 2. Data collected during 2015 TWDB White Rock Lake survey

Data processing

Model boundaries

The reservoir boundary was digitized from aerial photographs, also known as digital orthophoto quarter-quadrangle images (DOQQs), obtained from the Texas Natural Resources Information System (TNRIS, 2015a) using Environmental Systems Research Institute's ArcGIS software. The quarter-quadrangle that covers White Rock Lake is Dallas NW. The DOQQ was photographed on July 24, 2014, while the daily average water surface elevation measured 458.3 feet above mean sea level (D. Qualls, personal communication,

December 9, 2015). According to metadata associated with the 2014 DOQQs, the photographs have a resolution or ground sample distance of 1.0 meter and a horizontal accuracy within ± 6 meters to true ground (TNRIS, 2015b, USDA, 2015). For this analysis, the boundary was digitized at the land-water interface in the 2014 photographs and assigned an elevation of 458.3 feet.

Triangulated Irregular Network model

Following completion of data collection, the raw data files collected by TWDB were edited to remove data anomalies. The reservoirs current bottom surface is automatically determined by the data acquisition software. DepthPic©, software developed by SDI, Inc., was used to display, interpret, and edit the multi-frequency data by manually removing data anomalies in the current bottom surface. TWDB developed an algorithm to automatically determine the pre-impoundment surface, i.e., sediment thickness, based on the intensity of the acoustic returns. Hydropick, software developed in-house and in collaboration with Enthought, Inc. (GitHub, 2015a, GitHub, 2015b), was used to calibrate the algorithm and manually edit the pre-impoundment surfaces in areas where the algorithm did not perform as expected. For further analysis, all data was exported into a single file, including the current reservoir bottom surface, pre-impoundment surface, and sediment thickness at each sounding location. The water surface elevation at the time of each sounding was used to convert each sounding depth to a corresponding reservoir-bottom elevation. This survey point dataset was then preconditioned by inserting a uniform grid of artificial survey points between the actual survey lines. Bathymetric elevations at these artificial points were determined using an anisotropic spatial interpolation algorithm described in the next section. This technique creates a high resolution, uniform grid of interpolated bathymetric elevation points throughout a majority of the reservoir (McEwen et al., 2014a). Finally, the point file resulting from spatial interpolation was used in conjunction with sounding and boundary data to create volumetric and sediment Triangulated Irregular Network (TIN) models utilizing the 3D Analyst Extension of ArcGIS. The 3D Analyst algorithm uses Delaunay's criteria for triangulation to create a grid composed of triangles from non-uniformly spaced points, including the boundary vertices (ESRI, 1995).

Spatial interpolation of reservoir bathymetry

Isotropic spatial interpolation techniques such as the Delaunay triangulation used by the 3D Analyst extension of ArcGIS are, in many instances, unable to suitably interpolate bathymetries between survey lines common to reservoir surveys. Reservoirs and stream channels are anisotropic morphological features where bathymetry at any particular location is more similar to upstream and downstream locations than to transverse locations. Interpolation schemes that do not consider this anisotropy lead to the creation of several types of artifacts in the final representation of the reservoir bottom surface and hence to errors in volume. These include: artificially-curved contour lines extending into the reservoir where the reservoir walls are steep or the reservoir is relatively narrow; intermittent representation of submerged stream channel connectivity; and oscillations of contour lines in between survey lines. These artifacts reduce the accuracy of the resulting volumetric and sediment TIN models in areas between actual survey data.

To improve the accuracy of bathymetric representation between survey lines, TWDB developed various anisotropic spatial interpolation techniques. Generally, the directionality of interpolation at different locations of a reservoir can be determined from external data sources. A basic assumption is that the reservoir profile in the vicinity of a particular location has upstream and downstream similarity. In addition, the sinuosity and directionality of submerged stream channels can be determined by directly examining the survey data, or more robustly by examining scanned USGS 7.5 minute quadrangle maps (known as digital raster graphics) and hypsography files (the vector format of USGS 7.5 minute quadrangle map contours), when available. Using the survey data, polygons are created to partition the reservoir into segments with centerlines defining directionality of interpolation within each segment. For surveys with similar spatial coverage, these interpolation definition files are in principle independent of the survey data and could be applied to past and future survey data of the same reservoir. In practice, however, minor revisions of the interpolation definition files may be needed to account for differences in spatial coverage and boundary conditions between surveys. Using the interpolation definition files and survey data, the current reservoir-bottom elevation, pre-impoundment elevation, and sediment thickness are calculated for each point in the high resolution uniform grid of artificial survey points. The reservoir boundary, artificial survey points grid, and survey data points are used to create volumetric and sediment TIN models representing the reservoir bathymetry and sediment accumulation throughout the reservoir.

Specific details of this interpolation technique can be found in the HydroTools manual (McEwen et al., 2014a) and in McEwen et al., 2014b.

In areas inaccessible to survey data collection, such as small coves and shallow upstream areas of the reservoir, linear interpolation is used for volumetric and sediment accumulation estimations. The linear interpolation follows a linear definition file linking the survey points file to the lake boundary file (McEwen et al., 2014a). Without linearly interpolated data, the TIN model builds flat triangles. A flat triangle is defined as a triangle where all three vertices are equal in elevation, generally the elevation of the reservoir boundary. Reducing flat triangles by applying linear interpolation improves the elevation-capacity and elevation-area calculations. It is not always possible to remove all flat triangles, and linear interpolation is only applied where adding bathymetry is deemed reasonable.

Figure 3 illustrates typical results from application of the anisotropic interpolation and linear interpolation techniques to White Rock Lake. In Figure 3A, steep slopes indicated by surveyed cross sections are not continuously represented in areas between survey cross sections. This is an artifact of the TIN generation routine rather than an accurate representation of the physical bathymetric surface. Inclusion of interpolation points in creation of the volumetric TIN model, represented in Figure 3B, directs Delaunay triangulation to better represent the reservoir bathymetry between survey cross-sections. The bathymetry shown in Figure 3C was used in computing reservoir capacity and area tables (Appendix A, B).

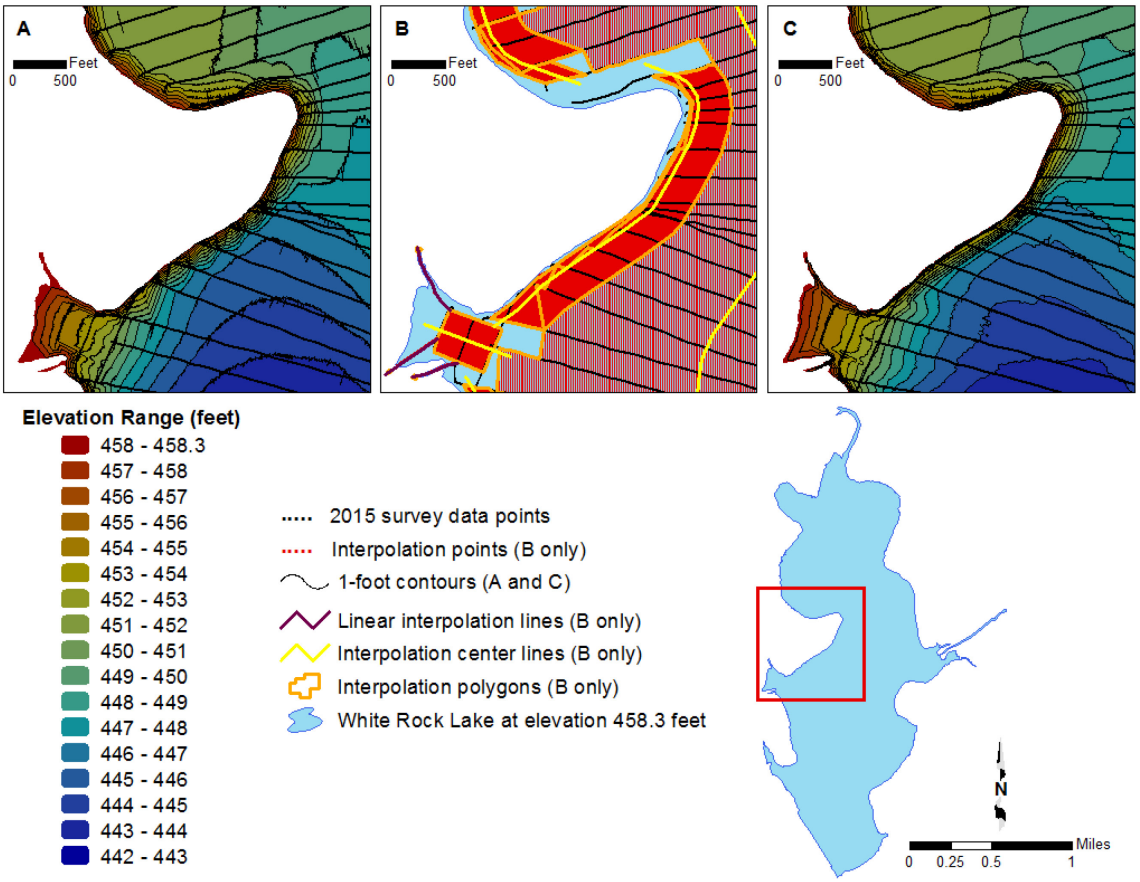


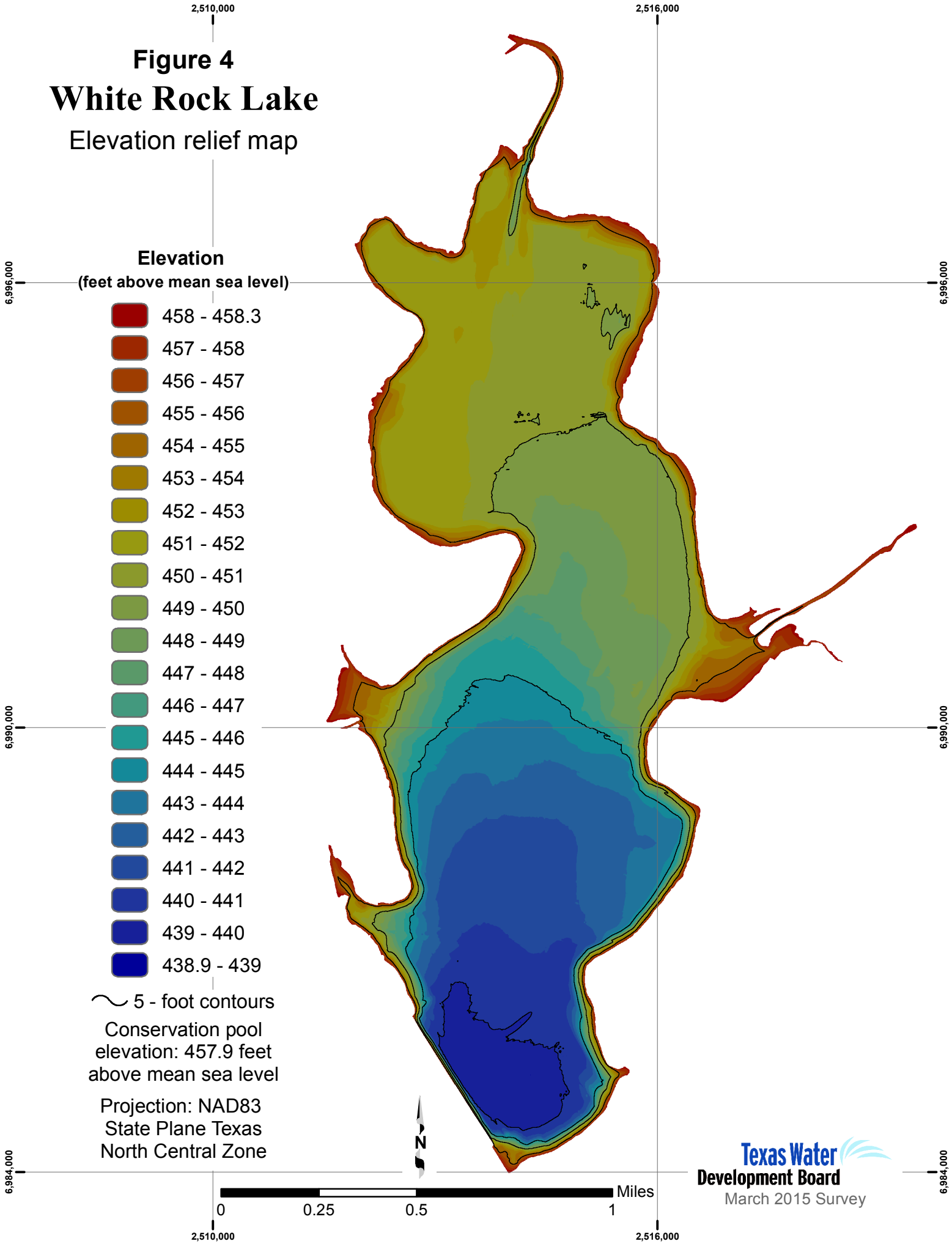
Figure 3. Anisotropic spatial interpolation and linear interpolation of White Rock Lake sounding data - A) bathymetric contours without interpolated points, B) sounding points (black) and interpolated points (red), C) bathymetric contours with the interpolated points

Area, volume, and contour calculation

Using ArcInfo software and the volumetric TIN model, volumes and areas were calculated for the entire reservoir at 0.1-foot intervals, from 438.8 to 458.3 feet. The elevation-capacity table and elevation-area table, updated for 2015, are presented in Appendices A and B, respectively. The capacity curve is presented in Appendix C, and the area curve is presented in Appendix D.

The volumetric TIN model was converted to a raster representation using a cell size of 1 foot by 1 foot. The raster data was then used to produce: an elevation relief map (Figure 4), representing the topography of the reservoir bottom; a depth range map (Figure 5), showing shaded depth ranges for White Rock Lake; and a 1-foot contour map (Figure 6).

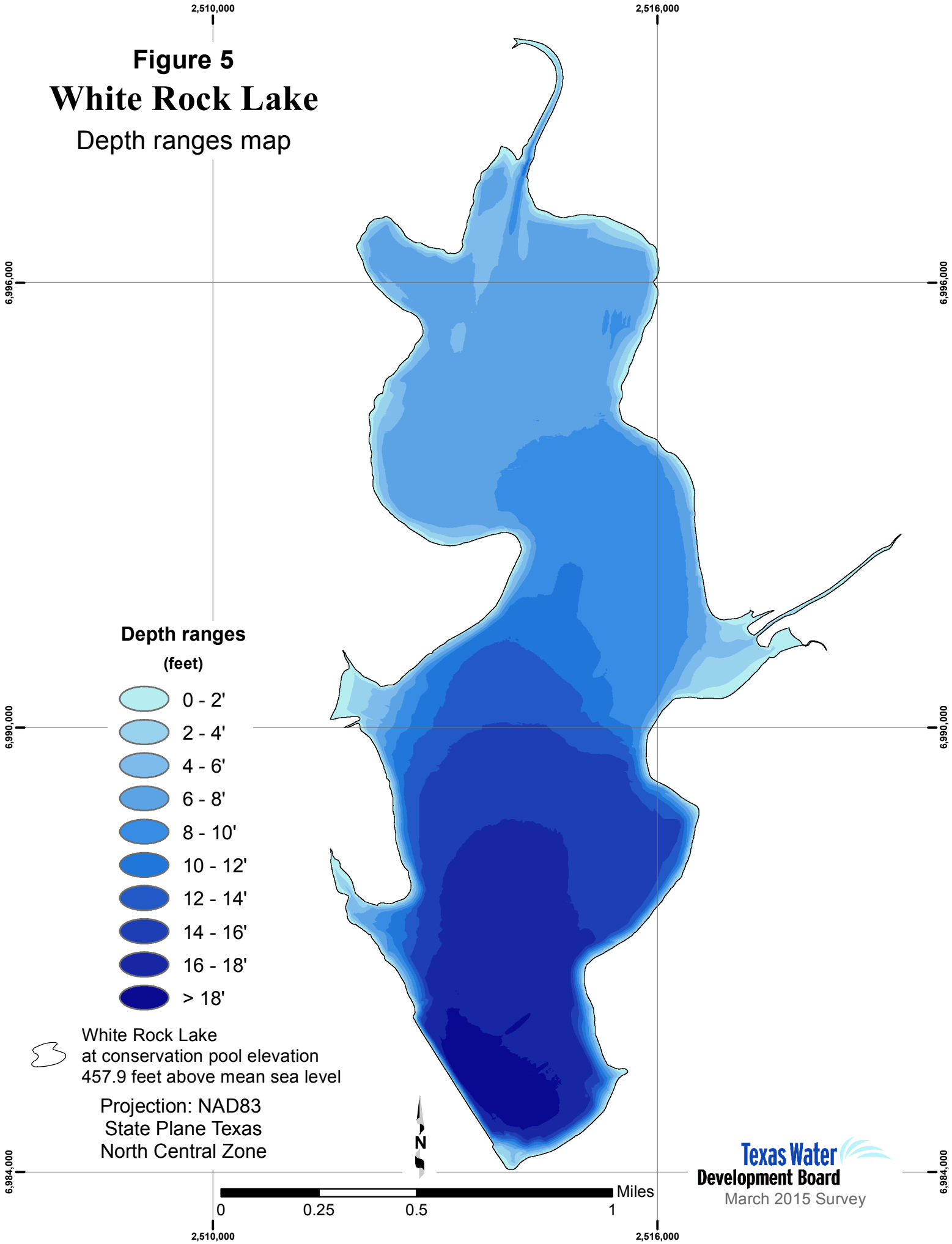
Figure 4
White Rock Lake
Elevation relief map



Texas Water Development Board

March 2015 Survey

Figure 5
White Rock Lake
Depth ranges map

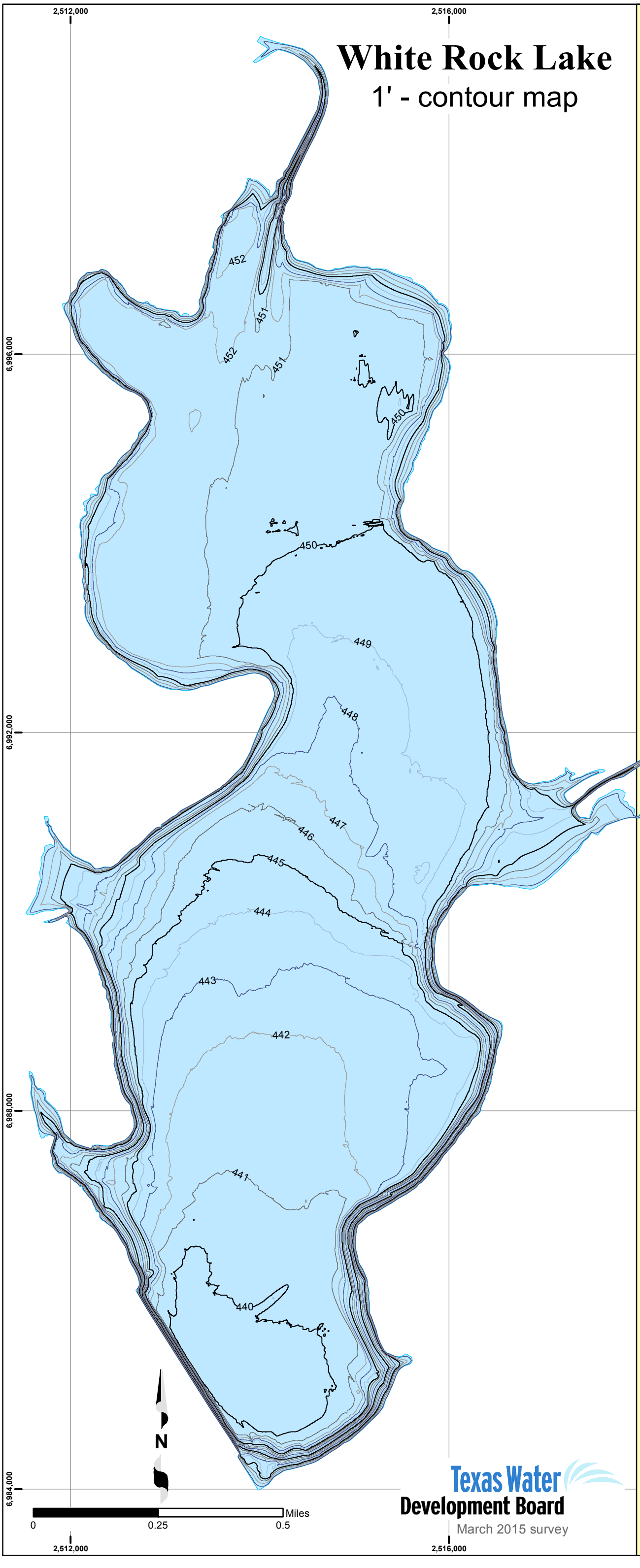


Texas Water Development Board

March 2015 Survey

White Rock Lake

1' - contour map



Texas Water Development Board

March 2015 survey

Figure 6

Contours (feet)

458
457
456
455
454
453
452
451
450
449
448
447
446
445
444
443
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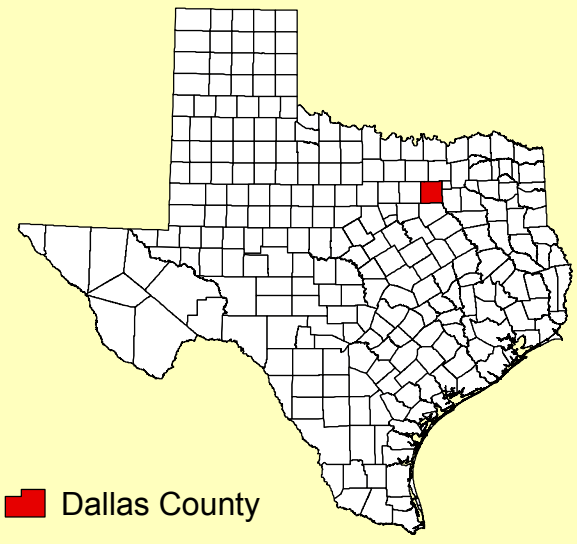
441
440
439

White Rock Lake elevation 458.3 feet above mean sea level

Conservation pool elevation: 457.9 feet above mean sea level

Projection: NAD83 State Plane Texas North Cental Zone (feet)



Dallas County

This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of White Rock Lake.

The Texas Water Development Board makes no representations nor assumes any liability.

Analysis of sediment data from White Rock Lake

Sedimentation in White Rock Lake was determined by analyzing the acoustic signal returns of all three depth sounder frequencies using customized software called Hydropick. While the 208 kHz signal is analyzed to determine the current bathymetric surface, all three frequencies, 208 kHz, 50 kHz, and 24 kHz, are analyzed to determine the reservoir bathymetric surface at the time of initial impoundment, i.e., pre-impoundment surface. Sediment core samples collected in the reservoir are correlated with the acoustic signals in each frequency to assist in identifying the pre-impoundment surface. The difference between the current surface and the pre-impoundment surface yields a sediment thickness value at each sounding location.

Analysis of the sediment core samples was conducted at TWDB headquarters in Austin. Each sample was split longitudinally and analyzed to identify the location of the pre-impoundment surface. The pre-impoundment surface is identified within the sediment core sample by one or more of the following methods: (1) a visual examination of the sediment core for terrestrial materials, such as leaf litter, tree bark, twigs, intact roots, etc., concentrations of which tend to occur on or just below the pre-impoundment surface; (2) changes in texture from well sorted, relatively fine-grained sediment to poorly sorted mixtures of coarse and fine-grained materials; and (3) variations in the physical properties of the sediment, particularly sediment water content and penetration resistance with depth (Van Metre et al., 2004). The total sample length, sediment thickness, and the pre-impoundment thickness were recorded. Physical characteristics of the sediment core, including Munsell soil color, texture, relative water content, and presence of organic materials, were also recorded (Table 2).

Table 2. Sediment core sampling analysis data - White Rock Lake

Core	Easting[a] (ft)	Northing[a] (ft)	Total core sample/ post-impoundment sediment	Sediment core description	Munsell soil color
WR-1	2514523.30	6985496.02	120”/ 80.0”	0-27.5” high water content, loam	GLEY1 2.5/10Y
				27.5-80.0” high water content, dense, few clay pockets, clay loam	GLEY1 3/10Y
				80.0-89.0” high water content, more dense, few clay pockets, clay loam	GLEY1 2.5/10Y
				89.0-120.0” low water content, high density, small dry clay pieces, clay loam	GLEY1 2.5/10Y
WR-2	2515596.90	6988558.12	120”/67.0”	0-11.0” very high water content, loam	GLEY1 2.5/10Y
				11.0-67.0” lower water content, dense	GLEY1 3/10Y
				67.0-117.5” very dense, small dry clay pockets, loamy clay	5Y 2.5/1
				117.5-120.0” very dense, dry soil, tiny pieces organic matter, clay	5Y 4/1
WR-3	2514351.07	6991309.18	67”/55.0”	0-1.5” fluff lost in compression	N/A
				1.5-22.5” high water content, dense, silty clay loam	5Y 3/1
				22.5-55.0” high water content, more dense, silty clay loam	5Y 2.5/1
				55.0-65.5” very dense, clay loam	5Y 4/1
				65.5-67.0”low water content, dense, tiny organic matter, loamy clay	2.5Y 3/1
WR-4	2512841.05	6993637.50	93”/38.0”	0-8.0” fluff lost with compression	N/A
				8.0-18.0” high water content, silty loam	2.5Y 2.5/1
				18.0-38.0” layer identified by color change seen in photograph of core	N/A
				18.0-77.0” high water content, very dense, small organic matter at top 1” of layer, small clay pockets, clay loam, possible layer from 18.0-38.0”	5Y 2.5/2
				77.0-93.0” low water content, small organics present, clay loam	10YR 4/1

[a] Coordinates are based on NAD83 State Plane Texas North Central System (feet)

A photograph of sediment core WR-3 is shown in Figure 7 and is representative of the sediment cores sampled from White Rock Lake. The base of the sample is denoted by the blue line. The pre-impoundment boundary (yellow line) was evident within this sediment core sample at 55.0 inches and identified by the change in color, texture, moisture, porosity, and structure. Identification of the pre-impoundment surface for the remaining sediment cores followed a similar procedure.

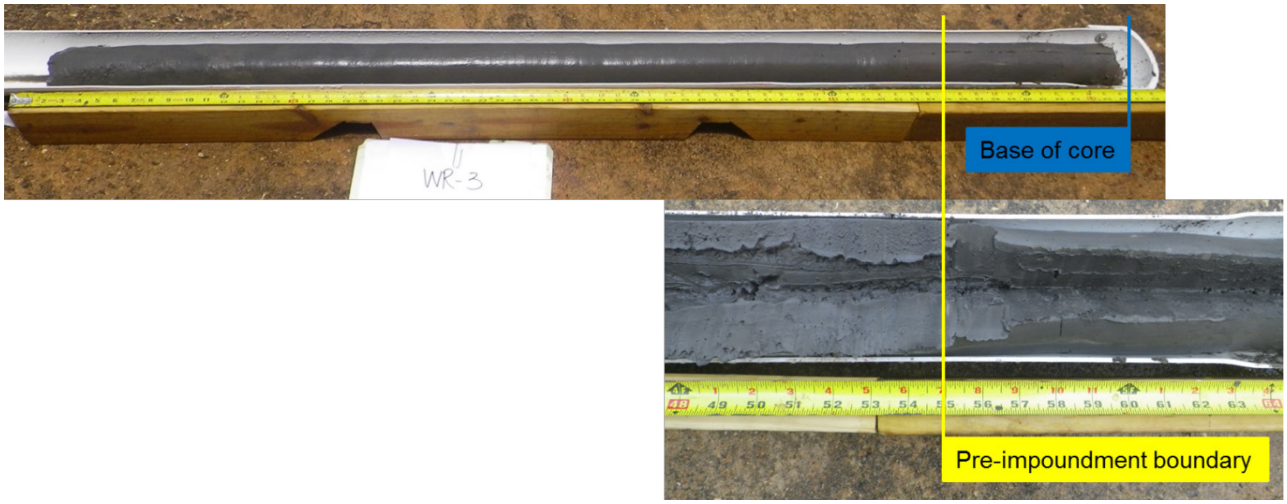


Figure 7. Sediment core WR-3 from White Rock Lake

Figure 8 and 9 illustrate how measurements from sediment core samples are used with sonar data to help identify the interface between the post- and pre-impoundment layers in the acoustic signal.

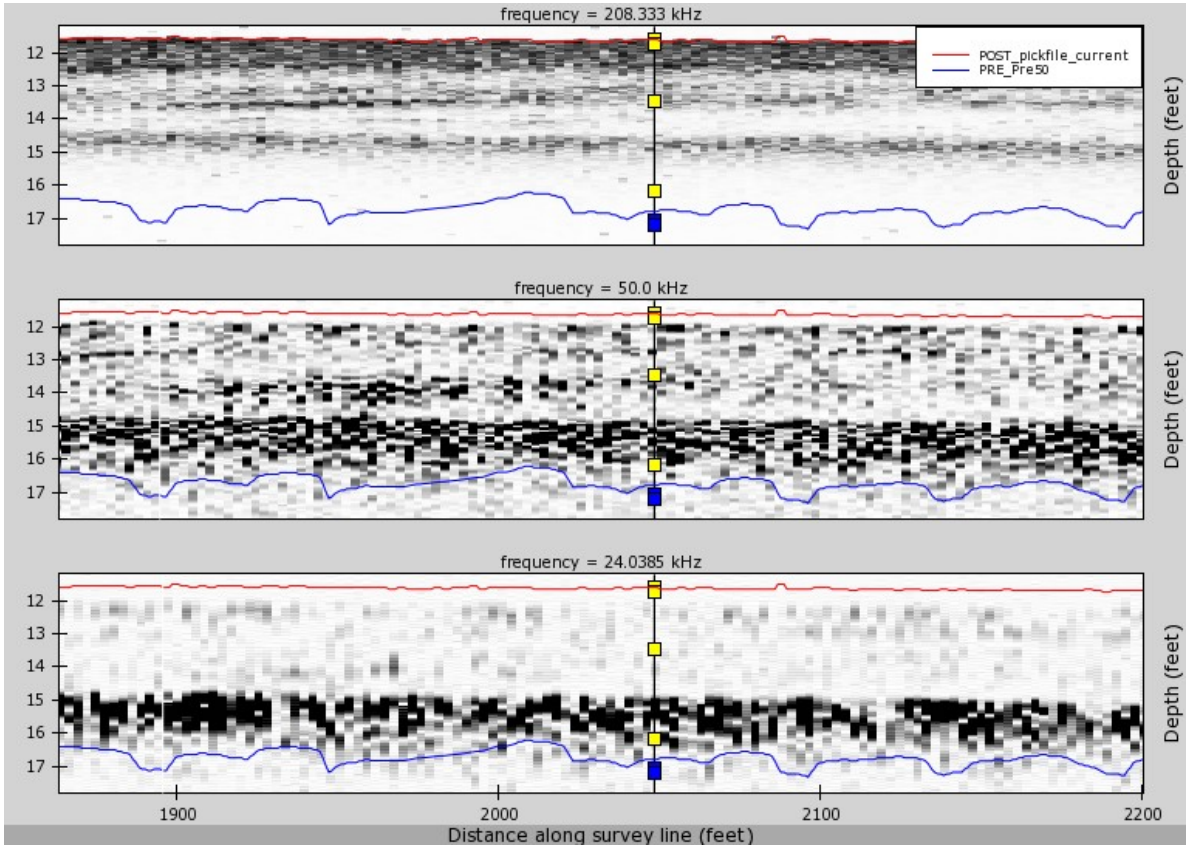


Figure 8. Comparison of sediment core WR-3 with acoustic signal returns

Figure 8 compares sediment core sample WR-3 with the acoustic signals as seen in Hydropick for each frequency: 208 kHz, 50 kHz, and 24 kHz. The current bathymetric surface is automatically determined based on signal returns from the 208 kHz transducer

and represented by the top red line in Figure 8.The pre-impoundment surface is identified by comparing boundaries observed in the 208 kHz, 50 kHz and 24 kHz signals to the location of the pre-impoundment surface of the sediment core sample. Each layer of sediment identified in the sediment core sample during analysis (Table 2) is represented by a yellow or blue box. The yellow boxes represent post-impoundment sediment. The blue boxes mark the bottom of the pre-impoundment sediment layers and the lower blue box is also the bottom of the sediment core sample.

In this case the boundary in the 50 kHz signal most closely matched the pre-impoundment interface of the sediment core sample; therefore, the 50 kHz signal was used to locate the pre-impoundment surface (blue line in Figure 8). Figure 9 shows sediment core sample WR-3 correlated with the 50 kHz frequency of the nearest surveyed cross-section. The pre-impoundment surface is first identified along cross-sections for which sediment core samples have been collected and used as a guide for identifying the pre-impoundment surface along cross-sections where sediment core samples were not collected.

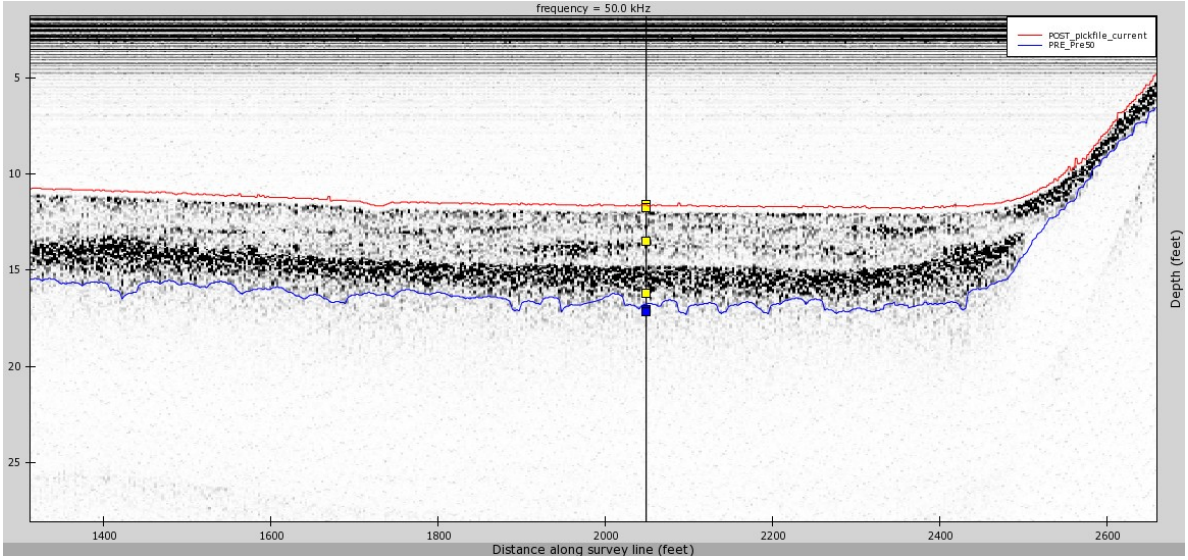


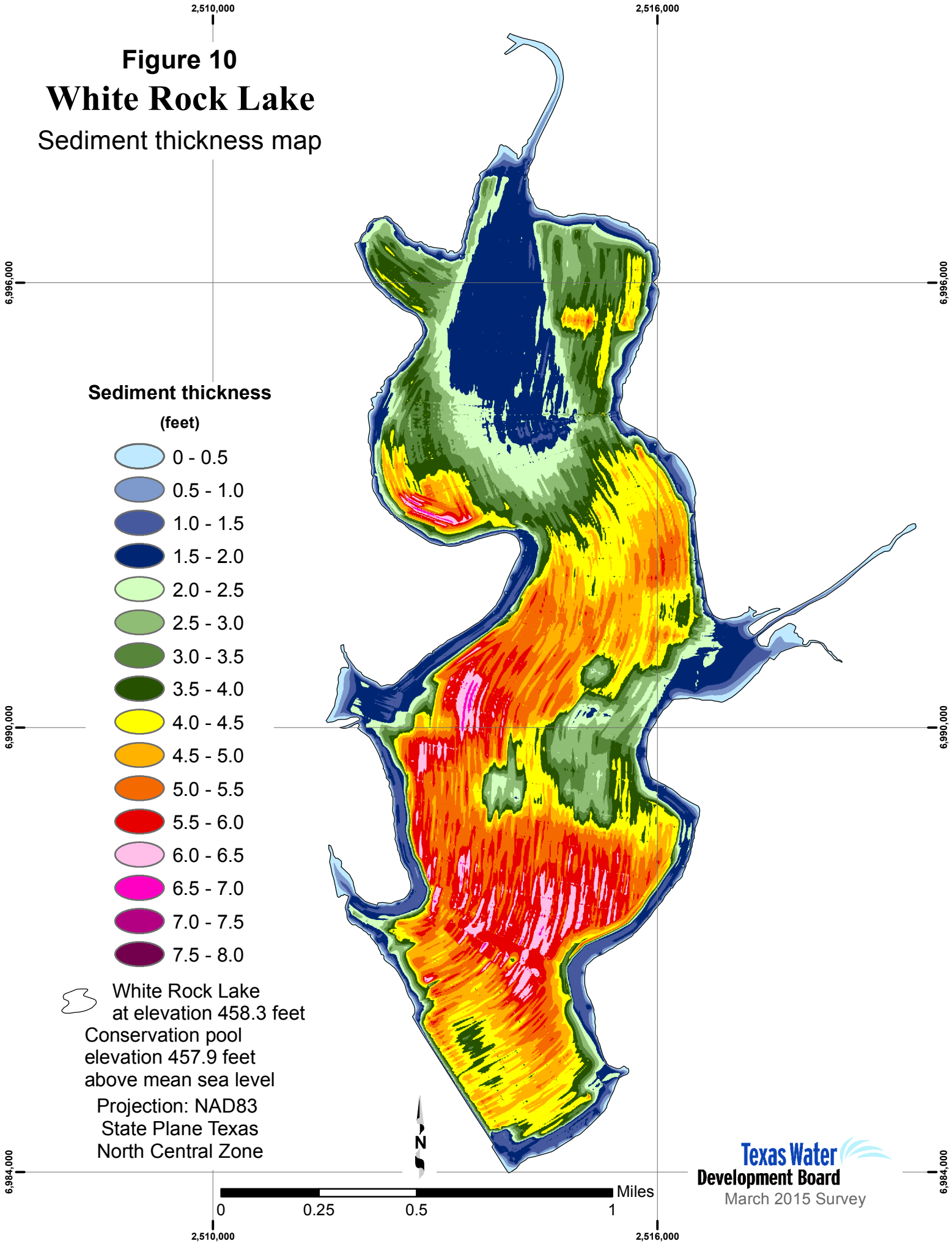
Figure 9. Cross-section of data collected during survey, displayed in Hydropick (50 kHz frequency), correlated with sediment core sample WR-3 and showing the current surface in red and pre-impoundment surface in blue

The pre-impoundment surface was automatically generated in Hydropick using Otsu's thresholding algorithm of classifying greyscale intensity images into binary (black and white) images based on maximum inter-class variance. The acoustic return images of a selected frequency from each survey line were processed using this technique and the pre-impoundment surface identified as the bottom black/white interface (where black is the sediment layer) of the resulting binary image (D. Pothina, personal communication,

October 2, 2014). The pre-impoundment surface is then verified and edited manually as needed.

After the pre-impoundment surface from all cross-sections is identified, a sediment thickness TIN model is created following standard GIS techniques (Furnans, 2007). Sediment thicknesses were interpolated between surveyed cross-sections using HydroTools with the same interpolation definition file used for bathymetric interpolation. For the purposes of the TIN model creation, TWDB assumed sediment thickness at the reservoir boundary was zero feet (defined as the 458.3 foot elevation contour). The sediment thickness TIN model was converted to a raster representation using a cell size of 1 foot by 1 foot and used to produce a sediment thickness map of White Rock Lake (Figure 10).

Figure 10
White Rock Lake
Sediment thickness map



Texas Water Development Board

March 2015 Survey

Survey results

Volumetric survey

The results of the 2015 TWDB volumetric survey indicate White Rock Lake has a total reservoir capacity of 10,230 acre-feet and encompasses 995 acres at conservation pool elevation (457.9 feet above mean sea level, NGVD29). Previous capacity estimates for White Rock Lake, calculated at spillway elevation 458.0 feet above mean sea level, are provided in Table 3. Because of differences in past and present survey methodologies, and dredging since the lake was built, direct comparison of volumetric surveys to estimate loss of capacity is difficult and can be unreliable.

Table 3. Current and previous survey capacity and surface area data at spillway elevation 458.0 feet above mean sea level

Survey	Surface area (acres)	Total capacity (acre-feet)
Original design, 1910[a]	1,254	18,158
1935[a]	1,150	14,276
1956[a]	1,095	12,321
1970[a]	1,119	10,743
1977[a]	1,075	10,721
TWDB 1993[b]	1,088	9,004
TWDB 2015	998	10,329

[a] Source: (SCS, 1978)
[b] Source: (TWDB, 2003)

Sedimentation survey

The 2015 TWDB sedimentation survey measured 3,550 acre-feet of sediment below conservation pool elevation (457.9 feet NGVD29). Because White Rock Lake has been dredged multiple times, on and off between 1937 and 1941, from 1955-1956, 1974, and again from 1996 to 1998 (Butler, 2011, WRLC, 2014, Rodriguez et al., 2011), a reliable sedimentation rate could not be calculated. Dredging between 1937 and 1941 removed approximately 500,000 tons of sediment and reclaimed 90 acres of land (Butler, 2011, Rodriguez et al., 2011). During the 1955-1956 dredging, approximately 15,000 cubic yards of sediment were removed (Butler, 2011). During the 1974 dredging approximately 850 acre-feet of sediment was dredged (SCS, 1978); however, sediment was not removed from the site, but instead used to create Mockingbird Point where a dog park now exists (WRLC, 2014). Following a Clean Lakes Study in 1994 on the lake's sediment levels, approximately three million cubic yards of sediment were removed (Ostdick, 2007, Visser,

2011). Sediment accumulation is greatest in the area where the reservoir narrows northwest of the Dallas Arboretum and in pockets throughout the reservoir.

Recommendations

To improve estimates of sediment accumulation rates, TWDB recommends resurveying White Rock Lake in approximately 10 years or after a major flood event. To further improve estimates of sediment accumulation, TWDB recommends another sedimentation survey. A re-survey would allow a more accurate quantification of the average sediment accumulation rate for White Rock Lake.

TWDB contact information

More information about the Hydrographic Survey Program can be found at:
http://www.twdb.texas.gov/surfacewater/surveys/index.asp

Any questions regarding the TWDB Hydrographic Survey Program may be addressed to:

Jason J. Kemp
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Phone: (512) 463-2456
Email: Jason.Kemp@twdb.texas.gov

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Appendix A

White Rock Lake

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — March 2015 Survey

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 457.9 feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
438	0	0	0	0	0	0	0	0	0	0
439	0	0	0	0	0	1	2	3	5	8
440	12	17	23	29	37	45	53	62	71	80
441	90	100	111	122	134	146	160	174	189	205
442	222	240	259	278	298	319	340	362	385	409
443	433	458	484	511	538	566	595	624	654	684
444	714	745	776	808	840	873	906	939	972	1,006
445	1,041	1,075	1,110	1,145	1,181	1,217	1,253	1,290	1,327	1,364
446	1,402	1,440	1,478	1,517	1,556	1,595	1,635	1,674	1,714	1,755
447	1,795	1,836	1,878	1,919	1,961	2,003	2,045	2,087	2,130	2,174
448	2,217	2,262	2,306	2,351	2,397	2,443	2,490	2,538	2,586	2,636
449	2,685	2,736	2,788	2,841	2,895	2,950	3,007	3,065	3,124	3,183
450	3,243	3,304	3,367	3,430	3,496	3,563	3,632	3,702	3,773	3,845
451	3,918	3,992	4,067	4,143	4,221	4,300	4,381	4,464	4,547	4,632
452	4,717	4,803	4,890	4,977	5,064	5,152	5,240	5,328	5,417	5,506
453	5,595	5,685	5,774	5,864	5,954	6,045	6,135	6,226	6,317	6,409
454	6,500	6,592	6,684	6,776	6,869	6,961	7,054	7,147	7,241	7,334
455	7,428	7,522	7,616	7,711	7,805	7,900	7,995	8,090	8,185	8,281
456	8,376	8,472	8,568	8,664	8,761	8,857	8,954	9,051	9,148	9,245
457	9,343	9,441	9,538	9,637	9,735	9,833	9,932	10,031	10,130	10,230
458	10,329	10,429	10,529	10,630						

Appendix B

White Rock Lake

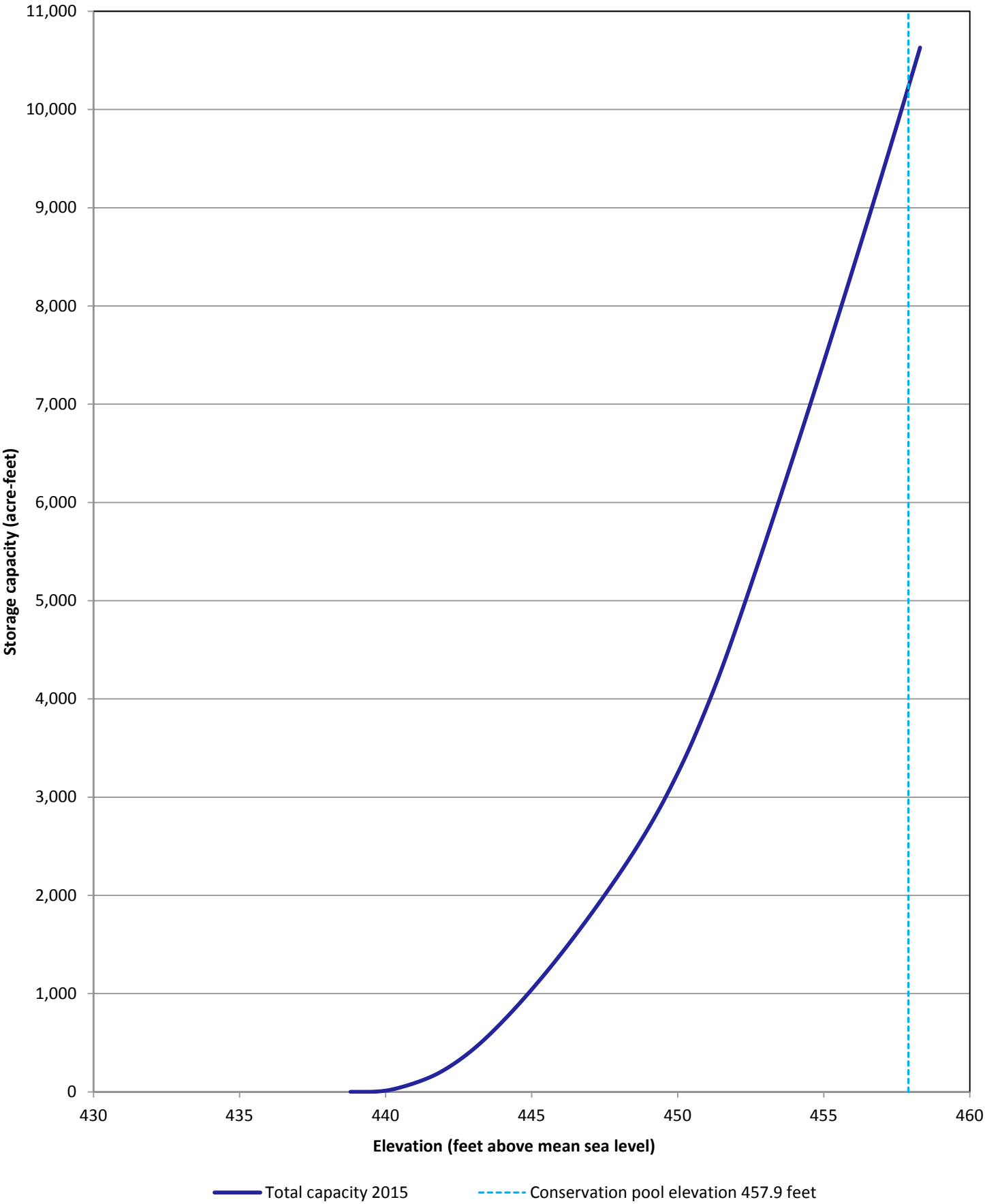
RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD — March 2015 Survey

AREA IN ACRES — Conservation Pool Elevation 457.9 feet NGVD29

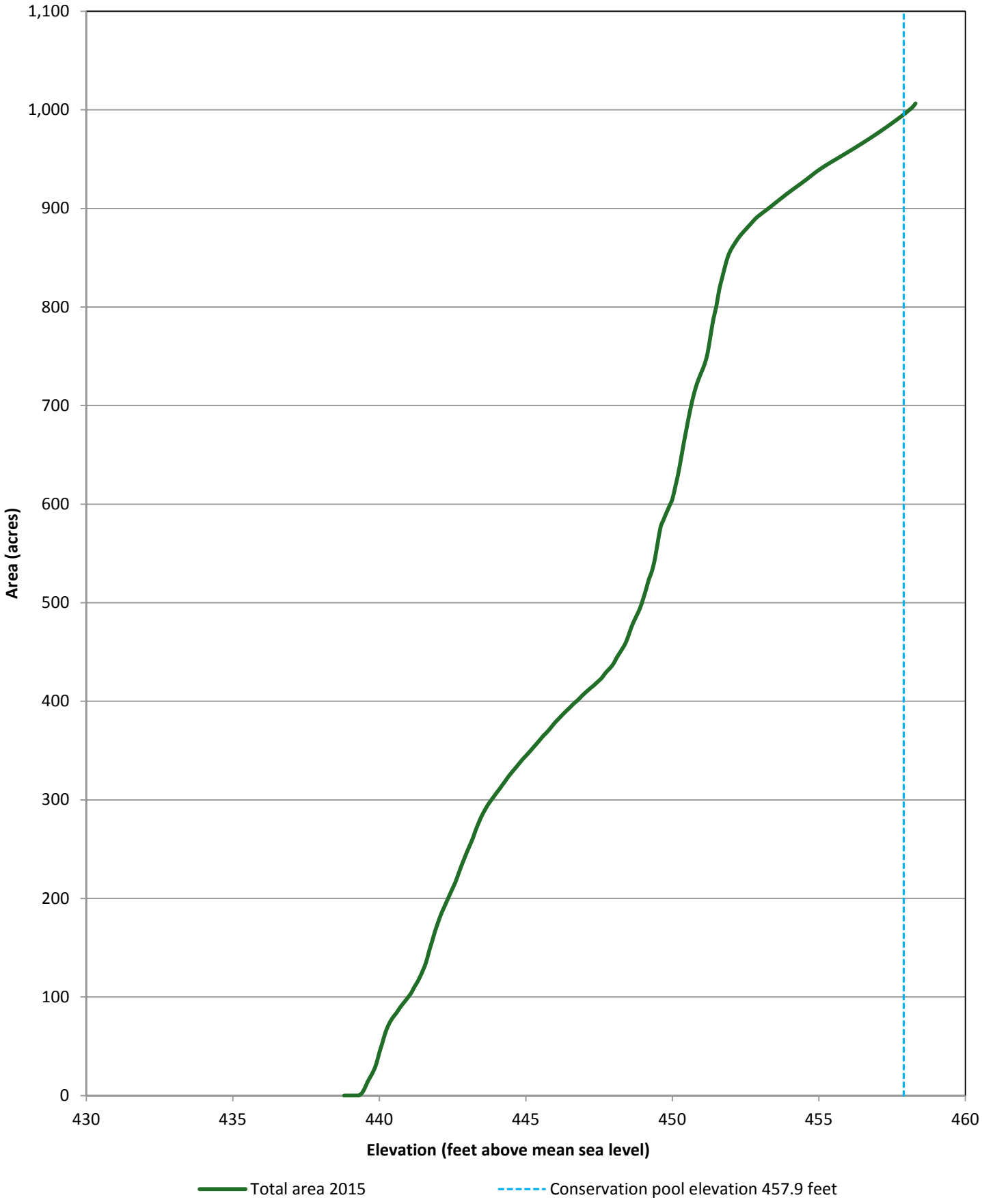
ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
438	0	0	0	0	0	0	0	0	0	0
439	0	0	0	0	2	7	14	19	25	32
440	43	53	63	71	76	81	84	89	93	97
441	100	105	110	115	121	128	135	146	156	166
442	175	183	190	197	204	210	217	225	233	240
443	248	254	262	270	277	284	289	295	299	303
444	307	311	315	319	323	327	331	334	338	341
445	345	348	351	355	358	362	365	368	371	375
446	379	382	385	388	391	394	397	399	402	405
447	408	411	413	416	418	421	424	428	431	435
448	438	444	449	454	459	466	475	482	488	495
449	503	513	524	532	544	560	577	584	591	598
450	605	617	631	647	663	679	694	707	718	727
451	734	742	753	770	787	800	817	829	841	851
452	858	863	868	872	875	879	882	885	888	891
453	894	896	898	900	903	905	907	910	912	915
454	917	919	921	923	925	928	930	932	935	937
455	939	941	943	945	947	948	950	952	954	955
456	957	959	961	963	965	966	968	970	972	974
457	976	978	980	982	984	987	989	991	993	995
458	998	1,000	1,003	1,006						



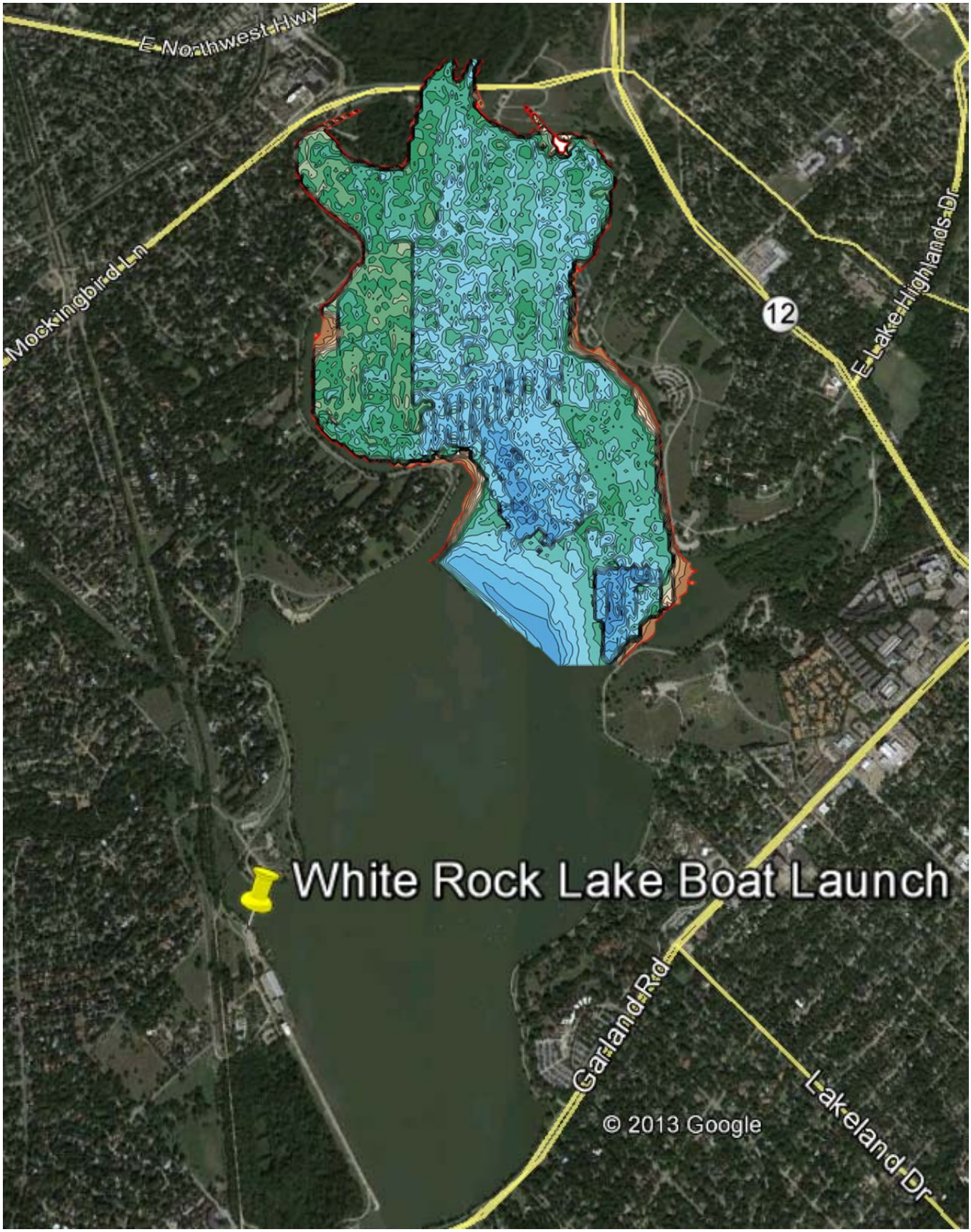
White Rock Lake
March 2015 Survey
Prepared by: TWDB

Appendix C: Capacity curve



White Rock Lake
March 2015 Survey
Prepared by: TWDB

Appendix D: Area curve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Mockingbird Ln
12
E Lake Highlands Dr
White Rock Lake Boat Launch
Garland Rd
Lakeland Dr
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