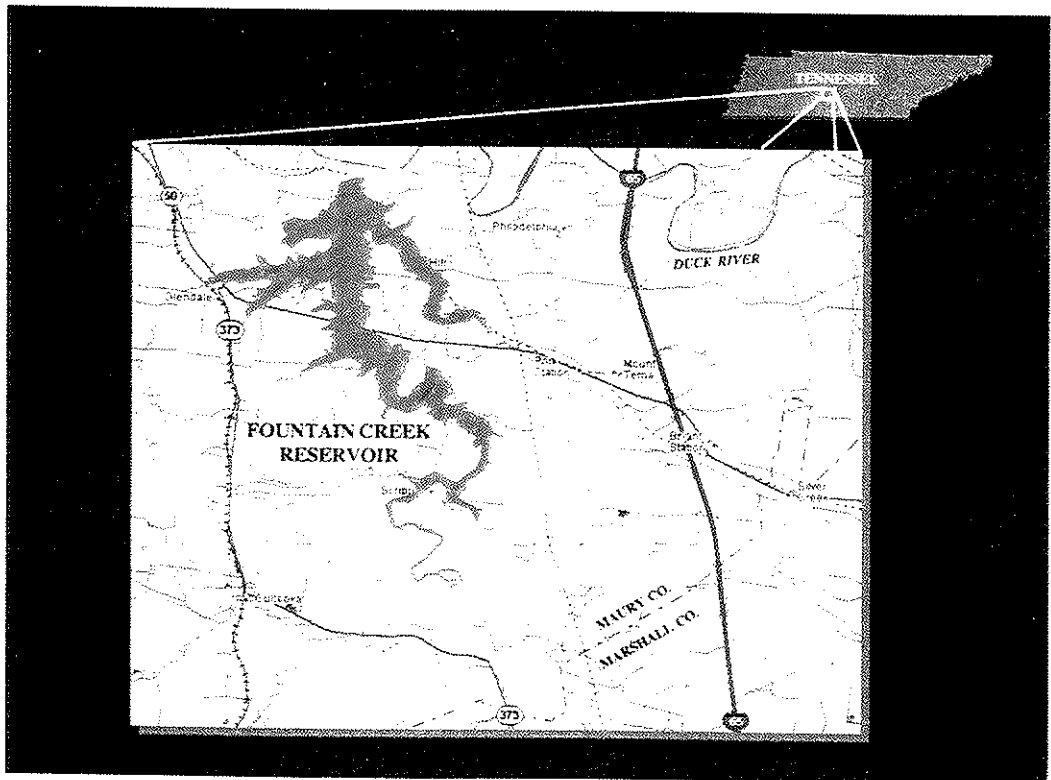




US Army Corps
of Engineers
Nashville District

Fountain Creek Reservoir Duck River Basin

Foundation Feasibility Report



December, 1997



Tennessee Valley Authority, 400 West Summit Hill Drive, Knoxville, Tennessee 37902-1499

February 27, 1998

Dr. Dimitra Syriopoulou
U.S. Army Corps of Engineers
Nashville District
Post Office Box 1070
Nashville, Tennessee 37202-1070

Dear Dr. Syriopoulou:

TVA has completed its review of the Foundation Feasibility Report for the proposed Fountain Creek Reservoir, as submitted by the U.S. Army Corps of Engineers (COE). The report is well prepared and contains critical information needed in part for sound decisionmaking concerning identification of a water supply alternative that will meet future needs of Marshall, Maury, and Southern Williamson Counties.

Although this level evaluation was not prepared for actual project design or initiation of any construction activities, it does present a critical need for additional evaluations of the questionable underlying geology.

In Paragraph 3.0, the document states that the proposed site is feasible for construction, providing that certain geophysical treatments of the Karst drainage system are implemented.

Recognizing both the historic reservoir leakage that has occurred in reservoir projects in this physiographic province and the collective experiences of COE and TVA, we believe there is a high probability of leakage. With proper investigation, adequate funding, and appropriate treatment, this potential could be decreased. We agree that additional intensive study is needed to evaluate potential flow through sinkholes and solution features.

Dr. Dimitra Syriopoulou
Page 2
February 27, 1998

As potential project cost estimates are prepared, we would recommend the establishment of a large contingency for unforeseen problems. The report suggests that other geophysical features, such as caves and sinkholes, may be discovered during the clearing and borrowing phase of construction. An additional contingency should be included for this potential. Additionally, funds should be held in reserve to address any rim leakage that may occur after the reservoir is filled. Further, we believe it to be in the project's best interest to include in the design a low-level sluiceway to ensure the ability to draw the pool down if remedial treatment becomes necessary.

We feel that it would be beneficial to add language in Paragraph 3.1 that clearly states the probability of additional treatments being required--particularly for those readers who often skip technical text and progress immediately to summaries or conclusions.

Thank you for completing this important investigation and evaluation. Your work, as both a cooperating agency and as a contractor, is highly valued and will become an integral component of the successful completion of the regional water supply evaluation for Marshall, Maury, and Southern Williamson Counties.

Sincerely,

A handwritten signature in black ink, appearing to read "Daniel H. Ferry". The signature is fluid and cursive, with a large loop at the end.

Daniel H. Ferry
Project Specialist
Water and Hydro Resource Projects

FOUNDATION CREEK RESERVOIR

FOUNDATION FEASIBILITY REPORT

**PREPARED FOR
THE DUCK RIVER AGENCY
OF
THE STATE OF TENNESSEE**

**BY
THE U.S. ARMY CORPS OF ENGINEERS
NASHVILLE DISTRICT**

DECEMBER 1997

ACKNOWLEDGMENTS

Several persons outside the U.S. Army Corps of Engineers contributed to the completion of the Fountain Creek Reservoir Foundation Feasibility Report.

The U.S. Army Corps of Engineers appreciates the hospitality and willingness of Ms. Mary Jane Brooks to permit drilling on her property.

Mr. Richard Sudderth, Mr. Keith Morgan, and the management of the Duck River Agency assisted the drilling program by providing logistical support as well as overseeing the security of the equipment.

The Tennessee Valley Authority employees, Mr. Jim Hamby, Mr. Charles Wagner, Mr. Tom Waller, Mr. Dan Ferry, Mr. Gary Godfrey, and Mr. Art Soderberg collectively provided mapping, Columbia Dam records, general technical information, and access to drill sites.

Ms. Donna Flohr, Mr. David Green, Mr. Rodney Knight, Mr. Jerry Lowery, and Mr. Pat Hollyday of the U. S. Geological Survey (USGS) contributed by providing topographic information, technical information, and valued advice. The USGS executed the Fountain Creek Water Balance Study which is an integral part of the Fountain Creek Foundation Evaluation.

FOUNTAIN CREEK RESERVOIR FEASIBILITY REPORT

TABLE OF CONTENTS

Report Narrative

Page	Paragraph	Description
1		Introduction / Tasks
3	1.0	General
3	1.1	Reservoir Location
3	1.2	Physiography, Structural Geology and Drainage
3	1.3	Site Geology
4	1.4	Mapping and Survey
4	1.5	Subsurface Investigation Program
4	1.6	Definitions of Terms
5	2.0	Site Feasibility Study
6	2.1	Karst Evaluation
6	2.1.1	Solutioning in Limestone
6	2.1.2	Lineaments
6	2.1.3	Karst
7	2.1.3.1	Reservoir Yield
7	2.1.3.2	Surface Expressions of Karst
7	2.1.3.3	A Major Solution Feature Identified at Saddle Dam No. 2 Location
7	2.1.4	Subsurface Investigation Evaluation
8	2.1.4.1	Open Features Within Rock/ Pressure Testing Results
8	2.1.4.2	Water Losses During Drilling
8	2.1.5	Water Balance Study
9	2.1.6	Source/ Receptor Study
10	2.1.7	Columbia Dam Foundation Preparation
10	2.1.8	Karst Evaluation Summary
11	2.2	Engineering Parameters of the Rock Mass
11	2.2.1	Rock Quality Designation
11	2.2.2	Rock Core Recovery
11	2.2.3	Jointing and Mapping
11	2.2.4	Clay Borrow
11	2.2.5	Geology and Grouting at Columbia Dam
12	3.0	Conclusions and Recommendations
12	3.1	Viability of Site as a Reservoir
13	3.2	Treatment of Karst Features

FOUNTAIN CREEK RESERVOIR FEASIBILITY REPORT

TABLE OF CONTENTS continued

Report Narrative

<u>Page</u>	<u>Paragraph</u>	<u>Description</u>
13	3.2.1	Rim and Foundation Grouting Program
13	3.2.2	Sinkhole Identification and Treatment
13	3.2.3	Backfilling of Domestic and Farm Wells
13	3.3	Suitable Clay in Sufficient Quantities on Site
13	3.4	Rock Fill for Dams
14	3.5	Relocation of Spillway and Increasing Height of Dams
14	3.6	Additional Saddle Dam (Saddle Dam No. 2) Required
14	3.7	Water Loss Through Sinkholes

PLATES

<u>Plate No.</u>	<u>Title</u>
1	Reservoir Location-Regional Plan
2	Plan of Project Features
3	General Plan of Borings, Karst and Lineaments
4	Plan of Borings, Karst and Lineaments- North Rim
5	Section A-A
6	Section B-B
7	Section C-C
8	Section D-D
9	Section E-E
10	Logs of Borings, C-1 Thru C-5
11	Logs of Borings, C-6 Thru A-11
12	Geologic Legend
13	Geologic Mapping-Confluence of Fountain and Silver Creek
14	Geologic Mapping-Silver Creek
15	Recommended Minimum Rim Treatment

TABLES

<u>Table No.</u>	<u>Title</u>
1	Rock Quality Designation Summary
2	Core Recovery Summary
3	Pressure Test Data with Hydraulic Conductivity Computation

CHARTS

1	RQD VS. Depth Below Top of Rock
2	Zones of Missing Rock
3	Distribution of Hydraulic Conductivity

APPENDIX

USGS WATER SUPPLY STUDY- FOUNTAIN CREEK BASIN

Introduction. This study addresses the feasibility with respect to geologic conditions of a potential Fountain Creek Reservoir as defined by a main dam 1200 feet from the confluence of Duck River and Fountain Creek and by two saddle dams in the left rim. The general location is shown on Plate 1. The proposed reservoir and project features are included on Plate 2. The scope of the investigation is limited to the tasks as detailed in the "Cost Sharing Agreement for Planning Assistance Between the U.S. Army and the Duck River Agency" dated 21 March 1997. These tasks are included as follows:

Task 4 - Fountain Creek Dam Site Karst Investigation

The investigation to be conducted under this task will provide qualitative data at the natural confluence (control point) of the hydrogeologic flow regime within the reservoir. The proposed investigation sites are: (a) at the potential damsite, approximately 1200 feet from the confluence of the Duck River and Fountain Creek; and (b) a "saddle" fill located at the headwaters of a tributary of Fountain Creek at Mile 1.28. The investigation will evaluate the subsurface flow regime and the potential impacts to the environment. The investigation is outlined in detail in the following paragraphs and will be conducted by the USACE, Nashville District.

- A. A windshield survey and limited on-ground reconnaissance of the study area will be conducted.
- B. Utilizing existing topographic mapping of the entire impoundment area and buffers prepared by the U.S. Geological Survey (USGS) at a scale of 1 inch = 1,000 feet with 5-foot contour intervals, a field reconnaissance will be conducted to locate depressions indicative of karst. The identification of karst surficial conditions will be limited to the accuracy of the USGS mapping.
- C. Results of a water balance study of Fountain Creek conducted by the USGS for the DRA will be obtained, identifying reaches where surficial water is lost or gained, as an indicator of Karst features.
- D. The Project Team will meet to discuss the specific investigation(s) proposed. During these discussions, issues such as right of access, access constraints, utilities (above and below ground), disposal of waste materials, restoration of disturbed areas and the like should be identified. Support will be requested from key Team Members

having related expertise and the ability to provide local liaison services.

E. The field services portion of this task will be initiated by conducting a Fracture/Lineament study to evaluate the presence of major fracture, jointing, bedding planes or strike features which influence groundwater flow. Readily available aerial photographs and geologic information for the study area will be collected from sources such as the Soil Conservation Service, TEA, Tennessee State Geologists Office, the Geology Department of Tennessee Technological University and the USG for analysis.

F. A source (sinkholes, caves, wells, etc.) and receptor (seeps, springs, wells, etc.) inventory will be conducted in an area of up to 0.25 miles in circumference from the investigation sites.

G. Utilizing the normal pool elevation generated in the H&H study (Task 2), core holes will be drilled along the proposed water's edge and near the base of the creek. At this time, the karst subsurface investigation is anticipated to consist of ten (10), 30-degree-angle, holes (utilizing a NQ coring bit) drilled 60 feet into the bedrock at 300-foot centers, on or in the vicinity of the proposed sites. Seven (7) holes are proposed for the damsite and three (3) in the saddle.

H. Packer tests will be conducted at 10-foot intervals where openings are indicated in the rock core at a pressure approximating the anticipated static pressure of the "full" reservoir to evaluate the leakage rate at that location.

I. Each boring location will be located horizontally and vertically at an acceptable accuracy for purposed of the feasibility study.

J. A report of findings will be published documenting the field investigations and testing, addressing the feasibility of the impoundment to retain water.

K. The draft report will be presented to the Project Team for comments. Upon resolution of all issues/comments resulting from the review, the final report will be published for public dissemination.

1.0 General.

1.1 Reservoir Location. As shown on Plate 1, the proposed reservoir is located in southeastern Maury County, Tennessee on Fountain Creek approximately 1200 feet upstream of the confluence with Duck River. At spillway crest elevation of 629 the pool occupies about 2000 acres. A map depicting project features is shown on Plate 2.

1.2 Physiography, Structural Geology and Drainage.

Physiographically, the site lies in the Interior Lowlands Province which is characterized by relatively low elevations, gently rolling topography, and essentially flat lying or slightly dipping bedrock. Subject site is also located in a subdivision of the province referred to as the Nashville Basin. Doming in conjunction with the Appalachian Mountain building process occurred in Middle Tennessee. The maximum uplift of the doming, which was centered near Murfreesboro, totaled 150 feet. Because the uplifted rock was more susceptible to erosion than the surrounding rock, a topographic basin developed on the structural dome. The rock surrounding the basin is known as the Highland Rim and generally ranges between 200 and 400 feet higher than the basin. The drainage pattern for the streams in the area of the proposed reservoir is largely controlled by preferred weaknesses in the rock called jointing which are a product of stresses and strains generated by crustal movements. Prominent jointing may also indicate a relatively brittle rock mass. Although jointing is prominent in the region, faulting is rare. Prior to the construction of the Columbia Dam only two faults were mapped in Maury County--an unlikely graben on Nodgrass Hill. Exploration for the Columbia Dam also revealed a fault which crossed the dam's foundation.

1.3 Site Geology. The proposed Fountain Creek Reservoir embraces three geologic units including the Ridley Limestone, the Lebanon Limestone, and the lower member of the Carters formation. The oldest unit, the Ridley Limestone, outcrops in a limited area near the center of the reservoir immediately adjacent to Fountain Creek. The Ridley Limestone is a cryptocrystalline to very fine crystalline limestone varying in color from brownish gray to yellowish brown. Its bedding thickness ranges from medium to thick bedded. Minor amounts of chert are present in the form of thin lenses. Overlying the Ridley Limestone and occupying approximately 80 percent of the reservoir foundation is the Lebanon formation. This formation is comprised of limestone varying in crystallinity from cryptocrystalline to coarse-crystalline and varying in color from medium gray to medium dark gray while fresh. The unit

is thin bedded with thin shale partings. The lower member of the Carters Limestone overlies the Lebanon formation. The lower member of the Carters is described as a cryptocrystalline to very fine crystalline limestone containing occasional coarse-crystalline beds. The bedding thickness is medium to thick bedded with thin beds of chert. Consistent with the regional geology, the bedding is essentially horizontal. Subterranean drainage in the limestone (Karst) has developed throughout the region as well as within the proposed Fountain Creek Reservoir. Because they are more thickly bedded than the Lebanon formation, the Ridley and the Carters are more susceptible to solutioning. Structurally, there is no evidence of faulting within the proposed reservoir.

1.4 Mapping and Survey. Topography on five-foot-contour intervals was furnished by the United States Geological Survey. Features such as roads, power lines, streams, and gaslines, were taken from other mapping. Borings C-5 through C-8 were located by the Global Positioning System (GPS). The remaining borings, which were located using a Brunton compass and tape, were referenced from well defined features on the ground.

1.5 Subsurface Investigation Program. The subsurface investigation consisted of ten (10) borings in the vicinity of the main dam and the two (2) saddle dams. Boring locations are depicted on Plate 3. Down hole water pressure testing was performed on a majority of the holes. Holes were advanced through the overburden using a 7 and 1/4-inch O.D. auger. One (1) hole was drilled vertically, while the remainder were drilled on a 30-degree-angle. Three (3) borings were terminated at the top of rock. Of these, two (2) were not extended into rock because of excessive overburden depth. The third was drilled to define the depth of overburden upstream of the proposed main dam. Using an NQ size core barrel (1 and 7/8-inch diameter core), seven (7) borings penetrated rock. Logs of borings are shown on Plates 10 and 11. A geologic legend is included as Plate 12 to assist in interpreting the boring and associated data. Representative overburden samples and all rock cores were collected and stored at an Army Corps of Engineer warehouse facility. The rock core will be transferred to a location designated by Duck River Agency upon request.

1.6 Definitions of Terms. The following terms are defined according to the "Dictionary of Scientific, and Technical Terms" or as noted.

Grout- A fluid mixture of cement and water, or a mixture of sand, cement, and water.

Grouting- The process of applying or of injecting grout into grout holes or in crevices of a rock.

Karst- A topography formed over limestone, dolomite, or gypsum and characterized by sinkholes, caves, and underground drainage.

Faulting- A fracture in rock along which the adjacent rock surfaces are displaced.

Hydraulic Conductivity- (For the purpose of this report) The rate of water flow in gallons per day through a cross section of one square foot under a unit gradient, at the prevailing temperature or at 60 degrees F.

Lineament- A significant line of landscape that reveals the hidden architecture of the rock basement (Taken from "a Dictionary of Mining, Mineral, and Related Terms.

Permeability- The capacity of porous rock, soil, or sediment for transmitting a fluid without damage to the structure of the medium.

Rock Quality Designation (RQD)- RQD was proposed by Deere (1963) as a method for classifying core recovery to reflect the fracturing and alteration of rock masses. For RQD determination the core should be at least 50 mm in diameter (NQ)...RQD is obtained by summing the total length of core recovered, but counting only those pieces of hard, sound core which are 10 cm (4 inches) in length, and taking that total length as a percentage of the total length cored. (Taken from Hunt Roy E. (1984), Geotechnical Engineering Investigation Manual, pp. 114-115, McGraw-Hill Book Company)

Water Balance Study- The water balance method is a measurement of continuity of flow of water. For this study water volumetric measurements were taken on Fountain Creek and its tributaries to determine if the stream was losing or gaining (water) as it flows toward Duck River.

2.0 Site Feasibility Study. The site feasibility study is divided into two general components, which are (1) an evaluation of the Karst development and (2) a brief discussion of the engineering design parameters of the soil and rock mass. It is understood that there is considerable overlap between the two components. Because of knowledge of

the area geology, it was predetermined from an array of geotechnical parameters that the karst evaluation is, overwhelmingly, the most critical element when considering the site as a potential reservoir. Consequently, the focus of the study is on the Karst development. However, additional geotechnical elements are also addressed such as rock strength, rock quality, spillway location and materials for dam construction.

2.1 Karst Evaluation.

2.1.1 Solutioning in Limestone. Although the primary permeability of the rock mass is extremely low, the secondary permeability poses the most serious threat to the viability of the reservoir. Each of the geologic units which comprise the Fountain Creek basin are limestones and are, therefore, subject to Karst development. Karst features develop when meteoric and ground water move through openings in the rock such as fractures, open bedding planes, and joints. Each of these are common features of subject rock mass. Although limestone is only slightly susceptible to solutioning in water, the solubility of limestone is enhanced by carbonic acid which is readily formed by meteoric water in the presence of carbon dioxide. Because of solutioning activity, subterranean drainage or karst has developed in the region.

2.1.2 Lineaments. In the Nashville Basin lineaments are generally near vertical, virtually linear planes of weakness in the rock mass. These lineaments represent dominant jointing, which can be readily located via topographic mapping. Plate 3 depicts the most pronounced lineaments in the vicinity of the proposed reservoir. These relatively weak elements in the rock mass offer less resistance to the downward cutting streams and, in effect capture them. Because of enhanced rock permeability, sinkholes also commonly develop along lineaments. Boring locations and orientation of the borings were selected to intersect with the more critical of these features.

2.1.3 Karst. Karst surface features are shown on Plate 3. At least 12 sinkholes or ponds, which may be temporarily plugged sinkholes, are present within the reservoir limits. Each are referenced by number, coordinates, surface elevation shown within the table included on Plate 3. It is likely that several of these are merely farm ponds but warrant more investigation prior to construction. It is also probable that additional sinkholes are present beneath the alluvial material of the valley floor.

2.1.3.1 Reservoir Yield. Volumetric computations for reservoir yield, as determined by the Task 2 Hydrology and Hydraulics Study, are based upon losing no more than a total of five (5) percent of water through the minimal flow structure built into the dam or through rim seepage. Consequently, for the reservoir to function as modeled with respect to yield, the seepage through the rim must be relatively small or the yield will be less than computed.

2.1.3.2 Surface Expressions of Karst. In addition to sinkholes, poorly defined surface drainage may also indicate a Karst environment. The topography of saddle dam sites 1 and 2 reflects no surficial expression of runoff. A one (1)-foot diameter hole in the ground was noted about 20 feet from boring C-4. Its origin, which remains unresolved, is either the product of a burrowing animal or is a source (inlet) for surface runoff, and therefore part of the karst drainage system.

2.1.3.3 A Major Solution Feature Identified at Saddle Dam No. 2 Location. Subsequent to the lineament study, boring sites were selected to verify the foundation of dam sites and to intercept lineaments. The Hydrology and Hydraulics team, which responded to Task 2, selected the saddle area between the main dam and the saddle dam as the reservoir spillway. However, the subsequent lineament study of Task 4 revealed that a dominant lineament crossed the proposed feature. Boring C-4 was situated to intercept the lineament. The boring was advanced sixty-two (62) feet (elevation 580) on a thirty (30) degree angle before refusal at what was interpreted to be top of rock. Because the depth of solutioning of the limestone is pronounced, Boring C-3 scheduled for the Saddle Dam (No. 1) was shifted to spillway area to further identify the subsurface feature. Rock was encountered at a depth of 37.5 feet (elevation 597). Boring C-3 lost all drilling water in the hole. Although no cavities were encountered in the limited rock cored, it is probable that a substantial solution feature exists in the rock in association with the lineament. It was beyond the scope of the program to drill additional holes along this particular lineament.

2.1.4 Subsurface Investigation Evaluation. Boring locations and detailed logs of borings are shown on Plates 3, 4, and 10 and 11 respectively. Plate 4 depicts the location of Sections A-A through E-E. Plates 5 through 8 contain sections of project features, borings, and approximate top of rock. Section E-E includes the two saddle dams, main dam, and spillway in a general section.

2.1.4.1 Open Features Within Rock/ Pressure Testing Results. Each of the seven (7) borings that penetrated rock encountered minor open features which includes unaccountable losses resulting from solutioning activity, open bedding planes, fractures or rock core that was ground up by drill action. The largest opening encountered, measuring one and two tenths (1.2) feet, was near the top of rock in Boring C-2. The accumulative unaccountable loss of core for the seven borings was six and nine tenths (6.9) feet compared to the approximate 210 feet drilled into rock. This computes to just above three (3) percent of the rock mass. As shown on the logs of borings, fractures in the rock are a common feature. However, openings within the rock mass are relatively small with limited permeability, which is illustrated by the low volume of water forced into the rock during pressure testing. The testing interval varied from ten (10) to 20 feet. Intervals varied if the core was solid or obviously impermeable or if fractured rock were present which would prevent the seating of the packer. Some intervals were tested twice. Pressure testing data is shown adjacent to the logs of borings on Plates 10 and 11. In Table 3 pressure test data is converted to hydraulic conductivity. A distribution of hydraulic conductivity computations are presented in Chart 3. Both the hydraulic conductivity and the average water take, which was less than one-half gallon per minute per linear foot of hole, is considered small and an indication of a groutable rock mass with conventional cement grout.

2.1.4.2 Water Losses During Drilling. Holes were advanced using a Mobile 53-B rotary drill rig. The overburden was drilled using a seven and one quarter (7 1/4)-inch O.D. auger. Holes were advanced through rock using NQ equipment and continually washing the drill bit with water. The drilling fluid (water) was monitored for percent returned to the surface during the program. This data, which is included on the logs of borings, is another indication of the rock mass permeability. Borings C-1 and C-2 in the foot print of Saddle Dam No.1 experienced 100 percent drill water return. In the vicinity of Saddle Dam No. 2, Boring C-3 penetrated (eight and one tenth) 8.1 feet of rock. All drilling fluid was lost at or near the top of rock. At the Main Dam total water losses occurred fairly consistently in Borings C-5, C-6, C-7, and C-8 between elevations 535 and 542.

2.1.5 Water Balance Study. A water balance study was performed on Fountain Creek by the United States Geological Survey (USGS) for the Duck River Agency. The data derived from the study was furnished to the Army Corps of Engineers.

for consideration in the analysis of the reservoir subterranean drainage (Karst). The data, which is included as an appendix to this report, includes sampling locations, discharge area above sampling station, volumetric stream determinations (discharge), loss/gain computations in cubic feet per second (cfs), temperature, and conductivity measurements in microsiemens (cm). As a supplement to the appendix, an excerpt from the Water Resources Data for Tennessee is included to illustrate typical discharges for Fountain Creek. The losses and gains noted during the study are shown graphically in Loss/Gain Summary Chart (Shown in the appendix). An alternating pattern of gains and losses is reflected. This indicates that the stream, at least in part, went subterranean only to reemerge on the surface a short distance downstream. This occurred throughout the basin as opposed to a limited area, and is a reflection of the general rock mass permeability. The gain was consistently greater than the loss, or in other words the gain occurred throughout the basin. Ten and four-tenths (10.4) cfs or about 10 percent of the 105 cfs measured in the stream prior to its confluence with the Duck River was due to a net gain. It is most likely that the net gain is the result of basin groundwater moving down gradient through openings in the rock and emerging in the stream. It is possible, however, that the gain resulted from captured ground water from an adjoining basin. Subterranean drainage from this basin to an adjoining basin could, if unchecked, reduce its capability to function as a reservoir. The study clearly reflects that secondary permeability of the rock mass is ubiquitous and subterranean drainage exists on a significant level.

As shown in the Water Resources Data for Fountain Creek, the discharge during the water balance study was elevated. Although significant data was derived from the study, a water balance study with the stream at or near baseline flow is recommended should the project advance toward construction. As shown in studies in the Karst region of western Kentucky, subterranean flows into and out of the drainage basin may be influenced by the relative height of the ground water. Consequently, another study during baseline flow would assist in understanding the groundwater regime and subterranean flows.

2.1.6 Source/ Receptor Study. Sinkholes, caves, and wells are examples of potential entry points (sources) for the impounded reservoir water to gain access to a subterranean drainage system. Because of their existing connection to subterranean drainage sinkholes and caves pose the most substantial threat. While there are no known caves within

the Fountain Creek basin, sinkholes abound. Locations of area sinkholes and ponds are shown on Plate 3. Wells are less critical because the regional limestone aquifers generally produce less than 50 gallons per hour. Sealing wells which exist within the reservoir with grout or concrete should prevent the migration of reservoir water through them. The water balance study revealed that much of the ground water did not emerge as springs but rather surfaced in the primary streams. Few springs were noted via field reconnaissance. In fact, the USGS has listings for only 2 in the basin. USGS data also demonstrates that Duck River is a losing stream in the vicinity of Fountain Creek. Therefore, this is an indication that receptor springs between the proposed reservoir and the river should be rare since much of the drainage is underground and not emerging above the streambed elevation. Additionally, with much of the rock covered with alluvial deposits, springs and seepage zones exiting the rock are not visible.

2.1.7 Columbia Dam Foundation Preparation. Located in similar geology only three and one-half (3 and 1/2) miles from the proposed Fountain Creek Reservoir, the Columbia Dam provides insight into the Fountain Creek Dam and Reservoir foundation conditions. With the exception of the treatment of the fault which had spawned considerable dissolution of the limestone foundation in the area surrounding it, the Columbia Dam foundation was competent and relatively tight. The maximum "take" per any grout hole was 160 cubic feet of solids. Many of the holes experienced no grout takes at all. Voids caused by limestone dissolution are relatively small. The foundation beneath the concrete portion of the dam and earth embankment was successfully treated by grouting.

2.1.8 Karst Evaluation Summary. Qualitatively, each element of the Karst study verifies, either directly or indirectly, that the rock mass exhibits secondary permeability. This indicates that the reservoir rim is susceptible to leakage. Direct indications include the water pressure tests, the water balance study, grout takes at the Columbia Dam, water losses during drilling, and the regional well study performed by the USGS for the TVA. Indirect indicators of secondary permeability include close centered open joints of the mapping program, openings within the rock core, sinkholes, topographic features indicating a Karst drainage system, and the presence of lineaments. Quantitatively, the study consistently demonstrated that the karst development, though ubiquitous, has yielded a relatively low secondary permeability of the rock mass. Although there is no

indication of large scale openings in the rock, the possibility does exist that some are present.

2.2 Engineering Parameters of the Rock Mass.

2.2.1 Rock Quality Designation (RQD). Rock quality data is depicted on Plates 10 and 11, and summarized in Table 1. The average RQD is 39.2 % which falls within the poor range. Chart 1 relates the RQD to depth. There is a steady increase in the RQD from zero (0) to ten feet. The RQD remains at the approximate same percentage to a depth of 22 feet. From 22 to 25 feet deep the RQD increased slightly. From 24 to 31 feet the average RQD drops to about 30 % but rebounds to 55 % for the next 5 feet. The maximum RQD also reflects this trend with depth peaking above 90 % from a depth of 14 to 21 feet. The RQD values are low because of the core separation along bedding planes of the generally thinly bedded limestone and fractures within the rock.

2.2.2 Rock Core Recovery. Although the RQD values are relatively low, the core recovery was high- 96.6%. High recovery rates generally reflect a competent rock.

2.2.3 Jointing and Mapping. Mapping of the rock joints was performed at the confluence of Silver Creek and Fountain Creek and at the Silver Creek Bridge. These maps are included for reference on Plates 13 and 14 respectively. Joint orientations or bearings just downstream of the Silver Creek Bridge on Vaughn Road reflect the lineament bearings with few exceptions. Prominent joints are on about 10-foot-centers. The closer the joint spacing the greater the vertical and horizontal permeability of the rock mass.

2.2.4 Clay Borrow. Typically, residual clay development in the basin is less than one (1)-foot. However, in the low lying saddle areas, such as Saddle Dams 1 and 2 locations, residual-like clays are present in significant quantities. The bulk of the available clay is alluvial. These deposits increase in thickness (and volume) as Fountain Creek approaches Duck River. At the proposed Main Dam Site much of the valley floor is blanketed with over 20 feet of clay.

2.2.5 Geology and Grouting at Columbia Dam. With the same geologic units at the Columbia Dam and Fountain Creek sites, significant, practical parallels can be drawn for rock quality, grout takes, rock strengths, and borrow for the clay fill. The Tennessee Valley Authority (TVA) provided the Army Corps of Engineers access to the foundation and borrow records for the Columbia Dam. According to the borings logs the rock was generally good outside the fault

zone. Although some small solution features and fracturing were present, grout quantities were extremely low. A majority of the holes took 4 cubic feet of solids or less. The maximum grout take was 160 cubic feet of solids. Grout takes at the Fountain Creek site are expected to be slightly higher because of relative location higher in the geologic section than the Columbia Dam site. Compressive strength tests were performed for selected core from the Columbia Dam site. Unconfined compressive strength tests on core from the Lebanon formation ranged from 5,590 to 10,380 psi. The same tests on core from the Ridley formation yielded values of about 9,000-10,000 psi. These results indicate that bearing strengths would be sufficient to accommodate an earth/rockfill dam and intake towers for water withdrawal. Borrow for the clay fill was readily available on site from the alluvial material. The low plasticity clay was separated into four groups which had different optimum water contents or other properties. It is probably very similar to the low plasticity clays identified in the Fountain Creek Subsurface Investigation. Additionally, test wells were drilled in the Columbia Dam basin to answer questions concerning the leakage of the reservoir. Fifty holes were drilled and volumetric determinations of their respective discharges were made. Data from 27 of the wells were reviewed. The wells generally extended to a depth in excess of 150 feet. The wells yielded volumes that ranged from zero (0) to 90 gallons per hour which are considered small yields. The TVA hydrologic study did conclude that the Ridley Formation is prone to solutioning activity and losses and gains of stream flow are likely to be associated with the formation.

3.0 Conclusions and Recommendations.

3.1 Viability of Site as Reservoir. It is geologically feasible to construct a reservoir at the location and to the elevation detailed in this report. It will, however, require treatment of the karst drainage system that has developed at the site. Based on the collective experiences of the TVA and the Army Corps of Engineers, reservoirs sited on limestone terrains are highly susceptible to leakage. The potential for leakage can be reduced with the proper subsurface investigation and subsequent grouting program. Prior to the formulation of detailed design and specifications, intensive exploration of the rim by drilling and identification of the reservoir sinkholes are recommended to identify potential seepage pathways. Substantial monetary contingencies are, therefore, recommended to respond to unforeseen problems related to

reservoir leakage. It is prudent to design the project with a low-level sluice which would permit draining the reservoir. This would facilitate remedial treatment of the reservoir if needed.

3.2 Treatment of Karst Features.

3.2.1 Rim and Foundation Grouting Program. As delineated on Plate 15, a minimal grouting program of the foundation of the main dam, two saddle dams and selected areas of the reservoir rim is recommended. Based on a similar grouting program at Center Hill Reservoir in 1992, the cost of the Fountain Creek grouting is projected in 1997 dollars at a minimum of \$2.8 million. This allows for 77,000 linear feet of grout holes. Grout holes should be extended, at least, to elevation 510.

3.2.2 Sinkhole Identification and Treatment. It will also require cleaning and plugging of existing sinkholes in the reservoir with concrete. These are the primary sources for the impounded water to migrate through the reservoir rim. Because much of the reservoir bottom is shrouded with stream deposits, sinkholes may be present but are not visible. Later studies within the reservoir should include geophysical methods to peer beneath sediments and map the rock surface for depressions in the rock surface.

3.2.3 Backfilling of Domestic and Farm Wells. Although not considered a significant source for water loss. All domestic and commercial wells should be backfilled (tremied) with grout comprised of water and cement.

3.3 Borrow for Clay Core of Dams. Suitable clay in sufficient quantities exist on site to construct the clay cores of the dams. This is reinforced by the clay borrow at the Columbia Dam which met the clay core criteria for composition and plasticity. It is recommended that the borrow be extracted downstream from the reservoir. Although some clay could be borrowed from the reservoir where the cover is thick, its removal could enhance seepage through the rock mass. Borrow from within the reservoir should be permitted when the "in situ" clay is of sufficient depth to permit at least a 10-foot buffer between the reservoir and the underlying rock.

3.4 Rock Fill for Dams. Excavation of the spillway will yield sufficient quantities of relatively high quality stone which can be utilized as rock fill in the construction of the dams.

3.5 Relocation of Spillway and Increasing Height of Dams.

The presence of a major, clay-filled solution feature at the original spillway location dictated its relocation. The new spillway site on the right rim was selected for the following three (3) reasons: (1) to avoid the high pressure gas line located downstream of the left rim, (2) to minimize the flow distance to Duck River--thereby, minimizing erosion potential, and (3) to provide sufficient quantities of rock for dam construction. A rough balance study between the required volume of fill needed for the dams and excavation quantities was performed to determine if the new spillway location would produce an excessive amount of rock. The respective fill and excavation quantities for the embankments and spillway are presented on Plate 9. Hydraulic studies indicated that with less than a 400-foot-wide spillway the discharge during the Probable Maximum Flood (PMF) exceeded Army Corps of Engineer Standards for spillway velocities. Excavation quantities for both a curved 400 and 500-foot-wide spillway is also included on Plate 9. The balance between excavation and fill favors the 400-foot-wide spillway. However, a more detailed balance and cost analysis is needed to finalized the width of the spillway and height of the dam. A 400 and 500-foot-wide spillway requires raising the height of the dams two (2) feet and one (1) foot respectively to allow for passage of the PMF with sufficient additional height to address wave action.

3.6 Additional Saddle Dam (Saddle Dam No. 2) Required. As previously discussed, the original spillway site was selected by the Hydrology and Hydraulics Study because it is a broad area that lies just above the spillway crest elevation. The deep solution feature discovered at the site necessitated the relocation of the spillway and the construction of an additional saddle dam.

3.7 Water Loss Through Sinkholes. During the next design phase a study should be conducted to determine the maximum water flow accepted by the sinkholes within the basin. This study would define the ultimate hydraulic conductivity of the underground drainage system.

TABLES AND CHARTS

TABLES

Table No.	Title
1	Rock Quality Designation Summary
2	Core Recovery Summary
3	Pressure Test Data with Hydraulic Conductivity Computation

CHARTS

Chart No.	Title
1	RQD VS. Depth Below Top of Rock
2	Zones of Missing Rock
3	Distribution of Hydraulic Conductivity

**Table 1
ROCK QUALITY DESIGNATION (RQD) SUMMARY**

1	C-1	615	Ls	17.2'	21.2'	597.8	593.8	46	0
2	C-1	615	Ls	21.2'	28.7'	593.8	586.3	51	0
3	C-1	615	Ls	28.7'	39.0'	586.3	576	20	0
4	C-1	615	Ls	39.0'	49.2'	576	565.8	48	0
5	C-1	615	Ls	49.2'	59.5'	565.8	555.5	75	0
6	C-2	612	Ls	18.7'	21.1'	595.8	593.7	33	30°
7	C-2	612	Ls	21.1'	24.9'	593.7	590.4	0	30°
8	C-2	612	Ls	24.9'	27.9'	590.4	587.8	16	30°
9	C-2	612	Ls	27.9'	37.9'	587.8	579.2	48	30°
10	C-2	612	Ls	37.9'	46.6'	579.2	571.6	39	30°
11	C-2	612	Ls	46.6'	54.4'	571.6	564.9	11	30°
12	C-2	612	Ls	54.4'	60.5'	564.9	559.6	49	30°
13	C-3	618	Ls	37.5'	46.9'	585.5	577.4	53	30°
14	C-5	585	Ls	24.5'	27.8'	563.8	560.9	0	30°
15	C-5	585	Ls	27.8'	33.3'	560.9	556.2	40	30°
16	C-5	585	Ls	33.3'	38.5'	556.2	551.6	40	30°
17	C-5	585	Ls	38.5'	48.6'	551.6	542.9	80	30°
18	C-5	585	Ls	48.6'	52.8'	542.9	539.3	73	30°
19	C-6	561.9	Ls	25.6'	32.9'	557	533.4	34	30°
20	C-6	561.9	Ls	32.9'	39.5'	533.4	527.7	33	30°
21	C-6	561.9	Ls	39.5'	49.1'	527.7	519.4	75	30°
22	C-7	582.18	Ls	26.9'	29.6'	558.9	556.5	0	30°
23	C-7	582.18	Ls	29.6'	38.9'	556.5	548.5	34	30°
24	C-7	582.18	Ls	38.9'	49.1'	548.5	539.6	56	30°
25	C-8	581.5	Ls	25.4'	29.1'	559.5	556.3	12	30°
26	C-8	581.5	Ls	29.1'	36.4'	556.3	549.9	36	30°
27	C-8	581.5	Ls	36.4'	38.6'	549.9	548.1	0	30°
28	C-8	581.5	Ls	38.6'	47.1'	548.1	540.7	59	30°
29	C-8	581.5	Ls	47.1'	52.5'	540.7	536	34	30°
30	C-9	584.2	Ls	23.7'	27.1'	563.7	560.7	15	30°
31	C-9	584.2	Ls	27.1'	30.4'	560.7	557.9	0	30°
32	C-9	584.2	Ls	30.4'	37.3'	557.9	551.9	26	30°
33	C-9	584.2	Ls	37.3'	39.4'	551.9	550.1	60	30°
34	C-9	584.2	Ls	39.4'	49.4'	541.4	541.4	93	30°
35	C-9	584.2	Ls	49.4'	59.5'	532.7	532.7	84	30°

RQD AVERAGE: 39.2%

RQD (Rock Quality Designation)	
0% - 25%	Very Poor
25% - 50%	Poor
50% - 75%	Fair
75% - 90%	Good
90% - 100%	Excellent

**Table 2
CORE RECOVERY SUMMARY**

1	C-1	615	Ls	17.2'	21.2'	597.8	593.8	4	3.9	97.5	0
2	C-1	615	Ls	21.2'	28.7'	593.8	586.3	7.5	7.5	100	0
3	C-1	615	Ls	28.7'	39.0'	586.3	576	10.3	10.3	100	0
4	C-1	615	Ls	39.0'	49.2'	576	565.8	10.2	10.2	100	0
5	C-1	615	Ls	49.2'	59.5'	565.8	555.5	10.3	10.3	100	0
6	C-2	612	Ls	18.7'	21.1'	595.8	593.4	2.4	1.2	50	30°
7	C-2	612	Ls	21.1'	24.9'	593.7	590.4	3.8	3.2	84.2	30°
8	C-2	612	Ls	24.9'	27.9'	590.4	587.8	3	2.8	93.3	30°
9	C-2	612	Ls	27.9'	37.9'	587.8	579.2	10	10	100	30°
10	C-2	612	Ls	37.9'	46.6'	579.2	571.6	8.7	8.7	100	30°
11	C-2	612	Ls	46.6'	54.4'	571.6	564.9	7.8	7.6	97.4	30°
12	C-2	612	Ls	54.4'	60.5'	564.9	559.6	6.1	6.1	100	30°
13	C-3	618	Ls	37.5'	46.9'	585.5	577.4	9.4	9.4	100	30°
14	C-5	585	Ls	24.5'	27.8'	563.8	560.9	3.3	3.1	93.9	30°
15	C-5	585	Ls	27.8'	33.3'	560.9	556.2	5.5	5.5	100	30°
16	C-5	585	Ls	33.3'	38.5'	556.2	551.6	5.2	5.2	100	30°
17	C-5	585	Ls	38.5'	48.6'	551.6	542.9	10.1	10.1	100	30°
18	C-5	585	Ls	48.6'	52.8'	542.9	539.3	4.2	4	95.2	30°
19	C-6	561.9	Ls	25.6'	32.9'	557	533.4	7.3	7.3	100	30°
20	C-6	561.9	Ls	32.9'	39.5'	533.4	527.7	6.6	6.3	95.5	30°
21	C-6	561.9	Ls	39.5'	49.1'	527.7	519.4	9.6	9.6	100	30°
22	C-7	582.18	Ls	26.9'	29.6'	558.9	556.5	2.7	2.7	100	30°
23	C-7	582.18	Ls	29.6'	38.9'	556.5	548.5	9.3	8.9	95.7	30°
24	C-7	582.18	Ls	38.9'	49.1'	548.5	539.6	10.2	10.2	100	30°
25	C-8	581.5	Ls	25.4'	28.9'	559.5	556.3	3.5	3.3	94.3	30°
26	C-8	581.5	Ls	28.9'	36.4'	556.3	549.9	7.5	6.9	92	30°
27	C-8	581.5	Ls	36.4'	38.6'	549.9	548.1	2.2	2.1	95.5	30°
28	C-8	581.5	Ls	38.6'	47.1'	548.1	540.7	8.5	8.3	97.6	30°
29	C-8	581.5	Ls	47.1'	52.2'	540.7	536	5.1	4.5	88.2	30°
30	C-9	584.2	Ls	23.7'	27.1'	563.7	560.7	3.4	2.7	79.4	30°
31	C-9	584.2	Ls	27.1'	30.4'	560.7	557.9	3.3	1.1	33.3	30°
32	C-9	584.2	Ls	30.4'	37.3'	557.9	551.9	6.9	6.9	100	30°
33	C-9	584.2	Ls	37.3'	39.4'	551.9	550.1	2.1	2.1	100	30°
34	C-9	584.2	Ls	39.4'	49.4'	541.4	541.4	10	10	100	30°
35	C-9	584.2	Ls	49.4'	59.5'	532.7	532.7	10.1	10.1	100	30°

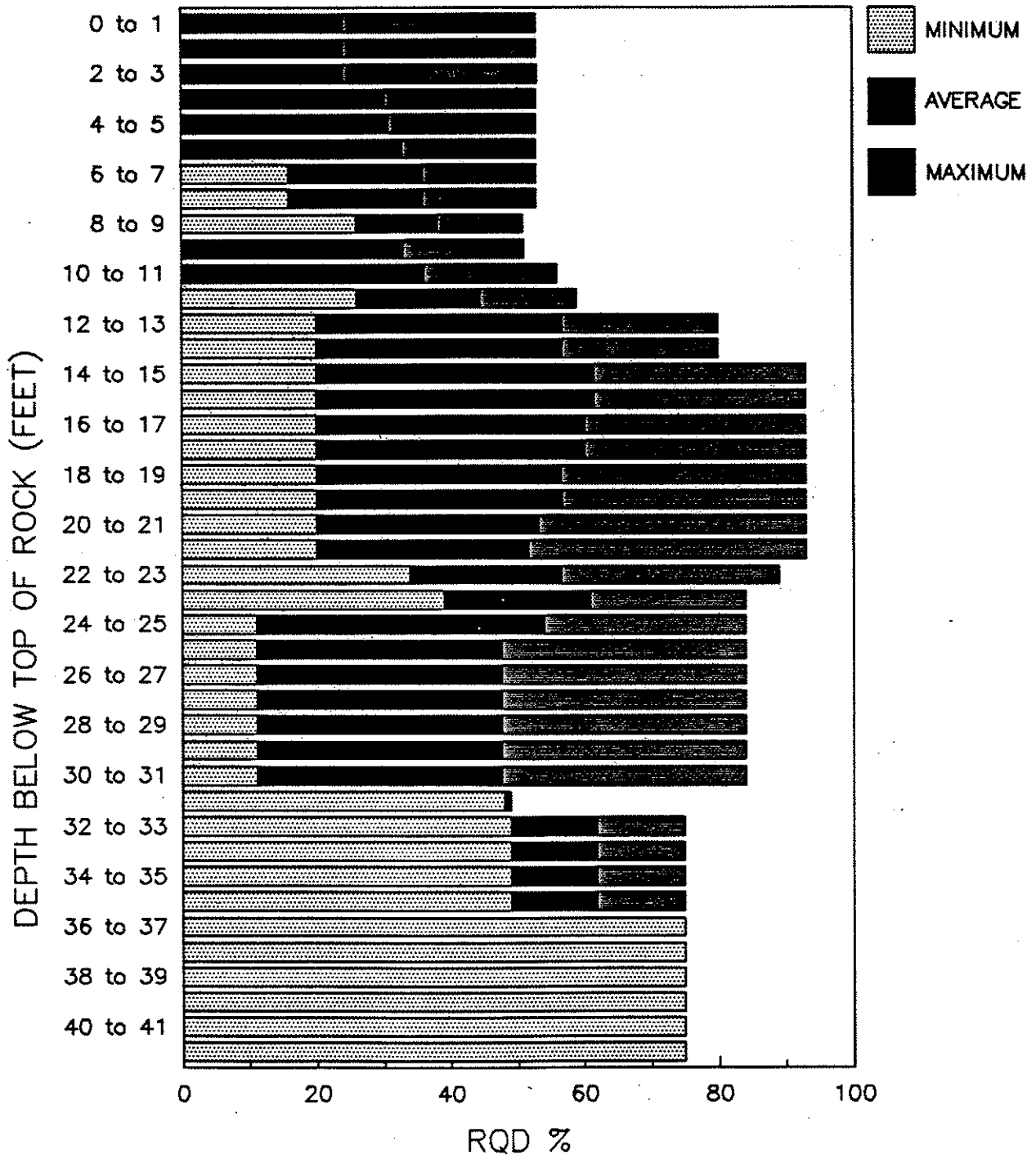
AVERAGE RECOVERY: 96.6%

TABLE 3
**FOUNTAIN CREEK
 PRESSURE TEST DATA WITH HYDRAULIC CONDUCTIVITY COMPUTATION**

HOLE #	HOLE ANGLE	DEPTH TO WATER	PACKER DEPTHS		TEST LENGTH	PRESSURE PSI	TAKE (GAL)	TEST TIME (MIN)	TAKE (OPM)	HYDRAULIC CONDUCTIVITY GAL/DAY/SQ.FT
			TOP	BOTTOM						
C-1	0	1	19	39	20	40	50	10	5.00	2.94
C-1	0	1	39	59.5	20.5	40	33	10	3.30	1.90
C-2	30	2.2	28.2	37.9	9.7	40	32	10	3.20	3.25
C-2	30	2.2	38.1	46.6	8.5	40	37	10	3.70	4.15
C-2	30	2.2	47.8	60.5	12.7	40	43	10	4.30	3.56
C-2	30	2.2	17.4	60.5	43.1	40	43	10	4.30	1.34
C-5	30	11.8	31.1	38.7	7.6	20	1	10	0.10	0.20
C-5	30	11.8	39.8	48.6	8.8	15	535	12	44.58	99.19
C-5	30	11.8	18.8	53	34.2	15	430	10	43.00	33.04
C-6	30	22.5	29.8	39.5	9.7	19	0	10	0.00	0.00
C-6	30	22.5	39.8	49.1	9.3	18	113	10	11.30	17.48
C-6	30	22.5	25.6	49.1	23.5	18	149	10	14.90	11.23
C-7	30	23.3	29.4	38.9	9.5	15	8	10	0.80	1.35
C-7	30	23.3	39.2	49.1	9.9	15	97	10	9.70	15.83
C-7	30	23.3	25.6	49.1	23.5	15	127	10	12.70	10.58
C-8	30	29.2	29.8	36.4	6.6	15	99	10	9.90	19.81
C-8	30	29.2	39.3	47.9	8.6	15	81	10	8.10	13.33
C-8	30	29.2	43.9	52.2	8.3	15	105	10	10.50	17.75
C-8	30	29.2	29	52.2	23.2	15	74	10	7.40	5.65
C-9	30	20	19.5	30.4	10.9	15	90	10	9.00	14.48
C-9	30	20	29.7	39.5	9.8	15	104	10	10.40	18.14
C-9	30	20	39.6	49.4	9.8	15	114	10	11.40	19.88
C-9	30	20	20.3	59.5	39.2	15	81	10	8.10	4.73

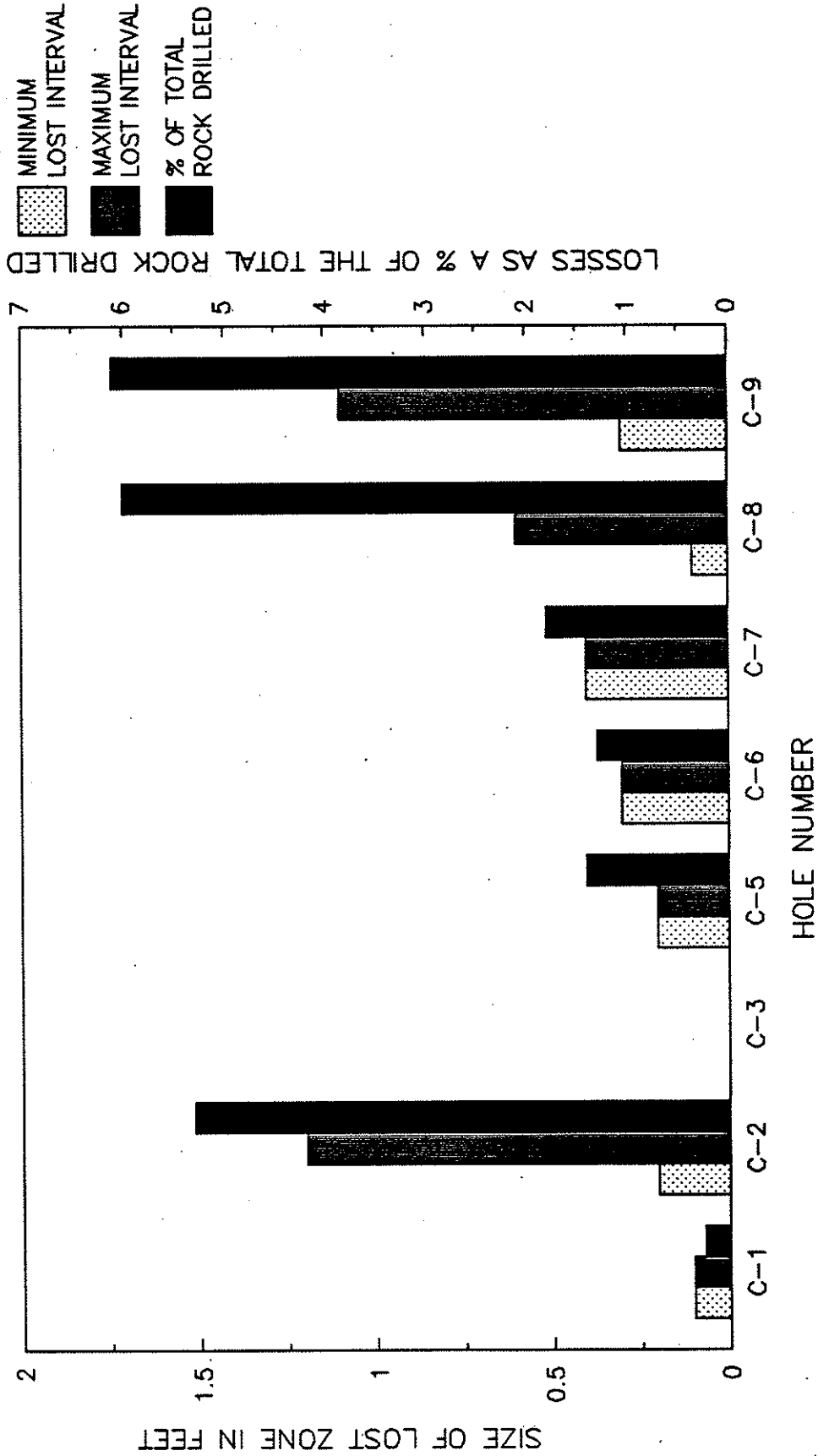
CHART 1

RQD VERSUS DEPTH BELOW TOP OF ROCK



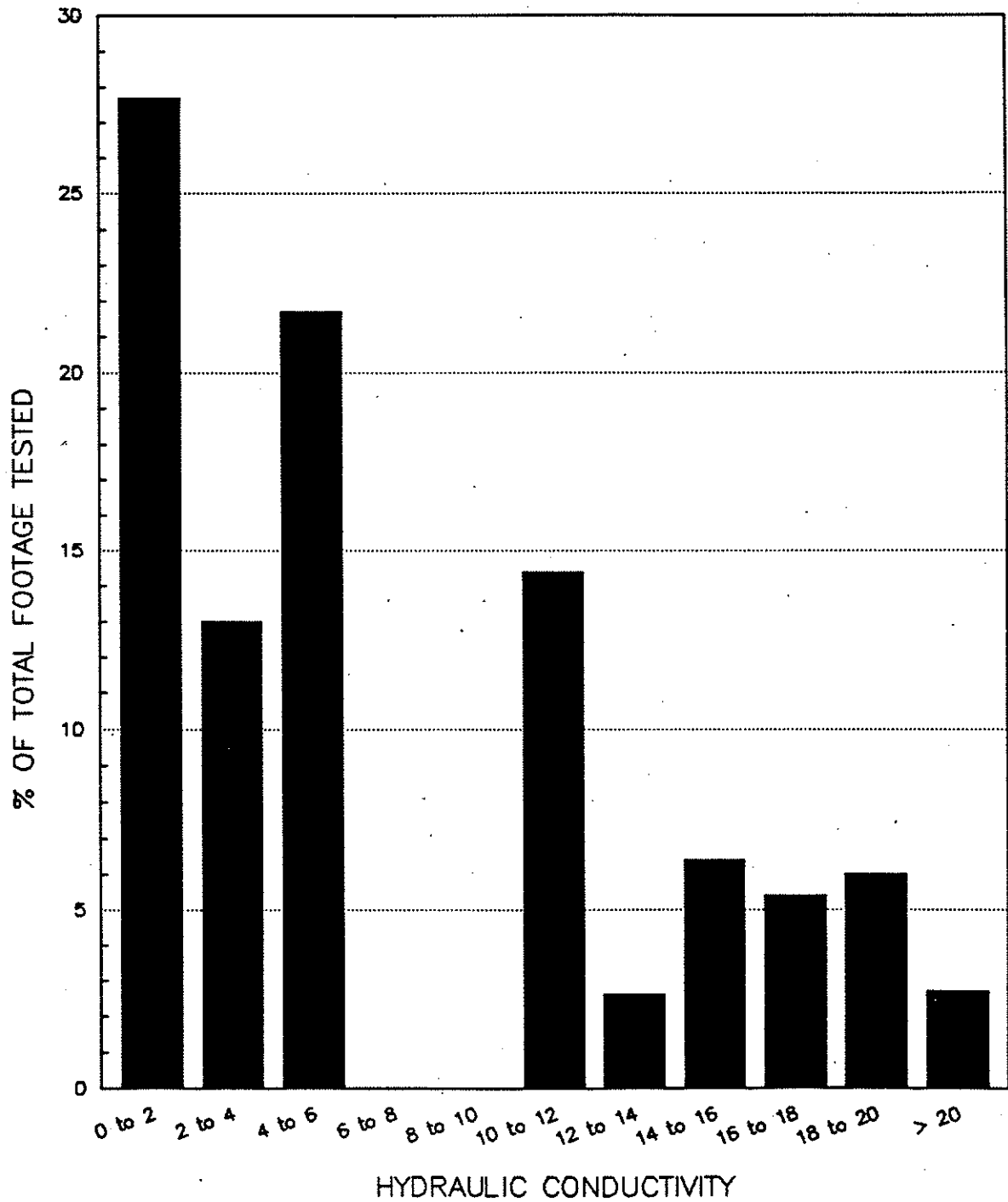
Most of this data is from angle holes. Depth below top of rock is corrected to vertical.

CHART 2
ZONES OF MISSING ROCK



Zones of missing rock may or may not represent cavities but certainly represent areas of weakness.

CHART 3
DISTRIBUTION OF HYDRAULIC CONDUCTIVITY
GALLONS PER DAY PER SQUARE FOOT

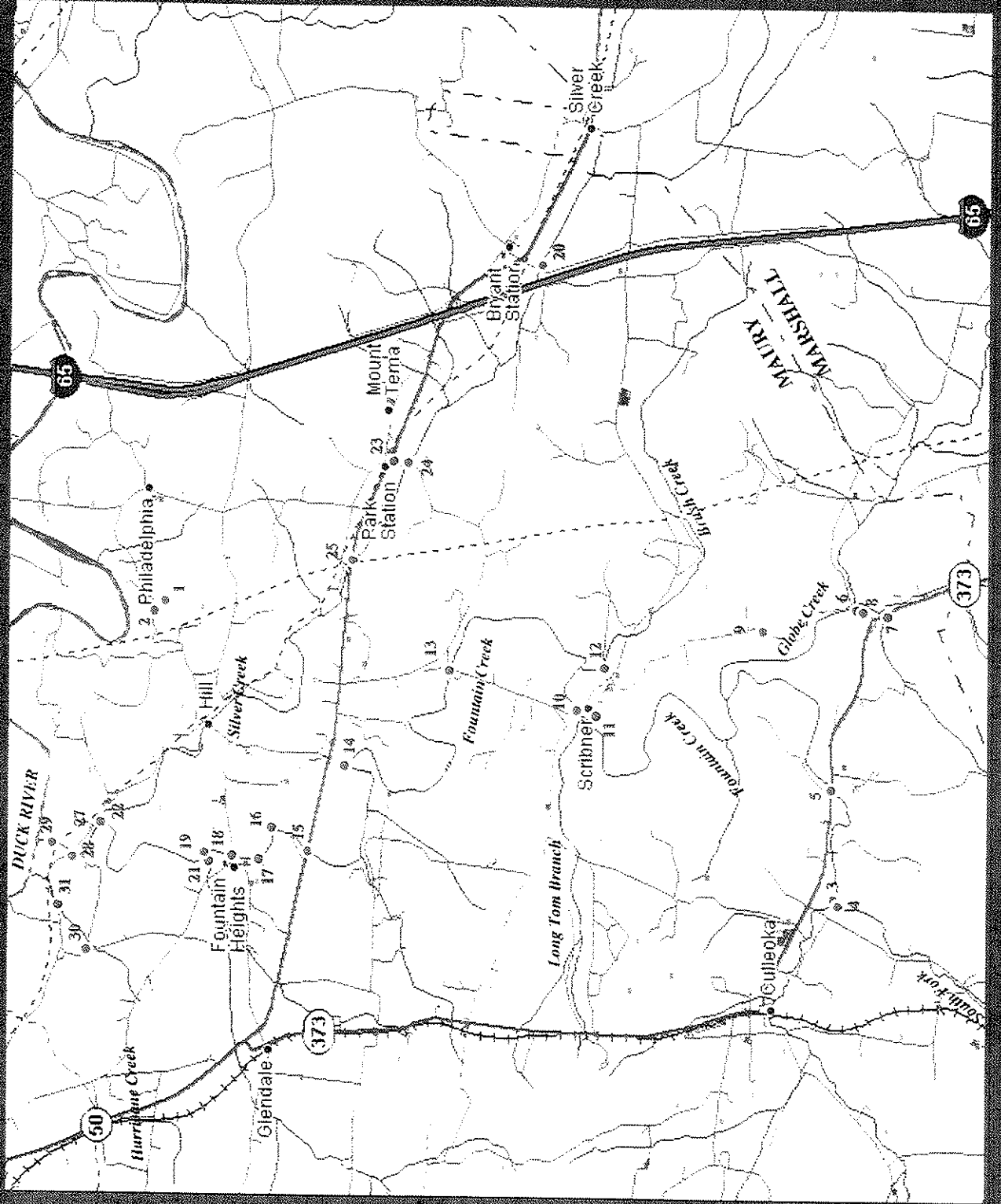


Computed based on packer type pressure test data.

APPENDIX

**USGS WATER BALANCE STUDY
FOUNTAIN CREEK**

USGS WATER BALANCE STUDY FOUNTAIN CREEK BASIN



USGS WATER BALANCE STUDY
 FOUNTAIN CREEK
 08 JULY 1997

<u>Site No.</u>	<u>Station No.</u>	<u>Name</u>	<u>DA</u>	<u>Discharge</u>	<u>Gain/Loss</u>	<u>Temp.</u>	<u>Cond.</u>
1	035994253	Unnamed Spring near Whitworth Bend		.015		15.5	515
2	035994256	Unnamed trib near Whitworth Bend	0.24	.052		18.8	430
3	035994289	Fountain Creek above South Fork near Culleoka	15.99	14.9	START	20.7	365
4	035994297	South Fork near Culleoka, TN	10.17	10.6		21.0	333
5	03599430	Fountain Creek near Culleoka, TN	27.0	25.7	+0.2 cfs	21.0	350
6	03599439	Globe Creek near Mooresville, TN	25.97	17.5		21.0	393
7	03599442	Sheepneck Creek near Mooresville	2.61	1.88		22.0	291
8	03599445	Bear Creek near Mooresville, TN	7.87	5.96		21.0	355
9	03599446	Smith Spring near Mooresville, TN		.303		16	26
10	035994468	Fountain Creek at Long Tom Branch near Scribner, TN	64.51	43.1	-6.36 cfs	20.4	367
11	035994475	Long Tom Branch at mouth near Scribner, TN	2.96	2.12		19.3	407
12	03599449	Bush Creek near Scribner, TN	4.38	1.48		19.5	422
13	03599450	Fountain Creek near Fountain Heights	77.0	56.4	+9.70 cfs	21.2	370
14	035994512	Fountain Creek above Hwy 50 near Fountain Heights	78.74	57.4	+1.0 cfs	21.9	367

USGS WATER BALANCE STUDY
 FOUNTAIN CREEK
 08 JULY 1997

<u>Site No.</u>	<u>Station No.</u>	<u>Name</u>	<u>DA</u>	<u>Discharge</u>	<u>Gain/Loss</u>	<u>Temp.</u>	<u>Cond.</u>
28	035994556	Fountain Creek near mouth near Fountain Heights	105.73		backwater		
29	03599455	Fountain Creek at mouth near Fountain Heights	105.66	72.6	3.60 cfs	20.7	369
30	035994557	Unnamed trib near Harris Cemetary	0.28	no flow			
31	0359945572		0.69	dry			

USGS WATER BALANCE STUDY
 FOUNTAIN CREEK
 08 JULY 1997

<u>Site No.</u>	<u>Station No.</u>	<u>Name</u>	<u>DA</u>	<u>Discharge</u>	<u>Gain/Loss</u>	<u>Temp.</u>	<u>Cond.</u>
15	035994514	Fountain Creek at Hwy 50 near Fountain Heights	81.01	51.6	-5.8 cfs		365
16	035994516	Fountain Creek below Hwy 50 near Fountain Heights	81.15	66.0	+14.4 cfs	22.4	368
17	035994518	Fountain Creek above Fountain Heights at Plesant Mount Church	81.65	61.8	-4.2 cfs	20.5	367
18	03599452	Fountain Creek at Fountain Heights	81.71	70.4	+8.6 cfs	20.9	368
19	035994521	Fountain Creek near Hurricane Creek near Fountain Heights	81.74	63.5	-6.9 cfs	21.7	366
20	0359945260	Silver Creek at Bryant Station	7.59	2.32		20.0	372
21	0359945261	Hurricane Creek near Fountain Heights	7.82	2.83		24.0	444
22	0359945262	Fountain Creek at Silver Creek near Fountain Heights	90.42	66.1	-0.23 cfs	22.0	373
23	0359945263	Silver Creek near Mt. Tema	11.08	3.45		20.9	419
24	0359945265	Unnamed Spring near Mt. Tema		0.068		14.9	533
25	0359945267	Silver Creek near State Hwy 50	11.85	2.79		22.4	428
26	03599453	Silver Creek at Fountain Heights	14.07	3.16		23.1	414
27	035994545	Silver Cr at Mouth nr Fountain Heights	15.04	2.84		27.0	369

EXCERPT FROM WATER RESOURCES DATA FOR TENNESSEE
UNITED STATES DEPARTMENT OF THE INTERIOR U.S.G.S.
PAGE 1 OF 2

144

TENNESSEE RIVER BASIN

3-3994.3. Fountain Creek near Fountain Heights, Tenn.--Continued

DISCHARGE, IN CFS, WATER YEAR OCTOBER 1966 TO SEPTEMBER 1967

DAY	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.
1	6.6	9.9	11	161	89	148	29	289	158	39	.80	29
2	3.4	17	10	128	88	134	28	539	88	29	.80	26
3	2.9	20	9.5	106	77	121	27	231	74	32	.58	24
4	2.9	26	9.0	89	68	108	26	152	64	23	1.56	23
5	3.0	32	9.0	77	63	115	25	111	54	51	.78	21
6	3.0	92	9.0	67	59	2,560	24	92	46	953	.99	19
7	3.2	56	9.5	68	52	1,020	23	507	41	307	.47	17
8	3.3	40	9.5	60	46	505	22	217	36	191	200	20
9	180	40	2,660	53	44	331	21	147	32	109	436	89
10	84	445	950	49	43	247	22	108	29	73	192	49
11	29	175	388	45	41	197	23	108	26	57	128	102
12	17	192	237	43	36	162	20	2,070	24	242	95	51
13	12	126	182	43	34	135	20	8,050	22	279	75	34
14	9.9	91	136	74	32	114	19	1,360	20	162	58	28
15	13	68	105	62	31	100	18	1,580	19	105	48	24
16	18	54	85	56	32	83	18	750	17	75	41	22
17	12	43	70	53	37	76	19	473	16	57	37	20
18	48	37	61	47	41	66	16	324	15	45	35	18
19	32	32	53	47	35	61	14	242	14	37	37	16
20	22	28	47	44	246	60	13	198	13	31	30	15
21	17	25	42	43	204	43	13	178	15	27	35	14
22	14	22	37	41	164	53	15	163	20	188	29	17
23	12	20	104	39	136	49	35	130	17	132	25	14
24	10	19	91	37	110	46	81	108	14	86	23	13
25	9.0	17	75	35	93	42	29	95	29	167	43	12
26	8.0	14	70	112	86	39	232	86	23	151	192	11
27	7.5	16	81	360	112	37	109	75	14	154	115	13
28	7.0	15	832	198	195	34	65	67	12	119	67	31
29	6.6	13	416	183	---	35	49	109	158	223	48	17
30	7.0	12	260	126	---	33	41	203	74	228	39	14
31	7.5	---	196	105	---	30	---	151	---	113	33	---
TOTAL	610.4	1,818.5	7,257.5	2,621	2,294	6,785	1,096	18,813	1,188	4,035	2,597	803
MEAN	19.7	60.6	234	84.5	81.9	219	36.5	610	39.6	130	83.8	26.8
MAX	180	445	2,660	360	246	2,560	232	8,050	158	953	436	102
MIN	2.9	9.5	9.0	35	31	30	13	67	12	23	23	11
CFSM	-27	.82	3.16	1.14	1.13	2.96	.49	8.24	.54	1.78	1.13	.36
IN.	.31	.91	3.63	1.32	1.15	3.41	.55	9.51	.60	2.03	1.31	.40
CAL YR 1966: TOTAL												
WAT YR 1967: TOTAL 50,018.4												
				MEAN	MAX	MIN			CFSM	IN		
				MEAN 137	MAX 8,050	MIN 2.9			CFSM 1.45	IN 25.14		

Peak discharge (base, 1,500 cfs)

Date	Time	Gage height	Discharge	Date	Time	Gage height	Discharge
12-9	1300	15.68	5,530	5-13	1245	26.54	20,000
3-6	1815	14.40	4,620	5-15	1330	10.82	2,730

EXCERPT FROM WATER RESOURCES DATA FOR TENNESSEE
UNITED STATES DEPARTMENT OF THE INTERIOR U.S.G.S.
PAGE 2 OF 2

TENNESSEE RIVER BASIN

143

3-5994.5. Fountain Creek near Fountain Heights, Tenn.

Location.--Lat 35°31'05", long 86°54'31", on downstream side of second pier from left abutment of Rowden Bridge, 2.3 miles southeast of Fountain Heights, 3.1 miles southeast of Glendale, and 3.3 miles northeast of Collinsville, Henry County.

Basin area.--74.0 sq mi.

Records available.--March 1966 to September 1967.

Gage.--Digital water-stage recorder. Altitude of gage (= 600 ft (from topographic map). Prior to July 13, 1966, graphic water-stage recorder at same site and datum.

Extremes.--1966: Maximum discharge during period March to September, 2,700 cfs May 22 (gage height, 10.75 ft); minimum, 2.4 cfs July 28. 2nd (gage height, 0.95 ft).
 1966-67: Maximum discharge during water year, 20,000 cfs May 13 (gage height, 24.54 ft), from rating curve extended above 4,450 cfs on basis of contracted-opening determination of peak flow; minimum, 2.7 cfs Oct. 3 (gage height, 1.12 ft).

Remarks.--Records fair.

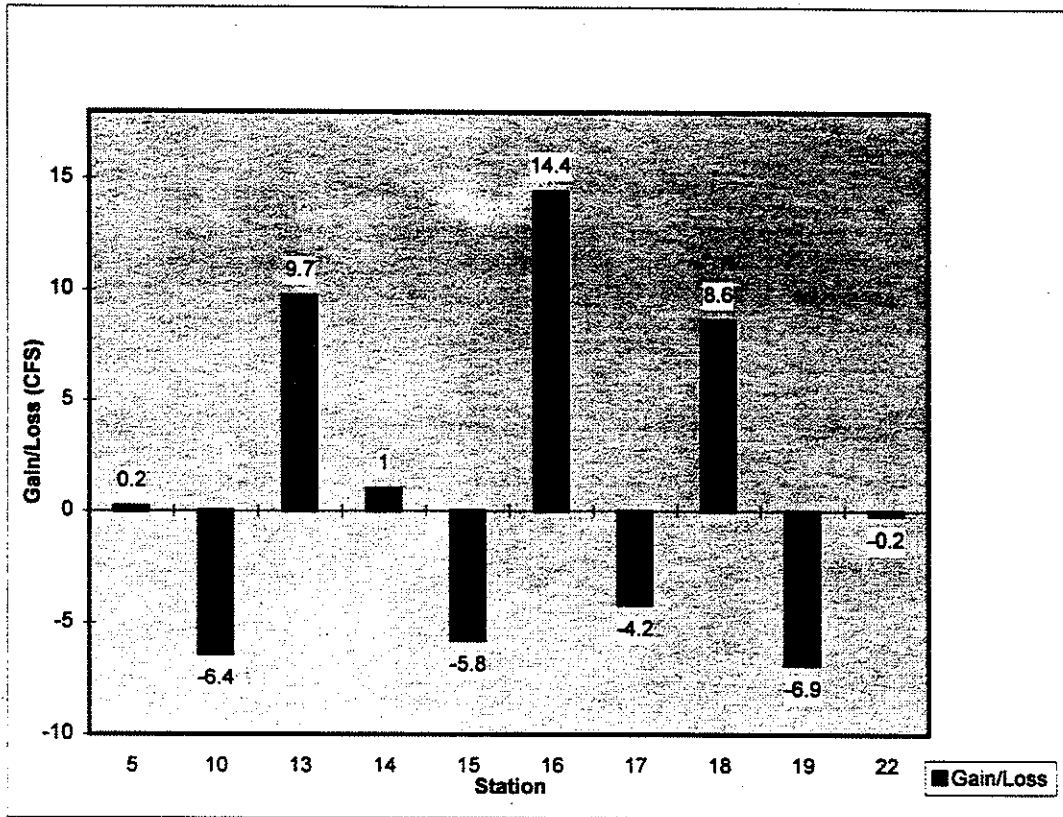
Discharge, in cubic feet per second, March to September 1966

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1							20	752	40	5.7	32	6.0
2							19	527	37	21	2.9	4.6
3							18	304	34	48	3.1	3.8
4							19	187	31	13	3.0	3.4
5							16	132	29	7.5	2.9	3.8
6							16	97	28	5.6	1.7	3.5
7							16	76	29	8.0	2.0	3.3
8							16	60	25	13	4.9	3.3
9							16	50	23	6.0	3.3	3.3
10							14	40	21	4.2	3.0	3.5
11							14	34	20	3.3	3.6	3.8
12							15	31	19	3.4	2.6	4.2
13							15	34	18	3.2	2.3	4.9
14							14	32	42	3.0	13.1	4.2
15							14	26	15	2.9	6.8	4.5
16								132	68	2.8	4.4	4.6
17						38	14	55	41	2.9	2.3	3.8
18						36	13	203	17	2.9	2.6	3.8
19						35	13	115	12	3.0	8.5	4.4
20						32	13	85	9.0	3.2	9.8	1.4
21						31	31	68	7.5	3.0	3.0	4.6
22						29	19	633	6.3	2.8	2.2	3.3
23						29	22	183	5.6	2.8	1.7	2.9
24						28	18	126	4.9	2.6	3.8	2.7
25						26	25	93	4.2	2.6	9.0	2.6
26						25	23	74	3.5	2.6	6.6	2.9
27						24	39	65	3.4	2.5	6.0	2.9
28						23	41	60	3.3	2.4	4.9	2.9
29						22	113	53	3.3	1.7	4.6	3.0
30						22	130	48	3.8	2.0	2.4	3.4
31						20		43		6.3	9.5	
TOTAL							774	4,418	603.8	227.2	769.9	161.9
MEAN							25.8	143	20.1	7.33	24.8	5.48
MAX							130	732	68	48	131	44
MIN							13	26	3.3	2.4	2.9	2.4
CFPM							.35	1.43	.27	.10	.34	.87
IN.							.39	2.22	.30	.11	.39	.88

CAL YR 1965: TOTAL - MEAN - MAX - MIN - CFPM - IN -
 MAY YR 1966: TOTAL - MEAN - MAX - MIN - CFPM - IN -

Peak discharge (base, 2,500 cfs)--May 22 (0230) 2,700 cfs (10.75 ft).

**USGS WATER BALANCE STUDY - FOUNTAIN CREEK
LOSS/GAIN SUMMARY**



Total Gain	33.9 CFS
-Total Loss	23.5 CFS
Balance	+10.4 CFS