GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

9-16

Date: July 6, 1976

Project Title: Optimum Water Management in Kaolin Mining of Aluminum Production

Project No: E-19-692, E-20-694, E-20-695, B-471

Project Director: Dr. J. E. Husted

Sponsor: Office of Water Research and Technology/U.S. Dept. of Interior

Agreement Period: From 6/1/76 Until 11/30/77

Type Agreement: Grant No. 14-34-0001-6229

Amount:		
$108,931 - OWRT	E-19-692/$38,567	E-19-370/$854
2,179 - GIT	E-20-694/$12,735	E-20-370/$393
	E-20-695/$35,615	E-20-371/$393
	B-471/$22,014	E-__-___/$539

Reports Required: Quarterly Progress Reports; Annual Summary Report; Final Technical Completion Report; Publications Reprints

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Mr. William S. Butcher
Director
U. S. Department of the Interior
Office of Water Research and Technology
Washington, D. C. 20240

Defense Priority Rating:

Assigned to: Chemical Engineering (School/Laboratory)

COPIES TO:

- Project Director
- Division Chief (EES)
- School/Laboratory Director
- Dean/Director—EES
- Accounting Office
- Procurement Office
- Security Coordinator (OCA) /
- Reports Coordinator (OCA) ✓
- Library, Technical Reports Section
- Office of Computing Services
- Director, Physical Plant
- EES Information Office
- Project File (OCA)
- Project Code (GTRI)
- Other ___

CA—3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: 1/23/79

Project Title: Optimum Water Management in Kaolin Mining of Aluminum Production

Project No: E-19-692 (sub-projects are E-20-694/Pohland/CE, E-20-695/Wallace/CE and B-471/Dodson/EES)

Project Director: Dr. J. E. Husted

Sponsor: Office of Water Research and Technology/U. S. Dept. of Interior

Effective Termination Date: 1/15/79

Clearance of Accounting Charges: 1/31/79

Grant/Contract Closeout Actions Remaining:

- X Final Invoice ~~and Closing Documents~~
- X Final Fiscal Report
- _ Final Report of Inventions
- _ Govt. Property Inventory & Related Certificate
- _ Classified Material Certificate
- _ Other ______________________

Assigned to: Chemical Engineering (School/Laboratory)

COPIES TO:

Project Directors
Division Chief (EES)
School/Laboratory Director
Dean/Director—EES
Accounting Office
Procurement Office
Security Coordinator (OCA)
Reports Coordinator (OCA)
Library, Technical Reports Section
Office of Computing Services
Director, Physical Plant
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other ______________________

CA—4 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

no action acts OK

Date: July 6, 1976

Project Title: Optimum Water Management in Kaolin Mining of Aluminum Production

Project No: E-20-694

Project Director: Dr. F. G. Pohland

Sponsor: Office of Water Research and Technology/U.S. Dept. of Interior

Agreement Period: From 6/1/76 Until 11/30/77

Type Agreement: Grant No. 14-34-0001-6229

Amount: $108,931 - OWRT	E-19-692/$38,567	E-19-370/$854
2,179 - GIT	E-20-694/$12,735	E-20-370/$393
	E-20-695/$35,615	E-20-371/$393
	B-471/$22,014	E-__-___/$539

Reports Required: Quarterly Progress Reports; Annual Summary Report; Final Technical Completion Report; Publications Reprints

Sponsor Contact Person (s):

Technical Matters

Contractual Matters (thru OCA)

Mr. William S. Butcher
Director
U. S. Department of the Interior
Office of Water Research and Technology
Washington, D. C. 20240

Defense Priority Rating:

Assigned to: Civil Engineering (School/Laboratory)

COPIES TO:

- Project Director
- Division Chief (EES)
- School/Laboratory Director
- Dean/Director—EES
- Accounting Office
- Procurement Office
- Security Coordinator (OCA) ✓
- Reports Coordinator (OCA)
- Library, Technical Reports Section
- Office of Computing Services
- Director, Physical Plant
- EES Information Office
- Project File (OCA)
- Project Code (GTRI)
- Other ____________________

no action

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

Date: 12/12/78

Project Title: *Anaerobic-Activated Carbon Filters for the Removal of Refractory and Toxic Organic Compounds in Wastewater*

Project No: E-20-695

Project Director: Makram T. Suidan

Sponsor: U. S. Department of the Interior
Office of Water Research & Technology

Agreement Period: From 10/1/78 Until 9/30/79

Type Agreement: Annual Allotment Agreement No. 14-34-0001-9011; A-077-GA

Amount:

$ 10,470	OWRT
5,700	GIT Cost-Sharing
$ 16,170	Total

Reports Required: Annual Report; Conference Reports; Final Report

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Gary D. Cobb
Director
Office of Water Research and Technology
U. S. Department of the Interior
Washington, D. C. 20240

Defense Priority Rating: None

Assigned to: CE (School/Laboratory)

COPIES TO:

- Project Director
- Division Chief (EES)
- School/Laboratory Director
- Dean/Director—EES
- Accounting Office
- Procurement Office
- Security Coordinator (OCA)
- Reports Coordinator (OCA)
- Library, Technical Reports Section
- EES Information Office
- EES Reports & Procedures
- Project File (OCA)
- Project Code (GTRI)
- Other

CA–3 (3/76)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

no action ACCS OAH

Date: July 6, 1976

Project Title: Optimum Water Management in Kaolin Mining of Aluminum Production

Project No: B-471

Project Director: Mr. George Dodson

Sponsor: Office of Water Research and Technology/U.S. Dept. of Interior

Agreement Period: From 6/1/76 Until 11/30/77

Type Agreement: Grant No. 14-34-0001-6229

Amount:		
$108,931 - OWRT	E-19-692/$38,567	E-19-370/$854
2,179 - GIT	E-20-694/$12,735	E-20-370/$393
	E-20-695/$35,615	E-20-371/$393
	B-471/$22,014	E-__-___/$539

Reports Required: Quarterly Progress Reports; Annual Summary Report; Final Technical Completion Report; Publications Reprints

Sponsor Contact Person (s):

Technical Matters

Contractual Matters (thru OCA)

Mr. William S. Butcher
Director
U. S. Department of the Interior
Office of Water Research and Technology
Washington, D. C. 20240

Defense Priority Rating:

Assigned to: Economic Development Laboratory (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
School/Laboratory Director
Dean/Director—EES
Accounting Office
Procurement Office
Security Coordinator (OCA) ✓
Reports Coordinator (OCA)

Library, Technical Reports Section
Office of Computing Services
Director, Physical Plant
EES Information Office
Project File (OCA)
Project Code (GTRI)
Other ______

CA-3 (3/76)

B-471

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

June 17, 1977

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Technical Report Number 4
Period: March 1, 1977 through May 31, 1977

Gentlemen:

Ground water conditions in Glascock, Jefferson, McDuffie, and Warren Counties have been analyzed. Piezometric contours have been developed for Tuscaloosa, Barnwell, and Irwinton sand aquifers. Current and projected water use have been determined. A tentative location of a test well has been located and preliminary arrangements have been made with the Georgia District, U.S. Geological Survey, to log test holes and date (geologically) core samples.

As a part of the test well study, permission has been obtained from Jefferson County Board of Roads and Revenues to run a seismic profile along a secondary county road. Running of the profile has been delayed due to malfunction of the equipment. The seismic equipment is on loan from the School of Geophysical Sciences. If the equipment can be brought into operating condition, an attempt will be made to correlate the profile with the test well data.

A preliminary population impact projection also has been completed.

On May 12, 1977, Dr. Husted presented a summary of work to date on the project to the Georgia Water Resources Research Colloquium.

Work is continuing with primary aluminum companies to obtain data concerning technology related to the project.

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

B-471

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

June 17, 1977

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Financial Letter Number 4
Period: March 1, 1977 through May 31, 1977

Gentlemen:

The following financial report is given of expenditures for the fourth quarter with the cumulative total of the first four quarters. Attached is a graph of budgeted expenses and expenses to date. Items, Materials and Supplies and Travel are sufficiently close to constitute one line.

Item	Fourth Quarter	Cumulative Total
Personal Services	$4,331.57	$23,122.51
Retirement (*9.1%)	278.66	1,745.66
Materials and Supplies	209.01	613.88
Travel	190.08	880.88
Overhead (**68%)	2,945.46	15,832.25
Totals	$7,954.78	$42,195.18

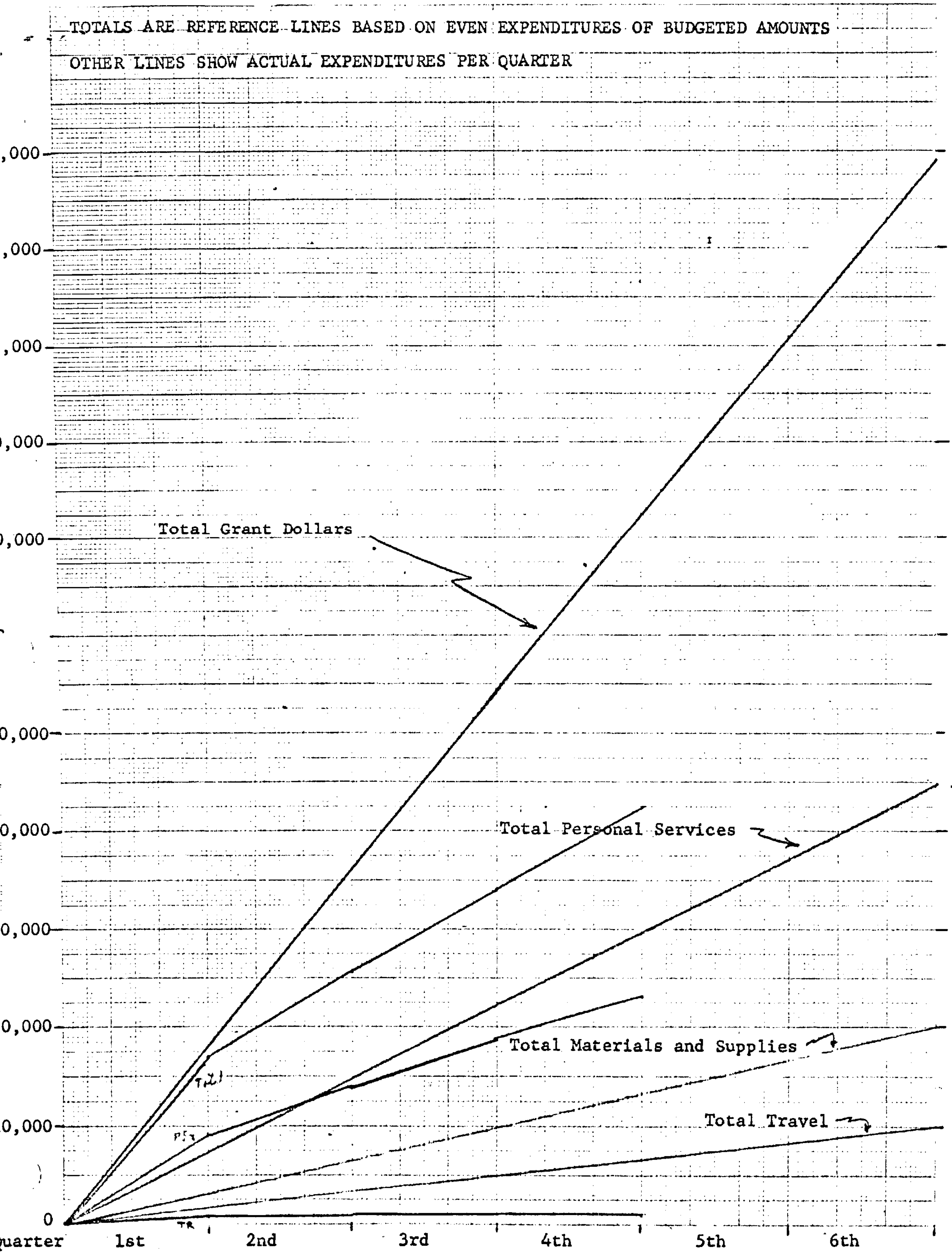
* Based on Personal Services of Salaried Personnel
** Based on total Personal Services

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

Attachment



OWRT/U.S. Dept. Interior Grant No. 14-34-001-6229; Ga. Tech Nos. E-19-692 E-20-694

E-19-692

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF CHEMICAL ENGINEERING

October 20, 1976

Mr. William S. Butcher
Director
U. S. Department of the Interior
Office of Water Research and Technology
Washington, D. C. 20240

Reference: OWRT/U. S. Dept. of the Interior Grant No. 14-34-001-6229
Quarterly Technical Report No. 1
Period June 1, 1976 - August 31, 1976

Gentlemen:

The research program has been organized as four tasks. These are: Hydrology of the subject area, Dr. Jim Wallace; impact imposed upon sewage and effluent disposal systems resulting from plant operation, Dr. Pohland; impact of such new plants in relationship to planning for communities and their water and sewage systems, George Dodson; chemical systems of removing alumina from kaolin and their relationship and impact on groundwater and surface water, as well as coordination of the entire project, Dr. John E. Husted.

Major impact areas selected were on the basis of potential plant locations as gathered from industry and a knowledge of the available reserves. These were the Wrens, Georgia area, Sandersville, Georgia area, McIntyre, Georgia area, Jeffersonville, Georgia area, and the Andersonville, Georgia area.

Counties included in these areas are: 1. Wrens area: Jefferson, Glascock, and Warren Counties, 2. Sandersville: Washington County, 3. McIntyre: Wilkinson County, 4. Jeffersonville: Twiggs County, and 5. Andersonville: Macon, Schley, and Sumter Counties.

During the past quarter letters have been sent to the U. S. Geological Survey, each of the kaolin mining companies, each of the Planning and Development Commissions, and the State Geological Survey. The letters explained the program and requested that a contact person be designated for information gathering. Each of the above responded in the affirmative. Potential alumina companies were also informed of the program.

Early in the quarter a meeting was held in Sandersville by the entire research team with all of the above organizations invited to send participants. The purpose of the meeting was to explain the program in more detail and invite questions. The meeting was relatively well attended and was successful.

In addition the following has been accomplished and is being planned by Drs. Wallace and Pohland.

Water Supply

1) The map showing the public water supplies in Georgia as of January 1972 has been partially updated.
2) The readily available information regarding the supplies in the study area has been tabulated.

3) A further updating of this information is being made using the data files of the Water Supply Branch of EPD. Present area of concentration is in Washington, Wilkinson and Twiggs counties.
4) Information regarding the availability of water (i.e. piezometric surface, aquifer characteristics) is being gathered from personal contacts with USGS, DNR, and the individual kaolin companies. Present area of concentration is in Washington, Wilkinson, and Twiggs counties.

Wastewater Treatment
1) A map showing the location and type of treatment for municipal and industrial wastewater treatment facilities across the study area has been constructed.
2) Tabulation of pertinent information regarding these facilities is being completed.

Tasks: (concentrating on initial 3-county area) of Washington, Wilkerson, and Twiggs Counties.
1) Establish availability of groundwater
   a) Piezometric surface
   b) Regional transmissivity
2) Establish areas of possible dewatering problems
   a) Piezometric surface
   b) Ground surface elevations
   c) Mining elevations
3) Project municipal water demands
4) Complete water supply facility inventory
5) Complete wastewater treatment facility inventory

George Dodson's work is to a large degree dependent on information gathered by Drs. Husted, Pohland, and Wallace and hence will be phased in more completely as the project progresses. His work during the subject quarter was as follows: During the first quarter guidelines were developed concerning the tasks to be preformed, data needed, processing plant location criteria, and the possible impact on communities which might result from processing and satellite plant development. A literature review and coordinated data collection efforts with others involved in the study was also made.

Dr. Husted has been obtaining information concerning maximum water useage in terms of "new" water required for each of the various chemical systems that may be employed in an alumina from kaolin facility. He is also obtaining from potential manufacturers of alumina preliminary estimate of their projected man power requirements. During the coming quarters work will be directed toward water disposal and the chemical makeup of effluents from the various processes.

Among the data obtained has been an indication of abnormalities of water supply with potential shortages in the Wrens area. Preliminary investigations have been made concerning the possibility of geologic structural control of the anomalous hydrology of the area. This will be further investigated.

During the subject period the Principal Investigator was moved from the Engineering Experiment Station building to the School of Chemical Engineering building. The tardiness of this report in large part resulted from problems, including the timing, of the move. Dr. Husted's telephone number is (404) 894-2893.

Sincerely yours,

John E. Husted, Principal Investigator

JEH:ghm

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

December 16, 1976

Mr. William S. Butcher
Director
Office of Water Research and Technology
U. S. Department of the Interior
Washington, D. C. 20240

Reference: QWRT/U. S. Department of the Interior Grant. No. 14-34-001-6229
Quarterly Technical Report No. 2
Period September 1, 1976 - November 30, 1976

Gentlemen:

A detailed analysis of water usage and ground water hydrology of a three-county area has been completed. The area includes Twiggs, Washington and Wilkinson counties and was selected for the initial study because their appears to be a high potential for development of the alumina industry in this area. Concentration of the quarter's work was on a three-county area rather than the entire kaolin belt to allow development of data collection procedures which will subsequently be employed on other areas in the belt.

Information on present water usage in the study area was obtained from the files of the State of Georgia's Department of Natural Resources. All significant water supplies in the area are obtained from ground water. Information obtained from permit applications for the development of ground water supplies (from EPD offices) includes location, depth, yield, specific capacity, water surface elevation, and date drilled for each well. This applies to all wells pumping more than 100,000 gallons per day. For each water system serving more than 100 persons, information on source of water and age of water system, type and size of storage facilities, and the type of treatment facilities employed to purify the water was obtained.

Another source of data was the present kaolin industry. Visits were made to major kaolin companies which operate in this area. Information was obtained from these companies on their water uses and the problems which they are encountering and which they anticipate. These companies also provided copies of reports which their consultants had developed on the ground water hydrology of the area.

The information on the current water usage in the area was used to develop a water demand for each county. The history of population growth was studied and projections of the future population through the year 2000 were made based on information supplied by local goverments and planning agencies. This information provided for a projection of the future water needs in each county.

Other work has included the obtaining and review of economic data concerning selected communities in the study area. A review has also been made of areas and companies to be interviewed in the field along with state officials and agencies to be contacted concerning selected urban impact data.

Work has continued on reviewing technology of various methods of alumina from kaolin processing as it will relate to optimum water management.

Sincerely yours,

John E. Husted,
Principal Investigator

JEH:ghm

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

March 17, 1977

Director
Office of Water Research and Technology
U. S. Deaprtment of the Interior
Washington, D. C. 20240

Reference: OWRT/U.S. Deaprtment of tne Interior Grant No. 14-34-001-6229
Quarterly Technical Report No. 3
Period December 1, 1976 - February 28, 1977

Gentlemen:

Work, as reported for Twiggs, Washington, and Wilkerson County in Report No. 2, has been extended to Glascock, Warren, McDuffie, and Jefferson Counties.

Preliminary raw data have been collected on specifics of water quality, existing water treatment required, and the nature of existing treatment of the water in the subject counties. In addition, data are being gathered concerning quantity of water and transmissibility. The progress of data gathering appears to be on schedule.

Mr. George Dodson of the study team attended the Georgia Water Quality Control Program seminar in Atlanta on February 16, and a monthly Environmental Resources Center Seminar on State-Wide Allocation of Water Resources on February 17, 1977 at Georgia Tech.

Dr. Husted was requested by the U. S. Fish and Wildlife Service to attend a meeting in Nashville, Tenn. to participate in a meeting concerning natural resources. The primary purpose of Dr. Husted's attendance was to explain the objectives of the work being performed for OWRT as well as to give some input regarding environmental considerations of an alumina from kaolin industry.

In January Dr. Husted visited the U. S. Bureau of Mines mini-pilot plant in Boulder City, Nevada, and U. S. Bureau of Mine personnel in Reno, Nevada regarding alumina from kaolin technology. In addition Dr. Husted also visited Kaiser Aluminum and Chemical Corporation in Oakland, California to discuss alumina from kaolin technology work done prior to their U. S. Bureau of Mines contract. A visit was also made to Alumax in San Mateo, California regarding technology of alumina from kaolin.

Other investigations were made with various primary aluminum companies concerning technology and economics of alumina from kaolin.

Sincerely yours,

John E. Husted
Principal Investigator

JEH:ghm

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

June 17, 1977

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Technical Report Number 4
Period: March 1, 1977 through May 31, 1977

Gentlemen:

Ground water conditions in Glascock, Jefferson, McDuffie, and Warren Counties have been analyzed. Piezometric contours have been developed for Tuscaloosa, Barnwell, and Irwinton sand aquifers. Current and projected water use have been determined. A tentative location of a test well has been located and preliminary arrangements have been made with the Georgia District, U.S. Geological Survey, to log test holes and date (geologically) core samples.

As a part of the test well study, permission has been obtained from Jefferson County Board of Roads and Revenues to run a seismic profile along a secondary county road. Running of the profile has been delayed due to malfunction of the equipment. The seismic equipment is on loan from the School of Geophysical Sciences. If the equipment can be brought into operating condition, an attempt will be made to correlate the profile with the test well data.

A preliminary population impact projection also has been completed.

On May 12, 1977, Dr. Husted presented a summary of work to date on the project to the Georgia Water Resources Research Colloquium.

Work is continuing with primary aluminum companies to obtain data concerning technology related to the project.

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

September 15, 1977

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Technical Report Number 5
Period: June 1, 1977 through August 31, 1977

Gentlemen:

In June as part of a Master's degree program in Civil Engineering, a Special Research Problem report was presented to the faculty of Civil Engineering and was approved. This will be included in the final report. The report, "Optimum Water Management in Kaolin Mining for Alumina Production--Preliminary Report Twiggs, Washington, and Wilkinson Counties, Georgia," by Raymond J. Lawing, contained 85 pages on the hydrology of the subject counties as well as some impact analysis.

The seismic profile work has been canceled due to equipment difficulties. A well site is planned in Jefferson County to check work done to date in that area.

Dr. Pohland was on academic leave in Holland, Dr. Husted was on annual leave during July and August, and Dr. Wallace was on summer quarter leave during the subject period. Work during the subject period was by Mr. Dodson and co-workers in city planning on impact, and a graduate student in Civil Engineering.

A request for a no-cost extension will be made as soon as a more firm time schedule can be set for the test well. The well drilling will be on state bid and hence a longer time will be needed.

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

January 4, 1978

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Technical Report Number 6
Period: September 1, 1977 through November 30, 1977

Gentlemen:

Early in September as part of a Master's degree program in Civil Engineering, a Special Research Problem report was presented to the faculty of the School of Civil Engineering and was approved. This will be included in the final report. The report, "Optimum Water Management in Kaolin Mining for Alumina Production for Glascock, Jefferson, McDuffie, and Warren Counties, Georgia," by Jeffrey R. Hutchins, contained 91 pages on the hydrology of the subject counties as well as some import analysis. This essentially completed Dr. Wallace's part of the project.

Dr. Pohland's efforts, since his return from the Netherlands in September, have been directed toward assessing the reports prepared in his absence on the water reports of the target area and filling in gaps specifically related to location maps and supporting information on municipal and industrial waste water treatment facilities and available water quality. Since a format has been established, this information is being assembled and will be integrated in such a way that both water supply and waste water treatment will be treated in the final report. Dr. Pohland anticipates completion well within the required dates provided by the extension.

Work by the Area Planning team is essentially complete. All potential sites have been visited, as well as local and county officials, and Area Planning and Development Councils. Interviews with the above have been directed toward experience with water availability, i.e., is there too little or too much? Another area of investigation was labor availability and new labor demand on existing water supplies.

Close liaison has been maintained with private water wells drilled in the Jefferson-Glascock Counties area. The Thiele Kaolin Company has drilled six test holes to assist in locating a test well site in the Jefferson-Glascock area. Samples from these holes were made available to the project and evaluation and selection of a site area is essentially complete. A six-month, no-cost extension has been granted in order to complete the water test well portion of the contract.

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

April 7, 1978

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant Number 14-34-0001-6229
Quarterly Technical Report Number 7
Period: December 1, 1977, through February 28, 1978
(includes information to date above)

Gentlemen:

A major portion of the effort during the subject period was utilized trying to get a contract for the test water well, Specifications were obtained from the U.S. Geological Survey and the State of Georgia and processed through the State Purchasing Department.

No bids were received in the first request. The time for this reception was the end of February.

Telephone calls to two of the four companies on the list revealed that they had not received bid requests from the State.

The request for bids was sent out again. Only one bid was received. This was over $35,000 and well outside of our budgeted amount of $14,000. The bid was rejected April 3.

On April 4, 1978, the Principal Investigator visited with one of the well-drilling companies to determine how the specifications could be changed to get an acceptable test well for the purposes of the contract and to lower the cost to a minimum. A minimum of approximately $18,000 was estimated to be the current cost to obtain a test well as needed.

We are now faced with two problems:

1. We cannot get bids out and back and a well drilled and reported on by May 31, 1978.
2. We will need to transfer $3,000 in Travel funds to Materials and Supplies. This would give us approximately $21,000 which should leave enough for report printing after paying for the well, without changing the total contract amount.

We therefore request:

1. A no-cost extension of contract to the end of August, 1978.
2. Permission to transfer Travel funds to Materials and Supplies in the amount of approximately $3,000.

Sincerely yours,

John E. Husted
Principal Investigator

JEH:cah

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

June 21, 1978

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant Number 14-34-0001-6229
Quarterly Technical Report Number 8
Period: March 1, 1978 through May 31, 1978

Gentlemen:

The effort during this period was primarily in two areas. The first activity was to discuss terms of specifications for the test water well with drilling companies, rewrite specifications and submit same to the State Purchasing Office. We understand a bid has been submitted that is within our budgeted cost, but we have not received official notification as yet.

The second effort was work on the report by the Engineering Experiment Station and Civil Engineering members of the project team.

Sincerely yours,

John E. Husted
Principal Investigator

JEH:chr

E-19-692

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

November 4, 1976

Mr. William S. Butcher
Director
Office of Water Research and Technology
U. S. Department of the Interior
Washington, D. C. 20240

Reference: OWRT/U. S. Dept. of the Interior Grant No. 14-34-001-6229
Quarterly Financial Letter Number 1
Period June 1, 1976 - August 31, 1976

Gentlemen:

Expenditures during the first quarter, which is in this instance also the cummulative total, are as follows.

Item	First Quarter	Cummulative Total
Personal Services	$ 9,098.22	$ 9,098.22
Retirement (9.1%*)	736.94	736.94
Materials and Supplies	163.37	163.37
Travel	572.60	572.60
Overhead (68%**)	6,186.79	6,186.79
Totals	$16,757.92	$16,757.92

*Based on personal services of salaried personnel
**Based on total personal services.

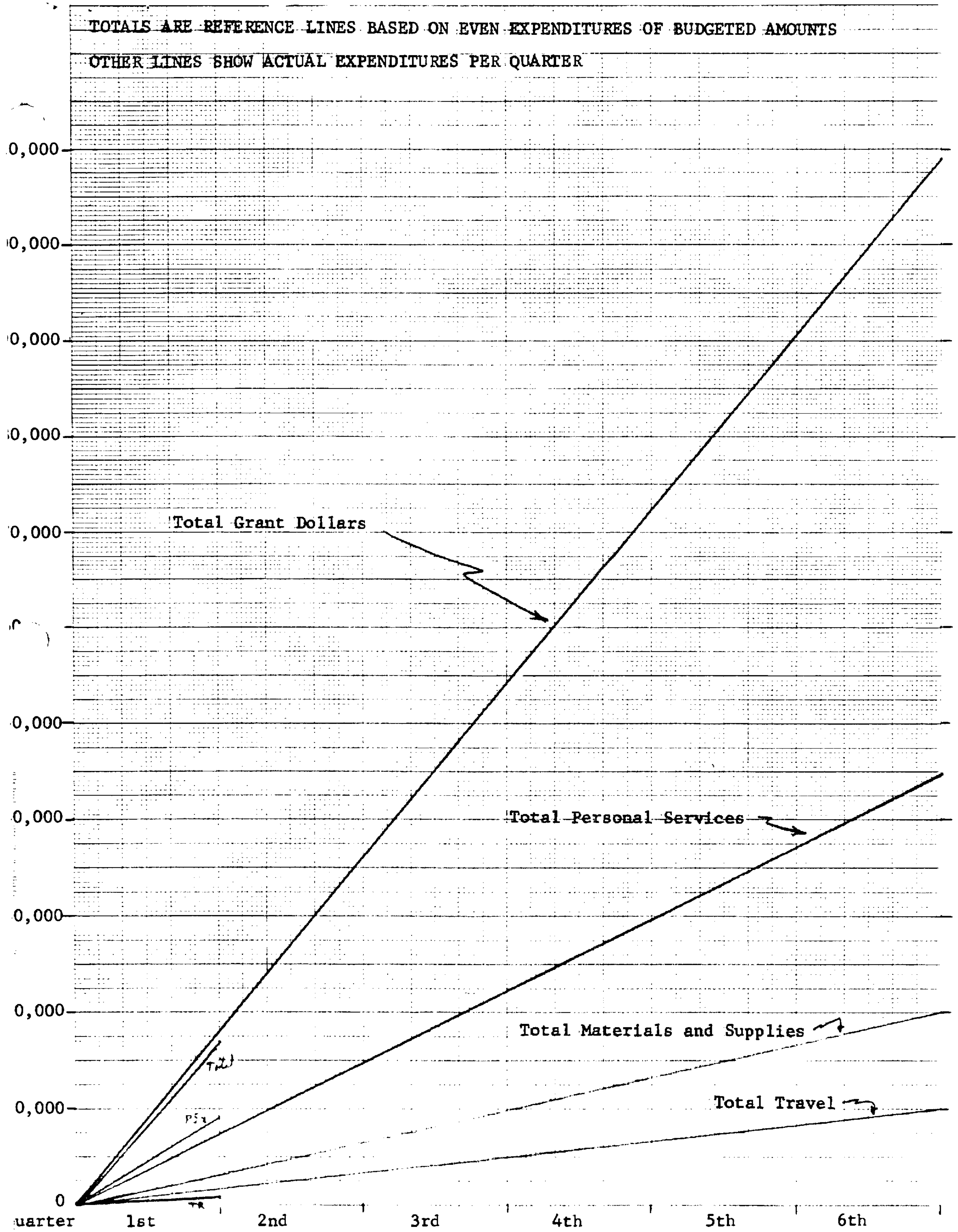
This project is broken into four sub-projects, two of which are in the School of Civil Engineering, one in the School of Chemical Engineering, and one in the Engineering Experiment Station. The tardiness of this report results in part from establishing a routine with the financial personnel of the various schools and in part from the move mentioned in the Technical Report. Future reports should not encounter these difficulties. Budget sheet print-outs for a given month are usually received by the 15th of the following month. Financial reports will be prepared promptly after the reception of printouts at the end of each quarter.

Attached is a graph of budgeted expenses and expenses to date. Materials and supplies was not plotted for this quarter because of the smallness of the amount.

Sincerely,

John E. Husted
Principal Investigator

JEH:ghm



OWRT/U.S. Dept. Interior Grant No. 14-34-001-6229; Ga. Tech Nos. E-19-692,E-20-694

E-19-692

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

December 16, 1976

Mr. Walter S. Butcher
Director
Office of Water Research and Technology
U. S. Department of the Interior
Washington, D. C. 20240

Reference: OWRT/U. S. Department of the Interior Grant No. 14-34-001-6229
Quarterly Financial Letter No. 2
Period September 1, 1976 - November 30, 1976

Gentlemen:

The following financial report is given of expenditures for the second quarter with the cumulative total of the first two quarters. Attached is a graph of budgeted expenses and expenses to date. The item, materials and supplies, was not plotted because of the smallness of the amount.

Item	Second Quarter	Cumulative Total
Personal Services	$4,839.81	$13,938.03
Retirement (*9.1%)	379.74	1,116.68
Materials and Supplies	199.83	363.20
Travel	34.54	607.14
Overhead (**68%)	3,481.74	9,668.53
Totals	$8,935.66	$25,693.58

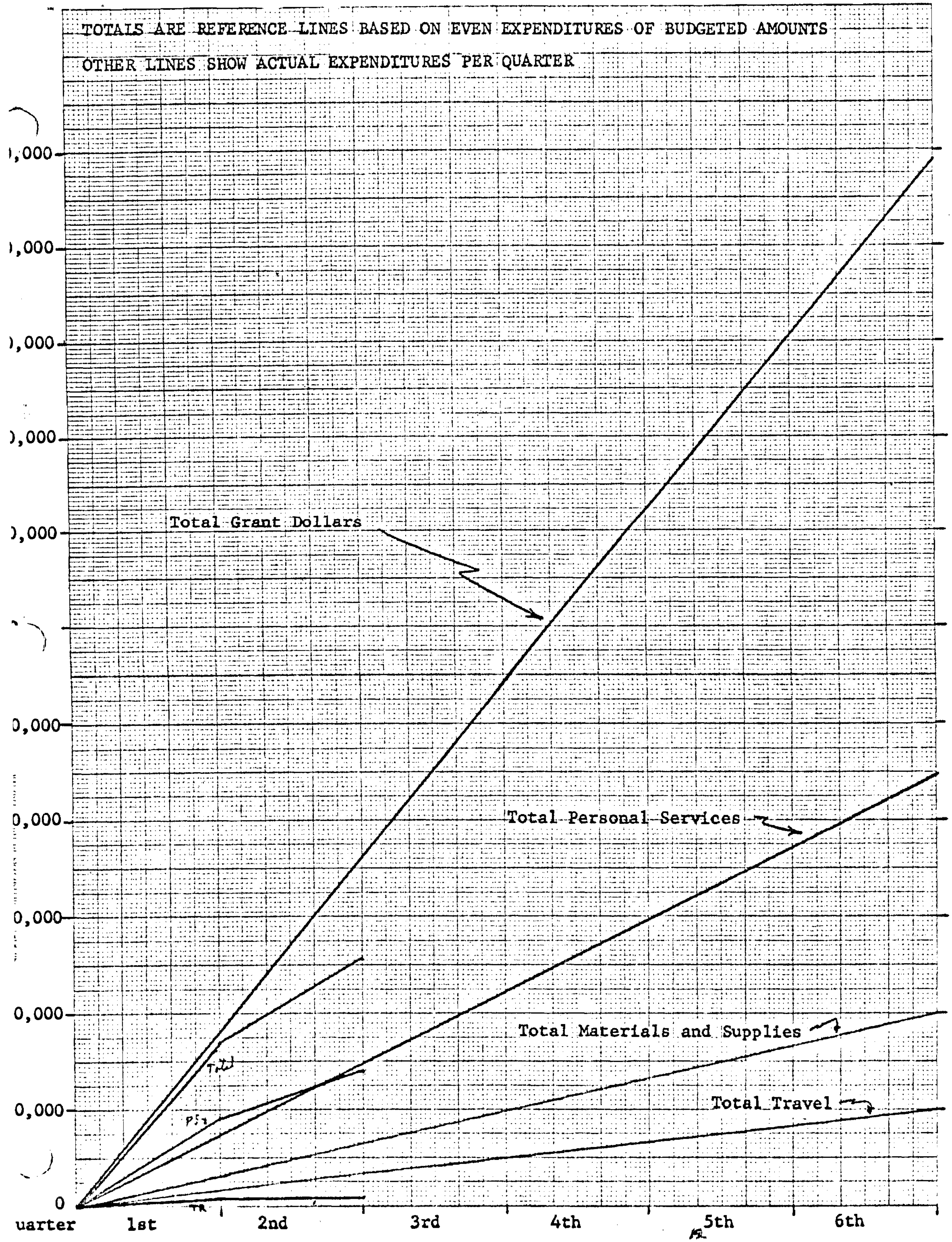
* Based on Personal Services or Salaried Personnel
**Based on Total Personal Services

Sincerely yours,

John E. Husted,
Principal Investigator

JEH:ghm

Optimum Water Management in Kaolin Mining for Aluminum Production



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GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

March 15, 1977

Director
Office of Water Research and Technology
U. S. Department of the Interior
Washington, D. C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-001-6229
Quarterly Financial Letter Number 3
Period: December 1, 1976 - February 28, 1977

Gentlemen:

The following financial report is given of expenditures for the third quarter with the cumulative total of the first threee quarters. Assached is a graph of budgeted expenses and expenses todate. The item, materials and supplies was not plotted because of the smallness of the amount. The bulk of this expenditure will be for the final report and will appear in the final quarter.

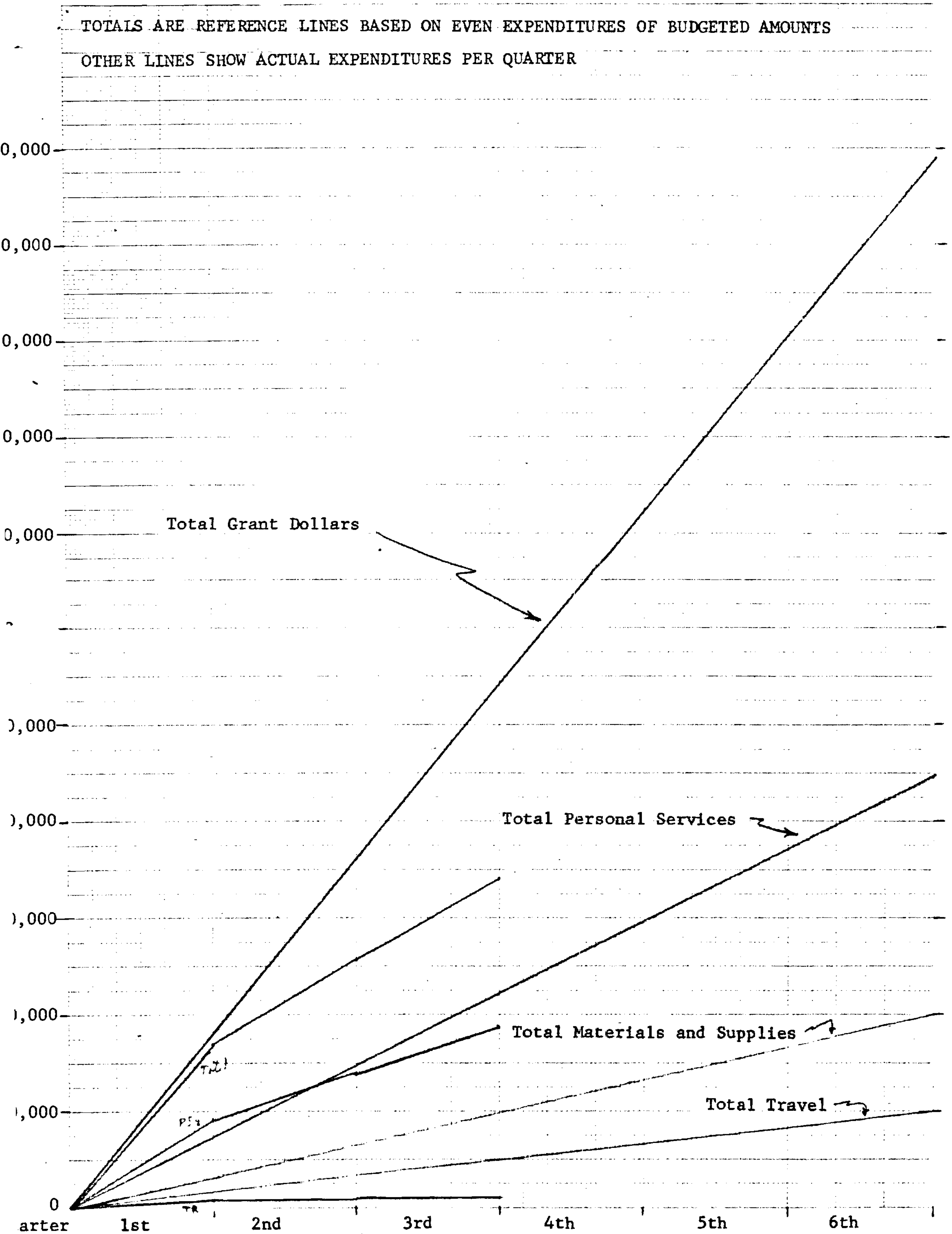
Item	Third Quarter	Cumulative Total
Personal Services	$4,852.91	$18,790.94
Retirement (*9.1%)	350.32	1,467.00
Materials and Supplies	41.67	404.87
Travel	83.66	690.80
Overhead (**68%)	3,218.86	12,886.79
Totals	$8,546.82	$34,240.40

* Based on Personal Services of Salaried Personnel
** Based on total personal services

Sincerely,

John E. Husted
Principal Investigator

JEH:ghm



OWRT/U.S. Dept. Interior Grant No. 14-34-001-6229; Ga. Tech Nos. E-19-692,E-20-694

E-19-692

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

June 17, 1977

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Financial Letter Number 4
Period: March 1, 1977 through May 31, 1977

Gentlemen:

The following financial report is given of expenditures for the fourth quarter with the cumulative total of the first four quarters. Attached is a graph of budgeted expenses and expenses to date. Items, Materials and Supplies and Travel are sufficiently close to constitute one line.

Item	Fourth Quarter	Cumulative Total
Personal Services	$4,331.57	$23,122.51
Retirement (*9.1%)	278.66	1,745.66
Materials and Supplies	209.01	613.88
Travel	190.08	880.88
Overhead (**68%)	2,945.46	15,832.25
Totals	$7,954.78	$42,195.18

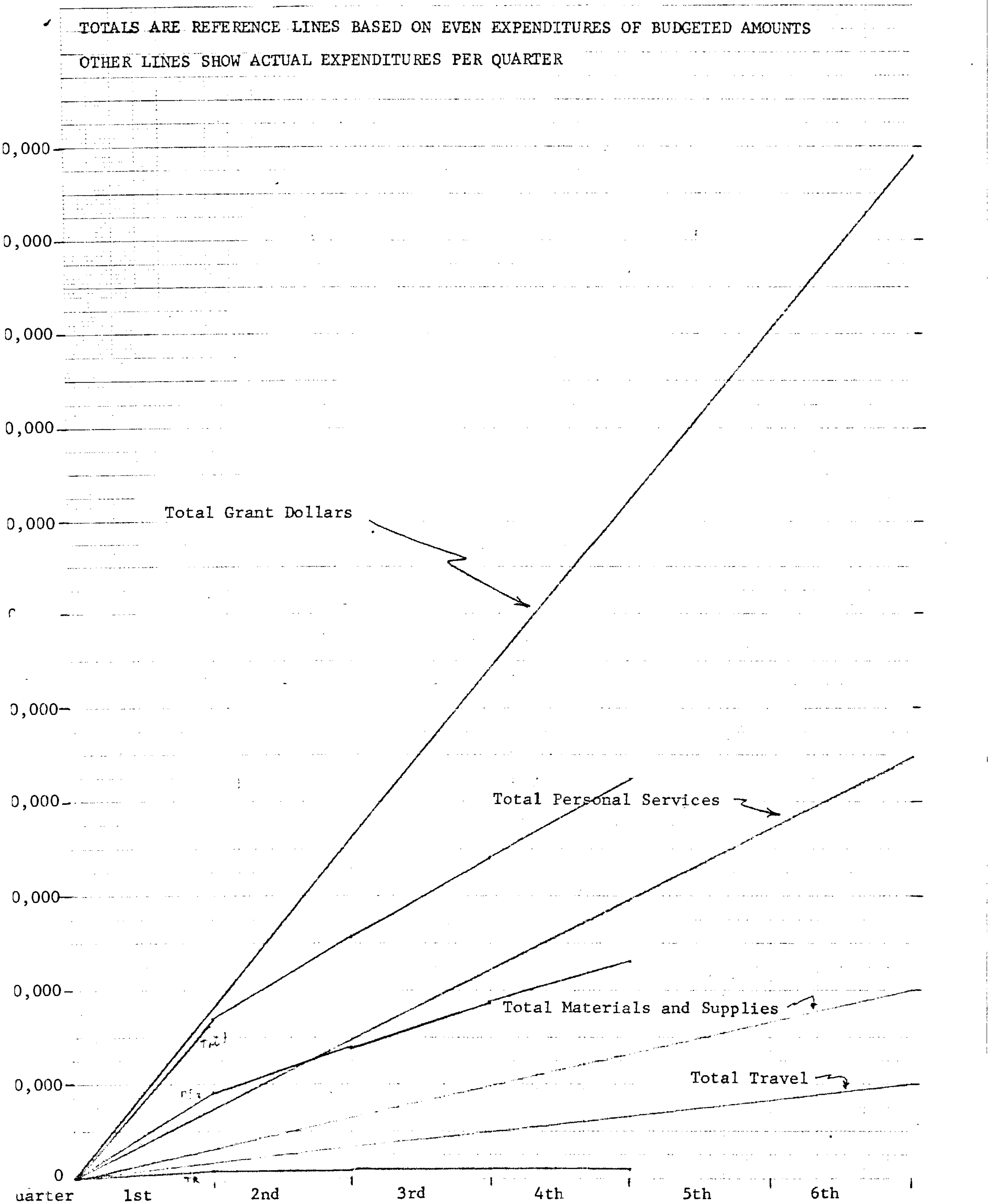
* Based on Personal Services of Salaried Personnel
** Based on total Personal Services

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

Attachment


TOTALS ARE REFERENCE LINES BASED ON EVEN EXPENDITURES OF BUDGETED AMOUNTS
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Total Grant Dollars
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E-19-692

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

September 14, 1977

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Financial Letter Number 5
Period: June 1, 1977 through August 31, 1977

Gentlemen:

The following financial report is given of expenditures for the fifth quarter with the cumulative total for all five quarters. Attached is a graph of budgeted expenses and expenses to date. Materials and Supplies were too low to plot. As explained in the Technical Letter, there were no personal services charges for Drs. Husted, Pohland, and Wallace during July and August. A graduate student and work by Mr. Dodson was charged.

Item	Fifth Quarter	Cumulative Total
Personal Services	$4,120.91	$27,243.12
Retirement (9.35%*)	260.73	2,006.39
Materials and Supplies	165.60	779.48
Travel	538.77	1,419.65
Overhead (68%**)	2,802.65	18,634.90
Totals	$7,888.66	$50,083.84

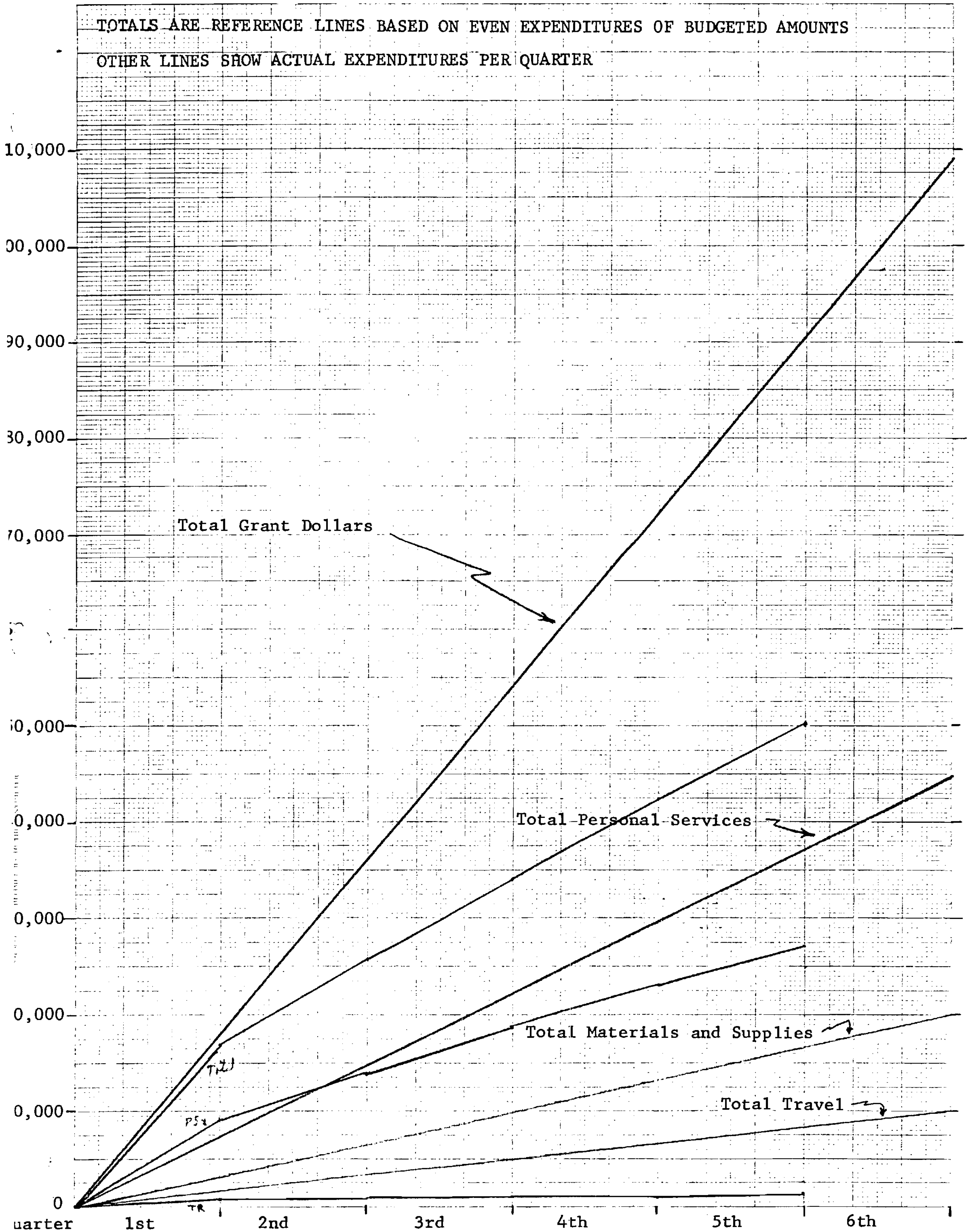
*Based on Personal Services of salaried personnel
**Based on total Personal Services

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

Optimum Water Management in Kaolin Mining for Aluminum Production



OWRT/U.S. Dept. Interior Grant No. 14-34-001-6229; Ga. Tech Nos. E-19-692, E-20-694
E-20-695, B-471

E-19692

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

January 3, 1978

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-340001-6229
Quarterly Financial Letter Number 6
Period: September 1, 1977 through November 30, 1977

Gentlemen:

The following financial report is given for the sixth quarter with the cumulative total for all six quarters. As also noted in the Technical Letter, a six-month, no-cost extension has been granted. A major expenditure of a test well is anticipated during this period. Dr. Pohland has returned from his year's teaching leave in Holland and expenditures are proceeding on his portion of the contract.

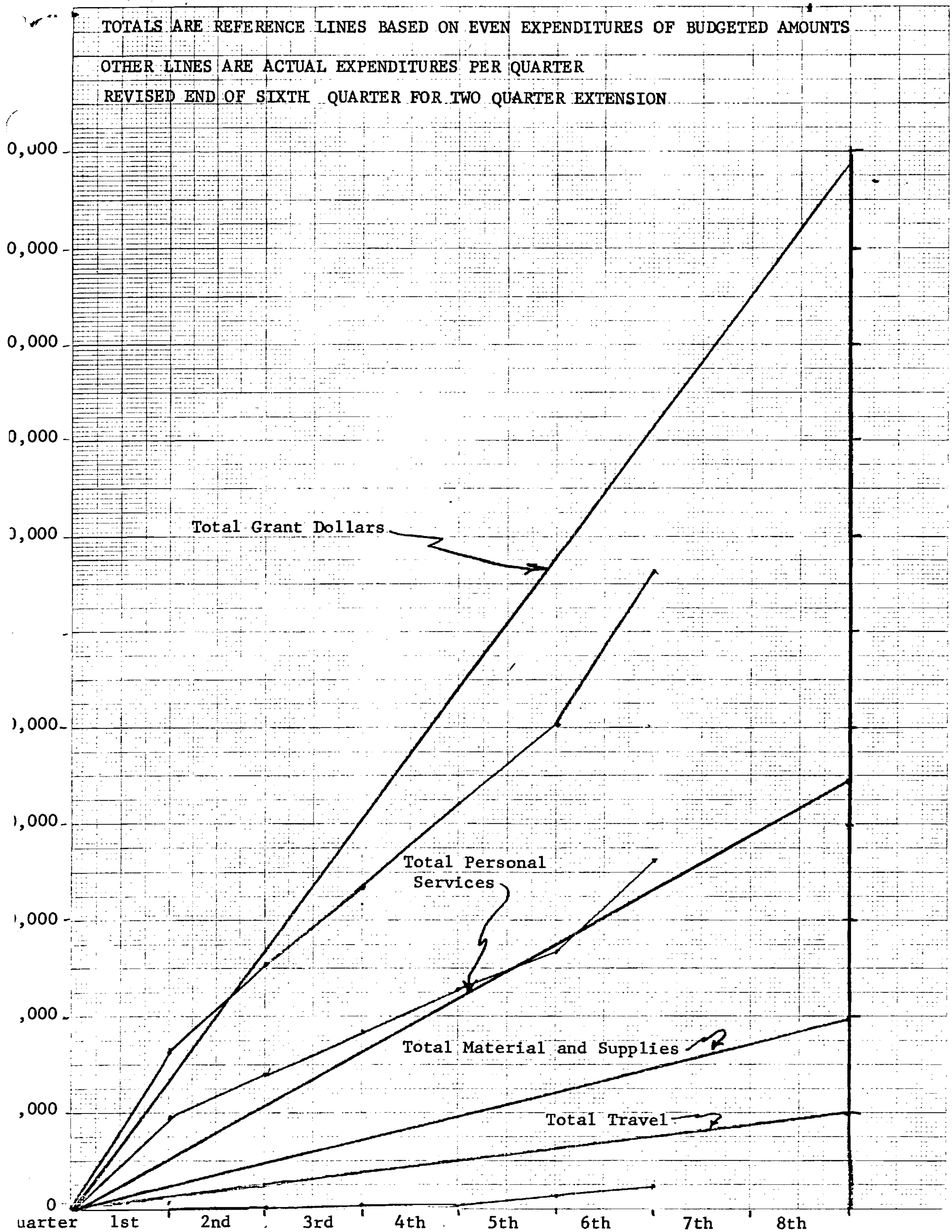
Item	Sixth Quarter	Cumulative Total
Personal Services	$ 8,765.63	$36,009.05
Retirement (9.35%*)	746.84	2,753.23
Materials and Supplies	71.05	850.53
Travel	1,010.75	2,430.40
Overhead (68%**)	5,960.63	24,595.53
TOTALS	$16,554.90	$66,638.74

*Based on Personal Services of salaried personnel
**Based on total Personal Services

Sincerely,

John E. Husted
Principal Investigator

JEH:cah



OWRT/U.S. Dept. Interior Grant No. 14-34-001-6229. Ga. Tech Nos. E-19-692, E-20-694
E-20-695, B-471

E 19-692

GEORGIA INSTITUTE OF TECHNOLOGY

ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

April 7, 1978

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant Number 14-34001-6229
Quarterly Financial Letter Number 7
Period: December 1, 1977, through February 28, 1978

Gentlemen:

The following financial report is given for the seventh quarter with the cumulative total for all seven quarters.

Item	Seventh Quarter	Cumulative Total
Personal Services	$3,888.10	$39,897.15
Retirement (9.35%*)	365.22	3,118.45
Materials and Supplies	35.00	885.53
Travel	41.20	2,471.60
Overhead (68%**)	2,656.15	27,251.68
Totals	$6,985.67	$73,624.41

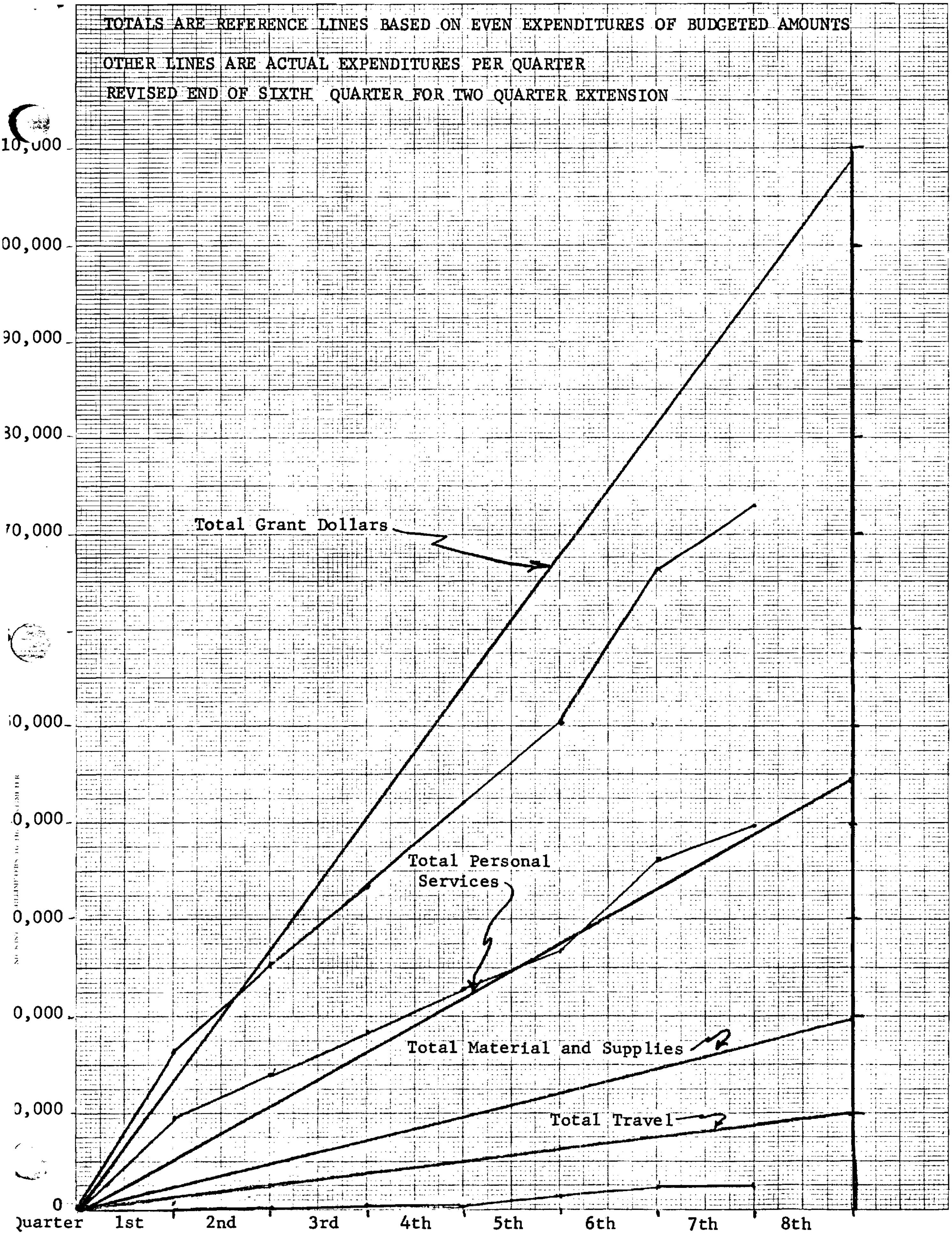
*Based on Personal Services of salaried personnel.
**Based on total Personal Services

Sincerely,

John E. Husted
Professor, Mineral Engineering
School of Chemical Engineering

JEH:cah

Optimum Water Management in Kaolin Mining for Aluminum Production



OWRT/U.S. Dept. Interior Grant No. 14-34-001-6229. Ga. Tech Nos. E-19-692, E-20-694
E-20-695, B-471

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

June 21, 1978

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant Number 14-34-0001-6229
Quarterly Financial Letter Number 8
Period: March 1, 1978 through May 31, 1978

Gentlemen:

The following financial report is given for the eighth quarter with cumulative totals for all eight quarters.

Item	Eighth Quarter	Cumulative Total
Personal Services	$3,975.88	$43,873.03
Retirement (9.35%*)	371.00	3,489.45
Materials & Supplies	652.62	1,538.15
Travel	775.76	3,247.36
Overhead (68%**)	2,703.60	29,955.28
Totals	$8,478.86	$82,103.27

*Based on Personal Services of salaried personnel
**Based on total Personal Services

Sincerely yours,

John E. Husted
Principal Investigatory

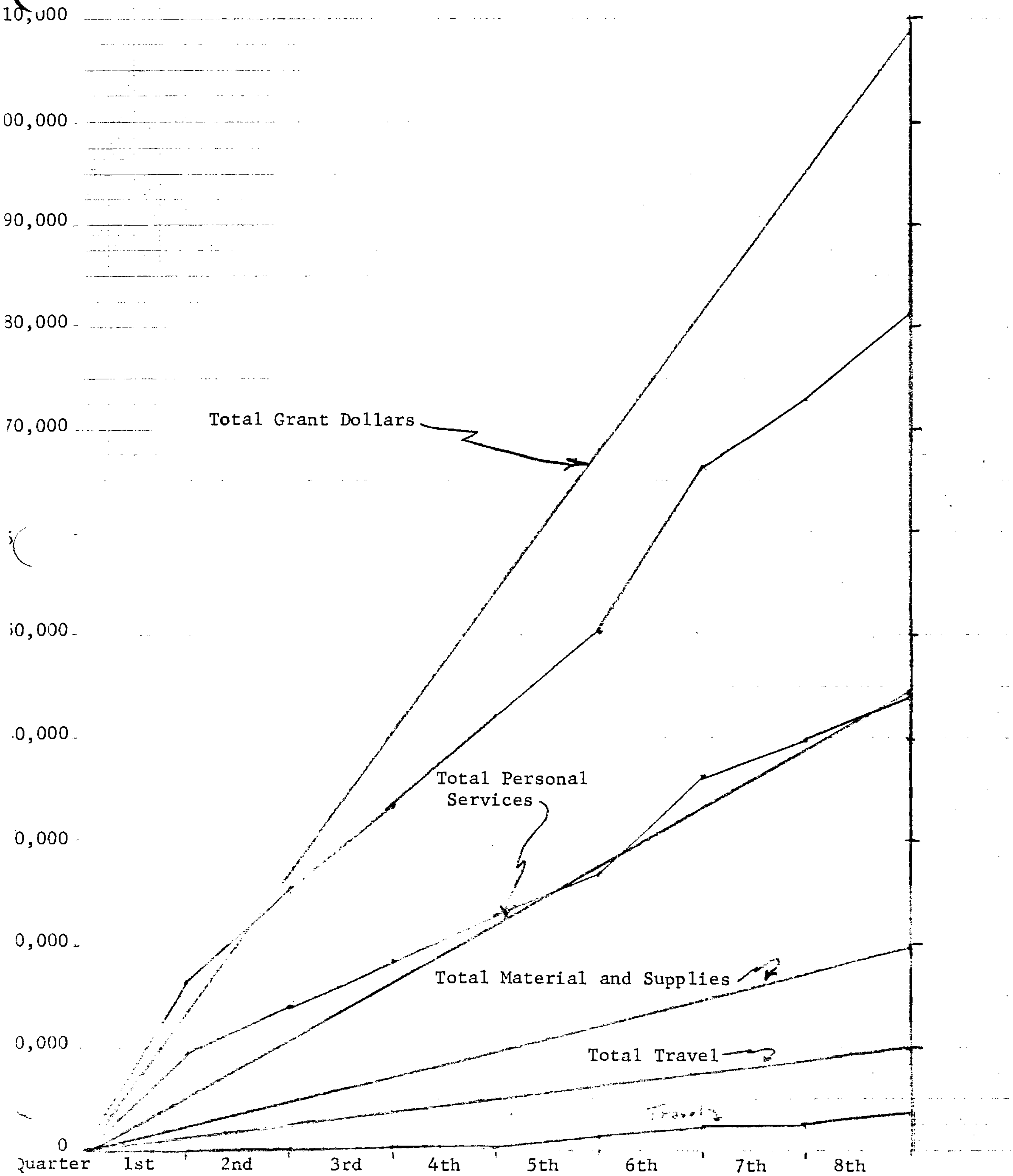
JEH:chr

Optimum Water Management in Kaolin Mining for Aluminum Production

TOTALS ARE REFERENCE LINES BASED ON EVEN EXPENDITURES OF BUDGETED AMOUNTS

OTHER LINES ARE ACTUAL EXPENDITURES PER QUARTER

REVISED END OF SIXTH QUARTER FOR TWO QUARTER EXTENSION



OWRT/U.S. Dept. Interior Grant No. 14-34-001-6229. Ga. Tech Nos. E-19-692, E-20-694, E-20-695, B-471

E-20-694

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF CHEMICAL ENGINEERING

June 17, 1977

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Technical Report Number 4
Period: March 1, 1977 through May 31, 1977

Gentlemen:

Ground water conditions in Glascock, Jefferson, McDuffie, and Warren Counties have been analyzed. Piezometric contours have been developed for Tuscaloosa, Barnwell, and Irwinton sand aquifers. Current and projected water use have been determined. A tentative location of a test well has been located and preliminary arrangements have been made with the Georgia District, U.S. Geological Survey, to log test holes and date (geologically) core samples.

As a part of the test well study, permission has been obtained from Jefferson County Board of Roads and Revenues to run a seismic profile along a secondary county road. Running of the profile has been delayed due to malfunction of the equipment. The seismic equipment is on loan from the School of Geophysical Sciences. If the equipment can be brought into operating condition, an attempt will be made to correlate the profile with the test well data.

A preliminary population impact projection also has been completed.

On May 12, 1977, Dr. Husted presented a summary of work to date on the project to the Georgia Water Resources Research Colloquium.

Work is continuing with primary aluminum companies to obtain data concerning technology related to the project.

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

E-20-629

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

June 17, 1977

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Financial Letter Number 4
Period: March 1, 1977 through May 31, 1977

Gentlemen:

The following financial report is given of expenditures for the fourth quarter with the cumulative total of the first four quarters. Attached is a graph of budgeted expenses and expenses to date. Items, Materials and Supplies and Travel are sufficiently close to constitute one line.

Item	Fourth Quarter	Cumulative Total
Personal Services	$4,331.57	$23,122.51
Retirement (*9.1%)	278.66	1,745.66
Materials and Supplies	209.01	613.88
Travel	190.08	880.88
Overhead (**68%)	2,945.46	15,832.25
Totals	$7,954.78	$42,195.18

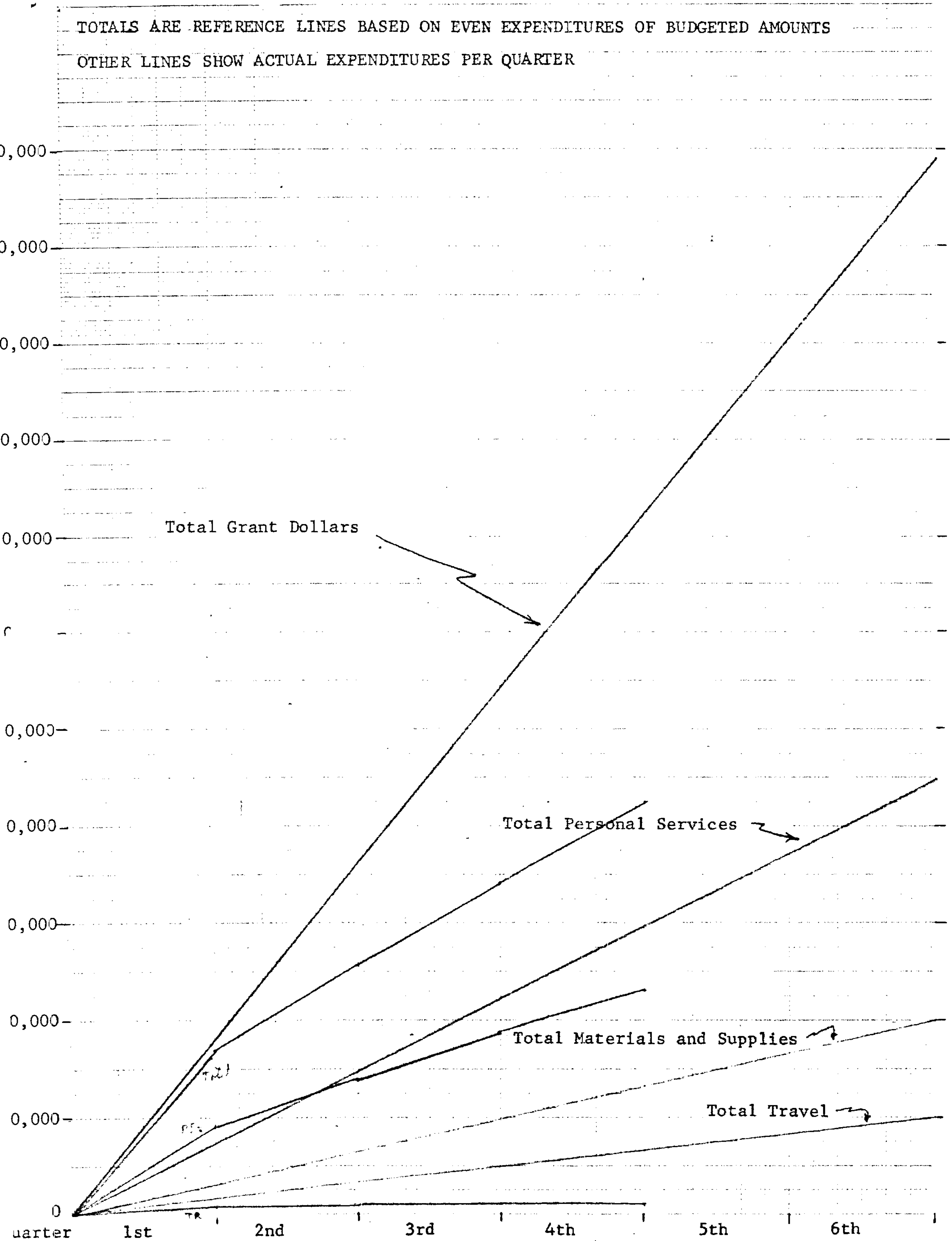
* Based on Personal Services of Salaried Personnel
** Based on total Personal Services

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

Attachment


TOTALS ARE REFERENCE LINES BASED ON EVEN EXPENDITURES OF BUDGETED AMOUNTS
OTHER LINES SHOW ACTUAL EXPENDITURES PER QUARTER
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E-20-695

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

June 17, 1977

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Technical Report Number 4
Period: March 1, 1977 through May 31, 1977

Gentlemen:

Ground water conditions in Glascock, Jefferson, McDuffie, and Warren Counties have been analyzed. Piezometric contours have been developed for Tuscaloosa, Barnwell, and Irwinton sand aquifers. Current and projected water use have been determined. A tentative location of a test well has been located and preliminary arrangements have been made with the Georgia District, U.S. Geological Survey, to log test holes and date (geologically) core samples.

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A preliminary population impact projection also has been completed.

On May 12, 1977, Dr. Husted presented a summary of work to date on the project to the Georgia Water Resources Research Colloquium.

Work is continuing with primary aluminum companies to obtain data concerning technology related to the project.

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

E-20-698

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

SCHOOL OF
CHEMICAL ENGINEERING

June 17, 1977

Director
Office of Water Research and Technology
U.S. Department of the Interior
Washington, D.C. 20240

Reference: OWRT/U.S. Department of the Interior Grant No. 14-34-0001-6229
Quarterly Financial Letter Number 4
Period: March 1, 1977 through May 31, 1977

Gentlemen:

The following financial report is given of expenditures for the fourth quarter with the cumulative total of the first four quarters. Attached is a graph of budgeted expenses and expenses to date. Items, Materials and Supplies and Travel are sufficiently close to constitute one line.

Item	Fourth Quarter	Cumulative Total
Personal Services	$4,331.57	$23,122.51
Retirement (*9.1%)	278.66	1,745.66
Materials and Supplies	209.01	613.88
Travel	190.08	880.88
Overhead (**68%)	2,945.46	15,832.25
Totals	$7,954.78	$42,195.18

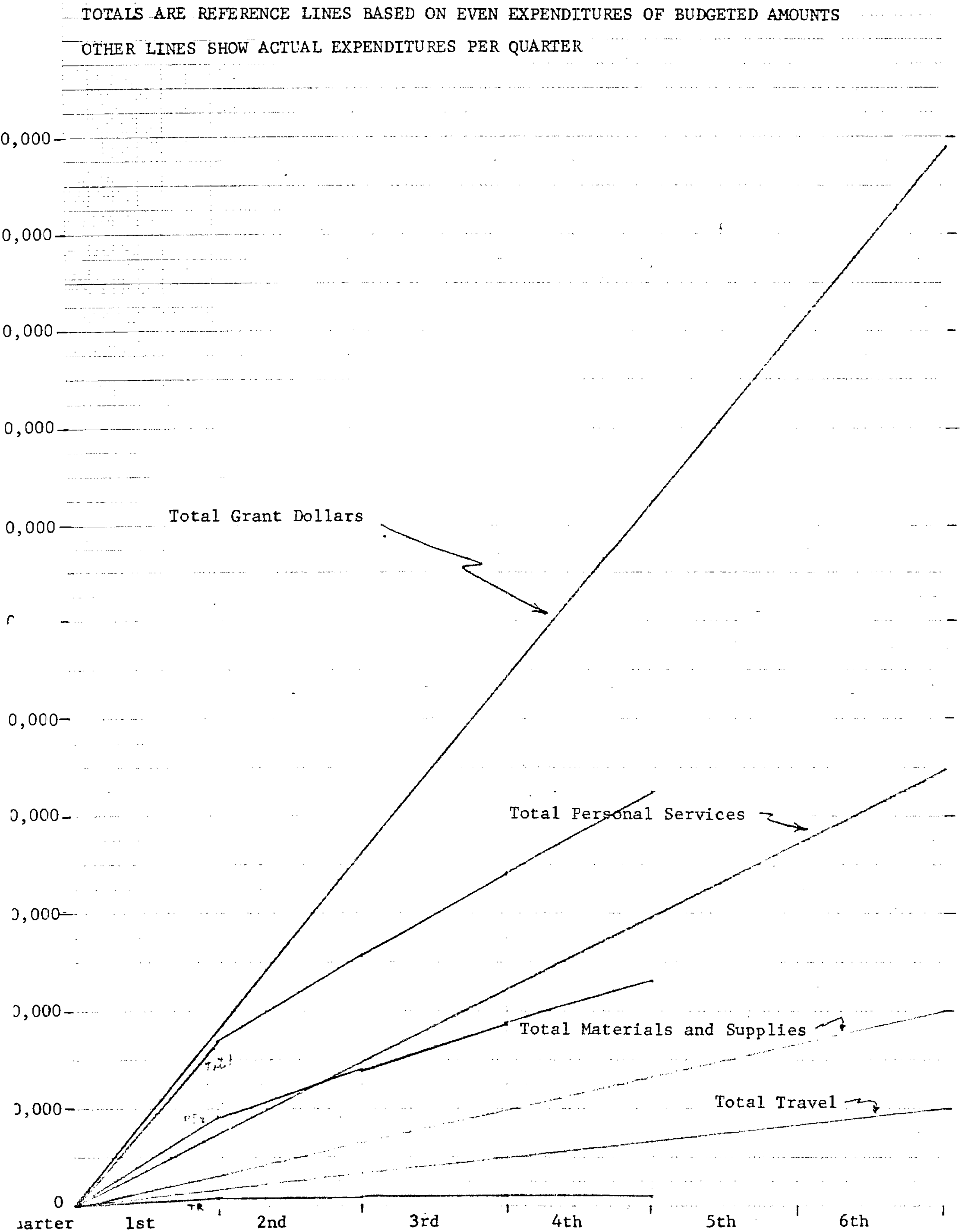
* Based on Personal Services of Salaried Personnel
** Based on total Personal Services

Sincerely,

John E. Husted
Principal Investigator

JEH:cah

Attachment



TOTALS ARE REFERENCE LINES BASED ON EVEN EXPENDITURES OF BUDGETED AMOUNTS
OTHER LINES SHOW ACTUAL EXPENDITURES PER QUARTER
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Total Grant Dollars
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E-19-692

SEGIT-78-178

OPTIMUM WATER MANAGEMENT IN KAOLIN MINING FOR ALUMINUM PRODUCTION

By

John E. Husted
Frederick G. Pohland
J. W. Wallace
George Dodson

Co-Principal Investigators

Prepared for

OWRT/U. S. DEPARTMENT OF INTERIOR
GRANT NO. 14-34-001-6229

November 1978

GEORGIA INSTITUTE OF TECHNOLOGY
Atlanta, Georgia 30332

OPTIMUM WATER MANAGEMENT IN KAOLIN MINING FOR ALUMINUM PRODUCTION

Co-Principal Investigators

John E. Husted
Frederick G. Pohland
J.W. Wallace
George Dodson

Georgia Institute of Technology
Atlanta, Georgia 30332

November, 1978

OWRT/U.S. Dept. of Interior
Grant No. 14-34-001-6229

Georgia Institute of Technology
Projects No. E-19-692
E-19-694
E-19-695
B-471

SCEGIT-78-178

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Acknowledgements

This is to acknowledge the work of Messrs. James W. Hudson, Jeffrey R. Hutchins, Raymond J. Lawing, and David Shank, whose special Master's degree projects in Civil Engineering each made substantial contributions to the project.

The work on the project of Robert B. Cassell, Principal Research Scientist, and Nicholas S. Gibson, Research Scientist, of the Engineering Experiment Ztation is also acknowledged.

Information from private hydrology studies is acknowledged from Thièle Kaolin Company, Anglo-American Clays Corporation, J.M. Huber Corporation, Yara Engineering Corporation and its affiliates, as well as general water consumption information from other kaolin producing companies.

Records concerning municipal water and sewer systems is acknowledged from the Environmental Protection Division of the Georgia Department of Natural Resources.

Water analyses included in this report were done by the Geologic and Water Resources Division of the Georgia Department of Natural Resources.

INTRODUCTION

Kaolin is a clay consisting of substantially pure kaolinite or related clay minerals which have many industrial uses. The so-called "soft" kaolins are used for coating and filler for high-grade white paper, filler for paints and plastics, and filler in rubber and ceramics. The hard refractory kaolins are used for fire brick, mortar and cement. Kaolin may also be used for the manufacture of aluminum.

The most extensive commercial deposits of kaolin found anywhere in the world exist in a narrow belt reaching across central Georgia along the southeast edge of the Fall Line (See Figure 1). Reserves of kaolin in Georgia alone are estimated at 5 and 15 billion tons with the largest amounts and highest quality being concentrated between Augusta and Macon with new mining reserves continually being identified. The U.S. Bureau of Mines reports that in 1973, 5.8 million tons of kaolin were produced in the United States; in the same year, Georgia produced 4.3 million tons (Patterson, 1974).

The economic importance of these deposits of kaolin is increasing rapidly because of the potential development of a new alumina from kaolin industry. With the cost of importing bauxite escalating rapidly, the use of bauxite as the only important source of alumina for aluminum has placed the United States in a vulnerable position with respect to supplies of this metal. However, a 1974 report by the Industrial Development Division for the Georgia Department of Community Development concluded that the technology is now such that kaolin and bauxite are economically even as a source of alumina for aluminum (Husted, 1974). The problem has previously been the economic advantage of the technology of using bauxite as compared to the technology of using other aluminum-bearing minerals.

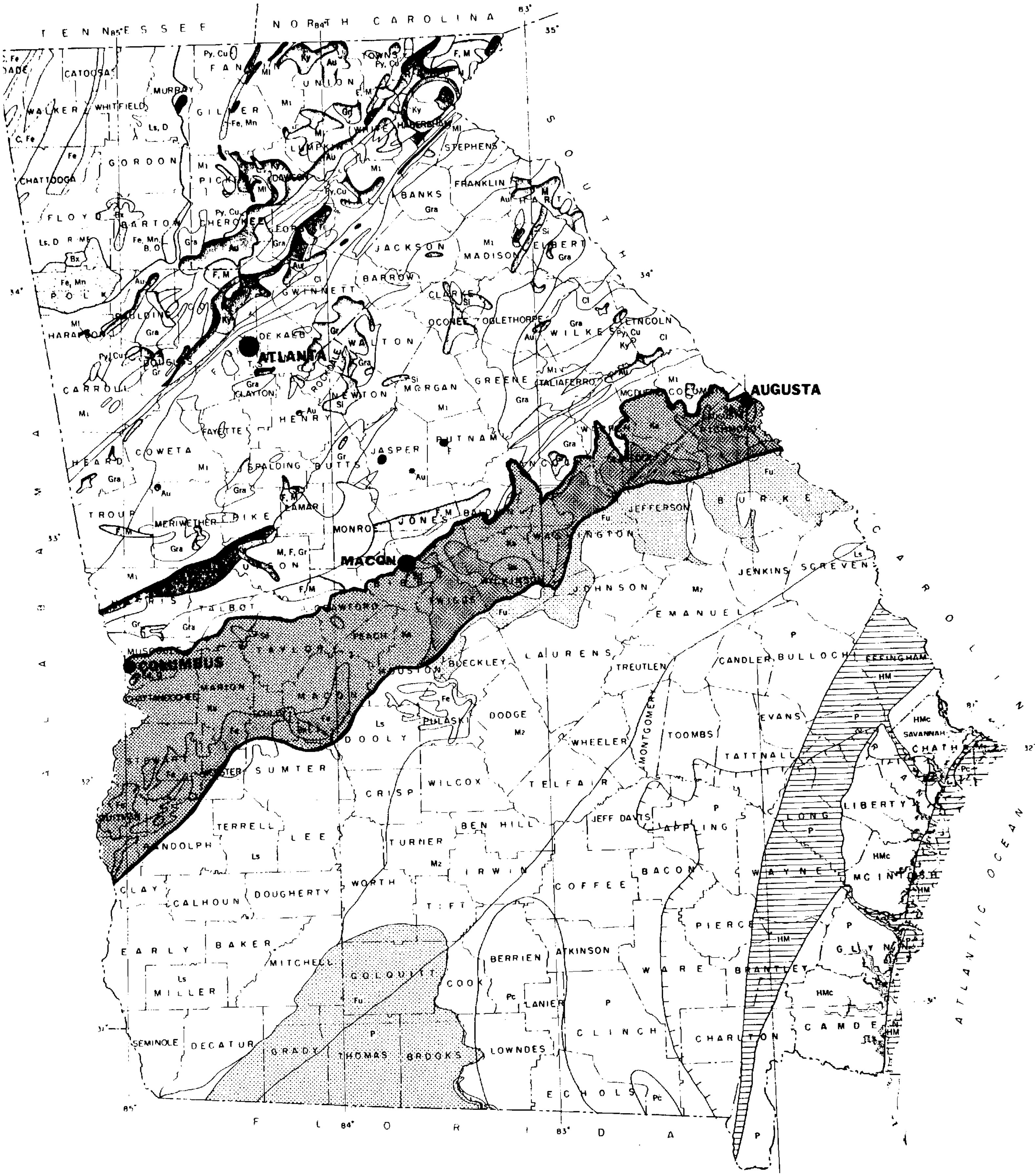


FIGURE 1. Location of the Kaolin Belt in Georgia

It is anticipated that within the next 25 years, developments in the kaolin for alumina mining and processing industry in Georgia could result in the extraction of up to 9000 short tons per day of mined and processed kaolin and up to 3000 short tons per day of processed alumina. Based on commercial plant range capabilities of 300,000 to 1,000,000 tons of alumina production per year, the processing water requirements for this potential expansion are estimated between 3.0 and 25.0 MGD depending on operating capacities and type of processing employed.

The purpose of this portion of the overall study was to examine the relationships between this potential development and the water resources of the kaolin-rich areas of the State of Georgia, concentrating on those counties where the potential was considered greatest. Accordingly, the study area covered by this report has been intentionally limited to a seven-county area located between Augusta and Macon (See Figure 2). This area is composed of Glascock, Jefferson, McDuffie, Twiggs, Warren, Washington and Wilkinson counties. Data were collected to provide a basis for recommending water and wastewater management strategies within the perspective of the concomitant development of satellite industries and supporting populations.

DESCRIPTION OF THE STUDY AREA

Physiography

The area covered by this report includes 2718 square miles in east-central Georgia including Glascock, Jefferson, McDuffie, Warren, Twiggs, Washington and Wilkinson counties. The area is divided from North to South by the Ogeechee River, is bounded on the West by the Ocmulgee River, and adjoins on the North, South and East, 13 other counties in Georgia. The northeastern part of the area lies in the Piedmont Plateau with the remaining area located in the Coastal Plain. Cutting across the northern part of the

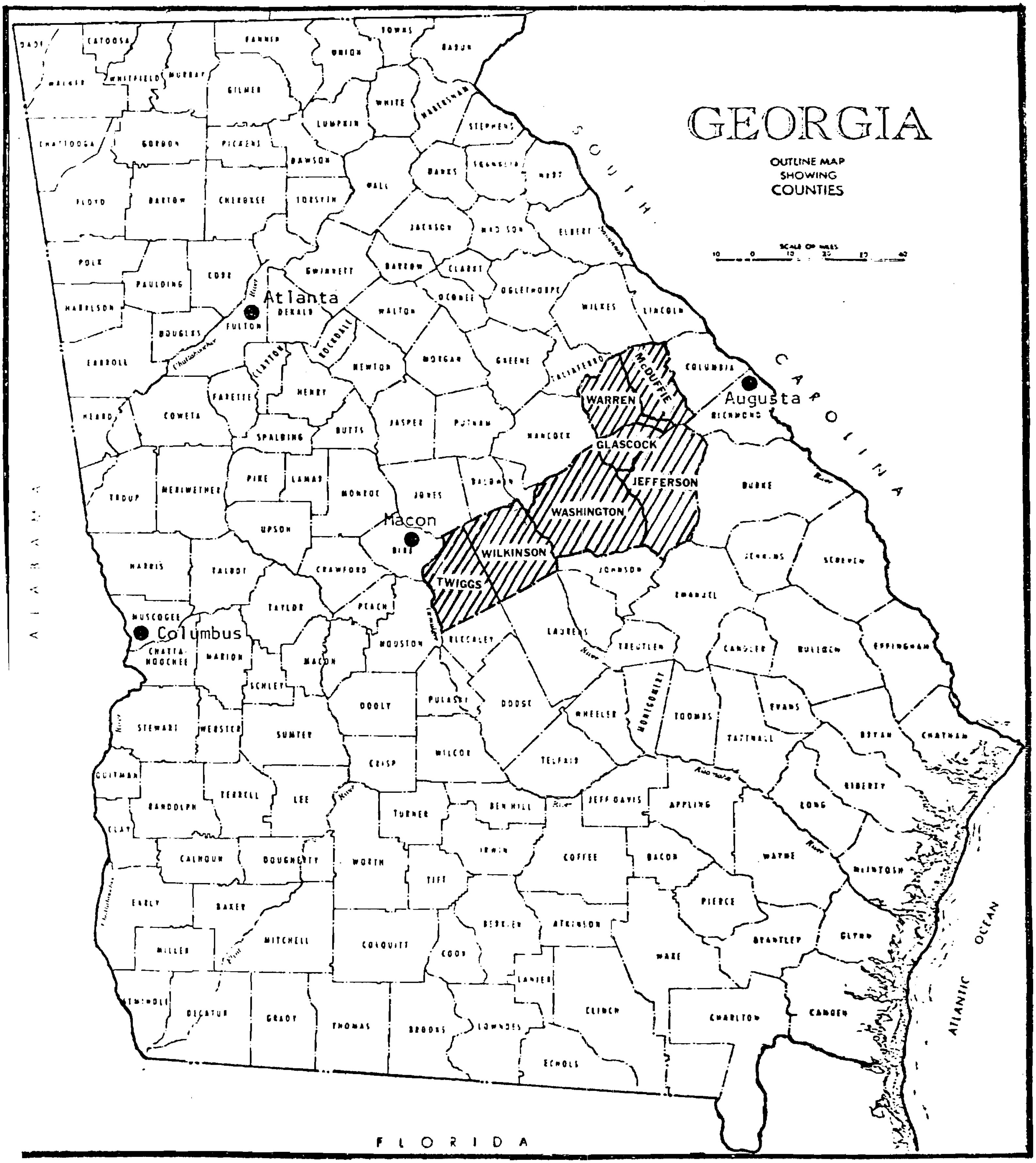


FIGURE 2. Location of Counties Covered by this Report

study area and forming an irregular boundary between the Coastal Plain and the Piedmont Province is a five to 20-mile wide transition zone identified as the Fall Line (See Figures 3-5).

The Piedmont Plateau or province is underlain by an an ancient complex of igneous or metamorphic rocks, and include granites, gneisses, schists, and highly-metamorphosed shales, sandstones, and limestones. They constitute the oldest rocks of the State and have been subjected to intense folding and faulting. The rocks are deeply weathered, and the general topography of the area tends to be smooth. The valleys are broad and shallow and have long gentle slopes. The entire province slopes gradually to the southeast.

Adjacent to the Piedmont Plateau, the Coastal Plain province includes practically all of the State lying south of a line passing through Macon, Augusta, and Columbus. The Coastal Plain, as a region, is a low plain having a gentle southward slope. In comparison to other physiographic divisions of the State, this plain has been subjected to erosion for only a short time, and its topography over a greater part of the area may be described as youthful. On the whole, it is level, although it comprises some hilly and broken areas in the northern part where in some places it is dissected and appears somewhat more mature. None of the hills rise above the general level, and their tops present an even skyline. Underlain by Cretaceous and younger sediments such as sands, clays, marls, and limestones, the Coastal Plain shares the Fall Line as an irregular boundary with the Piedmont province. In this region the sediments of the Coastal Plain thin to the north like a wedge, and meet the ancient crystalline rocks.

Using topography, underlying geologic formations, and soils, the Coastal Plain can be further divided into three distinct physiographic regions. These regions are the Sand Hills, Red Hills, and Tifton Upland.

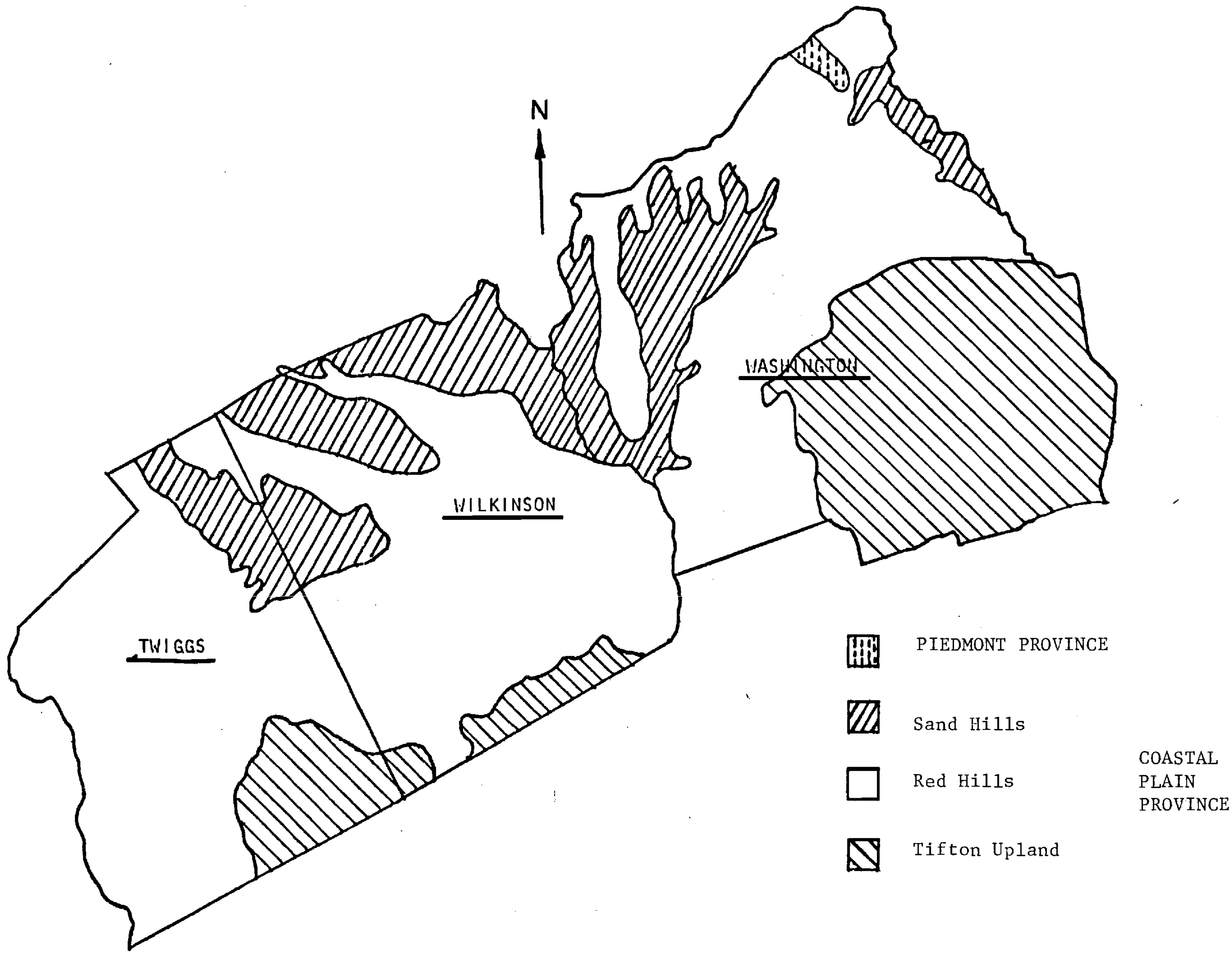


FIGURE 3. Physiographic Regions of East-Central Georgia (Lamoreaux, 1946)

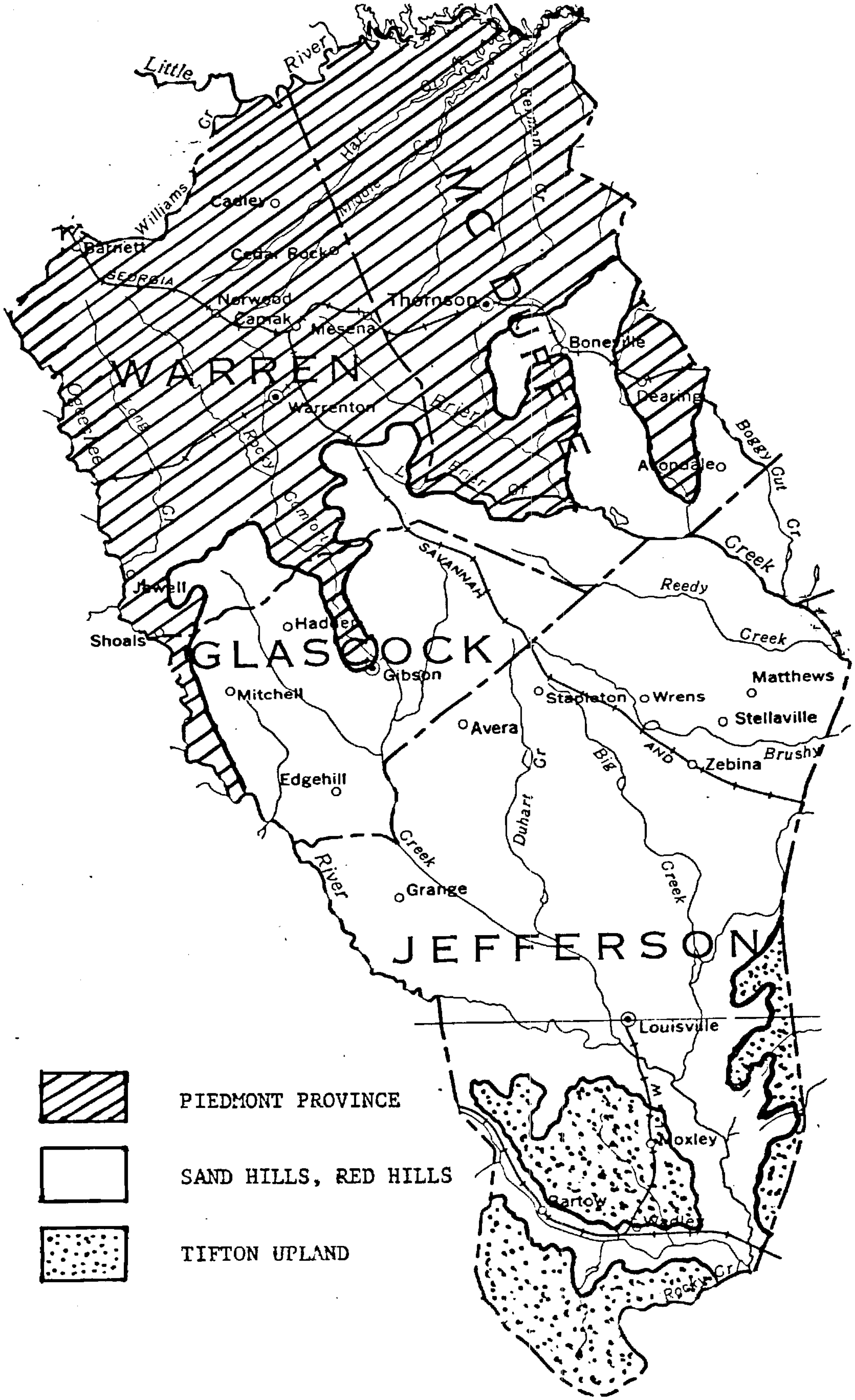


FIGURE 4. Physiographic Regions of East-Central Georgia (Carter,1956)

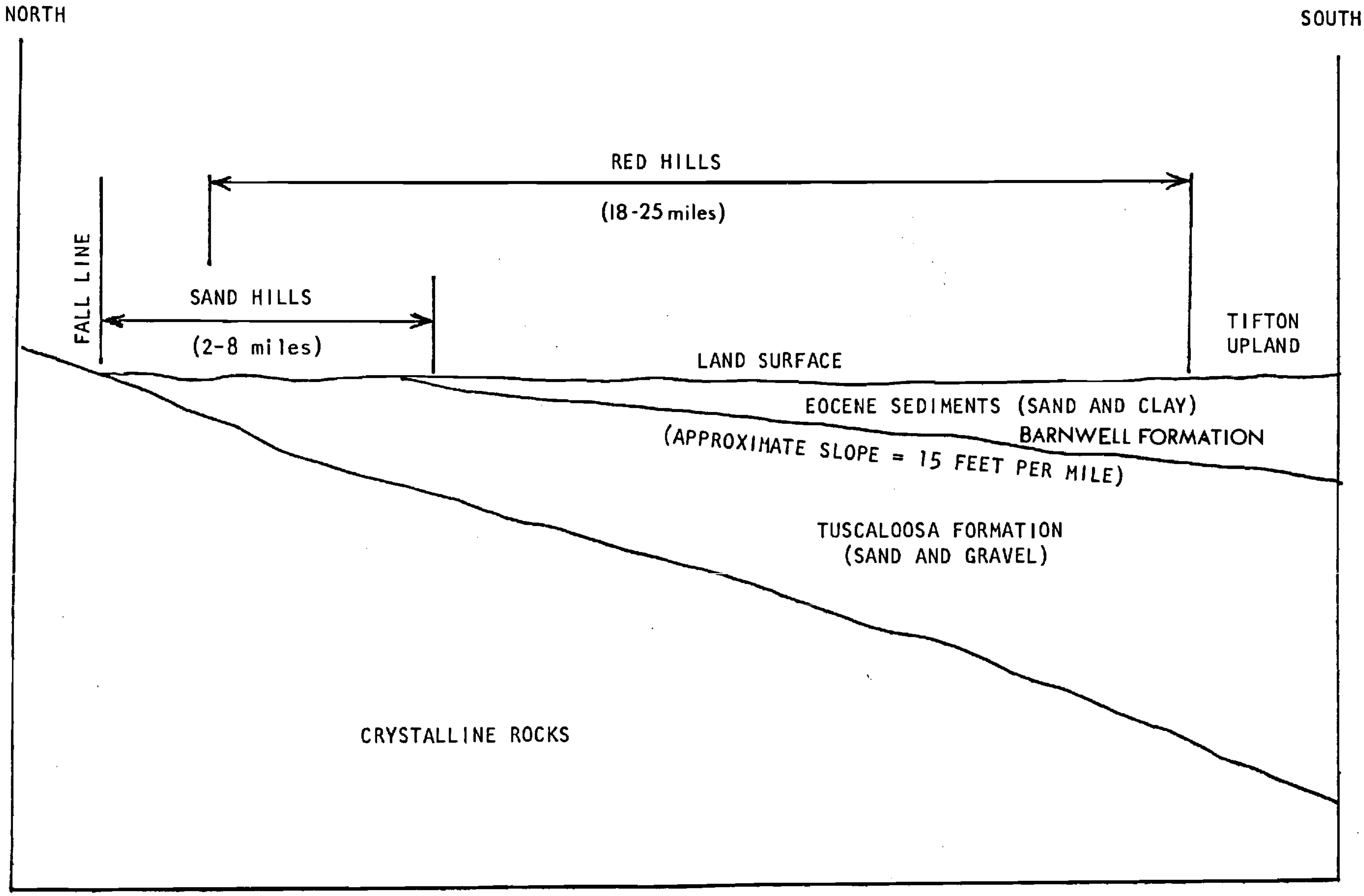


FIGURE 5. Generalized Profile of East-Central Georgia

The Sand Hills area is an irregular belt less than 10 miles wide adjacent to the Fall Line in which the Tuscaloosa formation is exposed. It is characterized by a notable covering of gray to brownish loose sand, which is a residual from the underlying Cretaceous and Eocene formations.

At some points, the Sandy Hills area is overlain by later age deposits. At these points of overlap, the Red Hills project across the Sand Hills creating the discontinuous nature of the belt. The relief in the area rarely exceeds 100 to 150 feet. The topography consists of broad rolling hills with gentle slopes. The soils in the area are light colored sands and sandy loams and are highly productive if fertilized. However, left unfertilized, the soil is poorly productive and tree growth is mainly stunted oak and scattered long leaf pine. Natural drainage is to the southwest and southeast.

The Red Hills, remnants of a former upland plateau, form a belt of hills approximately 20 miles wide across east-central Georgia. They are typically a series of hills capped by brilliant red sands and sandy loams weathered from Eocene and Oligocene rocks. In the northern part of the Red Hills area, streams have cut the former upland plateau into a series of elongated northeast-southwest and northwest-southeast running hills on which little of the original surface remains. In the southern part of the area, the hills broaden out loosing their elongated characteristic. In the central and southern part of the area, some deep gullying has occurred due to the high altitude of the upland plateau above the streams and rivers and the high erosional character of the geologic formations present. Relief throughout the area rarely exceeds 200 feet, although the erosional characteristics of the soils have created areas with relief of 250 feet in some areas of southeast Washington and southwest Wilkinson Counties. Typical elevations range from 500 feet above sea level near Stapleton, in north Jefferson County, to about 320 feet at Louisville, in the southern part of the county. Drainage in this physiographic region is to the southeast and southwest and the soils are only moderately productive.

The Tifton Upland is located south of the Red Hills. The topography consists of gently rolling hills with broad rounded summits. There exists no parallelism of ridges as in the Red Hills and relief rarely exceeds 50 feet. Dissection by streams has occurred only near large rivers where slopes become steeper. In southwest Georgia, the northern limit of the Tifton Upland forms an inland-facing escarpment as much as 150 feet high in some places. This escarpment is not present in the southern part of the study area because later age deposits form only a thin layer over the underlying Eocene rocks. There are many shallow ponds and sinks along the northern margin of the area indicating the presence of limestone near the surface. Weathering of the sand and sandy clay residuums of the Oligocene and Miocene formations that form the Tifton Upland has produced a gray or yellowish gray sandy soil with scattered red ferruginous modules.

Geologic Formations--Water-Bearing Properties

The geology of the Coastal Plain is less complex than that of other parts of the State. The region is underlain by sediments, ranging in age from Upper Cretaceous to Recent, which outcrop in roughly parallel bands, the oldest resting upon crystalline rocks of the Piedmont province and the youngest at the sea coast. The beds dip gently southeastward at rates ranging from about 35 feet per mile at the Fall Line to very little at the coast. Figures 6 and 7 show the geologic formations at the surface of the area, and Table 1 gives a generalized geologic cross-section with summarized information. Figure 8 illustrates the geologic cross-section constructed from wells located at various cities (Georgia Geologic Survey Bulletin 55).

Ei | Ecm | Es — IRWINTON SAND (Ei), up-dip equivalent of Twiggs Clay, Sandersville Limestone, and Cooper Marl. As mapped, also includes younger clastics of indefinite Late Tertiary age. "COOPER MARL" (Ecm). It is now recognized that this unit is not the precise lithologic or biostratigraphic equivalent of type Cooper Marl (Huddlestun, Marsalis & Pickering, 1974). SANDERSVILLE LIMESTONE (Es).

Etw — TWIGGS CLAY

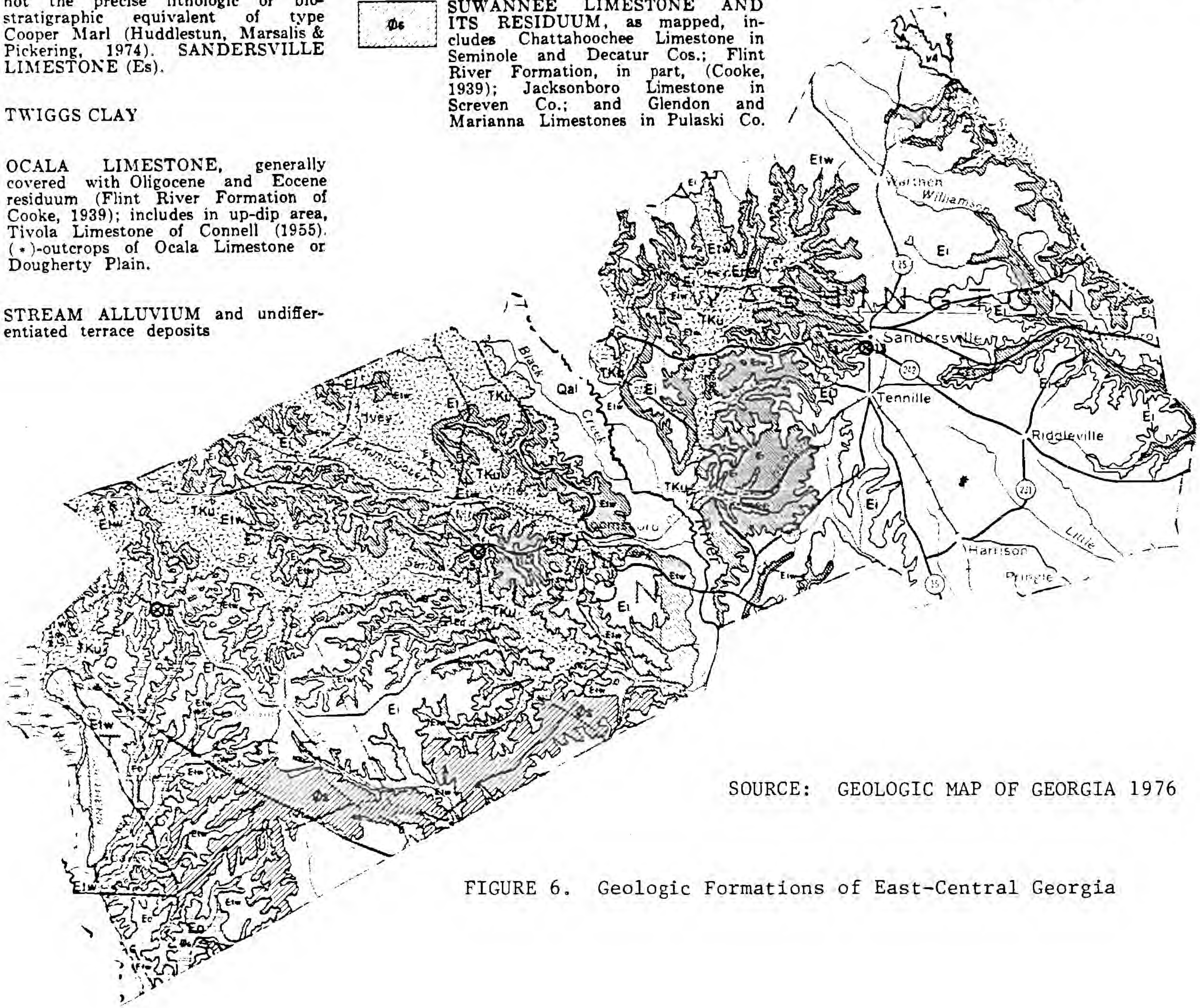
Eo — OCALA LIMESTONE, generally covered with Oligocene and Eocene residuum (Flint River Formation of Cooke, 1939); includes in up-dip area, Tivola Limestone of Connell (1955). (•)-outcrops of Ocala Limestone or Dougherty Plain.

Qal — STREAM ALLUVIUM and undifferentiated terrace deposits

Nu — NEOGENE UNDIFFERENTIATED, includes Altamaha Grit (Dall, 1892); Citronelle Formation (Matson & Berry, 1916); and "Hawthorn Formation" (Cooke, 1939). (•)-outcrops of indurated sandstone and claystone

Øs — SUWANNEE LIMESTONE AND ITS RESIDUUM, as mapped, includes Chattahoochee Limestone in Seminole and Decatur Cos.; Flint River Formation, in part, (Cooke, 1939); Jacksonboro Limestone in Screven Co.; and Glendon and Marianna Limestones in Pulaski Co.

TKu — LOWER TERTIARY-CRETACEOUS UNDIFFERENTIATED, as mapped includes Middendorf Formation (Sloan, 1904); "Channel Sands" (LaMoreaux, 1946); Tuscaloosa Formation (Cooke, 1939); and "Huber beds" (Buie, informal terminology)



SOURCE: GEOLOGIC MAP OF GEORGIA 1976

FIGURE 6. Geologic Formations of East-Central Georgia

qla QUARTZITE/MICA SCHIST

gr1 GRANITE UNDIFFERENTIATED

gr3 GRANITE/GRANITE GNEISS

gg1 GRANITIC GNEISS UNDIFFERENTIATED

gg4 GRANITE GNEISS/AMPHIBOLITE

v3 FELSIC METAVOLCANICS

v4 UNDIFFERENTIATED METAVOLCANICS/SERICITE PHYLLITE/META-ARGILLITE/QUARTZ MICA SCHIST

v5 META-ARGILLITE/SERICITE PHYLLITE/METAVOLCANICS

mm8 AMPHIBOLITE/BIOTITIC GNEISS/QUARTZ SERICITE SCHIST

pms5 SERICITE SCHIST

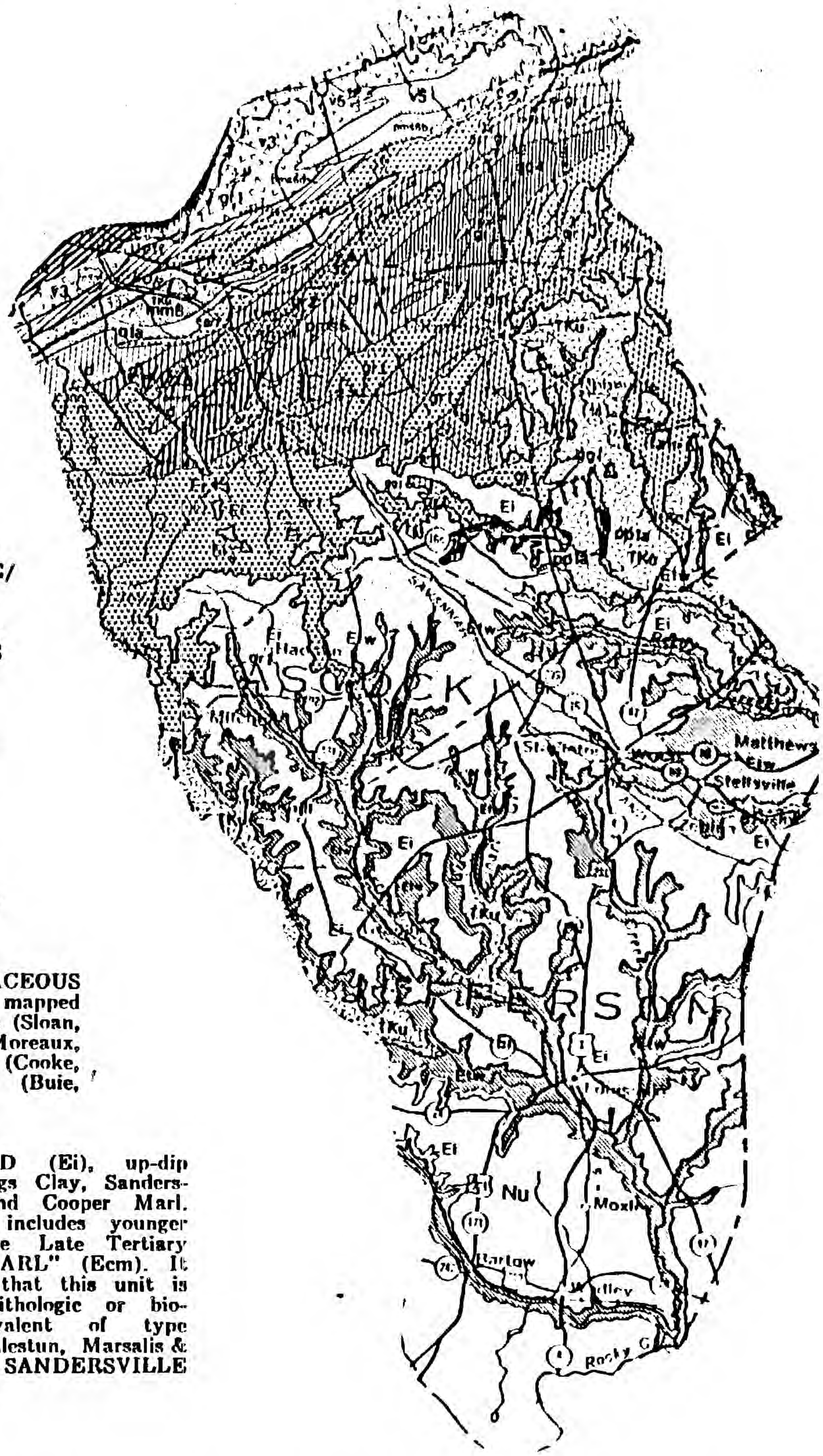
bms6a QUARTZ SERICITE SCHIST/BIOTITIC GNEISS

TKu LOWER TERTIARY-CRETACEOUS UNDIFFERENTIATED, as mapped includes Middendorf Formation (Sloan, 1904); "Channel Sands" (LaMoreaux, 1946); Tuscaloosa Formation (Cooke, 1939); and "Huber beds" (Buie, informal terminology)

Ei Ecm Es IRWINTON SAND (Ei), up-dip equivalent of Twiggs Clay, Sandersville Limestone, and Cooper Marl. As mapped, also includes younger clastics of indefinite Late Tertiary age. "COOPER MARL" (Ecm). It is now recognized that this unit is not the precise lithologic or biostratigraphic equivalent of type Cooper Marl (Huddlestun, Marsalis & Pickering, 1974). SANDERSVILLE LIMESTONE (Es).

Etw TWIGGS CLAY

Nu NEOGENE UNDIFFERENTIATED, includes Altamaha Grit (Dall, 1892); Citronelle Formation (Matson & Berry, 1916); and "Hawthorn Formation" (Cooke, 1939). (•)-outcrops of indurated sandstone and claystone



SOURCE: GEOLOGIC MAP OF GEORGIA 1976

FIGURE 7. Geologic Formations of East-Central Georgia

TABLE 1. Summary of the Coastal Plains Geology of East-Central Georgia (LeGrand, 1956)

System	Series	Formation	Thickness in area, ft.	General Character	Water Bearing Properties
	Miocene	Hawthorn Formation	0 - 125±	Commonly massive, mottled orange and gray coarse sandy clay.	Thin, relatively impervious unit. Yields moderate supplies to dug-wells only.
	Oligocene	Suwanee Limestone	0 - 50	Cherty limestone and some mottled red clay.	Too thin to be of major importance Solution cavities in limestone yield some water.
Tertiary	Eocene	Barnwell Formation	0 - 220	Composed chiefly of brilliant red sand grading downward into interbedded yellow sand and gummy clay lamina. Thick beds of fullers earth, typical of basal member, Twiggs clay, thin fossiliferous limestone beds are present throughout formation, though sporadically leached away.	Very permeable. Coarse, loose sands characterizing much of formation, yield bountiful supplies of potable ground water. Extensive outcrop area favors high recharge, artesian water is obtained S.E. from area of outcrop, impermeable basal clay member acts as confining stratum between sands of Barnwell and water bearing strata below.
		McBean Formation	0 - 150	Consists of gray and yellow calcareous sand and fossiliferous limestone beds.	Composed of permeable sand and marl beds, but relatively unimportant as an aquifer because of its thinness and limited outcrop area.
	Upper Cretaceous	Tuscaloosa Formation	0 - 850	Generally composed of pink & white kaolinic micaceous sands. Cross bedded sands are common but thin clay beds are rare. Upper part of formation generally contains considerable white kaolin.	Excellent aquifer. Preponderance of sands allows easy transmission of water in zone of saturation. Deep permeable beds hold artesian water and are a practicable source of water in much of area. Natural recharge of the aquifer is abundant. Water of good quality.
Pre-Cretaceous	Crystalline			Schist, biotite, gneiss & granite of Precambrian age and porphyriticmuscovite and biotite gneiss of Paleozoic age.	Supplies small private industrial and municipal wells. Individual wells rarely produce over 50 gpm.

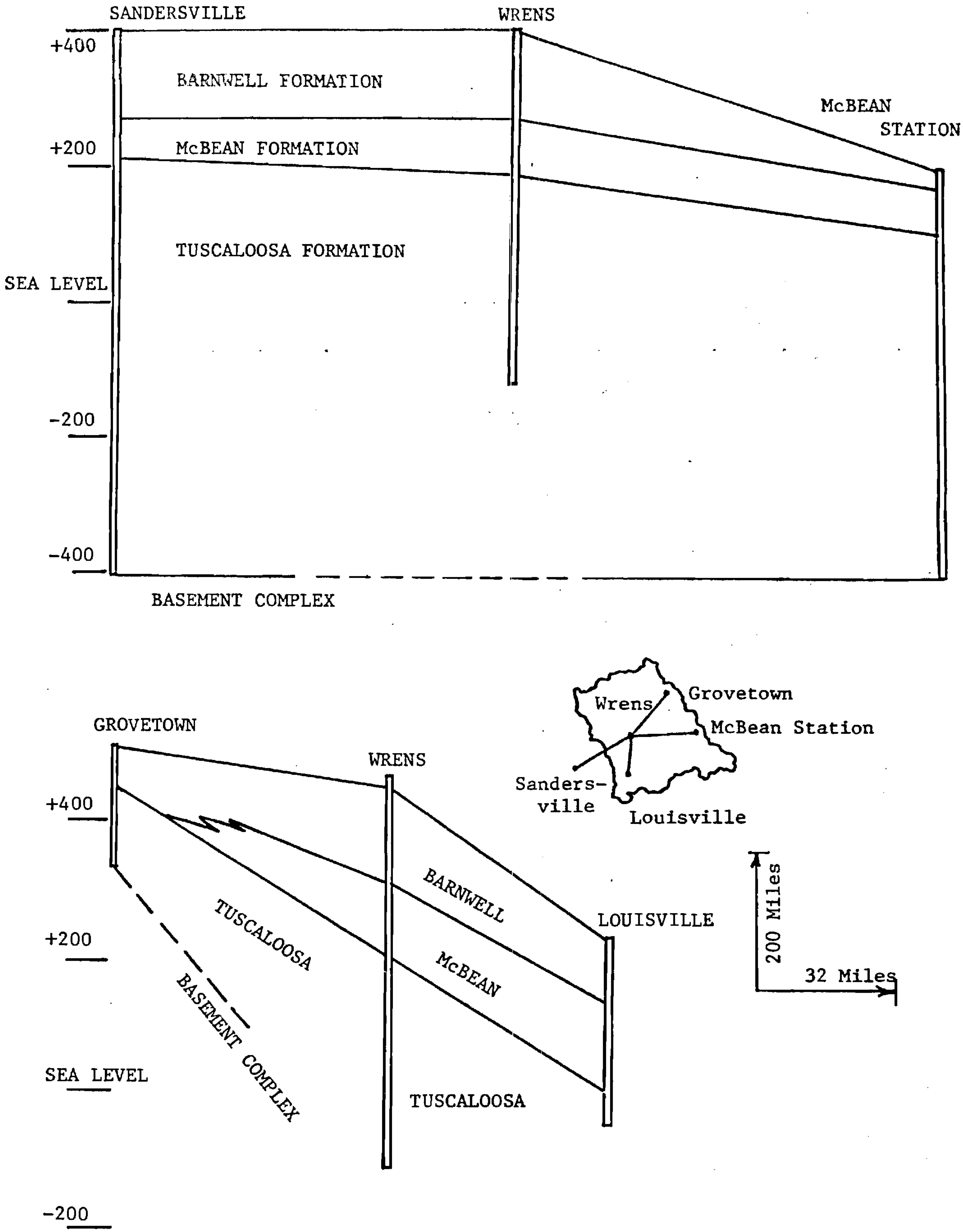


FIGURE 8. Generalized Cross Section Through Wrens, Georgia
(Georgia Geologic Survey Bulletin 64)

Throughout Georgia, the basal sedimentary beds of the Coastal Plain lie on crystalline rocks which include granite, granite gneiss, diorite, and diorite gneiss, diabase, hornblende, mica schist, and quartzite. Erosion with time has levelled the edges of the upturned beds. Because of their complexity, these rocks do not have the continuity of water-bearing beds as those of the Coastal Plain. Only rarely do wells produce sufficient ground water for municipal or industrial demands. At many localities in Warren, McDuffie, and other counties of the Piedmont, a series of several wells may be needed.

Following the final metamorphism and uplift of these crystalline rocks, a long period of erosion occurred during which the surface of these rocks was reduced to a peneplane. The Tuscaloosa formation of the Upper Cretaceous Age lies unconformably on the peneplaned crystalline rocks and crops out as shown in Figure 6. Throughout most of east-central Georgia, the clays, sands, and gravel of the Tuscaloosa formation are overlain by deposits of the Eocene Age. During the Eocene Age, 150-200 feet of sand, clay, marl, and limestone were deposited in a shallow marine sea. These deposits, referred to as the Barnwell and the McBean Formations, have been divided into a Twiggs Clay member, Irwinton Sand member, and a thin unnamed sand layer. Lying unconformably on these formations are undifferentiated deposits of Miocene and Oligocene Ages. Some recent alluvium deposits are also present along the river channels. Since the Tuscaloosa and Barnwell formations play an important role in the ground water of the east-central Georgia, they will be dealt with in more detail subsequently.

The McBean formation is composed chiefly of green fossiliferous calcareous sand and marl. Because adequate water supplies have been obtained from the underlying Tuscaloosa and overlying Barnwell formations, the water-bearing properties have never been fully tested. However, in the study area, it is comparatively thin with little outcrop area and therefore has little water supply use. The Eocene formation as a whole dips southeastward at slightly less than 15 feet per mile.

Eocene--Barnwell Formation - The Barnwell formation is an important aquifer in this area and has a greater areal extent than any other formation. Consisting of red ferruginous sand and clay, it has been divided into three parts; the Twiggs Clay member, the Irwinton Sand member, and a thin upper member of coarse red sand with flat round pebbles.

The Twiggs Clay member consists of about 25 to 50 feet of pale green clay and limestone layers. In east-central Georgia it dips southeast about 15 feet per mile. Wells penetrating solution cavities in this aquifer yield supplies of up to 150 gpm, but the water is often high in hardness and dissolved solids.

The Irwinton Sand member consists of beds of fine to coarse loose sand lying unconformably on the Twiggs Clay member. The sands form the upland areas in the Red Hills. This 15 to 50-foot thick member is an excellent source of groundwater because it is underlain by the less permeable Twiggs Clay. It supplies water to many shallow non-artesian wells and deeper artesian wells. Yields are not large but are adequate for rural demands. Down-dip from the outcrop area, the yields from drilled wells increase substantially and may be as much as 300 gpm.

The upper sand member is highly weathered throughout and seldom exceeds 20 feet in thickness. Therefore, it is not a good aquifer. Moreover, the channel sands, which may be a part of the Barnwell Formation but separate the Barnwell and Tuscaloosa Formations at some locations, are discontinuous and do not provide a usable supply of water.

Cretaceous--Tuscaloosa Formation - As shown in Figures 6 and 7, the Tuscaloosa formation is exposed in a belt in eastern Georgia as much as 18 miles wide bordering the Piedmont province. In the western portion of the study area, the belt narrows to two to three miles. It also outcrops as V-shaped exposures in valleys where streams have washed the younger sediments away. In these areas of outcrop, the Tuscaloosa is less than 150 feet in thickness and thins even more to the north. However, at Wrens in Jefferson County, where it is under cover and down-dip, it is 355 feet thick. At Louisville in south Jefferson County, an oil well completely penetrates the Coastal Plain and encounters crystalline rock at 1140 feet below the surface. At this point, the probable thickness of the Cretaceous formation is 790 feet.

The Tuscaloosa formation consists of arkosic sand composed of angular quartz grains, along with white to gray, yellow and pink kaoline and mica. Discontinuing lenses of gray clay are present throughout the formation and balls of pure white kaoline are common.

The coarse, permeable sand and gravel beds of the Tuscaloosa formation are an excellent source of water and the best source for east-central Georgia. Water from these sands, at depths accessible to wells, is extensively used for domestic, municipal, and industrial supplies. In the outcrop area, wells less than 40 feet deep reach large sources of water. The Tuscaloosa deposits become deeper to the south and east because of the inclination of the strata. Wells drilled to the water bearing sands of this formation yield more than 800 gpm for municipal and industrial use at many locations throughout the area. Northwest of a line connecting Sandersville, McIntyre, and Huber, the Tuscaloosa Formation thins updip to the Fall Line. As the sand and gravel beds thin and the catchment decreases, the yield attainable also decreases. Southeast of a line between Huber and Sandersville, supplies of 500 gpm or more may be expected.

Water in the outcrop areas is generally under water-table conditions. However, down-dip and under impermeable beds, the Tuscaloosa formation yields artesian water. In the floodplains of the Ocmulgee and Oconee Rivers and along some of their tributaries, conditions of artesian flow exist. These areas were delineated by LaMoreaux (1946) and have been substantiated by data obtained since the original study. The waters, as well as water in general from the Tuscaloosa formation, are low in dissolved mineral content.

Drainage

Drainage in the study area is influenced by four major rivers and numerous streams as shown in Figures 9 and 10. The Ogeechee River flows in a southeasterly direction dividing the study area north to south as well as forming the country line between Washington, Glascock and Jefferson counties. The river is approximately 100 feet wide and is characterized by low swampy banks. The Ogeechee has two major southeast flowing tributaries. The Little Ogeechee drains the northern portion of Washington County, and Williamson Swamp Creek drains diagonally across eastern Washington County.

The Oconee River, although not the largest river in the study area, has the greatest drainage area. The river flows in a southeasterly direction dissecting the study area and forming the county boundary between Washington and Wilkinson Counties. It is approximately 200 feet wide and is characterized by low swampy banks. At some places, its floodplain is five to six miles wide. Southwest-flowing tributaries are Gumm, Bluff, and Buffalo Creeks. Gumm Creek forms a portion of the boundary between Washington and Baldwin Counties. Buffalo Creek is the largest of the three tributaries. Southeast-flowing tributaries are Commissioners and Big Sandy Creeks. These two major tributaries drain all of Wilkinson and northeast Twiggs Counties as well as portions of Baldwin and Jones Counties to the north of the study area.

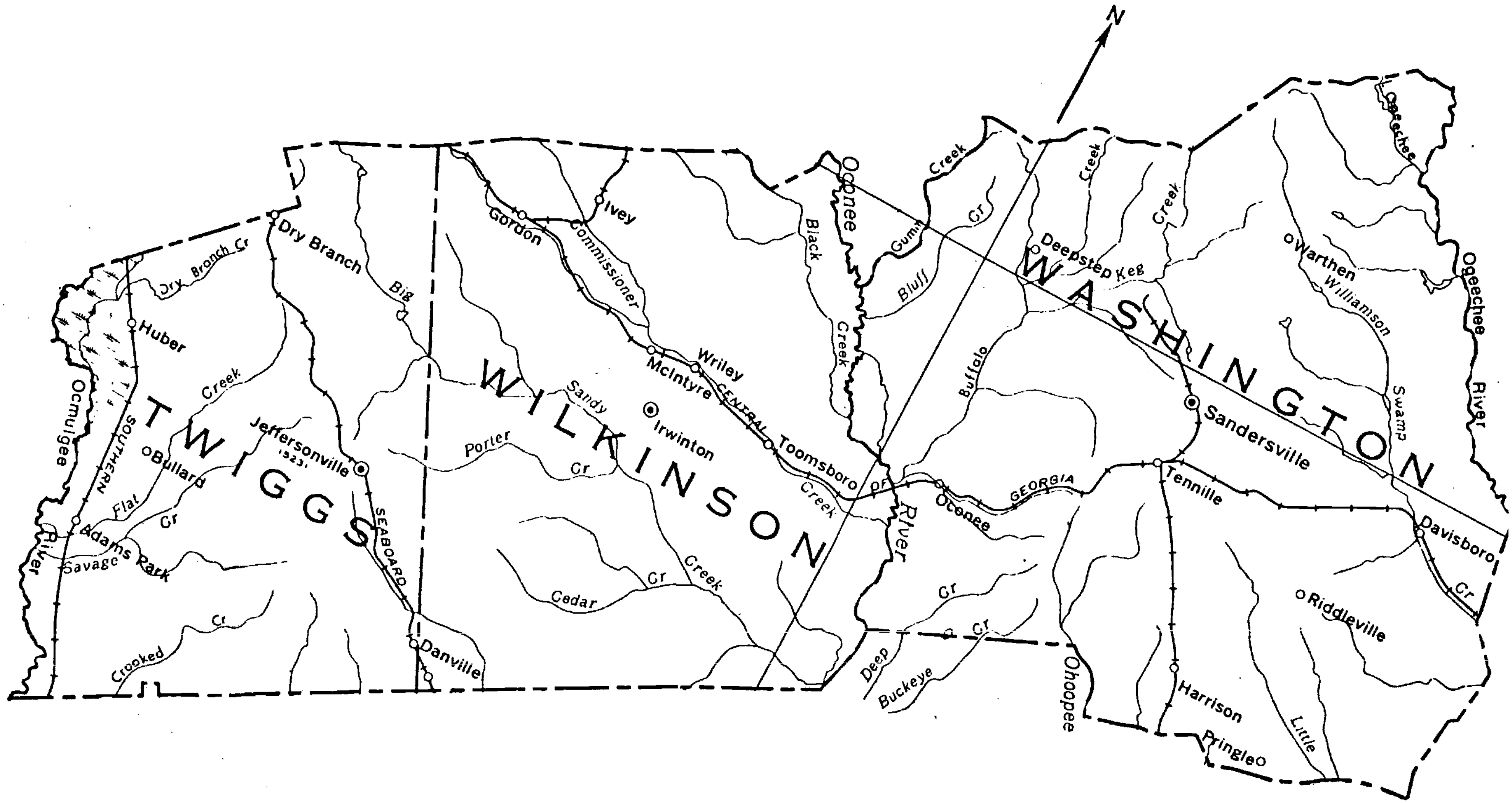


FIGURE 9. Drainage Pattern Base Map for Washington, Wilkinson and Twiggs Counties

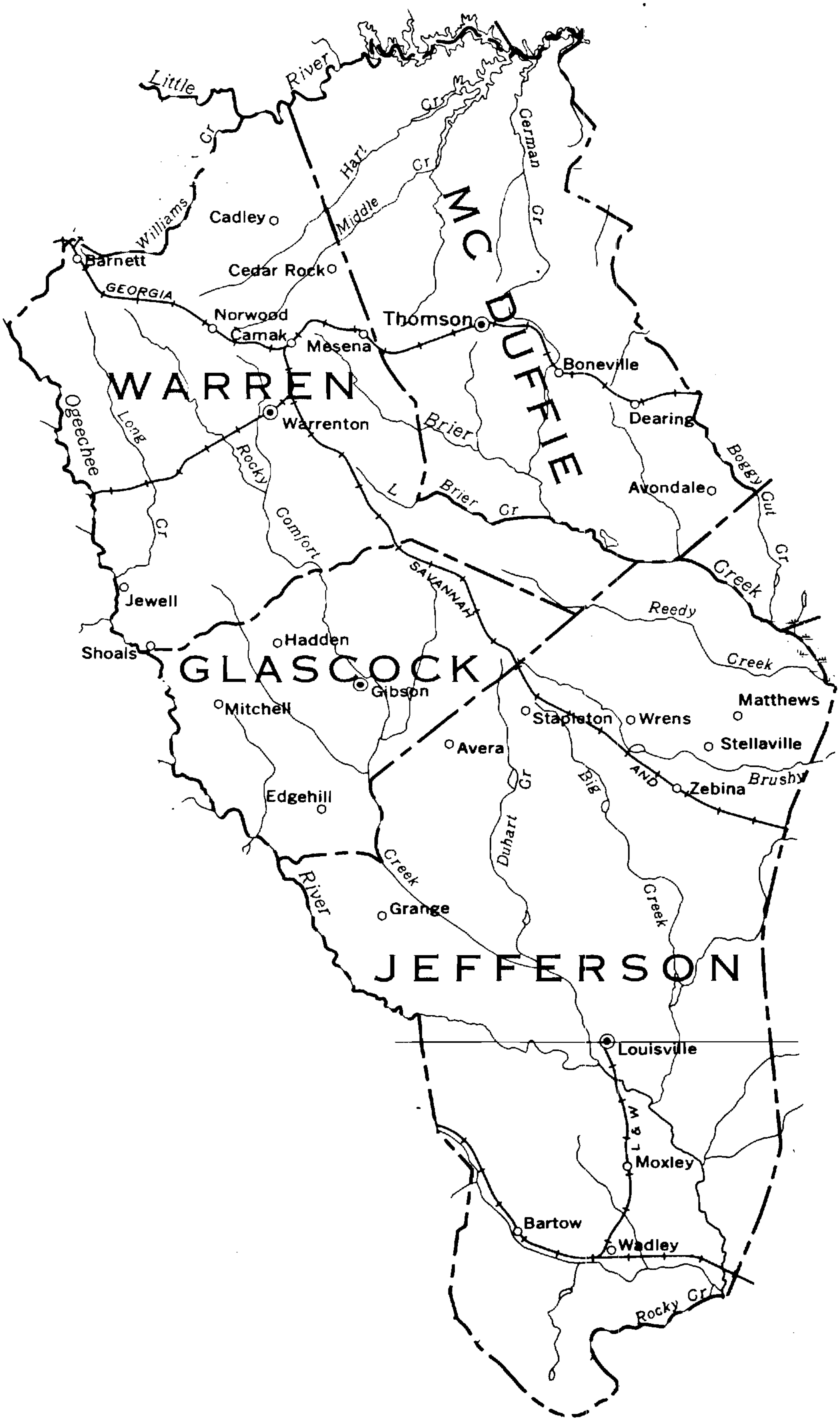


FIGURE 10. Drainage Pattern Base Map for Glascock, Jefferson, Warren and McDuffie Counties

The Ocmulgee River flows in the southeasterly direction forming the western boundary of the study area and the Twiggs County line. The major tributaries from north to south are Dry Branch Creek, Flat Creek, Savage Creek, and Crooked Creek. Flat and Savage Creeks exert the greatest drainage influence flowing southwest diagonally across Twiggs County. The Ocmulgee is comparable in size and nature to the Oconee River with a wide swampy floodplain. The Ocmulgee and Oconee Rivers meet about 45 miles south of the study area to form the Altamaha River.

Tributaries of the Savannah River, which is to the east, drain much of the eastern four counties. The Little River, which forms the northern boundary of Warren and McDuffie counties, drains much of the Piedmont before it empties into the Savannah. Hart, Middle, and German creeks all flow northeast to drain the Piedmont province into the Little River. Briar Creek and Rocky Comfort Creek both drain in a southeasterly direction from Warren, McDuffie and Jefferson counties. They are swift in the Piedmont province and develop swamps as their slope lessens in the south. Other, smaller creeks, such as Big Creek, Bushy Creek, and Reedy Creek, all help to drain the Coastal Plain area.

Climate

The climate of east-central Georgia is typified by long, warm summers and short, mild winters. Snowfall is extremely rare. The average annual temperature is 61°F. During a typical day in January, the temperature ranges from 40° to 62° F and in July from 70° to 93° F. During the year, the temperature drops below 32° F. in the Piedmont area about 50 times; in the Coastal Plain about 10 times. The frost-free growing season of the area is about 240 days.

The mild and humid climate of the area is accompanied by an average annual precipitation of 47 inches which is fairly well distributed throughout the year. The summer months usually receive the largest amount of rain with the fall months receiving the least. Short, heavy, sporadic showers characterize the summer precipitation; steady, gentle winter rains soak the ground and furnish the recharge for ground water storage.

Population

The historical and projected populations of each county are listed in Tables 2 and 3 and are shown graphically in Figures 11 and 12. The Twiggs County statistics were obtained from a report entitled Population - Economic Study Update - 1975 published in 1975 by the Middle Georgia Area Planning and Development Commission. The Washington and Wilkinson County statistics were obtained from a report entitled Oconee Area Economic Base and Population Study published in 1972 by the Oconee Area Planning and Development Commission. The statistics for the remaining counties were obtained from the U.S. Census (1970) and from a report published by the Georgia Office of Planning and Budget entitled Population Projections for Georgia Counties 1900-2000. Specific details on methodologies used to develop these projections are included in each report.

The pattern of population trends in the area has generally followed that of the Southeast. Outmigration from rural to urban areas has occurred on a large scale. Most of the smaller towns are expected to grow, but the rural farm population is expected to continue to decline. The absence of new jobs in rural areas compels young people to seeks jobs in the city where they enter the labor force. Automation on the farm has greatly reduced the number of employees needed and consequently the number of residents in rural locations. The projections for Twiggs, Washington and Wilkinson counties show a reversal in this general trend with a stabilization and moderate

TABLE 2. County Populations; Historical and Projected

Year	Twiggs County Population	Twiggs County % Change	Washinton County Population	Washinton County % Change	Wilkinson County Population	Wilkinson County % Change
1940	9,117		24,230		11,017	
		-8.3		-13.3		-11.0
1950	8,308		21,012		9,781	
		-4.5		- 9.6		- 5.5
1960	7,935		18,903		9,250	
		+3.6		- 7.5		+ 1.5
1970	8,222		17,480		9,393	
		+1.4		+10.0		+ 5.8
1980	8,335		19,228		9,941	
		+4.0		+10.0		+ 7.4
1990	8,670		21,150		10,680	
		+2.8		+10.0		+ 7.1
2000	8,915		23,265		11,440	

TABLE 3. County Populations; Historical and Projected

Year	Glascock County		Jefferson County		McDuffie County		Warren County	
	Population	% Change	Population	% Change	Population	% Change	Population	% Change
1950	3,579		18,855		11,443		8,779	
		-25.3		-7.4		+10.3		-16.2
1960	2,671		17,460		12,627		7,360	
		-14.7		-1.7		+21.0		- 9.4
1970	2,280		17,174		15,276		6,669	
		+ .9		-2.8		+ 0.2		- 8.5
1980	2,300		16,700		15,300		6,100	
		+ 4.3		-2.4		+ 2.6		- 3.3
1990	2,400		16,300		15,700		5,900	
		- 4.2		-6.1		- 1.3		-11.9
2000	2,300		15,300		15,500		5,200	

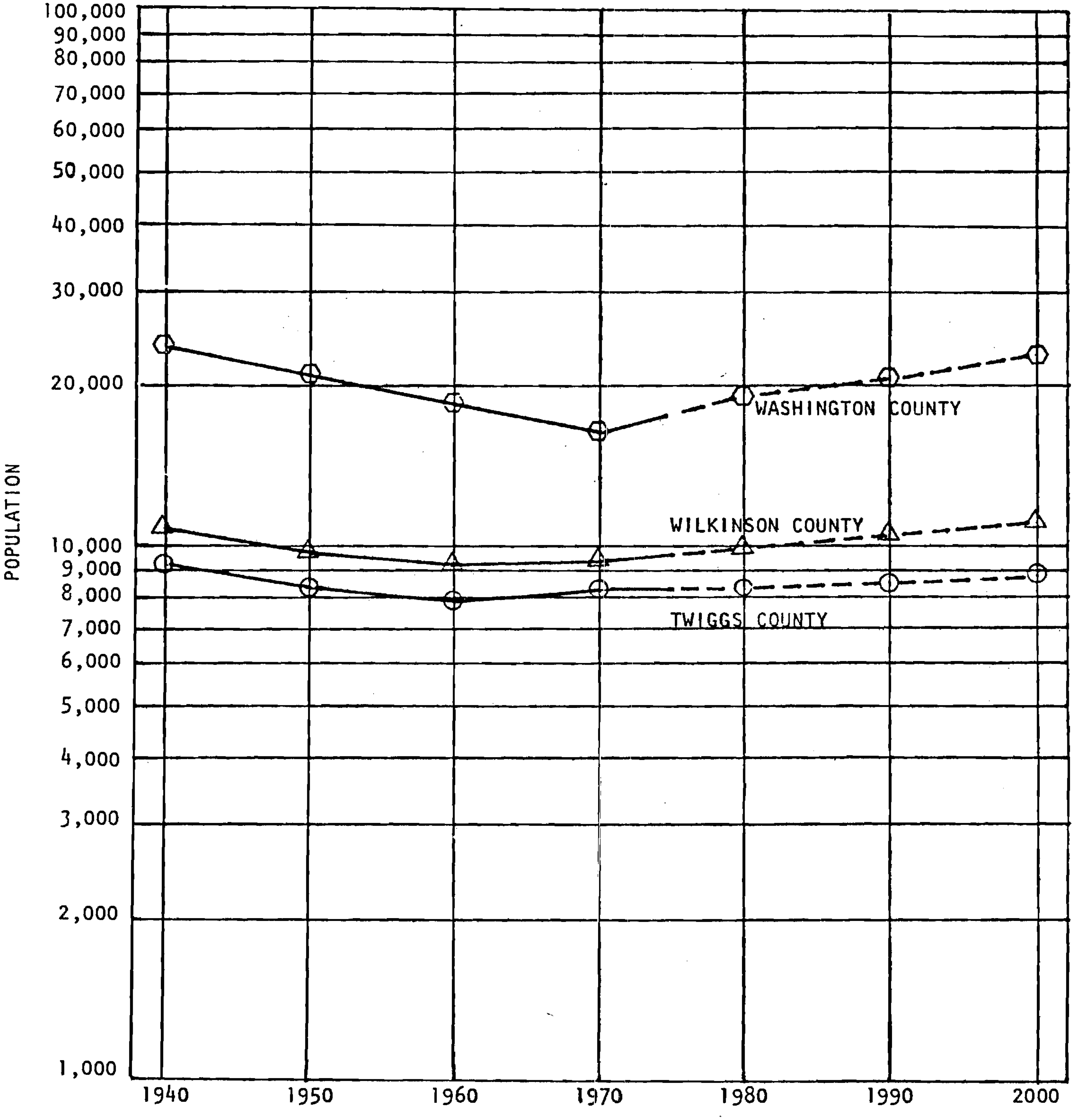


FIGURE 11. Historical and Projected Populations

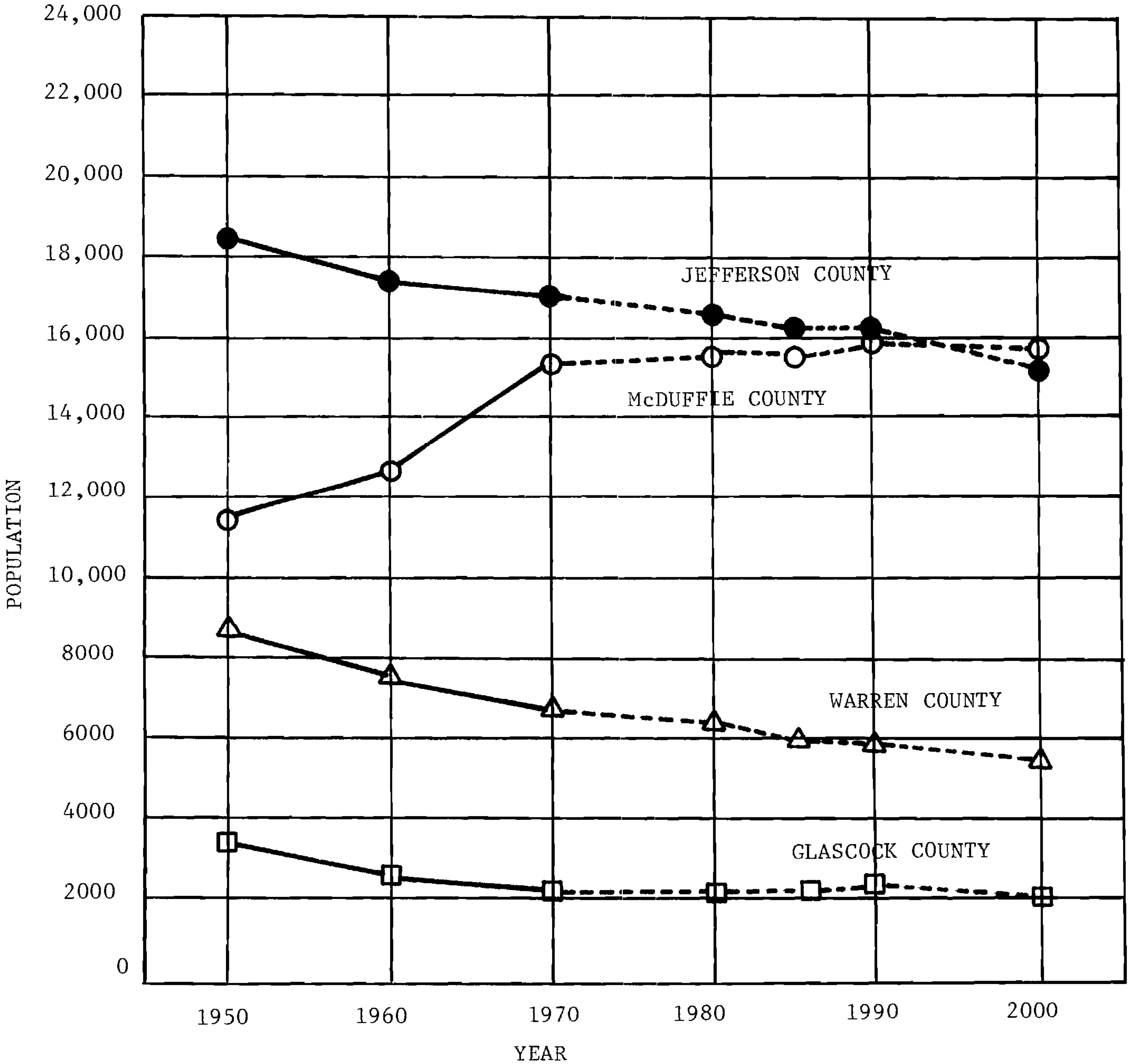


FIGURE 12. Historical and Projected Populations.

growth predicted for the future. Based on a broad economic base of valuable natural resources, these projections seem to be reasonable. The population increases should occur in and around the small towns and cities scattered across the three-county area.

A few of the cities and towns have become convenient locations for small industries. Warrenton and Thomson serve as textile and agricultural centers. Louisville, the old State capital, has large agricultural services and tourist facilities plus some manufacturing. However, since Jeffe son, Glascock and Warren counties are basically agriculture oriented, a population decline is projected.

McDuffie County is not following this trend of decline which is probably related to the fact that Thomason is the city with the largest population in the seven-county area. Also, Thomson is the largest center for commerce in the area. Employment is high in areas of paper and textile products, foods, and rubber and plastic products. The rise of population in this county seems reasonable.

<u>Economic Profile</u>

Historically, the study area of Georgia has depended upon agriculture as the principal economic activity. Field crops, especially cotton, were a major source of income. The production of agricultural goods and first stage processing provided jobs for most of the labor force even as late as 1950. However, since World War II, industrial growth has been experienced, primarily based on minerals, forest resources, and the introduction of textile and apparel mills. Mineral products produced include kaolin, fullers earth, limestone, bauxite, granite, quartz, peat, sand, gravel, and rock. Moreover, agricultural production has become more diversified with a shift from field crops to increased production of timber, livestock, and poultry. Commercial forests of oak, hickory, and various pines occupy approximately 70 percent of the area.

The recent industrial expansion has been greatly facilitated by the presence of an abundant supply of high quality groundwater. This readily available supply of water has been especially important in the development if the mineral industry in the area. Primary development in the mineral industry has been with kaolin clays with estimated reserves between 5 and 15 billion tons. Washington County alone is presently the largest producer of kaolin in the United States.

CURRENT WATER USERS AND TREATMENT SYSTEMS IN THE STUDY AREA

Current Water Demand

Current water demand was determined using information compiled from previous studies and the permit files of the Water Supply Branch of the Environmental Protection Division (EPD) of the Georgia Department of Natural Resources. The EPD files contain detailed information on municipal water supply systems and surface and groundwater users for the entire State of Georgia.

Information on municipal water supply systems for the seven counties was compiled from the EPD files and is presented in Tables 4 through 8. Information was collected for only Class II systems; i.e., those providing services to at least 100 people. Information presents source and storage facilities by type and size and each well is described by depth, size, year drilled, and yield.

Information on major groundwater users for each of the seven counties was compiled from the EPD files and is presented in Tables 9 though 12. Locations of wells are shown in Figures 13 and 14. Different size circles are used to show the location of these groundwater users and provide a picture of the distribution of groundwater use in the study area. The information was obtained from groundwater use permits required by the state for any user

TABLE 4. Water Supply System for Washington County

County	Owner/Facility	Source of Supply: Well No.	Total Depth, ft.	Diam., in.	Year Drilled	Yield, gpm	Storage Facilities: Type	Size, gal.
Washington	American Industrial Clay Co., Sandersville	1	400	12/10	1969	750	Elevated	40,000
		2	385	8	1961	500		
		3	420	12/10	1966	750		
		4	430	12/10	1971	750		
	Davisboro	1	(not in use due to high concentration of undesirable chemicals)					
		2	503	8	1972	354	Elevated	100,000
	Deepstep	1	200	-	1966	60	Pressure	5,000
	Harrison	1	700	8	1967	800	Elevated	75,000
	Oconee	1	311	8	-	100	Standpipe	113,000
	Riddleville	1	500	8	-	120	Pressure	5,000
	Sandersville	1	200	6	UKN	75	Elevated	400,000
		2	700	10	1944	250	Ground	150,000
		3	550	8	1953	300		
		4	400	8	1960	175		
		5	750	8	1960	500		
		6	550	10	1966	600		
	Tennille	1	165	12	1962	450	Elevated	250,000
	Warthen	1	301	-	1971	163	Pressure	5,000

TABLE 5. Water Supply System for Wilkinson County

		Source of Supply					Storage Facilities	
County	Owner/Facility	Well No.	Total Depth, ft.	Diam., in.	Year Drilled	Yield, gpm	Type	Size, gal.
Wilkinson	Allentown	1	525	8	1965	200	Elevated	75,000
	Gordon	1	–	8	1940	100	Elevated	200,000
		2	275	6	1966	230		
		3	344	6	1970	500		
	Irwinton	1	160	6	1954	200	Elevated	17,000
		2	270	6	1956	400	Ground	20,000
		3	260	6	1972	600		
	Ivey	1	220	8	1965	50	Pressure	5,000
		2	238	6	1970	200	Pressure	5,000
	McIntyre	1	230	–	1956	200	Elevated	100,000
	Toomsboro	1	300	8	1950	375	Ground	65,000
		2	300	8	1955	150		

TABLE 6. Water Supply System for Twiggs County

		Source of Supply					Storage Facilities	
County	Owner/Facility	Well No.	Total Depth, ft.	Diam., in.	Year Drilled	Yield, gpm	Type	Size, gal.
Twiggs	Danville	1	795	12	1965	160	Elevated	75,000
	Georgia Kaolin Co., Dry Branch	1	UKN	UKN	1945	250	Ground	20,000
		2	UKN	UKN	1945	170		
		3	372	10	1955	450		
		4	552	10	1965	600		
		5	431	12	1968	800		
	Jeffersonville	1	570	8	1957	N.R.	Clearwell	UKN
	J. M. Huber Corp.	1	250	8	1938	584	Elevated	75,000
		2	200	8	1951	584		
		3	195	8	1961	632		
		4	230	12	1972	1040		
	North Elementary Complex 1, Dry Branch	1	305	6	1975	60	Pressure	500
	North Complex 11,	1	263	4	1957	10	Pressure	500
	South Complex 11, Hwy 96 and 358	1	200	4	-	10	Pressure	500
	Twiggs County Junior High School, Jeffersonville	1	346	6	-	130	Elevated Pressure	10,000 500

TABLE 7. Water Supply Systems for Glascock and Jefferson Counties

		Source of Supply					Storage Facilities	
County	Owner/Facility	Well No.	Total Depth, ft.	Diam., in.	Year Drilled	Yield, gpm	Type	Size, gal.
GLASCOCK								
	Gibson	1	200	8	1970	157	Elevated	165,000
		2	113	8	1963	52		
		3	155	-	1960	31		
	Mitchell	1	90	8	1963	50	Elevated	40,000
		2	90	8	1969	30		
		3	500	18	-	-		
		4	355	18	1968	27.4		
		5	510	20	1975	12.4		
		6	300	8	1964	74.0		
		7	145	20	1975	33.1		
JEFFERSON								
	Avera	1	186	8	-		Elevated	60,000
		2	352	8	1972	350		
		3	147	8	-	50		
	Bartow	1	370		1967	100	Unknown	75,000
		2	415		1969	100		
		3	385		1969	175		
	Louisville	1	367	8	1958	868	Elevated	150,000
		2	348	10	1963	884	Ground	120,000
	Stapleton	1	300	8	1956	50	Elevated	135,000
		2	500	8	1964	75		
		3	266	-	1964	220		
	Wadley	1	481	8	1952	503	Elevated	150,000
		2	280	-	1963	300		
		3	491	8	1976	703		
	Wrens	1	150	10	1941	100	Elevated	410,000
		2	150	8	1950	100		
		3	150	8	1965	175		
		4	200	8	1970	140		

TABLE 8. Water Supply Systems for McDuffie and Warren Counties

		Source of Supply					Storage Facilities	
County	Owner/Facility	Well No.	Total Depth, ft.	Diam., in.	Year Drilled	Yield, gpm	Type	Size, gal.
MCDUFFIE								
	Dearing	1	400	6	1948	90	Elevated	100,000
		2	700	6	1970	40		
		3	500	6	1969	36		
	Kingley Mills	1	379	10	1950	90	Elevated	115,000
		2	383	10	1950	44.5		
	Thomson		Surface Supply		Usery Road Creek Sweetwater Creek		-	-
WARREN								
	Camak	1	610	6	1975	27	Elevated	65,000
		2	620	6	1946	15		
	Briarwood Academy	1	250	6	1970	12	Pressure Tank	1,000
	Norwood	1	600	6	1977	40.5	Elevated	625,000
	Warrenton		Rocky Comfort Creek					

TABLE 9. Major Groundwater Users in Washington County

County	Owner/Facility	Vol., MGD	No. of Wells	Hrs./ Day	Purpose	Use Began
Washington	Anglo-American Clays Corp., Sandersville	2.88	2	18	Process Water	11/73
	American Industrial Clay Co., Chambers Mine	0.72	1	24	Sanitary Facilities Cooling Water, Process Water	-
	American Industrial Clay Co., Franklin Mine	0.72	1	24	Sanitary Facilities Cooling Water, Process Water	-
	American Industrial Clay Co., Sandersville	5.213	5	24	Sanitary Facilities Cooling Water, Process Water	3/58
	Engelhard Minerals and Chemicals Div. Gardener Plant - Oconee	0.2448	3	20	Process Water	1908
	Engelhard Minerals and Chemicals Div. Washington County Mine	1.467	3	20	Process Water	1908
	Freeport Kaolin Co. Scott Mine	2.16	3	24	Process Water	4/76
	Holmes Canning Co.,Sanders-ville	0.20	2	10	Central Water Supply Cooling Water, Process Water	1946 1960
	Thiele Kaolin Co.,Avant Mine	1.154	3	14	Sanitary Facilities, Process Water, Boiler Feed	8/71
	Thiele Kaolin Co.,Hall Mine	0.26	1	12	Sanitary Facilities, Cooling Water, Process Water	6/73
	Thiele Kaolin Co., Main Plant, Sandersville	1.08	1	20	Sanitary Facilities, Process Water, Boiler Feed	-

TABLE 10. Major Groundwater Users in Wilkinson and Twiggs Counties

County	Owner/Facility	Vol., MGD	No. of Wells	Hrs./ Day	Purpose	Use Began
Wilkinson	Engelhard Minerals and Chemicals Div. Gibraltor Mine	1.170	2	18	Process Water	1908
	Engelhard Minerals and Chemicals Div. Klondike Mine	0.78	2	13	Process Water	1908
	Engelhard Minerals and Chemicals Div.- Main Plant, McIntyre	6.44	7	24	Process Water	1908
	Gordon	0.15	3	12	Water Supply	1920
	McIntyre	0.216	1	24	Water Supply	1956
Twiggs	Cyprus Industrial Minerals, Jeffersonville	0.72	1	24	Sanitary Facilities Process Water	10/66
	Georgia Kaolin Dry Branch	4.18	9	19	Sanitary Facilities Central Water Supply Process Water	1937
	J. M. Huber Corp. West of Jeffersonville	31.3	8	24	Consumptive use for Dewatering	9/68
	J. M. Huber Corp. Huber	1.77	4	12	Sanitary Facilities, Cooling Water, Process Water	12/38
	Jeffersonville	0.15	2	12	Central Water Supply	1944

TABLE 11. Major Groundwater Users in Glascock and Jefferson Counties

County	Owner/Facility	Vol., MGD	No. of Wells	Hrs./ Day	Purpose	Use Began
Glascock	Gibson	0.38	3	-	Municipal Water Supply	1960
	Mitchell	0.07	7	-	Municipal Water Supply	1963
	Theile Kaolin Co.	0.30	2	5.5	Sanitary Facilities Central Water Supply Process Water	1971
Jefferson	Avera	0.05	3	-	Municipal Water Supply	1972
	Bartow	0.14	3	-	Municipal Water Supply	1968
	J. M. Huber	1.47	3	20	Process Water	1965
	J. P. Stevens Kaolin Co.	UNK	3	UNK	No Records at EPD	1962
	Louisville	1.66	2	-	Municipal Water Supply	1958
	Stapleton	0.05	3	-	Municipal Water Supply	1956
	Wadley	0.94	3	-	Municipal Water Supply	1952
	Wrens	0.50	4	-	Municipal Water Supply	1941

TABLE 12. Major Groundwater Users in McDuffie and Warren Counties

County	Owner/Facility	Vol., MGD	No. of Wells	Hrs./Day	Purpose	Use Began
McDuffie	Dearing	0.13	3	-	Municipal Water Supply	1948
	Kingley Mills	-	2	-	Municipal Water Supply	1950
Warren	Camak	0.09	2	-	Municipal Water Supply	1946
	Briarwood	1.5	1	-	Municipal Water Supply	1970
	Norwood	-	1	-	Municipal Water Supply	1977

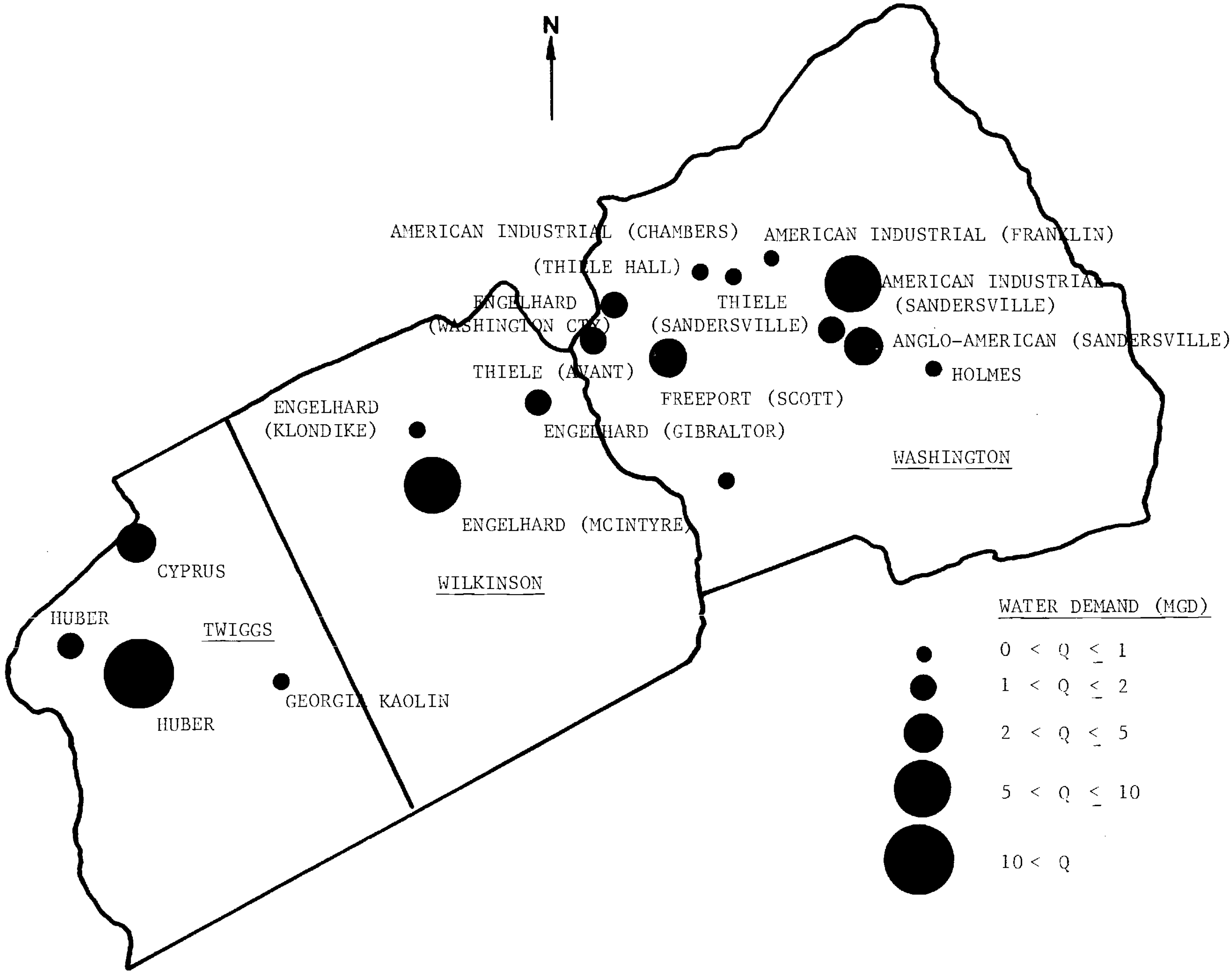


FIGURE 13. Location of Major Groundwater Users in Washington, Wilkinson and Twiggs Counties

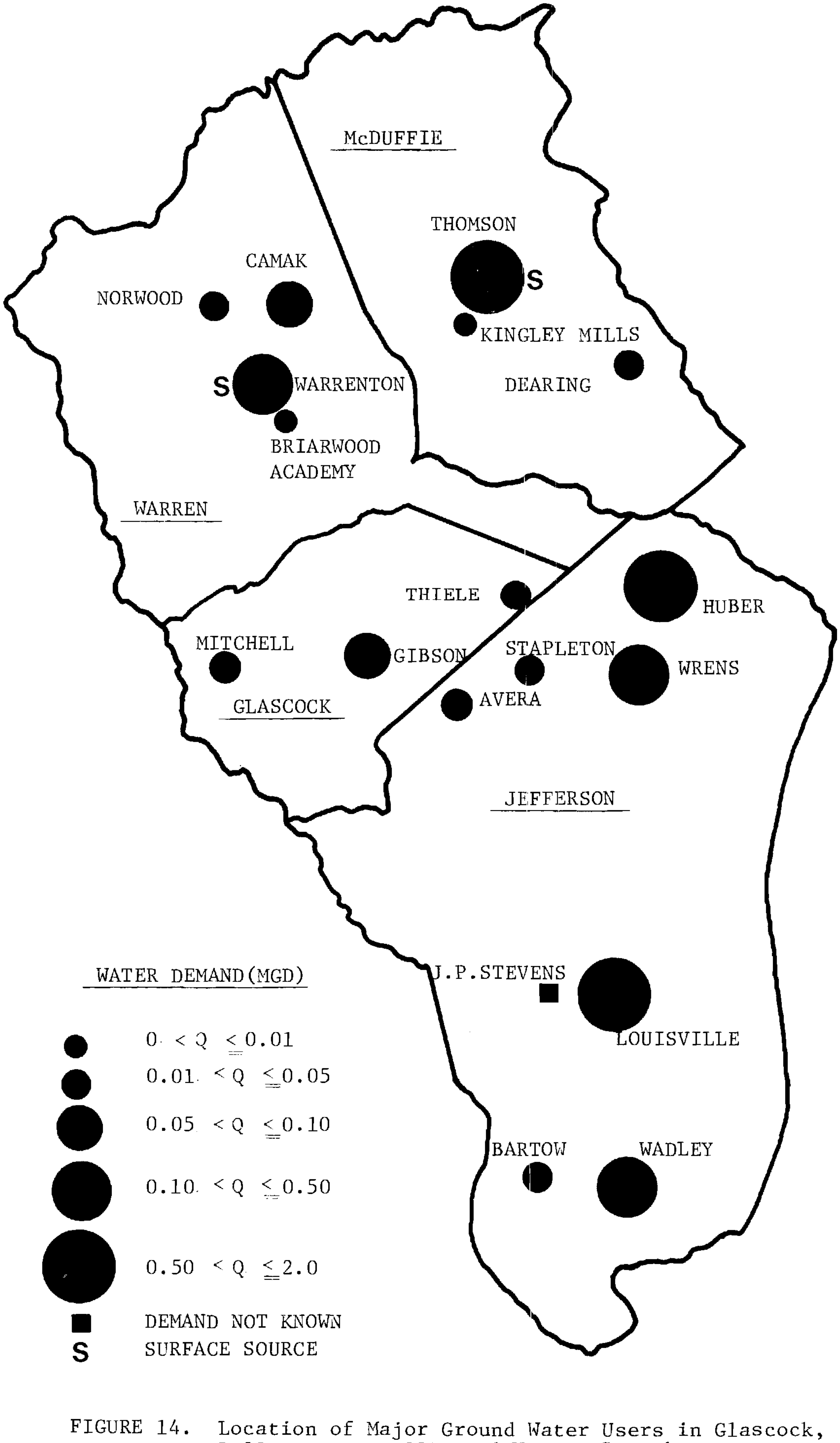


FIGURE 14. Location of Major Ground Water Users in Glascock, Jefferson, McDuffie and Warren Counties.

withdrawing greater than 100,000 gallons per day. The information presented includes the name of the owner or facility, authorized withdrawal, number of wells, hours pumped per day, purpose or use of supply, and the date usage began. Volumes vary from 0.15 to 31.3 MGD. A semi-annual monthly usage report must be filed with the EPD by each user. Presently this usage report appears to be only a formality as the monthly usage figures reported are always the authorized volumes on the permits. Therefore, these values are actually estimates of groundwater withdrawal.

Water Treatment Facilities

Although the availability of water is most important, treatment is often required to provide acceptable supplies for both municipal and industrial activities. Industrial activities in the study area influence the water resources in two ways; either in terms of use or in terms of effluent discharge and associated impact on the environmental receptor or downstream user. Municipal activities exhibit similar influences but, compared to industry, these influences on the water resource are often of lesser magnitude. This would be anticipated to be the case if a new alumina from kaolin industry were established. Depending upon location, such an industrial expansion with its associated influx of population could cause an overloading of existing municipal treatment facilities.

Information on municipal water treatment plants for the seven counties of the study area was compiled from EPD files, Water Quality Management Unit reports, and other earlier reports and is presented in Tables 13 and 14 and Figures 15 and 16. Each treatment facility is described by location, raw water source, rated capacity, average daily flow, type of treatment, and the population served. The last two columns, potential population and percent change in population, are calculated values which can be used as indications

TABLE 13. Municipal Water Treatment Facilities in Washington, Wilkinson and Twiggs Counties

County	Location	Source	Rated Cap., MGD	Ave. Flow, MGD	Treatment Type	1970 Population Served	1970 Population	Potential Population	Population % Change
Washington	Davisboro	Well	0.5	0.1	C	480	480	1600	233
	Deepstep	Well	0.0864	0.04	C	100	100	144	44
	Harrison	Well	0.80	0.05	C	330	330	3520	960
	Oconee	Well	0.03	0.017	C,K	260	260	305	17.3
	Riddleville	Well	0.043	0.015	C	150	105	280	87
	Sandersville	Well	2.16	0.93	C,K	5550	5550	8600	55
	Tennille	Well	1.296	0.248	C	1750	1750	6100	248
	Warthen	Well	0.06	0.015	C,S	125	200	333	167
Wilkinson	Allentown	Well	0.72	0.035	C,K	450	295	6170	1270
	Gordon	Well	1.0	0.25	C,K,S	2500	2600	6670	167
	Irwinton	Well	0.1	0.1	C,K	750	750	750	0
	Ivey	Well	-	0.05	C,K	350	245	-	-
	McIntyre	Well	0.216	0.15	F,C,K	1200	971	1200	0
	Toomsboro	Well	-	0.055	C,K	800	682	-	-
Twiggs	Danville	Well	0.075	0.025	C,K	500	500	1000	100
	Jeffersonville	Well	0.30	0.15	A,F,C,S	1300	1300	1730	33

Treatment Key:

A - Aeration
C - Chlorination
F - Filteration
K - Corrosion Control
V - Fluoridation
S - Softening

TABLE 14. Municipal Water Treatment Facilities in Glascock, Jefferson, McDuffie and Warren Counties

County	Location	Source	Rated Cap., MGD	Ave. Flow, MGD	Treatment Type	1970 Population Served	1970 Population	Potential Population	Population % Change
Glascock	Gibson	Well	0.38	0.079	C,K	700	701	2245	221
	Mitchell	Well	0.07	0.009	C,K	75	187	390	108
Jefferson	Stapleton	Well	0.045	0.035	C,K	392	390	390	-
	Louisville	Well	1.50	0.80	C,K,F	4000	2691	5000	25
	Wadley	Well	0.94	0.25	C,V	2450	1989	6140	151
	Wrens	Well	0.50	0.20	C	1628	2204	2710	66.5
	Avera	Well	0.05	0.025	C,K	220	217	290	31.8
	Bartow	Well	0.14	0.05	C	400	333	750	87.5
McDuffie	Dearing	Well	0.13	0.035	C	560	555	1380	146
	Thomson	Surface	1.0	0.5	F,C,K	4972	6503	6630	33.3
	Kingley Mills	Well	-	0.01	-	150	150		
Warren	Camak	Well	0.09	0.012	C	300	224	1500	400
	Warrenton	Rocky Comfort Ck Surface	1.5	.25	F,C	2603	2073	10400	300

Treatment Key:

A - Aeration
C - Chlorination
F - Filteration
K - Corrosion Control
V - Fluoridation
S - Softening

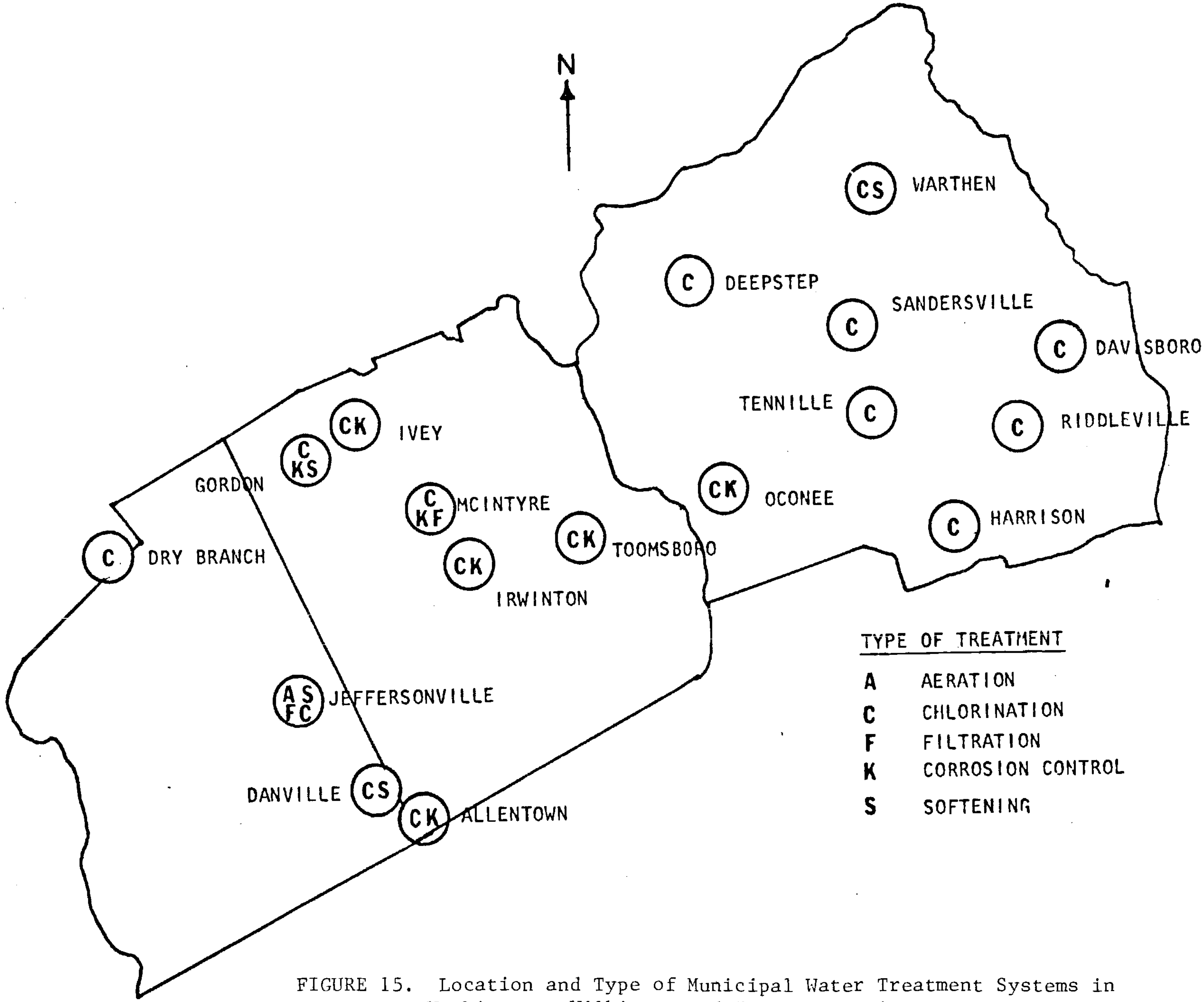


FIGURE 15. Location and Type of Municipal Water Treatment Systems in Washington, Wilkinson and Twiggs Counties

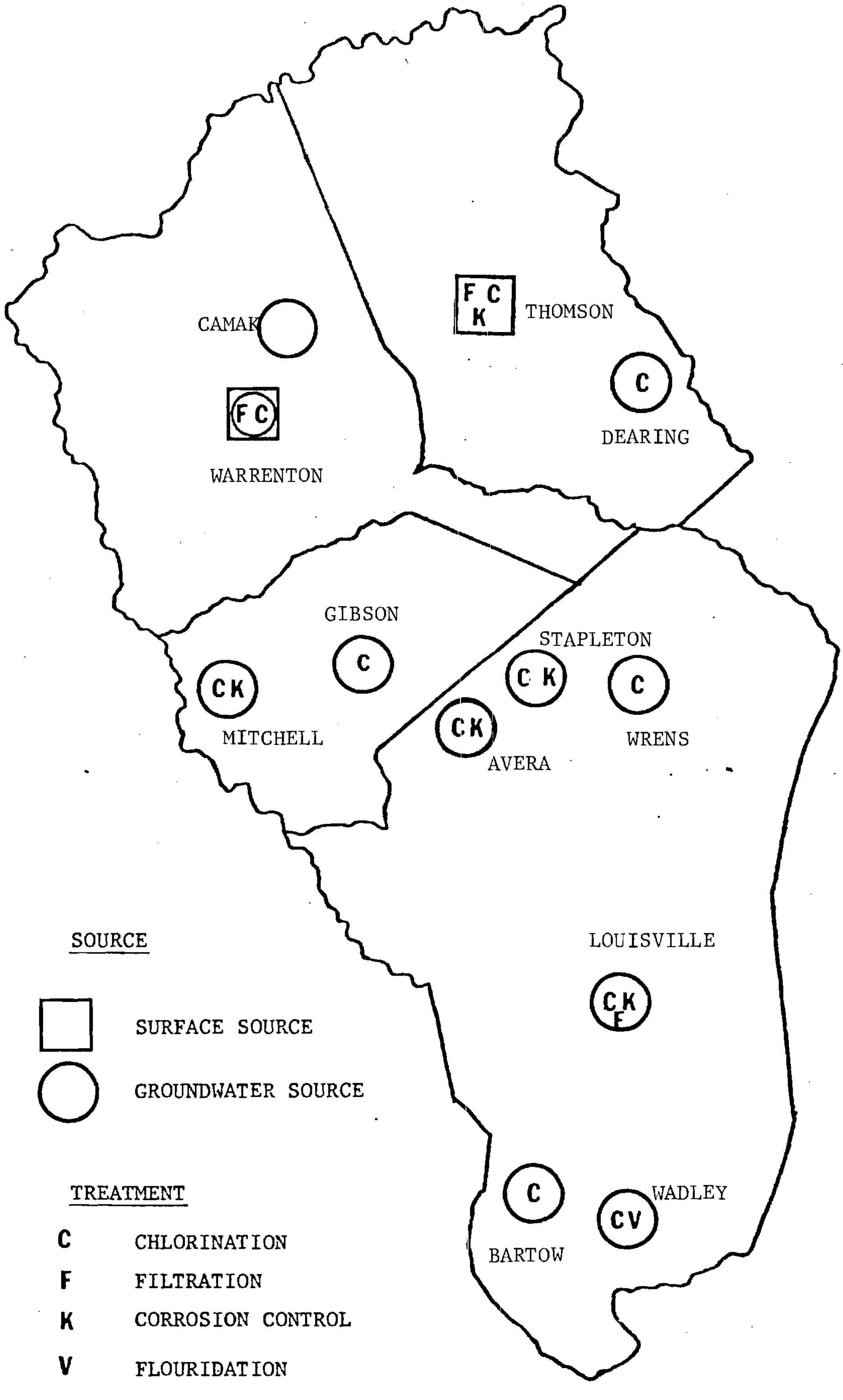


FIGURE 16. Location and Type of Municipal Water Treatment Systems in Glascock, Jefferson, McDuffie and Warren Counties

of population increases. To obtain the potential population, the plant's rated capacity was divided by 150 percent of the current per capita use. The per capita rate is the average flow divided by population served. Hence,

$$\text{Potential Population} = \frac{\text{Rated Capacity}}{1.5\ (\text{Average Flow/Population Served})}$$

The factor 1.5 is included to provide adjustment for peak flow rates. The percent change in population is simply the percent increase from the population served to the potential population. This percent increase can occur without hydraulically overloading the plant. However, it should be noted that the plant can be overloaded in terms of some other functional parameter while not being hydraulically overloaded, but to determine this would require a detailed study of the specific facility under consideration.

In the seven-county area, the current (1970) population served by municipal water supplies is approximately 34,800 and the potential population is 77,700. Thus the quantity of treated water available should not create particular problems.

The issue of water quality is another matter. While a detailed evaluation of each of the 29 plants reported is beyond the scope of this report, several assumptions can be set forth. First, any plant currently not in compliance with drinking water standards will be required to upgrade operations whether a new industry develops or not. Furthermore, no plant should violate this requirement due to a population increase which does not cause the plant to exceed its design capacity. Finally, equipment and/or plants will be periodically replaced or rebuilt as they become obsolete or insufficient to meet more rigorous future quality standards. It should be noted that as a result of this last assumption, population projections much past the year 2000 become meaningless when related to existing water treatment plants.

In discussing the treatment facilities in this area, it is necessary to keep in mind the actual extent of treatment. Of the 29 facilities in the seven-county area, nine have only chlorination facilities. Indeed, Bartow in Jefferson County reports treatment only at their No. 1 Well. Another 11 plants have only chlorine addition and pH control. Thus, if water supplies should become insufficient due to a new industry, it appears that the major cost of expansion will be the drilling of new wells.

These assumptions lead to the conclusion that drinking water quality should not be effected by the creation of an alumina from kaolin industry assuming that the industry would cause an influx of about 300 people and that the probable source of water would be the groundwater resource. However, the towns of Thomson and Warrenton draw their water from surface supplies. Should a new industry also utilize this source of water or cause discharges detrimental to the raw water source, these towns might have to install additional treatment facilities.

Kaolin mining companies are the major groundwater users in the study area. Review of the municipal groundwater demand values revealed that the average 1970 use statistics developed by Carter and Johnson (1974), provided the best and most complete estimate of current municipal groundwater demand. For the other estimates, some rated capacity and total water treated values were missing and some others seemed to be questionable. Using the usage figures included in Tables 9 through 12 and the 1970 population served estimates, a per capita usage rate of approximately 94 gallons per day was obtained for each county. This figure pertains only to the incorporated areas included in the data presentation.

Wastewater Treatment Facilities

Information on municipal wastewater treatment facilities for the seven-county area was compiled from EPD files and personal contact and is presented in Table 15. Locations of these plants are also graphically illustrated in Figures 17 and 18 together with type of treatment involved. Wastewater treatment facilities currently serve about 25,200 people with an estimated capacity to serve 34,700 people based upon the same assumptions used to determine potential population under the section on water treatment facilities but not less than the population presently served. This represents a permissable increase of 27.4 percent. However, it should be emphasized that only 33 percent of the current population of the area is served by municipal facilities. Thus existing facilities could become insufficient without a population change within any one county either by expanding services or by population shifts into the urban areas if not by imposition of regulatory requirements.

As with water treatment facilities, wastewater treatment facilities will require capital investments over time to replace equipment or meet new standards whether an alumina industry develops or not. However, unlike the water treatment plants, there are several waste treatment plants that probably do not meet current regulatory standards. Notable is the city of Stapleton which does not have treatment facilities yet reports flow. In addition, it will be shown that although there are 29 water treatment plants, only 10 communities report wastewater flows. Finally, several plants show large unused capacities but are situated on water quality limited streams. This situation would be of significance if industrial discharge from the alumina from kaolin is planned for these locations.

It may be concluded, therefore, that where treatment plants exist, the creation of an alumina industry employing a few hundred people at a site

TABLE 15. Existing Municipal Wastewater Treatment Facilities

County	Location	Capacity, MGD	Ave. Flow, MGD	Population Served	Potential Population	Treatment Type	Receiving Stream	Stream Designation	Comments
Washington	Sandersville	0.50	-	5550	5550	A,D	Buffalo Cr.	-	Assume ave. flow=100 gpcd
	Tennille	0.20	0.18	175	175	P	Dyers Cr.	-	
Wilkinson	Gordon	0.20	<0.15	3700	3700	S	Lt. Commissioners Cr.	-	
Glascock	Gibson	0.21	0.08	650	1130	P,A,D	Rocky Comfort Cr.	EL	
Jefferson	Louisville	0.40	0.01	3500	5065	P	Rocky Comfort Cr.	EL	
	Louisville	0.36	-			P	Ogeechee R.	EL	Assume ave. flow=100 gpcd
	Stapleton	0.08	0.04	390	520	P*	Duhart Cr.	WQL	
	Wadley	0.30	0.14	2000	2860	P	Williamson Swamp Cr.	EL	
	Wrens	0.28	-	1630	1870	S	Bushy Cr.	-	Assume ave. flow=100 gpcd
McDuffie	Thomson	1.00	-	5000	6660	S	Little Brier Cr.	-	Assume ave. flow=100 gpcd
Warren	Warrenton #1	0.22	0.10	2600	4850	P	Goldens Gr.	WQL	
	Warrenton #2	0.10	0.04			P	Goldens Cr.	WQL	
	Warrenton #3	0.10	0.01			P	Goldens Cr.	WQL	
Totals		3.95	1.91	25195	32380≠ 34682∤				

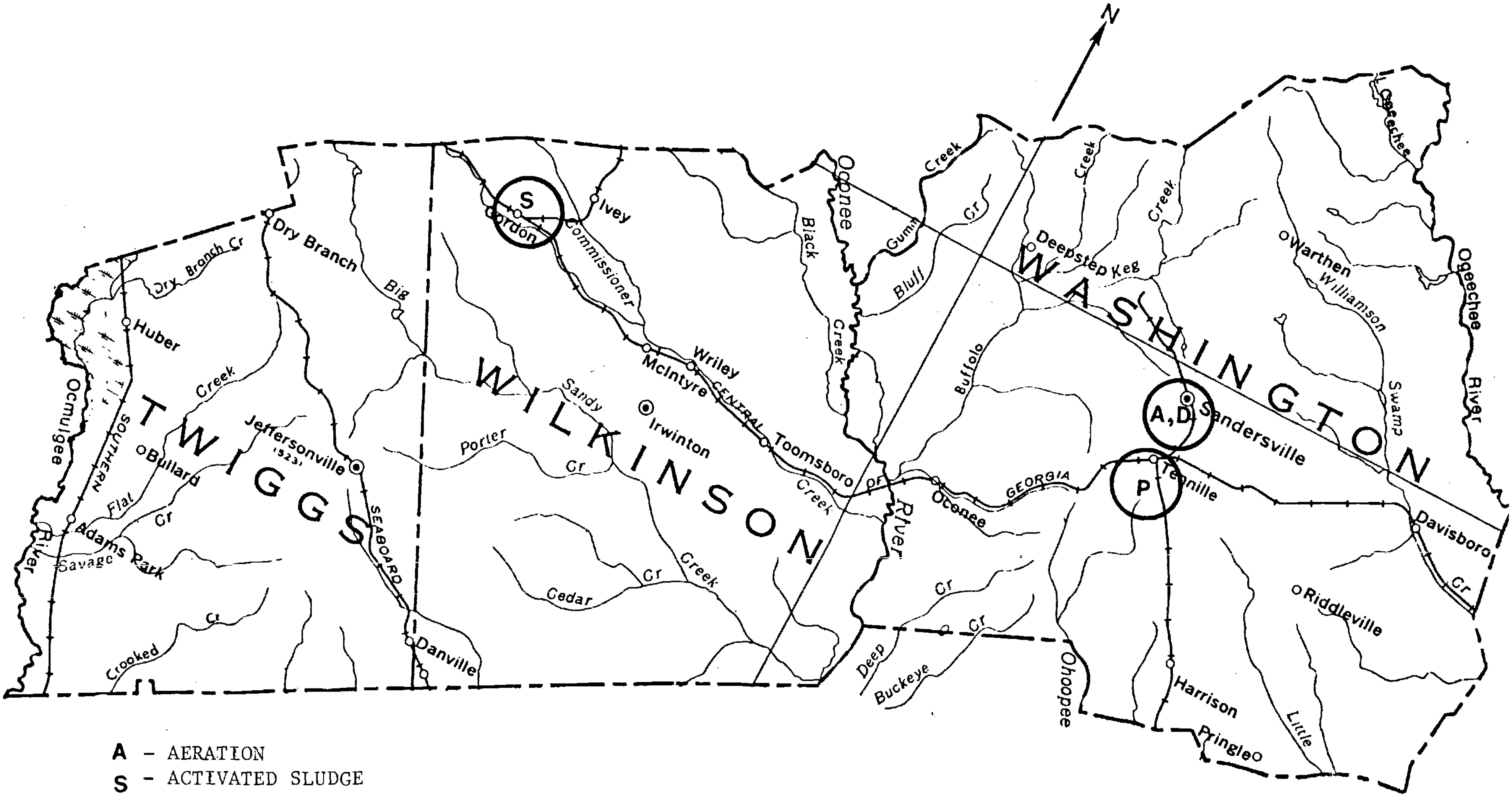
Treatment Key

S - Activated Sludge
P - Waste Stabilization Pond
A - Aeration
D - Disinfection

Stream Designation Key

EL - Effluent Limited
WQL - Water Quality Limited

∤ Calculated from Totals
≠ Summation of Column
* Planned



A - AERATION

S - ACTIVATED SLUDGE

P - WASTE STABILIZATION POND

D - DISINFECTION

FIGURE 17. Location and Type of Wastewater Treatment Facility in Washington, Wilkinson and Twiggs Counties

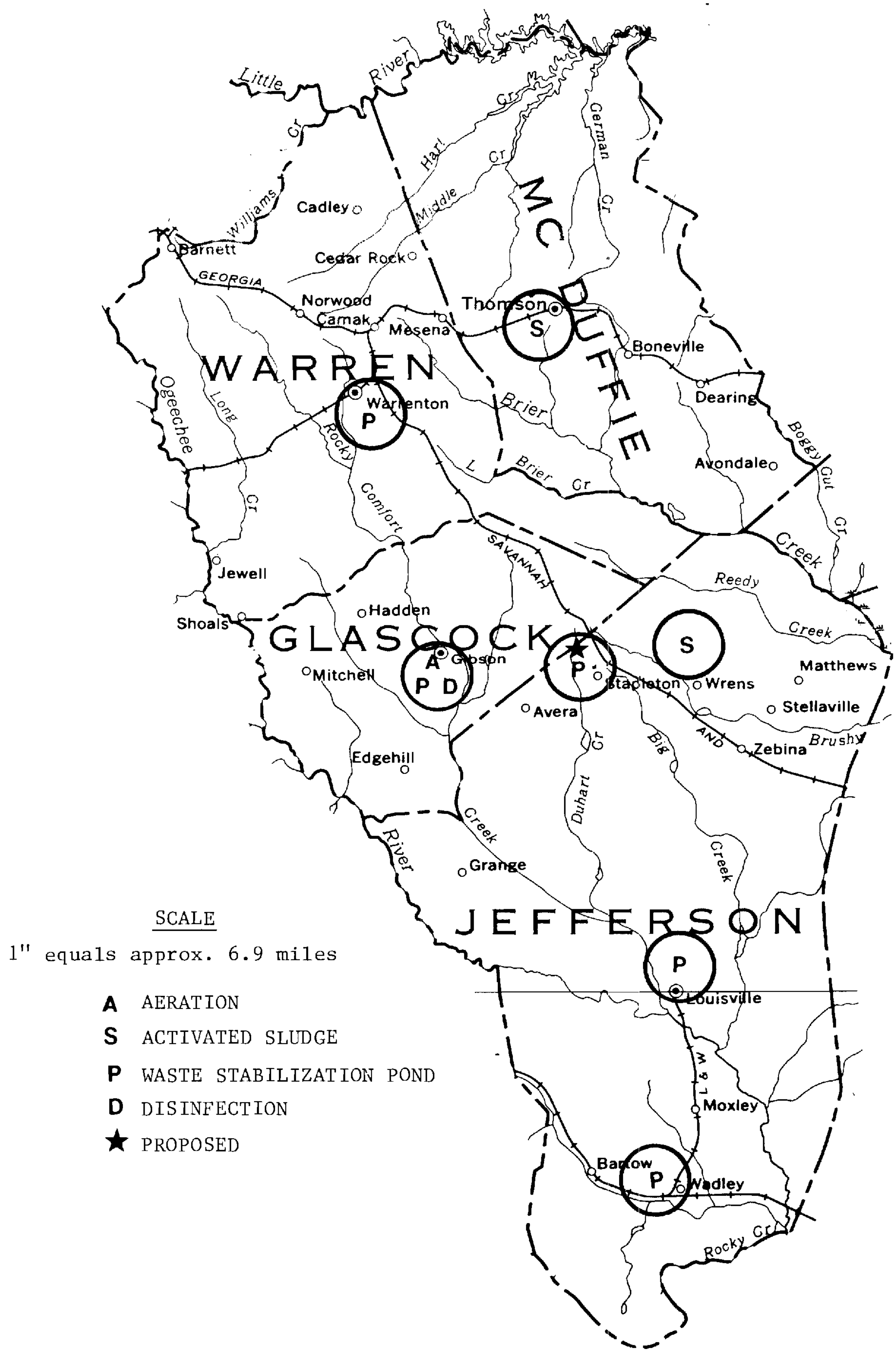


FIGURE 18. Location and Type of Wastewater Treatment Facility in Glascock, Jefferson, McDuffie and Warren Counties

will normally not cause existing plants to be overloaded. However, capital investments for wastewater treatment facilities could be required for any of the following reasons:

1. Influx of population may require the development of a public facility to replace current individual systems;
2. Increased population may cause the current level of treatment at a public facility to become insufficient for discharge into water quality limited streams (particularly at Stapleton);
3. A large increase in population at one locality could overload an existing plant; and,
4. The industry itself would likely be required to pretreat its wastewater effluent prior to discharge.

ASSESSMENT OF GROUNDWATER RESOURCES

Data Base

The water-bearing beds of the Barnwell and Tuscaloosa formations have been the major sources of groundwater in east-central Georgia. The Tuscaloosa formation contains the largest supplies of groundwater, but the Barnwell formation also contains many wells because it is shallower. Well data for the seven counties have been compiled in Tables 16 through 22 with the following information presented:

1. Well number
2. Owner
3. Use
4. Depth (feet)
5. Diameter of well (inches)
6. Ground surface elevation (feet - mean sea level datum)

TABLE 16. Information on Wells in Washington County

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
131	J. C. Archer	Private	185	3	-	1944	(-110)	6	
132	T. R. Duggan	Private	204	3	475	1944	455	7	
133	M. M. Veal	Private	131	8	280	1942	273	15	
134	J. P. Veal	Private	178	8	278	1942	261		
135	H. B. Avant	Private	85	3	-	1944	(-15)		
136	W. Brown	Private	215	3	-	1944	(-65)		
137	L. M. Amerson	Private	253	3	455	1944	265	15	
138	J. H. Taylor	Private	110	2	335	1944	246		
139	Davisboro	Public	288	8	295	1944	285	100	
140	Sandersville	Public	760	10	465	1944	245	500	
141	B. Tarbutton	Private	220	4	-	1944	(-65)	5	
142	W. Harris	Private	85	3	255	1944	243		
143	W. Harris	Private	125	3	255	1944	235		
144	B. F. Chambers	Private	100	3	265	1944	255		
145	L. A. Wood	Private	274	8	271	1944	276	35	
146	G. Hutchings	Private	304	10	269	1944	276	270 150 600	
147	Brooks Springs	Private	425	-	256	1944	276	30	
148	Edgar Bros.	Industrial	303	8	290e	1944	190e	450	
149	Edgar Bros.	Industrial	249	8	290e	1944	215e	250	
150	G. S. Garbutt	Private	95	2	315e	1944	235e		
151	T. J. Veal	Private	41	3	293	1944	280	10	
152	T. J. Veal	Private	18	3	270	1944	268	4	
153	B. L. Helton	Private	110	2	320	1944	290		
154	W. H. Avant	Private	96	2	348	1944	333		
155	Deepstep Jr. H.S.	Public	109	3	358	1944	337	7.5	
156	E. P. Wood	Private	174	4	-	1944	(-100)		
157	O. M. Ennis	Private	312	4	270e	1944	160e		
158	A. J. Hobbings	Private	450	4	240e	1944	220e	13.3	
159	N. Tucker	Private	75	3	260e	1944	245e		
160	A. J. Carr	Private	244	3	-	1944	(-50)		

TABLE 16. Continued

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge gpm	Specific Capacity, gpm/ft
161	Edgar Bros.	Industrial	123	2	222	1944	230	10	
162	Edgar Bros.	Industrial	123	4	222	1944	232	60	
163	Edgar Bros.	Industrial	123	4	221	1944	230	40	
164	Edgar Bros.	Industrial	123	2	221	1944	230	5	
165	Edgar Bros.	Industrial	82	6	217	1944	208	60	
166	English China Clay	Industrial	156	4	218	1944	230	40	
167	E. M. Shepherd	Private	120	2	218	1944	221	15	
168	E. M. Shepherd	Private	120	3	225	1944	230	3.5	
200	Thiele, Avant 1	Industrial	465	10	265	1972	224	75	4.2
201	Thiele, Avant 2	Industrial	400	10	265	1972	217	1230	6.6
						1975	213		
202	Thiele, Avant 4	Industrial	152	6	-	1976	215	20	20
203	Englehard, WC1	Industrial	320	10	300	1959	230	468	3.2
						1975	219		
204	Engelhard, WC2	Industrial	373	10	300	1959	230	336	2.3
205	Freeport 1	Industrial	312	10	-	1975	(-63)	500	14.29
206	Freeport 2	Industrial	315	10	-	1975	(-81)	500	18.05
207	Freeport 3	Industrial	317	10	-	1976	(-67)	500	11.90
208	Engelhard, Gard 1	Industrial	186	6	220	1966	220	185	4.62
209	Deepstep, 1	Public	200	-	302	1966	247	210	5.4
						1975	256		
210	Am.Ind.Clay, M4B	Industrial	321	10	320	1967	257	572	7.3
						1975	258		
211	Thiele, Hall 3	Industrial	315	8	270	1973	225	503	12.5
						1975	218		
212	Am.Ind. Clay, M5	Industrial	368	10	270	1963	263	668	10.3
213	Am.Ind. Clay, P4	Industrial	430	19	414	1971	230	983	26.8
214	Am.Ind. Clay, P2A	Industrial	390	10	435	1972	224	1016	29.0
215	Am.Ind. Clay, P1B	Industrial	400	10	430	1968	241	810	19.7
216	Am.Ind. Clay, P3	Industrial	430	10	414	1966	239	781	13.2
						1975	174		
217	Am.Ind. Clay, P5	Industrial	410	10	416	1950	245	400	22
218	Thiele Plant 1	Industrial	700	10	454	1950	254	400	

TABLE 16.Continued

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
219	Thiele Plant 3	Industrial	718	10	440	1961	236	542	
220	Sandersville 4	Public	475	10	451	1966	241	686	
						1969		250	
221	Sandersville	Public	431	8	465	-	331		
222	Sandersville, 5	Public	565	8	480e	1952	390e		
223	Tennille	Public	990	-	477	1892	287		
224	Holmes Canning 1	Industrial	318	8	400	1946	260	150	9.2
225	Holmes Canning 2	Industrial	335	8	395	1973	255	215	10
226	Davisboro, 1	Public	400	8	336	1966	285	175	
227	Davisboro, 2	Public	503	8	300e	1972	190e	850	7.3

e = estimated

TABLE 17. Information on Wells in Wilkinson County

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity. gpm/ft
131	I. F. Carr	Private	115	3	370	1944	290		
132	W. G. Aycock	Private	110	2	365	1944	280		
133	J. E. Wood	Private	110	2	290	1944	225		
134	F. Riley	Private	28	36	247	1944	235	25	
135	C. Daniel	Private	74	3	300	1944	266	3	
136	D. A. Bloodworth	Private	22	48	290	1944	272		
137	Bill McCook	Private	72	2	300	1944	278		
138	J. T. Bloodworth	Private	84	2	338	1944	263		
139	C. R. Johns	Private	63	2	341	1944	285	5	
140	M. H. Council	Private	75	2	300	1944	233		
141	V. C. Johns	Private	26	48	301	1944	279	6	
142	C. C. Johns	Private	95	48	377	1944	289		
143	C. C. Johns	Private	24	48	300	1944	281		
144	O. B. Snow	Private	100	2	420	1944	368		
145	L. J. Dyer	Private	68	2	340	1944	308		
146	J. H. Hardie	Private	110	2	400	1944	319e		
147	W. Young	Private	87	2	410e	1944	370e	2	
148	J. Humphries	Private	60	48	420	1944	366		
149	A. R. Cobb	Private	48	48	400e	1944	362e		
150	E. L. Vinson	Private	205	2	520	1944	345	3	
151	Gordon	Public	146	6	340	1944	322	65	4.3
152	E. E. Miller	Private	175	4	325	1944	322	60	
153	A. B. Brooks	Private	65	2	340e	1944	325e	3	
154	W. B. Richardson	Private	78	2	370e	1944	330e	3	
155	J. B. Hornsby	Private	32	36	330e	1944	298e		
156	E. M. McCook	Private	64	2	340	1944	308		
157	J. R. McCook	Private	86	2	305	1944	277		
158	R. L. Hardie	Private	85	2	360	1944	310	7	
159	Mt. Carmel School	Public	82	2	400	1944	342		
160	Edgar Bros. #7	Industrial	295	10	370	1944	325	700	35.0
161	Edgar Bros. #5	Industrial	315	4	285	1944	230	40	

TABLE 17. Continued

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
162	Edgar Bros. #4	Industrial	203	10	308	1944	272	835	41.8
163	Edgar Bros. #1	Industrial	204	10	260	1944	220	300	
164	Edgar Bros. #3	Industrial	198	10	260	1944	212	500	
165	Edgar Bros. #2	Industrial	185	10	260	1944	212	600	
166	Edgar Bros. #6	Industrial	315	10	380	1944	275	100	
167	J. M. Shephard	Private	121	2	290	1944	275	12	
168	Wilkinson Motor	Private	70	8	259	1944	244	300	
169	J. T. Stevens	Private	168	2	255	1944	252	3	
170	W. C. Bentley	Private	93	3	297	1944	332		
171	H. E. Stephens	Private	60	2	410	1944	365		
172	M. H. Wall	Private	110	1	230	1944	208	64	
173	M. H. Wall	Private	28	4	230	1944	208		
174	Toomsboro T.S.	Public	88	2	225	1944	229	2	
175	L. L. Curry	Private	18	1	230	1944	216	12	
176	Wilk. Co. Lumber	Private	85	2	223	1944	225	2	
177	C. Thompson	Private	87	3	200	1944	240	30	
178	C. Thompson	Private	85	2	205	1944	240	8	
179	N. Toller	Private	87	2	282	1944	292	3	
180	M. B. Beal	Private	65	2	272	1944	285	1	
181	L. W. Beck	Private	117	2	303	1944	283	6	
182	L. W. Beck	Private	195	2	343	1944	283	5	
183	R. W. Culpepper	Private	250	4	457	1944	343	8	
184	R. W. Culpepper	Private	265	3	457	1944	343	12	
185	L. W. Bell	Private	102	2	322	1944	260	3	
186	Pennington	Private	60	48	316	1944	265		
187	J. H. Lavender	Private	81	2	310e	1944	220e	3	
188	G. Hatcher	Private	292	2	360e	1944	255e		
189	W. H. McDonald	Private	116	2	330e	1944	260e	3	
190	W. H. McDonald	Private	86	2	320e	1944	270e	3	
191	Pierce & Orr	Private	360	2	390e	1944	350e		
192	Pierce & Orr	Private	136	4	-	1944	(+40)	60	
200	Ga. Kaolin 13	Industrial	440		370	1965	322	806	
						1975	233		

TABLE 17. Continued

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
201A	Gordon, 1	Public	267	10	360	1966	344	500	
201B	Gordon, 2	Public	344		360	1975	334		
201C	Gordon, 3	Public	340		380	1974	316	450	4.9
202	Ivey	Public	223		363	1968	293	363	
203	Engelhard Klon 1	Industrial	300		360	1940	296	500	20
204	Engelhard Klon 3	Industrial	352		315	1956	240	563	4.4
205	Engelhard Gib 1	Industrial	365	6	355	1971	229	400	7.1
206	Engelhard Gib 2	Industrial	585	12	425	1975	295	863	13.7
207A	Engelhard 10	Industrial	245	12	262	1966	244	1370	13.2
207B	Engelhard 11	Industrial	310	12	270	1966	240	1230	12.8
207C	Engelhard 12	Industrial	464	12	330	1968	238	770	11.7
207D	Engelhard 13	Industrial	495	12	270	1971	215	1212	13.0
						1975	215		
207E	Engelhard 14	Industrial	360	12	290	1973	232	1040	11.4
207F	Engelhard 15	Industrial	305	12	265	1974	210	1040	13.3
208A	Freeport 1	Industrial	350		350	1963	338	150	
208B	Freeport 2	Industrial	351		350	1963	330	500	
208C	Freeport 3	Industrial	348		400	1964		447	
						1975	380		
208D	Freeport 4	Industrial	344		340	1964	320	500	
208E	Freeport 5	Industrial	332		340	1964	320	600	
209	Freeport Research	Industrial	325		400	1960	340	120	1.5
						1975	312		

e = estimated

TABLE 18. Information on Wells in Twiggs County

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
131	C. H. Kitchens	Private	70	48	450e	1944	380e		
132	Morgan Moore	Private	76	2	442	1944	393		
133	Dan Gardener	Private	34	3	400e	1944	330e		
134	L. M. Crosby	Private	85	2	383	1944	318	6	
135	L. M. Crosby	Private	104	2	-	1944	(-85)	6	
136	L. M. Crosby	Private	52	3	-	1944	(-37)	6	
137	Ed Chambers	Private	82	2	380e	1944	318		
138	Steve Ethridge	Private	49	2	360e	1944	320		
139	H. E. Cannon	Private	60	2	390e	1944	348		
140	C. C. Humphries	Private	76	3	330e	1944	294		
141	D. Y. Caleb	Private	20	48	357	1944	339		
142	Ga. Kaolin, #4	Industrial	291	10	411	1937	346	500	38.5
143	Ga. Kaolin, #5	Industrial	306	10	425	1944	346	300	
144	Ga. Kaolin, #7	Industrial	313	10	415	1941	346		
145	Ga. Kaolin, Twisco	Industrial	238	10	522	1944	352		
146	T. J. Johnson	Private	37	2	370e	1944	350e	7	
147	A. J. Land, Jr.	Private	85	2	389	1944	311	4	
148	Ga. Kaolin Co.	Industrial	158	10	-	1944	-	150	
149	Sgoda Corp.	Industrial	194	8	272	1938	266	465	
150	F. Lawson	Private	1000	8	271	1944	283	75	
151	M. D. Durden	Private	138	2	390	1944	272	7	
152	J. C. Solomon	Private	252	3	555	1944	413	3	
153	Jeffersonville	Public	533	8	523	1944	323	50	
154	D. C. Howell	Private	368	2	480	1944	330		
155	J. McElrath	Private	300	3	285	1944	325	60	
156	I. Fitzpatrick	Private	98	4	270	1944	290	20	
157	M. Fitzpatrick	Private	43	2	320	1944	308		
158	Wembley School	Private	48	2	325	1944	281		
159	Miller Hendrick	Private	360	6	258	1944	272		
160	B. F. Johnson	Private	82	2	323	1944	249		
161	C.A. Little	Private	160	2	376	1944	287		

TABLE 18. Continued

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
162	R. W. Edwards	Private	105	2	375	1944	290		
163	J. T. McCormick	Private	76	2	363	1944	302		
164	O. B. Fitzpatrick	Private	200	3	380	1944	230		
165	E. D. Ashley	Private	83	2	390	1944	327		
166	Marion Bapt. Church	Private	63	2	380	1944	332		
200	Ga. Kaolin, #10	Industrial	372	8	400	1955	340	584	14.2
						1975	340		13.2
201A	Ga. Kaolin, #12	Industrial	552	10	478	1965	344	608	21.0
						1975	336		
201B	Ga. Kaolin, #13	Industrial	490	10	375	1965	327	806	18.3
						1975	327		
201C	Ga. Kaolin, #14	Industrial	325	12	425	1968	324	935	30
						1975	324		
202	Ga. Kaolin, #7	Industrial	-	10	380	1974	301	421	30
203	Ga. Kaolin, #11	Industrial	433	10	380	1955	277	560	21.5
204	Cyprus Ind. Min.	Industrial	560	8		1966	(-240)	500	33.33
205A	J. M. Huber DW1	Industrial	225	18	326	1967	295	2060	52.8
205B	J. M. Huber DW2	Industrial	282	18	334	1968	296		
205C	J. M. Huber DW2A	Industrial	280	18	322	1968	307		
205D	J. M. Huber DW3A	Industrial	330	18	361	1968	294		
205E	J. M. Huber DW3B	Industrial	305	18	356	1968	295		
205F	J. M. Huber DW5	Industrial	290	18	337	1972	252	3400	45.3
205G	J. M. Huber DW6	Industrial	330	18	402	1972	254	2565	24.0
205H	J. M. Huber DW7	Industrial	340	18	397	1972	259	2830	34.5
206A	J. M. Huber 1	Industrial	194	8	270	1938	264		23.2
						1975	248	584	
206B	J. M. Huber 2	Industrial	278	8	270	1951	263	388	32
						1975	242	584	
206C	J. M. Huber 3	Industrial	195	8	270	1961	255		71.5
						1975	244	632	
206D	J. M. Huber 4	Industrial	230	12	270	1972	256	1040	34.67
						1975	226		

e = estimated

TABLE 19. Information on Wells in Glascock County

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
1	G. Denton	Private	45	40	540	1946	508		
2	A. J. Guy	Private	38	36	555	1946	574		
3	F. E. Pebbles	Private	37	36	550	1946	516		
4	G. Counsel	Private	44.7	36	485	1946	444		
5	S. O. Smith	Private	51	36	525	1946	485		
6	Ellis Chalker	Private	25	36	487	1946	470		
7	Glenn Poole	Private	25.8	36	505	1946	486		
8	Ray Johnson	Private	38.4	36	540	1946	509		
9	James Willifred	Private	64.8	24	555	1946	494		
10	Cecil Davis	Private	48.8	36	550	1946	518		
11	H. S. Wilkerson	Private	49	36	545	1946	503		
12	E. O. Hadden	Private	69	40	550	1946	487		
13	C. Rivers	Private	64	36	531	1946	472		
14	J. A. Rivers	Private	40	36	500	1946	466		
15	J. H. Thigpen	Private	30	38	510	1946	490		
16	Blankenship School	Private	42	36	458	1946	423		
17	J. Thompson	Private	42	36	481	1946	443		
18	J. May	Private	30	36	310	1946	294		
19	H. Dickson	Private	50	36	405	1946	365		
20	R. Melber	Private	60	40	451	1946	396		
201	Thiele Kaolin,#1	Industrial	153	6	425	1976	363	87	6.21
202	Thiele Kaolin,#2	Industrial	139	6	425	1976	356	50	1.22
101	J. Usery	Private	25	36	341	1946			
102	C. Chalker	Private	45	40	370	1946	332		
203	Gibson, #1	Public	200	8	420	1971	305	157	
204	Gibson, #2	Public	113	8	350	1975	274	52	1.9
205	Gibson, #3	Public	155	-	400	1973	340	31	.3
206	Mitchell, #1	Public	90	8	520	1974	503	50	
207	Mitchell, #2	Public	90	8	496	1975	489	30	
208	Mitchell, #3	Public	500	18	575	1974	492		
209	Mitchell, #4	Public	355	18	512	1974	495	27.4	
210	Mitchell, #5	Public	510	20	528	1975	486	12.4	.0639
211	Mitchell, #6	Public	300	8	512	1975	496	74.0	
212	Mitchell, #7	Public	195	20	535	1976	473	33.1	.5015

TABLE 20. Information on Wells in Jefferson County

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
1	R. Lamb	Private	86	3	460	1946	362		
2	F. Norton	Private	31	36	340	1946	311		
3	L. English	Private	57	40	360	1946	307		
4	H. Jordon	Private	81	40	375	1946	298		
5	W. Dye	Private	110	36	410	1946	306		
6	W. Dye	Private	100	36	400	1946	308		
7	C. Brown	Private	64	36	440	1946	379		
8	C. McGahee	Private	75	36	445	1946	376		
9	M. Simmons	Private	52	36	410	1946	365		
10	P. Dixon	Private	100	3	420	1946	370		
11	M. Kelly	Private	105	3	415	1946	367		
12	R. Beckworth	Private	55	48	485	1946	435		
13	G. Landrum	Private	80	2.5	410	1946	410		
14	R. Wilson	Private	50	36	424	1946	376		
15	E. Rhodes	Private	65	2	371	1946	321		
16	W. Avern	Private	35	36	395	1946	363		
17	L. Hobbs	Private	60	36	455	1946	410		
18	J. Raburn	Private	51	36	520	1946	473		
19	Reedy Creek Church	Private	52	2	460	1946	420		
20	W. Gray	Private	70	36	495	1946	435		
21	S. Arrington	Private	80	2	446	1946	401		
22	W. Millborn	Private	67	36	470	1946	415		
23	L. Poole	Private	66	3	460	1946	415		
24	Town of Wrens	Public	130	12	423	1946	401		
25	J. Bell	Private	31	40	370	1946	352		
26	O. Lancaster	Private	39	36	420	1946	390		
27	E. McNair	Private	24	1.5	438	1946	418		
28	A. Russell	Private	80	2	370	1946	320		
29	M. Pennington	Private	85	40	405	1946	330		

TABLE 20. Continued

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
30	Thompson Church	Private	25	36	390	1946	368		
31	H. Jones	Private	30	36	385	1946	360		
32	C. Clifton	Private	38	36	379	1946	351		
33	H. King	Private	35	36	361	1946	330		
34	C. Minton	Private	65	3	397	1946	367		
35	M. Henson	Private	65	2.5	365	1946	309		
36	M. Bridges	Private	77	3	320	1946	275		
37	J. Brown	Private	125	3	350	1946	295		
38	A. Barfield	Private	47	40	350	1946	310		
39	R. Beckworth	Private	50	36	340	1946	295		
40	J. Walden	Private	213	3	255	1946	261	20	
41	R. Farmer	Private	125	3	325	1946	300		
42	Baptist Church	Private	21.5	36	321	1946	307		
43	J. Waters	Private	170	3	245	1946	240		
44	J. Penrow	Private	36	36	305	1946	279		
45	C. Mosely	Private	200	3	325	1946	295		
46	H. Thomas	Private	189	3	285	1946	233		
47	M. Lamb	Private	25.4	36	250	1946	229		
48	M. Overstreet	Private	110	4	210	1946	210	15	
49	S. Cameron	Private	215	3	284	1946	269		
50	H. Morris	Private	45	36	280	1946	242		
51	J. Greenway	Private	81	2	230	1946	234	6	
52	B. C. Jordan Co.	Private	60	4	218	1946	227		
53	L. Rachels	Private	78	2.5	230	1946	232	5	
54	L. Smith	Private	128	1	244	1946	234		
101	J. Duprew	Private	20	40	380	1946	364		
102	C. James	Private	48	6	348	1946	306		
103	J. Norton	Private	166	3	360	1946	300		
104	A. Burch	Private	350	3.5	340	1946	280		
105	P. Hudson	Private	260	3	356	1946	301		
106	J. Davis	Private	215	-	220	1946	237	60	
107	Louisville	Public	35	6	238	1946	258	75	

TABLE 20.Continued

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
108	E. McNeill	Private	183	4	183	1946	198		
109	Wadley	Public	445	2	220	1946	224	35	
201	J. M. Huber, #1	Industrial	352	10	484	1976	322	305	8.5
202	J. M. Huber, #2	Industrial	312	12	426	1976	306		
203	J. M. Huber, #3	Industrial	300	12	405	1976	302	620	14.4
204	J. P. Stevens, #1	Industrial	486	-	315	1969	255	1,200	
205	J. P. Stevens, #2	Industrial	396	-	315	1969	248	1,200	
206	J. P. Stevens, #3	Industrial	393	-	315	1969	259	1,200	
207	J. P. Stevens, #4	Industrial	425	-	315	1969	260	1,200	
208	Avera 2	Public	352	8	450	1975	346	350	5.8
209	Stapleton 3	Public	266	-	410	1975	349	220	1.8
210	Wadley 1	Public	481	8	230	1975	225	503	8.58
211	Wadley 3	Public	491	8	280	1975	217	703	12.78
212	Wrens 4	Public	200	8	430	1974	370	190	6.3
213	Bartow 3	Public	305	-	240	1975	239	-	-
214	Louisville 1	Public	367	8	243	1975	230	860	-
215}	Anglo-American 1	Test	377	2	347	1971	-		
216	Clay Corp. 2	Wells	362	4	348	1971	-		

TABLE 21. Information on Wells in McDuffie County

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
1	E. Reeves	Private	12	36	436	1946	430		
2	H. McGahee	Private	32	30	498	1946	471		
101	J. Hinton	Private	15	30	560	1946	550		
102	S. Anderson	Private	56	36	590	1946	492		
103	M. Ansley	Private	64	30	573	1946	513		
104	L. Watson	Private	30	30	496	1946	471		
105	W. McCorkle	Private	51	36	590	1946	493		
106	V. Brown	Private	10	38	489	1946	485		
107	L. Whitaker	Private	42	36	485	1946	453		
108	L. Whitaker	Private	29	36	480	1946	456		
109	S. Holloman	Private	35	40	375	1946	470		
110	W. McCorkle	Private	17	30	398	1946	336		
111	A. Reeves	Private	14	36	345	1946	332		
112	G. Arrington	Private	19	36	340	1946	326		
113	S. Turner	Private	30	40	460	1946	443		
114	C. Guy	Private	-	40	380	1946	395		
115	D. Rawborn	Private	34	30	490	1946	462		
201	Dearing 1	Public	400	6	524	1974	501	90	
202	Dearing 2	Public	700	6	-	1974	-	40	
203	Dearing 3	Public	500	-	530	1975	486	36	
204	Kingsley Mill	Public	379	10	528	1976	510	90	

TABLE 22. Information on Wells in Warren County

Well No.	Owner	Use	Depth, ft.	Diam., in.	Ground Elevation (ft-MSL)	Year Measured	Water Elevation	Discharge, gpm	Specific Capacity, gpm/ft
1	Camp Br. Church	Private	14	36	510		500		
2	O. Reeves	Private	26	40	505		485		
3	W. Usery	Private	40	38	550		515		
4	W. Todd	Private	35	40	547		515		
5	W. Todd	Private	50	40	550		506		

NOTE: Wells at Camack all drawn water from basement crystalline rock.

7. Water elevation (feet - mean sea level datum)

8. Year measured

9. Discharge (gallons per minute)

10. Specific capacity (gallons per minute per foot)

The well numbers are used to locate each well on Figures 19 through 21 where the Tuscaloosa and Barnwell Formations were differentiated as sources of groundwater resource. The well numbers from 1 to 100 signify that the wells are in the Barnwell formation and that the information was obtained from the report, Geology and Ground Water Resources of Central-East Georgia by LeGrand and Fuercron (1956). Well numbers from 101 to 130 signify wells in the Tuscaloosa formation and that the data are also from the 1956 report. Numbers from 131 to 200 signify that the wells are in the Tuscaloosa formation and that the data are from the Geological Survey of Georgia Bulletin No. 52, Geology and Groundwater Resources of the Coastal Plain of East-Central Georgia, by LaMoreaux (1946). Well numbers from 201 to 299 signify that the information was obtained from the Water Supply Branch files and is of more recent origin. These wells are located in the proper formation columns except in cases where the exact aquifer was not known. The LeGrand and LaMoreaux reports were the principal sources of data on the groundwater resources of the area. The EPD files of the Water Supply Branch were a secondary source of information, with other information abstracted from a current USGS study of the Cretaceous aquifer in Georgia. Some additional data regarding specific locations were obtained from kaolin companies currently operating in the study area.

Anglo-American Study - Some detailed information for groundwater in this area was obtained from the Anglo-American Clays Corporation. Anglo-American is considering locating a kaolin clay processing plant five miles north of Wrens in Jefferson County near Reedy Creek. Jefferson County wells 215 and 216

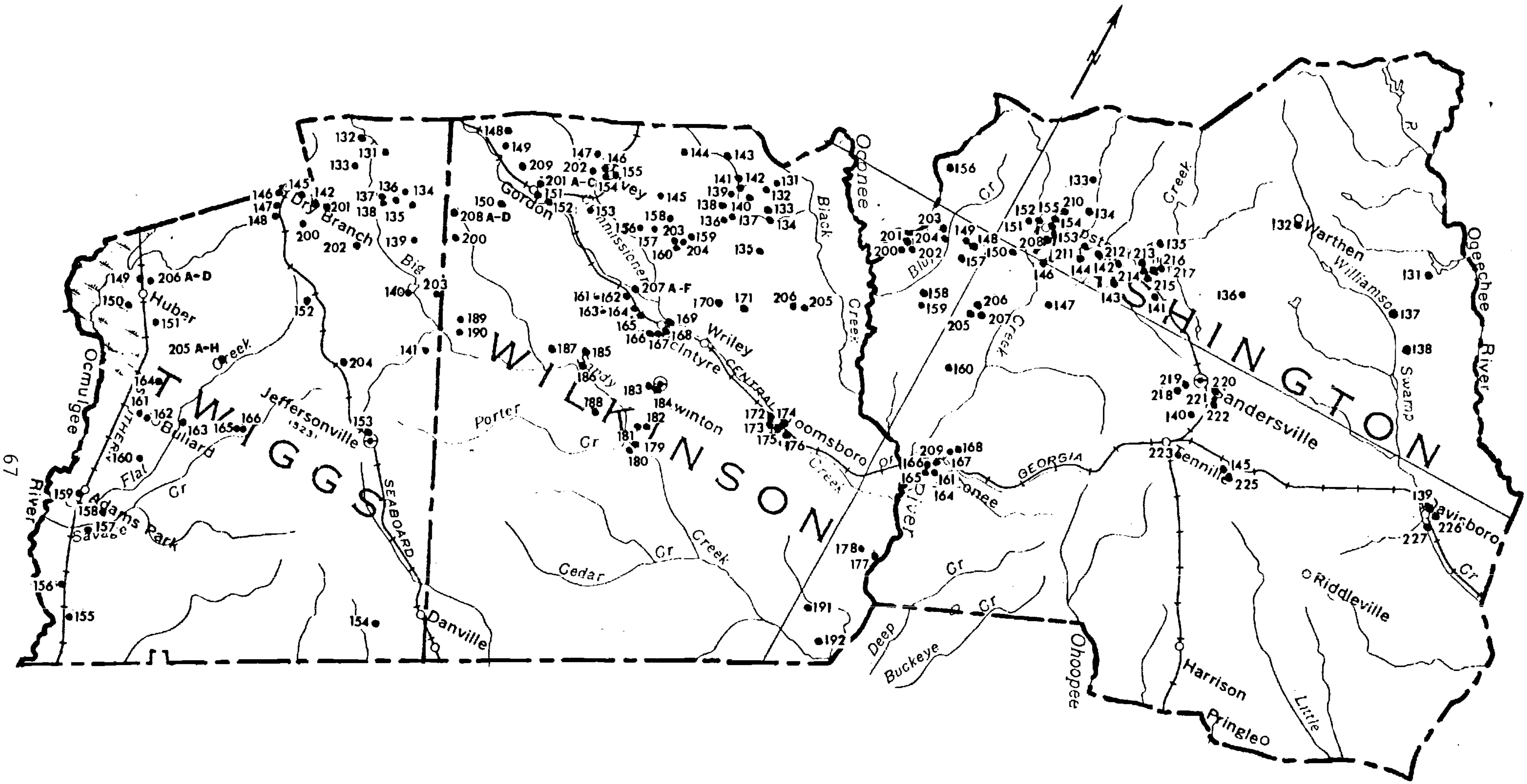


FIGURE 19. Location of Wells Utilizing the Tuscaloosa Formation in Washington, Wilkinson and Twiggs Counties

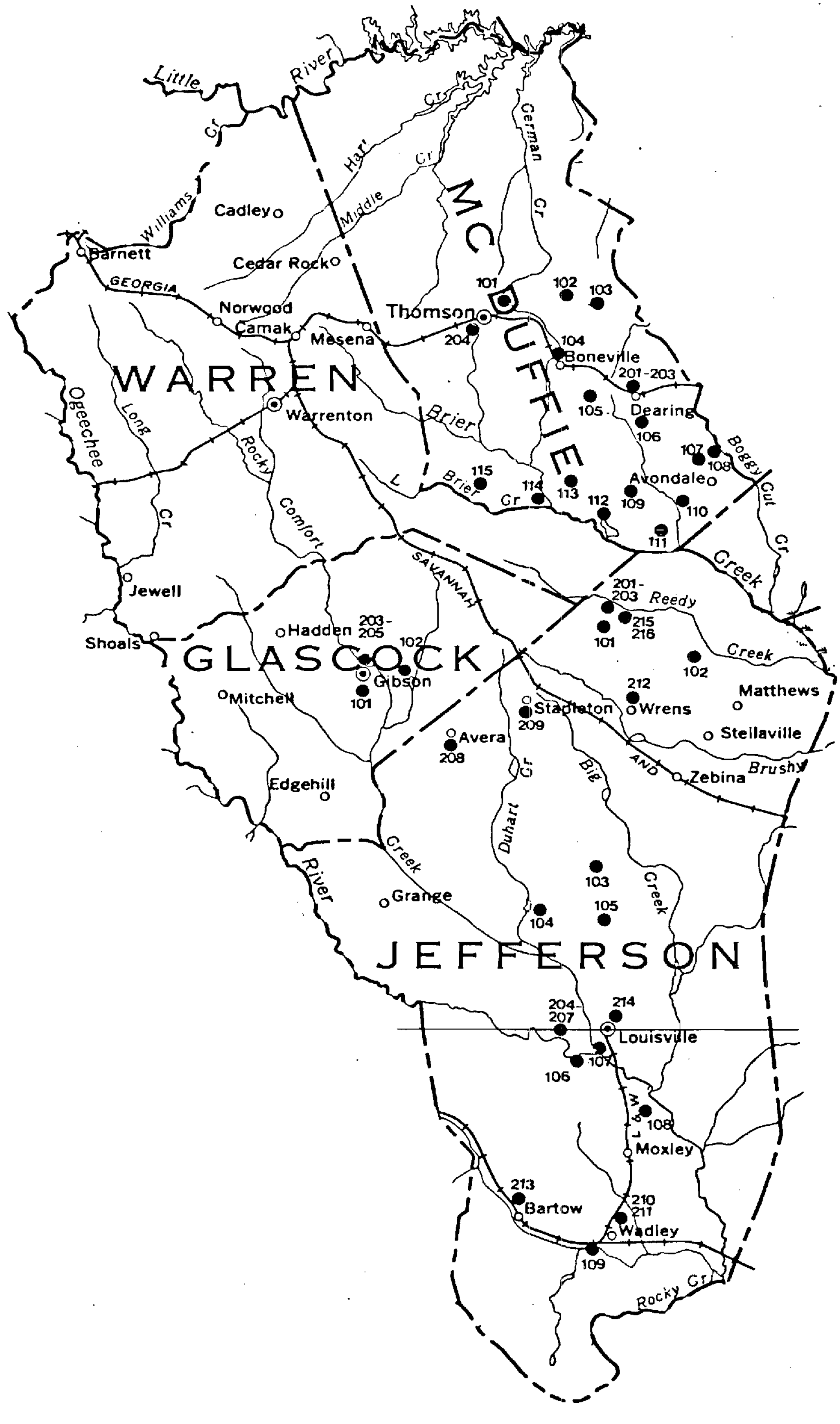


FIGURE 20. Location of Wells Utilizing the Tuscaloosa Formation in Glascock, Jefferson, McDuffie and Warren Counties

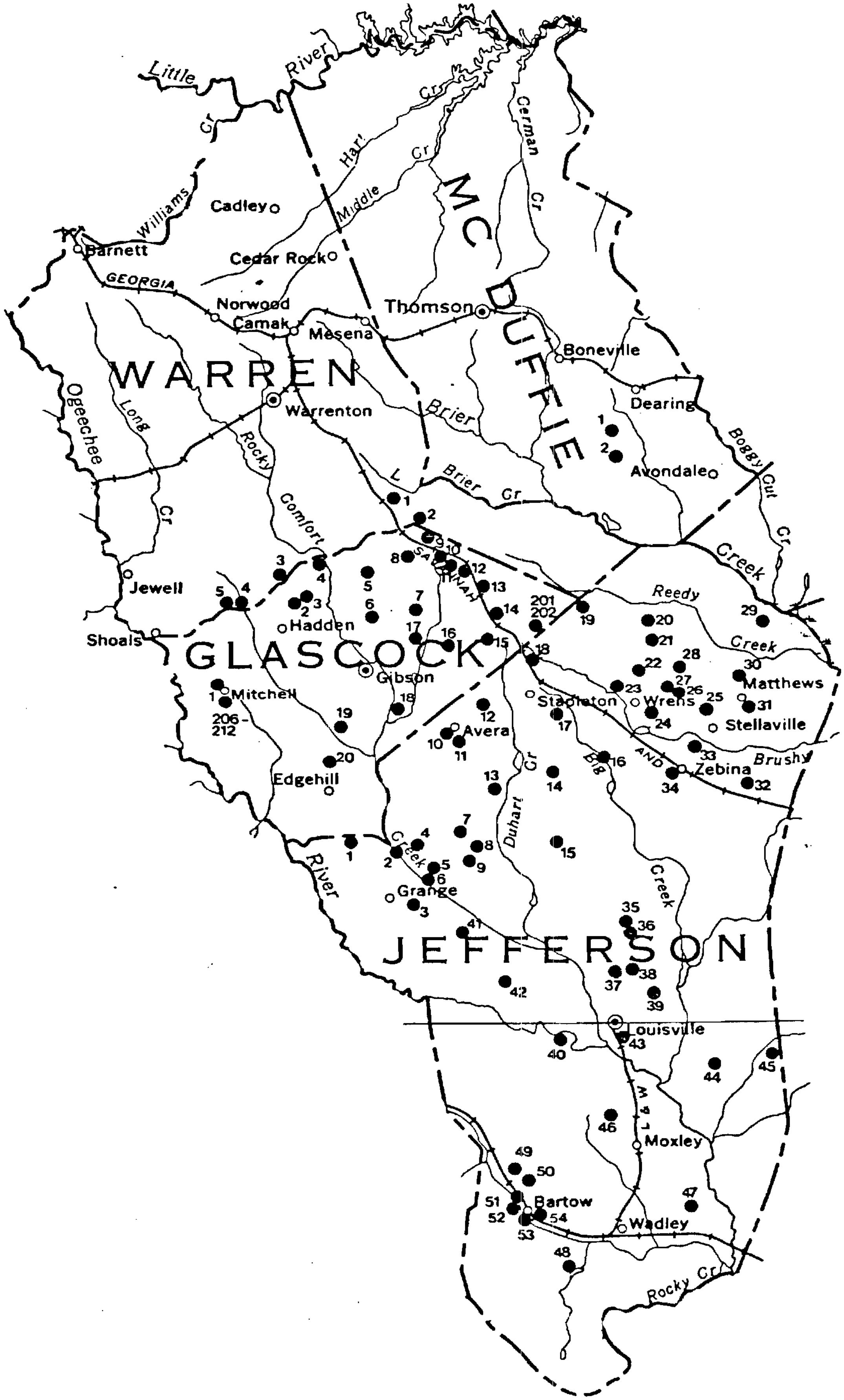


FIGURE 21. Location of Wells Utilizing the Barnwell Formation in Glascock, Jefferson, McDuffie and Warren Counties

of Figure 20 show this location. The plant will require a continuous flow of 1000 gallons of water per minute (gpm) when it begins operations, but it is anticipated that it will need 3300 gpm within 10 years after the plant begins operation.

The potential sources of water supply for Anglo-American in the area are from wells, or from Brier and Reedy creeks or both. Surface water would not be available in the area without substantial and expensive "off-channel" storage facilities. The initial study began with the drilling of five test wells to obtain geologic and hydrologic information. It was found that artesian water existed with a hydrostatic pressure in the wells of 40 to 60 feet. Samples from the well were taken and an electric log was made for correlation to the sample log. The rocks penetrated in the test drilling could be divided into two principal water-bearing beds consisting of heterogeneous sand and gravel separated by lenses of clay having a thickness of 10 to 20 feet. These beds describe the Barnwell, Twiggs Clay and/or McBean and Tuscaloosa formations of this area. Particle size analyses were made of cuttings from the two aquifers. Analyses and evaluation of the information obtained indicated that it is feasible to pump 1000 gpm from two or three wells in the area.

With the additional requirement of 3300 gpm needed, three more wells were drilled in an adjacent property. Similar geologic conditions were found as in the other five wells except that the new wells encountered cleaner, coarser, more permeable sands in the Tuscaloosa formation. In addition, the clay lenses between the two water-bearing beds thin to less than five feet thick in the new area, allowing a good hydrologic connection between the aquifers. A more thorough study after drilling confirmed the fact that the water-bearing units under the new property have better water-bearing characteristics than the same units underlying the first properties that were drilled. Therefore, Anglo-American believed that in a long-range water supply development program, they could expect to produce 3300 gpm from six to eight wells on a sustained basis from the three properties. This would be provided that proper locations, pumping rates of production wells, and spacing are planned and implemented. (No pump test data are available at this time.)

Anglo-American Clay and Thiele Kaolin (Sandersville) - Anglo-American Clay withdraws its process water from the principal artesian aquifer (i.e., Cretaceous Aquifer). Water is also available in some local perched water tables above the kaolin beds, but these local conditions disappear with the removal of the kaolin.

Generalization of the geologic structure throughout the area is not possible. There are many horizons of kaolin resulting in conditions of artesian water and local perched water tables. Throughout Washington, Wilkinson, and Twiggs Counties, there appears to be a confining layer consisting of different grades of clay. Constant reference to lenses of clay appears to be an economic differentiation used by the traditional kaolin companies to distinguish between the different grades of kaolin. In the Deepstep area, the clays are located at about 300 feet-MSL with a dip of approximately 20 feet/mile to the southeast and downdip. As the Tuscaloosa Formation thins out eastward of Buffalo Creek, the high grade kaolins become too deep to mine economically. The deposits are also too deep in northeast Washington County to be of commerical value. The commerical clays are of the Cretaceous Age or younger. The aluminum companies are looking at thick downdip Eocene deposits with approximately 100 feet of overburden over 100 feet of clay.

Anglo-American experienced a dewatering problem just east of the Oconee River in western Washington County and just south of Thiele Kaolin's Avant

Mine. Apparently, Thiele Kaolin is operating just at the upper level of artesian pressure. Anglo-American encountered 65 to 70 feet of artesian head above the kaolin beds. Therefore, due to this potential dewatering problem and the presence of only marginal clay deposits, the site was not developed.

A joint study for Anglo-American and Thiele Kaolin on the Cretaceous aquifer in the Sandersville area showed that the aquifer there is approximately 500 feet deep. Results of the study were:

	Range	Average
Storage Coefficient ($x10^{-4}$)	7.6 - 8.4	8.1
Transmissivity (gpd/ft)	315,000 - 330,000	325,000
Yields	2000 gpm/ft	
Specific Capacity Well #1	67.5 gpm/ft	
Specific Capacity Well #2	75 gpm/ft	

The piezometric head in the vicinity of Deepstep on Buffalo Creek is approximately 240 ft-MSL. Transmissibility tracts are oriented in a NW-SE direction in the Sandersville area.

Water use within the traditional kaolin industry will not increase substantially due to the increased recycling of process water.

Georgia Kaolin (Deepstep) - Georgia Kaolin is presently experiencing some dewatering problems at certain mines. In Washington County at Deepstep and in Twiggs County southeast of Dry Branch (Humphrey's property) three to four feet of artesian head above the clay beds have been experienced. At each site, dewatering at pumping rates of 500-600 gpm are currently required. Georgia Kaolin is conducting additional studies to further delineate these areas of artesian pressure.

The clay is distributed throughout the area in discontinuous lenses shaped like pods, saucers, or elongated ovals (i.e., drainage basins). These are areas of no clay or just a sand/clay mixture in a matrix formation. Between the Ocmulgee and Ogeechee Rivers, the clay exists in lenses.

J. M. Huber Corporation (Huber) - The Huber Mine located east of Huber has a system of 8 wells pumping a total of 31.3 MGD for dewatering. At this site there is approximately 50 feet of artesian pressure head above the clay. Only a few miles north of this area, Huber has operated with little or no dewatering. The artesian water became a problem when the confining clay layer was breached during exploratory drilling. The dewatering system has been operated since 1968 and no adverse effects on local water supplies have been reported. However, it should be emphasized that the dewatering is taking place in the Cretaceous aquifer, while many of the local supplies are withdrawn from shallower aquifers. Huber currently has two observation wells in the area to monitor the effects of this dewatering.

A comprehensive study on the dewatering site was completed in 1967. Another study on the property directly to the north of this site was completed in 1971. Results of these studies were:

	Range	Average
Site #1		
Storage Coefficient ($x10^{-4}$)	1.07 - 8.23	5.74
Transmissivity (gpd/ft)	221,000 - 276,000	247,000
Site #2 (Well #1)		
Storage Coefficient ($x10^{-4}$)	1.1 - 7.2	4.4
Transmissivity (gpd/ft)	213,000 - 269,000	248,000
Site #2 (Well #2)		
Storage Coefficient ($x10^{-4}$)	1.7 - 8.3	5.37
Transmissivity (gpd/ft)	230,000 - 265,000	251,000

Copies of these studies were obtained for use in this report.

United States Geological Survey (USGS) - USGS (Doraville) has been concerned with reporting on the Cretaceous aquifer in Georgia. The effort has dealt with the recharge, discharge, and areal distribution of the aquifer and has indicated that there was a major lack of detailed information throughout the study area including: 1) storage and transmissivity data; 2) pumping test data; and, 3) observation wells to assess areal effects. The USGS does have considerable information on the location of the aquifer, its physical dimensions, and its potentiometric surface.

Piezometric Surface

The piezometric surface for the study area was developed using the static water elevations presented in Tables 16 through 22. Using the historical measurements of LaMoreaux and LeGrand as a basis and the more recent data as a verification, the piezometric surface shown in Figures 22 through 24 were developed. Areas of artesian flow have been delineated by LaMoreaux in 1946 for Twiggs, Washington and Wilkinson counties and by LeGrand in 1956 for the remaining counties. According to the interviews with officials of certain kaolin companies, conditions of artesian flow still exist in these areas today. The piezometric surface shows that the major rivers and streams in east-central Georgia receive groundwater from the Cretaceous aquifer.

For Glascock, Jefferson, McDuffie and Warren counties, the piezometric surface of both the Tuscaloosa and Barnwell formations was developed. In the remaining counties, the only formation extensively used is the Tuscaloosa and thus the only piezometric surface included in this report.

Some problems were encountered in the development of the piezometric surface. Some of the water surface elevations appeared to be influenced by pumping of nearby wells (i.e., induced drawndown). At a few locations there appeared to be evidence of perched water table conditions. This condition could be caused by the discontinuous nature of the clay lenses in the Tuscaloosa. Overall the piezometric surfaces shown in the figures represent a good approximation of the actual surface and agrees with the information

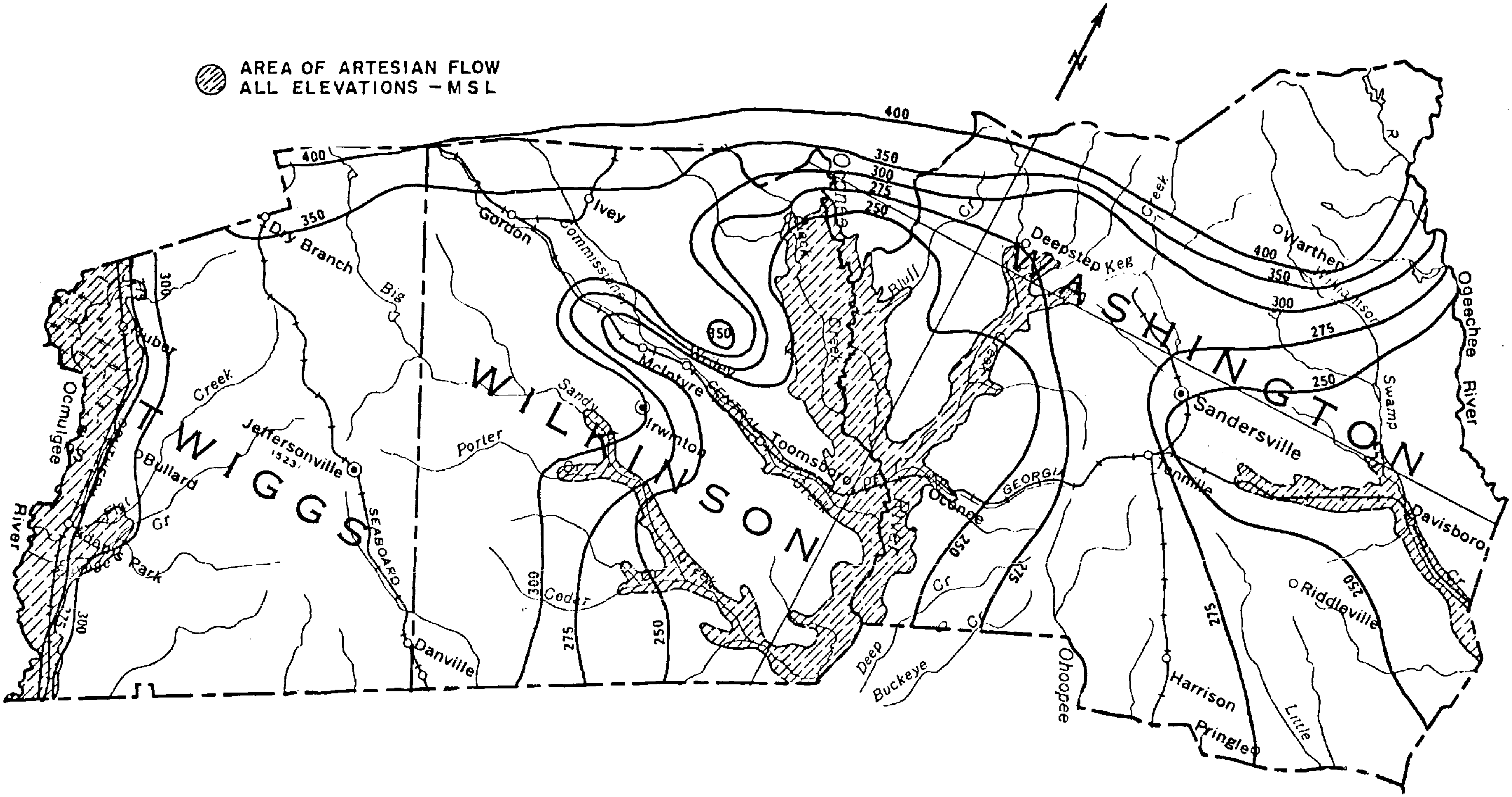


FIGURE 22. Piezometric Surface of the Tuscaloosa Formation in Washington, Wilkinson and Twiggs Counties (Lamoreaux, 1946)

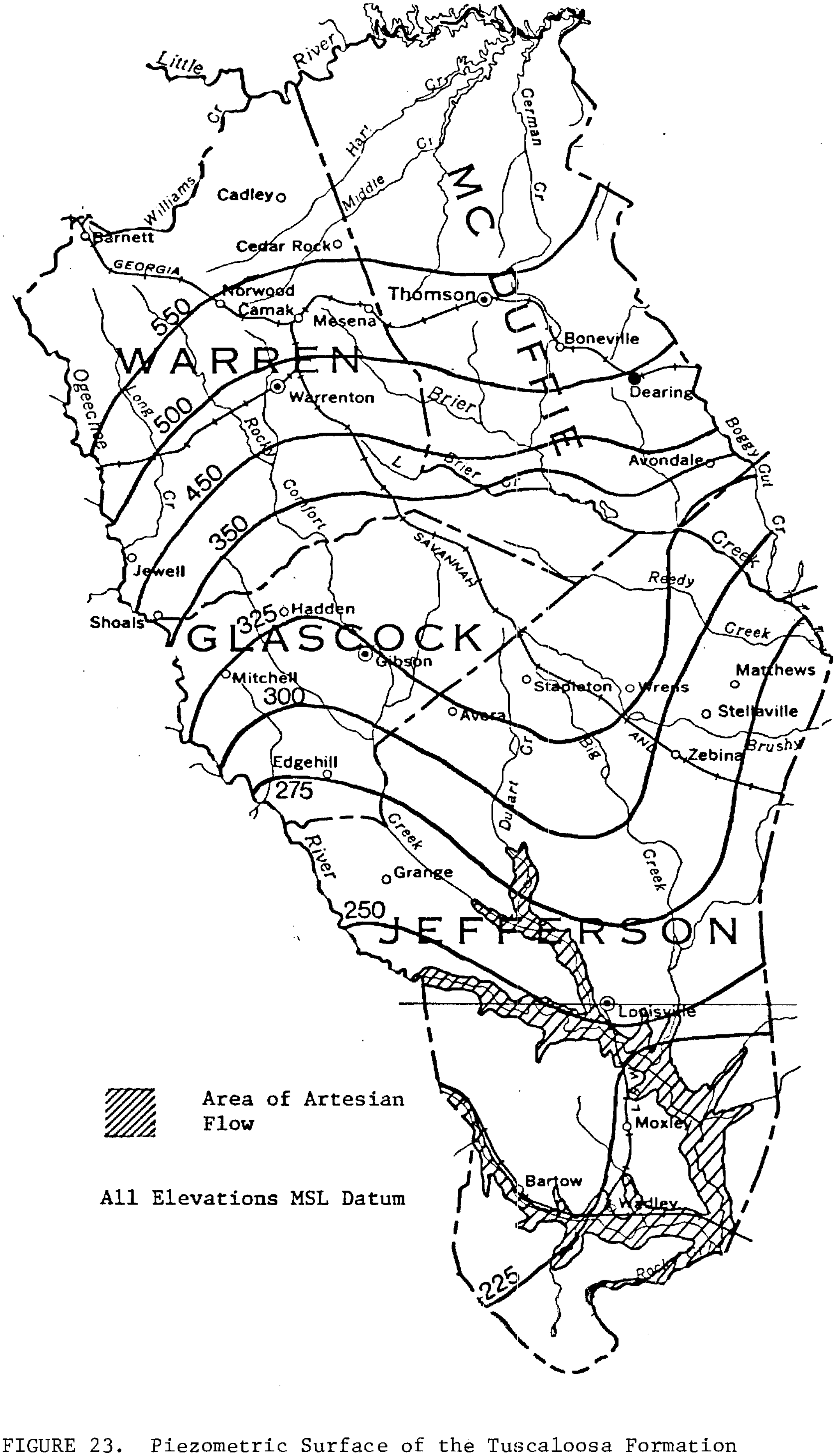


FIGURE 23. Piezometric Surface of the Tuscaloosa Formation in Glascock, Jefferson, McDuffie and Warren Counties (LeGrand, 1956)

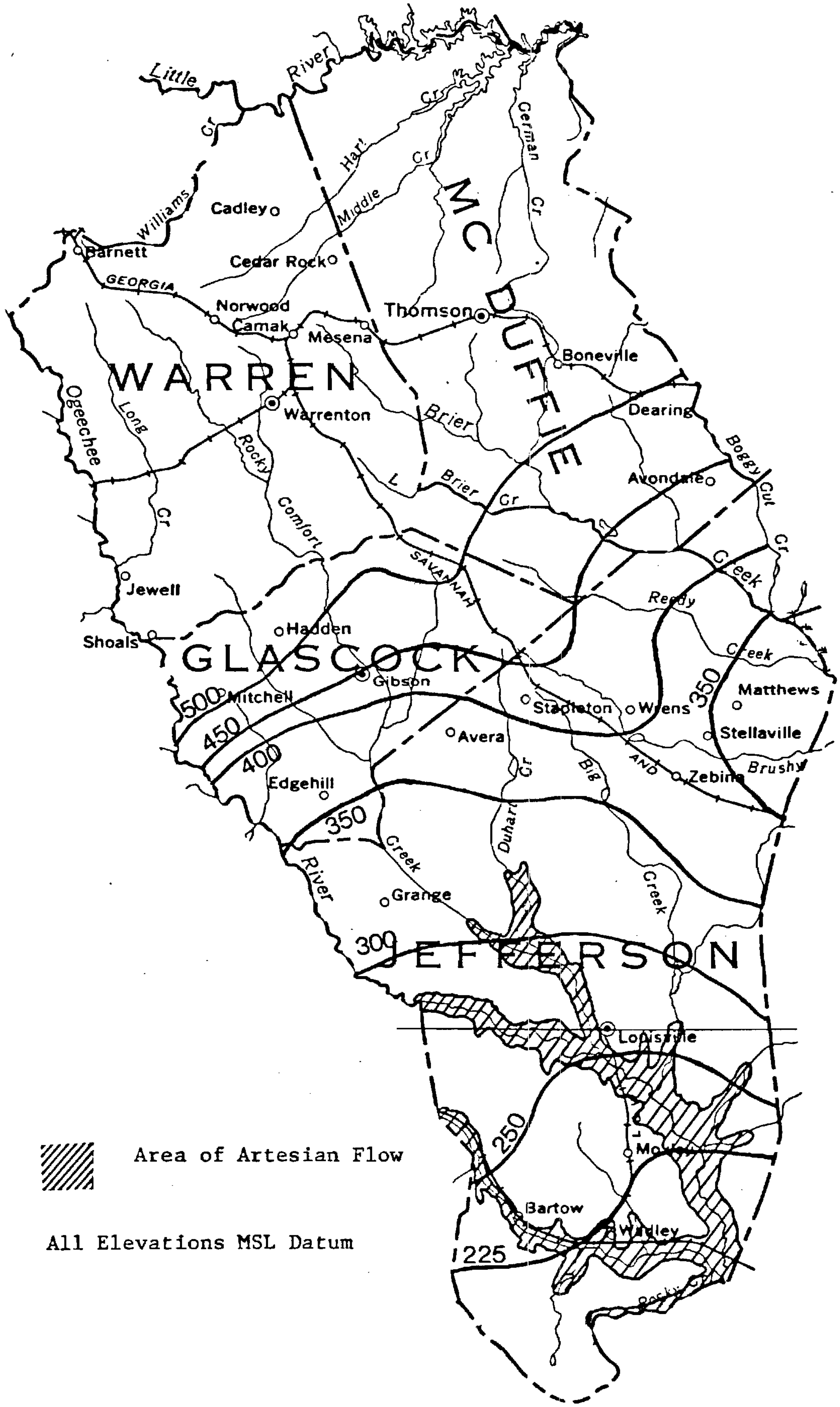


FIGURE 24. Piezometric Surface of the Barnwell Formation in Glascock, Jefferson, McDuffie and Warren Counties (LeGrand, 1956)

obtained by local interviews. The general slope of the piezometric surface in the east-central Georgia area is approximately 15 - 20 feet per mile to the southeast.

Regional Transmissivity

Development of a regional transmissivity for the area was not possible due to a lack of sufficient data. The specific capacities (gpm/ft) presented in Tables 16 through 22 were plotted at their respective locations in Figures 25 and 26, but no regional transmissivity tracts were discernable. In general, the specific capacities appear to increase from north to south across the area with the largest values concentrated in Twiggs County near Huber. The range of values was quite large with most of the values obtained from the well data in the files of the EPD Water Supply Branch. It should be noted that specific capacities are greatly influenced by the quality of well construction.

By using the data that was presented in the reports by Anglo-American Clays Corporation for their best borings, some information on the aquifer characteristics of the area may be calculated. As mentioned previously, Anglo-American Clays drilled eight test wells north of Wrens to obtain data on aquifer conditions. A sieve analysis was conducted on selected samples from the wells. The use of the Fair and Hatch permeability formula (Fair and Hatch, 1933) in conjunction with the sieve analyses can lead to the determination of the specific permeability of the aquifer. The specific permeability is given by:

$$k = \frac{1}{m\left[\frac{(1-\alpha)^2}{\alpha}\left(\frac{\Theta}{100}\Sigma\frac{P}{d_m}\right)^2\right]}$$

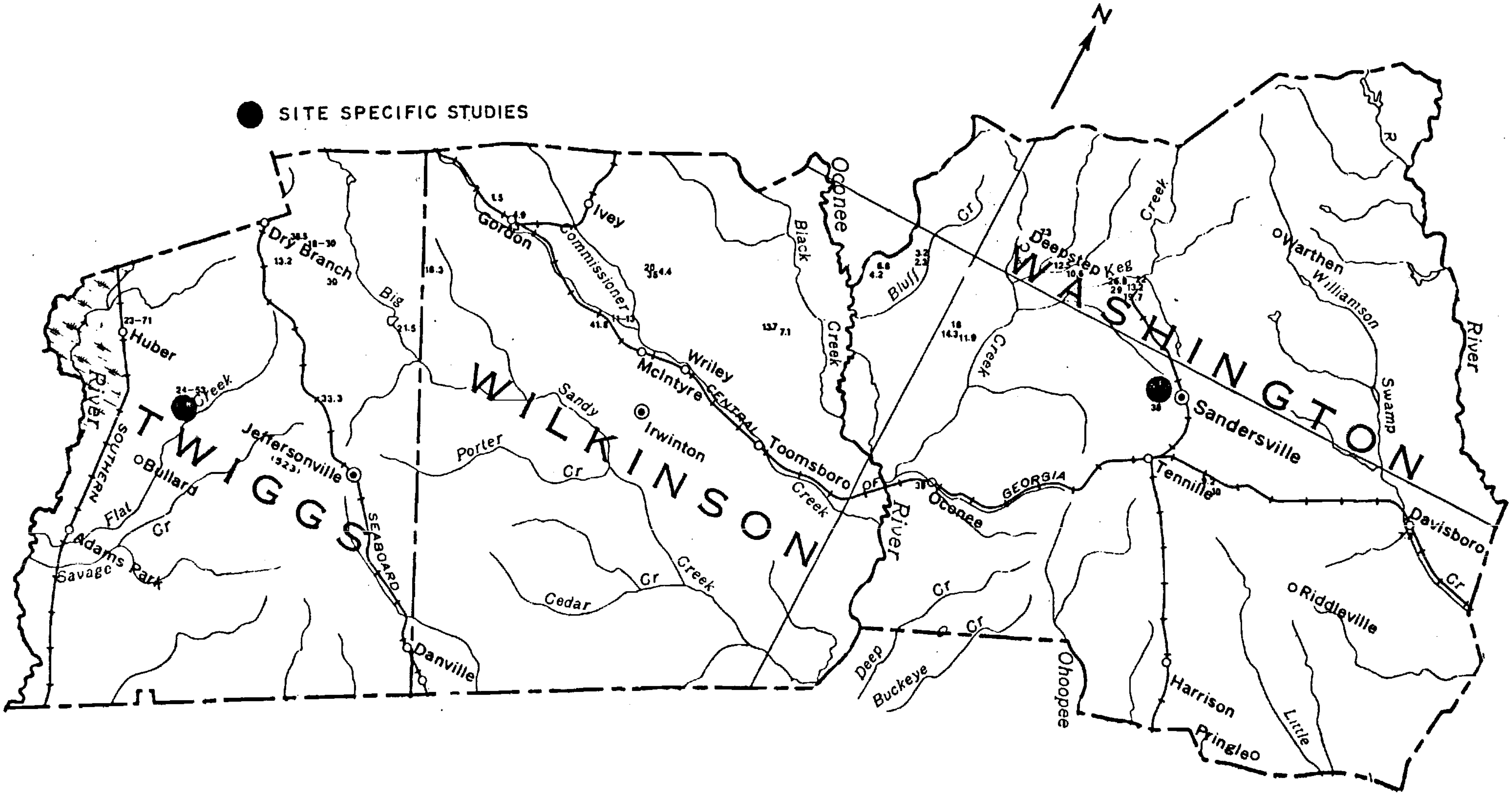


FIGURE 25. Specific Capacities for Washington, Wilkinson and Twiggs Counties

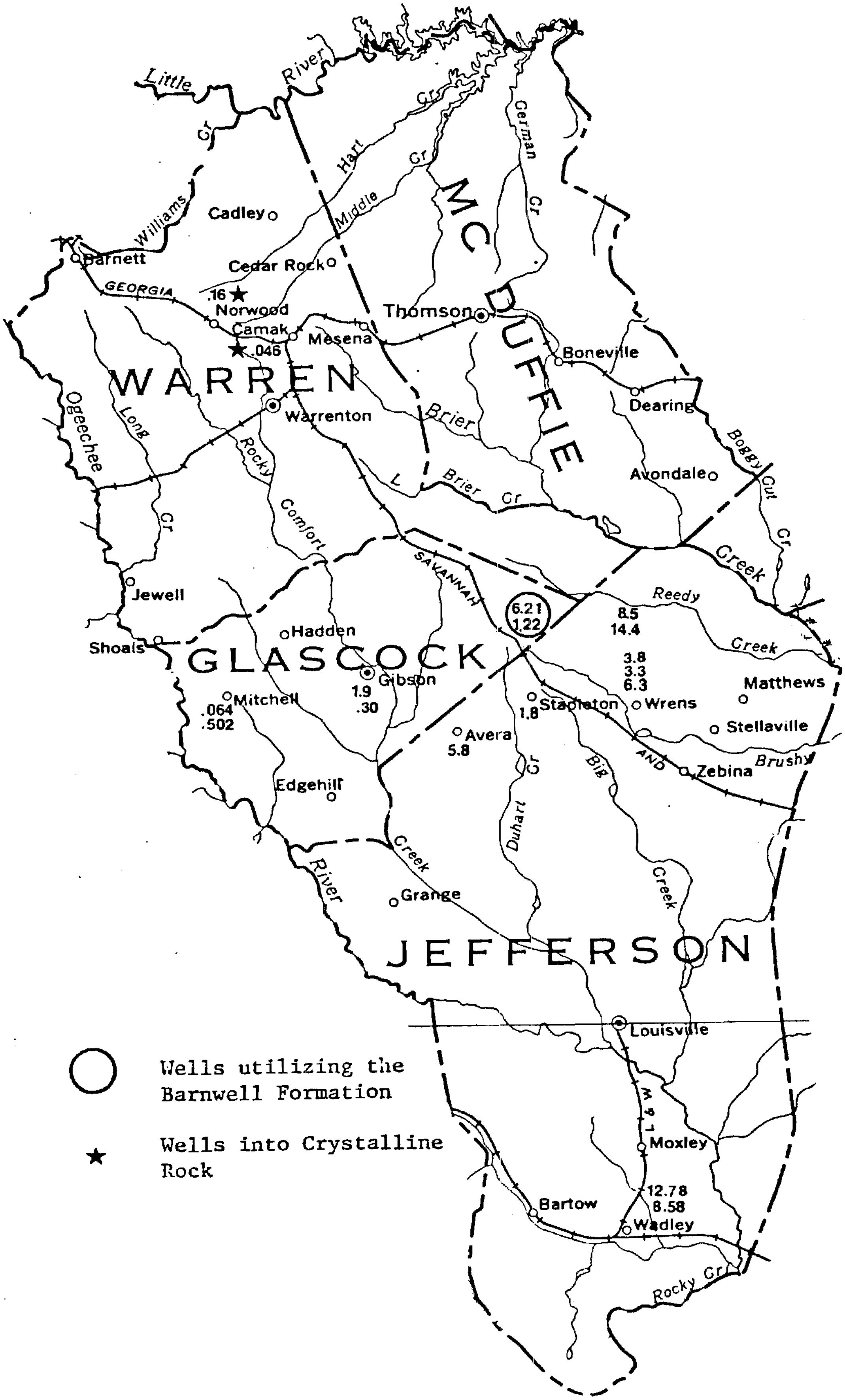


FIGURE 26. Specific Capacities for Glascock, Jefferson, McDuffie and Warren Counties

where;

α is porosity, usually between 30 to 40 percent for most ranges of sand and/or gravel

m is a packing factor, found experimentally to be about 5

Θ is a sand shape factor, varying from 6.0 for spherical grains to 7.7 for angular grains

P is the percentage of sand held between adjacent sieves

d_m is the geometric mean of rated sizes of adjacent sieves

Once the specific permeability, k, is found, the permeability, K, in the traditional units of gallons per day per square foot can be obtained. Noting that $K = kg/\gamma$, where g is gravity and γ is the kinematic viscosity of the fluid, a series of conversion factors will lead from specific permeability, k, to permeability, K. Applying the Fair and Hatch formula to the data from Anglo-American's eight wells and converting to the more desirable K, values of permeability from 900 to 6500 gpd/ft^2 for the two aquifers were obtained. By using the information from the well logs and data from the report on the aquifer thickness, transmissivities for the area were calculated and ranged from 80,000 gallons per day/foot to 275,000 gallons per day/foot. The values that were obtained for permeability, and subsequently for transmissivity, are in the range for a good aquifer. However, the results from the Fair and Hatch equation must be used with caution for a larger permeability value may be obtained than is actually present. This is because the fines are often washed out, making the percent of coarse material appear larger, thereby increasing the K value.

Potential Induced Drawdown from Pumping

The most useful information was obtained from the site specific studies at Sandersville and Huber presented earlier in this report. The locations of these studies are shown in Figure 25. Using average values of transmissivity and storage coefficient at each site and assuming an arbitrary continuous withdrawal of 1000 gpm, the drawdown in the piezometric surface in the area adjacent to the center of pumping has been computed for withdrawal periods of 1 month and 1, 5, and 10 years and is shown on Figure 27 for the Sandersville area, Figure 28 for the Huber area, and Figures 29 and 30 for the Wrens area with two different transmissivities. The drawdowns were computed using the Theis nonequilibrium formula as shown below:

$$s = \frac{114.6Q}{T} W(u)$$

where;

$$W(u) = \frac{e^{-u}}{u} du = -0.5772 - \log_e u + u - \frac{u^2}{2x2!} + \frac{u^3}{3x3!} - \frac{u^4}{4x4!}$$

$u = 1.87\ r^2 S/Tt.$

s = drawndown, in feet, at any point of observation in the vicinity of a well discharging at a constant rate

Q = discharge, in gallons per minute

T = coefficient of transmissibility, in gallons per day per foot

r = distance, in feet, from discharging well to point of observation

S = coefficient of storage, expressed as a decimal fraction

t = time, in days, since discharge began

The nonequilibrium formula is based on the following assumptions:

1. The aquifer is infinite in areal extent and is homogeneous and isotropic (transmits water in all directions with equal facility);

2. The coefficients of transmissibility and storage are constant;

3. The aquifer is confined between impermeable beds;

4. The discharging well penetrates the entire thickness of the aquifer; and,

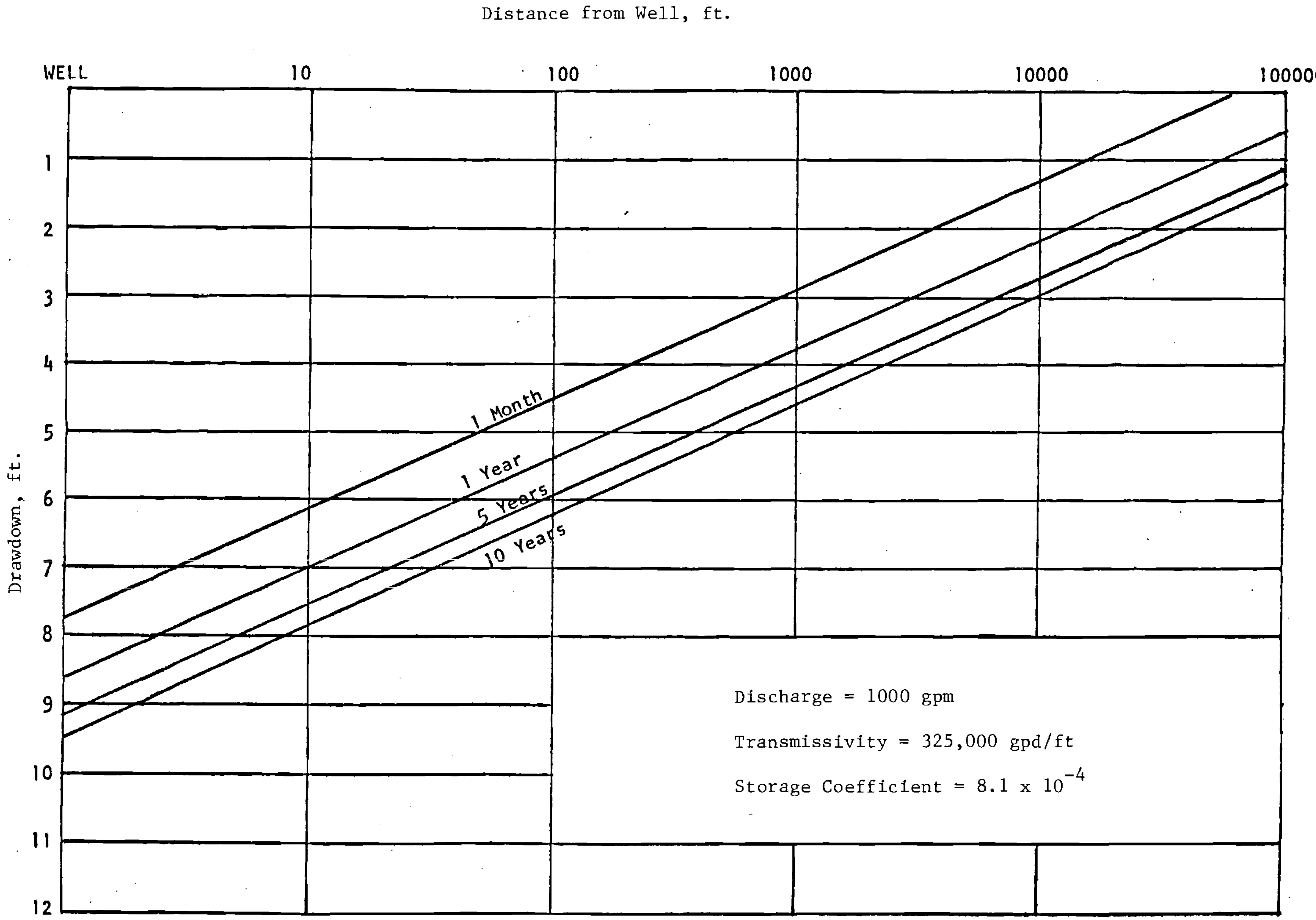


FIGURE 27. Theoretical Drawdown Curves Near Sandersville, Georgia

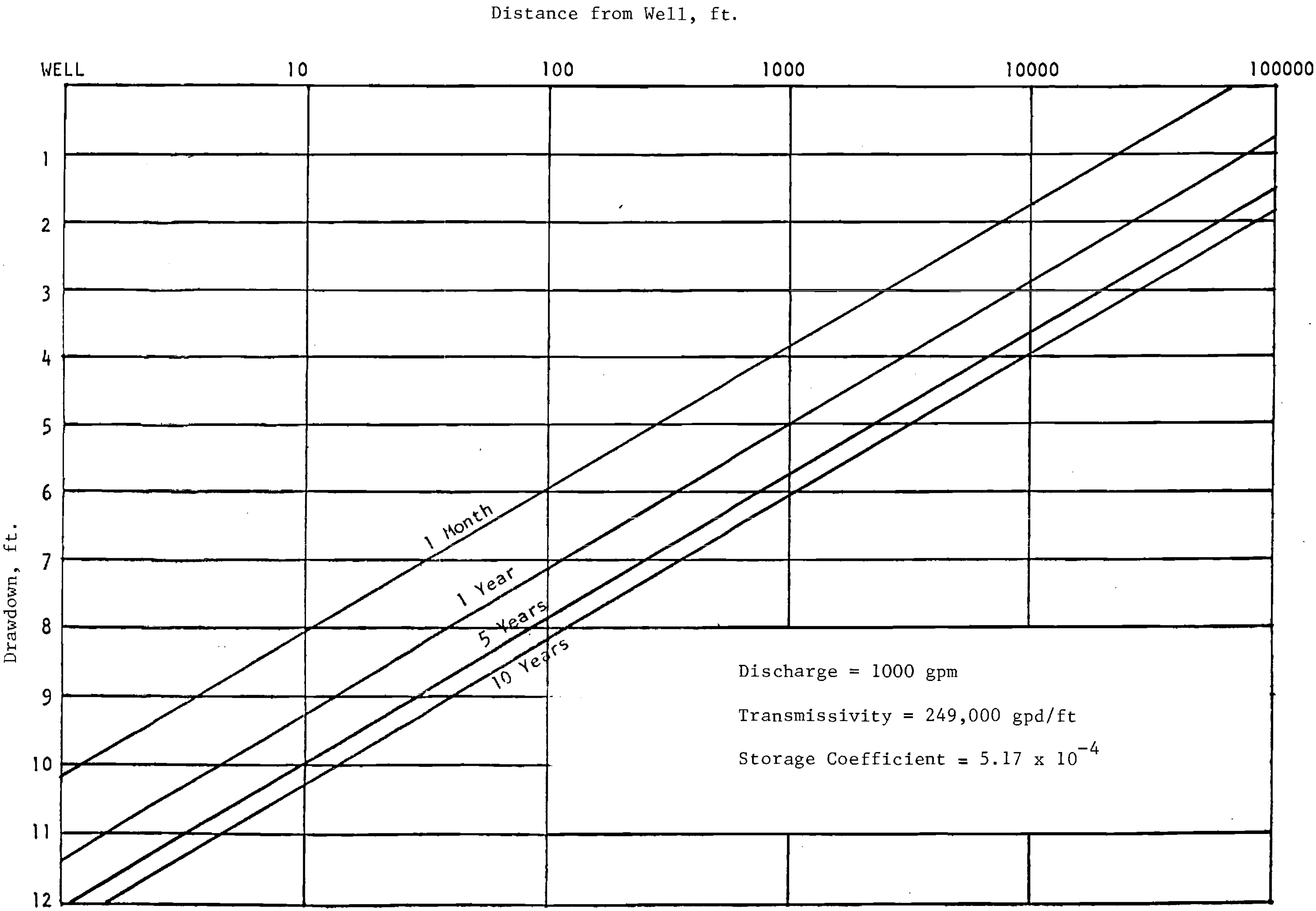


FIGURE 28. Theoretical Drawdown Curves Near Huber, Georgia

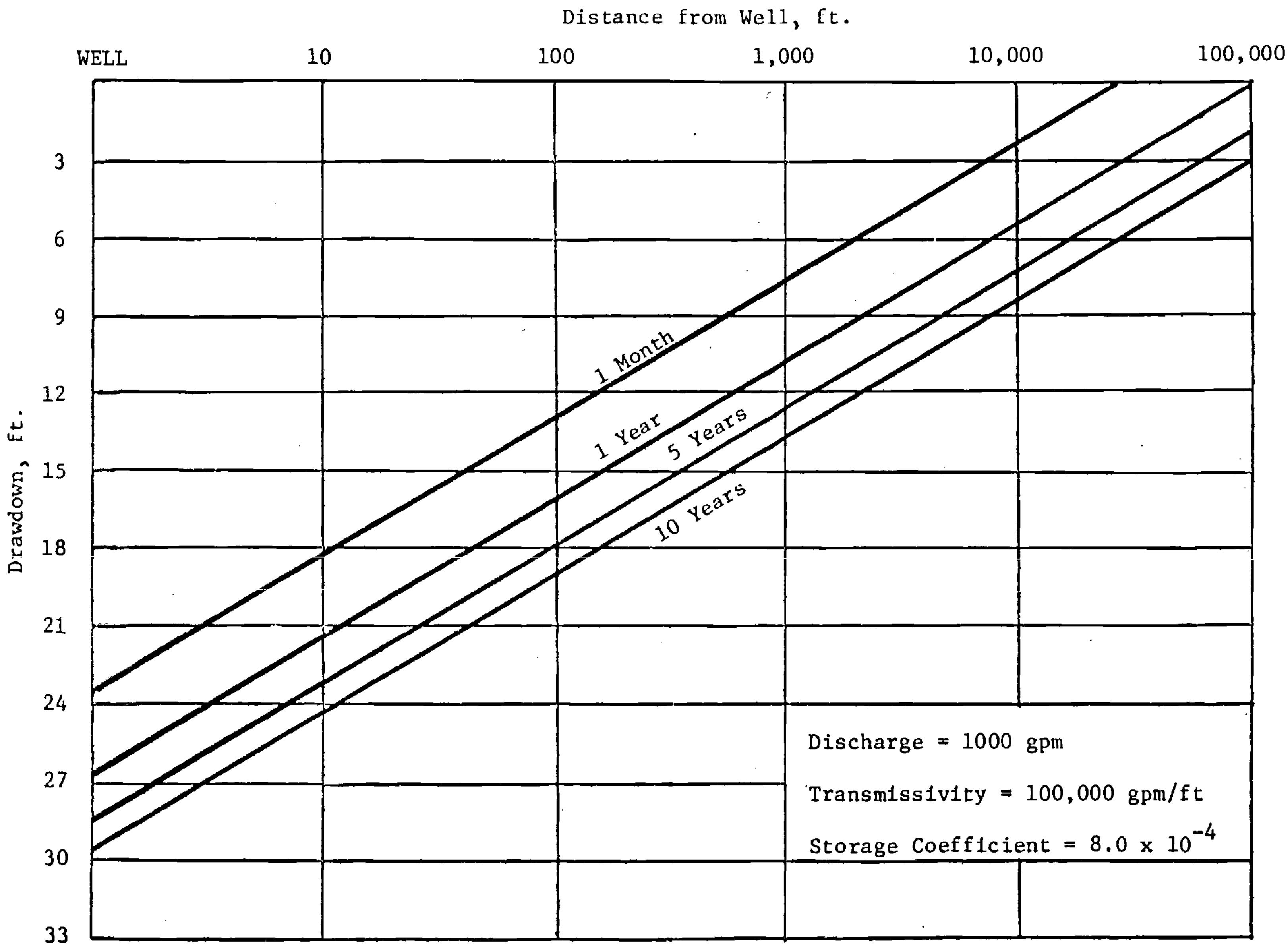


FIGURE 29. Theoretical Drawdown Curves Near Wrens, Georgia

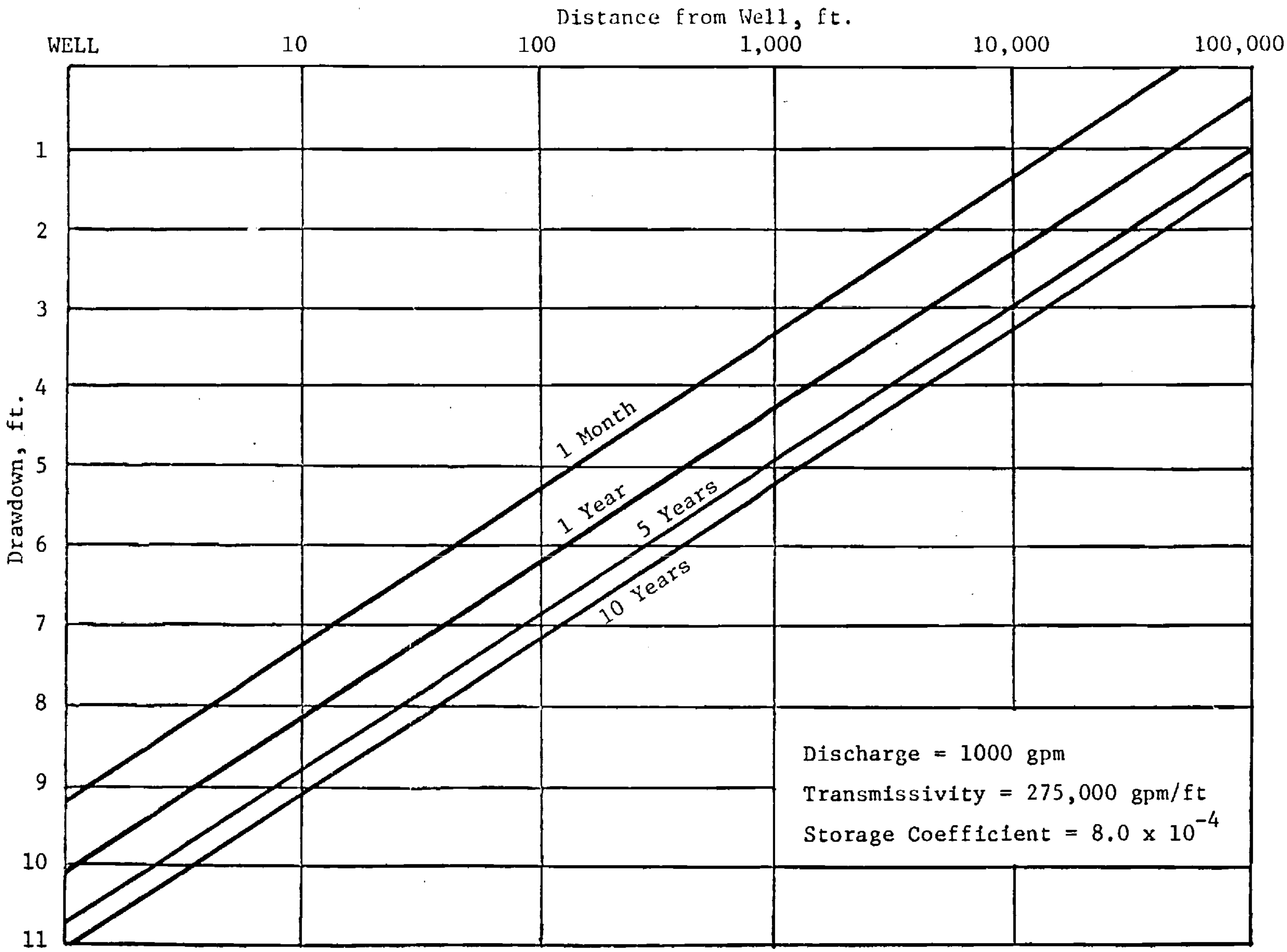


FIGURE 30. Theoretical Drawdown Curves Near Wrens, Georgia

5. The discharged water is released from storage instantaneously with decline in head.

None of these conditions is fully met in nature, and considerable experienced judgment is necessary to decide the extent to which they apply. Despite the restrictive assumptions on which it is based, however, the nonequilibrium formula can be successfully applied to many problems of groundwater flow. The Theis formula has been applied in this area with a high degree of success in projecting water levels that would occur from existing dewatering projects. A few values of theoretical drawdown from the pumping center for Sandersville and Huber are summarized in the table below:

Location	Distance (mi.)	Theoretical Drawdown, ft. 1 yr.	Theoretical Drawdown, ft. 10 yr.
Sandersville	Well	8.6	9.4
	0.2	3.8	4.6
	2.0	2.0	2.9
Huber	0.0	11.4	12.4
	0.2	5.0	6.0
	2.0	2.8	3.9

More detailed theoretical drawdowns were calculated for the Wrens area to demonstrate the effects of different pumping rates in addition to the time and distance variables. These data are shown in Tables 23 and 24.

Estimates of drawdowns for more than one pumping center can be made by adding the drawdown effects caused by each well. Since drawdowns are directly proportional to pumping rate, the theoretical drawdown at any rate Q can be computed from the curves in Figures 27 through 30 as follows:

$$Q/1000 \times S_{1000} = S_Q$$

where;

S_{1000} is the drawdown at 1000 gallons per minute (gpm)

S_Q is the drawdown at pumping rate Q (gpm)

TABLE 23. Theoretical Drawdowns for Various Pumping Rates at Wrens, Georgia

Transmissivity = 100,000
Storage Coefficient = 8.0×10^{-4}

Q, gpm	Distance From Well, mi.	Theoretical Drawdown, ft. 1 Month	1 Year	5 Years	10 Years
	0.0	16.57	18.59	19.85	20.41
	0.1	6.61	8.67	9.94	10.38
	0.5	4.06	6.04	7.30	7.91
694	1.0	3.00	5.01	5.43	6.84
(1 MGD)	5.0	.64	2.42	3.65	4.21
	15.0	.01	.87	1.93	2.48
	0.0	23.87	26.77	28.60	29.42
	0.1	9.52	12.49	14.33	14.96
	0.5	5.85	8.70	10.52	11.40
1000	1.0	4.32	7.21	8.39	9.86
	5.0	.92	3.48	5.27	6.06
	15.0	.02	1.25	2.78	3.58
	0.0	49.73	55.79	59.58	61.28
	0.1	19.84	26.02	29.84	31.18
	0.5	12.19	18.13	21.94	23.75
2083	1.0	9.00	15.04	13.32	20.53
(3 MGD)	5.0	1.92	7.26	10.98	12.63
	15.0	.03	2.61	5.80	7.46
	0.0	414.51	465.04	496.60	510.72
	0.1	165.35	216.89	248.69	259.84
	0.5	101.56	151.10	182.64	197.96
17,361	1.0	75.05	125.33	111.09	171.10
(25 MGD)	5.0	16.01	60.54	91.52	105.27
	15.0	.25	21.76	48.35	62.23

TABLE 24. Theoretical Drawdowns for Various Pumping Rates at Wrens, Georgia

Transmissivity = 275,000
Storage Coefficient = 8.0×10^{-4}

Q, gpm	Distance from Well, mi.	Theoretical Drawdown, ft. 1 Month	1 Year	5 Years	10 Years
	0.0	6.31	7.04	7.51	7.72
	0.1	2.69	3.41	3.88	4.08
694	0.5	1.77	2.49	2.96	3.15
(1 MGD)	1.0	1.36	2.09	2.55	2.75
	5.0	.48	1.17	1.63	1.83
	15.0	.06	.57	.99	1.18
	0.0	9.09	10.15	10.81	11.13
	0.1	3.88	4.92	5.59	5.88
1000	0.5	2.56	3.59	4.26	4.55
	1.0	1.97	3.01	3.68	3.96
	5.0	.69	1.68	2.35	3.96
	15.0	.08	.78	1.43	1.71
	0.0	18.94	21.14	22.53	23.18
2083	0.1	8.09	10.25	11.65	12.24
(3 MGD)	0.5	5.34	7.49	8.88	9.47
	1.0	4.10	6.27	7.66	8.26
	5.0	1.44	3.50	4.89	5.49
	15.0	.17	1.64	2.99	3.56
	0.0	157.93	176.17	187.82	193.24
	0.1	67.50	85.44	97.09	102.08
17,361	0.5	44.50	62.44	74.01	79.00
(25 MGD)	1.0	34.14	52.23	63.81	68.80
	5.0	12.03	29.17	40.73	45.72
	15.0	1.41	13.67	24.88	29.67

Local Attitudes and Opinions

As part of the effort to determine the impact of the development of an alumina from kaolin industry, interviews were conducted in the areas considered promising for such an enterprise. In addition to the kaolin mining and processing companies, other local industries, city officials, county officials, soil conservation services, and area planning and development commissions were contacted. Included in the survey was a focus on impacts of a new industry on the water resources of the area with emphasis on availability of water and possible water pollution from industrial discharges which appeared to be the greatest area of concern.

For purposes of the interview process, the kaolin belt was divided into four areas including:

1. Jefferson, Glascock and Warren Counties; interviews were conducted in Wrens, Louisville and Augusta
2. Washington County; interviews were conducted in Sandersville and Milledgeville
3. Twiggs and Wilkinson Counties; interviews were conducted in Gordon, McIntyre, Huber, Jeffersonville, Dry Branch and Macon
4. Schley and Sumter Counties; interviews were conducted in Andersonville and Ellaville

Except for Area 4, these areas essentially embrace the study area of concern in this report and considered the most likely for the development of an alumina from kaolin industry.

The results of these interviews can be summarized as follows:

Area 1: It was generally agreed that groundwater would be difficult to obtain in the quantities which would be required (up to 7.0 MGD). Where groundwater has not met local expectations, surface water has been used to supplement the supply, primarily by the erection of storage reservoirs which are fed from streams during rainy periods. A figure of 7.0 MGD or about 5000 gpm exceeds by 2000 gpm the water needs of the kaolin company interviewed and which had indicated difficulty in locating adequate groundwater supplies. Therefore, it could be anticipated that if the maximum of the estimated 3 to 7 MGD water requirement is necessary for the industry, groundwater supplies would need to be augmented by surface water resources.

Area 2: The Fall Line lies just north of the northern border of Washington County. Therefore, the thickness of sediments in this county was considered more than adequate for a good and plentiful water supply. Moreover, Herrick (Georgia Geological Survey Bulletin 70) has identified eleven potential water zones just outside of Sandersville. Local estimates of 1000 gpm were given for areas as distant as 10 miles north and east of Sandersville.

Area 3: There were mixed reactions concerning groundwater availability in the region; the conclusion being that water availability is purely geologic and site-specific. One kaolin mining operator felt that 7 MGD would be difficult to acquire. However, another operator less than 20 miles from the first is currently using 7 MGD pumped from wells within a 1-mile area. In addition, the wells are from 250-350 feet deep and there has been no noticeable drawdown of the water table. Other mining operations in the area have no problems with availability of water, in fact, one particular operation has encountered exceptional dewatering problems. This was caused by a mining error which broke into an area with high artesian pressure. Nearby wells are employed to create cones of depression to allow for continuing operations. Again, the item of concern would center on the removal of that magnitude of water from the ground.

Area 4: This area has encountered no problems with water availability. However, much of the water used is surface water, rather than groundwater; there are a number of creeks plus the Flint River flowing through the area. Neither of the two kaolin mining operations have problems acquiring water or with dewatering the mines. There would be possible problems with using the surface water, particularly the Flint River. One is the installation of a new pulp plant which would be a major water user and discharger. The other is that use of the Flint River is closely regulated. Each of these issues would need to be considered should the potential location of an alumina from kaolin industry be considered for this area.

ASSESSMENT OF SURFACE WATER RESOURCES

The surface resources of east-central Georgia are usually divided into two categories; the principal streams and the lesser streams. The term "Principal Streams" is used to describe portions of rivers and major creeks that have substantial drainage basins and flows. The term "Lesser Streams" is used for smaller, perennial streams, usually called creeks, and for the headwater portions of rivers. In the seven-county area, the Ogeechee River, Oconee River, Ocmulgee River, Big Sandy Creek, and Briar Creek are considered principal streams.

Due to the large amount of high quality groundwater available throughout the area and the minimal economic costs associated with developing groundwater supplies, the surface water resources of the area have remained virtually undeveloped. There is not much information available regarding the low flows of streams and rivers in the area. The following data indicate some of the information presently being compiled by USGS regarding low flows at a few locations on principal streams in or near the study area:

River/Stream	Drainage Area, sq. mi.	7-Day, 10-Year Flow, cfs	Flow Per Square Mile
Oconee River near Milledegeville (R)	2950	250	0.085
Oconee River near Dublin (R)	4400	570	0.13
Oconee River near Mt. Vernon	5110	680	0.13
Ocmulgee River at Macon (R)	2240	410	0.18
Ogeechee River near Louisville	800	91	0.114
Big Sandy Creek near Jeffersonville	31	3.6	0.12

(R) designates flow is regulated by upstream reservoir.

The flow on the Oconee River at Milledgeville, which is located just north of the study area, is composed of drainage from the Piedmont; while the flow at Dublin, which is located south of the study area, is composed of drainage from the Piedmont and Upper Coastal Plain. The flow on the Oconee River near Mt. Vernon contains drainage from the Piedmont and Upper Coastal Plain as well as the Lower Coastal Plain. The increase in flow and flow per square mile downstream on the Oconee River shows the influence of groundwater on the stream flow. An incremental analysis between the three stations yields a flow of 0.22 cfs/mi^2 between Milledgeville and Dublin, but a flow of only 0.15 cfs/mi^2 between Dublin and Mt. Vernon. The higher flow between Milledgeville and Dublin verifies that the Oconee River receives groundwater from the Cretaceous Aquifer.

The Ogeechee River rises in the Piedmont province and has a drainage area of 800 square miles and an average flow of 868 cfs or 560 MGD at Louisville, where it is gauged by the USGS. There is a potential for industrial growth in its valleys for the Ogeechee River has rail transportation running along the greater part of it. The combination of heavy duty transportation with good industrial water supplies makes industrial growth promising.

Macon is located just northwest of the study area on the Ocmulgee River, Louisville directly east of the study area on the Ogeechee River, and Jeffersonville in east-central Twiggs County on Big Sandy Creek. The small flow in Big Sandy Creek is probably due to the fact that it does not cut into the highly productive Cretaceous Aquifer, but rather receives its water as drainage from upper channel sands.

Briar Creek, a major tributary of the Savannah River, rises in the Piedmont province but has most of its drainage area in the Fall Line, Sand Hills region. It leaves Jefferson County, however, in the northeast and will not benefit much of the study area.

The predominant characteristics of lesser streams in the physiographic regions are summarized in Table 25.

As mentioned previously, the surface water resources of the area have remained virtually undeveloped. Warrenton, until 1948, obtained its supply of water from wells, but abandoned these in favor of a surface supply from Rocky Comfort Creek. Thomson now derives its municipal water supply from Sweetwater Creek south of the town. An abandoned well more than 500 feet deep in granite originally supplied the town, but because of its meager yield, it has not been used for many years. These two towns need the surface supply because of their location in the Piedmont province. Other communities south of these have a vast supply of groundwater from which to draw. The development of surface streams would require a detailed study of the area, the physiographic area through which they flow, and the characteristics of the stream itself.

TABLE 25. Characteristics of the Lesser Streams in the Physiographic Regions of Georgia

Characteristic or Feature	Piedmont Province Streams	Fall Line Sand Hill Streams	Tifton Upland Streams
Average Flow, MGD/sq. mi.	0.4-0.6	0.6-1.4	0.4-0.6
Flood Flows	flashy frequent and high	infrequent	moderate but long drawn out
Dry Season Flows	low for short periods	plentiful flows	low for long periods
Channel Gradients	steep	steep	gentle
Channels	deep	shallow	swampy
Flood Plains	narrow	narrow	wide
Storage Sites	many	some	very few

FUTURE CONSIDERATIONS

Future Water Demand

Using the current water demand estimates and the population projections presented in previous sections, a projection of water demand through the year 2000 was developed. The water demand projections for each county are listed in Tables 26 and 27 according to municipal demand and industrial demand with and without the potential alumina from kaolin requirements. These projections were based on the following assumptions:

1. Both municipal and industrial current water demands are accurate;
2. The population projections provide an accurate estimate of potential growth;
3. The potential population increase will occur in and around the cities and towns, exerting a direct demand upon an existing municipal water supply system;
4. Water demand will average approximately 100 gallons per capita per day; and,
5. Industrial demand will not increase substantially due to environmental restrictions encouraging reuse of process water in the kaolin mining and processing industry.

Numerous problems were encountered in the development of the water demand projections. All of these problems affect the accuracy of the projections and, therefore, should be considered when evaluating the data. The base data used to estimate the current water demand were sometimes suspect or not even available. Moreover, the estimate is applicable only to municipal supplies and does not consider any rural demand. However, neglecting rural demand is not unreasonable since rural supplies are usually drawn from shallow groundwater aquifers and the total rural demand

TABLE 26. Projected Water Demand for Washington, Wilkinson and Twiggs Counties

Year	Type	Washington County Water Use, MGD	Wilkinson County Water Use, MGD	Twiggs County Water Use, MGD
1970	Municipal	0.805	0.415	0.175
	Industrial	16.1	8.4	38.0
1980	Municipal	0.980	0.470	0.186
	Industrial	16.1	8.4	38.0
	w/ Alumina-Kaolin	19-26	11-15	41-45
1990	Municipal	1.172	0.544	0.220
	Industrial	16.1	8.4	38.0
	w/Alumina-Kaolin	19-26	11-15	41-45
2000	Municipal	1.384	0.620	0.244
	Industrial	16.1	8.4	38.0
	w/Alumina-Kaolin	19-26	11-15	41-45

TABLE 27. Projected Water Demand for Glascock Jefferson, McDuffie and Warren Counties

Year	Type	Glascock County Water Use, MGD	Jefferson County Water Use, MGD	McDuffie County Water Use, MGD	Warren County Water Use, MGD
1970	Municipal	0.090	1.22	2.045	0.304
	Industrial	0.030	2.0	0	0
1980	Municipal	0.090	1.173	2.050	.254
	Industrial	0.03	2.0	0	0
	w/Alumina-Kaolin	3-7	5-9	3-7	3-7
1990	Municipal	.100	1.133	2.094	.234
	Industrial	0.03	2.0	0	0
	w/Alumina-Kaolin	3-7	5-9	3-7	3-7
2000	Municipal	.090	1.033	2.072	0.200
	Industrial	0.03	2.0	0	0
	w/Alumina-Kaolin	3-7	5-9	3-7	3-7

county-wide would be insignificant when compared with large municipal or industrial uses. The population projections are very optimistic and are generally based on reversal of an existing trend. Nevertheless, using these optimistic growth figures will provide a certain degree of safety in the projected water demand estimate and also potential impacts on wastewater treatment requirements.

Probably the most questionable part of the water demand projections is the constant industrial usage over the next 25 years. Kaolin companies are by far the largest water users in the study area and may not experience any additional water demand in the future. This assumption is based on information obtained from the interviews with officials of certain kaolin companies. Any future increases in demand might be satisfied through shifts in allocation of existing supplies, use of large quantities of water which are presently discharged to streams from dewatering operations, and increased reuse of process water.

The projected municipal and industrial water demand does not include the potential requirements and effects of the alumina from kaolin industry. Preliminary estimates of personnel requirements for development of this new industry are quite small (about 300 people) and should be adequately supplied by the anticipated normal growth in the area. More detailed information on both primary and secondary employment requirements caused by the development of the industry is currently being developed and will be available to allow revision of the preliminary water demand estimates presented in this report if necessary.

Processing water requirements for new alumina from kaolin industry are estimated to be between 3.0 and 7.0 MGD depending on operating capacities and type of processing employed. All the processes are based on alkaline acid methods; nitric, hydrochloric, or sulfuric acid. Pilot plant studies are currently being conducted by the U.S. Bureau of Mines to better define the water use and treatment requirements of each process. For analysis purposes, it was anticipated that production would begin between 1980 and 1985 and in Tables 26 and 27, the potential demand was shown to occur in each county. It is very likely, however, that the development of the industry will eventually take place in only one county; location will be dependent on specific site development information which is currently not available.

Development of an alumina from kaolin industry in Georgia will place a demand on groundwater in the areas where the process plants will be built. The demand for process water has been estimated to range from 3 to as high as 25 MGD depending on process for the extraction of between 3000 and 12,000 tons of kaolin per day. In certain areas of the kaolin belt, kaolin mines that have an elevation below the piezometric head have considerable dewatering operations. In the seven-county area of interest, a company seeking commercial kaolin below the piezometric head may place a demand on the groundwater resources by the need to dewater its mines. However, if the process plant were built near the mine, water removed for dewatering could be used for process water.

The pilot plants that are conducting research on the extraction of the alumina from the kaolin have not yielded sufficient data to determine exact water demands. Anglo-American Clays Corporation estimates a demand of 3300 gpm will be needed in 10 years of starting for its Wrens plant. This is for an ordinary kaolin plant, but it does fall into the 3 to 25 MGD range which had initially been used. Based on the data from Anglo-American, drawdown amounts have been calculated as presented previously in Table 23.

To summarize, for a Q of between 3 and 25 MGD and a transmissivity of 100,000 gpm/ft, the following values were obtained:

Distance from well, mi.	Theoretical Drawdown, ft.			
	1 month	1 year	5 years	10 years
0.0	50-415	56-465	60-497	62-511
0.1	20-165	26-216	30-249	31-260
0.5	12-101	18-151	22-182	24-198
1.0	9-75	15-125	13-111	21-171
5.0	2-16	7-60	11-92	13-105
15.0	0-.2	3-22	6-48	8-62

Kaolin deposits occur in sedimentary beds (Tuscaloosa formation) that overlap and lie unconformably on the crystalline basement rocks. All of the kaolin deposits of east-central Georgia were thought to be of Cretaceous age, but many are now known to be younger (Eocene). The commercial kaolin clay deposits are distributed throughout the area in discontinuous lenses, ranging from a few feet to 50 feet in thickness. The size of deposits, character and uniformity of deposits, and the overburden are all factors that determine if a deposit will be opened for mining. The thickness of a kaolin deposit has an important influence on the mining costs. Deposits of kaolin only 4 or 5 feet thick have been mined under favorable conditions, but as the thickness increases, the mining costs per ton decrease. The quality and uniformity of the deposit are critical factors that must be considered as are the thickness of overburden that can be removed economically from a kaolin deposit which depends upon: the value and thickness of the clay; the character of the overburden; and, other mining and preparation costs. Kaolin beds dip gradually to the southeast about 20-30 feet per mile. Many deposits are too deep to be of commerical value, with established mining companies usually removing up to 100 feet of overburden to reach kaolin of desired quality.

Elevations of commercial kaolin deposits are not available, but since they usually lie between the Tuscaloosa and Barnwell formations, and because the piezometric surface is usually above this location, dewatering problems seem likely. The alumina companies will seek a lower quality kaolin and, thus, may mine a larger and deeper area than traditional companies. Therefore, a need for even more dewatering seems likely. In many cases, an aquifer may be overlain by a confining clay layer which is itself overlain by a kaolin deposit. In this case, the kaolin deposit is below the piezometric surface but will not encounter water unless the impermeable clay layer is either pierced from above or broken by upward artesian pressure from below.

When examining the seven counties, the location of the kaolin dominates over the areas of the best water supply. In McDuffie County, the kaolin deposits are small, isolated lenses, occurring in the southern part of the county in the Tuscaloosa formation. In Glascock County, the kaolin deposits occur principally in the valleys of Rocky Comfort Creek and its tributaries near Gibson. These deposits consist of small lenses of soft kaolin and larger lenses containing hard kaolin. The northern and western parts of the county are underlain by the sands and kaolin of Eocene to Cretaceous ages (Figure 31). Thiele Kaolin Company is operating a plant on Bushy Creek east of Gibson, but reports of operations were not available. Glascock County, for the most part, seems to have a sparse supply of groundwater available for an alumina from kaolin facility.

Warren County, lacking the thick, water-bearing beds of the Tuscaloosa, seems to be an unfavorable area to establish mining or processing plants. Jefferson County, as seen on the Mineral Resources Map (Figure 31), contains kaolin in a small northern strip. The groundwater resources seem to be

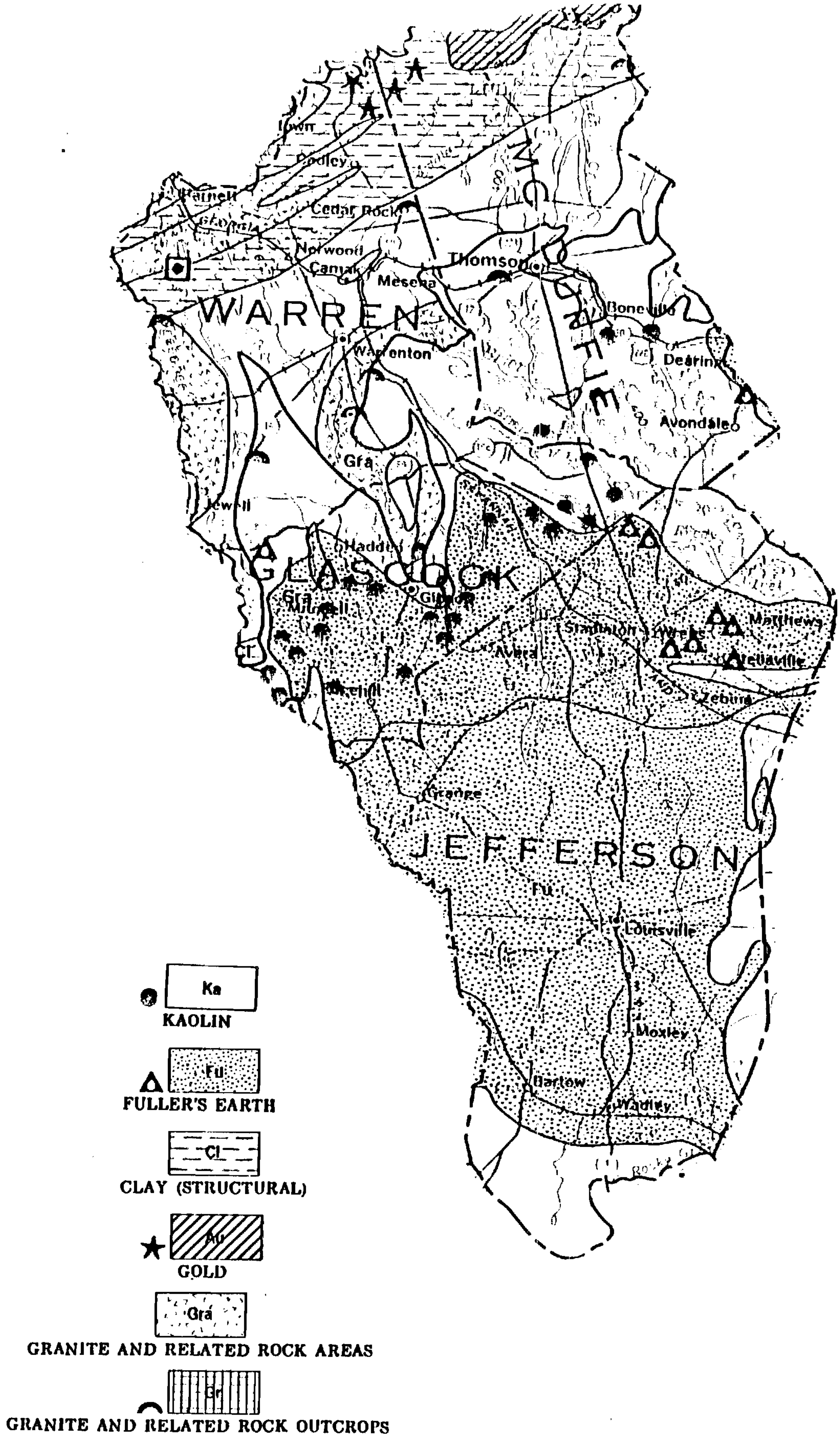


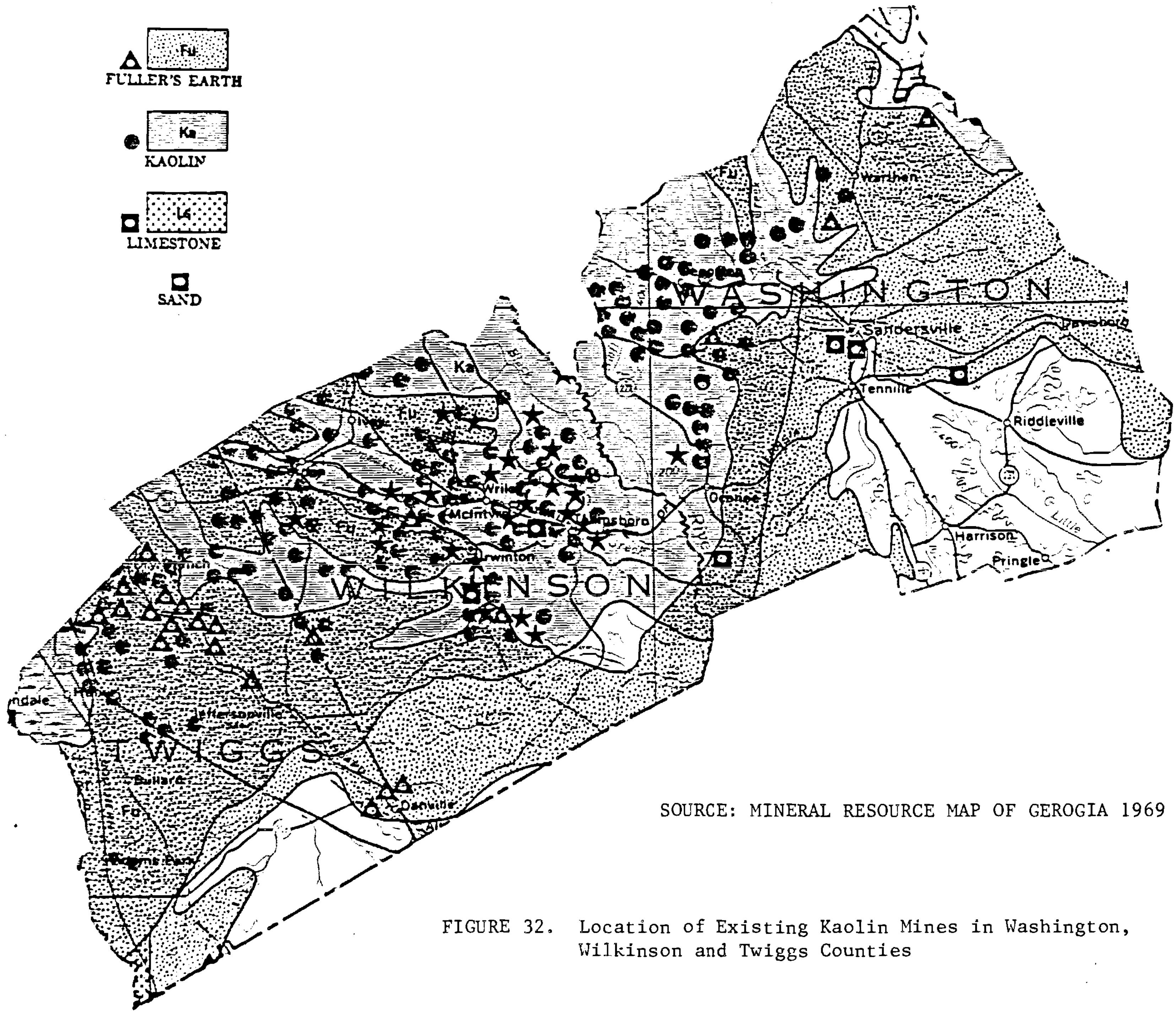
FIGURE 31. Location of Existing Kaolin Mines in Warren, McDuffie, Glascock, and Jefferson Counties

abundantly available, and the test wells of Anglo-American indicate that a pumping rate of 3300 gpm is feasible in this area. The J.M. Huber Corporation is operating near Reedy Creek north of Wrens. They report water to be sparse with a pH of approximately 4.5. Silting is a problem.

Since Washington, Wilkinson and Twiggs counties have been the center of the kaolin mining industry in Georgia, considerable information on the size and location of the kaolin beds has been collected by the kaolin mining companies. The location of existing kaolin mines are shown in Figure 32. An attempt was made to delineate those parts of the three-county area in which dewatering is expected to be a problem. Specific dewatering sites were identified near Huber, Dry Branch, Deepstep, and along the Oconee River. A more accurate delineation of potential dewatering areas was not possible because the exact elevation of the commercial kaolin deposits was not readily available. In areas where suitable quantities of kaolin exist, the main problem of potential alumina from kaolin plants would seem to be the dewatering problem and not the groundwater supply.

Future Wastewater Treatment Impacts

Since the quantity of water required by the alumina from kaolin industry and to be provided from a local source is site specific depending upon location actually selected, it is difficult to predetermine impacts on water resources. Generally, however, sufficient quality water is available in most probable locations which, with appropriate treatment before discharge, will not adversely influence receiving water quality. The impact of the industry on municipal wastewater treatment systems should be negligible but with large discharges to local streams, the overall hydraulic and ecological effects should be considered. Fortunately, the nature of the industry serves to minimize these problems since most of the water use would be for cooling



SOURCE: MINERAL RESOURCE MAP OF GEROGIA 1969

FIGURE 32. Location of Existing Kaolin Mines in Washington, Wilkinson and Twiggs Counties

which can be recovered and recycled. Only about five percent of the estimated 60,000 gallons of water per ton of product is required for makeup. Just how well process water (about 2000 gallons per ton of product) can be treated for recycle or discharge is not known at this time, but the technology is available to protect natural waters from such discharges.

Since water needs for producing alumina are of such magnitude, it is unlikely that a producer would use a city water system as a source of supply. Mine dewatering water and wells located on-site would appear to be the best sources of water supply. Likewise, industrial wastewater treatment would probably be handled on-site because of the character of the process wastes and the potential for recycle. Therefore, it is also unlikely that a producer of alumina from kaolin would discharge process wastes to the municipal treatment system. Moreover, because of the relatively small personnel requirements, discharge of domestic wastes would be insignificant and easily accommodated by existing municipal waste treatment systems.

It may be anticipated that effluent limitations for discharges from an alumina from kaolin industry in Georgia will be controlled by the Georgia Department of Natural Resources, Environmental Protection Division (EPD) and its authority to implement the National Pollutant Discharge Elimination System (NPDES) Permit Program. For this purpose, the environmental standards developed for the "Ore Mining and Processing Point Source Category" (Federal Register, November 6, 1975) and its section on "Bauxite and Other Aluminum Ores" can be used as a guide. Specific details on environmental considerations and regulatory procedures and authorities have been prepared previously in a report titled "Alumina from Kaolin Environmental Considerations" by Ward and Husted (1976).

SUMMARY AND CONCLUSIONS

1. Water demand for processing alumina from kaolin will be in the range of 3 to 7 MGD. This range represents the requirements for a production rate of from 300,000 tons to 1,000,000 tons of alumina product per year. The amount of this water that can be recycled is not currently known. Better information is expected soon as a result of pilot plant studies that are currently being conducted.
2. The principal aquifer in the seven-county area is the Tuscaloosa formation from which larger quantities of groundwater may be withdrawn. Smaller rural demands may be met by the shallower Barnwell formation.
3. Current withdrawals of groundwater from the principal aquifer are being made for municipal and industrial demands. By far the larger amount of this withdrawal is for industrial demands; a large portion of the industrial withdrawal is for dewatering of kaolin mines. Although some of the water from the dewatering operations is presently used for processing, the majority of the water is simply discharged to the nearest stream. This "waste" represents a potential supply for local municipal demand. Unfortunately, previous attempts to establish this type of operation in the area have failed due to problems with state regulations.
4. Projection of population and municipal use to the year 2000 show that no dramatic increase in municipal demand is expected. However, if new, large industrial withdrawals are made within a radius of several miles of current wells, induced drawdown created by the industrial demand could considerably increase the required lift and hence the cost of municipal pumping. The following table summarizes some of the typical drawdown for each site (i.e., Sandersville, Huber and Wrens for a

demand range of 3-25 MGD:

Location	Distance from well, mi.	Range of Drawdown, ft. 1 yr.	10 yrs.
Sandersville	1.0	6-46	7-59
	5.0	3-26	5-40
	10.0	2-18	4-31
Huber	1.0	8-61	9-79
	5.0	5-35	7-53
	10.0	3-24	6-42
Wrens	1.0	15-125	21-171
	5.0	7-68	13-105
	15.0	3-22	8-62

5. High rates of withdrawal of groundwater from the principal aquifer may be necessary to dewater alumina-kaolin mines. Pumping rates up to 31 MGD are required to dewater kaolin mines which are now in operation. Data on piezometric levels and elevations of commerical kaolin deposits indicate that dewatering should be anticipated. The alumina-kaolin mines, which may be larger and deeper than the traditional kaolin mines, could require larger amounts of dewatering. Studies are being conducted to provide additional information on this issue.

6. Surface water may provide an additional source of water for future industrial development in the area. Due to the variability of flows in streams throughout the area, the development of surface water supplies requires site specific studies. The interrelationship between surface and groundwater is very important throughout the study area. Streams are not only influenced by natural discharge from the aquifers, but also by the dewatering operations which can add directly to the streamflow. The potential increase in dewatering operations caused by development of kaolin-alumina industry may greatly affect flows in small streams near the mining operations.

7. Industrial wastewater discharge and/or treatment will require particular attention as the industrial processes associated with the alumina from kaolin industry are developed. Discharge limitations will be site specific and will depend upon whether the receiving stream is effluent or water quality limited. Guidelines and technology are available to accommodate these requirements and information is being developed to determine most applicable procedures.

8. Because of the limited personnel requirements of the industry, increases in domestic wastewater discharge should be easily accommodated by existing municipal treatment systems.

9. Water in the kaolin areas west of the Ogeechee River is generally more abundant than east of the Ogeechee River. Some areas east of the Ogeechee River, such as in Warren and McDuffie counties, have only slightly more than sufficient water for present kaolin operations in the immediate vicinity of operations. Water should be sufficient for expanded kaolin operations, however, including that for alumina from kaolin in this area if piped approximately 7 to 10 miles, and more than sufficient, particularly in areas west of the Ogeechee River in the vicinity of operations.

10. Insufficient data is available from wells or test holes drilled to the basement in much of the area east of the Ogeechee. Present information indicates that for wells of 1000 gpm or better, it will be necessary to drill approximately 7 to 10 miles south of the Jefferson-Glascock county line in the area south of Stapleton and Wrens. Additional testing will be necessary to determine if this distance may be shortened.

11. Two years in succession of drought conditions in the kaolin areas has resulted in an increase in irrigation wells which are likely to continue to increase as local financing from crops permits.

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Test Well
Drilled in Glascock County, Georgia
(see location maps)

Drilling was begun on July 10, 1978, by the Grosch Irrigation Company, under state contract 503-0004-590. Three wells were drilled.

One 14-inch well was drilled with a Failing hole master 4000-foot rig, using a soft formation roller bit with six-inch stems. Well was drilled with reverse circulation. A 26 O.D.-inch hole was drilled to 300 feet of depth.

Surface elevation of well was 516 feet above mean sea level.

Casing was 14 inches O.D. in random lengths of 38 to 40 feet and were welded together.

Johnson galvanized irrigator screen, 0.040 slot, was set 285-295 feet and 245-253 feet. Well was gravel packed with #1/4-inch river-washed gravel, using 72 tons to fill to top. Mill slot (1/8 inch) was set on bottom from 300 feet to 295 feet and between the two sections of Johnson irrigator screen, with one additional section of mill slot above the topmost Johnson irrigator screen.

Holes "A" and "B" were drilled on a line having a compass bearing of N 55° E. Well "B" was 50 feet southwest of the 14-inch pump well and well "A" was on line 50 feet southwest of well "B" or 100 feet southwest of the 14-inch pump well. Estimated regional strike was N 40-45° E with a shallow south dip for the formations of the area.

Both holes "A" and "B" were drilled with a Failing 1500 rig using a roller rock soft formation bit using two passes. The first pass was with an 8-inch bit followed by a second pass that reamed with a 13-inch bit to give a 13-inch O.D. hole. Standard threaded pipe in 21-foot lengths using 4-inch couplings was used. Well "A" was drilled to 310 feet. One joint of pipe was set on the bottom with the Johson irrigator screen (0.035 slot) from 285-290 feet followed by two joints of pipe, then five more feet (240-245 feet) of Johnson irrigator screen, then cased to surface. Well "B" was cased in a similar manner with the Johnson irrigator screen (0.035 slot) being from 295-300 feet and 248 to 253 feet. Both "A" and "B" were tested by air reverse flushing to approximately 10 gpm out of the top of the casing.

Pumping prior to test pumping reached a peak of 350 gpm on July 26, 1978.

A 24-hour pump test was run from 8:00 a.m. July 28, 1978, to 8:40 a.m. July 29, 1978. Water pumping rate at both start and finish was 285 gpm.

Difficulty was had with the recording equipment as well as the pump during this test. The pump developed bearing trouble and pumping was not uniform, so the test was repeated August 2-3, 1978.

An analysis of the water at the start and end of pumping is attached.

Several observations and possible conclusions should be made concerning the well.

The wells went through approximately 44 feet of kaolin between 168 feet and 212 feet of depth. Approximately 1/2 ton of bentonite drilling mud was used in drilling the 14-inch well and proportionate amounts in the smaller wells. The result was an undue amount of surging and pumping required to condition the wells. In fact, there is a strong question that the 14-inch well may require extended periods of pumping before it is clear of kaolin and bentonite. The smaller wells were bailed twice before the final pumping.

The nature of the gravel in the formation where the Johnson irrigator screens were placed was coarse and should have yielded more water than was obtained. Hence, a conclusion is that there is a strong possibility of water flow being inhibited by excess kaolin and bentonite.

Because this was a test well, a further conclusion is that future wells should probably not use bentonite drilling mud, particularly if a thick kaolin bed is encountered.

The experience from this well further indicates that where a bed of kaolin is encountered above aquifers, a roller cone rock bit should not be used, but rather a fish-tail bit. A rock bit grinds up the kaolin, causing it to be dispersed in the drilling mud so that it infiltrates the aquifer and blocks water flow. A fish-tail bit slices the clay in chunks, allowing it to be brought to surface and removed before recirculation. A further recommendation is that once a kaolin bed is drilled through, the well should be circulated until clear water emerges before drilling deeper.

The difference in static water level in the well furthest from the pump, and the other two wells could be either (a) difference in aquifers or (b) saturation by kaolin and bentonite from 14-inch well and middle well to the extent of blocking flow from the furthest well to the pump well. This latter view if favored as the aquifer zones in each well appear at about the same level and of the same thickness. It is our opinion also that the aquifers were partially blocked by kaolin and should have yielded more water.

The increase in pH from beginning to end of the 24-hour pump test, on the basis of the rest of the analysis, is believed to be from dissolved CO_2.

The search for a suitable well site for the test well revealed that the probability is low that there is sufficient water for an alumina from kaolin operation in most of Glascock County, all of Warren County, and parts of the extreme north of Jefferson County. The most likely area in Glascock County appears in the southeast corner, extending in an area of perhaps a mile wide just west of the railroad to perhaps two miles north of the Jefferson County line.

Three to five hundred gpm per well is likely in this area. West of this area to the Ogeechee River along and north of the Glascock-Jefferson County line, water is sparse.

A further complication reported is that wells north of Wrens become acid (pH $\sim$ 4.5) after pumping and silt up unless continuously and evenly pumped.

Northwest Jefferson County has been insufficiently drilled, but reports of test holes in the area indicate the need for test wells.

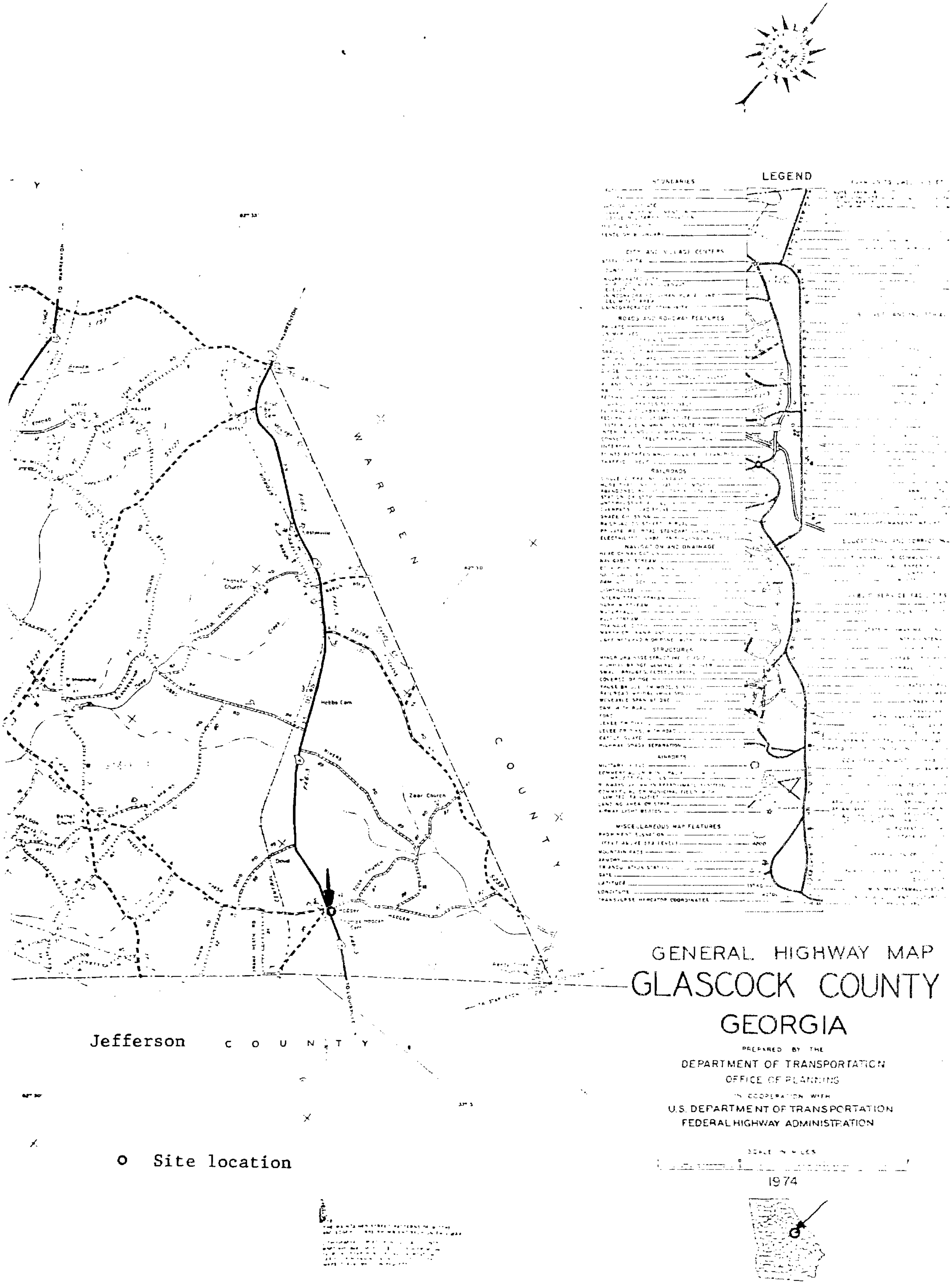
Approximately halfway between Stapleton and Louisville, water appears abundant and yields of 1200 gpm have been realized.

Pump Test
August 2-3, 1978

	Pump Well	B	A
Static water level	153 ft	178 ft	101 ft
August 2			
9:00 hrs	pump started 300 gpm flow	--	--
12:25		190 ft	108.5 ft
13:00		190.3 ft	108.7 ft
17:00		191.3 ft	108.9 ft
21:00		194.0 ft	109.5 ft
24:00	pump shut down 10 min to add gasoline	192.5 ft	108.6 ft
August 3			
1:00		193.15 ft	108.65 ft
5:00		194.05 ft	108.65 ft
8:30		193.85 ft	108.80 ft
9:00	pump rate 234 gpm-when pump shut off		
9:37		185.05 ft	106.4 ft
12:00	182.5 ft	181.5 ft	102.0 ft

Water temperature from well was 68°F.

The automatic recorder was not working properly. The above water levels were obtained manually. Obstructions in pump well with pump in place and operating prevented checking water level. Water pressure calculations to determine depth proved inaccurate.



LEGEND
WARREN COUNTY
Hebbs Cem
Zoar Church
Jefferson COUNTY
Site location
GENERAL HIGHWAY MAP
GLASCOCK COUNTY
GEORGIA
PREPARED BY THE
DEPARTMENT OF TRANSPORTATION
OFFICE OF PLANNING
IN COOPERATION WITH
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
1974

Joe D. Tanner
COMMISSIONER

[Jo]m Pickering, Jr.
DIRECTOR

Department of Natural Resources

GEOLOGIC AND WATER RESOURCES DIVISION
19 DR. MARTIN LUTHER KING, JR. DRIVE, S. W.
ROOM 400
ATLANTA, GEORGIA 30334
(404) 656-3214

Start
8/2/78
0900 hrs

WATER ANALYSIS

Laboratory No. 79-52 Date October 12, 1978 County Glascock

Water Well No. ____________

Location Well on north side of Ga. Hwy. 16, 1 mile inside Glascock County from Jefferson County line.

Owner Thiele Kaolin Company

Address ____________

Submitted by John Husted, Department of Chemical Engineering, Georgia Tech, Atlanta, Georgia 30332

pH (standard units)	5.2	Sulfate (SO_4)	1
Color (Pt-Co units)	80	Chloride (Cl)	2
Turbidity (Jackson units)	1,000	Fluoride (F)	0
Silica (SiO_2)	10	Nitrate (NO_3)	0
Iron (Fe)	0.5	Phosphate (PO_4)	0
Manganese (Mn)	0.05	Alkalinity as $CaCO_3$	4
Calcium (Ca)	1	Hardness as $CaCO_3$	4
Magnesium (Mg)	0.3	Dissolved Solids	20
Sodium (Na)	2.3	Bicarbonate (HCO_3)	5
Potassium (K)	0.5		

Parts per million (ppm) unless otherwise noted

Remarks:

Joe D. Tanner
COMMISSIONER

Sam Pickering, Jr.
DIRECTOR

Department of Natural Resources

GEOLOGIC AND WATER RESOURCES DIVISION
19 DR. MARTIN LUTHER KING, JR. DRIVE, S. W.
ROOM 400
ATLANTA, GEORGIA 30334
(404) 656-3214

Pump off
8/3/78
0900 hrs

WATER ANALYSIS

Laboratory No. 79-53 Date October 12, 1978 County Glascock

Water Well No. ______

Location Well on north side of Ga. Hwy. 16, 1 mile inside Glascock County from Jefferson County line.

Owner Thiele Kaolin Company

Address ______

Submitted by John Husted, Department of Chemical Engineering, Georgia Tech, Atlanta, Georgia 30332

pH (standard units)	4.5	Sulfate (SO_4)	1
Color (Pt-Co units)	5	Chloride (Cl)	2
Turbidity (Jackson units)	50	Fluoride (F)	0
Silica (SiO_2)	10	Nitrate (NO_3)	0
Iron (Fe)	0.2	Phosphate (PO_4)	0
Manganese (Mn)	0.00	Alkalinity as $CaCO_3$	0
Calcium (Ca)	1	Hardness as $CaCO_3$	4
Magnesium (Mg)	0.3	Dissolved Solids	17
Sodium (Na)	1.9	Bicarbonate (HCO_3)	0
Potassium (K)	0.5		

Parts per million (ppm) unless otherwise noted

Remarks:

Well Construction Final Report

Project No — 1 - Pump Well | Well Construction Starting Date — 7-12-78

Rig No — White Rig | Well Construction Completion Date — 7-14-78

Driller — Newt | Final Report Checked & Ok'd by —

PURCHASER State of Georgia

EXACT LOCATION 4 N 3 W off Stapleton in Glascock county CITY ______ STATE GA

WELL NUMBER 1 SIZE HOLE DRILLED 26" CASING OD 14" ID 13½

TYPE CONSTRUCTION V ☒ STRAIGHT ROTARY ☒ REVERSE

CONCRETE — CASING DATA	STEEL — CASING DATA
No. Screen Blocks Used ______ Feet ______	Screen Casing Used 100' Size ____ Type ____ Feet ____
No. Plain Blocks Used ______ Feet ______	Plain Casing Used 200' Size ____ Type ____ Feet ____
No. Spacer Sets Used ______ Type ☐ Metal ☐ Wood	No. Spacer Sets Used 3 Type ☒ Metal ☐ Wood
☐ Separate Plug ☐ Plug-Screen	☒ Separate Plug ☐ Plug-Screen
Comments:	Comments:

CONCRETE — FINISH DATA	STEEL — FINISH DATA
Casing Finished ______ ☐ Above ☐ Below Ground Level	Casing Finished 1 ft ☒ Above ☐ Below Ground Level
Type Gravel Used	Type Gravel Used
Gravel Obtained From	Gravel Obtained From
How Gravel Placed ______ How High ______	How Gravel Placed ______ How High ______
Water Proofing Used ☐ Yes ☐ No Amount ______	Water Proofing Used ☐ Yes ☐ No Amount ______
Sanitary Seal ☐ Yes ☐ No Type ______	Sanitary Seal ☐ Yes ☒ No Type 4'x4'x4" Cement
Length ______	Length 300 ft

Driller's Comments -- In relationship to the drilling & casing of the well

HOLE DRILLED 305 FEET BELOW GROUND LEVEL. WELL MEASURES 300 FEET FROM BOTTOM INSIDE. DATE WELL COMPLETED 7-14-78

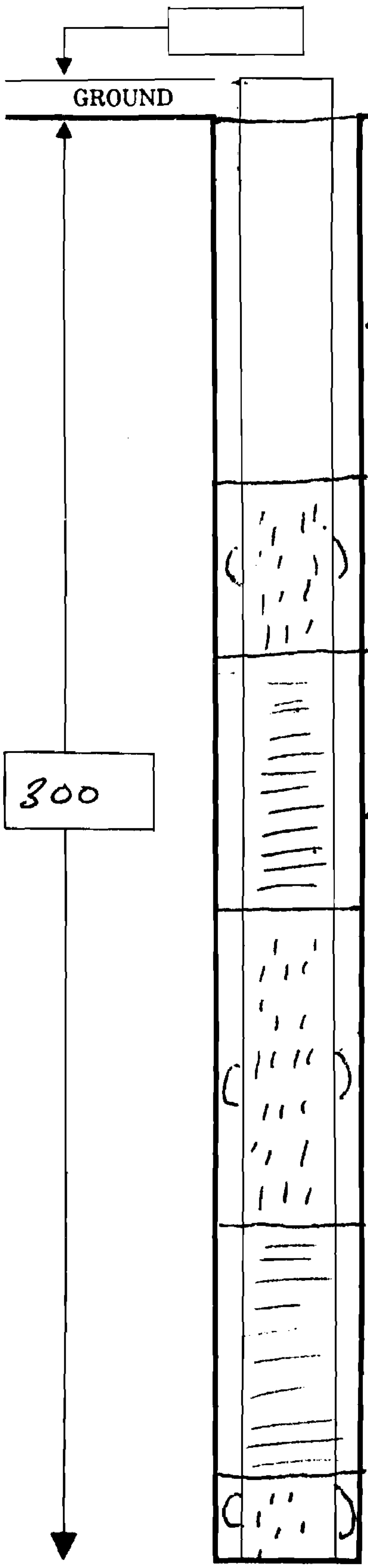
CONSTRUCTION FOREMAN Fred Alexander

FORM #1

Well Log Data

26 HOLE O.D. | 14 CASING O.D. | 13½ CASING I.D. | STATIC W. L.

GROUND LEVEL



LIST FORMATIONS BELOW

200 - to Ground Level Plain

240 - 200 mill Slot

250 - 240 johnson Screen

285 - 250 mill Slot

295 - 285 johnson Screen

5 ft mill Slot 300 - 295

Sketch in any special construction notes such as pits, sanitary seals, clay fill, special base, etc.

PRINT NO.

Well Construction Final Report

Project No — 2 = "A" Well Construction Starting Date — 7-12-78

Rig No — Test Rig Well Construction Completion Date — 7-14-78

Driller — Jim Walls Final Report Checked & Ok'd by — ______

PURCHASER State of Georgia

EXACT LOCATION 4N 3W Glascock County CITY Stapelton STATE GA

WELL NUMBER 2 SIZE HOLE DRILLED 13 CASING OD 4 5/8" ID 4"

TYPE CONSTRUCTION V ☒ STRAIGHT ROTARY ☐ REVERSE

CONCRETE — CASING DATA	STEEL — CASING DATA
No. Screen Blocks Used ______ Feet ______	Screen Casing Used 10 Size 4" Type ____ Feet ____
No. Plain Blocks Used ______ Feet ______	Plain Casing Used 300 Size 4" Type ____ Feet ____
No. Spacer Sets Used ______ Type ☐ Metal ☐ Wood	No. Spacer Sets Used ______ Type ☐ Metal ☐ Wood
☐ Separate Plug ☐ Plug-Screen	☒ Separate Plug ☐ Plug-Screen
Comments:	Comments:

CONCRETE — FINISH DATA	STEEL — FINISH DATA
Casing Finished ______ ☐ Above ☐ Below Ground Level	Casing Finished 1 ft ☒ Above ☐ Below Ground Level
Type Gravel Used ______	Type Gravel Used ______
Gravel Obtained From ______	Gravel Obtained From ______
How Gravel Placed ______ How High ______	How Gravel Placed ______ How High ______
Water Proofing Used ☐ Yes ☐ No Amount ______	Water Proofing Used ☐ Yes ☐ No Amount ______
Sanitary Seal ☐ Yes ☐ No Type ______	Sanitary Seal ☐ Yes ☒ No Type 4'X4'X4" Cement
______ Length ______	______ Length ______

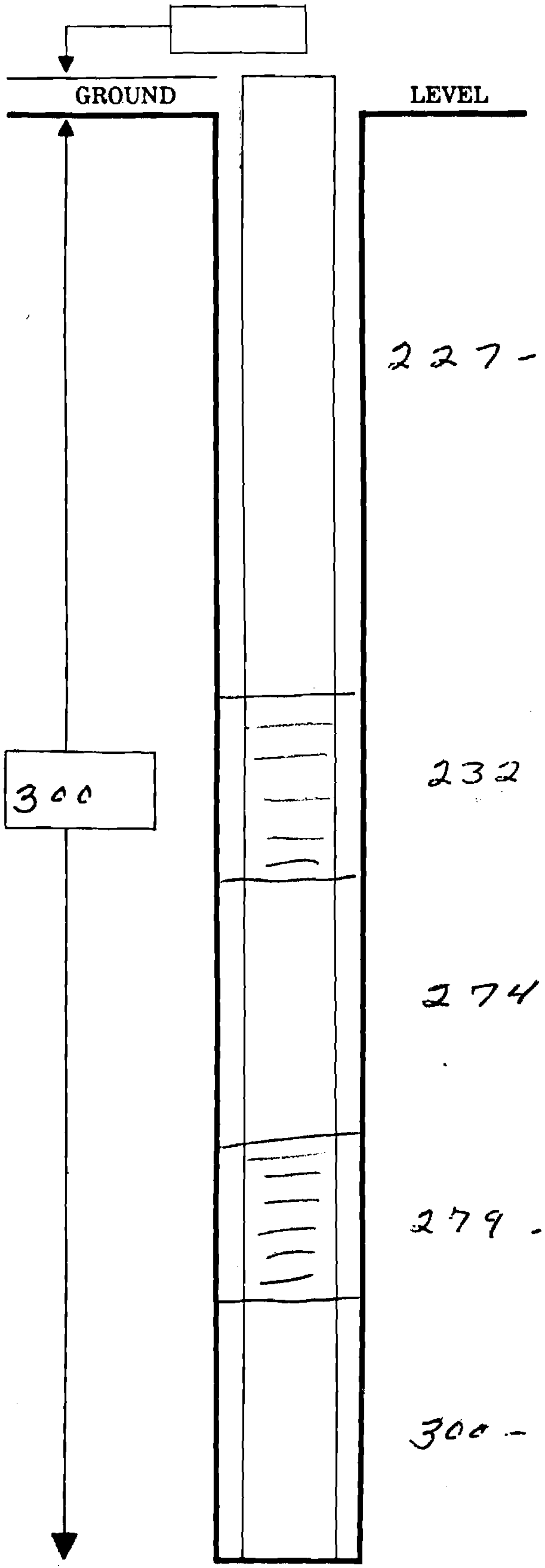
Driller's Comments -- In relationship to the drilling & casing of the well

HOLE DRILLED 315 FEET BELOW GROUND LEVEL. WELL MEASURES 310 FEET FROM BOTTOM INSIDE. DATE WELL COMPLETED 7-14-78

CONSTRUCTION FOREMAN ______

Well Log Data

13 HOLE O.D. | 4 3/8 CASING O.D. | 4 CASING I.D. | STATIC W. L.



LIST FORMATIONS BELOW

227 - Ground Level Plain 4"

232 - 227 Johnson Screen

274 - 232 Plain 4"

279 - 274 Johnson Screen 4"

300 - 279 Plain 4"

Sketch in any special construction notes such as pits, sanitary seals, clay fill, special base, etc.

PRINT NO.

Well Construction Final Report

Project No — 3 - "B" Well Construction Starting Date — 7-17-78

Rig No — Test Well Construction Completion Date — 7-24-78

Driller — Jimmy Walls Final Report Checked & Ok'd by — ______

PURCHASER Ga. Tech.

EXACT LOCATION 4 mi. N. & 3 mi. W. CITY Stapleton STATE Ga.

WELL NUMBER 3 SIZE HOLE DRILLED 13 CASING OD 4 5/8" ID 4"

TYPE CONSTRUCTION V ☑ STRAIGHT ROTARY ☐ REVERSE

CONCRETE — CASING DATA	STEEL — CASING DATA
No. Screen Blocks Used ______ Feet ______	Screen Casing Used Johnson Size 4" Type Steel Feet 10'
No. Plain Blocks Used ______ Feet ______	Plain Casing Used ______ Size 4" Type Steel Feet 290
No. Spacer Sets Used ______ Type ☐ Metal ☐ Wood	No. Spacer Sets Used 2 Type ☑ Metal ☐ Wood
☐ Separate Plug ☐ Plug-Screen	☑ Separate Plug ☐ Plug-Screen
Comments: ______	Comments: ______

CONCRETE — FINISH DATA	STEEL — FINISH DATA
Casing Finished ______ ☐ Above ☐ Below Ground Level	Casing Finished 300' ☐ Above ☑ Below Ground Level
Type Gravel Used ______	Type Gravel Used Pea Gravel
Gravel Obtained From ______	Gravel Obtained From Lammley
How Gravel Placed ______ How High ______	How Gravel Placed ______ How High Ground level
Water Proofing Used ☐ Yes ☐ No Amount ______	Water Proofing Used ☐ Yes ☐ No Amount ______
Sanitary Seal ☐ Yes ☐ No Type ______	Sanitary Seal ☐ Yes ☐ No Type ______
______ Length ______	______ Length ______

Driller's Comments -- In relationship to the drilling & casing of the well

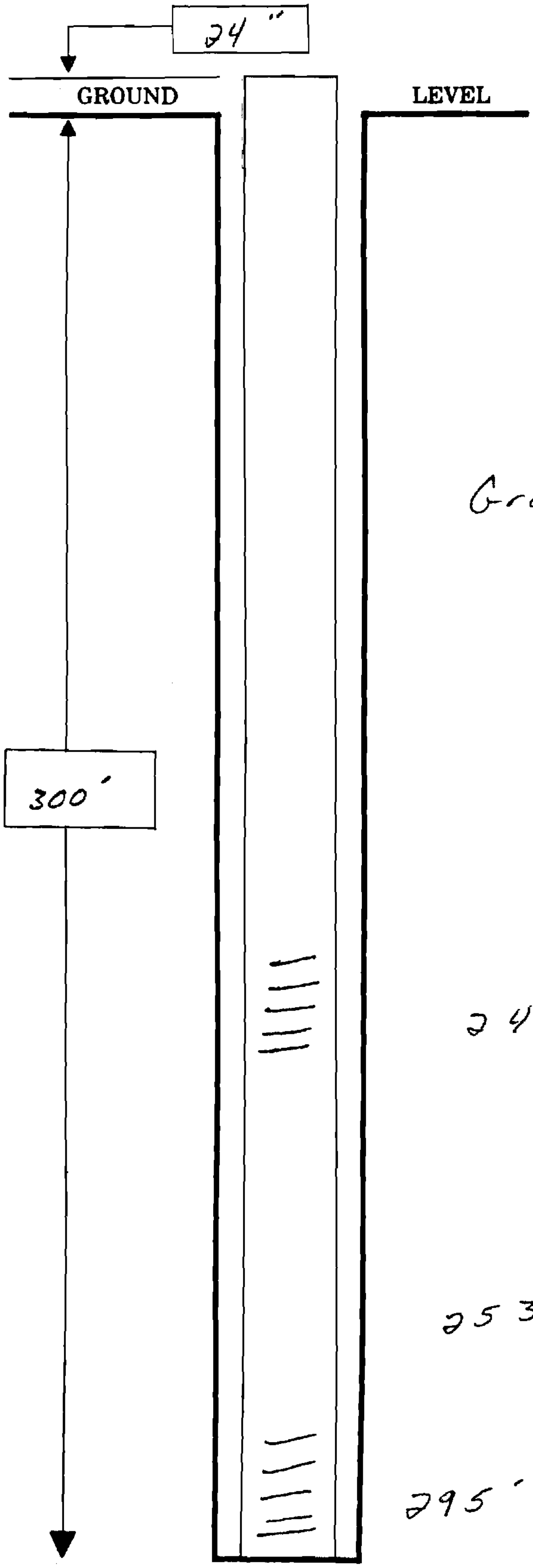
HOLE DRILLED 300 FEET BELOW GROUND LEVEL. WELL MEASURES ______ FEET FROM BOTTOM INSIDE. DATE WELL COMPLETED 7-24-78

CONSTRUCTION FOREMAN Fred A. Alexander

FORM #1

Well Log Data

13" HOLE O.D. | 4⅝" CASING O.D. | 4" CASING I.D. | STATIC W. L.



LIST FORMATIONS BELOW

Ground level 248' Plain

248 - 253 Johnson Screen

253 - 295 Plain

295' - 300' Johnson Screen

Sketch in any special construction notes such as pits, sanitary seals, clay fill, special base, etc.

PRINT NO.