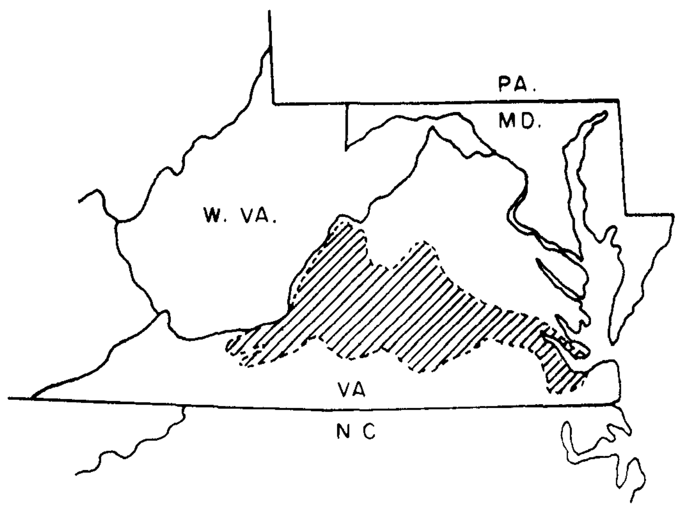
WATER SUPPLY AND WATER QUALITY CONTROL STUDY GATHRIGHT RESERVOIR JAMES RIVER BASIN VIRGINIA

STUDY OF NEEDS AND VALUE OF STORAGE FOR MUNICIPAL AND INDUSTRIAL WATER SUPPLY AND WATER QUALITY CONTROL



DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION III
CHARLOTTESVILLE, VIRGINIA
MAY 1965

WATER SUPPLY AND

WATER QUALITY CONTROL STUDY

GATHRIGHT RESERVOIR

JAMES RIVER BASIN

VIRGINIA

A survey has been made of the area of influence of the proposed Gathright Reservoir to determine municipal and industrial water supply needs. Present and future need for reservoir storage to provide water quality control by streamflow regulation was also determined. Present and future water needs were based on economic and demographic studies of the area, with future needs determined from projections of population and industrial growth.

U. S. DEPARTMENT OF THE ARMY
U. S. Army Engineer District, Norfolk, Virginia

In Cooperation With The

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region III
Charlottesville, Virginia

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INTRODUCTION

Authority

In a letter to the Public Health Service dated November 17, 1962, the Norfolk District of the Corps of Engineers requested a restudy of the Gathright Reservoir Project to evaluate the need for reservoir storage for water supplies and water quality control in the James River Basin.

This study has been conducted in accordance with the Federal Water Pollution Control Act as amended (33 U.S.C. 466 et seq) and the Memorandum of Agreement between the Department of the Army and the Department of Health, Education, and Welfare, dated November 4, 1958.

Purpose and Scope

The purpose of the study is to determine the need for and value of reservoir storage for municipal and industrial water supply, and for flow regulation for water quality control in the James River Basin. The location of Gathright Reservoir, the physical characteristics of the James River Basin, and the location of population centers within the Basin limit the area of influence of the proposed reservoir. Therefore, the study area considered in this report contains only the main stem of the Jackson and James Rivers and the areas directly effected by these rivers. The estuary portion of the river system, a reach of approximately 100 miles, was not considered in detail because of the difficulty in measuring effects of the relatively small reservoir flows into the almost unlimited volume of the estuary.

Acknowledgments

The cooperation and assistance of the following Federal, State, and local agencies are gratefully acknowledged:

U. S. Army Engineer District, Norfolk

U. S. Geological Survey

U. S. Department of Commerce

Virginia State Water Control Board

Virginia Division of Mineral Resources

Virginia Division of Water Resources

Virginia State Department of Health

Virginia Division of Industrial Development and Planning of the Governor's Office

Department of Public Works, Richmond, Virginia

Local Municipal Officials

Officials of Industries Within the Study Area and Industrial Consultants

SUMMARY OF FINDINGS AND CONCLUSIONS

Summary of Findings

1. The James River Basin encompasses 10,060 square miles and can be divided into two primary areas: the upper portion, which includes the headwaters of the Basin to the Fall Line at Richmond; and the lower section, made up of the coastal and estuary portions of the Basin.

2. The site of the proposed reservoir is 19 miles above Covington, Virginia, on the Jackson River, as shown on Figure 1 at back of report.

3. The Jackson and James Rivers extend some 385 miles below the reservoir site, to the Chesapeake Bay. The estuary portion of the river reaches upstream 100 miles from the Bay, to Richmond, leaving approximately 285 miles of flowing stream below the dam site.

4. Above Covington, Virginia, the flow of the Jackson River averages 485 cfs and is of good quality for all current or anticipated water uses.

5. Jackson and James River water is presently used for municipal and industrial water supplies at the rate of 114.35 mgd.

6. Water treatment problems exist at Richmond during low flow conditions in the James River. The principal problems are tastes and odors caused by algal concentration in the stream.

7. Treated and partially treated municipal and industrial wastes are discharged to the river at the rate of 106.41 mgd. These wastes contribute some 122,500 pounds of 5-day BOD per day to the streams.

8. Secondary treated industrial waste discharges and primary treated municipal waste discharges in the Covington, Virginia, area degrade stream quality below the point of discharge. During the summer, extremely low to zero dissolved oxygen levels extend 10-15 miles below Covington.

9. Water quality problems presently exist during periods of low flow in about 2-3 miles of the James River between Reusen's Dam and Lynchburg Dam. Power generation at Reusen's during low flow periods requires storage of river flows and results in a

virtually dry stream bed for a 2-3 mile stretch, causing nuisance conditions and sporadic fish kills.

10. Nuisance conditions exist in Richmond during low James River flow. During such periods, James River flow passes through the Kanawha Canal, leaving little or no flow in the natural river channel for about 9 miles, Bosher's Dam to 14th Street Bridge.

Conclusions

1. The proposed Gathright Reservoir will have no direct effect on areas upstream from the reservoir site, as the site is located above all communities and population centers in the Basin.

2. Existing and projected upstream water uses in the Jackson River are not expected to adversely affect the quality of water stored in Gathright Reservoir.

3. Projections of population and economic growth for municipalities and industries in the Basin to year 2020 indicate that Covington (22,000), Lynchburg (280,000), and Richmond (1,150,000) areas will continue as the largest users of the Jackson and James Rivers as a source of water supply.

4. Natural flows of the Jackson and James Rivers are adequate to meet present and future water supply demands beyond year 2020, using projections of current trends in water use. Therefore, no storage is needed for municipal and industrial water supplies.

5. At flows greater than approximately 900 cfs, the City of Richmond experiences few treatment problems at the water plant. With flows of this magnitude, and greater, algal populations in the James River are apparently below nuisance concentrations; suspended and dissolved solids are minimal; and hardness is not excessive. Flow regulation for water quality control in the Jackson and James Rivers will help reduce algae, hardness, or other water treatment problems at Richmond stemming from low flow conditions.

6. Minimum average dissolved oxygen concentrations of 4.0 milligrams per liter, with individual sample values not less than 3.0 milligrams per liter, were established as the quality objectives for critical sections of the Jackson and James Rivers, for purposes of this report.

7. The stream flow considered dependable for water quality control is the lowest monthly average occurring once in twenty years.

8. Expected municipal and industrial waste loads for the Covington area in years 1995 and 2020 are 16,500 and 20,660 pounds of 5-day Biochemical Oxygen Demand, respectively. These are the loads remaining after the wastes have received adequate treatment (i.e., 85% removal of BOD).

9. During low flows, the Jackson River is incapable of assimilating present or projected waste loads while maintaining established water quality objectives. The stretch of stream below Covington is, and will continue to be, the critical stream section for maintaining these objectives.

10. Storage for water quality control should be included in Gathright Reservoir. The cheapest alternate method of meeting water quality objectives was used to measure the value of benefits resulting from Gathright's water quality control storage. A single purpose reservoir to be constructed by 1970 was found to be the cheapest alternate, providing a value of benefits of $556,000 per year. This value for the annual benefit represents amortization of operation and maintenance costs of the single purpose reservoir over a 50-year period, with interest at 3 1/8 per cent.

11. Quality control flows provided at Covington must be passed through existing run-of-river power generation stations without peaking for the quality control benefits to be realized. The passing of these flows will maintain the stream environment between Reusen's and Lynchburg Dams, eliminate dry stream bed conditions, and eliminate fish kills caused by low or zero flows.

12. Reservoir releases will affect water supply, recreation, agriculture, plus other uses throughout 385 miles of stream, thereby benefiting about one-half million persons. These benefits are widespread in scope and are sufficient in magnitude to warrant provision of storage for water quality control; i.e., water supply, recreation, aesthetic values, commercial fishing, waste assimilation and transport, and agriculture. Benefits extend into the estuary portion of the river; however, the flow from the reservoir is such a small portion of the estuary volume that the benefits in this portion of the river are unmeasurable.

13. Multiple-level outlet structures and provision for monitoring quality of discharged water should be provided in the proposed reservoir to permit selection and discharge of highest quality water.

PROJECT DESCRIPTION

The Gathright Reservoir and Falling Spring Re-regulating Dam Project is being considered for multiple purpose reservoir development by the Corps of Engineers. The project would be located on the Jackson River about 19 miles above Covington, Virginia. (Figure 1, inside back cover.) Stream quality in the Jackson River at the site of the proposed project is usually high: dissolved oxygen approaches saturation, biochemical oxygen demand is low, and other physical, chemical, and biological characteristics indicate a stream of satisfactory water quality for most beneficial uses. However, during periods of low flows in the Jackson River, hardness and solids (dissolved and suspended) generate quality problems for installations operating boilers or users requiring process waters with constant chemical characteristics.

Stream flows at the site are quite variable; ranging from about 24,700[1/] cfs to 58[2/] cfs, with an average of 485 cfs over the 37 years of record.

1/ Maximum flow of record, USGS, Falling Springs Gage

2/ Minimum flow of record, USGS, Falling Springs Gage

DESCRIPTION OF STUDY AREA

The James River Basin is an irregular, tapering area extending in a southeasterly direction from the West Virginia State line, through the central portion of Virginia, to Hampton Roads at the mouth of the Chesapeake Bay. All or parts of 38 counties in Virginia, plus a portion of one county in West Virginia, are included in the James Basin. Bounding the James are the Potomac, Rappahannock, and York River Basins on the north; Ohio on the West; Roanoke and Chowan Basins on the south; and Chesapeake Bay on the east.

The James River has its source in the Allegheny Mountains and drains an area of 10,060 square miles; 9,980 square miles in Virginia and 80 square miles in West Virginia. (Figure 1.) The James flows southeasterly past Richmond, then into the Chesapeake Bay at Hampton Roads. The largest tributaries are the Jackson and Cowpasture Rivers, which join to form the James River; the Maury, Buffalo, and Rivanna Rivers from the north; with the Appomattox River entering from the south. Principal tributaries are listed in Table I on page 8. Total stream length (confluence Jackson-Cowpasture Rivers to Hampton Roads) is 339.7 miles, with a fall of 988 feet. Below the Fall Zone at Richmond, the James becomes an estuary.

Portions of four physiographic regions make up the James Basin: Valley and Ridge Province, Blue Ridge Province, Piedmont Plateau, and the Coastal Plain. A fifth region, the Allegheny Plateau, adjoins the Watershed on the west. Climate within the James Basin is mild, with yearly averages of temperature around 56°F, and rainfall about 42 inches. More temperate weather with slightly higher yearly precipitation occurs near the mouth of the James, because of the moderating effects of Chesapeake Bay and the Atlantic Ocean.

TABLE I

Principal Tributaries of the James River

Principal Tributaries of the James River	Miles from Confluence to Mouth of James River	Drainage Area Square Miles
James River	--	10,060
Chickahominy River	41.5	468
Appomattox River	71.6	1,610
Rivanna River	162.1	777
Buffalo River	213.8	413
Pedlar River	264.1	102
Maury River	279.7	837
Craig Creek	323.7	374
Jackson River	339.7	907
Cowpasture River	339.7	460

THE ECONOMY

Introduction

Water quantity and water quality requirements of the area affected by a reservoir are determined using projections of the area's population and economic growth. These projections are based on present population and economic characteristics plus expected development and growth in the area.

The growth of an area depends not only on its own characteristics, but, in varying degrees, on the type and extent of growth reflected by the Nation and the region of which it is a part. As a frame of reference for the areas to be considered in this study, historical and projected employment for the State of Virginia has been used. These projections were prepared by the National Planning Association, Washington, D. C., as part of their Regional Economic Projection Series[a/]. Employment projections to 1990 are included in Table II. Total employment in the State is projected to be 86 per cent higher in 1990 than in 1960. In absolute terms, agriculture, mining, and the manufacture of furniture and wood products are projected to decline in employment, while other employment categories are expected to increase. Those categories with projected increasing percentages of the total employment are fabricated metals; electrical equipment; and all the non-commodity industries, except government (including public administration and education). Total population for the State is projected to increase in accordance with the increased employment opportunities.

The James River Basin is the southernmost sub-basin of the Chesapeake Bay Drainage Area. An economic base study of the Chesapeake area, with projections, is being prepared by the National Planning Association for the Chesapeake Bay-Susquehanna River Basins Water Pollution Control Project of the Public Health Service. The NPA study is scheduled for completion too late for use in this report, but the use of the NPA projections for the State of Virginia, as a frame of reference for this study, assures a degree of coordination between this report and the NPA study.

Three economic sub-regions within the James River Basin are herein considered. They are the regions in the Basin associated with the economic and population centers of Covington, Lynchburg, and Richmond.

Table II Virginia Employment

Historical* and Projected

Employment Categories	1950	1960	1970	1980	1990
Agriculture, Forestry, and Fisheries	216,800	165,300	139,300	91,600	46,900
Mining	21,400	16,800	16,800	17,000	16,600
Furniture and Wood Products	44,000	43,300	41,600	38,900	37,000
Primary Metals	3,700	7,600	8,200	8,800	9,200
Fabricated Metals	6,800	8,400	14,900	18,800	23,500
Non-Electric Machinery	2,000	5,400	6,300	7,200	8,200
Electrical Equipment	100	8,400	15,700	23,000	29,000
Motor Vehicles, Transportation, Equipment	11,400	21,200	21,800	23,000	24,000
Other Durable Goods	9,900	14,300	18,400	23,300	25,900
Food and Kindred Products	20,700	28,200	35,600	41,700	46,700
Textile Mill Products	41,800	37,900	38,200	38,700	38,900
Apparel	16,700	23,900	25,000	26,200	26,900
Printing, Publishing, and Allied Products	6,400	10,100	14,000	17,600	19,700
Chemicals, n.e.c.	35,800	35,800	41,600	46,300	50,100
Other Non-Durable Goods	34,500	33,300	39,300	44,900	44,900
Commodity Totals	472,000	459,900	476,700	467,000	447,500
Construction	69,900	89,700	125,700	171,600	230,300
Transportation, Communications, & Utilities	88,700	95,000	120,900	151,100	185,200
Trade	210,400	249,500	342,400	465,100	601,200
Finance, Insurance and Real Estate	30,400	47,800	70,500	105,600	141,800
Services	141,500	205,000	307,400	430,700	570,000
Government (Public Administration & Educ.)	152,500	190,000	224,000	262,500	317,500
Total Employment	1,165,400	1,336,900	1,667,600	2,053,600	2,493,500

* Source: National Planning Association, Washington, D. C.

Region I - Covington and Clifton Forge

Allegheny, Bath, Bedford, Botetourt, Craig, and Rockbridge counties; Clifton Forge, Covington, and Buena Vista cities.

Present Economy

This region lies mostly in the Valley and Ridge Province, with only the eastern part of Bedford County extending out into the Piedmont Plateau. The southern end of the Great Valley of Virginia extends into Rockbridge County, but most of the region is hilly or mountainous. The Jefferson and Washington National Forests include much of the land area of the region, and about 75 per cent of the region is forested.

Population is not heavily concentrated in this region. The City of Roanoke lies just south of the region, and is its major trading center. Within the region, about 35 per cent of the population is located in the cities of Covington, Buena Vista, Clifton Force, and the towns of Lexington and Bedford. The population density of this region is only about 33 people per square mile, as compared to 132 people per square mile for the whole Basin.

The dominant agricultural activity is the production of livestock and their products. However, forest products represent about 20 per cent of all farm products sold. Farm production has continued to increase in the region, even when measured in constant dollars, and the value of farm products sold per farm resident was $1,227, as compared to $1,279 for the Basin as a whole[b/].

The manufacturing in the region is located in Bedford, Allegheny, and Rockbridge Counties (including the independent cities within their borders). The manufacturing industries with the largest employment are textiles and pulp and paper. Textile plants are located in Covington, Buena Vista, Rockbridge County, and Bedford County. There were six plants altogether in 1963[e/], and one in Rockbridge County employs over 1,000 people. Pulp and paper plants are located in Covington, Buena Vista, and Bedford, with the plant in Covington employing about 2,000 people. The industry with the third largest number of employees is furniture and wood products, characterized by a rather large number of small establishments employing less than 20 persons. The remainder of the region's industry is diversified, as can be seen in Table III.

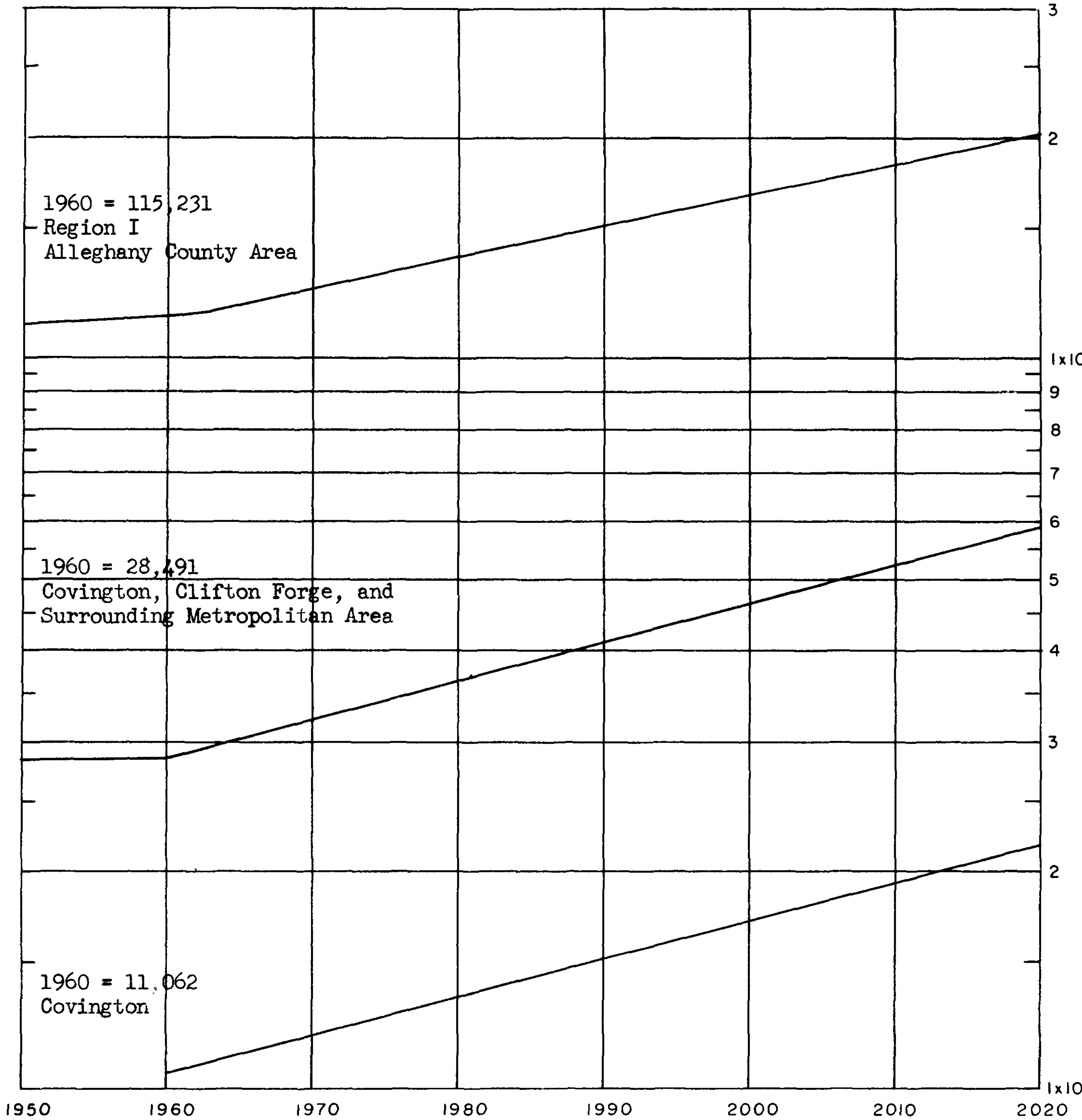
Table III

Region I
Historical* and Projected Employment and Population

Employment Categories	1950	1960	Diff. Shift**	1970	1980	1990
Agriculture, Forestry, and Fisheries	9,088	6,336	- 593	4,000	2,000	1,000
Mining	343	327	58	330	330	320
Furniture and Wood Products	1,506	1,817	335	2,600	3,500	4,240
Primary Metals	97	125	- 74	120	120	100
Fabricated Metals	43	177	124	580	840	1,180
Non-Electrical Machinery	44	92	- 27	100	100	120
Electrical Equipment	0	186	186	500	880	1,200
Transportation Equipment	10	12	- 7	0	0	0
Other Durable Goods	320	722	260	1,170	1,770	2,120
Food and Kindred Products	450	595	0	730	840	930
Textiles	3,873	4,349	837	4,500	4,600	4,700
Apparel	282	626	222	690	760	800
Printing, Publishing	140	213	8	290	350	390
Chemicals	1,180	658	522	2,200	2,300	2,400
Other Non-Durable Goods	3,412	3,948	655	4,250	4,600	5,000
Total Commodity Employment	20,788	20,183		20,630	21,540	23,020
Construction	2,252	2,331		2,550	2,870	3,270
Transp., Communications, Utilities	3,700	3,351		3,500	3,670	3,900
Wholesale Trade	5,150	5,948		6,580	7,450	8,300
Finance, Insurance, Real Estate	453	673		790	970	1,220
Services	4,469	6,446		7,800	9,380	11,200
Government	2,613	2,213		2,060	2,370	2,800
Total Employment	39,425	41,145		45,340	49,680	55,190
Population	112,648	115,231		126,000	138,000	153,400

* Source: National Planning Association, Washington, D. C.

** The Differential Shift is a measure of the competitive advantage the area has for a particular industry. It is the difference between the actual change in employment in the industry and the amount employment would have changed if the employment in the industry had increased in the same proportion as the State industry in this case.



WATER SUPPLY AND WATER QUALITY CONTROL STUDY
JAMES RIVER BASIN – VIRGINIA

REGION I – POPULATION

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION III CHARLOTTESVILLE, VIRGINIA

FIGURE 2

Employment in the region increased only four per cent between 1950 and 1960, compared to an increase of 18.5 per cent in the total civilian employment in the Basin as a whole.

Employment data for this study have been taken from the Censuses of Population. Because of the practice of reporting employment at the place of residence in the population censuses, some of the Roanoke employment is reported in this Basin region. This effects the population of the region even though it is not located in the region.

Agricultural employment in the Basin declined following the National and regional pattern. The increased employment in manufacturing, services, and trade made up for the decrease in agricultural employment; therefore, there was a net gain in employment.

Among the commodity industries with over four per cent of the total employment in 1960 and showing apparent locational advantage, as measured by the differential shift[d/], are furniture and wood products, textiles, and other non-durable goods (including pulp and paper).

The population of the region increased 2.2 per cent between 1950 and 1960, as shown in Table III. This was in conformity with the small increase in employment. During the same period, the population of the whole Basin increased 12.2 per cent. The region population has increased only 11 per cent since 1920.

Table IV shows the population increase was concentrated in age groups 5-21 and over 65. The major labor force age group, 21-65, stayed almost constant, with the increase in the labor force resulting from a greater participation rate in this age group.

Comparable age group distribution for the United States is given in Table V, and a comparison of the two sets of figures reveals that the region is considerably below the National average in all percentage changes, although the percentage in each age group is quite similar. This indicates that there was considerable out-migration from the region during the ten-year period 1950-1960.

The population has become increasingly urban, and the farm population decreased in accordance with the number of workers in the agricultural labor force. But the region still had 15 per cent of its population living on farms, which compares

Table IV

Region I - Population by Age Groups 1950 and 1960[e]

Year	Total	Per Cent	Under 5		5 - 21		21 - 65		Over 65	
			No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
1950	112,648	100	12,275	10.9	33,664	29.9	57,675	51.2	9,034	8.0
1960	115,231	100.1	11,929	10.4	35,062	30.4	57,329	49.7	10,911	9.5
Percentage Change	2.2		-2.8		4.2		-0.6		20.8	

Region I - Population by Type of Residence

Year	Total	Urban		Rural Non-Farm		Rural Farm	
		No.	Per Cent	No.	Per Cent	No.	Per Cent
1950	112,648	26,906	23.9	49,335	43.8	36,407	32.3
1960	115,233	36,088	31.3	61,730	53.6	17,413	15.1
Percentage Change	2.3	34.1		25.1		-52.2	

Table V - Population by Age Group
United States, 1950 and 1960
Number and Percentage Change

	Total		Under 5		5 - 21		21 - 65		Over 65	
	Number (Thousands)	Per Cent	Number (Thousands)	Per Cent	Number (Thousands)	Per Cent	Number (Thousands)	Per Cent	Number (Thousands)	Per Cent
United States										
1950	150,216	100	16,240	10.8	39,519	26.3	82,200	54.7	12,257	8.2
1960	178,467	100	20,207	11.3	50,209	28.1	91,844	51.5	16,207	9.1
Percentage Change	18.8		24.4		27.1		11.7		32.2	

to five per cent for the Basin as a whole. The greatest absolute increase in population took place among the rural non-farm groups. But the greatest percentage increase was in the urban group.

Future Economy

Employment projections to 1970, 1980, and 1990 in Table III show moderate increases. These projections are based on the NPA projections for the State of Virginia and a continuation of past competitive industry positions. Using the same trend of growth, the region population for the years 2000 and 2020 are projected to be 169,000 and 204,000, respectively.

The projected increases in population in the region, as shown in Table III, are moderate, in conformity with the projected employment, and the fact that this region is likely to include more people commuting into Roanoke. Because the effect of population and economic growth on water requirements from the James River is critical in the Covington area, projections of employment and population for the area of Allegheny, Covington, and Clifton Forge, and population projections for the City of Covington are included in Table VI. Based on the same trend, the population for the Allegheny County, Covington and Clifton Forge area is projected to reach 47,000 by the year 2000 and 55,000 by the year 2020. The Covington population is projected to reach 17,000 by 2000 and 20,000 by 2020. Projected growth in this area is very slow. The pulp and paper industry, which is the largest commodity industry in the area, has been projected on the basis that, while production may increase as much as 100 per cent by the year 2020, the increase will result mostly from process changes in the current plant, and employment will increase only slightly.

The chemical industry showed a negative differential shift between 1950 and 1960; however, since 1960 the Hercules Powder Company, maker of plastic materials in Covington, has increased its employment. Some future increase in employment is proposed until an optimum size is reached. At present, optimum size is anticipated to be a little less than 2,000 employees.

Table VII summarizes employment in industrial categories during 1963, according to the 1963 Directory of Manufacturing and Mining, published by the Virginia State Chamber of Commerce.

Table VI

Covington, Clifton Forge, Allegheny County
Historical* and Projected Employment and Population

Employment	1950	1960	1970	1980	1990
Agriculture	545	234	100	50	50
Construction	367	438	480	540	620
Furniture and Wood Products	245	278	390	540	650
Other Durable Goods	---	80	120	160	200
Food and Kindred Products	103	75	90	110	120
Textiles	580	552	450	460	470
Chemicals	998	509	2,000	2,000	2,000
Pulp and Paper	2,054	2,163	2,190	2,520	2,740
Transportation, Communications, Utilities	1,883	1,605	1,670	1,750	1,870
Wholesale and Retail Trade	1,500	1,689	1,870	2,110	2,350
Finance	165	172	200	250	310
Service	1,287	1,398	1,700	2,000	2,400
Government	402	582	670	750	860
Total	10,129	9,775	11,930	13,240	14,640
Population Covington, Clifton Forge, Allegheny County	28,934	28,491	32,500	36,500	41,500
Covington Population		11,062	11,800	13,500	15,200

* Censuses of Population

Table VII

Summary of Manufacturing Plants by Counties, 1963
Covington, Clifton Forge, Allegheny County

SIC*	Description	Employees
Covington		
2086	Bottled and Canned Soft Drinks	29
2514	Metal Household Furniture	80
2621	Paper Mills, except building	2,000
2711	Newspapers	27
2821	Plastics Materials	470
		2,606
Clifton Forge		
2026	Fluid Milk	24
2086	Bottled and Canned Soft Drinks	33
2339	Women's, Misses' Outerwear Nec.	220
2711	Newspapers	12
3069	Fabricated Rubber Products, Nec.	479
3843	Dental Equipment and Supplies	75
		843
Allegheny		
1421	Crushed and Broken Stone)	
3274	Lime)	142
3295	Minerals: Ground or Treated)	
		142

* Standard Industrial Classification Code, Bureau of the Budget, 1957.

Source: Directory of Manufacturing and Mining, Virginia State Chamber of Commerce.

Region II - Lynchburg

Lynchburg, Appomattox, Amherst, Campbell, and Prince Edward Counties

Present Economy

Except for the western two-thirds of Amherst County, which is in the Blue Ridge Province, this area lies in the Piedmont Plateau. The James River flows along the northern boundary of Lynchburg and between Amherst and Appomattox Counties. The southern portion of Appomattox County and northern Prince Edward County are drained by the Appomattox River.

Outside of Lynchburg the region is very rural, with population densities in the magisterial district ranging between 10 and 100 people per square mile.

Approximately 70 per cent of the area is forested, and currently the average annual cut of saw timber is about 63 per cent of the growth. In the growing stock class, the current cut is about 90 per cent of the annual growth.

The chief agricultural products are tobacco and livestock products, and the value of farm products sold, measured on a constant dollar basis, increased 28 per cent between 1954 and 1959.

Manufacturing is the area's chief industry. It centers in Lynchburg, although there are establishments in Altavista, Brookneal, Farmville, Appomattox, and in Amherst County, across the river from Lynchburg. The manufacturing base is rather broad. The chief manufacturing industries in 1960, as measured by employment, were furniture and wood products; primary metals; electrical equipment; textiles; apparel; and other non-durable goods, which is largely shoe production. About 84 per cent of the plants in the area employ less than 100 workers. Two major employers are the Lynchburg Foundry Company, which manufactures gray iron castings and employs 1,400 workers, and Lane Company, makers of furniture, which employs about 1,300 workers.

Employment in the region increased from about 45,000 in 1950 to about 50,000 in 1960--an increase of about 11 per cent. The chief areas of increase were primary and fabricated metals, electrical equipment, and services. Both fabricated metals and electrical machinery showed substantial positive differential shifts. This is particularly significant as both these industries are projected to grow rapidly in the State. Furniture and wood and chemicals showed positive shifts. However, neither of these is projected to grow very rapidly in the State. All the other industries had negative shifts. Agricultural employment declined, in accordance with National and regional trends.

The population of the area increased by nearly 11 per cent between 1950 and 1960, as shown in Table VIII. Rural non-farm population increased more in absolute numbers and percentage-wise than did the urban population, while the farm population declined, in accordance with the reduced employment in agriculture. There was an increase in each age group. The age group from which most of the labor force is drawn, 21 through 65, increased by slightly less than five per cent, but became a smaller portion of the total. Part of the increased labor force resulted from a greater participation rate in this age group. Population growth in all age groups was less than the National average, but the percentage in each group was not greatly different.

Future Economy

Employment is projected to increase by about 13 per cent each decade to 1990. These projections are made within the National Planning Association employment projections for the State of Virginia and are based on a continuation of the competitive position the industries held between 1950 and 1960, an increasing proportion of employment in service industries. The manufacturing industries with projected increases are wood products, fabricated metals, and electrical equipment. Other industries are expected to hold their own or increase slightly, with the exception of non-durable goods, which decreases. All non-commodity industries are projected to increase, with trades and services making substantial gains. Agriculture will continue to decline.

Population of the region is projected to increase, in accordance with the employment increase, to a total of 220,000 in 1990. (See Table IX.) The trend line projected at the same rate of increase shows a population of about 400,000 by 2020.

The majority of the population will be concentrated in the Lynchburg City area. In 1960 the population of Lynchburg City and Elon and Brookville magisterial districts was 79,279, or 59 per cent of the total population of Region II. This has risen at a fairly constant rate from 52 to 59 per cent since 1940. It is estimated that the Lynchburg City percentage will increase at a decreasing rate to about 70 per cent in 2020, with a population of 280,000.

Table VIII

Region II - Population by Age Groups 1950 and 1960

Year	Total	Per Cent	Under 5		5 - 21		21 - 65		Over 65	
			No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
1950	121,098	100	12,681	10.5	34,559	28.5	64,390	53.2	9,468	7.8
1960	133,970	100	14,154	10.6	40,081	29.9	67,426	50.3	12,309	9.2
Percentage Change	10.6		11.6		16.0		4.7		30.0	

Region II - Population by Type of Residence

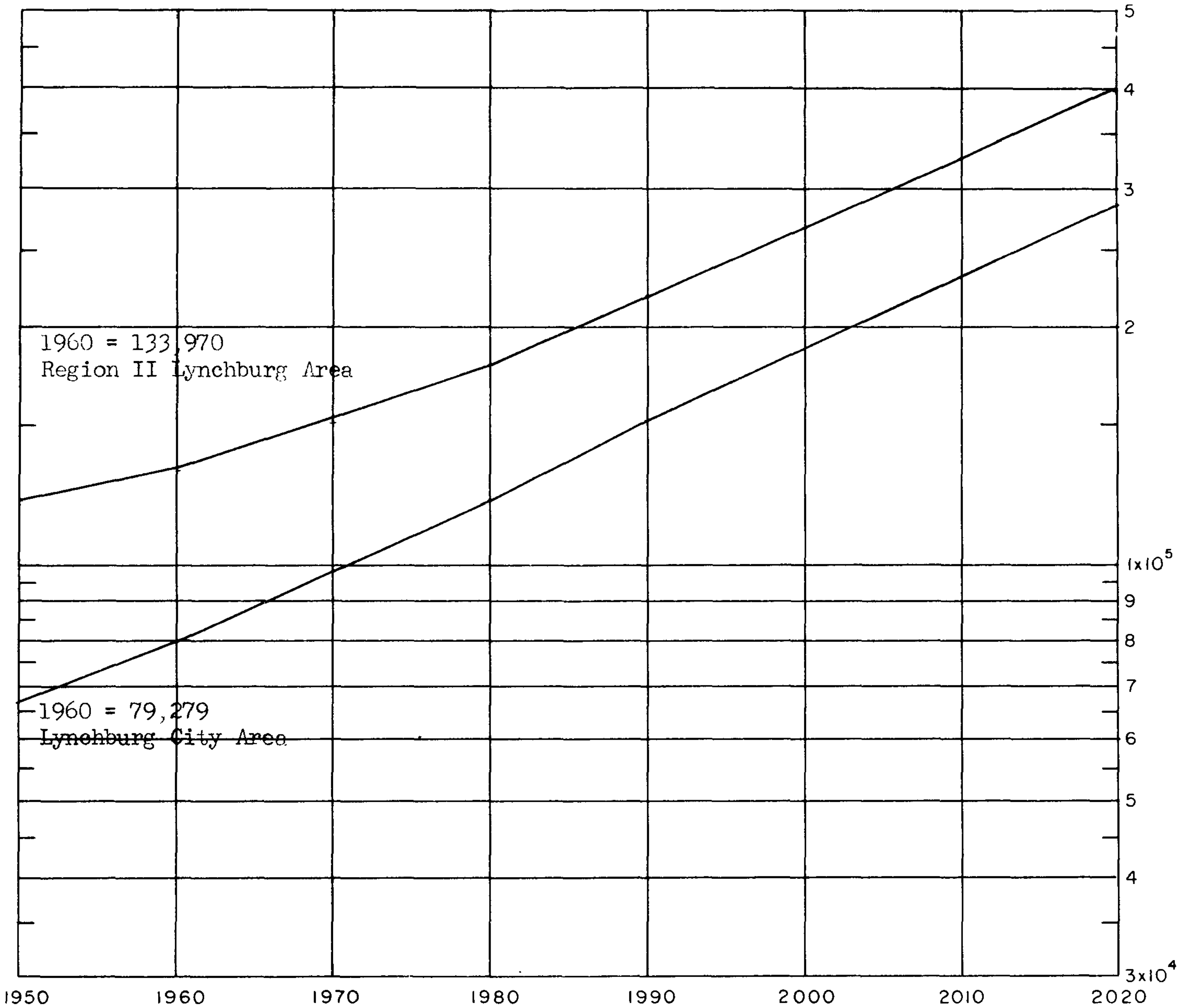
Year	Total	Urban		Rural Non-Farm		Rural Farm	
		No.	Per Cent	No.	Per Cent	No.	Per Cent
1950	121,098	58,264	48.1	34,105	28.2	28,729	23.7
1960	133,970	66,911	49.9	49,906	37.3	17,153	12.8
Percentage Change	10.6	14.8		46.3		-40.3	

Table IX

Region II
Historical* and Projected Employment and Population

Employment Categories	1950	1960	Diff. Shift	1970	1980	1990
Agriculture, Forestry, and Fisheries	8,165	6,208	- 17	5,200	3,400	1,700
Mining	74	122	64	100	100	100
Furniture and Wood Products	2,182	2,360	213	2,600	3,000	3,500
Primary Metals	1,220	1,936	- 570	2,000	2,000	2,000
Fabricated Metals	56	787	718	2,500	4,200	5,500
Machinery	98	235	- 30	300	300	300
Electrical Equipment	7	1,644	1,056	3,000	4,500	6,500
Transportation Equipment	27	39	- 11	0	0	0
Other Durable Goods	367	365	- 165	300	300	300
Food and Kindred Products	652	816	- 72	900	1,000	1,100
Textiles	2,547	1,612	- 697	1,500	1,200	1,000
Apparel	2,433	2,701	- 781	2,700	2,700	2,700
Printing and Publishing	203	300	- 20	300	400	500
Chemicals	578	656	78	700	800	900
Other Non-Durable Goods	4,198	3,492	- 560	2,600	2,300	1,600
Total Commodity Employment	22,807	23,273		25,539	27,194	33,391
Construction	2,775	3,555		4,400	6,000	8,000
Transp., Communications, Utilities	3,111	2,745		2,700	3,000	3,500
Trade	8,191	8,554		10,000	12,000	15,000
Finance, Insurance, Real Estate	961	1,597		1,800	3,000	4,000
Services	6,323	8,987		12,000	16,000	21,000
Government	2,783	2,634		3,000	3,500	4,500
Total Employment	46,951	51,345		58,600	69,700	83,700
Population	121,098	133,970		154,000	180,000	220,000
Population - Lynchburg, Elon, Brookville Magisterial District, Lynchburg City area	67,050	79,279		97,000	120,000	150,000

* Source: National Planning Association, Washington, D. C.



WATER SUPPLY AND WATER QUALITY CONTROL STUDY
JAMES RIVER BASIN - VIRGINIA

REGION II - POPULATION

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION III CHARLOTTESVILLE, VIRGINIA

FIGURE 3

Region III - Richmond

Region III is composed of the following counties: Hopewell, Amelia, Charles City, Chesterfield, Goochland, Henrico, New Kent, Powhatan, and Prince George, which takes in the cities of Richmond, Colonial Heights, and Petersburg.

Present Economy

Region III extends across part of the Piedmont Plateau and into the Coastal Plain, with the James River flowing through its center. This area is more densely populated than the upper reaches of the James Basin and is part of what has been termed the Urban Corridor or Crescent, i.e., the fast growing area of Virginia, extending from the northern counties around Washington, D. C., to Norfolk. Production of tobacco, chemicals, paper, food, and metal products is concentrated around Richmond, making it the largest manufacturing center in the State. Richmond is also the largest financial and wholesale trade distribution center in the State. It is the State capitol and the regional office for many Federal agencies (about 10 per cent of the Region's employment was in government activities in 1960).

Manufacturing employment remained nearly constant between 1950 and 1960, with an increase of over one per cent shown only in primary metals and decreases of about one per cent in textiles, chemicals, and other non-durable goods (largely tobacco). The large number of industries with negative differential shifts for the 1950-1960 period indicates a poor competitive position for most of the major commodity producing industries during that decade. Primary metals and transportation equipment were the only manufacturing industries with positive shifts. Agriculture showed a positive shift, but, in accordance with the declining trend in agricultural employment in the State, employment in the region decreased by about 22 per cent. Tobacco and livestock products are the main farm products sold. Measured in constant dollars, the value of these farm products increased by 30 per cent between 1954 and 1959. Lumber is also an important product of this region, with the cut of saw timber in 1960 estimated at 126.5 million board feet. This compared to an annual timber growth rate of 163.4 million board feet, so this rate of cut can continue.

Population of this region increased by 22.5 per cent, as shown in Table X. Three-fourths of the population of this region is urban, but percentage-wise, the rural non-farm group is the fastest growing. The population of each age group increased, with the percentage increase in the younger groups and the over

Table X

Region III - Population by Age Groups 1950 and 1960

Year	Total	Per Cent	Under 5		5 - 21		21 - 65		Over 65	
			No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent
1950	430,148	100.0	44,051	10.2	98,244	22.8	257,791	60.0	30,062	7.0
1960	526,740	100.0	58,101	11.0	144,559	27.4	277,525	52.7	46,555	8.9
Percentage Change	22.5		31.9		47.1		7.7		54.9	

Region III - Population by Type of Residence

Year	Total	Urban		Rural Non-Farm		Rural Farm	
		No.	Per Cent	No.	Per Cent	No.	Per Cent
1950	430,148	323,572	75.2	75,139	17.5	31,437	7.3
1960	526,850	400,730	76.0	111,473	21.2	14,647	2.8
Percentage Change	22.5	22.8		48.4		-53.4	

65 group increasing at a rate greater than the National average; however, the increase in the 21-65 group was 4 per cent less than the National percentage increase for that group. The changes between 1950 and 1960 brought the percentage distribution by age groups more in line with the National distribution than it was in 1950, when the labor force age group had been a considerably higher percentage.

Future Economy

Employment is projected to increase by about 20 per cent between 1960 and 1970, and between 15 and 20 per cent per decade from 1970 to 1990. This compares to an increase of 9 per cent between 1950 and 1960. Between 1950 and 1960 the ratio of employment to population declined from 41 to 36.5 per cent. Further declines of this magnitude are not anticipated; therefore, there will be a need for greater increases in employment opportunities if population growth is to be maintained. Most of the projected increase is in the non-commodity industries, resulting from the region's position as a financial, trade, and government center.

Some industries with a negative differential shift are projected to grow, as conditions since 1960 indicate improvement over the 1950-1960 situation. The largest projected manufacturing employment category is chemicals. According to the 1959 Census of Manufacturers, there were 15 chemical plants in this region; while in 1963, according to the Directory of Manufacturing of the Virginia State Chamber of Commerce, there were about 30 plants. Many of these plants were small, but at least five employed over 1,000 persons, and employment has increased since 1960. Employment in fabricated metals has also increased since 1960.

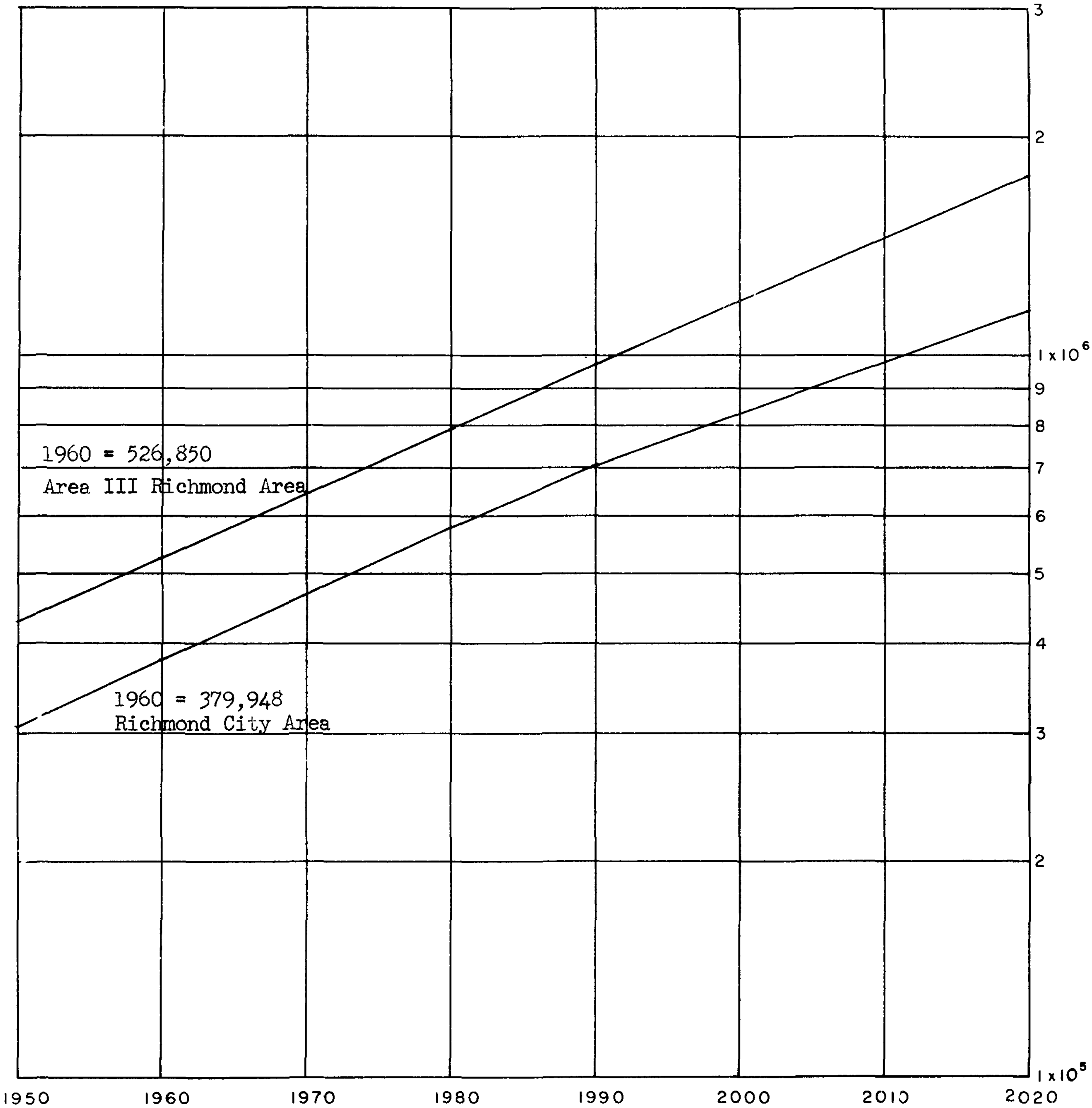
The projected employment will sustain a rate of population growth about the same as it was between 1950 and 1960. The City of Richmond, Henrico County, and the Magisterial District of Manchester and Midlothian in Chesterfield County accounted for about 72 per cent of the population of the region in 1960, and it is expected that this percentage will increase slightly to 1980 and then decline to about 65 per cent by 2020. The population of the region is projected to reach 641,000 by 1970 and 1,770,000 by 2020. The population of the Richmond City metropolitan area is projected to reach 468,000 by 1970 and 1,150,000 by 2020. (See Table XI and Figure 4.)

Table XI

Region III
Historical* and Projected Employment and Population

Employment Categories	1950	1960	Diff. Shift	1970	1980	1990
Agriculture, Forestry and Fisheries	8,126	6,647	451	5,800	4,600	2,800
Mining	183	111	- 33	100	100	100
Furniture and Wood Products	3,742	3,123	- 559	3,300	3,700	4,600
Primary Metals	511	3,366	2,316	4,000	4,900	5,600
Fabricated Metals	2,555	1,202	- 1,954	2,000	2,300	2,800
Machinery	503	1,192	- 166	1,300	1,700	2,100
Electrical Equipment	13	446	- 646	800	1,100	1,700
Transportation Equipment	171	551	233	600	800	800
Other Durable Goods	2,126	2,635	- 436	3,000	3,500	3,900
Food and Kindred Products	3,513	4,111	- 675	4,900	6,000	7,000
Textiles	1,902	252	- 1,473	-----	-----	-----
Apparel	3,042	2,778	- 1,576	3,500	4,000	5,000
Printing and Publishing	1,561	2,335	- 128	3,500	4,600	5,700
Chemicals	9,903	9,113	- 790	15,000	19,000	23,700
Other Non-Durable Goods	17,210	15,387	- 1,224	12,000	10,600	8,800
Total Commodity Employment	55,061	53,249		59,800	-----	-----
Construction	10,813	13,294		18,000	23,900	32,000
Transp., Communications, Utilities	15,492	16,370		20,000	24,400	29,400
Trade	41,489	42,531		51,000	64,800	79,600
Finance, Insurance, Real Estate	9,264	11,903		14,000	18,000	23,000
Services	27,352	36,439		49,000	65,000	84,000
Government	18,442	19,933		22,200	24,500	31,000
Total Employment	177,913	193,719		234,000	287,500	353,600
Population	430,148	526,850		641,000	790,000	970,000
Population - Richmond City Area, Richmond, Henrico, Manchester, and Midlothian Districts in Chesterfield County	307,037	379,948		468,000	577,000	708,000

* Source: National Planning Association, Washington, D. C



WATER SUPPLY AND WATER QUALITY CONTROL STUDY
JAMES RIVER BASIN – VIRGINIA

REGION III - POPULATION

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION III CHARLOTTESVILLE, VIRGINIA

FIGURE 4

WATER REQUIREMENTS

Past and Present Water Uses

Water uses in the James River Basin include domestic water supplies; municipal and industrial water supplies; recreation; commercial and sport fishing; agriculture; and waste-water transport and assimilation. All these uses depend upon surface water sources, with agriculture and water supplies utilizing both surface and ground water sources.

Recreational water use along the main stem of the Jackson and James River System is quite extensive, with opportunities afforded for swimming, boating, fishing, hunting, and aesthetic enjoyment. The James is the principal sport fishing stream in Central Virginia.

Commercial fishing and oystering is of considerable consequence in the James River estuary. The James estuary is one of the most prolific producers of seed oysters on the Atlantic Coast, with beds located in the estuary reported to be the best continual producing seed areas in the world.

Hydroelectric power is generated at several run-of-the-river installations along the Jackson and James Rivers, with total generating capacity of approximately 25,000 KW. Reusen's Dam above Lynchburg is presently the largest of these facilities, having a capacity of 12,500 KW.

At this time, irrigation along the Jackson and James System is limited in application; however, use of these rivers as a dependable source of supply for livestock watering is of some importance.

Use of the Jackson and James Rivers as a source of community water supply involves only three significant community or metropolitan areas: Covington, Scottsville, and Richmond, presently using a total of 37 mgd. Lynchburg presently has an auxiliary supply line to the James River, but its water use was not included in the above total, as additional reservoir capacity to serve Lynchburg is being constructed on the Pedlar River. The additional reservoir capacity on the Pedlar will make use of the James River as a water supply source for Lynchburg unnecessary, except as an emergency measure. Industrial water use of the Jackson and James Rivers above Richmond involves about 64 mgd from surface sources, used primarily as process or cooling water. The remaining communities and industries of the Basin use surface water from tributaries or well supplies to meet their needs.

Inventories of water users, sources of supply, and quantities of water used within the James Basin show most large water users relying on surface water supplies. Within the area considered in this study, most of the large surface water users have the main stem of the Jackson or James Rivers as their source. Private water supplies and small water users usually have ground water sources being supplied by home or community wells. Table XII on page 29 lists the principal water users located within the study area, and a summary of water use is shown below:

WATER USE SUMMARY

	Population Served	Municipal Use (MGD)	Industrial Use (MGD)	Total Use
Surface	377,900	49.45	64.90	114.35
Ground	7,150	0.70	1.60	2.30
Totals	385,050	50.15	66.50	116.65

Use of the Jackson and James Rivers for waste assimilation and transport is significant at several locations along the system. Table XIII on page 30 lists the major contributions of waste to the Jackson and James Rivers. A relatively small amount of the total waste load above Richmond is from municipalities; the largest loads originate from scattered but large industries. A summary of Table XIII shows the population served by sewerage facilities as 336,115, with a total waste flow discharged to the river of 106.41 mgd, containing a population equivalent of 612,740.

Ground Water Sources

There are four distinct geologic regions within the Basin, and each region has its own ground water characteristics. In this general evaluation, the Blue Ridge, Ridge and Valley, and Piedmont Regions are similar enough to be considered together, with the Coastal Plain discussed separately.

Table XII

WATER INVENTORY

Community or Industry	Estimated Population Served	Average MGD 1964 Surface	Average MGD 1964 Ground
Covington	7,200	1.40	---
West Virginia Pulp and Paper	---	34.00	1.0
Hercules Powder Company (at Covington)	---	1.50 2/	---
Clifton Forge	8,350	1.80 2/	---
Iron Gate	(740) 1/	from Clifton Forge	---
Virginia Hot and Warm Springs	2,000	---	0.2
Buchanan	1,900	---	0.2
Buena Vista	6,500	0.30 2/	0.3
Glasgow	1,200	0.80 2/	---
James Lees and Sons	---	---	0.6
Owens Illinois	---	14.00	---
Lynchburg	51,000	9.70 2/	---
Meade Corporation	---	12.00	---
Glamorgan Pipe and Foundry	---	3.40	---
Madison Heights	3,000	0.30 2/	---
Scottsville	900	0.15	---
Richmond	303,000	35.00	---
TOTALS	385,050	114.35	2.3

1/ Population supplied by Clifton Forge

2/ Supply taken from tributaries to Jackson or James Rivers

Table XIII

WASTE INVENTORY

Community or Industry	Population Served	Flow MGD	Treatment	P. E. Discharged[1/]
Covington	11,160	1.10	Primary	7,440
West Virginia Pulp and Paper	---	32.00	Secondary	60,000
Hercules Powder Company (at Covington)	No Waste Discharge			
Clifton Forge	6,500	0.65	Primary	4,550
Iron Gate	715	0.07	Primary	500
Virginia Hot and Warm Springs	2,000	0.20	Secondary	200
Buchanan	1,350	0.13	Primary	950
Buena Vista	6,300	0.60	Primary	4,200
Glasgow	1,090	0.11	Primary	750
James Lees and Sons	---	0.60	Primary	7,500[2/]
Owens Illinois	---	12.00	Intermediate	105,000
Lynchburg	55,500	5.50	Primary	38,500
Meade Corporation	---	11.00	Intermediate	105,000
Glamorgan Pipe and Foundry	---	Cooling Water Discharge		
Madison Heights	1,000	0.10	Primary	650
Scottsville	500	0.05	None	500
Richmond	250,000	24.00	Primary	166,000
		18.30	None	195,000
TOTALS	336,115	106.41		612,740

1/ P. E. values for industries were computed using 0.2#/day of 5-day BOD per capita (#BOD/02 = P. E.) to make municipal and industrial discharges comparable.

2/ Discharges to North River 0.6 miles above confluence with James River.

Shallow wells less than 200 feet deep in these three regions usually yield about 2-20 gpm, while deeper wells seldom yield over 300 gpm. Chemical water quality is generally better from the shallow wells than from the deeper wells; however, corrosiveness, iron, sulfur, and hardness frequently make both sources undesirable from quality considerations. The primary advantage of deep wells is "yield stability," as shallow wells tend to show greater fluctuations in yield and are much more dependent upon rainfall. Aquifers in these three provinces have little permeability, resulting in relatively small yields, since wells must depend upon penetration of water through openings and fissures for supply and recharge. There are a few wells in each region having high yields (greater than 100 gpm); however, they are situated in more favorable geologic and hydrologic areas such as valleys and draws, or near surface streams.

In the Coastal Plain Province, wells 10-100 feet deep furnish most of the domestic supplies. Wells 50-700 feet deep average about 50 gpm, with industrial wells 6-12 inches in diameter yielding up to and greater than 500 gpm. Deeper wells give water high in dissolved solids, particularly fluorides and bicarbonates. Excessive hardness, iron, and corrosiveness are characteristics of many of the deep wells, with salinity a factor near Chesapeake Bay.

Ground water is generally available throughout the area that would be influenced by reservoir development at the Gathright Reservoir site, but seldom in quantities adequate to sustain larger users. It is anticipated that future use of ground water will be primarily restricted to homes, small communities, and other uses requiring relatively small volumes of water, and that ground sources will be adequate to meet these demands.

Existing Surface Water Sources

Flows in the Jackson and James Rivers show considerable seasonal fluctuations, average to high flows December through June, then low water conditions July through November, resulting from prolonged periods of little or no precipitation. Profiles of average and minimum stream flow for the Jackson and James Rivers are shown by Figure 5, following page 31.

In the Jackson and at the headwaters of the James, steep gradients in the stream bed produce high velocities. Downstream, the James River becomes larger, channel slope decreases, and its flow characteristics become more uniform. Below Richmond, the

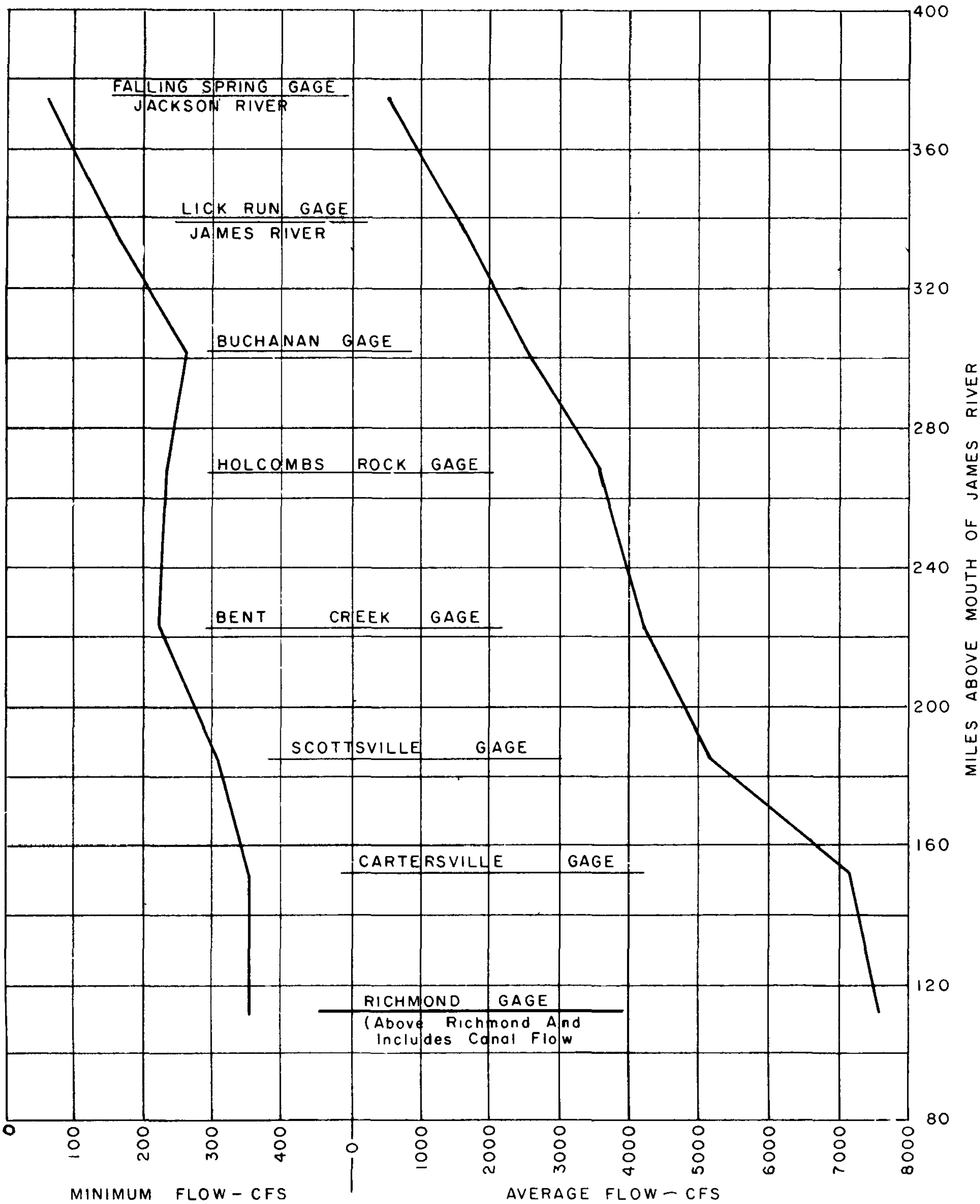
James becomes an estuary. During periods of average to low flow, alternating pools and rapids are characteristic of much of the river system.

Water quality samples of the Jackson and James Rivers at several State and industrial sampling stations along the rivers indicate: high quality water above Covington, Virginia, suitable for almost all uses; low water quality having high turbidity, color, and BOD, with periods of low to zero D. O. for as much as 15 miles below Covington; generally good water quality in the remainder of the system, with zones of depressed water quality below the larger industrial and community waste discharges. During periods of low flow, water hardness is a problem, as ground water inflow having high hardness concentrations becomes a larger per cent of total stream flow. Water quality of the Jackson and James Rivers is generally satisfactory for most water uses; however, stretches of stream immediately below community and industrial waste discharges are of degraded quality, especially for bodily contact recreation.

Water Quality Criteria

Water quality goals and quality requirements in a stream or watercourse should permit maximum utilization of the water for each beneficial use, while minimizing the costs of achieving or maintaining this stream quality. Methods of meeting water quality goals usually consist of limiting concentrations or volumes of wastes in the waste flow to the stream (effluent standards), or in the stream itself (stream standards). No universal procedure for obtaining or maintaining specified water quality has been adopted, but some combination of the above two methods is usually utilized in application.

Specific water quality standards and/or goals have not been established for all streams in the State of Virginia by the Virginia Water Control Board. Each stream, and each waste discharged to the stream, is considered on its respective merits, taking into account: volume or concentration of waste discharge, assimilative capacity of the stream, and beneficial uses to be protected below the point of waste discharge. However, the following pollution control criteria are generally used throughout the State, subject to modification and/or expansion: (1) dissolved oxygen not less than 5.0 mg/1 in the stream, (2) no appreciable floating or settleable solids, (3) no noticeable coloration or discoloration of the receiving stream, (4) toxic substances to be reduced below the toxicity limit of the stream, (5) no appreciable change in pH of the receiving stream, and



WATER SUPPLY AND WATER QUALITY CONTROL STUDY
JAMES RIVER BASIN - VIRGINIA

PROFILE OF JAMES RIVER FLOWS

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION III CHARLOTTESVILLE, VIRGINIA

FIGURE 5

(6) stream flow for design of sewage treatment facilities equal to minimum average 7-day low flow, occurring in a 10-year frequency.

In the Jackson River and the James River above Richmond, the primary uses to be preserved and protected are: water supplies, fish and aquatic life of the stream (biological characteristics), plus recreation. Periods of degraded water quality adversely affect many water uses of the stream, resulting in restriction or cessation of beneficial water uses. Recreation and water supply uses could be restricted during short periods of low water quality; however, fish and aquatic life of the stream usually sustain severe damage from adverse stream conditions. Biological characteristics of a stream reflect long-term or residual effects from even short periods of low water quality. Other uses require satisfactory quality only during the periods of use, and generally do not suffer residual effects.

At Richmond, flows of approximately 900 cfs pass through the Kanawha Canal for purposes of power generation. During periods of low flow, the Richmond water supply also takes water from the Canal, with little or no flow resulting in the natural channel of the James River from Bosher's Dam to 14th Street Bridge, about 9 miles. Water treatment plant records at Richmond indicate that with river flows greater than about 900 cfs, few water treatment problems develop from algal blooms, suspended and dissolved solids, and water hardness. When river flows drop much below 900 cfs, during summer months, algal blooms occur upstream from Richmond, stemming from ideal concentrations of nutrients, warm temperatures, and long periods of sunlight. These algal blooms generate tastes and odors in the water which are greatly intensified by chlorination of the water supply, and are believed to be the principal source of the tastes and odors in the Richmond water supply. The resultant tastes and odors require use of extra chemicals in the water supply (primarily chlorine, activated carbon, and alum) to relieve the condition. A portion of the additional chemicals (alum) is used to combat coagulation problems in the water supply induced by low flows. These additional chemicals reduce the problem; however, significant tastes and odors currently remain in the water, giving rise to large numbers of complaints (up to [illegible] per week).

The principal cause of excessive algal growth is the high concentration of nutrients [illegible] phosphates) in the river during periods of low flow. In the James above Richmond, there are several probable sources of nutrients, with agricultural land drainage and municipal waste discharges upstream being the most significant. Because of the lack of information on critical nutrient concentrations, present nutrient concentrations, agricultural land use practices, and the expected effects of institution of secondary treatment at waste discharges upstream, the taste and odor problem at Richmond was not considered as a design criteria for water quality. It is anticipated that future studies of the James River will provide adequate data to consider this problem in greater detail.

Water quality sufficient to protect the fish and aquatic life in the Jackson and James Rivers usually provides water quality satisfactory for most other beneficial uses. For this reason, the biological characteristics of the stream have been given primary consideration for setting quality standards and objectives. The parameter most affecting the stream's biological characteristics is the dissolved oxygen (D. O.) in the stream. Ponding, low stream velocities, and increasing water temperatures are natural conditions which cause low D. O. concentrations. These conditions also induce higher rates of D. O. utilization in the stream from more rapid bio-oxidation of organic wastes. Prolonged periods of low D. O. can damage or destroy the aquatic flora and fauna of a stream, sometimes requiring extremely long periods of time for the stream to recover.

After consultation between the Virginia Institute of Marine Science and Virginia State Water Control Board, it was agreed that average values of 4.0 mg/l D. O. and minimum instantaneous values of 3.0 mg/l D. O. were generally adequate to retain the biological environment of most streams in Virginia, maintain the other water uses, and prevent development of nuisance conditions in these streams. These objectives have been specifically adopted for the James River estuary by the Virginia Water Control Board and are being used when determining amounts and strengths of wastes that may be discharged to the estuary.

After reviewing and evaluating the dissolved oxygen objectives discussed above, these objectives were determined to be both reasonable and adequate, so have been adopted for purposes of this report.

A once in 20-year low flow recurrence interval was used as a basis for meeting or maintaining water quality in the Jackson and James Rivers. Computations were made using average monthly low flows, 20-year return frequency, and the assumption that the critical flows for each month occurred within the same year. The assumption that monthly 20-year low flows will occur within the same year is statistically valid and was used in determining the most critical yearly conditions to be met.

Periods of degraded water quality conditions in the stream can require from several months to several years for the biological environment to recover. Because of the long periods required for the environment to recover, a recurrence interval of one year in 20 was selected. A shorter frequency, such as one year in five or ten years, would result in much greater damage to natural fish and aquatic life in the critical stretch of stream.

ADDITIONAL WATER NEEDS

Increased per capita water use, expanding population, expanded industrial usage, plus greater diversification of water use have all combined to push national water requirements to higher levels. The rate of water use in a municipality is affected by a variety of factors: size and location of the community, habits and standards of living of the people, availability of water (including cost and quality), extent and use of water meters, existence of sewers, degree of industrialization, plus other less specific factors.

Industrial water use in the United States has increased six-fold between 1900 and 1955, with the increases in use primarily restricted to manufacturing and process water. Predictions of future industrial water use range from very nominal annual increases to increases of 16 per cent per year. Predictions of small yearly increases in industrial water use are generally based on growth of existing facilities; whereas, predictions of large yearly increases are usually based on the anticipated establishment of new plants or facilities.

Municipal[1/] and Industrial[2/] Water Needs in the James River Basin

Anticipated economic growth and development of economic resources in the Jackson and James River Basins will lead to significantly higher industrial water use at Covington, Lynchburg, and Richmond. Much of this industrial demand is incorporated in water use projections for the above municipalities, as these municipalities presently provide about 30 to 50 per cent of the industrial supply. Additional industrial growth is expected at intermediate locations along the stream; however, the lowest stream flows of record are much above anticipated water use at these intermediate locations.

Covington, Lynchburg, Scottsville, and Richmond presently utilize the main stem of the Jackson or James Rivers as a source of water supply and are expected to continue as the most significant demands on this source into the future. Present and projected municipal water needs at Covington, Lynchburg, and Richmond

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1/ Any domestic, commercial, industrial, or other water demand supplied through a community system.

2/ Those industries or commercial water users having their own water supplies, i.e., sources or intakes.

are compared with the minimum flow of record at the corresponding stream section in Table XIV, on page 38. The municipal requirements shown in Table XIV include industrial supplies utilizing the municipal system.

Figures for present water use (mgd) and total persons served were obtained from the communities considered. Economic and population projections, from which water needs were calculated, were obtained utilizing past and present trends; then these trends were extended into the future. Projected municipal water use was calculated using economic and population projections included in this report with figures for per capita water use in the communities of interest (125 gpcd for Covington, 140 gpcd for Lynchburg, and 140 gpcd for Richmond). Future per capita water use was determined considering present water use and water use in other communities of comparable size and economic background. Projected water use figures for Covington, Lynchburg, and Richmond, contained in Table XIV, were in close agreement with projections furnished by the municipalities; however, Public Health Service projections of water use were used, as they had benefit of more recent economic and population data, were not limited by corporate boundaries, and gave greater weight to the trend toward higher per capita water use.

By year 2020, combined municipal and industrial water use at Covington is expected to approximately equal the Jackson River low flow of record. Water use is projected to increase from the present level of 34 mgd to about 49 mgd in 2020. Industrial usage would make up approximately 46 of the 49 mgd total, with the 46 mgd projected as a relatively constant demand beyond the year 2020. Jackson River flow is considered sufficient to provide water supplies for industry and the City of Covington beyond year 2020.

Considerable industrial growth in the Lynchburg area is projected, with municipal and industrial water use expected to follow a similar trend. Almost all the industries in the Lynchburg area are served by the City's municipal supply taken from its Pedlar River source. Only a few industries at Lynchburg have separate water supplies utilizing the James River as a source. Projections of this separate industrial water use show it is expected to amount to about 30% of the lowest river flow on record, some 44 mgd. The City of Lynchburg also has an auxiliary supply line to the James River in case of failure of the Pedlar River supply. Should complete failure of the Pedlar supply occur, only 60 per cent of the low flow of record in the James River would be required to supply the combined municipal and industrial needs, by year 2020.

Table XIV

PROJECTED MUNICIPAL WATER USE

Community and Population Served	Present Use (1965) - mgd	Present GPCD	Projected GPCD - 2020	Projected Use (2020) - mgd	Minimum Daily[1/] Flow on Record
Covington	1.4	121	125	3	48 mgd
1965 - 11,500					
2020 - 22,000					
Lynchburg[2/]	9.7	155	140	39	145 mgd
1965 - 62,500					
2020 - 280,000					
Richmond	35.0	115	140	160[3/]	226 mgd
1965 - 303,000					
2020 - 1,150,000					

1/ Flows adjusted from gaging stations above and/or below point of interest.

2/ Lynchburg presently has an auxiliary supply to the James River, but new reservoir capacity on the Pedlar River will make its use unnecessary except as an emergency measure.

3/ About 30% or 48 mgd supplied to industry.

Water use in the Richmond area is expected to follow the economic growth pattern of the area. The Richmond area population is expected to increase by about three times the present population by the year 2020. Manufacturing and employment are projected to have moderate increases for the immediate future, with a leveling off thereafter, as shown in the Economic Section of this report. These economic projections were obtained utilizing past and present conditions to obtain trends; then extending these trends into the future.

Richmond presently uses an average of approximately 35 mgd for its municipal water supply, serving almost all industries in the area with water supplies (excluding water used for power generation). Industrial usage of the City water system presently makes up about 30 per cent of the City's demand, some 10 mgd, and this industrial usage is expected to remain near the 30 per cent level in the future. Projected municipal water use at Richmond indicates a use of approximately 160 mgd by year 2020 (see Table XIV).

When evaluating water usage and future water supply needs at Richmond, the water rights for 645 cfs of James River flow must be considered. These water rights are deeded to the Chesapeake and Ohio Railway Company, then leased on a long-term basis and apportioned as follows:

City of Richmond	88
VEPCO	173
Albemarle Paper Company	384
	645 cfs

During periods of summer low flow in the stream, water rights almost equal stream flow. James River flow during the summers of 1954 and 1963 almost equaled water rights in the James, especially in 1963, when flows of 646 cfs were recorded at Richmond. The City of Richmond has negotiated an agreement with VEPCO, giving Richmond use of VEPCO's 173 cfs water rights for municipal supply during periods of low flow when James River flow would not support the City's needs. The 173 cfs cannot be used for any purpose other than municipal water supply. Combined City and VEPCO water rights amount to 261 cfs (167 mgd), which is approximately equal to the projected 160 mgd required by year 2020.

Based on the projection of economic and population trends for the Richmond Metropolitan Area, and the Agreement with VEPCO, adequate quantities of water are available to supply municipal and industrial needs at Richmond until year 2020. Even though projections show adequate quantities of water available, projected water demand and supply are so nearly equal that investigations of other sources will probably be carried out in the next few years. Preliminary investigations have already been made in the Petersburg area toward developing the Appomattox River for water supply storage. The Richmond area could also use this source, as it is located very close to Richmond, some 20 miles. The York River Basin, primarily Pamunkey and Mattaponi Rivers, also offers potential sources of water supply to the Richmond area.

Water supply storage in a reservoir located above Covington, Virginia, is not considered as a solution to future water needs at Richmond, because of the extreme distance (285 miles) between the source of supply and the user. The availability of other sources of water supply near Richmond make water supply storage in the Gathright Reservoir site above Covington infeasible at this time.

It must be recognized that large scale growth of industry, manufacturing, commerce, etc. may appreciably alter water requirements derived from projections of present economic trends. Should economic growth occur at greater than the anticipated rates, the resources of the Richmond area indicate most of the growth would be of the "clean" types (little water used other than cooling water, and little waste discharged).

Only municipal and industrial users of the James River upstream from the estuary have been considered. There is a tremendous volume of water in the James estuary available for use when salinity or other quality indicators are not prohibitive. This availability of water would probably influence heavy industrial water users to consider this area as a source, thereby eliminating a demand on the James River.

Waste Load Projection

Projections of waste loads to the stream must be done on an area basis when considering wastes from municipalities or municipal-industrial complexes. In the study area, three municipal-industrial complexes were considered: Richmond, Lynchburg, and Covington. All calculations were based on waste loads after adequate treatment (considered as 85% 5-day BOD removal for this report).

Economic projections indicate moderate industrial and population increases for the Richmond area. The waste load drawn from these projections, plus the tremendous volume of water in the James estuary, should allow maintenance of quality objectives in the James below Richmond, after secondary treatment has been provided1/.

Economic projections for the Lynchburg area indicate this area will show a greater percentage of industrial and population growth than Covington or Richmond. After consideration of waste load projections, stream flow, and quality data for the area, it was calculated that natural stream flows are adequate to meet water quality objectives at the selected protection level of once in 20 years. The stream can assimilate approximately 53,000 lbs/day at the selected low flow, approximately 3 1/2 times the present load to the stream after secondary treatment. The 2020 waste load is projected as approximately 40,000 lbs/day, which is within the assimilative capacity of the James at Lynchburg.

During periods of low flow, water quality problems presently exist in a 2-3 mile zone just above Lynchburg, between Reusen's Dam and Lynchburg Dam on the James River. During the low flow conditions, river flows are stored at Reusen's for periods of 2-5 hours, then released for power generation. When river flows are being stored, a dry stream bed, or very little flow, exists in a 2-3 mile stretch below Reusen's, sometimes causing small fish kills and destroying portions of the stream environment within the affected area.

Passing of the water quality control flows released from Gathright Reservoir would eliminate the problems created by low to zero flow in the James below Reusen's, i.e., maintain the biological characteristics in the area. If the quality control flows are "peaked" for power generation, very little improvement would occur in this stream stretch. It is anticipated that power licenses on the James River will be re-negotiated if Gathright Reservoir is constructed, in order to require passage of water quality flows without "peaking" for power generation.

1/ Private report on BOD assimilation capacity of Lower James River, Virginia - Donald J. O'Connor, July 196[illegible].

Report on assimilation capacity of the Upper James River (estuary) - Hydro-Science Inc., August 1963.

Using available stream flow and quality data, present waste data, and economic projections, the Jackson River below Covington was determined to be the critical stretch of the Jackson and James Rivers for meeting the water quality objectives set forth on pages 34 and 35 of this report. The primary problem in this portion of the stream, considering present and projected stream uses, is maintaining 4.0 mg/l dissolved oxygen. With secondary treatment of waste discharges through the length of the Jackson and James Rivers, meeting dissolved oxygen requirements at Covington can be expected to eliminate problems of low dissolved oxygen concentrations within the study area.

Since the stretch of stream below Covington was determined to be critical, detailed municipal and industrial waste loading projections for water quality calculation have been made for only the Covington area.

Municipal waste load projection is based on a contribution factor of 0.2 pounds of 5-day BOD per person per day. Used in conjunction with population projections, the 0.2 lb/day contribution factor allows computation of realistic municipal (domestic) waste loads. Utilizing population projections and 85% waste treatment in the Covington area, the domestic waste loads for years 1995 and 2020 are estimated at 500 and 660 pounds of 5-day BOD, respectively. (See Table XV).

Present industrial waste discharges to the stream at Covington receive secondary treatment and discharge some 12,000 lbs of 5-day BOD/day. It is expected that the degree of treatment will be maintained or improved in the future.

Projections of industrial waste loads to the stream at Covington, after secondary treatment, amount to 16,000 lbs of 5-day BOD by year 1995, and 20,000 lbs by year 2020. (See Table XV). These loadings were based on economic projections of industrial growth in the Covington area, after consultation with industry.

Table XV - WASTE LOAD PROJECTIONS - COVINGTON AREA

Type of Waste Load	Present (1964) (# 5-day BOD/day)	1995 1/ (# 5-day BOD/day)	2020 1/ (# 5-day BOD/day)
Municipal	1,480 2/	500	660
Industrial	12,000	16,000	20,000
TOTAL	13,480	16,500	20,660

1/ Projections based on provision of adequate treatment.
2/ City of Covington presently provides only primary treatment.

Project Investigation and Data Analysis

The determination of BOD assimilative capacities for the Jackson and James Rivers required data from various points in the stream and for various flow and temperature conditions. Data from special studies of the Jackson River at, above, and below Covington, conducted by West Virginia Pulp and Paper Company, were used in the computations, plus stream quality data gathered from eight stations along the Jackson-James System by the Virginia State Water Control Board, 1959 through 1962. Data used in the analysis included measurements of dissolved oxygen, temperature, biochemical oxygen demand, stream flow, and velocity, plus observations of stream conditions during periods of critical dissolved oxygen concentrations. The data were combined and analyzed to determine de-oxygenation and reaeration rates for use in computing assimilative capacities of the stream[f/] Computations of assimilative capacity to meet established dissolved oxygen objectives are necessarily based on averages of physical and chemical conditions in the stream, especially temperature and waste load. When using maximum averages for temperature and waste load, normal fluctuations of indicator values cause variable dissolved oxygen concentrations in the stream for similar flow conditions. Calculations of assimilative capacity in this report were made, recognizing the above variables and their effect on, and relationships to, instantaneous stream dissolved oxygen concentrations.

Because of the size of the present waste load at Covington (14,560 of 5-day BOD including background stream BOD) and the low flow in the Jackson River during the summer months (available flow of 55 cfs for August), waste assimilation calculations indicate Covington is, and will be, the problem area for maintaining water quality. Criteria used for the calculation of stream flows required to obtain or preserve water quality in the Jackson River are as follows:

1. Minimum allowable average dissolved oxygen of 4.0 mg/l with minimum allowable instantaneous values of 3.0 mg/l.

2. Background BOD in the stream (from land drainage, etc.) of 1.0 mg/l.

3. Initial dissolved oxygen deficit upstream from Covington of 1.0 mg/l. This value reflects natural stream conditions as recorded by state sampling. It is anticipated that reservoir operation will be such to maintain high dissolved oxygen conditions in the releases by the use of multiple level

outlets, Howell-Bunger Valves[1/], or some other measure. Natural aeration of the stream, as it flows the 19 miles from the dam site to the critical point below Covington, will help maintain the required stream D. O. values for use in waste assimilation.

4. Drainage area of Jackson River above Dunlap Creek is equal to 440 square miles.

5. Minimum monthly average low flow conditions with a return frequency of one in 20 years (shown in Figures 6a and 6b). (Monthly low flows plotted vs. drainage area for the Jackson River above Covington.)

6. 46 MGD of water used at Covington and returned as waste water with DO = 2 mg/l. To be used to adjust values from figures 6a and 6b.

7. Figure 7 was constructed to determine minimum flow necessary to assimilate a given waste load at a given temperature. (Temperature vs. waste load vs. flow to maintain 4.0 mg/l dissolved oxygen.)

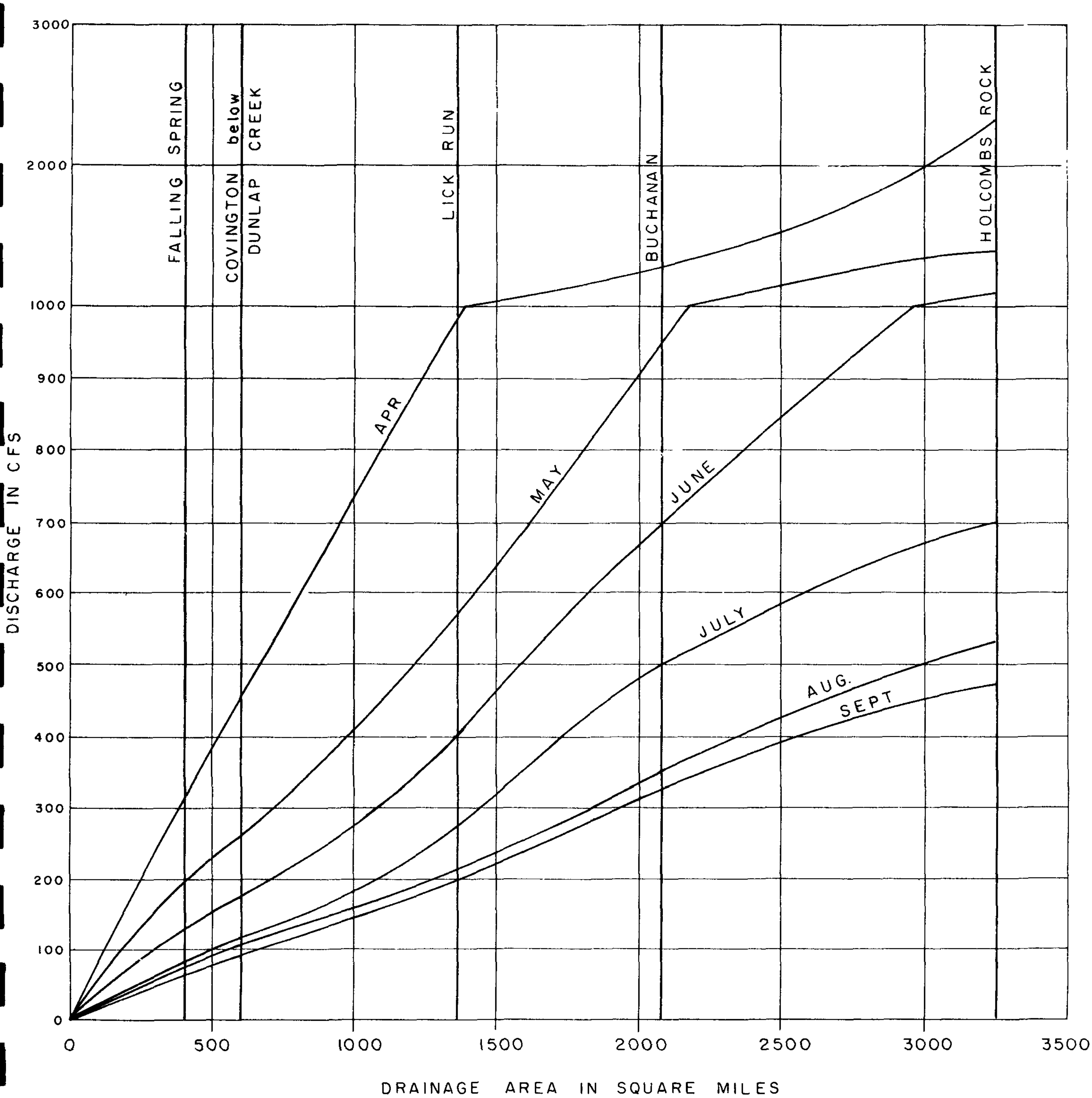
A sample calculation demonstrating the use of values, figures, and tables is given below:

EXAMPLE - Given:

1. Initial D. O. Deficit = 1.0 mg/l
2. Minimum allowable average D. O. = 4.0 mg/l
3. Temperature = 25°C
4. Daily waste load = 40,000 lbs/day of ultimate BOD
5. Available stream flow = 200 cfs (20-year monthly low flow adjusted for reduced quality, D. O., of the waste)

Using Figure 7, flow required to maintain 4.0 mg/l dissolved oxygen in the stream is 250 cfs.

1/ Mechanical Aeration Devices sometimes used on water treatment plants and have proved helpful in maintaining high D. O. values in reservoir releases.

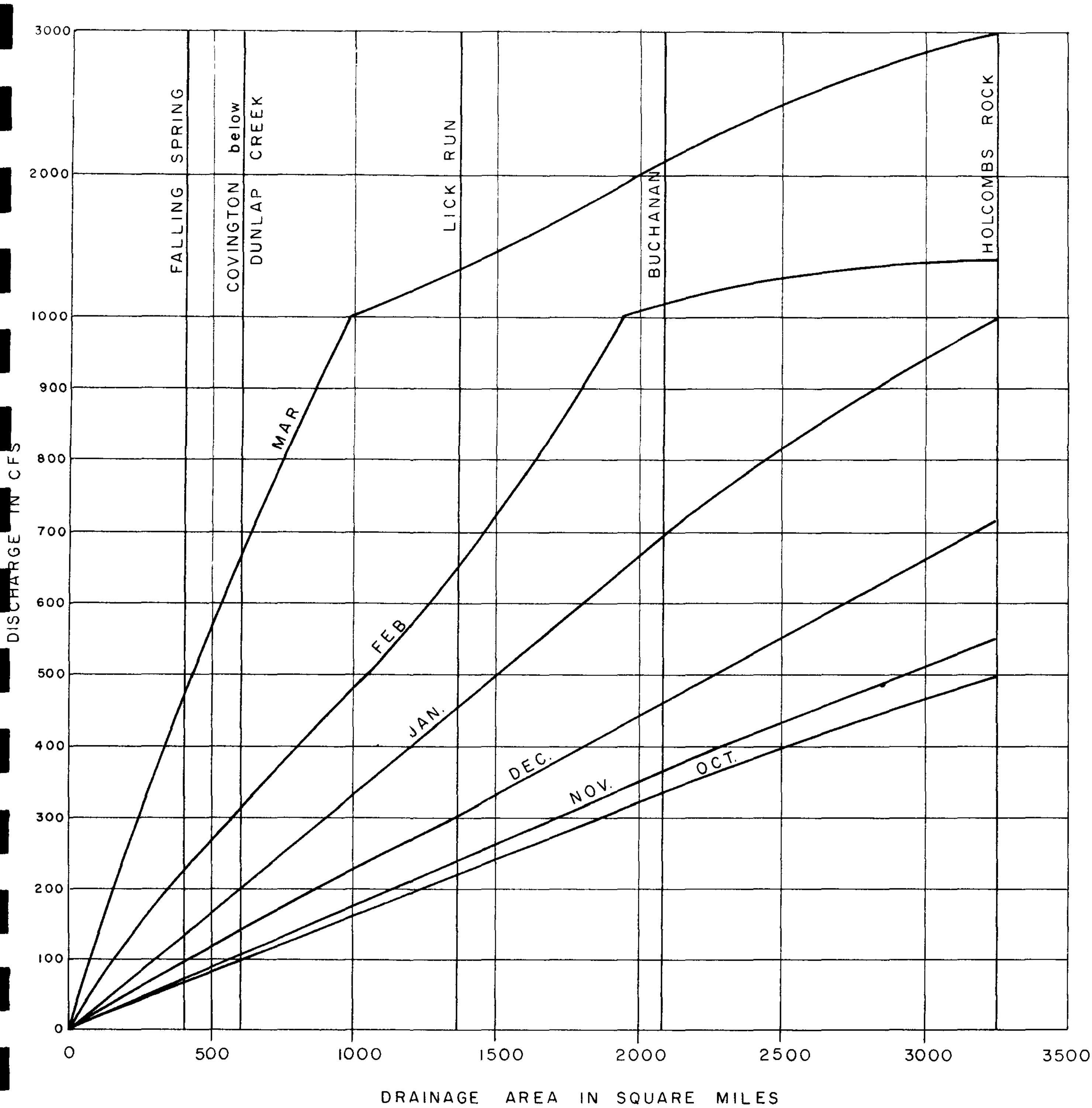


WATER SUPPLY AND WATER QUALITY CONTROL STUDY
JAMES RIVER BASIN – VIRGINIA

JAMES RIVER 20 YR. LOW FLOW

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION III CHARLOTTESVILLE, VIRGINIA

FIGURE 6A



WATER SUPPLY AND WATER QUALITY CONTROL STUDY
JAMES RIVER BASIN — VIRGINIA

JAMES RIVER 20 YR. LOW FLOW

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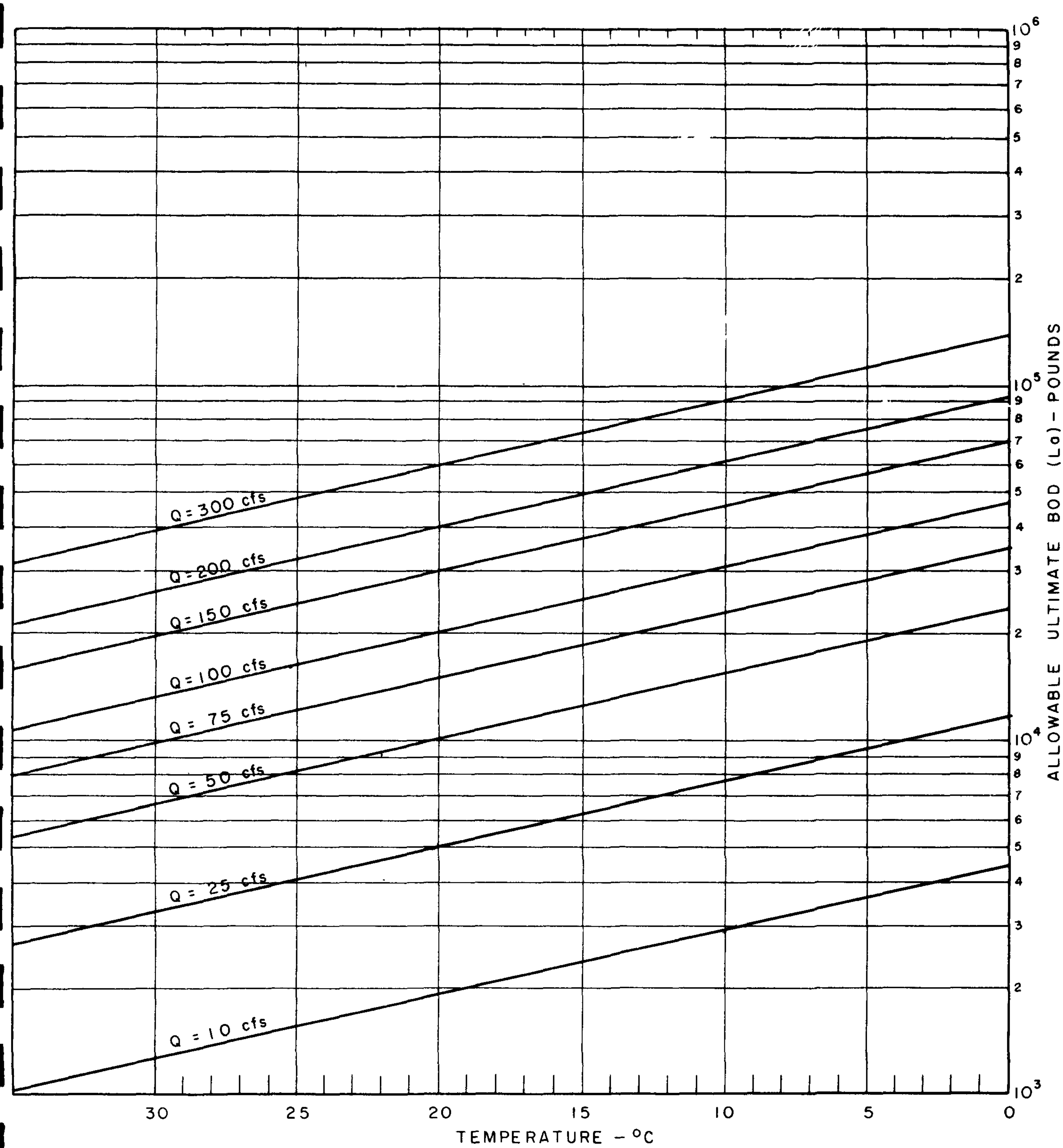
PUBLIC HEALTH SERVICE
REGION III CHARLOTTESVILLE, VIRGINIA

FIGURE 6B



WATER SUPPLY AND WATER QUALITY CONTROL STUDY
JAMES RIVER BASIN – VIRGINIA

ASSIMILATIVE CAPACITY BELOW COVINGTON

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FIGURE 7

Additional flow to maintain the stream quality at a level to support the beneficial uses of the stream is 250 - 200 = 50 cfs for this month. This additional flow can be converted easily to reservoir storage and monthly flows accumulated to give seasonal requirements.

Applying the above procedure to stream and waste conditions at Covington, the draft on storage[1] required for water quality control amounts to 40,000 AF/year in 1970, 50,000 AF/year in 1995, and 60,700 AF/year in 2020. Table XVI, on page 46, gives monthly average flows which must be provided to maintain the desired water quality objective in the Jackson and James Rivers. The monthly design low flows and the yearly draft on storage are also shown in Table XVI. The necessary flows are shown by month, to indicate distribution of the need for flow regulation for water quality control throughout the year.

Table XVI is not to be used as a reservoir operating schedule, but should be used as a guide for developing a reservoir operating or release schedule.

1/ The volume of storage that must be available on an annual basis to meet water quality objectives with flow regulation.

Table XVI

MONTHLY DESIGN LOW FLOWS AND YEARLY DRAFT ON STORAGE FOR JACKSON RIVER AT COVINGTON

Month	Required Flow for Waste Assimilation (cfs)	Monthly Average 20 yr. Low Flow Above Covington 1/ (cfs)	Flow Available For Waste Assimilation 2/ (cfs)	Additional Flow Required (cfs)	AF of Yield Required From the Reservoir
January	100	140	82	18	1,110
February	100	240	172	---	---
March	100	505	434	---	---
April	130	335	271	---	---
May	165	205	139	26	1,600
June	210	140	81	129	7,700
July	225	90	32	193	11,900
August	225	80	27	198	12,200
September	190	70	15	175	10,800
October	135	75	22	113	6,970
November	100	80	19	81	4,840
December	100	100	42	58	3,580
				TOTAL	60,700 AF/YR.

1/ The values from Figure 6a and 6b reduced by a ratio of 440 square miles divided by 610 square miles to remove flow contribution from Dunlap Creek.

2/ Flows adjusted for the large water use at Covington.

BENEFITS OF STORAGE

Benefits can result from reservoir releases for water quality control that increase the flow in a stream during periods of critical or low flow. Some of these incidental benefits may include increased recreational opportunities and greater aesthetic characteristics.

Water quality control through flow regulation by the Gathright Reservoir will provide many benefits by improving conditions in the Jackson River for about 45 miles and in the James River for approximately 340 miles. These improved conditions will decrease with progression downstream because the reservoir releases become an increasingly smaller percentage of the total stream flow. The benefits are widespread, affecting some one-half million persons, with greater benefits occurring near population or industrial centers above the James estuary.

Maintenance of higher flows during the summer and fall months would afford greater opportunity for water-oriented recreational use of the Jackson and James Rivers. Of the recreational uses, fishing and boating would receive the greatest benefits, since the James River is the principal stream in central Virginia. Fish production, for example, would be increased by the maintenance of a larger water surface area which is generally conceded as one of the principal factors in propagation. The most significant benefits would result in a 10-15 mile stretch of the Jackson River below Covington, Virginia, where warm water fish and biological life can be maintained.

Riparian property owners would be benefited because of improved aesthetic values resulting from improved water quality and increased stream flows. Aesthetic benefits would stem primarily from a more desirable and appealing water environment. These benefits will be significant in both rural and metropolitan areas, affecting residential, commercial, and industrial establishments. The additional flows would also prevent deposition of solids in pools of the Jackson and James Rivers during periods of low flow.

Fewer water quality control problems for industry would result, as increased flows tend to reduce hardness and solids concentrations. Reduced solids and hardness concentrations in water supplies are especially beneficial for boiler operation and for use as industrial process water.

Records of water treatment plant operations at Richmond indicate that James River flows above 900 cfs present few water treatment problems. With flows of this magnitude, algal populations are apparently below nuisance concentrations; suspended and dissolved solids are minimal, and water hardness is of little significance. When flows drop below about 900 cfs, severe taste and odor problems begin to appear in the Richmond water. The magnitude of the taste and odor problem is indicated by the number of complaints to the Richmond Commissioner of Public Works. Complaints average about 2 per week during normal operations, but jump to about 70 per week during periods of taste and odor problems. The increased stream flows of 18-198 cfs to maintain quality objectives during periods of critical stream flow will also reduce the potential for water treatment problems at Richmond. On the average, some 5-6 thousand dollars are spent yearly combating taste and odor problems at Richmond.

During periods of low James River flow, most of the flow passes through the Kanawha Canal, leaving little or no flow in the natural channel from Boshers Dam to 14th Street Bridge. The low flows in the natural channel allow mosquito breeding and, during 1963, several square miles of the City of Richmond were afflicted with acute mosquito problems. The additional flows would help relieve the mosquito nuisance and improve aesthetic conditions in 9 miles of the stream bed.

There would be quality control benefits in the estuary portion of the James River stemming from increased flows of higher quality water into the estuary; however, flows contributed by the reservoir are small when compared to the estuary volume, making measurement of the benefits in this section of the stream extremely difficult.

The most significant benefits from water quality control storage in Gathright would occur in a 15-25 mile stretch of stream below Covington, Virginia. These benefits result from increasing D. O. levels to an average of 4 mg/l; allowing production of warm water fish, as well as other biological life, and greatly improving the aesthetic qualities in this reach. These benefits are of measurable value and are directly attributable to stream flow regulation by Gathright Reservoir.

A measure of water quality control benefits in the Jackson and James Rivers has been made in terms of costs of obtaining the same quantity and/or quality of water by the cheapest alternate means which would most likely be developed by potential users, in the absence of a Federal project.

Inclusion of storage for quality control by stream flow regulation must be considered when planning a Federal reservoir. However, this quality control storage, with subsequent water releases, shall not be provided as a substitute for adequate waste treatment. Adequate treatment has been interpreted to be a minimum of conventional secondary treatment for municipal sewage, and its equivalent for industrial wastes, after evaluation of the individual industrial waste to be treated. Secondary treatment was assumed as 85% BOD removal for water quality benefit calculations.

Based upon present knowledge, adequate treatment is expected to remove 85 per cent of the total organic waste load prior to discharge to the watercourses of the study area. Although higher removals can be achieved by the treatment facilities, the average reduction for the area will be somewhat less because of the discharge of organic material through storm water sewers and numerous individual home disposal systems. The 85% BOD removal is a realistic efficiency of treatment which can be economically attained by municipalities and industries in the area.

In the critical area for water quality control, Jackson River below Covington, adequate treatment is unable to reduce the pollution load to a level that would satisfy established stream quality objectives at design low flow. Using minimum average monthly flow with a 20-year return frequency--80 cfs at Covington during August (Figure 6a), then adjusted to 55 cfs because of the reduced quality M & I water returned from Covington--the Jackson River can assimilate approximately 8,000 pounds of 5-day BOD per day at 28°C (Figure 7). This assimilative capacity is inadequate to maintain the quality objectives with present (1964) waste loads of about 14,560[1/] pounds of 5-day BOD per day, and no assimilative capacity is available for the increase in load to about 22,000 pounds of 5-day BOD/day in 2020.

Methods presently available for reducing waste loads contributed to the stream after conventional secondary treatment include: lagooning, holding ponds for regulated release of effluent or waste, additional treatment above secondary, waste transport downstream, and complete removal. If removal of waste below the critical amount is not economically feasible, one additional alternative exists--a reservoir to provide additional stream flow, i.e., flow regulation.

The methods of achieving water quality objectives in the Covington area are evaluated below.

1/ BOD loadings include municipal, industrial, and natural BOD in the stream.

Lagooning

This method of achieving stream quality is not feasible. The area required for such an installation is not available in the very narrow Jackson River Valley.

Holding Ponds for Regulation of Waste Releases

The use of holding ponds is limited to places where large areas can be utilized for the construction of the ponds. For the Covington area, waste holding ponds are not practical because of their necessary size, and the non-availability of land for pond construction. Sulphur in the paper mill waste would also present problems. Long periods of storage would tend to chemically reduce the sulfate compounds to sulfides, and the sulfides would exert a large oxygen demand when released to the stream.

Additional Treatment Beyond Secondary

The wastes from the Covington area are almost entirely industrial. The industrial wastes have undergone treatment in an extensive and unique secondary treatment process; a pioneering effort in the treatment of paper mill wastes. The treatment processes include: mixing tank to blend mill and sanitary wastes and adjust the pH, primary clarifiers, nutrient fed activated sludge units, and secondary settling.

Modifications of existing treatment facilities are continually being carried out when research indicates the new measures will be effective. A cooling tower is presently under construction to lower waste temperatures and increase the efficency of the activated sludge unit.

For these reasons, this method of achieving established water quality objectives is not considered a feasible alternative.

Transport of the Discharge to a Point Downstream

This approach was not applicable in the Lower Jackson and Upper James River area. Transporting the waste load downstream would destroy one of the best warm water fishing streams in the State of Virginia.

Complete Removal of Pollutants

Treatment methods which would economically accomplish complete removal of all pollutants are not presently available. However, certain processes are far enough advanced to be considered when comparing alternate methods of obtaining water quality objectives.

The "freezing and gas hydrate process," developed for demineralizing sea water, is one of the most promising methods which may be adapted to treating waste waters by concentrating dissolved solids to about one per cent by volume. This process is one of the least expensive methods for complete removal of pollutants (estimated cost is $0.40 per 1000 gallons). Conventional secondary treatment would necessarily precede the process to condition the waste. Treatment of Covington area wastes would have an average annual cost of approximately $4,970,000/year. The annual cost includes operation, maintenance, and amortization charges, but disposal of concentrated solids produced by the process was not considered in the above cost estimates. Since this additional disposal problem would result in additive costs to this expensive method of waste treatment, no further analysis was made.

Single Purpose Reservoir

After wastes from the Covington area have undergone secondary treatment, it is estimated that a single purpose reservoir for quality control must provide a draft on storage of 60,700 AF/year to maintain water quality objectives in the Jackson and James Rivers until year 2020. Existing and proposed uses of the Jackson River above Covington are not expected to adversely affect the quality of water stored in a reservoir located in this area.

Other reservoir sites were investigated on the Jackson and its tributaries, and it was found that the site of Gathright Reservoir offers the cheapest construction site. Estimated construction costs and typical annual operation costs (O and M plus annual charges) for a reservoir to provide the necessary draft on storage were prepared by the Corps of Engineers, using data furnished by the Public Health Service. (Shown in the table below.) Interest rates have been taken as 3 1/8 per cent, and 1970 is considered a reasonable date for the reservoir to become operational.

Year Constructed	Storage Provided AF	Estimated Construction Cost	Annual Operation Costs (O&M Plus Annual Charges)
1970	60,700	$12,140,000	$72,700

Using the above data, the average annual value of quality control storage in a single-purpose reservoir at the Gathright site amounts to $556,000 per year when amortized over a fifty year period. As the single-purpose reservoir, in conjunction with secondary waste treatment, is the most feasible and most economical method for providing water quality control, the $556,000 per year is the minimum annual value of water quality control benefits over the life of the reservoir project, 1970 to 2020. The benefits from reservoir storage would be widespread in scope, affecting 385 miles of stream and some one-half million persons in their use of the Jackson and James Rivers for water supply, recreation, agriculture, plus other beneficial water uses.

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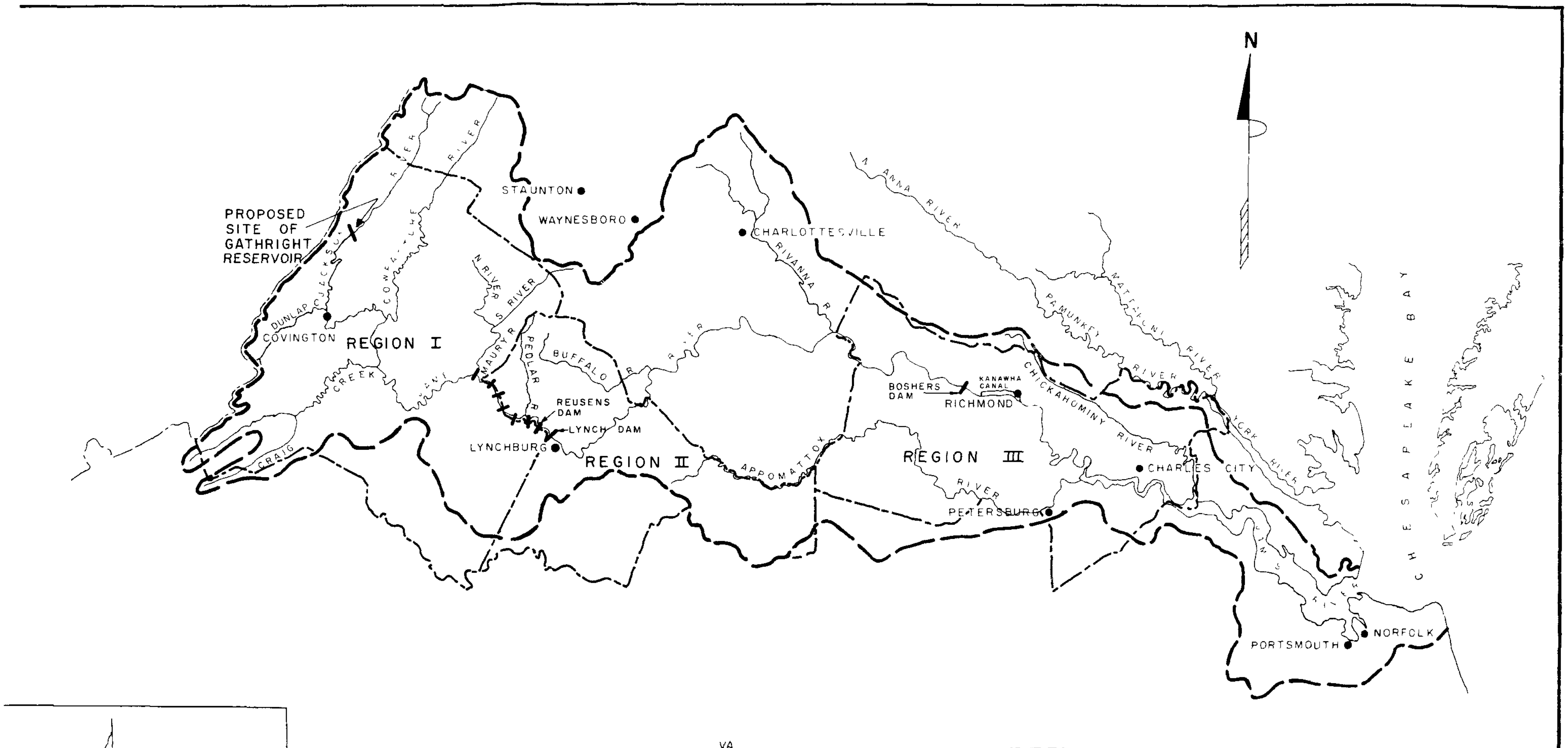

WATER SUPPLY AND
WATER QUALITY CONTROL STUDY
JAMES RIVER BASIN – VIRGINIA

LOCATION MAP

U S DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE
REGION III CHARLOTTESVILLE, VIRGINIA

FIGURE I