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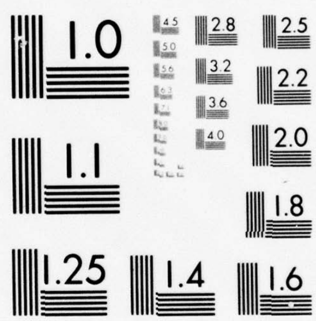
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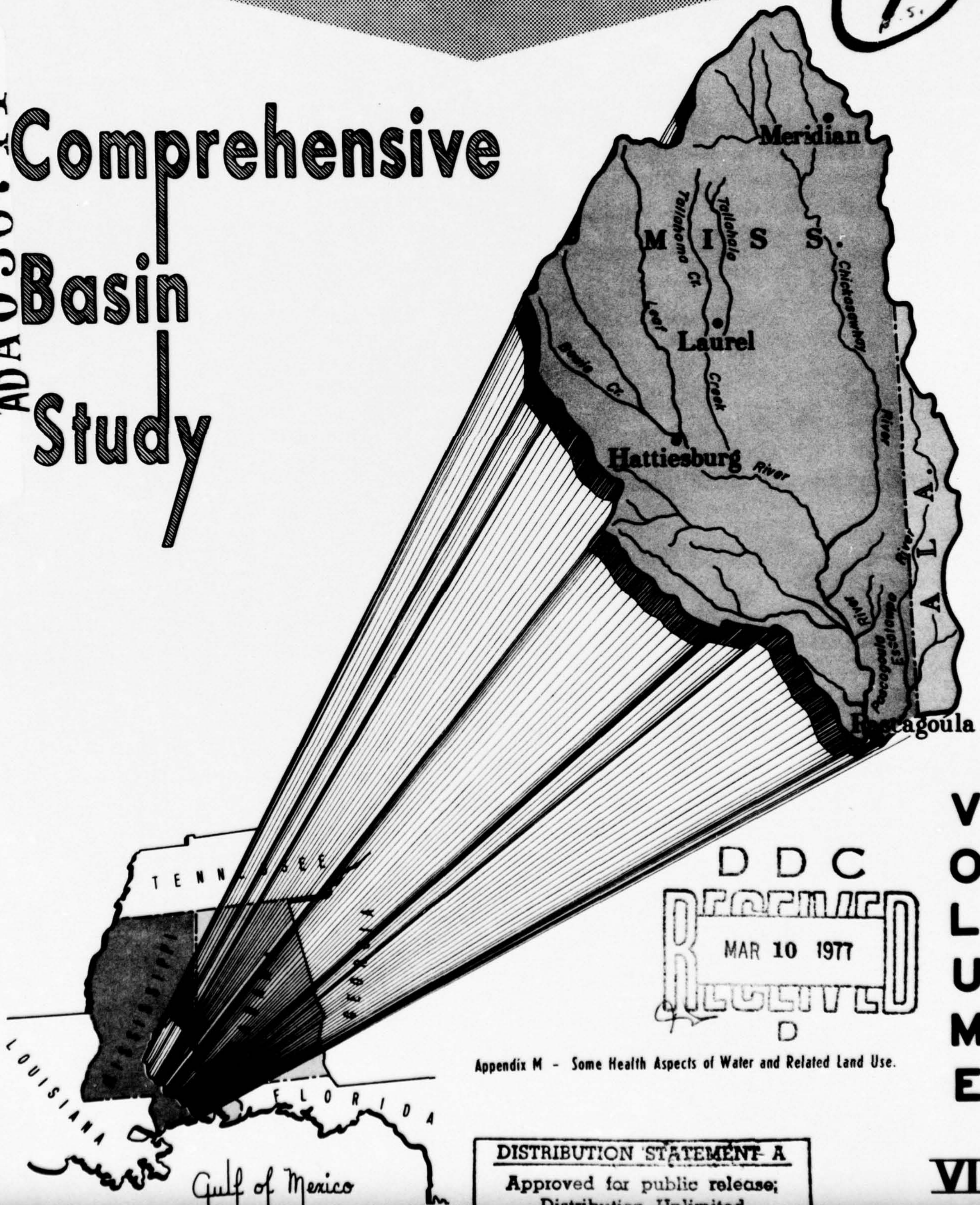
PASCAGOULA RIVER

Comprehensive Basin Study



Appendix M - Some Health Aspects of Water and Related Land Use.

VOLUME VII

PASCAGOULA RIVER COMPREHENSIVE BASIN STUDY

VOLUME INDEX

PASCAGOULA RIVER COMPREHENSIVE BASIN STUDY.

Volume VII.

APPENDIX M.

SOME HEALTH ASPECTS OF WATER AND RELATED LAND USE OF THE PASCAGOULA RIVER BASIN

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Pascagoula River Comprehensive Basin Study

U. S. Department of Health, Education, and Welfare
Public Health Service
Bureau of Disease Prevention and Environmental Control
Region IV, Atlanta, Georgia

PREFACE

The U. S. Department of Health, Education and Welfare (DHEW) became involved in the comprehensive study of the Pascagoula River Basin subsequent to a 1961 proposal by the Select Committee on National Water Resources. Federal water pollution control activities at that time were administered by the Public Health Service. During the past few years that program operating unit in the Southeast has conducted studies on municipal and industrial water supply needs of the basin, by agreement with the Department of the Army; and water quality studies of surface streams in the basin in accordance with the Federal Water Pollution Control Act, as amended.

In 1965, the Federal water pollution control program as explained above became the Federal Water Pollution Control Administration (FWPCA) – a separate agency of DHEW. Then on May 10, 1966, the FWPCA was transferred to the Department of the Interior (DI) by Reorganization Plan No. 2 of 1966. However, the functions transferred were those authorized in the Federal Water Pollution Control Act, as amended – less health aspects of that Act. The health aspects of the Act retained are as defined in an interdepartmental agreement between DHEW and DI and approved by the President on September 1, 1966.

These organizational changes were quite germane to completion of the Pascagoula comprehensive study report, since DHEW still has significant responsibility in water and related land resource development. The Public Health Service Act (Public Law 410) authorizes many functions of a water-health related nature which, of course, were not transferred in Reorganization Plan No. 2 of 1966. The PHS drinking water supply program, vector control activities, and shellfish sanitation are just a few of these functions. Recent air pollution control and solid waste disposal legislation is also pertinent to comprehensive water and related land use development. The Secretary of DHEW is a member of the Federal Water Resources Council, in accordance with the Water Resources Planning Act of 1965. In such membership capacity, DHEW must assure that interagency coordination in water resource development will provide for protection of the health and well-being of all persons affected by such development.

As a part of interagency coordination in developing the comprehensive study report for the Pascagoula River Basin, it was considered important to include some health aspects of water and related land resource development. The FWPCA Appendix G deals extensively with surface water quality, and quantity needs for municipal and industrial water supplies. Quality studies and parameters used in Appendix G, indicated an emphasis on fish and wildlife, and recreation. Other agency appendices reviewed also included excellent background information for basin development – especially through multipurpose reservoir construction – but evaluation of safe development from a health standpoint, had not been made.

Many facets should be investigated for any comprehensive river basin water resource development study. For example, appendices on history and archaeology are included in this comprehensive basin study report. But, health aspects were not adequately covered. Some specific questions regarding the safe use of proposed reservoirs for recreation were raised. Therefore, it was decided by the Mobile District of the Corps of Engineers (study coordinators) and concurred in by the other participating agencies .... that a health agency report was necessary.

Purpose of this health aspects appendix is to evaluate existing data included in the other agency appendices, and also information obtained by State and local health units as well as the Public Health Service. The evaluation will pertain to health aspects of water contact recreation, shellfish sanitation, vector control and drinking water supply.

Because of time and resources limitations for completion of the full basin study report, the health agency input will necessarily be limited in scope to evaluation and not include field studies. Some questions of a health significant nature affecting proposed water and related land use development remain unanswered, because DHEW budget requests inadvertently did not reflect the need for such studies. Other areas of public health significance will not be evaluated. Solid waste disposal practices in the basin and their relation to reservoir development, and surface or groundwater contamination by such practices have not been determined. Studies and evaluation of air pollution in relation to health and industrial development have not been considered.

Though the economic base study appendix dwells upon population parameters of sex, race, and education — the health parameter has been omitted. It is hoped that questions raised in this appendix and perhaps some of these other unknown factors can be properly investigated and evaluated during the early stages of future basin development.

Much praise is due representatives of the various agencies participating in this comprehensive study and who have assisted in making this appendix possible:

U. S. Department of the Army

Corps of Engineers (Corps)

U. S. Department of the Interior (USDI)

Bureau of Outdoor Recreation (BOR)
Federal Water Pollution Control Administration (FWPCA)
U. S. Geological Survey (USGS)
Bureau of Sport Fisheries and Wildlife (BSFW)

U. S. Department of Agriculture (USDA)

Soil Conservation Service (SCS)
Economic Research Service (ERS)
Forest Service (FS)

Pat Harrison Waterway District

Mississippi State Board of Health

Special thanks is due the Southeastern Region of the FWPCA for their assistance and cooperative attitude towards implementing the inter-departmental agreement required by Reorganization Plan No. 2 of 1966.

This appendix, subtitled 'Some Health Aspects of Water and Related Land Use of the Pascagoula River Basin', discusses the following subjects:

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and Drinking Water Supply.

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SUMMARY AND RECOMMENDATIONS

Fecal coliform levels in many tributaries to the Pascagoula River indicate a contamination that must be considered in developing areas for water contact recreation. Source of some of this contamination is not apparent and should be investigated. Some proposed reservoir developments could include the recreation benefit immediately, from a health standpoint. Other proposed reservoir developments in the basin could include the recreation benefit, if more is known about high coliform levels. It is well-known that high total and fecal coliform levels attributable to man constitute a health hazard. But, it should be recognized that contamination from cattle or poultry origin is also of public health significance. During the planning stages of specific early action projects, it is recommended that studies be initiated to determine the origin and health significance of high total and fecal coliform densities in tributaries of the Pascagoula River which do not now receive municipal, industrial or agricultural wastes.

The estuarine areas of the Pascagoula River were once an important source of commercial oyster harvesting, but have been closed to shellfishing since 1961. To better utilize these oyster producing areas in the future, plans should be implemented for eliminating existing sources of pollution and enhancing water quality by streamflow regulation. A benefit to shellfish sanitation might be realized by construction of the various upstream reservoir projects which provide for streamflow regulation. Comparable to the need for determining the health significance of total and fecal coliforms (regardless of source) on water contact recreation, it is recommended that similar studies be initiated concerning shellfish sanitation in Pascagoula Bay and adjacent estuaries.

The mosquito-borne disease which poses the greatest threat to health in the Pascagoula Basin is viral encephalitis. Health agencies should maintain adequate surveillance activities in regards to this arbovirus. Vector control needs of the basin are several. Sanitary surveys should be conducted in all towns of the basin. Such surveys not only highlight conditions conducive to mosquito breeding and harborage, but also lay groundwork for a correctional program. A study should be made to determine the impact of overflowing artesian wells as mosquito sources. Emphasis should be placed upon ditching or land drainage as a permanent method for mosquito control. A detailed plan to help meet vector control needs in the basin is recommended in Section III of this report.

Water quality studies by various agencies indicate that groundwater in the Pascagoula area does not meet all limits of the Public Health Service 1962 Drinking Water Standards. Additional analyses should be performed to more precisely quantify those questionable substances. Construction of the early action reservoir project proposed for the Escatawpa River (Corps of Engineers) would alleviate water supply needs in the Pascagoula metropolitan area.

Important to any water resource surveillance and/or development — from a health standpoint — is an effective state health agency drinking water supply program. Mississippi does not possess an adequate program. Federal agencies solicit support from each other, local groups, and state water agencies for their proposed water resource development projects and programs. These agencies, together with the State of Mississippi, will actively seek support for the recommended early action plan for the Pascagoula River Basin. The total estimated first cost of this plan is $192,882,000. It is highly recommended that similar active support be given for the establishment of an adequate public water supply program for the Mississippi State Board of Health.

SECTION I

WATER CONTACT RECREATION

by

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Introduction

Waters polluted with human and other animal wastes can contain infectious agents to which man is susceptible. Diseases that have been transmitted by polluted water include Typhoid fever, Salmonellosis, Shigellosis, Leptospirosis, Amebiasis, and Infectious Hepatitis. Other diseases can also be waterborne but have a geographic range that does not now include the United States, or seem to occur infrequently and are not a waterborne public health problem. There are also illnesses associated with swimming that are not as well defined. These involve infection of the ear, eyes, and skin caused by several bacteria, fungi, and viruses. Larger parasites have bothered swimmers, such as the schistosomes causing "swimmer's itch", and the cat and dog hookworm causing "creeping eruption."

None of the diseases, except swimmer's itch, are exclusively a waterborne problem and transmission usually occurs from person to person contact. Disease outbreaks associated with public water supplies result in a large number of cases and have been recognized as being waterborne. Disease resulting from water contact recreation may not involve many people and few outbreaks have been recorded. The cases that may be occurring from using contaminated water for recreation are unrecognized among the more numerous reported cases resulting from person to person contact.

Immersion in water also causes illnesses to man. Three studies conducted by the Public Health Service on the relationship of bathing water quality to health demonstrated that swimming in water of any quality increased the minor illness rate of swimmers over nonswimmers. With the increase of illness due to swimming alone, it is then difficult to measure an additional increase of illness that can be correlated to increased pollution of water. Studies of the effect of grossly polluted water have not been made, because the public does not choose to use such areas for recreational swimming. There are, of course, a few small boys who will swim anywhere but they have not been the subject of medical research.

Unpolluted water will present less of a health risk to recreators than polluted water, but all surface waters have some contamination. A balance must be struck between the benefits, both physical and psychological, to water recreation and the health hazards involved. There is really no level of contamination that will be completely safe for all persons who might recreate in the water. Past epidemiological studies were able to detect a measurable increase in illness when the total coliform content was 2300 per 100 ml. Newer bacteriological techniques have since been developed to detect and quantitate the fecal coliforms which gives a more direct measure of the health hazard. The fecal coliforms have recently been about 18 percent of the total coliforms in the stretch of the Ohio River where the above 2300 level of contamination was established. Thus, about 400 fecal coliforms per 100 ml could be associated with a measurable health effect.

A fecal coliform level of 200 per 100 ml should provide a quality of water suitable for primary contact recreation without significant health risks. Primary contact recreation would be swimming, water skiing, and wading (dabbling by children). Also, in some rivers, canoeing becomes a primary water contact endeavor.

Proposed DHEW recommendations for bacteriological water quality standards regarding waters used for contact recreation are:

- Fecal coliform density not to exceed 200 per 100 ml (geometrical mean); and

- Fecal coliform density not to exceed 400 per 100 ml in more than ten per cent of samples analyzed per month.

Other forms of water based recreation such as fishing and duck hunting do not involve the same chance for ingestion of water. Water quality criteria for these forms need not be as stringent. There are really no guides to a suitable criteria. The water should be as clean as can be obtained. A fecal coliform concentration of 1000 per 100 ml is suggested for secondary contact recreational waters.

Present Water Quality

Leaf River Subbasin

Waters below the population centers of Hattiesburg and Laurel have been degraded and are not suitable for recreation. Ten Federal Water Pollution Control Administration sampling stations provide data on the headwaters of the Leaf River.[1] Only two of these, Tallahala Creek (274890)* and Big Creek (275610), indicate that impounded

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* Numbers in parenthesis represent FWPCA's sampling station identifications as utilized in their national water quality network data retrevial system, called STORET. Both total and fecal coliform densities are represented by the geometrical mean.

water would be suitable for primary contact recreation during the season when there would be such use. Five additional sites are now suitable for secondary contact recreation; Thompson Creek (274590), Bogue Homo Creek (274683), Bowie Creek (275350), Oakohay Creek (275730), and the upper Leaf River (275810).

The station on Okatoma Creek (275260) had a geometric mean of 1335 fecal coliforms per 100 ml from the 16 samples collected during the period of May-August 1965. This contamination undoubtedly reflects the contribution from the communities of Magee and Collins.

The Tallahoma Creek station (274940) is affected from wastes from the Laurel area. Municipal and industrial lagoon treated wastes contribute to the geometric mean of 1607 fecal coliforms. Thus the station does not really give an indication of the quality of headwaters in this basin.

Gaines Creek (274575) does not receive discharges of municipal or industrial wastes, but the quality of the water is not fit for recreational use. The mean fecal coliform density was 1206 per 100 ml and may indicate agriculture pollution from cattle or poultry operations, as well as wildlife. Cattle contamination of bathing waters has resulted in Leptospirosis in humans and Salmonella are frequently carried by chickens.

Chickasawhay River Subbasin

Unlike the Leaf River, a considerable stretch of the lower Chickasawhay River has a quality that is suitable for recreation. Six Federal Water Pollution Control Administration sampling stations provide data on the headwaters of the Chickasawhay River. The station on Okatibbee Creek (274305) is affected by the pollution from Meridian and does not reflect what the water quality would be at the upstream reservoir site. Two of the tributaries, Souinlovey Creek (274170) and Chunky River (274240) have a quality that is suitable for primary contact recreation. The other four tributaries; Big Creek (273920), and another Big Creek (273985), Bucatunna Creek (274010), and Tallahatta Creek (274220); have a water quality that makes them suitable for secondary contact recreation.

Lower Pascagoula Subbasin

The quality of the main stem is suitable for secondary contact recreation and some stretches may be suitable for primary contact recreation. Most of the stations had water that could be used for swimming in June-July; but the water had been of poorer quality in March-April.

Water of the Escatawpa River is suitable for secondary contact recreation with some stretches that could be used for swimming, but more data would be necessary to define specific areas as some stations had higher counts in June than in the spring. Bathing water quality must be judged during the recreation season.

Data are available on two tributaries to the lower Pascagoula. Red Creek is suitable for swimming and other water sports except in the upper reaches where it has been degraded by municipal and industrial wastes from Lumberton. Black Creek has excellent water for recreation and is being developed as the site for float trips. When other waters are compared to the bacteriological quality of Red and Black Creeks, it can be seen that many of the other tributaries have been degraded by some form of pollution. In some cases this pollution has not come from municipal or industrial wastes and may be from agriculture or other sources such as wildlife.

Pascagoula-Escatawpa Estuary

The estuary is not suitable for recreation due to high coliform counts. This poses a problem because the area is adjacent to the population center and will be used by the public for recreation.

Areas of the bay are also unsuitable for primary contact recreation, but the more pressing health problem here is the unsuitability of the water for shellfish harvesting. Commercial operations may be controlled but recreational harvesting of aquatic life will present a health hazard to the public in this area.

Proposed Water Recreation

Recreational use is proposed on the reservoirs to be constructed by the Corps of Engineers, Pat Harrison Waterway District, and U. S. Department of Agriculture. Consideration must be given to the quality of water that will be impounded in these projects.

Experience with many large reservoirs has demonstrated that the quality of inflowing water will improve in the reservoir; and recreation areas can be developed where the water quality is suitable for this purpose. There are, of course, many small reservoirs in the Southeast but they have not been studied from a bacteriological point of view.

The Federal Water Pollution Control Administration conducted a special study on three small reservoirs in the Tombigbee River Basin during April-June 1967 to assist the Public Health Service in evaluating what water quality might be expected in the smaller reservoirs proposed by the U. S. Department of Agriculture in the Pascagoula River Basin (See Tables I - 1, 2, and 3). The results of this study indicated that in the main, improvement in bacteriological quality can be expected as water passes through impoundments of that size.

TABLE I - 1
BACTERIOLOGICAL STUDY
BUGS LAKE - ALABAMA

Description

Location:	Section 35 & 2, T. 15S/T. 16S, R. 11W, Fayette Co., Alabama
Size:	125 Acres
Drainage Area:	7,000 Acres
Upstream Land Use:	85 per cent woods, 8 per cent pasture, and 7 per cent under cultivation.
Estimated Flow into Lake:	Approx. 3.5 cfs
Method of Discharge:	Over flow pipe.

Bacteriological Data

	Total Coliform		Fecal Coliform	
Date	Inlet	Outlet	Inlet	Outlet
5/12/67	3,300	330	330	130
5/15/67*	35,000	1,800	17,000	80
5/17/67	7,900	2,300	330	230
5/18/67	7,900	1,300	130	220
5/19/67	4,300	130	130	80
5/23/67	2,800	4,900	50	460
5/25/67	3,300	90	110	< 20

* Inlet flow was high and muddy and lake water was muddy.

TABLE I - 2
BACTERIOLOGICAL STUDY
FAYETTE COUNTY LAKE - ALABAMA

Description

Location:	Section 13 & 24, T.16S, R.12W, Fayette Co., Alabama
Size:	65 Acres
Drainage Area:	804 Acres
Upstream Land Use:	All wooded area, 3 to 4 cows in small pasture and perhaps one to two gardens.
Estimated Flow into Lake:	Approximately 50 gpm flow.
Method of Discharge:	Water flows over low head dam and bridge.

Bacteriological Data

	Total Coliform		Fecal Coliform	
Date	Inlet	Outlet	Inlet	Outlet
5/12/67		80		20
5/15/67	92,000	700	92,000	50
5/17/67	230	700	< 20	40
5/18/67	330	< 20	50	20
5/19/67	130	490	< 20	< 20
5/23/67	3,400	700	330	< 20
5/25/67	130	700	20	20

TABLE I - 3
BACTERIOLOGICAL STUDY
LOWNDES COUNTY LAKE - MISSISSIPPI

Description

Location:	Approx. 8 miles southeast of Columbus
Size:	165 Acres
Drainage Area:	Approx. 800-1,000 Acres (Guess)
Upstream Land Use:	Mostly pasture land plus some woods
Method of Discharge:	Spillway
Configuration of Lake:	Y-shaped

Bacteriological Data

	Total Coliform		Fecal Coliform	
Date	Inlet	Outlet	Inlet	Outlet
5/18/67	1,700	40	140	20
5/12/67	790	490	20	90
5/15/67	92,000	3,400	35,000	170
5/17/67	7,900	790	490	< 20
5/18/67	3,300	330	1,300	< 20
5/19/67	13,000	790	490	< 20
5/23/67	17,000	2,200	490	50
5/25/67	410	490	70	< 20
5/31/67	6,300	1,100	1,100	< 20
6/2/67	3,300	490	490	< 20
6/6/67	11,000	700	790	< 20
6/7/67	3,400	270	490	< 20
6/8/67	7,900	7,900	1,400	70

One of the reservoirs, (Bugs Lake), rendered data that is difficult to interpret unless there was pollution to the lake itself from nearby houses.

Data are not available on the specific sites of all proposed reservoirs and in other cases water quality data are not available on the specific tributary that will be impounded. More detailed studies will be needed when more detailed planning is done on each project. Evaluation of the available data indicates that sites for reservoirs can be selected that would impound water of a quality that is suitable for primary contact recreation.

Tributary waters that are now suitable for secondary contact recreation with a mean fecal coliform density of 1000 per 100 ml or less could be expected to improve in a reservoir to below 200 fecal coliforms per 100 ml. Consideration of inflow and storage volume on retention time in the reservoirs as well as the reduction of effective volume for dilution due to thermal stratification will be necessary to predict what water quality may result in recreational impoundments. If the inflowing water is not of adequate quality it may be necessary to locate bathing beaches in locations where water quality is not affected by the low quality inflows or shortcircuiting currents.

Higher bacterial levels on some tributaries are known to be caused by municipal and industrial wastes and improvements in waste treatment should precede any reservoir developments on these tributaries. In other cases the sources of higher counts are not known, but agriculture pollution is suspect. The nature and control of this type of pollution needs more study in this basin. The U. S. Department of Agriculture predicts future increases in poultry and cattle production and these operations could cause significant pollution on some tributaries. This and other pollution potential presents a health hazard to the public and will have to be controlled in waters that are to be used for swimming and other forms of water based recreation.

Health Protection at Recreational Areas

Recreational areas such as reservoirs, parks, boat launching ramps, camp sites, and picnic areas cause the congregation of large numbers of people in more primitive settings. Sanitation facilities must be provided and maintained for the protection of the public and to prevent water pollution. Safe drinking water must also be provided.

Recreational areas can be polluted by recreators so that they become undesirable from an aesthetic standpoint and can also be contaminated to the degree that they are a health hazard. Provision of sanitary facilities such as toilets and refuse containers can contribute to the protection of recreational areas, but an organizational arrangement must be provided for the maintenance of the facilities.

Fecal discharges from recreational boats and other vessels are individually a small contribution to contamination and may not be detected by bacteriological sampling. But, these discharges represent a rather direct health hazard and must be controlled in or near recreational areas.

Summary and Conclusions

The Soil Conservation Service of the USDA proposes twenty multipurpose reservoir projects which include the recreation benefit. Water quality studies indicate that water contact recreation would be safe – from a health standpoint – for the projects:

Big Creek (2)
Chunky River
Souinlovey Creek, and
West Tallahala Creek.

It is very possible that water contact recreation would be safe and could be included as a benefit for the other fifteen proposed projects. However, origin and health significance of high total and fecal coliforms should be determined prior to development of the latter reservoirs. Similar information should be obtained for the seven reservoir projects proposed by the Pat Harrison Waterway District – all of which include the recreation benefit. If the source of contamination is of cattle or poultry origin, it is of public health significance. In particular areas, wildlife densities may be great enough to cause health hazards.

Experience has shown that in large reservoirs, inflowing water quality greatly improves. The five Corps of Engineers projects proposed should safely accommodate the water contact recreation use, if the recreation areas are properly located based upon sanitary surveys.

REFERENCES

[1]Appendix G - Municipal and Industrial Water Supply and Water Quality Control Study, Pascagoula River Basin, Mississippi and Alabama. Pascagoula River Comprehensive Basin Study. Dept. of Interior, FWPCA, 1967.

SECTION II

SHELLFISH SANITATION

by

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Introduction

The shellfish species of concern in the Pascagoula estuary is the Eastern Oyster, *Crassostrea virginica*. This bivalve has the ability to concentrate particulate matter and chemicals from estuarine water sometimes to a very high degree. Often these marine animals are consumed raw or only partially cooked. If they are harvested from waters containing harmful microbiological organisms or other substances adverse to man, they could cause disease or toxicosis when eaten. So that oysters may be safe for human consumption, sanitary controls are administered over the shellfish industry.

Since 1925, Mississippi has participated in a cooperative program with 21 other shellfish producing states, the U. S. Public Health Service, and the shellfish industry. Technical and administrative guidelines have been established and are continually revised in light of research and technological advances. All participants follow the manual of the National Shellfish Sanitation Program which includes shellfish growing water quality requirements.[1] Adherence to these requirements assure that shellfish can be shipped in interstate commerce and be safe to eat.

Much of the information for this section was obtained by contacting knowledgeable persons who have been closely associated with the National Shellfish Sanitation Program and Mississippi's seafood industry. Grateful acknowledgement is especially made to Messrs. Garner Russell and William Moorer, Mississippi State Board of Health; Mr. William Demoran, Mississippi Marine Conservation Commission; Dr. Travis Love, Bureau of Commercial Fisheries; and Messrs. Richard J. Hammerstrom and Victor Casper, U. S. Public Health Service, Gulf Coast Marine Health Sciences Laboratory.

Area Description

The estuarine area at the mouth of the Pascagoula River pertinent to this appendix may be defined as 10 miles wide at latitude 30°20' and six miles into Mississippi Sound from the Louisville and Nashville Railroad bridge (Figure 1). This region could support oyster growth

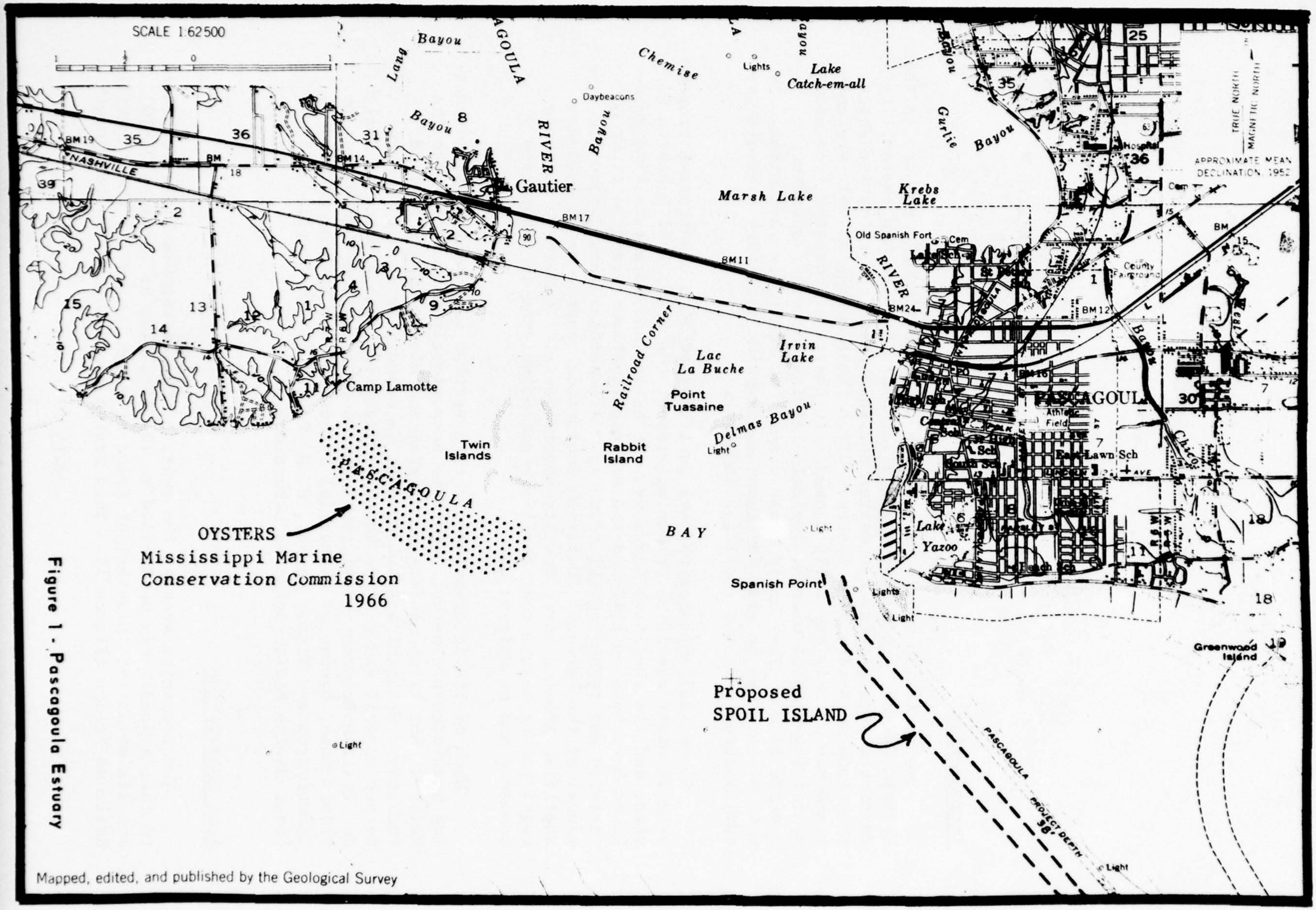

Figure 1 - Pascagoula Estuary

if bottom conditions and water quality were favorable. Salinities in this area vary considerably with season and hydrographic conditions. During prolonged freshets oyster mortalities increase. At peak flows of the Pascagoula River, salinities in the estuary are less than one part per thousand. During periods of low river flows and dry conditions, salinities will approach or exceed 27 parts per thousand. Desirable salinities for oyster propagation and growth are between 10 and 30 parts per thousand.[a]

Depths at mean low water average two to four feet except in the ship channel which is maintained at 38 feet. Bottom materials may be described as soft to sticky mud mixed with some oyster shell. Much of the area cannot support oysters because of unsuitable bottom types or current. A 1966 oyster resource survey conducted by the Mississippi Marine Conservation Commission marine biologist established that approximately 150 acres of seed oysters were located at the mouth of the West Pascagoula River (Figure 1). This reef, according to the Mississippi Marine Conservation Commission biologist, could be expanded to at least 225 acres if the existing area was harvested and the periphery planted with shell. Other scattered oyster clusters were also noted in the vicinity. No other significant oyster resource could be found in the estuarine area.

History of Shellfish Industry

There are no accurate past oyster production statistics which can be given for the Pascagoula estuary. The best information available concerns the value of oyster landings which were gathered during a very active tonging period (1960-1961) on the West Pascagoula oyster reef. It was estimated that the reef oysters harvested brought an ex-vessel value of $1,500 per month in the late fall and winter season.

Until 1936 all of the estuary was open for the taking of oysters. In that year a closed oystering area was made by the Mississippi State Board of Health at the mouth of the East Pascagoula River, an area two miles square (Figure 2). The next reclassification of waters occurred in 1961. An epidemiological investigation in that year disclosed that 84 persons had infectious hepatitis which was traced to the consumption of raw oysters.[3] These oysters had been gathered surreptitiously from the mouth of the East Pascagoula River. Concurrently with the investigation all the estuary was closed to oystering (Figure 2). This is the present classification with no immediate plans to alter the designation.

There are six to eight certified interstate shellfish shippers whose establishments are located in and around Pascagoula. These shippers must obtain their oysters from other approved Mississippi waters or out of state. It is more difficult for these dealers to transport or obtain oysters and keep them fresh the further the source

Figure 2 - Pascagoula Estuary

from Pascagoula. Thus, these dealers could benefit greatly if a safe and dependable source of oysters was available from the Pascagoula estuary.

Oysters for processing in steam plants are gathered almost exclusively by power dredge boats. These boats usually require a water depth of four to six feet to navigate. Because of the shallow water depths, especially over the oyster reefs, power dredges cannot utilize Pascagoula estuary oysters. If the oysters were available, they would have to be hand-tonged. This method of gathering in Mississippi is used almost entirely by those oyster dealers who pack and sell fresh oysters, locally referred to as the "raw trade."

Water Quality and Shellfish

Harmful contaminants to man are not necessarily harmful to oysters. There are many chemical, biological, or radiological substances which can be transmitted to man by the consumption of oysters. Sanitary surveys have been made to determine location, amount, and types of pollution entering the Pascagoula River system. There are significant domestic and industrial pollution sources located in Pascagoula, Moss Point, Escatawpa, and Bayou Casotte. Other pollution sources are located along the river and in the harbor area. Of major concern are the industrial waste waters and treated or partially treated sewage which contain pathogenic microorganisms. Most of these sources are confined to the East Pascagoula and Escatawpa Rivers.

Pascagoula fish meal plants are a source of salmonella. This organism can cause salmonellosis, gastroenteritis, or typhoid fever. The Bureau of Commercial Fisheries laboratory at Pascagoula has conducted a sampling program, in and around the fish meal plants since 1963. Salmonella sp. have been isolated frequently from the soil, plant equipment, and Pascagoula river water. Such contamination must be controlled by adequate treatment with disinfection if the Pascagoula estuary is to be used for shellfishing.

Sewage treatment plants are located or planned for at Moss Point, City of Pascagoula, East Side of Moss Point, Bayou Casotte, and Escatawpa. These plants should provide acceptable treatment of domestic wastes, but are always a potential source of pathogenic organisms and must be carefully evaluated for effective and reliable operation.

Coliform bacteria are used to judge the sanitary quality of shellfish growing waters in the National Shellfish Sanitation Program. The standard has been used for over 40 years in this program for approved shellfish areas. This standard reads in part --

> "The coliform median MPN of the water does not exceed 70 per 100 ml., and not more than 10 percent of the samples ordinarily exceed an MPN of 230 per 100 ml. for a 5-tube decimal dilution

> test (or 330 per 100 ml., where the 3-tube decimal dilution test is used) in those portions of the area most probably exposed to fecal contamination during the most unfavorable hydrographic and pollution conditions."

It is important to understand that if the sanitary reconnaissance of the watershed shows no significant fecal pollution sources, the coliform standard need not be followed. The fecal coliform test has been suggested as a better way to judge the sanitary significance of pollution conditions but no meaningful density value has been determined for shellfish growing waters. It is well established that southern Mississippi's natural surface waters, i.e., receiving no human or industrial wastes, are exceedingly high in coliform and fecal coliform densities. There is no explanation why such high values occur in these natural surface waters. The U. S. Public Health Service Gulf Coast Marine Health Sciences Laboratory is currently engaged in a study of the source and significance of fecal coliforms in the Graveline Bayou drainage area, about eight miles west of Pascagoula. Until better parameters are available to classify shellfish growing waters, a great reliance must necessarily be placed on the sanitary reconnaissance and continued surveillance of the pollution sources.

Chemical and radionuclides do not appear to be present in such concentrations in the Pascagoula estuary as to make consumption of oysters a public health hazard. If these oysters are to be utilized in the future, there must be assurances that chemicals and radionuclides are not allowed to reach unsafe levels in the estuary. The National Shellfish Sanitation Program is now considering specific guideline limits in shellfish for selected radionuclides and certain heavy metals and pesticides. These guidelines should be available for program administration in 1969.

Future Shellfishing

Future direct utilization of oysters from the West Pascagoula River reef for the raw oyster trade is dependent upon pollution abatement activities in the lower Pascagoula and Escatawpa Rivers. Currently a westward movement of polluted Pascagoula River water is possible over or around the spoil banks on the west side of the ship channel. It is suggested that filling around these spoil banks with channel dredgings to make a continuous spoil island for three to four miles out from the mouth of the East Pascagoula River be considered in future studies. This would prevent pollution in the lower Pascagoula from the Pascagoula, Moss Point, and Escatawpa area from being carried westward toward the West Pascagoula oyster reefs (Figure 1). Then if there were no pollution inputs directly into the West Pascagoula River, the West Pascagoula River reef could possibly be opened for direct harvesting or for depuration.

Depuration is a purification process intended to cleanse the oysters of microbiological contamination. This is accomplished by holding oysters in a controlled environment for approximately one to two days and allowing them to pump on treated sea water. Studies are continuing on the depuration process at the Gulf Coast Marine Health Sciences Laboratory for Gulf Coast oysters.

The Corps of Engineers has under study sixteen sites for multipurpose reservoirs in the Pascagoula River Basin. These impoundments in most instances will improve the bacteriological quality of the water. By virtue of these reservoirs reducing flood crests downstream and some providing low flow augmentation, the estuarine areas may be beneficially affected for oyster culture. Reducing the time and extent of low salinities will assist in the survival of juvenile and adult oysters. By augmenting low flows, estuarine salinities could be maintained below levels conducive to an influx of oyster predators such as the oyster drill, Thais haemastroma. The suspected beneficial effect of these reservoirs on oyster culture and shellfish sanitation should be evaluated during final planning stages and after they become operational.

Technological advances in shellfish industry practices and improved shellfish culturing techniques could make the West Pascagoula River oyster reef an important manageable, renewable, natural resource. Its utilization will depend upon good water quality and classification by the responsible control officials of the Mississippi Marine Conservation Commission and Mississippi State Board of Health.

Summary and Conclusions

1) The Mississippi State Board of Health's sanitary controls over the shellfish industry meet the with the requirements of the National Shellfish Sanitation Program. Their program is endorsed by the U. S. Public Health Service and shellfish shippers are certified to ship in interstate commerce.

2) The actual and potential oyster crop in the Pascagoula estuary is a renewable, manageable, natural resource; however, because of bacterial pollution, the estuary is closed to harvesting of these oysters.

3) Future plans for industrial and domestic waste treatment and control, multipurpose reservoirs and navigation improvements could be planned to protect the Pascagoula oyster resource in order that they could be utilized for direct harvesting or be subject to further processing.

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SECTION III

VECTOR CONTROL PROBLEMS IN THE PASCAGOULA RIVER BASIN AND THE MISSISSIPPI COASTAL BASINS, MISSISSIPPI

by

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INTRODUCTION

Vector control is one of the essential elements of comprehensive river basin planning. The control of mosquitoes and other vectors* is necessary to safeguard the health and comfort of the public — not only to prevent disease but to promote health. Health agencies are vitally concerned about vector problems because they are growing along with rapid increase in population and suburbanization; the vast increase in water resource developments; the expansion in industrialization; and the great upsurge in outdoor recreation. These various factors are intensifying the need for both immediate and long-range vector control planning.

This report has been prepared to summarize information on (1) the present status of vector problems in the Pascagoula and Mississippi Coastal Basins, (2) the status of vector control programs, (3) existing vector control needs, and (4) a proposed plan to help meet Basin needs.

Mosquitoes are of foremost concern and therefore receive major consideration in this report. Brief treatment is given to other biting insects.

PRESENT STATUS OF VECTOR PROBLEMS IN THE PASCAGOULA AND MISSISSIPPI COASTAL BASINS

Arthropods of public health importance include not only those species capable of transmitting specific diseases but those species that cause extreme physical annoyance, mental anguish, secondary infections, and allergic manifestations.

Mosquito-borne diseases that have been a problem in the area or are potentially important include: yellow fever, malaria, dengue, and viral encephalitis.

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* Vector is here defined as an insect or other arthropod that directly or indirectly transmits disease to man or causes annoyance and irritation.

The following groups of insects are important because of their annoyance to humans in the region: salt-marsh mosquitoes, fresh-water mosquitoes, deer flies, biting gnats, and stable flies.

Mosquito-Borne Diseases

Yellow Fever

Historically, yellow fever was an endemic disease throughout the State of Mississippi during the 18th, 19th, and early part of the 20th centuries (Harden 1967). The major epidemic year was 1878, when 14,922 cases with 3,231 deaths were reported in the State. Soon after the discovery that the disease was transmitted by the domestic mosquito, *Aedes aegypti*, yellow fever disappeared from this country. The last case in the United States was reported in 1905.

The Mississippi Gulf Coast was an important area for yellow fever. Undoubtedly the large number of open cisterns behind every house on the Coast was a contributory factor for hordes of *Aedes aegypti* mosquitoes.

Malaria

Unlike yellow fever, which was widespread throughout the State, malaria had its highest level of incidence in the Delta region followed by, in order of incidence, the Bluff, Northeastern, Southeastern, and Coastal regions. Morbidity statistics for the Coastal Region readily demonstrate that malaria was uncommon compared to the rest of the State, in many years there being no reported cases (Harden 1967).

During recent years there has been no significant malaria transmission in Mississippi (last indigenous case on record being 1955 — Harden 1967) or any other State in this country.

Even though *Anopheles quadrimaculatus* (vector of malaria) is a common mosquito in the Pascagoula River Basin, it is concluded that malaria constitutes only a minor public health threat in the area. The principal threat is associated with introduced cases of malaria, i.e., contracted from imported cases, such as military personnel from Vietnam.

Dengue

This virus disease, which is transmitted by the yellow-fever mosquito, *Aedes aegypti*, was especially prevalent in Mississippi during the 1920's. In 1922, a total of 4,158 cases was reported for the State. The last reported outbreak (22 cases) occurred in 1942.

Viral Encephalitis

Viral encephalitis ("sleeping sickness") is potentially the most important mosquito-borne disease in Mississippi. It is a serious disease because it has a high epidemic potential, there is no specific treatment, and the disease may damage the brain permanently.

The four principal types of mosquito-borne encephalitis in the United States are Eastern (EE), Western (WE), St. Louis (SLE), and California (CE).

In Mississippi, confirmed human cases of encephalitis have been a rarity — the only one for the period of record being a Western encephalitis case in a 70-year-old woman in Hinds County in 1958 (USPHS, 1959).

Outbreaks of encephalitis among Mississippi horses — principally the Eastern type — have been recorded for many years. Reported horse cases for the period of record are summarized in table III-1. It will be noted that the largest number of cases were reported in 1958. Of the 61 cases, there was only one survivor. Although county records are not available, Dr. L. J. Pate, an U. S. Department of Agriculture Veterinarian in Jackson, Mississippi, estimates that 95% of the 61 cases occurred in the following counties, which are located in the extreme southeastern part of Mississippi: Pearl River, Hancock, Stone, Harrison, George, and Jackson. Each of these counties is included in the Pascagoula River Basin or the adjacent coastal areas covered in this comprehensive report.

Present knowledge concerning the natural history of the encephalitis viruses indicates that there are two basic groups — bird reservoir (EE, WE, SLE) and rodent-rabbit reservoir (CE). Normally the infection chain is limited to birds and small mammals and mosquitoes. Under certain conditions the virus spills over to horses and humans. Man and equines appear to be dead-end hosts and are not important in the natural cycle.

Table III-1

Reported cases of encephalitis among horses in Mississippi, 1935-1965

Year	Equine Cases	Year	Equine Cases
1935	0	1950	25
1936	0	1951	7
1937	35	1952	4
1938	0	1953	3
1939	0	1954	0
1940	26	1955	11
1941	50	1956	9
1942	9	1957	3
1943	0	1958	61
1944	0	1959	3
1945	0	1960	5
1946	21	1961	17
1947	3	1962	2
1948	11	1963	3
1949	14	1964	2
		1965	7

Source: Annual reports of the U. S. Department of Agriculture.

Primary vectors of the four principal encephalitides in Eastern United States are as follows:

Type of Encephalitis	Enzootic Vector	Epidemic Vector
Eastern	Culiseta melanura	Aedes sollicitans Aedes vexans
Western	Culiseta melanura	--
St. Louis	Culex pipiens quinquefasciatus	Culex pipiens quinquefasciatus
California	Aedes spp. (woodland)*	Aedes spp. (woodland)

* Include Aedes atlanticus, Aedes canadensis, and Aedes triseriatus.

Based on present knowledge, the one vector problem that appears to be a significant one in the Basin is mosquito-borne encephalitis — including the Eastern, St. Louis, and California strains.

Eastern encephalitis has caused considerable losses among horses in the Basin. Sooner or later it could cause epidemics among man, as occurred in New Jersey in 1959 (this constituted New Jersey's first confirmed human cases, even though it had killed horses there for at least 50 years.) The Eastern disease occurs principally in areas with vast fresh-water swamps and salt marshes.

St. Louis encephalitis, a human disease, is not known to have occurred in the Basin, but in 1966 a small outbreak of SLE was reported in nearby New Orleans, La. This disease presents a threat to communities in the Basin that allow uncontrolled production of Culex p. quinquefasciatus mosquitoes. Breeding areas for these mosquitoes are frequently associated with improper disposal of sewage, such as overflowing septic tanks.

California encephalitis has only recently been recognized as a public health problem in the country. Newer knowledge indicates that in areas where it has been studied (principally Ohio and Wisconsin) a considerable number of cases occur every year, particularly in children. It is transmitted by woodland mosquitoes, which are abunant in the Pascagoula Basin.

On the basis of current knowledge concerning mosquito-borne encephalitis, the only feasible approach to control of the disease is a program of prevention — mosquito control for the community (or population groups) and protection against mosquito bites for the individual.

Insect Nuisance Problems

Salt-Marsh Mosquitoes

The most formidable biting insects on the Mississippi Gulf Coast are the so-called salt-marsh mosquitoes, particularly Aedes sollicitans. Other salt-marsh or brackish-water species include Aedes taeniorhynchus, Culex salinarius, Anopheles atropos, and Anopheles crucians.

At times A. sollicitans occurs in such overwhelming numbers that outdoor activities during the day or night are practically impossible. The bites of these mosquitoes result in numerous cases of secondary infections in children. Furthermore, scourges of salt-marsh mosquitoes are an impediment to industrial and recreational developments along the coast. Invasions of these mosquitoes are generally an aftermath of unusually high tides and heavy rains that inundate the higher marsh areas that normally are not subjected to daily tides. The last severe invasion of these mosquitoes along the Mississippi Gulf Coast occurred in 1963.

Two factors are particularly significant in considering the potential salt-marsh mosquito problem: viz, the extent of the total breeding areas is tremendous (especially after periods of prolonged droughts) and the flight range of these mosquitoes is exceptionally great. Salt-marsh mosquitoes commonly fly 5 to 10 miles and under certain wind conditions may migrate 20 miles or more.

Other Important Species of Mosquitoes

Major pest species along the Gulf Coast, in addition to salt-marsh mosquitoes, include the floodwater types, *Aedes vexans* and *Psorophora confinnis*; the versatile fresh-water and salt-water breeder, *Culex salinarius*; and the common domestic mosquito, *Culex pipiens quinquefasciatus* (southern house mosquito). The latter species is referred to as a "dirty water" breeder, since it prefers water high in organic pollution.

The relative prevalence of these four species and other types at three communities near the Pascagoula River in Jackson County is shown in tables III-2 through III-4. It should be noted that these tables are based on light trap catches, and *C. p. quinquefasciatus* is only weakly attracted to such traps. Thus, this species is much more abundant than the data would indicate.

During World War II, the U. S. Army made detailed studies of mosquitoes at Camp Shelby, about 10 miles southeast of Hattiesburg, in Forrest County, Mississippi (Michener 1947). The 12 most important man-biting mosquitoes in this area were:

Aedes atlanticus	Culex p. quinquefaciatus
Aedes sticticus	Culex salinarius
Aedes triseriatus	Psorophora confinnis
Aedes vexans	Psorophora ferox
Anopheles punctipennis	Psorophora horrida
Anopheles quadrimaculatus	Psorophora varipes

Table III-2

Mosquitoes collected by a New Jersey light trap at Pascagoula, Jackson County, Mississippi, 1965

Trap Nights	April-May 16	June-July 15	Aug.-Sept. 16	Oct.-Nov. 11	Total 58
Aedes					
atlanticus			26	26	52
sollicitans	19	720	246	5	990
taeniorhynchus	4	127	29		160
vexans	67	50	10	17	144
Anopheles					
atropos	10	9	2		21
crucians	27	97	85	60	269
Culex					
pilosus	1				1
pipiens quinq.*	28	22	23	10	83
restuans				17	17
salinarius	414	307	84	103	908
Culiseta					
inornata				15	15
Psorophora					
ciliata			2	4	6
confinnis	39	796	1745	45	2625
Uranotaenia					
sapphirina		1	25	2	28
	609	2129	2277	309	5319

* quinq. = quinquefasciatus.

Source: Gulf Coast Mosquito Control Commission.

Table III-3

Mosquitoes collected by a New Jersey light trap at Vancleave, Jackson County, Mississippi, 1965

	April-May	June-July*	Aug.-Sept.	Oct.-Nov.	Total	
Trap Nights	14	0	8	8	30	
Aedes						
atlanticus			11		14	25
infirmatus			3			3
mitchellae	1					1
vexans	118		3		18	139
Anopheles						
crucians	42		8		19	69
quad.**			1			1
Culex						
pilosus			3			3
pipiens quinq.***	13		2		20	35
salinarius	97		3		17	117
Culiseta						
inornata					1	1
Mansonia						
perturbans	4					4
Psorophora						
ciliata			1			1
confinnis	3		7		9	19
Uranotaenia						
sapphirina			2			2
Total	278		44		98	420

* Trap was not operated during June, July, and September.
** quad. = quadrimaculatus.
*** quinq. = quinquefasciatus.

Source: Gulf Coast Mosquito Control Commission.

Table III-4

Mosquitoes collected by a New Jersey light trap at Three Rivers, Jackson County, Mississippi, 1965

Trap Nights	April-May 16	June-July 13	Aug.-Sept. 15	Oct.-Nov. 9	Total 53
Aedes					
Atlanticus			8		8
infirmatus		5			5
sollicitans		8	39	12	59
taeniorhynchus			2		2
vexans	15	29	14	22	80
Anopheles					
crucians	4	16	46	31	97
punctipennis	1				1
quad.*		6	1		7
Culex					
pilosus			15		15
pipiens quinq.**	23	9	22	8	62
restuans				9	9
salinarius	15	78	15	3	111
Culiseta					
inornata				26	26
Psorophora					
ciliata		7	7	2	16
confinnis		166	288		455
Uranotaenia					
sapphirina			9	9	18
Total	59	324	466	122	971

* quad. = quadrimaculatus.
** quinq. + quinquefasciatus.

Source: Gulf Coast Mosquito Control Commission.

Deer Flies

Deer flies (Chrysops species) are especially troublesome along the Gulf Coast. Localized deerfly problems occur throughout the Pascagoula Basin. Breeding grounds for deer flies include salt marshes, fresh-water marshes, and the margins of ponds and streams. Frequently, the adult flies do not remain on the marsh, but move to adjacent uplands, especially into wooded areas, where they constitute a real daytime threat.

Biting Gnats (Culicoides species)

The principal problem area for biting gnats or "sand flies" is salt marshes along the Coast. Two of the most abundant of the man-biting species are Culicoides canithorax and Culicoides furens.

Stable Flies

Stable or "dog" flies (Stomoxys calcitrans) are an economic problem that affects the tourist and cattle industries along coastal areas. These flies, for the most part, breed in fermenting tidal deposits of marine grasses. Although marine grasses constitute the principal source, stable flies also breed in hay and litter around dairies and in manure around chicken ranches.

Stable flies are vicious biters and can force thousands of bathers to head for home — especially if a north wind causes the flies to congregate on the beaches. Normally the stable-fly season extends from August through October.

Because of the severity of the problem along the Gulf Coast, the Florida State Board of Health has recently established the West Florida Research Laboratory at Panama City, Fla., to conduct research on the control of stable flies and other biting insects.

STATUS OF VECTOR CONTROL PROGRAMS

Legislative Authority

Under Mississippi legislation passed in 1928, a mosquito control commission may be established in any county of the State by the County Board of Supervisors with approval of the State Health Officer.

The State has specific health regulations pertaining to the impounding of water. Permits are issued for the construction of farm ponds built to comply with State Board of Health regulations.

Vector Control Programs in Inland Areas of the Pascagoula Basin

Most of the mosquito control activities are restricted to adulticidal measures. All of the larger towns, such as Meridian, Laurel, and Hattiesburg, operate thermal-aerosol fog machines; but there is very little larviciding, and virtually no drainage work. Unfortunately, the fogging programs are quite routine and are not based on entomologic inspections.

Vector Control Programs in the Coastal Area of Mississippi

Accomplishments Prior to 1964

During the 1930 s, as a part of emergency relief programs, a major salt-marsh ditching program was implemented in the three coastal counties — Jackson, Harrison, and Hancock. Off-shore islands (Cat and Ship) were also ditched. The extent of the ditching program by the Work Projects Administration (WPA) is shown in table III-5.

Table III-5

WPA ditching for mosquito control along the Mississippi Gulf Coast during the 1930's*

	Open Ditching (Feet)	Paved Ditching (Feet)	Piping & Culverts (Feet)
Biloxi	6,780	1,189	2,245
Gulfport	DNA	900	DNA
Pass Christian	10,925	2,975	58
Bay St. Louis	7,100	20,000	1,000
Miss. City	6,894	1,310	150
Long Beach	DNA	1,998	590

DNA = Data Not Available.
*Source: See White 1940 (Selected References).

This hand-dug ditching activity demonstrated that excellent control of salt-marsh mosquitoes could be achieved but the program failed after a few years because there was little or no maintenance of the ditches.

Following World War II, the principal mosquito control activity along the Coast was fogging operations by the various municipalities.

Serious invasions of salt-marsh mosquitoes occurred along the Mississippi Gulf Coast during June and July 1963. The problem was so severe at the site of the National Aeronautics and Space Administration (NASA) Mississippi Test Facility in Hancock County, that large-scale aerial spraying was employed. During the period July 17-26, two airplanes from the U. S. Air Force, Special Spray Flight, Langley, Virginia, applied malathion at the rate of 0.2 lb. per acre to the infested area. The cost of this one treatment was $30,000. This operation provided the first real evidence that mosquitoes in the region could be controlled effectively.

By August 1, 1963, the three coastal counties in Mississippi had indicated by vote of their boards of supervisors their interest and determination to join cooperatively with NASA officials in an area-wide mosquito control program. Subsequently, each board of supervisors appointed mosquito control commissioners in each of the three counties. An organizational meeting of newly appointed mosquito control commissioners from these three counties was held on October 10, 1963 (Fehn and Beadle 1963).

As a result of this renewed interest in mosquito control, the first organized mosquito control programs in Mississippi were established in 1964. These two programs were the Gulf Coast Mosquito Control Commission and the Insect and Pest Control Unit of General Electric-Mississippi Test Support Department.

The Gulf Coast Mosquito Control Commission

The first Mosquito Control District in Mississippi was officially begun on January 1, 1964. The Gulf Coast Mosquito Control Commission is made up of the joint Mosquito Control Commissions of Harrison, Jackson, and Hancock Counties. This district covers the entire Mississippi Gulf Coast and includes the major cities of Gulfport, Biloxi, and Pascagoula. Approximately 1,700 square miles and a population of approximately 200,000 are included in this district. Because of a provision in the State law restricting the amount of tax that could be levied for mosquito control purposes, the district was established with an inadequate budget of $101,000. Efforts were successful in obtaining two amendments to the State mosquito control law in the 1964 session of the State legislature; this made it possible to obtain increased financial support. For fiscal year 1967, funds of $219,000 have been provided. Additional work is being carried out in Hancock County on a subcontract ($30,000 support) with General Electric Company and NASA at the Mississippi Test Facility. At present the number of full-time and part-time employees if 16 and 40, respectively.

The Commission recognizes the necessity of having a balanced control program, i.e., the proper balance between ditching and other means of "permanently" eliminating mosquito breeding and the "temporary" control afforded by chemicals. It also recognizes the value of entomological inspections in making the control efforts more efficient.

Because of the restricted budget, virtually all mosquito suppressive measures during the first 3 years have involved the use of chemicals. Emphasis has been given to chemical treatment of breeding areas and fogging as a supplemental measure to kill mosquitoes that escape and fly into heavily populated areas.

Principal activities of the Gulf Coast Mosquito Control Commission are summarized in the following paragraphs.

Permanent Control

Ditching. — Recently NASA obtained a military surplus dragline, which has been supplied to the Gulf Coast Mosquito Control Commission for mosquito control ditching in Hancock County. It has been equipped with a new 5/8-cubic yard bucket. In May 1967, the dragline started to excavate large drainage ditches in a salt marsh (Point Clear Island), a few miles southwest of Bay Saint Louis, Mississippi. This represents the first permanent mosquito control on the Mississippi Gulf Coast since the 1930's.

Temporary Control

Airplane larviciding. — The Commission owns one agriculture-type airplane (Snow-2C), equipped with a large hopper, for application of paris green pellets to the larger salt-marsh mosquito-producing areas. The rate of application for the 5% paris green pellets is from 20 to 30 pounds per acre. The Commission has budgeted about 90,000 pounds of pellets for 1967.

Ground-machine and hand larviciding. — Seven Jeep and truck-mounted Bean power sprayers are available for application of petroleum oils to local or domestic mosquito-producing sources. Each of the units is equipped with knapsack sprayers and dusters for hand application of oil and paris green pellets, respectively.

Airplane adulticiding. — The single-engine airplane can also be used to apply chemical sprays (malathion or naled) in rural areas or isolated areas for the control of adult mosquitoes.

Ground adulticiding. — The Commission uses six truck-mounted Tifa fogging units, each with 280-gallon insecticide tanks, in the three-county area for control of adult mosquitoes. The fogging insecticide is either malathion or naled (Dibrom).

Thermal fogging is also used to alleviate the *Culicoides* biting problem.

To control stable flies, naled at the rate of 3.4 ounces of technical material per gallon of oil (twice the dosage recommended for mosquitoes) is applied by the thermal-aerosol units.

Survey and Evaluation Program

Much emphasis is placed on a good inspection program because it increases greatly the efficiency of control operations.

The Commission attempts to locate all potential sources of mosquitoes within 5 to 10 miles of heavily populated areas along the coastal strip, and within 2 miles of population centers in the northern part of the three-county area.

A helicopter (Hughes 300), on yearly contract, is used for rapid, efficient inspection coverage of large salt-marsh and fresh-water mosquito producing sources, especially on coastal islands. The determination of exact locations of mosquito breeding areas by helicopter enables the airplane to apply the chemical pellets in the right areas. The current budget provides for 400 hours of actual flight time by the helicopter at $60.00 per hour (= $24,000).

To evaluate the mosquito problem, the Commission operates 28 New Jersey light traps 3 nights per week; and 1-minute daytime landing rate counts are made at about 100 stations 3 times per week.

Another valuable type of surveillance is maintenance of rain-gauge records. About 75 operators read these guages daily, and the information is called in immediately if the reading is 0.5" or more. These data on excessive rains are utilized by crews who go promptly to the affected areas for inspection of potential mosquito breeding areas.

In summary, the inspection-chemical treatment cycles, as outlined above, are repeated throughout the year. Mosquito suppression by chemical means has reduced vector populations considerably; but for the long-range program, emphasis needs to be given to water management techniques.

The Insect and Pest Control Unit of the General Electric-Mississippi Test Support Department, Bay St. Louis, Miss.

The mosquito control program at the National Aeronautics and Space Administration's (NASA) Mississippi Test Facility (MTF) is unique among organized mosquito control programs in this area for two reasons: First, the area has no permanent residents, only transient employees of NASA and its contractors (work force of 5,000). Secondly, the program is under the supervision of a non-governmental agency, the General Electric Company, which is NASA's support contractor at MTF (Harden, 1965).

The Mississippi Test Facility consists of two areas, the Fee Area and the Buffer Zone.

The U. S. Government-owned Fee Area consists of 13,500 acres of pine forest and hardwood swamps in Hancock County, Miss. The Buffer

Zone, under easement to the U. S. Government and uninhabited, surrounds the Test Site and includes 128,500 acres of Hancock and Pearl River Counties, Miss., and St. Tammany Parish, La. The northern and south-central parts of the Buffer Zone are a flat, poorly drained pine forest. Southeast of and bordering the Fee Area is a 20-square-mile pine and hardwood swamp referred to as "Devil's Swamp." The Pearl River Swamp is the western boundary of the Fee Area. Beginning at the northwest corner of the Buffer Zone, it is 5 miles wide. Twenty miles south, where it joins the Gulf of Mexico, it is 20 miles wide. North of U. S. Highway 90, it is primarily a very dense hardwood swamp, criss-crossed by the three branches of the Pearl River and by numerous small bayous and streams. Just north of the highway, the tree swamp begins a transition into a grassy salt marsh (Harden, 1965).

Within 20 miles of the Fee area there are 50,000 acres of this type of salt marsh.

The organized insect and pest control program began on March 25, 1964, when a consultant entomologist was employed. At present the number of full-time and part-time employees is 9 and 2, respectively. The current annual budget is $130,000 (including $30,000 subcontract with the Gulf Coast Mosquito Control Commission for control work in Hancock County).

The Unit controls several types of pests in addition to mosquitoes, such as rodents, termites, roaches, house flies, stable flies, deer flies, and fire ants.

A summary of the mosquito control activities of the Insect and Pest Control Unit is as follows:

Source Elimination

Ditching. – As mentioned previously, a dragline started operations in a salt marsh near Bay Saint Louis, Miss., in May 1967.

Control of flowing wells. – Free-flowing wells are very common in the southwestern part of Hancock County (Newcome, 1967). The mosquito control program at the Mississippi Test Facility has led to the shutting in of all flowing wells in the Fee Area and of many in the Buffer Zone. An act of the Mississippi Legislature (First Extraordinary Session 1965) empowers the Hancock County Board of Supervisors to cap, fill, or take other necessary action to stop the flow of water from abandoned wells in the Buffer Zone in Hancock County.

Chemical Control

Airplane larviciding. – Under a subcontract arrangement the Gulf Coast Mosquito Control Commission has been provided with 60,000 pounds of 5% paris green pellets for aerial application in the large marshes south of the Mississippi Test Facility.

Ground-machine and hand larviciding. — Temporary rain pools are treated with #2 fuel oil or with paris green pellets (hand broadcast).

Airplane adulticiding. — There has been no aerial treatment since the special spray flight in July 1963.

Ground adulticiding. — Much emphasis is given to night fogging and daytime misting for the control of adult mosquitoes in the Fee Area. For fogging alone, from 30,000 to 45,000 gallons of insecticide are used during a normal mosquito year; this figure would be increased to 75,000 gallons for a plague year such as 1963. For calendar year 1967, it is proposed to use naled (Dibrom 14) applied as a fog (1.75 oz. technical material to 1 gal. #2 fuel oil) by three truck-mounted Leco 120 machines, each with 280-gallon insecticide tanks, to over 12,000 acres.

Owing to the dangers of using a hydrocarbon-base insecticide thermal fog near Liquid Oxygen fuels in the Test Complex, the Unit plans to change in the Test Area only, to a non-thermal fog using a Dynafog 4000 machine.

For the misting programs, two truck-mounted mist blowers will apply emulsion sprays using malathion (0.48 lb./gal.) or 5% DDT. It is proposed to treat biweekly during the breeding season a total of 1,200 acres of roadside areas, lawns, etc. The residual treatment to dense undergrowth around buildings is highly effective in controlling mosquitoes.

Naturalistic Control

Fish stocking. — As an experiment, quite a few larva-eating fish have been released throughout the summer and fall in the Fee Area. This experimental work on biological control involves two types of fish — Gambusia and Heterandria.

Survey and Evaluation Program

The Unit recognizes that one of the most important aspects of mosquito control depends upon entomological inspection. Information gathered is obtained by such means as 1-minute landing rate counts (120 stations), New Jersey light traps (15), 1 truck trap, rain gauges (50), identification of species collected, and the location and mapping of mosquito breeding areas by species.

For adequate inspection of salt marshes in the Buffer Zone and farther south, the subcontract with the Gulf Coast Mosquito Control Commission includes $7,200 for helicopter time.

The basic strategy of the Unit is to treat only when needed. Control operations are geared to inspection and are not routine.

Encephalitis Surveillance Program

This program, which was initiated in 1964, involves the collection of live mosquitoes by special light traps (six CDC minature battery-operated) for virus tests. The specimens are tested by the Arbovirus Unit of the National Communicable Disease Center, USPHS, Atlanta, Ga. This study has demonstrated that the California encephalitis virus is present in the area. It has been isolated from three pools of the woodland mosquito, *Aedes atlanticus*.

EXISTING VECTOR CONTROL NEEDS

Needs for the Entire Pascagoula Basin

Survey of Flowing Wells

A study should be made to determine if wasteful flows from artesian wells in the Pascagoula Basin are important sources of mosquitoes. If so, there would be need for regulations to require the control of wasteful flow from such wells. This type of legislation already exists in Hancock County, Miss.

Sanitation Surveys

Sanitation surveys should be conducted in all towns of the Basin. The Mississippi State Board of Health has demonstrated that the sanitation survey is one of the most successful approaches to vector control. It not only points out conditions conducive to breeding and harborage of vectors, but it lays the necessary groundwork for a correctional program.

One example of the findings of a sanitation survey may be cited. A recent survey of old Gulfport, Miss., revealed that 723 premises had overflowing septic tanks (a condition conducive to the breeding of encephalitis mosquitoes). The obvious solution to the problem is clear — the need for expansion of the present sewerage system of old Gulfport.

Surveillance on Encephalitis Viruses

The mosquito-borne disease that poses the greatest threat to health in the Pascagoula Basin is viral encephalitis. Health agencies should maintain adequate surveillance activities for arboviruses in the area.

Needs for the Gulf Coast Area of the Basin

Adequate Funding

One of the greatest needs of the Gulf Coast Mosquito Control Commission is adequate funding so that emphasis can be given to water management techniques, such as ditching, rather than to chemical control. For long-range planning concerning land and water uses, emphasis should be given to procedures that result in an environment by the year 2000 that would require only a minimum of repetitive pesticide application. With adequate funding, it would be possible to purchase at least one dragline for mosquito control work in Jackson County, Miss.

Research

Some of the major research and demonstration project needs for the coastal area include permanent control techniques that would control mosquitoes in salt marshes and at the same time be of benefit to other interests, such as wildlife conservation.

Two promising methods are the use of improved water management ditches, and the use of impoundments in the higher marsh areas. Both of these water-management methods have proved effective in Florida and in other States along the Atlantic Coast, but studies on the effectiveness of these methods in the coastal areas of Mississippi have not been conducted.

Experience in some areas indicates that ditches with a minimum width of 6 to 12 feet and a depth of 1 to 2 feet below mean low water are needed to obtain adequate drainage in marshes where the tidal fluctuation is slight and where the hydraulic "pull" consequently is low.

The impoundment method consists of the construction of dikes together with permanent flooding of the marsh. This method is effective in controlling salt-marsh mosquitoes, since the breeding of these pests is restricted to areas that are intermittently dry and flooded.

Domestic Mosquito Problems

Up to the present, the principal attack has been against the agressive salt-marsh mosquitoes. In the past, not too much concern has been given to *Culex pipiens quinquefasciatus* in Mississippi from the standpoint of public health importance. This species is not an agressive biter, and frequently populations will build up without too many complaints from the public. However, in view of the recent outbreak of St. Louis encephalitis in New Orleans, La., *Culex p. quinquefasciatus* must be considered as a potential threat to public health in the State. Uncontrolled production of this species along the highly populated Gulf Coast should not be permitted.

Needs for the Inland Area of the Pascagoula Basin

Since vector control programs of the various municipalities are not under trained entomologists, one of the principal needs is the establishment of an educational program for local health personnel, who could give guidance to the programs. The health personnel would be trained in mosquito identification, ecology, and control techniques.

At present, the principal activity of the typical municipal vector control program is fogging. With the improved type of program, there would be more emphasis to mosquito larviciding and source elimination. Each city in the Basin should have from one to several year-round mosquito control workers who would inspect for larvae during the mosquito season, operate adulticiding machines occasionally when large mosquito infestations occur, and do maintenance and minor ditch construction during the winter months.

A PROPOSED PLAN TO HELP MEET BASIN NEEDS

Fundamental Principles

It is important that the following basic requirements for mosquito control in the development of the Pascagoula Basin be clearly set forth:

1. The agencies and groups concerned with water and associated land resources should be continuously aware of (a) the importance of mosquito and other vector problems associated with the development projects, and (b) the necessity for coordinating and integrating vector prevention and control with the primary functions during the planning, construction, and operational phases.

2. The sponsoring and/or operating agency, group, or individual should accept full responsibility for the prevention and control of mosquito problems created by their projects or developments. Such responsibility is associated with land ownership or operating rights.

3. The determination of minimum basic health requirements and the effectiveness of prevention and control measures is a responsibility of the public health agencies. This means that the health agencies must review project plans, provide specifications for mosquito prevention and control for individual projects, and engage in the necessary followup studies.

4. There should be continuous and close liaison and cooperation between the public health agencies and those concerned with the development and utilization of water resources.

The proposed plan for mosquito control, which is summarized in the following paragraphs, will continue, essentially, along the above lines. The plan provides four basic types of activity as shown in table 6.

Mosquito Control Operations

For all Federal projects, legislation authorizing or providing appropriations for project planning, construction, and/or operation should provide adequate funds for mosquito prevention and control measures. Mosquito control should be coordinated with other interested agencies. Administration of these funds for the specified purpose should be a designated responsibility of the project sponsor and/or operating agency.

In developing the control programs, the cardinal principle should be: Incorporate mosquito prevention into the design or planning stage of the project. The following are examples of basic environmental planning measures:

Large reservoirs: Provision for preimpoundment clearing, particularly in the normal summer fluctuation zone. Provision for a slight drawdown of water levels during the summer months.

Farm ponds: Provision for steep side slopes to discourage growth of aquatic weeds. Provision for a water level control structure.

Waterfowl refuges: Location of such developments in remote places. Avoidance of flooding of food plants until late in the season.

Recreational developments: Location of sites in sections where the mosquito potentials are low.

For the control of existing mosquito control problems, the present system of organized mosquito control programs in the Gulf Coast area should be adequately supported. The establishment of organized mosquito control in the three-county coastal area has been of great benefit to the entire State.

Investigations should be made of possible ways and means whereby the State of Mississippi could provide financial assistance to local mosquito control programs.

Surveillance

Continuing analysis of mosquito-borne disease occurrence and vector problems to guide the efforts of other activities is a specific concern of health agencies. In view of the virtual eradication of malaria from this country and the consequent curtailment of malaria control measures, there should be adequate surveillance to halt any malaria threat in the future. Likewise, surveillance activities should be stepped up to define better the public health importance of encephalitis.

Research

The following research-demonstration activity should be initiated as soon as possible: Development of permanent measures for controlling the salt-marsh mosquito problem along the Gulf Coast. For this type of problem, it is recognized that the ultimate control would be proper water management.

Because of the magnitude and complexity of this type of problem, State and local groups might seek Federal assistance. These problems could best be solved through joint investigations by the agencies representing the various basic interests, such as wildlife conservation, health, and agriculture. Through such cooperative research, it would be possible to develop mosquito control measures that are most compatible with all interests.

Technical Assistance

The water development agencies require continued technical assistance and guidance from health agencies in planning and executing mosquito control operations. Careful surveys should be made of individual projects to determine what measures for mosquito control will best fit local and project conditions and basic project functions. The recommendations must be practical and economically sound. Other types of technical assistance should include development of procedures for routine appraisal of control operations, provision of assistance in training personnel, and conduct of investigations on special problems which may arise.

The health agencies should prepare appropriate educational materials on mosquito control for distribution to the agencies responsible for the construction and operation of water utilization projects.

Ample funds should be made available to the Mississippi State Board of Health for expanding the technical services.

In summarization, the project owner or operator should provide the necessary onsite mosquito control measures together with routine appraisal of control operations, and the health agencies should maintain a high level of surveillance, research, and technical assistance.

Appropriate preventive and control measures need to be planned and built into each project from its very inception, and continued as a part of the regular operations program. Mosquito control should be coordinated with other basic interests such as soil and water conservation, flood control, navigation, hydroelectric power, fish and wildlife management, and recreation. When this is done, it will help to achieve the maximum benefits from the development of the Basin with minimum deleterious effects upon the health and general welfare of the resident and tourist populations.

Table III-6

Delegation of Responsibility for Mosquito Control on Water Resource Development Projects

Activity	Project Sponsor: Federal	Project Sponsor: State	Project Sponsor: Private
Mosquito Control Operations and Appraisal	COA	COA	Owner
Surveillance	PHS*	SHD**	SHD**
Cooperative Research	PHS*	SHD**	SHD**
Technical Assistance	PHS*	SHD**	SHD**

COA - Construction and/or Operating Agency
PHS - U. S. Public Health Service
SHD - State Health Department
* - In close cooperation with State agencies (also other Federal agencies for special research).
** - With the assistance of the Public Health Service as requested.

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SECTION IV

DRINKING WATER SUPPLY

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Introduction

Health aspects of this most important use of the water resources relate to biological, chemical, and radiochemical characteristics which can adversely or beneficially affect the users. Guidelines used to evaluate water supplies – by health agencies at all levels of government and the water works industry in general – are the Public Health Service 1962 Drinking Water Standards (STANDARDS).[1] The STANDARDS are periodically revised to reflect man's changing environment, knowledge obtained regarding identification of new contaminants in drinking water brought about by these changes, and significance of these characteristics to human health. For purposes of this report, other characteristics not mentioned in the current STANDARDS will be considered in light of new knowledge. Although the STANDARDS apply to finished drinking water, raw water sources at surface water intakes or well points must also be considered, since conventional water treatment plants remove only certain contaminants. Trace elements such as lead, cadmium, etc., can pass through our conventional treatment plant barriers; and, if in high enough concentrations, may be harmful to health.

DHEW has adopted the STANDARDS as regulations[2] for all supplies which serve interstate or foreign carriers. The American Water Works Association, national group representing the industry, considers them minimum for all public water supplies. State health agencies in Alabama and Mississippi, although not adopting them by law or regulation utilize the STANDARDS in evaluating public water supplies.

This section of Appendix M will be an evaluation of water supplies and/or water supply sources in the Pascagoula River Basin from a health standpoint. It is based upon existing information obtained by the USGS, FWPCA, and Mississippi State Board of Health. Data provided and assistance rendered by these other agencies are very much appreciated. Also, data obtained by the Public Health Service is included in the evaluation.

Special acknowledgment for professional opinions is due:

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Dr. Melvin W. Carter, Officer in Charge, Southeastern Radiological Health Laboratory, Montgomery, Alabama

Dr. Gene P. Lewis, Assistant Program Director, Division of Dental Health, PHS, Atlanta, Georgia

Mr. Roy Newcome, Hydrologist, USGS, Jackson, Mississippi

Mr. Joe Brown, Engineer, Mississippi State Board of Health, Jackson, Mississippi.

Background

Most existing drinking water systems in the Pascagoula River Basin are served by groundwater sources. Meridian, Mississippi, is the only basin community which uses surface water; and Mobile, Alabama, though located outside of the basin, uses a tributary of the Pascagoula River for its source of supply.

Projected basin drinking water supply needs indicate that quantity requirements to 2015 can be achieved by a combination of surface and groundwater developments.

Four Corps of Engineers early action multipurpose reservoir projects provide for water supply. The Okatibbee Creek project (presently under construction) includes provisions to meet future water supply needs in the Meridian, Mississippi area.

The proposed Tallahala Creek project includes provisions for both municipal and industrial water supply requirements for the Laurel, Mississippi area. Also proposed are Corps of Engineers projects on Bowie Creek to meet industrial (and perhaps municipal) water supply needs in the Hattiesburg area, and on the Escatawpa River (Harleston project) to meet both municipal and industrial needs in the Pascagoula area. Other developments on the lower Pascagoula and tributaries, not now proposed, may be necessary several decades hence to meet fresh-water requirements in the Pascagoula area by 2015.

The Pat Harrison Waterway District has included water supply in three of eight proposed multipurpose reservoir projects (Flint Creek, Big Creek, and Thompson Creek). Of these three, only for Thompson Creek is FWPCA water quality data available. No water supply considerations are included in the twenty proposed USDA multipurpose reservoirs.

Except for the population areas mentioned above, it is anticipated that groundwater sources can accommodate drinking water supply requirements — from a quantity standpoint — in all other areas of the basin through 2015.[3]

Surface water quality of basin streams in the immediate vicinity of proposed Corps of Engineers reservoir projects (which would include the water supply use) has been partially determined by FWPCA. Water quality data of health significance is included in Table IV - 1 for the proposed Corps' projects of Bowie Creek, Harleston, and Tallahala, and for the Pat Harrison Waterway District Thompson Creek project.

Groundwater quality information available for evaluation is included in Tables IV - 2, 3, and 4. Table IV - 2 represents an excellent summation by the U. S. Geological Survey of water quality characteristics for which they monitor. Table IV - 3 represents groundwater quality data acquired by the Public Health Service in the spring of 1967. Such information was needed to reflect constituents not reported by USGS, but which are included in the STANDARDS, or which recently have become significant from a health standpoint. The Jackson, Mississippi office of USGS assisted in selecting representative wells — from both aquifer and geographic standpoints.

Water supplies which serve interstate carriers in the Pascagoula area were also monitored in 1967. Table IV - 4 lists finished water quality characteristics for eleven wells serving seven different water systems. Collection and analyses were accomplished by the Mississippi State Board of Health and Public Health Service.

The last table (Table IV - 5) gives results of the Public Health Service National Sodium in Drinking Water Survey for supplies monitored in the Pascagoula River Basin. Quarterly samples were analyzed from nine municipal water systems in the basin over a two-year period from 1963-1965. The Heart Disease Control Program of the Public Health Service sponsored this survey in order to evaluate the occurrence of the sodium ion in drinking waters nationally, and seek ways to better protect the health of cardiovascular patients needing a low sodium diet.

Health and Drinking Water Quality — Surface Waters

Some water quality characteristics included in the STANDARDS or of special significance have been obtained at stream locations proximate to proposed reservoir sites where water supply will be a benefit (See Table IV - 1). Information on color, chlorides, manganese, nitrates, total residue, total filtered residue, total coliform, and fecal coliform have been determined at one or all of the four reservoir sites:

Thompson Creek Project (Pat Harrison Waterway District);

Bowie Creek Project (Corps of Engineers);

Harleston Project (Corps of Engineers); and

Tallahala Creek Project (Corps of Engineers).

TABLE IV - 1

	Corps of Engineers Bowie Creek Proj. Bowie Creek Station 275350 May-August, 1965	Corps of Engineers Harleston Project Escatawpa River Station 273670 March-June, 1965	Corps of Engineers Tallahala Creek Proj. Tallahala Creek Station 274890 Feb.-August, 1965	Pat Harrison W. D. Thompson Cr. Proj. Thompson Creek Station 274590 May-August, 1965
Color (S.U.)	NA	NA	95 60 125	NA
Chloride (MG/L)	7 1 26	165 4 1660	27 2 100	10 5 16
Manganese (MG/L)	NA	0.0 0.0 0.0	NA	NA
Nitrate (MG/L)	1.05 0.10 2.00	NA	1.85 0.10 5.00	1 0 1.6
Total Residue (MG/L)	305 210 400	NA	429 148 1100	229 58 400
T. Filtered Res. (MG/L)	42 10 75	NA	49 6 135	145 40 250
Total Coliform MPN/100ml	6030 700 92000	966 130 24000	5512 940 54000	6885 1410 54200
Fecal Coliform MPN/100ml	340 20 7900	150 20 24000	526 50 7000	224 20 3300

1. Three figures for each characteristic are average, minimum, and maximum.
2. Averages are arithmetic for all characteristics except total and fecal coliform.
3. Averages shown for bacteriological parameters are geometrical means and not arithmetic averages.
4. NA means data not available.

HEALTH SIGNIFICANT CHARACTERISTICS OF SURFACE WATERS AT PROPOSED RESERVOIR PROJECTS INCLUDING WATER SUPPLY USE
PASCAGOULA RIVER BASIN
(Data by FWPCA, U. S. Department of the Interior)

TABLE IV-2

CHEMICAL ANALYSES OF WATER FROM WELLS IN THE PASCAGOULA RIVER BASIN (MG/L)

Well No. on map	Depth (ft)	Date of analysis	Dissolved solids	pH	Silica (SiO_2)	Total iron (Fe)	Hardness as $CaCO_3$	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Analyst[a]
[b]Recommended limit (USPHS, 1962)			500			0.3				250	250	1.0	45	
						CLARKE COUNTY								
G1	411	May 1955	232	8.9	4.4	0.16	2	88	187	12	3.0	0.3	0.1	USGS
M102	209	do	224	7.5	23	.18	75	43	185	10	3.0	.2	.8	Do
R1	550	do	738	8.6	--	.28	10	294	713	3.6	7.2	--	2.2	Do
R2	200	do	451	8.2	3.6	.24	17	182	436	33	22	1.0	1.5	Do
						COVINGTON COUNTY								
B1	210	Jan. 1959	98	7.4	7.3	4.9	59	6.3	76	7.2	3.0	0.2	0.2	USGS
F2	217	Sept. 1959	40	6.8	5.5	.23	8	2.1	12	1.0	2.2	.1	.4	Do
						FORREST COUNTY								
D4	485	Feb. 1964	80	6.2	26	0.91	24	9.2	43	8.8	2.5	0.4	0.1	USGS
D5	678	do	121	7.1	12	.42	32	30	108	8.8	1.6	.2	.0	Do
D29	134	May 1964	19	5.3	20	.07	6	2.1	10	.2	2.3	.0	.1	Do
L5	525	Sept. 1964	162	7.4	30	.20	1	54	130	9.4	3.4	.4	.0	Do
M2	700-900	do	127	6.9	38	1.5	12	33	95	.6	3.4	.2	.1	Do
						GEORGE COUNTY								
B1	525	Apr. 1959	281	8.7	5.1	0.08	4	105	226	6.4	7.0	0.3	1.0	USGS
B3	185	do	221	7.4	7.7	.33	6	66	144	2.2	21	.4	.6	Do
C15	1,020	Dec. 1958	186	6.9	8.9	.10	2	56	114	8.4	18	.1	.2	Do
F14	63	Apr. 1959	26	5.4	2.3	.46	4	2.2	5	.8	3.5	.0	.6	Do
K2	93	do	112	7.6	18	.45	24	16	64	6.2	3.2	.0	.3	Do
						GREENE COUNTY								
D1	205	May 1964	41	5.8	52	11	20	2.5	25	3.2	2.7	0.0	0.1	USGS
N4	164	do	91	8.4	25	1.3	2	38	76	6.4	4.5	.4	.1	Do
P3	125±	do	111	8.1	26	.02	3	41	97	5.4	3.2	.1	.0	Do
R1	58	do	20	5.3	11	3.7	6	1.1	4	.0	3.7	.0	.6	Do
						JACKSON COUNTY								
B3	1,128	June 1959	297	8.8	3.8	0.04	6	106	236	6.6	6.2	0.5	2.1	USGS
E1	230	Dec. 1959	158	7.4	17	.18	6	44	118	6.4	2.5	.2	.6	Do
G1	416	Dec. 1958	442	8.3	4.1	.07	2	169	410	2.6	20	.7	.1	Do
G11	258	Aug. 1960	380	8.2	6.4	--	10	132	346	1.4	13	.3	.5	Do
G12	810	Sept. 1960	400	7.9	2.5	--	7	146	382	1.6	12	.8	.3	Do
K23	326	Dec. 1958	347	8.2	4.6	.26	4	131	320	3.6	18	.6	.4	Do
K41	800	do	500	8.2	6.1	.07	6	180	280	2.6	123	.4	.1	Do
K43	1,333	Oct. 1961	559	7.7	12	--	10	212	408	1.4	93	.8	.1	Do
L28	660	Nov. 1959	684	8.6	7.7	.15	6	259	576	.0	48	1.4	.8	Do
O8	217	Dec. 1958	226	7.0	19	.20	19	55	144	3.4	16	.2	.2	Do
O13	964	May 1959	772	8.7	6.9	.26	6	287	462	2.2	150	1.3	.9	Do
P14	328	Dec. 1958	405	8.2	4.0	.18	4	148	300	2.0	57	.6	.4	Do
P21	1,220	May 1959	1,120	8.5	5.5	.30	8	421	536	.2	312	1.9	1.2	Do
P41	207	May 1960	637	7.3	13	.35	42	189	244	.0	190	.6	2.2	Do
P54	829	Nov. 1958	686	8.2	6.0	.15	8	257	346	.8	200	.7	.2	Do
P62	326	May 1959	516	8.0	11	.18	10	178	324	1.0	95	1.2	1.5	Do
P84	600	June 1959	589	8.7	3.1	.00	2	221	344	.4	122	.9	.5	Do
P94	758	Apr. 1960	588	8.6	22	.07	8	192	296	.0	120	1.1	1.1	Do
P123	340	May 1959	602	7.9	13	.12	10	211	308	.6	155	.8	1.6	Do
P124	801	do	867	8.1	9.0	.16	8	306	352	1.4	275	1.1	.4	Do
P125	179	Apr. 1960	341	7.8	9.5	1.6	83	90	188	.0	91	.2	1.2	Do
Q30	255	May 1960	614	8.2	8.4	.11	14	213	412	.0	105	1.1	2.8	Do
Q32	241	Dec. 1958	657	8.2	4.7	.18	9	248	448	1.0	126	1.1	.2	Do
Q34	1,253	May 1959	1,050	8.4	5.6	.40	7	401	744	1.4	175	2.7	1.5	Do
Q42	415	do	825	8.6	5.1	.55	6	300	434	1.6	192	1.3	.7	Do
Q68	654	Dec. 1958	863	8.0	6.8	.15	8	324	360	4.6	285	.9	.4	Do
Q92	308	May 1959	532	8.0	6.0	.27	29	185	318	1.6	118	1.1	2.5	Do
Q95	156	Apr. 1960	546	7.3	8.4	1.3	66	173	232	2.6	195	.7	2.8	Do
Q101	374	Sept. 1958	605	8.1	5.3	.24	10	228	348	.8	155	1.4	.6	Do
Q104	151	Nov. 1959	524	7.9	8.2	3.6	104	138	200	1.4	185	.1	3.1	Do
Q105	840	Aug. 1959	834	7.8	7.7	—	8	305	364	.2	260	1.0	1.6	Do
Q111	357	Nov. 1958	582	8.1	7.8	.26	16	207	352	.4	128	1.2	.5	Do
						JASPER COUNTY								
D1	265	Dec. 1962	187	7.0	4.0	1.0	147	[c] 15	184	17	6	0.1	--	MBH
E1	404	Aug. 1961	528	8.0	14	.1	168	[c]128	286	102	73	.1	--	Do
J101	652	May 1955	420	7.4	12	.26	14	142	230	73	40	.7	0.3	USGS
K1	341	Dec. 1962	366	7.1	4.4	.1	177	[c] 70	238	71	41	.1	--	MBH
Q1	864	Apr. 1952	355	8.7	—	0	0	[c]154	348	8.2	5	.1	--	Do
Q2	360	Apr. 1955	418	8.5	11	.08	9	152	287	56	30	.1	1.1	USGS
						JONES COUNTY								
A1	46	May 1955	50	6.8	--	1.2	19	2.1	22	0.6	4.0	--	2.0	USGS
B11	120	July 1955	35	5.9	--	2.1	12	2.8	12	3.0	2.5	--	.0	Do
C2	235	May 1955	112	6.9	17	.67	37	12	62	11	3.2	--	.4	Do
C27	78	July 1955	47	6.0	--	12	18	4.3	17	8.0	3.5	--	.1	Do
C7	158	May 1955	46	6.4	--	2.4	28	2.0	34	1.0	3.0	--	.3	Do
D3	640	Apr. 1955	556	8.6	--	.32	1	218	429	49	28	2.0	2.6	Do
D4	70	May 1955	134	7.0	27	4.0	15	21	65	10	2.8	--	1.8	Do
D5	126	do	236	8.4	--	.32	43	64	194	12	4.2	--	.5	Do
D6	76	Mar. 1955	86	7.9	--	.41	46	6.2	64	6.2	4.0	--	.0	Do
D7	210	do	296	8.5	--	.17	14	110	250	19	4.2	--	1.2	Do
D28	226	do	141	7.0	35	.25	34	18	78	8.2	4.0	--	.6	Do
G1	326	Feb. 1964	183	7.7	39	.04	2	59	140	9.6	2.7	.3	.0	Do
K2	549	do	174	7.6	59	.07	9	46	112	12	2.3	.1	.0	Do
Q1	190	July 1943	120	7.3	17	.65	57	20	103	9.1	4.4	.0	.0	Do
						LAMAR COUNTY								
A8	396	Jan. 1962	62	6.2	15	6.0	22	5.5	41	0.8	1.2	0.1	0.0	USGS
A33	255	do	120	6.2	52	5.6	22	8.5	49	.6	1.3	.2	.0	Do
B37	382	Mar. 1964	47	6.7	27	.05	10	3.0	17	.0	3.2	.1	.1	Do
D20	400	Jan. 1962	126	6.8	43	8.9	33	9.4	63	.0	3.0	.1	.0	Do
D31	724	do	98	6.4	28	10	18	14	54	.6	4.1	.2	.0	Do
E13	500	do	97	6.2	42	4.9	16	8.3	30	6.0	3.9	.3	.0	Do
E26	420	Dec. 1961	27	6.1	2.0	1.2	5	6.7	12	5.6	2.9	.4	.0	Do
G14	137	Jan. 1962	47	6.4	20	8.5	5	4.1	12	.0	4.0	.0	.0	Do
H23	455	do	91	6.9	32	2.8	22	14	64	.0	3.0	.1	.0	Do

TABLE IV-2

CHEMICAL ANALYSES OF WATER FROM WELLS IN THE PASCAGOULA RIVER BASIN (MG/L) (Cont'd)

Well No. on map	Depth (ft)	Date of analysis	Dissolved solids	pH	Silica (SiO_2)	Total iron (Fe)	Hardness as $CaCO_3$	Sodium (Na)	Bicar-bonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Analyst[a]
						LAMAR COUNTY-Continued								
K26	90	Sept. 1961	46	3.3	4.2	1.6	18	2.3	0.00	0.2	1.0	0.4	1.0	USGS
K32	85	May 1961	14	5.5	4.6	.98	4	1.8	6	.0	2.2	.0	.6	Do
L8	35	Sept. 1961	48	5.7	5.7	.06	13	6.8	5	.6	14	.0	7.1	Do
L16	978	Feb. 1962	109	6.5	43	--	5	19	46	4.6	4.1	.2	.0	Do
L35	250	Jan. 1962	64	6.7	32	.05	6	5.5	20	.8	2.0	.2	.0	Do
N22	132	Jan. 1962	27	6.2	8.7	.21	7	3.9	14	.4	2.9	.1	.4	Do
N36	1,005	Sept. 1961	141	7.6	27	.00	0	47	122	1.4	3.0	.2	.6	Do
O17	640	Jan. 1962	185	7.7	27	1.0	10	63	169	3.8	3.0	.4	.0	Do
						LAUDERDALE COUNTY								
A1	492	Sept. 1961	149	8.3	3.6	0.1	64	[c] 36	154	3.6	4	0.2	--	MBH
B3	231	do	87	6.3	2.8	7.5+	48	[c] 2.5	50	17	5	.2	--	Do
H1	478	do	126	7.2	5.6	4.5	89	[c] 9.5	127	3.3	6	.2	--	Do
L1	280	do	229	7.9	10	Trace	134	[c] 26	173	46	5	.2	--	Do
M2	300	Oct. 1954	210	8.7	--	.08	10	78	184	5.8	2.8	--	0.7	USGS
M102	728	Sept. 1962	198	8.5	15	.02	16	62	170	5.6	4.0	.2	.0	Do
N13	296	Dec. 1955	142	6.5	--	15	55	10	78	11	3.5	--	.1	Do
N18	745	Oct. 1961	154	7.4	34	.04	90	10	132	5.6	2.2	.0	.0	Do
O1	260	Sept. 1961	174	7.8	5.2	.2	103	[c] 28	168	11	6	.1	--	MBH
S2	250	do	62	6.3	6.4	.2	35	[c] 8.0	47	6.2	5	.2	--	Do
U1	320	do	226	8.2	4.8	0	112	[c] 30	222	34	6	0	--	Do
U2	420	do	277	7.3	29	.3	199	[c] 20	232	36	8	.2	--	Do
						NEWTON COUNTY								
G2	335	Dec. 1960	102	5.9	8.8	1.0	48	[c] 16	65	19	7	0.2	--	MBH
K13	312	do	119	6.2	6.0	.5	81	[c] 13	113	6.4	6	.2	--	Do
L2	88	do	64	5.2	3.6	.2	21	[c] 13	10	16	18	.2	--	Do
						PERRY COUNTY								
A2	294	Sept. 1955	156	8.0	--	0.17	23	45	134	9.8	3.5	0.2	0.2	USGS
A8	658	Sept. 1964	144	7.2	6.4	.65	48	35	129	11	4.4	.1	.0	Do
B1	85	Sept. 1955	43	5.8	--	.04	8	2.6	8	2.4	3.0	.1	.8	Do
C8	1,192	do	60	5.7	--	.17	16	5.2	9	2.0	8.5	.2	8.8	Do
C10	728	do	157	7.4	--	2.9	4	43	111	1.6	5.0	.2	.0	Do
H14	786	May 1964	259	8.1	12	.07	2	104	201	.0	42	.4	.1	Do
J6	483	Oct. 1964	86	6.2	26	.84	22	14	51	6.8	4.0	.2	.0	Do
M21	460	May 1964	411	7.9	18	.03	7	154	148	14	148	.1	.1	Do
O3	315	Sept. 1964	160	7.8	6.6	.00	7	62	148	5.0	9.6	.2	.1	Do
						SMITH COUNTY								
K101	1,180	May 1955	220	8.4	6.0	0.12	2	80	198	11	2.0	0.1	0.4	USGS
P1	160	June 1962	--	6.4	--	1.5	22	--	53	--	2	--	--	MBH
R1	357	May 1955	121	6.6	24	1.6	9	21	50	10	2.8	.1	.1	USGS
R2	1,135	do	467	8.5	--	.21	4	173	362	30	26	--	2.4	Do
						STONE COUNTY								
B2	200	Sept. 1959	29	6.3	2.3	0.00	6	2.8	4	0.8	4.5	0.1	0.9	USGS
B3	425	do	39	6.8	2.8	.12	4	4.6	15	.2	3.8	.2	.4	Do
						WAYNE COUNTY								
D6	190	Sept. 1964	270	7.9	20	0.36	112	54	256	19	4.2	0.3	0.1	USGS
N2	110	May 1955	198	7.4	9.4	.20	129	21	180	16	6.2	.0	.3	Do
T6	650	Sept. 1964	806	7.9	7.5	.02	10	310	716	.0	67	2.9	.2	Do
T8	125	Nov. 1956	40	5.5	3.3	5.0	4	5.5	12	.0	4.0	--	--	Curtis Lab.
						CHOCTAW COUNTY, ALA.								
163	108	Sept. 1948	--	--	--	--	13	--	10	1.0	5.0	0.0	16	USGS
						MOBILE COUNTY, ALA.								
20	61	Aug. 1954	40	5.5	--	--	12	--	4	--	6	--	--	USGS
21	110	do	22	5.8	--	--	8	--	9	--	5.5	--	--	Do
22	735	do	152	8.1	15	0.11	1	49	125	3.2	11	0.2	0.4	Do
70	212	do	41	6.2	--	--	7	--	36	--	3.0	--	--	Do
96	65	Jan. 1947	--	--	--	--	12	--	4	3	8	--	3.2	Do
						WASHINGTON COUNTY, ALA.								
19	256	Jan. 1947	--	--	--	--	57	--	79	6	4	--	0.1	USGS
29	147	do	--	--	--	--	12	--	109	2	8	--	.1	Do

[a] USGS is U. S. Geological Survey; MBH is Mississippi Board of Health.

[b] Public Health Service Drinking Water Standards, 1962.

[c] Sodium and potassium, reported as sodium.

TABLE IV-3

CHEMICAL ANALYSES OF SELECTED GROUNDWATER SUPPLIES PASCAGOULA RIVER BASIN - FEBRUARY, 1967

(Analyses by U.S. Public Health Service. Characteristics are in milligrams/liter.)

County	Community	Well number Owner	Well number USGS	Well depth (ft)	Cadmium	Barium	Beryllium	Lead	Chromium	Manganese	Iron	Nickel	Molybdenum	Vanadium	Copper	Zinc
Recommended maximum limit										0.05	0.3				1.0	5.0
Maximum permissible limit					0.01	1.0		0.05	0.05							
Clarke	Quitman	3	M103	289	[a]<0.008	0.006	<0.00004	<0.016	<0.004	0.0072	0.040	<0.008	<0.016	<0.016	<0.004	<0.008
Covington	Collins	2	F2	217	<.003	.112	.0001	<.006	<.001	.0028	.005	<.003	<.006	<.006	.049	.013
Forrest	Hattiesburg	1	D4	485	<.003	.031	<.00007	<.007	<.002	.042	.680	<.003	.010	<.007	.003	.031
	do.	4	D7	688	<.007	.033	<.00003	<.013	<.003	.0197	.204	<.007	<.013	<.013	<.003	.016
George	Lucedale	2	C17	1,000	<.008	.005	<.00004	<.016	<.004	.0072	.640	<.008	<.016	<.016	<.004	<.008
Greene	Leakesville	3	P2	125	<.006	.008	<.00003	<.012	<.003	.0046	.008	<.006	<.012	<.012	.174	.037
Greene	State Line	--	D1	205	<.002	.084	.00006	<.005	<.001	.050	.360	<.002	.012	<.005	.001	.007
Jackson	Pascagoula	3	P124	801	<.053	.011	<.00026	<.106	<.027	<.027	<.027	<.053	<.106	.222	.032	<.053
Jasper	Bay Springs	4	J7	1,008	<.014	.007	<.00007	<.028	<.007	<.007	.039	<.014	<.028	.059	<.007	<.014
Jones	Laurel	5	C34	383	<.005	.018	<.00003	<.011	<.003	.015	.029	<.005	<.011	<.011	<.003	<.005
Lamar	Purvis	2	L16	984	<.004	.026	<.00002	<.008	<.002	.020	.095	<.004	<.008	<.008	.002	<.004
Lauderdale	Collinsville	1	A2	692	<.006	.068	<.00003	.017	.010	.102	1.140	.011	<.011	.014	.003	<.006
Newton	Newton	1	K13	312	<.007	.018	<.00004	.022	<.004	.038	.096	<.007	<.015	.026	<.004	<.007
Perry	New Augusta	1,2	[b]H6,H7	720	<.016	.019	.00008	<.032	<.008	<.008	<.008	<.016	<.032	<.032	<.008	<.016
Simpson	Magee	--	Q1	112	<.004	.042	.00011	.010	<.002	.072	.006	<.004	<.008	.014	.004	.033
Smith	Raleigh	New	K2	1,160	<.012	<.001	<.00006	<.023	<.006	<.0058	<.046	<.012	<.023	<.023	.028	<.012
Stone	Wiggins	1	B2	200	<.003	.015	<.00001	.023	<.001	.0038	.008	<.003	<.005	<.005	.022	.025
	do.	3	B9	954	<.008	.006	<.00004	<.016	<.004	.0288	.017	<.008	<.016	<.016	<.004	<.008
Wayne	Waynesboro	3	N6	118	<.011	.067	<.00005	<.021	<.005	.0116	.011	<.011	.084	<.021	<.005	<.011

County	Community	Well number Owner	Well number USGS	Well depth (ft)	Cobalt	Silver	[c]A.B.S.	Arsenic	Selenium	Boron	Fluoride	Aluminum	Cyanide	pH	Phosphorous	Strontium
Recommended maximum limit							0.05	0.01			1.0		0.01			
Maximum permissible limit						0.05		.05			1.6		.2			
Clarke	Quitman	3	M103	289	<0.008	<0.0008	<0.03	All samples < 0.01	<0.002	0.029	0.11	<0.016	All samples < 0.005	8.1	<0.032	0.138
Covington	Collins	2	F2	217	<.003	<.0003	<.03		<.002	.015	.26	<.006		7.8	<.011	.018
Forrest	Hattiesburg	1	D4	485	<.003	<.0003	<.03		<.002	.032	<.06	<.007		7.7	<.014	.061
	do.	4	D7	688	<.007	<.0007	<.03		<.002	.051	.2	<.013		8.2	<.027	.121
George	Lucedale	2	C17	1,000	<.008	<.0008	<.03		<.002	.088	.14	1.600		7.9	<.032	.014
Greene	Leakesville	3	P2	125	<.006	<.0006	<.03		<.002	.041	.08	<.012		8.2	<.028	.015
Greene	State Line	--	D1	205	<.002	<.0002	<.03		<.002	.020	.08	<.005		7.4	<.024	.031
Jackson	Pascagoula	3	P124	801	<.053	<.0053	.06		<.002	1.165	.84	<.106		8.1	<.212	.011
Jasper	Bay Springs	4	J7	1,008	<.014	<.0014	<.03		<.002	.112	.12	<.028		8.0	<.056	.095
Jones	Laurel	5	C34	383	<.005	<.0005	<.03		.002	.034	.12	<.011		7.9	<.022	.041
Lamar	Purvis	2	L16	984	<.004	<.0004	<.03		<.002	.025	.14	<.008		7.6	<.015	.026
Lauderdale	Collinsville	1	A2	692	.011	.0029	<.03		<.002	.035	.12	<.011		8.0	<.025	.131
Newton	Newton	1	K13	312	<.007	<.0007	<.03		<.002	.019	.12	<.015		8.2	<.030	.132
Perry	New Augusta	1,2	H6,H7	720	<.016	<.0016	<.03		<.002	.368	.48	<.032		8.1	<.064	<.002
Simpson	Magee	--	Q1	112	<.004	<.0004	<.03		<.002	.016	<.06	.008		6.7	<.015	.048
Smith	Raleigh	New	K2	1,160	<.012	<.0012	<.03		<.002	.100	.16	<.023		8.2	<.046	<.001
Stone	Wiggins	1	B2	200	<.003	<.0003	<.03		<.002	.009	<.06	<.005		6.4	<.010	.005
	do.	3	29	954	<.008	<.0008	<.03		<.002	.120	.26	<.016		7.8	.080	.036
Wayne	Waynesboro	3	N6	118	<.011	<.0011	<.03		<.002	.096	.22	<.021		8.1	<.042	.263

[a] < means "less than value" when accuracy of instrument or method is limited.

[b] Composite, finished water sample.

[c] Alkyl benzene sulfonate.

TABLE IV-4

CHEMICAL ANALYSES - FINISHED WATER CHARACTERISTICS
INTERSTATE CARRIER WATER SUPPLIES IN VICINITY OF PASCAGOULA, MISSISSIPPI
MARCH 1967

Ownership	Pascagoula, City	Pascagoula, City	Pascagoula, City	Pascagoula, City	Pascagoula, City	Pascagoula, City
Location	Pascagoula	Pascagoula	Pascagoula	Pascagoula	Pascagoula	Bayou Casotte
USGS Well #	P134	P150	P68	P124	P69	Q180, Q181
Owner's do.	(Beach Well)	(Community St.) #2	(Lake Ave.)	(Community St.) #4	(Telephone Rd.)	Nos. 1 & 2
Depth	750'	785'	292'	801'	302'	663', 682'
Cadmium	<.030	<.034	<.020	<.047	<.030	<.027
Barium	.004	.007	.017	.009	.005	.017
Beryllium	<.00015	<.00017	<.00010	<.00024	<.00015	<.00014
Lead	<.060	<.067	<.040	<.094	<.06	<.054
Chromium	<.015	<.017	<.010	<.024	<.015	<.014
Manganese	<.015	<.017	.060	<.024	.027	<.014
Iron	.071	<.017	.072	.113	.060	<.014
Nickel	<.030	<.034	<.020	<.047	<.030	<.027
Molybdenum	<.060	<.067	<.039	<.094	<.060	<.054
Vanadium	<.060	<.067	<.040	<.094	<.060	<.054
Copper	.029	<.019	<.[illegible]	<.024	<.015	<.014
Zinc	<.030	<.034	<.020	<.047	<.030	<.027
Cobalt	<.030	<.034	<.020	<.047	<.030	<.027
Silver	<.003	<.0034	<.002	<.0047	<.003	<.0027
A.B.S.	.03	.03	.05	<.03	.06	.08
Arsenic	<.01	<.01	<.01	<.01	<.01	<.01
Selenium	<.002	<.002	<.002	.003	.002	<.002
Boron	.649	.600	.507	-	.555	.621
Fluoride	.91	.8	.66	.84	.89	.75
Aluminum	<.060	<.067	<.04	<.094	<.059	<.054
Cyanide	<.005	<.005	<.005	<.005	<.005	<.005
pH	8.4	8.2	8.2	8.3	8.3	8.2
Phosphorous	<.118	<.134	.064	<.190	<.118	<.11
Strontium	.006	.006	.070	.009	.009	.014
Strontium - 90	7.0 ± 138% pci/l					2.5 ± 240% pci/l
Total Radium	2.0 + 35% pci/l					<5 pci/l
Gross Beta	2.4 ± 37% pci/l					2.0 + 32% pci/l
Chloride	196	285	198	326	320	290
Sodium	259	320	228	364	316	318
Iron	0	0	0	0	0	0
Turbidity	<5	<5	<5	<5	<5	<5
Color	70	60	30	60	40	60
Odor	(H_2S)	(H_2S)	(H_2S)	(H_2S)	(H_2S)	(H_2S)
Total Flt. Res.	717	799	585	854	792	786

Notes:
1. Characteristics "Cadmium" through "Gross Beta: were analyzed by Public Health Service. Those from "Chloride: through :Total Filtered Residue" by Mississippi State Board of Health.
2. " < " means less than value.
3. All values given in milligrams per liter, except as indicated.
4. Radiochemical results of Strontium-90, Total Radium, and Gross Beta reported as pico curies/liter.

TABLE IV-4

CHEMICAL ANALYSES - FINISHED WATER CHARACTERISTICS
INTERSTATE CARRIER WATER SUPPLIES IN VICINITY OF PASCAGOULA, MISSISSIPPI
MARCH 1967 (CONTINUED)

Ownership	Coastal Chemical	Ingalls Shipyard	Jackson County Port Authority	Jackson County Port Authority	Standard Oil of Kentucky
Location	Bayou Casotte	Pascagoula	Bayou Casotte	Pascagoula	Bayou Casotte
USGS Well #	Q107, Q108	P131	--	P108	Q135, Q137
Owner's do.	1, 3, 2, 4	--	--	--	--
Depth	346', 356', 361', 357'	812'	--	785'	137', 335'
Cadmium	<.027	<.062	<.027	<.017	<.027
Barium	.057	.040	.050	.006	.057
Beryllium	<.00013	<.00031	<.00013	<.00009	<.00013
Lead	<.053	<.124	<.053	<.035	<.053
Chromium	<.013	<.031	<.013	<.009	<.013
Manganese	<.013	.068	<.013	<.009	<.013
Iron	<.013	.136	.200	.031	.098
Nickel	<.027	<.062	<.027	<.017	<.027
Molybdenum	<.053	.124	<.053	<.035	<.053
Vanadium	<.053	<.124	<.053	<.035	<.053
Copper	<.013	<.031	.017	<.009	<.013
Zinc	<.037	<.062	<.027	<.017	<.027
Cobalt	<.027	<.062	<.027	<.017	<.027
Silver	<.0027	<.006	<.027	<.0017	<.0027
A.B.S.	.04	.07	<.03	.06	.04
Arsenic	<.01	<.01	<.01	<.01	<.01
Selenium	.002	<.002	<.002	<.002	<.002
Boron	.795	.460	.690	.470	.795
Fluoride	1.21	.68	.91	.91	.95
Aluminum	<.053	<.124	<.053	<.035	<.053
Cyanide	<.005	<.005	<.005	<.005	<.005
pH	8.2	8.1	8.3	8.3	8.3
Phosphorous	<.106	<.25	<.106	<.07	<.106
Strontium	.060	.254	.061	.045	.050
Strontium - 90	<1	2.2 ± 26%	1.8 ± 320%	<1	2.0 ± 309%
Total Radium	1.3 ± 53%	<1	2.2 ± 34%	2.2 ± 34%	1.7 ± 40%
Gross Beta	3.0 + 28%	5.0 ± 24%	3.0 ± 33%	2.4 ± 35%	3.3 ± 29%

Notes:
1. Samples analyzed by the Public Health Service
2. " < " means less than value.
3. All values given in milligrams per liter, except as indicated.
4. Radiochemical results reported as pico curies/liter.

TABLE IV - 5

WATER QUALITY RESULTS
PHS NATIONAL SODIUM IN DRINKING WATER SURVEY
PASCAGOULA RIVER BASIN
MISSISSIPPI

Town	County	Est. Pop. Served	Water Source	*Avg. Na + ppm
Ellisville	Jones	4,000	Ground	58
Gulfport	Harrison	30,000	Ground	69
Handsboro	Harrison	1,200	Ground	89
Lumberton	Lamar	1,800	Ground	50
Meridian	Lauderdale	50,000	Ground & Surface	9
Moss Point	Jackson	6,500	Ground	242
Newton	Newton	2,910	Ground	9
Pascagoula	Jackson	15,000	Ground	270
Stonewall	Clarke	1,015	Ground	92

* Represents the average of quarterly sampling over a two year period, 1963 - 1965.

The FWPCA Appendix G did not include similar information for two other proposed multipurpose reservoirs which include storage for water supply:

Flint Creek (Pat Harrison Waterway District); and

Big Creek (Pat Harrison Waterway District).

Thompson Creek Project. Chlorides, nitrates, and total filtered residue are well within limits prescribed by the STANDARDS. Total and fecal coliform levels in Thompson Creek during the period of sampling were within limits presently recommended by the Public Health Service as being safe for drinking water supply sources — if the water is given "conventional"* treatment. Bacteriological raw water quality standards recommended for surface supplies, and results obtained from the Thompson Creek studies are:

	PHS Recommended Limits	Thompson Creek Quality
Total Coliform	20,000	6,885
Fecal Coliform	4,000	224

Many water quality characteristics mentioned in the STANDARDS were not determined for Thompson Creek. Since this is a proposed source of water supply, such determinations should be made prior to project planning stages.

Bowie Creek Project. Chlorides, nitrates, total filtered residue, and total and fecal coliform levels are within acceptable raw water quality limits. The additional characteristics required by the STANDARDS should be determined prior to project planning stages.

Harleston Project (Escatawpa River). Manganese, total coliform, and fecal coliform levels are satisfactory. Chloride levels are now excessive, since the range reported was from 4 to 1660 MG/L. Construction of the reservoir would have a stabilizing effect on these salinities and other chemical characteristics. Though the STANDARDS include a limit for chlorides of 250 MG/L, a concentration in excess of that value does not constitute grounds for rejection of the supply. The 250 MG/L limit is based more upon aesthetics (taste) than health. However, if the chloride ion is induced from salt brine (N_aCl), then a correspondingly high concentration of sodium ion could be detrimental to health. (The sodium ion in drinking water will be more thoroughly discussed later in this section.)

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* "Conventional" water treatment in its simplest form may include coagulation, sedimentation, rapid sand filtration, and disinfection with chlorine.

The FWPCA Appendix G indicates that the source of chloride pollution is not from tidal influence; but from oil field brine pits in the Citronelle area. Pollution control is extremely important here because of the small upstream watershed area and relatively low river flows. The determination of additional water quality characteristics is most advisable at this station (273670) of the Escatawpa, since oil field pollution could contain phenols and other organics (carbon chloroform extracts - CCE), which are included in the STANDARDS. The phenol limit of 0.001 MG/L is based upon aesthetics (taste). The limiting concentration for CCE of 0.2 MG/L is based upon the fact that it is a practical gauge of organics in drinking water; and that many organics — such as pesticides — have a known toxic effect to man. If CCE concentrations exceed 0.2 MG/L, then analyses for specific organic contaminants should be practiced.

Trace elements and other chemical water quality characteristics included in the STANDARDS should be determined before this proposed project is authorized with water supply benefits.

Tallahala Creek Project. Chlorides, nitrates, total filtered residue, and total and fecal coliforms are within recommended raw water criteria for sources of potable water supply. Average color of 95 units exceeds the proposed PHS limit of 50 units for raw waters subject to conventional treatment. The 50 unit level is being considered for raw water, since with moderate doses of coagulant chemicals, color can be reduced to the 15 units recommended in the STANDARDS.

Color, as well as turbidity and odor, are included in the STANDARDS as a gauge of water treatment plant effectiveness. If finished water quality cannot meet these STANDARDS, then perhaps the treatment facilities are not operating properly. If consumers find a tainted water unacceptable, they may turn to alternate supplies, such as shallow backyard wells, which may be much less acceptable from a health standpoint.

The additional chemical characteristics required by the STANDARDS should be determined for water at the Tallahala Creek Project site, as well as the two other Pat Harrison Waterway District proposed projects of Flint Creek and Big Creek.

Health and Drinking Water Quality - Groundwater

Many trace elements in varying concentrations are usually found in groundwater. Since most drinking water supplies in the Pascagoula River Basin are derived from underground sources, it was deemed important that the prevalence of trace elements be considered. Neither the USGS nor the Mississippi State Board of Health had acquired such data for existing groundwater supplies in the basin. Trace elements and chemical substances in drinking water can be either detrimental or beneficial to the health of consumers.

The following substances in excess of concentrations listed constitute grounds for rejection of the finished water supply:

Substance	MG/L
Arsenic	0.05
Beryllium	1.0
Cadmium	0.01
Chromium	0.05
Cyanide	0.2
Lead	0.05
Selenium	0.01
Silver	0.01
Fluorides	1.0*

Based on data in Tables IV - 3 and 4, the following substances found in groundwater of the Pascagoula River Basin are within limits of the STANDARDS: arsenic, beryllium, chromium, cyanide, selenium and silver.

Cadmium concentrations might exceed the STANDARDS in 5 of 19 representative wells scattered throughout the river basin. (The emission spectrophotometry method was used to analyze water samples for trace elements. Less than value (<) indicates that the substance determined was present in concentrations not exceeding the value shown. But because of possible interferences during analyses, exact quantity of the substance was not determined. If the less than value (<) is greater than the limit recommended in the STANDARDS, then the water should be analyzed for that particular constituent using a wet chemistry or more exact method.)

Of the nineteen representative basin supplies sampled, the highest cadmium concentration was reported for the City of Pascagoula. Chemical analyses made of eleven wells in the Pascagoula area which serve seven interstate carrier water supplies revealed that cadmium concentrations in each well might exceed the 0.01 MG/L limit. The highest concentration was less than 0.062 MG/L — which was from the Ingalls Shipyard water supply. From a chronic disease standpoint, cadmium is suspected as being responsible for adverse renal arterial changes in man.[4] Also, contamination with sufficient amounts of cadmium can cause acute poisoning.

Of the nineteen selected groundwater supplies sampled in the basin, lead in excessive concentration was possible in one location. Again, the suspected groundwater source was at Pascagoula. Analyses of interstate carrier water supplies in the Pascagoula vicinity revealed that

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* Lower, optimum, and upper limits for fluoride concentrations vary with average air temperature. The figure of 1.0 mg/l is the upper limit for fluoride, when the average temperature ranges from 70.7° to 79.2°F.

lead concentrations from nine of eleven well water sources might exceed the STANDARDS. Lead can enter the body by both inhalation and ingestion, and total lead intake must be considered.* Intake of this element can be injurious to health; and if prolonged exposure exists, relatively small quantities may result in serious illness or death.

Fluoride concentrations reported for groundwater in the Pascagoula River Basin indicate that some drinking water supply sources have excessive amounts. Based on USGS and Mississippi State Board of Health data (see Table IV - 2), fluoride concentrations in excess of the upper limit of 1 ppm were reported for fifteen wells. It is understood that results reported in Table IV - 2 were for grab samples and not averages over a long period of time. Two wells showed fluoride concentrations of almost 3 ppm.

Fluoride in water, if in optimum concentrations, can be very beneficial to dental health in that significant reduction of caries will occur. Excessive fluoride in drinking water supplies can produce objectionable fluorosis of the teeth and often an apparent mottling effect. Bone changes can occur if water containing 8 to 20 MG/L of fluoride is consumed over a long period of time.[5] No surface or groundwater supply monitored in the basin revealed concentrations in the latter range. But, those wells, in which fluoride levels exceeded the upper limits recommended in the STANDARDS, should be resampled on a routine composite basis. If fluorides continue above the upper limits, measures should be taken to provide a safe level.

Other substances listed in the STANDARDS which have recommended limits have been considered in Pascagoula River Basin groundwaters. Alkyl benzene sulfonate (ABS), copper, cyanide, nitrate, sulfate and zinc were not found to be in excess of concentrations recommended in the STANDARDS.

Chloride, iron, manganese and total filtered residue (total dissolved solids) were exceeded in various groundwaters analyzed. Limits for these latter four concentrations, however, are based more upon aesthetics than on public health. High iron concentrations were reported for various locations throughout the basin. Fifty of 131 wells sampled by USGS and the Mississippi State Board of Health (see Table IV - 2) had iron exceeding the limit of 0.3 mg/l, the highest level recorded was 15 mg/l. Depth of wells containing iron in excess of the limit ranged from 46 to 1,253 feet, with a median depth of 210 feet. Measures should be taken by the Mississippi State Board of Health to ascertain which municipal supplies, if any, should resort to iron removal facilities or perhaps selection of different aquifers.

In the Pascagoula area, chloride concentrations generally exceed the 250 mg/l level recommended in the STANDARDS. As water consumption

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* The maximum permissible concentration of 0.05 mg/l recommended in the STANDARDS is based upon an individual water consumption of two liters per day.

and over-pumpage increases in Jackson County, this condition could become aggravated.

Concentrations of other trace elements, not included in the STANDARDS, were determined for the 19 representative wells in the basin and also for the 11 interstate carrier water supply wells in the Pascagoula area. Beryllium is known to be toxic, but levels found in basin groundwater are extremely low and are probably of no health significance. The maximum nickel concentration found was less than 0.062 mg/l. Nickel is believed to have a very low toxicity and the only country with a limit for this element in drinking water is Russia — 1.0 mg/l.[6] Molybdenum in drinking water, if in trace amounts, can be beneficial to health. However, it can also be harmful if in significant amounts.[7] To date tolerance limits have not been suggested by health authorities, and a health significance cannot now be related to the 0.124 mg/l high recorded for groundwaters in the basin.

Vanadium in drinking water is suspected of being beneficial to human health. This element in drinking water has been determined for various areas of the United States. Small amounts were reported for waters in certain areas of New Mexico, which ranked lowest of all the states in deaths from coronary heart disease. On the other hand, vanadium was not found in waters of New York State that have been analyzed; and this state had the highest incidence of coronary disease.[8] The vanadium content in 19 representative wells in the basin and the 11 wells sampled in the Pascagoula area ranged from less than 5 parts per billion to less than 124 parts per billion. This is comparable to the levels determined in New Mexico which were 20 to 150 parts per billion.

Levels for cobalt, aluminum and phosphorous reported should be of no health significance, or at least no medical studies to date have been made which would indicate cause for alarm.

A level for boron has been suggested.[9] The highest boron concentration found in groundwaters of the basin was 1.165 mg/l and is less than the suggested limit of 5 mg/l.

Strontium in drinking water (if strontium-90) can be a radioactive element which is bone seeking. Exposure to this radiochemical should be avoided.[10] However, radiochemical analyses of the general environment in Mississippi area have indicated no problems from radioactivity. This is of special significance, since two underground nuclear blasts have been detonated in the basin.

"Project Dribble" is a part of the U. S. Department of Defense — U. S. Atomic Energy Commission seismic research program to improve this country's capability to detect, locate and identify underground nuclear detonations. First detonation was the "Salmon" event on October 22, 1964; the second was dubbed "Sterling" and exploded on December 3, 1966. Both were geologically in a salt dome area located

19 miles southwest of Hattiesburg. Extensive environmental monitoring has been conducted both pre-and-post blasts, and background as well as post-detonation radioactivity levels indicate no health hazards developed.[11] This environmental monitoring program will continue.

For purpose of this appendix, the last drinking water constituent to be evaluated is the sodium ion. Though not mentioned in the STANDARDS, excessive sodium is of health significance to people with diseases of congestive heart failure, renal and metabolic disorders, pregnancy, and atherosclerosis.[12] When persons so affected are under a physician's care, a sodium restricted diet is prescribed. Sodium ion concentration in drinking water can be an important factor in this diet. The American Heart Association's standardized diet for special patients recommends that ingested water contain no more than 20 mg/l sodium ion.[13] Results of USGS and the Mississippi State Board of Health sampling of 131 wells (Table IV - 2) indicated that water from 76 wells had sodium and potassium (measured as sodium) combined above this 20 mg/l limit. In the Pascagoula area, sodium levels are very high. The highest recorded for a well supplying the City of Pascagoula was 344 mg/l (Na + K) measured as sodium. Most of this total is probably sodium — as associated with common salt (sodium chloride).

For proper cognizance of this drinking water characteristic, medical practitioners in each state should be informed of sodium ion concentrations in their community supplies. The Public Health Service conducted a national survey to determine the existence of sodium in drinking water. Nine municipal supplies of the Pascagoula River Basin were included (see Table IV - 5). In summer of 1966, official state health agencies were given results for their states, along with the suggestion that such data be made available to practicing physicians. (To date, this suggestion has not been implemented in Mississippi.)

Health Agency Water Supply Surveillance Program

Evaluation of water quantities available for drinking water supply — now used and proposed — is very important in development of the river basin. Equally important are the programs which are to provide for the safe use of this water. The Mississippi State Board of Health, through their Division of Sanitary Engineering, is responsible for surveillance and improvement of existing water supply systems, and the promotion of new systems to serve the needy.

Establishment of new supplies to serve the smaller communities has received much emphasis in Mississippi — including the Pascagoula River Basin. Development of over 350 small water systems involving Federal loans totalling $41,000,000 has been sponsored by the USDA Farmers Home Administration. Mississippi State Board of Health personnel have assisted in this program by reviewing plans and specifications for each project, so as to assure that systems would not begin operating with built-in health hazards.

Board of health participation in the FHA program over the past three years has resulted in a forced de-emphasis of needed and minimal surveillance activities. Presently, for the entire state drinking water supply protection program, including FHA project plan reviews, slightly over one man year's effort is available. This practically neglects a program so important to the safe and orderly use and/or development of water resources for drinking or domestic purposes. The DHEW effort expended in Mississippi for this program is similarly inadequate. Though sixteen water systems are classified as interstate carrier supplies and subject to Federal surveillance and/or improvements, only 1/5 man year is available for work in the State.

Finished drinking water quality analyses and evaluation by the state health agency is also practiced — but at a level below minimums recommended in the STANDARDS. Laboratory resources are not available to analyze many chemical substances included in the STANDARDS. Water bacteriological laboratory facilities are certified acceptable from a quality standpoint, but are not large enough to meet the minimum number of analyses required by the STANDARDS.

The problem of inadequate program is <u>not</u> that professionals now retained by the Board of Health are not qualified. To the contrary, they are exceptionally well qualified from both academic and experience standpoints. And by necessity, they are extremely productive individuals.

The problem of inadequate water supply protection program stems from the fact that sufficient <u>resources</u> have not been made available to do the minimum job. In fact, Mississippi State Board of Health efforts are spread so thin in this area of environmental control, that not a single man can devote full time to public drinking water supply.

An additional deterrent to obtaining or retaining qualified personnel in this program is the very low salary scale paid to engineers and scientists, as compared to other state health agencies in the southeast, Federal agencies, and private industry.

Minimal needs for an adequate public water supply program in Mississippi are:

(1) A public water supply unit within the Mississippi State Board of Health with sufficient positions;

(2) Additional laboratory facilities (both chemical and bacteriological) and competancies to meet the minimum requirements of the STANDARDS:

(3) Salary levels competitive with other State and Federal agencies for similar professional capabilities;

(4) Passage of State Board of Health Rules and Regulations concerning public water supplies — similar to minimum criteria included in the STANDARDS;

(5) And most important, authorizations and budget to implement the program.

Often Federal agencies solicit the assistance and support of State agencies and other groups interested in water resource development. This support is usually for particular Federal agency projects or programs. It is equally important that the Federal agencies give this same level of support to state agencies which are responsible for the safe and healthful utilization and development of water resources.

The USDA proposes watershed improvement projects for land treatment measure, channel improvements, floodwater retarding structures, and multipurpose reservoirs totalling $57,227,000.[14] The Corps of Engineers proposes five early action multipurpose reservoir projects with total first costs of $121,647,000.[15] Costs for the seven proposed Pat Harrison Waterway District projects total $14,008,000.[16]

It seems reasonable that the Mississippi State government and legislature should be willing to provide sufficient resources for maintenance of a public drinking water supply protection program.

Summary and Conclusions

Early action reservoir projects which include the water supply benefit proposed by the Corps of Engineers and the Pat Harrison Waterway District are needed. This is especially true in the Pascagoula area where groundwater cannot meet the quality as recommended in the PHS 1962 Drinking Water Standards (STANDARDS). Construction of the proposed Harleston project on the Escatawpa would materially benefit the domestic water supply picture in the Pascagoula metropolitan area.

Surface water quality at all proposed reservoir sites, which will include the water supply benefit, should be determined insofar as substances mentioned in the STANDARDS.

Groundwater quality in the Pascagoula area does not meet the STANDARDS regarding limits of total dissolved solids (total filtered residue), chlorides, and perhaps cadmium and lead. The latter two characteristics are particularly significant from a health standpoint, and further analytical work should be conducted to more precisely determine their occurrence.

The Mississippi State Board of Health program for surveillance and improvement of public drinking water supplies is inadequate. Federal, State, and local support to realize an effective program is urgently needed — so as to provide for the safe and healthful utilization of the most important use of water resources — drinking water.

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