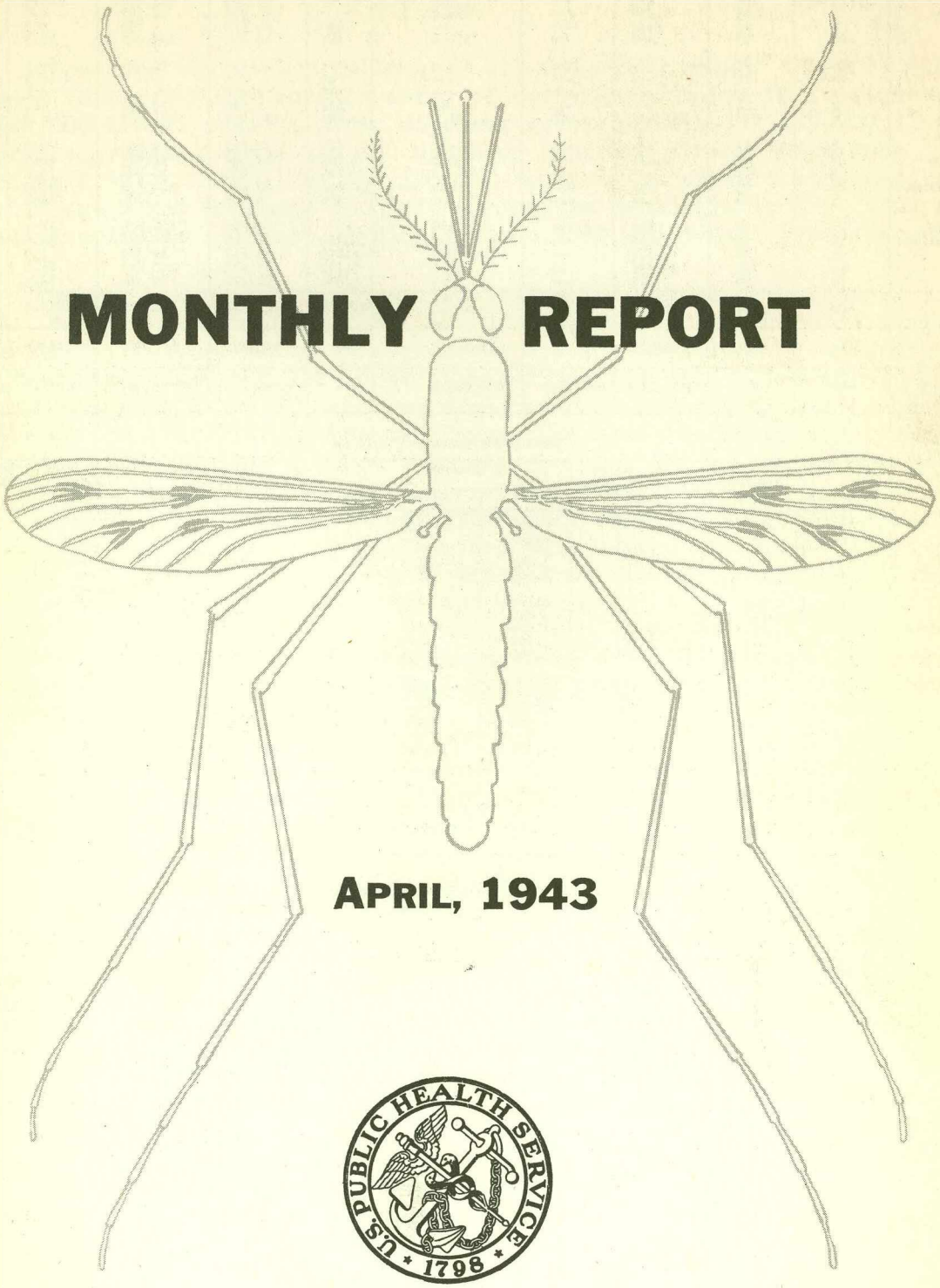
MALARIA CONTROL IN WAR AREAS



MONTHLY REPORT

APRIL, 1943

FEDERAL SECURITY AGENCY
U. S. PUBLIC HEALTH SERVICE
ATLANTA, GEORGIA

TABLE I — MCWA LARVICIDE AND MINOR DRAINAGE PROJECTS — APRIL 1 - 30, 1943

STATE	Areas In Operation	War Establishments Protected	LARVICIDAL WORK: Larvicide Used: Oil Gals.	Larvicide Used: Paris Green Lbs.	Surfaces Treated: Acres	OTHER WORK: Ditching: Cu.Yds.	Ditching: Lin.Ft.	Cleaning: Lin.Ft.	Clearing: Acres	Total Man Hours	Total Men Employed
Alabama	5	58	---	---	---	1,374	7,948	12,360	1.1	4,449	29
Arkansas	15	56	223	---	3.8	4,880	44,262	183,176	109.9	25 978	167
California	3	10	3,238	---	263.2	---	21,960	12,597	4.7	4,533	25
D. C.	1	23	---	---	---	490	14,611	894	0.3	4,216	23
Florida	10	58	660	96	112.0	183	95,822	199,981	37.3	54,658	173
Georgia	10	85	---	346	325.3	3,591	44,113	20,929	77.2	22,990	123
Illinois	2	17	---	---	---	50	225	---	0.2	694	6
Indiana	1	15	---	---	---	539	2,350	---	0.4	2,088	11
Kentucky	4	41	---	---	---	232	1,620	26,006	8.7	5,692	45
Louisiana	8	56	46,425	1,078	4,066.7	10,621	115,157	136,187	290.7	80,411	433
Maryland	2	21	---	---	---	727	9,117	9,420	0.9	4,904	24
Mississippi	8	49	2,611	---	52.4	3,109	42,400	99,761	34.5	19,854	116
Missouri	3	22	---	---	---	155	865	10,420	5.2	3,321	24
North Carolina	10	65	153	---	4.4	10,006	66,472	342,770	48.3	31,804	163
Oklahoma	4	21	---	---	---	422	5,605	4,289	26.3	4,678	29
Puerto Rico	7	17	820	3,955	1,534.8	---	65,833	126,604	11.2	58,639	388
South Carolina	10	99	1,816	---	40.5	2,310	12,645	95,240	35.6	16,709	107
Tennessee	5	58	4,687	---	79.7	1,659	10,617	12,300	1.5	10,139	51
Texas	14	123	12,799	15	508.5	5,179	85,820	198,662	84.0	45,269	243
Virginia	4	73	23	---	0.5	3,086	97,720	67,124	32.3	28,100	166
Total	126	967	73,455	5,490	6,991.8	48,613	745,162	1,558,720	810.3	433,126	2,346
March Total	109	588	24,174	5,652	6,141.5	---	634,370	1,469,527	1,053.3	396,660	1,121
Total July 1 - April 30	---	---	1,513,063	100,385	140,786.4	---	4,559,910	15,105,083	9,957.9	4,078,353	---

TABLE II — MCWA MAJOR DRAINAGE PROJECTS — APRIL 1 - 30, 1943

STATE	No. of Projects	Clearing Brushing Acres	Channel or Ditch Cleaning: Lin.Ft.	New Ditching: Lin.Ft.	New Ditching: Cu.Yds	Fill: Cu.Yds	Ditch Lining Placed: Sq.Ft.	Ditch Lining Placed: Lin.Ft.	Underground Drains: Lin.Ft.	Water Surf. Eliminated Acres	Total Man Hours
Alabama	3	13.5	958	2,362	1,848	150	---	---	---	3.5	7,141
Arkansas	4	40.7	8,210	2,025	82	---	---	---	62	5.5	4,373
Florida	1	2.1	4,860	---	---	---	---	---	---	---	6,916
Illinois	1	---	4,640	8,645	1,333	---	---	---	---	4.0	1,642
Kentucky	3	---	1,100	2,300	1,137	134	---	---	---	21.0	5,020
Mississippi	2	0.6	---	6,139	1,264	1,287	8,385	800	---	7.3	7,491
Missouri	1	0.8	760	546	35	10	112	---	---	6.0	361
North Carolina	4	8.0	73,443	31,569	7,369	1,544	320	---	237	124.4	23,939
Oklahoma	2	1.0	5,905	3,130	428	---	---	---	---	58.0	4,576
Puerto Rico	2	7.5	1,200	1,400	4,639	262	---	---	---	---	40,116
South Carolina	13	26.8	21,196	17,078	7,009	835	5,681	1,177	2,992	25.0	34,849
Tennessee	3	17.8	5,600	14,359	2,934	518	---	---	---	14.5	6,440
Texas	6	0.3	134	10,745	4,450	290	---	---	---	14.2	10,235
Virginia	2	1.6	600	2,986	264	---	4,059	1,468	---	---	4,042
Total	46	120.4	128,606	103,278	32,792	5,030	18,557	3,445	3,291	283.4	157,141
March Total	56	177.9	160,477	116,916	47,319	15,512	---	---	---	254.8	225,466
Total July 1 - April 30	--	1,044.8	1,497,752	557,003	330,902	54,678	18,557	3,445	3,291	1,467.9	1,005,570

TABLE III — MCWA PERSONNEL ON DUTY ON APRIL 30, 1943 AND TOTAL PAYROLL FOR MONTH OF APRIL — APRIL 1 - 30, 1943

STATE	Commissioned: No.	Commissioned: Pay	Prof. & Sci.: No.	Prof. & Sci.: Pay	Sub-Prof. (1): No.	Sub-Prof. (1): Pay	C. A. F.: No.	C. A. F.: Pay	Custodial: No.	Custodial: Pay	Total: No.	Total: Pay	Percent of Total: No.	Percent of Total: Pay
Alabama	1	284	5	1,328	2	347	2	410	57	7,066	67	9,435	1.8	1.9
Arkansas	5	1,418	2	633	24	4,477	4	689	154	19,499	189	26,716	4.9	5.5
California	2	531	--	81	5	998	2	440	23	3,454	32	5,504	0.8	1.1
D. C.	2	674	2	406	3	549	2	393	14	1,833	23	3,855	0.6	0.8
Florida	2	531	5	1,297	13	2,894	4	750	230	32,161	254	37,633	6.6	7.7
Georgia	1	284	5	946	24	4,745	4	584	96	12,228	130	18,787	3.4	3.8
Illinois	3	948	3	669	1	598	1	152	9	1,022	17	3,389	0.4	0.7
Indiana	1	284	1	264	--	---	1	146	11	1,383	14	2,077	0.4	0.4
Kentucky	2	511	3	988	9	1,576	3	556	50	6,735	67	10,366	1.8	2.1
Louisiana	5	2,308	6	1,844	39	7,701	5	996	401	50,244	456	63,093	11.9	12.9
Maryland	--	---	--	---	4	781	2	410	20	2,533	26	3,744	0.7	0.8
Mississippi	2	616	3	791	12	2,555	2	410	131	16,397	150	20,769	3.9	4.2
Missouri	2	567	2	466	9	1,717	1	225	13	1,640	27	4,615	0.7	0.9
North Carolina	4	936	9	2,652	9	1,729	3	556	300	36,630	325	42,503	8.5	8.7
Oklahoma	2	567	3	846	5	1,024	1	146	40	5,225	51	7,808	1.3	1.6
Puerto Rico	6	*	--	*	9	*	5	*	589	*	609	27,930	15.8	5.7
South Carolina	4	863	7	1,900	25	5,467	3	592	476	59,440	515	68,262	13.4	13.9
Tennessee	4	1,097	7	1,257	1	274	2	428	86	10,781	100	13,837	2.6	2.8
Texas	4	1,135	7	2,061	28	5,769	3	851	273	34,733	315	44,549	8.2	9.1
Virginia	2	567	3	688	9	1,619	2	428	184	20,991	200	24,293	5.2	5.0
Aedes aegypti														
Florida	--	---	1	319	42	7,454	2	310	27	3,637	72	11,720	1.9	2.4
Georgia	--	---	1	160	7	1,014	1	82	--	---	9	1,256	0.2	0.3
Louisiana	1	284	--	---	18	1,024	1	146	--	---	20	1,454	0.5	0.3
South Carolina	1	284	--	---	12	1,889	1	73	6	772	20	3,018	0.5	0.6
Texas	--	---	3	317	9	2,170	1	146	10	1,511	23	4,144	0.6	0.9
H.Q. & Dist. (2)	34	11,469	6	1,832	17	3,714	69	11,148	5	645	131	22,808	3.4	5.9
Total	90	26,158	84	21,745	336	62,085	127	21,067	3,205	330,580	3,842	489,565	100.0	100.0
Percent of Total	2.3	5.7	2.2	4.7	8.8	13.4	3.3	4.6	83.4	71.6	100.0	100.0		

* Figures not available
(1) Includes Entomological Inspectors
(2) Includes Headquarters and District offices, malaria survey, special investigations and employees temporarily attached to Headquarters pending assignment to States.

MONTHLY REPORT
Malaria Control in War Areas
April, 1943

SYLLABUS

Approximately 73,500 gallons of oil and 5,500 pounds of paris green were used to treat 7,000 surface acres of ponds and ditches in 12 states. Over 745,000 lineal feet of minor ditching were completed, 1,599,000 lineal feet of ditch were cleaned and 800 acres of pond and stream banks were cleared in April. A total of 433,126 man hours of labor were expended on larvicide and minor drainage projects during the month (Table I). Bids for airplane dusting in Airplane Dusting Regions 1, 3 and 4 have been approved.

Forty-six major drainage projects were in operation this month in 14 states. Nearly 20 miles (103,278 lineal feet) of new ditch were constructed, 128,500 lineal feet of ditch were cleared, 3,300 lineal feet of underground drains were installed and 283 acres of water surface were eliminated. A total of 157,141 man hours of labor were expended on major drainage projects in April (Table II). The project at Pryor, Oklahoma was completed during the month.

The M-7 postal card form developed for reporting current entomological conditions in the field was first used this month. The first adult male quadrimaculatus of the season were reported from Florida, Louisiana, Texas, Mississippi, South Carolina, Alabama and Georgia.

Equipment secured through transfer from other Government Agencies included office equipment, centrifugal pumps, power dusters, 6 trucks and 2 sedans.

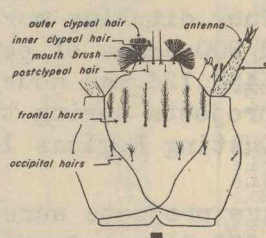
Sixty-six maps were planographed and copies were sent out for use in the field. Five maps were field checked and returned from Florida and the tracings are being revised; twenty-two other maps have been sent to the field for checking.

A coordinated program for in-service training of MCWA personnel was developed this month and will be inaugurated in May. A one week basic lecture course will be augmented by carefully supervised field training in the various phases of malaria control.

An Aedes aegypti survey was started in New Orleans and the survey of the East Texas Area, comprising Orange, Beaumont and Port Arthur, was completed during the month.

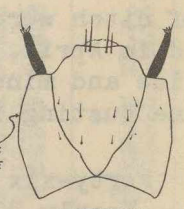
A report prepared in April on the basis of March payrolls showed that 76% of the 3,351 MCWA employees are participating in the voluntary payroll savings plan for the purchase of War Bonds. New regulations issued by the War Manpower Commission now make it compulsory that all appointments be cleared by this Commission in addition to the usual Civil Service clearance. Encumbrances for the month of April totaled approximately $579,000. Personal services amounted to about $489,500 and other major items totaled $89,500.

A PICTORIAL KEY
TO THE
NEARCTIC ANOPHELINE LARVAE



SPICULATED ANTENNA; FRONTAL HAIRS PLUMOSE

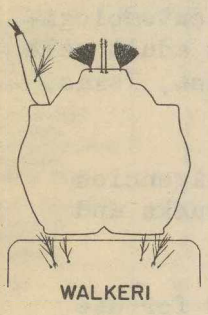
OR



GLABROUS ANTENNA; FRONTAL HAIRS BARE

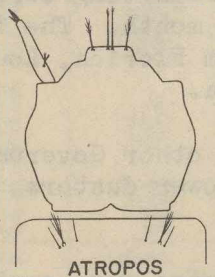
BARBERI

OUTER CLYPEALS DENSELY BRANCHED; INNER CLYPEALS CLOSE, SPARSELY FEATHERED AT TIP



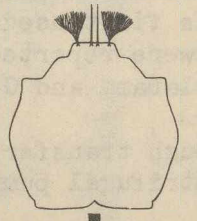
WALKERI

OUTER & INNER CLYPEALS SPARSELY FEATHERED ON TIPS; INNERS CLOSE

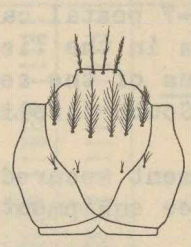


ATROPOS

INNER CLYPEALS SIMPLE OUTERS DENSELY BRANCHED

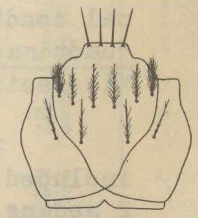


OUTER & INNER CLYPEALS FEATHERED TO BASE; LATTER WIDELY SEPARATED



ALBIMANUS

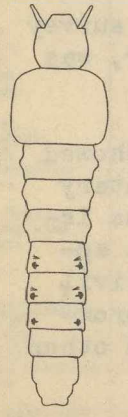
BOTH CLYPEALS BARE & WIDELY SPACED



PSEUDOPUNCTIPENNIS

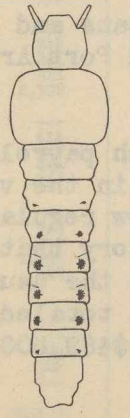
Subspecies *franciscanus* lacks the "tails" on the posterior spiracular plate that are present in the type species.

PALMATE HAIRS ON 4th– 6th SEGMENTS



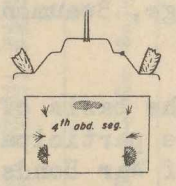
GEORGIANUS

PALMATE HAIRS ON 2nd, 7th(2nd&7th POORLY DEVELOPED)



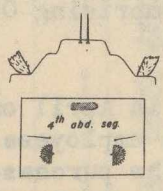
BRADLEYI

2 PAIRS MULTIPLE ANTEPALMATE HAIRS ON 4th SEGMENT; INNER CLYPEALS CLOSE



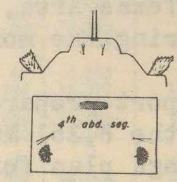
CRUCIANS

1 SINGLE ANTEPALMATE; INNER CLYPEALS WIDTH OF TUBERCLE APART



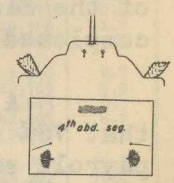
QUADRIMACULATUS

1 DOUBLE ANTEPALMATE INNER CLYPEALS CLOSE



PUNCTIPENNIS AND M. FREEBORNI

1 SINGLE ANTEPALMATE INNER CLYPEALS CLOSE



M. OCCIDENTALIS

A.m. aztecus, from Mexico keys out with *A. quadrimaculatus*, on the basis of inner clypeals but has antepalmate hair (no.2) branched.

Prepared by
Stanley B. Freeborn &
Eugene J. Gerberg

MALARIA CONTROL IN WAR AREAS
U. S. PUBLIC HEALTH SERVICE

MONTHLY REPORT
Malaria Control in War Areas
April, 1943

Bids for airplane dusting in Airplane Dusting Regions 1 (North Carolina, South Carolina, Georgia, Florida), 3 (Alabama, Mississippi, Louisiana, Texas, Oklahoma, Arkansas) and 4 (Delaware, Maryland, Pennsylvania, New Jersey , Virginia, District of Columbia) have been approved for operation. No bids were received from Region 2 (Kentucky, Tennessee, Missouri, Illinois, Indiana); since no dusting projects are anticipated in this Region, bids will not be resolicited. The only areas in which definite plans for airplane dusting are contemplated at the present time are the Potomac River below Washington, New Orleans, Louisiana, and Newport and Walnut Ridge, Arkansas.

Data on the larvicidal minor drainage work are presented in Table I.

Major Drainage - Eleven major drainage project proposals were reviewed and approved this month. By the end of April, 113 major drainage projects, total estimated cost $1,099,649, had been approved by the Headquarters Office. Forty-six projects were in operation and the one at Pryor, Oklahoma was completed in April. The progress of major drainage work in April is shown in Table II, together with the cummulative figures on major drainage projects from July 1 to April 30.

Purchase orders were placed for 124,000 pounds of dynamite to be used in major drainage ditching. Every month reports from the field illustrate the efficiency of dynamiting as a time, labor and money saving method of malaria control ditching. Two of the more interesting reports received in April are as follows:

At Miami, Oklahoma a ditch almost nine-tenths of a mile long (4650 lineal feet), 3 feet deep, 6 feet wide at the top and 2 feet wide at the bottom, was constructed with dynamite in only two days. The first day, 2250 lineal feet were completed and the remaining 2400, the second day. An average of 1.33 cubic yards of earth were moved for every pound of dynamite used.

The middle of November, a major drainage project was started at Walterboro, South Carolina and in January a dragline was assigned to this project. By the end of March, only 1½ miles of ditch had been completed. Test shots indicated the advisability of completing the project with dynamite and dynamiting was started in April. Approximately 4 miles of ditch were constructed during the month and the project should be completed in May. It was estimated that it would have required at least 18 more months to have finished the job with the only available 1/4 cubic yard dragline.

Entomology - The M-7 postal card report form developed to provide the Headquarters Office with current information concerning entomological conditions in the field was first used during April. Of the 313 zones reporting this month 119 reported adult Anopheles quadrimaculatus. Adult "A" station counts of quadrimaculatus were satisfactorily low in all zones, although "E" stations showed moderately heavy counts in some places. The first male "quads" which indicate the emergence of the first brood of adults

for the season were reported for Florida, Louisiana and Texas during the week ending April 10; for Arkansas, Mississippi and South Carolina, the week ending April 17; for Alabama, the week ending April 24; and for Georgia, the week ending May 1. A. maculipennis freeborni males appeared in California at the latitude of Marysville in the week ending March 26.

The ever increasing manpower shortage makes it more than ever essential that current entomological information be used to guide control operations, so that available personnel can be concentrated in areas where work is most necessary. Entomological information gathered during the last season has been used in recommending that operations in a number of zones be discontinued or that they be placed on inspection only.

Equipment - Enough office equipment was secured by transfer from the Nashville, Tennessee, Work Projects Administration warehouse to supply the entire Aedes aegypti Unit Office in New Orleans. Automotive equipment received from other Federal Agencies during April included four 1½-ton stake body trucks, two ½-ton pick-up trucks and two sedans. These have all been allocated to the states where they are most needed. Two much needed items received this month were centrifugal pumps and power dusters. No further shortage in this type of equipment is predicted for this season.

Maps - Sixty-six maps were planographed and copies were sent out for use in the field. Of these, 54 were of areas in Virginia, 8 in Florida, 2 in Georgia and 1 each in Arkansas and Oklahoma. Five maps were field checked and returned from Florida and the tracings are being revised. Twenty-two other maps have been sent out for field checking. The large amount of work that has been done by the various states in revising maps during the winter and improving the quality of drafting on maps has made it apparent that much less work will need to be done by this office than was originally anticipated.

In-Service Training Program - A coordinated program for in-service training of MCWA personnel was developed this month and will be inaugurated in May. Its purpose is primarily the training of new personnel, but will include additional training for personnel now in active service. The training program will be related to the definite needs of malaria control as determined by job analysis. Materials best suited to a classroom method of presentation will be given in a basic one week course. Carefully supervised field training will augment the basic lecture course.

Aedes aegypti Control - At New Orleans, the historic gateway of Yellow fever invasion into the United States, a group of approximately 20 men is making a complete survey of the City. Incidental corrections of "mother foci" and an intensive educational program are being carried on at the same time. The survey should be completed about July 1.

The aegypti survey of the East Texas Area, comprising Orange, Beaumont and Port Arthur, was completed this month. During the 40 days

spent surveying this area, twenty-two talks were made to teachers and school children. These talks were followed by two to five days of instruction in mosquito biology and control taught in the schools by the regular teachers. At the end of the instruction period, inspection report blanks were issued to 29,971 students. Over 90% of these students inspected their own homes for mosquito breeding and returned the inspection blanks properly executed.

Payroll, Personnel and Encumbrances - A report prepared in April on the basis of March payrolls showed that 2,572 of the 3,351 MCWA employees (76%) are participating in the voluntary payroll savings plan for the purchase of War Bonds. Records indicate that 881 Bonds of various denominations have been issued. During the 3rd. quarter of fiscal year 1943, $41,736.92 was deducted from MCWA employees' salaries for Victory Tax and deposited with the Department of Internal Revenue.

During the month various personnel reports were prepared and submitted to the Office of the Surgeon General in connection with the "freeze" order which was effective from March 25. Authorization was obtained for the employment of temporary employees in lieu of the usual full time War service employees. New regulations issued by the War manpower Commission now make it compulsory that all appointments be cleared through this Commission in addition to the usual Civil Service clearance. Table III summarizes data on the number of employees and the payroll by states.

Approximatly $579,000 of Public Health Service funds were encumbered this month. April encumbrances together with comparative figures for the two preceding months and totals from July 1 to April 30 are presented in Table IV.

Table IV
MCWA Encumbrances by Major Items

	April	March	February	Total July 1-Apr. 30
.01 Personal Services	$489,560	$487,380	$438,000	$3,847,030
.02 Travel	21,480	14,990	20,450	143,630
.03 Transportation	3,000	7,820	440	22,300
.04 Communication Services	1,030	1,200	1,210	13,220
.05 Rent	1,650	1,520	1,180	12,910
.06 Printing and Binding	400	680	730	1,960
.07 Other Cont. Services	4,690	4,420	10,550	52,230
.08 Supplies and Materials	47,090	28,090	29,210	357,420
.09 Equipment	10,210	30,980	12,650	111,770
Sub-total other than Personal Services	89,550	89,700	76,420	715,440
Total	$579,110	$577,080	$514,420	$4,562,470

UNDERGROUND DRAINAGE FOR MALARIA CONTROL

Underground drainage for malaria control was used by Le Prince and Gorgas in Panama more than 30 years ago. Their drainage systems were constructed of tile laid in narrow contour trenches and covered with broken stone. The trenches were completely filled with broken stone without an earth backfill so that they could carry some surface water. Large stone was placed in the bottom of the ditch and smaller stone in the top layer at the ground surface. To prevent the deposition of impervious material in the voids between the stones, the spoil was placed on the downhill side of the trench.

Satisfactory underground drainage may be constructed of brickbats, rock, gravel, tile or poles covered by a layer of leaves, straw or other filter material and backfilled with earth. Properly constructed drains of this type are inexpensive to install and require little or no maintenance. Some systems have been reported to be giving satisfactory service after more than 50 years of use. Underground drainage as a factor in malaria control is gaining widespread recognition; it has been proved to be one of the most effective methods for permanently eliminating Anopheles breeding places caused by seepage.

Seepage outcrops are caused by a change in permeability of the soil; e.g., a sandy loam topsoil underlain by a clay subsoil. Water flowing through the loam is arrested by the clay subsoil and must flow along this more impervious stratum until it reaches an outcrop on a hillside, stream bank or similar location. The line of seepage outcrop may be relatively short or it may extend along the entire toe of slope of a hill and become the source of a marsh or swamp.

Permanent seepage marshes provide excellent breeding places for Anopheles mosquitoes. The water is fresh and abundant vegetation provides food and protection for the larvae. Such areas are generally small, but in some instances marshes and ponds covering several acres have been formed by seepage outcrops. When located near towns or other centers of population, these breeding areas may provide a constant supply of malaria carrying mosquitoes.

It is most important that the design of an underground drainage system for the elimination of seepage areas be properly planned and executed. In general, a deep, narrow trench is constructed just above the toe of slope of the hill, and this trench usually follows a contour (Fig. 1). The depth of the trench will be determined by the elevation of the seepage stratum and by the elevation of the outlet ditch. Whenever possible, the ditch should be at least 3 feet deep. A 2-inch earth auger or post-hole digger may be used for locating the depth of the water table and determining the type of underlying subsoil. This information is indispensible in locating the ditch and establishing the grade. Underground drainage must be executed by an engineer familiar with this work, as the conventional design for land drainage will not be effective. Where the seepage outcrop extends well up on the side of a steep slope, it may be necessary to construct a series of parallel contour ditches only a few feet apart along the side of the hill (Fig. 2). The line of the drain should be as straight as possible, but when line changes occur, the tangents should be connected by a smooth curve. Each lateral should enter the main drain at an acute angle.

Narrow trenches, usually from 1 to 2 feet wide will be sufficient for all systems. Generally, it is best not to have the trench longer than 500 or 600 feet. If great care is taken in the construction of the individual ditches in the system, there is no great objection to making the ditches somewhat longer. However, with the average crew, long underground drains are seldom satisfactory. The grade of drains consisting of material other than tile should not exceed 2 feet per 100 feet. Grades of 0.20 to 0.50 feet per 100 feet will tend to make the system more permanent since none of the soil will be lost by erosion. A profile of the system must be made in order to lay a grade suitable to the topography.

Tile, rock, brickbats, stone, poles or other suitable material should be placed in the trench to a depth of from 12 to 18 inches and covered with straw, grass, leaves or brush to a depth of 6 to 12 inches after thorough compaction. The trench is then backfilled to a height of about 1 foot above the original ground level (Figs. 3 and 4). Care must be taken in placing the material in the trench so that voids will be left to allow a free flow of water. When tile is used, it is surrounded with broken stone, above which the straw, grass, hay or leaves are placed in the drainage way. If the soil is very sandy, the filter should extend down around the drain. The backfill should be tamped down to make it as water-tight as possible.

If poles are used as the material in the drains, the joints should not coincide. Experience has proved that failures always occur in the filter when two or more joints are placed together. The poles should be from 4 to 8 inches in diameter and 3, 5, 7 or more may be used in the cross-section of the drain, depending on the volume of water to be carried. The placing of materials should begin at the upper end of a ditch so that the chips, debris or flotage will be washed away rather than into the finished drain.

Although poles placed underground and submerged in water will last indefinitely, they deteriorate rapidly when exposed to air and may thereby cause a failure of the whole system. The drain outlet should be protected by building head-walls of brick and mortar, concrete or rock. Two or more joints of tile should be used in the drain at the head-wall to provide further protection for the drainage material (Fig. 5).

Uses of underground drainage for malaria control other than intercepting seepage outcrops are: (1) sub-draining open earth ditches and concrete inverts; (2) stabilizing ditch banks; (3) draining marshes caused by springs; and (4) providing outlets for overflowing drinking fountains and artesian wells (Figs. 6,7,8).

If the banks of a ditch are saturated with seepage and tend to cave in or are hard to hold in place, they can be stabilized by using a small underground drain as shown in Figure 6. A narrow trench is dug perpendicular to the seepage outcrop and sufficiently deep to intercept the flow, or to a depth which will permit drainage into the outlet ditch. This drain may be placed as illustrated, or it may be several feet from the edge. The trench should be filled with any suitable material as has already been explained, the filter placed, and the backfill made as in any underground drainage ditch. A joint of small tile is used to carry the seepage water from the drain into the ditch, and should enter the side of the invert at an acute angle.

Figure 7 illustrates the method for sub-draining open earth ditches and inverts. If a great amount of seepage water is encountered which seems to prohibit the construction of an invert in the ditch, the difficulty may be removed by sub-draining the ditch to lower the water table as shown in the diagram. The drain is constructed directly under the proposed invert and should be from 12 to 18 inches in depth. If the grade of the ditch is sufficient to allow the construction of spillways, the underground drains can be made shorter and their effectiveness increased. On ditches having a steep grade, the spillway will serve three purposes; namely, decrease the grade of the main ditch, prevent erosion, and make possible the construction of short underground drains.

Sub-draining open earth ditches will eliminate water standing in potholes and behind small obstructions. To prevent erosion, it is desirable to provide spillways on open earth ditches having steep grades. The spillways may be constructed of brick and mortar, concrete or masonry. It is not advisable to use regular curves to break the grade at the spillways as in the case of invert ditches, but rather to use abrupt drops of about 6 inches, making the spillway similar to stair steps. These abrupt drops will tend to decrease the velocity of the water so that erosion of the ditch

bottom will be decreased. The banks should be riprapped at the spillways.

Figure 8 illustrates drainage of marshes fed by springs. Springs causing marshes and swamps may be irregularly located with reference to contours and for this reason cannot be eliminated by the regular contour trench. To eliminate the swamp, a system of underground drains consisting of the main ditch and a separate lateral for each spring must be installed as shown in the diagram. The laterals should enter the main ditch at an acute angle. Two laterals should not enter the main ditch directly opposite each other, but should be alternated.

Along ditches through sandy soil or soil containing a large amount of gravel, it will be noted that in dry weather, potholes occur at intervals along the stream bed. Upon close examination it will be observed that the soil between the potholes is quite porous and permits the natural flow of water below the ditch bottom. It will also be observed that this porous material has been washed out to a depth below the hydraulic gradient of the ditch, producing the potholes as shown in Figure 9.

Holes thus formed in the ditch bottom often provide excellent breeding for Anopheles mosquitoes since the conditions are similar to those formed by seepage outcrops. To destroy these breeding places only one thing need be done; that is fill in the missing portions of the porous stream bed. This task may be accomplished by filling the holes to the approximate water level with gravel, using larger stones in the bottom and smaller ones toward the top. The gravel should be covered with a thick layer of sod turned grass side down, and the job completed by covering the sod with a compacted layer of dirt to the original elevation of the stream bed.

If the holes are large, it will be advisable to fill in the sides with dirt to provide a narrow channel before placing the rock or gravel. Considerable time will be saved by following this method since a much smaller amount of gravel or rock will be required. The flow in most cases is small and the narrow channel or drainage way will suffice to carry the water. After the holes have been properly filled, the water flow is below the ditch bottom at all places so that no Anopheles breeding places exist.

The following may be listed as points in favor of underground drainage over open ditches:

1- Completely eliminates mosquito breeding and hence obviates any need for inspection or larvicide work.
2- Low cost of material.
3- Low cost of construction (costly supervision not necessary).
4- Low cost of maintenance.
5- Permanency.
6- No land lost for right-of-way, since cultivation can be extended over the drain.
7- Can be used where other types of drainage are impossible.

The two most important factors relating to any malaria control drainage project are the ultimate cost, and the permanency of the system. When properly planned and executed, underground drains are not expensive to construct and will give many years of satisfactory service free from maintenance. In view of these points, underground drains should be used for malaria control drainage whenever conditions indicate the feasibility of this method.

HILLSIDE SEEPAGE DITCHES

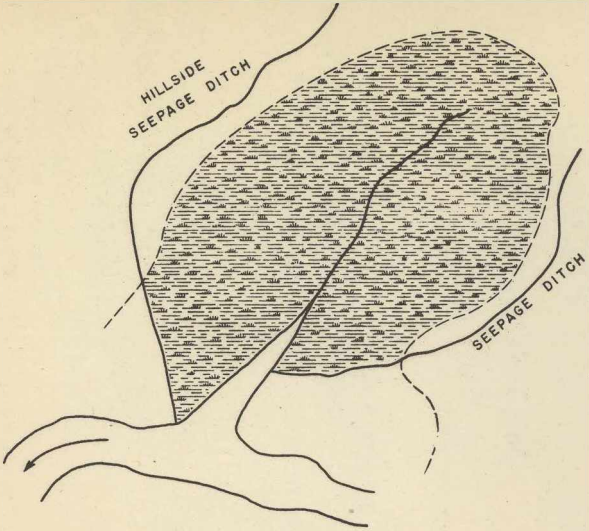


Fig. 1

UNDERGROUND DRAIN USING TILE

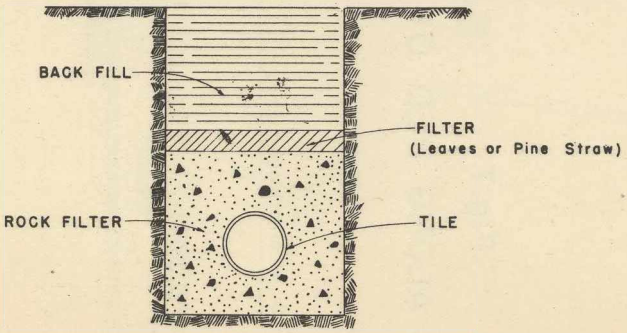


Fig. 3

MULTIPLE SEEPAGE DITCHES

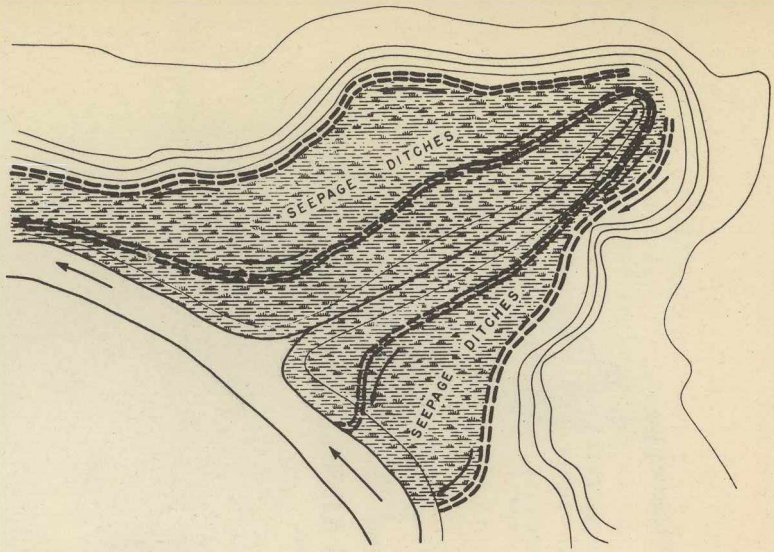


Fig. 2

UNDERGROUND POLE DRAIN

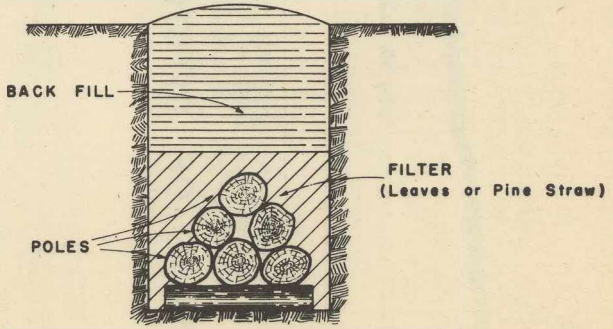


Fig. 4

DETAIL OF TILE OUTLET

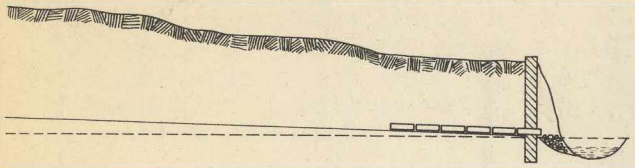


Fig. 5

SUB-DRAINAGE OF DITCHES

STABILIZATION OF DITCH BANKS

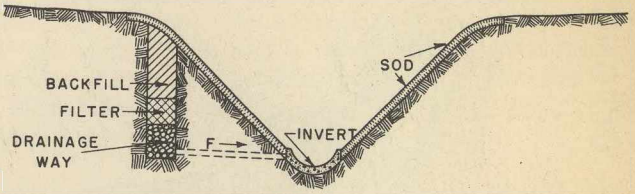


Fig. 6

DRAINING SPRING-FED MARSHES

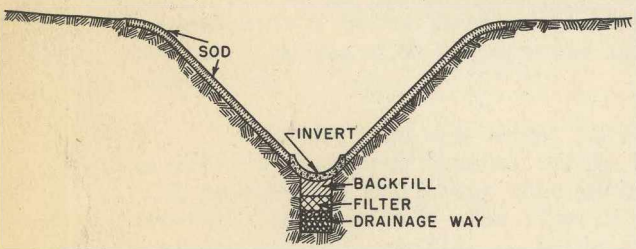


Fig. 7

POTHOLES ALONG BED OF DITCH

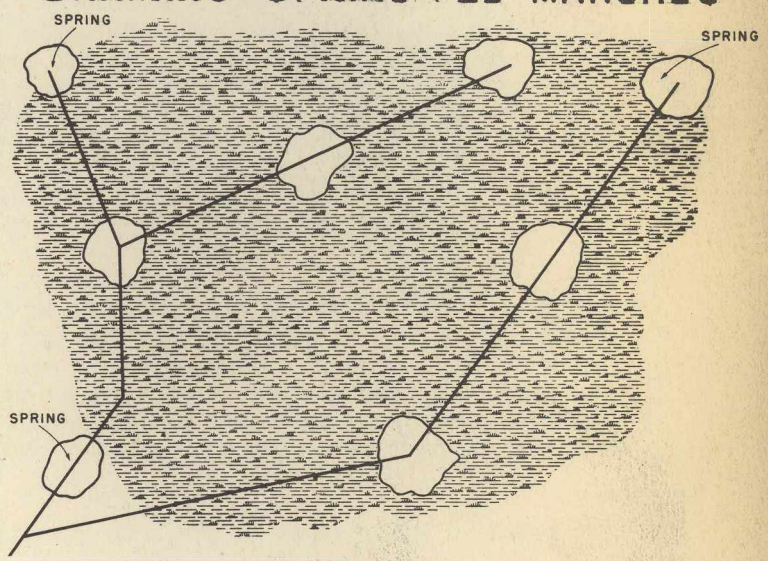


Fig. 8

METHOD OF REPAIR

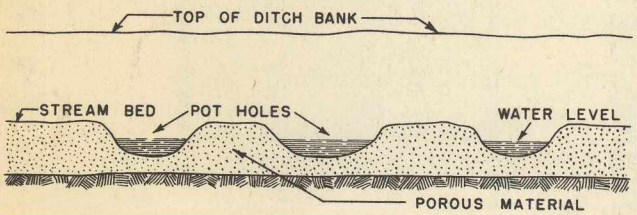


Fig. 9

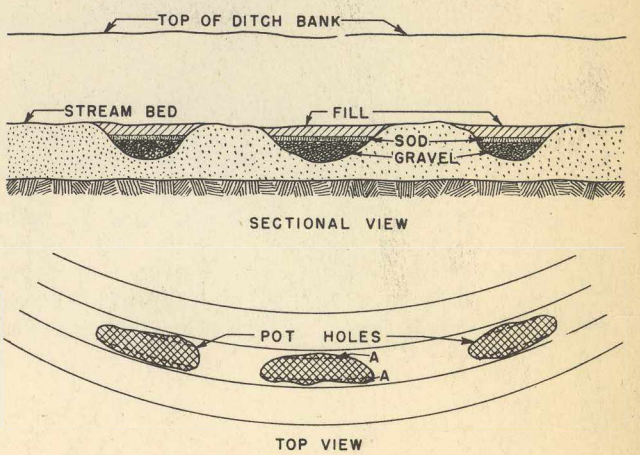


Fig. 10