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Malaria control engineering on the Pickwick Reservoir

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MALARIA CONTROL ENGINEERING ON THE PICKWICK RESERVOIR

BY

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INTRODUCTION

During the past year in an area extending south of a line between Norfolk, Virginia and St. Louis, Missouri, it has been estimated that about 10,000 deaths and staggering economic losses were caused by malaria fever.

Although some of the secrets of this mosquito-borne disease have been revealed four decades ago, malaria still remains an unyielding problem to health organizations responsible for the planning and directing of control measures.

The influence of impounded waters on the production of the malaria vector in the Southeastern United States, Anopheles quadrimaculatus, was observed by the United States Public Health Service in Alabama in 1913. Their reports gave rise to the state regulations governing the preparation and maintenance of artificially impounded waters. Since the recent inauguration of river development projects on the various streams in the so-called "malaria belt" of our country, malaria control methods on impounded waters have been of increasing concern to the health workers of the South.

The general consensus of opinion indicates that the most effective procedure for the control of malaria in this country is in eradication of the mosquito responsible for the transmission of the disease. Mosquito eradication is in every sense an engineering problem

requiring an analysis of the problem, planning and execution as in the construction and maintenance of any engineering structure. Mosquito control on impounded waters must be constructed into the dam design and requires a careful program of reservoir preparation or conditioning of the body of water so that the shoreline will not encourage the production of the malaria vector. The shoreline preparation together with with planned water level variations is called "biological control" of mosquito breeding.

In planning and executing the complex program of malaria control on the impoundages of the Tennessee Valley Authority, the Director of Health has assembled a staff consisting of a malariologist, a biologist, sanitary engineers, entomologists, aquatic botanists, and an airplane dusting pilot. In addition, the services of a geologist, chemist, bio-chemist, boat designers, and hydraulic engineers are required for certain problems. For guidance in planning the research program of the Tennessee Valley Authority, there is selected a board of consultants made up of several men having broad and diversified experience in malaria and in the control of malaria, who review the work at intervals, presenting helpful suggestions and criticisms.

It will be the purpose of this paper to discuss in detail only the engineering aspect of the malaria control practices employed by the Authority on the Pickwick Landing Reservoir.

IMPOUNDED WATER REGULATIONS

Basically, all of the southern states' regulations governing impounded water have the same objective in mind, the objective of a clean water's surface obtained principally through the removal of timber and drainage of depressions in the zone of water level variation.

The Pickwick Reservoir was cleared according to the Alabama State Board of Health Regulations, with some few approved modifications.

CLEARING AND DRAINAGE

Preliminary Work

The Pickwick Landing Project was authorized by the Tennessee Valley Authority Board of Directors on November 19, 1934. The dam is located 52.7 miles downstream from Wilson Dam and impounds a reservoir having 496.3 miles of shoreline, affecting Hardin County, Tennessee, Tishomingo County, Mississippi, and Lauderdale and Colbert Counties, Alabama. The operation levels of the reservoir are as follows:

Maximum design flood El. 430' MGL

Controlled surcharge El. 418'

Malaria Surcharge
Upper Limit El. 414'
Lower Limit El. 409'

Minimum El. 408'

The topography of the reservoir in the lower two-thirds may be considered as upland or precipitous terrain, while the upper thrid consists chiefly of flat or gently rolling lowlands. The steep shoreline of the reservoir affords very little problem, while the upper shallow reaches of the reservoir presents a more difficult situation.

In the summer of 1935, reservoir preparation studies were initiated in the Pickwick area by the Sanitation Section of the Health and Safety Department of the Tennessee Valley Authority. A field reconnaissance consisting of surveying and recording in the field the character of the growths, topography, natural drainage, soil formations, wind directions on the proposed reservoir was made prior to preparation of

clearing specifications. The information from the field studies, along with other data and reports, was incorporated into the clearing and drainage specifications which are given as follows:

CLEARING

(A) In all of the reservoir, its branches, bights, and indentations, as defined by the 414' contour, all trees, brush, and logs or other material which might float when water is impounded are to be removed or disposed of by burning, excepting certain areas to be left for experimental observations and certain trees proposed for leaving along the shoreline, hereafter described.

Brushing is to extend landward a distance of ten feet beyond the 414' contour as measured along the slope of the ground, excepting situations hereafter described. All dead trees or those leaning so that the limbs hang down to the 414' contour are to be removed. This shall include the removal of logs, drift, and debris found lying in the ten-foot zone beyond the 414' contour. Felled trees, logs, limbs, etc., are not to be disposed of by piling outside of the ten-foot zone. Such material will be disposed of by burning along with the regular operations. It shall be the practice in clearing areas between the 410 contour and the 414 contour to cut trees as near to the ground as is practicable. This will apply particularly to willow trees.

(B) On practically sheer cliffs the clearing may be stopped at the 414' contour and only the brush and trees removed beyond this point which would hang down and touch the water at elevation 414'. Any shoreline may be placed in this classification where workmen cannot find adequate purchase for working safely.

(C) All clearing may be stopped along the margins of the Tennessee River and Bear Creek where the 414' contour intersects the average summer time water elevation.

(D) On all the shoreline exposed to the main body of the lake and of a soil likely to be eroded by wave action, removal of trees and brush is to be extended six to twelve feet horizontally beyond the high water line, contour 414'. The roots of stumps in the cleared area which do not have a good purchase in the ground and would therefore quickly enter the reservoir as a result of soil erosion from wave action shall be pulled up where it is convenient to reach them by machine or other operations. Disposal shall be effected by burning. Specification under Section A providing for brushing, etc., in the 10' zone shall be considered complied with after application of the section.

The extent and location of marginal clearing on the shoreline where erosion from wave action is anticipated shall be set out by the Health and Sanitation Section representative, following field inspection of the individual areas.

(E) Bights or indentations exposed to the main body of the lake which are likely to collect drift and flotage shall be cleared back at the heads for a distance of 15 feet from contour 414', where space does not already exist, for piling removed drift.

(F) After impoundage, a number of narrow exposed islands will be formed in the reservoir. It is proposed that these be cleared completely.

(G) On the upper reaches of the Tennessee River, Bear Creek, and smaller creeks and tributary sloughs, where the 414' contour is confined to the banks of the streams, the following provisions are to apply:

(1) That all the regular clearing specifications for the removal of timber be applied below the 413' contour, except:

(a) Sound young, (well-foliaged for the purpose of providing shade) cypress trees above the 409' contour shall be left where they are not more than a six-foot horizontal distance from the 414' contour.

(b) Sound young (well-foliaged for the purpose of providing shade) tupelo gum trees above the 411' contour shall be left where they are not more than a six-foot horizontal distance from the 413' contour.

(2) Above the 413' contour for a distance of ten feet beyond the 414' contour, as measured on the slope of the ground, all underbrush and trees less than four inches in diameter are to be removed, except that:

(a) Willow trees in the ten-foot strip extending inland from the 414' contour shall be trimmed up and left standing. By trimming up is meant the removal of low branches, undergrowth, and bushes, including the thinning out of thick groves of willows and other trees desirable to be left and mentioned below. Box elder and hawthorne are not desirable and should be removed wherever encountered in the ten-foot zone.

(b) It is particularly desirable to leave a stand of the smaller trees in open areas where large trees are not encountered. The principal trees desired to be left are cypress, tupelo gum, willow, sycamore, maple, sweet-gum, iron wood, oaks, cottonwod, and hackberry.

(c) Brush and log piles should be located in natural openings as far as practicable, in order that burning operations shall cause as little damage as possible to trees which are left standing.

(d) River bank trees standing on the 413' contour or above where the root system has been partly exposed by bank erosion, should be left standing if the trees are healthy and the roots seem to have a good purchase in the bank.

(e) In necks and indentations off the banks of the streams, where these modifications are intended to be applied, if the distance between the 413' and 414' contour is greater than a horizontal distance of ten feet, the brushing and other operations described above shall extend to the 414' contour and for a distance of 10' beyond.

(H) In the flat areas on Seven Mile Island and the flood plain of the River immediately to the north, complete clearing is to extend to the 413' contour, excepting the cypress in Collier's Slough which are to be left as an experiment, and certain other cypress and tupelo gum trees covered in another section. Brushing is to be carried out between the 413' and 414' contour, and for a distance of ten feet beyond as measured along the slope of the ground. The brushing shall include removal of dead or unsound trees, logs, limbs, other debris, etc. Disposal shall be by piling and burning in natural openings.

In certain of the most heavily wooded sections it may be necessary to clear banks to facilitate boat operations. It is understood that these will be located by subsequent field inspections.

EXPERIMENTAL AREAS

(A) There is a cypress slough located on the north shore of the reservoir below Florence. This slough is approximately five miles long with a width varying from 100 to 600 feet. The elevation of the ground varies from 409' to 413'. Is is proposed to brush and clear this area, leaving only sound young cypress.

(B) In the vicinity of the above slough, and on Yellow Creek (Mississippi) due north of the present crossing of Highway 25,

are extensive shallow flat areas which are most certain to prove difficult and expensive for mosquito control on account of aquatic growth. After clearing, it is proposed to plant certain of these areas, not exceeding thirty acres, to cypress and gum tree seedlings. The areas will be located between contours 411' and 416'.

DRAINAGE

All depressions which may become filled at times of maximum water level and form isolated pools when the water is lowered shall be connected with the main body of the lake. For the purpose of mosquito control this work need embrace only drainage between the 410' and 414' contours.

INTERPRETATIONS AND DISCUSSION

(A) This section provides for clearing the reservoir to the 414' contour and brushing for a landward distance of ten feet beyond, excepting certain shoreline where modification appears desirable.

(1) In the interest of economy and the conservation of shade along the shoreline, it might appear that clearing should extend only to the 413' contour in all of the reservoir. However, along most of the shoreline, particularly in the lower part of the reservoir, pine trees and other upland growth are found in great abundance. Such growth is readily killed by continual submergence of the root system. Dead trees at and near the water line are not desirable, hence the provision for clearing to the 414' contour.

(2) The removal of brush, dead and leaning trees and fallen trees and branches from the ten-foot zone bordering the 414' contour is considered desirable in minimizing cost of removing such material which might enter the reservoir after water is impounded. For the same reason no brush or logs should be piled and left above the contour. Stumps extending an excessive distance above the ground in shallow areas near the contour offer an obstacle to boat operations. They should, therefore, be cut as low as practicable. It is felt that the limits can be set by the Reservoir Clearance Division in the field.

The clearing and burning operations should be carried out in such a manner as to limit injury to the trees which are left standing, as is consistent with economical clearing operations. While the provisions for burning are subject to field interpretation and adjustment to suit local conditions, it is expected that the clearing forces will make every effort to dispose of brush and logs without injury to trees which are left.

(3) In the case of willow, it is felt that the closer the trees are cut to the ground the greater the chance of the stump being killed by submergence when the water is impounded.

(B) It is felt that clearing operations may be safely stopped at the 414 foot contour on sheer cliffs or other precipitous shoreline where workmen would find difficulty in carrying out the operations. There will not be much of this type shoreline and in most cases it will be open and exposed to wave action.

(c) In explanation of Section C, statement is made that mosquito production does not normally occur along the banks of Bear Creek under natural conditions. Impoundage would not change this condition above the point where the 414' contour intersects the normal summer time elevation of the stream. No treatment above these points would, therefore, appear necessary.

(D) Observations have been made on other reservoirs, particularly Lake Wilson, that wave action will result in soil erosion on steep banks of loose soil exposed to a considerable expanse of water. This appears to occur regardless of whether or not the shore is wooded. Sections of the shoreline on Pickwick may be expected to erode from wave action. If trees are left standing along the shoreline in these sections, they will in time be washed into the lake. Section D provides for removal of trees back six to twelve feet from the 414' contour as the reservoir is being cleared to forestall the removal after water has been impounded.

(E) Note has been made on other reservoirs that the greatest accumulation of flotage brought down by the streams occurs in shallow bights and indentations along the main body of the reservoir. Very often removal of this flotage is essential to mosquito control. Present methods of removal consist of piling the floating material at the head of the bight or indentation. Section E provides a cleared space at the heads of the indentations for piling accumulated material.

(F) Impoundage of the Pickwick Reservoir will result in a number of small narrow islands in the main body of the lake. They are composed of a silt formation and in most instances will be exposed to expanses of water on both sides. Erosion is expected and Section F provides for complete clearing of these islands to forestall the more expensive and inefficient method of removal after impoundage.

(G) Section G is more or less self-explanatory. It provides for the same modifications as were carried out in the Wheeler Reservoir where the high water contour was confined to the banks of the major streams, excepting the provision for leaving certain cypress and tupelo gum trees. The trees encountered along the banks are subject to aquatic conditions. The object of leaving them at and near the water line is to provide shade and minimize sprouting which will occur extensively in the case of willow stumps. It is recognized that the trunk of a tree is far less objectionable at the water's edge than a multitude of sprouts.

(H) The 414' and 413' contours on Seven Mile Island and the flood plain of the River to the north follow natural sloughs and low lying areas which for the most part are heavily wooded. The growth encountered is semi-aquatic and now stands in water for several months during the year. With summer time water level fluctuation below the 413' contour natural conditions should not be altered materially. The sound trees in this area are specified to be left for the purpose of providing shade in an area which, if cleared, would be covered completely with secondary growth.

MARGINAL CLEARING

Tree Marking for Marginal Clearing

In order to insure proper interpretation of the clearing specifications, the marginal clearing limits are marked in the field under the supervision of the representative of the Health and Safety Department. In the Pickwick Reservoir, two men were used as tree markers. Their equipment consisted of one gallon of paint (1 part red barn paint to 1 part gasoline), a long handle brush and hand level. The Engineering Service Division accurately set, at intervals of approximately fifty feet, the 414' contour, using white stakes or painting white bands on trees which stood on the contour. The marginal tree markers used this contour as a base line. The markers were supplied each day with a large scale map (1" = 500') showing in colors areas where the different clearing provisions were to be carried out. Every tree along the margin of the reservoir to be left had to have a red spot marked plainly upon it or the clearing forces would remove it. The procedure proved very successful and economical in executing the specifications since the tree markers could stay well ahead of the clearing units around the reservoir and the cost of labor and materials for marking was small.

In summarizing, in the Pickwick Reservoir 486.32 miles of shoreline were marked for marginal clearing. Approximately 10 miles of shoreline were not marked, since it fell under the classification of complete Island Clearing (F). The average progress was 3.25 miles per man-day, using paint at a rate of 4.5 miles per gallon.

Clearing Practices

The Tennessee Valley Authority has a Division of Reservoir Clearance which is composed of men specially trained in large scale clearing operations. There follows a brief description of their efficient clearing practice. Their organization is divided into clearing units located about various sections of the reservoir. Each unit is composed of 60 laborers, 2 tool sharpeners, 3 sub-foremen, 1 field first aid man-clerk, and one unit foreman. Each sub-foreman is in charge of a particular clearing operation. In front are sent the bush hooks employed in cutting all small brush and originating the locations of the brush piles. Following the bush hooks are the axe crews which cut the small trees and pile brush. The next operation is the small and large saws which fell all sizable timber and work them up into convenient log lengths, piling the tops in the brush piles. The last operation consists of the lug-hooks, cant-hooks, and mule team utilized in piling the logs for burning. This latter operation is quite important as the piles must be carefully constructed to insure complete consumption when burned.

The general practice in log piling is to center the large logs and then pile or "wrap up" the large logs with the smaller poles and logs. Then in burning very little cleaning or "chunking up" of the log piles will be necessary. A properly built log pile will burn evenly and when practically consumed, usually just moving the log butts together will leave no unburned material.

The Clearance Division sometime employ light dragline cranes equipped with log tongs to aid in piling the heavy logs in wet ground where men and mules have poor footing. On bank clearing operations a "bank machine" is utilized. This is a tractor equipped with a dragline wench and stiff-leg which pulls the felled trees from the streams so the men can work up the timber on dry ground.

Throughout the entire clearing of the 12,500 acres of timber in the Pickwick Reservoir, steps were taken to save and dispose of all merchantable timber.

Semi-Aquatic Growth Control

Willow stumps, along with button ball, have been quite a problem in newly impounded lakes due to their rapid and continual resprouting characteristics. In order to rid the marginal area of the willow sprouts and seedlings, operations were developed to control these growths.

Along with the pre-impoundage marginal clearing operations, willow stump poisoning was carried out between the 414' and 408' contours of the Pickwick Reservoir. At the inauguration of the program, a 12 per cent solution of sodium arsenite was applied to hack-girdled stumps with very good results. A kill of between 75 to 95 per cent was obtained on stumps of four to eighteen inches in diameter, a lesser kill being secured on willow seedling beds. The procedure employed was to completely hack-girdle the stumps with an axe near the ground line and spraying a small quantity of the herbicidal solution into the band of gashes. To get the best results, care was taken to completely hack the entire circumference of the stump. The gashes were not required to be deep but just so that the cambium layer was severed to permit the entrance of the herbicide into the layer of growing tissue of the stump. For poisoning seedlings and button ball, the sprouts were trimmed to the ground and the stubble sprayed with the herbicide. A knapsack spray can was utilized for applying the solution. This equipment was capable of producing a forceable stream for stumps and a fine spray for the seedlings.

Since arsenic solutions are extremely poisonous if ingested, emphasis on safety in handling the sodium arsenite compounds was made to field

men on willow poisoning operations. Below are four routine precautions that were taken by the Pickwick operations.

1. That soap, wash basin, and water be provided on the job and that thorough washing of hands and arms be enforced before lunch and at the conclusion of the day.
2. In addition to the use of gloves (cloth), it was recommended that a heavy grease be applied to the hands and arms. This procedure protected the hands from cuts and scratches and prevented the entrance of the solution beneath the finger nails.
3. That the unit be equipped with first aid kits and that antiseptic dressings be applied to all cuts and scratches as soon as they occurred.
4. That periodical physical examinations, with urinalyses, be made at monthly intervals.

Later in the development of the operation, it was found advisable to discontinue the use of sodium arsenite as a herbicide due to the possible liability for deaths of grazing stock and cattle in the free range portions of the Pickwick Reservoir. Satisfactory results were received on willow stumps, using Diesel oil 33° Be. full strength as a herbicide, employing the same procedure as in the arsenic solution.

A total of 452.5 acres were poisoned in the drawdown area of the Pickwick Reservoir without any damage to cattle or men and the results aided greatly in effecting a clean water's surface in the shallow areas of the reservoir.

MARGINAL DRAINAGE

The maximum normal pool elevation of the Pickwick Reservoir is 414', and all depressions that would have remained isolated when the water level

was lowered to 410 feet were connected to the main body of the lake by drainage ditches. The representative of the Health and Safety Department made the reconnaissance of the reservoir area and requested that surveys for marginal drainage projects be made by the Maps and Surveys Division of the Tennessee Valley Authority. After the estimates of quantities and costs were submitted, the authorization for the construction was made to the Reservoir Clearance Division who in turn executed the drainage. The final approval of the projects was made by the Health and Safety Department. The designs of the ditch sections were given careful consideration so as to provide minimum maintenance after impoundage. All drainage followed natural outlets when practical, eliminating any sharp turns in alinement. Spoil banks were carefully placed with at least a six-foot berm and adequate laterals for side drainage.

The general practice in the Pickwick Reservoir was to provide side slopes to fit the condition of the soil. The majority of the sections had a minimum of a four-foot bottom, with 1 to 1 side slope, in cuts under five feet. The side slopes were increased to 3 to 1 on deeper cuts. The local topography governed the design of grades, but effort was made to have at least a 0.1% grade or more on all drainage ditches. At the conclusion of this report may be found pictures of typical marginal drainage with a sample of a preliminary plan and profile. A total of 59,048 feet of marginal drainage was constructed in the Pickwick Reservoir, representing 29,015 cubic yards of excavation. Most of the yardage was moved by speeder dragline, with a three-fourths yard bucket, but some minor projects were constructed by hand.

MARGINAL CONDITIONING OPERATIONS

It was necessary to schedule the initial removal of timber from the

Pickwick Reservoir over a period of two growing seasons. Heavy growths of coppice and herbaceous plants occurred in the cleared portions experiencing one or more growing seasons prior to impoundage. These growths favor mosquito breeding and are objectionable if left in the zone of fluctuation. Past experience in other reservoirs made it necessary to thoroughly condition the marginal areas of the Pickwick Reservoir prior to impoundage in 1938.

It was estimated that 5,000 acres lay between the 414' and 408' contours. Of this area approximately 2,500 acres consisted of old fields and meadows and 2,500 acres of timber land. A total of 4,447 acres were conditioned between the 414' and 408' contours. Approximately 1,893 acres below the 408' contour were worked for the removal of the scattered sprouts which extended into the zone of water level fluctuation.

Specifications

The Pickwick Landing Dam provided for a six-foot drawdown between the elevations 414' and 408' contours, the proposed schedule of fluctuation took full advantage of this available drawdown. This was deemed necessary for insuring adequate mosquito control during the first season of impoundage, regardless of the fact that possibly the entire six-foot drawdown might not have to be utilized. It was considered advisable to set the lower limit of conditioning at the 408' contour in order that a more complete inundation would prevail, constituting a greater killing effect upon the upland growths.

The final specifications set up for the Marginal Treatment Operations were as follows:

1. That the conditioning operations be started no earlier than September 1, 1937, and completed prior to impoundage.

2. That sprouts, weeds, other annual growths, corn stalks, vines etc., be generally removed between the 414' and 408' contours.

3. That sprouts which would extend above the 410' contour be cut.

Discussion of Specifications

The selecting of September 1 as the date of inaugurating the conditioning operation was a compromise. After this date, ordinarily, very little growth occurs, however, if the date was postponed to the first frost, approximately October 15, probably an appreciable amount of the grass and weeds would be dried and dissipated by the frosts thereby saving considerably on the conditioning operation. But taking into consideration the lost time due to fall rains after frosts and the difficulty of burning brush during this season in the low lands, it was desired to start the conditioning operation at the earliest possible time. This operation was completed about January 1 and it was then evident that further reconditioning after that date would be difficult and costly due to unfavorable weather conditions.

Section 2 refers to the conditioning of the zone of fluctuation. The degree of refinement was obtained by practical field interpretation. Generally, all sprouts and sizable annual growths were removed and disposed of in this zone, however, certain mediums were struck between what was essential to remove and what was not seriously objectionable. In small, protected areas close to high population densities, careful hand and mower treatment was employed while modifications were permissible on steep shoreline. In some areas rough conditiong below the 408' contour was employed. The extent of this operation was determined by the topography of the ground, size and density of the sprouts, and amount of exposure from wave action. It was not considered necessary to pile and burn any of the felled growth

below this point of drawdown. Observations indicate that only a very small per cent of such material will rise to the surface after impoundage if cut and pushed down.

Since the removal of sprouts and herbaceous plants on such a large scale had not been undertaken heretofore, field methods and practices required development. Various hand tools, drags, and team-drawn mowing machines and hay rakes were all given a trial under different conditions for development of the most efficient methods. Subsequent developments resulted in a very efficient and practical operation. Success of the operation may be attributed principally to the adaption to the work of horse-drawn mowing machines and hay rakes. The average cost for mowing and raking sprouts and annual growth for burning was $2.71 per acre as compared to $8.26 per acre for areas requiring hand cutting and piling.

Conditioning below the 408' contour which did not require piling cost only $1.44 per acre. The average cost of all methods and types of reconditioning combined was $6.16, or 1.4 man-days per acre. The total marginal area conditioned was 6,340 acres.

CONSTRUCTION OF FACILITIES FOR LARVICIDAL MEASURES

On large reservoirs it sometimes becomes necessary to supplement "biological control" with larvicidal measures. This method is very costly and has only a temporary value so that it is fast becoming merely a secondary method of mosquito control. Facilities for larvicidal measures were constructed for the Pickwick Reservoir under the planning and supervision of the Malaria Control Division to meet temporary and emergency situations in and around the high population densities. Two principal larvicides, oil and Paris green, were used on the Pickwick project.

The oil used is a mixture of four parts kerosene and one part black oil, having the following specifications:

Kerosene

To conform to Federal Specifications VV-K-211, having a specific gravity between 0.824 and 0.795 at 60 degrees Fahrenheit. At least 25%, 50%, 75% and approximately 100% by volume of the crude kerosene to be distilled off at 210, 220, 230 and 300 degrees Dentigrade, respectively.

Black Oil

To be a pure petroleum product free from fatty oils, fatty acids, resins, soaps, or other non-hydrocarbons, and having a specific gravity between 0.946 and 0.921 at 60 degrees Fahrenheit. The mixed oil to yield no more than 0.5% bottom sediment by centrifuge. Samples of the unmixed constituents to be supplied by bidders.

The purpose of the black oil is to give the mixture color in order to observe the rate of application. The oil is applied in either knapsack spray cans or in "water-oil" boat units. The water-oil unit (see attached photograph) consists of a 24-foot, flat bottom, shallow draft hull, powered with a 20 h.p. utility motor. The hull is equipped with a rotary, high-pressure pump unit, propelled with a 2-1/2 h.p. air-cooled unit which takes water from the lake and discharges through six feet of 1-1/4 inch hose and a 3/8 inch spray nozzle. Larvicidal oil is injected from two 70-gallon storage tanks into the suction line of the pump at any concentration desired which is discharged along with the water through the hose and nozzle. This equipment is capable of throwing a larvicidal stream from 75 to 100 feet with sufficient force to break up fine flotage and penetrate through vegetation.

The crew is made up of two men, one to maneuver the boat, the other to operate the spray equipment. The spray operator controls the amount of larvicide by observing the color of the spray of the oil-water mix, which

may vary from pale yellow to dark brown. When areas are encountered where the boat unit cannot operate, the crew equip themselves with the knapsack spray cans and treat the area by hand. Roughly, it may be assumed that oil is applied at a rate of 25 to 45 gallons per acre with the knapsack and of 20 to 30 gallons per mile of shoreline with the "water-oil" unit.

For the Pickwick Reservoir, fourteen of these water oil boats were constructed along with four warehouse bases and docks located about the reservoir (see map) from which to carry out the larvicidal program. Each of these subbases was equipped with a floating boat house, dock, tool storage building, 1,000-gallon gasoline tank with pump, 6,000-gallon larvicidal oil storage tank and small tools necessary for minor repair work. Each base was provided with a safe water supply and sanitation facilities conforming to Health Department regulations.

Paris green as a larvicide has a principal advantage over oil, mainly in ease of application, as dust may be drifted over areas where oiling methods would be difficult. Oil is a better larvicide and may be expected to kill most species of mosquitoes in any stage of larval development. Parisgreen, however, is effective only on the genus Anopheles, whose larvae feed at the water surface. Also, larvae in the pupae stage do not eat and consequently are not affected by the Paris green larvicide. In the concentrations applied for mosquito control in the Pickwick Reservoir, Paris green may safely be used in areas open to cattle without danger of harming them.

Paris green used as a larvicidal dust is applied mixed with a diluent of powdered soapstone (talc). The following is the specifications for Paris green.

> That the Paris green shall contain at least 50 per cent arsenious oxide; with no more the 3-1/2 per cent being soluble in water, and of such fineness that 100 per cent will pass 200-mesh screen, and 85 per cent pass 300-mesh screen, and that the product be toxic to Anopheles larvae in natural breeding places.

The dust is applied with knapsack hand dust blowers or mechanical dusters placed in boats. All of these units are similar to equipment used in dust applications for agricultural purposes. Operators of dusters soon become expert in drifting dust clouds over shallow exposures of water, obtaining satisfactory results at a low labor cost. For sizable "flats" or shallow areas requiring larvicidal treatment, favorable results have been received from airplane dusting equipment. The Tennessee Valley Authority had available two Stearman Biplane dusters for mosquito control operation in the Pickwick Reservoir.

The airplane dusting apparatus is similar to the agricultural "crop duster" (see photograph) and consists mainly of an 800-pound capacity dust hopper with mechanical agitator, having on the underside of the fuselage a venturi from which the dust is discharged.

The dust used in the airplane operation is mixed 22.2% Paris green by weight, while the hand dust is 16.6% Paris green by weight. To get the best results, the dust is applied at a rate equivalent to one pound of Paris green per acre.

To shorten the "hauling" or non-dusting flying time, an airplane landing strip, 2,000' x 300', and a dust storage house were constructed on Bear Creek to facilitate dusting operations in the central reservoir area. The landing field, an area already cleared and fairly well drained, was carefully grubbed of all sprouts and stumps. The approaches were cleared to provide safety in taking off the with heavy loads.

Since all airplane dusting operations are conducted in the early morning, it is necessary to have the landing strip smooth in order that the loaded ship may gain sufficient speed to get off on such a comparatively short runway without the aid of wind. For grading the surface, a road grader and "35" caterpillar were utilized. The field was planted in lespedeza early in the spring of 1938 and very little washing has been observed. The gullies which have occurred have been sodded with Bermuda grass with very excellent results.

Prior to May 1, 1938, all floating equipment, including boat houses, water-oil units, and inspection boats were transported to their respective bases, along with shipments of oil and dust larvicides. Twelve reservoir larvicidal oil tanks, with capacity of 2,000-gallons, were located about the reservoir to provide additional storage for emergency conditions.

A small scale map will be found in the appendix upon which has been superimposed the location of oil tanks, subbases, docks, airplane landing strip, and mosquito checking stations.

MAINTENANCE PROGRAM

Inspection and Reporting

To determine the effectiveness and to indicate where work was to be done, routine reports of larvae and adult mosquitoes were made in the Pickwick Reservoir. Prior to the impoundage, 50 adult mosquito catching stations were located about the reservoir and routinely inspected during the breeding season. The catching stations consisted of suitable resting places for the Anopheles quadrimaculatus, such as a dark barn with adequate blood supply located sufficiently close to the reservoir. The pre-impoundage mosquito density studies were obtained for three seasons and constitute a

representative baseline for comparison with post-impoundage catches. The measurement of mosquito densities in the Pickwick Reservoir is under the guidance of entomologists of the Malaria Studies and Control Division.

For the larval densities, each base has an inspector who is assigned a section of the reservoir to determine location and amount of anopheline breeding. The inspectors or "larvae dippers" work from outboard boats in order that the territory may be covered thoroughly each week.

For reporting the record of the adult inspections, we have the following form: In the first column is placed the number of the catching station, accompanied with any remark about the unusual condition of the station at the time of the visit. The technique was to first count the number of the resting adults and then catch as many as possible. The catch was then identified and tabulated in the remaining column. Punc and Cruc are abbreviations for Anopheles punctipennis and Anopheles crucians, two species not considered of medical importance in malaria transmission in this country but found in the Pickwick Reservoir area. The last column is provided to indicate catches of all genera of mosquitoes other than Anopheles.

The shoreline of the Pickwick Reservoir has been divided into mile stations to facilitate progress reporting. The mileage begins with zero at the north side of Pickwick Dam and accumulates around the entire main shoreline back to mile 418, which is the south side of the dam. This, an area may be defined by its mile post and extent of work from mile post to mile post. This is the method used in describing the area inspected for larvae and progress of treatment measures.

Below is the inspection form for mosquito breeding. In the first column the numbers indicate the miles between which the inspection was

TVA 434 (8-1-38)
TENNESSEE VALLEY AUTHORITY

INSPECTION FOR MOSQUITO LARVAE

RESERVOIR PICKWICK INSPECTOR GAILIL DATE 6/8/38

LOCATION PLACE INSPECTED	CONDITION	NO. DIPS		LARVAE FOUND						
				ANOPHELES STAGES						CULICINE
		TOT.	POS.	TOT.	1	2	3	4	P.	
105-106	Floatage	50	0	0	0	0	0	0	0	10
106-107	Drift	60	18	24	12	11	1	0	0	10
107-108	Vegetation	50	8	12	8	4	0	0	0	0
111-112	Willow weed	45	14	20	12	6	2	0	0	10
113-114	Floatage	55	16	20	14	5	1	0	1	0
114-115	"	40	3	4	4	0	0	0	0	0

REMARKS. Breeding found in pond near station number 36.

TVA 435 (3-1-36)
TENNESSEE VALLEY AUTHORITY

INSPECTION FOR ADULT MOSQUITOES

RESERVOIR PICKWICK INSPECTOR ANDERSON DATE May 21

STATION	REMARKS	NUMBER OF MOSQUITOES FOUND						
		ANOPHELES						CULICINE
		QUADRIMACULATUS				PUNC.	CRUC.	
		COUNTED	CAUGHT	F	M			
1		2	2	2	0	3	0	0
2		11	11	11	0	0	0	0
3		12	12	12	0	0	0	0
4		0	0	0	0	0	0	0
5		4	4	4	0	1	0	0
6		46	46	45	1	3	0	0
7		7	6	6	0	0	0	0
8		2	2	2	0	0	0	0
9		2	2	2	0	0	0	0
10		1	1	1	0	0	0	0

REMARKS: No stock in station 10

made, with the area more definitely defined by the condition found, such as drift or fallen tree tops. The inspector is trained to pick out only likely breeding places in which to make his representative number of dips, using a common water dipper of rugged construction. Each dip is recorded and dips containing larvae are counted under "Positive Dips". The total number of Anopheles larvae obtained in the positive dips are recorded in the next columns, with a breakdown as to larvae stages. P in the last stage stands for pupae. The predominant size of the larvae is an important factor in the control operation for the stage will determine to some extent what area will have priority of treatment. For example, two areas have sufficient larvae production to demand use of larvicides. Both are close to equal population densities but one area must be treated prior to the other because it has larvae predominantly in the fourth and pupal stages, while the other has larvae in the second and third stages. The last column on the dipping report is used to record the number of mosquito larvae found other than Anopheles.

Control Procedure

The Resident Sanitary Engineer in the Pickwick Reservoir is responsible for executing the control program as set out by the Malaria Studies and Control Division of the Tennessee Valley Authority. Assisting the engineer are two control foremen trained to direct field activities in mosquito control. Reporting to the malaria control foremen are the base sub-foremen who are responsible for the boats, supplies and equipment assigned to his base, and directs the forces in the control work, whether larvicidal measures, drainage, or growth control. The work is outlined and assigned to the sub-foreman each day by the malaria control foremen after the field findings

have been analyzed with the engineer. In attempting to resort principally to "biological control", it is impossible to set out a routine plan of mosquito control which could be followed on the Pickwick Reservoir. At the end of each work day, the sub-foremen prepare a daily time sheet and progress report, an example of which is attached.

The daily report form proved very successful in the Pickwick operations and serves many purposes as shown below. From this sheet the time is supplied for the pay roll office. This daily report form is designed to give the detail breakdown of the various operations for cost accounting purposes. On the same sheet is the daily summary of the anti-larval measures for each boat unit operating from the bases, giving information on the number of hours operated with amounts of fuel and larvicide used. Under progress is shown the miles between which treatment was made, with an estimate of the actual miles or acres treated. If the operation was listed as (1), or oiling, the progress would be recorded in miles, while operation (2), or dusting, would be recorded in acres. The form is supplied with plenty of room for including any request for supplies or pertinent remarks relative to the daily operation. The small black in the bottom center is a memo or receipting the sub-foreman's supplies as he receives them from day to day.

All of the base forms are sent daily to the main office for posting along with the larval dipping records. These records are used in preparing the monthly cost statements and the engineer's weekly summary of mosquito control operations, which is sent out to various persons and agencies interested in the operation. The engineer's report, example of which is attached, summarizes the operations and inspections for the week. Under daily water elevations is plotted the fluctuation as recorded at different

sections of the reservoir, since the upper reaches are subject to a considerable backwater curve.

Summary of Season 1938

The water elevation of the Pickwick Reservoir was raised to the maximum controlled surcharge of 418' on April 13 and held there sufficiently long to effectively strand the majority of the drift and fine flotage. This is called seasonal water level fluctuation. That is, high water level during the winter and early spring and lowering rapidly to the maximum summer elevation at the beginning of the mosquito season to produce a clean shoreline upon which all plant life has been considerably retarded. Routine water level variations were inaugurated on May 1, after the water had been maintained in excess of 414' elevation for the greater portion of April. The routine water level fluctuation on Pickwick provided for a cyclical fluctuation of 1.2' weekly, combined with 0.1' per week recession.

The unusually clean shoreline condition, with the water level variations, provided favorable mosquito control with no use of larvicides until the malaria control water level fluctuation was interrupted due to high stream flows in the Tennessee Valley. The high water level, together with ideal breeding weather, resulted in increased breeding of Anopheles quadrimaculatus. Larvicidal operations were directed at once to control increased production. The reservoir as a whole was handled by boat and hand equipment with reasonably good results.

Airplane dusting equipment was employed in one area where emergent aquatic vegetation and shallow water made that method desirable. The general reservoir condition was greatly benefitted by the rapid drawdown which occurred during the week ending August 10. With normal stream flows, the routine fluctuation schedule was resumed, with favorable results with but little use of larvicides. Some breeding was experienced in marginal

depressions which were filled by high water elevations and by backwater curves, and the drainage of these depressions was carried out throughout the remainder of the season. There is attached a chart showing the influence of larvicide and water level fluctuation on Anopheles control in the Pickwick Reservoir for the season of 1938.

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(2) Stromquist, W. G. - "Malaria Control in the Tennessee Valley", Civil Engineering, Vol. 5, No. 12, 1935, pp 771-774.

(3) Regulations Governing Impounding of Waters - Alabama State Board of Health.

(4) Kiker, C. C. - Stromquist, W. G. - "Importance of Reservoir Preparation in Mosquito Control on Impounded Water", delivered at the National Malaria Committee in Oklahoma City, Oklahoma, November 1938.

(5) Kruse', C. W. - Williams, J. W. - "Report on Marginal Conditioning Operations in the Pickwick Reservoir - 1937"

(6) Kiker, C. C. - "Lectures on Malaria and Mosquito Control", delivered at Vanderbilt University November 1937.

DAILY TIME DISTRIBUTION

NAME	HRS	RATE	OPERATION * 1	2	3	4	5	6	7
James Statom	8	.75	8						
Bob Brown	8	.45½		8					
M. Matlock	8	.45½		8					
J. Aston	8	.47½						8	
R. Gammel	8	.47½						8	
N. Steveson	8	.47½				8			
Bill Curtis	8	.47½				8			
TOTALS									

PROGRESS Ditching at ml 178 150 lin ft.

Drift removal at mile 192 300 lin ft.

DAILY REPORT OF MOSQUITO CONTROL WORK

RESERVOIR PICNICK BASE Spring Creek DATE 6/1/68

EQUIPMENT NO.	LARVICIDES TANK NO.	LARVICIDES OIL GALS.	LARVICIDES P.G. DUST LBS.	HERBICIDES LBS.	FUEL GAS. GALS.	FUEL OIL QTS.	MOTOR OPERATED HOURS	MOTOR OPERATED MINS.	PROGRESS *	PROGRESS FROM	PROGRESS TO	PROGRESS MILES	PROGRESS ACRE
54031	2	52			10	1	6	0	1	145	183	3	
54032			100		8	0	4	30	2	210	218		5
TOTALS	X												

* OPERATIONS: 1 - Oiling 2 - Dusting 3 - Rebrushing 4 - Drift Removal 5 - Aquatic Growth Control 6 - Drainage 7 - Others

SUPPLIES RECEIVED

Oil _____ gal.
P. G. Dust _____ lb.
Gasoline _____ gal.
Motor Oil 55 gal.

REMARKS

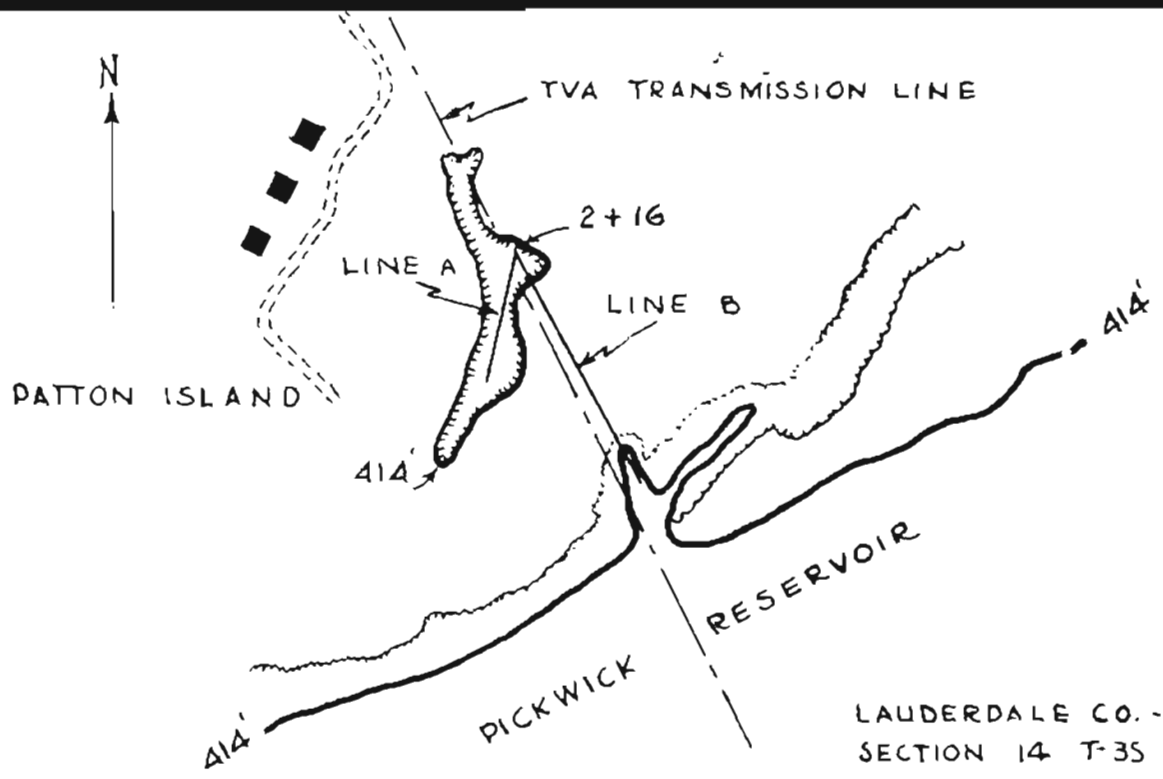
James D. Statom
Foreman

1/29

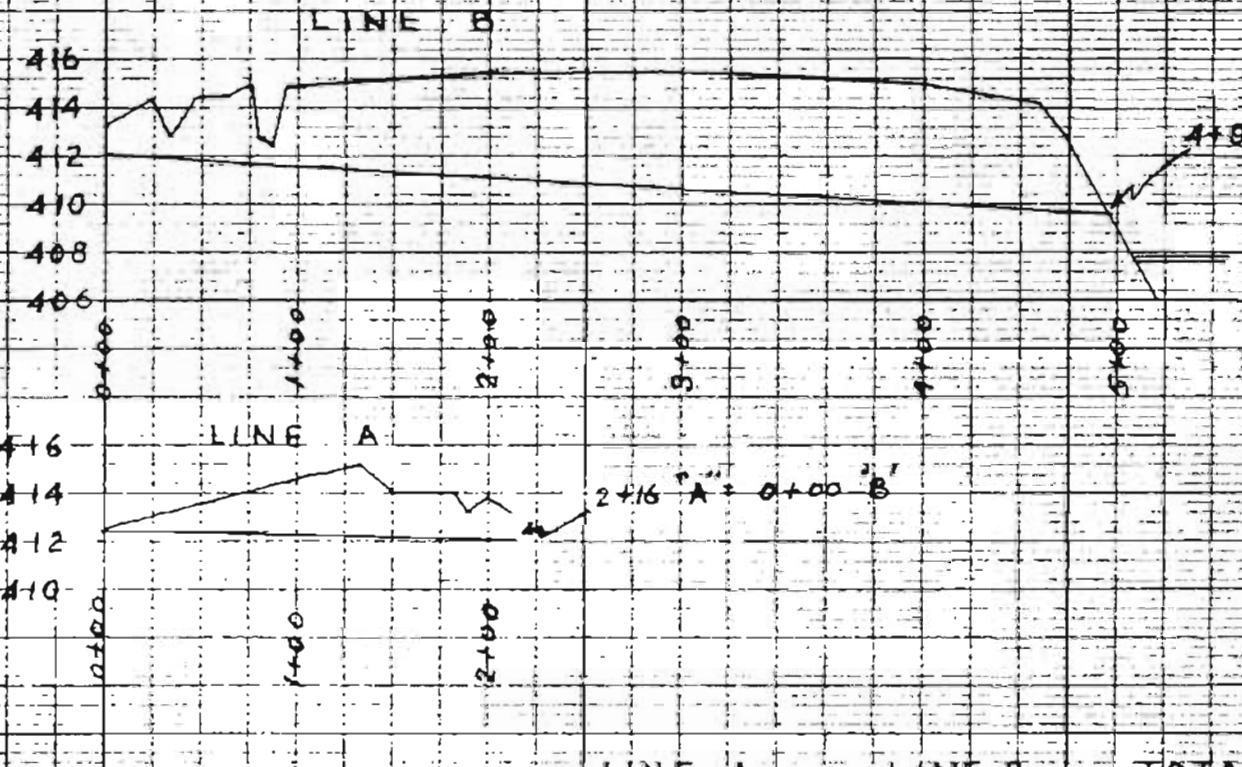

7-1-36 P-588

MARGINAL DRAINAGE PROJECT A - 1

SEVEN MILE ISLAND PICNWICK RESERVOIR



MARGINAL DRAINAGE PROJECT A-10



	LINE A	LINE B	TOTAL
LENGTH	216'	192'	708'
GRADE	0.18%	0.44%	
SIDE SLOPE	1 to 1	1 to 1	
BOTTOM WIDTH	4'	4'	
YARDAGE	67.04	556.66	623.10

Upstream view of completed ditch on Marginal Drainage Project A-5, Collier Slough, in Pickwick Reservoir, Alabama. The ditch has a six foot bottom with a 3 to 1 side slope. This area was under water when excavation was executed.


12-15-37-P-K-2464 H

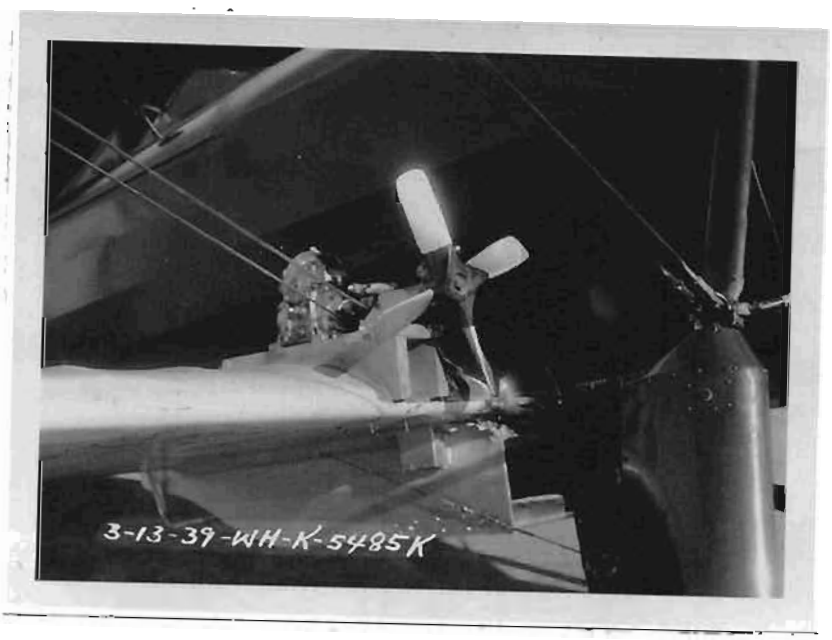
MARGINAL CONDITIONING OPERATIONS

Showing hand removal of coppice and herbaceous growth in the shallow flats of upper Yellow Creek in the Pickwick Reservoir.

Tools used in the final marginal conditioning operations. From left to right: "air-oil" wood burner, mower tooth or fire rake, home made topping blade, double blade bush hooks, ax, and pitch fork for piling growth for burning.

Shoreline condition after conditioning with team drawn mowers. This area is ready for wind-rowing and burning.

Stearman dusting airplane used in mosquito control opera tions in the Pickwick Reservoir.



Close up view showing agita tor drive, venturi and arm to dust release valve.

Larvicidal boat equipped with power dust blower

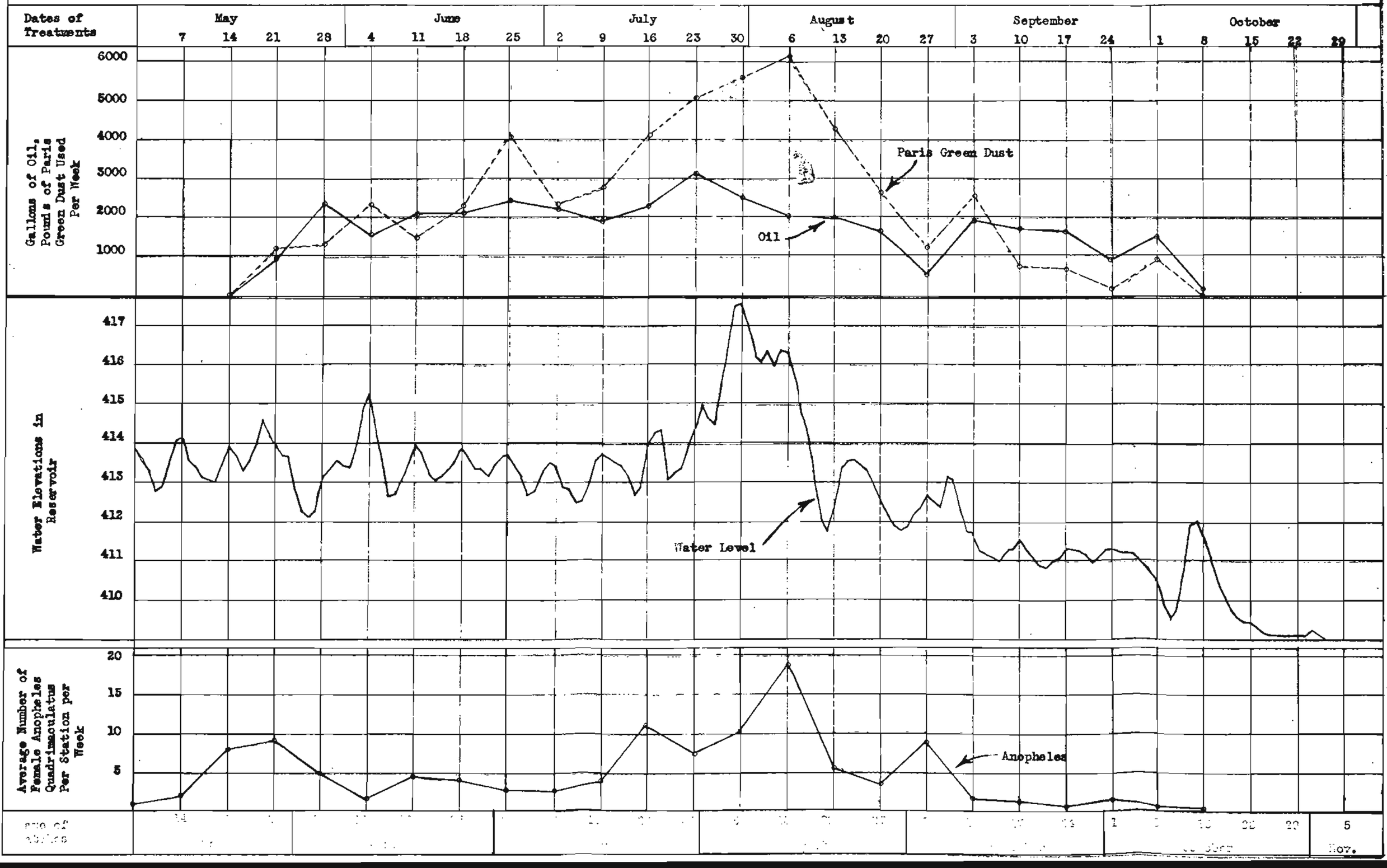
"Water-oil" boats of the Pickwick mosquito fleet.

Knapsack spray can and hand dust blower equipment.

Airplane loading field near Bear Creek of Pickwick Reservoir.

INFLUENCE OF LARVICIDES AND WATER LEVEL FLUCTUATION ON ANOPHELES CONTROL

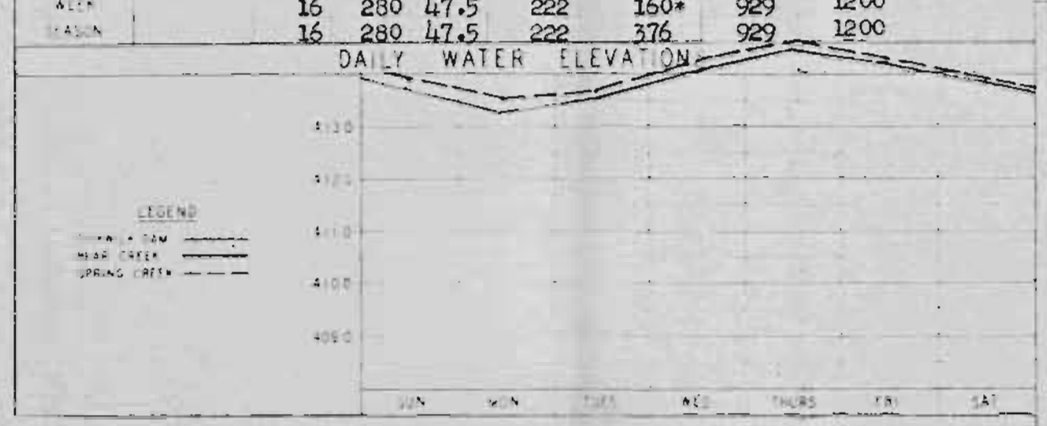
PICKWICK RESERVOIR - 1938



SUMMARY OF OPERATIONS

	SHORELINE TREATMENT: SHORELINE MAINTENANCE MILE	MAN HOURS: LARVAL	MAN HOURS: SHORELINE IMPROVEMENT	MAN HOURS: ADULT	MATERIALS USED: LARVAL GALLONS	MATERIALS USED: SHORELINE IMPROVEMENT CU. YDS.	MATERIALS USED: ADULT GALLONS
WEEK	16	280	47.5	222	160*	929	1200
SEASON	16	280	47.5	222	376	929	1200

DAILY WATER ELEVATION



*Week: 167.9 cubic yards
Season: 329.9 cubic yards

SUMMARY OF INSPECTIONS

DATE	LARVAL: INSPECTIONS	POSITIVE	NEGATIVE	% POSITIVE	DIPPERINGS	POSITIVE	NEGATIVE	% POSITIVE
5-16	2	2	2	0	35	11	50	
"	11	11	11	0	71	35	111	
"	12	12	12	0	56	31	59	
"	0	0	0	0				
"	4	4	4	0				
"	46	46	45	1	45	12	34	
"	7	6	6	0				
"	2	2	2	0	25	4	7	
"	2	2	2	0				
"	1	1	1	0	35	14	27	
5-17	19	19	19	0	35	9	24	
"	0	0	0	0				
"	2	2	2	0	70	14	60	
"	0	0	0	0	45	3	4	
"	7	7	7	0	145	48	174	
"	2	2	2	0				
"	10	10	10	0	50	10	21	
"	3	3	3	0	80	19	48	
"	2	2	2	0	35	4	4	
"	0	0	0	0				
"	0	0	0	0	100	0	0	
"	0	0	0	0	30	4	18	
5-18	0	0	0	0				
"	1	1	1	0				
"	1	1	1	0				
"	5	5	5	0	200	14	20	
"	0	0	0	0				
"	1	1	1	0				
"	14	10	10	0				
"	0	0	0	0				
"	12	10	10	0	175	59	81	
"	5	5	5	0				
"	0	0	0	0				
"	3	3	3	0	75	12	24	

DATE	ADULT: INSPECTIONS	POSITIVE	NEGATIVE	% POSITIVE	DIPPERINGS	POSITIVE	NEGATIVE	% POSITIVE
5-18	22	22	10	12	110	40	59	
"	100	91	91	0	95	32	45	
5-19	45	38	38	0	310	121	206	
"	6	6	6	0				
"	2	2	2	0				
"	1	1	1	0				
"	8	6	6	0				
"	2	1	1	0	43	29	194	
"	0	0	0	0	26	20	106	
"	15	14	14	0				
"	16	15	14	1	137	83	214	
"	4	4	4	0				
"	10	10	10	0	31	22	125	
"	15	14	14	0	50	24	66	
WEEK TOTAL	420	391	377	14	2109	681	1783	
AVERAGE	8.7	8.1	7.8	0.2				0.8
SEASON TOTAL	549	517	502	15	3982	1701	2294	
AVERAGE	2.8	2.7	2.6	--				0.4
5-16	22	22	22	0				
5-18	0	0	0	0				
5-13	0	0	0	0				
WEEK TOTAL	22	22	22	0				
AVERAGE	7.3	7.3	7.3	-				
SEASON TOTAL	31	31	31	0				
AVERAGE	2.5	2.5	2.5	-				

WEEKLY REPORT OF MOSQUITO CONTROL OPERATIONS
WEEK ENDING May 21 '38

PICKWICK LANDING RESERVOIR
TENNESSEE VALLEY AUTHORITY

I N D E X