DRAINAGE MAINTENANCE

FEDERAL SECURITY AGENCY
U. S. PUBLIC HEALTH SERVICE
MALARIA CONTROL IN WAR AREAS
ATLANTA, GEORGIA OCTOBER 1945

CONTENTS

DRAINAGE MAINTENANCE AND RELATED ACTIVITIES

Maintenance as discussed in this handbook includes the periodic improvement of drainage ways and certain accessory facilities, such as access roads. Small items of non-recurrent repair work are also included.

All drainage needs some maintenance, but the need for maintenance work is greatest on temporary drainage construction. Most MCWA drainage has been of a temporary nature since the war emergency needs of 1942 and 1943 justified rapid construction with emphasis on conservation of materials and equipment.

The cost of drainage maintenance can be held to a minimum if ditches are patrolled frequently, if obstructions are removed promptly, and if other needed work is noted. Immediate removal of an obstruction may take only a few minutes; but if it is allowed to remain, large quantities of silt may accumulate behind it. Bank slides and culvert blockage can be cared for with least expense if repairs are made at an early stage. Prompt attention to these maintenance needs also avoids unnecessary larvicidal costs.

PLANNING MAINTENANCE WORK

Most MCWA projects involve a mixture of larviciding, drainage maintenance, and drainage construction. In this country, malaria transmission is seasonal; and, accordingly, larviciding is necessary only during the malaria season. However, work on projects should be planned, as far as possible, on an annual basis. In this way, a nucleus of experienced laborers may be kept from year to year.

This is not always possible because of sheer lack of useful work which can be done in the "off season". In most cases, drainage construction and the heavier and less urgent maintenance items should be reserved for "off season" projects. Accordingly, light cleaning, such as removing vegetation from ditches, ditch banks, or ponds and removing obstructions from ditches, is carried on actively during the breeding season. During the "off season", larviciding and removal of quick-growing vegetation are discontinued.

During the winter months, these activities are replaced by drainage construction and heavier types of maintenance work, such as re-grading ditches, repairing ditch banks and special structures, heavy clearing required in making trails for vehicles and foot travel, snagging and clearing boat lanes in streams and ponds, "corduroying", and filling and grading low places in swamp roads. Occasionally, heavy work on water courses must be done when flow is low, irrespective of the season.

ACTIVITIES OF MAINTENANCE CREWS

On large projects, it may be desirable to have special maintenance crews, but generally it is preferable to shift the crews from one type of work to another as the need arises. Maintenance work should be planned to permit quick shifts from maintenance to larviciding and vice versa. This is essential, because the need for larviciding is directly affected by entomological findings and weather, while maintenance can be carried on in any weather which permits outdoor work.

Frequently a crew may perform both maintenance and larviciding during the course of a day's work. Paris green generally can be applied effectively only when the air is still, or nearly still. It is often possible to dust breeding areas early in the morning when the air is still and use crews on maintenance in the same vicinity during the balance of the day. Regardless of the type of larvicide used, crews larviciding small, widely-scattered breeding places should often perform mixed activities during the course of the day.

Careful planning is essential, if maintenance activities are to be properly coordinated with larviciding. The distinction between off-season and current maintenance is important. This must be made with consideration of entomological findings and efficient utilization of supervisory and labor personnel during the winter months.

PRIORITY OF MAINTENANCE WORK

Selection of maintenance work should be based on importance. Determination of what is most important must be left to a large extent to the judgment of the area supervisor, but it should conform to the general principle of bringing about the greatest *reduction in number of "quads" reaching the protected area.* The following general order of priority should be observed:

First: Heavy "quad" breeding places within one-half mile of the protected population which *cannot* be effectively larvicided until maintenance is performed.

Second: Heavy "quad" breeding places within one-half mile of the protected population which *can* be effectively larvicided.

Third and Fourth: Same as First and Second, but breeding places over one-half mile distant from the protected population.

Fifth: Same as First and Second, but where breeding is moderate or light but continuous.

Sixth: All other "quad" breeding problems where maintenance is needed.

While this order of priority should be followed in principle, it can be modified for individual situations. For example, light breeding a hundred yards from the protected population can be far more important than heavy breeding over a half-mile away.

CREW COMPOSITION

Maintenance labor crews should be small unless heavy clearing or re-grading work is involved, in which case several small crews should be used. Three to five men with a foreman make a very satisfactory crew for most work.

Since maintenance often involves widely separated small jobs and extensive patrolling of drainage systems, it is desirable to have a "straw boss", in addition to the foreman, who can take charge of the unit when the crew is divided on small jobs. Promotion of the "straw boss" to senior laborer makes a satisfactory arrangement. Where job conditions and type of labor permit, laborers should be given an opportunity to do the work they like best.

DETAILED MAINTENANCE ACTIVITIES

The remainder of this manual is devoted to a more detailed discussion of various drainage maintenance activities. These include methods of restoring to proper grade badly eroded ditches, the maintenance of clean, free-flowing drainageways, keeping drainage structures in good repair, herbiciding of ditch banks, prevention of silting, removing vegetation from ponded areas, inspecting and maintaining outlet structures and underground drainage systems, and the construction of fence crossings to prevent damage to drainage ditches by livestock.

RE-GRADE DITCHES WHEN NECESSARY

A primary problem in malaria control maintenance is the re-grading of existing drainage ditches and other water courses. Re-grading is distinguished from ditch reconstruction by arbitrarily setting an average maximum excavation depth of 6 inches. Since re-grading usually requires considerable labor, it should be planned for "off season" performance where feasible.

Assuming, of course, that all of the ditches are of direct malaria control importance, ditches should be re-graded when —

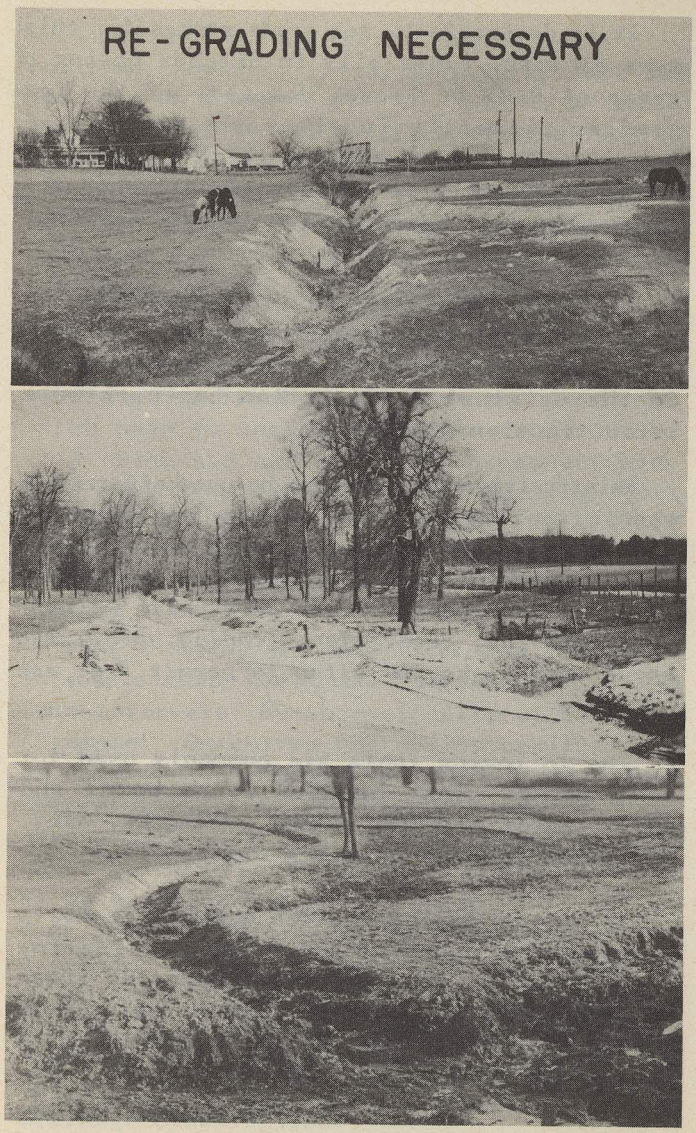
1. The bottom is irregular, with holes and mounds causing water to stand long enough for mosquito breeding.

2. The original ditch has a fairly even bottom but has silted enough to prevent complete drainage of the pond or other water-holding areas which the ditch was originally intended to drain.

3. "Quad" breeding is occurring ir pockets along the edge of the ditch.

4. Re-grading will concentrate water in a small channel in the center of a wide-bottom ditch.

5. The ditch has too great a fall and should be flattened by installing ditch checks.



It is desirable to set grade stakes for this type of work, especially in ditches having a grade of 0.2% or less. However, if the re-grading primarily involves the removal of loose sand or loam from a ditch in clay or other hard earth, it is easy to tell when the excavation has been carried to the original grade.

A primary consideration in planning the re-grading job is an adequate outfall. In many cases, the absence of a satisfactory outfall in the original construction has created a reconstruction problem.

Relatively large crews can be used effectively when extensive or major re-grading is being done. Ten to fifteen men (two or three larvicidal crews) can work efficiently on such jobs. *Organize the laborers into work units (clearing, cleaning, excavation, grading, etc.) and space them along the ditch to permit free use of tools.*

The following tools are commonly used for re-grading: long-handled round-point and square-point shovels, spades, mattocks, axes, and miscellaneous clearing tools.

In an old drainage ditch which is heavily overgrown with grass and brush, a clearing crew of two to four men should precede those on excavation and grading. The brushing crew should be followed by the dirt-removing crew during the re-grading. On the lighter jobs, the dirt moving may all be done in one step by

a single unit crew. Where heavy re-grading is required, however, it may be well to have the men in two groups, one on rough excavation and the other to cut to finished grade and to shape and finish the ditch bank. Three groups may be desirable if the bank-shaping needed is heavy enough to justify making this a separate operation. Bank-shaping should precede finishing work on the ditch bottom.

In brushing, willows and similar trees which grow rapidly should be completely removed from the ditch. (Willows on the banks which help to anchor the soil should not be cut.) Bank sod and roots which prevent erosion should not be disturbed. Skinning roots and grasses from the banks may temporarily improve the appearance of a ditch, but it will increase future maintenance and should be avoided.

After clearing, set grade stakes at convenient intervals along the ditch, generally at 50-100 foot intervals, but occasionally at 25 feet. (Example: On curves where fine grading must be done, set at shorter intervals.) Details of determining grade, setting grade boards, etc. are covered more fully in the manual on Hand Labor Drainage Construction. If the ditch is to be straightened or relocated, this may be done either before or at the time grade stakes are set. Throw all spoil well back from the ditch bank and spread to keep surface water from washing the earth back into the ditch. Where possible, use spoil to fill adjacent low spots, as indicated in the manual on Hand Labor Drainage Construction.

USE GRADE MONUMENTS TO PREVENT SCOURING

In ditches with very flat grades requiring frequent re-grading, it may be desirable to set concrete grade monuments in the ditch bottom. As indicated by the name, "grade monuments" are concrete blocks 12 to 18 inches wide, 2 to 6 inches thick, and in length equal to 12 inches more than the width of the ditch. They may be of concrete (precast or poured in place) or masonry construction and are set at the grade of the ditch bottom at intervals of 100 to 500 feet. Grade monuments save repeated setting of grade stakes for maintenance work and prevent excessive scouring of the ditch bottom.

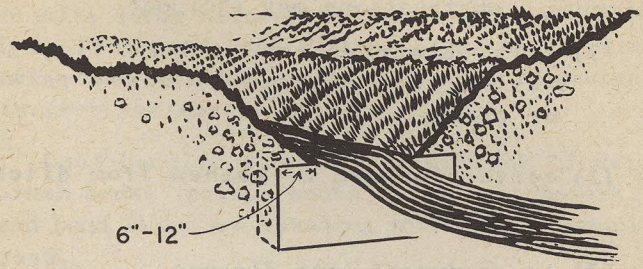
* * *

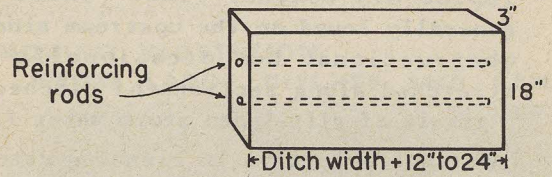
If ditches receiving adequate light maintenance and patrolling also require re-grading more frequently than once a year, consideration should be given to permanent construction measures, including lining.

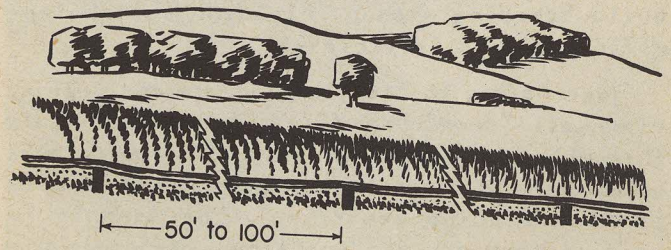
If the ditch flow carries large quantities of silt and sand, careful investigation should be given to the possibility of settling out the sand and silt in low flat places before the water reaches the ditch; or installing erosion control devices, such as sod and ditch checks, in tributary ditches.

Under average conditions, from two to five man-hours are required per cubic yard of excavation in re-grading work.

GRADE MONUMENTS







Longitudinal Section of Ditch

MAINTAIN CLEAN, FREE-FLOWING DITCHES

Ditch-cleaning involves the removal of vegetation and obstructions from drainage ditches. Obstructions may include:

(1) logs, branches, and other flotage washed into ditches by heavy rains or floods.

(2) earth sloughed or washed from ditch banks.

(3) trash dumped into ditches.

(4) small deposits of sand or silt which impede dry weather-flow. (These are generally found on the upstream side of obstructions, but occasionally are stretched along sections of ditches as a result of silt-laden storm water flow.)

An important objective in cleaning ditches and other water courses is *to keep water flowing* in order to prevent mosquito breeding. Since vegetation grows most rapidly during the mosquito breeding season, cleaning must be coordinated with larviciding.

Just *before* the larviciding seasons begins, clean all "*quad*" *breeding ditches* thoroughly. This will avoid the necessity of cleaning work interfering with the larvicidal schedule. During the larviciding season, ditches should be cleaned from one to five times—depending on their proximity to a protected area, the amount of water present, and the rapidity of plant growth. Vegetation in ditches not only impedes the flow of water but, more important, gives shelter to mosquito larvae.

In newly dug ditches, cleaning may be needed at frequent intervals — especially if heavy runoffs occur before the ditch bank is stabilized. *Inspect such ditches after heavy rains and remove obstructions immediately to prevent further sedimentation.*

Long-handled shovels, ditch-bank blades, brush hooks, potato hooks, axes, pitch-forks, and hand lines are cleaning tools most commonly used.

Depending on the amount of work to be done, a crew of one to three men is best for most ditch-cleaning operations.

REMOVING VEGETATION FROM LARGE DITCHES AND CANALS

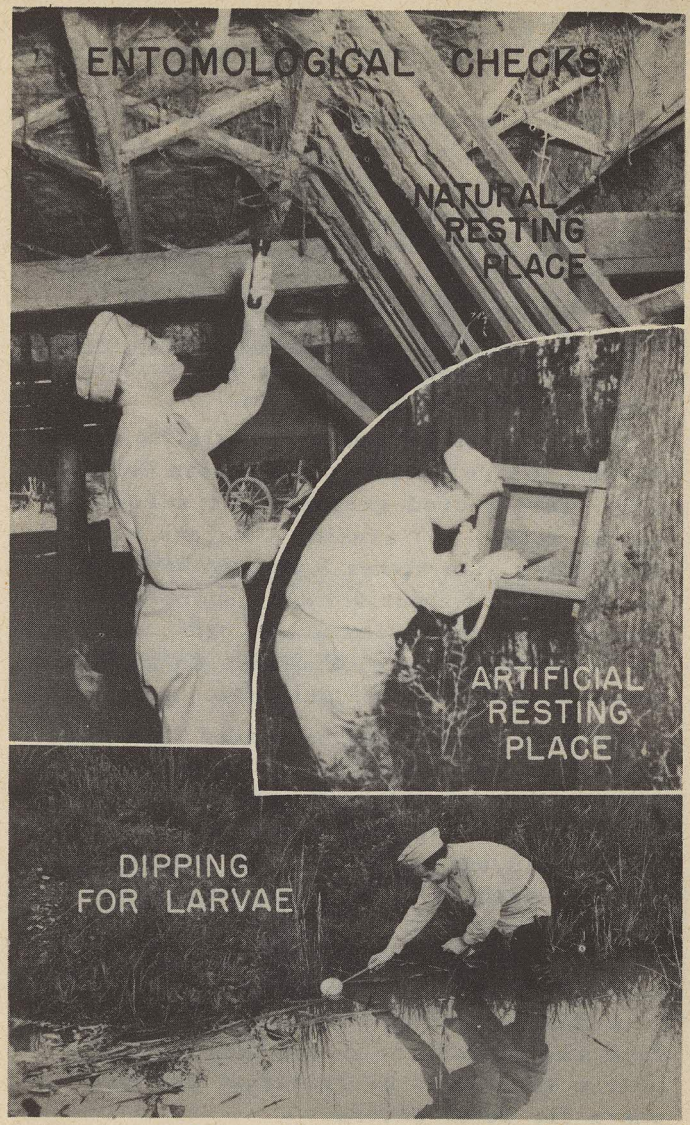
COORDINATE DITCH CLEANING AND OTHER MAINTENANCE ACTIVITIES WITH ENTOMOLOGICAL FINDINGS

Such coordination is not always possible to the extent desired at the beginning of project operations on an emergency program. But progress can be made as information is collected on "quad" breeding in individual breeding places and over the general area.

On some projects, especially in those areas most favorable for *punctipennis* and *crucians*, "quad" breeding rarely occurs in either ponds or grassy ditches. Under these conditions, it is useless to continuously clean many miles of ditches year after year on the grounds of preventing "quad" breeding. *Keep these places under surveillance, and do not carry on larviciding or drainage maintenance until "quads" are regularly found in considerable numbers in larval and adult mosquito collecting stations.* If adult counts in nearby resting stations reach 10 females or more, larviciding and drainage maintenance activities should be initiated on these ditches.

In those few zones where experience shows that "quad" breeding occurs promptly when drainage is neglected, *plan maintenance work to prevent breeding before it takes place.*

Still other project zones are intermediate between these extremes. Here, the "rule of reason" should be applied.



KEEP DRAINAGE STRUCTURES AND ACCESSORIES IN GOOD REPAIR

Repairs to drainage structures should be made during the "off season", except those that are urgent. Drainage structures and accessories include:

1. Drainage ditches.

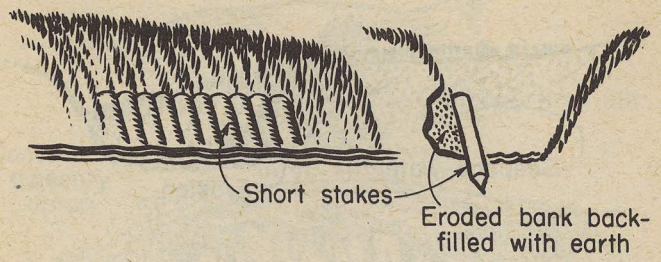
2. Bridges, culverts, and tide gates.

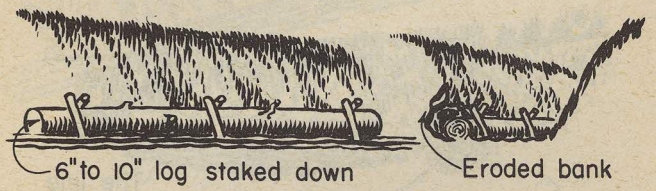
3. Access roads and trails used primarily by by MCWA vehicles and men.

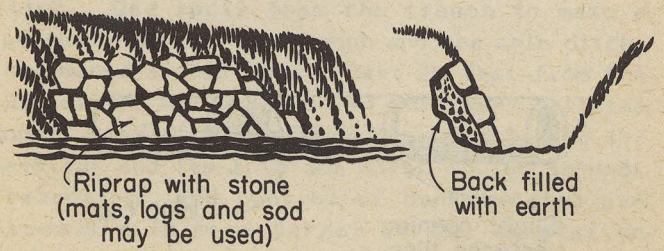
Principal repairs needed on existing drainage ditches are (a) sodding banks with Bermuda or other well-rooted grasses (not suitable for winter work), (b) staking the toes of eroded ditch banks with stakes 1 to 3 inches in diameter and spaced about 2 inches apart to prevent further damage, (c) installing other revetments at failure points, (d) relocation, replacement, or revetment of culverts.

Surface run-off can be guided into ditches by digging short trenches 6 inches to a foot deep leading into the side of the ditch. This can be done in hard clay without causing erosion. Where soils are softer and the volume of run-off appreciable, it may be necessary to place an apron on the ditch bank at each principal trough. Aprons may be constructed of loose field stone, field stone with mortared joints, or a thin slab of concrete. They should extend from the top of the ditch bank to the ditch bottom and should be flared at the upper end where the water enters.

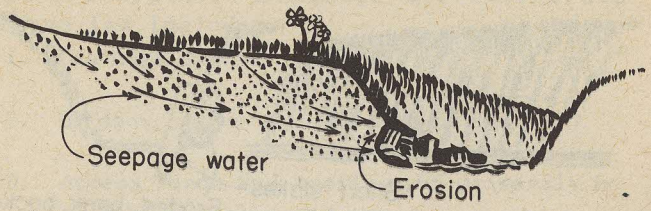
DITCH BANK EROSION REPAIRS

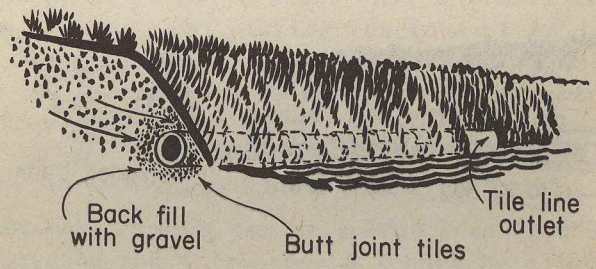


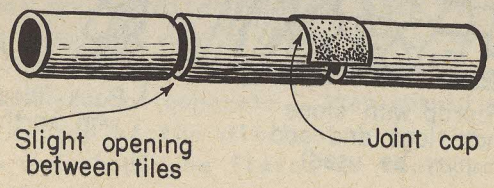




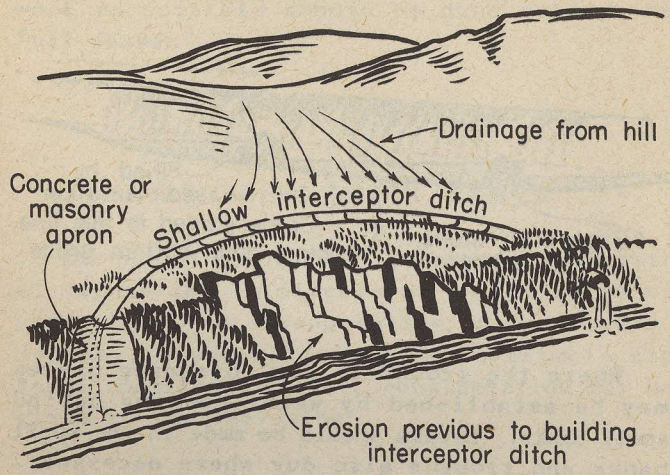
SEEPAGE EROSION IN DITCHES





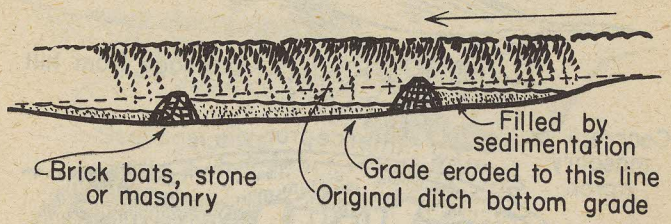


PROTECTION OF BANK AGAINST SURFACE EROSION



Erosion of ditch banks in deep cuts can be corrected by digging shallow trenches in the high ground alongside of and paralleling the ditch. Use spoil from the trench to make a low mound between the trench and the main ditch. This mound should be at least 2½ feet from the edge of the ditch bank. In this way, hillside runoff can be guided along the ditch beyond the deep cut and fed into the ditch in low ground. Prevention and control of bank erosion are discussed in more detail in the chapter on Drainage Design.

DITCH BOTTOM EROSION



Where the ground is low, breeding places may be established by water pooling behind spoil banks. Breaks should be made in the spoil banks, and troughs also dug where necessary.

Fill water-holding stump holes when spoil banks are near. Old spoil banks which are too close to the ditch and which are "ravelling" into the ditch should be trimmed back. Dead trees or trees along ditch banks whose root systems have been weakened by excavation are likely to slide into the ditch. These trees should be cut down.

Improperly functioning bridges and culverts on county, State or Federal Aid highways should be reported to responsible authorities. If, however, the correction is minor and urgent, it should be done immediately by MCWA labor. This refers only to the drainage features of these structures.

Roads and trails (and their drainage structures) used primarily by MCWA vehicles and men should be maintained in passable condition during the malaria season, but as much of this work as possible should be done during the "off season".

* * *

HERBICIDING DITCH BANKS

The use of herbicides to prevent the growth of vegetation in ditches or on the edges of ponds has been disappointing in most cases. However, where materials are available and local conditions permit, consideration may be given to the following:

1. Several *chemicals* have been used successfully to kill grass and weeds, but it must be remembered that these are very poisonous and may kill small animals and fish in the vicinity.

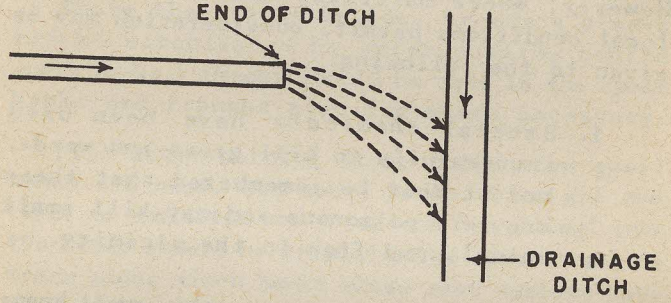
2. *Burning* the vegetation with a small knapsack flame-thrower works fairly well but is a hazardous undertaking in dry weather.

3. A number of projects have used old *crankcase oil* to spray on the vegetation. This kills the vegetation fairly well but is hardly worthwhile unless the oil can be obtained without cost.

PREVENT SILTING IN DITCHES

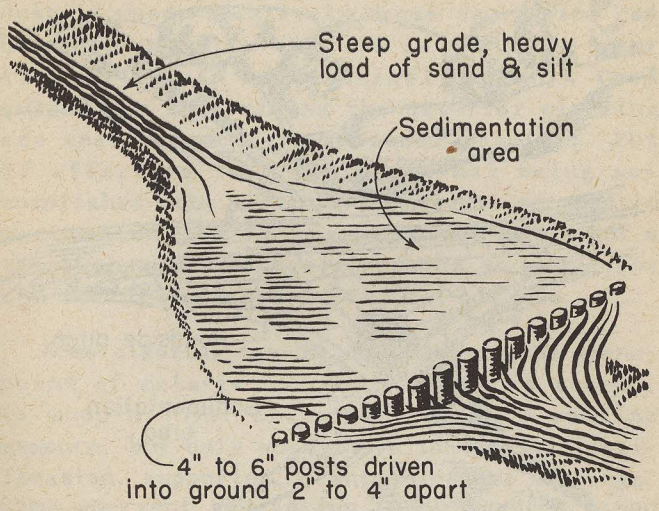
The first consideration in silt prevention is control of erosion at its source. In areas where new earth work construction is under way — new roads, air fields, and other work requiring removal of protective vegetation — drainage ways may become clogged from surface run-off depositing heavy loads of silt. When this condition is noted, preventive measures must be taken.

(1) DO NOT CONNECT LATERALS CARRYING SAND AND SILT WITH THE MAIN DRAINAGE SYSTEM. Where practical, such ditches should overflow into a flat area so that sand and silt can be dropped.



(2) IMPEDE THE FLOW OF WATER TO ALLOW SAND OR SILT TO SETTLE OUT. This can be done by driving a line of posts 3 to 6 inches in diameter, spaced about 4 inches apart, across the drainage-way immediately below the eroding area. Sand and silt will drop out, and the clear water will trickle into the ditch. This treatment may create a small pool, requiring larviciding— but the posts can be removed as soon as the source of sand or silt becomes stabilized.

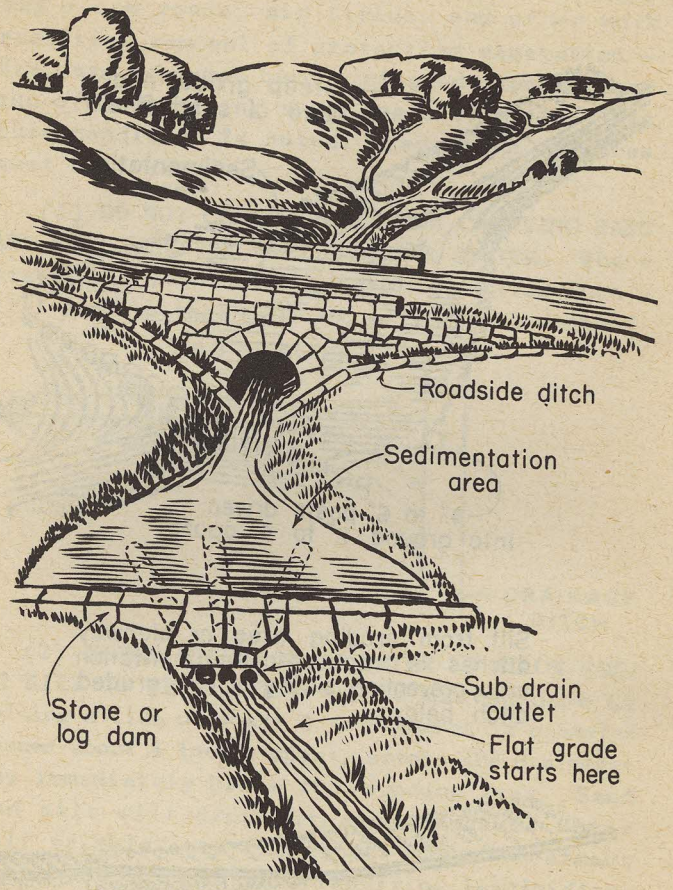
SEDIMENTATION DEVICE



Silt from eroding area or highway ditches is trapped in sedimentation area, preventing silting in flat graded ditch below.

Longitudinal section of sedimentation device

SILT BASIN



REMOVING VEGETATION FROM PONDED BREEDING AREAS

In order to effectively larvicide "quad" breeding places, it is sometimes necessary to remove aquatic vegetation. When paris green dust is used, relatively dense vegetation can be penetrated; but when oil is used, the water surface should be relatively clean. Good guides for determining the need for clearing are unsatisfactory larvicidal results. But if effective larviciding is not being accomplished with oil in the presence of aquatic vegetation, paris green should be given a thorough trial before resorting to recurrent and costly vegetation removal.

Some clearing may be harmful from the standpoint of malaria control. For this reason, it should never be carried on as a routine measure, but only when there is special justification, supported by entomological findings. Some emergent vegetation (plants which stand above the water surface) is so thick that "quad" breeding is "shaded out". In such cases, "quad" breeding may actually be increased as a result of plant removal.

Fine rather than *coarse* vegetation is most favorable to "quad" production, and most places requiring clearing for control of breeding have vegetation of this type. In large shallow areas such as swamps, shallow ponds, or wide shorelines of deep ponds and the upper reaches of impoundments, emergent grasses may be cut with scythes and brush hooks and piled with

a pitch-fork. If the water is deep, it may be necessary to load aquatic plants into a boat or barge with a potato hook or similar tool and carry them to shore, where they can be dried and burned. Although this may be done immediately before the larviciding season, frequently it must be repeated from one to four times during the season, depending on the type of plant present.

Dead flotage, algal mats, and light strands of floating aquatic plants can often be removed economically by lightly weighting a rope or wire and dragging it across the pond.

Power-driven underwater cutters are used for cutting extensive areas of heavy aquatic plants. Such areas must be free of obstructions such as logs, stumps, and shoals. Facilities must be available to remove the cut plants except where they drift away naturally due to current or wind action.

Plant-killing chemicals, known as herbicides, may also be used effectively under special conditions to kill aquatic vegetation.

The clearing of lanes for boat passage is often necessary where larviciding can be performed more effectively or more economically from boats than by land-based equipment. Methods of removing aquatic vegetation have been outlined previously. Dynamite can be used effectively to dislodge submerged stumps and logs. It should not be used in fish ponds, since the

concussion will kill fish. Where work is limited, stumps and logs can be towed to shore and lifted out with ropes, chains, peavey hooks, and timber carriers. More extensive work justifies the use of work-boats equipped with hand-winches or hand-winches operated from shore. Similar methods should also be used to remove these obstacles on channel clearing work to improve the drainage of creeks and swamps.

INSPECT AND MAINTAIN DRAINAGE OUTLET STRUCTURES

A drainage system is only as good as its outlet. For this reason, all outlet structures should be inspected and maintained at regular intervals (every two or three weeks or after each extra high tide or storm). Neglect of these structures not only increases mosquito breeding but may also require heavy maintenance work on the drainage ditches. Common types of outlet structures are:

1. Tide gates.
2. Fluctuating valves and weir boards in dams.
3. Arrowhead flumes.
4. Flushing siphons.

Assign the inspection of these structures to one of the better laborers or a sub-foreman, and make him responsible for their satisfactory operation.

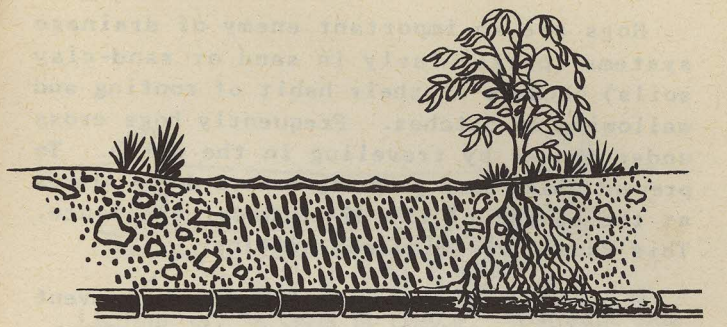
INSPECT UNDERGROUND DRAINAGE SYSTEMS

Even though open-butt joint tile or log underground drainage systems require very little maintenance, they should be inspected at least once each year and maintained when necessary. This is another "off-season" job. In making these inspections —

1. Check the outlet to see if it is flowing freely. If the water stands above the outlet, or the outlet ditch has silted badly, this should be remedied since it will quickly cause extensive damage to the system by silting the tile or filling the spaces between the logs.

2. Look for ponded water over or near an underground drain. If previously dry, this indicates a clogged drain. The best procedure is to inspect manholes or, in their absence, to dig down to the drain at various points along the line until the clogged section is located. Usually the difficulty will be found a short distance down-stream from the lowest point at which surface water exists—except in tiled ditches, where the trouble is usually on the upstream side of the pooled water.

3. Holes in the ground over the underground drainage line indicate that muddy surface water is entering the drain directly without filtration. If the drain is



still functioning satisfactorily, uncover a short section around the hole and place new filter material over the drain.

4. Where pipe is used to underdrain an open ditch, filtering material forming the ditch bottom is sometimes "gouged out" by storm water flow. Installing additional curtain walls in the ditch will correct this. The number of curtain walls varies with the slope of the ditch, but a customary spacing is 100 feet. Reduce this distance to 50 feet in the trouble section. If trouble continues, reduce this space to 25 feet. Place the top of the curtain wall flush with the bottom of the ditch and if the grade is steep, place it above the bottom of the preceding curtain wall.

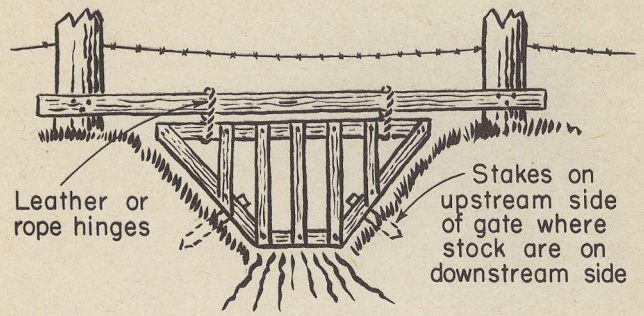
FENCE CROSSINGS

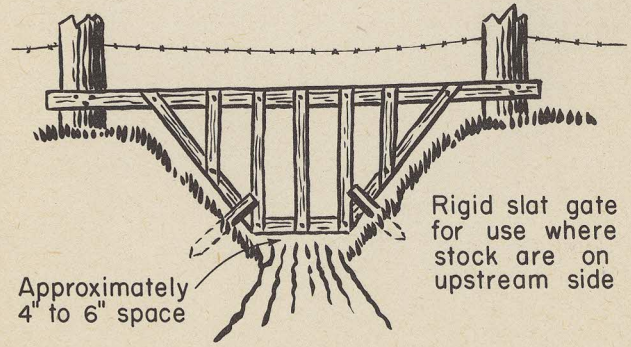
Hogs are an important enemy of drainage systems (particularly in sand or sand-clay soils) because of their habit of rooting and wallowing in ditches. Frequently hogs cross under fences by traveling in the ditch. To prevent this, some property-owners drive stakes at the bottom of the ditch under the fence. This causes clogging and silting.

Where the purpose of the fence is to prevent animals from going upstream, the best solution is the swinging gate. This is hung from a cross bar at ground level and is generally made with boards 1 inch thick in the form of a slat frame shaped to fit the ditch cross-section. "Stops" are placed in the ditch bank to prevent the gate from swinging upstream. Leather or rope thongs are better than metal hinges. The bottom and side members of the gate frame should clear the ditch bottom and sides by 3 or 4 inches. When flotage gathers, the force of the water opens the gate and washes away the flotage.

If it is necessary to prevent downstream passage of animals, the best solution in ditches which do not carry storm water, or which have a flat slope, is a rigid frame fixed in place and suspended from the top. This frame should clear the bottom of the ditch by about 6 inches. While not as satisfactory as the swinging gate, it is far better than stakes driven into the ditch bottom.

STOCK GATE FOR DITCH





NOTES