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ZANZIBAR MALARIA CONTROL PROJECT

REVIEW OF ANTI-LARVAL MEASURES IN ZANZIBAR TOWN

FINDINGS AND RECOMMENDATIONS

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by

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LIST OF ABBREVIATIONS/SYMBOLS

G.R.	=	Geographic Reconnaissance
ha.	=	hectare
Hect.	=	hectare
l	=	liter
m	=	meter
m^2	=	cubic meters
m^3	=	cubic meters
M.B.S.	=	Mass Blood Surveys
ULV	=	Ultra Low Volume
ZMCP	=	Zanzibar Malaria Control Project
"	=	inch or inches
'	=	foot or feet

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EXECUTIVE SUMMARY

1. All available means of *Anopheles* mosquito control (larviciding, adulticiding (residual house spraying and space spraying) source reduction, and biological control) should be fully implemented. Efforts should be well planned and coordinated. Intense public health education campaign should be launched in coordination.

2. - **Management** at all levels should be improved; Larviciding program should be planned, implemented and evaluated.

   - **Source reduction projects** should be prioritized, implemented, and evaluated.

   - **Biological control** viz., the use of the larvivorous fish, *Tilapia mossambica*, should be planned, implemented, and evaluated.

   - **Residual house spraying** (at least two cycles each year) should be planned, implemented, and evaluated.

   - Space spraying should be planned, implemented, and evaluated based on sound entomological data.

3. Proper reporting forms for all field operations should be developed and used. Appropriate record-keeping system should be set up.

4. A field operation's manual should be developed. Specific recommendations that could be most usefully implemented in the next 10 months are:

   (a) Develop larvivorous fish transplant program.

   (b) Plan, implement, and evaluate effective chemical larvicide spray program.

   (c) Select, plan, and implement 4-5 source reduction projects that are feasible of accomplishment within time period.

   (d) Develop field operation's manual.

   (e) Implement residual house spraying program within Zanzibar Town.

I. INTRODUCTION

A. Background

Zanzibar Town is located on the southeast coast of the Island of Unguja, the larger of the two islands (Pemba is the smaller), making up Zanzibar.

The Island of Unguja is 640 square miles in area and has a population of 310,000. Zanzibar Town is approximately seven square miles in area and has a population of 146,687. Thus, Zanzibar Town represents 1.2% of the land area of the island and contains 47.3% of the population. There are an estimated 25,500 houses in Zanzibar Town.

Suyud Tarkojosopuro, a short-term malaria consultant, pointed out in his June 1985 report that 10,090 positive malaria cases were reported from the Zanzibar Town Hospital in 1984, representing 73% of all the positive cases on the Island of Unguja. To be sure, this figure is skewed by people from rural areas who come to town for treatment. However, entomological and epidemiological data show malaria transmission occurs in all sectors of the town throughout the year. Although malaria cases have decreased on the rest of Unguja Island since 1983, mass blood surveys (MBS) have shown that malaria transmission is stable in Zanzibar Town. In 1983, the MBS figure was 43.8%; in 1984, 52.0%; in 1985, 40.5%; and in 1986, 44.1%.

Malaria control is ineffective in Zanzibar Town for several apparent reasons. There is no residual house spraying in Zanzibar Town. There are virtually no anti-larval measures being applied on a systematic and regular basis. The only adult _Anopheles_ control in Zanzibar Town has been limited ULV spraying, which has been hampered by equipment breakdowns. The malaria vectors are virtually reaching their environmental carrying capacity in Zanzibar Town. Malaria transmission is being regulated only by the natural immunity of the local population. There is no source reduction program.

Another important factor that accounts for continuing high malaria transmission is the growth of the town boundaries to the north, east, and south into the large natural breeding areas of _An. gambiae_ and _An. funestus_.

Written records show that malaria has been a problem in Zanzibar Town since 1811. The principal vectors are _An. gambiae_ ss., _An. funestus_, and _An. arabiensis_. Other _Anopheles_ species include _merus_, _coustani_, _squamosus_, _marshalli_, _rufipes_, and maculipalpis. Plasmodium falciparum is the predominant malaria species; P. malariae is seen occasionally.

The USAID-funded Zanzibar Malaria Control Project started in 1981 and is scheduled to end in September 1987.

Zanzibar has two monsoon seasons each year; the major one in March, April and May. The minor one is in October, November and December. Malaria transmission peaks correlate with these rainy seasons. The annual rainfall for Zanzibar Town averages 60.40" (53 years of record), with a range from 27.47" to 111.89." Rain occurs on average 138 days per year. The temperature ranges from 70°F to 90°F, with a low daily range of 7.8°F in Zanzibar Town. There is a tidal range of 10' at neap tide and 15' at spring tide.

B. Purpose

At the request of the Zanzibar Malaria Control Program (ZMCP) and USAID/Tanzania in March 1987, the Vector Biology & Control Project hired Glenn Stokes to survey the mosquito breeding areas in Zanzibar Town. The precise scope of work was:

1. Review anti-larval methods currently underway by ZMCP

2. Survey to obtain an overview of seasonal and perennial breeding areas

3. Determine the feasibility of source reduction methods, including drainage, filling, use of hygroscopic plants

4. Advise on long-term strategies for alleviating persistent and chronic breeding areas

5. Prepare, with ZMCP staff, a plan of operations for a more comprehensive and efficient anti-larval program, including applicable source reduction measures

This review is an effort to reorient the control program so that the traditional anti-larval measures of chemical spraying, source reduction, and biological control are focused on the recurring high malaria incidence in Zanzibar Town.

C. Field Trip Description

Following a meeting with Mr. Hamad J. Haji, Acting Director, ZMCP and Mr. Robert Turner, Malaria Advisor, USAID, field trips were arranged to observe all recorded major Anopheles breeding sites, both temporary and permanent. All parts of the Zanzibar Town were inspected, as well as immediate environs. Because the

Town is growing so rapidly, there are no precise boundaries. The urban area grades into the suburban area, which in turn grades into the rural area. Daily meetings were held with field personnel of the ZMCP. All larviciding records were reviewed, along with maps and other relevant information. The larviciding sprayers and the larvicide storage area were examined. The mixing and application of the larvicide oil was observed. Record forms and information storage were observed. Local fish were collected and tentatively identified.

II. FINDINGS

A. Chemical Larviciding

The larviciding unit consists of one supervisor, Mr. Nasser Khalid; one assistant supervisor, Mr. Mohammed Musa, and seven spraymen. There were seven Hudson X-Pert compressed air sprayers, four of which were in working condition. Two of the four sprayers had adjustable nozzle tips. The storage area for the sprayers and larvicides is not organized or clean. The only larvicides in evidence during the first inspection were Triton X 207 and some diesel oil in drums. Later some motor oil was obtained. There is no stock-keeping system for larviciding chemicals. There is no inventory control on stock levels. The only larvicide being used is a mixture of diesel oil, surfactant (Triton X 207), and used motor oil. Abate granules were used experimentally 1985. In 1986, experimental monolayer and Bacillus thuringiensis israelensis tests were carried out. No larviciding was conducted in February, March, or April 1987.

Larviciding records for 1986 reveal glaring discrepancies. For example, monthly records could be located for only five months. An annual summary of larviciding for 1986 indicated no record of spraying in January, February, and April. Moreover, the monthly totals in the annual report for 1986 did not always match the individual monthly reports for the same months. For example, the annual report indicated that 210 liters of larvicide oil mix were applied in March, whereas the monthly report for March indicated that 419 liters were applied. The annual report indicated that 298 liters of mix were applied in May, 248 liters were noted in the monthly report for May.

The individual monthly reports also indicate that the larvicide oil mixture was made improperly. For example, in May 1986, 96 liters of Triton were mixed with 323 liters of crude oil (no diesel oil was available). The percentage of Triton to crude oil was 22.9%, which is much too high. Moreover, it is unlikely that this mixture is effective as a larvicide because it lacked diesel oil, the principal ingredient. In June 1986, 12 liters of Triton were mixed with 192 liters of crude oil (again, no diesel oil was available). The percentage of Triton in this mix was 5.8%, still too high. Again, it was ineffective because there was no diesel oil. In December 1986, the larviciding oil totals indicated 24 liters of diesel, six liters of Triton, and six liters of crude oil. The percentage of Triton was 2.4%, still too high. It should be noted that Triton is the most costly component of the mixture. Also, it should be mentioned that there is no way to determine correct application rates. Too little larvicide will result in no control and is wasteful. Too much is wasteful and environmentally damaging.

Larviciding report forms are inadequate because they do not include measurements of the areas treated, or whether the site was positive or negative for larvae. Also, these forms do not indicate the date of last treatment, or the kind of larvicide used. There are no larviciding spray forms for weekly, monthly, and annual totals. In addition, the present larval collection forms are inadequate because they do not indicate the number of larvae per dip, the larval instar, or the date of the last larviciding.

A list of 40 permanent breeding sites was provided. All 40 of the sites were visited by the author and ZMCP supervisory personnel. Many sites turned out to be temporary, holding water only after the monsoons. At the time of inspection, at virtually every site, Anopheles were found to be breeding. Some sites contained as many as 10 per dip.

It turned out that many of these 40 known Anopheles breeding sites have never been treated because the ZMCP did not have enough chemicals, the area was too large, or the ZMCP staff did not know how.

The present larviciding spray procedure is for all seven men and one supervisor, with sprayers, to go in one truck to a breeding site, spray, get back into the truck, and go to the next site. Many breeding sites may require only one sprayman.

In the report of the short-term consultant, Suyud Tarkojosopuro, 1985, it was recommended that for planning and spray operation efficiency, Zanzibar Town be divided into five spray zones. However, this has not yet been done.

There are no maps of adequate scale being used in the planning, spraying, record keeping, and evaluation of the larviciding program.

In addition to the 40 "permanent" breeding sites, other Anopheles breeding sources inspected were water accumulations from leaky faucets, broken water lines, blocked ditches, and sand pits.

B. Source Reduction

There is no source reduction activity in the ZMCP, and never was. When the 40 "permanent" breeding sites were inspected, notes were made as to possible source reduction solutions. These solutions will be presented under Recommendations in Section III B. - Source Reduction.

C. Biological Control

There is no biological control component planned for the ZMCP at the present time. However, as a result of a concerted search, an effective larvivorous fish was found well established in and around Zanzibar Town. The species is probably *Tilapia mossambica*. Specimens were collected and preserved in alcohol to confirm the identifications. This fish was found in the Victoria Garden ornamental pool, the population of which derived from the Kianga River about five kilometers northeast of Zanzibar Town. Also, a large population of this species was found in the "swimming pool" between the Malawi Road and the Hoteli ya Bwawani. Apparently, this fish, called "perege" in Swahili by the local people, has been on Unguja Island for a long time. It is used locally as a food fish and is caught on small hooks or with seines. The mature adults reach about 20 centimeters in length. It was observed that the young fish, 5-8 centimeters in length, feed avidly and voraciously on mosquito larvae and pupae. The adults do not seem to feed on mosquito immatures, at least not in captivity. The literature on *T. mossambica* indicates that the adult prefers to feed on floating vegetation and organic matter, while juveniles feed on mosquito larvae.

Other fish mentioned as potential mosquito control agents in East Africa are the genera *Nothobranchius* and *Pachypanchax*. *Gambusia affinis* has been introduced all around the world including Africa as a mosquito control agent. Under optimum conditions, *G. affinis* has provided effective mosquito control at 205 fish per square meter of water surface. It is not known whether *G. affinis* occurs in Zanzibar or not. Indigenous mosquito feeding fish should be used in preference to introduced species.

During the examination of *Anopheles* breeding sites in and around Zanzibar Town, other natural predators of mosquitoes were noted, including dragon fly adults and nymphs, dytiscid beetles, gerrids (water striders), and frogs. It is not know what part these predators play in the biological control of *Anopheles* mosquitoes.

D. Other Related Control Activity

The ULV spray division was observed. This division has six Curtis Dyna Foggers and one Swing Fog (five of which were said to be working). There are five model G-9HD Micro-Gen ULV spray units (two of which were mounted on pickup trucks (neither of which were working) and five G-7 Micro-Gen ULV spray units.

Particle sizes apparently have never been checked, and flow rates are not routinely checked. In addition, there is no specific planned use for these foggers or ULV sprayers. They have not been used in several months. There are adequate supplies of pyrethrum insecticide in stock (1.420 liters of Divercide, which is mixed with diesel oil). There is no residual house spraying in Zanzibar Town, and has not been since the World Health Organization (WHO) sprayed in the mid-1960s.

There is no apparent organized, or functioning health education program to assist the ZMCP.

The insectary was not in operation. No entomological work was in progress for observation.

III. RECOMMENDATIONS

A. Chemical Larviciding

1. Personnel

The number of personnel in larviciding should be increased from the present nine (one supervisor, one assistant supervisor, and seven spraymen) to 17 (one supervisor, one assistant supervisor, five spray chiefs, and 10 spraymen).

FIGURE 1

PROPOSED ORGANIZATION CHART FOR ZMCP LARVICIDING DIVISION

Supervisor

Assistant Supervisor

ZONE 1 — Spray Chief — Spraymen(2)

ZONE 2 — Spray Chief — Spraymen(2)

ZONE 3 — Spray Chief — Spraymen(2)

ZONE 4 — Spray Chief — Spraymen(2)

ZONE 5 — Spray Chief — Spraymen(2)

The above organization structure presupposes that Zanzibar Town will be divided into five spray zones (two spraymen per zone) for reasons of efficiency.

2. Spray Equipment

Each zone should have three sprayers (one for Spray Chief and one for each sprayman) for a total of 15, plus at least three spares. Each sprayman should be assigned a sprayer which he should keep in good repair and be held responsible for. Additional spray equipment is needed including at least three motorized back pack sprayer/dusters and five hand dusters (one for each zone).

3. Chemical Larvicides

Inasmuch as the cost of oil (diesel, kerosene or other) plus surfactant (Triton or other) is 5-30 times as costly as the chemical larvicides temephos, Fenthion or Paris green, it is recommended that ZMCP stop using oils. Also, chemical larvicides have greater residual activity meaning fewer applications and additional economies.

(a) Paris Green

Standard technical grade Paris green is a finely-ground powder, green in color, containing 90% copper acetoarsenite. It is practically insoluble in water and floats well on the surface. Paris green dusts have been extensively used in Anopheles control in the past. However, dust is normally subject to wind action and requires special care and supervision in its application. Use has been made of a mixture of one part Paris green to two parts kerosene as an emulsion concentrate which when mixed with water in the field can be applied at the desired dosage with a sprayer.

The application dosage of Paris green varies from 0.055 g to 0.11 g of the actual toxicant per square meter. It has a long-standing record of safety for fish, wildlife, domestic animals, and man.

(b) Temephos

Temephos (Abate) is an organophosphate larvicide; it is safe and effective with good residual properties. It can be obtained as 50% E.C. or as a 1% sand granule. Recommended dosage rate is 0.111 kg/hectare of active ingredient. It would be less costly for ZMCP to purchase E.C. and make their own sand granules with a small cement mixer. Residual control is from 2-8 weeks depending on water chemistry and temperature.

(c) Fenthion

Fenthion (Baytex) is an organophosphate with good residual effect. It comes as a 50% E.C. Recommended dosage is 0.111 kg/hectare of active ingredient. Residual control from 2-10 weeks depending on water chemistry and temperature.

(d) Pyrethrum

Pyrethrum is another safe, effective larvicide. Many formulations of pyrethrum have been successfully used as larvicides. The emulsion of pyrethrum, alone or in combination with other materials, may be used as a larvicide. The following formulation was developed in 1930 (known as New Jersey larvicide):

Kerosene 66%
Pyrethrin 0.07%
Water 33.5%
Sodium laurel sulfate 0.5%

This formulation can be used as a larvicide at the rate of 4.7 ml/m^2 with sufficient water added to suit the spraying equipment utilized up to a maximum of 350 liters per hectare. The only drawback to this larvicide is its cost and availability, but these factors may not apply since Tanzania produces considerable quantities of pyrethrum (see Figure 2 - Map of Proposed Spray Zones for Larviciding, and Figure 3 - Population and Major _Anopheles_ Breeding Areas by Zone).

FIGURE 2

PROPOSED SPRAY ZONES FOR LARVICIDING

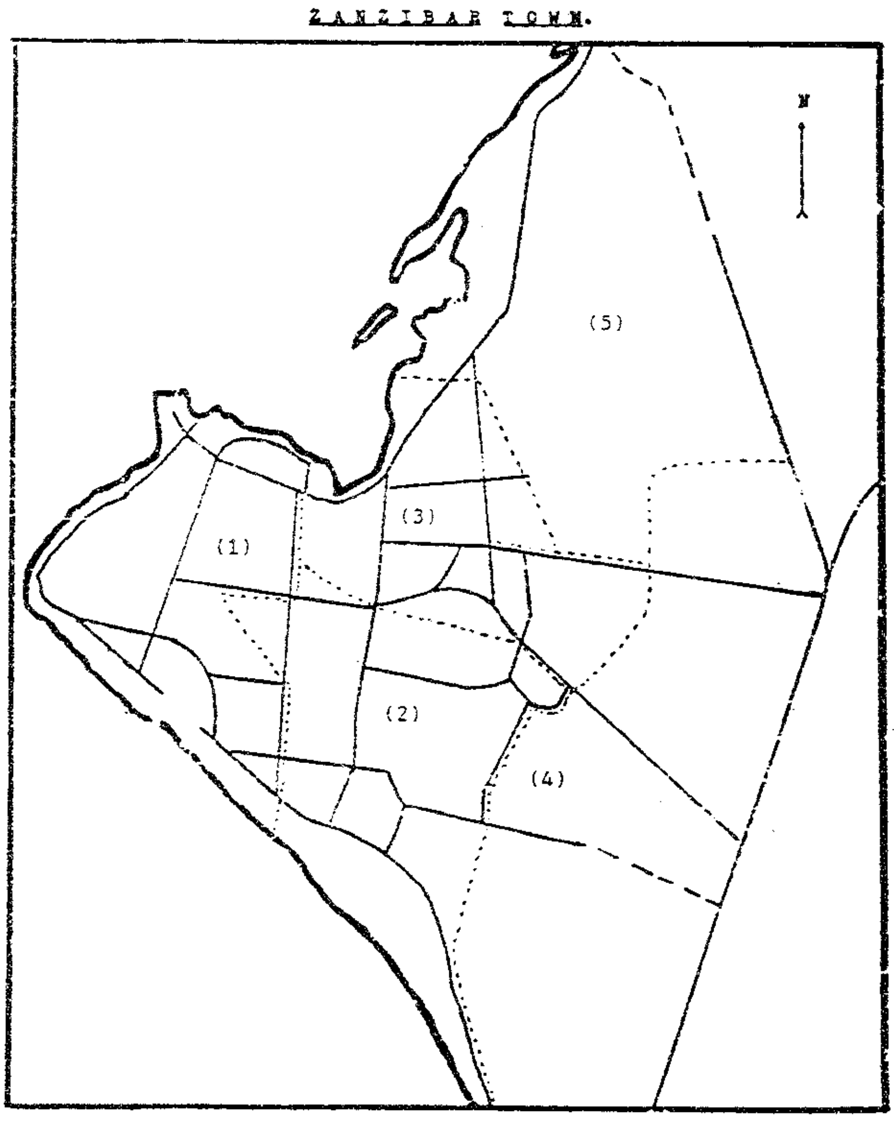


FIGURE 3

POPULATION AND MAJOR ANOPHELES BREEDING

Areas by Zone
(see proposed zone map, previous page)

Zone	Estimated Population	Number of Major Breeding Areas
1	32,359	8
2	23,531	8
3	21,154	6
4	35,410	9
5	16,309	8
ENVIRONS		3

4. Other Larvicides

Other larvicides are Dursban (Chlorpyriphos), Actellic (pirimiphos methyl), Altosid (insect growth regulator), and B. thuringiensis (H-14).

5. Larviciding for Special Situations

(a) Water Wells

In water wells (or sources of drinking water), the following larvicides can be safely used:

Temephos and pyrethrum; also deodorized kerosene or leadless aviation fuel can be used.

(b) Dense Vegetation

Mosquito sources with dense vegetation, granules should be used to get the insecticide to the water.

(c) Rice Fields

A medium weight dust formulation of Paris green or fenthion may be drifted over considerable distances by taking advantage of favorable breezes. The application can be made by hand or powder duster.

Granules can be used where rice paddies are more accessible. If the larvicide oil mixture is used by ZMCP in the future, Figure 4 provides the recommended formula and dosage rates:

FIGURE 4

LARVICIDING OIL FORMULATION

Mixture in Gallons	10	20	30	40
Triton X-45	5 oz.	9.5 oz.	14.5 oz.	19.5 oz.
Motor Oil 30W non-detergent	13 oz.	25.5 oz.	38.5 oz.	51.5 oz.
Number 2 diesel Oil	9 gals.	19 gals.	29 gals.	38 gals.

This oil mixture should be applied at the rate of 90 liters/ hectare (9 ml/m^2).

6. Equipment and Chemical Storage

The storage of all spray equipment and chemicals should be neatly stored in an orderly fashion in a storage area of adequate size that is protected from rain and can be locked.

7. Stock Record Keeping

Accurate stock records should be kept on all spray equipment and chemicals. An individual stock card should be kept on each sprayer with date purchased, who it is assigned to, and repairs made and date, etc. Also, reorder levels should be kept for all chemicals being used (e.g., when the level of temephos in stock reaches that level in gallons that will last until a new supply can be ordered and delivered based on average usage). For example, if it takes 12 weeks to receive temephos and the use rate is one gallon per month, then the reorder level should be at least five gallons to avoid running out of material. In addition, an order level should be established. Using the same example, probably a two-year supply (or 24 gallons) would be adequate. The order level would be 24 gallons and the reorder level would be five gallons. All records should be kept up-to-date so that at any time, exact records are available on all equipment, who it is assigned to, chemicals in stock, chemicals on order, etc.

8. Larvicide Mixing

Ideally one man, either the supervisor, assistant supervisor, or the stockroom manager should be responsible for the correct mixing of insecticide stock solutions. This will insure adequate control of chemical inventory and proper mixing. If mixing is done in the field, the supervisor and/or spray chief should supervise the mixing process.

9. Dosage Rates

It takes the right chemical, at the right dosage, and at the right time to kill mosquito larvae. If the wrong dosage is used, there will be no control. Therefore, the precise dosage recommendations for the larvicide should be followed. This should be one of the main responsibilities of the supervisors and the spray chiefs.

10. Geographic Reconnaissance (G.R.)

Accurate and thorough G.R., by either an entomology team or the larviciders, is mandatory if larviciding is to be effective in reducing vector populations. Accurate, large scale (at least 1:10,000) maps are absolutely necessary for recording breeding sites and keeping tabs on them for inspection and larviciding.

11. Spraying Operations

Spray operations should be carried out precisely. They must be well planned, expertly executed, and thoroughly evaluated. Zanzibar Town must be broken down into manageable units or Spray Zones as recommended above. One three-man team is responsible for a Spray Zone. By repetition, this team becomes thoroughly familiar with this Zone. They are held accountable for the adequacy of their control efforts. Good spray operations presuppose adequate spray equipment, proper chemicals, adequate transport, and an effective spray plan, good supervision, and trained employees. Effective larviciding does not just happen; it is accomplished through dedicated personnel and motivated management.

12. Report Forms

Proper report forms are a must if an effective and continuing spray program is to be carried out. Report forms are necessary for recording progress, supervising personnel, and detecting control failures. See Annex 1-4 for recommended forms.

13. Program Planning and Management

Without a workable control plan and good management to implement that plan, the best equipment, most effective insecticides, and best trained personnel will accomplish nothing. A good control plan must be devised by management, and it must be based on sound information and a thorough knowledge of the problems, causes, and their solutions. Management at all levels must be enlightened, dedicated and effective for a successful larval control plan to be carried out. There can be no bottlenecks, no dead ends, and no gaps in chain of management from top to bottom. All personnel must function smoothly and efficiently as a team. Top management must insist on excellence of performance from all those under their command. The control plan is a dynamic working plan that must be constantly updated, adjusted, improved and streamlined; it cannot be static. Therefore, good field data and proper records are an absolute necessity.

14. Spraying Evaluation

A careful and continuing evaluation of all spray operations is necessary to determine insecticide effectiveness, dosage adequacy, skipped areas, poor sprayman performance, and insecticide resistance. Without constant and continuing evaluation of spraying operations, the control program is operating blindly if it is not known whether breeding sites are being sprayed, and/or if larvae are being killed. With proper spraying evaluation, reasons for control failures can be quickly detected and corrected without a breakdown in control efforts.

15. Transport

Adequate and appropriate transport vehicles for spray personnel are needed if the control program is to function at maximum efficiency and economy. At the present time, one large open bed truck is used to transport all larviciding spray personnel to one breeding site at a time. This is extremely inefficient and wastes personnel time. It is recommended that each member of the larviciding division be provided a bicycle. This bike should be permanently assigned to each individual in the division, and each employee should be responsible for its upkeep and maintenance; 150 bicycles for the ZMCP are on order and delivery is expected in the near future.

16. Training

Appropriate training of all larviciding division personnel is axiomatic for an effective and efficient control program. This training should entail a continuing year round in-house program covering all major areas of operation such as equipment maintenance and repair, insecticide mixing, insecticide application, and record keeping. A cadre of well-trained, highly-motivated spray personnel is the most important component of an effective control program; they are the cogs that turn the wheel that makes the program work.

B. Source Reduction

1. General

Source reduction can be an effective and integral part of a malaria control program, especially when it supplements and complements control activities such as larviciding, residual house spraying and biological control. Source reduction offers a long-term solution to recurring problem causes (often resulting in considerable cost savings in terms of insecticides and personnel) by obviating the need for repetitive larviciding operations.

It should be emphasized at the outset that source reduction is long term. However, there are also considerable indirect benefits in creating land for agriculture, housing, parks, and other valuable uses.

2. Permanent Breeding Sites/Findings/Recommendations

The "permanent" breeding sites visited with ZMCP personnel are shown in Table 1 with suggested spray zones, findings and recommendations.

TABLE 1

BREEDING SITES, FINDINGS AND RECOMMENDATIONS

Spray Zone	Name	Findings	Recommendations
Environs	Mwanakwerekwe	Pits; very little standing water	Regular inspection and larviciding; S.R. not economically feasible
Environs	Ziwa Maboga	Rice paddies in valley (25.8 hectare)	S.R. may be possible; should be surveyed. Meanwhile introduce fish plus larvicide.
Environs	Viwanda V. Vidogo	Manmade pit (.0057 hectare)	Regular inspection and larviciding. Introduce fish and cut and fill S.R. possible.
1	Mchangani	Temporary breeding after rains	Regular inspection and larviciding. Survey for possible S.R.
1	Kiwanda cha Madawa	Water storage tank	Regular inspection and larviciding. Survey for possible S.R.
1	Mkunazini (taxi)	Parking lot (holds water after rains)	Regular inspection and larviciding; survey for S.R.
1	Mbuyuni	Blocked drainage channel, breeds all	Regular inspection and larviciding; open outfall to sea
1	Mlandege	Drainage channel	Regular inspection and larviciding; improve storm drain system

Spray Zone	Name	Findings	Recommendations
1	Mnazi mmoja	Flooded field (1-10 hectare) depending on rainfall	Regular inspection and larviciding; reestablish drainage already in place
1	Vikokotoni	Standing water in drains; permanent; some pollution (blue green algae)	Regular inspection and larviciding; redesign drainage system
1	Bwawani	Impoundment breeds all year (7.5 hectare)	Regular inspection and larviciding around edges; should be channelized to sea, then filled in.
2	Migombani skuli	Rice paddies (.26 hectare)	Regular inspection and larviciding; introduce fish and S.R. possible by drain into sea
2	Ziwani polisi	Rice paddies	Regular inspection and larviciding; introduce fish; survey for S.R.
2	Kwahani	Rice paddies; drain not functioning (2.58 hectare)	Regular inspection and larviciding; introduce fish; survey for S.R.
2	Kisima majongoo	Temporary; drainage is a problem after rains	Regular inspection and larviciding; introduce fish; survey for S.R.
2	Kilimani	Basement of apartment buildings flooded	Screen all openings of wet basements; install 4" drain pipes for S.R.

Spray Zone	Name	Findings	Recommendations
2	Kilimani (between apts. and sea)	Rice paddies (2 hectare)	Regular inspection and larviciding; introduce fish; can be drained to sea
2	Kilimani (lower end)	Wet bog (cattails) of standing water	Regular inspection and larviciding; introduce fish; can probably be drained
2	Miembeni	Drainage channel (breeds after rains)	Regular inspection and larviciding; survey for S.R.
2	Kariakoo	Drainage channel (breeds after rains)	Regular inspection and larviciding; survey for S.R.
2	Maisara	Sewage backup (*Culex* breeding)	Correct sewage problem
3	Lumumba	Standing water for six months; rice paddy (.05 hectare)	Regular inspection and larviciding; introduce fish; S.R. through earth ditch appears possible
3	Kwa alimsha	Block drainage channel; sump at culvert	Regular inspection and larviciding; no way to drain
3	Gulioni	Standing water in lined ditch; temporary following rains	Regular inspection and larviciding; redesign drainage system
3	Kinu cha Kusagia mpunga (Saateni)	Standing water in lined ditch; permanent	Regular inspection and larviciding; redesign drainage system

Spray Zone	Name	Findings	Recommendations
3	Mwembeladu (two areas)	Standing water in lined ditch; standing pockets of water outside drainage channel	Regular inspection and larviciding; redesign drainage; fill in pot holes
4	Urusi	Stranded water following rains	Regular inspection and larviciding; survey for possible S.R.
4	Mpendae	Pond surrounded by high ground (.017 hectare)	Regular inspection and larviciding; introduce fish; can be cut and filled
4	Mtumwa jeni	Pond surrounded by high ground	Regular inspection and larviciding; introduce fish; can be cut and filled
4	Nyerere	Pond area surrounded by high ground; rice paddies (3.44 hectare)	Regular inspection and larviciding; introduce fish; survey for possible S.R.
4	Kiburi kikombe	Three separate ponds with rice paddies	Regular inspection and larviciding; introduce fish; can drain one pond into another; survey for S.R.
4	Jan'gombe	Standing water in lined drainage ditch	Regular inspection and larviciding; redesign drainage system
4	Binti amrani	Bowl shaped swale surrounded by ridges; rice paddies (1.12 hectare)	Regular inspection and larviciding; introduce fish; survey for possible S.R.; cut and fill would do

Spray Zone	Name	Findings	Recommendations
4	Kilimahewa	Drainage channel blocked with vegetation plus pot holes of water	Regular inspection and larviciding; introduce fish; channelizing of drainage bed possible
4	Miazini	Springs created bog; rice paddies (.13 hectare)	Regular inspection and larviciding; introduce fish; survey for possible S.R.
5	Darajani	Blocked drainage in ditches; flows into Mbuyuni	Regular inspection and larviciding; unblock drainage outfall at Bwawani
5	Mwembemakumbi	Concrete pit at old coir factory	Regular inspection and larviciding
5	Mkale	Blocked drainage	Regular inspection and larviciding; survey for possible S.R.
5	Saateni (Nur)	Wet boggy drainage	Regular inspection and larviciding; introduce fish; channelize and fill in adjacent holes
5	Chumbuni	Wet boggy seepages; rice paddies	Regular inspection and larviciding; introduce fish; channelize
5	Shaurimoyo (Msikitini)	Septic tank with open manhole cover (breeding <u>Culex</u> only)	Fit with tight cover

Spray Zone	Name	Findings	Recommendations
5	Afisi ya uchapishaji	Standing water after rains; municipal workers are redigging outfall ditch now	Regular inspection and larviciding; S.R. through earth ditch is possible
5	Maruhubi	Blocked drainage plus cattail bog (.5 hectare)	Regular inspection and larviciding; can be drained to sea by deepening existing channel

3. Kinds of Source Reduction

Breeding areas can be prevented or eliminated by several methods: drainage, filling, impoundment, and water level fluctuation.

(a) Drainage

Drainage is the most common type of source reduction. Various methods are open earth ditches, French drains, buried conduits, and mole drains.

(b) Open Ditch

The open ditch is the most commonly used structure for conveyance of water. The cross-section of earth ditches is usually trapezoidal, with the sides as steep as the soil material will stand when exposed to flowing water.

(c) French Drain

French drains are trenches half filled with materials, such as rock, rubble, gravel and course sand, that present only minor resistance to water flow. This material can be covered with cloth fabric,a layer of palm leaves, or long grass to prevent silting of the porous section.

(d) Buried Conduit

Buried conduits are an improvement on French drains. A pipeline with open joints or perforations is installed close to the bottom of a trench for the collection and conveyance of sub-surface water.

(e) Mole Drain

Mole drains are suitable for cohesive soils. They are formed by drawing a bullet-shaped former through the soil at the required depth. This method is mainly suitable for evenly sloping land.

4. Design of Drainage System

The source reduction supervisor or engineer must decide on the type of drainage that is best suited to the given situation. He must decide on the type of conveyance, the location of the outfall, and the general pattern of the scheme.

Ditches can also be lined with concrete, asphaltic concrete, brick or stone to improve water flow, stabilize soil banks and reduce weed growth in channel.

5. Mosquito Drainage

The drainage of a mosquito habitat may take as long as the time required by the mosquito to develop from egg to the adult. For Anopheles control, seven days should be the maximum time required for an area to drain.

6. Other Source Reduction Techniques

Source reduction solutions to relatively small mosquito breeding sites are vertical drainage (where perched water lies above an impervious soil layer, a hole can be drilled through this layer to drain site) and soakaways (where a hole or set of trenches in the ground are filled with stones through which waste water can seep away into the surrounding soil).

7. Land Filling and Grading

Frequently small mosquito breeding areas can be eliminated by simply filling in a low area or by grading the surface. Simple hand tools, shovels, picks and wheelbarrows can be used.

8. Procedures for Implementing Simple Source Reduction Process

a. Review and analysis of existing data and reports on Anopheles vector and its control.

b. Preliminary reconnaissance to collect additional general information, and to identify the mosquito problem.

c. Land surveying, including topographic surveying, as required, to provide detailed geographical information on the area concerned for use in the planning and design process.

d. Selection of source reduction measures to be applied, based on the data collected through (a), (b), and (c).

e. Detailed design of the source reduction works required, including construction plans and cost estimates.

f. Construction.

g. Operation and maintenance of completed works.

h. Continued evaluation of the impacts on the *Anopheles* vector and the introduction of corrective measures when and where necessary.

9. Improvement of Shorelines

Where water collections cannot be drained or filled, either because of their large extent, their useful purpose, or the soil conditions, it is still possible to modify the conditions that favor mosquito breeding by certain source reduction works. It may be possible to use the "cut and fill" technique wherein the edges of the shoreline are deepened and straightened, and other areas filled in. This technique results in a shorter shoreline with deeper edges. Thus, there are less *Anopheles* breeding at the shoreline. Furthermore, larvae that do occur are exposed to larvivorous fish and other natural predators.

10. Source Reduction (S.R.) Team

A source reduction team consisting of five men is recommended for the ZMCP. This team would consist of a supervisor and four laborers. The supervisor should have some background knowledge in land surveying, engineering, drainage or construction work. The S.R. team should have a truck for transport, a surveying transit and target rod, and hand tools (shovels, picks, and wheel barrows). The supervisor should report directly to the Director of the ZMCP.

11. Priority Projects

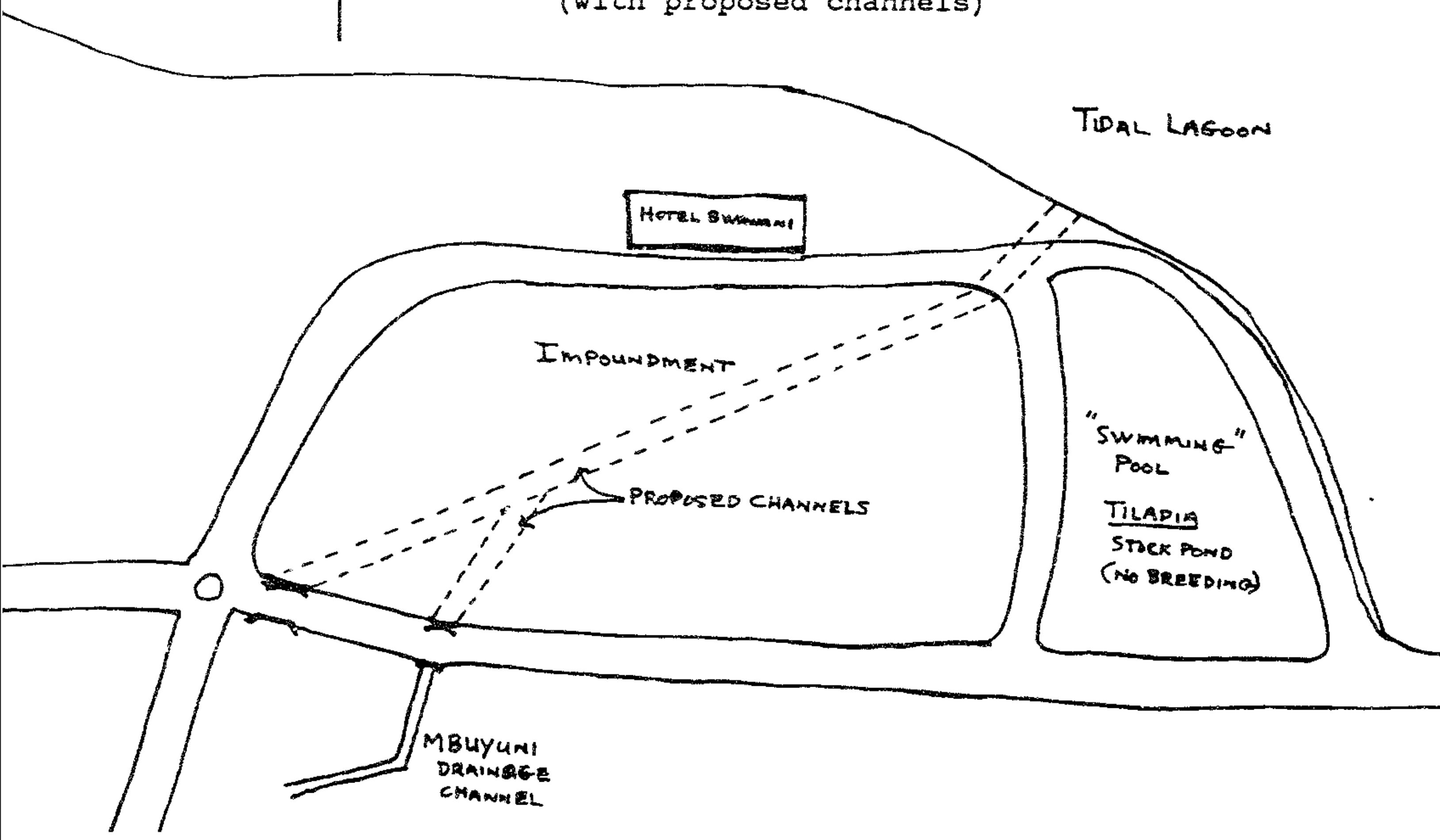
The following S.R. projects should be given priority and work should begin immediately:

- Kilimani - This area should receive priority because of severity of malaria problem; 1984 malariometric statistics show 1,692 malaria cases out of a total population of 2,210, which is the highest positive rate of any area in Zanzibar Town. First, all building sections with water standing in basements should be screened with 16-18 mesh (16-18 holes per linear inch) plastic screen. Measurements for materials for one building with all basements flooded are 335 m^2 of screen and 127 m of wood stripping to secure screen. Screens should be placed on inside walls to minimize chances of ripping and tearing. This is not a permanent solution to the problem, it is a temporary expedient that will provide effective control for a period of 6-12 months. The second recommended action is to construct 5" diameter holes through the walls of each flooded basement at the bottom, and place a 4" PVC pipe at a downhill gradually sloping grade (1" fall to 50'). The maximum length of this piping would be approximately 50' and extend across small roads in some cases. Third, the wet boggy area with cattails at the lower end of the Kilimani complex should be drained downhill toward the sea. This can be accomplished with a combination of open ditches and 4" PVC pipe. Finally, the rice field immediately adjacent to Kilimani should be either eliminated, or Anopheles control established. Anopheles control should consist of regular inspection and larviciding and the introduction of Tilapia.

- Hoteli ya Bwawani Lagoon - This represents the largest Anopheles (and Culex) breeding site within Zanzibar Town. It is 7.5 hectares in area. It holds water for 12 months of the year. The walls of this once proposed swimming pool or marina also have blocked drainage at the southwest end. It is recommended that a drainage channel be cut diagonally (from WSW to ENE) across the length of this impoundment, going across the hotel service road at its narrowest point (approximately 120'). This channel should be cut at a grade of about 1' per 100' of length. Upon completion, this channel may be tidal at spring tide which is fine. A secondary channel should be cut to this main channel allowing the surface drainage system (Mbuyuni, a heavy Anopheles breeder all year round) to function (Figure 5-Sketch of Hoteli Ya Bwawani Impoundment).

FIGURE 5

SKETCH OF HOTELI YA BWAWANI IMPOUNDMENT
(with proposed channels)



It is recommended that this area be designated a sanitary land fill, and gradually filled in. Over a period of years, this will ultimately result in high and dry land. This land would be particularly valuable for parks, a hotel, or a Town Hall. Also, it would solve a very bad mosquito problem area and drainage problems. Of course, it would be necessary to pipe the drainage channel to allow for continuing drainage function if entire area is filled in.

A faster alternative to filling this impoundment would be to dredge fill it with a small floating dredge located in adjacent tidal lagoon.

- Maruhubi - This major breeding site could be permanently corrected through S.R. by hand digging. There is an existing open drainage ditch that leads from the cattail pond to the sea. This outfall ditch should be cut about 1-2' deeper at a grade of 2-3" per 100'. The exact depth can be determined by surveying the bottom of the cattail pond which is the lowest point. Also, the drainage ditch at the highway side should be cleaned and deepened to the elevation of the drain invert at the road. This entire S.R. project could be completed with three or four men with shovels in four to five days.

- Mnazimmoja (Recreation Park) - This is a major Anopheles breeding area on Nyerere Road, right across from the National Museum, and V.I. Lenin Hospital. There is an existing buried drainage system in place at the west end of this area; however, it is blocked. I think the gate valve, before the beach ridge, is frozen in a closed position, which does not allow any flow. Also, I think some of the subsurface network of drainage pipes are broken.

  The drainage pipes should be excavated (they are very near the surface 8-10") and the main gate valve repaired. Apparently, the gate valve was placed in the line to prevent back flow of salt water at high tide.

12. Records

A separate file should be kept for each S.R. project. It should include drawings, proposed solutions, size, work accomplished and dates, completion dates, and maintenance dates.

13. Work Production

An average good workman can dig about 2 m^3 daily in not too compacted soils, at a bottom width of 1-2 m and a depth of about 1 meter.

14. Not Suited for S.R.

All breeding areas that are not amendable to S.R. should be inspected on a weekly basis and larvicide as required.

15. Outside Assistance

Assistance should be sought from all available government sources including the Road Works Department of the Ministry of Communication and Transport.

C. Biological Control

1. General

The only kind of biological control recommended for the ZMCP is larvivorous fish. Although the bacteria larvicide B. thuringiensis (H-14) is commercially available, it would be too costly for use in the ZMCP.

2. Use of Fish

Larvivorous fish alone cannot control malaria, but coupled with other strategies, they may have a cumulative effect. Fish are effective as mosquito control agents only when stocked in mosquito sources in high numbers. Fish are less effective where there is heavy weed growth and floating debris.

3. Tilapia mossambica

Tilapia mossambica is apparently well established in and around Zanzibar Town. It is being used as a food fish. Both adult specimens and subadults are being caught on tiny hooks and in seines. This species grows to about 20 cm in length. The African genus Tilapia includes many species, all of which incubate eggs in their oral cavity; the eggs are usually found in the female. Breeding is episodic, involving single pairs which remain together, giving parental care to the young. Breeding continues throughout the year if temperatures are from 20 to 25°C. Sexes are generally similar except at breeding time, when males are more brightly colored (red, blue, green or black). The juvenile fish are carnivorous, whereas the adult fish of most Tilapia species eat large amounts of aquatic vegetation. Tilapia mossambica has been extensively introduced throughout the tropics as a food fish. All Tilapia tolerate some salinity and a wide temperature range (8-35°C and higher). Tilapia have very high reproductive potentials.

4. Constraints in the Use of Fish

Obviously, where a major local problem exists because of mosquito breeding in temporary pools, fish cannot easily be used. Where mosquito breeding occurs in small bodies of water associated with human activities (e.g., empty food tins, discarded automobile tires, hoof prints), fish obviously have no use. In heavily polluted waters, with a little or no free oxygen, fish will not survive. Areas that are temporarily flooded, such as rice fields, will have to be restocked. If flooding occurs for short periods, fish populations may not increase rapidly enough before the next dry period to affect vector numbers significantly.

5. Use of Tilapia in Zanzibar Town

T. mossambica is very abundant in and around Zanzibar Town. Apparently, it has occurred here for some time since it has a local Swahili name "perege." I found it in the Victoria Gardens ornamental pool, in the backwater of the Kianga River and in great abundance in the proposed concrete-lined swimming pool at the Hoteli ya Bwawani on the Malawi Road. As a result, the "swimming pool," the Vector Gardens' ornamental pool, and the Kianga River could be used as stock sources of fish for distribution to other water bodies in and around the Town.

The fish should be collected from the stock ponds with a seine net and transferred immediately to buckets of water. Because seining and transfer may traumatize fish through injury to the skin, which can result in fungal or bacterial infection, the fish can be rinsed in a mild acriflavine aqueous solution for two to five minutes before being put in the transport container. I do not recommend this be done in Zanzibar unless problems with infection and survival arise. The containers may be polytene bags placed in clean, empty tins or cartons or clean 5-gallon buckets. Before releasing fish into new habitats, water should be added slowly from the intended habitat into the fish container to acclimate the fish to the new environment.

6. Operational Assessment

Operational assessment should include quantitative measurement of fish density and entomological and epidemiological data to determine effectiveness.

7. Stocking Rate

A stocking rate of 2-5 juvenile *Tilapia* per square meter of water surface is recommended. In temporarily flooded areas, fish should be stocked as soon as possible to allow for Anopheles control at the outset.

8. Other Larvivorous Species

Nothobranchius guentheri has been effectively used as a mosquito control agent in Somalia. Aphyosemion gardneri, an annual fish, was effective in West Africa in controlling An. gambiae. In certain stream bank situations Epiplatys bifasciatus was effective in reducing high larval populations late in the dry season in West Africa. Various species of Aplocheilus and Aphyosemion are found throughout sub-Saharan Africa and the Indian subcontinental regions and are excellent local candidates for mosquito control.

D. Other Related Control Activity

1. ULV Spray Operations

It is recommended that the ULV spray operation be improved. A definite program plan should be developed. All equipment should be kept in good repair. Spray operations should be carried out at times that coincide with peak Anopheles flight activity. ULV sprayers should be calibrated at least every two months for flow rate, and particle sizes should be checked. The ULV spray program should be planned in such a way as to complement and supplement the larviciding and residual house spray programs. That is, the ULV spray program should fill in gaps and augment other control operations rather than being done on a haphazard basis.

2. Operations Manual

I recommend that a detailed "Operations Manual" covering all aspects of the ZMCP program be developed and provided to all personnel.

3. Management

Improved management is needed at all levels; both office and field. Daily, weekly, and monthly work production totals in all program divisions should be targeted and achieved. Supervision should be stronger and daily work plans should be detailed yet flexible depending on weather, the mosquito problem, and special situations.

4. Improve Health Education

The health education component of the ZMCP should be strengthened. Again daily, weekly, and monthly work targets should be set up and adhered to. The proposed malaria training in Zanzibar and Zanzibar Town for health personnel trainers and trainees by the African Medical and Research Foundation (AMREF) is a very positive step. The objective is to supplement the present training levels of national, district health workers, and the public in general in basic management skills, malaria control, and primary health care.

5. Residual House Spraying

The resumption of residual house spraying in Zanzibar Town is strongly recommended. Certainly there is an obvious need based on malaria transmission and vector populations. In fact, a case could be made to concentrate indoor residual house spraying in Zanzibar Town, where the population is greatest and highest transmission is occurring. Residual house spraying is the most effective way of reducing vector longevity. The quantitative analysis of malaria shows that, while density changes in a vector population have an arithmetic effect, changes in the longevity of such a population have a geometric effect on the transmission potential. Effective spraying can also reduce longevity if precisely applied. It should be pointed out that larviciding, source reduction and biological control only reduce density of vectors; they have no effect on longevity of vectors actually produced.

6. Entomology Unit

It is recommended that the entomology unit be improved. Adult and larval surveillance are critically needed. Bioassays are vital. The insectary should function on a year round basis. More study on the bionomics of vector species in and around Zanzibar Town is needed. Geographical and seasonal distribution, their breeding, resting, dispersal, and feeding behavior needs continuous study. This information may provide clues to their control. A reference collection of both adult and larval <u>Anopheles</u> should be assembled.

7. House Siting

With the continued growth and expansion of Zanzibar Town, consideration should be given to locating houses upwind of the nearest <u>Anopheles</u> breeding source with at least a two kilometer radius from nearest source. This will be less expensive in the long run than to have to resort to expensive source reduction and/or repetitive larviciding and the medical cost of malaria.

8. Personal Protection

The use of personal protective measures such as proper screening, repellents and space sprays should be encouraged by ZMCP personnel and in particular the health education unit especially during the peak malaria transmission periods following the two monsoon periods.

9. Dry Belting Around Rice

Serious consideration should be given to not allowing people to build houses and live within two kilometers of a rice paddy. Rice growing should immediately be prohibited within the town limits of Zanzibar Town. Presently there is a Zanzibar law that prohibits this, however, it is not enforced.

10. Interministerial Group

An interministerial group including the Ministry of Communication and Transport (Road Works Department), the Ministry of Agriculture, the Ministry of Health, the Zanzibar Town Municipal officials, and other interested parties, along with the officers of ZMCP should hold a meeting to determine a suitable course of action to solve the rice paddy; Anopheles breeding problem in Zanzibar Town and its immediate environs.

11. Enlist Non-Governmental Help

In addition to the governmental organizations, non-governmental groups such as, the women's branch of the political party (UWT), the Parent's Association, and special clubs such as the Scouts and Community music clubs should be enlisted to assist in anti-mosquito efforts.

According to the socio-political makeup of the Government of Zanzibar, there are branches and 10 cell units down to the village level. Through such councils, the communities could be enlisted for the elimination of breeding places as well as in health education efforts. The ZMCP should provide technical advice, assistance and coordination in both of these activities.

IV. SUMMARY OF RECOMMENDATIONS

A. Blitzkrieg Approach

A blitzkrieg approach against the malaria vectors (An. gambiae, arabiensis and funestus) in Zanzibar Town is recommended. All available means of malaria control should be brought to bear on the problem, including: residual house spraying, adulticiding, larviciding, source reduction, biological control, legislative, and public health education. The malaria of Zanzibar Town is endemic not epidemic. In fact, the parasite index in Zanzibar Town has not changed much since 1934. D. D. McCarthy in his 1941, Report of the Zanzibar Research Unit, summarized extensive findings from field research obtained from a three year study. At that time, McCarthy divided Zanzibar Town into six zones for inspection purposes. Many of the same areas McCarthy found positive for Anopheles vectors were still breeding in May of 1987. McCarthy summarized the breeding places in Zanzibar Town into the following categories: rain pools, swamps, shallow wells, drains, pits, streams, cultivations, seepages, hoofmarks, and domestic. From his summary, swamps, wells and streams constituted the permanent larval producers, while rain pools, excavations, seepages, cultivations, drains and hoofmarks were seasonal producers. McCarthy noted that cattle hoofmarks within the town were prodigious breeders for as much as eight months of the year. He noted that hoofmarks, footprints and domestic utensils produced An. gambiae s.l. alone.

McCarthy noted that An. gambiae s.l. appeared in all types of breeding places in and about Zanzibar Town and breeds freely the whole year round, occurring in greatest density immediately following rains and diminishing with the dry season. McCarthy also noted that 75% of the Anopheles vector population occurred during the months of April to July while the other 25% was distributed over the remaining eight months and confined to the periphery of the town.

In 1934, McCarthy reported a crude parasite incidence of 43.2% and an index of 58.3% (based on the examination over a two-month period of 3,333 persons of whom 1,442 were positive). Not much has changed, in the period 1983-86, M.B.S. averaged 45.1%.

The control of urban malaria depends on technical measures, administrative approach, and good sanitation. All tools for effective control are available -- personnel, transport, spray equipment, and spray chemicals.

All that is missing is putting everything together in an efficient, persistent, systematic, integrated approach.

B. Larviciding

I recommend major refinement and improvements in the existing larviciding program, which is discontinuous and unfocused.

C. Source Reduction

I recommend that a source reduction program be implemented immediately and pointed out S.R. methods that could be utilized to permanently correct many *Anopheles* vector sources.

D. Biological Control

I found and identified an effective larvivorous fish, *Tilapia mossambica*, that is naturally occurring in and around Zanzibar Town. The use of this valuable control tool should be immediately implemented.

E. Other Related Control Activity

I discussed and made recommendations on many other control activities that impinge on the effective control of malaria vector population in Zanzibar Town.

I suppose the question is how much malaria in Zanzibar Town is politically, economically and socially acceptable?

ANNEX 1

LARVAE COLLECTION FORM

UCHUNGUZI WA VILUILUI VYA MBU = Larvae Collection

1. Mtaa ______________ TAWI ______________ Wilaya ______________
   Village CCM Branch District

2. Aina ya mazalio ______________________
   Type of Breeding

Bwawa safi Clean Pond	Minchirizi wa Bwawa Drainage	Kidimbwi Small water hole	Bwawa lenye majani Pond w/vegetaion	Mtaro Drain

3. Aina ya vya mbu vilivyoonekana ______________________
   Kind of Larvae

Instar	Anopheles Species	No./Dip	Instar	Culex Species	No./Dip

4. Kumbukumbu ya utiaji dawa ______________________
   Date of Last Spraying

Tarehe ya mwisho Last Spray Date	Dawa iliotiwa Kind of Insecticide

______________________ ______________________
SAHIHI YA MCHUNGUZI TAREHE
SIGNATURE DATE

ANNEX 2

DAILY LARVICIDING FORM

Jina la Mtia Dawa
Names of Spraymen ______________________

Mwangalizi
Supervisor ______________________

Daily by Zone

Zone ______________

KAZI ZA KUUA VILUI LUI VYA MBU ANOPHELES
MABWAWANI NA PNGINEPO

Siku Tarehe Date	Bwawa La Name of Pond	Pengineko Other Place	Mchanganyko Wa Dawa Iliotumika Abatena Triton Kind of Insecticide	Volume	Maelezo Area Treated	Remarks

TOTALS ____

SENIOR SUPERVISOR
SIGNATURE

DATE

ANNEX 3

WEEKLY LARVICIDING FORM

Jina la Mtia Dawa
Names of Spraymen ______________________ Mwangalizi
Supervisor ______________________

Weekly by Zone Zone ______________

KAZI ZA KUUA VILUI LUI VYA MBU ANOPHELES
MABWAWANI NA PNGINEPO

Siku Tarehe Date	Bwawa La Name of Pond	Pengineko Other Place	Mchanganyko Wa Dawa Iliotumika Abatena Triton Kind of Insecticide	Volume	Maelezo Area Treated	Remarks
TOTALS						

______________________ SENIOR SUPERVISOR SIGNATURE

______________________ DATE

MONTHLY LARVICIDING FORM

Jina la Mtia Dawa
Names of Spraymen ____________________

Mwangalizi
Supervisor ____________________

Monthly by Zone

Zone ____________

KAZI ZA KUUA VILUI LUI VYA MBU ANOPHELES MABWAWANI NA PNGINEPO

Siku Tarehe Date	Bwawa La Name of Pond	Pengineko Other Place	Mchanganyko Wa Dawa Iliotumika Abatena Triton Kind of Insecticide	Volume	Maelezo Area Treated	Remarks

TOTALS ____________________

____
SENIOR SUPERVISOR
SIGNATURE

____
DATE