REPUBLIC OF MALAWI

DEPARTMENT OF LANDS, VALUATION AND WATER

ASSIGNMENT REPORT

ON

Preventive Maintenance and Control of Unaccounted-for Water in Small Urban Water Supply Systems

Text

Volume 1 of 2 Volumes

World Health Organization
Regional Office for Africa

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CURRENCY EQUIVALENTS

Currency Unit	:	Kwacha (K)
1 K	:	100 Tambala (t)
1 US$	:	1.39 K (May 1984)

Fiscal Year	:	1st April - 31st March

Measures and Equivalents	:	1 metre = 3.28 feet 1 km = 0.622 Mile 1 Sq. Km = 0.3863 Sq. Mile 1 litre = 0.22 Imp. gallon 1 kg = 2.2 lb

ABBREVIATIONS AND ACRONYMS

AFRO	Regional Office for Africa (WHO)
DLVW	Department of Lands, Valuation and Water
IDWSSD	International Drinking Water Supply and Sanitation Decade
MWS	Ministry of Works and Supplies
O & M	Operation and Maintenance
OPC	Office of the President and Cabinet
STC	Short Term Consultant
WHO	World Health Organization

TABLE OF CONTENTS

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

0.01 DLVW operates and maintains 49 district water supply schemes and 5 institutional schemes and upon request assists in maintenance of another 69 institutional schemes. In spite of their large number and dispersal, the plants are kept clean and in good running condition, thanks to the sense of duty of staff in spite of their limited number at senior and middle management levels.

0.02 There is a large variety of makes and types of equipment and plant components are tailor-made to meet present and future demands during a planning horizon of about 5 years. This makes maintenance work more difficult and the stocking of spare parts uneconomical. An attempt should be made to rationalize procurement of equipment from a short list of international suppliers established through prequalification procedure. Furthermore, standard designs and sizes of plants and their components should be adopted as much as possible.

0.03 Some plants have stand-by units thus permitting maintenance work, others have one unit per function. Treated water storage capacity is on average on the low side which limits the available time to carry out maintenance/ repair work without interruption or reduction of supply. The storage capacity should be built-up, over say 5 years, to about 24 hours supply.

0.04 There are no complete records of plant equipment or up-to-date maps of main and distribution pipelines and valves. A start was made under the Japanese Data Book Project. This work should be continued and complete records of all equipment, as proposed in this report, and an updating of maps of distribution systems carried out at an early date.

0.05 Apart from very minor tasks carried out by plant operators, "breakdown maintenance" is centralized at the Regional Offices. Pipelines and water meters, although representing on average about 70% of investments, are given low priority. Repairs are carried out when leakages manifest themselves above groundlevel; water meters when broken or blocked are repaired on site without calibration. This could cause considerable loss of revenue.

0.06 Preventive maintenance entails the regular periodic inspection of all components and carrying out measures to prevent or minimize breakdowns. It should help achieve uninterrupted operation, determine the type and quantity of materials and spare parts to be stocked for repairs and distribute work load more advantageously. Although its introduction entails the initial deployment of resources - in facilities and personnel - in the long term it could prove more economical in avoiding premature failure of machinery and their costly replacement and the continuity of supply of potable water and related health benefits.

0.07 The writer visited all the 16 district water supply schemes and the 5 institutional schemes of the Cental Region and made an inventory of all plant structures and equipment. Encouraged by the willingness of plant operators to accept more responsibility and their dedication, an

approach towards decentralization has been adopted in designing the preventive maintenance programme. More maintenance tasks are to be carried out at the local level and at sub-regional level. Regional Offices will undertake major overhauls of machinery at 2 or 3 years intervals, the overall supervision of the programme as well as the stocking of sufficient quantities of materials and spare parts.

0.08 A total of 9 sub-regional maintenance centres are to be created or strengthened (their names and areas of responsibility are given in art 3.04). Tasks to be performed and their frequency, the level of responsibility - local, sub-regional and regional - and the composition of mobile maintenance crews are proposed in the text. Maintenance of electrical machinery and switch gear has been included in the preventive maintenance schedules with a view to taking over this work from MWS over a period of 3-5 years.

0.09 It should be pointed out that the maintenance tasks scheduled and the degree of decentralization is a goal to be aimed at when resources in personnel and equipement become available. It could be implemented in stages i.e. the Central Region performing the tasks of sub-regional level responsibilities until facilities at the chosen sub-regional maintenance repair centres are completed. Furthermore, the proposed schedule could be scaled down initially until physical and financial resources become available.

0.10 It is suggested to implement the preventive maintenance programme in the Central Region for a trial period of one year. An evaluation could then be carried out and the programme amended, if necessary, in the light of experience gained before introducing it in the other three regions.

0.11 The estimated cost of equipment and transportation facilities in the Central Region is estimated at K 103,500, and the annual recurrent costs at K 209,100. It is to be noted that no additional personnel (apart from electricians during a period of 3-5 years) are to be recruited to implement the programme and that the recurrent costs are not over and above what is being spent now on maintenance. An up-grading of skills through training programmes as suggested by Mr. M. Roy, WHO/STC should be implemented as soon as possible.

0.12 Unaccounted-for water (the difference between water produced and quantities billed to consumers) is attributed to leakage from pipes, pipe joints and service connections, open or partially open drain valves, overflowing reservoirs and broken or under-recording water meters. Although no assessment was made there are indications that the unaccounted-for water in DLVW systems has reached unacceptable levels. In Zomba water supply system over 50% waste has been reported. In 1983, this represented a loss of revenue of about K 436,057.

0.13 To redress this situation, the long term objective would be the setting-up of a "Waste Control Section" within DLVW with a view to reducing waste in small water supply systems to the most economic level and to maintaining it at that level.

0.14 Leak detection and control of waste is a specialized activity and the lack of such personnel and the necessary equipment have prevented DLVW from carrying out the necessary work. A pilot project covering the Zomba Municipality has been formulated.

0.15 The project covers carrying a leakage and waste survey by a firm of consulting engineers, reduction of waste by the maximum amount through repairs and other measures, training of nationals in waste control practices and acquisition of equipment for leakage and waste surveys. The estimated cost of the project is US$ 334,400 in foreign exchange plus a Government contribution in kind estimated at K 46,520.

0.16 A draft Project Document, on UNDP format, has been prepared and is attached to this report as a self contained annex No. XIV to enable the Government to seek external financial cooperation.

0.17 Until financial assistance to implement the pilot project in Zomba is secured, DLVW could commence carrying out some corrective measures to redress the situation in all water supply systems such as : updating maps of distribution systems, installing master flow meters on outgoing mains of plants and reservoirs, repairing float operated valves on inlet pipes to reservoirs, installing level gauges on reservoirs (and preferably installing an alarm system on reservoirs to alert plant operators when they are overflowing, measuring and recording pressures in the distribution systems with a view to reducing excessive pressures where they exist, installing boundary valves on pipes feeding certain zones, regular overhaul and calibration for water meters, etc... Such measures are given in more detail in Chapter IV.

I. INTRODUCTION

1.01 The Department of Lands, Valuation and Water (DLVW) requested WHO/AFRO's cooperation in establishing a preventive maintenance programme for its small urban water supply systems. Furthermore, DLVW is concerned at the relatively high percentage of unaccounted-for water in its water supply systems due to leakage and other causes and is desirous to reduce this percentage to the minimum economic level and keep it at that level.

1.02 AFRO responded positively to Government request and mounted a mission[1/] to Malawi from 12th March to 30th April, 1984. Terms of Reference for the mission are given in Annex I, names of persons met and their functions appear in Annex II.

1.03 Following discussions with senior officers in DLVW and in view of time constraints, it was decided that a preventive maintenance programme covering the 16 district water supply systems and the 5 institutional schemes in the Central Region be elaborated. For the leakage survey and control of unaccounted-for water, the Municipality of Zomba (population 44.000) with a high percentage of unaccounted-for water was selected as the project area where a firm of consulting engineers is to be retained to conduct the leakage and waste survey. As the Government may wish to approach bilateral cooperation agencies to fund the leakage survey and the purchase of the necessary equipment, a Project Document - including Terms of Reference for the consultants and justifications - was prepared and is enclosed as Annex XIV.

1.04 The mission visited all the 16 district water supply schemes and the 5 institutional schemes as well as the repair and maintenance workshops in the Central and Southern Regions with a view to acquainting itself with the current maintenance practices. As no up-to-date records of plant equipment exist in DLVW headquarters or the Regional Offices, the mission carried out an inventory of installations and machinery in all the water schemes in the Central Region; a necessary procedure for establishing a preventive maintenance programme for the Central Region as decided by Government.

1.05 The Chief Civil Engineer (O & M) accompanied the mission on a week's visit to Zomba (2 to 7 April 1984). All the facilities (source of supply, treatment plant, distribution system with its 21 service reservoirs) were inspected. Government's counterpart contribution in kind to the leakage and waste survey was discussed and evaluated with the Chief Civil Engineer (O & M) and the Water Superintendent, Zomba.

1.06 The proposed Preventive Maintenance Programme, described in Chapter III was discussed in detail with the Chief Civil Engineer, (O & M) and responsible officers of the Central Region where it will be implemented during a trial period of one year. The Programme will then be evaluated and amended, if necessary.

1/ undertaken by Mr. S. Bishara, STC

1.07 During a final meeting with Senior Government Officers of DLVW in which Dr. S.W. YUN, WHO Programme Coordinator and Mr. H. MWANZA, UNDP, participated, the writer presented the Mission's findings and recommendations, the Preventive Maintenance Programme and the leakage and Waste Survey.

1.08 The writer was received by the Resident Representative, UNDP at the start of the mission and was briefed at the end of the mission's activities and discussions with Government Officers.

1.09 The writer proceeded to AFRO (2-4 May 1984) to present the draft Assignment Report to the Director of Environmental Health and his staff.

1.10 The writer acknowledges with thanks the cooperation and assistance given to him during his assignment in Malawi by Government's Officers, the Resident Representative, UNDP and in particular Dr. S.W. YUN, WHO Programme Coordinator.

II. BACKGROUND

Water Supply and Sanitation Coverage

2.01 The provision of potable water supplies to urban and rural populations is accorded top priority by the Government. Even before the proclamation of the International Drinking Water Supply and Sanitation Decade (IDSSD) Malawi had successfully undertaken development programmes of water supplies both in rural and urban areas. With the consolidation of all water related matters in the Department of Lands, Valuation and Water (DLVW), development activities have gathered momentum and it is feasible that the goals of the Decade for water supply will be achieved, provided the necessary external capital and technical cooperation will be forthcoming.

2.02 For urban water supplies, plans to augment the present capacities of the various plants and to extend the services to the fringe areas by providing communal water points are underway. In the field of rural water supply Malawi has made commendable progress during the last 15 years. The main sources of supply are piped water gravity schemes, boreholes and protected shallow wells. Piped water systems draw water from protected forest catchments and serve large rural areas through multiple communal taps. The rural piped water programme is based on the provision of village level self help labour with capital cost provided by donors. To date 36 rural piped water schemes have been constructed and are benefitting over 815,000 rural people.

2.03 In 1980, it was estimated that 70% of urban dwellers and 37% of rural populations (i.e. a national average of about 50%) were served by public water supplies; a coverage which compares favourably with many developing countries under similar conditions.

2.04 The sanitation sub-sector has not kept pace with water supplies. In urban centres, parts of Blantyre, Lilongwe, Zomba and Liwonde are served by water borne sewerage systems. In other areas septic tanks and pit latrines are being used.

2.05 At present sanitation coverage is about 26% in all urban areas. A recent district wide survey showed that about 34% of rural population are served by pit latrines.

Institutional Framework

2.06 Prior to 1979, responsibilities for water related matters were divided between 14 departmental or sub-departmental units in 6 ministries. With that fragmentation progress was relatively slow and the sub-sector received little priority in the allocation of financial and human resources. The Government, therefore, decided to rationalize its water related functions by integrating them in one department, the Department of Lands, Valuation and Water (DLVW), under the Office of the President and Cabinet (OPC) so that high priority could be attached to the development of water resources in general and particularly to the water supply and sanitation sector.

The Ministry of Health still retains the responsibility for monitoring the quality of water supplies and promotion of rural sanitation. Blantyre and Lilongwe Water Boards continue to function but in close coordination with DLVW. A number of local authorities continue to run their own sanitation facilities but this service has broad supervision by DLVW.

2.07 The Department, headed by a Controller, is responsible for the provision of land services and property valuation services; the supply of treated water in urban centres and protected piped water or ground water to rural areas; design, construction and operation of irrigation schemes; assessment and development of water resources in the country and planning, design and construction of sewerage and sanitation works for certain town councils and municipalities.

2.08 The Water Division is divided into 3 branches: Water Resources branch, Water Supply branch and Irrigation branch. Each branch is headed by a Chief Water Resources Officer, Chief Water Supply Officer and Principal Irrigation Engineer respectively who are responsible to the Water Engineer-in-Chief who heads the Water Division and coordinates the activities of all branches within the Division.

2.09 The Water Supply Branch is responsible for the supply of treated water to all major towns except the cities of Blantyre and Lilongwe which have Water Boards. The Branch also plans, designs, constructs and operates some institutional water supply schemes. Besides the urban water supply, the Branch provides untreated but protected piped water supply to rural areas wherever feasible.

2.10 The Water Supply Branch operates at present 49 urban districts and 5 institutional water supply schemes and upon request assists in maintenance of a further 69 institutional schemes in the country with another four under construction. Particulars of the small district and institutional water supply systems are given in Annex III, and their location shown on the map given as Annex IV.

Human Resources

2.11 One of the major constraints for sector development is the scarcity of skilled and semi-skilled technicians and transport facilities. This situation has adversely affected operation and maintenance and resulted in frequent breakdowns and premature replacement of costly equipment.

2.12 With a view to redressing this situation and in answer to a Government request, Mr. Max Roy, WHO/STC, visited Malawi in January/February 1983 and submitted a report entitled "Training Programme for Waterworks Staff". The report describes the present staffing pattern and makes specific recommendations for human resources development within DLVW to upgrade the level of operation and maintenance in the facilities as well as training programmes for present and future staff up to the year 1990.

Operation and Maintenance Practices

2.13 Responsibility for operation and maintenance of water supply systems lies with the Regional Offices of DLVW viz Mzuzu for the Northern Region, Lilongwe for the Central Region and Blantyre and Zomba for the

Southern Region. Apart from the 49 district water supply systems, Regional Offices also operate and maintain 5 institutional schemes - given in Annex III - and upon request can assist in maintenance work for another 69 institutional schemes. The three Regional Offices are under the Chief Civil Engineer (O & M) at DLVW Headquarters in Lilongwe.

2.14 Apart from very minor tasks carried out by plant operators, all maintenance work is done by the Regional Offices. No preventive maintenance programmes have yet been introduced. As in many developing countries and due to scarcity of qualified personnel, equipment and transport "breakdown repairs" are carried out as needed. Plant operators advise the Regional Office - by phone and in less urgent cases by letter - of the nature of the breakdowns and the type of machinery involved. The Regional Office despatches a team to the site - within a day or two - to effect the repair required. This practice imposes a heavy work load on the existing staff at the Regional Offices. Occasionally, the repair team(s) is in the field on other jobs and the task - sometimes urgent - has to await its return.

2.15 Some plants have standby units, thus permitting maintenance work to be carried out without interruption, or reduction, of supply. Other plants have only one unit per function. Filtered water storage capacity in some installations is rather on the low side, which will limit the time available to carry out a preventive maintenance programme. The storage capacity should be built up, over say 5 years, to about 24 hours supply.

2.16 There is a large variety of makes and types of machinery, less in the case of diesel engines which are mainly of Lister and Perkins manufacture. This makes the stocking of spare parts at regional offices difficult and uneconomical. Some essential and frequently used spare parts are stocked but no organized system is in force for replenishing stocks when they reach minimum levels (provision action figures) and bring them up to maintenance figures. Spare parts are purchased from local representatives as and when needed; a precarious situation. An attempt should be made to rationalize procurement of machinery from a short list of international suppliers established through a pre-qualification procedure.

2.17 Maintenance of all electrical machinery and switchgear is at present handled by the Ministry of Works and Supplies (MWS) through the Regional Engineers Organization. Although their response to requests for repairs is satisfactory, the division of responsibility might cause undue delays in urgent situations. DLVW may wish to consider assuming the responsibility of maintaining electrical machines and switchgear after establishing the necessary capabilities in personnel and equipment.

2.18 Machinery in some installations are crammed together which does not facilitate maintenance work. In a few installations, access to plant machinery (very steep access roads, vertical narrow and tall ladders difficult to decend let alone with the necessary tools) and lack of footpaths on elevated storage reservoirs which renders maintenance work difficult, even dangerous. For future installations accessibility for maintenance operations and the safety of personnel should be borne in mind at the design stage.

2.19 Complete records of types and characteristics of plant machinery and equipment are not available at Regional Offices and DLVW Headquarters. A start has been made under the Japanese Data Book Project 1982. Collection of data on the Equipment History Cards, proposed by the mission, should be carried out.

2.20 Similarly no up-to-date maps of distribution systems exist at the plants. Some out of date maps are kept at the Regional Offices. A survey team should be mobilized to prepare maps of trunk and distribution pipelines showing position of valves and other appurtenances.

2.21 Repair facilities at the Regional Offices need upgrading in equipment and personnel to enable them to cope with the present work load and the proposed preventive maintenance programme.

2.22 Although universal metering is adopted, there are no meter repair and calibration facilities at the Regional Offices. Blocked or broken domestic water meters are dismantled and repaired on site by plant operators without any calibration. This could result in considerable loss of revenue. Water meter repair and calibration shops should be installed at Regional Offices as soon as possible. The facility could also serve for the repair and calibration of master flow meters on the outlet mains of boreholes and treatment plants.

2.23 Funding of recurrent costs - including operation and maintenance does not seem to pose special problems. The Water Supply Branch prepares budget proposals for the coming year and projections for the year after and submits them for approval by the Treasury. Once approved, expenditures are effected against the various budget lines up to the ceiling approved. Although the Treasury has in the past subsidized the short falls - especially personnel costs - it is expected that with the upward revision of the tariff structure the Water Supply Branch will break even in the current fiscal year 1983/84.

III. PREVENTIVE MAINTENANCE PROGRAMME

Approaches

3.01 As stated earlier in article 2.14 maintenance work is confined to "breakdown repairs" or corrective maintenance". Inspite of the large number (49 urban district schemes and 5 institutional schemes and upon request a further 69 institutional schemes) and their disperal, the plants are kept clean and in good condition, thanks to the sense of duty of staff inspite of their limited number at senior and middle management levels.

3.02 Preventive maintenance entails the regular periodic inspection of all components, replacement of parts after a given span of service, repair of damaged or worn out parts, lubrication, removal of carbon deposits in diesel engines etc., i.e. measures which are conducted to prevent or to minimize breakdowns. No preventive maintenance programme can hope to eliminate all breakdowns as some plant operators do not recognize the indications which precede breakdowns. Some "Corrective maintenance" will accordingly always be needed and this factor is taken into consideration, allowing time and personnel - in designing the proposed preventive maintenance programme covered by this assignment. However, a programme geared to preventive maintenance should attain better performance results than the present "Corrective maintenance" practice. It should help achieve uninterrupted operation, determine the type and quantity of materials and replacement parts to be stocked for repairs and distribute work load more advantageously.

3.03 Maintenance work is at present centralized in the three Regional Offices of Lilongwe, Blantyre (and the sub-regional office in Zomba) and Mzuzu, entailing heavy work loads on the existing staff and relative under-employment of personnel at local and sub-regional levels (e.g. Kasungu). Encouraged by their willingness to accept more responsibility and their dedication, an approach towards "decentralization" to local and sub-regional levels has been adopted in this programme. Maintenance costs and logistics could thus be greatly reduced. Regional Offices will continue the overall supervision of the preventive maintenance programme, maintain sufficient quantities of materials and spare parts and carry out major overhauls of machinery and equipment or special repairs above the level of competence of local and sub-regional levels. This decentralization will, of necessity, entail strengthening (or creating) sub-regional level repair facilities in equipment and personnel during a transition period of 2-3 years. The shifting of responsibilities should be effected gradually as and when enough tools and personnel become available at local and sub-regional levels.

3.04 Following discussions with the Water Superintendent and the Chief Works Supervisors and approval by the Chief Civil Engineer (O & M) the following decentralization pattern is proposed :

I - Northern Region

A - Mzuzu Maintenance Sub-Region
Mzuzu, Ekwendeni, Nkhata Bay, Chinteche I, Chinteche II and Mzimba

B - Karonga Maintenance Sub-Region
Karonga, Chitipa, Chilumba and Rhumphi

II - Central Region

A - Lilongwe Maintenance Sub-Region
Likuni, Chitedze, Bunda, Dowa, Kochilira, Mchinji, Kabudula and Lilongwe Airport.

B - Kasungu Maintenance Sub-Region
Kasungu, Mponela, Ntchisi and Kamuzu Academy

C - Salima Maintenance Sub-Region
Salima, Nkhotakota, Salima Army College and Mvera.

D - Dedza Maintenance Sub-Region
Dedza, Ntcheu, Nkhande, Dedza Secondary School, Dedza Customs Post.

III - Southern Sub-Region - Zomba

A - Zomba Maintenance Sub-Region
Zomba, Kuchawe, Domasi and Namadzi

B - Liwonde Maintenance Sub-Region
Liwonde, Machinga and Balaka

C - Mangochi Maintenance Sub-Region
Mangochi, Namwera and Monkey Bay

IV - Southern Region - Blantyre

A - Blantyre Maintenance Sub-Region
Mpemba, Mikolongwe, Chiradzulu, Mwanza and Thyolo

B - Ngabu Maintenance Sub-Region
Ngabu, Chikwawa, Nchalo and Nsanje

C - Mulanje Maintenance Sub-Region
Mulanje, Luchenza, Muloza and Phalombe.

Therefore, a total of nine Sub-Regional Maintenance Centres have to be created or strengthened. The existing facilities at Mzuzu, Lilongwe, Zomba and Blantyre will serve as Regional/Sub-Regional Maintenance Centres.

3.05 Following discussions with the Water Superintendents and Chief Works Supervisors at the Central and Southern Regions and approval in principle by the Chief Water Supply Officer and Chief Civil Engineer (O & M), maintenance of electrical equipment has been included in the

preventive maintenance programme with a view to assuming this responsibility over a period of 3-5 years by DLVWQ during which resources in personnel and repair facilities are built-up. No official "divorce" with MWS is contemplated here, but gradually less and less electrical maintenance work will be requested from MWS until it ceases.

3.06 For a preventive maintenance programme to function efficiently, technicians should be provided with the means of doing the job at the time it needs doing, the necessary instructions and technical information, the spare parts and tools. Manufacturers maintenance manuals, if available, should be kept at the plants. Spare parts lists should be kept at Regional Offices, and are to be requested from the manufacturers if not available.

It is now common practice to require the consulting engineering firms responsible for the design and supervision of construction to prepare maintenance manuals in simple language and train operation and maintenance staff as part of the engineering services and covered by their fees.

3.07 Transport (a complaint voiced at all plants) plays an important role in the successful implementation of the programme. Personnel and materials have to reach the site on time and frequent delays could render the planning of activities meaningless. The vehicles, described later in the text, although they form part of the fleet of the Regional Offices, should, if possible, be earmarked for the preventive maintenance programme and be well maintained and kept in good operating condition. The transport desk at the Regional Office, which has copies of the Work Plans, described in arts 3.14 and 3.18 should draw out weekly and monthly plans with dates, destination and reason for the journey to ensure optimum use and prevent misuse of the vehicles.

3.08 The preventive maintenance programme has been split in two sections, as the nature of work and job skills vary viz (a) Buildings, structures and equipment and (b) Main and distribution system pipelines and water meters. So far the maintenance of pipelines has been given low priority and water meter reconditioning and calibration hardly carried out. The speedy detection of leaks through the preventive maintenance programme and carrying out the necessary repairs should have the effect of increasing the available supply - in some cases near plant capacity - and represents to DLVW a considerable financial saving.

Design of the Preventive Maintenance Programme

3.09 Apart from the incomplete information collected under the Japanese Date Book Project in 1982, no records exist of the structures and equipment in the various water supply shemes. The mission, therefore, visited all the installations of the Central Region covered by the proposed programme and made an inventory of plant items to be maintained.

3.10 An "Equipment History Card" has been developed and appears as Annex V. The card gives all data relevant to maintenance work and the ordering of spare parts (make, type, serial number, horsepower, speed, discharge, etc.) as well as spare parts lists and manufacturers' maintenance manuals, as available. On the back page, the card also provides a record

of all maintenance/repair work carried out and by whom as well as costs of the maintenance/repair jobs. The card helps to monitor whether preventive maintenance tasks have actually been performed. The cards should be kept in a loose folder at the plant where the component is installed and duplicates at the Regional Offices. Advance copies of the Equipment Card have been distributed at the plants visited by the mission and a few forms duly completed by plant operators have been received at the Central Region.

3.11 A compilation and classification table for water supply schemes (district and institutional) in the Central Region has been completed and appears as Annex VI. This covers buildings, structures and equipment divided into sub-groups of source of supply, raw water pumping, treatment, treated water pumping, storage, diesel engine generating sets and windmills. The table, which would be kept at the Regional Office and Lilongwe Headquarters would indicate at a glance the number and function of components in each plant.

3.12 Based on Annex VI, an identification numbering system for plant components in the Central Region was introduced and is given in Annex VII. The identificaton number for each component is to be entered on its Equipment History Card and will remain unchanged even if certain components are to be replaced by similar or different components performing the same function. In that case data on the Equipment History Card will be changed accordingly. The identification number appears on all maintenance/repair work done on the component and helps the Accounts Section to trace and compile all expenses incurred on maintenance/repair jobs carried out on the component during a given span of time. It is to be noted that a gap is left between the identification numbers of one plant and another to permit additions of units through augmentation projects without losing the sequence.

3.13 Following discussions with the staff at the Central Region and plant operators, a Preventive Maintenance Schedule was developed based on current practices and is given as Annex VIII. The Schedule shows the tasks to be performed and their frequency-daily, weekly, monthly, etc., the level of responsibility - local, sub-region, region and the persons to carry them out - plant operators, mobile maintenance teams, engineers/technical officers, etc. The materials and spare parts likely to be used are also shown. The Schedule is drawn up on the assumption of a decentralized approach to preventive maintenance as discussed under articles 3.03 and 3.04. Electrical machines and switchgear have been included as stated in article 3.04.

3.14 It should be pointed out that the tasks scheduled and the degree of decentralization is a goal to be aimed at when resources in personnel and equipment become available. It could be implemented in stages i.e. the Central Region performing the tasks of sub-regional level responsibilities until facilities at the chosen sub-regional maintenance/repair centres are completed. Furthermore, the proposed schedule could be scaled down initially until physical and financial resources become available.

3.15 In view of the fact that the Central Regional Office has the necessary repair and transport facilities to commence a preventive maintenance programme (as a sub-regional maintenance centre) for a trial period of one year without waiting for procurement of equipment or recruiting

personnel (other than electricians), a yearly Work Plan for the mobile maintenance teams for plant buildings, structures and equipment has been prepared and appears as Annex IX. This has also been prepared in consultation with Central Regional Office staff. It takes into consideration the geographical location of the plants, the normal travel time and the number of plants to be visited during one or two working weeks. The mobile teams will return to base at the Regional Office to report on their operations and replenish their stocks of materials and spare parts. The Work Plan is to be accompanied by weekly or monthly circuits for mobile maintenance team(s) shown on appropriate maps.

3.16 It is to be noted that for the 6 diesel engines (3 at Dowa, 2 at Kochilira and one at Kabudula), the monthly preventive maintenance task of dismantling the injectors and testing the spray has not been included in the Work Plan to save costs. Instead, spare nozzles could be kept at the plants and replaced by the plant operators. The dismantled nozzles could be tested by the mobile maintenance teams during their 3 monthly visits and replaced if found defective. If they are found to be in good condition they could be re-used.

3.17 To enable the Regional Office to cope with "breakdown repairs" or "Corrective maintenance" a team consisting of one engine mechanic, one pump repairer (fitter), one plumber and 4 labourers will be earmarked for those emergency duties. They could, however, be employed on other repair jobs at the Regional Office inbetween emergency repairs.

3.18 Due to absence of detailed up-to-date maps of main and distribution system pipelines and valves, that part of the preventive maintenance programme could not be finalized during the mission. However, the same approach as that adopted for plant buildings, structures and equipment could be developed when an inventory of pipelines and valves and up-dating maps have been carried out. This should be followed by the preparation and up-dating of distribution network drawings (as built) showing location of valves, hydrants, and service connections for each zone to a suitable scale.

3.19 Annex X gives a format for a compilation and classification sheet for mains and distribution system pipelines and meters. An identification numbering system, similar to that used for water treatment plants could be introduced on the format given as Annex XI. The lengths of pipelines for each diameter should be given in Annex X with a view to determining the time required for the mobile maintenance team(s) to carry out the checks and repairs detailed in Annex XII.

3.20 No serial numbers are given to industrial/commercial and domestic meters. In the circumstances, the same account numbers could be used to identify the meters installed. This will not hinder drawing up a preventive maintenance programme. It is recommended that meters are removed for complete overhaul and calibration at the Regional Offices once every 3 years. A colouring system painted on the casing of the meter could be introduced to indicate the year it was overhauled and when the next overhaul is due.

3.21 Annex XIII gives a format for a yearly Work Plan for a mobile team for the maintenance of mains and distribution system pipelines and valves. The team would consist of a patrol man, a plumber and two labourers. The team should be equipped with the necessary tools and a long wheel base pick-up complete with hoisting gear and replacement parts to effect repairs as necessary.

3.22 Activities for routine inspection of pipelines and detection of leaks will be better organized after setting up of a "Waste Control Section" in DLVW and the acquisition of the necessary leak detection equipment under the Project described in Annex XIV.

3.23 In view of the large number of district and institutional schemes operated and maintained by DLVW, the implementation of the preventive maintenance programme and its monitoring could be greatly facilitated by the use of a small computer where data about structures, machinery and pipelines, as well as the preventive maintenance tasks for various plants could be stored and print-outs obtained at monthly intervals. The development of micro-computers is opening an entirely new range of low cost machines capable of supporting the needs of the Chief Civil Engineer (O & M) at DLVW Headquarters and the Water Superintendents at the Regional Offices.

Human Resources Requirements

3.24 The present staffing levels at the plants could be maintained as it stands after the introduction of the preventive maintenance programme. In view of shifting some maintenance tasks to Local Level (the plant) as detailed in Annexes VIII and XII their skills have to be improved. Training courses for plant operators and their syllibi have been given in detail in Chapter V of the Report entitled "Training Programme for Water Works Staff, 1983" by Mr. M. Roy, WHO/STC. Steps should be taken to implement the training programme recommended by Mr. Roy as soon as possible.

3.25 The following straffing pattern is suggested at the Regional and Sub-Regional levels, after having been discussed with the Chief Water Supervisor, Central Region:

A. Regional Workshops

- One diesel engine mechanic,
- one assistant diesel engine mechanic,
- one pump fitter,
- one assistant pump fitter,
- two welders (arc welding and oxy-acetylene),
- two water meter repairers (fitters),
- two assistant water meter repairers,
- one bricklayer,
- one carpenter,
- one painter.

For emergency breakdown repairs the following team is required:

- one diesel engine mechanic,
- one pump fitter,
- one plumber,
- four labourers.

B. Sub-Regional Maintenance Centres

Nine centres as given in Article 3.04, three of which in the Central Region.

- One supervisor,
- one foreman,
- one diesel engine mechanic,
- one pump fitter,
- one plumber,
- one bricklayer,
- one painter,
- one driver,
- one driver to replace any of the drivers on annual or sick leave.

3.26 An examination of the present staffing at the Central Region reveals that no additional recruitment is required, other than electricians, to man the 3 proposed sub-regional maintenance centres. An upgrading of skills is required at all levels in accordance with the training programme recommended by Mr. Roy. Maintenance of electrical machinery and switchgear is to continue being entrusted to MWS and gradually phased out over a period of 3-5 years during which the necessary personnel are recruited (or trained) and maintenance/repair facilities provided.

Estimates of Capital and Recurrent Costs

3.27 A. Capital Costs

The following table No. 1 gives details of equipment required to introduce the proposed preventive maintenance programme in the Central Region.

B. Recurrent Costs

3.28 There will be no additional personnel (other than electricians) required to implement the preventive maintenance programme; rather a better utilization of time of existing staff will result. A provision should be made, however, to defray subsistence allowance for personnel on duty travel when they cannot return home at the end of a working day. It is to be noted that the Work Plan is based on a 5 day working week, so no overtime is to be paid during week-ends.

3.29 Wages for electricians (one electrician grade I and one electrician grade II for each sub-regional maintenance centres) i.e. a total of 4 electricians grade I and 4 electricians grade II for the Central Region. The estimated cost per annum of electricians' wages is about K 8100, based on an hourly rate of 56t for electrician grade I and 35t for electrician grade II, working 42 1/2 hours a week for 52 weeks a year. This sum will be partially offset by payments currently made to MWS for maintaining electrical machines (a sum of about K 3000 during 1983).

TABLEAU No. 1 - CAPITAL COSTS OF EQUIPMENT REQUIRED FOR THE CENTRAL REGION

QTY	DESCRIPTION	UNIT PRICE K	TOTAL COST K	REMARKS
	A - Regional Office, Lilongwe			Also acts as Sub-Regional Maintenance Centre
	Pipe screwing machine	3,200	3,200	To replace the existing machine out of order
	Water Meter testing and Calibration equipment	-	-	To be transferred from Zomba stores.
	B - Three Sub-Regional Maintenance Centres at Kasungu, Salima and Dedza			
	Drilling machine	600	1,800	
	Grindstone	400	1,200	
	Pipe screwing machine	3,200	9,600	
	Arc Welding machine (transformer)	950	2,850	
	Gas acetylene welding equipment	1,550	4,650	
	Fuel injecter testing pump	400	1,600	
	Set of painters brushes, ladders, etc.	500	1,500	
	Set of bricklayers tools	200	600	
	Vehicle, 4WD pick-up with diesel engine fitted with canopy and seats	20,000	60,000	Regional office has 2 pick-ups.
	Motor cycle (light type) for use by supervisors	1,400	4,200	Regional office has a motor cycle.
	Bicycle	400	6,800	For plant operators at all plants. Four already exist.
	Tool box	500	5,500	To complete existing tool boxes at plants + one tool box for every mobile team.
	TOTAL		103,500	

Consideration could be given that DLVW lends K400 to each operator at low interest rates to purchase own bicyle, repayable over 2-3 years. Should this be approved the total cost of equipment is reduced to K 96,700.

3.30 Recurrent costs per annum for the implementation of the preventive maintenance programme could, therefore, be estimated as follows:

- subsistence allowance during duty travel	K 3,000
- electricians (in about 3-5 years)	K 8,100
- materials, spare part, etc.	K 150,000
- transport (based on K 1,000 per vehicle/month)	K 48,000
Total	K 209,100

3.31 It should be noted that the above annual recurrent costs for implementing the preventive maintenance are not additional costs to what is being spent at present. Electricians' wages will only be spent in about 3-5 years, annual transportation costs are on the high side and could be less and the cost of materials, spare parts, etc. is likely to go down through fewer breakdowns and, therefore, fewer premature replacements of costly items such as shafts impellers, etc. With a total sales of water (Jan.-Dec. 83) of 1,446,495 cu. m, the recurrent costs for all maintenance work per cu. meter sold is only about K 0.14 representing 30% of the average water rate of K 0.49.

Evaluation

3.32 The preventive maintenance programme should be implemented as soon as possible in the Central Region - first in Lilongwe where resources in personnel and facilities exist - and gradually in the remaining Sub-Regional Maintenance Centres at Kasungu, Salima and Dedza as and when equipment becomes available (no additional personnel required but upgrading of skills through the training programme recommended by Mr. Roy.

3.33 After a trial period of one year during which the programme is fully operative in the Central Region an evaluation of its effectiveness should be carried out. This should be conducted through field visits to installations by the supervisors, or preferably by a team of experienced evaluators from the Regional Office and DLVW Headquarters, who would interview plant operators as well as users.

3.34 Areas to be covered by the evaluation exercise would include: proportion of components/systems which are functioning as intended, the recurring operations and maintenance problems, adequacy of budgetary allocations and programme support services (spare parts, transportation, repair facilities, etc), recurrent costs for implementing the programme and consequently its cost effectiveness, suggestions for amendments/ improvements, etc.

3.35 Subsequent to the evaluation a decision could be reached to extend the programme, as amended if necessary, to the other three regions of DLVW.

IV. REDUCTION AND CONTROL OF UNACCOUNTED - FOR WATER OBSERVATIONS

Observations

4.01 Unaccounted-for water (the difference between water produced and quantities billed to consumers) is attributed to leakage from pipe joints and service connections, leakage from the pipes themselves due to corrosion or haircracks, open or partially open drain valves, over-flowing reservoirs and broken or under-recording water meters. Although no assessment has been made so far of the quantities of unaccounted-for water, there are indications that the percentage waste in DLVW water supply systems has reached unacceptable levels.

4.02 There are no up-to-date maps of distribution systems showing the location of pipelines, valves and service connections. Repairs of pipes and joints are carried out when leakage manifests itself above ground level. A proper inventory of all the pipe mains, giving their size, material, depth below ground, the number and location of sluice valves, scour valves, air valves and service connections should be made for each water supply scheme. For large towns, maps covering zones (or sub-zones) to a scale of say 1:1000 should be prepared.

4.03 Excessive pressures in some parts of the distribution system (e.g. Zomba) have the effect of increasing the quantities of water which leaks from a faulty joint (or initiating a leak from the walls of corroded pipes). In areas where pressures are in excess of consumers' requirements, water flowing from a given tap opening increases and thus results in undue consumption and misuse of water by subscribers. Pressure reading should be taken at various points of the distribution system - and preferably recorded over 24 hours - and pressure reducing valves installed to limit the pressures up to say 30-40 meters. Considerable waste reduction could be achieved by pressure reduction to pressures actually needed for adequate supply.

4.04 Overflow from service/storage reservoirs is suspected of causing considerable waste. Although all of them are fitted with float operated inlet valves, the mechanism could breakdown causing excessive waste through the overflow pipes. Level gauges should be installed at all reservoirs and preferably coupled with an overflow alarm system (operating through telephone lines) to alert plant operators when a reservoir is overflowing. Pressure readings at the inlet pipes to reservoirs should be taken and recorded over 24 hours, and pressure reducing valves installed where necessary. This will prolong the period between maintenance/repair of float operated valves.

4.05 It would help monitoring the degree of waste in the distribution systems if bulk flow meters are installed on the outgoing mains of treatment plants and boreholes, the storage reservoirs and on trunk mains feeding main zones. Regular readings of the bulk meters will alert the distribution system personnel on zones, reservoirs, etc. where excessive leakage/waste is taking place.

4.06 There seems to be long stretches of 50 mm diameter galvanized iron piping in use in various schemes. These are liable to corrosion, and leakage, over time and also higher friction losses. Their use should be discontinued and a programme of their gradual replacement by 80 mm diameter PVC piping is recommended. Service connections should also be made in PVC tubing.

4.07 Domestic water meters are almost all of the positive displacement type which is prone to stoppage due to particles of sand or iron from corroded pipes. Consideration should be given to using the less sensitive and easier to repair fan type water meters. They are also cheaper. Furthermore, no calibration of meters is practiced at present and a large number could be underrecording representing loss of revenue. Domestic and commercial/industrial water meters should be reconditioned and calibrated once every 3 years as recommended in art. 3.20.

4.08 At the treatment plants, water might also be lost through inefficient or incorrect treatment requiring more frequent backwashing of filters. At Mvera, the wash out water could be directed to the raw water inlet chamber before the sedimentation tanks instead of to drain thereby saving the energy required to pump an equal quantity from the intake several hundred meters below.

4.09 Illegal connections do not seem to be a problem in Malawi, although they contribute to a large proportion of unaccounter-for water in many developing countries. However, effective vigilence should be exercised to detect and prevent unauthorized connections, especially in premises where the service was discontinued for nonpayment and householders are tempted to reconnect illegally.

4.10 Leak detection and control of waste is a specialized activity and the lack of such personnel in DLVW should be redressed as discussed later in articles 4.15 and 4.16.

Zomba Water Supply System

4.11 The mission's visit to Zomba confirmed that almost all the foregoing factors contribute to the present large amount of unaccounted-for water, reportedly over 50%. Many service reservoirs are difficult to reach and hence less inspected; the float mechanisms in a few were defective causing water to run to waste through the overflows. Excessive pressures were noted at the inlet of some. In 1983, 822,749 cu metres were unaccounted-for representing a loss of revenue of about K 436,057.

About 62% of the distribution system pipelines are in galvanized iron and might be contributing to the large amount of waste.

4.12 The question of reduction and control of waste in Zomba is rendered more urgent due to the near saturation of capacity of the treatment plant. In October 1983, the hot peak period, the average daily production was 4705 cu m. representing 86% of plant capacity. Unless measures are taken to reduce and control waste, a project of augmentation of capacity of the system has to be implemented.

4.13 Waste in other water supply schemes of DLVW could well be of the same magnitude as in Zomba. Leak detection and control of waste should be a continuous activity and the cost of its introduction is justified.

Setting-up of a Waste Control Section

4.14 A long term objective would be the setting up of a Waste Control Section within DLVW with a view to reducing waste in small urban water supply systems to the most economic level and to maintaining it at that level.

4.15 To achieve this objective, a project has been formulated with the following immediate objectives:

a - Estimation of the level of waste in the water supply system of the municipality of Zomba by carrying out a leakage and waste survey.

b - To justify waste control by reducing waste in Zomba water supply system by the maximum amount through repairs and other measures.

c - Training of national engineers and technicians in waste control practices.

d - Aquision of equipment for leakage and waste surveys.

4.16 Leakage and waste surveys and training are to be carried out by a firm of consulting engineers to be retained by DLVW. The cost of the project is estimated at US $ 334.400 in foreign exchange plus a Government contribution in kind estimated at K 46.520.

4.17 To enable the Government to approach potential bilateral assistance agencies, a draft Project Document on UNDP format was prepared and is attached as a self contained Annex XIV.