# CHAPTER 8 CONCLUSIONS AND RECOMMENDATIONS

## 8.1 Water Quality Sample Collection

Encouraging the more regular testing of water qualities in Zambia should be an important part of the Master Plan. This will require building on the developing network of aid supported DWA regional laboratories as well as instituting the regular sampling of all streams as part of the national stream gauging programme. The stream gauging teams have already been used in this role during the 1994 Dry Season survey. They offer the real advantages of having available transport and a regular programme of regional visits. They are also becoming more interested in quality issues as, in some parts of the country, the easily developed water resources are becoming committed and a greater effort needs to be applied to next stage of reducing pollution loads. Introducing Hydrographic Branch to this work will also be a good example of using the best people to collect and analyse samples rather than setting up competing networks. Accordingly, it would be in ECZ's interests to contract DWA Hydrographic Branch for the monitoring of drainage returns.

## 8.2 Zambian Water Quality Laboratories

One conclusion from a survey of water quality laboratories in Zambia is the need to improve the staffing and equipment levels in all Zambian water laboratories. A hierarchy of capabilities needs to be encouraged with say the NCSR laboratory exercising a quality control role, and the other laboratories being subject to regular quality control inspections. The international aid programmes have already been active in this area and this involvement should be further encouraged.

## 8.3 Water Quality Testing

As the first steps in the adoption of new and tougher guidelines for Zambian water quality, all water testing should be for an expanded list of parameters such as those in the already referenced Australian Guidelines. The results of this new testing should be added to the planned DWA water quality data base as should the best of the historic quality records.

## 8.4 Long Term Water Quality Record

The Lusaka Water and Sewerage Corporation should be encouraged to continue (with hopefully, increased frequency) the long term Kafue water quality record at Iolanda. Any new testing should concentrate on the measurement of nutrient levels as a preliminary study to planned investigation of weed growth and algal blooms.

## 8.5 Introduction Of Ecosystem Guidelines

The introduction of any new water quality guidelines should be a DWA responsibility. During the negotiations with authorities and industry, the DWA should brief both NCSR and UNZA to provide working papers on selected quality topics and to relate world wide research findings to Zambian conditions and to otherwise act as a technical adviser to the Department. The setting of receiving water standards on a national basis is thus to be taken as a water resource issue not a pollution matter which otherwise would correctly belong with the ECZ. It is recommended that the Australian aquatic ecosystem guidelines be the starting point for the assessment of new Zambian figures.

## 8.6 Sedimentation Effects In Storages

As advocated in Section 5.11.4, regular sediment sampling should be re-introduced for the smaller Zambian catchments and silt sections should become part of the regular monitoring of all storages.

## 8.7 Initial Environmental Examinations

While limited at present, the programme of IEE's has confirmed that the best of the likely storage developments suffer from no "fatal flaws". The draft terms of reference for the special studies needed to support the feasibility study's EIS programme will require effort by design engineers, social planners and water scientists. This EIS work will be limited to those projects that clear the technical feasibility and economic justification hurdles. The draft terms of reference should be reviewed by the Assessment Section within the Environmental Council of Zambia.

## 8.8 Environmental Impact Assessments

The environmental concerns commonly associated with criticisms of water storage developments during the 1970's such as large reductions in productive agricultural and grazing land, effects on fish migration, displacement of native peoples, encouragement of disease vectors, draining of wetlands and the consequent reduction in biological diversity are all acknowledged and shall be addressed as the selected developments run their project cycles from goals and objectives, agreed actions, evaluation and justification, field investigations and thus to concept design, detailed design and finally to construction. This careful attention to environmental concerns has become an important and routine part of project design in the 1990's as has the use of a range of specialist scientists to report on the real environmental impacts in project terms. The IEE's included in this report are the first steps in the environmental assessment and impact mitigation process.

## APPENDICES

## APPENDICES

## APPENDIX 1

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# APPENDIX 2

# SUMMARY OF ZAMBIAN WATER CAPABILITY

## Appendix 2 Summary of Zambian Water Quality Laboratories Capability

| Name of Laboratory or Organisation | Location | Laboratory's Main Purpose | Contact or Leader | Water Quality Interests or Special Testing Capability | Discussions held with JICA/DWA Team |
|---|---|---|---|---|---|
| DWA - GRZ | Lusaka | General water quality | Robert Mulenga, tel 248304 | Limited physical/chemical | August, 1994 as counterpart |
| DWA - GTZ | Kabompo | General water quality | | | |
| DWA - Irish Aid | Kasama | Village water quality | Derek Carty, CMMU | Bacteriological testing | August, 1994 |
| DWA - Norad | Mongu | | | | |
| DWA - Netherlands | Solwezi | | | | |
| NCSR Water Resources | Lusaka | Special quality studies | Dr J Kasonde, PO Box 310158, Lusaka | AAS and thus wide range of parameters | August, 1994 |
| Public Health, Food & Drugs, GRZ | Lusaka | | Dr Sinyinda, tel 229267 | Physical/chemical and bacteriological | |
| Environmental Engineering Lab, UNZA | Lusaka | | Dr W Schaefer, tel 213221, PO Box 32379 | Physical/chemical and bacteriological | |
| Lusaka Water Supply and Sewerage Co. | Lusaka | Domestic supplies and sewerage | Mrs. P Okeowo, tel 261009, PO Box 50198 | Physical/chemical and bacteriological | |
| Ndola City Council | Ndola | Domestic supplies and sewerage | Mr. Kawalika | Physical/chemical and bacteriological | |
| Kitwe City Council | Kitwe | Domestic supplies and sewerage | Mr. Mwabe | Physical/chemical and bacteriological | |

| Name of Laboratory or Organisation | Location | Laboratory's Main Purpose | Contact or Leader | Water Quality Interests or Special Testing Capability | Discussions held with JICA/DWA Team |
|---|---|---|---|---|---|
| Mount Makulu Research Station | Chilanga | Agricultural research | | Chemical | |
| Geological Surveys, GRZ | Lusaka | Geochemical analysis | Dr Sharma, tel 227449/52 | Chemical | |
| ZCCM, Nchanga Division | | | Mrs. S N Chitah, Divisional Environmental Services Officer | Physical and chemical for a wide range of parameters. | |
| National Soils Laboratory | Mt Makulu C.R. Station, PB 7, Chilanga | Physical and chemical test on soils. Irrigation water quality | Mr M Damaske, tel 278 087 | Testing for and interpretation of irrigation water qualities. | |
| ZCCM, Nkana Division | | | M. Ngoma, Head of Analytical services | Physical and chemical for a wide range of parameters. | |

# APPENDIX 3

# POSTAL SURVEY OF ZAMBIAN WATER QUALITY LABORATORIES

THE JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE TEAM FOR THE STUDY ON THE NATIONAL WATER RESOURCES MASTER PLAN IN THE REPUBLIC OF ZAMBIA

JICA Study Team,
P.O. Box No. 34457,
Sheki Sheki Street, Lusaka, Zambia.
Telephone/Facsimile : + (260) 1 243 135

YEC LSK- 157___ September 9, 1994

TO WHOM IT MAY CONCERN

**QUESTIONNAIRE ON WATER QUALITY LABORATORY CAPABILITY**

The Japanese International Cooperation Agency (JICA) Study Team is conducting field and office research to help compile a Water Resources Master Plan to assist in the development of this most valuable resource in the Republic of Zambia.

The Master Plan will cover not only a full assessment of surface and groundwater resources, but will also consider water qualities and environmental issues.

To help with this latter task, the JICA Study Team is conducting a postal and facsimile questionnaire on the technical and administrative capability, future plans and past activities of the leading water quality laboratories in Zambia. The aim is to develop a comprehensive picture of past water qualities and to develop plans to enhance the collection, testing and reporting of water quality in the 21st century.

Your quick response to the attached questionnaire would be greatly appreciated and a stamped addressed envelope is enclosed to help with the return. The report section that will come from the questionnaire will be shared with your laboratory. Information supplied will be treated in the strictest confidence and will only be used in an aggregated form for Master Plan purposes.

Any questions on the survey form could be directed to Donald Macleod on Lusaka telephone/facsimile 243135.

Thanking you for your timely assistance.

Yours faithfully,

M. WATANABE
Deputy Team Leader

## SURVEY OF WATER QUALITY LABORATORIES IN ZAMBIA

### CONTACT DETAILS

Name of Laboratory.....
Address .....
Officer Contact.....Telephone.....Facsimile.....
Owner of Laboratory.....Source of Funds.....
Staff Numbers: Professional.....Assistants.....Administration.....

### DEFINED FUNCTION OF LABORATORY

.....
.....
.....

### EQUIPMENT

Laboratory Floor Space.....$m^2$ Bench Space.....$m^2$ Storage.....$m^2$
Physical Testing.....
Chemical Testing .....
Bacteriological Testing .....
Other .....

### ROUTINE TESTING PROGRAM

| Stream/Source ..... | Tests ..... | Frequency ..... |
|---|---|---|
| ..... | ..... | ..... |
| ..... | ..... | ..... |
| ..... | ..... | ..... |
| ..... | ..... | ..... |

### DATA BASES AND OTHER LONG TERM WATER QUALITY RECORDS.

| Stream/Source..... | Tests ..... | Frequency ..... | Form of Database ..... |
|---|---|---|---|
| ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... |
| ..... | ..... | ..... | ..... |

### SPECIAL WATER QUALITY INVESTIGATIONS

| Study Title ..... | Date ..... |
|---|---|
| ..... | ..... |
| ..... | ..... |
| ..... | ..... |

### PLANS FOR 1995

Equipment .....
Staff.....
Investigations.....

### ANY OTHER COMMENTS

.....
.....

# APPENDIX 4

# ZAMBIAN DRINKING WATER QUALITY GUIDELINES

REPUBLIC OF ZAMBIA

MINISTRY OF AGRICULTURE AND WATER DEVELOPMENT

DEPARTMENT OF WATER AFFAIRS

STANDARDISATION COMMITTEE FOR WATER SUPPLY

CIRCULATION NO. 3

(REVISED MARCH, 1986)

# WATER QUALITY GUIDELINES FOR DRINKING WATER

CONTENTS

# 1. INTRODUCTION

## 1.1. Establishment of Standardisation Committee

A Standardisation Committee on Water Supply was nominated on 7th August, 1984 by the Director of Water Affairs, Ministry of Agriculture and Water Development. The Committee was charged with the responsibility of drawing out guidelines for design of Water Supply Systems throughout Zambia. Such guidelines serve to provide uniform and coordinated approaches in the design of various components of water supply systems in Zambia. Many international and local organisations are involved in the design of water supply systems to a diversity of water users in the country and it is beneficial to have uniformity in design approaches, and many other relevant components of water supply systems. Standardised components and fittings and uniform operational procedures should eventually lead to easier operation and maintenance, reduction in types of stock of spare parts, and encourage local production of components. It is in recognition of these obvious advantages that the Standardisation Committee for Water Supply was formed.

## 1.2. Membership of the Committee

The original membership of the Committee in August 1984 was subsequently expanded such that it is now truly a national committee. The following organisations are currently represented:

(i) Department of Water Affairs (Chairman)
Ministry of Agriculture and Water Development

(ii) Buildings Department
Ministry of Works and Supply

(iii) Ministry of Decentralisation
(a representative from large urban district council)

(iv) National Housing Authority

(v) University of Zambia

(vi) Engineering Institution of Zambia

(vii) Association of Consulting Engineers of Zambia

(viii) Zambia Bureau of Standards

(ix) United Nations Children's Fund (UNICEF)

The list of current members of the Committee is given in Appendix I. In addition to the permanent members, the Committee is free to co-opt members from other organisations to serve for a limited period in order to accomplish limited specified objectives.

2/....

CIRCULATION NO.3

SCOPE OF WORK OF THE COMMITTEE

1. Overall Scope of Work of the Committee

At the meeting of the Committee on 20 July, 1984 a list of topics that would be covered by these guidelines was prepared. The list of topics, which can be revised or enlarged if necessary, includes the following:

(i) Consumption Figures and Population Projections for Design of Water Supply Systems

(ii) Pressure Pipes and Fittings

(iii) Water Meters

(vi) Pumps (all types)

(v) Wells (hand dug and drilled)

(vi) Boreholes

(vii) Water Treatment

viii) Storage Reserviors

(ix)

(ix) Water Distribution System Design Criteria

(x) Electrical Power and Equipment

(xi) Consumers's Connection

(xii) Communal Standpipes

xiii) Drinking Water Quality Guidelines

(xiv) Pumping Mains

It is not the intetion of the Committee to produce text books of comprehensive specifications on each of the above topics. The objective is to compile and highlight basic design approaches and operation and maintenance procedures which are widely applicable, or considered to be good practice in Zambia. Where necessary, reference will be made to various Zambian an other standards and/or specifications for more details on the topic being considered.

All the reference materials used in preparing each guideline are listed after the main text.

2.2 Scope of Circulation No.3

The scope of circulation No. 3 covers Water Quality guidelines for drinking Water. The Circulation deals with the following:-

(i) General Pysical and Chemical Guidelines.

(ii) Guidelines for Specifically Toxic substances

(iii) Guidelines for Non-Toxic substances

(iv) Standards of Bacteriological Quality

The details of the above are contained in TABLES I, II, III and IV.

One set of guidelines were recommended by some consulting E Engineers but the committee felt that two limits i.e. "Permissible" and "Desirable" seem most appropriate in Zambia at the moment.

3. REFERENCES

1. Small Community Supplies by International Reference Centre (T. P. 18).

2. Water Quality analyses, American Water Works Association (Water Supply Operation Vol. 4)

3. Basic Water Treatment, by George Smethurst Thomas Telford Limited London (1979)

4. Water Practice Manual Vol. 3 Water Supply and Sanitation in Developing Countries by Institution of Water Engineers and Scientists (London).

5. A guide to Standards of Quality for public streams affected by mining effluents in Zambia.
by Dr. G. Armstrong-Smith revised and Edited by Professor D. Morgan and Mr. S. O. Mensa

6. Drinking Water Standards WHO

CIRCULATION NO. 3

4. ASSISTANCE FROM SPCIALISTS:-

1. Mr. S. O. Mensa - Senior Biochemist, Lusaka Urban District Council.
2. Dr. P. A. Khan - Head of Enviornmental Laboratory, National Council for Scientific Research.

Circulation No. 3

TABLE I

DEPARTMENT OF WATER AFFAIRS
STANDARDISATION COMMITTEE FOR WATER SUPPLY

WATER QUALITY GUIDELINES FOR DRINKING WATER

GENERAL PHYSICAL AND CHEMICAL GUIDELINES

| CHARACTERISTIC | PERMISSIBLE LIMIT mg 1 | DESIRABLE LIMIT mg 1 | COMMENTS AND/OR UNDESIRABLE EFFECTS |
|---|---|---|---|
| Acidity | N. S. | N. S. | Taste and corrosion |
| Alkalinity as $CaCO_3$ | 400 | 30 - 250 | Taste and Scale formation |
| Colour(Hazen Units or TCU) | 15 | 5 | Aesthetic Consideration |
| Dissolved Solids | 1500 | 500 | Aesthetic Consideration |
| Hardness (total) as $CaCO_3$ | 500 | 250 | Scale formation and soap Consumption |
| pH (pH Scale) | 6.5 - 9.0 | 7.0 - 8.5 | Taste and Corrosion |
| Turbidity (NTU Scale) | 10 | 5 | Aesthetic filterabity and disinfection |

Note: * Not Specified

Circulation No. 3

TABLE II

DEPARTMENT OF WATER AFFAIRS
STANDARDISATION COMMITTEE FOR WATER SUPPLY
WATER QUALITY GUIDELINES FOR DRINKING WATER

GUIDELINES FOR SPECIFICALLY TOXIC SUBSTANCES

| SUBSTANCE | PERMISSIBLE LIMIT mg/l | RECOMMENDED LIMIT mg/l | COMMENTS |
|---|---|---|---|
| Arsenic (As) | 0.05 | 0.01 | |
| Cadmium (Cd) | 0.01 | 0.005 | |
| Cromium (Cr) | 0.05 | 0 | For Cr in hexavalent form |
| Cyanide (Cn) | 0.10 | 0.05 | |
| Fluoride (F) | 1.5 | 0.7-1-1 | If less than 0.7, Problems of dental carries |
| Lead (Pb) | 0.05 | .01 | |
| Mercury (Hg) | 0.001 | 0 | |
| Nitrate (N) | 10 | 5 | |
| Selenium (Se) | 0.01 | 0.005 | |
| Aluminium (Al) | 0.3 | 0.2 | |
| Radioactivity Constituents | | | |
| Gross alpha activity (Bq/l | 0.1 | - | |
| Gross beta activity (Bq/l | 1.0 | - | |

Circulation No. 3

TABLE III

DEPARTMENT OF WATER AFFAIRS

STANDARDISATION COMMITTEE FOR WATER SUPPLY

WATER QUALITY GUIDELINES FOR DRINKING WATER

GUIDELINES FOR NON-TOXIC SUBSTANCES

| SUBSTANCE | PERMISSIBLE LIMIT mg/l | DESIRABLE LIMIT mg/l | COMMENTS |
|---|---|---|---|
| Calcium (Ca) | 200 | 75 | Contributes to Hardness |
| Chloride (Cl) | 600 | 200 | Taste Problem |
| Cobalt (o) | 1.0 | 0.3 | Tentative Limits |
| Copper (Cu) | 1.5 | 1.0 | Acceptability may depend on concentration of other heavy metals |
| Hydrogen Sulphide | N.S | N.S | Colour and Smell |
| Iron (Fe) | 1.0 | 0.3 | Taste, Colour and Clogging of pipes |
| Magnesium (Mg) | 150 | 50 | Contributes to Hardness |
| Organics (total)(CCE) | 0.5 | 0.2 | |
| Sulphate ($SO_4$) | 400 | 250 | Contributes to Hardness |
| Zinc (Zn) | 15 | 5 | Above 5 taste may be noticeable |

DEPARTMENT OF WATER AFFAIRS
STANDARDISATION COMITTEE FOR WATER SUPPLY
WATER QUALITY GUIDELINES FOR DRINKING WATER

GUIDELINES OF BACTERIOLOGICAL QUALITY

The water in any part of the distribution system should, ideally, not contain any coliform organisms. In actual practice, it may not always be possible to ensure that no coliforms are present as these can enter the supply at some point in the system other than the intake. The following standards are recommended by WHO and are suitable for Zambia.

| Piped Supplies | Number per 100 ml |
|---|---|
| (i) Treated water entering the distribution system | Fael coliforms 0<br>Coliform organisms 0 |
| (ii) Untreated water entering the distribution system | Faecal coliform 0; organisms in any one amples, 0 in any two 0 in 98% of yearly samples. |
| (iii) Water in the distribution system | Faecal coliforms Nil. 3 coliform organisms in any one sample, Nil in any two consecutive samples, Nil in 95% of yearly samples. |
| Unpiped Supplies | Faecal coliforms Nil<br>Coliform organisms 10 |

NOTE: Further biological qualities are not discussed now, may be considered at a later stage.

# APPENDIX 5

# AUSTRALIAN WATER QUALITY GUIDELINES FOR FRESH AND MARINE WATERS, 1992

Table 2.1: Summary guidelines for protection of aquatic ecosystems

| Indicator | Units | Fresh waters | Marine waters |
|---|---|---|---|
| *Biological* | | It is premature to recommend specific values for these indicators. The need for biological evaluation is recognised, and these indicators are identified as important characteristics of ecosystem function (Section 2.2) | |
| *Physico-chemical* | | | |
| Colour & clarity | | < 10% change in euphotic depth[1] | < 10% change in euphotic depth |
| Dissolved oxygen[2] | mg/L | > 6 (> 80–90% saturation) | > 6 (> 80–90% saturation) |
| Nutrients/nuisance growths | | (Section 2.3.3) | (Section 2.3.3) |
| pH | | 6.5–9.0 | < 0.2 pH unit change |
| Salinity | mg/L | < 1000 (about 1,500 µS/cm) | |
| Suspended particulate matter/turbidity | | < 10% change seasonal mean concentration | < 10% change seasonal mean concentration |
| | | (see also colour & clarity) | (see also colour & clarity) |
| Temperature[3] | | < 2°C increase | < 2°C increase |
| *Toxicants* | | | |
| Inorganic toxicants | all µg/L | | |
| Aluminium | | < 5.0 (if pH < = 6.5)<br>< 100.0 (if pH > 6.5) | NR |
| Ammonia | | 20.0–30.0 (Table 2.3) | NR |
| Antimony | | 30.0 | 500.0 |
| Arsenic | | 50.0 | 50.0 |
| Beryllium | | 4.0[4] | NR |
| Cadmium | | 0.2–2.0[5] | 2.0 |
| Chromium | | 10.0 | 50.0 |
| Copper | | 2.0–5.0[5] | 5.0 |
| Cyanide | | 5.0 | 5.0 |
| Iron | | 1,000.0[6] | NR |
| Lead | | 1.0–5.0[5] | 5.0 |
| Mercury | | 0.1 | 0.1 |
| Nickel | | 15.0–150.0[5] | 15.0 |
| Selenium | | 5.0 | 70.0 |
| Silver | | 0.1 | 1.0 |
| Sulfide | | 2.0 | 2.0 |
| Thallium | | 4.0 | 20.0 |
| Tin (tributyltin) | | 0.008 | 0.002 |
| Zinc | | 5.0–50.0[6] | 50.0 |
| Organic toxicants | | | |
| Acrylonitrile | | NR | NR |
| Benzidine | | NR | NR |
| Dichlorobenzidine | | NR | NR |
| Diphenylhydrazine | | NR | NR |
| Halogenated aliphatic compounds | | | |
| Hexachlorobutadiene | | 0.1 | 0.3 |

**Table 2.1 cont.: Summary guidelines for protection of aquatic ecosystems**

| Indicator | Units | Fresh waters | Marine waters |
|---|---|---|---|
| Halogenated ethers | | NR | NR |
| Isophorone | | NR | NR |
| Monocyclic aromatic compounds | | | |
| Benzene | | 300.0 | 300.0 |
| Chlorinated benzenes | | (Table 2.8) | NR |
| Chlorinated phenols | | (Table 2.9) | (Table 2.9) |
| Phenol | | 50.0 | 50.0 |
| Toluene | | 300.0 | NR |
| Nitrosamines | | NR | NR |
| Pesticides | | | |
| Organochlorine | | (Table 2.10) | (Table 2.10) |
| Organophosphate | | (Table 2.10) | (Table 2.10) |
| Acrolein | | 0.2 | 0.2 |
| Phthalate esters | | | |
| di-n-butylphthalate | | 4.0 | NR |
| di(2-ethylhexyl)phthalate | | 0.6 | NR |
| other phthalate esters | | 0.2 | NR |
| Polyaromatic hydrocarbons | | | |
| Chlorinated naphthalenes | | NR | NR |
| Polychlorinated biphenyls | | 0.001 | 0.001 |
| Polychlorinated dibenzo-*p*-dioxins | | NR | NR |
| Polycyclic aromatic hydrocarbons | | 3.0 | 3.0 |

SPM: Suspended particulate matter; NR: no recommendation made at this time

Notes

1. For systems where depth is greater than 0.5 x euphotic depth ($z_e$). For waters shallower than 0.5 $z_e$, the maximum reduction in light at the sediment bed should not exceed 20%
2. Measured over at least one, but preferably several, diurnal cycles
3. Or use formula in Section 2.3.7; no data for temperature reductions
4. Higher values may be acceptable in hard waters
5. Depends upon hardness of water
6. Provided iron not present as Fe(II)

An indicator of ecological integrity is the degree to which ecosystems have been altered from their natural state. However, defining 'natural state' is problematic. In Australia, the natural state is often taken to be that existing before European settlement. However, it is now increasingly recognised that traditional Aboriginal land uses had significant impact on the terrestrial environment (e.g. structure and composition of vegetation communities and the distribution and abundance of fauna). The effects on the aquatic environment are not known, but would probably have been somewhat less. Nevertheless, the ecological changes resulting from European occupation have been significantly more rapid and far-reaching, such that few natural reference points now exist. Those that do exist are generally labelled as 'pristine' systems.

# APPENDIX 6

# JAPANESE ENVIRONMENTAL QUALITY STANDARD, 1970

[Reference 14.1] Water Quality Standards

Annex Table 1 Water Quality Standards for Protection of Our Health

| Item | Standard value | Measurement method |
|---|---|---|
| Cadmium | Not more than 0.01ppm | Conforms to the Article 40 of Japan Industrial Standard K-0102 (reffered to as the Standard thereafter in this Table and Table 2 |
| Cyanide | Not to be detected | Conforms to the Articles 29.1.2 and 29.3 of the Standard |
| Organic Phosphorus | Not to be detected | Conforms to the Article 23 of the Standard (thin layer chromato-molybdnum bleu method applies to methyll-2 metron) |
| Lead | Not more than 0.1 ppm | Conforms to the Article 39 of the Standard |
| Chronium (6-value) | Not more than 0.05 ppm | Conforms to the Article 51.2 ofthe Standard |
| Arsenic | Not more than 0.05 ppm | Conforms to the Article 48 of the Standard |
| Total mercury | Not more than 0.0005 ppm | Atomic absorption spectro photometry |
| Alkyll mercury | Not to be detected | Gas chromatography and thin layer chromatography separation-atomic absorption sepectro photometry |
| PCB | Not to be detected | Gas chromagraphy |

Notice:

1. The standard value should be taken as upper limit except for total mercury where the annual mean value is provided as standard.
2. The organic phosphorus refers to parathion, methyll-parathion methyl-2 methon and EPN.
3. "Not to be detected" means that the result of a measurement made in cofmity with the specified method doesn't exceed the quantitative lower limit. This rule applies also to the Table 2. For the item of alkyll mercury, an exception is made of alkyll mercury detected both by the gas chromatography and by the thin layer chromatography separation - atomic absorption spectro photometry.
4. The standard value fixed for total mercury is fixed to 0.001 ppm or less only if the source of a pollution in a river is found in natural conditions without doubt.
5. For the thin layer chromato-molybdenum blue method, refer to the [Reference 14.2].
6. For the atomic absorption spectro photometry, refer to the [Reference 14.3].
7. For the gas chromatography and thin layer chromatography separation - atomic absorption spectro photometry provided for alkyll mercury, refer to the [Reference 14.4].
8. The gas chromatography provided for PCB, refer to the [Reference 14.5].

(1) River (except for lake or marsh)

| Item / Category | Adaptable exploitation | Standard value | | | | | Applicable water area |
|---|---|---|---|---|---|---|---|
| | | Hydrogen ion concentration (pH) | Biochemical oxygen demand (BOD) | Suspended substances (SS) | Dissolved oxygen (DO) | Number of colitis germs | |
| AA | Tap water Class 1, Preservation of natural environments and exploitations in the categories A and after | From 6.5 to 8.5 | No more than 1 ppm | Not more than 1 ppm | Not less than 7.5 ppm | Not more than 50 MPN/ 100m | Water areas specified for each category by the Article 1.2.2 of the Notice 59 issued from the Environment Agency |
| A | Tap water Class 1, Fishing Class 1, bathing and exploitations given in the categories B and after | From 6.5 to 8.5 | No more than 2 ppm | No more than 25 ppm | Not less than 7.5 ppm | No more than 1000m | |
| B | Tap water Class 3, fishing Class 2 and exploitation given in the categories C and after | From 6.5 to 8.5 | No more than 3 ppm | No more than 25 ppm | Not less than 5 ppm | Not more than 5,000 MPN/ 100m | |
| C | Fishing Class 3, Insutrial water Class 1 and exploitation given in the categories D and after | From 6.5 to 8.5 | No more than 5 ppm | No more than 50 ppm | Not less than 2 ppm | - | |
| D | Industrial water Class 2, Agricultural water and exploitations given in the categorie E | From 6.0 to 8.5 | No more than 8 ppm | No more than 100 ppm | Not less than 2 ppm | - | |
| E | Industrial water Class 3, preservation of environment | From 6.0 to 8.5 | No more than 10 ppm | No suspended dust | Not less than 2 ppm | - | |
| Measurement method | | Conforms to the Standard 8 | Conforms to the Standard 16 | Conforms to the Standard 10.2.1 | Conforms to the Standard 24 | Quantitative analysis by most probable value | |

# APPENDIX 7

# LOWER KAFUE LONG TERM WATER QUALITY RECORD

WATER QUALITY DATA KAFUE RIVER RAW WATER AT THE LWSC OFFTAKE AT IOLANDA

| Date | Kafue Flow | pH | Colour | Turbidity | Conductivity | TDS | Alkalinity | Bicarbonate Hardness | Magnesium Hardness | Calcium Hardness | Total Hardness | Chloride | Ammonia | Nitrite | Nitrate | Silica | Phosphate | Calcium | Manganese | Iron | K2MnO4 | Dissolved Oxygen | Percent Saturation | Temp | BOD | OA | SS | Sulphate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6/01/70 | na | 7.20 | | | | | | | | | | | | | | | | | | | | 0.4 | 5.7 | | | | | | |
| 29/01/70 | na | 7.20 | | | | | | | | | 64 | | | | | | | | | | | | | | | | | | |
| 12/03/70 | na | | | | | | | | | | | | | | | | | | | | | 1.0 | 14.3 | 27.5 | 2.5 | | | | |
| 19/03/70 | na | 7.00 | | | | | 80 | | | | 70 | | | | | | | | | | | 2.7 | 36.5 | 26.0 | | | | | |
| 2/04/70 | na | | | | | 100 | 76 | | | | 64 | | | | | | | | | | | 1.8 | 25.7 | 25.0 | 1.5 | | 3.5 | | |
| 16/04/70 | na | 7.20 | 20.0 | 5.0 | | 80 | 76 | | | | 68 | 4.0 | 0.0500 | not det | nil | | | | | | 4.0 | 1.4 | 20.0 | 26.0 | 1.2 | | | | |
| 4/06/70 | na | 7.40 | 10.0 | 3.9 | | 80 | | | 30 | 50 | 80 | 3.0 | 0.0800 | | | | | 20.00 | | | 5.3 | 3.2 | 45.7 | 21.5 | 0.5 | | 10.0 | | |
| 18/06/70 | na | 7.30 | 10.0 | 3.0 | | 120 | 102 | | | | | 3.0 | 0.0140 | | | | | 20.00 | | nil | | 3.2 | 47.5 | 19.0 | not det | | 10.0 | | |
| 24/07/70 | na | 7.30 | 7.0 | | | 140 | 116 | | | | 96 | 6.0 | 0.1000 | trace | nil | | | | | nil | | 4.0 | 57.1 | 19.0 | | | | | |
| 24/07/70 | na | 7.30 | 7.0 | | | 140 | 116 | | | | 96 | 6.0 | 0.1000 | trace | nil | | | | | nil | | 4.0 | 57.1 | 19.0 | | | | | |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | | | 114 | [illegible] | [illegible] | [illegible] | [illegible] | | | | | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | | |
| 10/09/70 | na | 7.90 | 15.0 | 11.5 | | 144 | 160 | | | | | 8.0 | 0.1200 | nil | nil | | | | | | 2.9 | 6.9 | 98.5 | 21.5 | 4.0 | | | | |
| 7/10/70 | na | 8.10 | 7.0 | 7.0 | | 172 | 170 | | | | 190 | 8.0 | 0.0800 | nil | not det | | | | | | 2.7 | 7.0 | 100.0 | 24.0 | 1.5 | | | | |
| 5/11/70 | na | 7.90 | 28.0 | 36.0 | | 196 | 182 | | | | 190 | 10.0 | 0.1000 | | | | | | | | 3.1 | 7.0 | 100.0 | 24.0 | | | 13.0 | | |
| 17/12/70 | na | 8.00 | 25.0 | 58.0 | | 260 | 192 | | | | 188 | 12.0 | 0.1600 | nil | nil | | | | | | | | | | 2.1 | | | | |
| 31/02/71 | na | 6.90 | 45.0 | 40.0 | 155 | 142 | 82 | | | | 94 | 6.0 | 0.1600 | nil | | 0.9 | 8.00 | 1.24 | | nil | 6.6 | 0.5 | 7.0 | 26.0 | 1.4 | | 252.0 | | 17.3 |
| 14/03/71 | na | 7.00 | 40.0 | 16.8 | 140 | 628 | 78 | | 24 | 56 | 80 | 6.0 | 0.2200 | nil | trace | | 6.50 | 0.90 | | 0.18 | 5.4 | 2.0 | 28.5 | 26.5 | 2.4 | | | | |
| 23/03/71 | na | 7.10 | 40.0 | 36.0 | 120 | 145 | 70 | | 30 | 50 | 80 | 2.0 | 0.6000 | nil | | 0.5 | 7.00 | 0.84 | | 0.05 | 5.1 | 1.0 | 14.3 | 28.0 | 3.2 | | 46.0 | | |
| 6/04/71 | na | 7.40 | 35.0 | 30.0 | 135 | 238 | 76 | | 8 | 64 | 72 | 4.0 | 0.0200 | nil | nil | | 7.00 | 0.92 | | 0.02 | 3.6 | 2.6 | 37.1 | 27.0 | 0.8 | | 23.0 | nil | |
| 6/05/71 | na | 7.30 | 20.0 | 45.0 | 138 | 98 | 78 | | 22 | 58 | 80 | 2.0 | 0.1800 | nil | | 0.25 | 6.20 | not det | | nil | 3.8 | 2.3 | 32.8 | 23.0 | 0.3 | | | nil | |
| 2/06/71 | na | 7.20 | 6.0 | 14.0 | 138 | 36 | 86 | | | | 76 | 4.0 | 0.2600 | nil | trace | | 4.40 | | | nil | 2.4 | 3.5 | 50.0 | 19.0 | 1.3 | | | | |
| 16/06/71 | na | 7.20 | 15.0 | 12.0 | 140 | 56 | 90 | | 26 | 50 | 76 | not det | not det | nil | | 0.3 | 4.33 | | | nil | 1.2 | 3.5 | 50.0 | 19.0 | 4.2 | | | | |
| 16/06/71 | na | 7.20 | 15.0 | 12.0 | 140 | 56 | 90 | | 26 | 50 | 76 | not det | not det | nil | | 0.3 | 4.30 | | | | 1.2 | 3.5 | 50.0 | 19.0 | 4.2 | | | | |
| 19/06/71 | na | 7.30 | 5.0 | 4.0 | 160 | 60 | 94 | | 8 | 92 | 100 | 6.0 | 0.4500 | | 0 | 0 | | | | 0 | | 5.5 | 78.5 | 18.0 | 0.45 | 2.4 | 2.0 | | |
| 4/07/71 | na | 8.00 | 15.0 | 10.4 | 165 | 133 | 94 | | 22 | 74 | 96 | 6.0 | 0.7000 | nil | nil | | 5.30 | 1.30 | nil | nil | | 3.5 | 50.0 | 19.0 | 1.2 | 2.1 | | | |
| 27/07/71 | na | 7.30 | 15.0 | 11.2 | 165 | 80 | 104 | | 76 | 54 | 130 | 8.0 | 0.6000 | nil | nil | | 5.90 | 1.30 | nil | nil | | 2.2 | 31.4 | 19.0 | | 3.4 | | nil | |
| 4/08/71 | na | 7.30 | 15.0 | 22.0 | 175 | 225 | 108 | | 12 | 106 | 118 | 2.0 | 0.3800 | nil | | nil | 5.00 | 1.60 | | 20 nil | | 3.4 | | 19.2 | 0.6 | 2.4 | 10.0 | | 3.8 |
| 13/08/71 | na | 7.60 | 11.0 | not det | 185 | 116 | 120 | | 46 | 74 | 120 | 4.0 | 0.6000 | 0.00 | 0.00 | | 6.20 | 34.00 | | 0.0 0.00 | | 3.8 | | 20.0 | 0.6 | 1.6 | 0.0 | | 0.0 |
| 8/09/71 | na | 7.60 | 10.0 | 10.0 | 210 | 82 | 120 | | | 82 | 124 | 4.0 | 0.0500 | nil | nil | | 5.30 | 82.00 | | 0.0 0.00 | | 4.5 | 64.3 | 22.5 | 1.1 | 3.6 | not det | | |
| 13/10/71 | na | 7.60 | 15.0 | 8.6 | 245 | 155 | 150 | | | | | 5.0 | 0.6000 | 0.00 | 0.00 | | | | | nil | | 6.0 | 85.7 | 23.0 | 0.9 | 1.7 | nil | | |
| 10/11/71 | na | 7.60 | 6.0 | 4.4 | 270 | 110 | 156 | | | | 140 | 4.0 | 0.1800 | not det | not det | | 4.20 | | | nil | | 3.5 | 50.0 | 26.0 | 0.8 | 0.75 | | | |
| 7/12/71 | na | 7.70 | 15.0 | 5.2 | 290 | 200 | 160 | | | | 160 | 4.0 | 0.6000 | nil | | 0.02 | 4.80 | | | 0.00 | | 4.6 | 67.7 | 28.5 | 0.7 | 2.0 | 0.0 | | |
| 6/01/72 | na | 8.22 | 15.0 | 8.0 | 290 | 183 | 152 | | | | 152 | 8.0 | 0.1400 | 0.00 | 0.02 | | 4.80 | | | 0.00 | | 2.5 | 35.7 | 25.0 | 1.47 | | 3.6 | 2.0 | |
| 8/02/72 | 295.4 | 7.20 | 335.0 | 13.2 | 180 | 149 | 96 | | 0 | 80 | 80 | 8.0 | 0.1800 | 0.00 | 0.01 | not det | | | | 0.10 | | 0.3 | 4.3 | 26.0 | 1.2 | 5.0 | 5.0 | | |
| 7/03/72 | 359.9 | 7.50 | 38.0 | 22.0 | 190 | 95 | 194 | | 20 | 80 | 100 | | 0.3000 | 0.00 | 0.01 | 9.50 | | | | 0.08 | | 0.3 | 4.3 | 27.0 | not det | | 5.6 | 4.0 | |
| 4/04/72 | 323.5 | 7.10 | 25.0 | 6.8 | 180 | 68 | 84 | | 26 | 68 | 94 | 6.0 | 0.2100 | not det | | 0.02 | not det | | | 0.00 | 3.1 | 0.7 | 10.0 | 25.0 | 0.85 | | 2.0 | | |
| 16/05/72 | 351.4 | 7.22 | 15.0 | 7.6 | 160 | 114 | 90 | | 24 | 66 | 90 | 6.0 | 0.0400 | 0.00 | 0.00 | not det | | | | not det | | 2.6 | 39.1 | 28.0 | 1.2 | 2.5 | 4.0 | | |
| 6/07/72 | na | 7.30 | 15.0 | 4.4 | | 104 | 104 | | 32 | 70 | 102 | 6.0 | 0.3200 | 0.00 | 0.00 | | | | | 0.00 | | 10.6 | 155.0 | 18.0 | 0.55 | 2.55 | | | |
| 8/08/72 | na | 7.50 | 5.0 | 4.0 | 200 | 100 | 112 | | 90 | 22 | 112 | 6.0 | | 0.00 | 0.00 | | | | | not det | | 2.0 | 26.4 | 17.5 | 1.3 | 0.5 | 1.0 | | |
| 12/09/72 | na | 7.70 | 5.0 | 6.4 | 240 | 134 | 120 | | 38 | 100 | 138 | 6.0 | 0.4200 | nil | | not det | | | | | | 4.2 | 60.0 | 26.0 | 0.6 | 3.0 | 1.0 | | |
| 3/04/73 | 96.0 | 7.50 | 15.0 | 9.6 | 240 | 189 | 124 | | 40 | 100 | 140 | 16.0 | 0.0200 | 0.00 | 0.01 | | | | | 0.00 | | 2.5 | 35.7 | 27.5 | 0.6 | 2.9 | not det | | |
| 8/05/73 | na | 7.80 | 15.0 | not det | 240 | 200 | 128 | | 70 | 80 | 150 | 12.0 | 0.4100 | | 0 | 0.04 | | | | | | 3.0 | 42.9 | 24 | 1.4 | | | | |
| 8/08/73 | 33.0 | 7.40 | 15.0 | 4.0 | 260 | | 150 | | 30 | 110 | 140 | 16.0 | 0.5200 | nil | | 0.02 | | | | not det | | 4.5 | 64.2 | 20.0 | 1.2 | 4.1 | 2.0 | | |
| 19/09/73 | 55.0 | 8.00 | 25.0 | 6.8 | 320 | 259 | 168 | | 0 | 160 | 152 | 16.0 | 1.1100 | 0.00 | | 0.10 | | | | | | 4.5 | 64.0 | 23.0 | not det | | 1.9 | 5.0 | |
| 17/10/73 | 389.5 | 8.10 | 30.0 | 6.8 | 330 | 256 | 188 | | 30 | 170 | 200 | 22.0 | 1.1000 | not det | | 0.05 | | | | | | 5.0 | 71.4 | 25.0 | 0.5 | 3.0 | | | |
| 14/11/73 | 381.1 | 7.50 | 20.0 | 9.5 | 350 | 284 | 180 | 108.0 | 44 | 156 | 200 | 30.0 | 1.0000 | 0.00 | | 0.10 | | | | | | 5.7 | 80.0 | 25.0 | 1.1 | 4.9 | 5.0 | | |
| 11/12/73 | 353.9 | 8.00 | 40.0 | 9.0 | 350 | 295 | 180 | | 62 | 128 | 190 | 28.0 | 0.5000 | not det | | 0.20 | | | | | | 4.7 | 67.0 | 27.0 | 0.7 | 4.5 | 10.0 | | |
| 9/01/74 | na | 7.40 | 30.0 | 8.0 | 240 | 93 | 116 | | 16 | 106 | 124 | 12.0 | 0.4400 | not det | | 0.05 | | | | | | 2.8 | | 26.0 | 20.0 | 35.0 | 10.0 | | |
| 15/02/74 | 465.2 | 7.20 | 50.0 | 3.0 | 160 | 153 | 74 | | 16 | 64 | 80 | 4.0 | 0.1800 | 0.00 | | 0.05 | | | | | | 1.8 | 25.7 | 25.0 | 5.6 | 1.6 | 8.0 | | |
| 20/03/74 | 698.2 | 7.20 | 40.0 | 7.0 | 150 | 141 | 80 | | 16 | 64 | 80 | 6.0 | 0.0200 | not det | | 0.01 | | | | | | 0.1 | 1.4 | 27.0 | 5.6 | 1.5 | 10.0 | | |
| 17/04/74 | 896.9 | 7.20 | 40.0 | 4.0 | 135 | 136 | 82 | | 20 | 68 | 88 | 2.0 | 0.0300 | not det | | 0.10 | | | | | | 1.1 | 15.7 | 28.0 | 0.0 | 5.16 | not det | | |
| 15/05/74 | 868.5 | 7.00 | 20.0 | 2.0 | 110 | 99 | 74 | | 0 | 64 | 64 | 4.0 | 0.0200 | not det | | 0.05 | | | | | | 1.0 | 14.5 | 25.0 | 0.5 | 3.7 | 5.0 | | |
| 12/06/74 | 689.4 | 7.10 | 8.0 | 2.0 | 110 | 122 | 80 | | 15 | 65 | 80 | 4.0 | 0.0240 | not det | | 0.05 | | | | | | 1.5 | 21.4 | 23.0 | 0.6 | 2.9 | 2.0 | | |
| 10/07/74 | 735.2 | 7.40 | not det | not det | not det | | 47 | 80 | 10 | 66 | 76 | not det | 0.3000 | | 0.00 | 0.05 | | | | | | 2.1 | 30.0 | 22.0 | 0.5 | 1.3 | 2.0 | | |
| 18/09/74 | 151.0 | 7.50 | 15.0 | 3.0 | 190 | 115 | 106 | | 10 | 94 | 104 | 4.0 | 0.3000 | | 0.00 | 0.10 | | | | | | 2.7 | 38.5 | 24.0 | 1.25 | 6.8 | 2.0 | | |
| 9/10/74 | na | 7.50 | 15.0 | 2.4 | 200 | 167 | 120 | | 4 | 100 | 104 | 4.0 | 0.2400 | | 0 | 0.05 | | | | | | 2.7 | 7.5 | 27 | 0.7 | 9 | 2 | | |
| 6/11/74 | na | 7.60 | not det | | 210 | 191 | 130 | | 0 | 120 | 120 | 6.0 | 0.0200 | not det | | 0.1 | | | | | | 2.0 | 28.9 | 27 | 1.3 | 3.9 | 2 | | |
| 6/03/75 | 480.9 | 7.30 | 25.0 | 6.0 | 170 | 152 | 86 | | 20 | 60 | 80 | 6.0 | 0.2500 | | | 0.1 | | | | | | 1.5 | 21.7 | 25 | 1.7 | 2.2 | 5 | | |
| 9/04/75 | 725.8 | 7.40 | 20.0 | 5.0 | 165 | 140 | not det | | 24 | 50 | 74 | 8.0 | 0.1000 | nil | | 0.05 | | | | | | 2.0 | 28.5 | 27 | 2.5 | 5 | 4 | | |
| 7/05/75 | 868.9 | 7.60 | not det | 4.0 | 110 | 117 | 60 | | 4 | 60 | 64 | 8.0 | 0.0400 | nil | | 0.05 | | | | | | 1.2 | 17.1 | 26 | 0.9 | 3.5 | not det | | |

Q-App-20

| Date | Kafue Flow | pH | Colour | Turbidity | Conductivity | TDS | Alkalinity | Bicarbonate Hardness | Magnesium Hardness | Calcium Hardness | Total Hardness | Chloride | Ammonia | Nitrite | Nitrate | Silica | Phosphate | Calcium | Manganese | Iron | K2MnO4 | Dissolved Oxygen | Percent Saturation | Temp | BOD | OA | SS | Sulphate | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/06/75 | 806.7 | 7.30 | not det | | | 129 | 60 | | 12 | 52 | 64 | 4.0 | | | 0.06 | | | | | | | 2.6 | | 26 | 0.3 | 4 | 4 | | |
| 9/07/75 | 669.5 | 7.20 | 10.0 | 3.0 | 110 | 76 | 62 | | 8 | 62 | 70 | 4.0 | 0.2800 | nil | 0.08 | | | | | | | 2.5 | 35.7 | 23 | 0.9 | 4.8 | 2 | | |
| 6/08/75 | 440.9 | 7.40 | 15.0 | 3.0 | 140 | 87 | 82 | | 8 | 72 | 80 | 3.0 | 0.3000 | nil | 0.02 | | | | | | | 4.0 | 57.1 | 23 | 0.5 | 3.6 | 2 | | |
| 15/09/75 | 158.0 | 7.70 | 10.0 | 3.0 | 160 | 166 | 100 | | 6 | 86 | 92 | 4.0 | 0.5000 | nil | 0.01 | | | | | | | 6.5 | 92.8 | 26 | 2 | 4.6 | 3 | | |
| 5/10/75 | 152.0 | 7.80 | 12.0 | 3.0 | 190 | 130 | 105 | | 18 | 90 | 108 | 4.0 | 0.5400 | nil | 0.02 | | | | | | | 7.7 | 110.0 | 27 | 0.9 | 2.8 | 3 | | |
| 5/11/75 | 168.0 | 7.70 | 10.0 | 3.0 | 220 | 133 | 124 | | 6 | 104 | 110 | 6.0 | 0.6400 | nil | 0.04 | | | | | | | 7.0 | 101.4 | 30 | 0.8 | 3.6 | 2 | | |
| 5/12/75 | 156.0 | 7.70 | 10.0 | 4.0 | 240 | 152 | 132 | | 42 | 88 | 130 | 8.0 | 0.2000 | nil | 0.03 | | | | | | | 10.0 | 146.0 | 28 | 1.7 | 4 | not det | | |
| 11/02/76 | 165.0 | 7.70 | 25.0 | 6.0 | 200 | 160 | 112 | | 33 | 89 | 122 | 6.0 | 0.7600 | nil | 0.06 | | | | | | | 7.3 | 157.8 | 26.5 | 1.8 | 4 | 6 | | |
| 19/05/76 | 1257.2 | 7.20 | 20.0 | not det | 110 | 155 | 64 | | 0 | 60 | 60 | 4.0 | 0.5600 | nil | 0.06 | | | | | | | 1.3 | 18.1 | 23 | 1.1 | 17.7 | 2 | | |
| 9/06/76 | 96.0 | 7.20 | 15.0 | nil | 100 | 63 | 64 | | 2 | 46 | 48 | 4.0 | 0.2200 | nil | 0.12 | | | | | | | 1.2 | 17.4 | 23 | 1.1 | 5.9 | 3 | | |
| 7/07/76 | 1063.0 | 7.40 | 15.0 | | 98 | 66 | 64 | | 6 | 42 | 48 | 3.0 | 0.5000 | nil | 0.1 | | | | | | | 2.0 | | 24 | 1.36 | 0.5 | 2 | | |
| 4/08/76 | 773.3 | 7.30 | | | | 85 | 54 | | 2 | 48 | 50 | 4.0 | 0.2400 | nil | 0.06 | | | | | | | 2.6 | 37.1 | 22 | 5 | 2.6 | 4 | | |
| 1/09/76 | 487.8 | 7.50 | 10.0 | | 138 | 108 | 80 | | 31 | 41 | 72 | 5.0 | | 0 | 0.02 | | | | | | | 2.6 | 37.1 | 24 | 1.2 | 2.9 | 3 | | |
| 6/10/76 | 168.0 | 7.80 | 25.0 | 2.0 | 165 | 110 | 90 | | 40 | 50 | 90 | 6.0 | 0.5400 | 0 | 0.04 | | | | | | | 3.1 | 44.9 | 26 | 0.3 | 3.2 | | | |
| 3/11/76 | 124.0 | 7.50 | 15.0 | 3.0 | 160 | 174 | 92 | | 38 | 54 | 92 | 4.0 | 1.3000 | 0 | 0.12 | | | | | | | 3.1 | 43.3 | 26 | 1.1 | 4.1 | 4 | | |
| 1/12/76 | 168.0 | 7.70 | 15.0 | 5.0 | 150 | 167 | 100 | | 18 | 80 | 98 | 5.0 | 0.6400 | | 0.14 | | | | | | | 2.5 | 35.7 | 30 | 0.5 | 1.6 | | | |
| 5/01/77 | 142.0 | 7.90 | 25.0 | | 190 | 119 | 110 | | 22 | 60 | 82 | 6.0 | 1.6100 | 0 | 0.2 | | | | | | | 4.9 | 70.0 | 27.5 | 1.9 | 2.4 | | | |
| 1/02/77 | 149.0 | 7.80 | 40.0 | | 210 | 149 | 130 | | 44 | 70 | 114 | 6.0 | 1.1000 | 0 | 0.13 | | | | | | | 5.8 | 82.4 | 28 | 1.06 | 5 | | | |
| 2/03/77 | 165.0 | 7.90 | 15.0 | 4.0 | 240 | 183 | 132 | | 58 | 82 | 140 | 8.0 | 0.2400 | | 0.3 | | | | | | | 5.3 | 75.7 | 26 | 0.7 | 3 | | | |
| 6/04/77 | 155.0 | 7.60 | 25.0 | 4.0 | 220 | 186 | 112 | | 50 | 70 | 120 | 5.0 | 0.2000 | 0 | nil | | | | | | | 4.5 | 64.2 | 26 | 0.8 | 2.7 | | | |
| 4/05/77 | 157.0 | 7.70 | 25.0 | | 200 | 124 | 102 | | 40 | 70 | 110 | 6.0 | 0.6400 | nil | 0.08 | | | | | | | 4.2 | 60.0 | 26 | 1.2 | 3.8 | | | |
| 8/06/77 | 255.1 | 7.50 | 20.0 | | 180 | 156 | | | 42 | 60 | 102 | | 0.2000 | 0 | 0.08 | | | | | | | 6.5 | 141.0 | 22 | 1.3 | 2.3 | | | |
| 3/08/77 | 336.2 | 7.50 | | | 200 | 160 | | | 50 | 60 | 110 | 5.0 | 0.0200 | 0 | 0.1 | | | | | | | 5.0 | 71.4 | 22 | 1.45 | 0.3 | | | |
| 7/09/77 | 329.8 | 7.90 | 20.0 | | | 113 | 110 | | 50 | 64 | 114 | 4.0 | 0.0200 | | 0.15 | | | | | | | 5.5 | 78.6 | 25 | 0.7 | 2.2 | | | |
| 5/10/77 | 326.8 | 7.90 | 20.0 | | 190 | 280 | 106 | | 28 | 78 | 104 | 5.0 | 0.0000 | nil | | | | | | | | 6.3 | 90.0 | 28 | 1.6 | 1.3 | | | |
| 9/11/77 | 324.8 | 7.70 | 20.0 | 4.0 | 240 | 130 | 130 | | 56 | 84 | 140 | 5.0 | 0.5400 | | 0.08 | | | | | | | 7.0 | 101.0 | 28 | 1.1 | 3.7 | | | |
| 7/12/77 | 22.0 | 7.60 | 20.0 | 6.0 | 230 | 201 | 134 | | 56 | 80 | 136 | 6.0 | 0.5000 | | 0.08 | | | | | | | 7.5 | 107.0 | 29 | 0.4 | 4.9 | | | |
| 4/01/78 | 302.2 | 7.60 | 20.0 | 6.0 | 240 | 199 | 120 | | 50 | 90 | 140 | 6.0 | 0.0200 | | 0.06 | | | | | | | 6.2 | 88.5 | 28 | 0.9 | 3.5 | | | |
| 8/02/78 | 626.2 | 7.20 | 15.0 | 8.0 | 190 | 101 | 100 | | 36 | 60 | 96 | 6.0 | 0.0200 | 0 | 0.1 | | | | | | | 7.0 | 100.0 | 28 | 1.4 | 6.6 | | | |
| 8/03/78 | 770.9 | 6.90 | 25.0 | 10.0 | 170 | | 80 | | 10 | 70 | 80 | 4.0 | 0.0200 | nil | | | | | | | | | | | | | | | |
| 5/04/78 | 1274.4 | 7.20 | 20.0 | 5.0 | 120 | 31 | 74 | | 30 | 50 | 80 | 6.0 | 0.7000 | | 0.14 | | | | | | | 3.5 | | 25 | 1.5 | 1.8 | | | |
| 10/05/78 | 1296.0 | 7.20 | | | 100 | | | | 20 | 40 | 60 | | 0.6000 | | | | | | | | | 3.7 | | 26 | | | | | |
| 7/06/78 | 1326.9 | 7.20 | 10.0 | | 100 | 104 | 60 | | | | | 4.0 | 0.0100 | | 0 | | | | | | | 4.4 | 61.0 | 25 | 1.1 | 3.9 | | | |
| 13/09/78 | 991.9 | 7.20 | 10.0 | 10.0 | 120 | | 76 | | | | | 8.0 | 0.5000 | | 1.6 | | | | | | | 3.9 | 56.0 | | | | | | |
| 13/12/78 | 349.2 | 6.90 | 30.0 | | 150 | | 88 | | | | | 2.0 | | | 2.4 | | | | | | | | | | 1.7 | 3.4 | | | |
| 8/06/79 | 639.4 | 7.10 | 10.0 | | 160 | 89 | 100 | | 46 | 56 | 104 | 5.0 | 0.0600 | | trace | | | | | trace | | | | | | | 5.0 | | |
| 16/08/79 | 631.0 | 7.20 | 10.0 | | 140 | 83 | 90 | | 34 | 56 | 90 | 6.0 | 0.6800 | | 0.07 | | | | | | | | | | | 4.4 | | | |
| 12/09/79 | 726.5 | 7.30 | | | 160 | | 70 | | 36 | 64 | 100 | 6.0 | 0.0200 | | 0.08 | | | | | | | | | | 1.5 | 3.1 | | | |
| 21/11/79 | | 7.00 | 440.0 | | 160 | | 130 | | 36 | 54 | 90 | 8.0 | 1.0000 | | | | | | | | | | | | 2.2 | 3.4 | | | |
| 30/07/80 | | 7.20 | | | 180 | | | | | | | 4.0 | | | | | | | | | | | | | 1.3 | 3 | | | |
| 8/01/82 | | 7.70 | | | 160 | | | | | | | 6.0 | 2.4000 | | | | | | | | | | | | | | | | |
| 4/01/83 | | 7.60 | | 130.0 | 120 | | | | 110 | 20 | 130 | 6.0 | 2.7000 | | 1.5 | | | | | 0.08 | | | | 24 | | | | | |
| 27/06/83 | | 8.50 | | | 200 | | 104 | | | 120 | 124 | 6.0 | 0.0600 | 0.66 | 3.52 | 4.01 | 0.05 | | 0.4 | 0.02 | | | | | | | | | 20 |
| 14/09/83 | | 7.30 | | | 220 | | | | | | 80 | 6.0 | | | 11 | | | | | 0.12 | | | | | | | | | 21 |
| 21/06/85 | | 8.70 | 20.0 | 2.0 | 180 | | | | | | | 8.0 | 0.6900 | 0.18 | 1.2 | | 3.2 | | | 0.05 | | | | | | | | | |
| 4/11/85 | | 6.80 | | 0.1 | 200 | | | 31.0 | 20 | 60 | 80 | 10.0 | 0.3000 | | | | | | | trace | | | | | | | 5 | | |
| 11/11/85 | | 7.40 | | 1.0 | | | 240 | 134.2 | 70 | 100 | 170 | 20.0 | <0.001 | nil | 0.4 | | trace | 70.00 | | not det | | 7.0 | | | | | | | |
| 30/1/86 | | 7.50 | 25.0 | 2.1 | | | 70 | | 36 | 60 | 96 | 16.0 | 0.2600 | 0.1 | <0.5 | | | 24.00 | 6.8 | NO | 3.3 | | | | | | | | |
| 22/10/86 | | 7.40 | | 5.0 | 190 | | 90 | | 24 | 66 | 90 | 26.0 | 0.1200 | nil | nil | 1.50 | nil | | | nil | | | | | | | | | |
| 12/02/87 | | 7.00 | 10.0 | 4.0 | 210 | 143 | 100 | 65.4 | 35 | 63 | 98 | 10.0 | 0.0100 | nil | nil | | trace | | | nil | | | | | | | | | |
| 13/03/87 | | 7.40 | 5.0 | 8.0 | 250 | 170 | 100 | | 54 | 46 | 100 | 6.0 | 0.0200 | nil | nil | | not det | | | nil | | | | | | | | | |
| 26/03/87 | | 7.30 | 5.0 | nil | 250 | 170 | 100 | 30.0 | 42 | 78 | 120 | 18.3 | 0.1400 | 0.050 | <0.44 | | 0.02 | | | not det | | | | | | | | | |
| 11/06/87 | | 7.27 | | 25.0 | 200 | 136 | 108 | 71.5 | 52 | 62 | 114 | 4.0 | 10.0000 | nil | nil | 1.58 | nil | | | | 12.0 | 3.0 | | | | | | | |
| 25/09/87 | | 7.32 | 5.0 | 1.0 | 180 | 122 | 100 | 61.0 | | | | 2.0 | 0.0140 | 0.005 | nil | 7.60 | | | | nil | 7.9 | 7.6 | | | | | | | |
| 5/10/87 | | 6.98 | 5.0 | 1.0 | 180 | 122 | 104 | 120.0 | 160 | 148 | 308 | 16.0 | 0.0040 | nil | | 7.00 | nil | | | 0.31 | 0.427 | 0.1 | | | | | | | |
| 19/10/87 | | 7.10 | 10.0 | nil | 180 | 122 | 100 | 61.0 | 100 | 150 | 250 | 4.0 | 0.0050 | 0.000 | | 7.26 | nil | | | nil | not det | not det | | | | | | | |
| 21/10/87 | | 6.21 | 5.0 | 1.0 | | 0 | 112 | 85.4 | 60 | 58 | 118 | 4.0 | 0.0300 | 0.000 | not det | 7.63 | nil | | | nil | | | | | | | | | |
| 21/01/88 | | 6.68 | 300.0 | 50.0 | 200 | | 124 | 61.0 | | | | nil,residual? | | nil | 2.2 | 19.32 | nil | | | not det | | absent(?) | | | | | | | |
| 5/07/88 | | 7.40 | 30.0 | nil | 250 | | 124 | 61.0 | 60 | 60 | 120 | nil | 0.0480 | nil | nil | 10.50 | not det | | | not det | 13 | | | | | | | | |
| 20/07/88 | | 7.39 | 30.0 | 1.0 | 225 | | 124 | 61.0 | 54 | 70 | 124 | 4.0 | 0.0260 | not det | nil | 11.76 | nil | | | nil | 4.4 | 1.1 | | | | | | | |

Q-App-21

kafue rawwater quality
dm 26/10/94
2

| Date | Kafue Flow | pH | Colour | Turbidity | Conductivity | TDS | Alkalinity | Bicarbonate Hardness | Magnesium Hardness | Calcium Hardness | Total Hardness | Chloride | Ammonia | Nitrite | Nitrate | Silica | Phosphate | Calcium | Manganese | Iron | K2MnO4 | Dissolved Oxygen | Percent Saturation | Temp | BOD | OA | SS | Sulphate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3/08/88 | 203.0 | 6.55 | 30.0 | nil | 225 | | 244 | 61.0 | | | | nil/sewage | 0.0100 | 0.0003 | 2.2 | 10.56 | nil | | | nil | | | | | | | | |
| 20/08/88 | 203.0 | 7.10 | 10.0 | 2.0 | 200 | | 96 | 67.1 | 88 | 58 | 146 | 6.0 | 0.0050 | not det | nil | 3.15 | nil | | | not det | | | | | | | | |
| 23/08/88 | 187.6 | 7.98 | 10.0 | 11.0 | 200 | | 120 | 73.2 | | | | 5.0 | 0.0100 | nil | nil | | | | | nil | 4.2 | 1.1 | | | | | | |
| 28/10/88 | 161.0 | 8.26 | 15.0 | nil | 200 | | 92 | 67.1 | | | | 4.0 | 0.0050 | | <2.20 | 4.49 | not det | | | | | | | | | | | |
| 3/11/88 | 128.0 | 7.86 | 5.0 | nil | 200 | | 100 | 48.8 | | | 110 | 4.0 | 0.0060 | | <3.0 | | | | | | | | | | | | | |
| 18/11/88 | 161.0 | 6.75 | 5.0 | nil | 200 | | 110 | 61.0 | | | 112 | 6.0 | 0.0020 | | nil | not det | nil | | | nil | | | | | | | | |
| 24/11/88 | 157.0 | 7.22 | 5.0 | nil | 225 | | 110 | 67.1 | | | | 16.0 | 0.0040 | | nil | not det | nil | | | | | | | | | | | |
| 25/11/88 | 154.0 | 6.85 | <5 | nil | 200 | | 110 | 10.0 | | | | 8.2 | | | nil | | nil | | | | | | | | | | | |
| 7/12/88 | 156.0 | 7.00 | 5.0 | nil | 200 | | 102 | 61.0 | | | | 18.0 | not det | | nil | not det | not det | | | not det | | | | | | | | |
| 19/12/88 | 161.0 | 6.98 | 5.0 | 3.2 | 200 | | 106 | 73.2 | 25 | 95 | 120 | 16.0 | 0.0050 | | nil | not det | nil | | | nil | | | | | | | | |
| 21/12/88 | 161.0 | 7.03 | 10.0 | 4.3 | 200 | | 110 | 61.0 | | | | 42.0 | 0.0060 | | 4.4 | 3.20 | | | | | | | | | | | | |
| 3/01/89 | 161.0 | 6.98 | 30.0 | 4.1 | 200 | | 112 | 79.3 | not det | not det | not det | 16.0 | 0.0060 | | 3 | not det | nil | | | | | | | | | | | |
| 10/02/89 | 750.8 | 7.46 | 75.0 | not det | 150 | | 82 | 61.0 | | | | 8.0 | 0.0100 | | <0.22 | 7.50 | nil | | | nil | | | | | | | | |
| 19/04/89 | na | 7.43 | 15.0 | nil | 160 | | 100 | 61.0 | | | | 2.0 | 0.0100 | | nil | 4.80 | nil | | | | 4.8 | | | | | | | |
| 24/04/89 | na | | | | | | | | 30 | 50 | 80 | | | | | | | | | nil | | | | | | | | |
| 30/06/89 | | 8.15 | 15.0 | 2.0 | 200 | | 248 | 225.7 | | | | 8.0 | 0.0080 | nil | nil | | nil | | | | | | | | | | | |
| 18/08/89 | 190.7 | 7.61 | 10.0 | 1.0 | 200 | | 110 | 61.0 | not det | not det | not det | 6.0 | 0.0050 | nil | nil | 1.40 | nil | | | nil | | | | | | | | |
| 25/08/89 | 189.8 | 8.13 | 10.0 | 1.0 | 200 | | 100 | 61.0 | 39 | 59 | 98 | not det | 0.0020 | nil | nil | 3.45 | nil | | | nil | | | | | | | | |
| 1/09/89 | na | 8.15 | 10.0 | 2.5 | 200 | | 100 | 73.2 | 32 | 50 | 82 | 8.0 | 0.0060 | nil | nil | 2.20 | nil | | | | | | | | | 0.925 | | |
| 4/10/89 | 123.4 | 7.70 | 15.0 | nil | 295 | | 106 | 67.1 | | | | 10.0 | 0.0060 | nil | nil | 2.60 | nil | | | nil | | | | | | | | |
| 4/02/90 | 356.9 | 7.78 | 30.0 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7/02/90 | 408.3 | 8.76 | nil | <1 | 260 | | 84 | 102.0 | | | | 0.1 | 0.0050 | 5E-05 | nil | | | | | nil | | | | | | | | |
| 19/06/90 | 212.0 | 7.66 | 10.0 | | 250 | | 116 | 97.6 | | | | 8.0 | 0.0030 | <0.00005 | not det | 2.25 | nil | | | | | | | | | | | |
| 26/07/90 | 154.0 | 9.02 | <5 | nil | 225 | | 140 | 54.9 | | | | 58.0 | 0.0200 | not det | not det | not det | trace | | | | | | | | | | | |
| 13/08/90 | 147.0 | 7.90 | <10 | nil | 250 | | 120 | 42.7 | 40 | 56 | 96 | 24.0 | 0.0030 | nil | nil | 1.00 | nil | | | nil | | | | | | | | |
| 21/08/90 | 149.0 | 6.62 | nil | nil | 230 | | 116 | 48.8 | 56 | 62 | 118 | 114.0 | <0.004 | | nil | trace | 1.00 | nil | | | | | | | | | | |
| 24/08/90 | 148.0 | 6.41 | nil | nil | 250 | | 114 | 42.7 | 36 | 64 | 100 | 32.0 | <0.005 | | nil | trace | 1.28 | nil | | | | | | | | | | |
| 7/09/90 | 149.0 | 6.30 | 10.0 | <1 | 250 | | 126 | 48.8 | | | | 138.0 | nil | | nil | trace | | | | | | | | | | | | |
| 13/09/90 | 151.0 | 6.87 | nil | nil | 220 | | 126 | 36.6 | 42 | 64 | 106 | 26.0 | 0.0030 | nil | nil | 1.00 | nil | | | nil | | | | | | | | |
| 21/09/90 | 148.0 | 8.60 | 5.0 | nil | 230 | | 84 | 42.7 | 24 | 66 | 90 | 34.0 | <0.005 | | nil | nil | 1.00 | nil | | 5.656 | | | | | | | | |
| 12/10/90 | 150.0 | 7.63 | 10.0 | 1.0 | 225 | | 80 | 48.8 | 40 | 66 | 106 | 28.0 | <0.005 | | <0.0005 | trace | 1.00 | nil | | | | | | | | | | |
| 26/10/90 | 136.0 | 6.90 | 5.0 | nil | 210 | | 80 | 48.8 | 32 | 74 | 106 | 92.0 | 0.0040 | trace | nil | 1.84 | nil | | | | | | | | | | | |
| 15/11/90 | 164.2 | 7.03 | <10 | 0.5 | 225 | | 64 | 54.9 | 52 | 66 | 118 | 28.0 | 0.0050 | nil | nil | 1.68 | | | | | | | | | | | | |
| 22/11/90 | 137.0 | 6.75 | <5 | <1 | 250 | | 62 | 24.4 | 40 | 64 | 104 | 22.0 | 0.0010 | trace | nil | 1.28 | nil | | | | | | | | | | | |
| 6/12/90 | 137.0 | 7.07 | <5 | <1 | 240 | | 62 | 54.9 | | | | 38.0 | 0.0060 | nil | nil | 0.60 | nil | | | | | | | | | | | |
| 13/12/90 | 97.0 | 7.25 | nil | <1.0 | 240 | | 102 | 48.8 | 20 | 60 | 100 | 90.0 | trace | | nil | nil | 2.30 | not det | | | | | | | | | | |
| 20/12/90 | 136.0 | 7.72 | 10.0 | 1.0 | 250 | | 70 | 48.0 | 28 | 64 | 90 | 36.0 | 0.0010 | 0.001 | nil | 0.46 | nil | | | | | | | | | | | |
| 28/12/90 | 134.0 | not de | 15.0 | 2.5 | 250 | | 62 | 122.0 | 28 | 76 | 104 | 6.0 | nil | | nil | nil | not det | nil | | | | | | | | | | |
| 10/01/91 | 133.0 | 6.65 | 10.0 | nil | 230 | | 70 | 67.1 | 14 | 74 | 96 | 36.0 | 0.0260 | nil | nil | 1.60 | 1 | | | 1 | | | | | | | | |
| 25/01/91 | 133.0 | 6.94 | <5.0 | 1.0 | 250 | | 134 | 73.2 | 70 | 52 | 122 | 44.0 | 0.0020 | nil | | 1.80 | nil | | | | | | | | | | | |
| 4/04/91 | 118.0 | 8.07 | 15.0 | 1.0 | 225 | | 116 | 79.3 | 52 | 62 | 114 | 16.0 | nil | | nil | <2.20 | 1.80 | not det | | | | | | | | | | |
| 8/05/91 | 137.0 | 7.96 | 5.0 | nil | 250 | | 132 | 79.3 | 48 | 64 | 112 | 36.0 | trace | | nil | trace | | | | | | | | | | | | |
| 17/05/91 | 137.0 | 7.80 | 10.0 | nil | | 0 | 112 | 79.3 | | | | 46.0 | 0.0080 | nil | nil | | 1.00 | | | | | | | | | | | |
| 30/05/91 | 108.0 | 7.82 | <10.0 | nil | 250 | 170 | 118 | 79.3 | 4 | 76 | 80 | 30.0 | 0.0050 | nil | trace | | not det | | | | | | | | | | | |
| 31/05/91 | 108.0 | 7.82 | <10 | nil | 250 | | 118 | 79.3 | 4 | 76 | 80 | 30.0 | 0.0050 | nil | trace | | not det | | | | | | | | | | | |
| 6/06/91 | 140.0 | 7.87 | 15.0 | 1.0 | 250 | 170 | 122 | 79.3 | 36 | 64 | 100 | 36.0 | nil | | trace | nil | | nil | | | | | | | | | | |
| 28/06/91 | 145.0 | 7.62 | >5.0 | nil | 250 | 170 | 116 | 73.2 | 50 | 90 | 140 | 5.0 | 0.0050 | nil | nil | | | | | | | | | | | | | |
| 11/07/91 | 142.0 | 7.92 | 5.0 | nil | 250 | 170 | 192 | 67.1 | 32 | 60 | 92 | 6.0 | | nil | trace | nil | | | | | | | | | | | | |
| 25/07/91 | 149.0 | 7.98 | >5 | nil | 240 | 163 | 122 | 61.0 | 36 | 70 | 106 | 8.0 | 0.0030 | nil | trace | | | | | | | | | | | | | |
| 15/08/91 | 151.0 | 8.06 | 10.0 | nil | 240 | 163 | 120 | 140.3 | 44 | 56 | 100 | 8.0 | <0.001 | nil | not det | | | | | | | | | | | | | |
| 11/06/92 | 96.0 | 8.37 | >10.0 | | 300 | | 132 | 115.8 | 52 | 88 | 140 | 62.0 | nil | | trace | not det | 0.67 | | | | | | | 22.6 | | | | |
| 9/07/92 | 91.0 | 7.85 | >10.0 | 10.0 | 305 | | 124 | 109.8 | 30 | 130 | 160 | 56.0 | 0.0480 | trace | nil | 1.54 | | | | | | | | | | | | |
| 21/07/92 | 89.0 | 8.14 | >5.0 | | 250 | | 114 | 91.5 | 16 | 120 | 136 | 10.0 | 0.0050 | trace | not det | 0.74 | | | | | | | | | | | | |
| 13/08/92 | 84.0 | 8.32 | 10.0 | | 200 | | 120 | 85.4 | 18 | 112 | 1300 | 40.0 | 0.0050 | nil | nil | 1.23 | <4.0 | | | | | | | | | | | |
| 27/08/92 | 83.0 | 8.16 | 10.0 | | 250 | | 130 | 103.7 | | | | | 0.0010 | | | | | | | | | | | | | | | |
| 17/09/92 | 88.0 | 8.44 | 10.0 | | 300 | | 136 | 103.7 | 22 | 104 | 124 | 66.0 | 0.0020 | trace | nil | 1.23 | | | | | | | | | | | | |
| 24/09/92 | 87.0 | 7.89 | 5.0 | | 300 | | 122 | 91.5 | 50 | 90 | 140 | 18.0 | 0.0040 | trace | not det | 1.23 | | | | | | | | | | | | |

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| Date | Kafue Flow | pH | Colour | Turbidity | Conductivity | TDS | Alkalinity | Bicarbonate Hardness | Magnesium Hardness | Calcium Hardness | Total Hardness | Chloride | Ammonia | Nitrite | Nitrate | Silica | Phosphate | Calcium | Manganese | Iron | K2MnO4 | Dissolved Oxygen | Percent Saturation | Temp | BOD | OA | SS | Sulphate |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2/11/92 | 575.4 | 8.11 | | 5.0 | 300 | 128 | 91.5 | 20 | 114 | 134 | 26.0 | 0.0070 | nil | nil | 1.14 | | | | | | | | | | | | |
| 12/11/92 | 574.0 | 7.97 | >10.0 | | 340 | 126 | 103.7 | 22 | 108 | 130 | 56.0 | 0.0010 | nil | nil | 1.26 | 2.00 | | | | | | | | | | | |
| 26/11/92 | 590.7 | 8.34 | | 10.0 | 325 | 130 | 103.7 | 24 | 110 | 134 | 14.0 | <0.001 | nil | nil | not det | nil | | | | | | | | | | | |
| 21/01/93 | 642.8 | 8.08 | | 30.0 | 325 | 110 | 97.6 | 20 | 120 | 140 | 18.0 | 0.0080 | 1.000 | nil | 0.83 | | | | | | | | | | | | |
| 26/03/93 | 721.5 | 7.61 | | 15.0 | 220 | 102 | 48.8 | 72 | 82 | 154 | 8.0 | 0.0260 | trace | nil | 2.32 | | | | | | | | | | | | |
| 5/04/93 | 722.7 | 8.09 | | 30.0 | 245 | 102 | 42.7 | 58 | 74 | 132 | 10.0 | 0.0120 | trace | trace | 1.00 | | | | | | | | | | | | |
| 7/06/93 | 210.0 | 7.43 | <50 | | 201 | 114 | 67.3 | 18 | 122 | 140 | 26.0 | trace | nil | trace | not det | | | | | | | | | | | | |
| 5/10/93 | 152.0 | 7.37 | | 10.0 | 200 | 112 | 85.4 | 24 | 68 | 92 | 8.0 | 0.0010 | nil | nil | 0.74 | | | | | | | | | | | | |
| 6/12/93 | 106.0 | 7.95 | <10.0 | | 270 | 68 | 91.5 | 18 | 100 | 118 | 20.0 | nil | nil | nil | 1.00 | | | | | | | | | | | | |
| 16/12/93 | 146.0 | 7.64 | | 10.0 | 200 | 130 | 122.0 | 14 | 98 | 112 | 44.0 | 0.0020 | nil | nil | | | | | | | | | | | | | |
| 30/12/93 | 160.0 | 7.25 | | 10.0 | 210 | 98 | 85.4 | 8 | 96 | 104 | 30.0 | nil | nil | nil | | | | | | | | | | | | | |
| 13/01/94 | 132.0 | 7.31 | | 10.0 | 220 | 132 | 103.7 | 4 | 120 | 124 | 24.0 | nil | nil | nil | | | | | | | | | | | | | |
| 24/01/94 | 140.0 | 7.69 | nil | | 230 | 130 | 85.4 | 2 | 122 | 124 | 116(?) | nil | nil | nil | | | | | | | | | | | | | |
| 10/02/94 | na | 7.37 | nil | | 210 | 118 | 97.6 | 10 | 118 | 128 | 20.0 | nil | nil | nil | | | | | | | | | | | | | |
| 15/04/94 | na | 7.49 | | 10.0 | 185 | 98 | 79.3 | 23 | 101 | 124 | 76.0 | 0.0030 | nil | nil | 0.42 | | | | | | | | | | | | |
| 13/05/94 | na | 7.77 | | 15.0 | 211 | 90 | 79.3 | 32 | 90 | 122 | 12.0 | nil | nil | nil | | | | | | | | | | | | | |
| 1/06/94 | na | 7.79 | | 10.0 | 169 | 120 | 91.5 | 54 | 104 | 158 | not det | nil | nil | nil | 0.83 | 0.06 | | | | | | | | | | | |
| 14/07/94 | na | 7.90 | | 10.0 | 208 | 146 | 91.5 | 50 | 96 | 146 | 6.0 | nil | nil | nil | | | | | | | | | | | | | |
| 11/08/94 | na | 7.76 | <10.0 | | 217 | 124 | 106.8 | 62 | 90 | 152 | 23.0 | 0.0160 | nil | nil | | nil | | | | | | | | | | | |

JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF ZAMBIA
MINISTRY OD ENERGY NS WATER DEVELOPMENT

# THE STUDY

# ON

# THE NATIONAL WATER RESOURCES MASTER PLAN

# IN

# THE REPUBLIC OF ZAMBIA

# FINAL REPORT

# SUPPORTING REPORT [R]

# LAWS AND INSTITUTIONS

OCTOBER, 1995

YACHIYO ENGINEERING CO., LTD.
(YEC)

THE STUDY ON THE NATIONAL WATER RESOURCES MASTER PLAN
IN THE REPUBLIC OF ZAMBIA

SUPPORTING REPORT (R)
LAWS AND INSTITUTIONS

Table of Contents

# CHAPTER 1 INTRODUCTION

## 1.1 Composition of the Supporting Report

This Supporting Report (R) Laws and Institutions discusses subjects which cannot be sufficiently covered in the Main Report because of the limited pages allotted to "Laws and Institutions", whose main subjects are re-organisation of the sector. This Supporting Report comprises four chapters, excluding this introductory chapter. Each chapter describes the following subjects:

### Chapter 2: International Legislation on Water Resources Management

International legislation is discussed in this chapter. As referred in the National Water Policy, the Helsinki Rules is one of the common stipulation on international Basin Management. The SADC Protocol is also referred in the chapter.

### Chapter 3: Laws and Regulations for Water Resources Development

Currently in Zambia, the Water Board (Works) Regulation, 1993, regulates construction of water works which accompany water resources development. As is envisaged in the Study, water resource development will employ construction of large scale water works not only for hydro-electric generation, but for water supply and irrigation. The current regulation might not be able to keep with the future development needs. This chapter mainly deals with the *Japanese Guidelines on water resources development and water works construction.*

### Chapter 4: Laws and Regulation on Groundwater Development and Management

As currently discussed in drafting the revised Water Act, regulations of groundwater use and development would be a top in these days in Zambia, especially in those areas with congested abstraction such as Lusaka. Legal status, as well as regulation, of groundwater varies by country by country. In Japan, for example, groundwater is the property of the land owner, although excessive abstraction is restricted and regulated by the local governments. Regulation or control of groundwater is difficult in general because of its invisibleness. *Typical models of the groundwater regulations* are reviewed in the chapter.

### Chapter 5: Comprehensive Water Resources Management

Corresponding to the increasing congestion in water use with social and economic development, responsibilities of water resources management entity are growing everywhere in the world. Comprehensive resources management is thus discussed for discharging the increasing responsibility.

The National Water Policy also states "Integrated Management" as a basic approach of the resources management. The discussion in the Policy is still conceptual. This chapter illustrates examples of integrated management, showing *what of and how the parts of the government's management should be integrated.*

### Chapter 6: Water Pricing

As discussed in financial analysis of the water supply projects, current water tariff for water supply might be too low, although the Water Sector Development Group discusses full cost recovery of water supply and sanitation sector. Generally, once the tariff falls under the preferable level, often by political reasons, insufficient operation funds occur, causing deterioration in quality and reliability of the services, resulting in consumers' unwillingness to pay, further scarce funds, and a vicious circle follows. To recover from the vicious circle is normally a hard and long task. *Models of preferable tariff setting* are discussed in this chapter.

## 1.2 References

For the formulation of equitable policies, as well as successful implementation of programmes and projects, references to those in experienced countries are often useful, even though the practices of application should be conducted according to the local conditions, such as socio-economic needs, physical or natural conditions and constraints in financial or human resource. Reference to publications by international agency or of other countries would be helpful. Much portion of this Supporting Reports owes to those publications, especially to the following. Reference, study and group discussion by Zambian staff in DWA, WDB, WSDG, DISS in the MLGH, ECZ, DNR and other entities with the publications would highly recommendable.

Chapter 2: International Legislation on Water Resources Management

The texts of the Helsinki Rules are provided in

1) "The Law of International Water Resources" by Dante A. Caponera, Chief, Legislation Branch, Legal Office, Food and Agriculture Organization of the United Nation (FAO), 1980 (FAO Legislative Study No. 23).

Chapter 3: Laws and Regulations for Water Resources Development

2) "The Manual for River Works in Japan", River Bureau, Ministry of Construction, Japan; (This manual was provided to the DWA during the course of the previous hydrological measurement study by the JICA);
3) "Preparing National Regulations for Water Resources Management" by Stefano Burchi, Senior Legal Officer, Department of Law Services, FAO Legal Office, 1994 (FAO Legislative Study No.).

Chapter 4: Laws and Regulation on Groundwater Development and Management

For this chapter, the above No. 3) was also refered.

Chapter 5: Comprehensive Water Resources Management

4) "Water Resources Institutions - Some Principles and Practices", Harald D. Frederiksen, principle irrigation engineer in the Agricultural Division of the Asia Technical Department of the World Bank, December 1992 (World Bank Technical Paper No. 191);
5) "A Guide to the Formulation of Water Resources Strategy", edited by Guy Le Moigne, Ashok Subramanian, Mei Xie, and Sandra Giltner, Agriculture and Natural Resources Department of the World Bank, November 1994 (World Bank Technical Paper No. 263)

Chapter 6: Water Pricing

6) Pricing of Water Services", Organisation for Economic Co-operation and Development, 1987

7) "Water Allocation, Rights, and Pricing" by John R. Teerink and Masahiko Nakashima, published by the World Bank, February 1993 (World Bank Technical Paper No. 198)

These publications can be obtained in or through the offices or agents of respective organisation. The FAO has abundant studies and reports on water resources legislation. The publication numbered as 3) above would contain much valuable information to the staff working for water resource legislation, covering almost all fields of water resources management.

# CHAPTER 2 INTERNATIONAL LEGISLATION ON WATER RESOURCES DEVELOPMENT AND MANAGEMENT

As referred in the "National Water Policy", the Helsinki Rules provide legal principles and embody the concept of the best joint utilisation of internationally shared water resources. Development of international conventions and protocols would be necessary as stated in the Policy based on the Rules. As of the Zambezi River Basin, a "Protocol on the Zambezi River Basin and Other Shared SADC Watercourse Systems" (SADC Protocol) were agreed recently. Major stipulation of the Rule and the Protocol are summarised below and texts are provided in the Appendix 1 and Appendix 2, respectively.

Most of major water courses in Zambia are belongs to international basins. Water resources development and management should also cover the water allocation among the neighbouring countries, analysis of impacts of and on the water use and wastage of upstream and downstream countries and co-ordination with co-riparian countries. The Helsinki Rules provides a base for international agreement with the co-basin countries. Helsinki Rules and its annex provide common principles for reasonable management and administration of international drainage. These principles, in addition, could be a base for inter-jurisdictional co-ordination if the case that local or regional competitions or conflicts arise, if rules or stipulations are not provided or agreed among the communities.

With the SADC Protocol, a Monitoring Unit is to be established, covering not only environmental monitoring but all water resources management activities. Participation to the unit should be encouraged to not only for co-ordinated resources use, but also for information exchange on water resources development and management with co-riparian countries.

## 2.1 Helsinki Rules

### (1) General Principles

The Helsinki Rules, as agreed in 1966, provides general rules to be applied in the use of waters of an international drainage, including surface and underground waters, except those provided otherwise by a convention, an agreement or the biding custom among the basin states. The Rules entitles basin states to a reasonable and equitable share in beneficial use of the water. The following factors are raised for general consideration of reasonable and equitable share. All relevant factors, including, but not limited to, the above, should be considered together, with the weight given to each factor determined by the importance in comparison with other factors.

- geography
- hydrology
- climate
- existing and past utilisation
- economic and social needs
- population dependent on the water
- comparative cost of alternative means
- availability of other resources
- avoidance of unnecessary waste in the utilisation
- practicability of compensation as means of adjusting conflict among the users

- degree of the necessity, without substantial injury to a co-basin state

Any use, or category of use is not entitled to any inherent preference over any other use, or category of use. Any state may not be denied the present reasonable use, and an existing reasonable use may continue unless the factors justifying its use continuance are overweighed by other factors.

### (b) Pollution

All riparian states must prevent any new form of pollution or any increase in the degree of existing pollution, which would cause substantial injury in co-basin states, and should take all reasonable measures to abate existing pollution caused in their own territory. In case of the violation of the prevention of new pollution or increase in existing pollution, the states responsible shall cease the wrongful conducts and compensate the injured state.

### (c) Navigation

Each riparian state is entitled to enjoy rights of free navigation as follows in the entire course of a river or lake, with reasonable police exercises or restriction or prohibition of unloading of goods and passengers. A riparian state may grant rights of navigation to non-riparian state on rivers or lakes within its territory.

- freedom of movement
- freedom to enter ports and to make use of plants and docks
- freedom to transport goods and passengers, either directly or through transshipment among riparian states and open sea

Each riparian state is required to take available measures to maintain in good order that portion of the navigable course within its jurisdiction. A state intending to undertake works to improve navigability in its jurisdiction, is under a duty to give notice to the co-riparian states. If these works are likely to affect adversely the navigational use of co-riparian states, the co-riparian states may, within a reasonable time, request consultation. The concerned co-riparian states are then under duty to negotiate. In the case that such works be undertaken in whole or in part in the territory of one or more other states, the intending state must obtain the consent of the other states.

### (d) Prevention and Settlement of Disputes

With a view to preventing disputes among basin states, it is recommended that each basin state furnish reasonably available information to the other basin states concerning the water, its use and activities with respect to the water. A basin state should furnish to any other basin states the interest of which may be substantially affected, notice of any proposed construction or installation which would alter the regime of the basin with such essential facts as will permit the recipient to make an assessment of the probable effect, and should afford to the recipient a reasonable period of time for the assessment.

If a question or dispute arises regarding the present or future utilisation, it is recommended that the basin state refer the question or dispute to a joint agency to survey the basin, and to formulate plans or recommendations for the fullest and most efficient use with an instruction to submit reports on all matters within its competence. It is recommended, in appropriate cases, that the member states of the joint agency invite non-basin states which enjoy the use

of water by treaty to associate themselves with the work of joint agency or to appear before the agency.

### (e) International Water Resources Administration

For implementing the principle of equitable utilisation of the waters of an international drainage basin, and for the prevention and settlement of disputes, the basin should negotiate in order to reach agreement on the establishment of an international water resources administration. The establishment of an international water resources administration is without prejudice to the existence or subsequent designation of any joint agency, conciliation commission or tribunal formed or referred to by co-basin States in case of a question or dispute relating to the present or future utilisation of the waters of an international drainage basin. Member States of an international water resources administration in appropriate cases should invite other States including non-basin States or international organisations, which by treaty, other instrument or binding custom enjoy a right or have an interest in the use of the waters of an international drainage basin, to participate in the activities of the international water resources administration.

In order to provide for an effective international water resources administration the agreement establishing that administration should expressly state, among other things, its objective or purpose, nature and composition, form and duration, legal status, area of operation, functions and powers, and financial implications of such an international water resources administration. The objects and purposes of an international water resources administration, may include one or more of the following:

- collection and exchange of hydrological technical and other data, which may be undertaken by Member States separately or jointly, and their standardisation
- plan formulation, which may include the exchange of plans prepared separately by Member States or jointly formulated plans
- co-ordination of plans
- construction of waterworks, which may be undertaken by Member States separately or jointly, or which may be entrusted to a non Member State or to some organisation
- waterworks operation and maintenance, which may be entrusted to each Member State concerned separately or to joint administration
- control of one or more beneficial uses of water which may include: (i) domestic and community uses; (ii) agricultural uses, including the watering of animals and agro-allied industrial uses; (iii) industrial uses, including cooling; (iv) hydropower generation and transmission; (v) navigation; (vi) timber floating; (vii) fishing and (viii) other harmful effects of common interest
- water quality control including such coastal sea areas of the Member States, which may include: (i) prevention and abatement of water pollution resulting from one or more beneficial uses, and harmful effects and the measures to be taken separately or jointly by Member States; (ii) health preservation, including human beings and genetic resources (animals and plants), and the measures to be taken separately or jointly by Member States; (iii) environment protection, with reference to the waters of the basin, including minimum standards and measures to be taken separately or jointly by Member States.

## 1.2 SADC Protocol

### (1) General Principles

A protocol has been agreed since 1993 for the common use of watercourses of the Zambezi River, the Limpopo River, the Ngotwane River, the Marico River, the Sengu River, and the Orange River, among the People's Republic of Angola, the Republic of Botswana, the Kingdom of Lesotho, the Republic of Malawi, the Republic of Mozambique, the Republic of Namibia, the Kingdom of Swaziland, the United Republic of Tanzania, the Republic of Zambia and the Republic of Zimbabwe.

The utilization of the above watercourses, for domestic, agricultural, industrial, navigational and other social and economic uses, shall be open to the "Basin States" in accordance with the principles in the protocol, mainly described as follows:

1) The riparian states shall establish a close co-operation with regard to the study and execution of all projects likely to have a detrimental effect on the regimes of the watercourses.

2) The member states shall require any person intending to use the water to first obtain a permit from the relevant authority in the state.

3) The member should respect and apply the existing rules of customary international law and abide by the principles of the community interest and equitable apportionment of water.

4) The member states should maintain a proper balance between the resources development, and preservation and environmental improvement for higher living standards of the people preserving the resource.

5) The member states shall exchange available information and data regarding the hydrological, hydrogeological, water quality, meteorological and ecological condition.

6) The member states shall use and develop the resources in an equitable and reasonable manner with a view to attaining optimum utilisation consistent with adequate protection of the watercourse, taking into account all relevant factors and circumstances, including
   - geographic, hydrographic, hydrological, climatic and other factors of a natural character;
   - the social and economic needs;
   - the effects of the uses on other States
   - existing and potential uses

7) The member states shall notify other potentially affected states and competent international organisations of any emergency

8) Notwithstanding the provisions in 7), in the utmost urgency in order to save life or to protect public health and safety or other equally important interests as a result of an emergency situation, the member state may immediately proceed to implementation or execution of measures, provided that in such event a formal declaration of the urgency of the measures shall be communicated to the other member states

9) The member states shall take all measures necessary to prevent the introduction of alien aquatic species into a shared watercourse which may have detrimental effects to the ecosystem.

10) The member states shall maintain and protect shared watercourses and related installation, facilities and other works on the watercourses or within the relevant river basins in order to prevent pollution and other environmental degradation.

11) Shared watercourses and related installations, facilities and other works shall be used exclusively for peaceful purposes consonant with the principles enshrined in the SADC Treaty and in the Charter of the United Nations and shall be inviolable in time of armed international as well as internal conflicts

**(b) River Basin Monitoring Unit**

The member states establish a unit within the Environment and Land Management Sector to be responsible for the monitoring of the implementation of this Protocol

The Monitoring Unit shall have as its main objectives as follows:

1) The harmonisation and coordination of national water resources development policies, in order to ensure an equitable utilisation of such resources among the member states

2) The formulation, in consultation with the Basin States, of the general policy of the development of the Basin which shall be consistent with the international status of the River

3) The elaboration and execution of an integrated development Plan for the River Basin

4) The initiating and monitoring of an orderly and rational regional policy for the utilisation of both surface and underground waters of the River Basin

5) The designing and conduct of studies, research and surveys relating to the environmentally sound development and management plans for the Basin

The Monitoring Unit shall perform the following functions:

a) water resources legislation monitoring compliance with water resources legislation and, where necessary, recommending amendments and introduction of new legislation

b) research, information and data handling
   i) collecting, analysing, storing retrieving, disseminating, exchanging and utilising data relevant to the integrated development of the Basin resources, and assisting member states in the collection and analysis of data
   ii) reviewing National Development Plans within the Basin
   iii) monitoring and promoting research programmes aimed at the environmentally sound management and development of the resources of the Basin.
   iv) stimulating public understanding and participation in the sound management and development of the environment including human resources development

v) promoting in accordance with the National Development Plans of the Basin states, and in consultation with them, the formulation of a basin wide integrated master plan

c) water control and utilisation
   i) recommending regulation of the flow and drainage of the (Zambezi) River
   ii) promoting measures aimed at flood mitigation
   iii) recommending and promoting measures to control desertification, soil erosion and sedimentation

d) environmental protection
   I) promoting measures for the protection of the environment and the prevention of environmental degradation arising from the use and exploitation of the resources of the Basin including water pollution and the degradation of fauna and flora
   ii) assisting in the establishment of environmental standards
   iii) promoting environmental impact assessments of development projects within the Basin

e) navigation

monitoring the effects on the environment and on water quality arising from navigational activities

f) agro-pastoral and fisheries development
   i) encouraging in consultation with other SADC sectors the development of food crops, agro-pastoral and aquatic food production, fisheries and forestry resources
   ii) Monitoring irrigation projects undertaken in the Basin

g) hydrometeorological monitoring programme promoting in consultation with other SADC Sectors the setting up and running of a common hydrometeorological and water resources monitoring programme in the Basin

h) hydro-electricity monitoring hydro-electric power installations on the (Zambezi) River, its tributaries and sub-tributaries

# CHAPTER 3 LAWS AND REGULATIONS FOR WATER RESOURCES DEVELOPMENT

## 3.1 Necessity

As envisaged in the Master Plan, many water resources development projects will or should be implemented with limited financial and human resources. Generally, water resources development projects, such as construction of dams, pipelines or canal networks, incur huge costs and create large impact on environment in respect to physical conditions as well as to the society and economy, not only at present but also for future generations.

Current regulations on water works development in Zambia stipulate only basic rules, probably caused by a few experiences in large-scale water works development. Although the current revision of the Water Act contains substantial improvement in this sense, detailed regulations, instructions or manual should be provided for the practices in implementation of projects.

As many projects be implemented, many entities, including commercial utilities, will be involved in water resources development undertaking. Inadequate development might induce conflicts among users and between beneficiaries and the people negatively affected, as well as huge losses which might be able to be recovered. Regulatory instruments with strengthened capacity of technical appraisal would be necessary.

Regulations on groundwater development are discussed in the next chapter.

## 3.2 Items to be Included in Legislation

As discussed in the section 6.7.2, (2), (a), regulatory control on water works development generally should cover the following items:

1) criteria for water resource planning, including maintenance of required discharge (Compensation Discharge) for normal functioning of the rivers and the existing water use

2) criteria for water design of water facilities or structural works, including safety standards

2) procedure for water resource measurement, assessment, survey, planning and design

3) forms and procedures for application and approval of planning, design and construction, including impact assessment

4) design instruction or manuals used in the above procedures

5) methods and procedures for inspection and supervision of construction

6) operation instruction or manuals

7) instruction for reports of operation records and accidents

Qualification and registration of engineers, should also be included, comprising application, examination, certification, disqualification, fees for the services,etc.

## 3.3 Examples of Regulations and Forms

Instruction manuals for engineering practices for effective and efficient services are well covered in the "Manual for River Works in Japan", which was provided to the DWA in the course of the previous hydrological measurement study of the JICA. the Manual contains the following chapters. Since the natural and socio-economic conditions of Zambia are different from those of Japan, some parts are not necessary to be referred. However, some parts could be applied or modified suitably to conditions of Zambia

< Planning >

Chapter 1 Consolidated River Plan
Chapter 2 Fundamentals of Flood Defense Plan
Chapter 3 Fundamentals of Low Flow Plan
Chapter 4 Fundamentals of Sabo Plan
Chapter 5 Fundamentals of Environment Conservation Plan
Chapter 6 Fundamentals of Coast Conservation Plan
Chapter 7 Fundamentals of Landslide Prevention Plan
Chapter 8 Fundamentals of Steep-slope Failure Countermeasure Plan
Chapter 9 Waterway and River Structure Plan
Chapter 10 Multi-purpose Facility Plan (draft)
Chapter 11 Dam Installation Plan
Chapter 12 Erosion Control (Sabo) Facility Plan
Chapter 13 Landslide Control Facility Plan
Chapter 14 Steep-slope Failure Control Facility Plan
Chapter 15 Shore Facilities Planning

< Survey >

Chapter 1 Investigation of Precipitation
Chapter 2 Investigation of Water Stage
Chapter 3 Investigation of Discharge
Chapter 4 Hydrological Statistics
Chapter 5 Run-off Calculations
Chapter 6 Roughness Coefficient and Water Level Calculations
Chapter 7 Groundwater Survey
Chapter 8 Inner Water Survey
Chapter 9 River Mouth Survey
Chapter 10 Landslide and Steep-slope Surveys
Chapter 11 Sediment Yield Survey
Chapter 12 Sediment Transport Survey
Chapter 13 Coastal Survey
Chapter 14 Water Quality and Bed Material Survey
Chapter 15 Soil Investigation and Geological Survey

Chapter 16 Ecological Environment Survey

Chapter 17 Investigation of River Economy

Chapter 19 Surveys

Examples of regulations and forms for governmental control of water development works and structure are provided in the Appendix 3.

# CHAPTER 4 IMPROVEMENT IN INSTITUTION AND REGULATION ON GROUNDWATER DEVELOPMENT AND MANAGEMENT

## 4.1 Necessity of Improvement

The current revision of the Water Act includes change in legal status of groiunwater from "private water" which can be used by the land owner free of charge and without any authorisation to use, into "public water" whose use requires due grant and with due fees.

Governments in many countries have asserted themselves as guardians of the groundwater resource because of its increasing abstraction caused by its easy access and high quality as a source of supply and of consequent negative impacts caused by over-abstraction. Permission of groundwater abstraction requires assessment of aquifers' potential as well as the existing use, although the government is not necessary to guarantee the prospective volume of abstraction. For an equitable management of groundwater resource, the assessment of the potential, current use, current conditions in quality and the projection of demands and discharge into the aquifers would be the first needs. Conservation of the groundwater quality, as well as its quantity, requires a different approach in legislation and in practice, because once contaminated it could be more hard or impossible to recover.

Although the current revision covers parts of the required approaches for equitable management, subsidiary regulation and capacity enhancement of the relevant entities, The DWA and the WDB, for the enforcement of the regulations would be necessary.

## 4.2 Required Approaches

### (1) Potential Assessment

As conducted in the Study, the first step of the groundwater management is the assessment of the potential, stable and sustainable amount of yields from aquifers. Activities for data collection, using existing wells and monitoring wells would be required.

### (2) Strengthened Inspection of Water Use

Groundwater resource assessment should include not only the potential of aquifers mentioned above, but also current abstraction. An inventory of boreholes should be prepared, especially in those areas where massive abstraction is carried out or prospectively will occur, such as Lusaka Urban Area. Some measures for the encouragement of registration, such as moratorium during when the registration fee would be exempted or lowered, would be necessary coupled with after the period fines should be charged for the negligence of registration or incorrect information.

A field survey team would be necessary for the inspection, with some legal status, such as entry to the private land or building for the inspection. The team would be also responsible for the inspection of conformity to the granting, as well as inspection of surface water use.

### (3) Process of the Granting of Groundwater Development and Use

Typical process of the groundwater development and abstraction might be as follows:

- Registration and Control of Professional Drillers

- Application of Borehole Drilling and Well Construction with Project Plan and Attached Information
- Filing and Examination of the Plan
- Issue a permit with or without Modification or Limitation to the Plan or Deny the Project
- Construction of the Borehole
- Application of Modification of the Design of Borehole, Pumps or Other Facilities, if necessary
- Issue a permit with or without Modification or Limitation to the Modified Design
- Application of the Abstraction with Pumping Test Data and Quality Monitoring Result
- Inspection and Granting the Abstraction with or without the Order of Modification or Limitation to the Abstraction

Some period should be provided for the examination, thus the application should be submitted prior to the commencement of the construction. Sub-surface water abstraction, which could be prohibited as many countries with some restricted area near the surface water body, could be examined within the frame of surface water derivation at the location.

As the conditions of the aquifers are not visible, there might be some cases that the potential of the aquifers can not be known exactly, and some conflicts may occur with the existing water users and the new user. It might be necessary to include some stipulation in the regulation that the grants of groundwater use shall not incur any responsibility of the competent entity without any assertion of the use by the authority, while the authority should make as much effort for the assessment to manage the groundwater properly and to avoid conflicts as possible.

Even though the reporting of the result of the pumping test and quality monitoring would be the responsibility of prospective user at the own cost, cancellation of the registry of the professional driller or other penalties could be imposed when negligence or fabrication of the data occurs.

### (4) Impact Assessment of Groundwater Exploitation

Groundwater development might involve specific negative impacts, many of those can be avoided equitable management of the resource by a proper assessment and adequate control of abstraction. Monitoring efforts would remain necessary for ground depression, lowering water crest, salinisation of groundwater or impacts on surface water body or on ecology.

## 4.3 Models and Examples of Regulations and Forms

Currently the WDB refers Kenyan water rules in the process of the revision of the Water Act. References for regulations would also be efficient, even though regulations should alter according to the local conditions more than fundamental laws. Examples are attached in the Appendix 4.

# CHAPTER 5 COMPREHENSIVE WATER RESOURCES MANAGEMENT

## 5.1 International Trends of Water Resources Management

Today, the availability of water has become a crucial constraint for the preservation of civilisation, resulting from mainly four factors and the interactions; i) exponential population growth, ii) increasing food demands, iii) rapid urbanisation, and iv) spreading industrialisation. Industrial development has accompanied increased pollution loads and has reduced available clean or safe water. Raised living standards increases recreational and environmental demands. Thus, water demands grow near to the limit of the resource potential.

Water resource development plan should be formulated in accordance with the long- or mid-term socio-economic development plan of the region. When and where the availability of water is a constraint to social and economic development, priority order among various type of water use has to be established through effective and flexible legislation and its efficient implementation which devises optimal water distribution and utilisation in order to achieve the socio-economic development plan, in a harmonious way. Then, planning responsibility is increasing for co-ordinated water management in conformity with the national development plan. The responsibilities and duties imposed on the management entities are soaring in most of the governments of the world to attain comprehensive or integrated water resources management.

## 5.2 Co-ordinated, Consistent and Concurrent Management by Relevant Sectors

As water is essential for various sectors of the society and economy, many entities are involved for the administration and management of water resources. Projects or programmes for the exploitation and the conservation are planned, executed, operated, maintained, registered and monitored by various entities. Water resource development, conservation, utilisation and control cannot be successfully implemented unless relevant institutions and legislation at all levels-international, national, regional, and of basins-are adequately established and managed.

Concurrent operations will be attained under comprehensive policy formulation and consequent consistent programming, planning and implementation of projects. Comprehensive policy is the target of the Water Development and Allocation Policy Committee as recommended in the Main Report (Section 6.7.3 (5) (b)).

Consistent planning requires, first of all, appropriate information networks. The networks should include data of all relevant sector, including a database by river. Comprehensive model of the water resources database is illustrated in the Main Report (Figure 7-1).

## 5.3 Linkage among Sectors

The following linkage will be necessary. In long term, the Ministry of Natural Resources (Land, Water and Pollution Control) would preferably be established as a regulatory entity in charge of comprehensive policy formulation for rational use and conservation of natural resources with the development of decentralisation of operational entities.

### (1) Linkage of Water- and Land-use Management

Land, like water, is one of the fundamental element which subsoil human activities. Once synchronized land and water use are achieved, the socio-economic development of the region can be attained by exploiting these two resources efficiently. Land-use development accompanies increased water demands. Then, land-use development plan should be supported by water resources development plan. On the contrary, land-use plan, such as forest preservation plan in upstream areas, control or restriction of industrial or agricultural land use around water sources, can play eminent role for water resources conservation. Land use control has close relation with sedimentation yields, so that lives of water reservoirs.

### (2) Linkage of Quantity and Quality Management

Generally a specific use of water determines the quality of return flow, hence, the potential of downstream use. There are cost trade-offs between pollution control or prevention and water supply treatment. Linkage between quantity and quality management will grow more important in the congested resource use.

### (3) Linkage of Surface Water Management and Groundwater Management

To secure enough water for social and economic activity, both surface water and groundwater must be exploited in the least cost where water demands grow near to the potential to the source of supply. Trade-off in water use of both sources will be inevitable in case of hydrological event, such as drought, or pollution spill. Contingency re-allocation would require linked management of the two water sources. Current organisation will be favourable for the linked management.

# CHAPTER 6 WATER PRICING

## 6.1 Function of Water Pricing

Currently water tariff in Zambia shares only 0.57% of the household expenditure in urban areas, and merely 0.11% in rural areas. As discussed in the economic evaluation of water supply projects, the World Bank has estimated the affordability to pay by useres as much as 5% of the household income. Lower water tariff is commonly result in larger demands. To meet the larger demands, water service entity should invest for larger capacity. Further, in Zambia, the service entities apply flat rate tariff, where tariff is not directly related to the quantity of water used, and which often results in larger demands.

Tapped water supply services incur huge investment, especially those for large urban areas, such as Lusaka. Currently most of the water supply has fallen into deficit

Water fee for derivation or abstraction as set in the Water Code. The problem for the fee might be that the fee is collected only at the time of application and registration. Some bulk users could hold larger volume of water rights than their normal use.

## 6.2 Principles of Water Pricing

Marginal cost pricing system, where the price reflects the incremental cost to the community of satisfying marginal demands, is known as preferable tariff setting. The price of the last litre of water used or disposed of would be equal to the true marginal cost of providing that water service. In marginal cost pricing, the supply system would be used at its economic optimum rate, and in the long run, the supply system would be constructed and maintained at the optimal economic scale.

Progressive or increasing block tariff, where succeeding blocks of unit of water sold at higher and higher prices. This tariff structure has becoming increasingly common with income re-distribution objectives. This tariff is also meaningful because generally additional consumption becoming more and more expensive, as envisaged in the case of Kafue Pipeline Project in Lusaka.

User-to-pay should be a principle. Ultimately, in all cases of tariff structure, the community or the nation in aggregate all cost of the services except financed by foreign grants. Following user-to-pay principle means to avoid the situation that persons who do not use water pay for the water. Full cost recovery should be attained by tariff collection.

In the case of derivation or abstraction from water courses, charging as much as opportunity cost, which is defined as the economic value of water foregone by using scarce resource for some purpose instead of for the next best use, would be the best solution to maximise net economic benefit from water use.

## 6.3 Practices of Water Pricing

Improvement in flat rate charging could be a short term target without large investment for metering device installation. Some methods could be possibly applied for similar effect of progressive block tariffs by examining the correlation of the parameters to the water consumption amount. Introduction of metering should also be promoted from large urban areas at an early stage for equitable charging system. Low cost procurement of meters

should be studied, recommendably by the NCSR, developing domestic production or domestic parts production.

After the introduction of metering to all households, progressive block tariff would not only contribute to attaining the social fairness or income re-distribution to low income groups, but also encourage the reduction water wastage of middle and high income groups. Some particular tariff structure in case of droughts occurrence might worth to be examined.

For industrial use, the effect of progressive tariff is doubtful. Charging to the effluent would generally encourage demand reduction, as well as its main purpose of environmental conservation.

For water derivation or abstraction fee, the annual charging to large user with continuous revision of the fees would contribute to rational allocation of water rights.. In longer term, opportunity cost pricing would be recommendable for economically efficient demand control.

# APPENDIX 1 THE HELSINKI RULES

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### The Helsinki Rules

The Helsinki Rules on the Uses of the Waters of International Rivers (Helsinki, August 1966).

## CHAPTER 1 GENERAL

### Article I

The general rules of International law as set forth in these chapters are applicable to the use of the waters of an International drainage basin except as may be provided otherwise by convention, agreement or binding custom among the basin States.

# APPENDIX 1 THE HELSINKI RULES

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## The Helsinki Rules

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## CHAPTER 1 GENERAL

### Article I

The general rules of International law as set forth in these chapters are applicable to the use of the waters of an International drainage basin except as may be provided otherwise by convention, agreement or binding custom among the basin States.

Article II

An International drainage basin is a geographical area extending over two or more States determined by the watershed limits of the system of waters, including surface and underground waters, flowing into a common terminus.

Article III

A "basin State" is a state the territory of which includes a portion of an international drainage basin.

## CHAPTER 2 EQUITABLE UTILISATION OF THE WATERS OF AN INTERNATIONAL DRAINAGE BASIN.

Article IV

Each basin State is entitled, within its territory, to a reasonable and equitable share in the beneficial uses of the waters of an International drainage basin.

Article V

(1) What is a reasonable and equitable share within the meaning of Article IV is to be determined in the light of all the relevant factors in each particular case.

(2) Relevant factors which are to be considered include, but are not limited to:

(a) the geography of the basin, including in particular the extent of the drainage area in the territory of each basin State;

(b) the hydrology of the basin, including in particular the contribution of water by each basin State;

(c) the climate affecting the basin;

(d) the past utilisation of the waters of the basin, including in particular existing utilisation;

(e) the economic and social needs of each basin State;

(f) the population dependent on the waters of the basin in each basin State;

(g) the comparative costs of alternative means of satisfying the economic and social needs of each basin State;

(h) the availability of other resources;

(i) the avoidance of unnecessary waste in the utilisation of waters of the basin;

(j) the practicability of compensation to one or more of the co-basin sates as a means of adjusting conflicts among uses; and,

(k) the degree to which the needs of a basin State may be satisfied, without causing substantial injury to a co-basin State.

(3) The weight to be given to each factor is to be determined by its importance in comparison with that of other relevant factors. In determining what is a reasonable and equitable share, all relevant factors are to be considered together and a conclusion reached on the basis of the whole.

Article VI

A use or category of use is not entitled to any inherent preference over any other use or category of uses.

Article VII

A basin State may not be denied the present reasonable use of the waters of an international drainage basin to reserve for a co-basin State a future use of such waters.

Article VIII

(1) An existing reasonable use may continue in operation unless the factors justifying its continuance are outweighed by other factors leading to the conclusion that it be modified or terminated so as to accommodate a completing incompatible use.

(2) a. A use that is in fact in operation is deemed to have been an existing use from the time of the initiation of construction directly related to the use or, where such construction is not required, the undertaking of comparable acts of actual implementation.

b. Such a use continues to be an existing use until such time as it is discontinued with the intention that it be abandoned.

(3) A use will not be deemed an existing use if at the time of becoming operational it is incompatible with an already existing reasonable use.

## CHAPTER 3 POLLUTION

Article IX

As used in this chapter, the term "water pollution" refers to any detrimental change resulting from human conduct in the natural composition, content, or quality of the waters of an international drainage basin.

Article X

(1) Consistent with the principle of equitable utilisation of the waters of an international drainage basin, a State;

(a) must prevent any new form of water pollution or any increase in the degree of existing water pollution in an international drainage basin which would cause substantial injury in the territory of a co-basin State, and

(b) should take all reasonable measures to abate existing water pollution in an international drainage basin to such an extent that no substantial damage is caused in this territory of a co-basin State.

(2) The rule Stated in paragraph (1) of this article applies to water poilution originating:

(a) within a territory of this State, or

(b) outside the territory of the State, if it caused by the State's conduct.

Article XI

(1) In the case of a violation of the rule Stated in paragraph (1) a. of Article X of this chapter, the State responsible shall be required to cease the wrongful conduct and compensate the injured co-basin State for the injury that has been caused to it.

(2) In a case falling under the rule Stated in paragraph (1)b. of article X, if a State fails to take reasonable measures, it shall be required promptly to enter into negotiations with the injured State with a view toward reaching a settlement equitable under the circumstances.

## CHAPTER 4 NAVIGATION

Article XII

(1) This chapter refers to those rivers and lakes portions which are both navigable and separate or traverse the territories of two or more States.

(2) Rivers or lakes are "navigable" if in their natural or canalised State they are currently used for commercial navigation or are capable by reason of their natural condition of being so used.

(3) In this chapter the term "riparian State" refers to a State through or along which the navigation portion of a river flows or lake lies.

Article XIII

Subject to any limitations or qualifications referred to in these chapters, each riparian State is entitled to enjoy rights of free navigation on the entire course of a river or lake.

Article XIV

"Free navigation," as the term is used in this chapter, includes the following freedom for vessels of a riparian State on a basis of equality:

(a) freedom of movement on the entire navigable course of the river or lake;

(b) freedom to enter ports and to make use of plants and docks; and ,

(c) freedom to transport goods and passengers, either directly or through transshipment, between the territory of one riparian State and the territory of another riparian State and between the territory of a riparian State and the open sea.

Article XV

A riparian State may exercise rights of police, including but not limited to the protection of public safety and health, over that portion of the river or lake subject to its jurisdiction, provided the exercise of such rights does not unreasonably interfere with the enjoyment of the rights of free navigation defined in Article XIII and XIV.

Article XVI

Each riparian State may restrict or prohibit the loading by vessels of a foreign State of goods and passengers in its territory for discharge in such territory.

Article XVII

A riparian State may grant rights of navigation to non-riparian States on rivers or lakes within its territory.

Article XVIII

Each riparian State is, to the extent of the means available to it required to maintain in good order that portion of the navigable course of a river or lake within its jurisdiction.

Article XVIII bis

(1) A riparian State intending to undertake works to improve the navigability of that portion of a river or lake within its jurisdiction is under a duty to give notice to the co-riparian States.

(2) If these works are likely to affect adversely the navigational uses of one or more co-riparian States, any such co-riparian State may, within a reasonable time, request consultation. The concerned co-riparian States are then under a duty to negotiate.

(3) If a riparian State proposes that such works be undertaken in whole or in part in the territory of one or more other co-riparian States, it must obtain the consent of the other co-riparian State or State concerned. The co-riparian State or States from whom this consent is required are under a duty to negotiate.

Article XIX

The rules Stated in this chapter are not applicable to the navigation of vessels of war or of vessels performing police or administrative functions, or in general, exercising any other form of public authority.

Article XX

In time of war, other armed conflict or public emergency constituting a threat to the life of the State, a riparian State may take measures derogating from its obligations under this chapter to the extent strictly required by the exigencies of the situation, provided that such measures are not inconsistent with its other obligations under international law. The riparian State shall in any case facilitate navigation for humanitarian purposes.

## CHAPTER 5 TIMBER FLOATING

Article XXI

The floating of timber on a watercourse which flows through or between the territories of two or more States is governed by the following Articles except in cases in which floating is governed by rules of navigation according to applicable law or customs binding upon the riparians.

Article XXII

The States riparian to an international watercourse utilised for navigation may determine by common consent whether and what conditions timber floating may be permitted upon the watercourse.

Article XXIII

(1) It is recommended that each State riparian to an international watercourse not used for navigation should, with due regard to other uses of the watercourse, authorise the co-riparian States to use the watercourse and its banks within the territory of each riparian State for the floating of timber.

(2) This authorisation should extend to all necessary work along the banks by the floating crew and to the installation of such facilities as may be required for the timber floating.

Article XXIV

If a riparian State requires permanent installation for floating inside a territory of a co-riparian State or if it is necessary to regulate the flow of the water-course, all questions connected with these installations and measures should be determined by agreement between the States concerned.

Article XXV

Co-riparian States of a watercourse which is, or is to be used for floating timber should negotiate in order to come to an agreement governing the administrative regime of floating, and if necessary to establish a joint agency or commission in order to facilitate the regulation of floating in all aspects.

## CHAPTER 6 PROCEDURES FOR THE PREVENTION AND SETTLEMENT OF DISPUTES

Article XXVI

This chapter relates to procedures for the prevention and settlement of international disputes as to the legal rights or other interests of basin States and of other States in the waters of an international drainage basin.

Article XXVII

(1) Consistently with the charter of the United nations, States are under an obligation to settle international disputes as to their legal rights or other interests by peaceful means in such a manner that international peace and security, and justice are not endangered.

(2) It is recommended that States resort progressively to the means of prevention and settlement of disputes stipulated in Article XXIX to XXXIV of this chapter.

Article XXVIII

(1) States are under a primary obligation to resort to means of prevention and settlement of disputes stipulated in the applicable treaties binding upon them.

(2) States are limited to the means of prevention and settlement of disputes stipulated in treaties binding upon them only to the extent provided by the applicable treaties.

Article XXIX

(1) With a view to preventing disputes from arising between basin States as to their legal rights or other interest, it is recommended that each basin furnish relevant and

reasonably available information to the other basin States concerning the waters of a drainage basin within its territory and its use of, and activities with respect to such waters.

(2) A State, regardless of its location in a drainage basin, should in particular furnish to any other basin State, the interests of which may be substantially affected, notice of any proposed construction or installation which would alter the regime of the basin in a way which might give rise to a dispute as defined in Article XXVI. The notice should include such essential facts as will permit the recipient to make an assessment of the probable effect of the proposed alteration.

(3) A State providing the notice referred to in paragraph (2) of this Article should afford to the recipient a reasonable period of time to an assessment of the probable effect of the proposed construction or installation and to submit its views thereon to the State furnishing the notice.

(4) If a State has failed to give the notice referred to in paragraph (2)of this Article, the alteration by the State in the regime of the drainage basin shall not be given the weight normally accorded to temporal priority in use in the event of a determination of what is a reasonable and equitable share of the basin

Article XXX

In case of a dispute between States as to their legal rights or other interests, as defined in Article XXVI, they should seek a solution by negotiation.

Article XXXI

(1) If a question or dispute arises which relates to the present or future utilisation of the waters of an international drainage basin, it is recommended that the basin States refer the question or dispute to a joint agency and that they request the agency to survey the international drainage basin and to formulate plans or recommendations for the fullest and most efficient use thereof in the interests of all such States.

(2) It is recommended that the joint agency be instructed to submit reports on all matters within its competence to the appropriate authorities of the member States concerned.

(3) It is recommended that the member States of the joint agency in appropriate cases invite non-basin States which by treaty enjoy a right in the use of the waters of an international drainage basin to associate themselves with the work of the joint agency or that they be permitted to appear before the agency.

Article XXXII

If a question or a dispute is one which is considered by the States concerned to be incapable of resolution in the manner set forth in Article XXXI, it is recommended that they seek the good offices, or jointly request the mediation of a third State, of a qualified international organisation or of a qualified person.

Article XXXIII

(1) If the States concerned have not been able to resolve their dispute through negotiation or have been unable to agree on the measures described in Article XXXI and XXXII, it is

recommended that they form a commission of inquiry or an ad hoc conciliation commission, which shall endeavour to find a solution, likely to be accepted by the States concerned, of any dispute as to their legal rights.

(2) It is recommended that the conciliation commission be constituted in the manner set forth in the annex.

Article XXXIV

It is recommended that the States concerned agree to submit their legal disputes to an ad hoc arbitral tribunal, to a permanent arbitral tribunal or to the international court of justice if:

(a) A commission has not been formed as provided in Article XXXIII, or

(b) The commission has not been able to find a solution to be recommended, or

(c) A solution recommended has not been accepted by the States concerned, and

(d) An agreement has not been otherwise arrived at.

Article XXXV

It is recommended that in the event of arbitration the States concerned have recourse to the model rules on Arbitral procedure prepared by the International Law Commission of the United Nations at its tenth session in 1958

Article XXXVI

Recourse to arbitration implies the undertaking by the States concerned to consider the award to be given as final and to submit in good faith to its execution

Article XXXVII

The means of settlement referred to in the preceding Articles of this chapter are without prejudice to the utilisation of means of settlement recommended to, or required of, members of regional arrangements or agencies and of other international organisations.

ANNEX

**Model Rules for the Constitution of the Conciliation Commission for the Settlement of a Dispute**

(In implementation of Article XXXIII of CHAPTER 6)

Article I

The member of the commission, including the President, shall be appointed by the States concerned

Article II

If the States concerned cannot agree on these appointments, each State shall appoint two members. The members thus appointed shall choose one more member who shall be the president of the commission. If the appointed members do not agree, the member- president shall be appointed, at the request of any State concerned, by the president of the International

court of justice, or, if he does not make the appointed, by the secretary- general of the United Nations.

Article III

The membership of the commission should included persons who, by reason of their special competence, are qualified to deal with disputes concerning international drainage basins

Article IV

If a member of the commission abstains from performing his office or is unable to discharge his responsibility, he shall be replaced by the procedure set out in article I of this Annex, according to the manner in which he was originally appointed. If, in the case of:

(1) a member originally appointed udder article I, the States fail to agree as to a replacement; or

(2) a member originally appointed under Article II, the State involved fail to replace the member

Article V

In the absence of agreement to the contrary between the parties, the conciliation commission shall determine the place of its meetings and shall lay down its own procedure.

## Article on Flood Control (New York, 1972)

Article 1

In the context of following article,

1. 'Floods' means the rising of water levels which would have detrimental effects on life and property in co-basin States.

2. 'Floods control' means the taking of all appropriate steps to protect land areas from floods or to minimise damage therefrom.

Article 2

Basin States shall co-operate in measure of flood control in a spirit of good neighbourliness, having due regard to their interesting and well-being as co-basin States

Article 3

Co-operation with respect to flood control may, by agreement between basin States, include among others:

(a) collection and exchange of relevant data

(b) preparation of surveys, investigations and studies and their mutual exchange;

(c) planning and designing of relevant measures;

(d) execution of flood control measures;

(e) operation and maintenance of works;

(f) flood forecasting and communication of flood warnings;

(g) setting up of a regular information service charged to transit the height of water levels and the discharge quantities;

Article 4

(1) Basin States should communicate amongst themselves as possible on any occasion such as heavy rainfalls, sudden melting of snow or other events likely to create floods and of dangerous rises of water levels in their territory.

(2) Basin States should set up an effective system of transmission in order to fulfill the provisions contained in paragraph 1, and should ensure priority to the communication of flood warnings in emergency cases. If necessary a special system of translation should be build up between the basin States.

Article 5

(1) The use of the channel of rivers and lakes for the discharge of excess waters shall be free and not subject to any limitation provided this is not incompatible with the object of flood control.

(2) Basin States should maintain in good order their portions of water courses including works for flood control.

(3) No basin State shall be prevented from undertaking schemes of drainage, river draining, conservation of soil against erosion and dredging, or from removal of stones, gravel or sand from the beds of its portions of water - courses provided that, in executing any of these schemes, it avoids any unreasonable interference with the object of flood control, and provided that such schemes are not contrary to any legal restrictions which may exist otherwise.

(4) Basin States should ensure the prompt execution of repairs or other emergency measures for minimisation of damage by flooding during periods of high waters.

Article 6

(1) Expenses for collection and exchange of relevant data, for preparation of surveys, investigations and studies, for flood forecasting and communication of flood warnings, as well as for setting up of a regular information service shall be borne jointly by the basin States co-operating in such matters.

(2) Expenses for special works undertaken by agreement in the territory of one basin State at the request of another basin State shall be borne by the requesting State, unless the cost is distributed otherwise under the agreement.

Article 7

A basin State is not liable to pay compensation for damage cause to another basin State by floods originating in that basin State unless it has acted contrary to what could be reasonably expected under the circumstances, and unless the damage caused is substantial.

Article 8

In case of dispute, Article XXX to XXXVII of the Helsinki Rules are, so far as may be, applicable.

## Article on Marine Pollution of Continental Origin (New York, August 1972)

Article I

As used in this chapter "Continental sea-water pollution" means any detrimental change in the natural composition, content or quality of sea water resulting from human conduct taking place within the limits of the national jurisdiction of a State.

This conduct shall include, inter alia, the discharge or introduction of substances directly into the sea from pipelines, extended outlets, or indirectly through rivers or other watercourses whether natural or artificial, or through atmospheric fall-out.

Article II

(a) Taking into account all relevant factors referred to in Article III a State shall prevent any new form of continental sea-water pollution or any increase in the degree of existing continental sea-water pollution which would cause substantial injury in the territory of another State or to any of its rights under international law or to the marine environment, and

(b) shall take all reasonable measures to abate existing continental sea-water pollution to such an extent that no substantial injury of the kind referred to in paragraph (a) is caused.

Article III

(a) States should establish, as soon as possible, international standards for the control of sea-water pollution, having regard to all relevant factors, including the following:
   - the geography and hydrography of the area (inland waters, territorial sea, contiguous zone and continental shelf);
   - climatological condition;
   - quality and composition of affected sea waters;
   - the conservation of the maritime environment (flora and fauna);
   - the sources of the sea-bed and the subsoil and their economic value for present and potential users;
   - the recreational facilities of the coastal area;
   - the past, present and future utilisation of the coast area and sea water;
   - the economic and social needs of the (coast) States involved;
   - the existence of alternative means for waste disposal;
   - the adaptation of detrimental charges to beneficial human uses;
   - the avoidance of unnecessary waste-disposal;

(b) Until such standards are established, the existence of substantial injury from pollution shall be determined by taking into consideration factors, including those referred to in paragraph (a).

(c) The weight to be given to each other factor is to be determined by its importance in comparison with that of that of other relevant factors.

Article IV

When it is contended that the conduct of a State is not in accordance with its obligations under these Articles, that State shall promptly enter into negotiations with the complainant with a view to reaching a solution that is equitable under the circumstances.

Article V

In the case of violation of the rules in Article II, the State responsible shall cease the wrongful conduct and shall compensate the State for the injury that has been caused to it.

Article VI

In case of a dispute, Article XXXI to XXXVII of the Helsinki Rules are so far as may be, applicable.

## Maintenance and Improvement of Naturally Navigable Waterways Separating or Traversing Several States (New Delhi, 4 January 1975)

The following is the text of the Articles included in the report on Maintenance and Improvement of Naturally Navigable Waterways separating or traversing several States, which are to be added to the "Helsinki Rules" as Article XVIII bis:

1. A riparian State intending to undertake works to improve the navigability of that portion of a river or lake within its jurisdiction is under a duty to give notice to the co-riparian States;

2. If these works are likely to affect adversely the navigational uses of one or more co-riparian States, any such co-riparian State may, within a reasonable time, request consultation. The concerned co-riparian States are then under a duty to negotiate;

3. If a riparian State proposes that such works be undertaken in whole or in part in the territory of one or more other co-riparian States, it must obtain the consent of the other co-riparian State or States concerned. The co-riparian State or States from whom this consent is required are under a duty negotiate.

## Resolution on the Protection of the Water Resources and Water Installations in times of Armed Conflict (Madrid, 1976)

Article I

Water which is indispensable for the health and survival of the civilian population should not be poisoned or otherwise unfit for human consumption.

Article II

Water supply installations which are indispensable for the minimum conditions of survival of the civilian population should not be cut off or destroyed.

Article III

The diversion of waters for military purposes should be prohibited when it would cause disproportionate suffering to the civilian population or substantial damage to the damage or destroy the minimum conditions of the civilian population or the basic ecological balance of the area concerned or in order to terrorise the population should be prohibited in any case.

Article IV

The destruction of water installations containing dangerous forces, such as dams and dykes, should be prohibited when such destruction may involve grave dangers to the civilian population or substantial damage to the ecological balance.

Article V

The causing of floods as well as any other interference with the hydrological balance by means not mentioned in Arts. II to IV should be prohibited when it involves grave dangers to the civilian population or substantial damage to the ecological balance of the area concerned.

Article VI

1. The prohibitions contained in Arts I to V above should be also in occupied enemy territories.
2. The occupying power should administer enemy property to the indispensable requirements of the hydrologic balance.
3. In occupied territories, seizure, destruction or intentional damage to water installation should be prohibited when their integral maintenance and effectiveness would be vital to the health and survival of the civilian population.

Article VIII

The effect of the outbreak of war on the validity of treaties or of parts thereof concerning the use of water resources should not be termination but only suspension. Such suspension should take place only when the purpose of the war or military necessity imperatively demand the suspension and when the minimum requirements of subsistence for the civil population are safeguarded.

Article VIII

1. It should be prohibited to deprive, by the provisions of a peace treaty or similar instrument, a people of its water resources to such an extent that a threat to the health or to the economic or physical condition of survival is created.
2. When, as the result of the fixing of new frontier, the hydraulic system in the territory of one State is dependent on works established within the territory of another State,

arrangements should be made for the safeguarding of uninterrupted delivery of water supplies indispensable for the vital needs of the people.

## Resolution on International Water Resources Administration (Madrid, 1976)

Article 1

As used in this chapter, the term "international water resources administration" refers to any form of institutional or other arranged established by agreement among two or more basin States for the purpose of dealing with the conservation, development and utilisation of the waters of an international drainage basin.

Article 2

1. With a view to implementing the principle of equitable utilisation of the waters of an international drainage basin, and consistent with the provisions of chapter VI [of the Helsinki Rules] relating to the procedures for the prevention and settlement of disputes, the basin States concerned and interested should negotiate in order to reach agreement on the establishment of an international water resources administration.

2. The establishment of an international water resources administration in accordance with paragraph 1 above is without prejudice to the existence or subsequent designation of any joint agency, conciliation commission or tribunal formed or referred to by co-basin States pursuant of Article XXXI [of the Helsinki Rules] in case of a question or dispute relating to the present or future utilisation of the waters of an international drainage basin.

Article 3

Member States of an international water resources administration in appropriate cases should invite other States including non-basin States or international organisations, which by treaty, other instrument or binding custom enjoy a right or have an interest in the use of the waters of an international drainage basin, to participate in the activities of the international water resources administration.

Article 4

1. In order to provide for an effective international water resources administration the agreement establishing that administration should expressly state, among other things, its objective or purpose, nature and composition, form and duration, legal status, area of operation, functions and powers, and financial implications of such an international water resources administration.

2. The Guidelines annexed to these Article should be taken into account when an international water resources administration is to be established.

## Guidelines for the Establishment of an International Water Resources Administration

(In implementation of Article IV, paragraph 2 on International Water Resources Administration)

In establishing an international water resources administration, member States should consider, no the requirements of each particular case, the elements contained in the following guidelines:

1. Form and duration of an International Water Resources Administration will depend on all relevant factors identified in these guidelines, including:
   (a) its duration, which may be ad hoc or permanent, and
   (b) constitution which may take the form of: (I) separate national commissions or agencies; (ii) a joint commission or agency composed of national representatives, interest groups or representatives of users; (iii) a mixed commission or agency; (iv) a commission or agency vested with supranational decision-making powers.

2. Procedures for decision-making will include:
   (a) a quorum (for the validity of the meeting) which will depend on the importance of the decisions to be taken;
   (b) the principle of either unanimity, simple or qualified majority or an other combined form of decision-making.

3. The legal status of an International Water Resources Administration vis-a-vis both its member States and other States not parties to the administration as well as vis-a-vis international and other organisations should be defined; such legal status will cove:
   (a) the managing body,
   (b) the staff,
   (c) assets, equipment and other properties,
   (d) the whole administration as such, including the powers to sue and to be sued.

4. The territorial competence (ratione loci)of an international water resources administration should be defined. The choice will depend on a number of factors, such as: the extent of drainage area with respect to each member State; the contribution of water by each basin State to the hydrology of the basin; the economic and social requirements of the basin State; local interest; the other relevant factors to be considered in each particular case, having regard to Article V of the Helsinki Rules.

   Territorial competence may include:
   (a) the whole drainage basin, including surface water, underground waters or both;
   (b) more than one drainage basin (multi-basin);
   (c) part of a drainage basin (sub-basin);
   (d) an area otherwise defined and clearly delimited; and
   (e) all or part of boundary water.

5 The function and power of an international water resources administration should be defined. These may vary from case to case, depending upon various factors, including:
   (a) the kind of co-operation envisaged;

(b) the desire degree of involvement in international administration;

(c) the specific fields for which it is proposed to establish the administration.

Such functions and powers may include, without being limited to one or more of the following:

A. Advisory, consultative, co-ordinating, or policy-making function. In these cases, the agreement should specify the procedural rules for deciding on conflicting rights and interests, including notification, objections and timing.

B. Executive function, which may include carrying out of studies, exploration, investigation and surveys, preparation of feasibility reports, inspection and control construction, operation, maintenance or financing.

C. Regulatory function, including the implementation of the decisions of the administration, as well as lawmaking. Decision in these matters may take effect directly or after acceptance by Member States.

D. Judicial function, which may include arbitration or final dispute settlement.

6. As regards the objects and purposes (ratione materiae) of an international water resources administration, these may include one or more of the following:

(a) collection and exchange of hydrological technical and other data, which may be undertaken by Member States separately or jointly, and their standardisation;

(b) plan formulation, which may include the exchange of plans prepared separately by Member States or jointly formulated plans;

(c) co-ordination of plans;

(d) construction of waterworks, which may be undertaken by Member States separately or jointly, or which may be entrusted to a non Member State or to some organisation;

(e) waterworks operation and maintenance, which may be entrusted to each Member State concerned separately or to joint administration;

(f) control of one or more beneficial uses of water which may include: (i) domestic and community uses; (ii) agricultural uses, including the watering of animals and agro-allied industrial uses; (iii) industrial uses, including cooling; (iv) hydropower generation and transmission; (v) navigation; (vi) timber floating; (vii) fishing and (viii) other harmful effects of common interest;

(h) water quality control including such coastal sea areas of the Member States, which may be adversely affected, and which may include: (i) prevention and abatement of water pollution resulting from one or more beneficial uses, and harmful effects and the measures to be taken separately or jointly by Member States; (ii) health preservation, including human beings and genetic resources (animals and plants), and the measures to be taken separately or jointly by Member States; (iii) environment protection, with reference to the waters of the basin, including minimum standards and measures to be taken separately or jointly by Member States.

8. In establishing an international water resources administration, one or more of the following financial and economic matters should be considered:

(a) internal financing of the administration, including cost sharing and sharing criteria;

(b) development financing of projects and works in particular including: (i) cost sharing and criteria for sharing (based on i.e. at-site benefit analysis, system development); procedures and criteria for compensation; (ii) sharing of benefits including the assessment and collection of revenues, and criteria for sharing;

(c) external financing, with particular reference to the powers of the administration necessary to enter into agreement for this purpose.

9. The agreement establishing an international water resources administration should contain provision for the settlement of disputes arising out of its interpretation and implementation.

## Resolution of the Flow of Water of International Watercourses (Beograd, 1980)

Article 1

For the purpose of these Articles, "regulation" means continuing measures intended for controlling, moderating, increasing or otherwise modifying the flow of the waters in an international watercourse for any purpose; such measures may include storing, releasing and diverting of water by means such as dams, reservoirs, barrages and canals.

Article 2

Consistent with the principle of equitable utilisation, basin States shall cooperate in a spirit of good faith and neighbourliness in assessing needs and possibilities and preparing plans for regulation. When appropriate, the regulation should be undertaken jointly.

Article 3

When undertaking a joint regulation, basin States should settle all matters concerning its management and administration by agreement. When necessary, a joint agency or commission should be established and authorised to manage all relevant aspects of the regulation.

Article 4

Unless otherwise agreed, each basin State party to a regulation shall bear a share of its costs proportionate to the benefits it derives from the regulation.

Article 5

1. The construction of dams, canals, reservoirs or other works and installations and the operation of such works and installations required for regulation by a basin State in the territory of another can be carried out only by agreement between the basin States concerned.

2. Unless otherwise agreed, the costs of such works and their operation should be borne by the basin States concerned.

Article 6

A basin State shall not undertake regulation that will cause other basin States substantial injury unless those States are assured the enjoyment of the beneficial uses to which they are entitled under the principle of equitable utilisation.

Article 7

1. A basin State is under a duty to give the notice and information and to follow the procedures set forth in Article XXIX of the Helsinki Rules.

2. When appropriate, the basin State should invite other basin States concerned to participate in the regulation.

Article 8

In the event of objection to the proposed regulation, the States concerned shall use their best endeavours with a view to reaching an agreement. If they fail to reach an agreement within a reasonable time, the States should seek a solution in accordance with Chapter 6 of the Helsinki Rules.

Article 9

The application of these Articles to regulation for controlling floods is without prejudice tot he application of the relevant articles on Flood Control adopted by the International Law Association in 1972.

## Articles on the Relationship between Water, Other Natural Resources and the Environment (Beograd, 1980)

Article 1

Consistent with Article IV of the Helsinki Rules, States shall ensure that:

(a) The development and use of water resources within their jurisdiction do not cause substantial damage to the environment of other States or of areas beyond the limits of national jurisdiction; and

(b) the management of their natural resources (other than water) and other environmental elements located within their own boundaries does not cause substantial damage to the natural condition of the waters of other States.

Article 2

Articles XXVI and XXVII of the Helsinki Rules, duly expanded with the addition of consideration of acts or omissions concerning natural resources other than water of other environmental elements in their reciprocal relationships with water resources, are applicable tot he States referred to in Article 1.

## APPEMDIX 2 PROTOCOL ON THE ZAMBEZI RIVER BASIN AND OTHER SHAREDWATERCOURCE SYSTEMS

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### PREAMBLE

The People's Republic of Angola, the Republic of Botswana, the Kingdom of Lesotho, the Republic of Malawi, the Republic of Mozambique, the Republic of Namibia, the Kingdom of Swaziland, the United Republic of Tanzania, the Republic of Zambia and the Republic of Zimbabwe

HAVING in mind the Agreement on the Action Plan for the Environmentally Sound Management, Development and Utilisation of the Common Zambezi River System signed at Harare on the 28th day of May 1987 and the. recommendations contained in the Annexes thereto;

DESIROUS of extending the concept of Environmentally Sound Management, Development and Utilisation of resources to other shared SADC Watercourse systems;

DESIROUS of developing close cooperation for the judicious and coordinated exploitation of the resources of the shared SADC watercourse systems;

CONSIDERING the existing and emerging socio-economic development programmes in the SADC region and their impact on the environment;

CONVINCED of the need for a coordinated Socio economic development of the resources of shared SADC watercourse systems;

RECOGNISING that there are as yet no regional conventions regulating common utilisation and management of the resources of shared watercourse systems in the region;

MINDFUL of the existence of other Agreements in the region regarding the Common utilisation of certain watercourses, namely, the Zambezi River, the Limpopo River, the Ngotwane River, the Marico River, the Sengu River, and the Orange River, which Agreements shall now be superceded by this Protocol

HAVE AGREED AS FOLLOWS:

## ARTICLE 1 INTERPRETATION OF TERMS

For the purposes of this Protocol the following terms shall have the meanings ascribed to them hereunder:

"Agricultural use" means use of water for irrigation

"Basin" means an area in which all the streams of flowing surface water drain a common watershed terminating in a common outlet or outlets

"Basin State" means a State within a Basin

"Domestic Use" means use of water for drinking, washing, cooking, bathing and stock watering

"Emergency situation" means a situation that causes, or poses an imminent threat of causing serious harm to watercourse States or other States and that results suddenly from natural causes, such as floods, landslides or earthquakes or from human conduct as for example in the case of industrial accidents

"Industrial use" means use of water in industrial processes such as in manufacturing

"Member State" means a State which is a member of the SADC

"Navigational use" means use of water for sailing whether it be for transport, fishing, recreational or tourism.

"Riparian" means land contiguous to or abutting on waters of a stream or land through which a watercourse passes

"Riparian State" means a State through whose territory the watercourse passes or along whose borders it flows

"Shared Watercourse" means a watercourse shared by two more states "Watercourse" means a river or stream

"Watercourse State" means a State through whose territory a watercourse passes or in whose territory or part whereof a watercourse flows

"Watercourse system" means an embracement of hydrographic components such as rivers, lakes, canals and ground water constituting by virtue of their physical relationship a unitary whole, to the extent that use of waters in one part may affect waters in another part

## ARTICLE 2 GENERAL PRINCIPLES

1. The utilisation of shared watercourses within the SADC region shall be open to each riparian or Basin State in respect of the portion of the watercourse lying within its territory and without prejudice to its sovereign rights, in accordance with the principles contained in this Protocol. The utilisation of the resources of the shared watercourses shall include, inter alia, domestic, industrial, agricultural, navigational and other economic and social uses

2. Member States which are riparian to or which lie within the basin of shared watercourses undertake to establish close cooperation with regard to the study and execution of all projects likely to have a detrimental effect on the regimes of the watercourses

3. Member States shall require any person intending to use the waters of a shared watercourse lying within their respective territories for purposes other than domestic or who intends to discharge wastes into such waters to first obtain a permit from the relevant authority within the State concerned

4. Member States undertake to respect and apply the existing rules of customary international law relating to the utilisation and management of the resources of international watercourses and, in particular, to respect and abide by the principles of community interest in international drainage basins and equitable apportionment of water and related resources.

5. Member States riparian to or lying within the basin of a shared watercourse undertake to abide by the obligation to maintain a proper balance between resource development for a higher standard of living for their peoples on the one hand and preservation and enhancement of the environment on the other hand

6. Member States lying within the basin of a shared watercourse shall exchange available information and data regarding the hydrological, hydrogeological, water quality, meteorological and ecological condition of such a watercourse

7. Member States shall utilise a shared watercourse in an equitable and reasonable manner. In particular a shared watercourse shall be used and developed by Member States with a view to attaining optimum utilisation thereof and benefits therefrom consistent with adequate protection of the watercourse

8. Utilisation of a shared watercourse in an equitable and reasonable manner within the meaning of paragraph 7 requires taking into account all relevant factors and circumstances, including
   (a) geographic, hydrographic, hydrological, climatic and other factors of a natural character;
   (b) the social and economic needs of the watercourse States concerned;
   (c) the effects of the use or uses of a shared watercourse system in one watercourse State on other watercourse States
   (d) existing and potential uses of the shared watercourse system

9. Member States shall notify other potentially affected States and competent international organisations of any emergency originating within their respective territories

10. In the event that implementation or execution of any planned measures is of the utmost urgency in order to save life or to protect public health and safety or other equally important interests as a result of an emergency situation, the Member State planning the measures may, notwithstanding the provisions of paragraph 9 immediately proceed to implementation or execution provided that in such event a formal declaration of the urgency of the measures shall be communicated to the other Member States

11. Member States shall take all measures necessary to prevent the introduction of alien aquatic species into a shared watercourse which may have detrimental effects to the ecosystem of the watercourse

12. Member States shall maintain and protect shared watercourses and related installation, facilities and other works on the watercourses or within the relevant river basins in order to prevent pollution and other forms of environmental degradation

13. Shared watercourses and related installations, facilities and other works shall be used exclusively for peaceful purposes consonant with the principles enshrined in the SADC Treaty and in the Charter of the United Nations and shall be inviolable in time of armed international as well as internal conflicts

ARTICLE 3 ESTABLISHMENT OF A (ZAMBEZI) RIVER BASIN MONITORING UNIT

Member States hereby establish a unit within the Environment and Land Management Sector to be responsible for the monitoring of the implementation of this Protocol

ARTICLE 4 OBJECTIVES OF THE MONITORING UNIT

1. The Monitoring Unit shall have as its main objectives
   (a) The harmonisation and coordination of national water resources development policies, in order to ensure an equitable utilisation of such resources among the Member States
   (b) The formulation, in consultation with the Basin States, of the general policy of the development of the Basin which shall be consistent with the international status of the River
   (c) The elaboration and execution of an integrated development Plan for the River Basin
   (d) The initiating and monitoring of an orderly and rational regional policy for the utilisation of both surface and underground waters of the River Basin
   (e) The designing and conduct of studies, research and surveys relating to the environmentally sound development and management plans for the Basin

ARTICLE 5 FUNCTIONS OF THE MONITORING UNIT

1. In order to attain the objectives set out in Article 4, the Monitoring Unit shall perform the following functions:
   (a) Water Resources Legislation Monitoring compliance with water resources legislation and, where necessary, recommending amendments and introduction of new legislation
   (b) Research, Information and Data Handling
      (i) Collecting, analysing, storing retrieving, disseminating, exchanging and utilising data relevant o the integrated development of the Basin resources, and

assisting Member States in the collection and analysis of data in their respective States

(ii) Reviewing National Development Plans within the Basin

(iii) Monitoring and promoting research programmes aimed at the environmentally sound management and development of the resources of the Basin.

(iv) Stimulating public understanding and participation in the sound management and development of the environment including human resources development

(v) Promoting in accordance with the national development plans of the Basin States, and in consultation with them, the formulation of a basin wide integrated master plan

(c) Water Control and Utilisation

(i) Recommending regulation of the flow and drainage of the (Zambezi) River

(ii) Promoting measures aimed at flood mitigation

(iii) Recommending and promoting measures to control desertification, soil erosion and sedimentation

(d) Environmental Protection

(i) Promoting measures for the protection of the environment and the prevention of all forms of environmental degradation arising from the use and exploitation of the resources of the River Basin including water pollution and the degradation of fauna and flora

(ii) Assisting in the establishment of substances to be banned from being introduced into the waters of a shared watercourse system

(iii) Promoting environmental impact assessments of development projects within the River Basin

(e) Navigation

Monitoring the effects on the environment and on water quality arising from navigational

(f) Agro-Pastoral and Fisheries Development

(i) Encouraging in consultation with other SADC sectors the development of food crops, agro-pastoral and aquatic food production, fisheries and forestry resources

(ii) Monitoring irrigation projects undertaken in the Basin

(g) Hydrometeorological Monitoring Programme

Promoting in consultation with other SADC Sectors the setting up and running of a common hydrometeorological and water resources monitoring programme in the Basin

(h) Hydro-electricity Monitoring hydro-electric power installations on the (Zambezi) River, its tributaries and sub-tributaries

## ARTICLE 6 IMMUNITIES AND PRIVILEGES

The immunities and privileges of such staff as may be appointed under and within the Monitoring Unit or under any provisions of this Protocol shall be those as are prescribed in the Protocol of the Southern African Development Community on Immunities and Privileges

## ARTICLE 7 SETTLEMENT OF DISPUTES

1. Any dispute arising from the interpretation or application of this Protocol which cannot be settled amicably by negotiation, conciliation, enquiry, mediation or diplomatic means shall be referred to the Tribunal established under Article 9 of the Treaty of the Southern African Development Community

2 If a dispute arises between SADC on the one hand and a member state on the other hand, a request shall be made by the Council of Ministers for an advisory opinion to any legal issue involved in accordance with Article 16 (2) of the Treaty of SADC, and the opinion given by the Tribunal shall be accepted by the parties as final and binding.

## ARTICLE 8 TERMINATION

This Protocol may be terminated by the unanimous resolution of all Member States

## ARTICLE 9 AMENDMENTS

1. Amendments of this Protocol shall be adopted by a I decision of all the members of the Summit

2. Proposals for amendments of this Protocol may be made to the Executive Secretary by any Member State for preliminary consideration by the Council of Ministers, provided however that the proposed s amendment shall not be submitted to the Council of Ministers for preliminary consideration until all Member States have been duly notified of it and a period of twelve months has elapsed after such notification.

## ARTICLE 10 SIGNATURE

This Protocol shall be signed by duly authorised representatives of Member States

## ARTICLE 11 RATIFICATION

This Protocol shall be ratified by the signatory States in accordance with their constitutional procedures

## ARTICLE 12 ENTRY INTO FORCE

This Protocol shall enter into force thirty (30) days after the deposit of the instruments of ratification by two thirds of the Member States

## ARTICLE 13 ACCESSION

This Protocol shall remain open for accession by any State subject to Article 8 of the Treaty of SADC

## ARTICLE 14 DEPOSITORY

1. The original of this Protocol and all instruments of ratification and accession shall be deposited with the Executive Secretary of SADC, who shall transmit certified copies to all Member States

2. The Executive Secretary shall register this Protocol with the Secretariats of the United Nations Organisation and the Organisation of African Unity

IN WITNESS WHEREOF, WE, Heads of State and Government of SADC Member States have signed this Protocol.

DONE at ..... this day of ..... 1993 in two (2) original texts in the English and Portuguese languages both texts being equally authentic

| | |
|---|---|
| ..... | ..... |
| JOSEPH EDUARDO DOS SANTOSPRESIDENT OF THE PEOPLE'S REPUBLIC OF ANGOLA | QUETT KETUMILE JONI MASIRE PRESIDENT OF THE REPUBLIC OF BOTSWANA |
| ..... | ..... |
| HIS MAJESTY KING LETSIE II KING OF LESOTHO | HASTINGS KAMUZU BANDA PRESIDENT OF THE REPUBLIC OF MALAWI |
| ..... | ..... |
| JOAQUIM ALBERTO CHISSANO PRESIDENT OF THE REPUBLIC OF MOZAMBIQUE | SAM NUJOMA PRESIDENT OF THE REPUBLIC OFNAMIBIA |
| ..... | ..... |
| HIS MAJESTY KING MSWATI III KING OF SWAZILAND | ROBERT GABRIEL MUGABE PRESIDENT OF THE REPUBLIC OF ZIMBABWE |
| ..... | ..... |
| FREDERICK JACOB TITUS CHILUBA PRESIDENT OF THE REPUBLIC OF ZAMBIA | ALI HASSAN MWINYI PRESIDENT OF THE. REPUBLIC OF TANZANIA |

# APPENDIX 3 EXAMPLES OF REGULATIONS AND FORMS FOR WATER RESOURCES DEVELOPMENT

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## 1. Criteria for Project formulation (Philippines)

**PHILIPPINES - Water Rules and Regulations**

48. As a general rule, a water resources project/program may be implemented only if it is in accordance with the national socio-economic development goals and objectives or necessary for the national security or protection of life and property. Any project/program involving the appropriation of water shall be directed towards the optimum single and/or multi-purpose utilization thereof. Whenever practicable, projects shall be conceived and viewed according to multi-purpose water resource planning concepts within the area unit of a river basin. In the case of small scale water development projects not readily covered by large-scale water development projects, development planning of the latter shall proceed alongside the implementation of the former.

49. The size and time phase of projects/programs shall satisfy appropriate socio-economic indicators, more particularly the benefit-cost and/or cost-effectiveness criteria, their supplementary and complementary roles to the projects program of other government sectoral plans, and their ecological effects.

50. Government water resources and related projects/programs shall be submitted by the proponent agencies to the Council, which may, if necessary, refer the matter to the proper deputies or concerned agencies for evaluation and comment in accordance with the above guidelines before approving the same.

51. Any private interested party may propose any water resources project through the appropriate agencies and/or deputies who shall forward the same to the Council after evaluating and commenting with respect to the above guidelines. The Council, before approving the project, may, if necessary, refer or consult with other appropriate deputies and/or concerned government agencies.

52. Project/Program proposals shall contain indicators of socio-economic justification, relationship to the National Development Plan, impact statement on the sector's project/program supports and complement, regional impact statement, environmental impact statement, and such other information as the Council may require. Projects, such as artesian wells, spring development and barangay waterworks for purely domestic and municipal use, and such other small-scale projects as the Council may determine, shall be exempted from this requirement.

53. Any conflict involving the use of water that may arise from the project/program proposal shall be resolved on the basis of national/regional priority and needs, i.e., need for power generation in multipurpose project shall be reckoned on the quantity and time of such needs on a grid basis rather than on a single project basis alone.

Any conflict which adversely affects a particular segment of society, group of individuals or small community, may be resolved after a public hearing has been conducted by the Council or its proper deputies.

## 2. Application for Dam Construction Permit (Kenya)

**KENYA - Water (General) Rules**

Form W.A.B. 25

**Application for a Permit to Construct a Dam or Dams on Watercourse having no Normal Flow**

TO THE CHAIRMAN OF THE WATER APPORTIONMENT BOARD

| | |
|---|---|
| 1. Full name of applicant(s) (in block letters) | ..... |
| 2. Residence | ..... |
| Postal address | ..... |
| 3. (a) Land Reference No.(s) and district of applicant's holding(s) | ..... |
| (b) Land Reference No. of farm on which dam is to be constructed | ..... |
| 4. (a) Name of watercourse | ..... |
| (b) Is the watercourse situated in or does it abut upon or enter into a reserved area? | ..... |
| 5. (a) Estimated discharge of flood water | ..... cusecs. |
| (b) How many months in the year is the river dry? | .....months. |
| 6. Particulars of dam: | |
| (a) Nature of stream bed at site, e.g. "soil", "rock", "sand", etc. | ..... |
| (b) Nature of walls of river channel at site, e.g. "soil", "rock", etc. | ..... |
| (c) Will dam be founded on sound rock? ("Yes" or "No") | ..... |
| (d) Will dam be founded on any material which may be eroded by any underflow? | ..... |
| (e) Description of dam, such as earth with core wall (stating kind), concrete, masonry, etc. | ..... |

| | | |
|---|---|---|
| (f) | Fill in dimensions in space opposite | (f) ft. in.<br>Length of dam .. ..<br>Thickness at crest .. ..<br>Thickness at base .. ..<br>Greatest height of dam .. .. |
| (g) | Estimated area of reservoir at spillway level | (g) ..... acres. |
| (h) | Will the submerged area at high flood level be wholly within applicant's holding(s)? | ..... |
| | If not, state Land Reference Nos. and names of owners of the land affected | ..... |
| (i) | Are both banks of the watercourse at the proposed site of the dam on applicant's holding(s)? | ..... |
| | If not, state Land Reference Nos. and names of owners of land affected | ..... |
| (j) | Will any other works, including weirs, already constructed, be affected by the head and/or tail water levels of the proposed works? | ..... |
| | If so, give full details of the works affected | ..... |
| (k) | The following information is required if the dam exceeds 50 acre-feet in capacity or 15 feet in height. | |
| | Catchment Area: | |
| | (i) Area of surface catchment | ..... acres. |
| | (ii) Maximum length of catchment | ..... miles or yards. |
| | (iii) Average breadth of catchment (*Supply sketch of shape of catchment, with dimensions, on separate sheet*) | ..... miles or yards. |
| | (iv) Ruling slope of catchment | .....<br>(In degrees or expressed as one foot in ..... feet |
| | (v) Nature of ground in catchment (e.g. rocky, stony soil, clay soil, etc.) | ..... |
| | If soil, state whether this is deep or shallow | ..... |
| | (vi) Vegetation in catchment (e.g. forest, scrub, pasture, crops or fallow) | ..... |

| | |
|---|---|
| 7. Disposal of Excess Water Past dam:<br>state if excess water is to be disposed of by means of: | |
| (a) The dam acting as a weir | (a) ..... |
| (b) By-pass(es) or waste weir(s) on one or both flanks | (b) ..... |
| (c) State width and depth of by-pass(es) below crest level of dam | (c) ..... width.<br>..... depth. |
| (d) If by-pass(es) or waste weir is to be constructed, state nature of material in which the waste weir channel will be excavated | (d) ..... |
| (e) Gradient of waste weir channel | (e) ..... |
| 8. State the estimated period of construction of the works | ..... |

9. The General Map No. ..... and the following Plan Nos. ..... which have been prepared in accordance with the Water Act and the Rules thereunder, and which are sent herewith, are hereby declared to be part of this application.

10. I attach hereto verification of the names of the registered owners of the land mentioned in paragraphs 3 and 6 above.

11. I agree to supply any further information which may be required by the Water Apportionment Board.

12. I enclose herewith ..... for Shillings ..... cents ..... to cover the prescribed fees for the permit applied for.

.....

Date .....

*Signature of Applicant or duly Authorized Agent*

KENYA - Water (General) Rules

39. (1) Where the maximum depth of water impounded by the dam or weir measured from stream bed level (or ground level where no stream exists) to spillway cill level is not more than 16 feet, there shall be submitted the following plans of the dam or weir when required by the Water Apportionment Board:

(a) a sketch longitudinal section on the centre line of the dam showing -
  (i) the existing ground level;
  (ii) the crest of the dam; and
  (iii) the position of the spillways, sluiceways, sluice pipes or other outlet works, if any;

(b) sketch-dimensioned cross-sections of the dam, showing -
  (i) the nature of the foundation and the stream bed;
  (ii) the materials of which the dam is to be constructed;
  (iii) the level of the invert and details of the outlet works, if any;
  (iv) the level of the existing river bed;

(v) the full supply level;
(vi) the high flood level;
(vii) the maximum height of the dam above lowest foundation level; and
(viii) in the case of earth dams, the details of the core walls, if any, and of the precautions to be taken to prevent the erosion of the bank by wave action;

(c) any plan showing the levels of head water and tail water and any details of any works up-stream or down-stream of the proposed works which would be affected by the head and tail waters of the proposed works.

(2) In each such plan levels shall be referred to a datum line to be shown thereon.

40. Where the maximum depth of water impounded by the dam or weir measured from stream bed level (or ground level where no stream exists) to spillway cill level is more than 16 feet, the plans of the dam or weir shall, unless the Water Apportionment Board decides otherwise, include:

(a) accurate longitudinal and cross sections, on which, in addition to the information specified in rule 39 of these Rules, there shall be shown a graphical log, properly located thereon, of such boring, test pit or other exploration as may have been made, together with a brief description of the character and dip of the underlying material and, if possible, the position of the solid rock line;

(b) longitudinal sections along the waste weir channel or spillway from the point of ingress to the point of egress, showing the nature of the materials through which it will be constructed, the existing ground line, the proposed bed level and the position of all features such as cut-off, curtain walls, spillway, control gates and the like;

(c) type cross-sections of the waste weir channels, on which shall be marked the calculated velocity of the water and the full supply depth and the discharge capacity of the channel at full supply depth, and the nature of the materials in which it will be constructed;

(d) full details of the outlet works;

(e) such stress diagrams and calculations as the Water Apportionment Board may require;

(f) an estimate of the maximum flood flow expected at the dam and the capacities of the spillways at high flood levels;

(g) the levels of head and tail waters and details of any works up-stream or down-stream of the proposed works which might be affected by the head and tail waters of the proposed works; and

(h) a datum line, to which all levels be prepared.

41. In addition to the plans required for the dam, weir or other structure for raising the level of the water, the following plans shall be furnished, when so required by the Water Apportionment Board in the case of works involving storage:

(a) when the volume of the impounded water at full supply level will not exceed 100 acre-feet, a plan to a scale of not less than 1 inch to 500 feet, showing:
(i) the approximate position of the contour at full supply level and at estimated maximum high flood level;
(ii) the approximate capacity in acre-feet and the area in acres of the reservoir at full supply level;
(iii) the area on each farm or other piece of land which will be affected at high flood level; and
(iv) the nature of the material forming the bed and sides of the reservoir (for example, "porous soil", "volcanic ash", "clay" and son on);

(b) when the volume of the impounded water at full supply level will be greater than 100 acre-feet, a contour plan, prepared by a qualified engineer, of the reservoir site, to a scale of not less than 1 inch to 500 feet, showing:
(i) such contours as the Water Apportionment Board may require;
(ii) the original high and low water levels of the water surface;
(iii) the proposed high and low water levels of the water surface, which levels shall be shown by a green line;
(iv) the area on each holding which will be submerged at the proposed maximum high flood level;
(v) the nature of the material forming the bed of the reservoir; and
(vi) a table showing the capacities at each contour interval at the full supply level and the high flood level; and the capacities shall be stated in units of acre-feet.

## 3. Operation Rules and Dam Safety (Kenya)

- KENYA - Water (General) Rules

84. The right to store water shall be subject to prior right to its uninterrupted flow for so much as is required for actual and beneficial use, and to the obligations imposed by the Ordinance, and the Water Apportionment Board may require an operator to store water at certain periods of the year.

85. (1) An operator who has a licence, sanction or permit to store or impound water in any body of water may, with the approval of the chairman, turn the water so stored into a natural watercourse, and may, subject to the water so stored being appurtenant to the land upon which it is to be utilized, and subject to the conditions of his licence, sanction or permit authorizing the diversion or abstraction hereinafterwards mentioned, at a point down-stream of the point of storage, divert or abstract from the body of water into which the stored water is turned the quantity of water so turned, subject to such deductions for evaporation and seepage as the chairman may, from time to time, order.

(2) Such operator, before turning water into a natural watercourse as aforesaid, shall give to the water bailiff and to all persons entitled to use water from any part of the body of water between the point of release of the stored water and the points of utilization of the said water such notice of the use of the body of water for the purpose aforesaid and such particulars regarding the time during which it will be turned into the body of water, the rate of discharge of the store water and other matters as the Water Apportionment Board may, from time to time, require.

(3) No operator, other than the operator who releases the stored water as aforesaid, shall divert or abstract any proportion of the flow of the body of water due to the water so released, nor shall any operator impound or store, except to such an extent as may be imposed upon him by the maximum capacity of his works for discharging the flow of the body of water through or around his works which abstract the flow of the water, any proportion of the flow of the body of water due to the water so released.

86. An operator storing or arresting the flow of water by means of a dam or weir located on a body of water or watercourse shall, unless otherwise decided by the Water Apportionment Board, provide, at a depth measured from the top of the dam or weir and to be specified by the Water Apportionment Board in each particular case, an outlet, controlled by a valve, sluice gate or other device, which shall be capable of being operated at all stages of the flow of the body of water or watercourse so that the normal flow of such body of water or watercourse can be passed through or around such dam or weir at all stages:

> Provided that where the normal flow of the body of water or watercourse is autometically by-passed around the reservoir, without any storage or arresting the flow of the water being effected, no such outlet works need be constructed.

## 4. Free Movement of Fish Upriver and Downriver (Kenya)

KENYA - Water (General) Rules

98. Where, in the opinion of the Water Apportionment Board, after consultation with the Fish Warden, it is necessary for the free movement of fish up-stream or down-stream of any dam or weir on any body of water, the Water Apportionment Board may order that an operator shall provide in such dam or weir a fish pass, fish ladder or other structure, approved by the Water Apportionment Board, whereby fish may move freely up or down such body of water:

Provided that within thirty days of the service of such order it may be appealed against to the Water Resources Authority, who shall have the power to confirm, vary or cancel such order.