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Government of the
Republic of Sierra Leone

Ministry of Energy and Power

Bumbuna Hydroelectric Project Environmental Impact Assessment

Draft Final Report - Appendices

January 2005

NIPPON KOEI UK
INTERNATIONAL CONSULTING ENGINEERS

in association with

BMT Cordah Ltd

THE ENVIRONMENTAL FOUNDATION FOR AFRICA

Document Orientation

The present EIA report is split into three separate but closely related documents as follows:

Volume1 – Executive Summary

Volume 2 – Main Report

Volume 3 – Appendices

This document is Volume 3 – Appendices.

Glossary of Acronyms

AD	Anno Domini
AfDB	African Development Bank
AIDS	Auto-Immune Deficiency Syndrome
ANC	Antenatal Care
BCC	Behavioural Change Communication
BHP	Bumbuna Hydroelectric Project
BWMA	Bumbuna Watershed Management Authority
BOD	Biochemical Oxygen Demand
BP	Bank Procedure (World Bank)
CBD	Convention on Biodiversity
CHC	Community Health Centre
CHO	Community Health Officer
CHP	Community Health Post
CLC	Community Liaison Committee
COD	Chemical Oxygen Demand
dbh	diameter at breast height
DFID	Department for International Development (UK)
DHMT	District Health Management Team
DOC	Dissolved Organic Carbon
DRP	Dam Review Panel
DUC	Dams Under Construction
EA	Environmental Assessment
ECA	Export Credit Agency
EFA	Environmental Foundation for Africa
EHS	Environment, Health and Safety
EHSO	Environment, Health and Safety Officer
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPA	Environmental Protection Act
EPD	Department of the Environment
EPI	Expanded Programme on Immunisation
EPP	Emergency Preparedness Plan
ESAP	Environmental and Social Advisory Panel
ESCG	Environmental and Scientific Consulting Group, Freetown
EU	European Union
FAO	Food and Agriculture Organisation (of the United Nations)
FSL	Full Supply Level
GEF	Global Environment Fund
GIS	Geographic Information System
GOI	Government of Italy
GOSL	Government of Sierra Leone
GWh	Giga-watts per hour
ha	Hectare
HEP	Hydro-Electric Power
HH	Household
HIV	Human Immunodeficiency Virus
HQ	Headquarters

IDA	International Development Association
IEC	Information, Education and Communication
IFC	International Finance Corporation
IRBM	Integrated River Basin Management
ISWL	Insulated Shield Wire Line
IUCN	World Conservation Union
IWES	Institute of Women and Ethnic Studies
IWRM	Integrated Water Resource Management
km	Kilometre
kV	Kilovolt
LAIR	Livelihood Assessment and Income Restoration
LAWCLA	Lawyers Centre for Legal Assistance
LSA	Late Stone Age
MAFFS	Ministry of Agriculture, Forestry and Food Security
MCH-Aid	Maternal and Child Health Aid
MCH-FP	Provision of Mother and Child Health Services, including Family Planning
MCHP	Maternal and Child Health Post
MEP	Ministry of Energy and Power
mg	Milligramme
Mm^3	Million Cubic Metres
mm	millimetre
MOHS	Ministry of Health and Sanitation
MPT	Multi-Purpose Tree
MVA	Megavoltampere
MW	Megawatt
NaCSA	National Commission for Social Action
NBSAP	National Biodiversity Strategy and Action Plan
NCC	National Compensation Commission
NEP	National Environmental Policy
NEPB	National Environmental Protection Board
NGO	Non Governmental Organisation
NKUK	Nippon Koei UK Co. Ltd.
NPA	National Power Authority
OP	Operational Policy (World Bank)
OCP	Onchocerciasis Control Programme
ORT	Oral Dehydration Therapy
PAPs	Project Affected Persons
PCDP	Public Consultation and Disclosure Plan
PHU	Peripheral Health Unit
PIU	Project Implementation Unit
PMF	Probable Maximum Flood
ppm	Parts per million
PRA	Participatory Rural Appraisal
PRSP	Poverty Reduction Strategy Paper
RAP	Resettlement Action Plan
RESU	Regional Environment Sector Unit
RO	Resettlement Officers
ROW	Right of Way
SEA	Strategic Environmental Assessment

SHARP	Sierra Leone HIV/AIDS Response Project
SIV	Species Importance Value
SRDA	Seli River Development Authority
STD	Sexually Transmitted Disease
STI	Sexually Transmitted Infection
TBA	Traditional Birth Attendant
ToR	Terms of Reference
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNHCR	United Nations High Commission for Refugees
US	United States (of America)
VIP (latrine)	Ventilation-Improved
VRC	Village Resettlement Committees
WCB	Wildlife Conservation Branch
WHO	World Health Organisation

Table of Contents

A Administrative

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A.2 Summary of the 1st Report of the Environmental and Social Panel (ESAP 2004)

Adequacy of Terms of Reference (TOR)

The ESAP received and reviewed TOR for the EIA up-date, the Dam and Reservoir Resettlement Plan, and the Transmission Line Resettlement Plan. TOR for the resettlements are of good standard. The TOR for the EIA is acceptable.

Key Issues and Methods for Preparing the EIA and Resettlement Plans.

The EIA update needs more time for analyzing, presenting in conventional fashion, and integrating the 1996 and 2004 findings.

The Dam and Reservoir Resettlement Plan needs more time for fieldwork and analysis. The totality of villages, households, persons and croplands expected to be affected by reservoir inundation have not yet been located and counted. The field team does not have the necessary maps/images, GPS and transport to do their work efficiently. The team is persevering in difficult terrain and during a prolonged rainy season.

The Transmission Line Resettlement Plan needs adjustment of expected costs and commitment to alternatives to resettling households living within the right-of-way where the final 1 km of the line passes into Freetown and where it passes through Makeni.

The Bumbuna Project Implementation Unit (PIU) should ensure that the EIA update and the two resettlement plans correlate information, and that the resettlement plans recommended comparable means and rates for compensation and resettlement.

Recommendations and Findings of the EIA and Resettlement Plans

EIA Update

Surveys of chimpanzees, monkeys and birds, and an inventory of riparian forest trees, have been adequately conducted within the constraints of time and resources available. Small mammals, reptiles, amphibians, invertebrates and non-woody forest plants were only superficially studied, so only partial knowledge is available concerning the biodiversity of the riparian (or “gallery”) forest, and other parts of the project area. Further investigation of the fauna and flora of the forests to be inundated should be conducted as a matter of priority.

A careful comparison should be made of the riparian vegetation in the reservoir area in relation to similar vegetation elsewhere in the Seli River valley and elsewhere in the region so as to better determine the relative importance of the habitat that is to be destroyed. This is presently unknown.

The Panel finds that the consultant well-demonstrated that the project area is home to several communities of chimpanzees. However, we also agree with the consultant that further study (preferably for one full year) is needed to obtain a better knowledge of the size, distribution and socioecology of the chimpanzee population. This study should pay particular attention to the importance, or otherwise, of the riparian forest habitat for this species, and to the likely impacts of human resettlement (including changes in agricultural patterns) on chimpanzee food supply and ranging behavior.

The current proposal for a Bumbuna Dam Wildlife Sanctuary should be reviewed. A sanctuary might perform useful functions for ecotourism and wildlife conservation, but in its presently-proposed form the sanctuary might encompass only part of the range of one or perhaps two chimpanzee communities. Details of sanctuary size, location and management should be planned in the light of more information on biodiversity and more knowledge of the impact of human resettlement. The potential benefits of a sanctuary should be analyzed in relation to the option of including strong wildlife and chimpanzee conservation measures into a Bumbuna Watershed Management Plan.

An experienced ichthyologist should be contracted to assess the current fish fauna of the Seli River upstream and downstream of the dam site. Not only are species lists needed, but also an indication as to whether any of the species may be considered rare or threatened, and what the impact of the project may be on fish spawning and migration habits.

A limnological study should be done to establish whether the reservoir will become a well-mixed or stratified water body.

With regard to the additional studies recommended above, the Panel proposes that they be regarded as the initial components of a monitoring program. Construction work may continue while these studies are in progress, but reservoir impoundment should not take place before the studies are completed.

A proposal exists for impoundment based on cutting all flow in the river below the dam.

The ESAP does not endorse this proposal. Such action does not conform to International Practice. The Panel considers that during reservoir filling (both initial and annual), a minimum water flow must be provided to the river downstream of the dam to avoid dangerous consequences for aquatic life. If this filling takes place during the wet season, we recommend a minimum flow of at least 100 cumecs; in the dry season a minimum flow of 6 cumecs should be maintained. In no circumstance should the river flow be completely halted and the river bed allowed to dry downstream of the dam.

The Panel does not agree with the suggestion that new fish species be introduced to the reservoir. This could dangerously disturb the aquatic ecosystem.

Ecological surveys of the Sula Mountains (close to the east of the project site) and Loma Mountains (important chimpanzee and primate habitat 65 km to the east) should be conducted as a matter of priority to establish their relative importance as conservation sites, needs for conservation at these sites, and costs of establishing long-term conservation. These parameters will be needed when reviewing Bumbuna offset options.

The Panel supports the proposal that a Strategic Environmental Assessment be conducted for the projected four remaining phases of the Bumbuna hydroelectric scheme. This assessment would provide important baseline data that were not available in a timely manner for the current project.

Dam and Reservoir Resettlement Plan

The PIU should foster the creation of a single resettlement consultative committee for the reservoir and dam area. The committee should be the main interlocutor between the affected people and the project in negotiation of resettlement policy, procedures, rates and selection of rural development initiatives.

The resettlement plan should be adjusted to put the weight of effort on land compensation, agriculture and rural development, rather than on building houses.

The consultant should examine fully the feasibility of the Project locating and providing arable land for arable land to be inundated by the reservoir.

Transmission Line Resettlement Plan

Rates for compensation need review and elaboration.

The ESAP supports the consultant's proposal to avoid resettlement of 119 households with 1,253 persons in Makeni by moving the transmission line to bye-pass the town.

To avoid resettlement of 119 households with 1,547 persons in the Kingtom to Hillcut Road section, the ESAP supports evaluation of alternatives- either moving the substation and the line, or, using higher towers that allow electromagnetic and electric fields to meet international threshold standards inside the right of way and under the line conductors.

Management Capacity

The PIU should immediately recruit key staff for management of environment and resettlement plans.

The PIU should evaluate the option of varying the consultant contracts in order for plans implementation to commence while planning continues.

Communications Strategy

The strategy generally follows best practice design, but the tactics need to be more robust to overcome the difficulties of communicating with the many, scattered and isolated villages to be affected in the reservoir. So far, for that area, the voice of the directly impacted people is only evident in a revealing appendix to the resettlement plan.

Communication with the affected persons in the reservoir should be markedly intensified in order for them to participate as partners in crucial decisions which will change their lives irrevocably.

Other Aspects

Finance

The ESAP did not identify committed finance to accomplish Project resettlement, compensation and environmental management. The Government, as represented by the Minister of Energy and Power, and the Project Manager of the Project Implementation Unit were firm in their judgment that the Government does not have the necessary funds, and that government contribution would be based on a land for land swap, at minimal direct cost. The ESAP believes this position is an impasse, to be crossed with the help of participating sources of finance, for the Project to meet International Standard on resettlement and environment management.

Schedule

Given finance, the expectation is that construction completion could be accomplished, from an engineering standpoint, in two years.

A proposal exists for two stage impoundment, with a first stage, commencing December 2005/January 2006, reaching 25-50% full supply level. The ESAP can not endorse, at this time, the proposal for inundation to commence as early as December 2005. The ESAP believes more information is needed, and more planning and mitigation accomplished for this to be acceptable in terms of resettlement. People must be properly resettled and compensated before any impoundment starts which will affect them.

A.3 Summary of the 1st Report of the Dam Review Panel (2004)

The First Meeting of the Dam Review Panel (DRP) for the Bumbuna Hydroelectric Project was convened in Sierra Leone from 25 October to 4 November 2004. This Executive Summary synthesizes the findings of the Panel. A detailed description of activities, discussion of Project documents, comments related to the site visits, detailed findings and other supporting data and information are presented in the main body of this Report.

1. BACKGROUND PROJECT INFORMATION

The Bumbuna Hydroelectric Scheme (Phase 1) corresponds to the first stage of development of the hydropower potential of the Seli River in Sierra Leone. The Project includes, as main components:

- A run-of-river power plant with pondage afforded by an 88 m high dam and appurtenant river diversion, spillway and headrace structures. The powerhouse with an installed capacity of 2x25 MW is located at the downstream toe of the dam. Firm power is 18 MW, firm and secondary energy generations are estimated at 157 and 158 GWh/year respectively.
- A transmission system consisting of a local step-up substation, a 200 km long 161 kV transmission line connecting Bumbuna to Freetown and a step down substation in Freetown.

This Scheme corresponds to the first major hydropower development and transmission line in the Country's history.

2. IMPLEMENTATION ACTIVITIES

The construction of civil works and the procurement of equipment and installations of the Project were developed under different contracts and phases of implementation. In chronological sequence:

- Contract A0—Engineer's Camps---1981-1982
- Contract A1---Preliminary Civil Works---1983-1984
- Contract A2---Main Civil Works at damsite---1991-1993 and 1996-1997
- Contract B---Hydraulic Steel Structures---1996-1997
- Contract C---Electromechanical Equipment---1992/1993-1997
- Contract D---Transmission Line and Freetown Substation 1993-1997

In May 1997 Project implementation had reached an advanced state (estimated at about 80%) when it was interrupted due to the Civil War in Sierra Leone. Remaining needed implementation activities correspond to the completion of civil works for the dam and appurtenant hydraulic structures, second phase civil works for the powerhouse, control building, assembly and installation of equipment, completion of the transmission line, construction and equipment of the Freetown substation.
Starting in March 2004, after a 7 years interruption, activities related to the assessment of the state of the works and reinstatement of site facilities, camp and plant were initiated. One of the results of these activities was the re-scheduling of civil works and equipment procurement and installation to complete Project implementation until end of 2006.

3. DAM REVIEW PANEL (DRP). FIRST MEETING ACTIVITIES

Under the umbrella of Contract E---Logistic Support for the Bumbuna Project Implementation Unit (BPIU), a Dam Review Panel (DRP) was constituted in October 2004 and a first meeting scheduled and carried out during the period October 25 to November 4. Activities of the DRP were mainly focused on the assessment of the state, safety and quality of the civil works at site, on the provision of technical advice for future implementation activities and on the provision of technical advice aimed at the operation of the Project. Detailed terms of Reference are provided in the Appendix of this Report.
In order to carry out these tasks the Panel composed of Bela Petry (Chairman, Hydraulic Structures), Khalid Jawed (Hydrology), Peter Tschernutter (Dam) and William Moler (Geotechnics), undertook the following main activities in intense cooperation with representatives of BPIU and of the Engineer (Studio Pietrangeli):

- Briefing meetings in Freetown
- Technical inspection visits at the Bumbuna site
- Review of general planning documents related to the Project and its relevance for the Energy sector of Sierra Leone
- Extensive review, analysis, discussion and evaluation of Project documents related to the planning, site investigations, design and implementation of the civil works at site.
- Review and analysis of documents related to the operational characteristics of the civil works and hydro-mechanical equipment.
- Preparation of a Draft Report
- Presentation of the DRP findings and submission of the Daft Report in Freetown.

4. GENERAL QUALITY ASSESSMENT OF THE PROJECT

The DRP reached the general conclusion that basic investigations, planning criteria, engineering studies, design and construction of the civil works in Bumbuna followed sound and updated engineering practices. In spite of several interruptions of the implementation activities, in particular during the period from May 1997 to the present date, the achieved stage and quality of construction warrant a continuation and completion of the Bumbuna Hydroelectric Project, with adequate safety and reliability. Not-withstanding this favourable general assessment, attention is drawn to a number of main aspects to guide further Project development. These are listed under headings 5, 6, 7, 8 and 9.

5. BASIC SITE INVESTIGATIONS AND BASIC STUDIES

- Hydrology—comparative PMP/PMF studies, using recommended guidelines, to completely justify the selected Spillway Design capacity which is considered to be acceptable but in the lower range of expected values.
- Gauging stations---immediate installation and calibration of a gauging station downstream of the dam site. Future installation of two gauging stations in the reservoir area.
- Reservoir area---field reconnaissance and review of cartographic material, especially of the rim zone, to assess the potential for landslides and other potential occurrences.
- Dam foundation on the left abutment---search of available construction records to clarify the exact nature of the foundation surface underlying the rockfill (occurrence of weathered rock layer).

- Seismic records---review of regional seismic records after 1978 and confirmation of seismic parameters used for the Project.
- Riverbed scouring downstream---analytical forecast of riverbed scouring downstream of the tunnel outlet structures.

6. REHABILITATION AND COMPLETION OF CIVIL WORKS

- Asphalt concrete faced rockfill dam---mapping and condition assessment of the upstream impervious layer; application of an additional impervious layer in recommended areas using constructive details provided (see section 6.2.2.4); optimisation of materials and methods of application of the surface seal; rehabilitation and sealing of the perimetral joint; refurbishment and completion of dam instrumentation.
- Left and right bank tunnels---detailed inspection, mapping and repair of possible damages to tunnel linings and outlet works at the end of the river diversion phase, prior to the execution of the planned constructive modifications of these tunnels needed for the Project operation phase (plugging of diversion intakes, lining, construction of the terminal flip buckets, etc)
- Radial gate structure---inspection and rehabilitation of the gate support and gate block anchoring systems; installation of extensometers to register possible gate displacements
- Manifold and powerhouse structure---inspection and rehabilitation of steel linings and exposed reinforcement bars; testing and replacement of corroded bars where needed.

7. REHABILITATION OF EQUIPMENT AND INSTALLATIONS

The general inspection and assessment of damages to mechanical, hydro-mechanical and electrical equipment and installations has practically been completed. This assessment determined the need for minor and major rehabilitation and repair works and replacement of components.

- Equipment and installations---proceed with needed rehabilitation, repair and replacement activities. In the case of gates and valves these activities correspond mainly to detailed inspection, replacement of linings, cleaning and painting.
- Contingency Plan for Equipment---development of a Plan including provisions to cope with the fact that Manufacturer Guarantees and corresponding Liabilities may not apply in view of the long time since delivery and incurred damages; provision of spares, organizational and financial provisions to cope with this situation.

8. FIRST IMPOUNDMENT AND RESERVOIR OPERATION

- First Reservoir Impoundment---to be achieved in two phases. First phase, starting in December 2005/January 2006 (according to present schedule), partial impoundment of the Reservoir up to 40%-50% of dam height; observation of dam seepage and deformations and possible lowering of Reservoir level in the case of an observed anomaly. Second phase, at the beginning of Project Operation, complete Reservoir filling.
- Reservoir Operation Plan---development of detailed hydraulic operation guidelines for Reservoir operation under normal and exceptional conditions (e.g. flood occurrences) taking into account objectives and constraints of the operation.

1. Objectives---optimisation of Power and Energy Generation during normal, dry and wet periods; minimizing Plant outages. Forecasts including detailed evaluations at the level of daily averages.
2. Constraints---provision of environmental duty flows downstream during the phase of reservoir impoundment (and later) as required.
3. Use of the Left Bank Spillway as service facility for frequent floods and the Right Bank Spillway as auxiliary facility for exceptional floods.
4. Minimizing/avoidance of exposure of the Radial Gate to dynamic flow impacts and vibrations. Restriction/avoidance of use of this Gate to control flows (at partial opening) under high heads.
5. Emergency Preparedness---completion of the Dam Break Analysis and resulting potential maps of downstream inundations. Development of a standalone Plan for Flood related contingencies (forecasting, alarm, evacuation, other measures).

9. OPERATION AND MAINTENANCE

- Operation and Maintenance Manuals---preparation of detailed manuals for monitoring, inspections, operation and maintenance activities of the civil works, equipment and installations of the Bumbuna Project. Preference for an integrated approach for the entire Bumbuna Project including the Power Station and the Transmission System.
- Organizational Structure and Staffing---qualification of key personnel for O&M activities through education and training (schooling, formal education, on the job training, training in host organizations)

10. FURTHER DRP ACTIVITIES

Activities listed under headings 5 to 9 require follow-up actions from the Dam Review Panel to continue providing review and detailed discussion/orientation.
The DRP recommends that further activities are scheduled in accordance with actual Project development.

Recommended further activities for the near future are:

- Keeping follow-up contacts and technical communications with BPIU and the Engineer, by remote communication during the period preceding the first phase of Reservoir impoundment. Possible needed meetings in Sierra Leone and the Engineers Office in Italy, depending on further development of work activities.
- Meeting at site and in Freetown after the first phase impoundment, for an evaluation of results and other actions.

B Social Issues

B.1 Public Consultation and Disclosure Plan

Table of Contents

Action	Dates (all 2004 except where indicated) and Locations	Responsibility for Action
Scoping consultations with local and national stakeholders. Preparation of Scoping Report and recommendations for amendments to the Bumbuna EIA Update Terms Of Reference	22 August – 02 September (Freetown and in project area and along transmission line route) Week 1 September (Freetown)	NKUK NKUK
Consultations (as necessary) during EIA Update work	August – October (project area, transmission route and in Freetown)	NKUK
Consultations on draft EIA Update Report and/or Executive Summary	November (Freetown, Bumbuna, Fadugu and a village in the project area)	NKUK (with support from PIU/MEP)
Consultations on final EIA Update Report	December (Freetown)	PIU/MEP (logistical support to Director of Environment Department)
Consultation processes during completion of project and its operational period	December (project area)	NKUK to devise the framework for consultation as part of the EMP. PIU/MEP - with partners to initiate and support implementation
Evaluation of the effectiveness of the PCDP	Two evaluations: a) quarter 1 2005 b) quarter 1 2006	PIU/MEP (overseeing independent evaluators)

1. Introduction

Communication with organisations, groups and individuals (known collectively as the stakeholders) is an important component of the approach required by the Bumbuna Project Implementation Unit (PIU) of the Ministry of Energy and Power (MEP) to undertake the Environmental Impact Assessment (EIA) update process for the Bumbuna Hydropower Project (BHP).

The PIU is committed to active and continuing communication with all stakeholders in the current project. It is intended that a consultation and information disclosure programme will be integrated with both the EIA and project implementation. Project implementation includes both commissioning (including filling the reservoir) and the period during which the project is operational (which is expected to be 50 years, perhaps even longer). This latter period may include the next phase of the overall development plan for hydropower on the Seli River, when a second dam/reservoir may be constructed at Yiben, 28km upstream of the Bumbuna dam.

The Terms of Reference (ToR) for the EIA Update indicate that public consultation and disclosure should be in accordance with World Bank policy, and refers specifically to World Bank Operational Policy (OP) 4.01. To assist the EIA Update, and to ensure compliance with Bank policies, it has been decided to prepare a Public Consultation and Disclosure Plan (PCDP)[1].

The present document is the PCDP for the EIA Update. It has been prepared taking into account the consultations already undertaken during the preparation of the original EIA Report (issued in 1996). This PCDP presents a technically and culturally appropriate approach to consultation and disclosure, the goals of which are to ensure that:

- adequate and timely information is provided to project-affected, ‘primary’ stakeholders at the local-level and ‘secondary’ stakeholders who have legitimate interests in the project (with an ability to influence project-related decisions) at the national level;
- these stakeholders are given sufficient opportunity to voice their opinions and concerns; and
- their concerns are considered in determining the EIA work and project decision-making.

[1] Preparation of a PCDP is not strictly a World Bank requirement. It is required by the International Finance Corporation (IFC), a member of the World Bank Group. A PCDP for the Bumbuna EIA update has been prepared because a PCDP, in place as early as possible in the EIA process, will help ensure that adequate and effective consultation occurs, given the tight timescale for upgrading the EIA. In preparing this PCDP, particular reference has been made to the IFC Environmental and Social Review Procedure Guidance Note F entitled ‘*Guidance for Preparation of a Public Consultation and Disclosure Plan’* and the IFC Good Practice Manual entitled *'Doing Better Business through Effective Public Consultation and Disclosure'* issued in 1999.

A number of activities and outputs are specified to achieve these goals. These will form the basis for evaluating the performance and effectiveness of this PCDP.

2. Project Description

The Government of Sierra Leone has long aspired to meet the growing demand for electricity by developing a hydropower project. In 1980, a feasibility study for such a project near the settlement of Bumbuna, on the River Seli, indicated that it would be beneficial to Sierra Leone. Following various further feasibility and design studies, contractors were finally commissioned to construct a dam and hydropower station, with a transmission line to Freetown and connections to Makeni and other intermediate towns such as Lunsar, Port Loko and Masiaka.

The Bumbuna project, which is located about 250 km northeast of Freetown, consists of an 88m high dam, and a hydropower station with an installed capacity of 50 MW. Once the project is commissioned, the reservoir will inundate the lower levels of the Seli River valley for about 20 km upstream (it may also extend a short way into the tributaries of the Seli). The 21km^2 reservoir will be long and narrow due to the shape and steep slopes of the valley. The maximum water level is expected to be nearly 242m (nearly 800 feet) above sea level.

A 200km long, 161 kV transmission line will take the power to Freetown, and a sheath-wire system will distribute power to intermediate towns along the route. The transmission towers are in place, except for a small number that have been destroyed or badly damaged. Work will be needed to repair these towers, clear obstacles from the 30m wide Right of Way under the transmission line, and then 'string' new lines between the towers.

The current Bumbuna project may be the first phase of a programme to provide increasing amounts of power to meet the demand of Sierra Leone's developing economy. The next phase of that programme would be the construction of another dam at Yiben, 28km upstream of the Bumbuna dam. The future installed capacity of the whole programme would be 275 MW.

Work began on construction of the BHP in the early 1980s, but was suspended in May 1997 due to the conflict situation. However, the project is substantially complete (85%). Currently, the PIU plans that work on the project will recommence at the beginning of the next dry season (December 1, 2004). Engineering and other studies (including an EIA Report incorporating the results of public consultations in the project area) were undertaken in the 1980s and 1990s. The EIA Report was issued in 1996. Some of the environmental and social conditions might have changed since then, sometimes significantly. Thus, to facilitate approval of the completion of BHP, PIU/MEP has commissioned an update of the EIA Report.

The main external financiers of the project are the African Development Bank, the Government of Italy and the World Bank.

3. National Requirements for Consultation

The most pertinent source for these requirements is the *Environment Protection Act* of 2000 and the *EIA Guidelines* issued pursuant to the Act. Basically, EIA-related consultations occur at two stages:

- ***During the EIA work***: the Third Schedule to the Act, entitled 'Contents of Environmental Impact Assessment (EIA)', stipulates that an EIA shall contain a description of, "…..the communities, interested parties and Government Ministries consulted". It does not specify the timing, scope or methods to be used to undertake such consultations; and

- ***Submission of an EIA Report***: to the Director of the Environment Department (the Act refers only to an 'environmental impact assessment', but this is understood to refer to the Report). The EIA is circulated to, "……..professional bodies or associations, Government Ministries and non-governmental organizations for their comments." Also, the Director makes copies available for comment by placing them in public places and providing notice, to that effect, in the government *Gazette* and two issues of a newspaper. Comments from both these consultation processes must be submitted to the Director within 14 days of the last publication in the *Gazette* or newspaper whichever is applicable. The EIA and all comments are then submitted to the National Environment Board for its consideration. It is understood that the Board may, at its discretion, request external assistance from specialists to assist it consider the EIA Report.

Given that the consultations, to be described in the EIA Report, are not specified in the Act, it is reasonable to assume that scoping consultations, according to World Bank requirements, will meet national obligations if the types of stakeholders specified in the Act, are involved. To this end, this PCDP requires that such stakeholders are included in scoping consultations to inform the focus and content of the EIA Update.

The Act does not require that a draft EIA Report is subject to consultations. However, the World Bank requires such consultations. Again, in this PCDP, provision is made for such consultations to occur and be compliant with World Bank procedures.
The World Bank does not require consultations on the final EIA Report, though this is a national requirement. This PCPD stipulates that the PIU/MEP will provide all necessary support and assistance to the Director of Environment to enable him to undertake prescribed consultations in a timely and effective manner. It is not judged appropriate for this PCDP to specify the actions to be undertaken by the Director of Environment in fulfilling his/her requirements under the Act.

4. Stakeholders Consulted for the Original EIA

Consultations consisted of public meetings with the Paramount Chiefs of Makeni, Kasunko and Kalansogoia (Executive Summary of EIA Report, 1996). In addition to the Paramount Chiefs, these meetings were attended by District Officers, chiefs, elders, councillors and some inhabitants of the communities in which the meetings were held (EIA Report, 1996). Examination of the records of these meetings (contained in Appendices to the EIA Report, 1996) indicates a strong emphasis on resettlement in the meetings, though the records do show consideration of other impact issues. The evidence indicates that few women were involved. During the preparation of the original EIA there would undoubtedly have been ‘informal’ consultations during fieldwork in the area and during surveys of socio-economic conditions. However, these are not reported.

All consultations appear to have been focused at the local-level with no formal consultations with national-level stakeholders such as Ministries and Parastatals.
Also, there is little evidence of a formal analysis of the results of consultations in a scoping (or similar) report, and a direct link between the consultation results and the structure and content of the EIA. However, it is clear that issues raised (and possible solutions) in terms of resettlement were taken into account in drafting the EIA report. Thus, the present PCDP requires wider consultations at the local level and a national–level consultation forum. There will be a comprehensive stakeholder input to the EIA Update process, consistent with good international practice.

5. EIA Update: Inventory of Primary Stakeholders (local-level)

The original consultations focused mostly on **formal/traditional** male holders of power and authority. Although essential and appropriate at that time, such consultations would not now be considered sufficient in terms of compliance with current World Bank policies and procedures[1], or good international EIA practice, as they are somewhat limited in terms of obtaining a wide range opinions and views from all sectors of affected communities, particularly the “….disadvantaged and voiceless”.

For the EIA Update, it will be necessary to widen and deepen the range of stakeholders consulted. Thus, an input from women and other social categories, ‘sectoral’ interest groups, non-formal holders of knowledge and authority (teachers, etc.) and CBOs/NGOs and other stakeholders will be sought, as well as widening the consultation with formal/traditional sources of power and authority by consulting with the police/military and religious leaders.

An indicative list of primary stakeholders to be a basis for local-level consultations is presented in Box 1 below.

[1] World Bank (1993) *Environmental Assessment Sourcebook*. 3 vols. Washington, DC: World Bank; and World Bank (1999) *Public Consultation in the EA Process*: *A Strategic Approach.* Environmental Assessment Sourcebook Update No. 26. Washington, DC: World Bank

Box 1: Indicative List of Primary Stakeholders

Women - women's association in Bumbuna

Chiefs and Elders - in settlements near dam/reservoir and upstream including 'top end' of the inundated area

Provincial or District officers (Northern Province; Tonkolili and Bombali Districts)

Paramount Chiefs – in two chiefdoms (Kalangosoia and Bombali-Sheboia)

Young people (16 -19 years) – in Bumbuna

Community – based organizations/Non-governmental organizations -

Co-operative associations and/or special interest groups (farmers associations; fishermen) – in selected communities

Elected councillors - in selected communities

Religious leaders – Muslim and Christian

Security personnel – police and military

Salcost - contractor for current phase of the project

6. EIA Update: Inventory of Secondary Stakeholders (national-level)

As mentioned above, no national-level consultations are reported in the 1996 EIA Report. To provide a comprehensive set of stakeholder perspectives, for scoping purposes and subsequent consultations on the draft revised EIA Report, it will be necessary to undertake consultations in Freetown with organizations operating at national level, or representing the main beneficiaries, as a supplement to the local-level consultations. The EIA team will prepare a draft list of stakeholders and submit it to the PIU/MEP. A final list will then be prepared, invitations issued and a scoping workshop held by the end of August 2004. Box 2 provides an indicative list of national-level secondary stakeholders as a basis for compiling the draft list.

Box 2: Indicative List of Secondary Stakeholders

***Central Government Ministries**:-*

Ministry of Energy and Power
Ministry of Finance
Ministry of Lands, Country Planning and Environment
Ministry of Agriculture, Forestry and Food Security (Forestry, Land and Water Development Divisions)
Ministry of Health and Sanitation
Ministry of Development and Economic Planning
Ministry of Fisheries and Marine Resources
Cabinet Sub-Committee for the Bumbuna Project

***Parastatals**:-*

Sierra Leone Water Company (SALWACO)
National Commission for Social Action (NACSA)

***Political Bodies**:-*

Parliamentary Committees on Energy/Power and Environment
Council of Paramount Chiefs
Freetown City Council

***NGO Community**:-*

Chamber of Commerce
Forum of Environmental NGOs
Social Development NGOs
Bar Association of Sierra Leone
Sierra Leone Institution of Engineers

***Academic/Research Institutes**:-*

University of Sierra Leone (Fourah Bay and Njala Colleges)

7. EIA Update Stages and Project Implementation: Programme and Schedule of Consultation Activities

7.1 Introduction and summary of types of consultation methods to be used

As discussed above, there had been some limited local consultations for the 1996 EIA Report. Also, since construction began in the early 1990s, there have been interactions between local people and government staff and consultants acting for the government and contractors. The project is already a ‘neighbour’ that local people have learnt to ‘live with’.

Discussions with the PIU/MEP and others indicate that there are two dominating features in the public perception of the project:

- Public ‘weariness’ with the delay in getting the project operational; and
- Public desire for the project to be completed as soon as possible.

These two factors will work against each other, but it is hoped that the latter will dominate over the former.

Also, it is considered unlikely that many local individuals will be able to distinguish easily between the original and updated EIA Reports and will see only one big project and wish to discuss its current impacts. To encourage co-operative responses, the interview ‘framework’ will allow consultations to focus on a discussion of current impacts, before moving to concerns/issues regarding the future. It is hoped that this approach will allow stakeholders to raise concerns, obtain feedback from the interviewer, and to discuss issues relating to further development of the project within a supportive context.

Every effort will be made in the consultations to explain the current and future progress with the project, the need for additional studies, and to encourage co-operation.

The PIU/MEP has commissioned complementary, but related studies, to the EIA Update. These involve preparation of Resettlement Action Plans (RAPs) for the dam/reservoir and for the transmission line. It is known that some initial work will have begun before the EIA Update studies. To reduce the possibility of stakeholder ‘fatigue’, meetings will be held with the RAP consultants to ascertain the type of consultations undertaken, and proposed, in terms of stakeholder identity and location. To the extent possible, duplication of consultations will be avoided.

A range of consultation methods will be used depending on the aim of the consultation and the characteristics of the stakeholders. The methods are described below, according to the activities involved in the EIA update.

7.2 Scoping Consultations regarding the Terms of Reference for the EIA Update

There are two main types of scoping consultations, and the categories of stakeholders involved also differ. First, scoping consultations will be held with primary stakeholders from the local communities living in the vicinity of the project site and 161kV transmission line.

The methods to be used will vary. All will be undertaken using a semi-structured questionnaire. The number and type of questions will depend on the stakeholder. Community members (as opposed to those in 'official' positions) will be consulted in an informal 'discussion' style mode focused around a few open-ended questions.

Second, there will be a Scoping Workshop in Freetown involving five main stakeholder groups:

- Government Ministries/Beneficiaries;
- Political Bodies;
- Parastatals;
- The Academic/Research Community; and
- Non-Governmental Organizations.

Many stakeholders in these groups are familiar with the overall project, as individual Ministers and senior staff are members of the main Committees charged with oversight of the Bumbuna project. The members of these stakeholder categories are all based in Freetown or its immediate environs. Also, they are well educated and many are accustomed to EIA and scoping, and they understand their links to project design and implementation.

The half-day workshop will begin with a presentation on the project status and an account of the key characteristics of possible future development phases. A brief description of the current ToR will then be presented. (All inputs will be supported by PowerPoint presentations.) Following the presentations, there will be a facilitated ‘tour de table’ to consider:

- Current key impacts;
- Issues of concern for the EIA Update (and adequacy of the current ToR)
- Possible mechanisms for an institutional framework for environmental management for the project once construction is completed.

The proceedings of the workshop will be recorded and a summary report of the proceedings prepared and used as an input to the Scoping Report.

7.3 EIA Update: Implementation Phase

No formal consultations are planned during the EIA Update work. However, they may occur at any time to assist speedy progress of the EIA work.

7.4 Draft EIA Update Report

Once this report is completed it will be available for comment. It will be issued in English and placed on the project website (with a facility for comments to be posted). Although not a formal requirement of the World Bank, it is recommended, in this PCDP that a limited number of copies, and additional copies of the Executive Summary, will be placed in locations with easy public access such as schools, local government offices in Freetown, Bumbuna, Makeni and Fadugu

Given the prevailing local view concerning lack of consultation and the linguistic complexity of the project area, four open public meetings should be held in Freetown, Bumbuna, Fadugu and in a village in the dam/reservoir area. These will be announced in the national and local media and information posted in prominent public places in those local communities in the vicinity of the project site. In addition, the traditional authorities will be asked to play a role by using their networks for information dissemination to ensure that local people are aware of these meetings.

The public meetings will be held in the evenings rather than during the day to allow those that are working to attend. They will be chaired by an independent chairperson, perhaps a senior retired military officer or Paramount Chief (fluent in English and Krio) from an area not affected by the project. They will be facilitated by an EIA team member fluent in both English and Krio. The meetings will begin with a presentation outlining the key findings/recommendations of the EIA Update Report. This will be followed by a question and answer session and focused discussion.

All comments will be collated and analysed and entered into a specially-constructed reporting template. A single template will be used to synthesize all the comments from the workshops and provide a format for PIU/MEP to summarize its response to the comments and whether the issue needs to be taken into account in preparing the final EIA Update Report. Once completed, this template will be used by PIU/MEP to provide feedback to those consulted. Copies will be placed on the project website and in the public access locations used for the draft EIA Update Report/Executive Summaries.

A chapter of the final EIA Update Report will contain an account of the comments received on the draft EIA Update Report and an indication of how they were analysed and incorporated into the final EIA Update Report

7.5 Final EIA Update Report

The final EIA Update Report will be subject to consultation according to national legal requirements. PIU/MEP will assist this process by providing the following support to the Director of the Environment Department:

- Making sufficient copies available for review and consultation;
- Providing clarification of issues; and
- Responding to comments and recommendations.

To ensure the provision of maximum assistance, the PIU/MEP will organize a meeting with the Director of the Environment Department, prior to the initiation of the review and consultation process.

7.6 Post-EIA Update Report Consultations

To date, there have been no formal consultations on the Bumbuna project since the work done to prepare the 1996 EIA Report. At present, it appears that consultation occurs on an *ad hoc* basis when there is an issue or problem to be addressed. Consultations are then initiated either by the site contractors or local traditional authorities, usually the Paramount Chief of Kalangosoia.

The EIA Update Report will contain a section presenting an Environmental Management Plan (EMP) for the project. To be effective, the EMP must contain both institutional requirements for implementation as well as technical measures to manage impacts.

The Bumbuna project may be operational for a period of 50 years or even more. To ensure effective community consultations, the EMP will include a framework for involving local communities in the management of the interactions between the project and its immediate area. Without prejudging the outcome of the EMP work, there may be some merit in considering the establishment a Community Liaison Forum or Committee. The EIA team will consider the recommendations of the World Commission on Dams[1] regarding appropriate mechanism(s) for involving local (and indeed national) stakeholders in the post-EIA Update Report stage

Such a Forum could provide a structure to consider perceived and actual impacts. It might commission studies and consider the results. It could disseminate decisions and provide feedback to the communities. Records would be kept.

7.7 Methods and language for dissemination of information

Executive Summaries of EIA Reports should be available, normally, in local languages. Early discussions with local consultants working on the EIA Update indicate that Krio, the *lingua franca* of Sierra Leone, is not a significant written language. Similarly Limba and Koronko are not literary languages (Mende and Temne are literary languages, but are not widely used in the project area). In the larger settlements Krio is understood widely, but in remoter villages the inhabitants are more comfortable with either Limba or Koronko.

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[1] World Commission on Dams (2000) *Dams and Development: A New Framework for Decision-Making*. The Report of the World Commission on Dams. London: Earthscan Publications.

The EIA team must consult widely to determine the feasibility of translating the Executive Summary into Krio and Limba. If it were to be decided not to issue the Executive Summary in a local language(s) then the reasons must be justified and be defensible should there be national or international criticism of the decision.

Should English alone be used as the language for the EIA Update Report and the Executive Summary, then the Executive Summary will be presented, and discussion held, in Krio during the public meetings in the project area. It may have to be accepted that certain villagers will not be able to participate in the consultations, but that they can be represented effectively by their Krio-speaking fellow villagers.

Notification will be given in the *Gazette* and other national media outlets and in local media, one week in advance of the availability of the draft EIA Update Report. The announcements will indicate a date by which written comments must be received by PIU/MEP. This date will be selected to allow the public 21 days in which to respond. This is believed to be a realistic figure (indeed it is longer than the 14 days allocated under national legislation with respect to EIA Reports). Give the complexity of the EIA Update, an extra 7 days would appear to be warranted.

Multiple copies of the Executive Summary will be widely available. The PIU/MEP must consult with Paramount Chiefs /District Administrative Officers to determine the most suitable location for deposit of copies of the Executive Summary. Also, the most effective means of alerting local people to the location of the copies of the Executive Summary, how/when they may be consulted and the details of the consultation process must be agreed with these officials. The EIA team will prepare a brief plan for consultations on the Draft EIA Update Report and submit it for approval to the PIU/MEP at the end of October, 2004.

7.8 Outline of time schedule and agenda for consultation activities and their integration with EIA Update stages

These are presented in Table 1 below.

Table 1: Consultation Plan and links to EIA Update and Project Activities

Consultation activities	EIA Update/Project Activities	Responsibility for Actions
One workshop with national stakeholders in Freetown (listed in Box 2), *September 2004* Consultation meetings in Project area with local stakeholders (listed in Box 1). *August 2004*	***Scoping Report preparation and recommendations for revisions to the EIA Update Terms of Reference (ToR) (August - September 2004)*** The results of the workshop and consultation meetings will be summarized in a Scoping Report to be issued at the end of the second week of September 2004. The results will form the basis recommending changes to the ToR. Also, issues raised with relevance to the work being done by Azimut and Electrowatt-Techsult with respect to the Resettlement Action Plans will be noted and made available to these consultants.	PIU/MEP and NKUK (national-level workshop) NKUK (local-level consultations)
Consultations and interviews with stakeholders as necessary	***Implementation of EIA Update and preparation of draft EIA Update Report (August – October 2004)*** During EIA update work there may be a need to obtain additional baseline data. Also, there may be a need to refine impact prediction work to make it more focused and relevant. In such situations 'follow on' consultations with stakeholders and/or consultations *de novo* with other stakeholders may be required to assist the EIA update. Also, if stakeholders request meetings to discuss the EIA update progress and preliminary results then meetings may be held at the discretion of PIU/MEP.	NKUK PIU/MEP

Announcements in press and local notices in public places of details regarding the consultation process and period allowed for submission of comments. Draft EIA Update Report posted on the project website. Copies of Executive Summary available at key locations with good public access (in Krio/Limba/English – language(s) to be determined). Copies of draft EIA Update Report available at major settlements with good public access (in English). *All occurring in November 2004* Four public meetings to be held in Freetown, Bumbuna, and Fadugu and in a village in the project area respectively.	***Draft EIA Update Report (November 2004)*** Comments will be collated and analysed using a standard reporting template. PIU/MEP responses will be recorded in this template. The completed template with an account of consultations undertaken will be included as a section in the final EIA Update Report. The comments received may lead to changes in the draft EIA Update Report and, thus, determine to some extent the contents of the final EIA Update Report.	NKUK (with assistance from PIU/MEP regarding responses to comments received) NKUK
Final EIA Update Report posted on the project website. Technical review and consultations on the final EIA Update Report undertaken according the requirements of the Environment Protection Act.	***Final EIA Update Report (December 2004***	PIU/MEP (providing logistical assistance to Director of Environment Department)

	Post- EIA Update Report Consultations (Quarter 1 2005 et seq.)	
An organizational framework to facilitate community consultation will be established to assist effective impact management (may be a Liaison Forum or Committee). Its composition and *modus operandi* will be defined during the period September to October 2004 when the details of the scope and content of the Environmental Management Plan (including impact mitigation and monitoring) will become clear as a result of EIA Update work. Consultations will be held with key stakeholders to help evaluate PCDP implementation. Two evaluation reports of PCDP effectiveness will be prepared by December 2006 and reported to a senior PIU/MEP manager (see below) and used to assist future EIA update consultation activities	The following project-related activities will occur (time periods are indicative only): ▪ Work to finalize renovation and replacement of structures (December 2004 – September 2006); ▪ Inspection and installation of hydro-mechanical equipment and stringing of transmission line (December 2004 – September 2006); ▪ Commissioning of the dam and equipment including the filling of the reservoir (September – November 2006); and ▪ Operations including electricity generation, transmission and distribution (November 2006 – 2056 and beyond).	NKUK will devise the framework as part of the EMP. PIU/MEP (responsibility for implementing framework with partners and Bumbuna operator) PIU/MEP

7.9 Management of media publicity

The PIU has established a Communications Unit dedicated to facilitating public knowledge about, and awareness of, project progress. Within this context, one of its main tasks is to ensure that a consistent 'message' is conveyed to the Sierra Leonean and international 'public' concerning the Bumbuna project. It will also play a very important role in managing expectations, in Sierra Leone, about the project and the distribution of its benefits.

Three staff members have been appointed including an experienced journalist. The Unit is receiving support from World Bank specialists and it is intended that it will begin to operate effectively from early September, 2004. The Unit will:

- Issue press releases and other types of media briefings;
- Establish a website with regular features and up-to-date information on the project. It will include a Question/Answer (Q/A) section and a bulletin board for input from interested parties. The Q/A section will be revised regularly to take account of issues that appear to dominate the bulletin board and project-related events as they unfold; and
- Set up a local radio station based in Bumbuna to serve the needs of the local communities, but also to keep them abreast of project progress and to provide a forum to discuss issues of concern.

7.10 Management and staff resources allocated to PCDP tasks

Within the PIU, the responsible senior manager is Mr N. Vandy. He has overall responsibility for the entire EIA Update process. This includes the adequacy of the EIA Update process, the quality of the documentation and the effective implementation of the PCDP. In particular, he will ensure that the evaluation reports of the PCDP are circulated to appropriate MEP staff and that the lessons learnt are incorporated into future consultation activities.

He will allocate 4 days to the task of overseeing the implementation of the PCDP.

He will be supported by Mr M Kargbo, and the future Environmental Specialist of the PIU, who will be responsible for the day-to-day management of PCDP implementation and who will report directly to Mr Vandy. In particular, Mr Kargbo will ensure that the activities outlined in Table 1 above are implemented effectively and on schedule. He will ensure, finally, that the effectiveness of the PCDP is evaluated.

He will allocate 8 days to the task of implementing the PCDP.

The time allocations for Messrs Vandy and Kargbo (including the future Environmental Specialist) are not inclusive of time which may be spent attending consultation meetings. Also, time that may be required to participate in the consultation framework to be established for the post-EIA period (from Q1, 2005) is not included in these time allocations

8. Evaluation Criteria for Assessing PCDP Effectiveness

A PCDP is a document to be used to manage consultations. As in the case of all plans it is good practice to evaluate their effectiveness after a period of time. This allows them to be amended if necessary to improve performance, and for the organization responsible for the PCDP to learn from experience, thus improving the usefulness of PCDPs for future projects. Thus, it is recommended that this PCDP will be evaluated against the goals set out in the *Introduction* above.

These goals are to ensure that:

- adequate and timely information is provided to primary and secondary stakeholders;
- stakeholders are given sufficient opportunity to voice their opinions and concerns; and
- these opinions and concerns influence the EIA Update process and project decisions.

In addition, in the PCDP, there are a number of activities to be implemented and outputs to be produced accompanied by time 'milestones'. The evaluation will be based on the extent to which the activities and outputs have been undertaken according to the PCDP and within the specified time limits. In addition, the extent to which the goals have been achieved will be assessed. This assessment will depend, in part, on the extent to which the activities and outputs have taken place effectively.

It is recommended that at least two evaluations should be implemented. First, an evaluation should be conducted in Quarter 1 of 2005, focusing on the EIA Update process. A second evaluation should take place in Quarter 2 of 2006, focusing on the performance of the community liaison forum/committee that will have been established. The PIU/MEP will commission an independent organization to undertake the evaluations. A brief Terms of Reference will be written to guide the evaluations. The evaluations will require interviews with:

- PIU/MEP staff;
- the contractors involved in construction and commissioning of the project; and
- the project operator and selected stakeholders. It will also include an examination of written records and materials pertinent to implementation of the PCDP.

The evaluation results should be presented in a tabular format (see below for a possible template for the table and an indication of how the table may be used) with a brief narrative of the work done and main findings/recommendations. The reports should be submitted to project financiers/sponsors and placed on the project website. The PIU/MEP and contractors/operators must take cognisance of the findings/recommendations, and adjust their activities accordingly.

EVALUATION CRITERIA AND RESULTS				
Title: Bumbuna Hydropower Project PCDP - 2004				
Date:				
Goal Statements: • adequate and timely information is provided to project-affected stakeholders; • stakeholders are given sufficient opportunity to voice their opinions and concerns; and • these opinions and concerns influence the EIA Update process and project decisions.				
Activity 1: Scoping and revision of Terms of Reference for EIA Update: Scoping workshop in Freetown undertaken Local stakeholders consulted	**Evidence used:** Scoping Report Scoping Report	**Progress** All completed week ending 10 September 2004 and results incorporated in Scoping Report Extent to which scoping consultations complied with PCDP. Justification for any changes	**Comments:** No organizational problems encountered. Full and effective involvement throughout the workshop Satisfactory. Changes to PCDP requirements justified	**Rating*** 1 1
Output 1 Scoping Report received by PIU/MEP	File-based evidence	**Progress** Received on mm/dd/yy	**Comments** Met PIU/MEP and World bank requirements Used to revise EIA Update Terms of Reference	**Rating** 1
Activity 2: Draft EIA Update Report Consultations				
Output 2.				

Activity x **……………………………………………………………..**
Output x **………………………………………………………………** **AND SO ON……………**
Achieving Goals **(**As listed above) **Comment:**
Action (if required):
Lessons Learned: **(i) PCDP structure and contents:** **(ii) Consultation methods/stakeholder:** **(iii) Integration of consultations with EIA Update process and Project activities:**

Person(s) responsible for review: **Names:** **Signature(s):**	**Date**
PIU/MEP Senior Manager approval: **Names:** **Signature:**	**Date:**

Rating key
1 = Completely achieved ***4 = Achieved to a very limited extent***
2 = Largely achieved ***5 = Not realized***
3 = Partially achieved ***x = Too early to judge extent of achievement***

B.2 Public Consultation Scoping Report

1. Introduction

The main aim of scoping is to define the scope of an Environmental Impact Assessment (EIA) study, based on identification of the likely significant impacts arising from the proposed project. Scoping is undertaken by means of various activities, including consultations with those people whose interests are expected to be affected by the project (referred to as 'stakeholders').

In the case of the proposed Bumbuna Hydroelectric Project (BHP), an EIA Report was prepared in 1996. Unfortunately, construction work was abandoned in 1997 because of the civil war. The Government of Sierra Leone now wishes to complete the project, with support from multilateral financial institutions. However, it is thought that local conditions may have changed since 1996, and international expectations of the content of such an EIA have also increased. An update of the original EIA is therefore now required.

Terms of Reference (ToRs) for the EIA Update were prepared, based on the original EIA and knowledge of the local conditions in 1996. Scoping consultations have been carried out to ensure that the ToRs are adequate and do not omit any issues of importance as highlighted by the stakeholders.

As part of the early EIA Update work, a Public Consultation and Disclosure Plan (PCDP) was prepared, and the scoping work undertaken in accordance with its requirements. The present Scoping Report summarises the main findings of local and national-level scoping consultations. It also presents the consequent recommendations for clarifying, and amplifying the ToRs.

Finally, it presents an account of the expectations of local stakeholders with respect to the benefits they expect from the project when operational. This is not normally a scoping issue, but the local-level consultations brought this major issue to the fore – partly because local people have experienced impacts (positive and negative) since construction began and have extensive personal knowledge of past project-community interactions. Over time, these interactions have provided a context that has enabled individuals to frame specific types of expectations. It is considered important that the project proponent is aware of the nature of these expectations.

2. Project Description

The BHP is located on the Seli River, about 250 km (by road) northeast of Freetown. It consists of a rockfill dam (88m high and 440m crest length) with associated spillways and power tunnel, and two hydropower units with a total installed capacity of 50 MW. Work on construction of the BHP began in the early 1980s, but was suspended due to the conflict situation in May 1997, by which time it was 85% complete. The Ministry of Energy and Power (MEP) currently plans work on the project to recommence at the beginning of the next dry season (1st December 2004).

Once the power station is commissioned, a 21 km^2 reservoir will be created behind the dam. The reservoir will inundate the Seli River valley for 30 km upstream and, depending on water level, may also extend 7 – 11 km up the valleys of the two tributaries of the Seli. The reservoir will be long and narrow due to the shape and steep sides of the valley. The maximum water level is expected to be almost 242m (800 feet) above sea level.

A 200 km, 161 kV transmission line will take electricity to Freetown and intermediate towns such as Makeni, Lunsar and Port Loko. All the transmission towers are in place, except for a small number that have been destroyed or badly damaged. Work will be needed to repair these structures, clear obstacles from below the transmission line and then ‘string’ new cables between the towers.

The current project may be the first of five phases in a programme to exploit the full 275 MW potential at Bumbuna and provide increasing amounts of power to meet the demands of Sierra Leone’s developing economy. Another significant component of that programme would be the construction of an additional dam at Yiben, about 30km upstream of Bumbuna.

3. Scoping Approach

The scoping approach followed the requirements of the PCDP. The approach is summarised in brief below. Both local and national level scoping consultations were undertaken.

The overall scoping approach consisted of:

- Identification, compilation and review of available environmental and socio-economic information relating to the project;
- Liaison and discussion with the Bumbuna Project Implementation Unit (PIU) of the MEP and both the engineering design team and contractor based at the Bumbuna construction camp;
- Consultation with project-affected, primary stakeholders at the local-level, consisting of representatives of communities, various social groups and key individuals; and
- Consultation with secondary stakeholders at the national level who have legitimate interests in the project (with an ability to influence project-related decisions) including government ministries, NGOs, parastatals and academics.

4. Local-level Consultations

Box 1 shows the list of primary stakeholders consulted. The list is similar, but not identical, to the list presented in the PCDP. Once the consultation team was in the Bumbuna area (23rd to 28th August 2004), it became clear that no NGOs or military personnel were present in the locality. Also, the meetings with chiefs and elders (held in seven communities) were attended by representatives of special interest groups such as farmers and fishermen, so no separate meetings were considered necessary. Finally, it was discovered that all the Chief Administrators of District Councils were attending a week-long workshop in Bo and, thus, none was available for consultation.

Box 1: Primary Stakeholders: number and type of consultations

Women - women's farming association in Bumbuna (approximately 50 women attended). Women also attended and participated in meetings of chiefs/elders in Kadala, Kasokira, Kokeko and Kafogo

Chiefs and Elders - in each of the settlements of Bumbuna, Kadala, Gbuliya, Kasokira, Kokeko, Kafogo and Fadugu.

Acting Provincial Secretary of Northern Province (in lieu of a District Chief Administrative Officer) – in Makeni.

Paramount Chiefs – in Bumbuna (Kalansogoia chiefdom) and Makeni (Bombali Sheboia chiefdom).

Young people (16 -19 years of age) – in Bumbuna (16 students attended with a 50:50 sex ratio).

Co-operative associations and/or special interest groups (farmers associations; fishermen)*

Religious leaders – Muslim imams (in context of meeting of Paramount Chief and elders in Bumbuna) and the Roman Catholic priest in Bumbuna.

Security personnel – Police (officer commanding and two senior staff).

Acting Principal and teacher of secondary school – Bumbuna.

Site manager of Salcost – contractor for current phase of the project.

* Representatives of these interests attended the meetings of chiefs/elders in a number of settlements.

The consultations were undertaken in Krio, Limba, Koronko and English language, depending on the community and the individual stakeholder(s) consulted. They all followed a similar format. A simple, semi-structured questionnaire was prepared, with variants to accommodate the different perspectives of the stakeholders. The public, group discussions were informal and facilitated by a Sierra Leonean Krio speaker with a translator for Limba (two villages) and Koronko (1 village). The consultations were based on the questionnaires, but only as a starting point for discussion. One-to-one interviews followed a similar pattern. Notes of the consultations were taken by two team members.

The results of the local consultations are summarised in Table 1. A series of generic issues is listed, then the specific impacts/concerns for each issue. Finally, an indication of their importance to the stakeholders is presented - identified when appropriate by location (some issues were very prominent, but only in specific communities).

Issue	Specific impact/concerns	Stakeholder Interest
Livelihoods (compensation)	Compensation arrangements for resettlement of communities, individual houses and plots and/or economic displacement caused by the hydropower project and the 161 kV transmission line. Also, in terms of severance (see below)	The most significant issue in all settlements
Livelihoods (landtake)	Loss of agricultural land for crops	Very high in all settlements
	Loss of 'economic' trees (e. g. kola, citrus, palms)	Very high in all settlements
	Loss of areas for mining of gold and sand	Gold and sand mining is a particularly important issue for Gbulia and Kakeko respectively
Livelihoods (severance)	Access prevented to land and other natural assets by 'new' water levels in river; both upstream and downstream and other restriction that may be imposed in terms of reservoir and watershed management	Very high in all settlements
	Access made more difficult to land and other natural assets and to markets and social infrastructure facilities in neighbouring communities: ▪ village children attending secondary school in Bumbuna ▪ village patients visiting the dispensary/clinic in Bumbuna An important issue for Kakeko, Kafogo and Fadugu with the likely inundation of a section of the main road. Also, Kafogo villagers cross the Mawaloko river to reach their fields. Concerned that the level may increase and access become more difficult or even impossible.	Very high in Gbulia because a section of main footpath to Bumbuna is close to the river Seli. Moderately high in all settlements

Livelihoods (changes in occurrence and abundance in natural assets)	Changes to fish species in the upstream Seli river and its tributaries, and changes in size, type and value of catch	Moderately high in Bumbuna and Kadala, but only raised by those who fish as a secondary economic activity.
	Possible restrictions on hunting and reduction in numbers of key species in area	Moderately high in Bumbuna and Kadala
Hydrological regime changes (upstream)	Reservoir water level and fluctuations (security of crops, roads, footpaths and houses near reservoir edge)	High in communities near reservoir edge (Gbulia, Kafogo and Fadugu)
	Effects on tributaries flowing into reservoir (backing up in high rainfall and possible localized flooding in vicinity of villages)	
Hydrological regime changes (downstream)	Amenity of Bumbuna Falls (recreation area and possible future tourist attraction)	Moderately high in Bumbuna
	Likelihood of flooding if there is too large a release of water in case of exceptionally heavy rains and effect on crops, houses and other assets	Moderately high in Bumbuna
	Provision of sufficient flow for current downstream users	Moderately high in Bumbuna
	Changes in flooding pattern in Seli floodplain and effects on those farmers benefiting from the annual flooding	Moderately high in Bumbuna
Health and threats to life	Increased accidents in terms of children and reservoir if water level comes near to villages	High in Gbulia
	Changes in downstream flows creating areas of water with more limited flushing and increased risk of exposure to water-borne diseases to those using the river for bathing and washing clothes etc	Low in Bumbuna
	Increase in road traffic-related accidents	Moderately high in Bumbuna
	Increase in STDs and other infectious diseases from influx of workers	Moderately high in Bumbuna

	Increase in water- borne diseases such as malaria and onchocerciasis	Moderately high in Bumbuna
	Increased habitat for crocodiles (currently in Mawaloko river) from changes in hydrological regime. Threat to humans	High in Kakeko an Fadugu
Food security	Effects of loss of assets such as crops and farmland and inadequate or delayed compensation. Also, issue of time period for economic trees to reach fruit bearing potential in relocation areas. Links to potential nutritional health consequences	Very high in villages
Social changes	Numbers of in-migrants and local infrastructure capacity (such as waste disposal, schools, water supply, dispensary). An average local workforce of ~350 is expected over the next two years, with a peak of ~500. Currently, 200 are employed	High in Bumbuna (raised by Paramount Chief)
	Fate of structures such as dispensary and police station (some recently constructed) under or near transmission line. Compensation.	High in Bumbuna (raised by Paramount Chief)
	Increase in crime rates for theft, fraud, assault and domestic violence	High in Bumbuna
	Increase in smuggling activity from Kabala to Bumbuna and to the south	Low in Bumbuna
	Increase in prostitution	High in Bumbuna
	Conflict potential if 'outsiders' perceived to be obtaining more jobs than locals	Moderately high in Bumbuna
	Local inflation in housing market with locals unable to afford the higher rents for accommodation and 'losing' or not finding suitable housing	Moderately high in Bumbuna (mentioned by teachers)
	Potential damage to infrastructure such as roads and water supply network from increase in heavy vehicles	Moderately high in Bumbuna

	If more blasting at the quarry then potential damage to houses and other structures. Issue of compensation.	Very high in villages of Kadala and Kasokira
	Opportunity for improved communications (mobile phones and radio station)	Moderately high in Bumbuna
	Potential social and health benefits of electricity if supplied	Very high in all settlements
	Effects on sacred sites such as Bumbuna Falls and ritually important areas such as 'society bush'. Compensation for cost of performing 'abandoning/moving' rituals	High in all settlements
Economic changes	Potential of increased job opportunities	High in Bumbuna
	Potential for better economic 'integration' of project with local settlements especially Bumbuna e. g. more workers housed in camps in Bumbuna.	Moderately high in Bumbuna
	Displacement of trading networks by resettlement of communities. Need to find substitute locations for purchases, but may be no easy access	High in Fadugu
	Multiple use of the reservoir. Apparently was considered in early project studies	
	Likely enhanced economic growth in Makeni and other towns along the 161 kV line arising from electricity. Return of 'out-migrants'. Land-use changes.	High in Makeni and likely to be the case in other similar towns
Cumulative impacts	Agricultural land 'squeeze' due to removal of land near river from production, movement uphill to farm (less fertile), decreased fallow periods, land exhaustion. Growing rural population. Food security. More out-migration………. Effects of developing multiple areas for relocation with farmland, renovated or improved access	Moderately high in Bumbuna and higher in many villages
	Beneficial impacts acting to enhance tourism potential of area and consequent economic growth	Low, but mentioned in some Bumbuna consultations

Local-level expectations

In the project area people have considerable expectations regarding the potential benefits from the project to themselves and their communities. The expectations do not vary significantly between the local communities and are listed below in order of significance to them (those most frequently mentioned by stakeholders are listed first):

- Adequate compensation for previous and expected future loss of livelihood assets and social infrastructure facilities and disruption of access to them. Acceptable resettlement sites and assets for relocated people/villages;
- Provision of 'light' (electricity);
- Provision of new social infrastructure such as schools, clinics or renovation and extension of existing facilities;
- Improvement of scale and quality of services (e.g. a doctor based in Bumbuna, upgrade of the current school to senior secondary status and increased police complement and requisite transport and other equipment);
- Improved road network;
- Mobile phone network coverage and improved telephonic communication between local communities and between these communities and the major towns of Sierra Leone.

It is clear that the project will be implemented in a socio-political 'climate' of high expectations regarding local social development benefits. There is undoubtedly a general view, particularly in the villages, that they are 'owed' benefits because of the adverse effects that they have endured without compensation over a period of years during the construction phase[1].

National-level consultations

Box 2 below presents the list of secondary stakeholders who attended the Scoping Workshop. Some organisations were represented by more than one person. The programme of the workshop is provided at Annex 1.

It should be noted that the workshop participants were asked to provide their views and suggestions with respect to future consultation arrangements during the period following the EIA Update. The discussion focused on basic factors and principles that need to be considered when devising the requisite consultation arrangements. This topic was discussed in the Bumbuna area, but only with Acting Provincial Secretary of Northern Province and in the meeting with the Paramount Chief/elders in Bumbuna.

[1] This view is not expressed in these terms, but the consultations support this interpretation.

Box 2: Secondary Stakeholders

***Central Government Ministries**:-*

Ministry of Energy and Power
Ministry of Finance
Ministry of Lands, Country Planning and Environment (Director of Environment)
Ministry of Agriculture, Forestry and Food Security (Director of Land and Water Development Division)
Ministry of Local Government

***Parastatals**:-*

National Commission for Social Action (NACSA)
National Power Authority

***Political Bodies**:-*

Council of Paramount Chiefs

***NGO Community**:-*

Sierra Leone Chamber of Commerce
Conservation Society of Sierra Leone
Sierra Leone Institution of Engineers

***Academic/Research Institutes**:-*

University of Sierra Leone (Fourah Bay and Njala Colleges)

***Others**;-*

The News Press
Electrowatt –Techsult
Azimut

The results are presented in Table 2 using a similar format to Table 1.

Table 2: Summary of Main Issues: National Scoping Workshop

Issue	Specific impact/concerns	Stakeholder Interest
Livelihoods (compensation)	Adequate compensation arrangements for resettlement of communities, loss of assets and severance effects.	High
Livelihoods (landtake)	Production system disruption (e.g. loss of agricultural land)	High
Livelihoods (severance)	Disruption to communications if roads and footpaths are damaged or inundated	High
Environment	Changes in biodiversity value of the local area. Positive or negative?	Moderate
	Environmental impacts of the entire Resettlement Action Plans need to be investigated	Low
	Changes in water quality, particularly levels of nutrients and siltation processes both upstream of the dam (causing vegetation decay in the reservoir) and downstream and possible ecological effects and effects on users	Moderate
Hydrological regime changes (downstream)	Effects of reservoir filling on downstream flow (especially if it occurred in a period of low flow)	Moderate
	Effects of downstream flow changes on farmers	Moderate
Health and threats to life	Effects of electromagnetic fields on human health	Low
	Threat posed by live high tension cables being dislodged in 'extreme' weather events and causing damage to property and harm to people	Low
	Increase in STDs and other infectious diseases from influx of workers	Moderate
	Increase in water- borne diseases such as malaria, schistosomiasis and onchocerciasis	Moderate

Social changes	Numbers of in-migrants looking for a job and growth of an informal settlement near the dam site. May be environmental consequences in terms of sanitation, increased deforestation, etc. If they do not find work may start to farm, mine, etc. Possible land use conflicts and pressures on local politico-legal structures and processes	Moderate
	Increase in prostitution	Low
	Conflict potential if 'outsiders' perceived to be obtaining more jobs than locals.	Low
	Local inflation	Low
	Effects on ritually important areas such as 'society bush'. Compensation for cost of performing 'abandoning/moving' rituals	Moderate
	Possible political problems if expectations of local people are not met (e.g. supply of electricity, infrastructure improvement or provision).	Low/moderate
Economic changes	If farmers are displaced and not adequately compensated they may turn to mining to earn a living with possible environmental consequences.	Low

Suggestions of workshop participants on consultation arrangements following the EIA Update

During the workshop, there was a wide-ranging discussion of pertinent factors, with recommendations and principles to be adopted in designing a consultation framework. The highlights are presented below and will be used to inform preparation of both the EMP and the attendant consultation arrangements (incorporating a grievance procedure):

- A Seli River Basin Development Authority was established by Cabinet decree in the late 1990s with a defined structure, membership (18) and remit (e.g. monthly meetings). Due to the conflict situation it met only once, and has been ‘dormant’ since. The potential for it to resume its role needs to be taken into account, and future local-level arrangements, as an outcome of the EIA Update, should be defined in a manner that will be compatible with the Authority’s functions;

- The EIA Update should consider whether this Authority should be re-activated and, if so, whether its structure, composition and functions should be amended to take account of the current situation in Sierra Leone;

- May be a need for two ‘’umbrella’ organizations: one for the dam/reservoir and one for the transmission line;

- A local level grievance procedure should involve the traditional authorities (section chiefs and Paramount Chiefs);

- At the local level, in terms of dealing with problems arising between the operator and local people, an appropriate mechanism may be for the Paramount Chiefs to form a Committee to decide on a course of action and to enter into discussions to resolve issues. If this Committee were not satisfied, then the issue could be brought to the attention of a more formal body such as the District Council or Provincial Administration;

- The current strengthening of the local government administration system (Wards, District Councils and Provincial Administrations), but especially the improvement in functions of District Councils, means that they will need to play a major role. Paramount Chiefs are represented on District Councils;

- There should be an ‘open door’ policy for NGOs. They could be co-opted members as it is realised that NGO representation may fluctuate as NGOs are mobile and are not always permanently located and working in the project area;

- Need for balance in membership (national, local, ‘experts’, NGOs);

- The role of Members of Parliament and elected Councillors requires careful consideration; and

- Need a grievance procedure that avoids immediate recourse to the courts.

Analysis of local and national-level scoping consultation results

A number of general observations can be made:

- The main significant issue involves loss, or disruption, of livelihoods and irreversible changes to community links to sacred sites and the necessity of adequate compensation. The environmental consequences of the resettlement are considered by some national stakeholders to warrant attention. Local stakeholders 'see' the same issue, but in terms of threats to food security and health effects;

- Environmental impacts are not considered by most local stakeholders as being of interest *per se* rather as a threat factor to livelihoods. National stakeholders identify 'environmental' impacts, but they are a low proportion of the potential range of possible impacts which includes socio-economic issues*;*

- Hydrological changes and associated socio-economic and health impacts are important issues for both sets of stakeholders;

- Social, health and economic impact issues *per se* are important to both sets of stakeholders and are perhaps, second in importance to the issue of livelihood loss/threats and compensation; and

- There is considerable overlap between the impact issues identified by both sets of stakeholders, but there are differences. Some of the differences may be explained by the wider experience, knowledge and educational levels of the national-level stakeholders.

Recommendations for revision of the ToR

A comparison of the scoping consultations with the original EIA Report shows that **most** of the impact issues raised by the stakeholders were considered in that Report. The ToR for the EIA Update is a comprehensive list of further issues to be investigated. These refer to either a) new issues to be investigated or b) the need to update/expand upon specific issues already presented in the original EIA Report.

The ToR for the EIA Update has been examined in the light of the results of the scoping consultations and recommendations made for both expansion and more detail, in order to ensure that all significant environmental and environment-related concerns of the stakeholders are examined.

The recommended additions to the ToR are presented below. Original numbered ToR paragraphs are presented in *italics,* and the recommended additional issues are added in ***bold italics,*** in the form of questions.

8. An inventory of the primary forests that exist in this region should be carried out. The forest that is affected by the project should be studied to determine if endemic or rare species will be adversely affected (trees, plants, avifauna, mammals, (also accounting for the status of endangered primates), fish, amphibians, etc. There are rapids down river which provide a micro-habitat and which will also need an inventory due to the expected changes in flow regime.

Will changes in the hydrological regime of the Mawaloko river (and any other rivers with crocodiles) create opportunities for crocodiles to spread causing an increased threat to humans?

10. Address the general deforestation in the project area as well as in the region and propose land management strategy to mitigate the adverse impact of the slash and burn agricultural practices. Since the impoundment area will be cleared of vegetation, local communities should be involved and provided an opportunity to earn some incomes.

Is there a role for multiple use of the reservoir and enhanced tourism in the Bumbuna area (after-use of the construction camp, promotion of the dam/reservoir, the Bumbuna Falls and chimpanzee watching) to mitigate adverse livelihood impacts?

12. Along the route of the transmission line, determine the potential impact on sensitive areas. Since some towers are destroyed, new access roads may be necessary to construct in order to reach tower sites. Like wise, herbicides may be used in order to clear the ROW and overgrown towers, in which case the WB policy on Pest Management will be triggered.

What is the nature of likely enhanced economic growth in Makeni and other towns along the 161 kV line arising from provision of electricity? Might previous 'out-migrants' return? What likely land use changes can be expected and what might be the overall environmental effects of all these possible changes?

13. The changes and fluctuations of the river flow may have an impact on estuarine and coastal erosion. It may also impact spawning behaviour and timing in the delta. The consultant will identify the impacts, which may result from changes in the downriver hydrological regime.

What changes to the distribution and abundance of fish in the Seli River, and tributaries, might occur?

What are the effects on tributaries flowing into reservoir (backing up in high rainfall and possible localised flooding in vicinity of villages)?

Might the amenity and spiritual value of the Bumbuna Falls (recreation area and possible future tourist attraction) be adversely affected by changes in flow?

Is there a likelihood of flooding downstream if there is too large a release of water in case of exceptionally heavy rains? Which areas, livelihood assets and people might be at risk?

Will there always be sufficient flow for current downstream users?

Will there be any changes in the flooding pattern in the Seli River floodplain and effects on the families and communities that benefit from the regular flooding?

Will any changes in downstream flows create areas of water with more limited flushing and increased risk of exposure to water-borne diseases for those using the river for bathing and washing clothes, etc?

Is there likely to be an increase in water-borne diseases such as malaria and onchocerciasis?

If more blasting occurs at the quarry/river bed, then what is the potential for damage to houses and other structures, and what compensation mechanisms exist if damage occurs?

What are the implications of reservoir water level fluctuations in times of normal operations, and also extreme weather events, in terms of the security of crops, roads, footpaths and houses near the reservoir edge?

What is the potential for damage to infrastructure such as roads and water supply network from a likely increase in heavy vehicles?

With the above elaborations, the EIA Update should ensure that the important issues raised by scoping consultations, are examined and presented in a form that recognises any changes that have occurred since 1996. Consultations on the draft EIA Update Report will then enable stakeholders to confirm whether this objective has been achieved.

Finally, some concerns raised at scoping are completely outside the ToRs for the EIA Update and therefore cannot be related to them; these are listed below. It is considered that these concerns are related to the scope of the Resettlement Action Plan (RAP) being prepared for the PIU by Electrowatt-Techsult, and would be best examined within the context of that work. Similarly, the explicitly social, cultural and economic livelihood impact concerns outwith the EIA Update may also be considered within the RAP work.

(i) What might be the impacts of the loss of areas for gold mining and sand extraction, leading to exploitation in 'new' areas?

(ii) What might be the impacts of any such changes on livelihoods of fishing families / communities?

(iii) Is there a credible threat to food security (with consequent nutritional and health effects) from the effects of potential agricultural land 'squeeze' due to the combined effects of:

- ***removal of land near the river from agricultural production;***
- ***movement of farmers uphill to farm (less fertile) land;***
- ***decreased fallow periods and possible land exhaustion;***
- ***location and extent of land allocations for resettled people;***
- ***increased agricultural production to compensate for 'transition' time of reduced income before new economic tree plantations mature and the produce can be sold;***
- ***displacement of trading networks by resettlement of communities. Need to find substitute locations for trading, but may be no easy access; and a growing rural population?***

Annex 1

Bumbuna Hydroelectric Project: EIA Update

National Stakeholder Scoping Workshop

Thursday 2nd September 2004, Freetown

Progamme

Time	Topic	Speaker/Facilitator
09.00	Opening and Welcome Address	Mr D. Coomber, Permanent Secretary, Minister of Energy and Power
09.10	Description and status of Bumbuna Hydroelectric Project	Mr Nathaniel Vandy Project Engineer/Manager/PIU
09.30	Workshop Objectives and Programme	Mr Ron Bisset (Nippon Koei team)
09.45	Discussion on impacts of Bumbuna Hydroelectric Project – to date	Dr Abdul Karim (Nippon Koei team)
10.30	Tea/coffee	
11.00	Discussion on likely significant impacts of Bumbuna Hydroelectric Project requiring investigation in the EIA Update	Mr Ron Bisset (Nippon Koei team)
12.00	Discussion on consultation arrangements to assist implementation of the environmental management framework for Bumbuna Hydroelectric Project once operational	Dr Paul Driver (Nippon Koei team)
12.55	Closing address	Mr M. K. Kargbo (PIU)

B.3 Grievance and Dispute Resolution Procedure

1. Introduction

The Public Consultation and Disclosure Plan has introduced two mechanisms for public consultation during project completion, commissioning and operations, i.e. a Community Liaison Committee (CLC) and a grievance procedure. The former will deal with issues that have a community-wide focus and are of medium to long-term duration. The latter will deal with complaints and grievances from individuals, in a speedy, transparent and effective fashion. However, the proposed grievance procedure needs to be discussed and endorsed at the first meeting of the CLC, so that it can be seen to be a fair process that is accepted by all parties. The procedure should then be used in a spirit of goodwill, with the strong intent of resolution.

2. Making the Initial Complaint

The grievance procedure will be applicable both during the completion of construction and during operation. Given that most grievances will be small issues of interaction between the contractor or operator and the individual, it will be easiest for the contractor or operator to address the problem in the first instance. The contractor/BHP operator should brief all village and district authorities to advise them of project contact points, and encourage people to refer any complaints directly to the contractor/BHP operator so that they can be dealt with swiftly. The key contact will be the company's Community Liaison Officer, who will accept complaints orally or in writing. However, people will also have the option of making their initial complaint either through the section chief/Paramount Chief, or the District Council. Upon receipt of a complaint, the section chief/Paramount Chief will be able to advise on its validity. Should the complaint be considered valid, then the section chief/ Paramount Chief will relay the complaint to the appropriate Community Liaison Officer.

The construction contractor will have day-to-day responsibility for addressing grievances during construction, and the BHP operator will subsequently take primary responsibility during operation. However, the PIU/Ministry of Energy and Power will carry out regular monitoring of the contractor's and operator's performance in addressing grievances and achieving satisfactory outcomes for complainants. This activity will be the responsibility of the Communications Unit of the PIU.

3. The Grievance Procedure

The key steps of the proposed grievance procedure are as follows:

Step 1 – Complaint is received

Complaints received will be recorded in a grievance log. The construction contractor's Community Liaison Officer will maintain the log during the construction and commissioning phase. The BHP operator's Community Liaison Officer will maintain the log once BHP operations commence. The initial log entry will include a description of the grievance, details of the person lodging it and the date it was received.

Step 2 – Determination of Corrective Action

The construction contractor or BHP operator will consider the complaint and determine an appropriate corrective action, in consultation with the complainant, if required. The nature of the corrective action, the timeframe within which it is to be completed and the party to be responsible for implementing the action will be recorded in the grievance log. In addition to considering the immediate complaint, the construction contractor or operator, as the case may be, will determine whether any procedural changes are warranted to reduce the likelihood of similar adverse situations or conflict arising in the future.

Step 3 – Discussion with Complainant
The proposed corrective action and the timeframe for its implementation will be notified to, and discussed with, the complainant within 15 days of receipt of the complaint.

Step 4 – Corrective Action is Implemented
The corrective action will be carried out within the agreed timeframe. The date when the corrective action is completed will be recorded in the grievance log.

Step 5 – Outcome of the Corrective Action is Verified with the Complainant
Following completion of the corrective action, the appropriate Community Liaison Officer will verify the outcome with the complainant. The complainant will be asked to sign off on his/her acceptance of the 'solution' (or nominate someone to do so on his/her behalf). In the event that the complainant remains dissatisfied with the outcome, additional corrective action may be agreed and carried out by the construction contractor or operator.

Step 6 – Other means of Seeking Redress
In the event that the complainant is still dissatisfied, and no satisfactory response can be negotiated, the complainant has recourse to the pre-judicial and judicial processes available under Sierra Leonean law.

4. Grievance roles and responsibilities

The roles and responsibilities for completing the various tasks associated with grievance redress are summarised in the following table.

Task	*Construction and Commissioning*	*Operations (and Maintenance)*
Receive complaints and grievances	**Project:** Construction Contractor/Community Liaison Officer **Local/Administrative:** Section Chief Paramount Chief District Councillor	BHP operator/Community Relations Officer **Local/Administrative:** Section Chief Paramount Chief District Councillor
Maintain Grievance Log	Construction Contractor/Community Liaison Officer	BHP operator/Community Liaison Officer
Determine appropriate corrective actions and implementing responsibilities	Construction Contractor/Community Liaison Officer	BHP operator/Community Relations Officer with Environment Manager.
Sign off on satisfactory outcome	Complainant, Construction Contractor	Complainant, BHP operator
Verification that corrective action has been completed/closed out	Designated line manager of Community Liaison Officer	Designated line manager of Community Liaison Officer
Monitoring	PIU/Ministry of Energy and Power	

5. Monitoring of Outcomes

The nature of grievances and effective performance of the grievance redress process will be monitored as part of overall project supervision.

The grievance log, for a pre-defined reporting period, will be appended to all reports submitted by the construction contractor and BHP operator to the environmental working group. These will be forwarded to the Department of the Environment and thence to the PIU/Ministry of Energy and Power, so that overall performance in managing grievances can be evaluated. It is recommended that PIU/Ministry of Energy and Power, via its Communications Unit should undertake two specific targeted reviews of:

- Selected grievance log entries to ensure that corrective actions are proving effective and are being carried out in a timely manner; and
- Grievance logs to assess whether there are any recurrent types of grievance that point to a need for changes in procedures, and whether the project management has responded accordingly.

B.4 A Survey of Public Health in Bumbuna and the Surrounding Area (NKUK 2004)

DRAFT

Health Status Assessment of the Seven Chiefdoms Around Bumbuna

December 2004

Authored by Dr. Magbity, Consultant

BACKGROUND

The Government of Sierra Leone has for many years proposed to harness the Falls at Bumbuna for the purpose of generating electricity and transmitting the electric energy to areas where it is needed. The actualization of this project is now not too far away as the contractors are putting the finishing touches to the project.

Hydroelectric power is a project that is known to have negative impact on public health. The dam creates a reserviour of water, that sometimes serves as a suitable habitat for certain vectors of diseases, such as the snail vectors of schistosomiais and the Anopheles mosquito for malaria. The high velocity of the tailrace waterl created by the dam also provides favourable breeding places for the blackfly, the vector for Onchocerciasis. It may therefore be expected that if proper measures are not taken, Onchocerciasis, Schstosomiasis, Malaria and diarrhoea diseases could pose a serious public health threat to communities close to the river.

The objectives of this assessment therefore are to determine:

1. The current trend of morbidity among communities around the Seli river.
2. the logistics and personnel at the health facilities in these communities.
3. the health programmes that are either currently ongoing or planned, that would abate the threat posed by the dam to the health of people in these communities.

Overview of Health Situation in Sierra Leone

In general, the health of Sierra Leoneans has made very little improvement. The under-five mortality rate has dropped from 390/1000 in 1960 to 286/1000 in 2000, and Infant Mortality rate has dropped from 220/1000 in 1960 to 170/1000 in 2000. Life expectancy at birth has increased from 34 years in 1970 to 48 years in 2000 (MICS, 2000). However, there still exist wide variations between districts, and also between rural and urban populations. For example, populations with access to safe drinking water in 1998 was 58% for urban and 21% for rural, while the population with access to adequate sanitation in 1998 was 17% for urban and 8% for rural population (CSO report, 1998)

The 10-year civil war has severely affected the country's economy and health care delivery. It caused extensive damage to the entire health infrastructure in the country, by destroying (sometimes completely) about 56% of the health facilities. In fact, Sierra Leone was ranked last (191 out of 191 member states) in WHO index estimates of overall health systems attainment in 2002.

Sierra Leone, like other West African countries, continues to suffer from a heavy burden of communicable diseases, malnutrition, poor reproductive health and non-communicable diseases. Access, quality, equity and the utilization of PHC services are still low and there is considerable room for improving their effectiveness and efficiency. The insufficient number of functional health facilities to serve the vast majority of the population who live in rural areas limits access to health facilities. According to a World Bank staff appraisal report (1996), only about 65% of the population lives within 10 km of a health facility, and the proportion is even lower in the Northern and Southern provinces. In addition, many of the facilities provide poor quality service due to lack of diagnostic equipment, drugs, supplies, and qualified and motivated staff. For areas with better access to health care, inadequate knowledge about the need for health care, high fees charged by health workers, and the poor quality of care diminish the use of the health care services, particularly for the poor.

The morbidity pattern has not changed significantly over the years, with the population suffering from the same diseases such as malaria, respiratory and gastro-intestinal infections, tuberculosis, and STDs as well as nutritional deficiencies. However, non-communicable diseases like diabetes and cardio-vascular diseases are beginning to assume significance. The emergence of new infectious agents such as HIV/AIDS and Lassa fever adds to this growing public health burden.

Sierra Leone is facing a number of serious reproductive health problems. Many women die from complications of pregnancy, childbirth or unsafe abortion. Maternal mortality remains high: 1800 maternal deaths per 100,000 live births, one of the highest in the world (MICS, 2000)

Factors beyond the control of the health care system which contribute significantly to the relatively slow improvement in the health status of Sierra Leoneans include: poverty, poor nutrition of vulnerable groups, low literacy rates especially among women, high population growth, entrenched traditional beliefs and taboos, poor communication, limited access to safe water and sanitation and inadequate funding of health services.

The peripheral health care organization in the country has a good structure. There were over 700 Peripheral Health Units (PHUs) before the rebel war in 1991, located within the chiefdoms. The PHUs in the Government sector are either Community Health Centers (CHCs), at least one in each chiefdom, or Community Health Posts (CHPs) each serving a population of 2,000 – 5,000 within a five-mile radius, or Maternal and Child Health Posts (MCHPs) each serving 500 – 2000 people. General clinic services, under-fives clinic and antenatal services are provided at every unit. In addition, there are mission, NGO and industrial clinics in some areas. Because of the devastation in most of chiefdoms as a result of the rebel war, some PHUs have to be rebuilt or refurbished and personnel encouraged to return.

PHU activities in the districts are planned, implemented, supervised and evaluated by the District Health Management Teams. The District Medical Officer who is the administrative head and whose responsibility includes calling meetings and co-ordinating all PHC activities in the districts leads the DHMT.

DESCRIPTION OF THE STUDY AREA

Bumbuna is a valley town in the Kalongsogoia chiefdom, Tonkolili District in the Northern Province of Sierra Leone. It gets its name from a Limba word "Gbumgbu" meaning waterfall. The Kalongsogoia Chiefdom is an almagation of two former chiefdoms; Kalanthusa with five smaller sections (Kansokeria, Kakanlain, Kamalathe, Fuladugu and Kamakilon) and Dansogoia with two large sections.

Bumbuna is bordered by six chiefdoms, Kasunko in the North, Diang in the North-East, Sambaya in the East and South-East, Kafe Simiria in the South, Beriwa in the Northwest and the Safroko Limba in the South-West. Diang and Kasunko are in the Koinadugu District with Kabala as the headquarter town. Sambaya and Kafe-Simiria are in the Tonkolili District with Maagburaka as the district headquarter town. Biriwa and Safroko Limba are in the Bombali District with Makeni as the district headquarter town.

Bumbuna is a transition zone comprising of Savanna, Mountain Savanna Forest and Derived Forest. It is sub-divided into upper and lower sections. The lower section consists of ten villages with Bumbuna being the largest town and serving as the upper limit of the lower section. The upper section consists of twelve villages starting from Songorie to Dandaya.

The estimated population of Tonkolili District is 401,108, and Bumbuna accounts for four to five thousand. Although people in the local communities are engaged in various types of jobs, the majority obtain their living from farming, gold mining or fishing.

The town has an untreated tap system that has been in operation since the colonial era. It is supplied from an uphill stream that fills a tank-like structure which feeds a big pipe and then smaller pipes in various parts of the town. Recently, The Department for International Development (DFID), funded a project to replace most of the pipes and to erect a reservoir. The people in Bumbuna can therefore now boast of a more reliable water supply system.

The hydroelectric project has created jobs for some members of the community, but has also reduced people's access to their farmlands and other vital natural resources including herbs. The Dam has a height of 80m from the bed of the Seli River, and its reservoir will affect several villages along the river valley.

Bumbuna has an ill-equipped Community Health Centre (CHC) headed by a Maternal and Child Health Aid (MCH-aid). It is the only Clinic serving the entire Kalonsogoia Chiefdom. The town has few outlets that sell medicines. Most health problems are handled by quarks or "Pepper Doctor" and traditional healers. The majority of maternity cases are managed by Traditional Birth Attendants (TBA's) as most people cannot afford the CHC services.

Bumbuna town has three primary schools and only one junior secondary school, the Saint Matthew Secondary School.

METHODOLOGY

The consultant visited Government Hospitals in the District headquarter towns of Makeni and Magburaka, in the Bombali and Tonkolili Districts respectively. Health data on the district were collected from the monitoring and evaluation Officer, who explained that data was not compiled by chiefdoms. Interviews were held with the District Medical Officers of Bombali and Tonkolili to find out the following: the staffing situation in the various health facilities in the Districts, drug supply, equipment at the PHUs, the handling of referral cases, and the role of Non-governmental Organisations/Agencies in health issues. At Makeni, the Operational HQ of the Onchocerciaisis Control Programme (OCP) was visited and the Entomologist for the programme was interviewed.

The team also visited a sample of the health facilities in the chiefdoms surrounding Bumbuna to have a first hand assessment of the current health situation. Places like Boleya and Waia on the left bank and Kasokora, Kamator, Kasasi and Kadala on the right bank were visited to access their health facilities. Interviews were held with the chiefs and community people in the places visited.

In Bumbuna town itself, interviews were held with the Paramount Chief, P. C. Alimamy Bockarie Koroma Yallan III and his ruling council. The health officer in charge of the Community Health Centre was interviewed for information on the trend of morbidity in the township, methods of getting drugs, role of Non-governmental Organizations within the chiefdoms, current and future health management plans.

The Bumbuna Dam was visited, and interviews were held with some of the personnel on the construction team to have an in-depth idea of the nature of the project upon completion and its effect on the locality. Maps (scanning survey map of 2004) of the area were studied and the villages with direct impact were picked out. Additional information on the project was collected at the SALCOST Office in Freetown.

RESULTS

HEALTH FACILITIES AROUND BUMBUNA

The health facilities in the Kalonsogoia chiefdom and its surrounding six chiefdoms are given below. The health facilities are either headed by a Community Health Officer (CHO) or MCH-Aids, who are mostly trained in the Government Hospitals in the district headquarter towns (Makeni, Magburaka & Kabala).

Table 1. Health Facilities in Kalonsogoia and its bordering chiefdoms

NO	CHIEFDOM	HEALTH FACILITIES	TOWN/VILLAGES
1.	Kalonsogoia	C.H.C MCHP	Bumbuna Basainya
2.	Sombaya	MCHP	Rogbaneh
3.	Kafe Simiria	CHC	Mabontor
4.	Safroko Limba	MCHP MCHP	Maselleh Kabonka Binkolo Masongbo Kapeteh Kagbo Kanjassie Town
5.	Biriwa	MCHP MCHP MCHP CHC CHC CHP MCHP MCHP	Kamasikie Kagbankuna Manjoro Biriwa Kamabai Kagbameh Bumbaday Bumban Kendehka
6.	Diang	CHP CHC CHP	Yaru Kondembara Kondembaia

Please note: Community Health Officers undertake a –year training programme on clinical management of various health conditions. Maternal and Child Health Aids (MCH-Aids) undertake an 18 month training that focuses mainly on management of pregnant women and children.

According to the above table, huge variations exist in the distribution of health facilities within the chiefdoms around Bumbuna. For instance the Sumbaya chiefdom has only one health facility, a Maternal and Child Health Clinic, headed by an MCH Aid. The Biriwa Chiefdom on the other hand has 8 health facilities, including 3 CHCs.

HEALTH SITUATION OF BUMBUNA

In Bumbuna Town, there is only one functional Community Health Centre (CHC) for the entire Chiefdom. It is headed by a MCH – Aid. MSF, who used to assist the inhabitants, have long ago withdrawn from such areas. The Health Centre is ill-equipped and has very few drugs to attend to the mounting health problems in the Chiefdom. For this reason, most cases are transferred to Magburaka Hospital.

The common morbidity cases in Bumbuna Town as reported by the MCH-Aid and community people are malaria, diarrhoea, cholera and ARI. Drugs are also sold at a couple of drugstores in the township. Also there are several drug peddlers travelling from community to community selling drugs. Maternity cases are being handled by Traditional Birth Attendants (TBAs).

According to the MCH – Aid, most people come to the clinic only when their condition gets severe. Most of such cases are beyond the capability of the MCH-Aid running the clinic, so they are referred to Magburaka hospital. There is no ambulance in the township to transport referred cases, so public transport is used to take the sick for further treatment. Most families often cannot afford the cost of transporting sick relatives, so the patients are left to their own fate.

There are at present no current plans to upgrade the health facility.

Apart from HIV/AIDS Education over the radio, there is no form of HIV/AIDS education in the entire Bumbuna area, and no condom outlet could be identified.

Toilet facilities are poor as a large number of people still use the bush or streams to defaecate.

HEALTH SITUATION IN BOLEYA

Boleya is some nine miles up the valley from the dam site. It is a small village without a health post. The houses are principally huts with unprotected eaves and ceilings. The inhabitants are mostly subsistence farmers and gold miners. The inhabitants use the Moi Kororence stream for drinking water supply. This stream is some 400 metres away from the village. Another stream, the "signakolo" stream some 100 metres behind the village is used mainly for mining.

Health problems reported by the community were mainly onchocerciasis, malaria, diarrhoea, cholera, coughs, skin diseases, schsitosomiasis, and ARI. Measles, tetanus and ARI are reported to be high among under-fives. The tetanus situation is high because deliveries are conducted mainly by TBAs, with equipment of doubtful sterility.

The community has no health facility, so most cases are carried in hammocks to Bumbuna. It was disclosed that a large number of the serious cases die before reaching the hospital. Most people use traditional medicine to treat the sick.

HEALTH SITUATION AT WAIA

Waia is in the Diang Chiefdom and it is about nine miles from the dam and 3 miles from Boleya. There is no hospital and so most of the sick patients go to Magburaka via Bumbuna. People move their sick in hammocks, and many of the very ill cases die on the way to Bumbuna. The inhabitants are farmers and gold miners. They drink from either of the following streams: Discorea, which is some 400 metres away from the village, Fagbarama and Waiaroh (both of which are also used for gold mining). The main diseases reported by the community are: onchocerciasis, bilharzia, malaria, yellow fever, diarrhoea, cholera, dysentery, ARI, whooping cough, joint pains, tuberculosis, measles, tetanus. Measles and tetanus are common among under-fives because delivery is in the hands of TBAs, and the immunization centre is 43 miles away (Kabala). Traditional medicines are the main form of treatment used for most cases.

HIV/AIDS education is absent in the village. There is a community school with two unqualified teachers.

HEALTH SITUATION AT KASSASI

Kassasi is 9 mile from Bumbuna, with a population of about 100, with under-fives accounting for 10% of the population. The inhabitants are mostly farmers and gold miners. It has no hospital and most of the sick cases go to Bumbuna. The Masabulani stream is the main source of drinking water. However, it runs dry in the dry season, leaving the community to fetch water from wells dug up in swamps.

The majority use the surrounding bush as their toilet. The inhabitants highlighted malaria, onchocerciasis, schistosomiasis stomach trouble, cholera, diarrhoea, ARI with measles, tetanus and pneumonia, particularly amongst the under-fives. There is no drug store in the community, so most people rely on traditional medicines to treat the sick. Child delivery is in the hands of TBAs.

There is no HIV/AIDS education to the village.

HEALTH SITUATION AT KOCLALA

Koclala is four miles from Bumbuna, and has no health facility. The inhabitants are mostly farmers. The population is about 100.

The main source of drinking water is an unprotected well. The Masakriyan Stream, which leads to the Seli River, is used as their toilet. Inhabitants mentioned onchocerciasis, malaria, dysentery, diarrhoea, cholera, schistosomiaisis and waist bone pains as their main ailments. There was also a victim of elephantiasis. The sick are moved to Magburaka via Bumbuna. They rely heavily on native drugs to treat their various diseases.

HEALTH SITUATION AT KASOKERA

Kasokera is 7 miles from Bumbuna. It has a population of over 3000, with under-fives accounting for about 500. The streams, Makonranie or Malkomanie are used for drinking. The people use the bush as their toilet. There is no health centre, no drug sellers. Diseases mentioned are onchocerciasis, stomach troubles, yellow fever, malaria, diarrhoea, cholera, and coughs. Tetanus, measles and ARI were said to be responsible for most morbidity and mortality cases in under-fives. Tuberculosis was seen in one person. Pregnancies are handled by TBA's.

Amongst the STDs, only gonorrhoea was mentioned and they use herbs to cure it. The existence of HIV/AIDS was not demonstrated. Serious illnesses are taken to Katombo or Bumbuna. No NGO interference was seen.

HEALTH SITUATION AT KAMATUN

Kamatun is about 3 miles from Bumbuna, with a population of more than 1000. The Makamatun stream is the main source of drinking water, but it runs low during the dry season. There are few toilet facilities as people use the bush. Inhabitants made mention of malaria, dysentery, onchocerciasis, diarrhoea, cholera, and stomach trouble. Measles and tetanus are still seen in under-fives. Drugs for onchocerciasis do not reach them. Pregnancies are handled by TBAs. Complications are sent to Magburaka. NGO presence was not seen. HIV/AIDS education was not reflected in the people interviewed.

DATA ON HEALTH STATUS OF COMMUNITIES

Table 2a. ANNUAL MORBIDITY PATTERN FOR 2003 IN THE NORTHERN PROVINCE (Jan. – July 2004).

DISTRICT	KOINADUGU		BOMBALI		TONKOLILI	
AGE GROUP	**<5**	**>5**	**<5**	**>5**	**<5**	**>5**
Malaria	5373	9620	24220	18498	4769	6609
Diarrhoea	1833	2183	4545	2452	2465	2853
Dysentery	491	1325	1063	1516	255	1576
Cholera	0	0	0	0	0	0
ARI/Pneumonia	4614	5429	17613	9034	3625	3527
Meningitis	0	5	2	3	20	34
Measles	139	64	56	69	30	0
Neonatal Tetanus	14	0	23	0	74	0
Poliomyelitis	0	0	0	0	0	0
AFP	2	0	6	2	5	1
STDs	99	4020	0	5107	0	2162
Malnutrition	449	98	2199	880	2852	806
Tuberculosis	1	53	4	44	15	50
Leprosy	0	6	0	13	6	45
Lassa Fever	0	0	0	0	0	0
Yellow Fever	0	0	0	0	0	0
Onchocerciasis	1	31	13	80	17	64
Typhoid Fever	0	2	1	11	9	26
Schistosomiasis	105	268	237	301	35	383
Others	7500	18482	8119	13001	3289	8277
TOTAL	20621	41586	58100	51011	17465	26412
Grand Total	**62207**		**109111**		**43877**	

Table 2b. ANNUAL MORBIDITY PATTERN FOR 2002 IN THE NORTHERN PROVINCE.

DISTRICT	Bombali		Koinadugu		Tonkolili	
DISEASE	<5	>5	<5	>5	<5	>5
Malaria	22688.0	14597.0	5686.0	10433.0	8513.0	9959.0
W/Diarrhoea	5247.0	1969.0	1712.0	1954.0	2145.0	1406.0
B/Diarrhoea	659.0	1399.0	136.0	598.0	310.0	490.0
Cholera	0.0	0.0	0.0	0.0	0.0	0.0
ARI/Pneumonia	15177.0	8033.0	4262.0	5821.0	7744.0	7759.0
Meningitis	0.0	0.0	5.0	5.0	0.0	0.0
Measles	97.0	84.0	2.0	1.0	20.0	15.0
N/Tetanus	3.0	0.0	0.0	0.0	1.0	0.0
Poliomyelitis	0.0	0.0	0.0	0.0	0.0	0.0
AFP	4.0	1.0	0.0	0.0	1.0	0.0
STI's	0.0	4391.0	132.0	3808.0	0.0	1535.0
Malnutrition	1128.0	511.0	534.0	54.0	327.0	226.0
Tuberculosis	2.0	68.0	1.0	38.0	0.0	224.0
Leprosy	0.0	16.0	0.0	4.0	0.0	0.0
Lassa Fever	0.0	0.0	0.0	0.0	0.0	2.0
Yellow Fever	0.0	2.0	0.0	0.0	0.0	0.0
Onchocerciasis	0.0	927.0	0.0	21.0	24.0	479.0
Typhoid Fever	10.0	189.0	0.0	0.0	8.0	8.0
Schistosomiasis	8.0	46.0	16.0	36.0	3.0	77.0
Guinea Worms	0.0	0.0	0.0	0.0	0.0	0.0
Yaws	66.0	96.0	0.0	0.0	0.0	0.0
Others	9583.0	19296.0	5801.0	18857.0	4950.0	8387.0
TOTAL	54672.0	51625.0	18287.0	41630.0	24046.0	30567.0
GRAND TOTAL	**106297.0**		**59917.0**		**54613.0**	

From table 2a and 2b above, the main diseases affecting people in the districts of Bombali, Koinadugu and Tonkolili are seen to be: malaria, Acute Respiratory Infection (ARI), diarrhoea, malnutrition and sexually transmitted infections (STIs).

The malaria control programme in the Ministry of Health and Sanitation (MOHS) recently won a US$ 12 million grant for malaria control in Sierra Leone. The project is expected to benefit people in the 7 chiefdoms around Bumbuna by providing good quality anti-malarials, insecticide treated mosquito nets, and improved skills of health staff in the area.

The problem of schistosomiasis in the 3 districts covered is quite alarming. This problem is not expected to go away in the near future, because there is no schisitsomiasis control programme in the country, and there seem to be no immediate plans to handle the problem.

Table 3. Percentage of out-patient cases reporting various conditions (2003)

Diseases	Bombali	Koinadugu	Tonkolili	Total
Malaria	35.1%	28.8%	33.8%	32.5%
ARI	21.8%	18.0%	28.4%	22.1%
Watery Diarrhoea	6.8%	6.5%	6.5%	6.5%
Bloody Diarrhoea	1.3%	1.3%	1.5%	1.6%
Malnutrition*	1.5%	1.0%	1.0%	1.3%
STIs*	8.5%	9.1%	5.0%	7.9%
Schistosomiasis	0.09%	0.09	0.14%	0.08%

ONCHOCERCIASIS AROUND BUMBUNA

The authorities in the Makeni office revealed an increment in the incidence of onchocerciasis. This is associated with the ten year civil war, which resulted in the cessation of the Onchocerciaisis Control Programme (OCP) from 1996 until 2002 when the region was declared safe for operations. Initially, the strategy for controlling onchocerciaisis was spraying insecticides in the rivers and distribution of Ivermectin. However, owning to the high cost of the spraying, the programme now focuses on community distribution of ivermectin (CDTI) once per year and entomological surveillance. Ivermectin is distributed annually in all communities along the Seli River that are at risk of onchocerciaisis transmission.

Results from the dissections carried out on 33 flies on the 6th December, 2004 in the Bumbuna area revealed that only one was infected with four microfilaria worms in the head.

Below is a table showing the prevalence of onchocerciasis among various communities along the Seli River – 2002 Epidemiological Evaluation.

Table 4. Prevalence of Onchocerciaisis along the Seli river

Name of Village	District	Prevalence %
Yirafiliaria	Kionadugu	49.3
Foria	Kionadugu	27.1
Kalkonia	Kionadugu	34.7
Komoia	Kionadugu	4704
Yissiaia	Kionadugu	53.2
Kabare	Bombali	67.4
Ferengbeya	Tonkolili	64.3
Sonkoni	Tonkolili	41.5
Kulujage	Tonkolili	36.3
Masaka	Tonkolili	56.2

The results of the 2002 evaluation shows that onchocerciasis is still a problem among communities along the Seli river. The cumulative microfilariae load (CMFL = the number of microfilariae in 1mm2 of skin) ranges from 1.38 – 18.23 microfilariae in communities along the Seli river – which is unacceptably high.

It was also reported that onchocerciasis is the leading cause of blindness in the project area. After commissioning, transmission is expected to reduce upstream of the dam and perhaps increase immediately downstream.

HIV/AIDS Control.

Currently, there is no HIV/AIDS prevention programme in Bumbuna or anywhere in the Kalansongoia Chiefdom. However, there are two HIV/AIDs programmes in the 6 chiefdoms around Bumbuna – one in the Gbonkelenken Chiefdom and the other is in the Kholifa Rowalla Chiefdom. Both programmes are focused mainly on Information Education and Communication and Behaviour Change Communication (IEC/BCC). According to the monitoring and evaluation specialist at the National HIV/AIDs Secretariat (NAS), there are plans to have at least one HIV project in each chiefdom in the country, through the Sierra Leone HIV/AIDs Response Project (SHARP). SHARP is a 4-year, US$ 15 million World Bank funded project, aimed at reducing the spread of HIV/AIDs and mitigating its impact. It is expected that these communities will also benefit from a recently awarded Global Environment Fund grant of about US$ 8.5 million for 2-years, to scale-up HIV/AIDs interventions in the country. It is hope that affordable treatment will be provided for the treatment of STDs using resources from the World Bank and Global Fund for people in these communities.

No survey has yet been done on HIV/AIDS in the Bumbuna area and its surrounding chiefdoms. However, results of the recent National Antenatal Sentinel surveillance conducted in 2003 reported a national prevalence of about 3.0% and a prevalence of 0.6% at the only Northern region Sentinel site at Bombali.

Condom supply in the areas visited is limited. The only centres where people can have voluntary counselling and testing are at the district hospitals.

Logistical support.

All the health facilities in the 7 chiefdoms are government owned and therefore the DHMTs of the respective districts. All the health facilities visited were poorly equipped according to the health staff interviewed.

UNICEF supports the work of the DHMTs by supplying them with vaccines, motor-bikes and vehicles.

CONCLUSION

- Apart from the district head quarter towns, Makeni, Kabala and Magburaka, health facilities within the study area are poorly equipped. Most of the CHCs, PHUs, and MHPs, are headed by MCH-Aids who cannot go beyond providing basic health care services.

- The poor conditions of the roads worsen the health situation by making it very difficult for referred cases to access proper treatment.

- Onchocerciasis continues to be a serious threat to people's eyesight.

- Unprotected and untreated water sources could account for the water-borne diseases like diarrhoea, cholera, dysentery and schistosomiasis.

- Very little has been done with regards the prevention of HIV/AIDS and STIs in the communities.

RECOMMENDATIONS

- The DHMTs covering these areas should link with NGOs in the communities to improve the already existing health centres in the various regions and to provide additional health facilities.

- The Onchocerciasis Programme should intensify its operations in these areas so that more communities benefit for CDTI in these areas.

- Health education in these regions should be intensified to minimise diarrhoea, cholera and schistosomiasis and provide appropriate treatment for those with these conditions.

- HIV/AIDS sensitisation efforts should be Iitensified, including treatment of STIs.

Annex 1 Interviewees

Date	Location	Name	***Designation***
8th Dec. 2004	Makeni	Dr. Samuel J. Smith	*District Medical Officer (DMO) c/o Mariba Hospital*
		Mr. Alpha Kargbo	*Store Keeper, Makeni, ONCHO SIZ BASE*
	Magburaka	Dr. Wurrie	*DMO Magburaka Govt. Hosp.*
		Mr. Frederick Yambasu	*M&E Officer. Magburaka Govt. Hosp.*
	Bumbuna	Mr. Samuel M. Tisseh	*Chiefdom Speaker. Kolongosogoia*
		Mr. Marco Cruciani	*Site Agent of SALCOST*
10th Dec. 2004	Makeni	Mr. Simon Foday	*District Operation Officer EPI*
		Mr. Mohamed Conteh	*HIV/AIDS Focal person in Makeni Government Hospital*
		Mr. Paul Conteh	*Entomology Technician ONCHO SIZ BASE*
		Mr. Daniel Tolley	*c/o Makeni ONCHO SIZ BASE*
10TH Dec. 2004	Magburaka	Mr. Tarawali	*Lab. Technician Magburaka Govt. Hosp.*
	Bunbuna	P.C. Alimamy Bockarie Koroma Yillan III	*Paramount Chief Kalangsogria Chiefdom*
11th Dec. 2004	Boleya	Chief Giba Kargbo, Council of Elder and Youths	*Town Chief*
	Waia	Chief Foday Lansana Koroma, Council of Elders and Youths	*Town Chief*
12th Dec. 2004	*Kasasi*	*Chief Sara Mansaray* *Mr. Salieu Bah* *Mr. Kallie Conteh* *Mr. Sara Conteh* *Mr. Yakain Bangura*	*Town Chief*
	Kadala	*Chief Tenah Turay* *Tamba Koroma* *Sara Turay* *Tamba Bangura*	*Town Chief*
	Kosokera	*Chief Karim Turay* *Mr. Francis Sao Turay*	*Town Chief* *Teacher*
	Kamatu	*Chief Brima Turay* *Francis Kanu* *Sayo Kanu*	*Town Chief*

B.5 IFC Environmental Guidelines for Occupational Health and Safety

1 INTRODUCTION

AREA OF APPLICABILITY

This guideline applies to places of work associated with IFC projects. The place of work may be a building, an installation or an outdoor area. The guidelines also apply to temporary places of work. IFC project sponsors should ensure that suppliers, service providers, contractors, and subcontractors are required to follow comparable practices.

The guideline covers general aspects of occupational health and safety only. It does not adequately cover high risk activities or sectors requiring advanced labor protection measures. It must for projects involving especially hazardous situations be supplemented with appropriate international standards and guidelines or national standards of equal standing. Supplementary guidelines would thus be needed for e.g. construction sites, sectors such as mining, oil & gas, petrochemicals, etc., and for work involving extensive handling of dangerous substances such as hazardous or toxic compounds, biological agents, radioactive materials, etc.

DEFINITIONS, ABBREVIATIONS, AND ACRONYMS

Employer	Organization employing individuals, service providers or contractors.
Worker/employee	Person engaged by the organization, employed by a service provider or contractor carrying out an activity for the organization.
OHS	Occupational health and safety.
OHSMS	Occupational health and safety management system.
Confined space	Area not designed for continuous work having unfavorable natural ventilation and restricted access.
Hazardous material	Any compound or material posing an immediate or longer term hazard to human health due to its physical, chemical or biological effect.
Biological agents	Microorganisms, cell cultures, viruses, or human endoparasites able to provoke infections, allergy or toxic responses.
Microorganism	Microbiological entity, cellular or non cellular, capable of replication or transferring genetic material.
Exposure	Occupation-caused condition with potential immediate or long-term negative effect on the health and/or physical performance of the exposed person(s).
Exposure Limit (EL)	General term for expressions such as “Threshold Limit Values” (TLV), “Permissible Level”, “Limit Value”, “Occupational Exposure Limit” and similar terms used in regulations defining exposure limits for workers.
LA_{eq},*8h*	Equivalent 8-hour continuous A-weighted sound pressure level (dB(A)).
LA_{max},*fast*	Maximum A-weighted sound pressure level for “Fast” response time (0.125 sec).
mSv	MilliSievert - Dose equivalent unit for the amount of ionizing radiation energy ab-sorbedper unit mass (body weight) (mJ/kg)
PPE	Personal protective equipment.
UV	Ultra violet.
IR	Infra red.
WBGT	Wet bulb globe temperature (ºC).

DESCRIPTION OF SECTOR

Assigned employees and visitors to workplaces may be exposed to a variety of personal health and safety risks. The type and level of exposure is generally related to factors controlled by the employer. Such factors include without being limited to workplace design, installations, equipment, tools, work proce-dures, raw materials, byproducts, and the degree and sophistication of employee training. Administrative and managerial facilities generally involve fewer risks and hazards than industrial settings

Occupational health and safety risks that must be considered by the employer arise from normal functions and operations and during unusual circumstances such as accidents and incidents. The employer is responsible for implementing appropriate national and internationally recognized OHS standards, codes and guidelines. Maximum effectiveness of OHS systems requires the inclusion and meaningful participation of employees in implementation and maintenance of procedures and processes. To achieve meaningful and effective participation, the employer may have to implement a program to change employee culture and attitudes regarding health and safety.

2 GUIDELINES

GENERAL

The employer is responsible for planning, implementing and monitoring programs and systems required to ensure OHS on its premises. Such provisions shall be pro-active and preventive by identification of hazards as well as by evaluation, monitoring, and control of work related risks. The employer shall provide and maintain workplaces, plant, equipment, tools, and machinery and organize work so as to eliminate or control hazardous ambient factors at work. The employer shall provide appropriate occupational health and safety training for all employees. The organization shall, at no cost to the employee, provide adequate personal protective equipment. The employer shall record and report occupational injuries and illnesses. Contract specifications must include demands for service providers, contractors and sub-contractors to have or establish systems enabling them to meet the OHS requirements of the employer.

OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM

An Occupational Health and Safety management system (OHSMS) shall be established, operated and maintained for work associated with IFC projects. The OHSMS should be designed such that certification may be obtained. The comprehensiveness of the system depends on the nature and scale of the project and the magnitude of risks involved. The system may be based on OHSAS 18001, ILO-OHS 2001 or an equivalent internationally recognized standard. The content of an OHSMS is summarized in and further described in Annex I[1]. The adequacy of the adopted system shall be audited annually. Risk management within the OHSMS should be based on an internationally recognized standard such as AS/NZS 4360:1999[2]. The OHSMS shall be designed following a competent OHS audit to review the project, its organization and environment. The audit should identify needs for risk reduction and control measures related to transmission of blood borne pathogens (e.g. HIV, Hepatitis B virus etc.) at the place of work[3].

1. Occupational health and safety policy
2. Organizational framework of the OHSMS - staffing of OHSMS - competence requirements - operating procedures - training programs - system documentation - communication
3. OHS objectives (quantified)
4. Hazard prevention - Risk assessment - prevention and control measures (active and passive) - management of changes - emergency preparedness and response - procurement (tools, equipment, plants, services, contractors)
5. Performance monitoring and measurements - hazard prevention measures - ambient working environment - work related injuries, ill health, diseases and incidents
6. Evaluation - feed back - corrective measures action plan

Figure 2 Occupational Health and Safety Management System Features[5]

Footnotes for previous page:
[1] The OHSMS shall incorporate universal precautions and measures against transmission of blood borne pathogens (e.g. HIV, Hepatitis B, etc.). For high risk workplaces where workers come into regular contact with human blood and body fluids, comprehensive precautions and dedicated training should be undertaken. 2 Risk Management, Standards Australia/New Zealand, 1999 3 The ILO code of practice on "HIV/AIDS and the world of work," Geneva 2001, and the IFC Good Practice Note "HIV/AIDS in the Workplace," December 2002 provide background information and references for execution of reviews and policy implementation. 4 Prepared after ILO-OHS 2001 Guidelines on Occupational and Health Management Systems. 5 Prepared after ILO-OHS 2001 Guidelines on Occupational and Health Management Systems.

PHYSICAL FACTORS IN THE WORKPLACE
BUILDINGS AND STRUCTURES

Building facilities housing installations, activities or sectors not necessitating special labor protection and safety measures shall comply with the following physical requirements[6]. Where the nature of the activities or the materials used necessitates particular precautions, they must be designed according to local and internationally recognized standards as available for specific industries (e.g. mining, petroleum and chemical) and for hazardous materials such as asbestos.

Permanent and recurrent places of work shall be designed and equipped to protect OHS. Surfaces, structures and installations shall be easy to clean and maintain, and not allow for accumulation of hazardous compounds. Buildings must be structurally safe, provide appropriate protection against the climate and have acceptable light and noise conditions. Fire resistant, noise-absorbing materials should, to the extent feasible, be used for cladding on ceilings and walls. Floors should be level, even, and non-skid. Heavy oscillating, rotating or alternating equipment should be located in dedicated buildings or structurally isolated sections.

The space provided for each worker and in total must be adequate for safe execution of all activities including transport and interim storage of materials and products. Passages to emergency exits must be unobstructed at all times. The number and capacity of emergency exits must be sufficient for safe and orderly evacuation of the greatest number of people present at any time.

CONFINED SPACES
Engineering measures must be implemented to eliminate to the degree feasible existence and adverse character of confined spaces. Unavoidable confined spaces shall, to the extent possible, be provided with permanent safety measures for venting, monitoring and rescue operations. The area adjoining an access to a confined space shall provide ample room for emergency and rescue operations.

ACCESS
Passageways for pedestrians and vehicles within and outside buildings should be segregated and provide for easy, safe and appropriate access. Equipment and installations requiring recurrent servicing and cleaning should have permanent

6 Deviations from the general requirements are acceptable if the place of work and ambient environment are safe and the occurrence/duration of an activity limited.

means of access. Hand, knee and foot railings must be installed on stairs, fixed ladders, platforms, permanent and interim floor openings, loading bays, ramps, etc. Openings must be sealed by gates or removable chains. Covers shall if feasible be installed to protect against falling items. Measures to prevent unauthorized access to dangerous areas must be in place.

INSTALLATIONS, EQUIPMENT, TOOLS AND SUBSTANCES

Installations, equipment, tools and substances shall be suitable for their use and selected to minimize dangers to safety or health when used correctly. Appropriate shields, guards or railings must be installed and maintained to eliminate human contact with moving parts, or hot and cold items. Equipment must be provided with adequate noise and vibration dampers. Electrical installations must be designed, constructed and maintained to eliminate fire or explosion hazards and risks to employees. Ergonomic risks and hazards shall be minimized by selecting equipment, tools and furniture appropriate for the assigned worker.

SIGNAGE

Hazardous and risky areas, installations, materials, safety measures, emergency exits, etc. shall be appropriately marked. Signage shall be in accordance with international standards, be well known to, and easily understood by workers, visitors and the general public as appropriate[7].

LIGHTING

Workplaces should, to the degree feasible, receive natural light and be supplemented with sufficient artificial illumination to promote workers' safety and health. Emergency lighting of adequate intensity must be installed and automatically activated upon failure of the artificial light source to ensure safe shut-down, evacuation, etc.

VENTILATION AND TEMPERATURES

Sufficient fresh air must be supplied for indoor and confined work spaces. Factors to be considered in ventilation design include physical activity, substances in use and process related emissions. Mechanical ventilation systems shall be maintained in good working order. Point-source exhaust systems required for maintaining a safe ambient environment must have local indicators of correct functioning. Re-circulation of contaminated air is generally not acceptable. Air inlet filters must be kept clean andfree of dust and microorganisms. HVAC and industrial evaporative cooling systems shall be equipped, maintained and operated so as to prevent growth and spreading of disease agents (e.g. Legionnella pneumophilia) or breeding of vectors e.g. mosquitoes and flies of public health concern. Air distribution systems must be designed so as not to expose workers to draughts. The temperature in work, rest room and other welfare facilities should, during service hours, be maintained at a level appropriate for the purpose of the facility.

FIRE DETECTION AND FIRE FIGHTING

The workplace must be equipped with fire detectors, alarm systems and fire-fighting equipment. The equipment shall be maintained in good working order. It must be adequate for the dimensions and use of the premises, equipment installed, physical and chemical properties of substances present, and the maximum number of people present. Non-automatic firefighting equipment must be easily accessible and simple to use. Fire and emergency alarm systems shall be both audible and visible. The IFC Life and Fire Safety Guideline shall apply to buildings accessible to the public.

7 ISO 9186 and ANSI Z535.3 advise on signage design.

CLEANING

Washbasins with running hot and cold water shall be installed in sufficient numbers where demanded by the character of the work and when contaminants or pollution must be confined to the place of work. The washbasins must have soap and/or other appropriate cleaning agents. Places of work, traffic routes and passageways shall be kept free from waste and spillage, regularly cleaned, and maintained.

FIRST-AID

The employer must ensure that qualified first-aid can be provided at all times. Appropriately equipped first-aid stations shall be easily accessible throughout the place of work. Eye-wash stations and/or emergency showers shall be provided close to all workstations where the recommended first-aid response is immediate flushing with water. Where the scale of work or the type of activity being carried out so requires, dedicated and appropriately equipped first-aid room(s) must be provided. First aid stations and rooms shall be equipped with gloves, gowns and masks for protection against direct contact with blood and other body fluids. Remote sites shall have in place written emergency procedures for dealing with cases of trauma or serious illness up to the point at which care of the patient can be transferred to an appropriate medical facility.

WELFARE FACILITIES

The scope and comprehensiveness of welfare facilities depend on the number of workers present at any one time and the activities executed. Welfare facilities must include locker rooms, an adequate number of toilets with washbasins, and a room dedicated for eating. Separate eating facilities shall be provided for employees wearing clean and soiled work clothes respectively. Gender-segregated changing rooms with lockers and benches should be provided when special work-clothes are required. Hot and cold water shower facilities and wash basins should be available in connection with locker rooms. Water supplied to areas with food preparation or for the purpose of personal hygiene (washing or bathing) must meet drinking water quality standards. If the circumstances (e.g. dirt, dangerous substances, humidity, blood, microorganisms, etc.) so require, separate lockers must be installed for isolating street- from work-clothes for the exposed employees. Work-clothes that may be contaminated with dangerous or contagious substances or in any way involve a health hazard to the worker, his family or the general public shall not leave the premises of work, but be collected on site and adequately cleaned and disinfected at the employer’s expense. Staff exposed to risk of contamination shall change clothes and undergo decontamination before entering common facilities such as eating places.

PERSONAL PROTECTIVE EQUIPMENT

The employer shall identify and provide appropriate personal protective equipment (PPE) that will offer adequate protection to the worker, co-workers and occasional visitors without incurring unnecessary inconvenience. The employer shall actively enforce use of PPE if alternative technologies, work plans or procedures cannot eliminate or sufficiently reduce a hazard or exposure. The employer shall ensure that PPE is cleaned when dirty, properly maintained and replaced when damaged or worn out. Proper use of PPE shall be part of the recurrent training programs for employees. Table 1 presents selected examples of occupational hazards and types of PPE available for different purposes.

Objective	Occupational Hazards	PPE
Eye and face protection	Flying particles, molten metal, liquid chemicals, gases or vapors, light radiation.	Glasses, shields, protective shades, etc.
Head protection	Falling objects, inadequate height clearance, and overhead power cords.	Helmets with or without electrical protection.
Hearing protection	Noise, ultra-sound.	Hearing protectors.
Foot protection	Falling or rolling objects, pointed objects. Liquids.	Safety shoes and boots for protection against liquids and chemicals.
Hand protection	Hazardous materials, cuts or lacerations, vibrations, extreme temperatures.	Gloves made of rubber or synthetic materials, leather, steel, insulating materials, etc.
Respiratory protection	Dust, fogs, fumes, mists, gases, smokes, vapors, oxygen deficiency.	Facemasks with appropriate filters for dust removal and air purification (chemicals and gases) or air supply.
Body/leg protection	Extreme temperatures, hazardous materials, biological agents, cutting and laceration.	Insulating clothing, body suits, aprons etc. of appropriate materials.

Table 1 Occupational Hazards — Exposure Examples and Types of PPE Available

DRINKING WATER

The employer shall ensure an ample supply of drinking water 8 at all places of work. Water supplies shall be conveniently located especially for areas of elevated temperatures, high physical activity, and cold or dry environments. Drinking water supplies shall be clearly marked especially where non-drinking water is also available.

AMBIENT FACTORS IN THE WORKPLACE

NOISE

Noise limits for different working environments are provided in Table 2. No employee may be exposed to a noise level greater than 85 dB(A) for a duration of more than 8 hours per day. In addition no unprotected ear should be exposed to a peak sound pressure level (instantaneous) of more than 140 dBC. The use of hearing protection must be actively enforced when LA_{eq},8h reaches 85 dB(A), the peak sound levels 140 dB(C) or the LA_{max},fast 110dB(A).

Location /activity	Equivalent level LA_{eq},8h	Maximum LA_{max},fast
Heavy Industry (no demand for oral communication)	85 dB(A)	110 dB(A)
Light industry (decreasing demand for oral communication)	50-65 dB(A)	110 dB(A)
Open offices, control rooms, service counters or similar	45-50 dB(A)	-
Individual offices (no disturbing noise)	40-45 dB(A)	-
Classrooms, lecture halls	35-40 dB(A)	-
Hospitals	30-35 dB(A)	40 dB(A)

Table 2 Noise Limits LA_{eq},8h and Maximum LA_{max},fast[9]

VIBRATION

Exposure to hand-arm vibration from equipment such as hand and power tools or whole-body vibrations from surfaces on which the worker stands or sits shall be controlled through selection of equipment and limitation of time of exposure. The limits for vibration and action values, i.e. the level of exposure at which remediation should be initiated, are provided in Table 3. Exposure levels should be checked on the basis of daily exposure time and data provided by equipment manufacturers[10].

	Hand-arm vibration	Whole-body vibration
Daily exposure limit value standardized to an 8-hours reference period[11]	5 m/s^2	1.15 m/s^2 or
Daily exposure action value standardized to an 8-hours reference period[12]	2.5 m/s^2	0.6 m/s^2 or

Table 3 Vibration Exposure and Action Values Limits (acceleration, m/s^2)[13]

8 Drinking water shall as minimum comply with physical chemical and bacteriological requirements of the World Health Organization (WHO) Guidelines for Drinking Water Quality, Geneva 1998.
9 WHO guideline values for community noise in specific environments, Geneva 1999.
10 The UK Health and Safety Executive at http://www.hse.gov.uk/hthdir/noframes/vibrat.htm provides information on reduction of vibration risks and a "Vibration exposure calculator".
11 ISO standard 5349-1 (2001) chapters 4, and 5, and Annex A.
12 ISO standard 2631-1 (1997) chapters 5, 6 and 7 and Annex A and B.
13 European Community EC 2001/C 301/01).

ILLUMINATION, LIGHT RADIATION AND REFLECTIONS

Work area light intensity must be adequate for the general purpose of the location and type of activity and must be supplemented with dedicated work station illumination as needed. All light sources should be energy efficient with minimum heat emission. The employer shall take measures to
eliminate reflections and flickering of lights. The minimum limits for illumination intensity for a range of locations/activities appear in Table 4.

Location /activity	Light intensity
Emergency light	10 lux
Outdoor non working areas	20 lux
Simple orientation and temporary visits (machine storage, garage, warehouse)	50 lux
Workspace with occasional visual tasks only (corridors, stairways, lobby, elevator, auditorium, etc.)	100 lux
Medium precision work (simple assembly, rough machine works, welding, packing, etc.)	200 lux
Precision work (reading, moderately difficult assembly, sorting, checking, medium bench and machine works, etc.), offices.	500 lux
High precision work (difficult assembly, sewing, color inspection, fine sorting etc.)	1,000 – 3,000 lux

Table 4 Minimum Illumination Intensity on Objects of Work [14]

The employer shall take precautions to minimize and control optical radiation including direct sunlight. Exposure to high intensity UV and IR radiation and high intensity visible light shall also be controlled. Laser hazards shall be controlled in accordance with equipment specifications, certifications, and recognized safety standards. The lowest feasible class Laser shall be applied to minimize risks.

TEMPERATURE

The employer shall maintain indoor temperatures that are reasonable and appropriate for the type of work. Risks of heat or cold related stress must be adequately addressed and feasible control measures implemented for work in adverse environments. The wet bulb globe temperature (WBGT) or a nationally recognized method of equal standing should be used for screening environmental contribution to heat stress15. Commonly applied limits used for WBGT screening 16 appear in Table 5. Additional investigations are required to properly assess the magnitude of the problem and identify feasible heat stress control measures.

Level of physical activity - type of work	Maximum WBGT
Minimum to light	29.5°C
Moderate - walking, standing, use of hand tools	27.5°C
High - heavy burdens, intensive use of tools	26°C
Very high – high speed intensive and heavy work	25°C

Table 5 Heat Stress Screening Temperatures WBGT°C [18].

For continuous work in temperatures below -7ºC, the wind-chill temperature should be calculated to assess the need for cold-stress precautions in addition to protective clothing[19]. For wind-chill temperatures below –20ºC, a 10-minute warm-up period should be provided in a heated shelter in the middle of any 4-hour work period. A second warm-up period of equal duration shall be added if the temperature decreases to -32ºC. Additional warm-up periods shall be added for every following three degree temperature drop. Below wind chill temperatures of -43ºC non emergency work should cease.

HAZARDOUS MATERIALS

Organizations that produce, handle, store, transport and dispose of hazardous materials (chemicals, gases, vapors, fumes, dust, fibers, etc.) shall in addition to the present guidelines fulfill the requirements of the IFC Hazardous Materials Management Guidelines.

The employer shall avoid the use of any hazardous substance by replacing it with a substance that under its normal conditions of use is not dangerous or less dangerous to the workers, if the nature of the activity so permits. Precautions must be taken to keep the risk of exposure as low as possible. Work processes, engineering and administrative control measures must be designed, maintained and operated so as to avoid or minimize the release of hazardous substances into the working environment. The number of employees exposed or likely to become exposed must be kept at a minimum and the level of exposure maintained below internationally established or recognized exposure limits.

When ambient air contains several hazardous compounds with additive effects, the combined exposure is assessed by summarizing the relative level of exposure to each compound. The resulting level of exposure is considered acceptable if the outcome is less than or equal to one (? 1.0)[20]. of exposure as low as possible. Work processes, engineering and administrative control measures must be designed, maintained and operated so as to avoid or minimize the release of hazardous substances into the working environment. The number of employees exposed or likely to become exposed must be kept at a minimum and the level of exposure maintained below internationally established or recognized exposure limits.

When ambient air contains several hazardous compounds with additive effects, the combined exposure is assessed by summarizing the relative level of exposure to each compound.

14 Table 4 states minimum levels for illumination only. Final design of lighting levels and systems must adequately consider type and characteristic of the activity, required speed and accuracy of the performance, age of staff, reflectance of task surface, and color of the light, see e.g. Lighting Handbook 8th Edition, The Illumination Engineering Society of North America, New York, 1993

15 The wet bulb globe temperature WBGT (ISO 7243 is calculated using one of the following equations: i) without direct sunlight exposure WBGTin = 0.7*TWB + 0.3*TGT and ii) with direct sunlight exposure WBGTout = 0.7*TWB + 0.2*TGT+ 0.1*TDB. Where TWB = natural wet bulb temperature, TGT = globe temperature and TDB = dry bulb temperature

16 Canadian OHS regulation (http://regulation.healthandsafetycenter.com/s/GuidelinePart7.asp), Management and Prevention of Heat Stress - Guideline, Department of Minerals and Energy Western Australia, December 1997, and ACGIH 2001, contains detailed guidelines for assessing and controlling heat and cold stress.

17 Canadian OHS regulation (http://regulation.healthandsafetycenter.com/s/GuidelinePart7.asp), Management and Prevention of Heat Stress - Guideline, Department of Minerals and Energy Western Australia, December 1997, and ACGIH 2001, contains guidelines for assessing and controlling heat and cold stress.

18 American Conference of Governmental Industrial Hygienists, ACGIH, 2001.

19 W = 13.12 + 0.6215*TDB - 11.37*V0.16 +0.3965* TDB* V0.16, where W is the wind-chill index (ºC) (equivalent chill temperature), TDB = dry bulb - air temperature (ºC) and V = wind speed in km/h at 10 meters height.

The employer must ensure that all chemicals and hazardous materials present are labeled and marked according to national and internationally recognized requirements and standards. International Chemical Safety Cards (ICSC), Materials Safety Data Sheets (MSDS) or equivalent data/information in an easily understood language must be readily available to exposed workers and first-aid personnel. The employer must ensure adequate and competent supervision of the work, work practices, and the appropriate use of PPE.

BIOLOGICAL AGENTS

The employer shall avoid the use of any harmful biological agent by replacing it with an agent that, under its normal conditions of use, is not dangerous or less dangerous to the workers, if the nature of the activity so permits. Precautions must be taken to keep the risk of exposure as low as possible. Work processes, engineering and administrative controls must be designed, maintained and operated to avoid or minimize release of biological agents into the working environment. The number of employees exposed or likely to become exposed must be kept at a minimum. Levels of exposure must be maintained below internationally established/recognized exposure limits.
The employer shall review and assess known and suspected presence of biological agents at the place of work[21] and implement appropriate safety measures, monitoring and training programs.

Biological agents should be classified into four groups[22]:
1. Biological agents unlikely to cause human disease.
2. Biological agents that can cause human disease but are unlikely to spread to the community.
3. Biological agents that can cause severe human disease and present a serious hazard to workers and may present a risk of spreading to the community, for which there usually is effective prophylaxis or treatment available.
4. Biological agents that can cause severe human disease are a serious hazard to workers and present a high risk of spreading to the community, for which there is usually no effective prophylaxis or treatment available.

Measures to eliminate and control hazards from known and suspected biological agents at the place of work shall be designed, implemented and maintained in close co-operation with the local health authorities and according to recognized international standards. The employer shall at all times encourage and enforce the highest level of hygiene and personal protection especially for activities employing biological agents of group 3 and 4 above.

IONIZING RADIATION

Places of work involving occupational[24] and/or natural[25] exposure to ionizing radiation shall be established and operated in accordance with the, “International Basic Safety Standard for protection against Ionizing Radiation and for the Safety of Radiation Sources,”[26] and its three interrelated Safety Guides. The acceptable effective dose limits appear in Table 6.

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20 = ? 1.0; where n is the total number of hazardous compounds present, c_x the ambient concentration level of compound No. x, and EL_x its exposure limit.

21 Known presence means identified micro-organisms utilized in industry, research facilities and the like. Suspected presence are unidentified micro-organisms occasionally appearing in health care and veterinary facilities and laboratories or pathogens present in the work force.

22 European Community Directive 2000/54/EC of 18 September 2000 on protection of workers from risks related to exposure to biological agents at work.

24 Organizations processing, or applying radioactive substances for purposes such as medical or industrial processes, education, training, research, etc.

25 Underground mines (other than those for radioactive ore), spas, radon prone areas, etc.

26 IAEA Safety Series No. 115.

Exposure	**Workers** (min.19 years of age)	**Apprentices and students** (16-18 years of age)
Five consecutive year average – effective dose	20 mSv/year	
Single year exposure – effective dose	50 mSv/year	6 mSv/year
Equivalent dose to the lens of the eye	150 mSv/year	50 mSv/year
Equivalent dose to the extremities (hands, feet) or the skin	500 mSv/year	150 mSv/year

Table 6 Effective Dose Limits For Occupational Ionizing Radiation Exposure [mSv/year]

TRAINING AND DOCUMENTATION

TRAINING

The employer shall ensure that workers prior to commencement of new assignments have received adequate training and information enabling them to understand the hazards of work and to protect their health from hazardous ambient factors that may be present. The training must adequately cover: a) knowledge of materials, equipment, and tools; b) known hazards in the operations and how they are controlled; c) potential risks to health; d) precautions to prevent exposure; e) hygiene requirements; f) wearing and use of protective equipment and clothing; and g) appropriate response to operation extremes, incidents and accidents.

A basic occupational training program and specialty courses shall be provided as needed to ensure that workers are oriented to the specific hazards of individual work assignments. Training shall generally be provided to management, supervisors, workers, and occasional visitors to areas of risks and hazards. Training shall also be provided to account for new or changed risks whenever procedures are altered or new materials/equipment introduced. Training should be repeated periodically and supported by feasible incentives. Workers with rescue and first-aid duties shall receive dedicated training so as not to inadvertently aggravate exposures and health hazards to themselves or their co-workers. The latter training would include the risks of becoming infected with blood–borne pathogens through contact with bodily fluids and tissue.

The employer shall through appropriate contract specifications and monitoring ensure that service providers, as well as contracted and subcontracted labor is appropriately trained before start of their assignments.

3. MONITORING & REPORTING GUIDELINES

Safety features, ambient working environments and OHS-indicators are subject to regular monitoring and review. The collected information shall be processed and findings reported to national authorities as required. The compiled information and any corrective measures taken shall be applied in a continuous process to improve the OHS management system. An annual report adequately presenting performance and achievements in regard to OHS shall be submitted to IFC. The report shall also outline and justify changes made to the OHSMS. Employee monitoring data (originals) must be saved for a period of 5 years or longer if required by national regulations.
The OHSMS shall include specifications for performance monitoring, evaluation, and improvement of the system as well as for recording and reporting occupational diseases and accidents.

PERFORMANCE MONITORING

OHSMS organization.
The performance and achievements of the OHSMS organization shall be re-assessed annually.

Safety inspection, testing and calibration.
The employer shall arrange for regular inspection and testing of all safety features and hazard control measures at the premises. The inspection shall focus on engineering and personal protective features, work procedures, places of work, installations, equipment, and tools used. The inspection must ensure that issued personal protective equipment continues to provide adequate protection and is being worn as required. All instruments installed or used for monitoring and recording of working environment parameters must be regularly tested and calibrated. Records shall be kept of all inspections, tests, and calibrations.

Surveillance of the working environment.
The employer shall document compliance using an appropriate combination of portable and stationary sampling and monitoring instruments. Monitoring and analyses shall be conducted according to internationally recognized methods and standards. Monitoring methodology, locations, frequencies, and parameters shall be established individually for each project following a review of the seriousness of the inherent hazards.
Generally, monitoring should be performed during commissioning of facilities or equipment and at the end of the defect and liability period, and otherwise repeated according to the monitoring plan established as part of the OHSMS.

Surveillance of workers health.
When extraordinary protective measures are required (against biological agents group 3 and 4 and/or hazardous compounds), the employer shall provide appropriate and relevant health surveillance to workers prior to first exposure and at regular intervals thereafter. The surveillance shall, if deemed necessary be continued after termination of the employment.

Training.
Training activities for employees, and visitors shall be adequately monitored and documented (curriculum, duration, and participants). Emergency exercises including fire drills shall be adequately documented. Service providers and contractors must be contractually required to submit to the employer adequate training documentation before start of their assignment.

ACCIDENTS AND DISEASES MONITORING

The employer shall establish procedures and systems for reporting and recording: i) occupational accidents and diseases; and ii) dangerous occurrences and incidents. The systems must require and enable workers to report to their immediate supervisor immediately any situation they believe presents a serious danger to life or health. The systems and the employer shall further enable and encourage workers to report all: i) occupational injuries and near misses; ii) suspected cases of occupational disease; and iii) dangerous occurrences and incidents.

Occupational accidents and diseases.
The employer must with the assistance of a competent person investigate all reported occupational accidents, occupational diseases, dangerous occurrences, and incidents together with near misses. The investigation should as far as possible:
1. Establish what happened;
2. Determine the cause of what happened; and
3. Identify measures necessary to prevent a recurrence.

Occupational accidents and diseases should at a minimum be classified according to Figure 3. Distinction is made between fatal and non-fatal injuries. The two main categories are divided into three sub-categories according to time of death or duration of the incapacity to work. The total number of man-days and hours worked during the reporting period must be stated.

a. Fatalities (number)	**b. Non-fatal injuries** (number) [27]	**c. Total time lost** non-fatal injuries (days)
a.1 Immediate		**b.1** Less than one day
a.2 Within a month	**b.2** Up to 3 days	**c.1** Category b.2
a.3 Within a year	**b.3** More than 3 days	**c.2** Category b.3

Figure 3 Occupational Accident and Disease Reporting

REPORTING GUIDELINES

The annual report to IFC on OHS shall include a comprehensive summary of the following.

Host country regulatory compliance.
The employer shall record, list and preserve any reports submitted to host country authorities, e.g. on OHS, fire and safety inspections, compliance monitoring, emergency exercises, etc., as well as comments received and actions taken. Host country authority monitoring and inspections with subsequent actions taken shall also be summarized and reported.

OHSMS reporting.
The annual report shall include summaries of OHS performance monitoring, and records of occurred occupational accidents, incidents and diseases. Special emphasis shall be placed on evaluation of findings and actions taken or planned due to the number and type of accidents observed. The report shall also include an assessment of the degree of fulfillment of the previous year's OHS objectives and action plans for improvement.
The report shall include proposed revisions to the OHS Management System; revised quantitative objectives; action plans for technical improvements; and planned training activities.

27 The day on which an incident occurs is not included in b.2 and b.3.

4. BEST PRACTICE

For projects or components of projects with particular health and safety risks, this guideline shall be supplemented with recognized national and/or international standards. The following OHS websites may be used to obtain additional information.
ILO Safe Work, International Labour organization

- http://www.ilo.org/public/english/protection/safework/index.htm - Index with access to a range of facts, information, and links on occupational health and safety.
- http://www.ilo.org/public/english/protection/safework/cis/products/icsc/index.htm - International Chemical Safety Cards.
- http://www.ilo.org/public/english/protection/safework/cis/products/hdo/htm/index.htm - International Hazard Data Sheets on Occupation.
- http://www.ilo.org/public/english/protection/trav/aids/download/pdf/hiv_a4_e.pdf - Code of Practice on HIV/AIDS and the world of work.

NIOSH, National Institute of Occupational Safety and Health, US Department of Health and Human Services.

- http://www.cdc.gov/niOHS/siteindx.html -Site Index A_Z
- http://www.cdc.gov/niOHS/toplst.html - Safety and Health Topics.
- http://www.cdc.gov/niOHS/npg/npg.html - Pocket Guide to Chemical Hazards.
- http://www.cdc.gov/niOHS/81-123.html - Occupational Health Guidelines for Chemical Hazards, January 1981.
- http://www.cdc.gov/niOHS/ipcsneng/neng0068.html - International Chemical Safety Cards.

WHO, World Health Organization

- http://www.who.int/peh/Occupational_health/occindex.html - Protecting the Human Environment, Occupational Health.

5. REFERENCES

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/2/ Occupational health and safety management systems, OHSAS 18001, British Standards, 1999.
/3/ Ambient factors in the workplace, International Labour Office, Geneva, 2001.
/4/ Occupational Radiation protection, IAEA Safety Standard Series No. RS-G-1.1. International Atomic Energy Agency, Vienna, 1999.
/5/ International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources, IAEA Safety Series No.115; International Atomic Agency, Vienna 1996.
/6/ Safety in the use of chemicals at work, ILO code of practice. International Labour Office, Geneva 1993.
/7/ Occupational Safety and Health Standards, CFR29, Part 1910, OHSA, U.S Department of Labor, 2001
/8/ OSHA Handbook for Small Businesses, OSHA 2209, 1996.
/9/ European Communities Council Directives 89/654/EEC of 30 November 1989, 2000/39/EC of 8 June 2000, 2000/54/EC of 18 September 2000, 2002/44/EC of 25 June 2002.
/10/ Lighting Handbook 8th Edition, The Illumination Engineering Society of North America, New York, 1993.
/11/ HIV/AIDS and the world of work, ILO code of practice, Geneva, June 2001.
/12/ HIV/AIDS in the Workplace. IFC Good Practice Note number 2, 2002.

/13/ Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure; The American Conference of Governmental Industrial Hygienists (ACGIH), 2001.

6. ANNEXES

ANNEX 1

THE OCCUPATIONAL HEALTH AND SAFETY MANAGEMENT SYSTEM[28]

Occupational health and safety, including compliance with national OHS requirements, is the responsibility and duty of the employer. Implementation of a fully transparent OHSMS in an organization is a powerful tool towards fulfilling these obligations. The OHSMS signals the commitment of the organization to ensure safe working conditions. However, active participation from workers is required for optimum results. Meaningful participation by employees may be obtainable through efficient awareness raising and training to change the prevailing labor safety culture. An OHSMS must have features for continuous feedback and self-improvement.

POLICY

The OHS Policy Statement of the organization must be in writing and prepared in consultation with workers and their representatives. Senior management must endorse it. The policy shall be appropriate for the size and nature of the organization. The organization should, through a policy statement, be committed to: i) protect the health of all employees, ii) comply with relevant national and international OHS requirements, iii) ensure consultation with and active participation of the workers, and iv) continuously seek to improve the performance of the OHS system. The OHSMS should be integrated in or compatible with other management systems of the organization (e.g. ISO 9001-2000)and appropriately certified.

The employer should when feasible ensure establishment and efficient functioning of a “Safety and Health Committee.” The workers and their representatives should be given time and resources to participate actively in the processes of the OHSMS.

ORGANIZATION

REPONSIBILITY AND ACCOUNTABILITY

A person at senior management level should have responsibility and authority for development, implementation, management review and evaluation of the OHSMS. Structures and processes shall be created within the organization ensuring: OHS as a line management responsibility, effective supervision, co-operation and communication on implementation of the OHSMS, effective arrangements for identification and elimination or control of work related hazards and risks, the full participation of workers and their representatives, and appropriate allocation of resources.

COMPETENCE AND TRAINING

The organization must possess, develop or have permanent access to sufficient OHS competence to implement and maintain the OHSMS. Permanent competence is required to continuously identify, eliminate and/or control work related hazards and risks within the organization.

Appropriate OHS training programs must be established and implemented for all employees and levels of the organization. Training must be conducted by competent persons, take place prior to the start of a new activity, and be refreshed as needed. Training must be provided free of charge to the employees.

OHSMS DOCUMENTATION

An appropriately sized and scoped OHS manual shall be prepared and maintained. The manual shall at a minimum fulfill relevant national and international requirements for the activities of the organization. The manual should include: OHS Policy, OHS organization

and allocation of responsibilities, schedules, procedures, instructions and other internal documents used for OHS management and control. There should be a section identifying key risks and hazards arising from the organization's activities together with arrangements for their prevention and control. The manual shall establish procedures, schedules and methodologies for review of safety and control features, as well as plans and schedules for monitoring ambient working environment quality and individual exposure levels as appropriate.
OHS records with details appropriate to the needs of the organization shall be established, managed, and maintained locally. The records shall contain appropriate information regarding national OHS laws and regulation, the OHSMS itself, as well as monitoring data regarding elements such as workers health and exposure, ambient working environment, work-related injuries, ill health, diseases, incidents, training programs and lists of trainees. IFC requires original data and records to be saved for a minimum of 5 years.

COMMUNICATION

The OHSMS shall include effective arrangements for receiving and responding to internal and external communication. The system shall ensure communi-cation and exchange of information among relevant levels and functions within the organization. The system shall ensure that concerns, ideas and inputs of workers are considered and addressed.

PLANNING AND IMPLEMENTATION

OHS AUDIT

A competent person shall carry out an initial OHS audit for new and existing organizations. The audit shall: 1. Identify applicable current national and international laws, regulations, treaties, agreements and OHS standards relevant for the organization and its activities; 2. Identify, anticipate and assess hazards and risks to safety and health arising from the existing or proposed work environment and organization; 3. Determine whether planned or existing controls are adequate to eliminate hazards or control identified risks; and 4. Analyze data provided from workers' health surveillance for the present activities or equivalent ones elsewhere. The audit shall be appropriately documented (text, tables, and photos) and shall subsequently be used for decision-making on implementation/revision of the OHSMS. The audit will further establish a quantified baseline for the objectives and achievements of the OHSMS.

OHS OBJECTIVES

Consistent with the OHS Policy Statement and results of OHS audits, measurable objectives shall be established for the entire organization and for individual departments. The objectives shall be realistic, achievable and focused on continued improvements. The objectives should be communicated to all relevant functions of the organization. The objectives shall be periodically evaluated and revised.

SYSTEM PLANNING, DEVELOPMENT AND IMPLEMENTATION

The system shall, at minimum, be planned and developed to comply with national laws and regulations, IFC guidelines, and to fully support the elements endorsed by the organizations senior management. The planning, implementation and operation shall be closely related to the objectives established by the audit. The OHSMS shall ensure availability of sufficient resources for achieving the established goals.

HAZARD PREVENTATION AND CONTROL MESAURES

Hazards and risks to workers' safety and health shall be identified and assessed on a recurrent basis. Identified occupational hazards may be analyzed and prioritized using the below qualitative risk analysis matrix 30. Consequences Likelihood Insigni-ficant 1 Minor 2 Moderate 3 Major 4 Cata- strophic5 A. Almost certain H H E E E B. Likely M H H E E C. Moderate L M H E E D. Unlikely L L M H E E. Rare L L M H H Legend E: extreme risk; immediate action required H: high risk; senior management attention needed M moderate risk; management responsibility must be specified L: low risk; manage by routine procedures Preventive and protective measures should be introduced immediately when a hazard is recognized and fully implemented in the shortest feasible time. Further in the following order of priority: 1. Eliminate the hazard/risk; 2. Control the hazard/risk at source through use of engineering controls and organizational measures; 3. Minimize the hazard/risk through design of safe work systems and administrative control measures; and 4. Where a residual hazard/risk cannot be adequately controlled, the employer shall provide for free appropriate personal protective equipment and implement measures to ensure its use and maintenance. 30 Reference Australian, New Zealand Risk Management Standard AS/NZS 4360:1999.

The established preventive and protective measures and operational procedures shall be revised regularly and modified if necessary. Measures shall comply with national laws and regulation, reflect good practice, and consider the current status of knowledge of the sector.

MANAGEMENT OF CHANGE

The impact of proposed changes both internal (organization, staff, procedures, processes etc.) and external (new regulation, OHS knowledge, technology, organizational mergers, etc.) must be evaluated and preventive steps taken prior to their introduction. Application of new methods, materials, processes, equipment and tools should always be preceded by a hazard identification and risk assessment involving the affected workers. Issuance of a “decision to change” can ensure that all affected employees are properly informed and trained when needed.

EMERGENCY PREVENTION, PREPAREDNESS AND RESPONSE

Emergency prevention, preparedness and response arrangements shall be suitable for the needs of the organization. The plans shall be prepared in cooperation with external emergency services and agencies as applicable. The arrangements must ensure adequate internal exchange of information and communication, and provide for information and communication with outside authorities and the neighborhood as needed. The system must adequately address first-aid and medical assistance, firefighting and emergency evacuation of staff. Training and exercises shall be conducted.

PROCUREMENT

Procurement includes a potential for changes. Procedures must be established to ensure that safety and health requirements of the organization are implemented in procurement, renting and leasing specifications. The OHS requirements of the organization shall be identified and compliance with these demands ensured prior to procurement of goods and services.

CONTRACTING

Procedures shall be established to ensure that the OHS requirements of the organization apply to contractors, sub-contractors, service providers and their workers. OHS criteria should be included when evaluating and closing contracts. Contractors should be committed to provide OHS training appropriate for the contracted works to the involved workers and managers. Work-related injuries, ill health, diseases and incidents among the contractors' and subcontractors’ workers occurring while performing work for the organization shall be recorded according to the demands of the OHSMS and reported to the organization. The organization shall regularly monitor the OHS performance of contractors and sub-contractors and ensure that appropriate training has been provided and that on-site procedures are followed.

EVALUATION

PERFORMANCE MONITORING AND MEASUREMENT

Procedures to regularly monitor, measure and report OHS performance and procedures shall be developed, implemented and periodically reviewed. The OHSMS manual shall specify the monitoring responsibility of different levels of the employer's management. Qualitative and quantitative performance indicators shall be used according to the size and nature of the organization. The monitoring shall provide sufficient feed-back on OHS performance. Active monitoring should include elements required by a proactive OHS management system such as: 1. monitoring of the achievements of specific plans, established performance criteria, and fulfillment of objectives; 2. systematic inspection of work systems, premises, plant, and equipment (job hazard analyses); 3. surveillance and monitoring of the working environment, including the organization of the work and activities involved; 4. surveillance of workers' health where appropriate; and 5. compliance with laws, regulations and other requirements. Reactive monitoring should include identification, reporting and investigation of: 1. work related injuries, ill health (including record keeping and monitoring of sickness/absence), diseases, and incidents: 2. other losses such as damage to property; 3. deficient safety and health performance including OHSMS failures; and 4. workers rehabilitation and health restoration programs.

INVESTIGATION OF WORK-RELATED INJURIES, ILL HEALTH, DISEASES, AND INCIDENTS

All work related injuries, ill health, diseases, and incidents must be investigated by a competent person to identify any failures in the OHSMS. The outcome of investigations shall be communicated to the Safety and Health Committee where established and to persons responsible for corrective actions. Reports produced by external investigative agencies shall be acted upon in the same manner as internal investigations. AUDIT Arrangements shall be made for periodic audits of the OHSMS to confirm the adequacy of the system. An audit policy should cover independency of auditors, scope and frequency of audits, methodology and reporting.

MANAGEMENT REVIEW

The employer's management shall regularly review the OHSMS and assess whether it meets planned performance objectives and whether it is adequate for meeting the needs of the organization and its stakeholders. Management must evaluate the need for changes to the overall system or parts thereof, identify actions required to remedy deficiencies, and evaluate the effectiveness of follow-up actions from previous management reviews.

ACTIONS FOR IMPROVEMENT

The OHSMS shall include a capacity for continuous evaluation and analysis of system performance and follow-up actions to address partial or overall improvements. Planning and implementation of needed improvements should follow the decision process outlined above.

C Related Studies

C.1 Retrospective review of the Bumbuna Hydroelectric Project

Full report overleaf

DRAFT FINAL REPORT

21 January 2005

Retrospective Review of the Bumbuna Hydroelectric Project: Emphasizing the role and application of Options Assessment Concepts

Prepared for the:
The Bumbuna Project Implementation Unit (PIU)
Ministry of Energy and Power
Sierra Leone

Prepared by:
Lawrence J.M. Haas
In collaboration with the Bumbuna PIU
And with contributions from Stakeholders

Bumbuna Project Implementation Unit (PIU)
Mr. Nathaneil Vandy
Electricity House,
Siaka Stevens Street,
Freetown,
Sierra Leone.

21 January 2005

Reference: Draft Final Report
Retrospective Review of the Bumbuna Hydroelectric Project: Emphasizing the role and application of Options Assessment Concepts

Dear Mr. Vandy,

It is a pleasure to submit the Draft Final Report for the retrospective review of the BHP.

The report is based on discussions with stakeholders on two visits to Freetown in the September to November 2004 timeframe and a desk review of the available documents.

As required in the Terms of Reference, the retrospective review is prepared as a stand-alone report that integrates options assessment and stakeholder involvement concepts with the documentation of the project history. This reflects the unique situation where the Bumbuna HEP has been developed in stages from the early 1980's, and is 85% completed today.

To conform to national EIA regulations and World Bank environmental and social safeguard policies concerning the assessment of options and within-project alternatives, sections of this review are to be incorporated in the EIA Update study. Additionally, the report provides observations on how options assessment concepts are relevant to future power sector planning and efforts to secure project financing for sustainable alternatives.

I take this opportunity to express my appreciation for your time and the support extended by the Bumbuna PIU, as well as the other stakeholders from the government, the private sector and civil society who contributed their views and insights to date.

I look forward to comments and incorporating these in the Final Report.

Sincerely yours,

Lawrence J.M. Haas
Team Leader

PREFACE

Development of the 50 MW Bumbuna Hydroelectric Project (BHP) has long been the cornerstone of the Government's strategy to meet Sierra Leone's immediate and future electrical supply needs. The project was 85% completed when work was abandoned in May 1997 due to the escalating rebel war. Since the restoration of peace in 2002, the Government has sought to complete the project by late 2006 as a matter of urgency through a mix of financing facilities that include potential private sector participation.

In the short-term, the Bumbuna HEP will alleviate chronic shortages in power supply for the Western Area grid, essential to the post-war economic recovery strategy. This will enable a quantum improvement in the quality of life for close to a third of the country's population. Completion of the project otherwise represents a long awaited first step to reduce the nation's reliance on high-cost imported oil and to establish a platform for interconnection of isolated provincial power supply networks over the medium and longer term.

Objectives of the Retrospective Review

This retrospective review, firstly, considers the history of decision-making on the Bumbuna HEP focusing on the application of options assessment concepts for the project selection and choice of within-project alternatives. Secondly, it draws lessons for future power sector development. Here an underlying aim is to consider how improved options assessments can contribute to the sustainable development and financing of the power sector based on indigenous renewable energy resources, which include hydropower, biomass and solar.

Key Observations

The decision to develop hydropower and proceed with the Bumbuna HEP as the first major project in the country was well grounded in Sierra Leone's evolving national development and power sector policies from the time the project was first identified in 1970-71. Over 20 years ago, the Act passed by Parliament that created the National Power Authority (NPA Act-1982) mandated the NPA to, " … plan, construct, and operate the Bumbuna HEP and to provide for its integration into the overall electricity supply system in the country".

1. The Past: - with the benefit of hindsight:

- In reaching these decisions, the project was evaluated and optimised not only as a stand-alone hydropower project, but as the first stage of a possible larger Bumbuna-Yiben hydropower development scheme with an ultimate potential of 275 MW;
- The recommendations to develop the site and the selection of the preferred design and project layout were based strictly on engineering, economic and financial criteria;
- Environmental and social considerations were not explicit in the site selection, and there was no apparent effort to optimise the combined economic, social and environment performance of the project or the longer-term operating strategy – indeed the project EIA was not started until mid-way during construction of the project in the 1990's;
- There was no apparent consultation with locally affected communities or a broader group of national stakeholders on the decision-making criteria, apart from the government officials, the power utility and donor partners supervising the project consultants;
- Decisions regarding the project were made wholly within the power sector in the absence of any long-term basin development plan or water use plan for the Seli (Rokel) River basin, where the project is a long-life water infrastructure project;
- The options assessment methods acceptable then would not be sufficiently rigorous or participatory to secure project financing from international sources in today's context, or otherwise to engender stakeholder ownership and public support for the project.

Notwithstanding past weaknesses the analysis and decision-making approaches conformed to international practices of the day, with the exception of the lack of an EIA. Most critically, the Bumbuna HEP was evaluated as the least-cost power supply option for the Western Area grid in all the donor-supported studies that led to the decision to secure project financing in the late 1980's. The main concern then was the timing of the project in relation to the load growth and its national affordability in relation to the cost of the first stage, which led to the present scaled-down project to resolve these concerns.

2. **The Present-day: -** improving the overall development performance of the BHP

The post-war decision to complete the Bumbuna project is supported by economic appraisals prepared by the Donors in 2002-2003. There is little doubt its completion is widely supported by all segments of society - based on local and national level stakeholder consultations undertaken as part of the IDA supported safeguard studies from mid-2004.

The environmental and social safeguard studies also offer a fresh opportunity to evaluate alternatives for the "non-structural" infrastructure and management components of the project, with the benefit of full stakeholder participation that was absent in the 1990's. Apart from sustainable power services, these choices can enhance the project's overall development effectiveness and its acceptance by the local communities "hosting" or affected by the project. These include measures for environmental and social mitigation and enhancement, benefit sharing, institutional arrangements and mechanisms for sustainable financing of the chosen initiatives. In this respect, what is done with the Bumbuna HEP is important as a precedent and model for future power projects in Sierra Leone.

As discussed in this report, the present-day experience with the Bumbuna project also offers a number of general lessons about decision-making on water infrastructure abandoned partway during construction due to war or political instability for other countries in the region.

3. **The Future:** - choosing options for sustainable development of the power sector

Comprehensive options assessment has come to the forefront of the international dialogue on the sustainable provision of water and energy services, particularly around the financing, development and management of large dams.

A clear, integrated strategy is needed for the future expansion of power generation (for grid and off-grid settings), to interconnect isolated provincial networks and to initiate rural electrification programmes. The new Electricity Act and the Energy Policy are expected to clarify the policy framework. Strategic-level options assessments can inform key decisions on which options to pursue, with more comprehensive assessments to decide matters such as design and sequencing of preferred options and interim strategies. Among the challenges are to provide open, systematic and participatory processes for these assessments. For this it will be important to clarify the institutional responsibilities and roles both in strategic planning at the sector and basin levels and for project-level planning.

The new National Energy Policy and Coordination Unit to be established within MoEP can be positioned to play a key role in such efforts, where:

- Procedures for systematic and participatory options assessment may be developed as part of the new power and energy planning framework or system;
- Partnership approaches between government, civil society and the private sector may be pursued to bring the interests and the best capabilities and resources to bear (i.e. appropriate collaboration with university groups, professional associations, NGOs and the major auto generators and power users in the industry and commercial sectors), and
- capacity can be built drawing on the considerable body of international practice.

Among the benefits to be derived from improving the application of options assessment concepts in power sector planning and development, include:

Improving Sierra Leone's access to project financing

Mobilizing and diversifying sources of project financing is an ongoing concern. Improved options assessment can enhance eligibility and access to different financing sources, e.g.

- **International Public Sector Financing**: most multilateral and bilateral development funding agencies as well as the export credit agencies (ECAs) of the OECD countries today require explicit and participatory options assessment in strategic and project-level planning for projects they would support, as do World Bank safeguard policies.

- **International Private Sector Financing**: leading private banks and financing institutions that account for 70% of the global infrastructure financing today have adopted a voluntary industry protocol in 2002, called the "Equator Principles". This directly links lending policies of participating private commercial banks to IFC and World Bank Safeguard policies - sources important for public-private sector financing approaches.

- **CO_2 Emission Reduction/ Carbon Trading:** Financing mechanisms exist today to help developing countries reduce CO_2 emissions as part of climate change mitigation. New international carbon trading systems will be introduced in future. Apart from assessing power sector options against such criteria, Sierra Leone's ratification of the Kyoto Protocol would be an important step to enhance eligibility to such financing sources, not only for hydropower, but to finance alternatives for isolated networks and rural electrification where displacement of diesel generation can be demonstrated.

Moving to integrated management approaches to achieve sustainable development

It is widely acknowledged that sustainable development is synonymous with integrated resource planning and management:

- Options assessment offers a practical and effective tool to foster integrated and participatory planning processes and strengthen cross-sector coordination, particularly when adopted "upstream" in strategic planning and followed through in the design and management phases of dam projects that have multi-sector impacts.

- The philosophy of viewing the Bumbuna HEP as a platform to build experience in integrating environmental, social and economic concerns in power sector projects can provide positive synergies with regional development and environment / social sector policies. For example, to strengthen national environmental management capacities through the Bumbuna EIA review and Environment Management Plan implementation;

- Moreover, the Bumbuna project can serve as a catalyst and model to introduce integrated river basin management (IRBM) and integrated water resource management (IWRM) practices in the country. This will be important if the development of a hydro-based power system for Sierra Leone is preferred. At the same time, this can attract resources to meet relevant international commitments that Sierra Leone has made for environment management such as under RAMSAR (wetlands), UNFCCC (climate change mitigation and adaptation) and CBD (biodiversity management) Conventions.

Thus the completion and subsequent management of the Bumbuna HEP provides an opportunity to catalyse sustainable development not only in the power sector, but also in inter-dependent resource management sectors.

Table of Contents

List of Figures and Tables

Acronyms

AfDB	African Development Bank
DO	Diesel Oil
BHP	Bumbuna Hydroelectric Project
CBD	International Convention on Biological Diversity
DAMAP	Dam Planning and Management Action Plan (IDA)
ECOWAS	Economic Community of West African States
EIA	Project level Environment Impact Assessment
EPP	Emergence Preparedness Plan
ESMAP	Joint UNDP/World Bank Energy Sector Assessment Programme
GOI	Government of Italy
GoSL	Government of Sierra Leone
HFO	Heavy Fuel Oil
IDA	International Development Agency
IHA	International Hydropower Association
ISWL	Insulated Shield Wire Line
MoEP	Ministry of Energy and Power
NCP	National Commission on Privatisation
NEPPC	National Energy Policy Planning Coordination Unit in MoEP
NEPAD	New Partnership for Africa’s Development
NPA	National Power Authority
PIU	Bumbuna Project Implementation Unit
PRG	Partial Risk Guarantee
PPF	Project Preparation Fund
RAMSAR	International Convention on Wetlands
RAP	Resettlement Action Plan
RDP	Regional Development Plan
SEA	Strategic Environment Assessment (Sector, Regional or Basin level)
SLEC	Sierra Leone Electricity Corporation
UNECA	United Nations Economic Commission for Africa
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
WAPP	West African Power Pool
WCD	World Commission on Dams

Introduction

Objectives of Review

1. This retrospective review is part of a package of studies financed by a Project Preparation Fund (PPF) provided by IDA to inform decisions on the completion, commissioning and ongoing management of the Bumbuna HEP. This includes steps to optimise the economic, social and environmental performance of the project as well as its role in the transition to sustainable development and management of the power sector in Sierra Leone.

2. In that interest, the objectives of this review are to:

- Document the history of the project focusing on the options and criteria considered to arrive at the decision to develop the Bumbuna HEP and select the within-project alternatives;
- Illustrate who was involved in key decisions and the extent of the stakeholder consultations, both historically, and in the project preparation work underway today;

3. While the review is prepared as a stand-alone report, selected sections will be integrated in the Environment Impact Assessment (EIA) to conform to the national EIA procedures of Sierra Leone and World Bank safeguard policies, particularly Operational Policy and Procedures (OP 4.01) on Environmental Assessment that deals with options assessment.

Scope of Work and Approach

4. The review addresses the following questions that reflect key concepts in options assessment and the Bumbuna HEP situation, namely:

Q1. What are the main options for bulk power supply in Sierra Leone?

Q2. How and why was the Seli (Rokel) River selected as the first major hydropower development in the country? What were the key criteria and assumptions in reaching that decision?

Q3. How and why were the current site, project layout and design identified and selected, as well as the major within-project alternatives?

Q4. To what extent were local and national stakeholders and other interested parties involved or consulted in reaching the key decisions?

Q5. How would past practices compare with emerging “good practice” today in options assessment and effective stakeholder involvement?

Q6. How and why was the decision to resume the construction and completion of the project made in 2003, subject to the results of the safeguard studies?

Q7. What lessons may be drawn for future generation planning and project development and management activities in Sierra Leone, particularly in regard to the value-added benefits of improved options assessment as a tool for sustainable development of the power sector.

5. This Draft Final report is based on:

- Review of the key project documents and reports available in Sierra Leone with the government, the project consultant and contractors and non-government stakeholders;
- Interviews with key stakeholders with knowledge of the project history, and those representing decision-actors and stakeholder interests today;
- Field visits (to the Kingtom thermal power station in Freetown and field work of the transmission and reservoir Resettlement Action Plan (RAP) and EIA Update teams who consulted with affected communities and local authorities under the supervision of the PIU);
- Discussions with Team Leaders of the safeguard studies and other project preparation studies launched by the Government in 2004 with IDA support; and
- Comments on the circulation draft of the report, through the Dam Review and Environmental and Social Panels and the Government’s Technical Committee.

6. Members of the inter-agency Technical Committee overseeing the Project Implementation Unit (PIU) were briefed on the purpose and scope of this review at the start of the assignment. It is expected the draft final report will be presented to the Technical Committee along with the draft EIA and incorporated in the public consultation process for the EIA. Stakeholders contacted during an initial visit in September-October 2004 and a second visit in early November 2004, are listed in Annex F. The Final Report will be based on the comments received on this draft.

7. The reference points for the observations and lessons drawn on "good practice" for the application of options assessment concepts and effective stakeholder involvement in the selection, development and management of dams include:

- Relevant World Bank practices and safeguard policies, particularly the sourcebook, "Stakeholder Involvement in Options Assessment" prepared under the World Bank's Dam Planning and Management Action Plan (DAMAP), with ESMAP support in 2003. That builds on international dialogue and recent multi-stakeholder reports on the role of dams in development, and
- The Sustainability Guidelines and Compliance Protocol of the International Hydropower Association (IHA), 2004.

Report Structure

8. The retrospective review is presented in five sections:

Section 1: Briefly discusses today's context in respect to the policy, legal and institutional framework for power sector development in Sierra Leone and related factors relevant to this review. It then describes the nation's energy resource base, key features of the full Bumbuna-Yiben hydropower development scheme and the Bumbuna HEP.

Section 2: Provides a story of the project history, integrating that presentation with a discussion of the important project studies and investigation activities, the prevailing circumstances in power sector development and who was involved when key decisions were taken on the BHP project.

Section 3: Looks more in-depth at how options for bulk power supply were assessed at various stages leading up to the decision to finance the project in 1988-89, including the finalization of the project layout and design. This is compared with emerging "good practice" in options assessment today. Section 3 also highlights the types of options assessment important to future decisions on power sector development after completion of Bumbuna Phase 1, largely based on the recommendations of the UNDP/World Bank report "Issues and Options in the Energy Sector" (ESMAP-1987), and the Power Sector Master Plan (1996), both relevant in today's situation.[i]

Section 4: Looks at options assessment from the perspective of meaningful and effective stakeholder involvement and highlights the stakeholder consultation approaches and mechanisms that are employed in the current round of Safeguard studies. In these studies decisions on the "non-structural" alternatives of the BHP are being taken, including those for social and environmental mitigation and enhancement, benefit sharing, and institutional and financing arrangements.

Section 5: Provides summary observations and draws lessons for the application of options assessment concepts in future power sector development. This takes into account the nature of the choices faced by Sierra Leone. These also reflect emerging international "good practice", such as: clarifying institutional roles; building capacity and partnerships; fostering integrated management to achieve positive synergy between the development of the power sector and other sectors of the economy; improving access to project financing, including new carbon financing sources where fossil fuel generation is displaced; and meeting commitments under international Conventions important to sustainable development. Among the lessons offered are those on post-war decisions to rehabilitate and resume construction of water infrastructure previously abandoned or delayed.

Today’s Context

1.1 Country background

9. Sierra Leone presently ranks as the poorest country on the African continent despite its substantial natural resource endowment including abundant freshwater resources, fertile land, mineral resources, fisheries, biodiversity and tourist potential. The country’s history during the 1990s was characterised by military take-overs and escalating war between the Government and the Revolutionary United Front (RUF). As the nation emerged from 11-years of armed conflict supported by a peace process carried out under the military security and auspices of the international community, the general elections in May 2002 have been followed by the present peace and political stabilisation. More than a decade of rebel conflict has nevertheless left a legacy of destroyed public and private infrastructure, 2 million homeless out of an estimated population of 5.8 million (2004), almost 500,000 refugees, high unemployment and widespread poverty throughout the country.

10. From independence in 1961, governance in Sierra Leone has been founded on a constitutional democracy based on English law and customary laws indigenous to local tribes. The country is administratively divided into 3 provinces (the North, Southern and Eastern Provinces) and further into districts (61 in total). The Western Area Grid serves the major load centre around the capital city Freetown located in the North Province on the Atlantic coast. Close to 2 million people (roughly one third of the country’s population) live in this area, where much of the country’s commerce, government, light industry and non-agriculture employment are concentrated.

11. The Government’s post-conflict economic recovery programme, together with private sector investment resulted in an encouraging GDP growth rate that reached 6.5% in 2003. While there are serious cash shortages to contend with, the IMF has forecast an average GDP growth of just under 7% through 2008.[ii] This is premised on agriculture output gradually increasing after the resettlement of displaced farmers back to their farming communities, and the commercial and manufacturing sectors, particularly the mining industry gradually investing to restore their assets and production capacity. Economic growth is important both in respect to its implications for electricity demand growth and for the catalytic role that reliable, affordable power services in turn would play in sustaining the recovery, thereby generating much needed jobs, welfare improvement and poverty reduction benefits.

1.2 The BHP in relation to the National Policy Framework

12. Hydropower development, particularly the implementation of the Bumbuna HEP is well founded in the national development policy and energy policy framework. Consistent policy themes since first nation-wide hydropower inventory completed with UNDP support in 1970-71, include:

- Expanding electricity services to catalyse development, growth and job-creation in the modern sectors of the economy;
- Reducing the nation’s heavy reliance on high-cost imported fossil fuels;
- Developing and utilizing indigenous renewable energy resources, particularly to develop a hydro-based power system;
- Improving the reliability of power supplies in the interior of the country through interconnection of provincial centres, and as a basis for widespread rural electrification.

13. Presently Sierra Leone relies on expensive imported oil for virtually all its grid and off-grid power supply. Apart from producing one of the highest electricity tariffs for public supply in the world (over $USc 20 /kWh) it leaves the economic recovery and job-creation priorities vulnerable to rapid price fluctuations in international oil markets, as seen particularly since 2003.

14. The Government now aims to complete the construction and commissioning of the 50 MW Bumbuna hydropower project by 1ate 2006, through a mix of financing facilities that include potential private sector participation. At a Donor’s meeting held in Freetown in Sept 1993, the international community pledged support for this effort. IDA’s contribution is in the form of a Project Preparation Fund (PPF) and Partial Risk Guarantee (PRG) of $US 20 million. A portion of the PPF is directed to preparation of studies to comply with national legislation and World Bank safeguard policies, to be completed before the end of 2004 (See Annex C for the safeguard studies underway).

Ongoing Energy and Electricity Sector Reform

15. The NPA Act-1982 that transformed the Sierra Leone Power Supply Corporation into the National Power Authority was the country's first major legislation on hydropower. Section 14 of the Act mandated the NPA, to plan, construct, and operate the BHP and to provide for its integration into the overall electricity supply system of the country. However, primary legislation to help coordinate power sector policies with other sector development policies has been lacking.

16. To address this gap, the Ministry of Works, Energy and Power created in 1977 (later changed to MoEP) is preparing a draft Energy Policy in a collaborative process with private sector and civil society stakeholders. The UN (UNECA) is providing financial support. [iii] The main policy thrust as expressed in the draft is, "To provide an enabling environment for the efficient management of Sierra Leone's energy resources aimed at ensuring energy security for its citizens, in an environmentally benign manner for sustainable development."[iv] The pathway is seen as enhancing the development and utilisation of indigenous renewable energy sources and demand management. The policy document and ensuing discussion will help to clarify roles and responsibility for energy planning, management and cross-sector coordination and likely form the basis for a formal Energy Act.

17. Presently, the IDA is also helping the Government with a range of policy and regulatory reform tasks including developing the first Electricity Act, establishing a Regulatory Agency for the electricity sector, and instituting commercial reform of NPA through performance-oriented management contracts. A new National Energy Policy Planning and Coordinator Unit (NEPPCU) will also be created within MoEP. This is important as a likely responsibility centre for coordinating participatory options assessment exercises (i.e. involving all agencies and interest groups).

18. As part of the wider public sector reforms in the post-war situation, the responsibility of the MoEP for the NPA was redefined by the enactment of the National Privatisation Commission Act (2002).[v] Here, the National Privatisation Commission (NPC) was made responsible for a government-wide process to divest selected public enterprises, including NPA. The stated policy aim is to: a) enable the public sector to focus on delivery of basic services to the poor, especially in rural areas; b) allow wider private sector participation to enhance economic opportunities; and c) remove the fiscal burden imposed by non-performing public enterprises on the government budget.

19. In sum, the various legislative reforms now underway will help to clarify the policy, legal and institutional environment for the operation of the BHP, as well as the roles and responsibilities for planning and options assessment to inform future decisions on electricity supply development.

Other Sector Policies Impacting on the Bumbuna HEP

20. Various other sectoral laws and International Conventions have implications for present-day decision-making on the Bumbuna HEP, as well as balancing economic, social and environmental considerations in the evaluation of future power supply options.

21. National water resource policy: Presently, policies for water resource management in Sierra Leone are lacking, or at best formative. As yet there is no primary water legislation or formal Water Act. Observers suggest that any initial water legislation may focus more on water service provision than river basin management per se, the latter being more significant for hydropower development.

22. A potentially important development was the Cabinet Decree in the late 1990's that established a Seli River Basin Development Authority. While this entity is not functional today, a fully representative and functional River Basin Authority would play an important role in introducing IWRM practices into Sierra Leone, consistent with recent international developments in this field (e.g. IWRM approaches to water allocation and management from the upper catchment to the estuary). The key question is perhaps when to activate the Seli Basin Development Authority, not whether. This for example, would involve deciding if the investment in a fully functional basin authority is needed today to parallel development of BHP, or later, when decisions on subsequent stages of the full

Bumbuna-Yiben scheme are clear (stages are discussed later in this section). While Bumbuna is essentially a run-of-river project, the full development scheme has multi-annual storage capability and thus more substantive implications for water regulation, allocation and use in the Seli Basin.

23. National Environment policy: Sierra Leone has numerous laws relating to the sectoral management of the environment and natural resources. However, the 1994 EIA of the project observed that most of the laws at that time were inadequate, or not enforced. Sierra Leone's National Environmental Policy (NEP) was subsequently clarified with the National Environmental Protection Act (2000). It sets out the administrative responsibilities in the environment sector under the National Environment Protection Board. Presently, the Environmental Department (ED) within the Ministry of Lands, Housing and the Environment acts as the administrative arm of the NEPB. It coordinates policy development and tasks such as setting standards, monitoring and the provision of environmental data and information. Actual jurisdiction for environment management is split among a number of line Ministries (e.g. the Protected Areas Act and the Wildlife Conservation Act under the Secretary of State of Agriculture, Natural Resources and Forestry). Of immediate relevance to the BHP are the EIA procedures requiring options assessment, consultation with the affected communities and public review of the draft EIA report. This review will be led by the ED, which presents an immediate opportunity to strengthen the Department for its water sector responsibilities.

24. International / Regional Conventions and Partnerships: Sierra Leone is a Party to several international conventions relevant to the development and management of large dams. Those with potential significance and relevance for hydropower development are listed in Table 1.

Table 1: International Conventions with implications for hydropower in Sierra Leone

International Convention	Status in Sierra Leone	Relevance to BHP and future hydropower development
UNFCCC (United Nations Framework Convention on Climate Change)	Ratified in 1996. The First national communication is under preparation (dealing with GHG emission inventory and mitigation)	- potential mitigation of GHG emissions moving off-oil to hydro development - basis for collaboration with the international community on developing renewable energy sources and technologies - Commits Sierra Leone to preparing a strategy for climate change adaptation in the water resources sector (e.g. preparing NAPAs) [vi]
Kyoto Protocol (agreement on GHG reduction and targets)	Endorsed in 1996. Not yet ratified by Parliament (proposed ratification in late 2005-early 2005)	- Commits Sierra Leone to a GHG reduction schedule, including the power sector. - Opens the door to international financial support for renewable power generation to displace fossil generation - Opens the door to future international carbon trading credits for Sierra Leone.
RAMSAR Convention on the protection and management of wetlands	Ratified in 1999. Came into force 2000. Designates the "Sierra Leone River Estuary", a 295,000-ha coastline stretch from Cape Point on the Freetown Peninsula across to the Bunce Creek as a RAMSAR site.	- Commits Sierra Leone to develop wetland management policies and related programs and capacity building for wetland management. - Provides opportunity for financing support from the international community.
CBD Convention on Biodiversity	Member to the Convention since 1994 (by Accession), but not signed	- Commits Sierra Leone to the assessment of biodiversity impacts, protection of rare or endangered species and capacity building. - Provides a basis for impact assessments

		and wildlife management programmes – e.g. impacting on watershed management - Provides opportunity for financing support from the international Community.

25. The challenge in future will be link steps to meet these commitments with power sector policies and strategies. For example, hydropower options would be evaluated in light of the various Convention commitments (e.g. for positive synergies and adverse implications) up-front in strategic planning, and then at the project-level in the design and management of dams in a basin context.

26. Sierra Leone also participates in several Africa-region forums that may influence what options are selected for future power development. Among these forums, the New Partnership for Africa's Development (NEPAD) is exploring opportunities for collaboration on energy trade and power exchange. Here, the longer-term vision is to establish a West African Power Pool (WAPP) to facilitate grid interconnections between Sierra Leone and neighbouring countries (i.e. Guinea to the north and west, and Liberia to the southeast), though Sierra Leone is on the second or third tier. Sierra Leone is also a member of the Economic Community of West African States (ECOWAS). This entity encourages energy trade and information sharing in a number of areas including petroleum exploration and the development of renewable energy resources for power generation at all scales from grid supply to village and household-scale use. With Liberia and Guinea, Sierra Leone is in the Mano River Union (MRU) a customs union formed primarily to implement development projects and promote regional economic integration. However, the MRU has so far been inactive because of domestic problems and internal and cross-border conflicts in all three countries.[vii]

1.3 Sierra Leone's water and energy resource base

27. Sierra Leone's most significant energy resources are renewable, namely: its water resources, biomass and solar energy potential. The electrical conversion technologies for each energy source have different technical and economic potential for grid and off-grid applications. As documented in various energy assessment reports prepared in the last two decades.[viii]

- **Water Resources**: Sierra Leone is one of the wettest countries in Africa with annual rainfall between 2000 mm in the north and 4000 mm in the south, but with markedly dry winter periods. The 9 main river systems (800 km) have an estimated 1,200-1,300 MW economic potential of hydropower. Some 22 medium and large hydropower sites have been identified or studied at preliminary levels to date, along with a further 20 small hydro sites. There is limited experience with hydropower. Operating facilities include the 2.5 MW Goma hydropower station, owned by the water supply utility serving Freetown, and the 4.0 MW plant on the Dodo River near Kenema built with Chinese support to supply the Bo-Kenema local network.
- **Biomass Sources:** The biomass potential of the country is significant. The theoretical potential has been estimated at up to 2 million tonnes of oil equivalent, mainly from agricultural waste and crop residues (the main sources being rice husk and straw, palm fruit fibres and kernel shells). Forest regeneration is another potential biomass source with annual yield estimated at 9.5 to 15 million m^3 per year, though forest resources are under stress in many areas.[ix] Fuelwood and charcoal presently account for 80% of primary energy demand in the country. Experience with biomass generation includes two sawmills that produced steam to run turbines and the 2 MW cogeneration bagasse plant at the Magbass Sugar Cane complex in the Seli River basin.
- **Solar and wind**. Most energy assessments consider wind generation as having moderate site-specific potential. Wind velocities in Sierra Leone (as in many tropical countries) are generally low, averaging about 2-5 m/s, and are largely confined to 3 months of the year. Solar has large technical potential with estimated average solar radiation of 1,460 to 1,800 kWh/ (m^2/y). Presently it is uneconomical for grid-applications, but has immediate potential for stand-alone solar PV homes in rural areas to supply small but vital electricity services.[x] A few small demonstration photovoltaic projects have been funded by development agencies to date.

28. Sierra Leone has limited coal resources and as yet no proven oil or gas reserves. Lignite deposits were originally identified in the late 1940’s at Yema, about 42 km east of Freetown. Subsequent drilling and investigation studies have identified small deposits in other areas including Songo, Masanke and Kenema. Overall coal reserves have been estimated between 700,000 and 1.0 million tonnes (UNDP, 1980). However, a combination of high water content, low calorific value, heavy overburden and small quantities make the identified coal resources unattractive for grid-scale power generation. The Government is interested in evaluating the potential for hydrocarbons. It passed the Petroleum Exploration and Production Act in 2001 and in 2003 awarded concession to three international oil companies to explore for petroleum resources along the coastline.[xi]

1.4 The BHP in relation to the power sector situation: Demand and Supply

29. The electricity sector in Sierra Leone is relatively small. It essentially has 3 tiers, consisting of: (1) public services provided by NPA to customers on the Western Area grid; (2) autonomous commercial networks such as Bo-Kenema; and (3) isolated provincial stations with local networks. About 90% of the electricity supplied to the public is consumed in the country's four main cities: Freetown (82%), Kenema (3%), Bo (3%), and Makeni (2%). In addition there is auto-generation in industry and commercial sectors, particularly mining, as well as in the household sector.

30. NPA is responsible for the operation of the Western Area grid system and 12 of the 16 provincial stations and networks, but also provides technical support for local diesel power stations operated by other Ministries. It has oversight responsibility for the Bo-Kenema system (9 MW nominal capacity) serving the second largest urban area in the country. All larger private generators in the mining and commercial sectors, except for small household generation sets are licensed by NPA.

31. Demand and Constrained Supply: Historically, demand in the Western Area grid rose steadily from Independence in 1961 to a peak of 133.5 Gwh in 1982 when NPA was established (see Figure 1). Annual generation thereafter declined sharply, falling to a low of about 20 Gwh by 1992. Since 1983 there has been a proliferation of private generation ranging from a few kilowatts for private dwellings to hundreds of kilowatts for commercial and industrial establishments.

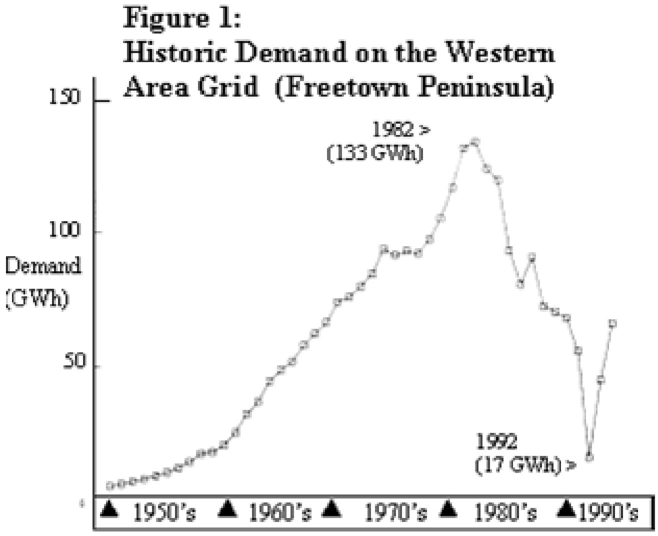


Figure 1: Historic Demand on the Western Area Grid (Freetown Peninsula)

32. Based on past surveys, about 30 MW of private generation capacity was running on gasoline or gas oil (diesel fuel) in the Western Area by 1985 (ESMAP, 1987) and in the order of 40 MW by 1992 (Master Plan, 1996). The output from these small producers, combined with private generation at the mines (estimated to be further 28 MW) has greatly exceeded NPA's total generation in past, though much of the installed capacity in the mines and provincial towns was lost or degraded during the 11-year conflict.

33. In the post-war context service to consumers on the Western Area grid is characterized by daily massive blackouts, high tariffs (20 $USc/kWh) and high losses (in excess of 40%) and low collections. In the interior Provincial centres, the chronic fuel supply constraints and resulting power shortages serve to restrict economic and social activities and cripple the effective functioning of health and water supply facilities.

34. Steady Deterioration of Diesel Generation: Previously, power supply to the Western Area was provided from three diesel power stations in the Freetown area. With ageing equipment, capacity has effectively been reduced to the one generating facility at Kingtom (27.2 MW nominal capacity). Available capacity with diesels operating on HFO/MO is now 14 MW, closer to 7.0 MW constant.

The Provincial power stations that mostly operate on more expensive diesel oil (DO) have a nominal capacity of 13.7 MW in aggregate. Since the early 1980's NPA has been unable to maintain a reliable supply from diesel generators due a variety of operational, management and external factors, despite cycles of donor-supported rehabilitation programmes.

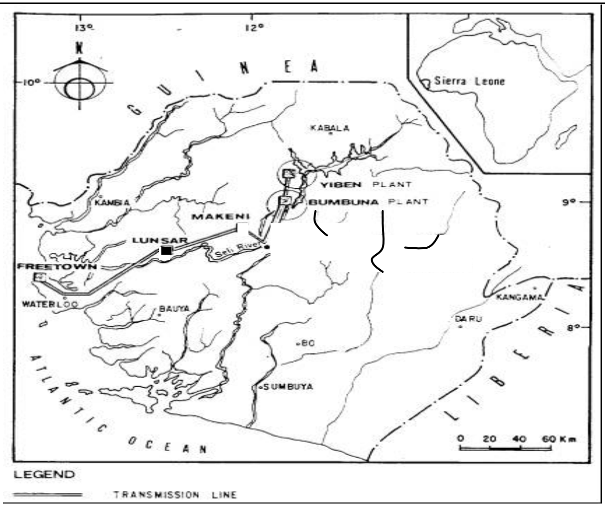
35. In 2004 the IDA provided a Power & Water Credit ($US 35 million from 2004 to 2009), the infrastructure component of which will support the rehabilitation of diesel generation at the Kingtom Power Station and complete essential transmission and distribution rehabilitation works in the Western area grid. Rehabilitation of the thermal capability (to 24 MW) will serve as a stopgap measure to partially restore power supply prior to commissioning the BHP. And will subsequently enable a thermal-hydro operation during the dry season once the BHP is on-line in late 2006.

1.5 Key Features of the Bumbuna-Yiben hydropower development

36. The Bumbuna damsite is located on the upper reaches of the Seli (Rokel) river 200 km northeast of Freetown. The Seli is the third largest of nine major river systems in Sierra Leone. It rises in the mountainous in the northeast of the country and flows for about 100 km across the Interior Plateau in a south western direction. About 30 km upstream of Bumbuna near the village of Yiben the river flows out of the interior plateau through the Sula Mountains in a relatively deep, narrow valley cut into pre-Cambrian crystalline basement rock. After a fall of about 40m over Bumbuna Falls and the adjoining rapids it reaches the interior lowlands floodplains. It subsequently flows eastward to a second fall about 30km upstream of its estuary to the north of Freetown Peninsula (see Figure 2). A regional road from Freetown provides direct access to Bumbuna Town and the dam site nearby.

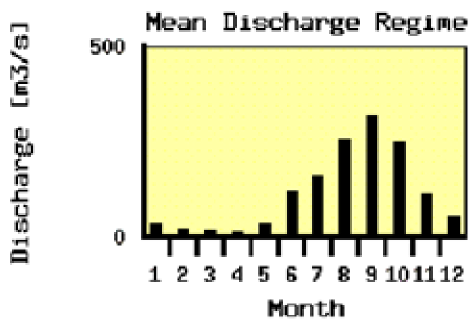
37. As indicated in Figure 3, the Seli River has large flows in the wet season. These drop markedly in the dry season to their lowest in the three months February to April. This hydrology is characteristic of all river systems in the country, which essentially means that a run-of-river hydropower project of any size will require thermal backup to meet the load in the dry season.

Figure 2: BHP Project Location



Source: 1980 Feasibility Study (Adapted)

Figure 3: Hydrology of the Seli River at Bumbuna



Source: Aquastat

The Total Bumbuna-Yiben Scheme

38. The development of the 50 MW Bumbuna project is envisaged as the first phase of a 5-stage development of the Seli River with an ultimate potential of 275 MW (135 MW firm). There are several different versions of the construction sequence to optimise the phases after Stage 1, but all schemes involve two dams (the first and current dam at Bumbuna 2.4 km upstream of Bumbuna Falls, the second dam 28 km upstream of the Bumbuna dam at Yiben) and three locations for powerhouses -

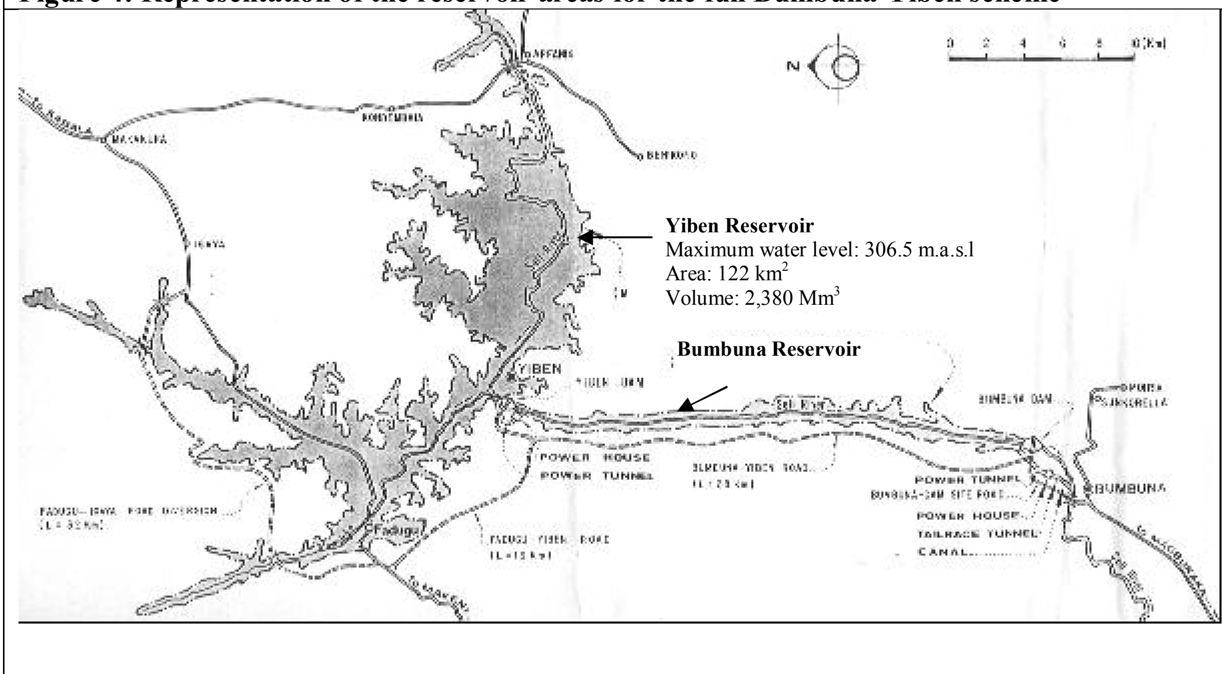
at the base of the Bumbuna dam, at the Yiben dam, and downstream of Bumbuna Falls.[xii] Table 2 illustrates the alternatives for staging the Bumbuna-Yiben development.

Table 2: Alternative phases for the full Bumbuna-Yiben hydropower development	
Stage 1	Completion of the present BHP with a 50 MW powerhouse (2 x 25 MW units) at the base of the 88m dam. Stage 1 will operate as a run-of-river scheme generating 50 MW in the wet season, reducing to 18 MW continuous (equivalent) in the dry season.
Stage 2	Envisages constructing a multi-annual regulation dam at Yiben, 28km upstream. This would regulate inflows to the Bumbuna reservoir, thereby increasing output at Bumbuna to its full installed capacity year round. Alternatives for additional generation capacity include installing a powerhouse at the Yiben dam (with an initial 17 MW unit, after the Power Sector Master Plan, 1996), or alternatively, extending the Bumbuna powerhouse with (2x25 MW) units to raise its output to 100 MW year round (after the 1980 Feasibility).
Stage 3a	Envisages raising the Yiben dam (by 15 meters, 1980 Feasibility study). Generation options include adding / expanding the powerhouse at Yiben (eventual 90-100 MW capacity), but initially installing 45 MW (Feasibility Study 1980); alternatively adding the third powerhouse downstream of Bumbuna Falls (40 MW) fed by a tunnel from the Bumbuna power station.
Stage 3b	Envisages raising the Yiben dam further (24 meters, 1980 Feasibility) and increasing the Yiben power station to full capacity, or adding capacity at the Bumbuna Falls power station.
Stage 4	Depending on previous stages, envisages upgrading capacity (additional units) either at the Yiben, Bumbuna or Bumbuna Falls power stations to their full development potential.

39. The actual timing of any subsequent stage of the Bumbuna-Yiben development would depend on optimisation based on technical-economic and environmental-social criteria, and prevailing circumstances such as the attractiveness of competing generation options and the state of the economy and consequent rate of load growth in the Western Area grid. Another consideration may be whether transmission interconnection with Guinea is pursued (a 114 km transmission would be required), which would impact on the timing and sequencing of any subsequent phase to the Bumbuna HEP.

40. As represented in Figure 4 extracted from the 1980 Feasibility study, the reservoir created by the full Yiben dam will be over ten times the size of the Bumbuna reservoir (2,130 million m^3 of regulation capacity) roughly equivalent to the mean annual flow of the Seli (Rokel) River.

Figure 4: Representation of the reservoir areas for the full Bumbuna-Yiben scheme



Source: 1980 Feasibility Study (Note: some configurations have changed today, but the overall scheme is similar)

50 MW Bumbuna HEP

41. The Bumbuna HEP is essentially a medium scale run-of-river facility. The damsite is located 2.5 km upstream of Bumbuna Falls close to Bumbuna town (population of about 3,000) in the Tonkolili District. The main structures consist of the 88m high rockfill dam now in place with an asphalted concrete upstream face. Two free-standing concrete bellmouth-intake spillways are located just upstream of the dam, one leads to the 9m diameter primary spillway tunnel under the left bank of the dam and the other to a combined power and auxiliary spillway tunnel under the right bank. A 93m tall single-level inlet tower intake 7.5m in diameter connects to the right power tunnel. The surface power station that is located at the toe of the dam (yet to be completed) will house 2 vertical-axis Francis turbines (2x25 MW) and the 161 kV switchyard will be located just downstream of the powerhouse.

42. The reservoir formed will have a 21 km^2 surface area and 445 million m^3 volume at the maximum water level (241.96 m a.s.l.). The active storage capacity will be 350 million m^3, equivalent to about 50 days of full generation output. It will have an inactive capacity (dead storage) of 95 million m^3 and provide 35 million m^3 of flood routing capacity. The spillways have a combined design discharge capacity of 3,000 m^3/s, equivalent to the calculated probable maximum flood. This is about 3-times the maximum-recorded flood flow of 1,052 m^3/s that occurred in September 1970.

43. Key features of the environmental and social "footprint" of Bumbuna are:

- After impoundment, the 88-m Bumbuna dam will create a Y shaped 30-km reservoir with two upstream branches. The width in the main river with narrow, steep valleys will vary between 200m and 1.0 km. The two upstream branches that are 7 km and 11 km long will form in flatter land and rolling hills. The maximum seasonal drawdown would be 31m, and daily fluctuations would be 0.1 m in the dry season, if the plant is used for peaking.
- Downstream, the Seli has a confluence with Port Loko Creek before it disgorges into a wide estuary north of Freetown. The lowest stretch of river is affected by high tide and backing up of saline water during dry season up to the first rapids, 30 km upstream of mouth.
- Subject to the final Resettlement Action Plans (RAP) of the reservoir area and transmission corridor, it is expected up to 1,200 people will be resettled (studies are underway) and up to 4,000 to 5,000 people affected to varying degrees, but will not have to relocate.

44. Once completed, the Stage 1 BHP would function as base and peak load supply during the wet season at the full 50 MW output. During the dry season generation would gradually reduce to 18 MW continuous (equivalent), at which time themal generation would be required to meet the load. If the upstream Yiben reservoir were built, the Bumbuna dam would remain rim-full and generate to its maximum installed capacity year round.[xiii] In that case, the minimum regulated inflow from the Yiben reservoir into the Bumbuna reservoir would be 80 m^3/s, which would be release at Bumbuna. This compares to the "without-dam" natural river flow at Bumbuna of 6.4 m^3/s in March and April.

45. The energy generated at Bumbuna will be supplied to a substation in Freetown through a 200-km 161 kV single-circuit transmission line. To supply provincial centres (in the short-term until conventional substations are built), a low cost solution will be employed by energizing the shield wire above the 161 kV conductors at 35.5 kV. This arrangement will supply Makeni town from the Bumbuna substation and Lunsar town from the Freetown substation with a single-phase service limited to 4 MVA. Thus while the Bumbuna project is primarily to supply the connected load on the Western Area grid network, it is also the cornerstone of provincial interconnection initially to Bumbuna township in the north of the country and the grid connection platform for Makeni / Magburaka, Port Loko / Lunsar and Rokupr / Kambia, and Lungi. Additional circuits would be added in the 161 kV right-of-way for any subsequent phases of the Bumbuna-Yiben development.

46. Figures 5 and 6 below are photos of the current situation at the damsite looking downstream. Presently the dam is in place but not impounded. Water is in free flow through the 9 m diameter spillway tunnel on the left bank. This was used as one of the two tunnels for the river diversion during the construction of the dam (the right spillway tunnel is used only for exceptionally high flood flows).

Figure 6: Seli River section downstream of the Bumbuna dam

Source: Bumbuna PIU (2004)

History of the BHP Project and Decision Making

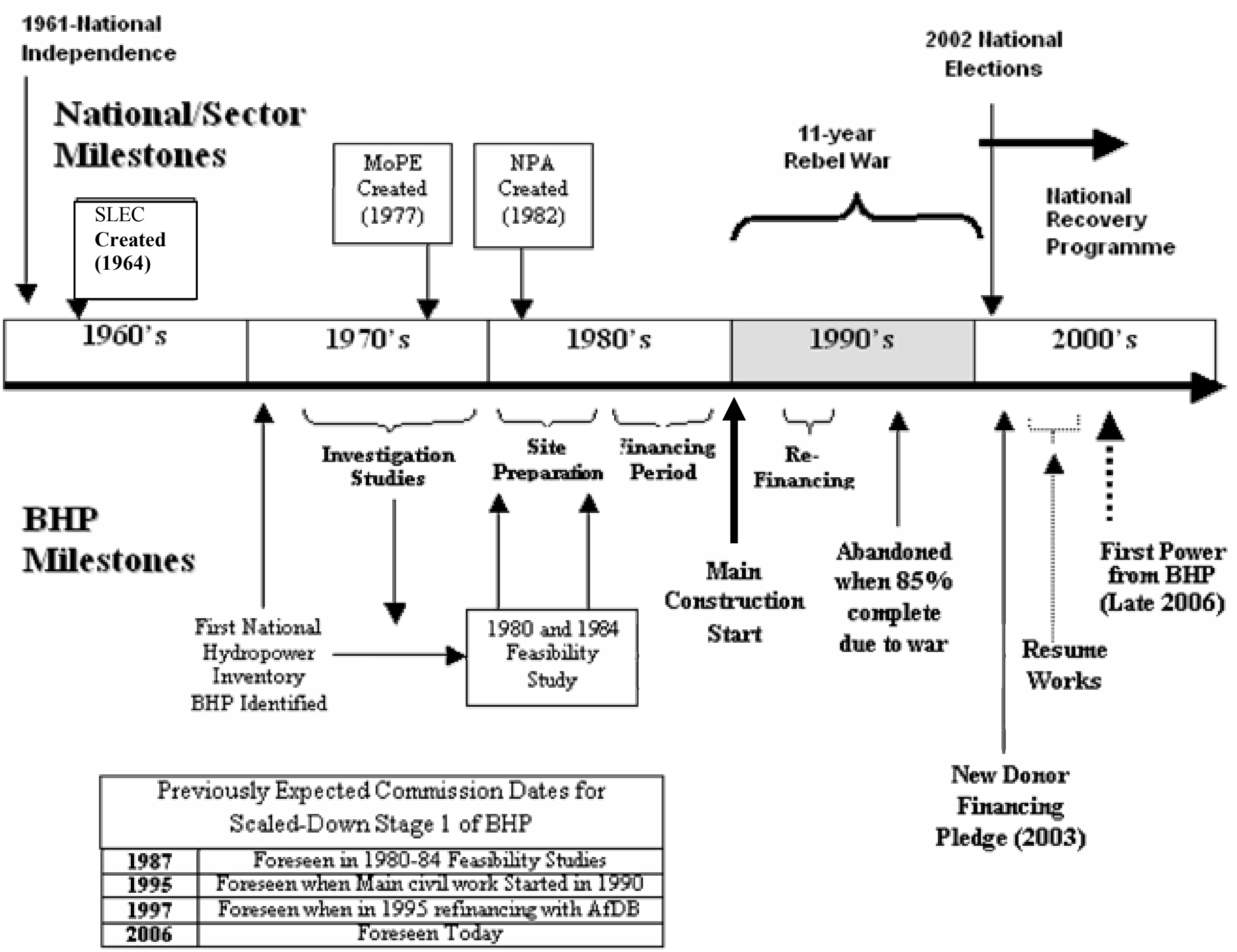
48. Sierra Leone's effort to develop the Bumbuna HEP has a long history, one that may be characterized in the four periods indicated in Table 3. These roughly correspond to different periods and events in the history of the country. The external context includes the price changes in the international oil and commodity markets as well as the emergence of present-day international thinking on sustainable development, integrated water management and stakeholder participation.

Table 3: Four periods in the Bumbuna Project's long history

1970-1985	From the first nation-wide hydropower inventory through feasibility study and initial site preparation work following the 1980 design of the project.
1986-1997	From identification of the scaled-down design (1984) and financing of the project (1989) to abandonment of work in May 1997, when the project was 85% completed.
1998-2002	During the intensified rebel conflict to the official end of hostilities in January 2002, when no work was undertaken on the project.
2002-present day	From the post-war national election in May 2002, to refinancing talks and PPF studies that aim to complete and commission the BHP by the end of 2006.

49. Figure 7 is a simplified schematic showing national and power sector events in a historical context. The major milestones for decision-making on the Bumbuna HEP are elaborated in Annex A. Annex B has a chronology key studies, indicating who was involved and the major conclusions.

Figure 7: Time line graphic of the Bumbuna project history



The 1970 to 1985 Period –Deciding which hydropower project

50. A decade after independence in 1961 Sierra Leone's first nation-wide hydropower inventory was completed. This was part of a study, "Strengthening of the Sierra Leone Electricity Corporation", undertaken by Moto-Columbus of Baden, Switzerland, finance by the UNDP. Twenty-two potential sites for hydropower were identified at that time (1970-71). Preliminary design and cost estimates were prepared to rank the sites in order of economic merit. It was concluded that a 72 MW development of Bumbuna Falls offered the most attractive option to expand and diversify power supply for the Western Area grid. A 15-year Electric Supply Development Plan (1970-1985) was then prepared, with further investigation studies of the Bumbuna in mind as a priority.

51. In 1972-73, SLEC engaged the Italian consulting firm Carloti, in a consortium of Canadian and Italian firms to prepare the Bumbuna Hydropower-Development Project Study. The study sought to determine an optimal layout for the Bumbuna site based on economic, technical and hydrological parameters. A second upstream reservoir site at Yiben not envisaged in the 1970-71 study was identified and a staged-development of the Yiben-Bumbuna scheme was recommended, beginning with a seasonal storage dam at Yiben with a 55 MW power station at the base of the dam.

52. In 1974 the Italian consultant firm Studio Pietrangeli from Rome was engaged by the consortium to review their work. Four possible 30 MW project configurations were identified and compared in the general area of Bumbuna. Studio Pietrangeli was subsequently engaged by the SLEC and GoSL in 1975 to update hydrological studies and prepare power market forecasts and economic studies. It recommended a revision of the first stage to start with a 35 MW power plant at the base of Bumbuna Falls regulated by an upstream reservoir (at the current site) with 320 mm^3 of storage.

53. The World Bank (IDA) became involved at that point when the Government requested technical assistance to review the alternatives and explore IDA's interest in financing the project. IDA staff concluded that it was necessary to upgrade the technical and economic studies. Provision was made for a full feasibility study to be financed by an IDA Credit (734-SL, 1977). The Credit was being discussed at that time to improve electricity generation and distribution facilities in the Freetown Peninsula and several provincial centres. The Bumbuna Hydro-Consultants, a consortium formed by Studio Pietrangeli, Moto-Columbus, Engineering and Management from Freetown, and Tecksult also from Freetown was subsequently selected. Their 12-volume report completed in July 1980 recommended a 305 MW project with five stages. Stage 1 was conceived as a $US 192 million (in mid-1980 US$), 74m high dam with a 53.4 MW plant utilizing the 40m head at Bumbuna Falls and a 2.5 km long headrace tunnel.[xiv] An assessment of the environment effects of the full scheme and the resettlement effects for three different heights of the Yiben dam were prepared, as the Yiben reservoir had considerably more resettlement than the Bumbuna reservoir. The 1980 feasibility study envisaged the completion of the BHP by 1987, after financing, final design and a 4-year construction period.

54. By 1981, the Government's interest in moving ahead with the BHP was high. Escalating oil prices were imposing a sever strain on the economy. With the NPA Act-1982, Parliament gave NPA the mandate to proceed with preparatory work. GoSL arranged financing for a $US 20 million equivalent loan from the Government of Italy and provided $US 4.5 million in government funds. Site preparation works started in late 1982 involving the construction of work camps and access roads and excavation of diversion tunnels. This work was completed by 1985. At the peak, about 1,200 local people were employed. There was resettlement in the area of the dam site though no documentation of number of people involved or the compensation provisions is available. The Italian contractor Salini Construttori, who was involved in road construction projects in Sierra Leone had been awarded a contract for the Bumbuna-Magburak road and bridges to serve as a regional road and site access. Salini was later engaged for geo-technical investigations at the Bumbuna dam site for the feasibility study, which grew into a deeper involvement in the project as prime contractor through Salcost.

55. Meanwhile, as discussions between the government and IDA continued on the 1980 Feasibility study results, IDA delayed he issue of pre-qualification notices for main civil works and E&M and preparation of tenders for International Competitive Bidding (ICB) until separate studies of the unit costs and the macroeconomic impacts of the project were completed. By late 1982 international oil prices had eased from their earlier peaks of $US 36 a barrel in 1980-81 (see Figure 10 in Section 3). Against this trend and the depressed state of the Sierra Leone economy from a downturn in international commodity prices, IDA raised two main concerns: firstly, the ability of the country to finance a project costing US$ 165 million[xv]; and secondly, the comparatively high specific cost ($/kWh) of the BHP stage 1 relative to subsequent stages of the Yiben-Bumbuna scheme.

56. In the ensuing discussions in Freetown in March 1984 involving the IDA, representatives of the Government and NPA, the consultant was directed to prepare a supplemental feasibility study. The conceptual design was to be refined for a scaled-down version of BHP Phase 1, specifically to reduce the total cost from $US 192 million to $US 100 million without jeopardizing the economic attractiveness of the full Bumbuna-Yiben development. The guidance given the consultant was to:

- Reduce the planned construction period from 4 to 3.2 yrs;
- Reduce the installed capacity to 47 MW (corresponding energy production from 424 Gwh/yr to 290 Gwh/yr – for Stage 1);
- Reduce the transmission and E&M costs where feasible, while maintaining acceptable but reduced reliability criteria;
- Postpone all the work not strictly necessary to transport power to Freetown (e.g. excluding the planned transmission lines south from Bumbuna to the diamond mining areas of Sefadu and Songar and defer substations for provincial centres Makeni and/or Lunsar).

57. The scaled-down project was estimated to cost $US 93 million (mid-1984 prices) including transmission to Freetown. The cost reduction was achieved by a combination of changes to the project design, namely: moving the powerhouse from Bumbuna Falls to the toe of the dam converting the existing spillway tunnel to combined spillway-power tunnel, thereby eliminating the expense of the 2-km pressure tunnel; adopting one 47 MW turbine instead of two units; adopting a single circuit (161 kV) transmission line, instead of the double 132 kV circuit and eliminating substations between the switchyard and Freetown. Further measures included reducing the length of the transmission line by rerouting to not follow roads (26km reduction in the Bumbuna-Makeni section and 8km in the Makeni-Freetown section). To compensate for the head loss by moving the powerhouse, the Bumbuna dam height was raised by 17m to 88m. The elimination of 161 kV substations was compensated by choosing a lower-cost 35.5 kV "Insulated Shield Wire Line" alternative to supply Makeni and Lunsar.

58. The study also concluded that the scaled-down Stage 1 would not compromise the ultimate economic development of the Bumbuna-Yiben scheme (1,400 Gwh versus 1,460 Gwh in the 1980 feasibility, with roughly the same portion of firm and secondary energy).

59. In parallel, with these discussions the IDA and GoSL began talks in 1985 on a further Power Sector Credit for transmission strengthening (e.g. replacing old and obsolete equipment) and rehabilitation of thermal plant in the Western Area grid. Apart from meeting immediate needs, these actions were to prepare for the efficient distribution of 50 MW of power from Bumbuna once it became available in Freetown and to enable the thermal-hydro operation in the dry season.

60. 1985 was also a period when the country's cash reserves were close to exhaustion due to prolonged stagnation of the economy. Revenue from mining operations had reduced considerably due to lower international commodity prices. One consequence was the government restricted oil imports. The cutbacks in 1985 were particularly severe, with net petroleum imports declining about 40% below 1984 levels. The expenditure restrictions included limitations on the imports of spares by NPA that were essential to maintain the diesel plant supplying the Western Grid and upcountry. The disruption to the economy from the lack of fuel was significant, especially in rural areas. Transportation services were greatly curtailed and electricity supply that relied on fuel oil being trucked in were limited to a few hours a day, with some areas going without electricity for as long as a month.

61. After a further unsuccessful discussion on the scaled-down BHP project, IDA eventually decided to withdraw from further financing discussions. The decision came against a background of IDA's broader concerns about the country's deteriorating debt servicing and balance of payments position and what it saw as the absence of effective policy responses. This led to a general suspension of all IDA disbursements to Sierra Leone in 1987. [xvi]

2.2 The 1986 to 1997 Period – Financing and construction delays

62. Just as the future of the BHP became highly uncertain, the report of the joint UNDP/World Bank ESMAP team (Sierra Leone: Issues and Options in the Energy Sector) was issued.[xvii] While the report was broadly concerned with short and long-term issues in the energy and power sectors, the ESMAP team placed special emphasis on comparing the Bumbuna project with other grid supply options (see details in Part 3). ESMAP concluded that the scaled-down Bumbuna project was economically attractive relative to alternative thermal options (imported coal and oil) over a wide range of load forecast and fuel price assumptions. While the ESMAP team had qualitative concerns the project was a "lumpy", relatively large investment for the Sierra Leone economy, it concluded that an investment in the scaled-down version of the BHP would not produce short-term macroeconomic consequences much different than investment in thermal generation with oil imports.

63. With the general suspension of IDA Credits in effect at that time, relations between IDA and the GoSL soured further. The Government then sought alternative financing for the BHP from the Government of Italy (GOI) and the African Development Bank (AfDB). After appraisals by these agencies (where the 1987 ESMAP findings were available and considered) a Financial Covenant between GoSL and GOI was agreed in 1988 for a $US 102.2 million equivalent loan for the main civil works. Its effectiveness was contingent on the Government reaching an agreement with the AfDB to fund the electromechanical components. In 1989 the AfDB committed $US 41.7 million of loan financing for these components and a further $US 3.1 million for engineering design and supervision. The agreements resulted in signature of the contracts that are cited in the Table 4 below.

Table 4: Contracts let for implementation of the Bumbuna HEP in the early 1990's

Contract	Component	Timing and Parties	Foreign Component Financing
Contract A0	Permanent and Resident Engineer Camp	▪ 1982-84	GOI ($US 20 million Eq. Loan for Contracts AO and A1)
Contract A1	Preliminary Works (Tunnel excavation)	▪ 1982-84 GoSL with Salini Costruttori (Italy)	
Contract A2:	Main Civil Works	▪ Signed 1988-GoSLwith the Contractor Salini Costruttori (Italy) ▪ Came into Force Aug 1989	GOI ($US 102.2 million equivalent Loan for contracts A2 and B)
Contract B:	Hydraulic Steel Structures	▪ Signed 1988-GoSL with the Contractor Salini Costruttori (Italy) ▪ Came into Force Aug 1989	
Contract C:	Electromechanical Equipment	▪ Confirmation of available financing given Jan 1989 (GoSL and AfDB) ▪ Contract signed and came into force 1993; ▪ Suppliers: Bumbuna Falls European Consortium; Turbines by TURBO-Ganz; Auxiliary Equipment COEMSA-Ansaldo	AfDB ($US 41.7 million equivalent Loan for Contracts C, D)

Contract D:	Transmission Line and Freetown Substations	▪ Confirmation of available financing Jan 1989; ▪ Contract Signed Jan 1993; Came into Force Sept 1993; ▪ Suppliers: ABB SAE, Saldelmi /ABB and Schaltanlangen	
Services	Engineering Services for contract C and D	▪ Loan Agreement 1991, Consultant Studio Pietrangeli	AfDB $US 3.1 million

64. The main civil work at site started in 1990 when GOI loans became effective. At that time the project schedule anticipated that impoundment would start in June 1995 after completion of the dam and major civil structures. Commissioning trials would begin in December 1995.

65. Meanwhile in 1991, as IDA and GoSL began to re-engage in talks about suspended Credits, IDA reappraised the delayed Power Project (US$ 28.89 million Credit). The Credit was to provide for long-delayed maintenance and rehabilitation of the generation, sub-transmission and distribution facilities. The deterioriation in power supply situation had become critical, as by 1991, the effective generation capacity on the Western Area grid had fallen to 6.5 MW (reaching the historical low of 20 Gwh annual generation in 1992). After agreement on a tariff reform package the Power Sector Credit was approved in April 1992. Amid concerns by IDA about the lack of provision for environmental and social mitigation for the Bumbuna project that was well under construction, the Power Credit was modified to fund an EIA, to provide a Resident Engineer, to assist with construction supervision and to form an International Panel of Experts to advise the government on the BHP completion.

66. In the early 1990's Italy was also reviewing its international development lending portfolio and practices. In July 1993, the GOI forgave debt for all principal amounts and interest for Bumbuna financing prior to December 1992. Meanwhile onsite, the main civil contractor was reporting frequent work stoppages due to the deteriorating security situation. The attacks by rebels that began sporadically in 1991 in the southeast had gradually spread throughout the country. By November 1993 it was also apparent that the external funding for the civil works components provided by Italy would be consumed before project completion. The Contractor soon after suspended work, reportedly on the grounds of arrears in payment of local contact amounts by the Government. At the same time, there was no indication the GOI would cover any additional funding requests.

67. In response to this new situation, the GoSL appointed an independent consultant (formerly from the World Bank) to review the status of the project, the reasons for any financing shortfall and the need for any further financing to complete the civil works. Apart from providing observations on project design and procurement procedures, the consultant identified a $US 56 million financing gap.[xviii] Based on the report and the ensuing discussions between the GOI and AfDB, in March 1995 a Protocol Agreement was signed between the Government and the Contractor and Consultant that resolved the claims issues.[xix] With this agreement in hand and an additional loan from the AfDB to cover the financing gap, construction on the half completed project resumed in February 1996. The on-line date was revised to 1998. In response to the consultant's urgent recommendations to provide closer project supervision and decide the institutional arrangements for the operation phase of the project, the AfDB also committed additional funds to establish the Bumbuna Project Implementation Unit (PIU) and strengthen capacities on the government side.

68. As these contractual and financing issues were being resolved, the Government and IDA (in late 1994 under the IDA Power Credit) engaged Lahmeyer International of Germany in partnership with Orient-EAT Enterprises from Sierra Leone to prepare a Power Sector Master Plan. Electrowatt Engineering Services Ltd with Techsult Co. Ltd of Freetown were hired to prepare the EIA. The Master

Plan included a load forecast and generation and transmission expansion studies with a 2020 time horizon. It was completed in draft final form in 1996, but not discussed with stakeholders. The baseline study component of the EIA was completed, but the EMP (environmental mitigation and management programme) was not, largely due to inability to visit the site and engage with local authorities and project affected communities as a result of the worsening security situation.

69. At the Bumbuna site, construction of the rockfill dam had been finished by 1993. The major civil structures were in place by late 1996 (e.g. spillways, intakes, tunnels, gates) and initial work on the powerhouse foundation was proceeding. By 1997 the civil contractor had engaged about 750 local staff and 85 expatriate technical staff. The electrical and mechanical contractors had erected all 550 transmission towers in the ROW extending from the Bumbuna switchyard to the substation location in Freetown and about 84% of the ACSR (161 kV) transmission line conductor was strung. Then in May 1997 all work on the project, then 85% complete, was suspended as the civil-armed conflict intensified across the country following a coup detat.

2.3 The 1998-2002 Period –Nationwide civil conflict

70. From that point in 1997 efforts were directed to protecting the Bumbuna facilities and the dam itself from rebel attack. While the major physical assets remained intact, there was considerable disturbance to community life in the valley. Most villages and families in the area were forced to shelter in the forested areas for months at a time to escape harm. The Government overthrown in 1997 was restored in 1998 with the support of the ECOWAS Military Observer Group (ECOMOG). The rebel war flared up again in 1999 but a cease-fire was brokered at the end of 2000. The peace process under the UN officially ended the war in January 2002.

71. Throughout the country physical infrastructure and construction equipment was either destroyed or sabotaged. About 20 transmission towers were toppled and the transmission cable was stolen. Otherwise, NPA's electrical supply operations in the provinces were shut down. Most facilities were vandalized and fuel transport was impossible. Similarly, small-scale power supply networks were destroyed, as were most power generation assets of mining companies and agro-processing industries.

2.4 2002 to Present-Day – Project completion decision-making

72. Following the National Elections in 2002, work did not restarted immediately on the BHP due to complex questions about outstanding claims, about the condition of the site and electrical and mechanical equipment and about the status of funding. In late 2002, the AfDB engaged Lahmeyer International to prepare an audit of the project, whose terms of reference included resolving claims questions and calculating any financing gap. In parallel, the newly elected government requested help from the Donor community for the early resumption and completion of the project as a key element in the national recovery strategy, as most of the country was without power services at that time.

73. The larger choices the Government and Donor partners faced in 2002 on the Bumbuna project were essentially: i.) to delay its final completion indefinitely; ii) modify the existing structures to be operated as a run-of-river plant without creating the reservoir, iii) remove the dam, or, iv.) proceed immediately with completion. Modifying or removing the dam was not seriously considered as such actions would jeopardize future development of the Bumbuna-Yiben hydropower sequence.

74. The donor community under took two missions in 2003 to evaluate the situation on the ground: the first in May 2003 by IDA alone; and the second in July 2003 with AfDB, GOI and IDA. Based on these Missions the Italian Government and AfDB prepared a joint appraisal in late July that recommended support for completion of the project.[xx] The annual cost to Sierra Leone of delay in doing so was estimated to be about $US 4.5 million, this based on the costs of importing oil for the equivalent thermal generation, but excluding unserviced energy costs and social consequences.

75. A Donor's Meeting was subsequently held in Freetown in September 2003 chaired by the Vice-President of the country. The financing plan agreed, based on the identified financing need, was to provide US$ 33 million in direct loans, augmented with private sector loan financing of US$ 20 million facilitated by a partial risk guarantee from IDA. This was subject to completion of safeguard studies and implementation of power sector reforms. The reforms called for largely reflected Government policy, such as forming public-private sector partnerships for power supply development, in this case a Special Project Company (SPC) to operate the Bumbuna project employing experienced international hydropower operators; and ensuring that the NPA, the sole purchaser of power from the Bumbuna project, was placed on a commercial footing. Given the nature of the BHP project itself (i.e. a run-of-river hydropower project that was 85% complete with relatively clear environmental and social implications) and the urgency of restoring power services, it was agreed that work on the physical restoration could proceed in parallel with preparation of the environmental and social safeguard studies that were a pre-condition for the financial participation of the IDA.

76. Work on the safeguard studies commenced at various stages in 2004, as soon as international and local teams were contracted and mobilized. Among these studies were: the two Resettlement Action Plans (RAPs), one for the 200 km transmission line and substations and one for the damsite and reservoir area; an updated of the EIA that was started in 1994, in particular to complete the environment management plan (EMP); the Emergency Preparedness Plan (EPP) and the Dam Safety and Environmental and Social Expert Panels. In parallel the Government established a Cabinet Level committee to oversee the “urgent implementation” of the project, supported by an Inter-Departmental Technical Committee mandated to resolve any inter-department issues and to direct the Bumbuna PIU in providing day-to-day supervision of the consultant teams on the safeguard studies, as well as the project contractor and consultant once new contracts were agreed.

77. The civil and electrical contractors began the detailed condition assessments of the facilities at the site and to inventory the status construction equipment, plant and vehicles at various locations. This work included evaluation of the condition of the imported electrical and mechanical equipment and civil construction materials that were actually in transit in 1997 when the conflict escalated, and these equipment were either left in the port area or stored hastily at site. The condition assessment of the electrical and mechanical equipment looked at functionality of equipment, and whether to repair or replace obsolete or damaged equipment. At that stage much the equipment was approaching a decade old, thus whether to replace obsolete components was a particularly important consideration for electronic controls and systems. Original suppliers were contacted to see if they were still in business and willing to provide quotes for replacements, parts and services.

78. The results of these condition assessments will inform the negotiation for the new completion phase contracts between the civil and E&M contractors and Government, for the contract-types noted previously in Table 4.

3. How and what options were assessed? How would it compare with emerging "good practice" today?

79. This section looks more closely at how and to what extent options were assessed in arriving at the decision to develop the BHP and the choice of within-project alternatives.

80. One question that is foremost in the international-level discourse on options assessment is whether power supply options, especially dams, are pursued to the exclusion of other options to improve electrical services such as supply-side efficiency improvements and demand-side management. The observation on this point is that supply-side efficiency measures were very much pursued in parallel with planning for new supply from the BHP, albeit with mixed success in respect to their sustainability.[xxi] There were cycles of rehabilitation of diesel generation plant and programs to improve transmission and distribution networks and their efficiencies since the 1960's.

81. From the early 1990's electricity tariffs were also raised sharply, though not as a deliberate demand management policy. Targeted end-use efficiency programs such as utility-based programmes to market and supply efficient appliances were not seen as a major option, or the most pressing development issue. The reality was Sierra Leone society had the lowest level of electricity supply and access in African. This is seen as a significant impediment to social and economic development. The prevailing view when the Bumbuna project was endorsed by Government first in 1982 and when project financing was approved in 1989 was not whether the Western Area grid needed new supply, rather how it would be provided, how reliably, the timing, and at what cost.

Leading to the selection of the BHP and prior to 1997

What options were considered for bulk power supply for the Western Area Grid?

82. In the nation-wide hydropower inventory in 1970-71 that identified 22 potential hydropower sites, three sites were identified as warranting detailed investigation. These were:

- Bumbuna Falls (72 MW) - 40 km north east of Makeni in the north east
- Benkongor Falls (15.2 MW) - 40 km west of Koidu in the central east
- Goma (18 MW) - 30 km north of Kenema in the south east of the county

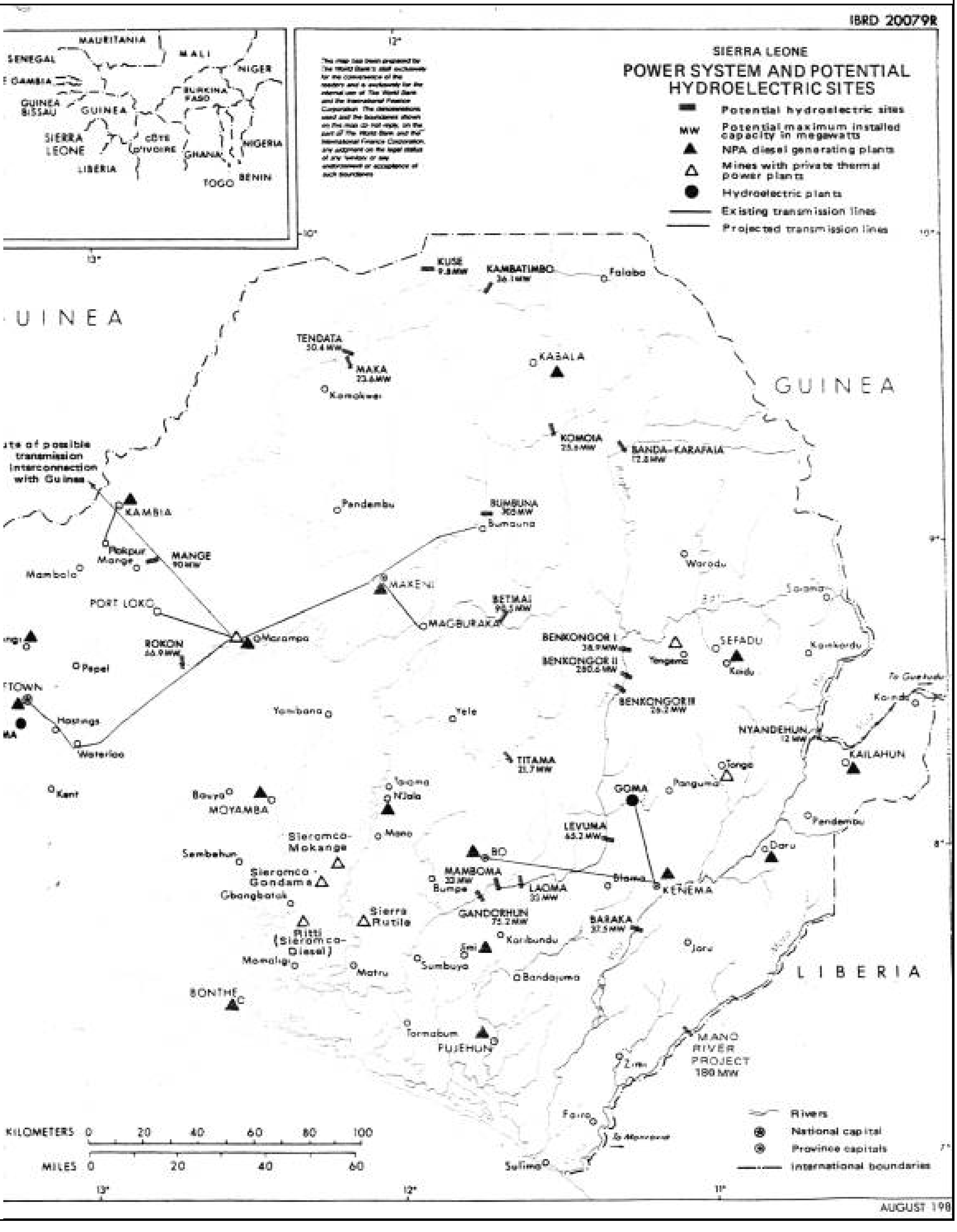
83. Map Figure 8 locates the main hydropower sites on the major river systems in Sierra Leone (from ESMAP, 1987). In the early 1970's the Bumbuna site was considered the most attractive of the three sites to supply the Western Area Grid on the basis of hydrology, head, technical characteristics and proximity to the Western Area load centre. From 1973 on, all studies that assessed new supply for the Western Area grid focused on comparing alternative Bumbuna-Yiben construction sequences with equivalent thermal options on imported oil or coal.

84. As discussed in Section 2, the ESMAP Issues and Options report (1987) provided the most comprehensive overall picture of the energy sector available at that time and came at a critical stage in the decision on financing the BHP. The ESMAP team prepared a least-cost analysis taking into account a range of load growth projections. Using the World Bank's internal oil and coal price scenarios, four generation sequences were compared:

- pure thermal schemes (imported coal and oil – HFO/MO and DO);
- the full Bumbuna development (as in the 1980 Feasibility study);
- the reduced Bumbuna Stage 1 (50 MW), followed by pure thermal; and
- the previous Bumbuna Stage 1 (71 MW), followed by pure thermal

85. The analysis concluded that the scaled-down Bumbuna project from the 1984 Supplemental Feasibility study (followed by thermal plants) was the most economically attractive of the four sequences. Out of the 16 combinations of future oil prices, discount rates and load growth examined, the reduced Bumbuna was the least-cost solution in 12 cases (including the base case). The original full Bumbuna development (i.e. the 1980 Feasibility Study and prices) was economically inferior to pure thermal options (in 12 out of 16 cases), particularly so in comparison to low-cost imported coal.[xxii] The analysis was made public when the ESMAP report was published in October 1987.

Figure 8: Rivers and hydropower sites in Sierra Leone (Note: Map will be provided in the Final Report)



86. Table 5 summarizes the grid supply options considered in the key studies leading to the decision to finance the Bumbuna HEP in 1988-89. For comparison, the options considered in the 1996 Power Sector Master Plan are included.

Table 5: Supply options assessed for the Western Area grid in arriving at the decision to develop the Bumbuna HEP

Study / Timing	**Generation Technologies Considered >**	**ENERGY RESOURCE OPTION**								
		Hydro			**Thermal**		**Other Renewables**			
		Small Hydro	Projects/ Sequences on the Seli	Other Med & Large Projects	Oil	Coal	Biomass (wood)	Biomass Agr. waste	Solar	Wind
1970-71 Hydropower Inventory	Small to medium and large-scale storage and run-of-river hydro.	■	■							
1980 - 1984 Feasibility and Supplemental Feasibility	▪ Alternative sequences of Bumbuna-Yiben scheme and the scaled-down (1984) Project ▪ Imported Oil: Diesel Generators (HFO) and Gas Turbines (gas oil) (1984 only)		■							
1987 ESMAP Issues and Options Report	▪ Bumbuna-Yiben sequences as the only hydropower options; ▪ Imported Oil: Diesel Generators (HFO), Gas Turbines (gas oil) and Steam systems (HFO) ▪ Imported Coal: Coal-fired steam plant in Freetown	□ [xxiii]	■	□	■	■	○	○	○	○
To consider options after Bumbuna 50 MW										
1996 Power Sector Master Plan	▪ Subsequent stages of the Bumbuna-Yiben scheme and alternative hydropower sites; ▪ Imported Oil: Diesel Generators (HGO), Gas Turbines (gas oil) and Steam systems (HFO) ▪ Biomass (as far as specific energy costs) ▪ Solar, Wind , Wave and domestic coal evaluated, but screened out in first stage	■ ○	■	■	■	□	□ ○	□ ○	□ ○	□ ○

Notes:
■ implies the option was part of the final least-cost analysis and comparisons
□ implies the option was analysed for grid generation, but rejected for least-cost simulation studies
○ Implies option was considered for isolated provincial generation or rural electrification

87. While the ESMAP (1987) team assessed the potential for biomass generation and small hydro to augment diesel-electric supply in isolated provincial networks, it was not until the Master Plan (1996) that more explicit consideration of non-hydro renewable sources for grid supply was provided, specifically for biomass, solar and wind generation. There was a 3-step process. Initially all potential energy sources and associated generation technologies were screened. Where the options were deemed technically feasible and potentially economically attractive, the specific energy costs ($/kWh) were determined. Options with attractive specific energy costs were then included in the least-cost simulations. However, no non-hydro renewable options advanced to the final stages for reasons cited below (i.e. the higher-cost options would not be selected by the least-cost optimisation procedures. They would have to be “forced”, that is a minimum “portfolio” of biomass generation, for example, would have to be specified as an optimisation criteria).

- **Biomass generation**: On the basis of screening, generation from biomass (wood and crop wastes) was taken to the second level of assessment where the specific energy costs ($/kWh) and preliminary plant layouts were prepared for a biomass steam turbine power plant and a biomass reciprocating engine plant, each for 0.2 MW and 2.0 MW cases. Two references for their practicality in Sierra Leone’s context were the FIC sawmill (1.2 MW capacity) at Kenema that had operated before it was shutdown due to a steam turbine failure, and the 2 MW cogeneration plant operated by the Magbass Sugar Cane Complex fired by direct combustion of bagasse.

The costs of biomass production / harvesting and processing was seen as a constraint except in special cases where the biomass fuel supply was assured (e.g. with sawmills, agro-processing and sugar cane processes). Raw supply of biomass sourced by collection and transport of crop residue from rural farms (e.g. rice husks) had previously been estimated in university studies to cost between 1-2.5 $USc/kWh and wood plantations from 2.5 to 4.5 $USc/kWh. A value of 10 US$/ton was applied in the analysis, which was roughly equivalent to oil costs at that time after adjusting for energy content, less duties. Specific energy cost for different plant factors were calculated as 10 and 15 $USc/kWh, respectively, for steam and reciprocating engine thermal plant operating at 100% plant factor. Costs were considerably higher at plant factors below 50%.

On the basis of these high specific energy costs, the biomass generation option was excluded from the least-cost simulations. The Master Plan noted that biomass generation could clearly have a role to play in the agro-processing industry for co-generation (process heat and electricity) as demonstrated by the existing examples. Biomass generation was recommended for evaluation to replace diesel-electric generation in up-country provincial power stations where grid connection would not be available in the near term and a ready supply of biomass was available.

- **Solar generation:** solar thermal (electric technologies) and photovoltaic technologies were evaluated based on technical, economic characteristics and their role as intermittent sources. They were screened out of further analysis due to high costs in grid applications: i.e. solar thermal electric (20-25 $USc/kWh) and photovoltaic (65-85 $USc/kWh). Solar electric generation was seen as viable in stand-alone solar homes in off-grid applications and was recommended for evaluation as a rural electrification candidate.[xxiv]
- **Wind generation:** was evaluated in regard to average wind potential in the country (wind velocity, location and frequency) and the state the technology in Europe and North America at that time. Costs of intermittently generated electricity were 8-10 $USc/KWh for 3-5 m/s velocities in Sierra Leone at site, before transmission. Wind generation was screened from further consideration as a grid supply option based on specific energy costs and low supply reliability, but was recommended for further investigation where higher wind regimes could be identified (much higher than the present national averages), and in particular if international prices for wind turbines and maintenance costs continued to reduce significantly.
- **Other renewable energy sources:** biogas generation and wave technology were reviewed but rejected on the basis of their high specific energy costs, low practicality and no proven experience for grid generation in the African context.

88. At the University of Sierra Leone in Freetown researchers have been following pilot projects for biomass generation in other African countries and have built up expertise that may be tapped in future. Proposals have also been made in the last few years by a UK-based private enterprise to develop a thermal power plant in Freetown fuelled by burning municipal waste. It can be developed in stages, potentially up to 50 MW. The proposals are preliminary and based on an IPP concession approach. This option would nevertheless need a full EIA to demonstrate its public health and safety aspects. More generally it will be important to confirm the economic feasibility of waste-power generation in respect to the availability and energy content of solid wastes in Freetown and the cost of collection, waste processing and separation processes.

89. Generally, renewable generation is seen as complementary to hydropower development to displace fossil-fuelled generation.

What methods and criteria were used to select the BHP and how were they applied?

90. The 1970-71 national hydropower inventory identified the Bumbuna site using economic and technical criteria consistent with power system and hydro investigation standards of the day. After 1975, IDA's technical staff supervised the detailed investigation and optimisation studies. The technical assumptions and techniques were acceptable to the World Bank (e.g. discounting analysis, scenario analysis and sensitivity tests).[xxv]

91. Three main factors driving the least-cost analysis were:

- The projected electricity demand growth;
- The cost of hydropower option (s); and,
- International oil price forecasts.

Projected Electricity Demand Growth

92. The reference point for power market surveys and demand forecasts for the Western Area grid prepared in the 1980's was the historic annual compounded growth in electricity supply of 4.0 % since Sierra Leone's independence in the 1960's (Figure 1 in Section 1). Regression analysis combined with the forecasts of GDP growth derived from World Bank economic projections were used to project future demand. Table 6 summarizes the assumptions made prior to 1989, and subsequently, including the more recent forecasts in 2003.

Table 6: Power / Demand forecasts for Western Area grid

Forecast	Demand Growth (% annual growth)			Base Case to High Forecasts[2] Energy (Gwh) and Demand (MW)					
				1995		**2000**		**2015**	
	Base Case	High	Low	MW (peak)	Gwh (annual)	MW (peak)	Gwh (annual)	MW Peak)	Gwh (annual)
Forecasts Prior to the BHP Financing Decision									
1980: Feasibility Study	4.6%	6.7%	3.0%	TBD(1)	TBD(1)	60	340	-	-
1984: Supplemental Feasibility Study	4% to 1995 after 4.5%	6.7%	4.0%	TBD(1)	TBD(1)	65	350	130	-
1987: ESMAP (Base and Accelerated growth cases)	4.6%	10.3%	-	29 to 48	169 to 280	38 to 69	221 to 444	-	-
Forecasts Subsequent to the BHP Financing Decision									
1992: IDA Appraisal of the Power Project				35	144	-	208		
1996: Power Sector Master Plan (generation excluding self-	7.9%	10.9%	9.1%	29	171	35	206	58	334

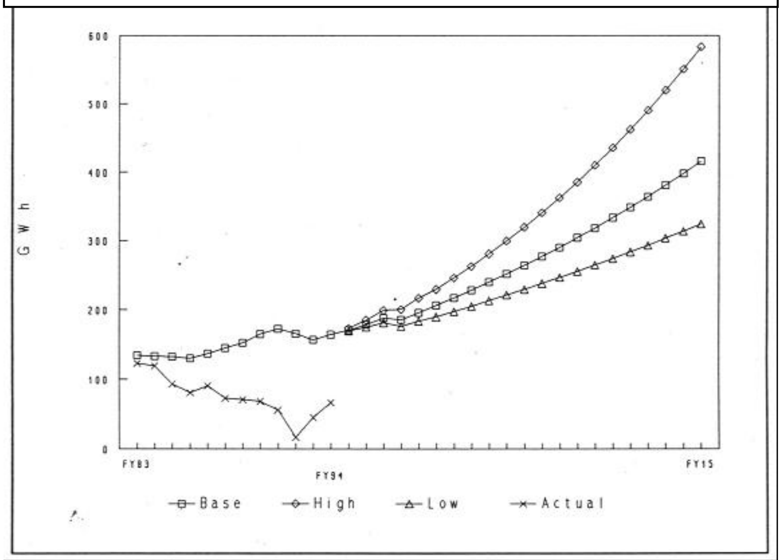
generation)									
IDA 2003 (3)	4%	7%	3%			25 to 40	-	37 to 96	-

Notes:
(1) TBD – to be included in the Final Report.
(2) With the exception of the 1980-84 Feasibility studies, forecasts are for Western Grid Service Area alone excluding connection to provincial stations and mining loads.
(3) Included in the IDA Power and Water Credit. The estimates of existing underlying demand is between 30 and 40 MW on the Western Grid. Figures shown for 2000 refer to the 2002 forecast.

93. The load growth in the 1980 and 1984 Feasibility Studies did not materialise. With the benefit of hindsight this may be attributed to the continued depressed state of the economy, the sharp decline in supply from NPA's diesels from 1982, and the failure to anticipate the armed conflict in the 1990's with it's consequent effect on the economy and electricity demand. At the same time it is clear that supply constraints masked underlying growth and suppressed demand. Forecasts made in the late 1980's and 1990's in effect shifted the expectation of load growth back a few years, where the critical assumption in each instance was the economy and the security situation would stabilize.

94. The load forecast provided in the 1996 Power Sector Master Plan was the most comprehensive in Sierra Leone. Figure 9 illustrates its energy projections for the Western Area grid, for low, base case and high scenarios, inclusive of demand for auto-generation. The load forecast procedure for the Master Plan featured:

Figure 9:
Load Growth Projections in the Power Master Plan



- A top-down estimate based on regression techniques and a bottom-up disaggregated demand projection analysing loads in different sectors.
- GDP growth scenarios derived from World Bank projections (low 2.8%, Med or base case 3.8%, and high 5.3%);
- Suppressed demand represented by auto generation, estimated by least squares regression analysis on 1965-82 growth (before supply constraints) subtracting technical losses, and
- Loss reduction measures being implemented (achieving 25% to 27%).

95. Under the base case forecast, the Master Plan (1996) foresaw the need for additional capacity from 2005 onward. The least-cost option was construction of the Yiben reservoir to firm-up generation at Bumbuna. This would be followed by installation of a 17 MW power station at Yiben in 2010. Under the high growth scenario, the Yiben plant would be advanced to 2005, and in between Bumbuna (1998) and Yiben (2005) additional diesel units would be required (12.5 MW in total).

96. Today there is general consensus that once power is received from Bumbuna it will be absorbed fairly rapidly. Observers expect that a significant portion of end-users now on private generation, estimated in post-war terms at between 30-50 MW, would quickly migrate back to grid supply. Consumers would likely retain their generators as backup or reserve, at least initially. Eventually the generation units will be taken up-country as reliable grid service is demonstrated. Recent load forecast prepared for the IDA Power and Water Credit (IPA-2003) suggests that reliable grid supply can stimulate rapid demand growth up to 60 MW a few years after Bumbuna is on-line.[xxvi]

97. The majority of households, perhaps the bulk of NPA's 40,000 registered customers at lower consumption levels who cannot afford private generators, will receive power again on a regular basis. Assuming tariffs and reconnection costs are affordable, these end-users will give up the high-cost paraffin they are forced to use now for lighting and return to electric lighting.

Cost of Hydropower Assumed

98. From a utility economics perspective (where hydro and thermal are the main conventional options) the choice between these forms of supply is essentially between thermal units – characterized by comparatively low installation costs ($/kW), but uncertain and continuous operating costs ($/kWh), and hydro – characterized by higher capital costs ($/kW), but significantly lower, comparatively predictable operating costs ($/kWh). This leaves debt repayment schedules and loan terms aside, which are considered in macroeconomic analysis.

99. The main cost assumptions employed in the 1980 and 1984 Feasibility studies that compared stages of the Bumbuna-Yiben development (as envisaged at that time) with equivalent thermal are shown in Table 7. These figures drawn from the ESMAP (1987) report, show the 1980 and 1984 Feasibility cost estimates escalated to $US 1986.[xxvii] These were also used in the ESMAP analysis, with the exception of the site preparation costs treated as sunk costs, and thus excluded.[xxviii]

100. The sequence represented in the table is based the 1980 Feasibility Study. The scaled-down Stage 1 alternative shown was based on the 1984 supplemental feasibility study design.

Table 7: Hydro Costs Assumptions In $1986	**Installed Capacity** (Cumulative)	**Annual Energy** Firm	Average	Capital Cost ($1986)	**Average Energy Cost (1) ($1986)**
	(MW)	(Gwh)	(Gwh)	(US$ M)	(US c/ kWh)
Full Scheme[xxix]					
Stage 1 – Bumbuna	53	206	350	159.0(2)	7.7
After Stage 2	80	368	534	134.6	9.2
after Stage 3A	125	718	886	94.8	7.4
after Stage 3B	185	1,148	1,212	80.6	6.4
After Stage 4	305	1,248	1,458	91.7	6.4
Total Development	**305**	**1,246**	**1,485**	**560.7**	**6.4**
Scaled Down Bumbuna HEP (Stage 1)	47	153	290	98.47(2)	5.9

Notes:
(1) ESMAP calculation of present value of capital and operational costs per unit of energy delivered to Freetown, based on 12% discount rate, 50-year life, excluding distribution costs.
(2) Excludes $US 24.5 million for works already completed (treated as a sunk cost)
(3) Figures may not add due to rounding

Source: 1987 ESMAP based on 1980 Feasibility Report and 1984 Supplemental Feasibility

101. Table 7 shows the average cost of the full scheme was anticipated to be 6.4 $USc/kWh. The higher average energy cost of the original BHP Stage 1 was 7.7 $USc/kWh compared to 5.9 $USc/kWh for the scaled down-version of BHP, a 23 % reduction in average lifetime energy costs.

102. The cost of alternative thermal plant were based on typical prices at the time for rehabilitation of low-speed diesel generators and procurement of new diesel generators, gas turbines, and oil and coal-fired steam plant. The key determinant of the $/kWh cost was the fuel price and plant factors.

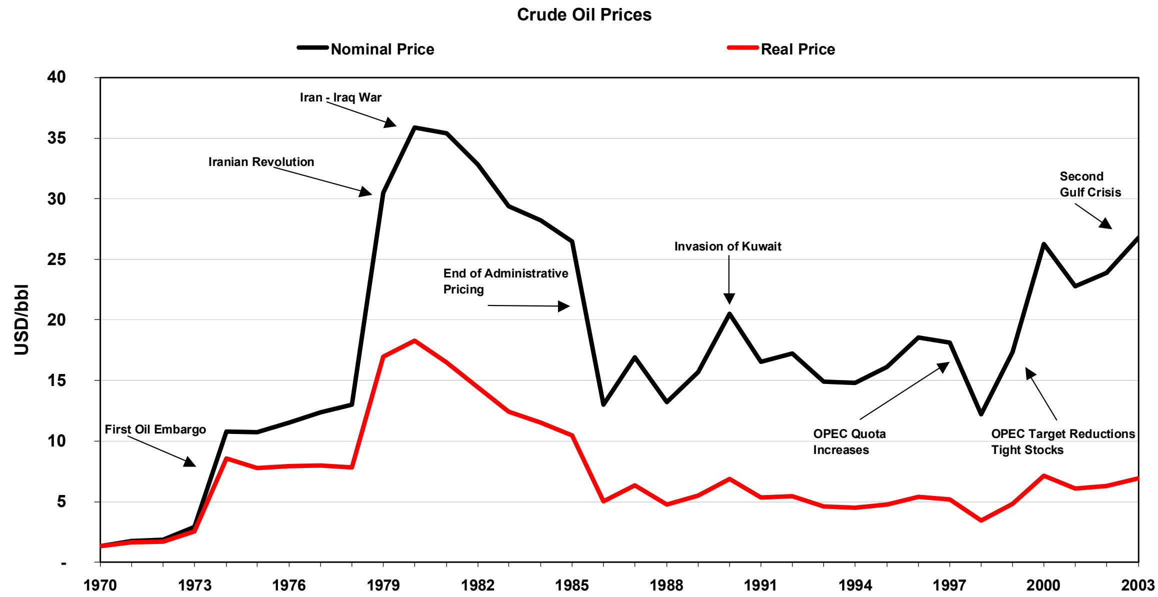
Oil Import Costs Assumptions

103. The price forecasts used to determine thermal operating costs ($/kWh) are noted below:

- **1980 Feasibility Study of the BHP:** the base was HFO priced at $US 180/ metric tonne corresponding to $US 26 /bbl. At that time crude oil was approaching $US 35 /bbl. Escalation scenarios were: Scenario A - annual increases of 5% for 5 years, dropping to 3% annually until a ceiling $US 53/ bbl was reached; and Scenario B - 5% annual increase for 10 yrs and then dropping to 3% annually up to US$ 53 / bbl.
- **1984 Supplemental Feasibility Study of the BHP:** in this case the discount rate was calculated that equalized hydro cost with fuel expenditure (HFO/MO and FO) with a crude oil equivalent of $US 27, $US 29, $US 31 and $US 33 /bbl. The price was held constant over the full discounting period (the spot price of crude oil at that time was $US 28 /bbl).
- **1987 ESMAP Issues and Options Study:** - two scenarios were used. The base case for different fuel types (i.e. HFO, GO and DO) was expressed in $1986, where HFO at $US 119/tonne corresponded to crude oil prices of $US 20 /bbl rising to $US 25 /bbl by 2000 ($US 48/bbl in 2000 price levels). The alternative (lower) scenario was $US 20 /bbl by 2000 with coal prices of $US 52 /tonne rising to $US 56 /tonne by 2000 (in $1986).

104. The ESMAP analysis was prepared after the volatility in the international oil markets in the early 1980's had settled somewhat. For comparison sake, Figure 10 shows the actual nominal and real oil process for crude oil in the international markets from 1970 (when the Bumbuna project was identified) to 2003, with 1970 as a base for the real price.

Figure 10: Nominal and Real International Crude Oil Prices (1970 to 2003)



Sources: 1970 - 1984 Arabian Light prices from the Oil Economists' Handbook. 1985 - 2003 Dubai M1 (Adj) prices from Platts. Real prices are calculated using the GDP deflator for GDP at Market Prices from OECD Economic Outlook N°74:

105. Figure 10 shows the relatively constant nature of real oil prices for the 15-year period from 1985 to 2000. The figure also illustrates the extent to which external events induce oil price shocks that impact on electricity supply costs in developing countries wholly reliant on generation by fuels purchased on international oil markets. The turbulence in the oil markets in the 1979-1985 period, as seen in Figure 10, was a major factor in the Sierra Leone's decision to base future power supply on indigenous sources. For further comparison, the oil price assumptions used in the Master Plan (1996) are shown in Table 8. These closely approximate the upward trends in international oil prices, until the recent sharper price rises in 2003-2004.

Table 8: 1996 Power Sector Master Plan Fuel Escalation Assumptions

	Crude	HFO	DO

	$US1994/BBL	US1994/tonne	
1995	17	129	182
2000	23	175	246
2005	28	212	300
2010	28	212	300
2015	30	228	321

How were the within-project alternatives for the BHP selected?

106. Decisions on the design and layout of the major infrastructure components of dam projects are important to the extent these choices impact on the overall economic, social and environmental performance of the project. They may also impact on the distribution of costs and benefits (in terms of who receives services) and the environment mitigation and enhancement actions.

Project Layout – Physical Components

107. As described in Section 2, the project evolved both in concept and detail in a succession of technical studies that relied on engineering-economic optimisation techniques. Together with project financing considerations, the optimisation studies were the main basis to decide the Stage 1 configuration and major features of the project layout. Specifically, the criteria introduced in 1984 where Phase 1 was to cost less than $US 100 million ($1984) - itself derived from macro economic considerations (i.e. national affordability) - provided the boundaries for the engineering-economic optimisation work to decide the project components, i.e.:

- Fixing the location of the dam site and powerhouse;
- Fixing the dam height and consequently the size of the reservoir, inundated area and ultimately the amount of resettlement;
- Design features (spillways, construction methods and materials, location of borrow pits, etc);
- Deciding the reservoir operating strategies, and in particularly the dry season releases;
- Selecting the transmission alignment and substation locations, and
- Deciding what provincial centres would receive power services and of what capacity.

108. Thus in addition to physical design, the financing criteria determined what groups in society would benefit from direct power services from Bumbuna in the short term, apart from consumers connected to the Western Area grid. For example, the interconnection of provincial centres to the south of Bumbuna was deferred to reduce costs (e.g. the transmission line to Sefadu).

Environment and Social Components

109. There was no apparent analysis of the environment and social mitigation and management measures for the construction phase of the project in the 1990's, and no analysis of the measures for operation phase monitoring and mitigation (until the present-day safeguard studies). The fact that EIA was not prepared was remarkable, even for a dam project in the early 1990's.

110. The 1980 Feasibility study did consider ecology, resettlement and downstream agriculture implications (Volume 1). The number of people to be resettled was calculated for different reservoir levels for the Yiben dam (i.e. at 280 m.s.l. and 304 m.s.l. levels). Nevertheless, the environmental impacts were seen in terms of as "effects" only. In practice they had no influence on infrastructure decisions, other than the fact that resettlement costs were factored into the economic optimisation calculations for the Yiben dam height. The 1984 study evaluated alternative dam heights for the reduced phase 1 Bumbuna scheme, but strictly from a power economics perspective with no explicit environment or social criteria, or rationale for their exclusion.

Operation Phase Alternatives – Flow Release Patterns

111. Assessment of operation strategies and procedure for reservoirs help to reveal opportunities to minimize potentially adverse impacts of releases from dams on the downstream communities and riverine ecosystems as well as opportunities to enhance potentially beneficial impacts. These issues are typically addressed in an environmental flow assessment, where today it is not just a single minimum flow that is assessed, but whole downstream regime involving the quality, quantity and timing of the releases.[xxx] Other concerns are public safety, such as in the case of a sudden load rejection and strategies for safely operating the spillways during normal and extraordinary floods.

112. The rule curve for the reservoir and the optimisation of control procedures to pass water through spillways during extreme hydrological events were studied in the early 1990's. Model testing of the design and operating procedures was done at Imperial College of Science and Technology in London, UK, where the main criteria were safety, efficiency and technical performance factors. [xxxi] Here the Bumbuna project was quite unique in the sense the original design located the powerhouse downstream of Bumbuna Falls. When the location was shifted to the toe of the dam, the 9m diameter right bank spillway tunnel (then in place) was converted to a combined power and spillway tunnel. While a combined tunnel is quite common, the tunnel also had to serve as the headrace. Thus the optimisation work focused on establishing safe and efficient operation procedures that accommodated those design changes, especially for operation of the right spillway in extreme flood situations where power production would be temporarily shut down.

113. While these technical analyses were essential, there was no apparent or explicit consideration of environment or social criteria. Because Bumbuna Phase 1 is essentially a run-of-river project, the wet season natural flow of the river (including the flood flow) is fully passed. No section of the river downstream of the dam is dewatered. The only concern for reduced downstream releases would be in the dry season if reservoir levels are unusually low following a poor rainy season and at the same time a daily ponding operation is adopted to provide for peaking generation. Otherwise the low flow regime downstream of the dam is enhanced. The issues thus related more to how the ecosystem processes would adapt to any deterioration in water quality and increased dry season flows (about 20 m^3/s), which is typically less serious than shortages. As mentioned in Section 1, if Yiben is built, the flow released from the multi-annual Yiben reservoir into the Bumbuna reservoir will be a minimum of 80 m^3/s, well above the present 6.4 m^3/s natural low flow of the Seli river in the dry winter months.

Institutional Alternatives

114. The independent consultant engaged in 1994 after the civil Contractor suspended work had recommended that an urgent assessment of the institutional arrangements for operation and management of the BHP project be undertaken. To that point no provision for analysis of institutional alternatives had been made, presumably because it was assumed that NPA would be responsible. This is despite the fact NPA had limited experience and no staff trained to operate hydropower projects.

3.2 Present-day project preparation studies: Non-structural alternatives

115. The main physical infrastructure components of the Bumbuna project are already fixed including the transmission alignment. Apart from one issue related to minimizing resettlement in the urban sections of the 200 km transmission right-of-way (ROW), the remaining alternative assessments in the present-day project preparation studies focus on the management, social-environmental infrastructure and capacity questions. These include:

- Selection and prioritisation of the environmental and social mitigation, monitoring and enhancement measures to be incorporated in the Environmental Management Plan (EMP) and the Transmission and Reservoir Resettlement Action Plans (RAPs);
- Finalizing the reservoir operating policies and procedures, particularly the policies and contingencies for environmental flow provision during impoundment and operation for normal hydrology, and operating policies for extreme flood management situations;
- Selection and prioritisation of the measures for dam safety monitoring and the Emergency Preparedness Plan (EPP). These also consider public safety risk from dam break (which is an exceptional flood related emergency) and more common releases from load rejection where a sudden release may pose a safety hazard for downstream users;
- Selection and prioritisation of measures for the wildlife and catchment management programmes and regional development plans (RDP);

- Identification of alternative benefit sharing provisions (e.g. what measures, what locations and what beneficiary groups) and the most appropriate methods to provide sustainable financing for the longer-term activities, either from project revenues or other sources; and
- Finalizing the choice of institutional arrangements for operation of the BHP and the various related resources management activities (monitoring, catchment management etc).

116. For some alternatives such as choice of compensation and resettlement locations, the actual decision-makers will be local, either traditional community leaders or the affected families themselves. As mentioned earlier, all these choices will influence the project's wider development effectiveness and its acceptance by communities hosting and affected by the project.

117. Among the remaining questions about physical infrastructure is a pending decision on the transmission arrangements that impact on the number of people to resettle. The transmission line RAP identified that resettlement in selected urban sections of the 30m wide 161 kV ROW will significantly exceed the expectations and the Donor pledges for the project completion budget. Normally the Government would pay all land acquisition and resettlement costs; however, post-war Sierra Leone does not have the financial resources. A large percentage of the households affected by the 200 km transmission line are in two urban locations: in a 1.5 km long section between Kingtom power station, where the 161 kV line would terminate and in Makeni town.

118. Public consultations as part of the RAP showed that most affected families in the section between Kingtom and Hillcut road do not want to move. At Makeni, located about 160 km up-country, the 161 kV transmission route deviates from a direct line to Freetown to pass through the centre of town. Since the alignment was selected and the towers were erected over 10 years many permanent dwellings have been built in the ROR. Alternatives to minimize resettlement are considered as part of the transmission line RAP process.

3.3 How would past practices compare with emerging "good practice" today?

119. New approaches have emerged on the application of options assessment concepts in water and energy service provision in the past decade. Annex E provides illustrates the nature of the guidance that is emerging at the international level. The new arrangements are in part aimed at reducing conflict that had arisen in many countries over the role of dams in development. But they also reflect the generally accepted need to develop a more diverse portfolio of options to meet the challenges of equitable water and energy service provision in today's context, including ways to meet the Millennium development goals as a priority. It is now accepted that the choice is no longer a matter of satisfying strict economic efficiency criteria, rather to satisfy a broader mix of development aims such as equitable benefit sharing, to target measures for poverty alleviation, to gain public acceptance, and to safeguard the interests of all stakeholders. These factors have to be balanced when choosing options to promote sustainable development.

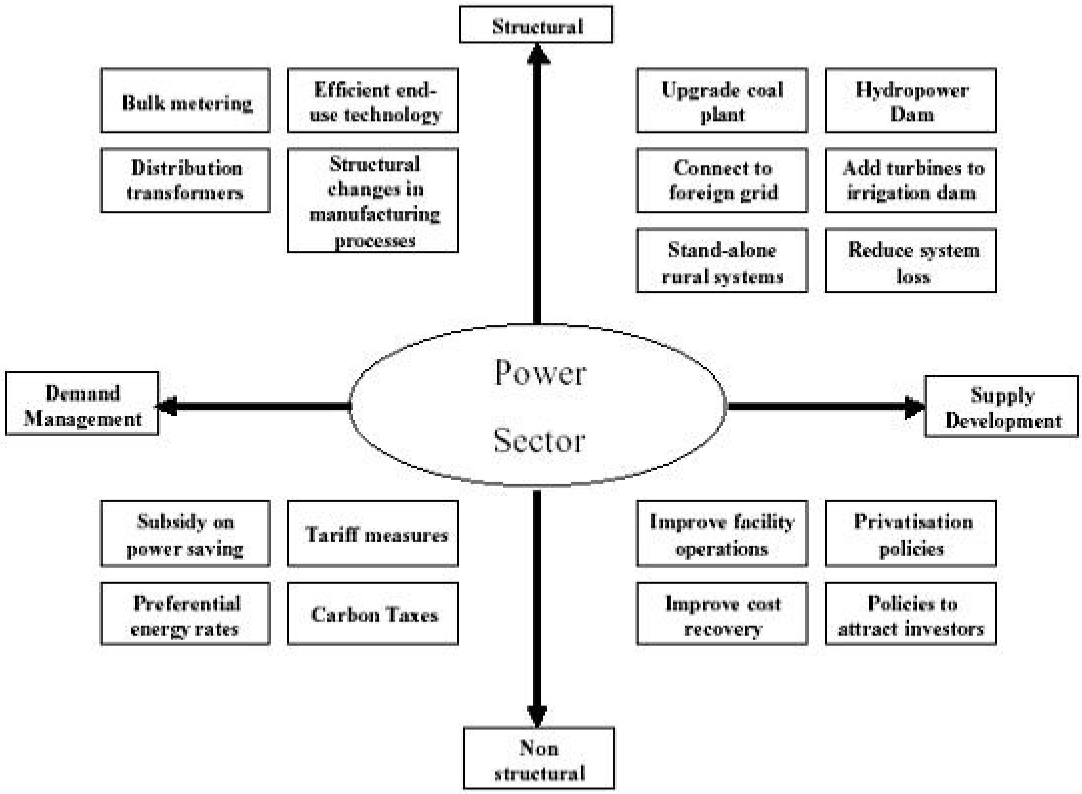
120. Generally accepted principles for improved options assessments for water and energy service provision include:

- Carrying out options assessments early and "upstream" in the planning process (e.g. at the sector or basin level planning), starting with a needs assessment, or confirming that existing needs assessments are valid;
- Putting all options on the table and agreeing on procedures to screen these, including all the feasible supply and demand-side management options, efficiency improvements of existing assets, and policy/ institutional options;
- Placing social and environmental criteria on an equal footing with economic and technical criteria and using sustainability criteria to evaluate options (economic, social and environmental) performance;
- Evaluating options in open, transparent and participatory processes that provide all stakeholders interests with an opportunity to be involved from that early stages and ensuring full access to information, with support to the poor and vulnerable to participate; and

- Continuing alternative evaluations through each stage of the project cycle (development and management of dams).

121. Figure 11 illustrates what placing all options on the table means in practice. Structural and non-structural options for supply and demand-side measures are considered.

Figure 11: Placing all options on the table to expand and improve electricity services



Source: Stakeholder Involvement in Options Assessment: Promoting Dialogue in Meeting Water and Energy Needs", published in 2003, World Bank

122. Table 10 provides observations comparing what was done on the Bumbuna HEP (in the pre-1997 situation) with generally accepted "good practice" principles for options assessment emerging today, particularly where dams are involved.

Table 10:
Retrospective comparison of the application of options assessment concepts (Pre-1997) with emerging "best practice" principles today

Emerging Principles	Relevance or Presence in BHP Decision Process	
	"Strengths"	"Weaknesses"
Carrying out options assessment early and "upstream" in the planning process (e.g. at sector or basin level planning); starting with a needs assessment and/or confirming existing needs assessments	▪ A clear policy existed to develop hydro and reduce imported fossil fuels ▪ Load forecasts included high, medium and low scenarios. ▪ Target beneficiaries were identified as consumers in the Western Area grid as well as consumers in provincial centres to be connected to the grid.	▪ No clear linkage to a comprehensive river basin development strategy or other water use interest in the basin (short or long-term). ▪ No demonstrated integration of water and electricity needs with environment and social policy. ▪ Little emphasis placed on the load forecast (needs assessment).
Putting all options on the table, including supply and demand-side management options, efficiency improvements of existing assets, as well as policy and institutional options;	▪ A hydropower inventory was used to prioritise the hydro candidates ▪ Conventional grid generation technologies feasible at that time were considered (e.g. other renewable options were demonstration technologies in the 1980's) ▪ Emphasis was given to rehabilitating existing thermal generation, transmission and distribution complementary to new supply planning	▪ No comprehensive options as part of the Feasibility Study (hydro and thermal options considered only) ▪ No explicit consideration of alternatives for the no-physical components of the project. ▪ No institutional options studies related to project implementation or operation
Placing social and environmental criteria on an equal footing with economic and technical criteria when evaluating options	▪ Preliminary assessment of resettlement impacts included in the Feasibility Study ▪ Awareness of the resettlement issues with Phase 1 (that were considered low and manageable)	▪ No explicit use/ reasons for rejection of environment & social criteria in project selection, or to evaluated the within-project alternatives ▪ No EIA on which to evaluate social and environment mitigation and enhancement options ▪ No resettlement studies.
Using sustainability criteria to evaluate options (economic, social and environmental) performance	▪ Hydro seen as a renewable and sustainable option versus thermal. ▪ Substantive analysis of the Stage 1 configuration with cost, timing and macroeconomic criteria (resulted in the scaled-down project better matched to load growth and national affordability.)	▪ No explicit demonstration of sustainability features of the project and its justification on that basis ▪ Narrow definition of sustainability assumed (e.g. economic) ▪ the social and environmental dimensions were not explored (even though they were present)
Evaluating options in an open and transparent manner with stakeholders involved from early in the process and making information accessible to all stakeholders	▪ Government stakeholders involved from early in the process ▪ ESMAP report evaluating alternatives was placed in the public domain ▪ There was media coverage of decisions reached to inform national stakeholders.	▪ No apparent involvement of water use interests in the basin or affected stakeholders in consultations. ▪ No apparent consultation with provincial centres when dropped from interconnection in Stage 1 ▪ No provision for placing information in the public domain
Continuing alternative evaluations through each stage of the project cycle (development and management)	▪ Economic and technical optimisation of selected infrastructure components of the project undertaken	▪ No analysis of environmental and social mitigation and enhancement alternatives. ▪ No analysis of longer-term benefit sharing alternatives ▪ No explicit assessment of alternative operating strategies or institutional arrangements

3.4 Challenges ahead for options assessment in the power sector

123. The ESMAP (1987) report and the Power Sector Master Plan (1996) both provide insights regarding the scope and future choices for power sector development that are highly relevant even today. Drawing from these studies and emerging practice, areas where options assessment concepts can be applied in power sector planning processes in Sierra Leone's situation would include:

- Introducing systematic, participatory procedures to develop "options portfolios " for the major infrastructure elements of power system expansion: e.g.
  - Grid generation expansion
  - Transmission expansion for interconnection of Provincial supply networks
  - Local supply alternatives for each isolated Provincial supply network and the major mining centres
  - Rural electrification in different areas of the country
  - Potential grid interconnection with neighbouring countries
- Developing a detailed power sector development strategy (10 and 20 year perspective plan) based on the guidance from the new Electricity Act and Energy Policy (once they are in place). In particular, clarifying thinking on the optimal development sequence of the Bumbuna-Yiben scheme to follow Bumbuna Stage 1;
- Developing of a clear long-term plan for the formation and build up of a national grid to interconnect with isolated Provincial systems, where it is economic to do so. At the same time exploring the possibility of joint ventures with mining and agro-processing interests in linking grid expansion to public and private sector generation expansion programs;
- Preparing a comprehensive load forecast for the whole country, including updated surveys of the needs and intentions of auto-producers;
- Determining the viability and sequence for development of small hydro schemes and assessing the enabling conditions for biomass, solar and wind generation to work in isolate networks to complement or replace diesel generation.
- Developing an action plan and priorities to undertake additional investigation studies of those energy resources where more information is needed to assess power generation opportunities (e.g. further coal, wind, biomass and small hydro resources assessments);
- Developing a policy and plan to improve end-use efficiency of electrical appliances and broader demand management-side management policy linked to tariff measures;
- Articulating a clear policy and action plan for rural electrification that considers local generation in isolated communities as well as stand-alone household options, in addition to the conventional grid-based approaches to rural electrification. The policy measures and merits of different options in terms of their ability to mobilize local entrepreneurs and create local employment in particular should be considered.
- Adopting partnership approaches for options assessment engaging other agencies, universities, civil society and major electricity use interests and auto-generators.

124. While many of the techniques and tools are readily available in the power sector planning discipline, these would be complemented with new approaches and tools emerging from the sustainable development and environment management fields (e.g. Strategic EAs, multi-criteria analysis, distribution analysis, environmental flow assessment and other IWRM tools). The new National Energy Policy and Coordination Unit in MoEP would be well positioned to coordinate these activities with power sector actors and ensure that the processes are open, inclusive and well linked to the development planning efforts in other sectors.

4. How were stakeholders involved Previously? what is the approach today?

125. Stakeholder involvement and public consultation is highlighted because it is key to building consensus in society on the choices for sustainable development of the power sector and informed decision-making by national and local decision-actors. [xxxii] The potential benefits in relation to hydropower projects are increasingly recognized to be:[xxxiii]

- Improved public acceptance of decisions
- Improved access to project financing
- Reduced risk of costly delays once project financing is arranged
- Improved and more equitable development outcomes
- Better options portfolios
- Fast-tracking immediate needs
- Early elimination of undesirable options

126. Nonetheless, these benefits cannot be realized without costs. The costs include adequate resources and lead-time for the study of alternatives, sufficient time for consultation and negotiation among water use interests, and mechanisms to enable poor and vulnerable groups to voice their concerns as legitimate stakeholders with valid perspectives.

4.1 To what extent were stakeholders involved prior to 1997?

127. The decision to develop hydropower was a national-level decision taken by the elected Parliament and subsequently expressed in the NPA Act-1982. The actors involved in the series of studies that led to recommending Bumbuna as the first hydro project and its design were, for the most part, government agencies and NPA acting in concert with donor agencies. Some information was in the public domain, but there was no broader stakeholder or public consultation on the principle components of the project as it stands 85% completed today.

128. When the initial site preparation work began in 1982 (i.e. construction of access roads and tunnel excavations), and later in 1990 when the main civil work construction started, the NPA and the contractors did have considerable interactions with the district and local authorities, as well as Paramount and Village Chiefs and elders in the affected communities. However, these consultations are undocumented. At that time there were no formal requirements for reporting on consultations and no accountability procedures in the public domain. This is not to say what was done on the Bumbuna HEP differed significantly from common practice elsewhere in the world at that time.

129. For example, there were compensation procedures and negotiations with property owners for land procurement to erect the transmission towers. Written compensation contracts were made at that time (1995-96) between the government and households, but unfortunately not paid. Similarly at the dam site, over 1,200 local residents were employed in construction activities. But there is no clear record of any compensation or resettlement provisions for the project affected households.[xxxiv]

4.2 Present-day safeguard and project preparation studies

130. The World Bank safeguard policies on Environment Assessment (OP 4.01) and Involuntary Resettlement (OP4.12) are applicable. They require that the project affected villages, individual households, as well as local NGOs and concerned stakeholders are consulted in a meaningful way. Those people who are adversely affected by the project are to receive compensation to restore their standard of living and ensure that their livelihood is restored to at least pre-project standards.

131. To accommodate these policies a three-step approach was followed in the main safeguard studies (the EIA Update study and the two Resettlement Action Plans - RAPs) to involve and consult with stakeholders at national, district and village levels. The general approach is noted in Table 11. Annex C provides more detail on the approach for stakeholder engagement on these studies.

Table: 11 Three-step processes in stakeholder interactions on safeguard studies in 2004

Step 1:	Introduction and eliciting concerns
▪ Initial presentations were made to stakeholder groups on the purpose and process of each study to elicit their concerns on the key issues and the proposed approach for the study. ▪ For example, in preparing the EIA Update, a scoping meeting for national stakeholders was held based on a Scoping Report and draft Public Consultation Plan. Subsequently, on-site meetings were held with communities, traditional leaders and local government authorities to discuss the same agenda. ▪ For the RAPs, a strategy for public consultation and information disclosure was prepared followed by a series of meetings with local communities at different locations, including presentation and discussion sessions with district and local government agencies, the Paramount and Village Chiefs and elders. ▪ Issues of concern such as the process steps and specific compensation policies and grievance procedures were discussed. Methods for their involvement in the process were agreed.	
Step 2:	**Active involvement in the data collection, surveys and evaluation**
▪ The field teams for each study then met individually with the affected communities and local leaders in group meetings, in focus groups, and in interviews with individual households to establish baseline data, attitudes and expectations, and areas of concern in carrying forward the analysis. ▪ In the case of the RAPs, this involved the delineation of the areas impacted by the project and the documentation of affected family's situation, livelihoods and amenities, etc. impacted by the project. The analysis was made in relation to codified and traditional rights and entitlements. ▪ For the EIA Update this involved surveys and field data collection consulting with local resources users and collecting local knowledge. National level stakeholders in the environment and resource management agencies were interviewed and consulted throughout the process.	
Step 3:	**Presentation, Stakeholder Review and Feedback**
▪ The results of the analyses and interaction with stakeholders were then presented for discussion. For this meetings were initially held with local government officials and Paramount Chiefs followed by open community meetings. ▪ Feedback on the outcome of the local meetings was provided to the inter-agency Technical Committee for the project and national stakeholders (some of these steps are still in progress and will be part of the disclosure of the safeguard report drafts). ▪ Depending on the particular study, this led to further negotiation, or steps to present the findings and recommendations to decision-makers (national-level or local decision makers depending on the issue), and to prepare for subsequent public consultations.	

Communications Plan

132. While each safeguard study team interacted directly with target stakeholder groups, a Communications Action Plan was developed to provide an overall communications framework for the PIU. This will help the PIU to provide consist information and messages to the different stakeholder groups during the completion phase and as the project moves into the commissioning trials and operation stages. The stated objective is to set up two-way communication mechanisms to:

- Ensure proper and timely dissemination of information on the project status and transparency in the decision process (including the implementation of agreed provisions);
- Ensure meaningful participation of all stakeholders in the completion phase decision-making processes; and
- Facilitate public acceptance and endorsement of the Project.

133. The Communications Action Plan outlines a series of media and outreach programmes with public dialogue forums to raise issues and debate concerns as they arise. There will be on-site information offices in the project-affected areas (e.g. both sides of the river in the reservoir area and at convenient locations along the 200 km transmission route that will be proactive in informing the affected communities with timely information and also serve as a centre where people can receive detailed information, support services and register and resolve any grievances that arise. These arrangements are set out in the Communications Action Plan and the more specific provisions and mechanisms are contained in the RAP documents.

Engagement of Local Authorities and Project Affected Communities

134. Presently the RAP and EIA Update studies are primary main platforms for interaction with affected communities. Those responsible for decision-making at this level include the local government and traditional authorities in the affected areas, e.g. Paramount Chiefs of Bumbuna, Fadugu, Kondembaia and Makeni, and the Local District Councils of Bombali in Makeni, Koinadugu in Kabala, and Tonkolili in Magburaka, as well as the Village Chiefs, community elders and other influential people in the communities such as teachers. The mechanisms for interaction have to date followed the 3-step approach indicated previously in Table 11. The RAPs and the EIA Update will collectively recommend mechanisms are appropriate for the completion phase and for subsequent operation phases of the project.

Engagement of national stakeholders, other audiences and interested parties

135. National Stakeholders and the public (as consumers) have a major stake in the successful completion of the project and the promised delivery of affordable power services. Print media, radio and television programs will be developed to inform the public of the project status and provide a forum for public debate (the first Radio Q&A was held on 26 Sept 2004).

136. Among the other audiences addressed by the Communication Action Plan include:

- Development Agencies and NGOs: This includes the development agencies active in Sierra Leone and particularly in the region, as well as the local and national NGOs and civil society groups to be contacted with information throughout the project implementation period and subsequently in the BHP project management and monitoring phases.
- International Stakeholders: The PIU is currently preparing material for a website that will provide international NGOs, other development agencies, civil society and professional associations with access to all safeguard studies and project implementation documents, as well as the Dam Review and Environment and Social Panel reports as they become available.

Government stakeholders

137. The primary mechanisms for government direction and cross-sector coordination are: a special Cabinet Sub-Committee; an Inter-Departmental Technical Committee; and, the Bumbuna Project Implementation Unit.

138. The Cabinet Sub-Committee established in December 2003 has a mandate to decide national energy policy with specific reference to BHP and provide oversight of a Technical Committee to help expedite decision-making. Membership consists of:

- The Vice-President of the Nation
- The Minister of Finance
- The Minster of Energy and Power
- The Minister of Works, Housing and Technical Maintenance
- The Minister of Lands, Country Planning and the Environment
- The Minister of Local Government and Community Development

139. The Technical Committee established at the same time as the Cabinet Sub-Committee has eight officials, collectively mandated to translate government approved policies into objectives and plans to be implemented by the Bumbuna PIU. It reports to the Cabinet Sub-committee on project progress including technical and financial matters and the performance of the PIU. Its mandate is to develop and promote appropriate mechanisms for all aspects of the project including those that require inter-agency coordination such as compensation issues, communications, watershed management, wildlife management and public health and safety. Membership includes:

- The Finance Secretary
- The Development Secretary
- The General Manager of NPA
- The Professional Head, The Minister of Works, Housing and Technical Maintenance
- The Chief Environment Officer, The Minister of Lands, Country Planning and the Environment
- The Bumbuna Project PIU Head
- A Representative from Professional Engineers Association and University

140. The Bumbuna PIU presently has two professional staff coordinating the safeguard and project preparation study teams. It acts as the Secretariat for the Technical Committee. The PIU will be staffing up in late 2004 with AfDB financial support. It will continue to function as the focal point for communications with national, local and international stakeholders and supervise the contracts with the project contractor and consultant.

141. It is generally recognized that how well and how effectively all the stakeholder groups are engaged in decision-making processes on completion and subsequent operation of the Bumbuna HEP will set precedents for future power projects in Sierra Leone.

5. Summary observations and Lessons

5.1 Retrospective observations - Decision-making on the BHP

142. Key observations on the context and decision to develop Bumbuna HEP as Sierra Leone's first major hydropower development are summarized as follows:

- The decision to develop hydropower was consistent with the national development policy and power sector policies as they evolved over time from the 1970's. The principle aim has been to reduce the country's dependence on costly imported fuel and establish a reliable, affordable power supply system based on indigenous energy resources, particularly hydropower.

- From the time the project was identified in the 1970-71 national hydropower inventory, onward, all evaluations of hydropower supply for the Western Area grid focused on comparing the alternative Bumbuna-Yiben sites and construction sequences with equivalent thermal options.

- The NPA Act (1982) was the key reference point in the evolution of hydropower policy that embodied the decision to develop the Bumbuna HEP. The newly created NPA was mandated to plan, build and operate the project. Parliament took this decision (in approving the NPA Act and subsequent revisions) on the strength of technical advice that it received from the Government, which itself acted on the 1980 Feasibility Study.

- Engineering-economic optimisation in the 1984 Supplemental Feasibility decided the main physical parameters of the project design and layout, as well as the initial beneficiaries – i.e. towns and provincial centres to be connected, apart from the main load centre in Freetown. The project was also optimised as the first stage of the larger Bumbuna-Yiben scheme.

- Financial criteria in the form of the cost limit of $US 100 million ($1984), derived from macro economic considerations (national affordability) introduced by IDA in 1984, set the boundaries for the engineering-economic optimisation. This essentially decided the within-project alternatives for the main physical infrastructure (e.g. location of the dam, dam height and major civil works components).

- Environmental and social criteria were not applied, or made explicit, either in selecting the Bumbuna project site, or to optimise the economic, social and environment performance of the project design and layout. All decisions on the project including the evaluation of the full Bumbuna-Yiben development scheme were prepared largely within the power sector, in the absence of any longer-term, integrated development plan for the Seli (Rokel) River basin.

- There was no apparent involvement of a broader range of stakeholders in the site selection or design optimisation other than the NPA officials, the government officials in the Ministry of Works, Energy and Power (and central ministries such as the Ministry of Finance), the project consultant and contractor, and the Donors.

143. The decision-making approach nevertheless conformed to international practices of the day for options assessment and stakeholder involvement. Moreover, the Bumbuna HEP was the least-cost supply option for the Western Area grid in all the key studies that led to the government decision to secure financing for the project in the late 1980's. The main concern raised at that time (by IDA) was the timing of the project in relation to load growth and national affordability in respect to the cost of the first stage, which led to the scaled-down version of the project.

144. The studies that started in 2004 with the IDA financed Project Preparation Fund (PPF) now provide the opportunity to address the non-structural or management and social infrastructure alternatives that will enhance the overall development effectiveness of the BHP. These studies are being undertaken with the involvement of stakeholders at national and local levels, particularly the project affected communities.

The final observation is that stakeholder and public consultation meetings that started in mid-2004 (as part of the PPF studies) suggest there is widespread consensus among all segments of society in Sierra Leone on the urgent completion of the project.

5.2 Lessons learned - Developing dams and post-war Infrastructure

On the decisions made 1980-1996:

i Perhaps the first lesson learned by 1984 was it is risky to start constructing a dam project before project financing is fully committed. The lesson is that project designs evolve over time in discussions with all stakeholders, particularly the affected communities and the financing parties. In this case, after completing the initial site preparation work that included tunnel excavations and placement in the early 1980's, the powerhouse location was moved. Retrofit measures were required to convert the right tunnel to a combined power tunnel and spillway.

ii A related lesson is financing of dams is generally a complex and protracted process. If Sierra Leone is to develop a hydro-based power system, appropriate capacities need to be established for policy and regulatory oversight. This is not only in respect to economic regulation but for environmental, social and public safety regulation covering the safeguard topics in the BHP project preparation studies. Reinforcing these capacities would not only improve the ability monitor the development performance of Bumbuna (e.g. help to ensure compliance and provide for adaptive management), but would help to streamline and enhance capacities to secure financing for future projects (small or larger) in a more timely way.

iii An overall lesson drawn from the 35-year gestation period of the BHP is the importance of enhancing strategic flexibility by having an "options portfolio" as diverse as possible. For grid supply, portfolios should contain projects at different scales suitable for different load growth situations. Otherwise, reliance on a single large project can expose the economy and society to a high level of risk. In this case, the scaled-down design (in the 1984 Supplemental Feasibility Study) was in principle easier to finance than the larger, original Phase 1 scheme. While it can be argued that strategic flexibility is provided for Sierra Leone through the availability of thermal options (i.e. adding diesel plant at any time) the establishment of the transmission facilities for the Bumbuna project will open up new opportunities to connect generation sources based on small hydro and other renewable sources, and these will increase as the grid network expands.

iv For its part, the IDA, has already suggested that the decision of the Bank to opt out of the development the Bumbuna Project in the late 1980's was a mistake - in the sense that its participation was pivotal to ensure the sustainability of the project as originally conceived.[xxxv] For example, the EIA was not started until well after project construction was underway.

On the decision made post-2002 to resume construction and completion of the project:

v The choices the Government and its Donor partners faced in 2002 as regard to the Bumbuna project were essentially: i.) delay its implementation indefinitely; ii) modify the existing structures to operate as a run-of-river plant without impounding the reservoir, iii) remove the dam; or, iv) proceed immediately with the completion of the project. The decision to complete the project as soon as possible was based on the combination of factors, as discussed previously.

vi The work from 2002 onward has provided an opportunity to ensure compliance with environmental and social safeguards policies that was not present in the 1990's. Moreover, a rich array of alternatives have been revealed while preparing the safeguard studies – such as for the social and environmental mitigation and enhancement components, for watershed management and environmental offsets, for benefit sharing, and to provide sustainable financing and supporting institutional arrangements. Thus the sustainable dimensions have been restored in large part and the potential contributions to the Millennium Development goals in Sierra Leone are enhanced (particularly MDG 7 that relates to ensuring environmental sustainability).[xxxvi]

On the post-war infrastructure decision more generally:

Sierra Leone's experience with the Bumbuna HEP also provides general lessons for governments in the region faced with decisions about whether to complete water infrastructure that had been abandoned partway during construction, due to war or other political transformation reasons. Certainly for dams, these decisions must be made in the context of new and tighter standards for securing international financing as compared to the 1990's.

Among the factors that contributed to the collective decision by Donors in September 2003 to support the completion and commissioning of the project, subject to safeguard studies were:

- The project had originally been identified as the least-cost power supply option. Moreover, as it was a run-of-river project there was a high confidence that compliance with environmental and social safeguard policies could be readily accommodated, given the political will and resources to implement the necessary mitigation and enhancement measures;

- The project had a clear rationale in the national policy context today (e.g. its completion was expressed as a priority in the post-war national recovery strategy; was consistent with the power development policy and investment strategy; and was seen as contributing to political stabilization through job creation and welfare improvements);

- Contractor claims resulting from suspension of commercial contracts due to war had to be resolved and cost estimates for completion of the project prepared before the international public and private financing organizations would become involved. In this situation, steps were taken early in the process by AfDB to bring in an independent auditor;

- Condition assessments were required for civil work and electromechanical equipment. In the Bumbuna case, these assessments indicated the need for rehabilitation work apart from resumption of construction. Similarly there were unanticipated resettlement issues. For example, after almost 10 years many new houses had been built in the transmission ROWs. This required new approaches to resolve resettlement issues.

- Estimates of the annual cost of non-completion (in this case $US 4.5 million a year for public expenditure on imported oil, excluding the cost of unserviced energy) helped to place the urgency of the decision in context;

- Positive appraisals of the economic and financial attractiveness of completing the project were required and facilitated decision-making by the donors (in this case treating the past investments with no debt attached as sunk cost the EIRR was 29.3 % and the FIRR 11.3 %. This assumed grid supply costs to NPA well below the thermal supply costs of $US 0.17 / kWh for the oil prices prevailing in 2003);

- Political support from the Ambassadors of Donor countries active in the country combined with real prospects for peace and security were present; and lastly,

- Public support for the urgent completion of the project was present. In this case it was motivated in part by the massive load shedding and decades of experience with costly and unreliable power supply on the Western Area grid, and in part by the genuine desire to develop the power sector with indigenous renewable sources. The recent turmoil in the international oil markets underscored the need to diversify the generation portfolio to manage risks.

5.3 Key observations - Moving forward in power sector development

145. Options assessment has come to the forefront of the international dialogue on the sustainable provision of water and energy services, particularly for the financing, development and management of large dams. As discussed in section 3.3, a clear, long-term integrated plan to provide reliable power services throughout the country is needed. This requires detailed consideration of options for:

- New grid supply, particularly for the post-Bumbuna generation investment
- Interconnection of Provincial supply networks, where economically feasible
- Local supply for isolated Provincial generation and networks, and mining industry loads
- Rural electrification based on conventional grid extension and off-grid technologies, and
- Potential grid interconnection with neighbouring countries in the medium term

146. The new Electricity Act and the Energy Policy expected in the next year will help to clarify the policy framework within which priorities can be set. Strategic options assessments can inform those decisions, but more comprehensive approaches will be needed to decide the mix of options and interim strategies. The challenges in doing so are to provide open, systematic, and participatory processes because it is clear the decisions will impact on all sectors of society and the economy.

147. Among the concerns and benefits to be derived from improving the application of options assessment concepts in future power sector planning and development, include:

- Strengthening institutions and partnership approaches to improve outcomes
- Expanding access to project financing
- Adopting integrated management approaches to achieve sustainable development

1. Strengthening institutions and partnership approaches to improve outcomes

148. Along with the current institutional reforms in the power sector, it would be important to clarify responsibilities and respective roles that key actors such as the new regulatory body, MoEP, the NPA, the new Bumbuna SPC and the entity responsible for transmission operation will play in assessment of options for different needs. The National Energy Policy and Coordination Unit to be established in MoEP would likely play a key role:

Considerations include:

- **Procedures and approaches:** Developing procedures and approaches for systematic and participatory options assessment as part of the new power planning system, that link to development policy and planning activities in other sectors;

- **Partnerships:** Developing partnership approaches between government, civil society, industry and entrepreneurs that bring the interests and best capabilities and resources to bear (e.g. appropriate collaboration with Universities on biomass and small-scale solar options, and collaboration with the private sector to coordinate public-private generation expansion with renewable energy source options and transmission extension investments);

- **Knowledge Networks:** Developing contacts and linking to African-based and international knowledge networks involved with options assessment and gaining exposure to viable demonstrations of renewable energy generation technologies at different scales.

- **Technical Resources:** Assembling a knowledge base of tools for risk and options assessment at different levels, such as Sector Environment Assessments (SEAs). And building on previous work starting with the Master Plan (1996) and Energy Sector Issues and Options Report (1987) and the guidance offered by organizations such as the World Bank and the International Hydropower Association (cited in Annex E).

2. Improving access to project financing

149. Many international financing agencies have adopted standards where options assessment directly or indirectly influences lending practices. New financing sources for sustainable development initiatives are also emerging that represent important new opportunities for Sierra Leone's power sector investment. For example:

- **Public Sector Financing**: These are the traditional sources of multilateral and bilateral development financing that Sierra Leone has relied upon for power investment in past. Most development agencies (including export credit agencies - ECAs) today require more explicit and participatory options assessment in strategic and project-level planning to demonstrate the extent of public support for projects they would help to finance: e.g.

o In September 2003, OECD countries announced a harmonizing agreement to 'strengthen their common approaches for evaluating the environmental impacts of infrastructure projects supported by their export credit agencies. The aim was to ensure that these meet established international standards, which are essentially standards of the World Bank.

o World Bank safeguard policies, for example, Operational Policy and Procedures (OP 4.01) on Environmental Assessment have explicit requirements for options and alternative assessment. These are coming under increasing attention, as illustrated by the Inspection Panel report (2002) on IFC/IDA support for financing the 250 MW Bujagali run-of-river hydropower project in Uganda. [xxxvii] The case illustrates the degree of emphasis now placed on improved options assessment in financing dam projects both in the international and African context;

o "Good practice" guidance material on options assessment related to dam projects is available from the World Bank's Dam Planning and Management Action Plan (DAMAP).

- **Private Sector Financing**: These sources will need to be tapped for public-private ventures and wholly private ventures in power supply development (as in the case of financing the Bumbuna HEP, where IDA's Partial Risk Guarantee will facilitating lending by commercial banks). Over 27 leading private financing institutions (PFIs) that account for over 70% of infrastructure financing globally adopted a voluntary industry protocol in 2002, called the "Equator Principles". [xxxviii] The aim is to standardize approaches to assess and manage environmental and social risk exposures for dam projects and other large infrastructure. This essentially links private bank lending policies to IFC and World Bank Safeguard policies for projects over $50 US million.

  The Equator Principles stipulates participating PFIs will only provide loans for dam projects (and other large infrastructure projects) that subscribe to a set of 9 principles that include:

  o Project risks are categorized in accordance with internal guidelines based upon the environmental and social screening criteria of the IFC and World Bank (which incorporate options assessment);

- o An Environmental Assessment (EA), is completed that complies with 17 relevant aspects;
- o Meeting all requirements under host country laws and regulations, applicable international treaties and agreements;
- o Participation of affected parties in the design, review and implementation of the project;
- o An Environmental Management Plan (EMP) is prepared with mitigation, action plans, monitoring, management of risk and schedules, and the borrower has covenanted to comply with the EMP in the construction and operation of the project;
- o Project-affected groups are consulted throughout, in a structured and culturally appropriate way, including indigenous peoples and local NGOs, and the EA has been made available to stakeholders and the public in a timely and appropriate manner.

The other Equator Principles relate to requirements for an independent environmental expert to provide additional monitoring and reporting services.

- **Emission Reduction/ Future Carbon Trading:** Financing mechanisms exist to help developing countries reduce CO_2 emissions from power generation. New international carbon trading systems will be introduced in future under the Kyoto Protocol (1995) and with UNFCCC (1992) encouragement to mitigate climate change. The power sector (mainly themal) generation accounts for close to one third of human CO_2 emissions globally. Sierra Leone has endorsed, but not officially ratified the Kyoto Protocol and is a party to the UNFCCC. Assessing power options against such criteria would be an important step to enhance eligibility to such financing, not only for hydro options, but for biomass and solar options in isolated centres and rural electrification.

Based on preliminary calculations the amount of CO_2 abated for power supplied from the Bumbuna HEP (i.e. displacing HFO use in the Kingtom Power Station) would amount to about 180,000 tonnes of CO2-equivalent per year after full absorption of the BHP supply. The 275 Bumbuna-Yiben development would displace closer to 300,000 tonnes of CO2-equivalent per year. How the carbon offsets are valued and translated into financial returns depends on a number of factors such as noted below.

Among the global trends in carbon financing:

- o Mechanisms for International carbon trading under the UNFCCC (1992) and Kyoto Protocol are under consideration, and organizations such as the World Bank have already established a prototype Carbon Financing Initiative program to act as a “proxy” for international carbon trading, for which developing countries are eligible to apply.

- o A EU-wide carbon emissions trading Directive will come into force January 2005 that means that all designated European industries and power utilities will come under EU carbon emission quotas for the first time. If they produce emissions above the quota, quotas from other companies or utilities that have not been used will have to be bought. In the initial year trading will be “virtual” and in the second year payments for quota trading will be executed.

- o While only a few trades have been made in the run up to full trading of EU Allowance Units (EAUs), the prices quoted in the forward markets have increased from about €6/tCO2 in April 2004 to the current levels of €12.50/tCO2. Industry observers expect that trading may level at in the €7.0 /tCO2 range by the end of 2006.

1. Adopting integrated management approaches for sustainable development

150. Options assessment is both a tool for integrated resource planning and management and a process to help strengthen cross-sector coordination. Integrated water resource management is now widely accepted as the primary pathway to sustainable development in the water sector.

151. The preferred institutional arrangement for effective integrated water management is the basin authority or river basin organization (RBO) and many new organizations have recently been established such as the International Association of River Basin Organizations have been established. (INBO). Since the 1990's national legislation requires RBOs to be created in virtually all Latin American countries. Similarly, the European Water Framework Directive (WFD-2000) requires RBOs in all European Member States. Under the WFD functional basin management plans developed in consultation with water use interests are required by 2009. Hydropower projects (proposals for the development of new dams and strategies for the management of existing hydropower dams) will be evaluated in the context of these basin management plans.

- **Integrated Water Resource Management (IWRM) in the Seli River Basin.** The Seli River Basin Development Authority that was created in 1999 would be an appropriate vehicle to introduce for IWRM practice in the Seli basin. A functional RBO would play a role in selecting, designing, developing and managing water infrastructure. As mentioned previously, the key question on this issue is perhaps when, not whether to activate the Seli Basin Development Authority. Or perhaps whether to do it in stages. While the Bumbuna (Phase 1) is essentially a run-of-river project with limited flow regulation changes the full Bumbuna-Yiben scheme has multi-annual storage capability, thus more substantive implications for water allocation and use in the Seli Basin where a river basin entity would be important.

- **Hydropower dams as instruments of development**: While the Bumbuna HEP will provide sustainable power services essential to the economy and the welfare and livelihood improvement electricity users, many of these direct beneficiaries live in urban centres and towns. The national investment in the Bumbuna project can also serve as an instrument for local development for the affected communities that "host" the project. In practice this can also mean paying special attention to the benefit sharing provisions associated with the Bumbuna project such as a direct monetary redistribution of project-related revenues or profits to project-affected populations. Such mechanisms go beyond resettlement and rehabilitation programmes and environmental and social mitigation or compensation measures. Typically these provisions would be embodied in legislation such as the Electricity Act.

  o Here there are many important precedents in developed and developing countries alike for a portion of the revenue from power sales to remain in the community. Under the World Bank DAMAP programme a technical review of approaches, "Benefit Sharing from Dam Projects", was completed which looked at mechanisms for direct monetary redistribution of project-related revenues, or profits, to project-affected populations. It reviewed current experience and further opportunities in different governance settings, namely with:

  - Redistribution of part of the dam's revenue to local or regional authorities in the form of royalties tied to power generation, or water charges in the case of non-hydro projects;
  - Establishment of development funds financed from projects with power sales;
  - Part or full ownership of the project by project-affected populations (equity sharing);
  - Levying property taxes by local authorities; and,
  - Granting preferential electricity rates and fees for other water related services to local companies and project-affected populations.

  o In Sierra Leone there is a precedent with a proposed new Mining Community Development Fund where local communities will receive a portion of the export tax on the sale of diamonds. Though its effectiveness has yet to be evaluated, it demonstrates acceptance of the principle of benefit sharing with local communities in resource development activities, where ownership of the resource is vested with the State and controlled by concession agreements with public or private development entities. The government has effective ownership of water resources in Sierra Leone, as in most countries. However, when evaluating the need for local benefit sharing of resource development, one of the main factors to be considered is the level of existing public infrastructure and services in the affected area.

Treating the completion and management of the Bumbuna HEP as a platform for local development will enhance its overall development effectiveness and sustainability credentials (e.g. help to balance its economic, social and environmental performance dimensions).

- **Synergies with Sierra Leone's commitments under International Conventions:** The extent to which a dam project will affect Sierra Leone's international commitments for environmental and social management (positively or negatively) made in signing International Conventions would typically be assessed in the Project EIA (e.g. RAMSAR – concerning conservation and management of wetlands and ecosystem services they provide; CBD – concerning biodiversity conservation and management; and the UNFCCC – concerning climate change emission reduction (avoiding thermal generation) and adaptation to increased climate extremes and variability in the water resource sector). The assessment should also be done more strategically "upstream" in the planning process when power development options are evaluated and screened.

  Other positive synergies to be achieved in the sustainable management of hydropower relate to monitoring and building institutional capacities, for:

  - Protected area management
  - Freshwater and ecosystem management
  - Strengthen the EIA processes nationally applied to dam projects
  - Strengthen the environment monitoring during project operations and promoting adaptive management
  - Developing plans to adapt to climate change in the water resource sector as required under the UNFCCC.

Thus the BHP experience can serve as a model to develop capacity in Sierra Leone future power sector projects and provide valuable lessons with these aims in mind.

Annexures

Annex A:
Milestones and Events in the BHP Project History: A Chronology

Milestones National / Power Sector	Year	Events Relevant to the Bumbuna HEP
National Independence	1961	
Establishment of the Sierra Leone Electricity Corporation (SLEC) succeeding the Electricity Division in the Ministry of Works	1964	
	1970-71	First nation-wide hydropower inventory funded by the UNDP 72 MW Bumbuna scheme identified as the most attractive site to supply the Western Area grid, meriting further study Further investigation of the BHP identified in the 15-year plan "Strengthening of the Sierra Leone Electricity Corporation"
	1973	A second upstream reservoir site at Yiben not envisaged in the 1970-71 study identified in the Bumbuna Hydropower Development Study A staged-development of a proposed Bumbuna-Yiben scheme was recommended beginning with a seasonal storage dam at Yiben with a 55 MW power station at the base of the dam
	1974	Additional technical optimisation studies were carried out to refine thinking on the first stage of the development The first stage of the scheme was revised to start with a 35 MW power plant at Bumbuna Falls regulated by an upstream reservoir (at the current site) with 320 Mm^3 storage
	1975	IDA becomes involved in technical reviews of the BHP alternatives
Ministry of Works, Energy and Power Created. IDA Power Sector Credit 734-SL	1977	IDA includes funding for a feasibility study in Credit 734-SL The Bumbuna Hydro-Consultant Consortium is selected to prepared the Feasibility Study
	1980	The Feasibility Study of the BHP is competed and proposes a 305 MW project in five stages The first stage at $US 192 million (in mid-1980 US$) includes a 74m high dam with a 53.4 MW plant utilizing the 40m head at the base of Bumbuna Falls, fed by a 2.5 km headrace tunnel
	1981	Start of preparation of ICB pre-

Milestones National / Power Sector	Year	Events Relevant to the Bumbuna HEP
		qualification notice and Tender documents for Stage 1 construction IDA temporarily suspends the ICB pre-qualification notice pending review of the unit costs and macroeconomic impacts
NPA Act (1982) Provides that the Authority shall be responsible for the construction, management and operation of the Bumbuna HEP	1982	Update study of unit prices and economic analysis prepared to assess impacts of price changes in oil markets Government through NPA starts site preparation work involving construction of camps and access roads and main diversion tunnels - based on the Feasibility Study design Work is financed by US$20 Million loan from the Government of Italy (via the Mediocredito Centre) and $USM 4.5 from GOSL
	1983	IDA completes study of macroeconomic impacts of Bumbuna While results are not available they increase IDA's concerns over the macroeconomic impacts of the Phase 1 project.
Government sharply curtails oil imports and access to FOREX, which Impacts on NPA's capacity to obtain O&M spares for diesel plant	1984	IDA discussions with GoSL result in direction of the Project Consultant to prepare a Supplemental Feasibility for a scaled-down Stage 1 alternative, limited to $US 100 million. Subsequent scaled-down version (47 MW) costs $US 93 million (1994$). Cost reductions achieved by a combination of design and layout changes, the most important being moving the powerhouse to the dame toe and adopting a single 161 kV circuit eliminating intermediate substations The dam was raised by 17m to 88m to compensate for the head loss by moving the powerhouse Tender Documents previously suspended completed for the reduced-scale project
	1985	initial site works programme (1982-85) completed.
	1986	Following ongoing discussions IDA withdraws from further financing support for BHP implementation
General suspension of IDA Credit disbursement to Sierra Leone. Discussions on IDA Power Sector Rehabilitation Project temporarily	1987	UNDP-World Bank ESMAP Issues and Options for the Energy Sector report completed Assessment confirms the scaled-down BHP project as least-cost option for supply to Western Area grid and that macroeconomic impacts are similar to thermal on imported oil. With the withdrawal of IDA, GoSL

Milestones National / Power Sector	Year	Events Relevant to the Bumbuna HEP
suspended.		requests the Government of Italy and AfDB to consider support for the scaled-down project
	1988	Financial Covenant between GoSL and Government of Italy for ($USM 102.2 equivalent) Loan for BHP civil works components GoSL and consortium negotiations (1986-88) on civil works Signed contract, with effectiveness subject to confirmation of AfDB financing for E&M components (as required by GOI)
	1989	ADB confirms financing of $USM 41.7 equivalent for electromechanical and transmission / substation components $USM 3.1 for engineering design and supervision. Civil works contract come into effect
	1990	Site construction starts under civil works contracts
IDA reengages GoSL on discussions for Power Sector Rehabilitation Credit.	1991	Loan agreement between GoSL and AfDB completed for Power Station E&M and transmission/substation components. Incorporates decision to move back to 2x25 MW units (50 MW)
Credit Approved after agreement on Tariff Reform. Rehabilitation of Kingtom diesel plant started.	1992	Provision made in new IDA Credit to finance an EIA for the project (then under construction), a Panel of Experts, a Power Sector Master Plan, and a Water Resource Engineer Advisor
Italian Govt cancels principal amounts for loans prior to Dec 31, 1992 ($20 for 1982- Loan and 62.5% of $US 102.2 million for 1989 loan for main civil works)	1993	GoSL enters into contracts with suppliers for AfDB financed E&M components of the project Contractor (Salini) suspends work in late 1993, claims of non-payment of local disbursements by Government.
	1994	MoPE / NPA engage an independent consultant to audit the situation, assess amounts due and identify any financing gap; Consultant recommends proceeding with BHP based on review of works quality, costs and economic evaluation Identifies a financing gap of $US 53 million Recommends urgent attention to project supervision for the completion work and steps to

Milestones National / Power Sector	Year	Events Relevant to the Bumbuna HEP
		identify institutional arrangements to operate the project (NPA has no hydro experience)
	1995	Protocol Agreement signed between GOI and the contractor (Salini) and project consultant to resolve claims matters 161 kV transmission work proceeds (erection of towers)
Power Sector Master Plan (1996)	1996	AfDB provides additional financing for Civil Works and civil work re-starts AfDB commits additional funds for Bumbuna PIU to strengthen project monitoring and supervision capacity
	1997	**Site Works abandoned due to civil war**
Official End of War (Jan 2002) National Elections (May 2002)	2002	Audit of the project status, outstanding claims and financing gap at that stage (by Lahmeyer International) Recommends procedures and basis for settlement of claims Recommends proceeding with completion of the project pending existing parties reaching agreement and financing
IDA Appraisal for Power and Water Credit Appraisal. Donors Meeting For Financing The BHP	2003	Donors complete two Missions to Sierra Leone to evaluate the status of the project AfDB and GOI prepare a Project Appraisal that recommends Donor support for completion of the project Donor Meeting held in Sept 2003 pledges support for BHP completion ($US 33 M in direct loans $20 Million in Partial Risk Guarantee (PRG) plus a PPF fund by IDA)
IDA Power and Water Credit Effective Sept 04	2004	Safeguard and project preparation studies for Bumbuna HEP start under IDA's Project Preparation Fund (PPF)

Annex B:
Chronology and Summary of Planning and Investigation Studies

	Study /Activity	Key Elements / Findings
1970-71	National Hydropower Inventory, prepared by Moto Columbus (Baden, Switzerland) with UNDP financing. Strengthening the Sierra Leone Electricity Corporation", UNDP-financed study undertaken by Moto Columbus (Baden, Switzerland)	Screened the country for hydropower sites and prepared preliminary design and cost estimates for 22 sites Sites ranked in order of economic merit 3 sites identified as warranting detailed investigation as near term development projects: o Bumbuna Falls (72 MW) - 40 km north east of Makeni o Benkongor Falls (15.2 MW) - 40 km west of Koidu o Goma (18 MW) - 30 km north of Kenema in the south east of the county Concluded Bumbuna site is most attractive to serve the Western Area grid system (location and economic-technical criteria) Further investigation of the BHP included in the 15-yr Electric Supply Development Plan (1970-1985)
1972-73	Bumbuna Hydropower-Development Project, Study Prepared by Carloti, with Salien /Comstock/ Tecsult of (Italy and Canada)	Investigation studies on the Seli river identified the Yiben dam site and a potential Bumbuna-Yiben development scheme Proposes a staged development starting with a dam at Yiben 30 km upstream of Bumbuna Falls with 55 MW power station
1974	Technical Review of the Caloti Study, prepared by Studio Pietrangeli, of Rome	Compared 4 different 30 MW first Stage options in area of Bumbuna upstream of the Falls Recommends the first stage as a 35 MW powerhouse below Bumbuna Falls regulated by an upstream reservoir (at the current dam site) of 320 million m3.
1975	Hydrology, Economic Analysis and Load Forecast, prepared by Studio Pietrangeli, Financed by SLEC/GoSL	Updated hydrology studies, load forecasts and prepared and economic analysis of the schemes under consideration
1980	Feasibility Study of BHP Prepared by the Bumbuna Hydropower Consultants, a consortium of Motor-Columbus and Studio Pietrangeli (under Bank financing and supervision)	First feasibility-level study including detailed site investigations Identified potential of the Yiben-Bumbuna development sequence as 305 MW and recommended five stages First stage as the 74m high dam with a 52 MW plant below Bumbuna Falls
1981	SLEC, Ten year Development Plan updated, Prepared by Oskar Van Minver	not seen in preparing this retrospective review

1981	Unit Price Update (IDA)	IDA commissioned study to update of the unit prices (Not seen / no references in other reports)
1983	Macroeconomic Impact of the Bumbuna Falls Project on the Sierra Leone Economy (IDA)	Assessed macroeconomic impacts of the project in light of the economy and changing international oil markets References only seen in preparing this retrospective review Expressed concerns of the national affordability of the project
1984	Supplemental Feasibility Study undertaken by the Bumbuna Hydropower Consultants (under Bank financing and supervision).	BHP Consultant recommends scaled-down version of 47 MW and 290 Gwh estimated cost of $US 93 M ($US 1984) Economic comparison made with equivalent thermal (diesel and combustion turbine) Cost reduction achieved by design changes: o moved powerhouse to the toe of the dam converting the right bank spillway to combine power tunnel o adopted a single 47 MW turbine o changed to single circuit (161 kV) transmission, instead of a double 132 kV circuit o eliminated intermediate sub-stations and reduced 34 km of transmission in Bumbuna-Freetown o exclude planned transmission lines south from Bumbuna to Sefadu o added insulated shield wire 35 kV service to Makeni and Lunsar Concluded scaled-down version did not compromise economic merit of the full Bumbuna-Yiben scheme ($600 million)
1987	ESMAP - UNDP/WB Energy Assessment Report: Sierra Leone Issues and Options in the Energy Sector	Evaluated four development sequences as grid supply to the Western Area grid: - pure thermal schemes (imported coal and oil) - full Bumbuna development (as 1980 Feasibility study); - reduced Bumbuna Stage 1 (47 MW), followed by pure thermal; - previous Bumbuna Stage 1 (71 MW), followed by pure thermal Concluded the scaled-down Bumbuna scheme (followed by thermal plant) was the most economically attractive of the 4 options Macroeconomic impacts were not significantly different from thermal based on imported oil with recurrent costs for oil import.
1989	Report on the Technical and Economic Issues Raised by the World Bank	not seen in preparing this retrospective review

1990	Proposal for Loan and Grant Financing for the Bumbuna HEP, African Development Fund	References to but not seen in preparing the retrospective review
1990	Cost estimate and economic analysis with 2 units	Recommended changing to 2x25 MW instead of one 47 MW unit
1992	WB Staff Appraisal Report for the Power Sector Rehabilitation Project	Recommended including financing in the Credit for: ▪ Bumbuna EIA ▪ Master Plan ▪ Expert Panel ▪ Hydropower Engineer The Credit became effective in 2003
1994	Report on the Status of the Bumbuna Falls Hydroelectric Project, undertaken by Alfonso Posada for the NPA, financed by GoSL.	Commissioned by GoSL after the civil contractor suspended work in late 1993 Reviews the economic justification for the project, concluding that while the cost was high for its size, the method of calculation quantities and unit rates conformed to international standards Considered past costs without attached debt as sunk cost, assessed the project to be economic compared to thermal options the estimated completion cost was $US 52 M ($1994)
1994	Environment Impact Assessment of the Bumbuna Hydroelectric Project. Prepared by Electrowatt Engineering Services Ltd & Techsult Co. Ltd of Freetown, financed by IDA.	EIA started in 1994 while project was underway The baseline work was completed The full EMP work was not completed, presumably due to the deteriorating security situation.
1996	Power Sector Master Plan, prepared by Lahmeyer International in association with Techsult Co. Ltd of Freetown financed by IDA	Comprehensive report that included a suite of studies, including o Load Forecast (Grid and Isolated Supply) o Hydro and Thermal Option Analysis o Rehabilitation Analysis and Inspection of Provincial Stations and Networks o Alternatives Analysis (renewable options) o Generation System Expansion Planning – Least Cost Analysis o Sub-transmission and distribution development o Medium-term system operation study o NPA Tariff and Financial Analysis o The EIA

		Draft Final submitted but no stakeholder consultations
2002	Lahmeyer International, Bumbuna Falls Hydroelectric Project Sierra Leone, Technical & Financial Audit Report, financed by AfDB	Recommends completion of project and confirms financing gap
2002	The World Bank, Transitional Support Strategy for the Republic of Sierra Leone, Report No. 23758-SL, March 3, 2002	Available on the Bank website
2003	Joint AfDB, GOI, WB Mission, Sierra Leone: Bumbuna Hydroelectric Project, Record of Discussions	Recommend project completion and commissioning
2003	Sierra Leone Completion Of The Bumbuna Hydroelectric Project (BHP), Joint Appraisal Report, African Development Bank Infrastructure Department, Central – West Region and Italian Ministry Of Foreign Affairs, Directorate General For Development	Recommends project for completion and commissioning
2004	Assessment Study for a Resettlement Action Plan for 33 kV sub-transmission for the Western Area, funded as part of preparation studies for the World Bank Power and Water Credit	Available on the Bank website
2004	NPA Resettlement Policy Framework, funded as part of preparation studies for the World Bank Power and Water Credit	Available on the Bank website
	IDA Project Preparation Fund (PPF) Safeguard and other Studies	
2004	Resettlement Action Plan (RAP) for Reservoir and Damsite Area	Available at Bank Website
2004	Resettlement Action Plan: (RAP) Transmission Line	Available at Bank Website
2004	Updated EIA	Available at Bank Website
2004	Retrospective Review and options	Available at Bank Website
2004	Emergency Preparedness Plan (EPP)	Available at Bank Website
2004	Institutional Arrangements	Available at Bank Website

	Study	
2004	Regional Development Plan (RDP)	Available at Bank Website

Annex C:
Stakeholder Consultation in the Safeguard Studies in 2004

The following table highlights the approach only and the status. - (To be updated in the Final Report)

Study Component	Stakeholder Consultation Approach / Activities	Timing
Environment Impact Assessment (EIA) – Update	Public Meeting on the Public Consultation and Disclosure Plan in meeting in Freetown Field investigations employing interviews, questionnaires and surveys engaging the PAP Local Authorities: Meetings with Paramount Chief Bumbuna on issues Public meetings with affected communities (Upstream, reservoir area, downstream) Government Agencies - Presentation of the preliminary finding to Technical Committee Presentation of the preliminary finding to national audience Presentation of the preliminary finding to Community audience	Consultant Mobilized late July 2004 Draft Final 22 Oct
Resettlement Action Plan for the Bumbuna to Freetown Transmission Line	(To be updated in the Final Report)	Field team mobilized Draft Final Report Mid October
Resettlement Action Plan for the Reservoir Area and Dam Area	(To be updated in the Final Report)	Field team mobilized late July 2004 Draft Final Report Mid October
Other Project Preparation Studies		
Institutional Arrangement for the Implementation and Operation of the Project (2-yrs, Sept 04 to Sept 2006) Retrospective Review (6 wks over Sept 2004 to Nov 2004) Regional Development Plan (RDP) Update of the electricity Sectors Financial Sustainability Review of the economic analysis Emergence Preparedness Plan (EPP) Dam Safety Panel of Experts and Environment and Social Advisory Panel		

Annex D:
Options for Power Supply Development in Sierra Leone:

Category	Supply Options	
Grid-connected supply	Oil:	- current technologies (e.g. low-speed diesel generators (medium and high speed), combustion turbines, steam-fired thermal plant) - rehabilitation and/or new - accelerating exploration for domestic oil/gas
	Hydro:	- Remaining Yiben-Bumbuna Sequences - Other hydro projects (see Map Figure 8)
	Other Renewable	- Biomass Generation (forest biomass or agriculture wastes) - Site Specific Wind Generation - Solar themal Electric
	Coal	- Coal Fired Steam Plant in Freetown or at min-site locations e.g. Yema
	Urban Waste	- Power from waste Incineration in Freetown
Interconnection of Local Supply Networks	Expansion of the 161 kV Bumbuna Transmission at different supply voltages to interconnect with: o Provincial supply networks o Mining centre Loads Further interconnection of isolated loads away from the Western Area grid (e.g. Goma, BO and Kenema transmission connection)	
Supply to Isolated networks at Provincial Centres and Mining centres	- Conventional Diesel Plant - Small Hydro - Biomass generation (conventional wood-fuel or agriculture waste steam technologies, reciprocating engine technologies and gasification.) - Site-specific Wind generation and Solar (thermal-electric) - Hybrid Systems e.g. hydro-thermal (with thermal based on conventional diesel oil or biomass-fired stem plant)	
Rural Electrification	- Rural electrification as stand-alone village or household systems (e.g. micro hydro, PV solar, biomass, gas generator, wind and hybrid systems, etc) - Rural electrification linked to isolated supply networks on diesel or alternative local generation (distribution) - Rural electrification based on conventional grid extensions (distribution)	
Grid interconnection with neighbouring countries	In the longer term, interconnection with electrical systems as a member of the West African Power Pool and to obtain benefits of mutual power and energy exchanges on a firm or standby basis. o Interconnection with Guinea (e.g. around Bumbuna-Yiben development to export surplus energy) o interconnection of the Sierra Leone and Liberia systems (e.g. around a Mano River hydropower development as a export project).	

Annex E:
International Guidance: Options Assessment Principles and Approaches

The following illustrates the type of guidance available on the application of options assessment concepts for power sector development and management, particularly where dam projects are under consideration as generation alternative.

1. The World Bank

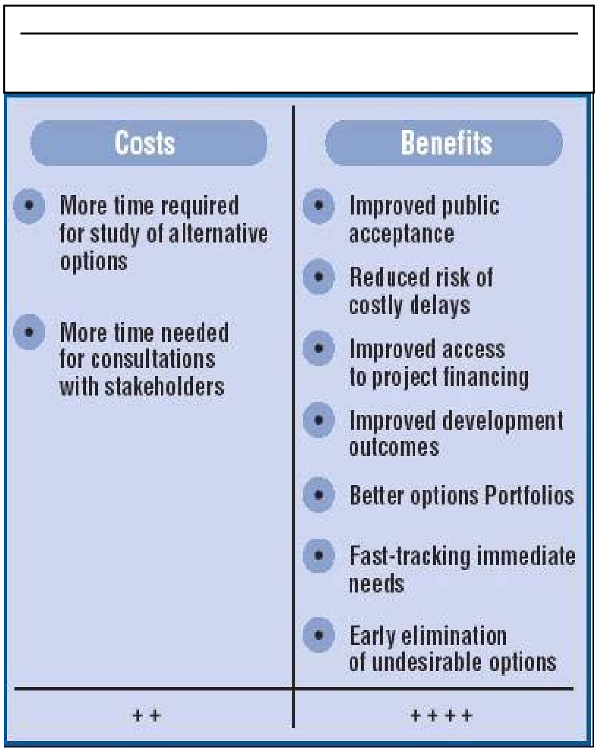
The World Bank has a number of management tools on options assessment that included the informal and formal guidance materials on Sector Environment Assessments and project level EIAs.

- Update No. 17 - Analysis of Alternatives in Environmental Assessment, December 1996 (79KB PDF)[xxxix]
- Strategic Environment Assessments (SEAs)

As part of its follow-up to the World Commission on Dams (WCD) report in 2000[xl], the World Bank launched the Dams Planning and Management Action Plan (DAMAP) in 2002. [xli] The aim was to provide a knowledge management tool that bank operation staff and their country counterparts could use in preparing water resource projects.[xlii] The new tools and knowledge introduced with DAMAP were also to support the new Water Resource Sector Strategy, approved by the World Bank Board in February 2003. The strategy sets out new priorities for engagement with client countries in their management of water resources, including more emphasis on the rehabilitation, development and management of existing, and development of new water infrastructure, where justified.

Two items are important for options assessment:

The first was the sourcebook, "Stakeholder Involvement in Options Assessment: Promoting Dialogue in Meeting Water and Energy Needs", published in 2003.[xliii] It offers guidance and practical examples on how to enhance stakeholder involvement in planning exercises for water and energy services, as well as the evaluation and selection of within-project alternatives (i.e. in the design, development and operation phases of dam-projects).



It offers four broad principles for improving options assessment.

- Create an enabling environment
- Involve all relevant Stakeholders
- Assess options strategically and comprehensively
- Reach a decision

The principles are expressed in practical terms with examples drawn from recent practice at both strategic planning and project-planning levels, including the development of supportive instruments and mechanisms and capacity strengthening measures.

The application of the knowledge and guidance that DAMAP offers is not a formal requirement in Bank lending, to the extent the safeguard requirements are.

The second DAMAP item was a technical review, "Benefit Sharing from Dam Projects", which focused on alternative mechanisms to ensure a direct monetary redistribution of project-related revenues, or profits, to project-affected populations. It looked at current experience and further opportunities in different governance settings, which enable going beyond traditional resettlement and compensation arrangements, namely with:

- Redistribution of part of the dams revenue to local or regional authorities in the form of royalties tied to power generation or water charges, in the case of non-hydro projects;
- Establishment of development funds financed from projects with power sales;
- Part or full ownership of the project by project-affected populations (equity sharing);
- Levying property taxes by local authorities; and,
- Granting preferential electricity rates and fees for other water related services to local companies and project-affected populations.

Additional information on emerging practices in options assessments for dam projects are located at the UNEP Dams and Development Project.[xliv]

2. The International Hydropower Association (IHA)

In 2003 IHA, which has members in 80 countries, recently produced a set of Sustainability Guidelines along with a Compliance Protocol.[xlv] The guidelines were produced to '…ensure that future energy options, including alternative hydropower schemes, are sustainable, (where) it is essential that criteria be developed to assess sustainability performance'.

The Compliance Protocol was developed to aid IHA members in implementing the IHA Sustainability Guidelines. It is intended to be a simple and easy-to-use approach. It contains three sustainability-rating assessments:

- Options Assessment – compares the sustainability of alternative energy supply options at the early stages of considering requirements for a new energy supply development.
- Evaluation of Hydropower Projects – compares the sustainability of alternative hydropower projects at the siting and design stage of a development proposal; and
- Appraisal of Hydropower Operation and Management – assesses the sustainability of existing hydropower schemes.

The IHA Sustainability Guidelines refer to participatory processes during strategic assessment of energy policies (section 3.2), during the evaluation of alternative energy options (section 4.1), during environmental assessment (section 4.2), and in designing social mitigation measures including benefit-sharing mechanisms (section 6). In particular, the Guidelines propose that a new project should aim for the following social outcomes (section 6.2):

- Providing communities with improved living conditions
- Improving public health conditions for affected communities
- Ensuring equitable sharing of the benefits of the project, particularly to affected and vulnerable communities, through processes such as revenue sharing, training programmes and educational outreach
- Ensuring that the local knowledge of communities is utilised in project planning
- Supporting additional community infrastructure associated with the project, particularly water and electricity connection, where positive benefits to the community will result.
- Ensuring resettlement is dealt with in a fair and equitable manner [a list of issues to address is provided in the Guidelines]

The guidelines are from the industry perspective and are ultimately to assist Members in achieving financial support for hydro options that provide sustainable outcomes.

Annex F:
List of People Met when Preparing the Review

(First Visit to Freetown 20 September to 8 October 2004)

Inter-agency Technical Committee Members*[1]

MoEP Principle Secretary

PIU Staff

World Bank / IDA Mission Staff

Other PPF Study Consultants engaged by the PIU

Bumbuna Project Engineering Consultants

Bumbuna Project Contractor

Private Sector and Civil Society

(Second Visit to Freetown 29 October to 14 November 2004)

PIU Staff

Dam Review Panel

Environment and Social Panel

Members of the Technical Committee

Other PPF Study Consultants engaged by the PIU

World Bank / IDA Mission Staff

[1] * Separate meetings also held with members of the Technical Committee

End Notes

[1] The ESMAP Report 6597-SL, October 1987. A PDF copy is available at http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?rc=82684&psz=20&ptype=advSrch&pcont=results&setID=5244766&pno=5 . The Power Sector Master Plan was completed under an IDA Financed Credit in 1996.
[1] Recent economic forecasts by the IMF place GDP growth at closer to 6.5% through 2008.
[1] UNECA, United Nations Economic Commission for Africa
[1] Energy Policy for Sierra Leone, a UNECA sponsored study conducted by CEMMATS Group Ltd. (Draft Version) 2004 and discussions with Professor R. Davidson, Dean Faculty of Engineering and Co-Chair of the Intergovernmental Panel on Climate Change (IPCC), Working Group 3.
[1] Within the NPC Act (2002) the NPA Act (1982) was revised to substitute the word "Commission" i.e. the Privatisation Commission, where ever the term "Minister" i.e. the MoEP occurred.
[1] National adaptation programmes of action (NAPAs) are an initial statement of the programme of action for climate change adaptation in each developing country. These are simplified as compared to the more detail programmes required in the national communications to the UNFCCC of Annex 1 Countries (essentially OECD and large countries). In the water sector, this would involve preparing impact and vulnerability assessments that lead to measures for improved basin water management and attention to the operation of water resource infrastructure, particularly the design and management of dams in regard to threats posed by increased climate variability (greater incidence of food an drought, intensified events, higher erosion and sedimentation, elevated temperatures and evapotranspiration, etc.) See IPCCC Third Assessment Report 2001.
[1] http://www.state.gov/r/pa/ei/bgn/5475.htm
[1] For example: the UNDP / World Bank report on Issues and Options in the Energy Sector, (ESMAP,1987); the AfDB Energy Sector Review in 2000; recent drafts of the Energy Policy For Sierra Leone a study sponsored by UNECA and undertaken by CEMMATS Group Ltd. in collaboration with MoEP and civil society stakeholders.
[1] Deforestation in the country is estimated at 3,000 hectares per year (Central Statistics Office, Sierra Leone in Figures 1998). The Sierra Leone: Energy Sector Review undertaken by the AfDB in 2000 (prepared for the Poverty Alleviation Strategy Coordinating Office of African Development Bank" concluded deforested land can be restored to productive use with the cultivation of energy crops. It observed, "These energy plantations can also be established on the available savannah and coastal woodlands. Of the existing forests in Sierra Leone, the estimated incremental growth is between 770 m3/yr and 1,500 m3/yr for closed high forests, 260 m3/yr for secondary forests and between 7,700 m3/yr and 11,000 m3/yr for forest re-growth. Savannah woodland, coastal woodland and plantations account for the rest of the 9,260 m3/yr to 15,010 m3/yr estimated wood yield from the forested area of the country (i.e., 730 m3/yr – 2,250 m3/yr). Leaving the high and secondary forests alone, the rest of the forest types mentioned above can provide feedstock to biomass conversion. Removal of the forest overgrowth in particular can increase the yields of the remaining high-quality wood".
[1] PV Solar Homes are being implemented in many development countries including ESCOM and SHELL where they provide small but vital loads (i.e. compact fluorescent lighting, radio, small DC refrigeration) before grid connection is available.
[1] In 2003 the National Petroleum Committee awarded concessions to Repsol YPF, a major Spanish Oil Company, Oranto Petroleum, an independent producer from Nigeria, and # 8 Investments Inc., a USA-based Company.
[1] There have been different optimisations for the installed capacity for the first and subsequent stages of the Bumbuna-Yiben scheme. The 1980 Feasibility proposed a 5-stage development of 305 MW. The Supplemental Feasibility (1984) that provided a scaled-down Phase 1 has 275 MW as the ultimate development potential. The ESMAP-1987 analysis uses 305 MW. The 1996 Master Plan has a 60 MW first stage for the BHP.
[1] The Yiben regulating dam is identified as the least-cost option for bulk supply after the Bumbuna project in the 1996 Master Plan.
[1] An alternative first phase plant of 71 MW plant with 380 Gwh production was also considered.
[1] Stage 1 cost at 1980 prices, excluding escalation and interest during construction, including cost of the initial site works.
[1] In the energy sector, IDA's concerns were about the adequacy of the institutional framework for power development, the absence of a single Ministry to formulate and coordinating energy sector policy (MoEP was subsequently created in 1987), electricity tariffs below the costs of supply, and the absence of institutional reforms within NPA (the sole purchaser of power from Bumbuna).
[1] ESMAP Report 6597-SL, October 1987. PDF copy available at http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?rc=82684&psz=20&ptype=advSrch&pcont=results&setID=5244766&pno=5
[1] The consultant observed the cost were high for a 50 MW project and total expenditures were $US 182.6 million. He noted that the unit prices were in line with usual contractor practice in pricing international jobs, and further that

because Limited International Procurement was used instead of full ICB it was impossible to tell whether other commercial quotes would have been lower. The Consultants findings conformed to findings by an Investigation Commission headed by a Professor from the University of Rome requested by the Government Agency FIDIMI. The consultant concluded the economic justification for continuing work was a US$ .039 /kWh return for future investment, calculated by treating past expenditure with no debt attached as sunk costs and treating debts to be repaid as costs (i.e. post 1992 costs taking into account that GOI forgave all debt on loans prior to December 1992).

[1] This rescheduled the outstanding payments for the 1988 Contract A2 and the Consultancy Agreement, providing for an initial settlement and payment of the balance as agreed from future project revenues.

[1] The appraisal looked at all factors influencing supply and demand in the Western Area grid network and the social and economic impacts known at that time. Recommendations to support the completion of the project included considerations that it supported: sustained economic reforms and political stability; was consistent with energy policy and sustained investment in the energy sector; and consistent implementation of electrification policy, including institutional capacity building. The assessment treated past costs as sunk, and on that basis the completion and commissioning project was financially and economically viable, with FIRR of 11.3 % and EIRR of 29.3 %, based on assumptions of grid supply costs to NPA, well below the prevailing themal supply costs of $US 017 / kWh based on imported oil prices at that time in 2003.

[1] The government and NPA were actively pursuing supply-side efficiency measures as a matter of urgency with rehabilitation of diesel generation, transmission and distribution networks. Consumers were resorting to high-cost, private generation, or going without power in response to the supply shortages on the NPA system.

[1] A discount rate of 8% was needed to make the full Bumbuna option attractive, relative to imported coal option.

[1] The ESMAP team also provided analysis and recommendations on several small hydro projects in other parts of the country. The other medium-scale project seen as technically viable was a 180 MW plant on the Mano River in the south of the country. Likely the project could only be developed as a longer-term export project for Liberia, in a joint venture between Sierra Leone and Liberia.

[1] For example, in the present-day context, after evaluation of the success and failure of the ESCOM solar home program in South Africa and the transferability of experiences.

[1] For example, the 1980 Feasibility study compared alternative hydro development sequences on the Seli River with diesel generation and combustion turbines using use discounted cash flow analysis and IRR techniques (equalizing discount rates). The analysis was prepared for three load growth scenarios, four fuel price scenarios, 4 thermal scenarios and 3 hydro sequences. While the Feasibility included an assessment of the resettlement and environment effects, there was no explicit environmental or social mitigation costs, except for compensation. The supplemental feasibility in 1984, focused on achieving a lower cost first stage prepared a similar IRR analysis, but with lower fuel price scenarios to reflect prevailing prices in the international oil markets. The 1987 ESMAP used present value analysis.

[1] Power Planning Associates, Rehabilitation And Reinforcement Of The Western Area
Sub-Transmission And Distribution, Final Report, 2003

[1] Costs are based on the designs at the time, which are slightly different from the project today (e.g. ESMAP assumes a 47 MW, reduced Phase 1 scheme where the current version is 50 MW, but with no changes in the main civil components).

[1] The analysis was prepared to support a decision at that time (i.e. whether to abandon, defer indefinitely, or continue the BHP) and thus the sunk cost principle was applied. Up to that point these costs included the $US 20 million equivalent loan from the GOI and the Government's expenditure of $US 4.5 million ($1980).

[1] The full scheme the ESMAP analysis assumed was used a first phase as the storage dam upstream of the Bumbuna Falls, a power tunnel through the hillside to a shaft power station developing a net head of 114 m with an installed capacity in Phase 1 two 26.7 MW units. In Phase 2, the storage reservoir at Yiben would be constructed capable of providing over-season storage, and a third unit would be installed in the Bumbuna power station, bringing the capacity to 80 MW. In Phase 3a, the Yiben dam would be raised by 15 m and three 15 MW turbines (fitted with 35 MW generators) installed in a power station at the foot of the dam. The Yiben dam would be raised by a further 24 m in Phase 3b and the Phase 3a units uprated to 35 MW by the installation of new turbine runners. The final phase (Phase 4) would involve the construction of a second power station at Bumbuna with three 40 MW units.

[1] See http://www.lk.iwmi.org/ehdb/EFM/efm.asp the website of the International Water Management Institute (IWMI) that provides a database of environmental flows methodologies and http://lnweb18.worldbank.org/ESSD/ardext.nsf/18ByDocName/SectorsandThemesWaterandEnvironmentEnvironmentalFlowRequirements the World Bank Environmental Flows window where resources on environmental flows can be accessed.

[1] Based on article "Bumbuna spillway tapped for Power" International Water Power and Dam Construction" May 1994, reporting on hydraulic test conducted by Imperial College of Science, Technology and Medicine in London, UK.

[1] To maximize the development effectiveness of dams decisions need to be taken by stakeholders at all levels. In this case, while the physical infrastructure components were decided at national levels, local stakeholders have a central role in informing government decisions that affect them, or otherwise directly deciding on critical aspects of the

management of physical infrastructure and development of the social infrastructure components of the project. For example, as land and associated resources in Sierra Leone are considered common property and tenure is based on non-title use and traditional rights, the Paramount Chief is the traditional custodian of land and resource access and ultimately grants access to households. Thus traditional as well as national laws apply to decisions taken locally, including those at the household level. Within the overlapping frameworks, negotiated approaches may also be required for social /environmental mitigation and enhancement and benefit sharing arrangements.

[1] "Stakeholder Involvement in Options Assessment: Promoting Dialogue in Meeting Water and Energy Needs", published in 2003, World Bank

[1] Unresolved issues from past resettlement and compensation are also being recorded through the Resettlement Action Plans (RAPs) for the transmission and reservoir areas, though the war makes these issues considerably more complex.

[1] Implementation Completion Report, (IDA-23560), Power Rehabilitation Project, June 6, 2003. The Credit provided financing for the Master Plan (1996) and the Bumbuna EIA (1995).

[1] Sierra Leone's Millennium development goals and targets particularly goal 1 (eradicating extreme poverty and hunger) and goal 7 (ensuring environmental sustainability that has local dimensions as well as CO2 emission aims): http://devdata.worldbank.org/idg/IDGProfile.asp?CCODE=SLE&CNAME=Sierra%20Leone&SelectedCountry=SLE

[1] In the Panel's view, a wider range of load forecasts would have enabled a more robust examination of the risks and rewards associated with the Bujagali Project. More information could have been provided to support the contention that the current data were too uncertain and the delays on collecting reliable data were too great for the geothermal alternative to be a realistic candidate. While a qualitative comparative analysis was undertaken of all the options in the facilities EIAs, a quantified analysis would have provided more certainty, even though not required by OP/BP 4.01 on Environmental Assessment. http://wbln0018.worldbank.org/IPN/ipnweb.nsf/%28webnews%29/0D7F7939F52C824985256BDB00687310

[1] See http://www.equator-principles.com/

[1] http://lnweb18.worldbank.org/ESSD/essdext.nsf/PrintFriendly/3F71A0BF3BE7883485256D1900646229

[1] The WCD offers 7 strategic priorities (SPs). The two most important SPs in this context were Comprehensive Options Assessment and Existing Dams. See www.dams.org and see www.unep-dams.org for an issue-based workshop on options assessment in the UNEP Dams and Development Project.

[1] Some 20 initiatives under different "windows" in the Bank, For Further Information Website: http://wbln0018.worldbank.org/esmap/site.nsf/pages/Jan_2004

[1] The five themes of DAMAP are:

- working with borrowers to move "upstream" in decision-making
- effectively implement the World Bank's existing "safeguard policies"
- continue to support borrowers in improving the performance of existing dams
- regulatory reform in water management and energy service provision, and
- international rivers

[1] for the source book on Stakeholder Involvement in Options Assessment see http://www-wds.worldbank.org/servlet/WDS_IBank_Servlet?pcont=details&eid=000012009_20031118154757

[1] See: http://www.unep-dams.org for the issues and options workshop

[1] See http://www.hydropower.org/1_5i.htm

D Climate

D.1 Precipitation (1921-1978)

KABALA

Completed Precipitation Records

mm

KABALA — MONTHLY RAINFALL

YEAR	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	SUM
1921	25.1	0.0	0.0	140.5	119.6	381.8	167.4	311.7	283.7	272.5	304.5	108.5	2115.3
1922	76.2	0.0	0.0	45.7	85.1	345.4	569.2	336.5	350.5	463.0	261.1	127.0	2659.9
1923	52.1	0.0	0.0	76.2	122.7	138.2	397.5	357.6	302.3	463.3	325.9	277.1	2512.8
1924	39.6	8.1	72.4	7.9	55.9	238.5	350.5	320.3	378.7	434.3	290.1	180.1	2376.4
1925	0.0	0.0	19.6	99.3	37.1	230.6	401.1	271.0	284.7	363.5	458.0	146.3	2311.1
1926	27.4	2.8	0.0	29.7	42.2	157.2	255.3	347.5	441.5	481.8	265.4	146.3	2197.1
1927	10.2	0.0	2.8	19.8	113.8	272.5	364.0	229.9	204.5	531.6	509.5	26.7	2285.2
1928	9.7	8.9	0.0	54.6	232.9	168.4	184.4	496.6	366.0	399.8	527.8	53.8	2502.9
1929	16.8	0.0	0.0	112.8	110.5	167.9	305.3	237.7	353.3	371.3	319.8	9.9	2005.3
1930	0.0	31.0	61.0	17.8	45.0	180.3	252.7	388.6	316.5	422.7	287.0	38.4	2040.9
1931	17.0	37.3	0.0	61.0	177.8	184.9	418.3	386.1	289.3	294.4	289.1	93.0	2248.2
1932	10.9	0.0	29.5	124.0	184.1	164.3	410.2	385.3	432.1	308.4	355.9	241.6	2646.2
1933	0.0	1.0	87.6	23.4	96.0	198.4	358.6	385.8	644.1	308.4	172.0	120.9	2396.2
1934	33.8	0.0	39.1	57.4	48.5	35.8	322.1	328.2	442.7	553.5	508.3	37.6	2406.9
1935	1.0	17.3	1.0	1.8	34.3	185.7	428.2	351.5	245.1	330.7	254.5	106.4	1957.6
1936	53.1	5.6	9.4	47.2	90.9	233.7	278.9	309.6	351.0	392.9	326.9	91.2	2190.5
1937	16.3	0.0	0.0	112.0	158.2	217.9	402.6	159.5	442.7	390.1	470.9	32.5	2402.8
1938	1.0	0.0	3.3	91.2	103.6	201.4	297.4	437.9	452.9	405.1	368.8	87.1	2449.8
1939	0.0	7.6	0.0	19.8	74.4	171.7	349.8	347.5	398.5	366.3	342.6	88.4	2166.6
1940	5.1	0.0	0.0	50.8	46.7	212.1	415.0	313.2	289.1	429.3	426.7	106.4	2294.4
1941	0.0	1.8	0.0	27.4	65.3	196.8	258.6	384.6	409.2	504.4	243.3	194.3	2285.7
1942	2.0	0.8	0.0	7.6	189.7	281.7	222.2	289.1	315.7	281.7	337.8	178.1	2106.4
1943	19.3	6.3	14.2	55.1	143.0	175.0	315.0	304.3	358.1	401.8	386.1	62.7	2241.0
1944	17.8	11.2	7.4	36.3	77.7	223.0	305.6	310.4	363.7	414.0	299.0	53.1	2119.1
1945	3.8	5.8	5.3	37.3	157.0	189.2	313.4	308.4	402.1	396.2	307.1	116.6	2242.3
1946	12.7	9.4	3.0	38.4	119.6	188.5	279.1	310.1	401.8	371.6	347.5	79.0	2160.8
1947	25.9	5.6	13.7	58.2	63.2	181.1	311.1	305.8	379.0	389.9	306.8	17.8	2058.2
1948	5.8	5.6	8.4	32.3	82.0	228.1	289.1	304.3	386.8	438.4	309.1	46.2	2136.1
1949	4.3	0.0	0.0	17.8	123.4	192.3	167.4	276.6	316.5	411.0	280.4	53.1	1842.8
1950	5.1	0.0	0.0	48.5	25.7	120.4	340.4	249.4	289.8	360.7	284.7	58.4	1783.1
1951	0.0	31.7	31.7	146.8	39.9	272.8	386.1	390.9	450.3	514.6	452.4	135.4	2852.7
1952	0.0	0.0	34.5	32.8	23.9	191.8	263.4	275.3	331.5	433.6	163.3	132.8	1882.9
1953	15.7	2.5	0.0	151.9	59.9	111.5	435.9	402.1	563.4	387.9	319.8	67.6	2518.2
1954	97.3	0.0	21.6	30.7	116.6	153.2	238.8	372.1	490.7	387.9	382.8	254.5	2546.1
1955	63.5	17.0	5.6	129.0	203.5	181.4	357.9	400.3	382.5	500.1	464.6	68.8	2774.2
1956	15.2	0.0	38.1	14.0	65.3	175.0	341.4	252.0	369.3	425.2	165.9	88.9	1950.2
1957	56.4	0.0	3.0	20.3	175.5	119.6	240.5	367.5	290.6	453.6	400.3	112.0	2239.5
1958	0.0	136.7	14.7	98.0	187.2	336.3	211.3	121.4	390.4	375.7	498.6	247.9	2618.2
1959	58.4	1.0	3.8	13.0	95.2	231.6	309.1	239.8	332.0	401.8	212.1	150.6	2048.5
1960	0.0	0.0	9.4	1.0	84.1	196.6	368.3	322.8	295.4	319.5	509.3	35.3	2141.7
1961	10.7	0.0	5.6	49.5	56.9	180.3	238.5	273.8	489.5	362.5	258.6	122.4	2048.3
1962	0.0	0.0	0.0	13.7	367.8	188.0	363.5	304.0	497.3	396.5	216.9	263.4	2611.1
1963	0.0	46.5	23.4	39.4	39.6	175.8	249.2	399.3	373.1	281.7	376.4	84.6	2088.9
1964	0.0	0.0	0.0	28.4	40.6	161.5	214.9	253.7	292.9	497.1	182.1	43.7	1715.0
1965	41.4	0.8	21.6	0.0	40.6	158.2	212.1	328.2	221.2	366.8	338.6	45.0	1774.4
1966	0.0	0.0	18.8	40.4	34.8	261.4	443.0	322.1	315.7	444.5	432.1	135.1	2447.8
1967	13.5	0.0	0.0	1.8	117.9	175.5	295.7	208.0	521.7	230.1	416.8	105.7	2086.6
1968	0.0	0.0	16.8	30.7	89.2	491.0	468.9	357.6	409.7	454.2	358.6	165.1	2841.7
1969	29.5	5.1	2.0	149.4	115.3	128.8	420.6	346.2	524.3	372.1	482.1	23.6	2598.9
1970	0.0	0.0	0.0	0.8	84.1	220.0	277.4	270.0	316.7	401.1	201.9	159.3	1931.2
1971	0.0	0.0	0.0	0.0	216.4	104.4	260.9	241.3	374.4	356.9	182.1	114.6	1850.9
1972	15.0	0.0	0.0	42.2	123.2	201.9	267.2	245.1	320.0	410.0	419.6	2.5	2046.7
1973	0.0	0.0	0.0	26.7	38.4	328.7	355.1	334.0	290.8	388.6	325.4	55.6	2143.3
1974	0.0	0.0	0.0	36.1	88.9	223.0	381.5	469.9	292.9	385.3	229.9	97.0	2204.5
1975	0.0	0.0	0.0	8.6	131.3	181.9	177.5	251.5	415.3	536.2	314.2	13.5	2030.0
1976	1.5	2.3	0.0	22.1	165.6	236.5	253.2	201.7	326.9	340.6	388.6	124.7	2063.7
1977	0.0	0.0	0.0	38.1	81.8	99.1	227.1	183.6	374.6	361.7	296.4	14.7	1677.2
1978	0.8	31.0	43.9	55.1	94.2	155.4	260.6	350.3	281.2	332.0	374.9	101.3	2080.8
SAMPLE MEAN	15.7	7.6	11.6	47.8	103.5	201.8	314.7	314.3	369.4	397.8	336.7	102.5	2223.4
HIGHEST VALUE	97.3	136.7	87.6	151.9	367.8	491.0	569.2	496.6	644.1	553.5	527.8	277.1	2852.7
LOWEST VALUE	0.0	0.0	0.0	0.0	23.9	35.8	167.4	121.4	204.5	230.1	163.3	2.5	1677.2

Source: Bumbuna Hydro-Consultants (1980)

MAKENI

Completed Precipitation Records

mm

MAKENI — MONTHLY RAINFALL

YEAR	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	SUM
1921	35.8	4.1	2.0	81.0	102.9	294.1	357.4	477.3	618.0	513.3	411.0	206.8	3103.6
1922	68.3	4.1	2.0	33.5	81.0	279.4	470.9	479.8	641.3	575.8	399.5	222.0	3257.8
1923	53.1	4.1	2.0	48.8	104.9	194.8	422.4	482.1	624.3	576.1	416.8	346.5	3275.8
1924	45.0	4.6	46.5	14.5	62.5	235.7	409.2	478.0	651.0	566.4	407.2	265.9	3186.4
1925	19.8	4.1	14.0	60.5	50.5	232.4	423.4	472.9	618.2	543.3	452.1	238.0	3129.3
1926	37.3	4.3	2.0	25.7	53.8	202.7	382.3	480.8	673.1	582.2	400.6	238.0	3082.8
1927	26.2	4.1	3.8	20.6	99.3	249.7	413.0	468.6	590.3	598.4	465.8	138.9	3078.7
1928	25.9	4.8	2.0	38.1	174.8	207.3	362.2	496.6	646.7	555.2	470.7	161.5	3145.8
1929	30.5	4.1	2.0	67.3	97.0	207.0	396.5	469.4	642.4	545.8	415.0	125.2	3002.3
1930	19.8	6.3	39.4	19.6	55.6	212.1	381.5	485.1	629.4	562.6	406.4	148.6	2966.5
1931	30.7	6.9	2.0	41.1	140.0	213.9	428.5	484.9	620.0	520.4	406.9	193.8	3089.1
1932	26.7	4.1	20.1	72.9	143.8	205.5	426.0	484.9	669.8	525.0	424.7	317.0	3320.3
1933	19.8	4.1	55.9	22.4	87.9	219.5	411.5	484.9	743.7	525.0	375.7	216.9	3167.1
1934	41.4	0.0	0.0	35.6	57.4	107.9	312.2	542.5	610.4	561.3	494.0	99.6	2862.3
1935	0.0	0.0	4.6	5.3	24.4	114.8	259.8	473.2	548.4	480.3	284.5	272.5	2467.9
1936	74.4	0.0	8.1	38.1	77.7	316.7	235.7	615.2	452.6	501.9	393.2	180.6	2894.3
1937	34.8	0.0	0.8	100.6	52.6	234.4	335.5	407.2	813.6	583.4	491.5	163.1	3217.4
1938	7.6	0.0	6.3	33.5	64.8	399.5	471.4	357.4	733.3	627.6	413.0	287.3	3401.8
1939	0.0	0.0	0.3	0.0	38.4	332.2	596.1	364.7	586.7	468.4	268.7	170.2	2825.7
1940	25.4	0.0	0.0	19.6	14.7	196.6	373.9	473.7	568.7	451.4	448.8	243.6	2816.3
1941	45.7	12.2	0.0	0.0	66.8	85.9	611.1	632.7	812.5	579.1	355.6	194.3	3396.0
1942	5.3	0.0	0.0	31.7	72.6	334.8	339.6	458.0	526.0	444.2	608.8	141.2	2962.4
1943	100.1	1.5	14.0	50.0	145.0	152.4	419.1	434.3	510.3	555.2	554.2	127.3	3063.5
1944	39.1	10.2	5.3	21.1	60.7	287.0	371.1	646.9	554.0	628.1	317.2	109.0	3049.8
1945	0.5	0.3	2.8	22.6	163.1	192.3	411.5	576.6	853.4	520.7	339.1	228.3	3311.1
1946	25.1	6.9	0.0	24.4	115.1	190.2	238.0	631.2	851.2	372.9	448.8	158.0	3061.7
1947	62.0	0.0	13.5	54.9	42.2	169.7	400.0	486.9	672.3	483.6	338.3	42.9	2766.3
1948	6.1	0.0	6.6	14.7	66.3	300.7	287.5	429.3	734.3	776.7	344.9	96.3	3063.5
1949	1.5	0.0	0.0	28.7	105.2	169.9	248.9	380.2	505.5	571.2	446.3	214.6	2672.1
1950	64.8	0.0	0.0	37.6	65.0	130.8	307.6	375.7	401.3	491.2	448.8	254.3	2577.1
1951	4.1	20.6	27.4	36.1	110.7	249.4	392.2	417.3	614.7	519.4	643.1	159.8	3194.8
1952	3.0	5.8	17.5	25.4	84.3	227.8	354.3	608.3	742.2	486.7	427.0	300.5	3282.9
1953	29.7	12.7	2.5	33.3	136.1	139.4	506.2	583.7	709.9	657.6	415.3	166.4	3392.9
1954	69.3	0.0	21.1	36.6	47.0	371.3	393.7	438.7	666.7	374.6	424.7	393.2	3237.0
1955	16.0	0.0	1.5	165.6	173.5	310.9	463.5	302.3	623.8	578.9	444.8	189.7	3270.5
1956	30.0	0.0	37.3	53.8	56.9	200.2	249.2	455.9	506.2	556.5	290.8	143.0	2579.9
1957	57.9	0.0	0.0	5.1	121.9	78.2	459.7	619.0	460.5	669.3	399.5	156.2	3027.4
1958	3.6	9.9	0.0	169.4	199.6	191.8	321.3	231.4	463.3	615.7	422.1	292.6	2920.7
1959	35.3	35.3	0.0	30.2	20.6	357.4	460.2	375.7	523.7	676.4	605.0	338.3	3458.2
1960	0.8	27.7	20.6	0.0	0.0	259.6	514.6	404.4	477.5	702.6	344.7	202.2	2954.5
1961	20.8	0.0	22.9	0.0	101.6	151.6	287.5	977.1	696.0	502.9	272.0	176.8	3209.3
1962	33.8	0.0	0.0	3.0	280.4	316.7	364.5	603.8	719.8	590.5	352.3	379.0	3643.9
1963	11.2	14.0	38.6	67.1	98.3	110.7	415.8	436.1	803.1	369.6	421.6	165.1	2951.2
1964	0.0	0.0	0.0	11.7	56.1	164.3	346.2	456.4	1008.4	634.0	341.6	196.6	3215.4
1965	68.1	25.1	1.0	3.0	55.4	215.6	331.7	507.7	694.9	519.7	428.5	204.7	3055.6
1966	0.0	0.0	9.7	34.8	111.5	238.3	368.8	289.6	721.1	622.3	323.6	263.9	2983.5
1967	32.0	0.0	0.0	9.4	88.9	203.5	426.2	511.8	671.8	480.1	473.5	294.1	3191.3
1968	9.4	0.0	27.2	33.0	46.0	289.3	605.8	389.1	593.3	745.5	495.3	184.7	3418.6
1969	44.7	0.0	3.8	44.2	132.6	237.7	452.6	475.5	695.7	570.5	448.3	188.5	3294.1
1970	52.3	0.0	2.5	31.2	61.7	207.5	385.8	813.1	466.1	598.4	354.3	193.0	3166.1
1971	14.0	0.0	0.0	1.3	298.7	120.1	303.3	509.3	726.4	741.2	323.1	191.8	3229.1
1972	130.3	0.0	5.6	45.7	95.2	255.5	432.3	542.0	751.1	481.6	391.2	24.1	3154.7
1973	0.0	0.0	0.0	16.0	51.3	272.3	368.8	324.1	977.6	332.5	527.8	152.1	3022.6
1974	0.0	0.0	0.0	0.0	62.7	192.8	400.8	477.5	544.3	660.4	423.4	177.3	2939.3
1975	0.0	0.0	0.0	7.4	99.3	254.0	373.9	707.4	690.4	482.1	472.2	24.9	3111.5
1976	36.8	0.0	3.3	17.8	116.8	134.1	598.4	289.3	489.2	580.4	507.0	229.1	3002.3
1977	31.0	1.5	2.0	5.8	112.5	193.5	317.0	385.8	834.4	509.3	381.5	59.2	2833.6
1978	7.6	9.4	30.5	11.9	166.9	295.4	372.6	578.1	669.0	553.7	439.2	200.7	3335.0
SAMPLE MEAN	29.6	4.4	9.2	33.8	94.4	222.6	392.6	486.9	649.0	553.4	418.0	197.4	3091.2
HIGHEST VALUE	130.3	35.3	55.9	169.4	298.7	399.5	611.1	977.1	1008.4	776.7	643.1	393.2	3643.9
LOWEST VALUE	0.0	0.0	0.0	0.0	0.0	78.2	235.7	231.4	401.3	332.5	268.7	24.1	2467.9

Source: Bumbuna Hydro-Consultants (1980)

TEKO

Completed Precipitation Records

mm

TEKO MONTHLY RAINFALL

YEAR	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	SUM
1921	27.9	5.6	4.6	69.1	92.2	277.6	375.2	478.5	572.8	525.5	407.7	175.3	3011.9
1922	46.2	5.6	4.6	32.0	75.9	267.0	479.8	480.6	583.7	572.8	399.8	188.7	3136.6
1923	37.6	5.6	4.6	43.9	93.7	205.7	435.1	482.1	575.8	572.8	411.7	298.7	3167.4
1924	33.0	6.3	49.5	17.3	62.2	235.2	422.9	479.0	588.3	565.7	405.1	227.6	3092.2
1925	18.8	5.6	16.8	53.1	53.3	232.9	435.9	475.5	572.8	548.1	435.9	202.9	3051.6
1926	28.7	6.1	4.6	25.9	55.9	211.3	398.0	481.1	598.9	577.3	400.6	202.9	2991.4
1927	22.4	5.6	6.3	21.8	89.7	245.4	426.5	472.2	559.6	589.8	445.3	115.6	3000.0
1928	22.4	6.6	4.6	35.6	145.5	214.6	379.7	492.8	586.2	557.3	448.6	135.4	3029.2
1929	24.9	5.6	4.6	58.4	87.9	214.4	411.2	472.9	584.2	550.2	410.5	103.4	2928.1
1930	18.8	8.6	42.4	21.1	57.1	218.2	397.5	484.4	578.1	562.6	404.6	124.0	2917.4
1931	24.9	9.4	4.6	38.1	119.6	219.5	440.7	484.1	573.5	530.9	404.9	163.8	3014.0
1932	22.6	5.6	22.9	62.7	122.4	213.4	438.4	484.1	597.4	534.4	417.1	272.5	3193.5
1933	18.8	5.6	58.9	23.4	81.0	223.5	424.9	484.1	632.5	534.4	383.5	184.4	3055.1
1934	31.0	0.3	2.5	33.5	58.4	142.5	333.5	526.3	569.0	561.8	464.8	80.8	2804.4
1935	7.6	0.3	7.1	9.9	34.0	147.6	285.5	475.7	539.5	500.6	320.8	233.4	2562.1
1936	49.8	0.3	10.7	35.6	73.7	294.1	263.1	579.4	494.0	516.9	395.5	152.4	2865.4
1937	27.2	0.3	3.3	84.6	54.9	234.4	355.1	427.2	665.7	578.4	463.0	136.9	3031.0
1938	11.9	0.3	8.9	32.0	64.0	354.1	480.1	390.9	627.4	611.6	409.2	246.4	3236.7
1939	7.6	0.3	2.8	5.8	44.4	305.3	594.9	396.2	557.8	491.7	310.1	143.0	2860.0
1940	21.8	0.3	2.5	21.1	26.9	207.0	390.4	476.0	549.1	478.8	433.6	207.8	2815.3
1941	33.5	16.5	2.5	5.8	65.5	126.5	608.8	592.3	665.2	575.1	369.8	164.3	3226.1
1942	10.7	0.3	2.5	30.7	69.8	307.1	358.9	464.6	529.1	473.5	543.6	117.6	2908.3
1943	64.3	2.3	16.8	45.0	123.4	174.8	432.1	447.3	521.5	557.3	506.0	105.2	2995.7
1944	29.7	14.0	7.9	22.4	61.0	272.5	387.9	602.7	542.3	612.1	343.4	89.2	2985.0
1945	7.9	0.5	5.3	23.6	136.9	203.7	424.9	551.2	684.5	581.1	358.4	194.3	3122.4
1946	21.8	9.4	2.5	24.9	101.3	202.2	265.4	591.1	683.5	419.6	433.6	132.3	2887.7
1947	42.7	0.3	16.0	48.8	47.2	187.5	414.5	485.6	598.4	503.2	357.9	30.7	2732.8
1948	10.9	0.3	9.1	17.3	65.0	282.4	310.9	443.5	627.9	724.2	362.5	78.0	2931.9
1949	8.4	0.3	2.5	28.2	94.0	187.5	275.3	407.7	519.2	569.2	432.1	182.4	2706.6
1950	44.2	0.3	2.5	35.3	64.3	159.3	329.4	404.4	469.6	509.0	433.6	217.2	2669.0
1951	9.9	27.7	30.2	34.0	98.0	245.1	407.2	434.8	571.0	530.1	567.2	133.9	3089.1
1952	9.4	8.1	20.3	25.7	78.5	229.6	372.4	574.5	631.7	505.5	418.6	258.1	3132.3
1953	24.4	17.3	5.1	31.7	116.8	165.4	512.1	556.5	616.5	634.2	410.7	139.7	3230.4
1954	47.0	0.3	23.9	34.5	50.8	333.8	408.7	450.3	595.9	421.1	509.8	421.6	3297.7
1955	55.4	0.3	4.1	135.4	144.5	289.8	472.9	358.6	574.8	575.1	428.5	10.4	3049.8
1956	0.0	0.0	48.5	18.8	26.9	294.4	261.6	443.0	485.9	725.7	369.8	156.5	2831.1
1957	63.5	0.0	0.0	0.0	160.8	81.0	329.9	591.8	604.0	808.0	356.1	190.0	3185.2
1958	14.5	25.4	5.6	156.0	234.7	276.9	342.1	206.0	417.3	661.7	346.7	344.2	3031.0
1959	49.0	36.1	0.0	0.0	48.8	377.7	855.5	308.9	440.2	590.0	510.8	289.6	3506.5
1960	0.0	19.8	0.5	55.4	30.0	168.7	450.8	453.9	442.5	573.8	321.8	71.9	2589.0
1961	13.2	0.0	10.7	0.0	77.2	235.2	301.5	820.9	404.6	357.1	275.3	85.3	2581.1
1962	0.0	0.0	0.0	4.3	194.8	279.4	365.5	627.4	657.6	517.1	365.3	282.7	3294.1
1963	12.2	8.9	33.8	38.4	70.4	156.5	404.6	373.6	696.7	405.1	465.8	94.7	2760.7
1964	0.0	0.0	0.0	29.5	14.7	165.6	356.6	617.7	721.1	730.5	397.3	152.1	3185.2
1965	56.9	71.9	4.8	10.2	48.0	167.4	428.5	508.0	706.9	499.4	372.1	194.1	3068.1
1966	0.0	0.0	39.4	29.7	56.6	182.4	374.1	341.4	753.6	610.1	347.7	169.2	2904.2
1967	30.2	0.0	0.0	31.2	44.2	251.2	360.4	644.9	698.0	508.0	435.1	211.1	3214.4
1968	3.3	0.0	22.4	25.4	81.5	283.0	625.6	397.5	683.0	863.6	391.4	156.7	3533.4
1969	31.7	1.3	19.0	59.2	106.7	180.1	339.1	542.3	640.1	649.7	396.7	173.0	3138.9
1970	48.0	0.0	2.5	40.4	62.2	265.2	301.8	782.3	600.5	500.1	269.7	199.1	3071.9
1971	38.4	0.0	11.4	3.6	226.3	170.9	306.3	229.9	831.6	568.7	338.6	222.0	2947.7
1972	61.0	0.0	0.0	46.2	97.3	223.3	596.6	544.6	744.7	360.7	478.8	4.1	3157.2
1973	0.0	0.0	0.0	6.3	52.6	288.8	342.9	370.1	635.3	436.9	517.7	193.5	2844.0
1974	3.6	0.0	0.0	27.9	81.0	125.2	336.8	510.8	426.0	454.9	474.7	162.8	2603.8
1975	0.0	0.0	0.0	0.0	116.8	258.6	342.6	574.0	656.1	429.0	448.8	56.9	2882.9
1976	33.5	0.0	10.4	2.8	139.2	146.8	598.4	386.8	314.2	585.5	532.4	207.5	2957.6
1977	27.4	0.0	0.0	4.3	48.0	207.3	496.3	531.6	479.0	745.2	425.2	36.8	3001.3
1978	2.5	9.4	58.4	11.2	155.4	279.4	377.2	474.7	596.9	591.8	442.2	170.2	3169.4
SAMPLE MEAN	24.4	6.1	11.8	32.2	85.9	225.8	407.7	485.7	587.5	556.5	412.5	167.1	3003.2
HIGHEST VALUE	64.3	71.9	58.9	156.0	234.7	377.7	855.5	820.9	831.6	863.6	567.2	421.6	3533.4
LOWEST VALUE	0.0	0.0	0.0	0.0	14.7	81.0	261.6	206.0	314.2	357.1	269.7	4.1	2562.1

Source: Bumbuna Hydro-Consultants (1980)

MUSAIA

Completed Precipitation Records

mm

MUSAIA — MONTHLY RAINFALL

YEAR	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	SUM
1921	14.2	3.6	1.5	96.3	90.2	312.7	218.9	296.4	254.3	329.4	270.3	104.4	1992.1
1922	40.4	3.6	1.5	32.0	79.5	287.8	404.1	308.9	299.2	388.6	243.6	121.4	2210.6
1923	27.9	3.6	1.5	52.6	91.2	146.0	324.9	319.5	266.7	388.6	283.2	258.8	2164.6
1924	21.6	6.6	51.6	6.1	70.6	214.6	303.3	300.7	318.3	379.7	261.4	169.9	2104.4
1925	1.3	3.6	15.2	68.3	64.8	209.3	326.6	276.1	255.0	357.6	363.7	139.2	2080.8
1926	15.5	4.6	1.5	21.1	66.3	159.0	259.3	314.5	360.7	394.5	246.4	139.2	1982.5
1927	6.6	3.6	3.6	14.2	88.4	238.0	309.4	255.5	200.7	409.7	395.2	29.5	1954.3
1928	6.3	6.9	1.5	38.1	125.2	166.6	226.8	389.1	309.6	368.8	406.1	54.4	2099.6
1929	9.9	3.6	1.5	77.5	87.4	166.4	282.4	259.6	301.2	360.2	279.4	14.2	1843.3
1930	1.3	15.0	43.7	13.0	67.3	174.8	258.3	335.0	276.4	375.9	259.6	40.1	1860.3
1931	10.2	17.3	1.5	42.2	108.2	178.1	334.5	333.8	258.1	336.3	260.6	90.2	1970.8
1932	6.9	3.6	22.1	85.1	110.2	163.8	330.7	333.5	354.3	340.6	301.5	226.3	2278.6
1933	1.3	4.1	62.2	16.8	83.1	187.2	307.1	333.8	497.3	340.6	189.2	115.8	2138.4
1934	18.5	3.6	28.7	39.9	68.3	75.9	290.1	304.8	361.4	416.6	394.2	39.6	2041.7
1935	1.8	9.9	2.3	2.0	64.0	178.6	339.1	316.5	228.1	347.5	239.8	102.6	1832.1
1936	28.4	5.8	8.1	33.0	81.3	211.3	270.3	295.4	299.7	366.8	283.7	88.6	1972.6
1937	9.7	3.6	1.5	77.0	102.1	200.7	327.4	220.2	361.4	366.0	371.6	34.8	2075.9
1938	1.8	3.6	3.8	62.7	85.3	189.2	278.9	359.7	368.3	370.6	309.4	84.8	2118.1
1939	1.3	6.3	1.5	14.2	76.2	168.9	303.0	314.5	331.7	358.4	293.4	86.1	1955.5
1940	4.1	3.6	1.5	35.3	67.8	196.6	333.0	297.2	257.8	378.0	344.7	102.6	2022.1
1941	1.3	4.3	1.5	19.6	73.4	186.2	260.9	333.0	338.8	401.3	232.9	183.1	2036.3
1942	2.3	4.1	1.5	6.1	111.8	244.1	244.1	285.2	275.8	332.2	290.3	168.1	1965.7
1943	11.2	6.1	11.4	38.4	97.5	171.2	286.8	292.9	304.5	369.6	319.8	62.5	1971.8
1944	10.4	7.9	6.6	25.7	77.2	204.0	282.4	295.9	308.1	373.4	266.7	53.6	1911.9
1945	3.3	5.8	5.3	26.2	101.9	180.8	286.3	294.9	334.0	367.8	271.8	111.8	1989.8
1946	7.9	7.1	3.8	26.9	90.2	180.3	270.3	295.7	334.0	360.2	296.4	77.5	1950.2
1947	14.5	5.8	11.2	40.4	72.9	175.3	285.2	293.6	318.5	365.8	271.5	21.3	1876.0
1948	4.3	5.8	7.4	22.9	78.7	207.5	376.4	206.5	266.4	608.6	290.3	101.6	2176.5
1949	2.3	0.0	0.0	20.6	88.4	177.5	228.6	406.1	279.9	316.0	191.8	35.1	1746.2
1950	4.1	0.0	0.0	30.7	24.1	181.6	244.1	186.9	273.3	283.0	238.3	61.5	1527.6
1951	0.0	80.8	52.8	139.2	64.0	301.2	270.3	289.6	387.3	420.9	479.8	201.2	2687.1
1952	0.0	0.8	15.7	18.8	4.3	149.9	344.9	315.5	306.8	199.9	212.1	152.1	1720.8
1953	21.8	10.9	3.3	63.8	89.9	80.8	391.2	285.0	501.4	319.3	329.2	100.3	2196.8
1954	61.0	0.0	14.0	10.7	61.2	171.4	189.0	395.7	400.0	305.8	285.5	286.5	2180.8
1955	42.4	2.8	13.2	122.9	185.7	264.2	271.0	343.4	298.7	333.5	301.0	52.8	2231.6
1956	6.6	0.0	39.6	31.7	62.7	86.9	354.6	266.7	315.0	341.1	125.2	98.3	1728.5
1957	36.1	0.0	0.0	10.7	43.7	124.7	264.9	271.3	346.2	390.4	523.2	105.9	2117.1
1958	0.0	40.1	22.9	53.8	121.2	179.3	179.3	208.0	254.5	445.0	363.5	201.7	2069.3
1959	0.0	0.0	0.0	16.5	36.6	280.4	207.0	290.1	242.6	334.8	327.4	157.7	1893.1
1960	0.0	0.0	6.3	9.7	47.8	234.7	277.4	347.7	266.7	409.2	442.0	49.0	2090.4
1961	0.0	0.0	0.0	0.0	75.2	194.3	272.0	289.3	367.0	480.8	267.7	112.5	2058.9
1962	0.0	0.0	0.0	21.1	143.8	221.2	261.1	453.1	398.0	398.0	161.3	211.1	2268.7
1963	0.0	27.2	35.8	7.9	76.5	96.5	254.8	419.6	412.0	407.2	292.9	66.5	2096.8
1964	0.0	0.0	0.0	90.9	67.1	92.5	141.5	192.8	160.5	468.9	212.9	0.0	1427.0
1965	22.9	4.3	4.1	0.8	72.6	228.3	220.2	259.6	158.0	458.5	282.2	26.7	1738.1
1966	0.0	0.0	0.0	36.1	125.0	217.4	436.6	332.0	338.1	464.8	220.7	120.6	2291.3
1967	0.0	0.0	0.0	0.0	49.3	171.7	247.1	177.0	375.2	271.5	380.7	23.6	1696.2
1968	0.0	3.6	13.2	21.8	80.8	387.3	357.9	319.5	339.3	385.8	303.0	156.2	2368.5
1969	16.5	5.6	3.0	102.4	88.9	139.4	335.5	313.7	416.6	360.4	378.5	26.7	2187.2
1970	1.3	3.6	1.5	1.3	79.2	201.9	269.5	275.6	276.6	369.3	207.5	150.9	1838.2
1971	1.3	3.6	1.5	0.8	120.1	122.9	261.9	261.4	315.5	355.6	195.6	110.0	1750.1
1972	9.1	3.6	1.5	29.5	91.4	189.5	264.9	263.1	278.6	372.1	340.4	7.4	1851.2
1973	1.3	0.0	0.0	6.3	94.7	342.9	229.4	245.9	306.8	356.9	272.5	32.0	1888.7
1974	0.0	0.0	0.0	28.4	109.0	136.7	332.0	388.6	337.6	242.6	221.7	107.4	1904.0
1975	0.0	0.0	0.0	0.0	84.1	206.5	320.8	259.3	327.7	380.0	303.0	49.5	1930.9
1976	32.0	8.9	16.0	0.0	165.9	163.1	410.2	134.9	314.7	260.3	245.1	113.3	1864.4
1977	0.0	14.5	0.0	0.0	25.4	93.7	206.2	359.7	272.5	375.7	251.5	4.3	1603.5
1978	3.6	3.0	10.2	26.2	189.0	180.1	269.5	262.6	193.5	302.5	217.4	97.8	1755.4
SAMPLE MEAN	9.4	6.5	9.7	33.4	85.3	189.5	286.8	297.9	312.1	368.3	289.8	99.0	1987.7
HIGHEST VALUE	61.0	80.8	62.2	139.2	189.0	387.3	436.6	453.1	501.4	608.6	523.2	286.5	2687.1
LOWEST VALUE	0.0	0.0	0.0	0.0	4.3	75.9	141.5	134.9	158.0	199.9	125.2	0.0	1427.0

Source: Bumbuna Hydro-Consultants (1980)

D.2 Relative Humidity, Temperature and Rainfall

METEOROLOGICAL DATA
(Temperature, Humidity and Rainfall)
MONTH/YEAR: May 1991

	Temperature (Deg.C)						Humidity (%)						Rainfall (mm)	
Date	6am	10am	2pm	6pm	Max.	Min.	6am	10am	2pm	6pm	Max.	Min.	R.E.'s	Bmb.*
1	23.2	26.1	29.6	28	31.3	23.2	95	89	74	83	95	64		
2	22.3	25	32	31.4	32.9	22.3	95	76	56	56	95	54		
3	23.8	27.7	33.1	31.7	33.4	23.5	79	71	51	53	86	49		
4	23.7	28	33	31.3	33.1	23.2	94	79	55	65	96	54		
5	23.2	28.3	33.3	24.8	33.3	23	93	69	52	94	94	51	22	
6	22.3	26	31	29.5	31.5	22.3	94	75	55	66	96	54		42.3
7	23.6	25.8	30.9	28.6	32	23.3	95	86	66	73	96	59		
8	24	25	31	30.8	32	23.9	96	93	66	67	96	59		
9	22.9	27.4	32	26	32	22.8	92	75	59	89	93	59		
10	21.2	25	31.1	29.9	31	21.2	94	93	70	71	96	64		
11	24.5	25.9	30.2	30.5	31.9	24.5	95	93	69	66	95	60		
12	32.1	23.9	28.5	29	30.5	23	93	93	77	73	95	68		
13	25	28.8	32.3	30.5	32.4	25	94	69	58	70	88	55		
14	22.5	28	32.9	30.5	32.9	22.5	88	59	54	73	93	47		
15	23	28.2	32.6	30.6	32.9	22.8	92	65	48	60	95	46		
16	23.9	26.9	33.2	25.8	33.2	23.7	64	60	39	89	95	39	9.6	
17	22	27	31.3	29.5	31.8	22	95	84	59	69	95	55	37.2	
18	24.4	28.8	31.2	29.8	31.9	24.3	95	77	64	70	95	62		
19	24.8	23.7	24.5	25.5	26	23.3	94	81	92	89	95	81	8.2	
20	23.1	25.1	28.9	28.9	29.8	23.1	95	82	76	75	95	71		63.4
21	24.2	26.8	27.8	26.9	29.9	24.2	94	79	76	86	95	70	0.4	
22	24	26	31.4	28.2	32	23.5	96	88	62	79	95	58	53.4	
23	23.2	26	30.2	29.6	30.8	23.2	95	89	69	69	95	67		
24	24.2	22.8	22.9	26.2	26.2	22	95	90	91	89	95	81	18.6	
25	23.2	24	28.9	29.3	30.3	23	95	95	77	73	94	68	0.2	
26	23.9	25.4	31.3	30.3	31.4	23.9	93	90	64	65	95	61		
27	24.5	28	31.8	29.4	32	24.1	95	75	60	75	95	59		67.2
28	24	26	30.9	29.3	31.5	24	95	85	63	70	95	58		
29	22.5	27.5	31.5	29.3	31.7	22.3	90	69	55	68	92	53		
30	24	26.5	31.1	29.3	31.4	24	88	79	57	64	89	85		
31	24	26.9	31	27.3	32.1	24	95	83	59	85	95	54	1.6	

Monthly Average			
Temperature		Humidity	
Max	31.4	Max	94.1
Min:	23.2	Min:	59.2

* Note:- Bumbuna rainfall record is from 29/4 to 27/5 and is taken at 10a.m. every Monday

Total Weekly Rainfall		
Period	R.E's Office	Bumbuna*
1/5 - 5/5	22	42.3
6/5 - 12/5	0	0
13/5 - 19/9	55	63.4
20/5 - 26/5	54.6	67.2
27/5 - 31/5	1.6	0
Monthly Totals	133.2	172.9

123/A1 WAYS/18AUG91

Studio pietrangeli - bumbuna

Source: Electrowatt/Techsult (1996)

METEOROLOGICAL DATA
(Temperature, Humidity and Rainfall)

MONTH/YEAR: June 1991

Date	Temperature (Deg.C) 6am	10am	2pm	6pm	Max.	Min.	Humidity (%) 6am	10am	2pm	6pm	Max.	Min.	Rainfall (mm) R.E.'s	Bmb.*
1	24	26.2	30.2	29.3	32	23.4	94	82	66	74	95	59	53.4	
2	22.2	25.5	28	25.8	30	22.2	94	90	76	93	95	72	28.4	
3	23.9	26.5	30	25.9	32	23.9	95	87	69	77	95	66	14.6	107.4
4	22.2	24.5	28	28.8	29.1	22.1	93	90	78	78	94	73	2.2	
5	24.1	26.7	31.8	30.2	32	23	95	89	66	73	95	57		
6	22	26.8	32	29.8	32.1	21.9	84	82	61	74	95	60		
7	24.2	26.6	30.5	30.3	31.3	24	94	84	65	69	95	63	2.8	
8	22.5	26.2	31.2	30.2	31.6	22.3	91	77	62	68	94	59	0.8	
9	23.9	26.9	30	30.1	31.3	23.8	93	83	73	68	96	66		
10	25.2	28	31.8	30.5	32.2	25.2	95	82	72	80	95	63		11.6
11	24.5	27.5	31.8	30	32	24.2	93	83	64	79	95	64	14	
12	23.3	26.5	30.5	29.3	30.8	23.3	92	84	73	83	93	69		
13	22.3	25.2	27.8	27.6	28.8	22.2	91	82	82	85	94	76	7.8	
14	24.2	27.3	30.9	27	30.9	24.2	95	94	70	88	95	65	9.2	
15	23.9	27.5	31.7	28.3	31.7	23.9	94	81	62	77	95	59	4.8	
16	24	25.8	26.9	27	28	23.8	94	91	84	87	95	71		
17	24.7	27.9	29.8	27.4	30.8	23.7	93	75	68	90	95	64	12.8	46.3
18	23.5	24.8	27.7	28.5	29.2	23.2	93	89	79	81	95	69		
19	24	25.8	30.9	29.3	31	22.2	95	88	66	80	95	64	7.6	
20	22.9	26.9	30.4	29	30.4	21.9	92	78	66	76	95	64	7.2	
21	22.2	25.5	28.2	26	28.9	21.9	93	78	74	89	96	68	1.6	
22	22.4	24.2	28.7	28	29.1	22.3	94	92	69	79	96	67	1.2	
23	22.9	24.2	28	27.3	28.2	22.9	95	91	75	85	95	74	20.4	
24	23.1	26.3	28.2	27.5	28.5	22.9	94	81	65	85	95	62	0.4	63.8
25	23	26	29.5	28	29.9	23	96	88	75	89	97	71		
26	24.3	26	30.3	28	30.6	24.3	97	90	71	86	97	68		
27	21.8	27	27.3	26.8	28.1	21.8	90	80	79	83	97	73	1.2	
28	21.3	25	30	26	30	21.3	95	86	64	86	97	62	20.6	
29	23	24.9	28	24	28.2	21.8	96	87	81	95	97	71		
30	21	27.2	29	27.3	29.3	21	95	77	73	74	96	65	21.6	
31														

Monthly Average

	Temperature	Humidity
Max:	30.2	95.3
Min:	22.9	66.1

Total Weekly Rainfall

Period	R.E's Office	Bumbuna*
1/6 - 2/6	81.8	107.4
3/6 - 9/6	20.4	11.6
10/6 - 16/69	35.8	46.3
17/6 - 23/6	50.8	63.8
24/6 - 30/6	43.8	
Monthly Totals	232.6	229.1

* Note:- Bumbuna rainfall record is from 29/4 to 27/5 and is taken at 10a.m every Monday

123/ALWAYS/10AUG91

Studio pietrangeli - bumbuna

Source: Electrowatt/Techsult (1996)

METEOROLOGICAL DATA
(Temperature, Humidity and Rainfall)

MONTH/YEAR: July 1991

	Temperature (Deg.C)						Humidity (%)						Rainfall (mm)	
Date	6am	10am	2pm	6pm	Max.	Min.	6am	10am	2pm	6pm	Max.	Min.	R.E.'s	Bmb.*
1	21.8	24.4	26.1	25.1	26.3	21.6	92	82	86	97	97	78	0.2	52.7
2	22.4	25	29.5	27.6	29.5	22.2	95	83	69	84	97	65		
3	23.6	21	24.8	24.5	25.8	20.4	98	95	89	94	98	82	50.4	
4	21.8	24.5	23.7	24	26.7	21.6	98	84	92	94	98	76	16.8	
5	21.2	24.5	29.8	28.1	30	21.1	98	91	63	79	98	63	1.2	
6	23.8	25	30	28.1	30	23.5	98	92	71	88	98	71	0.6	
7	23	25	30.5	29.1	30.9	23	98	83	69	77	98	65	0.4	
8	24	26.5	31.8	27.5	31.8	23.6	98	85	62	82	98	62	3.6	78
9	22.8	24.2	27	27.7	29.1	22.5	96	94	81	84	97	73	102.2	
10	22	23	25	26.1	26.5	21.3	97	94	84	84	97	81	2.6	
11	20.5	21.2	23	22.1	23.2	20.5	97	96	94	96	97	93	55.2	
12	20.5	24	27.9	27.2	28	20.2	97	87	69	72	97	79	1	
13	22.3	24.5	27.2	27	28.6	22.1	94	89	79	82	95	73	7.2	
14	22.7	23.4	26.9	27.5	28.2	22.7	97	89	84	79	97	76		
15	24	26	30.2	28.5	30.9	24	97	93	73	85	97	69	6.6	185.5
16	23	21	25.4	24.5	26.2	20.9	96	94	81	87	97	77	72	
17	22	25	26	24.2	28	20	97	92	87	91	97	74	18.4	
18	22.5	24.4	28.5	22.8	28.5	21.7	97	94	75	91	97	70	3.8	
19	21.2	23.5	27.9	27.5	25.7	21.1	96	94	79	74	96	70		
20	23.2	25	30.5	26.3	31.3	31.1	96	94	74	81	96	67	11	
21	23.2	24.5	25.8	25.5	28.5	22.3	96	96	89	86	96	79	13.6	
22	23.1	24.5	29.5	26.5	30	29.9	94	92	69	84	96	65	17.8	132.6
23	22.5	23.2	27	27.2	27.8	22.4	94	95	75	79	96	75		
24	22	22.2	23.9	24.7	24.9	21.5	97	97	89	84	97	84	0.8	
25	21.3	21.1	24.5	25.9	25.9	21.1	97	97	89	85	97	85	10.4	
26	20.7	19.9	25	25.3	25.9	19.9	97	97	81	81	97	76	13.6	
27	21	22	24	25	25.5	20.9	95	95	87	78	97	76		
28	21.2	22	25.1	25.9	26.8	21.2	97	96	84	77	97	76		
29	21.9	23.5	27	23.2	27.5	21.5	97	97	84	95	97	79	55.6	56.3
30	21.2	23	27	23.2	28	21.2	97	93	79	84	97	71	1.6	
31	20.2	24.3	28.2	27.7	29.1	20.2	96	83	64	65	96	56		

Monthly Average

Temperature		Humidity	
Max:	27.9	Max:	96.9
Min:	21.9	Min:	73.7

Total Weekly Rainfall		
Period	R.E's Office	Bumbuna*
1/7 - 7/7	69.6	52.7
8/7 - 14/7	171.8	78
15/7 - 21/7	125.4	185.5
22/7 - 28/7	42.6	132.6
29/7 - 31/7	57.2	56.3
Monthly Totals	466.6	505.1

* Note:- Bumbuna rainfall record is from 24/6 to 29/7 and is taken at 10a.m every Monday

123/ALWAYS/22AUG91 Studio pietrangeli - bumbuna

Source: Electrowatt/Techsult (1996)

METEOROLOGICAL DATA
(Temperature, Humidity and Rainfall)

MONTH/YEAR: August 1991

	Temperature (Deg.C)						Humidity (%)						Rainfall (mm)	
Date	6am	10am	2pm	6pm	Max.	Min.	6am	10am	2pm	6pm	Max.	Min.	R.E.'s	Bmb.*
1	22.3	24	28.2	27.5	29	22.2	95	88	65	63	95	60		
2	21.8	25	25.9	27.2	28.9	21.6	97	84	87	83	97	74	7.2	
3	22.6	23	23.2	28.2	28.9	22.4	97	97	78	77	97	72	43.6	
4	21	24.3	28	24	28.1	21	96	92	78	98	98	77	14.8	
5	22.8	24.5	26.5	23.8	26.8	21.9	97	93	93	94	97	84	17.6	134.7
6	21.5	23	22.1	22.5	23.5	21.3	97	97	97	96	97	95	70.6	
7	21	23.1	26.3	24.6	27	20.7	97	96	85	89	91	75	7.2	
8	21	23	26	22.5	26.9	20.9	97	91	79	94	97	72	14.2	
9	21	20.9	25	23	25	20	97	97	85	89	97	82	14.6	
10	20.7	22.7	26.4	23	27.8	20.8	97	98	84	94	98	75	27.8	
11	21.2	23.5	24.8	26	26.8	21.1	97	96	90	79	97	77		
12	21	23.5	24	23.4	25	20.9	93	97	96	96	97	84		238.5
13	21.8	23.8	27.8	26.6	27.8	21.5	97	93	76	87	97	74		
14	22	23	26.5	24.4	26.9	21.9	97	95	83	96	97	74		
15	21.9	23.1	26.5	22	27	21.9	96	92	79	97	97	74		
16	21.2	22	25.8	24	26.5	21	97	95	84	94	97	70		
17	21.8	23.5	25.3	22.3	26	21.8	97	92	86	97	97	80		
18	21.3	20.8	21.9	21.2	22.2	20.6	97	97	97	97	97	94		
19	21	22.5	25.2	22.6	26.5	21	97	96	97	91	97	83		236.4
20	21.2	22.5	23.1	22.9	25.1	21.2	97	96	96	97	97	86		
21	21.2	22.9	27	22.2	27.2	21.2	97	95	84	97	97	75	20	
22	21	22.3	23	22	25.1	21	97	97	97	97	97	80	18.8	
23	21	22.5	23	24	28.9	21	97	95	73	96	97	67	13.8	
24	22	23.7	26.2	23.5	27.9	21	97	93	85	92	97	74	54.4	
25	21	25.8	27.9	27.4	29.3	20.8	97	83	70	85	98	64	4	
26	22.8	27	27.8	26.5	28	22.8	98	83	80	83	98	79		161
27	22	24.9	27.8	25	28.8	22	97	90	78	86	97	74	113.4	
28	21.3	25	24.1	24	28	21.3	97	92	89	94	97	76	8.4	
29	21.5	24	28.9	23.8	29.3	21.5	97	90	74	94	97	70	44.4	
30	21.8	25	28.3	24.5	29	21.6	97	90	75	91	97	72	6.8	
31	21.8	22.8	25	22.6	25.2	21.6	96	96	92	97	97	88	18.4	

Monthly Average			
Temperature		Humidity	
Max:	27.0	Max:	96.8
Min:	21.3	Min:	76.8

* Note:- Bumbuna rainfall record is from 29/7 to 26/8 and is taken at 10a.m every Monday

21.3		
21.5	R.E's Office	Bumbuna*
21.6	65.6	134.7
5/8 - 11/8	159.8	238.5
12/8 - 18/8	27.8	236.4
19/8 - 25/8	170.8	161
26/8 - 31/8	191.4	
Monthly Totals	865.6	770.6

123/2NOV91

Studio pietrangeli - bumbuna

Source: Electrowatt/Techsult (1996)

METEOROLOGICAL DATA
(Temperature, Humidity and Rainfall)

MONTH/YEAR: September 1991

	Temperature (Deg.C)						Humidity (%)						Rainfall (mm)	
Date	6am	10am	2pm	6pm	Max.	Min.	6am	10am	2pm	6pm	Max.	Min.	R.E.'s	Bmb.*
1	22.0	21.5	24.0	24.8	25.4	21.2	95	95	91	84	96	82	26.8	
2	21.0	24.6	28.3	27.8	29.3	21.0	97	84	69	85	98	64		287.8
3	22.8	25.0	22.5	23.4	27.0	21.4	96		90	97	98	77	25.8	
4	21.0	23.0	27.3	24.0	29.0	21.0	96	90	72	92	98	61	7.6	
5	21.9	25.0	27.0	26.8	27.1	21.7	91	81	79	86	98	71	3.2	
6	22.3	24.8	26.3	27.0	28.0	21.6	95	90	82	89	98	73	62.0	
7	20.5	22.8	28.8	28.0	29.4	20.2	95	94	70	72	97	58	0.2	
8	22.7	24.0	27.3	24.5	28.4	22.7	98	95	82	93	98	73	9.0	
9	22.4	26.8	29.4	28.0	29.4	22.4	97	82	75	93	97	73	6.2	77.0
10	23.0	25.2	28.2	23.3	29.0	22.6	97	90	82	94	97	72	7.6	
11	22.0	24.0	28.0	27.3	28.6	22.0	97	90	77	87	97	71	2.4	
12	23.0	25.0	29.6	23.0	29.8	22.0	96	91	71	89	97	64	24.2	
13	21.0	26.0	28.9	26.0	29.9	20.9	96	85	70	83	96	67	26.6	
14	22.4	26.0	29.3	27.7	29.9	22.4	97	79	73	82	97	69	0.4	
15	23.4	28.0	30.0	26.9	30.9	22.9	94	74	74	79	95	68	0.8	
16	22.2	25.8	29.3	28.5	30.0	22.0	95	87	71	76	97	66	6.2	63.6
17	21.2	24.8	28.4	28.0	30.0	21.2	94	86	75	85	96	69	0.2	
18	23.0	27.0	30.0	24.3	30.9	22.8	96	76	71	90	97	67	8.2	
19	21.5	24.5	27.6	26.0	28.8	21.5	94	84	74	90	97	70	18.0	
20	22.7	24.2	29.0	27.6	29.1	22.2	97	94	76	84	97	73	13.2	
21	23.1	26.0	29.8	25.2	29.9	23.1	96	88	75	91	97	72	32.8	
22	21.9	25.1	28.6	27.7	28.8	21.5	89	84	81	90	97	62	23.4	
23	22.8	27.5	30.5	29.0	30.9	22.2	93	84	72	84	97	69	1.1	98.5
24	21.0	22.5	27.8	26.0	27.9	20.6	97	88	74	84	97	74	3.8	
25	22.8	25.5	27.0	27.0	21.8	21.9	97	73	79	87	97	67	1.4	
26	22.0	24.4	29.1	24.0	30.0	21.9	96	92	72	80	97	68	20.4	
27	21.5	24.8	29.3	28.5	30.1	21.2	97	86	71	84	97	68	0.2	
28	22.0	25.1	29.1	26.9	30.3	21.9	93	86	73	87	97	68	0.4	
29	22.3	26.4	30.4	28.3	30.5	22.3	96	90	69	76	97	68	0.4	
30	24.0	25.3	22.8	24.0	26.0	22.3	97	93	93	94	97	79	4.8	39.0
31														

Monthly Average			
Temperature		Humidity	
Max	29.0	Max	97.0
Min:	21.8	Min:	69.4

* Note:- Bumbuna rainfall record is from 26/8 to 2/9 and is is at 10a.m every Monday

Total Weekly Rainfall		
Period	R.E's Office	Bumbuna*
1/9 -	26.8	287.8
2/9 - 8/9	107.8	77.0
9/9 - 15/9	68.2	63.6
16/9 - 22/9	102	98.5
23/9 - 30/9	32.5	39.0
Monthly Totals	337.3	565.9

123/2NOV91

Studio pietrangeli - bumbuna

Source: Electrowatt/Techsult (1996)

METEOROLOGICAL DATA
(Temperature, Humidity and Rainfall)

MONTH/YEAR: May 1992

	Temperature (Deg.C)						Humidity (%)						Rainfall (mm)	
Date	6am	10am	2pm	6pm	Max.	Min.	6am	10am	2pm	6pm	Max.	Min.	R.E.'s	Bmb.*
1	24.9	25.6	27.3	26.3	28.4	24.8	97.0	97.0	86.0	87.0	97.0	77.0		
2	23.0	26.0	33.4	31.5	33.8	22.9	97.0	86.0	51.0	53.0	97.0	49.0		
3	23.7	28.7	31.0	30.2	31.9	23.2	80.0	76.0	64.0	64.0	92.0	59.0		
4	22.9	26.2	31.3	30.0	32.2	22.9	92.0	88.0	54.0	70.0	94.0	52.0		
5	23.5	26.0	30.4	30.5	32.3	23.0	96.0	92.0	64.0	59.0	96.0	57.0		
6	22.0	25.2	28.4	28.0	29.0	22.0	96.0	92.0	76.0	84.0	96.0	74.0	19.8	
7	23.0	28.0	33.0	32.8	34.1	23.0	96.0	84.0	63.0	53.0	96.0	49.0		
8	25.2	28.4	33.0	31.7	33.4	25.2	94.0	89.0	70.0	64.0	94.0	61.0		
9	26.0	27.6	30.3	29.4	31.3	25.8	96.0	89.0	76.0	81.0	96.0	69.0		
10	25.4	29.0	30.3	29.8	32.9	25.1	96.0	88.0	68.0	81.0	96.0	64.0	3.4	
11	25.2	27.8	32.3	29.7	32.8	25.0	96.0	89.0	68.0	89.0	96.0	64.0	0.6	
12	23.9	27.0	29.8	31.1	32.0	23.3	96.0	90.0	77.0	68.0	96.0	66.0		
13	24.8	27.5	32.3	31.4	32.8	24.8	97.0	85.0	68.0	63.0	97.0	58.0		
14	25.0	26.2	31.3	29.0	32.9	24.9	97.0	97.0	64.0	88.0	97.0	59.0		
15	25.0	28.0	31.2	30.0	33.1	24.3	96.0	80.0	63.0	69.0	96.0	57.0		
16	25.0	29.0	30.0	29.5	32.9	22.3	96.0	80.0	64.0	96.0	96.0	59.0	49.6	
17	22.3	23.0	27.3	27.0	27.9	22.0	96.0	96.0	90.0	88.0	96.0	85.0	2.4	
18	24.2	24.1	24.1	23.0	28.0	22.2	96.0	96.0	90.0	96.0	96.0	77.0	10.0	
19	21.6	26.5	29.8	30.1	30.9	21.6	96.0	79.0	63.0	65.0	96.0	59.0		
20	22.7	27.0	32.0	30.7	32.4	22.4	97.0	84.0	63.0	64.0	97.0	57.0		
21	24.3	27.3	27.9	28.8	30.3	24.3	97.0	83.0	82.0	80.0	97.0	70.0		
22	24.0	25.0	27.8	28.3	30.0	23.9	97.0	97.0	79.0	77.0	97.0	70.0	1.8	
23	23.9	25.0	30.4	29.0	31.4	22.3	97.0	96.0	74.0	71.0	97.0	63.0	17.6	
24	22.0	22.5	25.0	25.0	25.0	22.0	97.0	97.0	87.0	92.0	97.0	87.0	21.0	
25	22.0	27.8	30.5	28.5	31.4	22.0	97.0	84.0	64.0	79.0	97.0	63.0	10.2	57.9
26	23.0	25.0	24.9	24.3	25.0	23.0	96.0	89.0	96.0	95.0	96.0	89.0	8.0	
27	21.9	27.0	31.0	24.0	31.7	21.8	95.0	84.0	64.0	80.0	96.0	62.0	21.8	
28	21.2	25.0	30.9	28.1	31.1	21.1	96.0	93.0	70.0	76.0	96.0	67.0		
29	23.9	27.9	29.6	26.5	31.1	23.8	94.0	81.0	73.0	88.0	96.0	69.0	15.0	
30	22.9	26.8	31.6	29.0	32.0	22.3	96.0	90.0	68.0	75.0	96.0	65.0	0.8	
31	24.1	27.7	30.2	29.4	31.2	24.1	96.0	86.0	70.0	75.0	96.0	67.0		71.0

Monthly Average			
Temperature		Humidity	
Max:	31.1	Max:	96.1
Min:	23.3	Min:	65.3

* Note:- Bumbuna rainfall is from 15/5 to 1/6 and is taken at 10a.m on 1/6/92

Total Weekly Rainfall		
Period	R.E's Office	Bumbuna*
1st/3rd	0.0	0.0
4th/104th	23.2	No record
11th/17th	52.6	No record
18th/24th	50.4	57.9
25th/31st	55.8	71.0
Monthly Totals	182.0	128.9

P249L/METEOR/01 JUNE92

Studio pietrangeli - bumbuna

Source: Electrowatt/Techsult (1996)

METEOROLOGICAL DATA
(Temperature, Humidity and Rainfall)

MONTH/YEAR: June 1991

	Temperature (Deg.C)						Humidity (%)						Rainfall (mm)	
Date	6am	10am	2pm	6pm	Max.	Min.	6am	10am	2pm	6pm	Max.	Min.	R.E.'s	Bmb.*
1	22.6	28.0	31.0	29.4	31.3	22.0	95.0	85.0	72.0	79.0	95.0	69.0	13.0	
2	24.9	23.0	25.8	25.0	26.0	22.3	96.0	96.0	86.0	91.0	96.0	84.0	4.8	
3	23.0	25.7	25.0	25.0	28.9	22.9	96.0	88.0	94.0	96.0	96.0	76.0	3.8	
4	22.4	26.0	29.7	28.4	30.4	22.3	96.0	88.0	73.0	74.0	96.0	64.0		
5	23.9	26.0	29.9	26.9	30.3	23.8	96.0	93.0	69.0	89.0	96.0	69.0		
6	23.0	25.5	26.3	22.8	28.8	22.8	96.0	90.0	81.0	91.0	96.0	77.0	1.0	
7	22.9	23.5	27.9	24.4	28.4	21.9	96.0	90.0	74.0	86.0	96.0	73.0	14.4	
8	21.9	24.4	24.0	22.3	24.9	21.9	96.0	96.0	91.0	92.0	96.0	86.0	18.2	
9	21.2	25.0	28.4	27.8	29.1	20.9	94.0	85.0	71.0	71.0	96.0	64.0	10.4	47.4
10	21.9	26.0	30.6	29.0	31.0	21.8	94.0	87.0	64.0	67.0	96.0	64.0	4.2	
11	24.0	25.1	28.7	28.7	29.9	23.9	94.0	87.0	75.0	71.0	96.0	74.0	1.0	
12	24.1	25.0	30.8	29.2	31.2	24.0	94.0	91.0	72.0	72.0	96.0	63.0		
13	21.9	24.4	29.6	24.0	30.1	21.7	94.0	91.0	69.0	78.0	96.0	65.0		
14	20.8	24.5	28.1	27.9	29.0	20.7	93.0	85.0	73.0	74.0	96.0	70.0	9.2	
15	22.9	26.0	29.6	24.2	29.8	22.5	96.0	94.0	82.0	94.0	96.0	76.0	15.2	
16	22.3	25.9	29.0	27.9	29.3	22.1	95.0	79.0	70.0	86.0	96.0	68.0		
17	24.0	24.5	31.1	29.8	31.2	23.9	96.0	90.0	64.0	69.0	96.0	64.0	91.4	82.1
18	23.0	26.0	30.1	27.9	30.2	22.1	85.0	86.0	66.0	81.0	94.0	66.0	4.6	
19	22.8	25.9	30.5	29.0	30.9	22.1	94.0	89.0	69.0	77.0	96.0	67.0		
20	24.3	25.9	28.2	29.9	30.1	23.9	96.0	88.0	75.0	66.0	96.0	66.0	1.2	
21	24.3	25.9	30.2	30.3	31.3	24.1	96.0	91.0	66.0	66.0	96.0	61.0		
22	25.0	26.0	30.2	28.8	30.4	23.0	96.0	90.0	70.0	80.0	96.0	69.0	23.4	70.2
23	22.9	25.2	29.8	28.6	29.9	22.8	96.0	92.0	74.0	79.0	96.0	72.0	8.6	
24	24.0	24.5	28.0	29.0	29.9	21.8	96.0	96.0	88.0	76.0	96.0	71.7	18.3	
25	21.0	24.8	29.0	28.0	29.9	21.0	96.0	84.0	67.0	72.0	96.0	64.0		
26	23.0	24.0	28.0	28.8	30.0	23.0	96.0	96.0	84.0	71.0	96.0	68.0	4.8	
27	21.6	22.7	28.4	26.8	29.0	21.0	93.0	94.0	79.0	91.0	96.0	74.0	28.8	
28	23.0	26.0	28.6	25.0	30.0	22.9	96.0	84.0	68.0	95.0	96.0	66.0	17.4	
29	23.0	25.2	29.2	29.0	30.6	23.0	96.0	94.0	74.0	80.0	96.0	65.0	12.4	110.5
30	23.0	24.5	29.0	29.3	30.0	22.2	95.0	91.0	76.0	74.0	96.0	68.0	6.8	

Monthly Average			
Temperature		Humidity	
Max:	29.7	Max:	95.9
Min:	22.5	Min:	69.4

* Note:- Bumbuna rainfall record is from 29/4 to 27/5 and is taken at 10a.m every Monday

Total Weekly Rainfall		
Period	R.E's Office	Bumbuna*
1st/7th	55.2	47.4
8th/14th	40.0	82.1
15th/21st	106.6	70.2
22nd/28th	101.3	110.5
29th/30th	19.2	0.0
Monthly Totals	322.3	310.2

P249L/METEOR/01 JUL92

Studio pietrangeli - bumbuna

Source: Electrowatt/Techsult (1996)

METEOROLOGICAL DATA
(Temperature, Humidity and Rainfall)

MONTH/YEAR: July 1992

	Temperature (Deg.C)						Humidity (%)						Rainfall (mm)	
Date	6am	10am	2pm	6pm	Max.	Min.	6am	10am	2pm	6pm	Max.	Min.	R.E.'s	Bmb.*
1	22.9	24.1	29.4	28.5	29.9	22.1	93.0	89.0	75.0	79.0	96.0	72.0	31.4	
2	23.5	25.1	29.0	28.5	30.3	32.6	96.0	92.0	74.0	79.0	96.0	68.0	23.4	
3	22.4	23.5	23.0	24.2	24.2	22.1	89.0	93.0	93.0	91.0	97.0	87.0	33.4	
4	22.1	24.0	25.9	27.7	28.0	22.0	96.0	93.0	85.0	76.0	96.0	71.0	19	
5	22.8	25.2	27.7	29.9	29.9	22.3	96.0	85.0	79.0	77.0	96.0	64.0	25.6	
6	22.9	23.7	27.3	27.2	28.0	22.8	96.0	96.0	85.0	80.0	96.0	76.0	2.8	184.8
7	22.0	23.8	25.7	26.3	27.8	21.9	92.0	88.0	84.0	84.0	96.0	78.0	5.6	
8	23.0	26.0	30.0	26.8	30.0	23.0	96.0	88.0	69.0	82.0	96.0	66.0	31.8	
9	23.0	25.0	26.2	27.3	28.0	23.0	94.0	92.0	85.0	80.0	96.0	75.0	0.4	
10	22.9	23.1	25.8	24.0	26.9	22.0	96.0	95.0	90.0	96.0	96.0	85.0	69	
11	22.0	22.0	40.0	24.0	27.1	21.9	95.0	96.0	84.0	85.0	96.0	78.0	34.4	
12	22.7	24.7	27.9	22.6	28.6	22.4	96.0	91.0	80.0	80.0	96.0	67.0	5	
13	23.0	24.0	29.2	28.0	29.8	22.9	96.0	94.0	67.0	79.0	96.0	64.0	39.4	160.5
14	22.0	23.0	27.0	25.0	28.0	22.0	95.0	95.0	76.0	90.0	96.0	69.0	3.4	
15	22.1	23.9	27.5	25.0	28.3	22.0	96.0	94.0	80.0	90.0	96.0	70.0	15.6	
16	21.0	22.3	26.0	25.0	26.3	21.0	96.0	95.0	79.0	86.0	96.0	74.0	51.6	
17	22.0	22.3	29.1	27.4	29.2	21.9	94.0	93.0	69.0	75.0	96.0	65.0	12.2	
18	23.0	24.5	28.2	28.8	29.3	23.0	94.0	87.0	74.0	72.0	96.0	68.0	5.2	
19	23.1	24.0	27.0	27.3	28.1	22.0	95.0	95.0	90.0	83.0	96.0	75.0	31.6	
20	22.0	24.2	27.2	24.1	27.5	21.8	96.0	91.0	76.0	92.0	96.0	73.0	18.6	277.3
21	22.3	24.0	29.0	23.5	29.2	21.1	95.0	93.0	70.0	94.0	96.0	65.0	29	
22	22.2	23.8	28.0	26.0	28.3	22.5	96.0	91.0	79.0	89.0	96.0	72.0	18.8	
23	22.0	23.0	28.0	26.0	29.0	22.0	96.0	95.0	78.0	82.0	96.0	71.0	20.8	
24	21.3	22.0	25.8	23.0	26.0	21.1	96.0	96.0	90.0	95.0	96.0	83.0	31.4	
25	21.8	22.4	24.0	22.0	24.9	21.5	95.0	96.0	95.0	96.0	96.0	89.0	27.6	
26	21.8	23.0	24.9	27.0	27.8	21.8	96.0	96.0	90.0	75.0	96.0	73.0	14.2	
27	22.9	23.9	27.7	25.4	29.8	22.0	96.0	96.0	80.0	78.0	96.0	71.0	109.8	145.5
28	21.2	22.1	26.9	24.1	27.2	21.0	96.0	94.0	81.0	94.0	96.0	76.0	21.2	
29	22.0	23.9	28.0	24.5	29.3	22.0	96.0	95.0	75.0	90.0	96.0	71.0	12	
30	22.6	23.0	28.0	27.2	29.0	21.1	96.0	96.0	81.0	82.0	96.0	73.0	42.2	
31	23.0	23.8	26.9	25.0	27.1	22.9	96.0	96.0	92.0	89.0	96.0	83.0	25.4	

Monthly Average			
Temperature		Humidity	
Max:	28.2	Max:	96.1
Min:	22.4	Min:	73.3

Total Weekly Rainfall		
Period	R.E's Office	Bumbuna*
1st/5th	132.8	184.8
6th/12th	149.0	160.5
13th/19st	159.0	277.3
20th/26th	160.4	145.5
27th/31st	210.6	0.0
Monthly Totals	811.8	768.1

* Note:- Bumbuna weekly rainfall is measured at 10a.m every Monday

P249L/METEOR/03AUG92 Studio pietrangeli - bumbuna

Source: Electrowatt/Techsult (1996)

METEOROLOGICAL DATA
(Temperature, Humidity and Rainfall)
MONTH/YEAR: August 1992

Date	Temperature (Deg.C) 6am	10am	2pm	6pm	Max.	Min.	Humidity (%) 6am	10am	2pm	6pm	Max.	Min.	Rainfall (mm) R.E.'s	Bmb.*
1	22.5	24.4	22.8	23.8	26.0	22.5	96.0	96.0	96.0	94.0	96.0	85.0	17.2	
2	22.0	22.2	26.0	27.6	28.4	22.0	96.0	96.0	85.0	85.0	96.0	75.0	75	
3	22.9	23.3	26.3	26.0	27.8	22.1	96.0	95.0	90.0	88.0	96.0	79.0	79	268.8
4	21.6	24.2	26.5	26.5	28.0	21.2	94.0	88.0	76.0	82.0	96.0	74.0	74	
5	22.0	22.7	24.4	23.0	26.0	21.8	96.0	96.0	91.0	96.0	96.0	86.0	86	
6	21.4	22.3	21.4	21.3	22.6	20.6	96.0	96.0	96.0	96.0	96.0	96.0	96.0	
7	20.6	22.0	25.0	22.0	25.8	20.6	96.0	96.0	82.0	96.0	96.0	79.0	79	
8	21.2	23.0	25.5	24.5	26.0	21.1	96.0	95.0	90.0	94.0	96.0	84.0	84.0	
9	21.4	22.7	27.3	26.0	27.5	21.3	96.0	95.0	84.0	87.0	96.0	80.0	80	
10	22.0	26.0	28.0	27.5	28.8	22.0	95.0	94.0	80.0	83.0	96.0	77.0	77	335.3
11	23.0	24.3	29.3	28.0	29.9	22.9	96.0	90.0	70.0	79.0	96.0	66.0	66	
12	-	-	25.3	25.1	26.0	22.8	96.0	94.0	90.0	91.0	96.0	83.0	83	
13	22.5	24.0	26.5	26.0	27.0	22.5	96.0	93.0	85.0	89.0	96.0	80.0	80	
14	22.3	24.0	22.6	25.1	29.6	22.3	95.0	91.0	80.0	90.0	96.0	66.0	66	
15	22.2	23.5	28.0	26.0	29.0	22.2	96.0	96.0	80.0	86.0	96.0	74.0	74	
16	22.4	24.0	28.0	25.5	28.0	22.4	96.0	95.0	76.0	91.0	96.0	76.0	76	
17	23.0	25.5	28.9	26.0	29.6	23.0	96.0	82.0	78.0	95.0	96.0	75.0	75	184.1
18	23.0	22.9	25.5	23.8	25.5	22.8	96.0	96.0	96.0	96.0	96.0	90.0	90	
19	22.2	22.9	24.0	25.9	26.8	22.2	96.0	96.0	94.0	93.0	96.0	81.0	81.0	
20	22.3	23.0	28.2	28.0	29.9	22.3	96.0	96.0	78.0	85.0	96.0	70.0	70	
21	22.6	24.7	30.0	28.8	30.3	22.2	94.0	94.0	71.0	85.0	96.0	70.0	70	
22	23.3	25.9	29.0	26.0	29.8	23.3	96.0	90.0	84.0	86.0	96.0	76.0	76	
23	23.0	25.4	26.4	24.0	29.0	23.0	96.0	96.0	84.0	96.0	96.0	76.0	76	
24	23.2	26.0	28.0	24.9	28.5	23.1	96.0	88.0	84.0	96.0	96.0	77.0	77	219.0
25	22.8	24.6	28.0	25.3	28.1	22.2	96.0	91.0	80.0	90.0	96.0	75.0	75	
26	22.3	24.8	27.9	26.5	28.4	22.2	96.0	90.0	76.0	95.0	96.0	74.0	74	
27	22.8	21.4	23.9	21.8	24.1	21.2	95.0	96.0	90.0	96.0	96.0	84.0	84	
28	21.3	25.0	23.0	24.0	27.1	21.3	96.0	93.0	85.0	89.0	96.0	75.0	75	
29	21.9	25.6	27.9	24.0	28.9	21.8	96.0	91.0	77.0	92.0	96.0	63.0	63	
30	22.5	23.6	27.2	24.0	28.0	22.5	96.0	96.0	80.0	96.0	96.0	74.0	74	
31	22.9	24.9	27	24.2	27.2	22.5	96.0	93.0	85.0	96.0	96.0	81.0	81	222.1

Monthly Average

Temperature		Humidity	
Max:	27.7	Max:	95.9
Min:	21.1	Min:	77.6

* Note:- Bumbuna weekly rainfall is measured at 10a.m every Monday

Total Weekly Rainfall

Period	R.E's Office	Bumbuna*
1st/2nd	55.6	268.8
3rd/9th	370.2	33.5.3
10th/16th	164.6	184.1
17th/23rd	172.4	219.0
24th/31st	292.2	222.1
Monthly Totals	1055.0	1229.3

Studio pietrangeli - bumbuna

P249L/METEOR/01SEPT92

Source: Electrowatt/Techsult (1996)

TEMPERATURE AND RAINFALL

Month		Average Monthly Temperature (deg C) Minimum	Maximum	Rainfall (mm)
July	1982	22.0	36.0	572
August	1982	22.4	32.3	1.097
September	1982	22.0	36.6	956
October	1982	21.6	37.0	291
November	1982	21.2	38.2	72
December	1982	18.6	37.7	-
January	1983	17.3	38.3	-
February	1983	18.9	39.1	19
March	1983	22.1	34.8	20
April	1983	22.8	34.8	75
May	1983	24.1	33.3	302
June	1983	22.5	30.0	445
July	1983	23.2	30.6	508
August	1983	22.6	29.6	744
September	1983	22.3	30.4	514
October	1983	22.5	31.4	303
November	1983	23.5	31.5	18
December	1983	19.8	30.0	3
January	1984	18.3	30.4	-
February	1984	17.4	34.6	-
March	1984	20.8	37.4	46
April	1984	20.6	35.5	55
May	1984	21.8	34.0	258
June	1984	21.1	31.9	279
July	1984	20.8	31.0	488
August	1984	20.7	31.4	515
September	1984	20.3	31.7	219
October	1984	20.5	32.3	429
November	1984	20.5	33.4	53
December	1984	16.5	32.2	-
January	1985	17.4	33.1	-
February	1985	16.6	35.1	20
March	1985	19.6	34.9	7

Source: Electrowatt/Techsult (1996)

BUMBUNA MONTHLY PRECIPITATION

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OUT	NOV	DEC	SUM
1972	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	-1.0	426.1	341.8	79.4	0.0	-1.0
1973	0.0	0.0	13.4	55.4	223.9	229.1	619.0	787.1	505.3	343.2	149.2	48.3	3043.9
1974	0.0	0.0	25.9	52.5	86.3	272.6	507.3	661.1	439.7	566.6	0.0	0.0	2612.0
1975	0.0	0.0	0.0	33.8	98.8	271.2	-1.0	599.9	624.2	-1.0	-1.0	0.0	-1.0
1976	0.0	0.0	0.0	-1.0	388.8	359.2	402.9	225.7	-1.0	-1.0	-1.0	0.0	-1.0
1977	0.0	0.0	0.0	20.0	110.2	204.1	438.4	688.7	410.6	465	21.3	0.0	2358.3
1978	7.1	0.0	53.6	113.5	225.0	124.5	424.2	613.9	658.9	365.5	89.9	16.5	2692.6
1979	19.0	0.0	12.7	20.8	304.8	227.3	678.7	578.9	-1.0	-1.0	-1.0	-1	-1
SAMPLE MEAN	3.7	0.0	15.1	49.3	205.4	251.1	511.7	593.6	510.8	416.4	68.0	9.3	2634.5
HIGHEST VALUE	19.:	0.0	53.6	113.5	388.8	359.2	678.7	787.1	658.9	566.6	149.2	48.3	3043.9
LOWEST VALUE	0.0	0.0	0.0	20.0	86.3	124.5	402.9	225.7	410.6	341.8	0.0	0.0	2358.3

BUMBUNA

MONTHLY PRECIPITATION

mm

Source: Electrowatt/Techsult (1996)

D.3 Greenhouse Gases and Reservoirs

A power station obtaining its energy from the combustion of fossil fuels generates carbon dioxide throughout all of its operational life in quantities proportional to its electrical power output. The underlying combustion processes involved are understood and quantities of the different gases discharged are well known. In terms of global warming the most significant gas is carbon dioxide. The use of power generation plants which do not rely on fossil fuels therefore has the potential to reduce the quantities of green-house gases released to the atmosphere.

The relationship between hydroelectric power reservoirs and global warming has been reviewed by Rosa et al.(2002). Although no formal conclusions were drawn by the authors they recognise the potential for the generation of carbon dioxide and methane, a significant green-house gas, in tropical water reservoirs.

The impounding of a river which results in the inundation of previously dry areas will cause a change in the carbon cycle pathways within the ground which has been flooded and in the overlying water and hence a change in the type and quantities of gas released.

In a climax ecosytem where the combined living and detrital biomass remains constant the net carbon dioxide emission from the system is zero; although there may be seasonal processes which give relatively short term positive and negative emission rates. Consequently the existing forest in the Bumbuna Reservoir area has a neutral impact on the global carbon dioxide balance.

In the terrestrial environment the decomposition pathways are dominated by aerobic processes and so the end product of the decomposition process is carbon dioxide. When the environment changes to an aquatic system the decomposition processes change. As long as the overlying water remains oxic the decomposition will follow the aerobic pathway and generate carbon dioxide. Hutchinson (1957) provides a detailed description of the behaviour of carbon dioxide and methane in lakes. In a well-mixed water body there may be sufficient dissolved oxygen present at the sediment water interface for aerobic processes to take place within the upper few millimetres of the sediment layer. The lower limit of this layer is controlled by the rate of diffusion of oxygen through the interstitial water. Below the interface anaerobic carbon pathways are followed and the end point of the decomposition process is methane that will be released from the sediment as bubbles which will also contain hydrogen. As the bubbles rise through the water column the hydrogen dissolves in the surrounding water together with some of the methane. Bacterial activity in the water column oxidises the methane to carbon dioxide.

Carbon dioxide and methane are both significant greenhouse effect gases through their ability to ‘trap’ long wave infra-red radiation. Methane is more effective than carbon dioxide at absorbing infra-red by a factor of over 21 (USEPA, 2004).

Estimates of emissions of carbon dioxide and methane from lakes have been made by a number of workers over the last decade and their findings have been summarised by Rosa et al (2002) and Tremblay *et al* (2005). Data from the more recent study, which includes observations from tropical reservoirs, suggest average emission rates of around 190 mg/m^2/day for CO_2 and 200 mg/m^2/day for CH_4. Although there is debate in the scientific community regarding the degree to which HEP schemes help to reduce emissions of greenhouse gases, these figures can be used to give at least an approximation of the potential contribution of the BHP.

The operating range of the Bumbuna reservoir is between 210 and 238 m asl. At the average of these two levels the surface area is approximately $11x10^6$ m^2. Assuming average emission rates of 190 and 200 $mg/m^2/d$ for carbon dioxide and methane respectively gives daily emission rates for the whole reservoir of 2.1 and 2.2 tonnes/day. Because of the greater ‘efficiency’ of methane for trapping infra red radiation, the 2.2 tonnes per day is equivalent, in relation to global warming, to 46.2 tonnes of carbon dioxide. Daily carbon dioxide equivalents for the reservoir are therefore approximately 48 tonnes/day (17,000 tonnes/year).

Annual estimates of the carbon dioxide emissions of an equivalent thermal power station have been calculated (Haas, pers comm.) as part of a submission for carbon credits. For two operational scenarios, Bumbuna Reservoir alone and Bunbuna Reservoir with upstream regulation, the calculated annual carbon dioxide emissions were 179,600 and 287,300 tonnes respectively. Comparing the emissions from a thermal power plant with equivalent power output and those generated by a hydropower scheme driven by Bumbuna Reservoir alone shows a net annual ‘saving’ of approximately 162,000 tonnes of carbon dioxide.

It is anticipated that the large trees will be removed from the area to be inundated but that the under-storey and litter on the forest floor will not be removed. Data for carbon storage in the soil, forest floor and under-storey for tropical forest are not readily available. However an extensive study of forests in the United States reported by Birdsey (1992) indicates 110,000 lb/acre (12.3 kg/m^2) as an average figure for carbon content of the soil, forest floor and under-storey. The combined carbon dioxide and methane emissions represent a daily consumption of carbon of 2.7 g/m^2. Assuming that this rate only acts on the residual forest material it would take approximately 13 years for its carbon to be removed from the reservoir. This assumes no addition of allochthonous and autochthonous detrital material to the carbon pool. The inclusion of these two, un-quantified, sources will lengthen the time period until the carbon dioxide and methane emissions from the reservoir are due solely to these inputs.

References:

Birdsey, (1992)	Carbon Storage and Accumulation in United States Forest Ecosystems. United States Department of Agriculture Forest Service. General Technical Report W0-59. August 1992.
Hutchinson, (1957)	Hutchinson, G.E. A Treatise on Limnology, Volume 1, Geography, Physics, and Chemistry. Wiley. 1957.
Rosa et al., (2002)	Rosa, L.P., dos Santos, M.A., Matvienko, B. and Sikar, E. Hydroelectic Reservoirs and Global Warming. Rio 02 – World Climate & Energy Event, January 6-11, 2002
Tremblay *et al* (2005)	Tremblay A, Varfalvy L, Roehm C, Garneau M (Eds) Greenhouse Gas Emissions – Fluxes and Processes: Hydroelectric Reservoirs and Natural Environments. Springer, New York, Environmental Series
US EPA. (2004)	US EPA Global Warming Emissions. http://yosemite.epa.gov/OAR/globalwarming.nsf/contents/Emissions.html

Additional Information:

International Hydropower Association: Technical Note "Greenhouse Gas: Emissions from Reservoirs:

http://www.hydropower.org/DownLoads/Emissions%20from%20reservoirs.pdf

http://www.hydropower.org/DownLoads/Reservoir%20&%20Hydropower%20A3-4.pdf

Response of the Environment Committee of the IHA to IRN Report:

http://www.hydropower.org/DownLoads/GHG-Reply-IRN-2002-v10.pdf

E Hydrology

E.1 Pluviometric Stations in and around Bumbuna

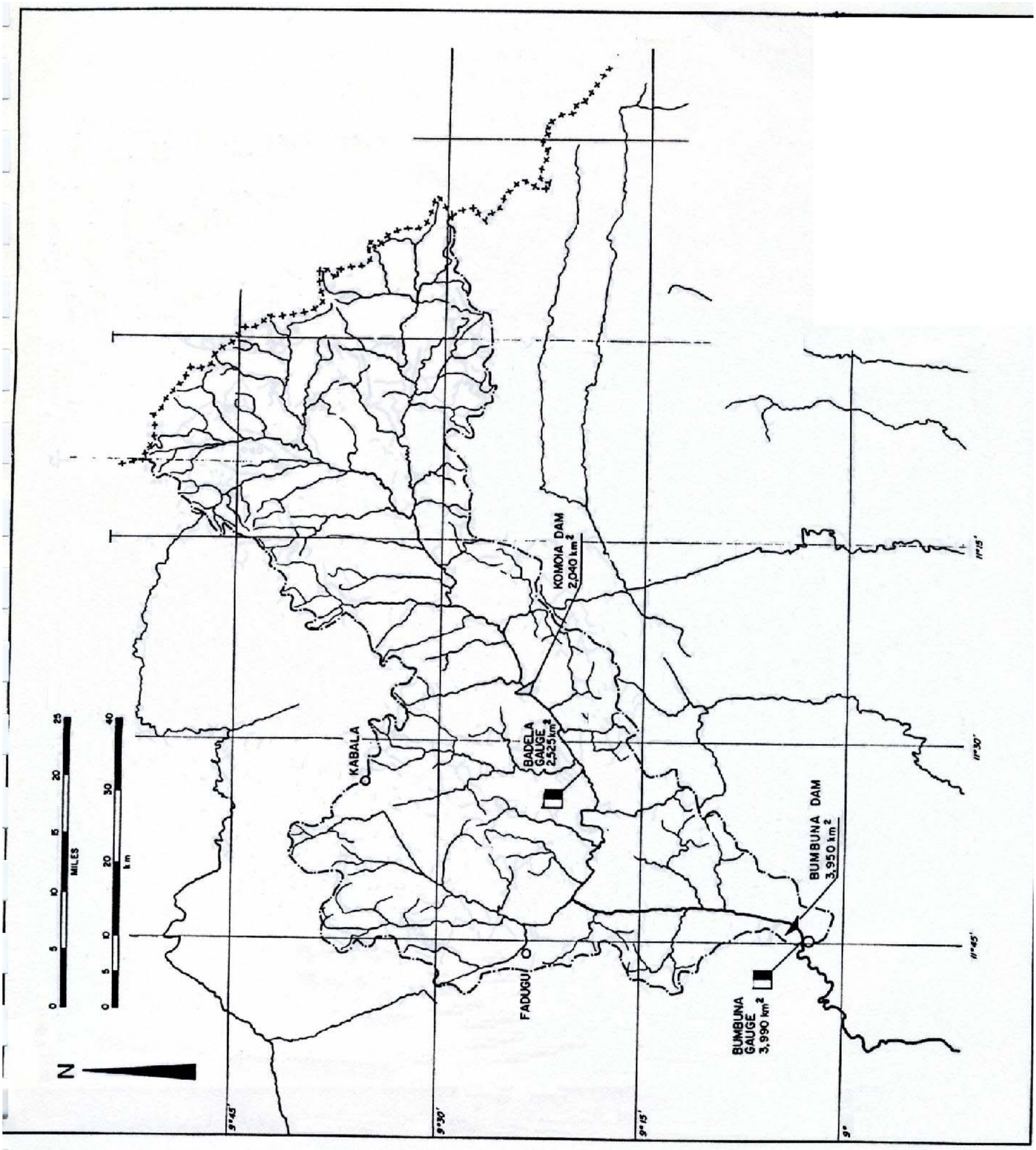
Station	Monthly Measurement	Daily Measurement	Mean Annual Precipitation (mm)
Kabala	1913-19, 1923-25, 1937-42, 1949-79	1951-79	2225
Bafodia	1954-56, 1959-64, 1973-75		*
Mongo Bendugu	1958-66, 1968-70	1958-66, 1968-70	2207
Gberia Timboko	1958-70, 1973		1862
Musaia	1948-1967, 1973-79	1948-67, 1973-79	1956
Bumbuna	1972-79	1972-79	2635
Makeni	1934-79	1936-37, 1939-42, 1944-78	3090
Teko	1954-78	1954-78	3024
Sumbaria	1947-77		2722
Farangbaia Tonkolili	1957-61		*

Source: Bumbuna Hydro-Consultants (1980)

E.2 Average Monthly Evaporation (mm): A-pan and Bumbuna Reservoir

Month	Bumbuna A-Pan	Reservoir Evaporation
January	169	135
February	176	141
March	218	174
April	181	145
May	154	123
June	135	108
July	99	79
August	82	66
September	92	74
October	111	89
November	129	103
December	148	118
Annual Total	1,694	1,355

E.3 Badela and Bumbuna Gauging Stations and Bumbuna Dam Catchment



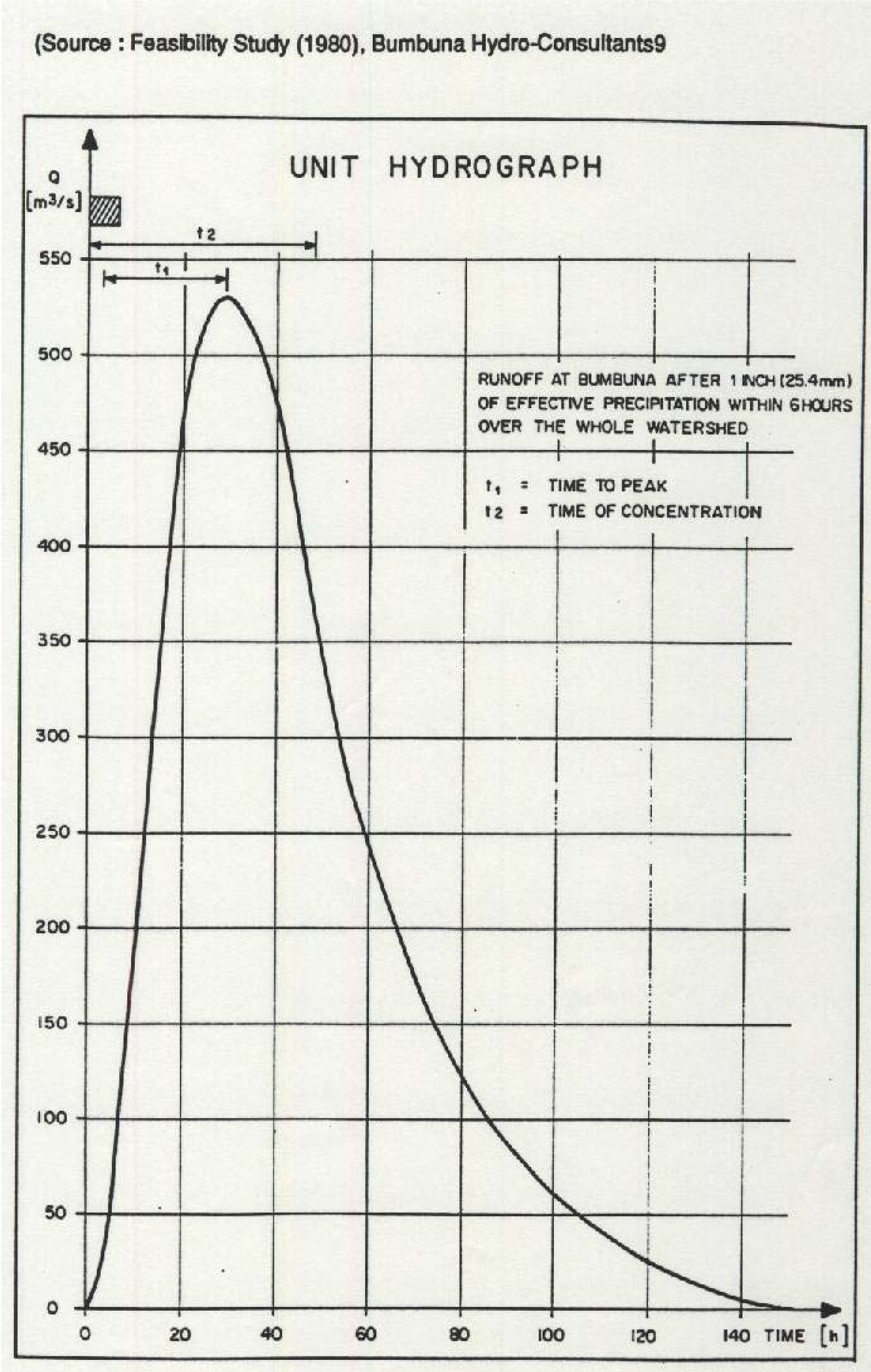
Source: Electrowatt/Techsult (1996)

E.4 Monthly Peak Flows at Bumbuna and Badela Gauges (1970-79)

	BUMBUNA												BADELA
	Jan.	Feb.	March	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Ann. Peak
1970						80.3	276	695	1,160	376	194	82.3	453
1971	39.4	18.2	11.5	58.0	31.4	193	577	493	399	401	255	125	239
1972	43.2	22.2	8.8	17.1	119.0	352	406	749	642	749	193	96.6	
1973	39.4	17.7	8.0	6.4	74.5	228	378	668	548	526	276	76.4	271
1974	35.7	17.1	11.0	12.5	27.4	116		540	499	971	195	67.9	503
1975	30.1	13.4	6.4	16.0	34.2	108	300	277	844	781	215	60.7	397
1976	28.7	15.0	6.0	41.6	79.3	352	311	289	546	735	468	105.0	335
1977	54.6	27.4			26.7	79.3	193	493	532	410	182	58.9	
1978	31.4	15.5	9.7	27.4	46.3	211	338	563	587	664	221	87.3	
1979	40.3	18.2	7.5	4.3			383	550	538				

Source: Bumbuna Hydro-Consultants (1980)

E.5 Unit Hydrograph for Bumbuna Catchment



F Geology and Mineral Resources

The following account of the Geology and Mineral Resources of the project area was presented in the Final Report of the 1996 EIA study (Electrowatt/Techsult 1996).

F.1 Methodology

Baseline information regarding the geology and mineral resources was obtained from following sources:

F.1.1 Data and Reports

An early appraisal of the geology and mineral resources of the Sula Mountains including the site of the Bumbuna dam and reservoir was made by Wilson and Marmo (1958).

Garrett and Nichol (1967) in a regional geochemical reconnaissance study in eastern Sierra Leone, recognized the occurrence of mineralization in the study area, including gold, nickel, molybdenite and chromite.

A survey of the geology and mineral resources of northern Sierra Leone which included the present project area was carried out by MacFarlance et al (1974).

Morel (1976) gives an overview of the mineral deposits in Sierra Leone, in his book, title, "Geology and Minerals of Sierra Leone".

In recent years, Wright et al (1985) published a book on the Geology and Mineral Resources of West Africa with a detailed review of the mineral occurrences in the subregion, including Sierra Leone.

Further relevant information on the geology and mineral resources of the project area, in the form of maps and reports were obtained from various government departments including the Geological Survey Department, the Department of Geology, Fourah Bay College and the Department of Geography, Fourah Bay College.

F.1.2 Field Surveys

A reconnaissance field trip was carried out in April, 1994. Visits were made to the dam site and the villages in the reservoir area, including Kasasi in the Kalansogoia Chiefdom and Kafogo and Fula Town in the Kasunka Chiefdom.

Actual field work started in May, 1994, before the start of the wet season, when the river water level was still low. Footpaths provided access to the very steep and hilly landscape of the reservoir area, mostly ending at settlements, although sometimes extending to streams and farmlands.

The left bank of the Seli River between Yiben and Bumbuna dam site is less accessible, being much steeper and more hilly than the right bank.

The geology of the project area is available on a map scale of 1:50,000, which was produced for the feasibility study. Basically only confirmation of the information on the map was required with regard to slope stability and potential mineral occurrence and only some minor corrections were made.

Rock samples were collected from various localities near the dam site and the reservoir area. The samples were labelled according to locality and then taken to the petrological laboratory, department of Geology, Fourah Bay College, for thin-section preparation.

Gold panning operations were observed along the entire stretch of the reservoir, especially the areas around Kasasi and Ketene. Interviews were conducted with the miners about their operations. Auriferous gravels were obtained near Kasasi.

F.1.3 Sample Analysis

Rock thin-sections were analysed using a petrologic microscope. Auriferous gravel was also analysed for gold, but there were no indications. The results of the rock analysis are presented in the following sections.

Having identified the samples and the necessary adjustments made, the existing maps were then updated to incorporate the additional information.

F.2 Geology of the Project Area

An updated geological map of the project area is presented in Figure F2.1-1. A summary of the geo-stratigraphic succession of the formations in the area is provided in Table F.2.3-1. The Bumbuna dam site lies on the western edge of a Precambrian curvilinear greenstone belt locally referred to as the Sula Group, which is surrounded by basement granitoids and late kinematic granites. Residues of weathered granite, i.e. laterites, overlie most of the Precambrian rock formations. These were developed during the various orogenic movements (uplifting and warping) of the West African Craton since the Paleozoicum.

F.2.1 Synkynematic "Basement" Granites

The rocks forming the basement are granitoids or granite - like rocks ranging in composition from quartz - diorite to true granites, with granodiorites predominating. The granites are mainly porphyroblastic and are found in association with migmatitic gneisses of similar composition of quartz, feldspar, biotite, muscovite and hornblende. Modal percentages of some granitoids found near the dam site are given in Table F.2.3-2.

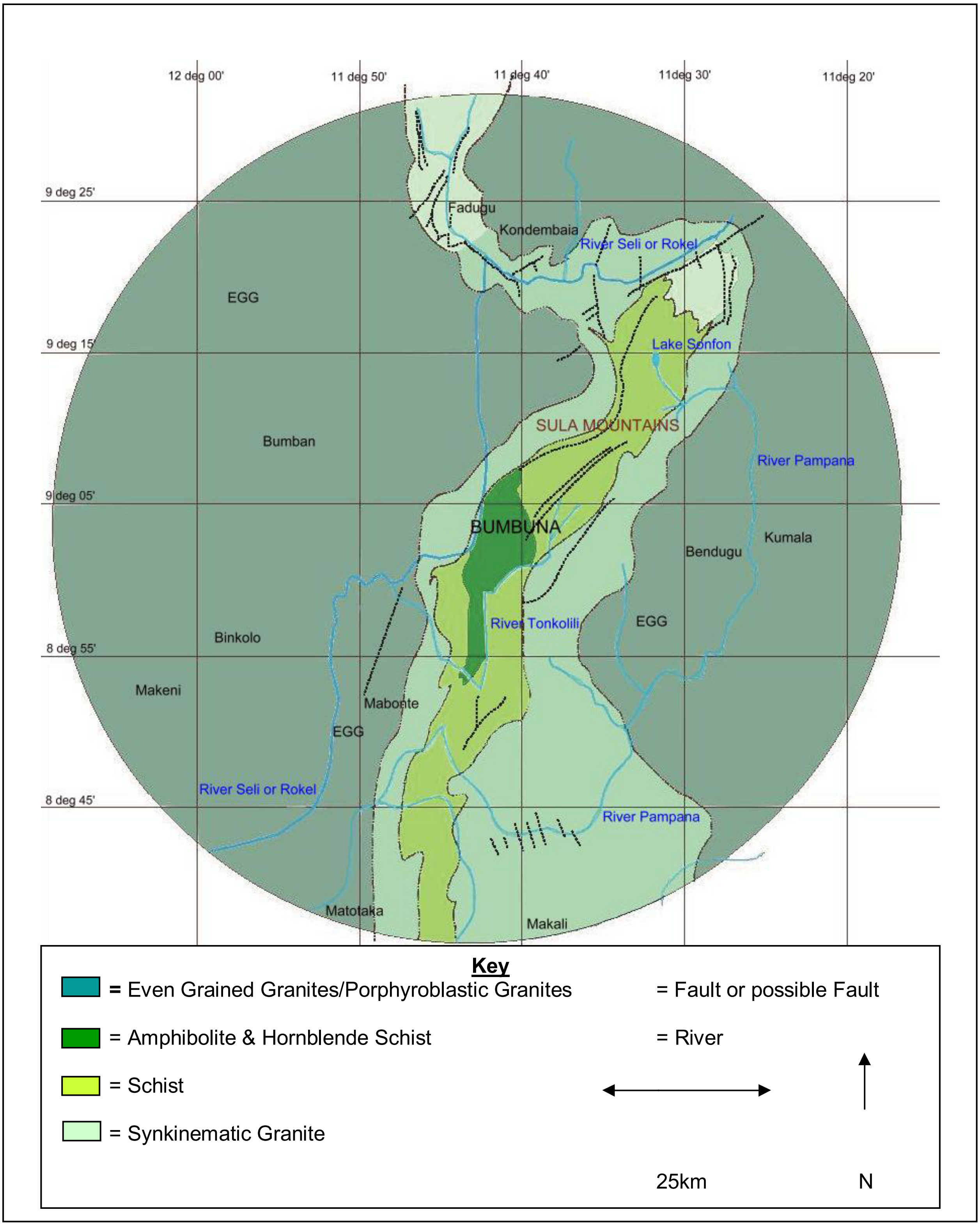


Figure F2.1-1Geological Map of the Study Area

Adapted from: Electrowatt/Techsult (1996)

Occupying synclinorial structures within the basement are supracrustal belts with typical greenstone lithologies. In the study area the Sula Group supracrustal form the Sula

Mountains and are tightly folded with a general subvertical dip in a western or northwestern direction. The Sula Group was metamorphosed mainly to the greenschist and epidote - amphibolite facies. The schist belt of the Sula Group can be traced southwards into the Kangari Hills , see Figure F2.1-1.

F.2.2 Greenstone Supercrustal

Macfarlane et al. (1974) subdivided the group into a lower Sonfon Formation and an upper Tonkolili Formation. The Sonfon Formation consists predominantly of amphibolites of varying grain sizes and compositions, and are either massive or finely foliated. Within the amphibolite sequence, we find thin layers of pyrite-bearing talc schists, talc-chlorite schists, quartzites and cummingtonite schists. The Tonkolili Formation is dominantly composed of clastic sediments within thin layers of siliceous and tuffaceous metavolcanics. The lithology is mainly greywacke turbidites, quartzites, cordierite-garnet schists and mica schists.

F.2.3 Late Kinematic Granites

The term "Late Kinematic" or younger granites refers to granites that are demonstrably younger than the greenstone supracrustals. These are common around the margins of the greenstone belt and range in size from large masses having gradational contacts with the basement, through smaller cross-cutting stocks and plutons, down to pegmatite's, aplites, quartz veins and graphic granites.

Within small bodies adjacent to amphibolite lenses, there is a wide variety in composition. Hybridization with basic material gives rise to hornblende syenites, diorites and granites.

Table F.2.3-1:Stratigraphy in the Bumbuna Area and its Immediate Surrounding

System	Series	Group	Formation	Lithology	Age (yr.)
Quaternary	Holocene	-	Recent deposits	Alluvium	0-10x10^3
Archaean	-	-	Late kinematic granite	Granitic Pegmatites, Aplites, graphic Granite	
		Sula	Tonkolili	Greywacke Turbidites, Pelites, Conglomerates	~ 2700x10^6
			Sonfon	Amphibolites, ultramafics	
	-	-	Synkinematic granite	Quartz diorite, Granodiorite, Migmatitic Gneisses	>2700 (x10^6)

Table F.2.3-2: Analysis of Granite Samples from the Project Area

Sample I.D.	Quartz %	Orthocl. %	Microcl. %	Plagiocl. %	Biotite %	Hornblende %	Acc. %
BG-1	10	20	60	-	5	-	5
MG-2	5	50	10	-	30	-	5
SG-3A	-	60	-	15	15	5	5
PG-3b	10	50	-	-	30	-	10

F.2.4 Tectonics

Both the basement granitoids and the Sula Group supracrustals have been affected by two major thermotectonic episodes. An earlier, Leonean deformation (~ 2900 million years ago), which left an east-west foliation trend with metamorphism up to the amphibolite facies. Only small remnants of Leonean structures occur today and are restricted to the Loko Group, with small patches of outcrop in the Loko Hills near Kamakwi. Most of the rocks in the project area bear imprints of the later, Liberian thermotectonic episode (~ 2700 million years ago). The Liberian event left a north-south to north-east - south-western oriented fabric on both the granitoids and the greenstone supracrustals.

Faults occurring along the course of Seli River to the west of the schist belt transgress the margins of the schist belt into the surrounding granites and probably resolved stresses built up due to the deformation of the schist belt. Faults with north-south trends are interpreted as a late stage phase of this Precambrian period of deformation. Cretaceous Kimberlite dikes and dolerites subsequently intruded along the pre-existing fractures during the following periods of regional deformation.

F.3 Geology of the Dam Site

The right embankment of the Seli River in the vicinity of the dam site consists of granite and granodiorite, the left embankment of amphibolites. The contact between the granites and the amphibolites is formed by a fault with an almost north-south trend, following the course of the Seli River to the west of the Sula Group (Wilson and Marmo, 1958). Between Bumbuna and Kagbema, the granites and granodiorites consist predominantly of quartz-diorites and diorites surrounding an elliptical mass of late kinematic granite, with outcrops of amphibolite along the edges and at the centre, see Figure F.2.1-1.

F.4 Recent Deposits

Loose, unconsolidated surface material in the area consists generally of up to 10 to 15 m thick insitu weathered rock sequences or alluvial deposits. Where the substratum is of amphibolite the weathered surface can become significantly deeper (up to 20 m).

The lateritic profile is not well developed, due most certainly to the steep inclination of the mountainous slopes. It is found mainly in the flatter areas such as Kamange, Kamato and Kasukra, where fragmented hardpan, of gravely and ferruginous nature occurs. Laterite formation is favoured by low relief, poor drainage, a warm climate with an alternating wet and dry seasons, and a fluctuating water table near the surface, which enables the insoluble ferric oxides to be precipitated in the zone of aeration. Laterites are formed through concentration of iron and aluminium oxides in the soil profile resulting from the heavy leaching of other minerals, such as silica, and the deposition of iron and aluminium from groundwater.

Alluvial deposits, virtually absent in the mountainous stretch of the Seli River, occur abundantly in the Bumbuna valley and downstream thereof. Where the river becomes more braided, alluvial islands and banks of gravel and sand occur. Erosion is the dominant geological process taking place in the entire stretch of the river under consideration and the Seli River itself has cut several meters into the existing alluvial deposits in the Bumbuna valley.

F.5 Mineral Resources

The mineral resources map presented in Figure F.5-1 shows the distribution of economic mineral deposits in the project area. Known mineral deposits occurring in the catchment, reservoir and potential resettlement areas include gold, nickel, iron ore, molybdenite, asbestos and talc, see Table F.5-1.

Table F.5-1: Mineral Deposits Occurring in the Project Area

Mineral	Occurrence	Reserve Estimate (Mio tonnes)
Gold	Quartz veins in amphibolites and granites	Not Known
Iron Ore	Banded iron formation	ca. 100
Molybdenite	Late kinematic granites	Not Known
Nickel	Laterites derived from ultramafic rocks	Not Known
Asbestos	Serpentinite	Not Known
Talc	Talc schist	Not Known
Construction Stone	Homogeneous granite	>1000

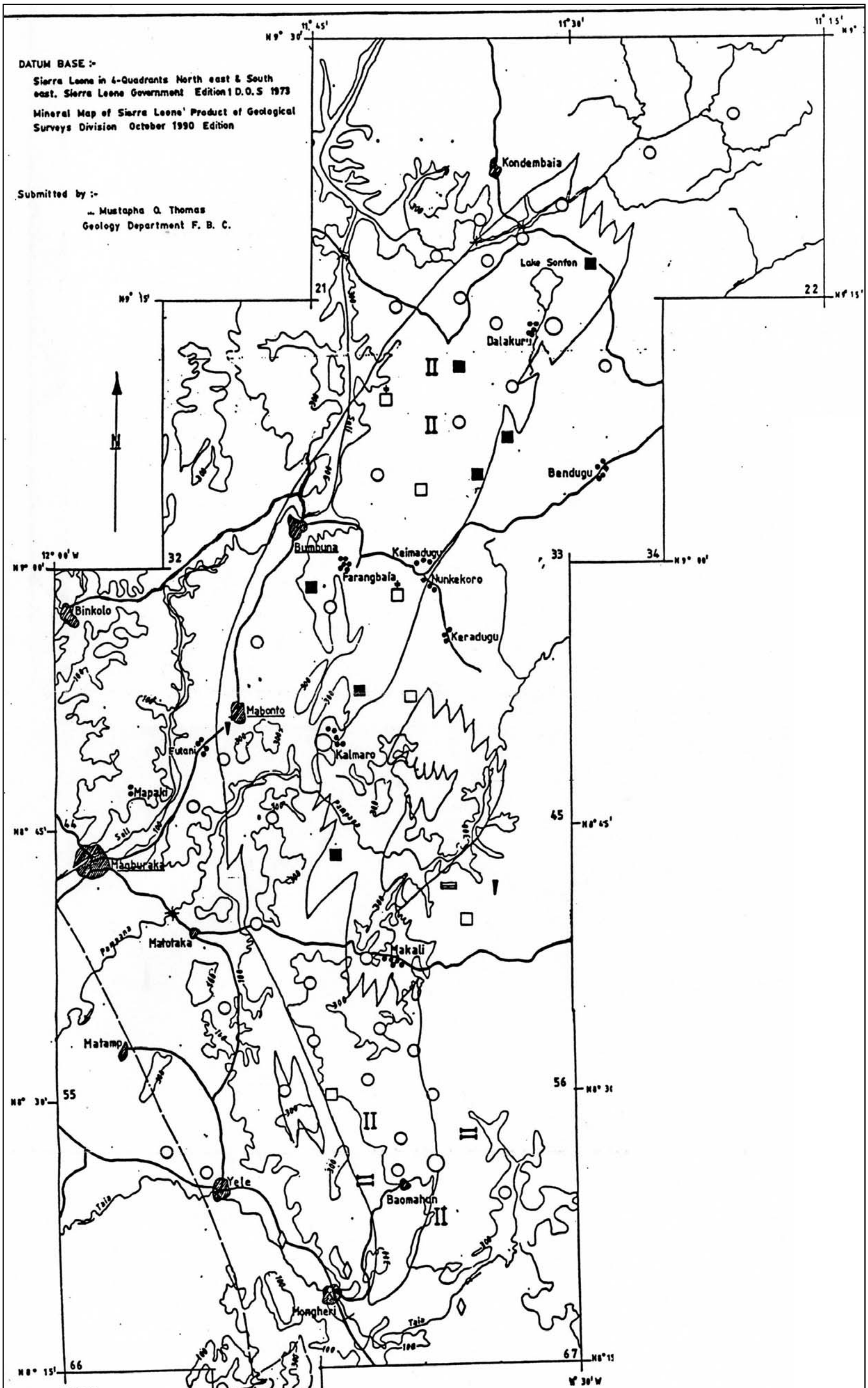


Figure F.5-1: **Distribution of Economic Mineral Deposits in the Project Area**
Source: Electrowatt/Techsult (1996)

F.5.1 Gold

Gold occurs in the upper catchment area of the Seli River and downstream of the dam for about 10 km. Some 340,000 oz. (ca. 10,000 kg) were mined between 1930 and 1956, mainly from alluvial workings in and around the green-stone belt in the Sula Mountains and Kangari Hills (Wright et al., 1985). Alluvial mining is still carried out by small groups of miners panning river gravels, but the major commercial interest has shifted to primary sources, which have been found by tracing the alluvial deposits back to their source. Gold-quartz veins, sometimes with pyrite and arsenopyrite or tourmaline, occur in the amphibolites and ferruginous schists. Some of these have been explored by drilling programs, notably at Baomahun in the southern Kangari Hills, see Figure F.5-1. Favourable grades in the range of about 10-30 ppm gold have been found. In the reservoir area only small quantities of alluvial gold are presently mined as a second (supplementary) source of income. From an economical point of view these volumes are, however, negligible.

F.5.2 Iron Ore

Iron ore occurs in banded iron formation found in the Kangari Hills - Sula Mountain greenstone belt near Tonkolili. Here, the banded iron formation rocks are interbedded with amphibolites and there has been considerable secondary enrichment by lateritisation processes throughout most of the Tertiary. Reserves are estimated to be of the order of 100 million tonnes, at grades of over 55% Fe (Wright et al., 1985). Despite extensive investigation of these deposits between 1930 and 1960, they have not been exploited, partly because of the distance from suitable port facilities and lacking infrastructure.

F.5.3 Molybdenite

Molybdenite is found in late kinematic granites around Dalakuru. Reserves are not known with any certainty. In the northern Sula Mountains though, there is an extensive zone with molybdenite contents in the range 1.5 - 3 ppm, generally coincident with the development of duricrust but extending on to adjacent areas of non-duricrusted schists, Synkinematic and Late Kinematic granites (Garrett and Nichol, 1967). Within this area of high regional background, two linear zones with values in excess of the threshold value of 3 ppm extend away from the known mineralization at Dalakuru with peak concentrations reaching 30 ppm. Molybdenum mineralization occurs in pegmatites adjacent to intrusive granite or as disseminations in granite. Stream sediment sampling indicates that molybdenite commonly occurs below or close to the detection limit of 1.5

ppm (Garrett and Nichol, 1967). Areas containing > 1.5 ppm are mostly confined to the schist belt proper.

F.5.4 Nickel, Asbestos, Talc

Nickel, asbestos and talc are associated with ultramafic rocks, but no worthwhile deposits have so far been found. Lateritisation of ultramafic rocks can result in secondary nickel enrichment and thick laterites in the northern Sula Mountains might have some potential. The asbestos minerals chrysotile and anthophyllite are wide spread among the serpentinites of the greenstone belts, sometimes accompanied by talc, and some occurrences may prove to be of economic interest.

F.5.5 Other Minerals

There may be some potential for uranium occurrences in the vicinity of granites, especially where they intersect the greenstone belts. Uranium exploration though, has begun in both Liberia and Guinea. The potential for extraction of relatively low-value resources from the rocks is fairly good. Most obvious is crushed rock for aggregate and fill, from fresh homogeneous granites as in the case of the Bumbuna Dam construction. Also, pure grades of quartzite and pegmatite-feldspar could be found and exploited for glass and ceramic manufacture.

G Induced Seismicity

G.1 Methodology

The 1996 EIA appraised the seismicity of the West African subregion and evaluated the frequency of earthquakes in the area to assess the probability of induced seismicity following reservoir impoundment. The following account was included in the Final EIA report (Electrowatt/Techsult 1996).

Information on seismicity in the area were obtained from:

- Acquisition of relevant information on the geology and tectonic setting of Sierra Leone and the West African subregion. These are contained in maps and reports.
- A global seismicity map showing the locations of epicentres. The position of Sierra Leone on the map was delineated to show whether the area falls within the globally recognized seismic zones.
- A record of induced seismicity of some dams constructed up to 1972 was compiled and presented in order to determine whether any meaningful correlation exists between dam height, storage capacity and seismicity for this project.
- From the feasibility study (Bumbuna Hydro-Consultants 1980) which gives a detailed assessment of the seismo-tectonics, seismicity and potential induced seismicity in the project area.

Unfortunately no seismograph has been installed near the dam site which would have recorded all seismic activity in the area, thus providing a source of first hand information to be used in the study.

G.2 Seismic Events

Seismological studies in Sierra Leone are not well established, probably because the country does not lie along the globally recognized earthquake belts. Between 1947 and 1978, only five felt events have been reported and there is only one credible epicentre quoted by the International Seismological Centre (ISC), however, with an unquoted magnitude.

An assessment of the present seismicity for the project area was made during the feasibility study (Bumbuna Hydro-Consultants 1980), which involved the palaeo-tectonic appraisal of West Africa, the structural geology of the area, seismicity and seismotectonic relationships, induced seismicity and vibratory ground motion. Its main findings were:

Of the five felt events reported between 1947 and 1978 none were recorded by the seismological station in Senegal. It is therefore unlikely that the intensity could have exceeded IV to V on the Modified Mercalli scale. The present level of seismic detection in the region is probably below M 4.5 to 5, since events of greater magnitude would have been recorded by the International Seismological Center.

Previous assessments of seismicity (Krenkal, 1923, and Sykes, 1968) place Sierra Leone in one of the lowest seismic zones of Africa.

Recent advances in the field have established a strong link between seismicity and tectonics. Seismic activity is not randomly distributed but confined to well-defined zones called earthquake belts. These are viewed in the broader context of sea-floor spreading and plate tectonics. For the most part, the major earthquake belts lie along island arcs and continental margins and represent areas where large rigid plates of the Earth's crust plunge downward.

Most of the recorded earthquakes are concentrated in two main belts. This is borne out globally by the world map of epicentres, which shows that the circum pacific and Alpine - Himalayan compression features correspond to broad epicentre belts including large magnitude events and that the ocean ridge system corresponds to a narrower belt of smaller magnitude events.

It is clear also, from the map, that the Bumbuna Dam does not lie within the globally recognized seismically active zones, such as the continental plate boundaries and rift zone. Sierra Leone as a whole lies within the West African Craton, where intraplate seismic disturbances are rare. Recent events in the West African subregion, however, such as earth tremors in Nigeria, volcanic eruptions in Cameroon, earthquakes in Ghana and Guinea, all lead to the suspicion that they may be closely linked to neo-tectonism (Ananaba, 1991).

Field mapping and satellite imagery indicate that the dam site at Bumbuna lies within a valley containing an old Precambrian fault, but there is no evidence of recent movement on any of the faults within the Craton since the Cretaceous period, some 65 million years ago. It is however, recognized that rare and potentially damaging earthquakes may occur by a reactivation of preexisting lines of crustal weakness within plates, particularly continental ones.

Two transform faults have been identified offshore from geophysical investigations. West of Conakry, the sharp change in direction of the continental shelf has been associated with the Guinea Fracture Zone. The Sierra Leone Fracture Zone occurs further south and has been interpreted as forming the estuary of the Sewa River. It has been suggested (Williams and Williams, 1977; Culver and Williams, 1979) that the Guinea Fracture Zone and the Sierra Leone Fracture Zone extend inland into Sierra Leone and Guinea and follow the ENE - WSW trend of the Kimberlite dikes.

Although seismicity could be associated with the Guinea and Sierra Leone fracture zones, it is worth noting that these transform faults are not normally linked to current seismicity except over a restricted length near the Mid-Atlantic Rift.

Williams and Williams (1977) postulate that the Sierra Leone Fracture Zone extends 150 km inland by inference from the course of the estuary and the alignment of the Sewa River.

Subsidence of the coastal margin had resulted in a series of fault - controlled basins which may still be active at present. The very slight seismicity recorded in the coastal regions may have been due to movements along the existing fault planes. As the Bumbuna Dam is about 150 km from the coast it would not be significantly affected by seismic disturbances occurring on the coastal fringe.

There is only one credible epicentre quoted by the International Seismological Centre (ISC) which event occurred on 4th January 1957, located in the Atlantic at 0.74^0N, 17.52^0W, however, with an unquoted magnitude.

Finally, as to the geotectonic situation in the project area itself, no recent fault was located at the site by geological investigations. The last deformation phase involving crustal rupturing was the possible Cretaceous intrusion of the Kimberlites which were emplaced along ENE-WSW trending faults.

H Soil, Land Use and Agriculture

H.1 Methodology

The Original EIA (Electrowatt/Techsult 1996) conducted an extensive review and assessment of the agriculture, soils and land use of the watershed. Further studies and surveys were conducted in 2004 by Nippon Koei UK, which included:

- Information from post-civil war programmes, Government and NGOs;
- Interviews with farmers, traders and Chiefs;
- Ecological field studies in August and September 2004.

Key documents included:

- Provisional Land Cover Map, Sierra Leone, 2004. Centre for Ecology and Hydrology (CEH), UK and the University of Sierra Leone, Fourah College.
- Agriculture Data Pack: 2nd Data Collection Exercise. Data processing by the Sierra Leone Information Systems. Technical Committee of the National Recovery Committee, October 2003
- 2002 Crop Survey Report. Ministry of Agriculture, Forestry and Food Security & FAO, March 2003
- Chiefdom Vulnerability Assessment, FAO, 2002
- Original EIA of the Bumbuna Hydroelectric Plant, Electrowatt, 1996
- Study on Watershed Degradation in Sierra Leone, Environmental and Scientific Consulting Group (ESCG). National Aid Coordinating Secretariat, May, 1988

H.1.1 Existing Studies and Previous Investigations

Since the original EIA, there have been no specific studies on agriculture and land use in the Bumbuna watershed. This is largely as a result of the civil war. Recent information is available on agricultural production at Chiefdam and District level.

In 1976/77, the Land and Water Development Division (formerly, the Land Resources Survey Project) of the Department of Agriculture, described the soils, vegetation, land use and agriculture of the area and prepared land suitability evaluation of various land forms for eight selected crops: cashew, cassava, maize, upland rice, paddy rice, groundnuts, citrus and coconuts.

In 1987 the Environmental Scientific Consulting Group (ESCG) was commissioned to proceed with a countrywide watershed degradation survey. The study identified the following causes of vegetation and land degradation in the Seli River watershed:

- Deforestation.
- Bush fires.
- Extension of agriculture on hill slopes which are marginal lands.
- Mining activities.
- Population pressure.
- Lack of adequate environmental awareness.
- Lack of education.
- Lack of a comprehensive land use policy.

The feasibility study (Bumbuna Hydro-Consultants 1980) took into consideration some environmental aspects related to agriculture, soils and land suitability for the staged development of the Bumbuna and Yiben reservoir. However, 15 years have passed since and the current project has deviated considerably from the original proposition.

H.1.2 Completion of Relevant Soil Data

The original EIA undertook an extensive soil assessment study, which remains valid.

The land form map of the immediate catchment area (scale 1:50,000) derived from interpretation of infra-red false colour photographs (1:70,000) of 1975/76, was used as a base map for soil surveys in the field.

Soil observations were done on various land forms or physiographic units occurring within the project area. Observations were carried out along motor roads, footpaths, road cuts and during the various traverses.

At each observation point, the soil was augered, and detailed description took place (horizon, depth, drainage class, depth to water table, soil colour texture, consistence, pH, parent material and geology). Surface conditions, as far as visible (e.g. rock outcrops, surface sealing, surface gravel, erosion, flooding etc.) were also investigated. All observations were recorded on specially designed field data sheets. Composite sampling was done on each physiographic unit from five randomly selected sites, i.e. five sites on each unit. All samples taken at 0-20 cm depth at the five sites were mixed to form one composite sample. A similar process was done for the 20-50 cm depths.

Soil samples for chemical and physical analyses were collected from the top and upper sub-soils at two depths 0-20 cm, and 20-50 cm from representative physiographic units. Slope measurements were done at each site, using first the abney level, and later the clinometer. The soil samples were analysed in the LWDD analytical laboratory.

H.1.3 Actualisation of Vegetation-cover and Land Use

Vegetation and land use studies of the immediate catchment area have been carried out by comparing the findings of the 1975/76, infra-red false colour photographs (scale 1:70,000) with the present situation on selected spots. Particular attention has been given to the present vegetation and land use patterns, vegetation types, cultivated areas, grazing areas, built up areas, road network etc. Boundaries were compared and adjusted to give a comprehensive picture of the present situation. Following such investigations, reconnaissance studies of soils, vegetation and present land use were conducted in the larger catchment area as far as Kondembaia in the northwest.

In addition to personal observations, discussions and interviews were held with extension workers, paramount chiefs, chiefdom elders, farmers and ordinary citizens. The informations collected were recorded directly on to the updated land use and vegetation map.

H.1.4 Present Agriculture

The present study investigated current agricultural systems in 2004, with the aim of assessing land use systems in the watershed to inform land management. Current agricultural practices were investigated through field observations and interviews, and centred on land preparation, methods of cultivation, duration of fallow period, crop diversity, yields and husbandry, and farm management. Issues of demand and supply at national, district and local level were also investigated as well as overall farming practices.

H.1.5 Land Degradation

The original EIA and the additional surveys in 2004 assessed the extent of, and potential for, land degradation within the immediate catchment by observing:

- Deforestation and earth moving activities around the dam site, the reservoir area, and the catchment.
- Farming practices within the catchment with special emphasis put on the steep slopes, which are being extensively cultivated.
- Mining activities along the banks of the Seli River and its tributaries.

Erosion and sedimentation hazards were assessed taking into consideration slope steepness, vegetation cover, cultivation practices etc.

H.2 Soils and Related Physiographic Units

Soil characteristics are closely related to the geomorphology units within the immediate catchment area as reflected in the description of the following five physiographic units (see Figure H.5.3-1)

(i) Soils on Hill Crests and Ridges

- Generally, shallow with depths of 30-50 cm to bedrock.
- Moderate deep to deep soils occur in places.
- Light textured soils: gravely sandy loams, gravely sandy clay loams and gravely sandy clays.
- Surfaces generally rocky and bouldery.
- Well drained, with dark brown top-soil overlying reddish and reddish brown subsoils.
- Acidic, pH 5.0-5.3, generally low in fertility and unsuitable for any form of agriculture.
- Highly porous with bulk density of 1.40.

(ii) Soils on the Hill Slopes (3 subunits depending on slope)

Steep Hill Slopes

- Generally shallow with varying depths 0-5cm, 0-30cm, 0-50cm to bedrock; deep soils occur in places.
- Surface usually dominated by rock outcrops and gravel.
- Light textured soils; loams, gravely loams, sandy clay loam topsoils over gravely sandy clays and clay loams.
- Well drained soils with dark brown, and dark yellowish brown top soils over dark red and reddish brown subsoils.
- Strongly acid, pH 4.7-5.1.
- Apart from the forest regrowth areas, such steep slopes are currently cultivated with rice, groundnuts or cassava.

Moderately Steep Slopes

- Shallow to moderate deep (80-100 cm), locally deep (120 cm)
- Gravely sandy loam or gravely clay loam over gravely sandy clay loam, or gravely sandy clay, with rocks and boulder outcrops
- Well drained, with very dark greyish brown topsoils over dark yellowish brown subsoils
- Strongly acid, pH 4.7-5.1
- Silts are generally low in fertility as they are extensively cultivated. They are presently used for the cultivation of subsistence crops such as rice, groundnuts, maize, cassava.

Irregular Hill Slopes (Undulating Plains and Interfluent minor flood plains)

- These land forms are more common in the dissected low-relief areas in the north-east and east of the Seli river, e.g. Kondembaia area.
- Shallow to moderately deep soils, soil depth being limited by gravel.
- Coarse sandy clay-loam topsoils on gravely sandy clays.
- Porous, well drained dark yellowish brown topsoils over yellowish brown subsoils with bulk density of 1.55 g/cm3.
- Strongly acid soils, pH 4.8.
- Soil fertility is generally low, and such soils are presently extensively used for grazing.

(iii) Soils of the Footslopes

- Shallow to moderately deep.
- Generally very gravely soils, with gravel contents exceeding 50% in some places.
- Generally light to medium textured; sandy loam, gravely-sandy loams, sandy clays, or gravely-sandy clay subsoils.
- Porous, well drained with dark greyish-brown surface soils over brownish yellow or yellowish brown subsoils with a bulk density of 1.40-1.45 g/cm3.
- Soils are strongly acid, pH 4-5, with medium organic matter content.
- The footslopes are presently used for arable crops, but are also potentially suitable for tree crops.

Soils of the Inland Valley Swamps

- Deep to very deep, alluvial and colluvial soils.
- Sandy loam to sandy-clayey loam top soil, overlying clayey loams, sandy-clayey loam or loamy sand subsoils.
- Poorly to very poorly drained and water logged during the rainy season with greyish, brownish or reddish mottles.
- Swamp soils are generally strongly to moderately acid, with pH 4.5-5.5.
- Suitable for paddy rice during the rainy season and for vegetables and tuber crops such as cassava, sweet potatoes and yam in the dry season.

Soils of the Minor Flood Plains

- Generally deep to very deep (90-150 cm), gravel free, locally gravelly in the subsoil.
- Loam and silty clay loam surface soils overlying silty clay, loamy sands or loamy clay subsoils.
- Soil structure porous and moderately to highly resistant.
- Well to moderately drained with matrix colours of black overlying yellowish brown and reddish and reddish brown mottles.
- Acid to strongly acid soils with pH 4.5 - 5.5.
- Flood plain soils are moderately fertile; they are extensively used for rice cultivation, bananas, potatoes, and cassava.

H.3 Soil Fertility

Chemical and physical properties of the soils which affect the fertility can be summarized as follows:

Soils on all physiographic units are acidic to strongly acidic with the highest and lowest pH values being 5.4 and 4.6 respectively. This reflects the general trend in the country where the soils are subject to intensive rainfall causing pronounced leaching.

Organic matter (OM) content ranges from medium to very high. The highest OM values of 6.52% (0-20 cm depth) and 6.15% (20-50 cm depth) occur in the inland valley swamps. The high OM contents can be attributed partly to the comparatively long fallow periods that are still being maintained in the project area.

The C/N ratio is generally high on all the land facets indicating high carbon content but extremely low nitrogen content. This is a further indication of low soil fertility.

Due to the high OM contents, Cation Exchange Capacity (CEC) values show medium to high values in the top soils and low to medium in the subsoils.

Based on the chemical characteristics, it can be concluded that the soils in the area have low to very low fertility. This is due to low available P contents (<4 ppm on the hill crests and 3 ppm on all other land facets), very low total nitrogen (< 0.2%), low exchangeable bases and low base saturation values (30%).

H.4 Land Suitability

The land suitability evaluation techniques adopted for this study correspond with those proposed in the FAO Soils Bulletin No. 52 "Guidelines: Land Evaluation for Rainfed Agriculture".

The current assessment is meant to establish the potential suitability of the identified land units under improved traditional management, which will be characterised by the use of some production inputs, such as limited amount of fertilisers, few agro-chemicals and credit. The assessment takes following assumptions into account:

- improvement of cultural practices i.e. farming techniques which will increase the efficiency of the labour input;
- provision for technical advice will be made available;
- marketing facilities will be improved and substantial reduction of the on-farm and post-harvest losses will be realised; and
- the level of total farm output can be raised above subsistence level.

H.4.1 Criteria Adopted

The adopted land suitability orders and the considered limitation factors identified are presented hereafter. See also Figure H.5.3-2, land suitability map.

Land Suitability Orders:

S-1: Very suitable, i.e. land units with no or only slight limitations (up to 3); land index generally > 75.

S-2: Moderately suitable, i.e. land with slight or not more than 3 moderate limitations; land index generally situated between 50-70.

S-3: Marginally suitable, i.e. lands with more than 2-3 moderate, or more than 1 severe limitation, however, none of the limitations excludes agricultural land use; land index is generally between 25-50.

N: Land not suitable for agricultural land use; lands with at least one severe limitation that excludes it from sustainable or economical agricultural use; land index normally less than 25.

Current Limitations:

r: Limited soil depth. Root development is hampered, due to gravely or gravely/stony characteristics of the soil, mainly in the B-horizon. This limitation occurs mainly on steep and moderately steep slopes, on footslopes and partly on the gently undulating uplands within the mixed tree-savanna.

y: Limited productivity due to outcropping rocks and boulders, covering 25% of the area or more.

e: Limited resistance to erosion, mainly steep and moderately steep slopes.

m: Shallow soils of coarse texture within all horizons. This limitation becomes effective generally towards the peak and the end of the dry season.

o: Limited drainage and thus lack of oxygen in the root zone. Soils characterised by this limitation are generally used for growing swamp paddy.

H.4.2 Special Note Regarding Soil Fertility

Soil acidity and nutrient status are the two main factors used to determine the fertility of the soils in Sierra Leone. A close study of the analytical data shows that the soils are generally acidic to strongly acidic (pH 4.5 - 5.5), with high C/N ratios which indicate low nitrogen levels. The high carbon content in the surface horizons can be attributed to the accumulations of decomposing leaf litter and other organic material.

It must be noted however, that the use of soil fertility as a land quality in the evaluation of land suitability for agriculture in Sierra Leone should be done with caution. The soils, particularly those on the uplands, have inherent infertility due to high acidity and low nutrient levels. A very dogmatic use of soil fertility as a parameter for land-suitability, would have classified all presently arable lands as not suitable (N) for cultivation. Farmers are quite aware of the situation and are always searching for ways and means of improving the fertility of their lands. Also it was observed that farmers have specific knowledge regarding indicator plants among the regrowth flora and they are perfectly in the position to relate them to the expected soil fertility.

H.4.3 Special Note Regarding Erosion Hazard

Surface stones and rocks (**y**) and slope steepness, would seem prohibitive for cultivation of almost all the crops considered. These limiting factors can be remedied, however, by physical and vegetal conservation measures such as terracing, contour ploughing, agro-forestry and alley-cropping.

Once the above measures are taken and assuming minor inputs of fertilisers and other chemicals, combined with timely land husbandry practices under improved traditional management, even S-3 type lands can bring about the needed increases in yields. It would be unrealistic to exempt such lands from further cultivation.

H.5 Vegetation, Land Use and Agriculture

H.5.1 Present Land Use

The present land cover of the Bumbuna watershed is dominated by vegetation cover consisting of a forest savanna mosaic, having a mixture of zones reflecting rainfall, altitudinal, hydrological, topographic and land use variations. This is in reflection of the land cover for the country and the northern province, as shown in the Provisional Land Cover Map for Sierra Leone (Figure H.5.1-1).

Within the Bumbuna Dam watershed, the forest savanna mosaic consists of the following (see Table H.5.1-1):

- Forest thicket and regrowth (r).
- Mixed tree savanna (sm).
- Fringing forests (ff).
- Closed moist forest (fm)
- Secondary closed forest, also described as gallery forests (sf).
- Upland grasslands (sg).
- Swamp thickets and grasses (i).
- Cultivated land (c)

The dominant groups are the forest thicket and regrowth (r) and the mixed tree savannahs (sm). The forest thicket and regrowth covers the dam site and the area 10-12 km upstream, including the steep hills bordering the V-shaped gorge, which will contain the reservoir. The mixed tree savanna dominates the northern half of the immediate catchment area, which stretches to the northwest as far as Fadugu and beyond, and to the east as far as Karnia. Relatively closed patches of secondary forests occur from the river embankments up to the steep and moderately steep slopes and crests of the surrounding hills.

The forest regrowth thickets present themselves in various stages of regeneration, referred to by the following suffixes:

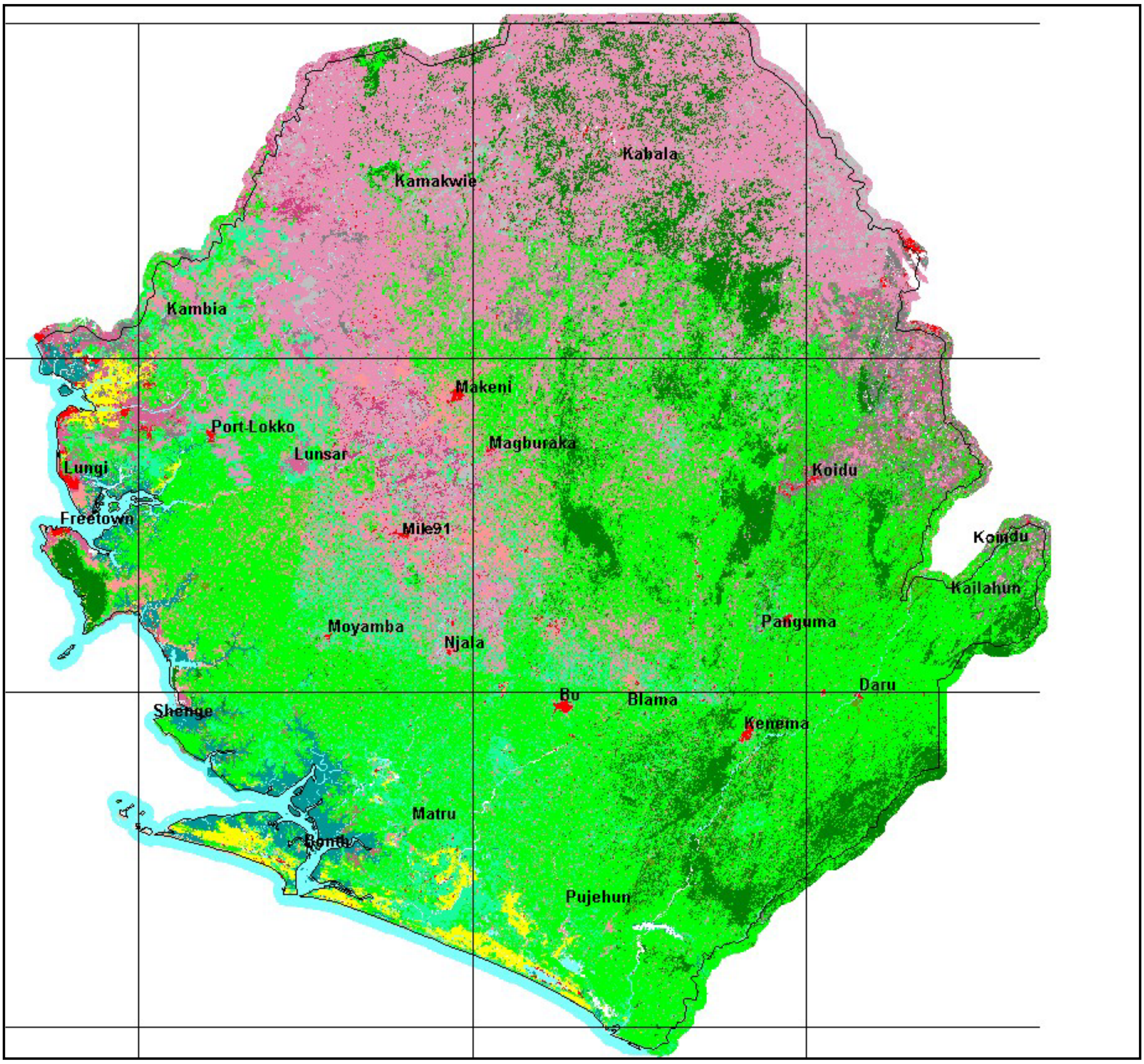
r1 = 1-2 year fallow period.

r2 = 3-5 years fallow period.

r3 = 6-10 years fallow period.

The mixed tree savannas are found on the moderately steep slopes and the gently undulating transitional zones. Where this vegetation has been severely degraded, grasses, mainly *Pennisetum purpureum* and to a lesser extent *Chasmopodium*, have replaced trees like *Parkia biglobosa* and *Cassia siebariana*. Most of the former swamp thickets appear today rather as swamp grasslands.

As reported in the ESCG study (1989) and original EIA (1996) there has been, over time, a gradual increase in the forest regrowth / farmland area, and a corresponding decrease in the mixed tree savanna vegetation zone (the main sub-component of the forest savanna mosaic). This does not necessarily result in an increase of land under cultivation at any point in time, but rather an increase in land under fallow. Similarly, there has been an increase in the transformation of swamp thicket into swamp grassland, as swamp areas have been cleared, cultivated and then returned to fallow.



Produced from 8 Landsat 7 scences, Dates vary from 2000 to 2003.

Produced by:

- Dr. A.B Karim, Dept. of Biological Sciences,
- Fourah Bay
  College, Freetown
- Prof. H. G. Morgan, Rokuprr RRI, Freetown
- Dr. R.A. Wadsworth, Centre for Ecology & Hydrology, UK.

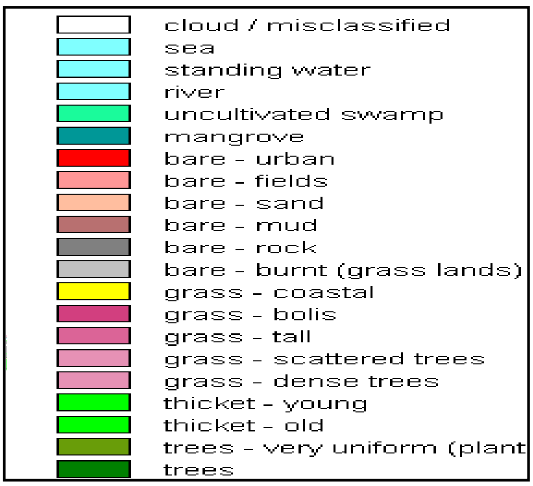


Figure H.5.1-1: Provisional Land Cover Map for Sierra Leone

The civil war led to general insecurity in rural areas and an exodus of people to urban areas. As a consequence, farming activities were significantly reduced, and since the end of the war, the international community has provided emergency agricultural support. It can be inferred that the reduction in farming and crop yields has also decreased the rate of clearing mixed tree savanna zones, as farmers have firstly resorted to clearing fallow regrowth areas. It is reported that there was a recovery of rice production to 78% of pre-war levels by the 2002 crop season and there is the expectation that production levels will reach pre-war thresholds by the end of the 2003 cropping season (MAFFS/FAO, 2003).

Table H.5.1-1: Area of Vegetation and Land Use Types in the Immediate Catchment

Vegetation type	Symbol*	Area (km^2)	Area (%)
Forest regrowth and thickets	R		
1-2 years fallow	r1	25	4
3-5 years fallow	r2	11	1.5
6-10 years fallow	r3	156	24
Cultivated land	C	22	3
Inland valley swamps	I	5	1
Upland savanna grassland	Sg	21	3
Mixed tree savanna	Sm	386	60
Closed moist forest	Fm	4	0.5
Riparian forest	Ff	10	1.5
River		4	0.5
Total		644	100

H.5.2 Agriculture

The current farming system is dominated by shifting agriculture (i.e. slash and burn) involving the clearing of vegetation to establish rainfed or swamp-based farming for one or two years before leaving the land fallow, and moving on to clear another area of vegetation (either regrowth/fallow vegetation, mixed forest or swamp). Fallow periods range from 3 to 15 years.

The main crop is rice – both swamp and upland. Yields are reported as a function of the quantity of seed planted. One bushel of rice seed produces 35 to 100 bushels of swamp rice, but only 20 to 30 bushels of upland rice, depending on seed variety and quality, land suitability and preparation, and rainfall. Other main crops include groundnut (grown after rice), maize (intercropped with upland rice), millet (in the northern watershed area), cassava and pepper. Garden farms support a variety of vegetables (beans, etc.). The palm is the dominant economic tree, producing palm oil and palm wine; others include citrus (orange, lime and grapefruit), mango and localised coffee (e.g. Kasasi village).

In the immediate catchment area, surplus agricultural produce is sold in key market towns and villages (e.g. Bumbuna, Fadugo, Badala, Kabala and Kondembaia). Farmers transport their produce to these market centres and either sell it themselves or resort to traders if they are constrained by time. Traders also purchase produce at Bumbuna and Fadugo to sell in Freetown and Makeni.

The civil war resulted in the collapse of the agriculture sector in Sierra Leone. National seed bank centres were looted and household seed stock consumed. Livestock was largely deciminated and Fula herders moved north out of the watershed area into Guinea. Post-civil war efforts in the agricultural sector aim to contribute towards relaunching the economy, as defined in the Interim Poverty Reduction Strategy Paper (I-PRSP). Rice self-sufficiency and production levels are critical indicators of poverty, and consequently Government and NGOs are promoting rice production through seed distribution and farm demonstrations. For example, the Korongoaia Farmers Association based in Bumbuna received 200 bushels of seed rice in June 2003 from the DFID-funded community rehabilitation programme, for distribution to 200 of its members. The initial beneficiary farmers are committed to supply one bushel of seed rice each for distribution to a further 200 members for the next season. Similar schemes and community demonstration plots are taking place within the watershed with support from international NGOs (e.g. CRS in Komdembaia). The Ministry of Agriculture, Forests and Food Security is currently embarking on programmes to distribute other crop seeds, for example the distribution of 20,000 cashew seedlings in northern Province during 2004 (pers. comm. Director of Agriculture, Tonkolili District).

Table H.5.2-1: Areas of rice cultivation and production from 2000 to 2002

District	2000		2001		2002	
	Hectares	Tonnes	Hectares	Tonnes	Hectares	Tonnes
Bombali	6,379	7,263	16,760	19,624	29,650	39,597
Tonkolili	26,634	28,498	35,049	36,893	34,431	37,225
Koinadugu	14,374	15,606	18,165	19,667	21,278	29,146

Source: Agriculture Data Pack: 2nd Data Collection Exercise. Technical Committee of the National Recovery Committee, October 2003

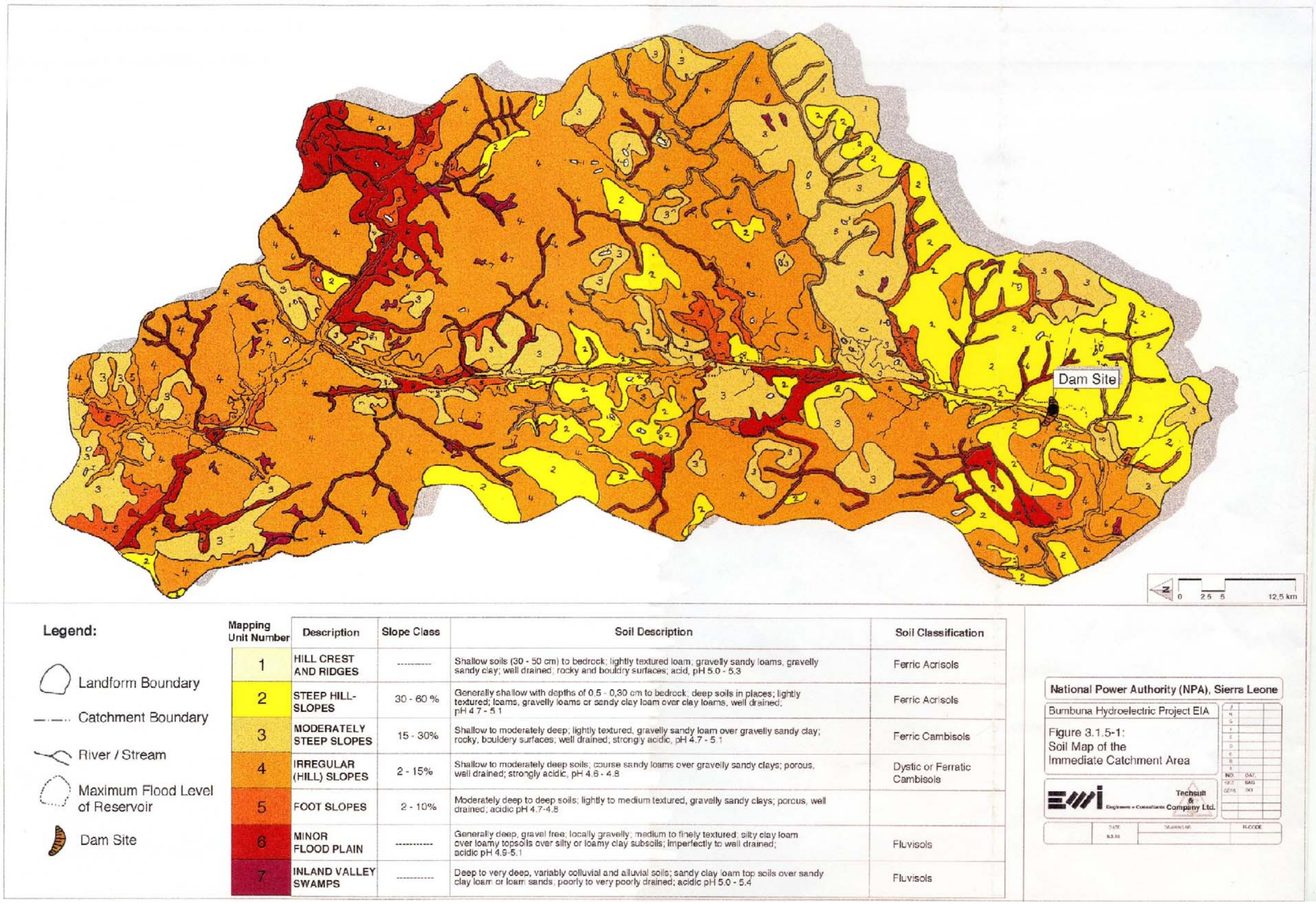
Table H.5.2-2: Changes in Land Use in the Lowermost Part of the Bumbuna Catchment Area

Vegetation and Land Use Type	Total Coverage				Changes
	1975		1987		1975-87
	ha	%	ha	%	%
Secondary forest	327.9	4.6	187.2	2.6	-2
Riparian forest	384.6	5.4	320.8	4.5	-0.9
Forest regrowth	3,599.1	50.6	4,225.5	59.3	+8.7
1-2 years fallow	-	-	431.1	6.0	
3-5 years fallow	-	-	2,930.1	41.2	
> 6 years fallow	-	-	864.3	12.1	
Mixed tree savanna	1,237.6	17.4	624.4	8.8	-8.6
Upland grassland	940.2	13.2	1,038.4	14.6	+1.4
Upland cultivation	504.0	7.1	597.1	8.4	+1.3
Swamp thicket	76.9	1.1	29.3	0.4	-0.7
Swamp grassland	5.0	0.1	67.8	1.0	+0.9
Swamp cultivation	32.3	0.5	17.2	0.2	-0.3
Total	7,107.6	100	7,107.6	100	

H.5.3 Present Rural Infrastructure and Communications

As it can be observed on the topographic map (scale 1:50,000), the catchment area is permeated by numerous footpath and a few motorable roads interconnecting the numerous villages and towns. The project area is accessible by good motorable roads from Kabala, Makeni and Magburaka. A new feeder road connects Bumbuna and Binkolo near Makeni. On the other hand it was observed that some former footpaths do no longer exist. Whether this is an indication for a population decline in the area remains to be confirmed.

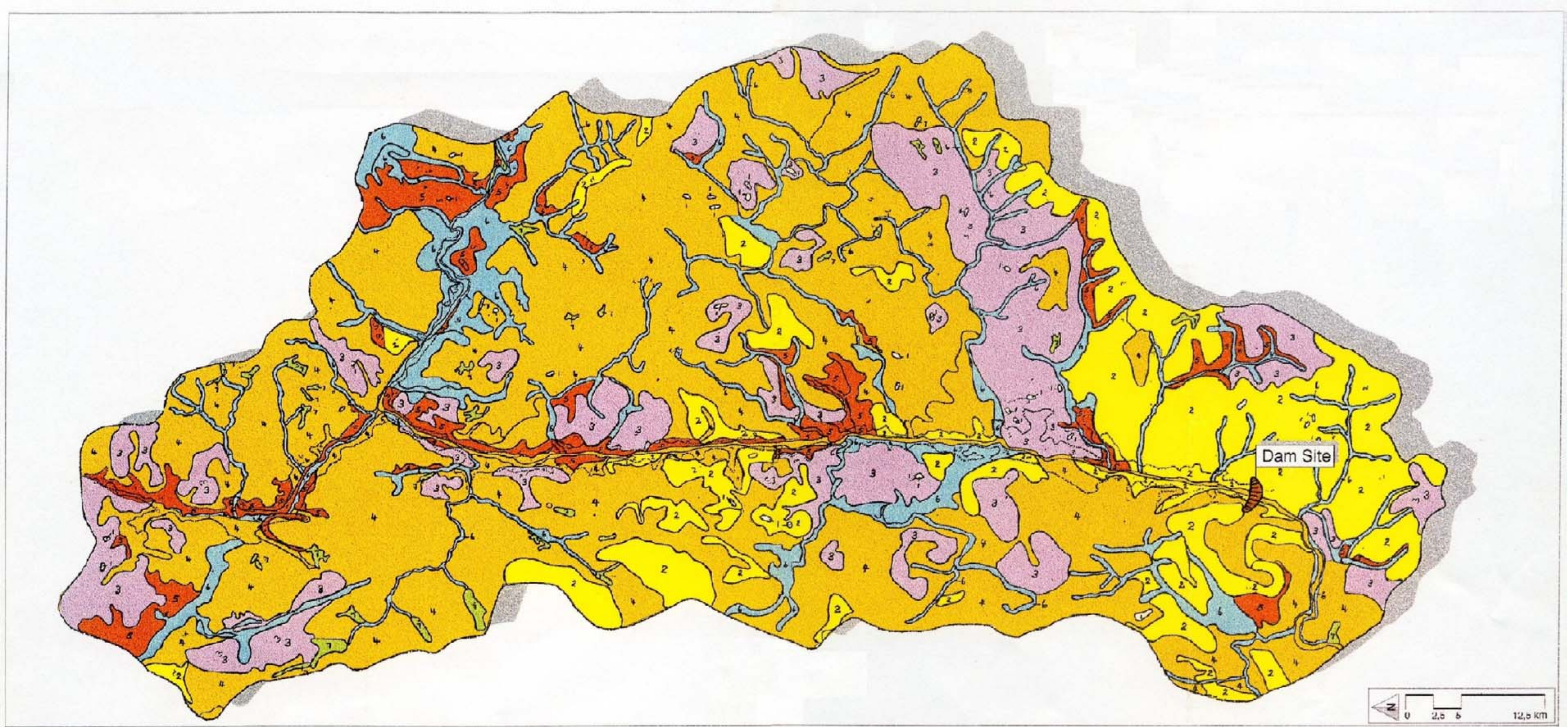
Fadugu in the north, and Bumbuna in the south are the two main towns in the project area. They serve as the main market centres for most of the agriculture products. Markets are organised every week to enable farmers to sell their products and to buy imported food and other necessary items for retail back in the villages. The transport of agricultural products from some villages to the markets is difficult as most villages are located at considerable distances from the main motorable roads. For the construction of the dam several access roads have been constructed leading to the dormitories, offices, the power house and to the damsite itself.



Mapping Unit Number	Description	Slope Class	Soil Description	Soil Classification
1	HILL CREST AND RIDGES	----------	Shallow soils (30 - 50 cm) to bedrock; lightly textured loam; gravelly sandy loams, gravelly sandy clay; well drained; rocky and bouldry surfaces; acid, pH 5.0 - 5.3	Ferric Acrisols
2	STEEP HILL-SLOPES	30 - 60 %	Generally shallow with depths of 0.5 - 0,30 cm to bedrock; deep soils in places; lightly textured; loams, gravelly loams or sandy clay loam over clay loams, well drained; pH 4.7 - 5.1	Ferric Acrisols
3	MODERATELY STEEP SLOPES	15 - 30%	Shallow to moderately deep; lightly textured, gravelly sandy loam over gravelly sandy clay; rocky, bouldery surfaces; well drained; strongly acidic, pH 4.7 - 5.1	Ferric Cambisols
4	IRREGULAR (HILL) SLOPES	2 - 15%	Shallow to moderately deep soils; course sandy loams over gravelly sandy clays; porous, well drained; strongly acidic, pH 4.6 - 4.8	Dystic or Ferratic Cambisols
5	FOOT SLOPES	2 - 10%	Moderately deep to deep soils; lightly to medium textured, gravelly sandy clays; porous, well drained; acidic pH 4.7-4.8	
6	MINOR FLOOD PLAIN	-----------	Generally deep, gravel free; locally gravelly; medium to finely textured; silty clay loam over loamy topsoils over silty or loamy clay subsoils; imperfectly to well drained; acidic pH 4.9-5.1	Fluvisols
7	INLAND VALLEY SWAMPS	-----------	Deep to very deep, variably colluvial and alluvial soils; sandy clay loam top soils over sandy clay loam or loam sands; poorly to very poorly drained; acidic pH 5.0 - 5.4	Fluvisols

Figure H.5.3-1: Soil Map of the Immediate Catchment Area.

Source: Electrowatt/Techsult (1996)



Legend:

- Landform Boundary
- Catchment Boundary
- River / Stream
- Maximum Flood Level of Reservoir
- Dam Site

Mapping Unit Number	Land Facet \ Crops	Cassava	Cashew	Citrus	Maize	Ground Nut	Swamp Rice	Upland Rice	Beans	Soy Beans	Millet	Oil Palm	Sweet Potatoes
1	HILL CREST AND RIDGES	S3 (ry)	S2 (ry)	S3 (ry)	S2 (re)	S2 (r)	N	S3 (ry)	S2 (ry)	S2 (ry)	S3 (ry)	S3 (rm)	S2 (ry)
2	STEEP SLOPES	N/S3 (re)	N/S3 (re)	N/S3 (re)	N/S3 (re)	S2 (re)	N	N/S3 (re)	N/S3 (re)	N/S3 (re)	S3 (re)	S3 (rme)	S3 (re)
3	MODERATELY STEEP SLOPES	S2 (re)	S1 (re)	S3 (re)	S3 (re)	S2 (re)	N	S3 (re)	S3 (re)	S3 (re)	S3 (re)	S3 (rme)	S3 (re)
4	IRREGULAR SLOPES	S2 (re)	S1 (re)	S3 (re)	S2 (re)	S2 (re)	N	S3 (re)	S2 (re)	S2 (re)	S2 (re)	S3 (rme)	S2 (re)
5	FOOT SLOPES	S3 (r)	S1 (r)	S3 (r)	S2 (r)	S2 (r)	N	S3 (r)	S2 (r)	S2 (r)	S2 (r)	S3 (rm)	S3 (r)
6	MINOR FLOOD PLAIN	N/S2 (o)	N	N/S2 (o)	N/S2 (o)	N/S2 (o)	S2	S3 (o)	N	N	N/S3(o)	N/S3(o)	N/S3(o)
7	INLAND VALLEY SWAMPS	* N	N	N	N	* N	S1	N	N	N	N	N	* N

National Power Authority (NPA), Sierra Leone

Bumbuna Hydroelectric Project EIA

Figure 3.1.5-2:
Land Suitability Map of the Immediate Catchment Area

EWI Engineers + Consultants — Techsult & Company Ltd.

Figure H.5.3-2: Land Suitability Map of the Immediate Catchment Area.

Source: Electrowatt/Techsult (1996)

Figure H.5.3-3: Earth Moving Activities near the Dam Site.

Figure H.5.3-4: Deforested Slopes Upstream of the Dam Site.

Source: Electrowatt/Techsult (1996)

H.5.4 Complementary Rural Activities

In general purely agricultural activities are insufficient to make a living for a rural family. In other words, at least one family member generates a complementary income from activities such as gold mining, fishing, palm wine and palm oil production etc. Especially, palm wine seems to have assumed a very important role in the social and economic life of the local populace. It is an important beverage and serves as source of income for a majority of the people. Palm oil is an important staple food component. It is one of the important cash crops and is consumed almost every day by everybody. These two products, palm wine and oil, make the oil palm tree an important and indispensable economic asset.

H.6 Problems related to Land and Agriculture

In addition to the problems already described in the preceding sections, namely, low unreliable yields, small farm sizes, intensive manual labour, lack of input such as fertilisers and other chemicals there are numerous other related problems, such as:

H.6.1 Rural-Urban Migration

A majority of the young and able-bodied men and women have migrated to towns and mining areas in search of employment and better living opportunities.

H.6.2 Natural Hazards and Limitations

Pests and diseases of crops and livestock pose serious limitations to agricultural production in the study areas. Birds and rodents do considerable damage to the rice crops while groundnuts, cassava, yams and potatoes are incidentally destroyed by squirrels, monkeys and ants. Outbreaks of foot and mouth disease as well as rinderpest have been reported by the Musaia veterinary station near Kabala (1993).

H.6.3 Irregular Relief and Land Suitability

The comparison of the land use and land suitability map, indicates that considerable portions of S-3 land are extensively cropped, while even larger portions of S-2 and occasionally S-1 land remain untouched. This is particularly the case in the vicinity of the towns Bumbuna and Kifogo, which represent the most densely populated areas within the immediate catchment.

H.6.4 Low Rural Income

Income from the various economic activities in the study area is generally very low. Socio-economic studies conducted in the Bumbuna catchment area (ESCG, 1988) have shown that the average income per household is Le. 180'000 per annum. About 70% of this income is generated from farm outputs, while the remaining is acquired through complementary activities. For many households, the gap is filled by money remitted by relatives employed in the urban areas.

H.6.5 Poor Health and Malnutrition

Diseases and malnutrition observed in rural as well as in urban settlements are pronounced amongst the children, most of them suffering of protein deficiencies in their daily diet. Although protein deficiencies appear to be less pronounced among the adults it becomes apparent in a latent manner, being at least partly responsible for reduced strength and working power.

H.6.6 Emphasis on rice rather than other crops

Rice farming is labour intensive, particularly in upland rice farming. Besides land preparation, much effort is required to manage the crop, for instance erecting fencing against rodents and scaring birds. Available labour is a constraint for the intensification of agriculture. There is scope for farmers to invest in higher return crops (e.g. chilli, cocoyam, potatoes), which may also require less labour input. However, farmers have a preference to grow rice, as it is a staple crop and Government/NGO programmes also favour rice growing.

H.6.7 Marketing and Storage

Farmers usually have to sell their produce when prices are at their lowest, normally at the beginning of harvest times, rather than benefitting from higher prices when the supply is limited. The absence of storage facilities, pressures for cash to pay school fees, and planting at the onset of the rains, results in farmers having to sell their produce as soon as it is harvested. Diversification to other crops would largely be dependent on farmers being convinced of the availability of seed and the existence of markets. The increased cultivation of pepper and yams offers an example of farmers responding to current market demand.

H.6.8 Land tenure

Land is owned by families and entrusted in the care of Paramount Chiefs. (Most land-owning families are unable to develop all of their land, and hence part of their land is entrusted with the Chiefs.) At village level, land-owning families or village chiefs/elders can distribute land to community members. The land tenure system does not favour farmer investment in land, as it is more likely for the farmer to be a tenant than the land owner.

H.6.9 Land degradation

The 1988 ESCG report classified the Seli River catchment as very severely degraded in terms of land and vegetation, the main problems being slash and burn cultivation in the area between Fadugo and Bumbuna, farming on hill slopes, and both overgrazing and bush fires in the upper watershed. The ESCG study applied the universal soil loss equation (using data on slope, vegetation and soil types) to determine potential soil loss values for different zones of the watershed. The original EIA puts this information within the context of *potential,* and highlights that soil loss is limited to recently cleared farmland on steep slopes. Observations in 2004 confirm the conclusions of the original EIA on this potential for soil erosion. Localised soil erosion is seen on recently cleared farms on steep slopes on the eastern side of the dam site (see Figure H.6.9-1) and other sites within the immediate catchment. However, forest regrowth and riparian forest zones on the lower slopes act as sponges that collect and retain soil, thus limiting the amount of silt reaching the Seli and its tributaries. Evidently, vegetation cover is a critical factor in the minimisation of soil loss.

Figure H.6.9-1: Steep slope upland rice farming with evidence of soil erosion (east of dam site 11.9.04).

The soils are inherently low to very low in fertility, as highlighted in the Original EIA. Soils were found to be low in available phosphorus content (<4 ppm on the hill crests and 3 ppm on all other land facets), very low in total nitrogen content (< 0.2%), low exchangeable bases and low base saturation values (30%). Consequently, recurrent rainfed agriculture on watershed slopes leads to the degradation of soil fertility. This can be restored through fallow (as currently practiced) or alternative means such as nutrient enriching farming practices and vegetative soil conservation measures.

H.6.10 Livestock grazing

Prior to the civil war, there were reports of conflicts between pastoral Fula herdsmen and farmers over access to grazing areas in the northern zones of the watershed (in the mixed tree/savanna zone north of Fadugo, Kafogo and Kania). Conflicts arose from damage to crops by livestock and the expansion of rainfed agriculture onto grazing lands. Since livestock numbers have not recovered to pre-war levels, overgrazing and conflicts concerning access to land are not current issues. However, with increased stocking levels, it can be assumed that conflict will arise in the future unless effective land management systems are put in place.

H.6.11 Agroforestry and soil erosion control

The ten year civil war precluded any advances in farming methods based on agroforestry, biological erosion control and the intensification of farming (as opposed to extensive slash and burn). The post-war agricultural programmes are largely centred on re-establishing seed stocks and crop yields of the main staple foods, and have provided little guidance or demonstration on effective upland farming techniques, other than swamp rice farming. Farmers are continuing to cultivate steep slopes without any biological (planted bunds, alley cropping) or physical (contour tilling, bunds) soil erosion control measures.

H.6.12 Land management and planning

Effective management of land requires an integrated multi-sectoral and decentralised approach to planning and management. The Watershed Degradation Study conducted by ESCG in 1988 recommended an outline of such an approach, although with a strong bias towards agroforestry and soil conservation. The original EIA made reference to an FAO supported Watershed Management Project covering the catchments of Bumbuna and Dodo HEP, with one senior technical staff member of the project undergoing specific training abroad. The MSc thesis produced by the trained staff member was reviewed in 2004, but there is no evidence of project outputs or even whether the project actually existed. It is concluded that there have not been any effective land management initiatives in the watershed of the future Bumbuna reservoir to date.

Currently there is limited planning and management within the Bumbuna watershed, but no evidence of sectoral linkages. Central level sectoral institutions (e.g. Agriculture, Forestry, Environment and Wildlife Departments) have very limited staff and financial resources to undertake work at Provincial, Council and Chiefdom levels. National policies and laws do provide the frameworks for elements of land management but there is no implementation.

For instance, Clause 7 of the Forestry Act, 1988, states that [the Forest Department shall] "Prepare and revise a plan for the management the nation's forest resources in order to provide the optimum combination of economic, social and environmental benefits. The plan shall take due account of national and regional land use plans prepared by other agencies of Government".

Clause 38 of the Forestry Regulations, 1989, states "No land between high and low watermarks nor any lands above the high water mark at the bank of both sides of waterways (rivers and large streams) extending a distance of one hundred feet [approx. 33 metres] shall be farmed or cleared of any vegetation, nor shall any tree or vegetation be removed from these areas without a clearance license from the Chief Conservator or an officer deputed by him."

The Environmental Protection Act, (2000) states "the Department of the Environment shall, co-ordinate all the environmentally related activities of Government Ministries and local authorities and act as the focal point of all national and international environmental matters relating to Sierra Leone". Among its various functions, the Department shall "formulate or promote the formulation of, and monitor the implementation of policies, programmes and projects, standards and regulations relating to environmental protection and management". No specific reference is made to watershed, land or ecosystem planning and management, but emphasis is placed on the application of EIA within the planning of "projects and programmes".

The little evidence of actual management is reflected in byelaws issued by Paramount Chiefs. For instance, the Paramount Chief of Komdembaia issued a ban on the clearing of riparian forests for agriculture, but extraction of valuable timber trees is still permitted subject to his endorsement. Whilst this reflects Clause 39 of the Forestry Regulations (1989), the actual width of the riparian forest rarely extends beyond 80 feet (25 metres). The Bumbuna Paramount Chief has issued a ban on the burning of grasslands because it is promoting the spread of weeds (e.g. elephant grass) at the expense of possible agriculture.

I Water Quality

I.1 Chemical and Physical Analyses of Drinking Water

Parameter	Units	VII DW Bumbuna May	VII DW Bumbuna Oct	VIII DW Sangban May	VIII DW Sangban Oct	IX DW Fadugu/ Kamekele May	IX DW Fadugu/ Kamekele Oct	X DW Fadugu Tank May	X DW Fadugu Tank Oct
Temp. Air	C	-	-	-	-	-	-	-	-
Temp. Water	C	-	-	-	-	-	-	-	-
pH		-	-	-	-	-	-	-	-
El. Conductivity	umho/cm	-	-	-	-	-	-	-	-
TDS	ppm or mg/l	-	-	-	-	-	-	-	-
Diss. O2	mg/l	-	-	-	-	-	-	-	-
BOD5	mg/l	-	-	-	-	-	-	-	-
COD	mg/l	3.50	1.50	1.10	1.00	3.40	-	6.20	0.50
Total Fe	ug/l	3.90	1.32	1.30	1.20	23.60	-	6.60	1.32
Ca2	mg/l	4.00	2.00	2.00	2.00	2.00	-	4.00	2.00
Mg2	mg/l	0.61	0.30	0.40	0.30	0.40	-	0.61	0.30
Cl	mg/l	2.13	-	1.42	-	3.55	-	2.13	-
N02-N	ug/l	n.d.	1.54	10.98	1.54	2.44	-	n.d.	6.92
N03-N	ug/l	81.37		371.5		367.5		481.2	
NH3-N	NH3-N/l	0.00	0.00	0.00	0.26	0.00	-	0.01	0.00
PO4-P	ug-atom/l	0.50	-	0.36	0.00	1.71	-	2.14	1.67
Hardness	d H	0.00	0.10	0.00	0.10	8.02	-	0.00	0.10
Total Alkalinity	(HCO-alkanity)	21.45	13.00	16.50	5.00	16.50	-	23.65	6.00
SO2	meq SO2-/l	0.01	0.00	0.00	0.00	0.00	-	0.00	0.00
PA	mg CaCO3/l	0.00	0.00	0.00	0.00	0.00	-	0.00	0.00
Faecal Coliforms	PNC/100 ml	-	-	-	-	-	-	-	-

Key
DW = Drinking water source
nd = not detected
- = not determined

Source: Electrowatt/Techsult (1996)

I.2 Impacts on upstream water quality from original EIA (1996)

The following account of the impacts of the BHP on upstream water quality was presented in the Final Report of the 1996 EIA study (Electrowatt/Techsult 1996).

I.2.1 Water Quality

I.2.1.1 Impacts

The impoundment will change water quality in the reservoir and will have various side effects which are usually more important in the reservoir than downstream thereof. The water quality of the Bumbuna Reservoir depends on various factors, of which the most important are:

- Retention Time
- Recovery period
- Inflowing water quality
- Quantity of biomass flooded

The retention time (tw) is in the case of the Bumbuna Reservoir is small. The tw which is the reservoir volume / annual river inflow is 0.12 yr.

The relative short retention time at FSL 241 m asl suggests that negative impacts on the water quality, normally related to reservoirs with long retention time and large impounded areas, will not be significant in the case of Bumbuna Figure 4.1.8.-1 indicates the location of the Bumbuna reservoir, on the graph developed by Garzon, 1984 (WB) for reservoirs in which adverse water quality problems may occur.

Furthermore, the short retention time will result in a short recovery period of the reservoir. Assuming that the reservoir is completely mixed the following correlation can be applied for estimating the recovery period (Garzon,1984):

$C=C_o e^{-(t/t_o)}$ where:

C_o is the initial concentration of any conservative contaminant;

C is contaminant at time t; and

t_o is the residence time in the reservoir

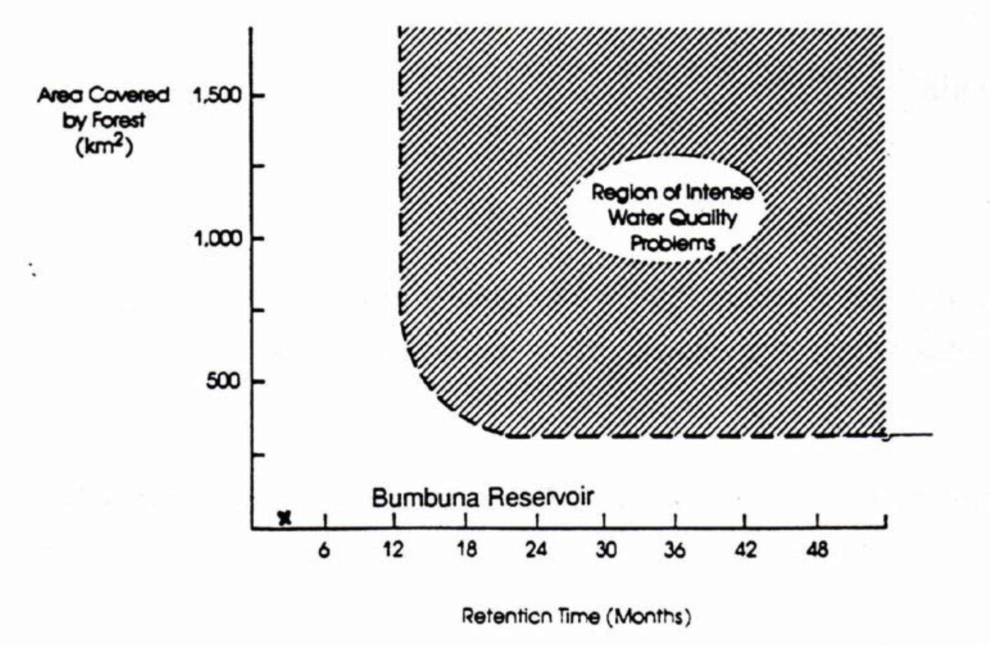


Figure I.2.1-1: The Bumbuna Reservoir Water Quality as Function of Retention Time and Area Flooded. (Garzon, 1984)

The recovery period is defined as the time required for removing 90% of the initial concentration of the contaminant from the reservoir. For the Bumbuna reservoir this would result in recovery period of about 3 and 4 months for FSL 241 m. The recovery duration is a slight underestimation since the reservoir probably is never a perfectly mixed as assumed. Taking the reduced flow during dry season into account the recovery period would be in the range of 6 to 7 months . Nevertheless, this implies that the reservoir would recover fast from any anthropogenic influences as the contaminants would be washed out rapidly.

Some further comments to the oxygen balance and water quality are:

- Wind action and subsequent wave action affects the oxygen balance in the reservoir as it improves the mixing of the lake introducing air (oxygen) throughout the lake, consequently improving the negative oxygen balance.
- In beginning stage of decomposition of the biomass in the flooded area, a certain portion of the organic matter would be discharged from the dam through turbine release and /or low level outlets. This would also reduce the oxygen demand and hence oxygen deficit in the initial stages.
- It may be assumed that power generation will start as soon as the filling of the reservoir has reached the operation level of 240 m asl, which is approximately after 1 month or even less. At this time larger releases can be made, slowing the rate of rise of the reservoir level, and subsequently reducing the oxygen demand after the first month thus improving the oxygen balance more rapidly from then onwards.
- Reservoir inflow will not be constant but will follow the seasonal pattern of the river flow and thus will depend on the timing of the start of the impoundment. Although a different (non-constant) pattern of inflow would result in a different rate of reservoir filling the oxygen balance

computation remains valid since it is essentially dependent on the relationship between flooded area and reservoir volume rather then being time dependent.

From the foregoing can be concluded that the water quality in the reservoir will be relatively poor in the initial stages of reservoir operation at FSL 241 m and water quality impairment (anaerobic conditions) may occur during the first 6 months of impoundment but conditions will improve rapidly after that period especially in the upper levels of the reservoir, and no serious negative side effects are to be feared neither in the reservoir nor downstream.

At the time this study was carried out the dam had been already in place for about one year, and there may already have been some negative impacts on water quality, e.g. contamination of the water with concrete. Such incidents can increase the pH dramatically because of the very low buffer capacity of the water.

The impoundment of a river causes a severe change of the physical and chemical conditions and the related biological communities. Terrestrial areas adjacent to the river bed become inundated and their ecosystems are destroyed.

The submerged organic matter decomposes and will lead to some eutrophication. In addition there will be the inflow of dissolved and suspended matter from the tributaries. Potential erosion of the steep slopes can result in increased sediment input with additional nutrient load. Initially the loosened soils and suspended matters will increase turbidity. The post impoundment phase of the reservoir is usually characterized by a period of increased water fertility (eutrophication) which within a few years gradually reduces to a lower equilibrium state. Eutrophication can result in oxygen depletion in deeper parts of the waterbody and water plant mass development.

The extent of clearing the reservoir area before impoundment will influence the level of eutrophication of the future lake. As a result of eutrophication in Lake Kariba (partial clearing) there was a dramatic decline of O_2 within one month after the dam was closed. Only the upper 5 m of the waterbody contained enough O_2 to sustain a bottom fauna (Ewer, 1965). Afterwards there was a spectacular growth of floating water plants. In the littoral zones of Lake Volta (no clearing) there was sudd formation by weeds (Ewer, 1965).

In Lake Volta during the initial eutrophic phase after impoundment a dramatic change in O_2 took place. The secchi-visibility was about 1m. Planktonic primary production could take place only in the narrow photic zone where oversaturation of O_2 up to 300% due to intensive photosynthesis occurred. Such an oversaturation can kill young fish. From about 5 m below surface down to the bottom the water became anoxic. In this zone there was no life except bacteria. Below weed mats the anoxic zone reached even further up to the surface. Stratification occurred in the uppermost one meter of the water column which was readily disturbed.

The formation of thermal stratification will be the main factor which determines the physical and chemical constituency of the effluent water and reservoir water. The water intake is situated near the bottom of the reservoir. In case of thermal stratification, a hypolimnion discharge will provide water which is slightly cooler, probably higher in plant nutrients and lower in oxygen than the river water in the present state. The occurrence of H_2S (by-product of decomposing organic matter) could be noxious to downstream aquatic life. Such negative effects will probably not surpass the Bumbuna Falls as the downstream river will have a self purification potential which will even be increased by oxygen input from the turbines and Bumbuna Falls.

Due to the special morphometric and hydraulic properties of the Bumbuna reservoir, it is unlikely that there will be serious problems with water quality. The narrow and relatively small waterbody of about 445 Mio. m^3 at maximum and the considerable water through flow results in a short residence time of the water (tw=0.12 yr.) and a relatively fast washing out of the plant nutrients.

Consequently the nutrient loads in the river water downstream of the dam site are not likely to change significantly. During the first year of reservoir impoundment the submerged vegetation will add considerably to the nutrient content of the reservoir water and thus also in the turbine discharges and the water downstream. This initial increase will eventually stabilise back to its original concentrations as the upper water layer in the reservoir with its short retention time will transmit most of the nutrients directly on the to the downstream area. In addition the remaining catchment area of the Seli river below the damsite, which still accounts for 60% of the total drainage area, will continue to contribute nutrients to the river which is positive for the downstream fisheries.

I.2.1.2 Mitigation Measures

A consequence of the reservoir impoundment will be the increased nutrient input from rotting organic material into the reservoir water and increased ionic content from submerged soils.
The measures should aim at lowering the biomass and plant nutrients in the future reservoir. The following is proposed:

Stabilise slopes where landslides may occur. Erosion should be controlled to minimize turbidity and siltation which can produce negative effects on the invertebrate fauna and fisheries.

Remove the vegetation in the reservoir area, except in the uppermost fringe of the drawdown area (see Section Aquatic Life & Fisheries).

Remove important arable soil masses from the reservoir area which could be used for amelioration elsewhere.

Keep the reservoir volume as low as possible during the initial phase of impoundment to keep the residence time of the water low in order to wash the plant nutrients out of the reservoir.

The enactment of appropriate legislation preventing the inflow of pollutants and pesticides from agricultural activity, food processing, industrial and domestic sewage disposal systems.

The water quality should be monitored at least through the expected transitional phase of eutrophication in order to be able to propose further mitigation measures if necessary. The monitoring program could be performed by the executor of the progressing Oncho Control Program by the WHO.

I.3 Limnological Implications of the Construction and Operation of the Bumbuna Reservoir

I.3.1 Introduction

Although the dam for the impoundment of the Bumbuna Reservoir has been constructed, the flow of the river through the diversion tunnel is yet to be stopped. As a consequence the conditions in the valley upstream of the dam are very much in their original state and the quality of the water in the river are much unchanged.

The closure of the diversion tunnel will result in a significant change in the hydraulics of the system. This will result in changes in the biological, chemical and physical nature of the impounded water body, the Bumbuna Reservoir. After an initial period of ‘instability’ the biological and chemical conditions would be expected to settle into a pattern of cyclic events as the biological system predator/prey relationships develop. In this sense predator/prey relationships not only include the biological relationships of the food web but also the interaction of the phytoplankton with the various chemical nutrient species in the water.

It is possible to apply relatively simple statistically based nutrient-chlorophyll models to lakes and reservoirs that have attained stability in order to predict the tropic state including average and peak chlorophyll concentrations. Given sufficient input data it is possible to carry out more sophisticated numerical modelling to predict the species type and chronology of phytoplankton blooms.

The sequence and magnitude of events during the initial period of biological and chemical instability is far more problematical and is best determined by consideration of events in other similar water bodies.

The physical behaviour of an impounded water body; flow, horizontal and vertical mixing, and thermal stratification, are more predictable since the internal interactions are better understood and inputs to the system more readily quantifiable.

I.3.2 Physical Behaviour

Horizontal Mixing

In plan view the proposed Bumbuna Reservoir will take the approximate shape of a ‘Y’. The length of the main limb will be approximately 30 km in length and each of the two branches approximately 7 km in length. With a top water level (t.w.l.) surface area of 21 x 10^6 m^2 the average width of the reservoir will be approximately 500m and at the dam water depth will be approximately 50m. This results in a width to depth ratio of around 10:1.

The main limb of the reservoir is aligned, dam to branch point, approximately North to South and is bordered to the West and East by ridges.

With these physical characteristics the proposed reservoir can not be considered as well mixed along the long axis and any assessment of the biological and chemical behaviour of the reservoir should be made by considering the reservoir as slow mixing river or 'plug flow' reactor in which lateral and vertical mixing of the water is dominant over much weaker longitudinal mixing.

There will be few constraints on lateral mixing given the irregularity in form of the banks along the long axis. At peak wet-season throughput the irregularities will generate maximum horizontal vortex shedding (eddies), which will give rise to good horizontal mixing and minimise longitudinal 'streaming' of flow.

Vertical Mixing

It is necessary to consider the vertical mixing of the reservoir. Vertical mixing is critical for the supply of oxygen to the bed of the reservoir where decomposition processes consume oxygen. Inadequate supply of oxygen to the bed will result in adverse changes in the chemical quality of the water in the deeper parts of the reservoir (see Section I.2.3 – Water Chemistry). Vertical mixing is also a critical factor in controlling the primary productivity (phytoplankton growth) in the reservoir. Weak mixing may result in under-utilisation of available light and nutrients by confining the phytoplankton to the upper water layers. On the other hand strong mixing may result in reduced productivity by forcing the phytoplankton into the deeper parts of the water column where light levels are sub-optimal.

The ability of the water column in a reservoir to undergo vertical mixing is controlled by three sources of energy.

- The horizontal momentum of the inflowing water;
- Transfer of wind energy across the atmosphere-water interface;
- Solar heating.

The horizontal momentum of water flowing into a reservoir acts to induce vertical mixing. In an impounding reservoir such a Bumbuna the velocity component of the momentum of the incoming water will be absorbed within a very short distance from its point of entry into the reservoir. In the absence of any water being abstracted at the dam the velocity in the main water body can, for all practical purposes, be considered as zero. In the condition in which water is being abstracted for power generation or river compensation flow there will be a horizontal velocity component with an average value, at any given point in the reservoir, equal to the volume being abstracted divided by the area of cross section of the reservoir at that point. Vertical mixing will be in the form of turbulence generated by the horizontal velocity interacting with the macro and micro 'roughness' of the shape of the reservoir and debris on the bed.

Similarly, wind blowing over a water surface acts to induce vertical mixing. As a general rule there is an approximate 1% transfer of velocity from wind to water. The closeness of the actual transfer to the 1% value depends on the length of water over which the wind acts and the amount of turbulence. In the case of Bumbuna Reservoir a wind blowing along the major axis will act over a long stretch of water, approximately 30 km, and because it is blowing along the valley will be relatively un-turbulent. A wind blowing along the minor axis will act on a short water length, approximately 500m and because it is blowing normal to the ridge axis, will be turbulent. The former wind has the greater potential for transferring momentum to the reservoir.

Solar heating acts to inhibit vertical mixing. In the presence of weak vertical mixing the thermal gain by the upper layer of a water body creates a vertical temperature gradient (thermocline) with which is associated a density gradient. During the early stages of the development of the thermocline the gradient is not clearly established and an increase in wind speed will provide sufficient energy to distribute the heat throughout the water column. In some cases a period of several days of cooler weather may be sufficient for back radiation to transfer the heat back to the atmosphere. The thermal gain by a tropical reservoir can be as high as 20 $MJ/m^2/d$ and this amount of energy must be imparted to the reservoir to distribute the heat evenly through the full depth of the reservoir. If this is not done thermal stratification will begin to become established. The depth at which the thermocline develops is a function of the isothermal temperature of the reservoir prior to the onset of intense heating, the solar energy input and the wind, or other physical, mixing energy provided to the reservoir. It is possible to provide, artificially, additional energy to a reservoir to prevent the onset of stratification or to break down stratification once it has become established (see I.2.4).

Stratification will break down naturally as air temperatures and solar radiation input fall and wind speed increase. This is known as overturn and can happen within a period of a few days and the water columns becomes vertically mixed until the next onset of stratification.

Seiche Movement

The large length of the reservoir along the major axis also gives rise to the possibility for the establishment of surface or sub-surface seiche movement. Seiche movement can occur following long periods of wind blowing in one direction and at a relatively stable speed. Over a period of time the wind will push water to the down-wind end of the reservoir thereby causing a rise in water level. When the wind drops the water level will return to horizontal but depending on the bed friction forces will to a greater or lesser extent over correct and so establish a rocking motion along the major axis. This motion will be damped out over a period of a few days. Depending on the length of the major axis and the strength and duration of the wind event the amplitude of the oscillations at the extreme ends of the reservoir may exceed 1m. While a seiche movement is primarily a physical phenomenon there are implications for water quality in a reservoir in which thermal stratification has become established.

I.3.3 Water Chemistry

General Chemistry

The geology of the catchment area of the Bumbuna Reservoir is dominated by igneous rocks, which dissolve only slowly in rainwater. Consequently the ionic strength of the surface and groundwaters is low, buffering capacity is low and the potential for the water to exhibit a wide range of pH range values, high. This has significant consequences for water quality under conditions of low oxygen concentration.

Phytoplankton Nutrients

The chemical analysis that is available for the inflowing water suggests high concentrations of phosphate and low concentration of inorganic nitrogen. High concentrations of phosphate from granitic rocks would normally be accompanied by high concentrations of silicate, an essential nutrient for the growth of diatoms. The low concentration of inorganic nitrogen in the rivers will be an important limiting factor for the growth of most phytoplankters in the reservoir. This will not limit the development of some of the blue-green algae (cyanobacter), which are able to fix atmospheric nitrogen and so overcome the absence of that element in the inflowing water. On decay this fixed nitrogen will be released into the water column as organic nitrogen, which will then be mineralised through ammonia to nitrite and nitrate. This then becomes available for non-blue green algae to utilise.

Unless the reservoir catchment becomes a closed area there will inevitably be inward migration of people who will farm the hillsides and introduce livestock. The excreta from the livestock and the human population together with the growth of leguminous crops will increase the nitrogen content of the run off into the reservoir further increasing the potential for development of algal growth in the reservoir.

In a reservoir that becomes thermally stratified, phytoplankton activity in the epilimnion may deplete nutrients to concentrations that become growth limiting, thereby self-limiting the magnitude of the 'bloom'. A mixed reservoir model will have predicted a higher biomass but since there are nutrients locked away in the hypolimnion, the potential is not achieved. However at overturn the sudden release of nutrients from the hypolimnion may shock the phytoplankton into a post-overturn bloom.

Effects of Reducing Conditions

In Section I.2.2 the possibility for the formation of a thermocline was discussed. This marked temperature gradient, through the creation of a density gradient, divides the reservoir, into three layers. The upper epilimnion, which has the ability to exchange gases freely with the atmosphere and so maintain oxygen concentrations close to saturation levels, and in which there is no vertical variation in temperature. The thermocline, in which the temperature, by strict definition, changes by more than one centigrade degree for each one metre change in depth, and in which the oxygen concentration may also show a steep gradient. Below these two layers lies the hypolimnion. This layer of water is isolated from contact with the atmosphere and any consumption of oxygen is replaced only by concentration gradient driven molecular-diffusion across the thermocline.

The oxygen consumption by decay processes at the interface between the bed of the reservoir and the overlying water could be in excess of $2g/m^2/d$. Assuming that at the time of isolation the water in the hypolimnion had a concentration of $8g/m^3$ ($\equiv$8mg/l), a typical figure for saturation concentration at tropical temperatures, and a hypolimnion thickness of say 15m, then all of the oxygen in the hypolimnion would be consumed in around 60 days. In reality it would take slightly longer to reach this state of anoxia, since below about 2mg/l the rate of decomposition is determined by the oxygen concentration rather than that of the primary substrate. As the concentration of free oxygen in the water approaches zero the decomposition pathways progressively switch to other, compound, sources of oxygen. Firstly to nitrate and nitrite, then sulphate and finally carbonate. As this sequence is followed ammonia, sulphide and finally methane are generated and at the same time the pH falls, less so in well-buffered hard waters than in the soft, weakly buffered water of Bambuna reservoir. The release of such water as compensation water from a draw off point deep in the reservoir would have significant impact on the support of the downstream ecology and on the materials used for the construction of the generating turbines. In an extreme condition of reservoir anoxia as seen in the Poza

Honda reservoir in Ecuador, particulate sulphur was deposited on the rocks in the section of river downstream of the dam and on concrete structures in the water treatment plant abstracting water from the reservoir.

Following the creation of reducing and low pH conditions in the hypolimnion, polyvalent metals will tend to dissolve; particularly prone to solution under these conditions are iron and manganese. Ferrous iron and manganous manganese reduce to the ferric and manganic states. Dissolved iron and manganese in hypolimnetic water, on exposure to oxidising conditions following release into the downstream river, will form the insoluble oxides. Under suitable reduced turbulence conditions these fine oxides will coat leaves of macrophytes and rocks and fill the interstitial spaces between small stones thereby reducing primary production, blanketing the epilithic diatom meadows on which many invertebrates graze, and coating fish eggs laid between the protecting stones.

Iron is a commonly occurring metal in igneous rocks together with phosphate. Under aerobic conditions in the sediment, the iron will form insoluble complexes with phosphate, effectively immobilising it from use by phytoplankton. In the reducing conditions of the hypolimnion, when iron is solubilised any bound phosphorus is released to the water in soluble form. On overturn the reservoir becomes vertically mixed and the additional phosphate is made available for phytoplankton the photic zone.

I.3.4 Co-conspiring Physical and Chemical Conditions

Previously in Section I.2.3 the likelihood of the water mass below the thermocline being of low quality was considered and that the draw off point in the reservoir for power generation and the supply of compensation water to the downstream river was located in the hypolimnion.

In Sections I.2.2 and I.2.3 the possibility of the formation of a thermocline at different depths in a water body was described together with the possibility that the thermocline could exhibit a periodic rocking motion.

If the level of the draw off point is above the thermocline, is it possible to be sure that hypolimnetic water will not be discharged through the turbines or as compensation water?

No. It is possible that following the formation of a thermocline a wind of in-sufficient speed to mix the reservoir but with sufficient strength to generate a seiche could occur. Under these conditions the water at the level of the draw off point would oscillate between eplimnetic, good quality, to hypolimnetic, poor quality for a number of days, thereby subjecting the down stream riverine ecosystems to fluctuations on a similar scale to those which the more tolerant estuarine ecosystems have become adapted.

I.3.5 Reservoir Ecology Instability

In temperate latitudes where temperature, day length and solar radiation intensity show marked seasonality phytoplankton growth in lakes and reservoirs also shows marked seasonality particularly in species composition and to a lesser extent quantity. In tropical water bodies where temperature, day length and solar radiation intensity show much less seasonal variation the phytoplankton growth similarly exhibits much less seasonality in species composition and quantity.

In Section I.2.1 reference was made to the biological instability of newly impounded bodies of water and the possible occurrence of extreme biological events, usually in the form of phytoplankton blooms. Because of the low individual biomass and short inter-generational times of the filter-feeding Cladocera and predatory Cyclopoid Copepoda the feed-back mechanisms imposed by them on the phytoplankton give rise short, sharp periods of algal growth. As the system matures these periods of growth tend to become longer and of smaller magnitude.

The benthic community in the newly flooded reservoir may also show an initial period of instability and extremes. The margins of newly filled reservoirs are an attractive habitat in which the Chironomid midge lays its eggs. The larvae of the Chironomid midge are benthic and on emergence from the water surface, form large clouds of insects. The Chironomid larvae are prey for larger predatory insects and for bottom feeding fish. Until these predators become established there is likely to be a period in which the emerging flies cause annoyance to people in the vicinity.

I.3.6 Recommendations

Phytoplankton Bioassay

<u>*Introduction*</u>

The technique of tri-genera phytoplankton bioassay to measure phytoplankton growth, in terms of total biomass and species dominance, was developed in the 1970s.

It was used as a tool to predict the phytoplankton potential of new water supply reservoirs, in particular pumped storage reservoirs where the operator had some control over the quantity and quality of water pumped into the reservoir. It could also be used to assess the effects of the reduction of nutrients entering rivers through pollution control or the addition of nutrients through changes in land use practices.

The tri-genera method measures the growth of uni-algal cultures of green, diatom and blue-green algae in the reservoir raw water under controlled light and temperature conditions. Where the river water is taken from two or more different sources the water are mixed, prior to inoculation, in the ratio(s) entering the reservoir. This ratio my vary seasonally.

For pumped storage reservoirs where the operator has the ability to vary the quantity of water selected from different sources, the bioassy technique and be used to examine options for blending to minimise phytoplankton growth.

<u>*Application to Bumbuna Reservoir*</u>

There is a limited quantity of chemical analysis available for the two principal rivers feeding the reservoir. It would appear that phosphate concentrations are high and that inorganic nitrogen concentrations are approaching or below limiting levels. The methods used to carry out the analysis, and whether the analysis was carried out on filtered or unfiltered samples are unclear. The results can only therefore be used as a rough guide to the levels of nutrients entering the reservoir.

It is therefore appropriate to consider the use of a phytoplankton bioassay programme to examine the phytoplankton potential.

<u>*Outline Procedure*</u>

- Carry out sampling and analysis of the main influent rivers during the wet and dry seasons:
  - Measurement of discharge at the point of sampling;
  - Collection of water samples for the analysis on filtered sub-samples for:
    - ortho-phosphate
    - Total phosphate
    - Ammonia
    - Nitrite
    - Nitrate
    - Silicate

- Obtain from a culture collection or establish uni-algal cultures of;
  - a planktonic unicellular or simple colonial green alga;
  - a planktonic unicellular diatom;
  - a planktonic unicellular or colonial nitrogen fixing blue green alga.

- Obtain or establish growth kinetics and limiting nutrient concentrations for the cultures.

- Monthly, over a period of at least one year, carry out growth bioassays and nutrient analysis on filtered samples of water from the main inflow rivers, mixed in proportion to their flows. At the same time carry out control bioassays using standard growth media.

- Evaluate the results of the bioassays and nutrient analysis.

Artificial Mixing

Introduction

As described in Section I.2.2 the onset of thermal stratification and the subsequent deterioration in water quality is a result of the high input of thermal energy into the water column compared with the wind and other physical mixing processes required to distribute the thermal energy evenly through the water column. It is not possible to reduce the thermal energy input. It is possible however to put additional mechanical energy into the system. This ability lies behind the concept of artificial mixing.

For more than half a century, pumped storage reservoirs have been mixed by inducing increasing the horizontal and vertical mixing energy in the water being pumped into the reservoir. Reducing the area of cross section of the inlet pipe with a nozzle increases the velocity of the water entering the reservoir. Since the kinetic energy of the incoming of the water is a function of the square of the velocity the mixing ability increases. For impounding reservoirs this technique cannot be applied unless a re-circulation pump system is employed.

A technique more suitable to impounding reservoirs is the use of rising air bubbles to induce vertical circulation cells. Two basic systems are used, confined air and free air. Confined air systems release air into vertical cylindrical tubes and as the air rises through the tube it pushes the water ahead of itself and so draws water into the bottom of the tube. By this means mixing cells become established. Free air systems operate in a similar way to confined systems but with the walls of the 'tube' being formed by the surrounding water. Free air systems have a significantly lower capital cost than do confined air systems; operating costs are similar.

Free Air Mixing System

The principle of the free air system is the creation of a line of ascending bubbles from a horizontal perforated pipe attached to anchor blocks on the bed of the reservoir. As the bubbles rise they entrain water from the surrounding water column and so set up counter rotating mixing cells either side of the line of bubbles. Air is provided to the system from either a standard diesel driven construction plant compressor or an electrically driven industrial compressor.

Typical capital cost items of a system would consist of up to 300m of 50mm ∅ HDPE pipe and a 150-200 cfm 7bar compressor; the major cost component being the compressor.

The volumetric air flow required to set up and maintain the mixing cells is based on calculations involving the daily thermal gain of the water body, the water depth and the volume of the reservoir or the volume of the sub-basin to be mixed and if the reservoir is already thermally stratified the time period within which a vertically mixed condition is to be achieved. Further calculations determine the size, number and spacing of the holes required to deliver the volumetric flow and finally the pressure required to expel the air through the holes.

Normal operating rules for a mixing system would require the switching on of the compressor following the establishment of a one Centigrade degree difference between surface and bottom water temperatures.

Application to Bumbuna Reserrvoir

The fact that Bumbuna Reservoir has not yet been filled makes the consideration of the installation of the pipework for a free air mixing system an attractive possibility. Confined air systems are more appropriate to installation in existing reservoirs since they require the water to support them in the vertical position.

For the capital cost of 300m of 50 mm ∅ HDPE pipe and fifty 15kg concrete blocks and a few fixings the basic pipework for a mixing system could be installed in the vicinity of the Bumbuna dam in dry conditions. Retro fitting of a perforated pipe system is a much more complex and expensive task, particularly in deep (greater than 30m) water requiring the use of divers. If required, a compressor could be connected and the system can become operational with a matter of days.

Weekly monitoring of surface and bed water temperature and dissolved oxygen concentration would indicate whether conditions of thermal stratification and de-oxygenation were developing.

For short-term use a normal construction plant compressor could be hired and the much larger capital cost associated with the purchase of a compressor deferred until a long-term requirement for the plant was demonstrated.

Reservoir Monitoring

In order to have some means of understanding the behaviour of the Bumbuna Reservoir and the changes that are taking place in the water following inundation, a period of basic monitoring should be undertaken. As an absolute minimum this should consist of weekly measurements of temperature and dissolved oxygen (absolute concentration and percentage saturation) at the deepest part of the reservoir. Initially measurements should be made at 1m intervals in the top 15m and bottom 10m of the water column and at 2m intervals for the remainder of the column. The results should be displayed graphically and used to plan the next week's measurement schedule.

The results of the monitoring will provide basic information on the progress of any thermal stratification and oxygen consumption in the hypolimnion and can be used as an operational tool to manage the quality of the water discharged to the downstream river.

If the use of artificial mixing of the downstream part of the reservoir is considered the results of the monitoring can also be used to monitor the progress of mixing and to optimise the use of the system.

J Primates

Government of the Republic of Sierra Leone

Update of the Bumbuna Hydroelectric Project Environmental Impact Assessment

Interim Report on Primates

Chimpanzee nests, located along the hillside northwest of the Bumbuna dam quarry.

NIPPON KOEI UK
INTERNATIONAL CONSULTING ENGINEERS

in association with

BMT Cordah Ltd

THE ENVIRONMENTAL FOUNDATION FOR AFRICA

UPDATE OF THE BUMBUNA HYDROELECTRIC PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

INTERIM REPORT ON PRIMATES
OCTOBER 2004

Table of Contents

Summary

The primate field study was conducted during August and September 2004, at the peak of the wet season. The study approach was to conduct reconnaissance walks and interviews with informants in communities throughout the Bumbuna reservoir basin. More sophisticated survey methods could not be used because of Bumbuna conditions, which rendered them impractical and/or damaging to chimpanzee habitat.

The principal finding was that there are chimpanzees living in the vicinity of the BHP. The chimpanzees are not present in large numbers, but they are not just a few isolated individuals either. The survey team found physical evidence of at least three communities of chimpanzees living in the southern portion of the project area (two to the west of the Seli River, and one to the east), and received verbal reports of at least two additional communities further north. Because it was not possible to survey the whole project area within the timescale of the EIA studies, the total number of chimpanzees inhabiting the area cannot be determined for certain. However, on the evidence of the chimpanzee groups observed and the nature of the vegetation, it is possible that ten to fifteen groups of chimpanzees utilise the area. The group observed nearest to the dam site was estimated to consist of at least twelve individuals.

These chimpanzees were actually recorded above the future full supply level (FSL) of the reservoir, on both sides of the river. However, they may range around the project area, including visits to the riverine forest at certain times of the year according to food availability, unless the disturbance of human traffic is keeping them away from the vicinity of the river. Observations were also made on other primate species in the project area.

On the important question of whether the project area is ‘critical habitat’ for chimpanzees as defined in the World Bank OP/BP 4.04, the study has concluded that it is not. The reason for this is that the forest has already been disturbed, degraded, and fragmented to the point where the area as a whole is no longer an ideal chimpanzee habitat. That degradation has included the clearance of 70% of the forest below FSL in 1992.

The potential impacts of completion and operation of the BHP on the chimpanzees of the project area have been considered as follows:

- It is unlikely that chimpanzees will be drowned at inundation because the water level will rise slowly. However, the prior removal of large trees, as recommended in the EIA report, would help to prevent the isolation of chimpanzees in the rising water;
- Filling of the reservoir may remove part of the chimpanzee’s range, and at the same time cause further degradation of chimpanzee habitat as the area used by humans is reduced and local people move their activities into formerly marginal forest fragments. This is the classic habitat ‘squeeze’ that is often associated with major developments;
- A consequence of habitat ‘squeeze’ is to bring humans and chimpanzees into closer proximity, with an increased likelihood of conflict in both directions (i.e. hunting by humans, and crop-raiding or physical attacks by chimpanzees).

However, the advent of the BHP should actually provide the opportunity to improve the conservation of those chimpanzees that remain in the project area. The mitigation measures that have been recommended for conservation of the chimpanzee population include:

- Long-term monitoring of the chimpanzee population;
- Declaring the most important chimpanzee habitat(s) as protected area(s);

- Improving chimpanzee habitat by the management of adjacent areas, including reforestation, and encouraging corridors that connect to other chimpanzee habitats;
- Creating local public awareness of all aspects of the chimpanzee population;
- Encouraging the development of the BHP as a centre for ecotourism and chimpanzee research, with the beneficial after-use of the construction camp; and
- Improving chimpanzee conservation in suitable habitat(s) outside the BHP area.

Finally, the conduct of further field studies on the Bumbuna chimpanzee population has been recommended over a period of one year. This will enable their numbers, distribution and movements to be better defined, and provide the information needed to elaborate on the above mitigation measures during implementation of the project.

1. Introduction

This report presents the Primate Assessment conducted as one of several additional studies carried out for the Bumbuna HydroElectric Plant Environmental Impact Assessment in 2004.

The approach to the work was described in the NKUK proposal, and in summary this was to:

1. Establish whether there are any chimpanzees inhabiting the forests of the project area.
2. If chimpanzees are found to be present, conduct a survey to determine the distribution and population estimate of chimpanzees (and other primates). The survey was to include informal interviews, recce (reconnaissance) walks, transect surveys, and the use of camtrakkers for phototrapping.
3. On the basis of the results collected, describe the existing status of the primate populations and determine the potential impacts of the HEP.
4. The update of the EIA would then include a management plan for the immediate catchment area and include recommendations for appropriate actions needed for conservation of the resident chimpanzee population and the maintenance of its sustainability. These actions might include establishment of corridor(s) to newly recognized protected areas or possible translocation to a suitable area.
5. Any proposed mitigation should be recommended only upon the advice of Primatologists and carried out with the support of the government of Sierra Leone.

2. Background

2.1 Overview of Chimpanzee Behavioural Ecology

Chimpanzees (*Pan troglodytes*) are an endangered species (IUCN, 2003). Currently, four subspecies are recognised: *P. t. troglodytes*, the Central chimpanzee; *P. t. schweinfurthii*, the Eastern chimpanzee; *P. t. verus*, the Western chimpanzee; and *P. t. vellerosus*, the newly recognized East Nigeria-West Cameroon chimpanzee. All are listed as endangered at the subspecies level. Of particular concern are the two subspecies ranging across West Africa, *P. t. verus* and *P. t. vellerosus*. Chimpanzees are found in a wide array of habitats. They may be found in very dry savanna mosaic/woodlands, high tropical rainforests, or riverine gallery forests. They are generalist feeders; throughout the year, chimpanzees select the flowers, seeds, fruits, piths, sap, and leaves from many plant species as they become available. This seasonal pattern is further influenced by annual variation in the availability of mammal or insect prey.

A gregarious species, chimpanzees typically live in large multimale-multifemale communities. They have a "fission-fusion" society. This means that, unlike most other primate species, chimpanzees do not travel in one large unit. Instead, they congregate and travel in parties (or sub-groups), and the community may never be observed together. Some parties may consist of mostly adult males. These may often include oestrous females and thus sexual competition may be evident. Frequently, a clever male may persuade an oestrous female to travel away from the rest of the males on a sexual "consortship," thus monopolising her time and increasing paternity assurance. Other parties contain mothers and their offspring, not interested in sex and less interested in covering the large distances often traversed by parties of males. On rare occasions, a solitary chimpanzee may appear to travel alone. Thus, it may take careful study (and perhaps a level of habituation) to identify how many individuals make up a particular community and to determine the male (and female) dominance hierarchy. Several factors influence how large a community may be. Some small forest fragments are home to as few as 12 chimpanzees, whereas the largest known community boasts more than 100 (D. Watts, personal communication).

Chimpanzees sleep in nests they construct by bending branches into a round bed of comfortable leaves. Each independent (i.e., juvenile and older) chimpanzee makes a nest every night and, on occasion, some chimpanzees make "day nests" for napping. Nightly nests are usually new constructions, though often chimpanzees will choose an old nest and add a few new leaves/branches to make it more comfortable. Females tend to make nests higher in the tree than males; dominant males tend to have large nests located lower to the ground than all others in the community (Plumptre & Reynolds, 1997). Nests provide a large, obvious piece of evidence that chimpanzees are in an area. Researchers use special methods to count them, estimate their ages, and use these figures to calculate population densities (see below).

As a general rule, male chimpanzees live out their lives and die in the same community where they were born. They do not emigrate. Therefore, they tend to have strong bonds with other males in the community (likely to be their fathers, uncles, brothers, cousins). For this reason, although there can be testy competition over females and food resources, the males in a chimpanzee community tend to be tightly bonded and may be seen spending hours in social grooming (Goodall, 1986; Nishida, 1990). They also hunt together; about 4% of chimpanzee diet is meat from monkeys or other mammals. Led by an alpha male (with a fairly strict hierarchy that includes the political drama surrounding occasional threats of a "coup"), males aggressively defend their territory. When chimpanzees of one community meet chimpanzees of another community (when borders are breached or they happen to overlap), fighting may erupt and this can have deadly consequences. Lethal wounds have been reported at a number of chimpanzee field sites (Goodall, 1986; Nishida, 1990).

Female chimpanzees, on the other hand, may choose to transfer between communities. They typically do this during adolescence and do so successfully only when exhibiting an oestrous swelling; females that attempt to transfer when not in oestrous may be attacked. Oestrous swelling lasts for approximately 12 days of the 36-day cycle. These cycles and other reproductive events have been found to have seasonal fluctuations, probably related to diet (Wallis, 1995, 2002). First pregnancies are often unsuccessful, twin births are rare, and interbirth interval is approximately 5.5 years (Wallis, 1997). Thus, in addition to many pressures threatening the future of chimpanzees in the wild, their rate of natural replacement is low.

2.2 Sierra Leone and Chimpanzees

Some scholars believe that the first chimpanzees to be described from early western exploration of Africa originated from what is now Sierra Leone. Hanno, the Carthaginian, was said to encounter these apes along the coast during his travels some 2,500 years ago (see description in Richards, 2000). Although the local people called them "gorillas," the description of their appearance and behaviour, combined with information of Hanno's likely travel location, suggest that these were indeed western chimpanzees (*Pan troglodytes verus*). Thus, Sierra Leone holds a special place in history with respect to the chimpanzee. The business of supplying chimpanzees for the medical industry (mostly done in the 1970s, but halted in the 1980s) is another - less positive - aspect of the country's international reputation with respect to apes.

Currently, very little is known of the numbers of wild chimpanzees remaining in Sierra Leone. Hanson-Alp et al. (2003) contributed to the recently completed "West African Chimpanzee Action Plan," calling for an urgent need to survey the country and establish protected areas for the apes. There is only one national park in the country and any remaining suitable habitat is rapidly disappearing.

Table I lists the primates of Sierra Leone and their current conservation status as determined by the IUCN "Red List" (IUCN, 2003). As can be seen, chimpanzees, the bay (red) colobus, and the Diana monkey are considered endangered. It should be noted, however, that many years have passed since the country's last primate surveys and hunting has continued since that time. Thus, more studies are needed to verify the precise status of Sierra Leone's primates.

3. Approach

3.1 General

Members of the Primate Survey Team are listed in Appendix A. The period of field work was August 24 – September 12, 2004, and a schedule of the team's activities is provided in Appendix B.

Although the original intention was to use camtrakkers to record chimpanzees and other animals remotely, and to cut line transects through the forest, the nature of the terrain and the fragmented nature of the habitat meant that these methods were inappropriate or could not be used as planned. Additional time was therefore spent on the other survey methods, which included carrying out 10 recce walks and 17 informal interviews (which included input from more than 60 people).

3.2 Informal Interviews

Informal interviews with local inhabitants were conducted to determine the presence of primates (especially chimpanzees) in the area. Specifically, these interviews asked questions related to:

- Local knowledge and awareness of chimpanzees and other primates;
- Locations of chimpanzee nests and feeding sites;
- Information regarding human-animal issues (crop-raiding, hunting);
- Other factors.

3.3 Recce Walks

Reconnaissance walks were used to assess the habitat and to attempt to observe chimpanzees in the areas around the Bumbuna Hydroelectric Project. The team aimed to spend an equal amount of time on either side of the river. Some of the recce walks were chosen to survey the forests in the vicinity of the dam site, and others were chosen based upon information gathered during the informal interviews. During these walks, direct and indirect observations were made of chimpanzees and other primates.

Specifically, records were made of:

- Sightings;
- Vocalizations;
- Footprints (and knuckle prints);
- Faeces;
- Evidence of food use;
- Chimpanzee nests (with data collected on approximate age of nest, height in tree, etc.).

Information on vegetation type, human disturbance, or other activities was also collected. This assessment helped to indicate which parts of the study area may be suitable for chimpanzees and other primates and was used to estimate the number of chimpanzee communities present.

4. Existing Situation

4.1 Interpretation of the Survey Data

As indicated in Figure 1, recce walks and informal interviews were carried out in the northern and southern parts of the Bumbuna HEP area. Table II provides the key information taken from the recce walk data sheets, Table III describes sightings of primates reported by the primate team outside the recce walks (supplemented by reports from the Forestry Team), and Table IV lists selected information from the informal interviews. Locations of the recces and interviews are illustrated in Figures 2 and 3.

The survey work found physical evidence of at least three communities of chimpanzees living in the southern portion of the affected area (Tables II and III), and verbal reports suggested that there are at least two additional communities in other areas nearby (Table IV).

On the west side of the Seli River, one chimpanzee community (a.k.a., “Dynamite Community”) lives in the forest ridge that runs above the rock quarry and dynamite storage building; another lives west of the village of Kakutan. East of the river, the team found nest evidence of one community living north/northeast of the village of Waia.

Based on statements from a number of individuals interviewed by the team at the northern part of the reservoir, there appear to be no chimpanzees living in that particular area. The team was informed, however, that there were chimpanzees in the south and east, so more effort was expended in this area (Figure 2). In the north, several people referred to the area where the rivers meet, so there may be at least one community living south/southeast of the confluence of the River Seli & the River Mawaloko. A report of a chimpanzee killed by a Masumarandugu resident suggests that yet another community may be near that village (Table III).

Combining the three areas with physical evidence and the two areas described in the informal interviews, this means that there are at least five chimpanzee communities, plus probably others on the un-surveyed land. Without an assessment of the habitat in that area, it is not possible to give an accurate figure for the chimpanzee population density. If the condition of this land is similar to that of the areas surveyed, then there could be as many as 10-15 communities of chimpanzees in the Seli River Valley as a whole. Such an estimate should be used with caution however, due to the lack of complete information about the habitat.

A number of other primate species were found in the area (Table II and III). Old World monkeys (Cercopithecidae) may be sub-divided into to sub-families, the Cercopithecinae and Colobinae, which have different relationships with humans. In general terms, the Cercopithecinae are considered “cheek-pouch monkeys”; they have the ability to store food inside their cheeks (much like squirrels) and typically have a very flexible diet of fruits, leaves and other plant parts, and even some animal products. Because of their variable diet, tendency to be more terrestrial, and ability to store food "for later", the Cercopithecinaes are more likely to be crop-raiders. Colobinae, on the other hand, are often called "leaf-eating monkeys." They have a chambered stomach adapted to allow digestion of the large amount of leaves found in their diet. Consequently, Colobines are less likely to be crop-raiders, spending more of their time high in the trees.

Several Cercopithecine species were observed or heard by the primate survey team; vervets, mangabeys, patas, spot-nosed monkeys, and Campbell's monkeys were found in various parts of the surveyed area (Figure 2) and are likely to occur in the non-surveyed areas, as well.

Although the informal interviews provided reports that black & white colobus are in the Bumbuna HEP area, no sightings by the team were recorded. Because their skin is highly sought after for use in society ceremonies, it is very likely that this species is on the decline in the Bumbuna area. Of particular concern is the apparent absence of the endangered bay colobus (red colobus; *Procolobus badius badius*). Historically, the red colobus was found throughout much of northern Sierra Leone (Jones, 1998), so it was expected that this species would be encountered during the survey. Recent hunting pressures on this subspecies (J. Oates, personal communication) and others living elsewhere in Africa have resulted in widespread concern for the red colobus monkeys (A. Rylands, personal communication).

4.2 Estimating Population Density from Nest Counts

A standard chimpanzee "census" uses a strict method of line transects to count nests and record other evidence of chimpanzee presence (Tutin & Fernandez, 1984). The typical situation involves having a forest block (identified as such by satellite imagery or at least known to be a relatively intact, homogeneous forest) from which sample transects can be used to calculate density for the whole area. An accurate method requires researchers to first assess the "decay rate" of nests for that particular habitat. Different habitats can have different decay rates, and nests may decay faster during one time of year vs. another (Plumptre, 2003). Plumptre and Reynolds (1996, 1997) developed a comprehensive method to monitor nests on a transect line and record their gradual decay. Using this simple technique, they found that some chimpanzee nests can take as long as 120 days to completely disintegrate. Thus, decay rate should be established prior to conducting a detailed census and the preferred method for doing this is the "marked nest" method (which can take 3-4 months to complete) (Plumptre & Reynolds, 1996, 1997). For a "typical forest block", therefore, once a team has assessed nest decay rate, they can then assess nests in several transects and use these data to calculate the density for the whole block.

In the case of Bumbuna HEP, however, the habitat is highly fragmented and degraded, so it is not possible to survey one forest fragment and use that information to calculate the population density of the entire area. To do so would result in a figure that would be much too large – an overestimate of the number of chimpanzees that can possibly live in such a degraded area. Moreover, although the recce walks conducted in the Survey provided estimates of the nest ages, these could be based only on a very general description (e.g., “fresh”, “recent”, “old”, and “very old”). Time did not allow proper assessment of nest decay rates, because local decay rate must first be assessed and this may take several months, as noted above.

In addition the standard method of cutting line transects was not appropriate in this survey mainly because of the condition of the habitat; further damage should not be inflicted on already fractured forest patches by cutting large transects. If further work is conducted in order to estimate the chimpanzee population in more detail (see below) this should adopt an approach of using a modified transect method and recce walks, combined with measurement of all forested areas in the vicinity.

To survey chimpanzees in this area in the level of detail required to design mitigation in full, it would be necessary to determine whether the various parties of chimpanzees identified (directly or indirectly) are, in fact, separate communities or whether adjacent parties are members of the same community. This information will aid in fully assessing how much pressure each community is under and to determine whether any communities are in need of translocation to another site. For example, is the community living near the rock quarry part of the same community that ranges west of Kakutan? Probably not; there is probably too much distance and too much patchy farmland between the two. Without further study, however, it is not possible to determine whether there may be movement between the two areas. Moreover, it is not possible to know if the group of six chimpanzees (seen near the quarry) represents the full extent of a small fragment community - or whether this is a small party of six from a community of, say, 45. Determining the answers to these questions would require several months of fieldwork, which is outside the scope of the present work.

Although a complete chimpanzee population estimate is not possible for this area (as explained above), for the three locations where chimpanzee nests were observed, the following assessments may be made:

Dynamite Ridge – The area to the west-northwest of the quarry and dynamite storage area was found to have a large number of chimpanzee nests, ranging in age from fresh (N=10) to rotten. From a very liberal assessment, using only the “fresh” nests, it is likely this community has at least 12 chimpanzees. A nest that is judged to be small typically indicates that it was built by a juvenile, and juveniles tend to start building nests when their mothers already have a newborn. This estimate assumes that all fresh nests were built on the same day, all community members were travelling together, and none of the nests were “day nests”. Some of these may not be correct, so the estimate should be viewed with caution. It is more likely that the 10 fresh nests were not actually the same age and were probably built by a sub-set (party) of a larger community. The forest area along this ridge appears to be substantial enough to support a community of 12-24 individuals.

Near Kakutan Village – Many chimpanzee nests were found in the forest northwest of Kukatan (see Figure 2). None of the observed nests was considered “fresh”, but there were seven considered “recent” (still with some green leaves, probably built during the previous two weeks). Local interviews confirmed a strong presence of chimpanzees, and the survey team assessed this as a very suitable habitat. The lack of fresh nests seen during the recce may suggest that the chimpanzees of this community were travelling elsewhere during that time.

Near Waia Village – Only two very old (rotten) nests were seen in this area. Village interviews suggest a decrease in chimpanzee sightings over the years. Depending on the forest cover, it may be that there are fewer chimpanzees found in the southeastern part of the affected area than should be expected.

4.3 Seasonality and Chimpanzee Ranging Behaviour

As noted earlier, chimpanzees are very seasonal in their dietary and ranging patterns. For this reason, data collected over a longer period would help to fully ascertain the chimpanzees’ use of the Bumbuna HEP area. For example, there were several very suitable chimpanzee fruit trees (i.e., tree species well known to be used by chimpanzees) found growing in the gallery forest along the Seli River, near the dam site. However, these fruits will not be ripe until March/April. Thus, the fact that no evidence of chimpanzees was recorded in that particular area during the survey does not mean that chimpanzees will not be using the area in March/April. A survey provides only a snapshot in time; it cannot provide a complete picture of how (and when) the chimpanzees use the affected area and how the loss of this area will affect their lives.

It should be noted, however, that the same species of tree were seen on the hillsides – containing chimpanzee nests. This may indicate that human activity along the river is preventing the chimpanzees from using those trees for nesting. It is not known, however, whether their seasonal use of the trees (for food) has been affected by humans, though it will clearly be affected by the elimination of the trees.

5. Possible Impacts of the HEP on Chimpanzees

5.1 Danger of Rising Water

The completion of the Bumbuna HEP scheme will affect the chimpanzees in a very obvious way: rapid rising of the river water will be perilous to any terrestrial animal (or arboreal animal left in standing trees). However, according to several representatives of the HEP consultants and contractors the river water will be allowed to rise gradually. If this is the case, and if large trees are removed prior to the onset of inundation, the risk of actually drowning wildlife should be minimized.

5.2 Further Degradation of the Habitat

From the data collected it is clear that the chimpanzees in the Bumbuna HEP area are under great pressure from human activity. Much of the damage to the environment has been done through unmanaged farming throughout the area. Most of the once-forested hillsides are now patchy mosaics of forest fragments, cropland, and abandoned cropland now covered with tall grass. Additional pressure will come with the completion of the dam and filling of the reservoir; as less land is available for human use, farmland will increasingly encroach upon the remaining forest fragments, resulting in less useable space for the chimpanzees and unavoidable clashes (see below).

5.3 Human-Wildlife Conflict

The problem of forest fragmentation and resulting human-wildlife conflict is ubiquitous in primate habitats around the world (Marsh et al., 2003). For example, in Uganda, uncontrolled development of a sugar plantation has left many forest fragments separated from the main forest block of the Budongo Forest Reserve (Reynolds et al., 2003). Several of these tiny fragments contain chimpanzees – physically isolated from other members of their species (Wallis et al., 2004). Predictably, when chimpanzees live in a small forest surrounded by readily available crops, inevitable human-wildlife conflicts arise. Farmers constantly complain that the chimpanzees (and other primates) raid their crops. As a result, several chimpanzees in Uganda have lost their lives either directly (through trapping or spearing) or indirectly (accidentally caught in the fires used as part of sugarcane harvesting) (see Munn & Kalema, 1999-2000). These events are regrettable tragedies in Uganda and conservationists are working with local people to ease the tensions and protect the apes. Ugandans appear to abhor the thought of eating apes; most people resort to killing them only as a means of defending their crops. In Sierra Leone, the situation is much more serious; there is little indication that Sierra Leoneans in the Bumbuna area have a taboo against eating primates. Indeed, there was substantial evidence that all primates in the area are readily hunted for the meat and, in some cases, their skins (Figures 4 & 5). When adult primates are killed, their young are often taken alive to keep or sell to others, thus producing the additional health and sanitation problems of keeping primates as “pets” (Figure 6).

Though there are claims that few guns are still owned by people in Sierra Leone, eleven freshly spent cartridges were found by the survey team and one gun shot was heard during a recce walk (Table II). Reports of at least two recent killings of chimpanzees were noted in the informal interviews; a man in Waia claimed to know someone from Masumarandugu who killed a chimpanzee last month and the team was shown a smoked chimpanzee arm at the village of Kakutan (Figure 7; Table IV). In both cases, a gun was used. These reports underscore the clear danger the chimpanzees already face in the area.

More often, however, hunting involves the use of wire snares. Countless snares were encountered during the surveys in the riverine forest (and in upland forest fragments) and several of the people interviewed stated that they eat any primates caught in this way (Figure 8). Though chimpanzees are probably too strong to be killed in such snares, they are at risk of being injured by them (Waller & Reynolds, 2001). Figure 9 illustrates the effects of chimpanzees accidentally ensnared by traps set for duikers (in

Uganda). As the chimpanzees try to pull away from the snares, the wire cuts into the tendons or digits, leaving them maimed for life. The frequent finding of snares in the forest suggests that chimpanzees in this area are likely to suffer snare injuries.

The dangers of human-wildlife conflict are not limited to chimpanzees; humans can be at risk when living in close proximity to the apes. In both Uganda and Tanzania, there have been several substantiated reports of human adults being attacked and human infants being killed and at least partially eaten (Wallis, personal observation). Richards (2000) noted several similar reports of human-chimpanzee conflict in Sierra Leone. He described stories of babies being snatched at the edge of the forest, while mothers tended to their farm work and young children being "mugged" by chimpanzees while walking through the forest. Such stories are real and have been reported in countries all across Africa. Although this particular problem was not reported during our interviews with people in the Bumbuna area, the possibility exists and should be taken into account when considering the potential consequences of forcing humans and chimpanzees to share a shrinking habitat. Unless measures are taken to reduce further encroachment, completion of the scheme threatens to escalate human-wildlife conflict in the area.

6. Possible Mitigation Measures

6.1 Rationale

Because there are chimpanzees in the Bumbuna HEP area that may be adversely affected by the completion of the reservoir, care must be taken to reduce the negative impact. The work conducted to date has identified at least five chimpanzee communities in the area around the reservoir site, and the likelihood of several others. As the area is very large, the habitat very degraded and fragmented, and a number of chimpanzee communities are in the area, there may be more than one solution for mitigation. For example, for a community of chimpanzees that is only minimally affected by the HEP the recommended action may involve simply monitoring the area and working with the local people to reduce pressure on the remaining forest in their range. At the other extreme, other communities may be already under such great pressure from nearby human activity that the HEP will lead to their eventual demise. In that case, translocation of this community may be recommended. These and other measures are described below.

6.2 Monitoring only

It is possible that some chimpanzee communities in the area could be unaffected by the completion of the HEP. In those cases, the most appropriate action may be to simply monitor those communities and their habitats through ongoing ecological surveys. If researchers have a general (and known) presence in the area, and carry out routine discussions and sensitization programmes with the local people, this may help reduce further pressure on the habitat (Marsh et al., 2002).

6.2 Establish protected status for specified habitat

It is more likely that chimpanzee communities in the area will need more protection than simple monitoring. Establishment of special protected status, such as “nature reserve” or “forest reserve” could be recommended in this case. This will add a level of power, backed by law enforcement by local leaders, to aid chimpanzee protection. In addition, such a plan could create local jobs and increase status for the designated areas.

6.3 Develop reforestation programmes and/or corridors

In some instances, protection alone is not enough to ensure long-term survival of a chimpanzee community. In this case plans for reforestation, to rehabilitate the habitat and enlarge the suitable vegetation available, may be recommended. This suggestion would require further study to determine which areas are the most appropriate to expand, which tree species are most appropriate to use for rapid growth, and whether tree patches can be joined together with planned plantings and corridor development. This suggestion would welcome involvement by the local communities; reforestation would be beneficial to them, too, and proper sponsorship of such a programme can create jobs for local people. For example, a successful corridor development project in Guinea relied on local people to take responsibility for a certain number of trees; they were paid rewards based on how many saplings in their care stayed alive each year (T. Matsuzawa, personal communication).

In the Bumbuna HEP area, such corridor development should be located in the areas that will yield the best results. For example, if the forestry survey has identified relatively healthy patches of forests separated by areas of cultivation, these should be examined as potential sites for corridor development. Careful planning, including working with the local villages, may allow the cultivated areas to return to forest. This would necessarily involve a scheme that relocates farmland and/or replaces lost income from crops.

6.4 Translocation

Unfortunately, it may be that some chimpanzee communities are under such pressure of reduced habitat that their only hope for survival is to translocate them to another area. This recommendation should be considered only if it is deemed absolutely necessary and must occur only under the strict supervision of experts.

Translocation should not be confused with reintroduction. Reintroduction involves taking animals that have been born in captivity or have spent a significant amount of time in captivity (after being confiscated and placed in a sanctuary, for example), and releasing them into a wild setting. Chimpanzee reintroduction has been carried out several times - with varying levels of success. Translocation, on the other hand, involves moving wild animals from one location to another. The translocation of chimpanzees has never been attempted, and it is therefore unlikely to be recommended for this project. The most successful translocations of a large primate have been accomplished in Kenya with baboons (*Papio anubis*) (Strum & Southwick, 1986; Strum, in press). Their success was measured only after many years of monitoring the baboons' adaptation to the environment, birth rates, and causes/rates of death. Strum's model (and personal advice) should be followed if a chimpanzee translocation plan were to be considered. In addition, the IUCN (2002) has developed very helpful guidelines for the reintroduction of primates. Though these procedures focus on reintroduction, most are also relevant to translocation.

If translocation were recommended, a number of factors would have to be considered:

- A detailed study of the chimpanzee community must be carried out to determine precisely how many chimpanzees there are, so that all the community members (and no extras) are collected.
- A careful plan for capturing the chimpanzees must be developed. This will include a combination of trapping (in large, baited cage/traps) and darting. A veterinary expert must be involved in this stage.
- Care must be taken to handle the chimpanzees in a manner safe for them and the humans involved, due to the ease of disease transmission between our species (Woodford & Rossiter, 1994; Wallis & Lee, 1999; Formenty et al., 2003).
- During the time the chimpanzees are immobilised, the opportunity should be taken to collect samples (blood, urine, hair, weights, etc.) to further study the population and obtain baseline health assessments.
- While the community is being assessed, a separate team must be assigned to finding a suitable location for release. This may be a difficult task; most habitats that would be considered as suitable for chimpanzees are likely to already contain chimpanzees.
- The translocated community must be monitored for several years after the movement. Only after several years of study can the success of such a plan be determined.

Before the above-listed mitigation measures are put into place, more information should be obtained about human use of the area, the habitat, and the chimpanzees. Any recommended action should take place only with the full cooperation of the government of Sierra Leone and under careful supervision and advice from primate experts.

7. Recommendations

The Primate Assessment Survey shows that the Bumbuna HEP area currently does not fit the World Bank's definition of critical habitat for chimpanzees; the area is highly degraded and fragmented, which is not the preferred habitat for a healthy chimpanzee population. It is likely that only a few years ago, the entire Seli River valley was a lush and highly suitable chimpanzee habitat. If the contents of the hillside forest fragments and the riverine gallery forest are an indication, the area should have once contained many primates and other mammals. This is no longer the case. Human settlements and their associated farmland have grown unchecked, resulting in severe fragmentation of the natural habitat. In other words, using the terminology of the World Bank's OP/BP 4.04, significant conversion and degradation of the affected area has already occurred prior to the completion of the HEP. The Bank's policy states that it does not support projects that involve the significant conversion or degradation of critical natural habitats, and the conclusion from this study is that this project is being conducted in an area that has been already converted. The scheme can therefore be completed and operated without damaging critical natural habitat.

It is clear, however, that completion of the scheme will remove some suitable chimpanzee habitat. In addition, some human homesteads and farmlands will be affected and these will probably be moved up the hillsides – thus encroaching further upon the chimpanzees' habitat. More encroachment means more pressure, which can lead to devastating human-wildlife conflict (as discussed above). However, because the World Bank promotes the rehabilitation of degraded natural habitats (OP 4.04, 3), it has the opportunity to improve the chimpanzees' fate in this area by supporting the recommendations of this study and, at the same time, still providing the benefit of electricity for the human population of Freetown.

The following specific recommendations are made as a result of this study:

- **Establish long-term ecological monitoring of the affected area**. As recommended in the original EIA, monitoring of flora and fauna should begin immediately and continue throughout the period of the HEP completion and for at least the first three years of HEP operation. This should be combined with an appropriate land management programme (as recommended by the forestry section of the EIA), to include strategic habitat retention and post-development restoration (as per the World Bank's, OP 4.04). Ecological monitoring is relevant to many aspects of the EIA and is especially applicable to the assessment of primate populations in the area.

- **Conduct a more detailed primate census to ascertain the population density of chimpanzees and other primates living in this area**. This work is a necessary supplement to the above-mentioned ecological monitoring, and is required to enable the mitigation measures identified above to be planned in detail. Data should be gathered over the course of at least one full year in all parts of the HEP area. Briefly, the budget and programme should include:
    a. Aerial photographs of the catchment area. These will aid in assessing the habitat and help determine suitable sites where modified line transects could be conducted.
    b. At least two field teams, working simultaneously on either side of the river. This will maximize the amount of work that can be carried out in the span of one year. Using the marked nest method, nest decay rates can be determined during the first few months so that a reliable population density of chimpanzees can be calculated for the entire area. Data collection over the span of one year will show land use by all primates in the area as seasons change.

c. Training of personnel. This will include detailed instruction in census data collection, use of field equipment, and necessary information related to potential translocation, health monitoring, and behavioural data collection.
d. A base of operation should be maintained at the Salcost camp site, and in the dry season the field teams should operate from mobile field camps to maximise time spent in the field.
e. In coordination with the field survey, an education programme – based on sensitization about wildlife and conservation issues – should be carried out with the human residents of the area. As most of the villages have no schools, this can serve as an important first step in developing educational opportunities for young people in the area.

- **Clear the largest trees in the area to be inundated.** As recommended in the original EIA, this measure will help to reduce decay in the reservoir water supply as well as to deter wildlife from using the area. It is assumed that if the area to be inundated becomes less attractive to animals, this may reduce the likelihood of drowning animals during the time of filling. This issue is especially important as it relates to chimpanzees. These apes can spend as much as 12 hours in their nightly nests. If the water level rises rapidly, it is conceivable that chimpanzees (and other primates) will be stranded in trees. If large trees are removed and the water level is allowed to rise slowly, however, this will aid in reducing possible drowning of wildlife (especially chimpanzees). The clearing of trees must be conducted in a systematic and closely monitored manner to minimise stress on animals in the area.

- **Establish protected status for the forest ridge near the camp site.** Establishing a protected area will, in effect, protect the "Dynamite Community" of chimpanzees living above the rock quarry and secure their habitat from further encroachment. The exact dimensions of the area to be protected should be determined through more detailed study of the chimpanzees' range.

- **Establish national parks and protected areas containing suitable chimpanzee habitats in other parts of Sierra Leone**. While working to minimize further habitat loss in the affected area, this action will support the World Bank's own policies of "establishing and maintaining an ecologically similar protected area" (OP 4.04). Specifically, the areas of the Goma Mountains and the Loma Mountains have been suggested as excellent habitat for chimpanzees. These should be properly surveyed and protected.

- **Designate the Salcost camp site as a satellite campus of the University of Sierra Leone.** The government of Sierra Leone should take this opportunity to use the Salcost camp site for the benefit of people and wildlife of the country, once the dam is operating. Although there may be a small presence of HEP personnel remaining on site as part of the ongoing operation, it appears likely that there will be a number of empty buildings available when the HEP is operating. The site is well situated to serve as a "Field Station" that can offer courses in environmental sciences, conservation biology, and animal behaviour. In addition to opening this opportunity to the students and faculty of USL, it would be highly beneficial to welcome students and visiting lecturers from other countries. Students and visiting researchers will be able to study the nearby primate populations (including chimpanzees), as well as other fauna (and flora) in the area. A portion of the site can be allocated for tourism use – thus providing additional means of generating both income and national and international recognition of the site. Although not yet appreciated in Sierra Leone, the economic impact of primate research and primate tourism in other countries is quite impressive (Wallis & Mittermeier, 2004). Moreover, this plan would create jobs for local people and provide a base of operation for the ecological monitoring and land management programmes recommended above, thus aiding the World Bank's stated policy to rehabilitate degraded habitats.

8. Conclusions

The results of the Primate Assessment indicate that there are at least five chimpanzee communities living near the Bumbuna HEP, with the likelihood that many more may be in the areas not yet surveyed. Though the Seli River valley and surrounding hills are not deemed critical habitat for chimpanzees, it is clear that the completion of the scheme will remove some areas of suitable habitat and lead to further potential for human-wildlife conflict.

Measures recommended to mitigate the impacts of the scheme are:

- long-term ecological monitoring;
- protection of existing forests above the planned waterline;
- improved land management so that some areas are allowed to return to forest and create corridors linking fragments;
- education and sensitization with respect to farming practices and avoidance of human-animal conflict; and
- monitoring, protection, and/or possible translocation of chimpanzees, based on the community-specific needs determined from a detailed primate survey of the area.

Further survey work of at least a year in duration is necessary to enable these measures to be designed in detail.

The chimpanzees in the Bumbuna HEP area are under great pressure even without completion of the dam and filling of the reservoir. Without the plans for the HEP, habitat destruction and hunting would surely continue to a point of eradicating all chimpanzees from the area. However, with the PIU's attention to a primate survey and careful mitigation measures being planned, it is quite possible that the Bumbuna HEP can actually be a positive outcome for the chimpanzees and other primates in the area. If these activities are assured (detailed survey and action upon these recommendations), then everyone wins: people are provided with electricity, chimpanzees stay safe.

Based on the information provided by the HEP consultants, it appears that the filling of the reservoir will not begin for another 18 months. If this is true, there should be sufficient time to carry out the one-year survey of the chimpanzees so that the recommendations for mitigation suggested above can be designed.

In conclusion to this study we do not recommend stopping construction of the HEP. In fact, we suggest that the PIU conduct a more detailed survey and carry out recommended mitigation measures as soon as possible to avoid any potential delay in HEP construction that relates to the presence of chimpanzees. A delay based on the chimpanzees could have disastrous results. Simply put, we fear that if word came to the people of Sierra Leone that they may lose their long-awaited ability to have electricity because outside sources want to protect the chimpanzees, the local population may take it upon themselves to escalate killing of the chimpanzees (i.e., "if the presence of chimpanzees means the project has to end, the absence of chimpanzees may mean the project can continue"). By taking timely action as described above, the PIU can both protect and enhance the chimpanzees' habitats, which might in time lead to an increase in the chimpanzee population in the affected area.

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Table I. The Primates of Sierra Leone. Conservation status information is taken from the 2003 IUCN Red List. Lack of recent primate surveys, however, may mean the threat level is underestimated.

Classification & Scientific Name		Common Name	Conservation Status*	In Bumbuna Catchment Area?
Prosimians				
	Galago senegalensis	Senegal galago	-	?
	Galagoides demidoff	Demidoff's galago	-	Yes
	Perodicticus potto	Potto	-	?
Monkeys				
	Cercocebus atys	Red-capped mangabey	LR	?
	Cercocebus torquatus	Sooty mangabey	LR	Yes
	Cercopithecus aethiops	Vervet monkey (green monkey)	-	Yes
	Cercopithecus campbellii	Campbell's monkey	-	Yes
	Cercopithecus diana diana	Diana monkey (Diana guenon)	EN	No
	Cercopithecus petaurista	Spot-nosed monkey (spot-nosed guenon)	-	Yes
	Colobus polykomos	King colobus (black & white colobus)	LR	Yes
	Erythrocebus patas	Patas monkey (red monkey)	-	Yes
	Papio papio (*or P. hamadryas papio)*	Guinea baboon (red baboon)	LR	No
	Papio anubis (*or P. hamadryas anubis)*	Olive baboon	-	?
	Procolobus badius badius	Red colobus (bay colobus)	EN	No?
	Procolobus verus	Olive colobus	LR	No
Apes				
	Pan troglodytes verus	Western chimpanzee	EN	Yes

* EN = endangered; LR = considered at low risk; - = not considered threatened.

Table II. Information Collected during the Primate Assessment Team's Recce Walks.

Recce #	Route	Date	Location Start/Stop (Altitude)	Start /End time	Degradation/ Forest type	Hunting pressure	Comments
Recce 1	From Batching Plant area to the hill northwest of Kasokira village	25-08-04	N 09°05′18" W 011°43'39" (302 m)	1126	Secondary forest, gallery forest, forest patches interspersed with rice farms, Ridge continues to the Dynamite community	Not evident	Though no primates were evident, this is the area where chimpanzees were sighted on Barrie's first visit to Bumbuna
			N 09°04′61" W 011°43'39"	1430			
Recce 2	Visit to farm by batching plant	25-08-04	N 09°04′61" W 011°43'38" (306 m)	1800	Secondary forest, gallery forest, forest patches interspersed with rice farms, Ridge continues to the Dynamite community	1 gunshot heard by 18:56	2 **chimpanzee** nests seen. (This recce was planned after receiving information from a farmer who saw 2 male and 2 female chimpanzees 1 week earlier.
			N 09°05′01" W 011°43'46"	1910			
Recce 3	Start from farm by batching plant to revisit the nest site of the previous day and continued into farmlands	26-08-04	N 09°05′02" W 011°43'39" (314 m)	0700	Secondary forest patch	2 new spent shells collected by Forest assessment team	Revisited the **nest site** and found 1 more rotten nest, fruits of *Uvaria chamae*
			N 09°05′20" W 011°44'28"	1240			
Recce 4	From dynamite store to Kegbema village, farm lands, and directly behind the ridge.	27-08-04	N 09°05′48" W 011°45'46" (322 m)	0700	Mature forest patch along the ridge	Many snares along the farms and village	Followed call of 3 **chimpanzees** and saw 4 (2 adults and 2 juveniles). Counted 29 nests and saw fruiting *Spondias mombin*.

Table II. (continued)

Recce 5	From dam to Waia, on the east side of river.	8-08-04	N 09°04′17” W 011°43’18” (311 m) N 09°07′57” W 011°41’26”	0730 1250	Degraded forest, interspersed with Farms. Mining of gold evident by the forest	Snares along farms	**Chimpanzees** confirmed present on the eastern part of the river, 1 km away from the village.
Recce 6	To Kakutan via Kayakala, to survey the riverine forest.	30-08-04	N 09°05′02” W 011°43’39” (308 m) N 09°09′28” W 011°43’03”	0730 1515	Degraded forest and farmlands, both lowland & upland	Snares and monkey trap shown to team. **Chimpanzee** arm (smoked) seen.	+ 5 Campbell’s seen, arm of a smoked chimpanzee shown to us and the claws of an eagle. + 3 Campbell’s monkeys seen by Bakarr
Recce 7	2nd visit to Waia and to Dulkoroh	31-08-04 01-09-04 (spent night in Waia)	N 09°07′47” W 011°40’21” (441 m) N 09°07′57” W 011°41’26”	1220 1558	Degraded forest and farm lands, interspersed with some secondary forest	3 shells found and snares found	A year ago chimpanzees were living close to the village, 1 **chimpanzee** killed about a month ago, 2 rotten nests seen by Dulkoroh stream area. (Recce was conducted based on interview information.)
Recce 8	Kakutan Village, leading to Kakutan chimpanzee nests	02-09-04 03-09-04 (slept in Kakutan)	N 09°09′28” W 011°43’03” (363 m) N 09°09′55” W 011°44’22”	1135 1834	Good chimpanzee habitat with mature secondary forest and plenty fruiting tree species	Guide showed us where he trapped a red river hog. Traps seen.	Counted **30 nests**. Many fruiting plant species noted.
Recce 9	Batching plant area.	04/09/04	Revisit of batching plant area (274 m)	0730	Young secondary forest with many fruits and palm wine tapping		Revisit of the batching plant area where Driver and Barrie first saw chimpanzees 28-07-04. **Chimpanzee** tracks, trails and signs of feeding observed.
Recce 10* (*not strictly a recce)	Along Seli River, north end near Kafogo	11/09/04	N 09° 23’ 50” W 011° 43’ 47” N 09° 22’ 54” W 011° 43’ 51”	1313 1603	Mostly gallery forest. Suitable habitat for chimpanzees.	Numerous snares found throughout the area	No sign of ANY mammals seen during the entire walk.

Table III. Other Sightings of Primates in the General Area of the Bumbuna HEP

These observations were made either by the Primate Survey Team members when they were not on recce walks and not doing informal interviews, or by other members of NKUK personnel.

Date	Location	Detection	Species	Comments
27-07-04	N 09°05′48” W 011°43’46	Calls	**Chimpanzees**	Seen during the first visit with Paul Driver, Consultants and contractors
28-07-04	N 09°04′00.6” W 011°43’11.9”	Sightings	2 Spot-nosed monkeys	Seen on the east side of the river (with Paul Driver)
28-0704	N 09°04′53.7” W 011°43’34.2”	Sightings	**Chimpanzees** (5+)	Seen on the road by the Batching plant (with Driver). Followed them & saw additional 6, including 1 adult male on palm tree. One spent shotgun shell and 1 chimpanzee day nest seen.
10-08-04	South of the dam	Sightings	Vervets and + 5 Campbells (+15 total)	Observed down stream, south of the dam
26-08-04	Near Kasasi forest	Sightings by Forest team	2 Mangabeys, 2 groups of Spot-nosed monkey (6 individuals)	2 new spent shotgun shells collected.
28-08-04	Near Kasasi forest	Sightings by Forest team	6 Spot-nose monkeys	
01-09-04	N 09°06′18” W 011°42’53”	Calls and sightings	+3 Campbell’s monkey (heard and seen fleeing)	
03-09-04	N 09°06′46” W 011°43’03”	Sighting and calls	1 Mangabey heard (Barrie) & 3 Campbell’s monkeys seen (Bakarr)	Likely the same troop as seen 1/09/04.
03-09-04	N 09°06′54” W 011°43’06”	Sightings by Bakarr	5 Spot-nosed monkeys & 3 Campbell’s monkey	
11-09-04	N 09°27’29” W 011°41’02”	Sighting by team	5 Patas monkeys	Seen crossing the road, far north end of the planned reservoir.

Table IV. Selected Information from Informal Interviews Conducted by the Primate Assessment Team.

Date, #	Location	Coordinates	Number/Name	Species in Area	Comments on crop-raiding or other human-primate conflict
25-08-04 #1	During Recce 1, Section Chief of Kasokira		Sara Koroma - Farmer (50 yrs old); 25 children, 2 wives.	• Have not seen chimpanzees for a long time, but heard them a few days ago in the northwest. • Reported Campbell's, spot-nosed, mangabeys, black & white colobus	• Monkeys raiding farms • Story of chimpanzees uprooting traps
25-08-04 #2	Sara Koroma from Kasokira Village		Alie Turay - Farmer (56yrs old); 2 wives.	• No chimpanzees reported. • Campbell's, spot-nosed monkeys in area.	• Crop raiding by monkeys • Chimpanzees stay away from people
25-08-04 #3	Kadala Village		Sara Turay – Farmer (55 yrs old); 9 children, 2 wives.	• Have not seen chimpanzees for a long time (since SALCOST operations started) • 4 chimpanzees in the last wk-2males & 2 females. • Described other monkeys: mangabeys, spot-nosed, vervets, black and white colobus. • Gave information leading to 3 chimpanzee nests	• Monkeys presently raiding his farms, but not chimpanzees
28-08-04 #4	Waia Village Chief's house, Focus Group Discussions	N 09°07′57" W 011°41'26"	15 people and some women and children led by Jonathan Koroma, a teacher at the primary school	• Chimpanzees present about 1km away near Dulkoroh • Some of the people imitated primate calls. • Black & white colobus in area	• Monkeys and chimpanzees do not like to be close to people now, but were close to village a few years ago. • Black & white colobus used for society rituals

30-08-04 #5	Kayakala Village	N 09°07′47” W 011°43’18”	Chief, son and two others, led by Mr. Edwin Mansaray. Farming- main activity	• About 10 chimpanzees seen in the last 2wks N/W. • Black & white colobus skins used for society rituals. Up to 7 skins per child may be used. • No red or olive colobus. Information on possible Diana was not clear). • Had local names for baboons and red colobus (but this is not clear)	• Monkeys raid crops, but no trouble reported with chimpanzees.

Table IV. (continued)

30-08-04 #6	Swamp (near Kakutan)	N 09°08′59” W 011°42’48”	Sara ? - Farmer	• 2 Campbell’s seen • Confirm the presence of Campbell’s and spot-nosed monkeys. • Chimpanzees said to be far away from here.	• Monkeys raid his rice farm, so it is easy to trap them. Showed his monkey trap to the team.
30-08-04 #7	Kakutan village	N 09°09′29” W 011°43’04”	5 people present, led by Alimamy Koroma	• Spoke of many chimpanzees 1hr walk away, where we later counted 30 nests before dark. (Nest age and placement in tree data, etc, collected by team.)	• Hunted chimpanzees in the past and his brother sold them to SALCOST personnel and in Bumbuna village. • Showed us the arm of a smoked chimpanzee and the claws of an eagle.
31-08-04 #8	2nd visit to Waia village	N 09°07′57” W 011°41’26”	Chief & others including 2 guides, Sulaiman and Salieu Kamara	• Chimpanzees in the area (we were led to 2 rotten nests)	• Report of a chimpanzee killed at Masumarandugu 1 month ago • Monkeys raid crops

31-08-04 #9 (not on map)	Bumbuna Village		11 farmers	• Black & white colobus identified from photos, though it is not clear where they see these. • Chimpanzees said not to be in the vicinity of Bumbuna village.	• Black & white colobus skins used in secret society rituals for boys. • Black & white colobus said to be becoming scarce. • Cane rats and birds said to be the worst crop-raiders, though monkeys and chimpanzees known to raid corn, mangoes, & bananas.
01-09-04 #10 (not on map)	Bumbuna Village		1 hunter	• Chimpanzees identified from photos. • Identified olive colobus and Diana monkeys from photos. However, neither of these species should be found in this area. Hunter's description are suspect.	• Chimpanzee skins said to be used for drums and their teeth are used for initiation rituals for girls.

Table IV. (continued)

02-09-04 #11	2nd visit to Kakutan	N 09°09′29" W 011°43'04"	Chief and 6 others	• Black & white colobus and Demidoff galago present • No Diana monkeys, olive or red colobus • Chimpanzees further away in hills	• Crop raiding mainly by monkeys (chimpanzees are further away in the hills)
04-09-04 #12	Quarry road	N 09°05′25" W 011°43'40"	Karfasewa Farmer and guide	• Chimpanzees, spot-nosed monkey, Campbell's monkey and vervets present.	• Monkeys raiding crops but not chimpanzees
04-09-04 #13	Chief compound	N 09°02′29" W 011°44'40"	Fernando Chiefdom police	• Chimpanzees, Campbell's, vervets and spot-nose present	• Crop raiding by monkeys a problem here

10-09-04 #14	Fulatown	N 09°23′51” W 011°43’37”	15-20, 2 people speaking most of the time	• Chimpanzees were present around Sandiya (but this is 12-15km to the east) • Black and white colobus, vervets, and patas monkeys described in the area. • “Black monkey” described is probably spot-nosed or mangabeys (reports were not clear)	• Crop raiding by patas monkeys a problem here • Monkeys said to be killed and eaten.
11-09-04 #15	On Road from Kabala to Kafogo	N 09°27’29” W 011°41’02”	4 people, including one woman, two children.	• 5 patas monkeys seen, crossing the road and lingering to watch us. • Vervets and spot-nosed in the area, too.	• Major crop raiding a problems reported, said to be ongoing when we were there.
11-09-04 #16	Kafogo	N 09° 23’ 37” W 011° 44’ 03”	15-20 people. Approximately 5 participated in discussion.	• Patas monkey, Campbell’s, spot-nosed monkey, mangabeys were reported to be present in the area. • Chimpanzees were reported to be present around the confluence of the two rivers (far south).	• Monkeys and cane rats described as most destructive to crops • Skin of patas
11-09-04 #17	In forest, east side of river (far north)	N 09° 23”13” W 011°43’50”	2 people.	• Patas, vervets, spot-nosed monkey present. • Chimpanzees present far away (12 km) in the northeast.	• Crop raiding of rice field. • Killed 1 patas about a week ago (in snare). • Many snares found throughout the forest in this area.

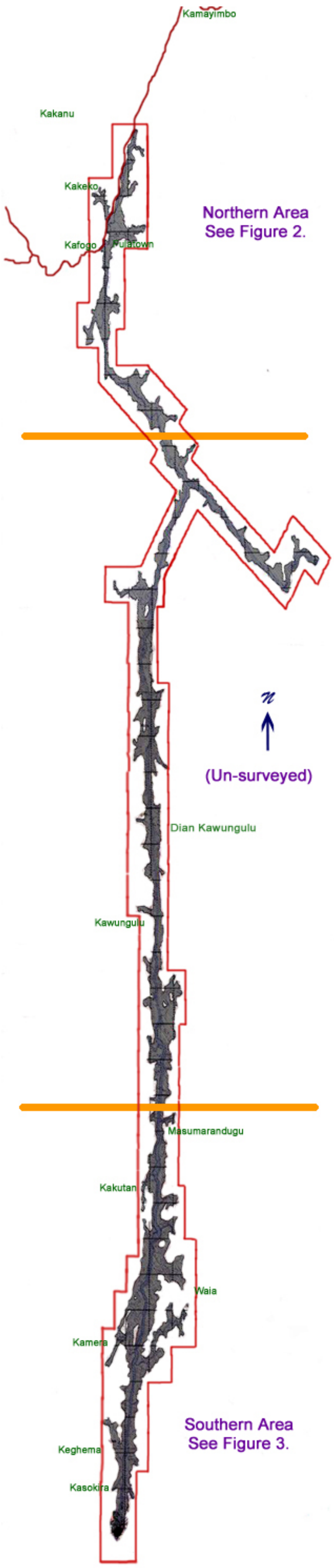

Figure 1.
Map of the Bumbuna HEP scheme. Details of survey and interviews are provided in Figures 2 and 3.

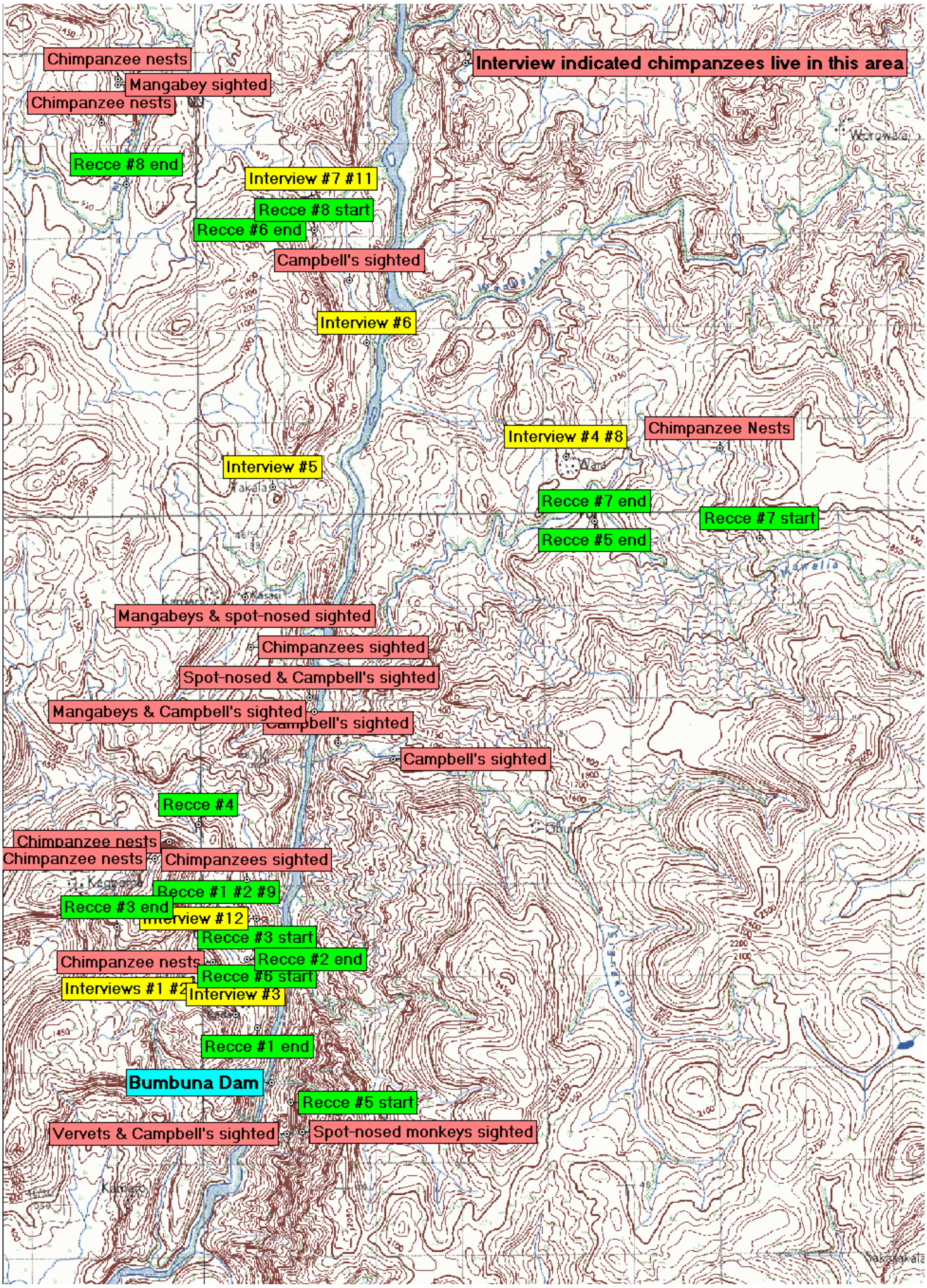

Figure 2. Location of recce walk routes, informal interviews, and additional sightings of primates in the southern part of the Bumbuna HEP area. Data are from Tables II, III, and IV. Note: only the start and stop points of the Recce Walks are illustrated.

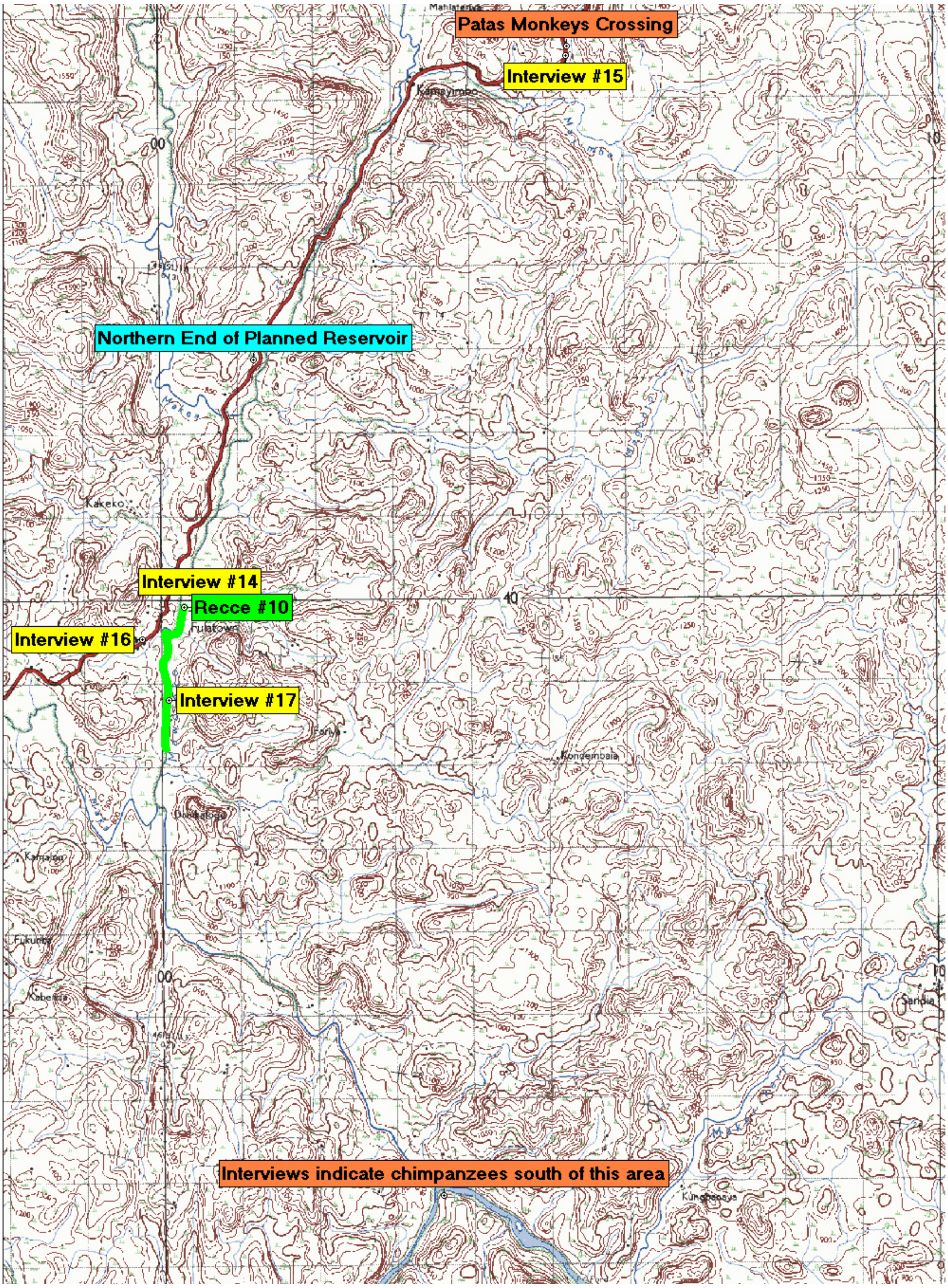

Figure 3. Location of recce walk routes, informal interviews, and additional sightings of primates in the northern part of the Bumbuna HEP area. Data are from Tables II, III, and IV.

Figure 4. A Kefogo resident demonstrates how monkey skins are used in ceremonial (or other celebratory) dance.

Figure 5. Close-up of the patas monkey skin seen in Figure 4. This species, *Erythrocebus patas*, is found in large numbers across the northernmost part of Sierra Leone. It is a gregarious species, often cited as a crop- raiding pest.

Figure 6. This young olive baboon (*Papio anubis* or *Papio hamadryas anubis*) was photographed in the outskirts of Freetown, with his "owner". Though not in the affected area, he represents an issue of great concern to primate conservationists – "primates as pets". The condition of his skin and sparse hair indicate past wounding and/or nutritional deficits. As this youngster grows, he will become intractable and potentially dangerous to his owners. An adult male baboon can grow to be very large (as much as 40 kg) and aggressive. Olive baboons are found in the north/northeastern part of Sierra Leone.

Figure 7. This smoked hand was from a chimpanzee said to have been killed near Kakutan.

Figure 8 (above). Our Kefogo guide demonstrates how snares are used to trap forest animals. This snare, located on the east side of the Mawoloko River (south of Fulatown), was one of many encountered during the primate survey.

Figures 9a & 8b. Due to such snare use as indicated above, it is highly likely that the chimpanzees of the Bumbuna region will be found to have snare injuries. For example: these two chimpanzees of the Budongo Forest Reserve (in Uganda) show the devastating results of snares. This female (a) accidentally walked into a snare that entrapped her right hand. In her struggle to free herself from the snare, the tendons in her wrist were severed, resulting in a complete loss of control of her fingers – now mangled for life. The male in (b) was caught in a snare in October 2000. All four fingers on his right hand were ensnared and it took several weeks for him to loosen and remove the wire. In the end, he lost two fingers, as can be seen in the photo.

Appendices to Primate Report

A. Primate Assessment Team Members

B. Schedule of work for the Primate Assessment Team (August 24-Sept 11, 2004)

APPENDIX A
Primate Assessment Team Members

Adbulai Barrie – TEAM LEADER (Local Primatologist)
- M.Sc. Environmental Biology, Njala University.
- Experience with chimpanzee work in Western Area Forest Reserve, Tiwai Island Wildlife Sanctuary, and Outamba-Kilimi National Park (OKNP)
- Assistant Research Coordinator, Tiwai Island Sanctuary Project

Ibrahim Bakarr
- B.Sc. Zoology, Fourah Bay College, University of Sierra Leone. Dissertation Topic: The Impact of Habitat loss on the Mammalian Fauna in the Fourah Bay College Botanic Reserve.
- M.Sc. Candidate. Thesis topic: Reassess Primate Population on Tiwai Island.
- Participated in Great Ape Project and Wild Chimpanzees survey on Tiwai Island

Asame Kabasawa
- B.A Anthropology, Hunter College CUNY, New York
- M.Sc. Primate Conservation, Oxford Brooks.
- Experience with chimpanzees field work in Guinea
- Currently managing role at Tacugama Chimpanzee Sanctuary, Freetown

Minah Conteh
- Assistant Project Officer: Tiwai Island Wildlife Sanctuary.
- Experience in field research on Tiwai and OKNP.
- Participated in Great Ape Project and wild chimpanzee survey

Alie B Fofanah
- BSc (Hons) Environmental Sciences, Applied Ecology, University of Sierra Leone
- Field Assistant, Tiwai Wildlife Sanctuary Project
- Participated in great ape training and wild chimpanzee survey on Tiwai Island

Rashida Dumbuya
- Third Year Environmental Sciences student, Njala University College
- Field visits to Western Area Forest Reserve, Tacugama Chimpanzee Rehabilitation Sanctuary and Tiwai Island Wildlife sanctuary

Janette Wallis, Ph.D. – International Primatologist
- Ph.D. – University of Oklahoma, USA
- Field experience with chimpanzees in Tanzania (Gombe Stream Research Centre) and Uganda (Budongo Forest Project and Kasokwa Forest Project)
- Chair – American Society of Primatologists' Conservation Committee
- Steering Committee Member – Bushmeat Crisis Task Force

APPENDIX B

Schedule of main period of field work for the Primate Assessment Team

Date	Activity of Primate Assessment Team
24/08/04	Barrie & Field Assistants travel to Bumbuna; visit to the Chief as courtesy and organizing accommodation for the Primate and Forestry teams
25/08/04	Briefing of the team; Recce Walk #1 and Informal interviews with some local people
26/08/04	Recce walk #2 around the ridge by the dam
27/08/04	Followed chimpanzee vocalizations to go to the top of the ridge to check what is now known as the "Dynamite Community" - through Kegbema village. Found a total of 29 nests and saw 4 chimpanzees.
28/08/04	Recce and travel to Waia village. Courtesy call on the chief and conducting a focus group discussion
29/08/04	Sunday. Team has the day off.
30/08/04	Recce and travel to Kakutan via Kayakala. Courtesy call on the chiefs and informal interviews.
31/08/04	2nd visit to Waia and Dulkoroh nest sites with two guides.
01/09/04	Interviews continued with some people at the chief's house and return to Bumbuna by 11:50
02/09/04	2nd visit to Kakutan and Recce walk to Kakutan chimpanzee nest sites.
03/09/04	Return to Bumbuna
04/09/04	Recce and continued observation of the ridge along the Quarry and Dynamite sites.
05/09/04	Barrie travelled to Freetown to receive Forbes, Wallis, & Watson. (Sunday – Team day off.)
06/09/04	Team conducted more interviews with farmers and hunters.
07/09/04	Wallis and Forbes travel back to Bumbuna. Team followed the Dynamite chimpanzees ands observed nest construction.
08/09/04	Team visited the Dynamite Community to see the site, new nests, collect faecal samples. Chimpanzees were heard. Later visited the Consultants and Contractors.
09/09/04	Team given an official tour conducted by the Consultants. Met with Father Tony in Bumbuna to conduct interview regarding history of the area.
10/09/04	Travel to Kafogo, visited the Chief and interviewed people at Fulatown. Travelled northward to assess far end of planned reservoir.
11/09/04	2nd visit to Kafogo and Recce along the riverine forest. Travelled to Makeni
12/09/04	Travelled to Freetown from Makeni.

K Other Terrestrial Fauna

K.1 List of Mammals Identified During Field Studies in 2004

Species	Local Name	Conservation Status
Pan troglodytes verus	Chimpanzee	Endangered
Cercocebus atys	Mangabey	Common
Cercopithecus aethiops	Green monkey	Common
Viverra civetta	African civet	Data deficient
Thryonomys swinderianus	Grasscutter	Abundant
Cercopithecus petaurista	Spotnosed monkey	Common
Tragelaphus scriptus	Common bushbuck	Common
Cephalophus monticola	Maxwell's duiker	Common
Cephalophus sp.	Yellow-backed duiker	Near threatened
Atherurus africanus	Brush-tailed porcupine	Rare
Epixerus ebii	Red forest squirrel	Data deficient
Syncerus cafer	African buffalo	Uncommon
	Red river hog	Uncommon
Rousettus aegyptiacus	Rosette bat	Data deficient
Proamys tulbergi		Common
Proamys jacksoni		Common
Malacomys sp.		Common

K.2 Birds Reported from the Study Area in 1994

Scientific Name	English Name	Feas.	EIA
Anhingidae	**Darters**		
Anhinga rufa	African Darter		O
Ciconiiformes	**Storks and allies**		
Scopus umbretta	Hammerkop		O
Falconiformes	**Birds of Prey**		
Accipiter badius	Shikra		O
Butea auguralis	Red-tailed Buzzard		O
Kaupifalco monogrammicus	Lizard Buzzard		O
Gyphohierax angolensis	Palm-nut Vulture		O
Galliformes	**Fowl**		
Francolinus bicalcaratus	Double-spurred Francolin		O
Chradriiformes			
Tringa hypoleucos	Common Sandpiper		O
Glareola pratincola	Rock pratincole		
Columbiformes	**Turtledoves**		
Turtur afer	Blue-spotted Dove		O
Turtur tympanistra	Tambourine Dove		O
Streptopelia semitorquata	Red-eyed Dove		O
Cuculiformes	**Cuckoos**		
Clemator levaillanti	Levaillant's Cuckoo		O
Cuculus solitarius	Redchested Cuckoo		O
Corythaeola cristata	Great Blue Turaco		O
Coraciiformes			
Eurystomus glaucurus	Broad-billed Roller		O
Halcyon senegalensis	Grey-headed Kingfisher		O
Ceyx picta	Pigmy Kingfisher		O
Alcedo cristata	Malachite Kingfisher		O
Bucerotidae	**Hornbills**		
Tockus fasciatus	Allied Hornbill		
Ceratogymna elata	Yellow-casqued Hornbill		O
Piciformes	**Woodpeckers**		
Dendropicos fuscescens	Cardinal Woodpecker		O
Apodidae	**Swifts**		
Apus affinis	Little African Swift		O
Passeriformes	**Songbirds**		
Hirundo abyssinica	Lesser Striped Swallow		O
Hirundo sp.	Swallow sp.		O
Psalidoprocne obscura	Fanti rough-winged Swallow		O
Motacilla clara	Mountain Wagtail		O
Pycnonotus barbatus	Common Garden Bulbul		O
Andropadus latirostris	Yellow-whiskered Bulbul		O
Artomyas ussheri	Ussher's Flycatcher		O

Scientific Name	English Name	Feas.	EIA
Fraseria cinerascens	White-browed Forest Flycatcher		O
Dicrurus adsimilis	Shining Drongo		O
Tchagra senegala	Black-crowned Tchagra		O
Oriolus brachyrhynchus	Black-headed Oriole		O
Hylia prasinia	Green Hylia		O
Camaroptera brachyura	Grey-backed Camaroptera		O
Ploceus nigerrimus	Violet’s Weaver		O
Lagonosticta senegala	Senegal Fire-Finch		O
Lonchura cucullata	Lonchura cucullata		O

Legend

Feas. = Feasibility Study
EIA = 1994 study

O = Observed (sightings or indirect evidence)

K.3 List of Bird Species Identified Within the Immediate Catchment Area

Date of observations: 25 August to 18 September 2004

FAMILY NAME	COMMON NAME	SCIENTIFIC NAME	HABITAT	STATUS
Barbet				
1	Naked-faced barbet	*Gymnobucco calvus*	Forest	Common
2	Double-throated barbet	*Lybius bidentatus*	Woodland	"
Bee-eater				
3	Little bee-eater	*Merops pusillus*	Savanna	Scarce
Bishop				
4	Black-winged red bishop	*Euplectes hordeaceus*	Savanna	Common
Boubou				
5	Sooty boubou	*Laniarius leucrohynctus*	Forest	Scarce
6	Tropical boubou	*Lamarius aethiopicus*	Savanna	Common
Bristlebill				
7	Grey-headed bristlebill	*Bleda canicapilla*	Forest	Common
Bulbuls				
8	Common bulbul	*Pycnonotus barbatus*	Woodland savanna	Common
Bush-shrike				
9	Sulphure-Breasted bush-shrike	*Malaconotus sulfureopectus*	Woodland	Common
Buzzard				
10	Lizard buzzard	*Kaupifalco monogrammicus*	Savanna forest	Common
Camaroptera				
11	Grey-backed camaroptera	*Camaroptera brachyura*	Grassland	Common
Coucals				
12	Senegal coucal	*Centropus senegalensis*	Woodland/Savanna	Common
Cisticola				
13	Whistling Cisticola	*Cisticola lateralis*	Woodland	Common
14	Red-faced cisticola	*Cisticola erythrops*	Grassland	"
Crake				
15	Black crake	*Amauromis flavirostris*	Wetlands	Common
Crombec				

16	Lemon-billed crombec	*Sylvietta denti*	Forest	Common
Crow				
17	Pied crow	*Corvus allous*	Various Habitats	Common
Cuckoo				
18	Levaillant's cuckoo	*Oxylophus levaillantii*	Savanna	Common
19	Klaas's	*Chrysococcyx klaas*	Woodland	Common
Cuckoo-shrike				
20	Red-shouldered cuckoo-shrike	*Campephaga phoenicea*	Forest	Common
21	Western wattled cuckoo-shrike	*Lobotos lobatus*	Forest	Endemic
Doves				
22	Laughing dove	*Streptopelia senegalensis*	Woodland savanna	Common
23	Red-eye dove	*Streptopelia semitorquata*	Forest/savanna	"
24	Blue-spotted wood dove	*Turtur afer*	Forest	"
25	Tambourine dove	*Turtur tympanistria*	"	"
26	Blue-headed wood dove	*Turtur brehmeri*	"	"
Drongos				
27	Fork-tailed drongo	*Dicrurus adsimilis*	Woodland savanna	Rare
28	Square-tailed drongo	*Dicrurus ludwigii*	Forest	Rare
Eagle				
29	Wahlberg's eagle	*Aquila wahlbergi*	Savanna	Common
30	Long-crested eagle	*Lophaetus occipitalis*	Forest savanna	"
Eremomela				
31	Green-backed eremomela	*Eremomela canescens*	Grassland	Common
Firefinch				
32	Red-billed firefinch	*Lagonosticta senegala*	Savanna	Common
Fiscal				
33	Common fiscal	*Lanius collaris*	Open	Common
Flycatchers				
34	Back & white flycatcher	*Bias musicus*	Forest	Uncommon
35	African paradise flycatcher	*Terpsiphone viridis*	Forest savanna	Uncommon
36	Red-bellied paradise flycatcher	*Terpsiphone rufiventer*	"	Common
Francolins				
37	Double-spurred francolin	*Francolinus bicalcaratus*	Savanna	"
38	Latham's forest francolin	*Francolinus lathami*	Forest	Rare
Greenbuls				

39	Baumann's greenbul	*Phyllastrephus baumanni*	Forest	Rare / Endemic
40	Little greenbul	*Andropadus virens*	"	Common
41	White-throated greenbul	*Phyllastrephus albigularis*	"	Scarce
42	Slender-billed greenbul	*Andropadus gracilirostris*	"	Common
43	Cameroon sombre greenbul	*Andropadus curvirostris*	"	"
44	Icterine greenbul	*Phyllastrephus icterinus*	"	"
45	Honeyguide greenbul	*Baespogon indicator*	"	"
46	Yellow-whiskered greenbul	*Andropadus latirostris*	"	"
47	Golden greenbul	*Calytocichla serina*	"	Rare
Hammerkop				
48	Hammerkop	*Scopus cimbretta*	Aquatic	Common
Harrier-Hawk				
49	African harrier-hawk	*Polyboroides typus*	Forest	Common
Honeyguide				
50	Greater Honeyguide	*Indicator indicator*	Woodland	Rare
Hornbills				
51	African red hornbill	*Tockus fasciatus*	Forest	Common
52	Piping hornbill	*Bycanistes fistulator*	"	"
53	Yellow-casqued hornbill	*Ceratogymna elata*	"	Rare
Hylia				
54	Green hylia	*Hylia prasina*	Forest	Common
Ibis				
55	Hadada Ibis	*Bostrychia hagedash*	Wetland	Common
Illadopsis				
56	Brown Illadopsus	*Illadopsis fulvescens*	Forest	Common
57	Blackcap Illadopsis	*Illadopsus cleaveri*	"	Endemic
Kingfishers				
58	Giant kingfisher	*Megaceryle maxima*	Aquatic	Common
59	Malachite kingfisher	*Alcedo cristata*	Aquatic	"
60	Grey-headed kingfisher	*Halcyon leucocephala*	Woodland	"
61	Woodland kingfisher	*Halcyon senegaleusis*	Woodland	"
62	African Dwarf kingfisher	*Ceyx lecontei*	Forest	Rare
63	Blue-breasted kingfisher	*Halcyon malimbica*	"	Common
64	African Pygmy kingfisher	*Ceyx pictus*	Various habitats	"
Leaflove				
65	Yellow-throated leaflove	*Chlorocichla flaviesltis*	Woodland	Scarce
66	Leaflove	*Pyrrhurus scandens*	Forest	Scarce
67	Simple leaflove	*Chlorocichla simplex*	"	Common
Mannikins				
68	Bronze mannikin	*Lonchura cucullata*	Woodland savanna	Common

69	Black-and-white mannikin	*Lonchura bicolor*	Forest	"
Martin				
70	Rock martin	*Hirundo fuligula*	Rocky	Common
Nicator				
71	Western Nicator	*Nicator chloris*	Forest	Scarce
Nightjar				
72	Plain nightjar	*Caprimulgus inornatus*	Grassland	Common
Oriole				
73	African golden oriole	*Oriolus auratus*	Savanna	Rare
Pigeons				
74	Western bronze-naped pigeon	*Columba iridutorques*	Forest	Scarce
75	African green pigeon	*Treron calva*	"	Common
Plantain-eater				
76	Western grey plantain-eater	*Crinifer piscator*	Forest	Common
Prinia				
77	Tawny-flanked Prinia	*Prinia subflava*	Grassland	Common
Roller				
78	Broad-billed roller	*Eurystomus glaucurus*	Woodland	Common
Sandpiper				
79	Common sandpiper	*Actitis hypoleucos*	Wetlands	Common
Saw-Wings				
80	Square-tailed saw-wing	*Psalidoprocue nitens*	Forest	Rare
81	Fanti Saw-wing	*Psalidoprocue obscura*	"	Common
Seedcracker				
82	Crimson seedcracker	*Pyrenestes sanguineus*	Forest	Common
Shrike				
83	White helmet-shrike	*Prionops plumatus*	Woodland	Common
Sparrow				
84	N. Grey-headed Sparrow	*Passer griseus*	Towns	Common
Spinetails				
85	Mottled spinetail	*Telecanthura ussheri*	Forest	Scarce
86	Sabine's spinetail	*Rhaphidura sabini*	"	Uncommon
Starlings				

87	Emerald starling	*Lamprotorins iris*	Savanna	Endemic
88	Copper-tailed glossy starling	*Lamprotorins cupreocauda*	Forest	Endemic
89	Narrow-tailed starling	*Poeoptera lugubris*	Forest	Scarce
Sunbirds				
90	Tiny sunbird	*Cinnyris minullus*	Forest	Rare
91	Splendid sunbird	*Cinnyris coccinigaster*	Wooded savanna	Common
92	Collard sunbird	*Hedydipna collaris*	Forest savanna	"
93	Variable sunbird	*Cinnyris venustus*	Savanna	"
94	Johanna's sunbird	*Cinnyris johannae*	Forest	"
95	Olive sunbird	*Cyanomitra obscura*	Forest savanna	Common
96	Olive-bellied sunbird	*Cinnyris chloropygius*	Forest	"
97	Copper sunbird	*Cinnyris cupreus*	Wooded savanna	"
98	Scarlet-chested sunbird	*Chalcomitra senegalensis*	Savanna	"
Swallows				
99	Lesser striped swallow	*Hirundo abyssinica*	Forest woodland	Common
100	White-throated blue swallow	*Hirundo nigrita*	Forest	"
Swift				
101	Little swift	*Apus affinis*	Towns	Common
102	African palm swift	*Cypsiurus parvus*	"	"
Tchagra				
103	Black-crowned tchagra	*Tchagra senegala*	Woodland savanna	Common
Thrush				
104	African thrush	*Turdus pelios*	Wooded habitat	Common
105	Finsch's Flycatcher thrush	*Stizorhina finschi*	Forest	Rare / Endemic
Tinkerbird				
106	Red-rumped tinkerbird	*Pogoniulus atroflavus*	Forest	Common
107	Yellow-rumped tinkerbird	*Pogoniulus bilineatus*	"	"
108	Yellow-throated tinkerbird	*Pogoniulus subsulphureus*	"	"
Turacos				
109	Great blue turaco	*Corythaeola cristata*	Forest	Common
110	Green turaco	*Tauraco persa*	"	"
Twinspot				
111	Dybowski twinspot	*Euschistospiza dybowskii*	Grassland	Scarce
Vultures				
112	Palm-nut vulture	*Gypohierax anglolensis*	Forest	Common
Wagtail				
113	African pied wagtail	*Motacilla aguimp*	Wetland	Common

Warbler				
114	African moustached warbler	*Melocichla mentalie*	Savanna	Common
Wattle-Eye				
115	Common Wattle-eye	*Platysteira cyanea*	Wooded habitat	Common
Waxbill				
116	Common waxbill	*Estrilda astrild*	Grassland	Common
117	Orange-cheeked waxbill	*Estrilda melpoda*	"	"
Weavers				
118	Village weaver	*Ploceus cucullatus*	Various	Common
119	Vieillot's black weaver	*Ploceus nigerrimus*	"	"
120	Yellow-mantled weaver	*Ploceus tricolor*	Forest	"
121	Back-headed weaver	*Ploceus melanocephalus*	Riverine	"
122	Compact weaver	*Ploceus superciliosus*	Woodland savanna	"
White-eyes				
123	Yellow white-eye	*Zosterops senegalensis*	Woodland	Uncommon
Whydah				
124	Pin-tailed whydah	*Vidua macroura*	Savanna	Common
Widowbird				
125	Yellow-mantled widowbird	*Euplectes macrourus*	Grassland	Common
126	Red-collard widowbird	*Euplectes ardeus*	Savanna	Common
Woodpecker				
127	Cardinal woodpecker	*Dendropicos fuscescens*	Woodland	Common
Yellowbill				
128	Yellowbill	*Ceuthmochares aereus*	Forest	Common

K.4 Timed Species Counts (TSC) for all Bird Species Recorded in 2004

		Day 1 Minutes						Day 2 Minutes						Day 3 Minutes						Day 4 Minutes						Total Scores	Occurrence
Common Names	**Scientific Names**	0-10	10-20	20-30	30-40	40-50	50-60	0-10	10-20	20-30	30-40	40-50	50-60	0-10	10-20	20-30	30-40	40-50	50-60	0-10	10-20	20-30	30-40	40-50	50-60		
Common bulbul	*Pycnonotus barbatus*		5												5					6						16	Abundant
Common fiscal	*Lanius collaris*									4				6								4				14	Abundant
Blue-spotted wood dove	*Turtur afer*						1							6						6						13	Abundant
Red-eye dove	*Streptopelia semitorquata*													6						6						12	Abundant
Vieillot's black weaver	*Ploceus nigerrimus*													6						6						12	Abundant
Leaflove	*Pyrrhurus scandens*		5											6												11	Abundant
Village weaver	*Ploceus cucullatus*		5											6												11	Abundant
Senegal coucal	*Centropus senegalensis*					2												2		6						10	Abundant
Double-spurred francolin	*Francolinus bicalcaratus*		5																1				3			9	Common
Naked-faced barbet	*Gymnobucco calvus*				3			6																		9	Common
Orange-cheeked waxbill	*Estrilda melpoda*				3			6																		9	Common
Variable sunbird	*Cinnyris venustus*			4												4										8	Common
Black-winged red bishop	*Euplectes hordeaceus*															4							3			7	Common
Bronze mannikin	*Lonchura cucullata*								5									2								7	Common
Black crake	*Amauromis flavirostris*																			6						6	Common
Fork-tailed drongo	*Dicrurus adsimilis*							6																		6	Common
Great blue turaco	*Corythaeola cristata*	6																								6	Common
Little greenbul	*Andropadus virens*	6																								6	Common
Senegal Firefinch									5										1							6	Common
Woodland kingfisher	*Halcyon senegaleusis*	6																								6	Common
Crimson seedcracker	*Pyrenestes sanguineus*																				5					5	Common
Grey-headed sparrow															5											5	Common
Levaillant's cuckoo	*Oxylophus levaillantii*																				5					5	Common
Palm-nut vulture	*Gypohierax anglolensis*								5																	5	Common
Pin-tailed whydah	*Vidua macroura*														5											5	Common
Western bronze-naped pigeon	*Columba iridutorques*														5											5	Common
Western Nicator	*Nicator chloris*		5																							5	Common
Grey-backed camaroptera	*Camaroptera brachyura*															4										4	Not common
Little bee-eater	*Merops pusillus*																					4				4	Not common
Narrow-tailed starling	*Poeoptera lugubris*																					4				4	Not common
Northern Black Flycatcher										4																4	Not common
Simple leaflove	*Chlorocichla simplex*			4																						4	Not common
Tambourine dove	*Turtur tympanistria*			4																						4	Not common
Black-headed weaver	*Ploceus melanocephalus*										3															3	Not common
Compact weaver	*Ploceus superciliosus*																3									3	Not common
White-throated greenbul	*Phyllastrephus albigularis*																3									3	Not common
African Pygmy kingfisher	*Ceyx pictus*																							2		2	Not common
Broad-billed roller	*Eurystomus glaucurus*											2														2	Not common
Copper-tailed glossy starling	*Lamprotorins cupreocauda*																	2								2	Not common
Grey-headed kingfisher	*Halcyon leucocephala*																							2		2	Not common
Splendid sunbird	*Cinnyris coccinigaster*					2																				2	Not common
Western grey plantain-eater	*Crinifer piscator*											2														2	Not common
Yellow-mantled widowbird	*Euplectes macrourus*																							2		2	Not common
Yellow-throated leaflove	*Chlorocichla flaviesltis*					2																				2	Not common

African pied hornbill	*Tockus fasciatus*												1													1	Not common
Blackcap Illadopsis	*Illadopsus cleaveri*												1													1	Not common
Black-crowned tchagra	*Tchagra senegala*						1																			1	Not common
Cardinal woodpecker	*Dendropicos fuscescens*																		1							1	Not common
Common waxbill	*Estrilda astrild*																		1							1	Not common
Emerald starling	*Lamprotorins iris*																		1							1	Not common
Fanti Saw-wing	*Psalidoprocue obscura*																								1	1	Not common
Hammerkop	*Scopus cimbretta*																		1							1	Not common
Red-collard widowbird	*Euplectes ardeus*																		1							1	Not common
Scarlet-chested sunbird	*Chalcomitra senegalensis*						1																			1	Not common
White helmet-shrike	*Prionops plumatus*																		1							1	Not common
African Dwarf kingfisher	*Ceyx lecontei*																									0	Rare
African golden oriole	*Oriolus auratus*																									0	Rare
African green pigeon	*Treron calva*																									0	Rare
African harrier-hawk	*Polyboroides typus*																									0	Rare
African moustached warbler	*Melocichla mentalie*																									0	Rare
African palm swift	*Cypsiurus parvus*																									0	Rare
African paradise flycatcher	*Terpsiphone viridis*																									0	Rare
African pied wagtail	*Motacilla aguimp*																									0	Rare
African thrush	*Turdus pelios*																									0	Rare
Back & white flycatcher	*Bias musicus*																									0	Rare
Baumann's greenbul	*Phyllastrephus baumanni*																									0	Rare
Black-and-white mannikin	*Lonchura bicolor*																									0	Rare
Blue-breasted kingfisher	*Halcyon malimbica*																									0	Rare
Blue-headed wood dove	*Turtur brehmeri*																									0	Rare
Brown Illadopsus	*Illadopsis fulvescens*																									0	Rare
Cameroon sombre greenbul	*Andropadus curvirostris*																									0	Rare
Collard sunbird	*Hedydipna collaris*																									0	Rare
Common sandpiper	*Actitis hypoleucos*																									0	Rare
Common Wattle-eye	*Platysteira cyanea*																									0	Rare
Copper sunbird	*Cinnyris cupreus*																									0	Rare
Double-throated barbet	*Lybius bidentatus*																									0	Rare
Dybowski twinspot	*Euschistospiza dybowskii*																									0	Rare
Finsch's Flycatcher thrush	*Stizorhina finschi*																									0	Rare
Giant kingfisher	*Megaceryle maxima*																									0	Rare
Golden greenbul	*Calytocichla serina*																									0	Rare
Greater Honeyguide	*Indicator indicator*																									0	Rare
Green hylia	*Hylia prasina*																									0	Rare
Green turaco	*Tauraco persa*																									0	Rare
Green-backed eremomela	*Eremomela canescens*																									0	Rare
Grey-headed bristlebill	*Bleda canicapilla*																									0	Rare
Hadada Ibis	*Bostrychia hagedash*																									0	Rare
Honeyguide greenbul	*Baespogon indicator*																									0	Rare
Icterine greenbul	*Phyllastrephus icterinus*																									0	Rare
Johanna's sunbird	*Cinnyris johannae*																									0	Rare
Klaas's	*Chrysococcyx klaas*																									0	Rare
Latham's forest francolin	*Francolinus lathami*																									0	Rare
Laughing dove	*Streptopelia senegalensis*																									0	Rare
Lemon-billed crombec	*Sylvietta denti*																									0	Rare
Lesser striped swallow	*Hirundo abyssinica*																									0	Rare

Little swift	*Apus affinis*																									0	Rare
Lizard buzzard	*Kaupifalco monogrammicus*																									0	Rare
Long-crested eagle	*Lophaetus occipitalis*																									0	Rare
Malachite kingfisher	*Alcedo cristata*																									0	Rare
Mottled spinetail	*Telecanthura ussheri*																									0	Rare
N. Grey-headed Sparrow	*Passer griseus*																									0	Rare
Olive sunbird	*Cyanomitra obscura*																									0	Rare
Olive-bellied sunbird	*Cinnyris chloropygius*																									0	Rare
Pied crow	*Corvus allous*																									0	Rare
Piping hornbill	*Bycanistes fistulator*																									0	Rare
Plain nightjar	*Caprimulgus inornatus*																									0	Rare
Red-bellied paradise flycatcher	*Terpsiphone rufiventer*																									0	Rare
Red-billed firefinch	*Lagonosticta senegala*																									0	Rare
Red-faced cisticola	*Cisticola erythrops*																									0	Rare
Red-rumped tinkerbird	*Pogoniulus atroflavus*																									0	Rare
Red-shouldered cuckoo-shrike	*Campephaga phoenicea*																									0	Rare
Rock martin	*Hirundo fuligula*																									0	Rare
Sabine's spinetail	*Rhaphidura sabini*																									0	Rare
Slender-billed greenbul	*Andropadus gracilirostris*																									0	Rare
Sooty boubou	*Laniarius leucrohynctus*																									0	Rare
Square-tailed drongo	*Dicrurus ludwigii*																									0	Rare
Square-tailed saw-wing	*Psalidoprocue nitens*																									0	Rare
Sulphure-Breasted bush-shrike	*Malaconotus sulfureopectus*																									0	Rare
Tawny-flanked Prinia	*Prinia subflava*																									0	Rare
Tiny sunbird	*Cinnyris minullus*																									0	Rare
Tropical boubou	*Lamarius aethiopicus*																									0	Rare
Wahlberg's eagle	*Aquila wahlbergi*																									0	Rare
Western wattled cuckoo-shrike	*Lobotos lobatus*																									0	Rare
Whistling Cisticola	*Cisticola lateralis*																									0	Rare
White-throated blue swallow	*Hirundo nigrita*																									0	Rare
Yellow white-eye	*Zosterops senegalensis*																									0	Rare
Yellowbill	*Ceuthmochares aereus*																									0	Rare
Yellow-casqued hornbill	*Ceratogymna elata*																									0	Rare
Yellow-mantled weaver	*Ploceus tricolor*																									0	Rare
Yellow-rumped tinkerbird	*Pogoniulus bilineatus*																									0	Rare
Yellow-throated tinkerbird	*Pogoniulus subsulphureus*																									0	Rare
Yellow-whiskered greenbul	*Andropadus latirostris*																									0	Rare

K.5 Amphibians and Reptiles Identified During Surveys in 2004

Species	Category
Hylarana albolabris	Amphibian
Hyperolius concolor	Amphibian
Afrixalus sp.	Amphibian
Bufo maculates	Amphibian
Bufo regularis	Amphibian
Ptychadena sp.	Amphibian
Xenopus tropicalis	Amphibian
Bitis gabonica	Reptile
Bitis arietans	Reptile
Agama agama	Reptile
Gastrophyxis smaragdina	Reptile
Varanus niloticus	Reptile
Mabuya carinata	Reptile
Dendroaspis viridis	Reptile
Naja nigricollis	Reptile

L Terrestrial Flora

L.1 Plant Species Identified in the Lower Kasasi Riparian Forest Plot

Species	Family	#subplots	# of Individuals	Basal Area (m^2)	Rel. Freq	Rel. den	Rel. Dom	SIV
Afrosersalisia sp.	Sapotaceae	4	10	2.20	1.92	1.68	1.12	4.73
Afzelia africana	Caesalpiniaceae	3	3	1.74	1.44	0.51	0.89	2.83
Albizia adianthifolia	Mimosaceae	1	1	0.32	0.48	0.17	0.16	0.81
Albizia zygia	Mimosaceae	2	2	0.37	0.96	0.34	0.19	1.49
Amanoa bracteosa	Euphorbiaceae	6	18	6.82	2.88	3.03	3.48	9.40
Amphimas pterocarpoides	Caesalpiniaceae	2	2	1.54	0.96	0.34	0.78	2.08
Anisophyllea laurina	Rhizophoraceae	5	11	1.92	2.40	1.85	0.98	5.24
Berlinia confusa	Caesalpiniaceae	1	2	0.40	0.48	0.34	0.20	1.02
Brachystegia leonensis	Caesalpiniaceae	2	3	3.00	0.96	0.51	1.53	3.00
Caloncoba brevipes	Flacourtiaceae	1	1	0.17	0.48	0.17	0.09	0.74
Calpocalyx brevibracteatus	Papilionaceae	2	2	0.40	0.96	0.34	0.20	1.50
Canarium schweinfurthii	Burseraceae	3	5	2.84	1.44	0.84	1.45	3.73
Carapa procera	Meliaceae	7	21	4.90	3.37	3.54	2.50	9.40
Ceiba pentandra	Bombacaceae	1	2	0.66	0.48	0.34	0.34	1.15
Chlorophora regia	Moraceae	1	1	0.45	0.48	0.17	0.23	0.88
Christiana africana	Tiliaceae	1	1	0.19	0.48	0.17	0.09	0.74
Chytranthus sp.		1	1	0.15	0.48	0.17	0.08	0.72
Cleistopholis patens	Annonaceae	3	6	1.65	1.44	1.01	0.84	3.30
Cola caricaefolia	Sterculiaceae	2	2	0.44	0.96	0.34	0.22	1.52
Cola chlamydantha	Sterculiaceae	1	1	0.13	0.48	0.17	0.06	0.71
Cola lateritia var. maclaudii	Sterculiaceae	4	6	1.60	1.92	1.01	0.81	3.75
Cola sp.	Sterculiaceae	5	10	2.03	2.40	1.68	1.04	5.13
Dacryodes klaineana	Burseraceae	1	1	0.36	0.48	0.17	0.18	0.83
Daniella ogea	Caesalpiniaceae	7	16	9.96	3.37	2.69	5.08	11.14
Daniella thurifera	Caesalpiniaceae	2	2	1.50	0.96	0.34	0.77	2.06

Dialium guineense	Caesalpiniaceae	8	31	5.77	3.85	5.22	2.94	12.01
Diospyros gabonensis	Ebenaceae	6	24	5.23	2.88	4.04	2.67	9.59
Diospyros heudelotii	Ebenaceae	5	23	5.40	2.40	3.87	2.76	9.03
Diospyros sp.	Ebenaceae	10	51	11.12	4.81	8.59	5.67	19.07
Diospyros thomasii	Ebenaceae	1	1	0.15	0.48	0.17	0.07	0.72
Drypetes sp.	Euphorbiaceae	6	11	2.47	2.88	1.85	1.26	6.00
Erythrophyllum sp.	Erythrixylaceae	3	4	3.18	1.44	0.67	1.62	3.74
Garcinia afzelii	Guttiferae	1	1	0.16	0.48	0.17	0.08	0.73
Garcinia kola	Guttiferae	2	3	0.70	0.96	0.51	0.36	1.83
Gilbertiodendron bilineatum		10	132	62.19	4.81	22.22	31.72	58.75
Hannoa klaineana	Simaroubaceae	4	10	3.64	1.92	1.68	1.86	5.46
Heritiera utiliis	Sterculiaceae	1	1	0.39	0.48	0.17	0.20	0.85
Holarrhena floribunda	Apocynaceae	1	1	0.22	0.48	0.17	0.11	0.76
Homalium letestui		1	1	0.26	0.48	0.17	0.13	0.78
Hymenocardia lyrata	Euphorbiaceae	8	37	8.46	3.85	6.23	4.31	14.39
Irvingia gabonensis		1	1	0.14	0.48	0.17	0.07	0.72
Lannea nigritania	Anacardiaceae	2	4	0.66	0.96	0.67	0.34	1.97
Leucanodiscus sp.	Sapindaceae	3	5	1.12	1.44	0.84	0.57	2.85
Manikara sp.	Sapotaceae	4	8	2.79	1.92	1.35	1.42	4.69
Memecylon sp.	Melastomataceae	3	3	0.48	1.44	0.51	0.25	2.19
Monopetalanthus pteridophyllus	Caesalpiniaceae	8	24	7.92	3.85	4.04	4.04	11.93
Musanga cecropioides	Moraceae	3	13	3.20	1.44	2.19	1.63	5.26
Myrianthus arboreus	Moraceae	1	1	0.15	0.48	0.17	0.08	0.73
Napoleona heudelotii	Lecythidaceae	2	2	0.38	0.96	0.34	0.19	1.49
Ochna membranacea	Ochnaceae	2	3	0.70	0.96	0.51	0.36	1.82
Ochthocosmus africanus	Ixonanthaceae	3	10	2.03	1.44	1.68	1.04	4.16
Parkia bicolor	Mimosaceae	6	10	7.24	2.88	1.68	3.69	8.26
Paunstystella sp.		1	1	0.17	0.48	0.17	0.09	0.73
Pentaclethra macrophylla	Mimosaceae	7	10	5.01	3.37	1.68	2.55	7.60
Pentadesma butyracea	Guttiferae	1	1	0.19	0.48	0.17	0.10	0.75
Piptadeniastrum africanum	Mimosaceae	1	1	0.59	0.48	0.17	0.30	0.95
Pseudospondias sp.		2	2	0.41	0.96	0.34	0.21	1.51
Pycnanthus angolensis	Myristicaceae	1	1	0.19	0.48	0.17	0.10	0.75

Samanea dinklagei	Mimosaceae	1	2	0.70	0.48	0.34	0.36	1.18
Santiria trimera		2	2	0.49	0.96	0.34	0.25	1.55
Smeathmannia pubescens	Passifloraceae	1	1	0.13	0.48	0.17	0.07	0.72
Sterculia tragacantha	Sterculiaceae	1	1	0.15	0.48	0.17	0.08	0.73
Syzygium sp.		4	4	0.58	1.92	0.67	0.30	2.89
Treculia africana	Moraceae	1	1	0.44	0.48	0.17	0.22	0.87
Trichilia heudelotii	Meliaceae	2	2	0.46	0.96	0.34	0.24	1.53
vine	Menispermaceae	3	5	0.94	1.44	0.84	0.48	2.76
Vitex grandifolia	Verbenaceae	1	1	0.30	0.48	0.17	0.15	0.80
Vitex micrantha	Verbenaceae	4	7	1.66	1.92	1.18	0.85	3.95
Xylopia acutiflora	Annonaceae	1	1	0.21	0.48	0.17	0.11	0.76
Xylopia quintasii	Annonaceae	1	6	1.57	0.48	1.01	0.80	2.29
TOTALS		**208**	**594**	**196.0661**	**100.00**	**100.00**	**100.00**	**300.00**

L.2 Plant Species Identified in the Middle Kasasi Riparian Forest Plot

Species	Family	#subplots	# of Individuals	Basal Area (m^2)	Rel. Freq	Rel. den	Rel. Dom	SIV
Acioa scabrifolia	Rosaceae	3	3	0.59	1.46	0.58	0.30	2.34
Afrosersalisia sp.	Sapotaceae	7	13	5.11	3.40	2.53	2.61	8.53
Albizia adianthifolia	Mimosaceae	2	2	0.71	0.97	0.39	0.36	1.72
Amanoa bracteosa	Euphorbiaceae	9	27	11.04	4.37	5.25	5.64	15.26
Amphimas pterocarpoides	Caesalpiniaceae	1	1	0.22	0.49	0.19	0.11	0.79
Anthonotha fragrans	Caesalpiniaceae	1	1	0.18	0.49	0.19	0.09	0.77
Anthonotha sp.	Caesalpiniaceae	1	1	1.02	0.49	0.19	0.52	1.20
Berlinia confusa	Caesalpiniaceae	3	4	1.78	1.46	0.78	0.91	3.14
Berlinia grandifolia	Caesalpiniaceae	2	2	0.49	0.97	0.39	0.25	1.61
Berlinia occidentalis	Caesalpiniaceae	1	2	0.37	0.49	0.39	0.19	1.06
Blighia unijugata		2	2	0.46	0.97	0.39	0.24	1.60
Caloncoba brevipes	Flacourtiaceae	1	1	0.31	0.49	0.19	0.16	0.84
Calpocalyx brevibracteatus	Mimosaceae	5	8	2.70	2.43	1.56	1.38	5.36
Canarium schweinfurthii	Burseraceae	5	6	2.59	2.43	1.17	1.32	4.92
Carapa procera	Meliaceae	10	42	17.20	4.85	8.17	8.78	21.80
Chidlowia sanguinea	Caesalpiniaceae	3	4	1.33	1.46	0.78	0.68	2.91
Chrysophyllum sp.	Sapotaceae	1	1	0.22	0.49	0.19	0.11	0.79
Cleistopholis patens	Annonaceae	2	3	0.44	0.97	0.58	0.22	1.78
Cola caricaefolia	Sterculiaceae	3	6	1.44	1.46	1.17	0.74	3.36
Cola chlamydantha	Sterculiaceae	2	2	0.72	0.97	0.39	0.37	1.73
Cola heterophylla	Sterculiaceae	1	1	0.28	0.49	0.19	0.14	0.82
Cola lateritia var. maclaudii	Sterculiaceae	1	4	0.97	0.49	0.78	0.49	1.76
Cola sp.	Sterculiaceae	3	3	1.46	1.46	0.58	0.74	2.78
Cola tenuifolia	Sterculiaceae	1	1	0.14	0.49	0.19	0.07	0.75
Dacryodes klaineana	Burseraceae	2	2	1.64	0.97	0.39	0.84	2.20
Daniella ogea	Caesalpiniaceae	2	2	1.83	0.97	0.39	0.93	2.29
Daniella thurifera	Caesalpiniaceae	1	1	0.21	0.49	0.19	0.11	0.79
Dialium aubrevillei	Caesalpiniaceae	1	1	0.49	0.49	0.19	0.25	0.93

Dialium guineense	Caesalpiniaceae	2	4	0.93	0.97	0.78	0.48	2.23
Dialium sp.	Caesalpiniaceae	1	1	0.16	0.49	0.19	0.08	0.76
Diospyros heudelotii	Ebenaceae	6	19	6.45	2.91	3.70	3.29	9.90
Diospyros sp.	Ebenaceae	6	25	7.36	2.91	4.86	3.76	11.53
Drypetes afzelii	Euphorbiaceae	1	1	0.23	0.49	0.19	0.12	0.80
Drypetes sp.	Euphorbiaceae	6	21	6.48	2.91	4.09	3.31	10.31
Elaeis guineensis	Palmae	1	1	0.32	0.49	0.19	0.16	0.84
Erythrophleum ivorense	Caesalpiniaceae	1	2	0.92	0.49	0.39	0.47	1.35
Erythrophyllum sp.		2	2	0.90	0.97	0.39	0.46	1.82
Funtumia africana	Apocynaceaea	1	1	0.41	0.49	0.19	0.21	0.89
Garcinia kola	Guttiferae	1	1	1.63	0.49	0.19	0.83	1.51
Gilbertiodendron bilineatum		10	131	59.20	4.85	25.49	30.21	60.56
Hannoa klaineana	Simaroubaceae	5	5	1.22	2.43	0.97	0.62	4.02
Holarrhena floribunda	Apocynaceaea	1	1	0.19	0.49	0.19	0.10	0.78
Homalium letestui		1	1	0.46	0.49	0.19	0.23	0.91
Hymenocardia lyrata	Euphorbiaceae	2	2	0.44	0.97	0.39	0.22	1.58
Lannea nigritania	Anacardiaceae	1	2	0.35	0.49	0.39	0.18	1.05
Macaranga barteri	Euphorbiaceae	1	1	0.15	0.49	0.19	0.07	0.75
Mammea africana	Guttiferae	1	3	0.77	0.49	0.58	0.39	1.46
Manikara	Sapotaceae	4	7	2.57	1.94	1.36	1.31	4.62
Memecylon sp.	Melastomaceae	3	7	2.68	1.46	1.36	1.37	4.18
Monodora tenuifolia	Annonaceae	1	1	1.78	0.49	0.19	0.91	1.59
Monopetalanthus pteridophyllus	Caesalpiniaceae	8	25	10.02	3.88	4.86	5.11	13.86
Napoleona heudelotii	Lecythidaceae	3	5	1.10	1.46	0.97	0.56	2.99
Newtonia aubrevillei	Leguminosae	1	1	0.13	0.49	0.19	0.07	0.75
Ochna membranacea	Ochnaceae	2	8	1.69	0.97	1.56	0.86	3.39
Ochthocosmus africanus	Ixonanthaceae	3	10	3.99	1.46	1.95	2.04	5.44
Ongokea gore		2	2	1.36	0.97	0.39	0.69	2.05
Parinari excelsa	Chrysobalanaceae	3	5	1.89	1.46	0.97	0.96	3.39
Parkia bicolor	Mimosaceae	6	8	4.30	2.91	1.56	2.19	6.66
Pentaclethra macrophylla	Mimosaceae	4	7	2.68	1.94	1.36	1.37	4.67
Pseudospondias macrocarpa		1	3	1.12	0.49	0.58	0.57	1.64
Pteridocarpus santalinoides	Papilionaceae	1	1	0.16	0.49	0.19	0.08	0.76

Pycnanthus angolensis	Myristicaceae	1	1	0.36	0.49	0.19	0.18	0.86
Sacoglottis gabonensis		1	1	0.35	0.49	0.19	0.18	0.86
Samakui		2	2	0.40	0.97	0.39	0.21	1.57
Samanea dinklagei	Mimosaceae	2	3	1.07	0.97	0.58	0.55	2.10
Santiria trimera		5	8	2.30	2.43	1.56	1.17	5.16
Smeathmannia laevigata	Passifloraceae	1	1	0.18	0.49	0.19	0.09	0.77
Smeathmannia pubescens	Passifloraceae	1	1	0.14	0.49	0.19	0.07	0.75
Sterculia tragacantha	Sterculiaceae	1	1	0.27	0.49	0.19	0.14	0.82
Syzygium sp.		7	10	3.62	3.40	1.95	1.85	7.19
Trichilia heudelotii	Meliaceae	1	1	0.15	0.49	0.19	0.08	0.76
Trichilia sp.	Meliaceae	1	2	0.69	0.49	0.39	0.35	1.23
Trichoscypha arborea	Anacardiaceae	3	3	1.49	1.46	0.58	0.76	2.80
vine	Menispermaceae	3	4	1.05	1.46	0.78	0.54	2.77
Vitex micrantha	Verbenaceae	2	2	0.59	0.97	0.39	0.30	1.66
Xylopia acutiflora	Annonaceae	3	5	1.21	1.46	0.97	0.62	3.05
Xylopia aethiopica	Annonaceae	1	1	0.43	0.49	0.19	0.22	0.90
Xylopia quintasii	Annonaceae	3	8	1.67	1.46	1.56	0.85	3.86
TOTALS		**206**	**514**	**195.918**	**100.00**	**100.00**	**100.00**	**300.00**

L.3 Plant Species Identified in the Upper Kasasi Riparian Forest Plot

Species	Family	#subplots	# of Individuals	Basal Area (m^2)	Rel. Freq	Rel. den	Rel. Dom	SIV
Acioa scabrifolia	Rosaceae	2	5	1.44	0.90	1.06	0.82	2.78
Afrosersalisia sp.	Sapotaceae	7	20	6.05	3.17	4.24	3.44	10.84
Afzelia africana	Caesalpiniaceae	3	4	4.39	1.36	0.85	2.50	4.70
Amanoa bracteosa	Euphorbiaceae	8	23	7.49	3.62	4.87	4.26	12.75
Anisophyllea laurina	Rhizophoraceae	2	4	1.44	0.90	0.85	0.82	2.57
Baphia nitida	Papilionaceae	1	1	0.48	0.45	0.21	0.27	0.94
Berlinia confusa	Caesalpiniaceae	2	3	2.08	0.90	0.64	1.18	2.72
Berlinia occidentalis	Caesalpiniaceae	1	1	0.34	0.45	0.21	0.19	0.86
Calpocalyx brevibracteatus	Mimosaceae	6	11	3.75	2.71	2.33	2.13	7.18
Canarium schweinfurthii	Burseraceae	1	2	2.11	0.45	0.42	1.20	2.08
Carapa procera	Meliaceae	5	13	3.39	2.26	2.75	1.93	6.95
Chidlowia sanguinea	Caesalpiniaceae	1	1	0.18	0.45	0.21	0.10	0.77
Chlorophora regia	Moraceae	2	2	1.51	0.90	0.42	0.86	2.19
Chrysophyllum sp.	Sapotaceae	1	1	0.25	0.45	0.21	0.14	0.81
Cleistopholis patens	Annonaceae	1	1	0.21	0.45	0.21	0.12	0.79
Cola caricaefolia	Sterculiaceae	2	3	1.23	0.90	0.64	0.70	2.24
Cola chlamydantha	Sterculiaceae	5	8	1.59	2.26	1.69	0.90	4.86
Cola lateritia var. maclaudii	Sterculiaceae	3	3	0.83	1.36	0.64	0.47	2.47
Dacryodes klaineana	Burseraceae	2	3	1.65	0.90	0.64	0.94	2.48
Daniella ogea	Caesalpiniaceae	2	2	1.60	0.90	0.42	0.91	2.24
Daniella thurifera	Caesalpiniaceae	2	3	2.53	0.90	0.64	1.44	2.98
Dialium guineense	Caesalpiniaceae	7	15	4.53	3.17	3.18	2.58	8.92
Dialium pobeguinii	Caesalpiniaceae	5	9	2.14	2.26	1.91	1.22	5.39
Diospyros elliotii	Ebenaceae	1	1	0.31	0.45	0.21	0.18	0.84
Diospyros gabonensis	Ebenaceae	3	3	0.93	1.36	0.64	0.53	2.52
Diospyros heudelotii	Ebenaceae	6	23	5.57	2.71	4.87	3.17	10.75
Diospyros sp.	Ebenaceae	9	19	4.23	4.07	4.03	2.40	10.50

Distemonanthus benthamianus	Caesalpiniaceae	2	9	4.41	0.90	1.91	2.51	5.32
Drypetes sp.	Euphorbiaceae	6	11	3.15	2.71	2.33	1.79	6.83
Erythrophyllum sp.	Erythroxylaceae	5	8	2.54	2.26	1.69	1.45	5.40
Fagara macrophylla	Rutaceae	2	2	1.44	0.90	0.42	0.82	2.15
Ficus sp.	Moraceae	2	4	2.26	0.90	0.85	1.28	3.04
Garcinia kola	Guttiferae	4	9	1.78	1.81	1.91	1.01	4.73
Gilbertiodendron bilineatum		4	7	2.98	1.81	1.48	1.70	4.99
Guibourtia leonensis		1	1	0.55	0.45	0.21	0.31	0.98
Hannoa klaineana	Simaroubaceae	7	11	4.60	3.17	2.33	2.62	8.11
Heritiera utilis	Sterculiaceae	1	1	0.33	0.45	0.21	0.19	0.85
Homalium letestui		2	2	0.79	0.90	0.42	0.45	1.78
Hymenocardia lyrata	Euphorbiaceae	7	37	9.03	3.17	7.84	5.13	16.14
Klainedoxa gabonensis		4	4	3.88	1.81	0.85	2.21	4.86
Manilkara sp.	Sapotaceae	3	15	5.79	1.36	3.18	3.29	7.83
Memecylon sp.	Melastomataceae	5	5	1.15	2.26	1.06	0.66	3.98
Menispermaceae	Menispermaceae	6	11	1.87	2.71	2.33	1.06	6.11
Monodora sp.	Annonaceae	2	2	1.23	0.90	0.42	0.70	2.03
Monopetalanthus pteridophyllus	Caesalpiniaceae	10	60	23.84	4.52	12.71	13.56	30.79
Napoleona heudelotii	Lecythidaceae	2	5	1.07	0.90	1.06	0.61	2.57
Nauclea diderrichii	Rubiaceae	1	1	0.18	0.45	0.21	0.10	0.77
Pachypodanthium staudtii		2	2	0.55	0.90	0.42	0.31	1.64
Parinari excelsa	Chrysobalanaceae	1	1	0.77	0.45	0.21	0.44	1.10
Parkia bicolor	Mimosaceae	5	9	6.82	2.26	1.91	3.88	8.05
Pentaclethra macrophylla	Mimosaceae	8	14	8.68	3.62	2.97	4.94	11.52
Piptadeniastrum africanum	Mimosaceae	3	3	1.27	1.36	0.64	0.72	2.72
Pterocarpus santalinoides	Papilionaceae	1	1	0.51	0.45	0.21	0.29	0.95
Pycnanthus angolensis	Myristicaceae	3	3	1.55	1.36	0.64	0.88	2.88
Samanea dinklagei	Mimosaceae	3	6	3.11	1.36	1.27	1.77	4.40
Santiria trimera		1	1	0.41	0.45	0.21	0.23	0.90
Smeathmannia laevigata	Passifloraceae	2	2	0.60	0.90	0.42	0.34	1.67
Sterculia tragacantha	Sterculiaceae	1	1	0.57	0.45	0.21	0.33	0.99
Strephonema pseudocola		1	2	0.81	0.45	0.42	0.46	1.34

Syzygium sp.		5	8	3.39	2.26	1.69	1.93	5.88
Tabernaemontana crassa	Apocynaceae	1	1	0.17	0.45	0.21	0.09	0.76
Treculia africana	Moraceae	1	1	0.45	0.45	0.21	0.26	0.92
Trichilia heudelotii	Meliaceae	3	3	1.47	1.36	0.64	0.83	2.83
Trichoscypha arborea	Anacardiaceae	1	2	0.52	0.45	0.42	0.30	1.17
Uapaca guineense	Euphorbiaceae	4	5	2.65	1.81	1.06	1.50	4.37
Uapaca heudelotii	Euphorbiaceae	1	1	0.67	0.45	0.21	0.38	1.05
Vitex micrantha	Verbenaceae	4	6	2.62	1.81	1.27	1.49	4.57
Xylopia acutiflora	Annonaceae	1	1	0.29	0.45	0.21	0.16	0.83
Xylopia quintasii	Annonaceae	3	10	2.84	1.36	2.12	1.61	5.09
TOTAL		**221**	**472**	**175.8615**	**100**	**100**	**100**	**300**

L.4 Plant Species Identified Along the Waia Path Transect

Species	Family	#subplots	# of Individuals	Basal Area (m^2)	Rel. Freq	Rel. den	Rel. Dom	SIV
Acioa scabrifolia	Rosaceae	2	5	1.02	1.52	2.43	1.26	5.20
Afrosersalisia sp.	Sapotaceae	1	1	0.49	0.76	0.49	0.61	1.85
Afzelia africana	Caesalpiniaceae	1	1	0.45	0.76	0.49	0.55	1.79
Alstonia boonei	Apocynaceae	1	1	0.99	0.76	0.49	1.23	2.47
Amanoa bracteosa	Euphorbiaceae	1	3	1.28	0.76	1.46	1.59	3.80
Amphimas pterocarpoides	Caesalpiniaceae	2	2	1.19	1.52	0.97	1.47	3.96
Anisophyllea laurina	Rhizophoraceae	2	2	0.31	1.52	0.97	0.38	2.86
Anthocleista nobilis	Loganiaceae	1	2	0.36	0.76	0.97	0.44	2.17
Antiaris africana	Moraceae	2	2	1.40	1.52	0.97	1.73	4.21
Berlinia confusa	Caesalpiniaceae	1	1	1.02	0.76	0.49	1.27	2.51
Brachystegia leonensis	Caesalpiniaceae	1	1	1.08	0.76	0.49	1.34	2.58
Bussea occidentatlis	Caesalpiniaceae	2	2	0.53	1.52	0.97	0.66	3.15
Calpocalyx brevibracteatus	Mimosaceae	6	13	4.23	4.55	6.31	5.23	16.09
Calpocalyx sp.	Mimosaceae	1	3	0.87	0.76	1.46	1.07	3.29
Canarium schweinfurthii	Burseraceae	2	2	0.33	1.52	0.97	0.41	2.90
Ceiba pentandra	Bombacaceae	3	4	0.96	2.27	1.94	1.19	5.40
Chidlowia sanguinea	Caesalpiniaceae	3	3	1.06	2.27	1.46	1.31	5.04
Chlorophora regia	Moraceae	2	2	0.36	1.52	0.97	0.44	2.93
Chrysophyllum perpulchirum	Sapotaceae	1	2	0.85	0.76	0.97	1.05	2.78
Chrysophyllum pruniforme	Sapotaceae	2	3	1.80	1.52	1.46	2.22	5.19
Cola caricaefolia	Sterculiaceae	1	1	0.32	0.76	0.49	0.39	1.64
Cola chlamydantha	Sterculiaceae	2	4	0.89	1.52	1.94	1.10	4.55
Cola sp.	Sterculiaceae	2	2	0.79	1.52	0.97	0.98	3.47
Dacryodes klaineana	Burseraceae	6	9	3.55	4.55	4.37	4.39	13.31
Daniella thurifera	Caesalpiniaceae	3	5	2.43	2.27	2.43	3.01	7.71
Dialium dinklagei	Caesalpiniaceae	1	1	0.48	0.76	0.49	0.60	1.84
Dialium guineense	Caesalpiniaceae	2	7	2.42	1.52	3.40	3.00	7.91

Dialium pobeguinii	Caesalpiniaceae	2	3	1.63	1.52	1.46	2.01	4.98
Dialium sp.	Caesalpiniaceae	1	2	1.08	0.76	0.97	1.33	3.06
Diospyros heudelotii	Ebenaceae	1	2	0.44	0.76	0.97	0.54	2.27
Distemonanthus benthamianus	Caesalpiniaceae	2	2	1.15	1.52	0.97	1.42	3.90
Drypetes sp.	Euphorbiaceae	1	1	0.37	0.76	0.49	0.45	1.70
Erythrophleum guineense	Caesalpiniaceae	1	1	0.80	0.76	0.49	0.99	2.24
Erythrophleum macrophylla	Caesalpiniaceae	1	1	0.81	0.76	0.49	1.00	2.24
Funtumia africana	Apocynaceae	2	2	0.80	1.52	0.97	0.99	3.48
Garcinia kola	Guttifera	1	2	0.29	0.76	0.97	0.36	2.08
Hannoa klaineana	Simaroubaceae	4	5	2.54	3.03	2.43	3.14	8.60
Hymenocardia lyrata	Euphorbiaceae	2	4	0.88	1.52	1.94	1.08	4.54
Lovoa trichilioides	Meliaceae	1	1	0.81	0.76	0.49	1.00	2.25
Monodora tenuifolia	Annonaceae	2	2	0.72	1.52	0.97	0.89	3.38
Monopetalanthus pteridophyllus	Caesalpiniaceae	8	19	10.73	6.06	9.22	13.28	28.57
Musanga cecropioides	Moraceae	1	1	0.20	0.76	0.49	0.24	1.49
Myrianthus serratus	Moraceae	2	3	0.87	1.52	1.46	1.07	4.04
Ochna membranaea	Ochnaceae	5	8	2.95	3.79	3.88	3.65	11.33
Parinari excelsa	Chrysobalanaceae	2	2	1.39	1.52	0.97	1.72	4.21
Parkia bicolor	Mimosaceae	5	8	2.85	3.79	3.88	3.53	11.20
Pentaclethra macrophylla	Mimosaceae	7	15	7.26	5.30	7.28	8.99	21.57
Piptadeniastrum africanum	Mimosaceae	1	1	0.70	0.76	0.49	0.87	2.11
Pterocarpus santalinoides	Papilionaceae	3	9	2.00	2.27	4.37	2.48	9.12
Pycnanthus angolensis	Myristicaceae	3	3	1.04	2.27	1.46	1.29	5.02
Samanea dinklagei	Mimosaceae	1	1	0.83	0.76	0.49	1.02	2.27
Spondias mombin	Anacardiaceae	2	3	0.93	1.52	1.46	1.15	4.12
Terminalia ivorensis	Combretaceae	1	1	0.13	0.76	0.49	0.16	1.40
Tetrochidium didymostemon	Euphorbiaceae	5	5	1.11	3.79	2.43	1.38	7.59
Trichilia heudelotii	Meliaceae	1	1	0.23	0.76	0.49	0.28	1.52
Trichoscypha aborea	Anacardiaceae	2	5	1.54	1.52	2.43	1.91	5.85
Uapaca guineense	Euphorbiaceae	2	2	0.88	1.52	0.97	1.10	3.58
Syzygium sp.		5	6	1.24	3.79	2.91	1.53	8.23
Xylopia acutiflora	Annonaceae	1	1	0.16	0.76	0.49	0.20	1.44
Total		**132**	**206**	**80.79829**	**100**	**100**	**100**	**300**

Note: Calculation Method

Relative Frequency: Proportion of the number of individual tree stems (> 10 cm) of species X occurring in subplots, divided by the total number of stems occurring in different subplots.

Relative Density: Proportion of the total number of individual stems (> 10 cm) of species X divided by the total number of stems within the plot.

Relative Dominance: Proportion of basal area of a species compared to the total area of the plot.

Species importance value (SIV): Sum total of Relative frequency, Relative Density and Relative Dominance.

M Aquatic Ecology

M.1 Freshwater Fishery Questionnaire Employed During surveys in 2004

1. Name of: village district

2. How many people live in the village? adults children

3. How many people are engaged in fishing? men women

4. Do the people who fish also have farms?

5. When is fishing done? Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

6. Which are the main fishing months?

7. What methods are used? Gill nets; Hook & line; Fish traps; Cast nets; Poison

8. Any other methods?

9. What is the main method?

10. Do women use different methods than men?

11 If yes, when do women fish (months) and what method do they use?

12 How many fishing boats are there in the village?

13. How many men per boat?

14. How many boats have outboard motors?

15. How far do people travel to fish?

16. When is fishing done? Morning Afternoon Overnight

17. In the fishing season do people fish every day?

18. How long does an average fishing trip take?

19. During which month(s) are the catches best?

20. How big is an average catch? weight number of fish

21. How big is a good catch? weight number of fish

22. Are the fish sold: In the village In nearby villages In a market (name?)

23. Are all fish sold fresh or are some smoked?

24. Fill in the attached table to provide information on the types of fish caught, the fishing and spawning grounds, breeding seasons, etc

25. Are there any fish that used to be caught, which are now scarce or not seen any more? What are their names?

Main fish types (local names)	Main catching period (months)	Where in the river are they caught?	When do they spawn? (Months)	Do they migrate upstream or down to spawn?	Where in the river do they spawn?	Are they caught during migration (before or after)?	Where do adults go after spawning?	Where do young go after hatching?

M.2 Freshwater Fishery Questionnaire Employed in the Original EIA

DESIGNED TO OBTAIN INFORMATION ON FISH & FISHERIES IN THE SELI RIVER UPSTREAM AND DOWNSTREAM OF THE BUMBUNA WATER FALLS.

1. Name and Tribe.

2. Approximate age

3. Do you fish for a living?

   (If yes) how often)?

4. What gear do you use for fishing?

   (What is the mesh size)?

5. Are there other methods in use in this village?

   (If yes what are they)?

6. What is the size of the catch?

7. What is the composition of the catch (or the different kinds of fish caught)?

8. What do you do with your catch?

9. What is the species that is caught most?

10. What factors affect the quantity of fish caught? (e.g. seasons, fishing gears)

11. Are there species you know about in this river that you do not catch or are rarely caught?

12. Are there kinds of fish that were part of the catch before now but are no longer caught?

N Archaeology

The following account of the Archaeology of the project area uses information from the original EIA (Electrowatt/Techsult 1996), supplemented by new data from studies and surveys conducted by Nippon Koei UK in 2004.

N.1 Culture, History and Archaeology of the Project Area

N.1.1 Introduction

The BHP project derives its name from the Chiefdom capital of Bumbuna in the Tonkolili District of the Northern Province of Sierra Leone. Bumbuna is a Limba town situated approximately 4km southwest of the dam site. The Kalansogoia Chiefdom was formed in 1953 from the amalgamation of two pre-existing chiefdoms: the Kalantaba Chiefdom, which consisted of five sections, all Limba, with its headquarters at Kasokira; and the Dansogoia Chiefdom which consisted of two sections (one Limba and one Koranko) with its headquarters at Bumbuna. Thus, the Kalansogoia Chiefdom consists of seven administrative sections: six are Limba, whilst the remainder is Koranko.

The BHP Feasibility Study (Bumbuna Hydro Consultants 1980) dealt with resettlement issues, but did not consider cultural, historical or archaeological phenomena likely to be affected by construction and operation of the dam. A sub-section deals with “administrative and political features”, but includes certain inaccuracies, such as referring to “native administrations” instead of Chiefdom Administrations. It also mentions District Councils, which were abolished in 1972, and have recently been reinstated with Local Government elections held in May 2004.

In the original EIA (Electrowatt/Techsult 1996) the study of cultural, historical and archaeological sites, materials and issues was based on (i) a desk-based assessment of relevant literature, (ii) fieldwork conducted during May 1994 which utilised guides provided by the Paramount Chief and interviews with members of the local populace, and (iii) in relation to archaeology, a surface survey and collection of artefacts conducted at two open air sites. These examined two relatively recently abandoned villages, Makali and Kakonta, that are of little archaeological significance, and did not discover any caves, rock shelters or other archaeological remains. It was concluded that “no protection or salvage measure will have to be taken” to mitigate the impacts of the dam.

An additional archaeological survey and assessment was conducted within the reservoir area during September 2004, in compliance with the WB Policy on Cultural Property for all reservoirs or large land takes. The study also seeks to satisfy the provisions of “World Bank Operational Policy Note 11.03”, concerning the management and preservation of cultural property, in the form of archaeological remains.

N.1.2 Methodology

Culture and History (from studies and surveys in 1994)

Three approaches were adopted for the study of culture and history in the original EIA: (i) review of existing historical, archaeological and sociological literature of broad interest that may have a bearing on both the study area and the disciplines involved, (ii) field work was conducted in the project area during May, 1994, (iii) based on information collected, archaeological surface survey was conducted at two sites of derelict settlements.

Oral interviews were conducted with traditional leaders and men of note in the chiefdom. The historical method of collecting oral traditions was mostly used. Although this is unstructured, questions on sociological phenomena as well as archaeological pointers were posed. A total of 46 persons were interviewed. Like not infrequently happens in oral traditions, consensus had to be reached on certain issues, as there is usually no single person who was the repository of the history and customs.

Archaeology (from studies and surveys in 2004)

Preparation and Background

The aim of the archaeological survey in 2004 was to locate as many and as varied a range of archaeological sites as possible within the 21km^2 of the proposed BHP reservoir. In preparation, a major literature review was conducted of past archaeological and historical fieldwork in Sierra Leone, and large-scale (1:50,000) maps were used to formulate the survey approach, highlighting areas of potential archaeological resources within the reservoir area. A support team trained in field walking techniques and shovel testing provided assistance throughout.

The BHP dam is located on the River Seli at grid reference UTM 29P 0200 1003 (Map: Sierra Leone Directorate of Ordnance Survey, Series G742 (D.O.S. 419), Sheet 33, Edition 2-D.O.S. 1972) (Fig. N.1.2-1). The reservoir area surveyed consists of a narrow Y-shaped area that extends approximately 40km north to south, varying in width from 200m to 1km (Thomas and Findlay 1996). The area encompasses the lower reach of the River Mawoloko (UTM 29P 0201 1042) to its confluence with the River Seli (29P 0203 1032; Map: Sheet 21), and extends to the Bumbuna Dam in the south. Geomorphologically, the area consists of a riverine valley with pronounced physical relief of 300–600m asl. Both rivers flow approximately north to south, with the drainage system of the Seli formed by steep sided slopes, especially along the eastern bank, and a valley floor that becomes progressively wider in areas to the north. After impoundment the surface area of the reservoir will be 21km^2, with the area submerged to a height of 241.25m asl (maximum operating level).

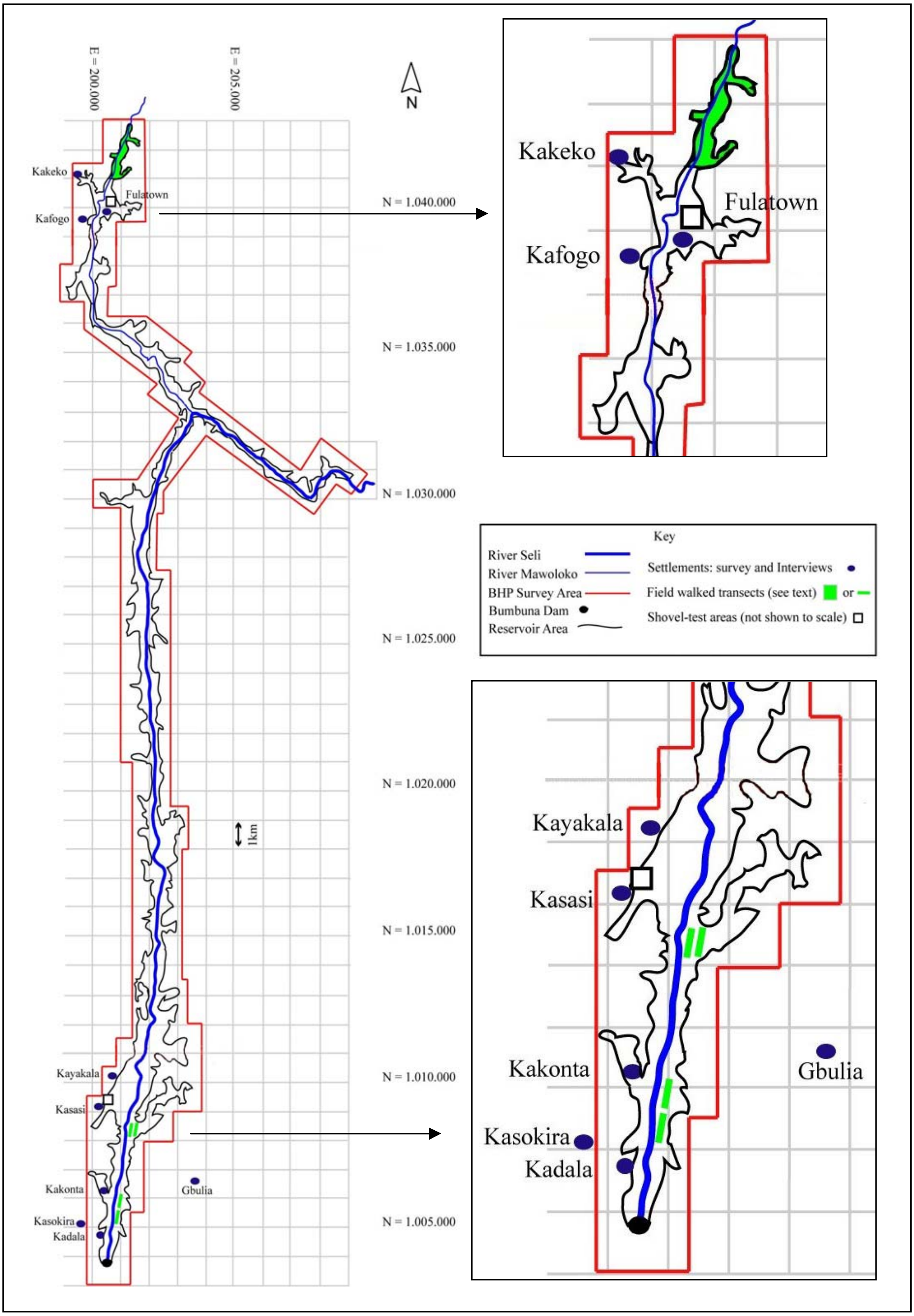

Fig N.1.2-1: Map of the Bumbuna HEP scheme, showing location of villages where inhabitants were interviewed and where archaeological survey was conducted in 2004

Field Survey Approach

The proposed survey methodology included stratified sampling of geomorphological zones within the reservoir area, with selected blocks sampled using shovel-tests, digging pits up to 1m deep x 0.5m diameter along transects to collect artefacts. Shovel-testing provides a means for locating sub-surface remains where the visibility of surface artefacts and sites is low, and is thus generally appropriate in savannah-forest. However the constraints imposed by the steep reservoir terrain, density of forest, and the difficulties of shovel-testing during heavy rainfall limited its effectiveness, as the probability of intersecting archaeological remains within a small transect area is low (cf. Kintigh 1988; Krakker *et al*, 1983; Orton 2000; Shott 1989).

After initial trials the methodology was therefore modified to conduct shovel-tests in potential sites/areas of archaeological interest identified by field walking transects, supplemented by qualitative information obtained from local knowledge through interviews with the inhabitants of the area (see below). Field walking involves dividing a sample (survey) area into a series of equally spaced paths (transects) that are then systematically walked in order to cover as much of the area as possible to intersect archaeological sites/materials. Upon discovery of a 'site' shovel-testing is utilised to determine presence/absence of stratigraphy (i.e. soil layers with evidence of human occupation/modification), artefactual remains (e.g. testing whether or not a site has been deflated by erosional processes) and the areal extent of a site.

Field Walking

Approximately 2km^2 (9.5%) of the reservoir area was examined by field walking (Fig. N.1.2-1). Each of the transects were 5m wide x 200m in length and walked in a zig-zag manner from the starting point. Field walking on the east side of the Seli extended a few metres from pathways due to the steepness of the slopes, and transects were placed adjacent to each other or started from the location where the previous one was completed. On the east side of the river Mawaloko, transects were spaced at intervals of 20m because of the density of the vegetation.

Shovel Testing

Shovel-testing was conducted near Kasasi and Fulatown (Fig. N.1.2-1). This technique involves digging a pit 1m deep x 0.5m diameter at predefined intervals to determine the presence/absence of sub-surface remains and areal extent of a site. At Kasasi, an area of potential interest was located by walking around the village and environs. This area is located to the north east of the settlement within the inundation zone and consisted of a large mound-like feature (dimensions ca. 50m x 50m), which might have been the focus of past habitation (i.e. a 'village' site). A grid of 100m x 100m was established and centred on the mound with an origin point of the grid (or south east co-ordinate) of

02005, 10093. Shovel-test pits were dug at 20m intervals to determine sub-surface remains and the possible extent of the apparent site.

The area shovel-tested near Fulatown was also chosen on the basis of a mound-like feature. A similar grid was established with an origin point of 02007, 10400, but the pits were dug at 10m intervals, as the ‘mound’ was only ca 20m x 30m.

A rock shelter was located near Kafogo (the Limba name for the site is Kayarina) and shovel-test pits were dug.

Interviews

Interviews were conducted with the Paramount Chiefs of the Chiefdoms encompassed by the survey area (Fig. N.1.2-1), and open fora discussions were held with the Chiefs and inhabitants of each of the villages visited. Additionally, Chiefs from the Koranko settlements of Waia and Gbulia were interviewed at Bumbuna. As far as possible discussions concentrated upon oral histories of the areas and discoveries made whilst engaged in agricultural or other activities, to identify potential archaeological sites or areas of potential significance. Additionally the Paramount Chief of the Kalansogoia Chiefdom in Bumbuna, Almamy Bakkari Yellam Koroma III, and the Chief of Kafogo, Kanufu II, provided guides in order to facilitate the surveys and interactions with local villagers.

Interviews were scheduled in accordance with the agricultural activities of the inhabitants of these settlements so that the maximum number of people could be involved. Most interviews were conducted with people of the Limba ethnic group. In the southern part of the reservoir area the settlements within the scope of the survey were Kadala, Kasokira, Kasasi and Kayakala (or “Yakala”) on the western bank of the river (the area compassed by grid squares 0200, 1003 – 0200, 1009 – 0201, 1009). As no settlements were within the survey area (i.e. adjacent to or within the future inundation zone) on the east bank of the river, this bank was field-walked from the Dam site to grid square 0202, 1009. In the northern reach of the study area along the Mawoloko River, survey was conducted at the settlements of Kafogo, Kakeko and Fulatown (grid squares 0199, 1039 - 1041 and 0200, 1039 – 1041). This was combined with field-walking transects in the uppermost part of the north west reservoir tail-zone (see above).

N.1.3 Present Situation

Culture and History

The Kalansogoia Chiefdom which has an area of approximately 250 km^2 is the northern-most chiefdom of the Tonkolili District in the Northern province. It is a predominantly Limba chiefdom, bounded on the east by Diang Chiefdom, on the north by Kasunko chiefdom (both in the Koinadugu District) on the west by Biriwa and Safroko chiefdoms of the Bombali District, and on the south by Kafe Simiria Chiefdom in Tonkolili District.

The relief is made up of mountain ranges, the most recognisable being the Wara Wara Mountains. These mountain ranges have been greatly influential in determining the settlement patterns and socio-economic life of the people. Settlements are carefully perched on hill-tops and well laid out. Historically, warriors founded these settlements and lived there for strategic reasons. The mountain ranges are separated by a number of valleys. This peculiar arrangement of the relief and terrain of the region has given rise to a very interesting development. This has to do with the proliferation of villages in the mountain tops totally separated and far removed from one another, with such villages living somewhat independently of one another and fairly isolated. An interesting phenomenon discovered during fieldwork revealed, that inhabitants of what can be considered to be neighbouring towns (with distances of about 5-7 kilometres) may not know anything substantial about one-another, other than their location, name of the village and in exceptional cases the name of the village or town chief.

Figure N.1.3-1 illustrates the geographical distribution of ethnic groups in Sierra Leone in 1963. As changes in the rural area are slow the main patterns still are valid for today. The ethnic composition of the project area is predominantly Limba. The inhabitants of the chiefdom mainly belong to the Limba Kalantuba group. They are distinguished from other classifications of Limbas by their distinct ideolects, coupled with other discernible cultural features of being hard and sturdy, which may have come about as a consequence of the geography of the area which is largely mountainous. Apart from the chiefdom headquarters town of Bumbuna, which is partially urban in structure with a considerable Temne population, formal structures and pattern of existence, and established institutions of education (schooling), health (health-centre), religion (churches and mosques) and economics (trading), in almost all the villages the inhabitants were all Limbas of the earlier identified group of the Kalantuba. In only one instance, in the village of Kayakala in the Kasokira section, did the team identify a Fula herdsman. An interview with him revealed that he was born and bred in the town by his parents who had gone back home to the neighbouring state of Guinea to resettle due to old-age.

There is nearly no road network in the project area of the Chiefdom. Apart from a disused road to Kasasi about six kilometres from the dam-site, all transportation is by head porterage along bush tracks. The rocky out-crops of the Seli River make it unsuitable for canoes. As a result, economic activity is mainly subsistence oriented, and administration is inhibited. The village of Katoina for instance, was said to avoid all official contacts as the population would simply cross into Diang chiefdom at sight of an official.

The origin of the Limba in this region like all other Limbas within the country is clouded in myths which has been passed on from generation to generation by oral tradition. The Limbas are believed to have their origins in a common ancestor by the name of Tonko Santigi who migrated from Northern Guinea apparently on a hunting expedition. The slave trade forced the original group led by their warrior ancestor to split up to form the major Limba groups in Sierra Leone. These comprise according to Gorvie (1944) the Limba Boi, the Limba Sela, the Limba Safroko, the Limba Kalantuba, the Limba Bakalay, the Limba Biriwa, the Limba Kaliang, the Limba Kamake, the Wara-Wara Limba, and the Limba Keh. The cultural and linguistic distance between some Limba groups can only be attributed to their long isolation from each other over historical time, and the influence of neighbouring ethnic groups. The Kalantuba have been subject to strong Koranko influence in the last few centuries, with a great deal of inter-marriage taking place between them.

The chiefdom is the traditional unit of administration in Sierra Leone. The Paramount Chief and the "Chiefdom Administration" system are colonial adaptations to suit modern conditions. As such, the Paramount Chiefs are subject to the authority of the central government, collect tax on behalf of it, receive salaries in lieu of customary payments, and no longer preside over courts. The Paramount Chief, Speaker, Section Chief and Chief Elders constitute a chiefdom council which makes decision. There is also a chiefdom Treasury into which revenue is paid.

The Paramount Chief is elected by chiefdom Councillors (one each representing 20 tax payers) and is confirmed by the central government which can also depose him.

Kalansogoia is divided into seven administrative sections each under a section chief who is also elected by chiefdom councillors. Each section is made up of towns and villages, the origins of which are associated with the activities of either warriors and hunters or individuals on farming expeditions. Oral traditions collected in the field pointed towards the founding of these villages to have taken place after fighting a war of conquest and the land on which the village is presently located being annexed thereafter. There were also explanations to prove, that the land was peacefully handed over to the founder of the village after a friendly request for farm land from the original owners, usually the ruler of the region. The founding of these villages by these heroes usually opened up a high degree of migration by their followers into newly founded settlements. With such migrations, the villages expanded in size through the clearing of more bush to accommodate more dwelling homes.

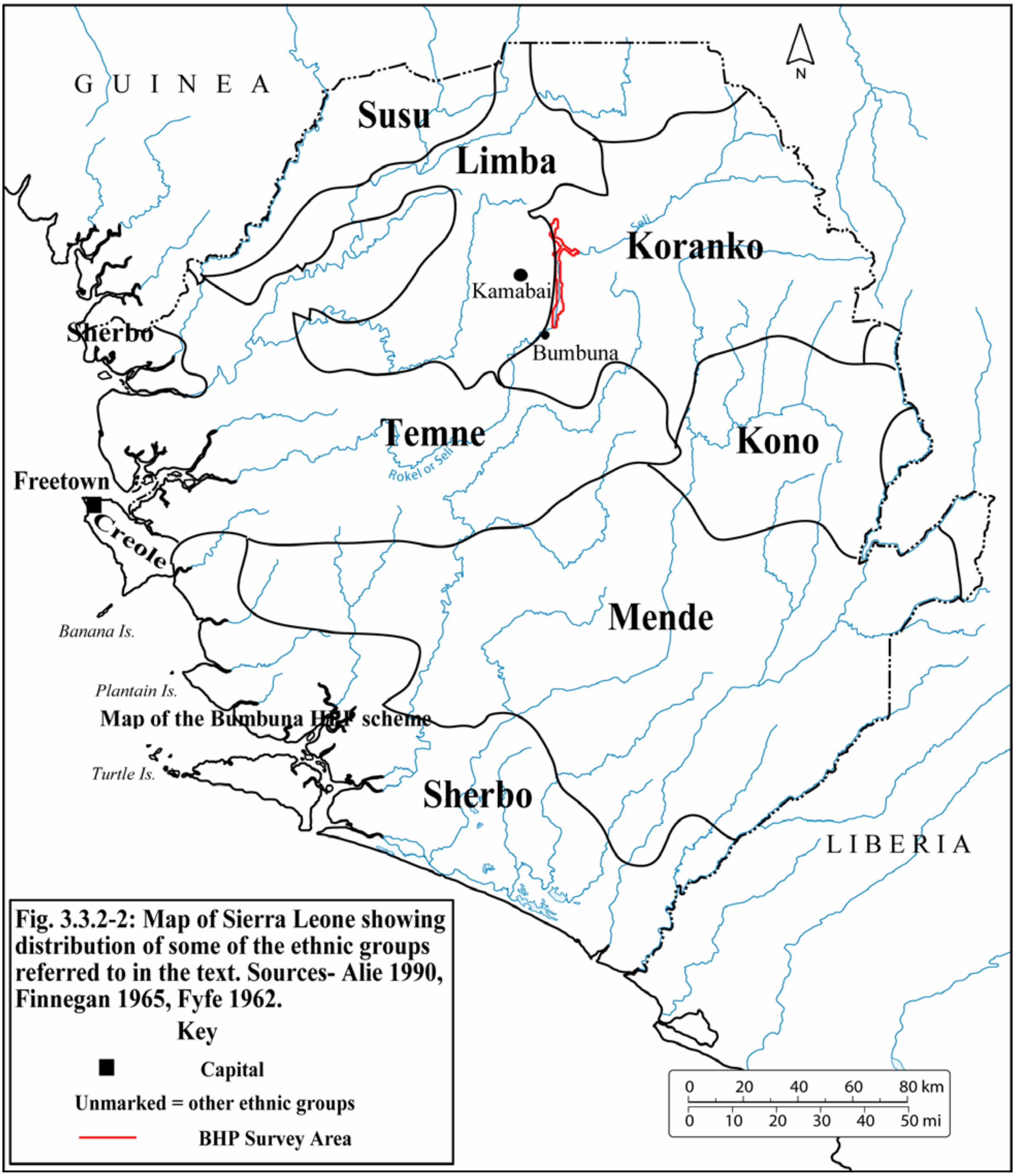

Fig. 3.3.2-2: Map of Sierra Leone showing distribution of some of the ethnic groups referred to in the text. Sources- Alie 1990, Finnegan 1965, Fyfe 1962.

The beginning of a village was more often than not accompanied by the move to acquire more land especially for farming purposes. Land was also in great demand in order to procure the necessary materials required for the construction of their characteristically modest dwelling homes in the villages. The size of villages and the farmlands were also determined by the degree to which the founder extended his original frontiers.

It was also discovered that the acquisition and distribution of land (within the town and for farming purposes) were undertaken on the basis of clan membership. Almost all the members or inhabitants of the villages belonged to either one clan or another. One interesting discovery was that in one of the towns visited further up-stream, Kayakala, all inhabitants belonged to the only clan living in the village, which was the Mansaray clan. The other clans which were discovered in the various villages included the following:

The Mansarays, the Contehs, the Kamaras, the Koromas, the Turays and the Kanus. The clans were distinguishable not only by names, but also by their claims to different ancestors and holding separate beliefs over certain world views. The members of the same clan also share common taboos and prohibitions. Intra-clan marriage is a taboo.

Customs

The customs and practices of the people showed a pattern that is peculiar to most ethnic groups of the region (such as the Temne and Koranko) with whom they often share common boundaries. In the customs of the Limba of the project area could be discerned interesting features making up their economic and social activities, see below.

Social Organisation

The social organization of the Kalantuba Limba follows the pattern that is peculiar to most ethnic groups in Sierra Leone. They are organised into patrilineal clans. Each of these clans directly and convincingly claims descent from a remote ancestor usually with the features and attributes of a great animal found in their environment, which becomes their totem. The names of the clans are used as surnames. The social significance of the clan name rests on the bond it creates between all men possessing it. McCulloh (1951) states that "It is stronger than nationality or speech "

The pattern of marriage is predominantly endogamous, with marriage partners being chosen from relatives whom tradition would allow to enter into marriage relationship but not within the same clan. In most of the cases, the bride is chosen at birth by the parents of the potential husband. The maintenance and upbringing of the girl are from then onwards shared by the natural parents and the parents of the potential husband. The marriage ceremonies are simple and modest, involving the performing of rituals and the payment of bride prices by the would-be husband.

Among the people, descent is claimed or transmitted agnatically from father to children, theoretically descending in this fashion from the individual's ancestor. Descent carries with it loyalty to the ancestor which involves observing certain conditions and prohibitions (totems).

The inhabitants of the towns and villages are organised into households. The domestic group is composed of the Head - usually a man (often the husband) and a woman (often the wife) or wives in the polygamous households. The other members of household include the children and other relatives, such as aged parents, brothers and sisters. The head of the household is the legal custodian of all household properties, including land, which he keeps in trust especially for younger household members. He is the economic back-bone (provider) of the household and also provides security and protection for all within the household.

Each household owns a living quarters (house). These are constructed using mainly locally acquired materials such as mud, wattle and grass (for roofing). The architectural design that is common is one that is circular in shape. There are no verandas. It is only in exclusive circumstances that compartments are provided within these houses to serve as rooms. At the back of the houses are constructed huts (sheds) of much smaller measurements to function as "barri" (living quarters for assembling), grain houses and cooking places. The towns or villages seldom have a house of modern architectural design with corrugated iron sheets for roofing. There is no evidence of pipe-borne water supply systems and the inhabitants rely on water from the stream for drinking and domestic services.

The inhabitants of the villages in the region falling within the project area practise traditional religions and Christianity. No Limba proper responded to being Muslim despite centuries of association with Muslim neighbours. They all preferred to be Christians. However, in all of the villages, there was no evidence of a permanent Church building. In Kasokira and Kasasi, there were huts (temporary), which were being used for Church services. The people receive religious education and moral (ethical) guidance from travelling Evangelists who visit them either from Bumbuna or Makeni. These Evangelists only visit on Christian-feast days like Christmas and Easter, as was reported by the Christian respondents to questions.

An interesting phenomenon which was brought to light was the peoples seemingly unconscious and perfect admixture of Christianity with traditional worship and religious practices. Each of the towns has a number of shrines or sacred groves either to keep their traditional religious figurines or provide an abode for the gods where the people meet to perform sacrifices. All the towns that fall within the project area have the following traditional religious places:

Bembe:	A shrine or Grove where the people assemble before embarking on any significant function or undertaking, e.g. farming, marriage, childbirth, naming ceremony, preparation for war, civil defence. In this Grove, the people led by the oldest surviving male figure in the town, who must also be a senior member of the male "Gbangbani Society", assemble whenever, it became apparent and necessary to feed the spirits and offer animal sacrifices (sheep, goat or bull) depending on the occasion and the intentions of the people.

At the first rains, the Limba farmer in Kalansogoia, visits the spiritual grove (Bembe), where rice-bread, cooked rice and livestock are sacrificed to the goddess of the earth and the departed ancestors, with prayers and solemn incantations. These ceremonies are designed to seek the goodwill of the spirits and ancestors in order to ensure a successful harvest. Each stage of the farming process is characterised by ceremonial practices and rituals.

Nabangere: A sacred "stone" is kept in the societal grove meant for the male society. It was also fed, and adored with sacrifices at the beginning of preparations for the male secret society. Various sacrifices are offered to it throughout the course of the initiation and other ceremonial rites. It is believed that the Nabangere has the power of protection and the ability to intercede on behalf of Gbangbani members who have offended the spirits of the society.

Kpouki: A sacred and revered "stone" in the female societal Grove. It is also used as a place of worship and sacrifices during the female initiation rites. Sacrifices are offered to it in order to grant fertility to young female initiates.

A representative stone of the Kpouki is also kept in the centre of the village or on a raised mound of earth in a special area within the village in order to offer protection to the village, the woman and the children.

Stream: Each town has a stream nearby, which is given various symbolic names. In Kakutan, for example, the stream is known as "Kamatane" (Holy water place). Such streams are used both as a source of drinking water sent by the "spirits" and "gods" and to provide a place of worship and sacrifices for good fortune and prosperity.

Ceremonial Trees: These trees often belong to different species in the classification of trees. They are mostly cotton trees. They are often found either at the entrance to the town or the back of it. In some cases they could be found in the nearest thick bush around the town. These trees are believed to be the permanent place of habitation of the ancestors who founded the towns and whose responsibilities are to protect and secure it. They are places of periodic ceremonial worship.

The existence of secret societies are a peculiar feature of the traditional African way of life. The Limbas also greatly revere and practise the rituals and ceremonies associated with secret societies.

It was discovered that the predominant secret society for the males in the area is the Gbangbani - which is believed to be a very powerful society of much masculine and aggressive features. Its ceremonies and rituals are organised in Groves usually located on the outskirts of towns. If the village is too small, the enclosure encompasses the whole village. This was the situation at Kadala during the survey. The bush surrounding the Grove and its immediate environs are referred to as "Kakutouhuga" by most of the members, while they have other names in other towns. The Gbangbani has no political function.

The women also practise a variant of the female secret society, the "Bondo". It is usually located on the outskirts of the village away from the area housing the male Grove. The Limba women also participate in another set of rituals of societal status, known as the "Kpouki", which possesses slight ritual differences from the Bondo.

It is significant to note that, irrespective of the distance or closeness in ties, like for example, between Kadala and Kasokira, no two towns could agree to blend their ritual ceremonies together. However, Kadala is much more important in the eyes of the Gbangbani members as providing the oldest Society-Grove within the area. Although all are held in independent lodges, the grand finale at Kadala is attended by all members. Now that Kadala will be close to the top water level of the dam project, the location of and the getting-to the Grove might be a sociologically important issue that should be prudently dealt with.

Archaeology

<u>*Results of Literature Review*</u>

The following is a summary of the full review of the literature relating to the archaeology of Sierra Leone, which is included in Appendix N.2 below.

There has been little archaeological research throughout the savanna-forest zone of sub-Sahelian West Africa, and knowledge of the Late Stone Age (LSA) and historical periods (e.g. African-European Contact from ca.1440) is very patchy (cf. Alie 1990; Anderson and Rathbone 2000; Fyfe 1962; Lamp 1983; MacDonald 1998; MacDonald and Allsworth-Jones 1994; Shaw *et al*, 1993; Watson 2004). Archaeological research in Sierra Leone is particularly underdeveloped, partly a result of the destruction of the socio-economic and academic infrastructure caused by civil war (1991-2002), and because a chair or department of archaeology has never been established in the country. Few systematic excavations or reconnaissance surveys have been conducted, and the limited number of publications present only generalised views of the area's archaeological heritage.

To contextualise the archaeology of a region it is necessary to consider past ecological conditions, because of the important interplay between environment and human behaviour. The few data available for the savannah-forest zone of West Africa relate primarily to the Holocene (a geological/environmental epoch beginning ca. 10,000bp[2]). This suggests that the ecological history was characterised by fluctuations in climate, with phases of marked aridity interspersed with more humid phases that were more conducive to human settlement and demographic movement (cf. Frank et al., 2001; Grove 1993; Lauer and Frankenberg 1980; Lézine 1987; Maley 1996; Neumann *et al*, 1996; Neumann and Ballouche 1992; Rognon 1976a, 1976b and 1980; Street and Grove 1976; Sowunmi 1981, 1985, 1986, 1999 and 2002; Talbot *et al*, 1984). However in the absence of palaeoecological evidence and with the limited archaeological data available (e.g. socio-economic systems and/or settlement patterns), it is not possible to accurately identify the impact of these fluctuations during human history. However, it is important to consider what is already known about the area to indicate what may be expected at the reservoir site.

A number of LSA (Late Stone Age) hunter-gatherer sites have been found in the Northern and Eastern Provinces (Fig. N.1.3-2) demonstrating that this area was inhabited from at least ca. 2,500BC. The only well documented sites are Yengema cave (Coon 1968) and the rock shelters at Kamabai and Yagala (Atherton 1972). These are typically situated on inselbergs[3] and are characterised by the differential occurrence of geometric and non-geometric microlithic[4] (quartz-based) and macrolithic[5] toolkits, double- and single-bladed polished and/or ground stone celts[6], and pottery. Similar LSA assemblages have been reported from the rock shelter sites of Kakoya and Bunumbu in the Northern Province (Newman 1966). This suggests that Sub-Saharan West Africa was populated by small, mobile and isolated bands of hunter-gatherers/fishers moving freely within a vast geographical area consisting of forests, rivers and grasslands (cf. MacDonald 1998; Watson 2004). This socio-economic adaptation proved to be exceptionally durable, as hunter-gatherer groups seem to have survived in the area until the 1st millennium AD (e.g. Yagala rock shelter).

2 Radiocarbon dates presented as 'bp' refer to years 'before present'.
3 An isolated rocky hill rising abruptly from a flat plain.
4 Small stone tools usually less than 2-3cm greatest length, and thought to have been hafted for use as composite tools (e.g. a saw).
5 Any stone tool kit with individual elements (i.e. tools) with greater dimensions that those described in footnote 5.
6 Stone axes predominantly made from dolerite, a coarse grained basalt

The terminal LSA assemblages from Yagala and Kamabai rock shelters were overlain by 'Iron Age' material, consisting of iron tools, different forms of pottery decoration and evidence for iron working (slag and similar by-products of the smelting process). There are also relatively large quantities of chipped stone (i.e. stone tools), indicating the continued use of this technology despite the advent of iron metallurgy (Atherton 1972; cf. Hill 1969). There appear to be two different pottery decorative traditions in Sierra Leone. Pottery associated with pre-metallurgical groups (i.e. prior to ca. AD 700) consists of potsherds (pottery fragments) mainly decorated with simple punctate or cord-impressed motifs, whilst later assemblages are decorated with a wider variety of motifs and techniques and appear to persist until ca. AD 1500 (cf. Atherton 1972; Lamberg-Karlovsky in Coon 1968).

No attempt was made to recover archaeobotanical remains during these excavations and no animal remains were reported. Consequently, there is little understanding of the subsistence economy of the hunter-gatherers or metallurgical group(s). There are also no data concerning early cultivation of indigenous staples of the savanna-forest/forest (i.e. tree and tuber crops; cf. Andah 1987, 1993; Sowunmi 1981, 1985, 1986, 1999 and 2002; Shaw 1985), so it is not clear whether the agricultural economies were indigenous developments, or originated in an adjoining part of West Africa.

Archaeological surveys of the area have generally been sporadic and unsystematic. Ozanne (1966, 1968) conducted surveys in the Western, Eastern and Southern Provinces, and postulates on the existence of an apparently widespread "medieval cultural complex" described as the "Beaker Group". This is defined from the presence of beaker-shaped pottery, dating from the late 15th to the early 17th century AD. Hill (1969) undertook surveys in the Chiefdoms of Bagbe, Komboya and Baja in the Bo District, and located over 100 sites. These ranged from "contemporary villages with archaeological materials" to defensive structures, a few "purely lithic sites" and a wide range of others yielding scatters of surface material. Following test excavations a mound site near Mano-Pendobu was interpreted as a "ritual deposit of pottery", and a supposedly older Joya rock shelter near Gbaama, yielded "[a] very limited number of stones and pottery artefacts…suggesting only occasional and limited occupation." Newmann (1966) surveyed areas within the Northern Province and located the remains of a few 19th century villages and apparent prehistoric sites.

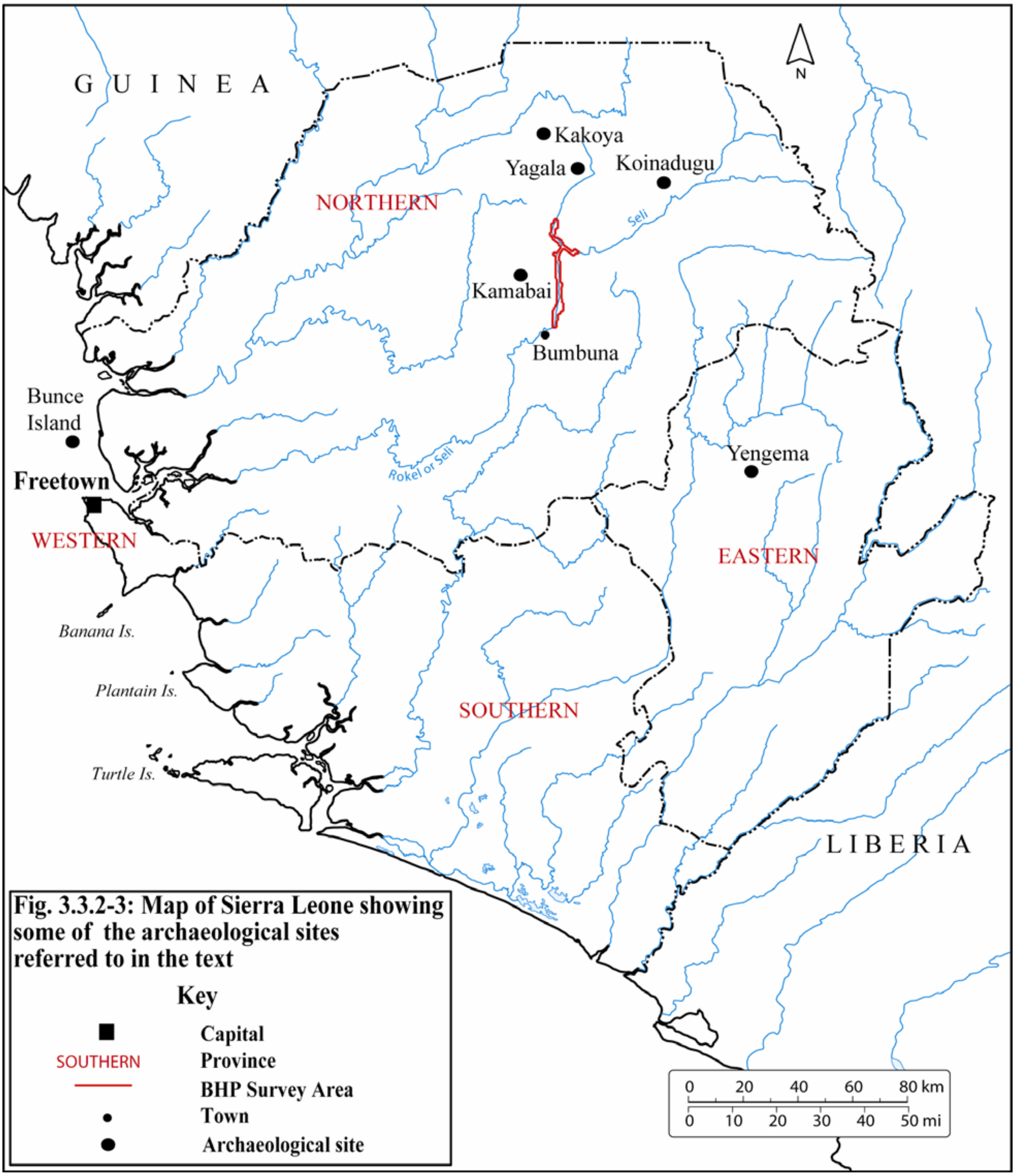

Fig. 3.3.2-3: Map of Sierra Leone showing some of the archaeological sites referred to in the text

There is a great deal of uncertainty surrounding several types of artefact that are either unique to Sierra Leone or widely distributed across sub-Sahelian West Africa. For example Atherton (1980; cf. Atherton and Kalous 1970) suggested that double-edged celts found at LSA sites were associated with "socioreligious" activities of "prehistoric populations" as they were used for the manufacture of *nomoli* (soapstone figurines representing ancestors or spirits). However, double-edged celts have been found outside the known distribution of the figurines (eg Côte d'Ivoire) and Lamp (1983) dates the beginning of the manufacture of *nomoli* to the 15th century AD. Atherton (1980) also suggested that *kwes* ("digging-stick weights") found in diamond areas might have been used for mining, although it has also been suggested that *kwes* - along with choppers, ‘picks’ and celts - were associated with forest clearance and culture of yams (see Watson 2004 for a review of the evidence).

Megalithic[7] monuments have also been reported from Sierra Leone, although their significance is unknown. Roll (1967) excavated two formations located in the Gaura Chiefdom within the Gola forest: one consisted of two upright stones in an ‘L’ shape, whilst the other comprised eight upright stones arranged in a circle with a ninth located in its centre.

Due in part to the cultures that lived in the area, and the oscillating climatic regime that may have had a destructive effect on preservation, rock paintings are rare in the savanna-forest of West Africa. The only examples reported from Sierra Leone are by Decorse (1988) from the rock shelter located near Kakoya. The designs are ovoid with a white outline and series of dots in their interiors. Their significance is unknown, but it has been suggested that they may be related to female excision rituals that still take place amongst the Limba.

The most recent archaeological research in Sierra Leone was conducted by Dr C. Decorse, comprising a survey of 25 protohistoric[8] and historic defensive sites in the Koinadugu District. These have been dated on the basis of European trade goods to the 19^{th} century AD (Decorse 1980, 1981). Further historical sites on Bunce Island were also located in 1993, but these are yet to be published (Dr C. Decorse, pers. comm.). Decorse (1989) also conducted an ethnoarchaeological study of the Limba, Yalunka and Koranko peoples, contiguous ‘ethnic groups’ resident in the Northern Province, into their ethnic affinity and its expression in material culture.

The origin of most ethnic groups currently, or recently, resident in Sierra Leone (Fig. N.1.3.1), and the date of their first incursion into the area, has never been accurately established. The historiography of the ‘Limba’, however, is germane to the current study, as the BHP falls within the modern extent of their settlement of the Northern Province. Despite the paucity of archaeological, historical and ethnographic data, there is a consensus that the occupation the Limba people is of considerable antiquity (cf. Fyfe 1962; Kup 1962). From the 17^{th} century onwards, accounts by European visitors differentiated between the Limba, related groups and others that were believed to have arrived in the recent past (Atherton 1969, 140-141). Atherton (1969) argued that the ‘Limba’ were descended directly from the LSA inhabitants of the area and it is important

[7] Large standing stone monuments such as Stonehenge in Britain.
[8] Early African-European contact period.

to test this theory as it has implications for the national and historic heritage of Sierra Leone and the surrounding area.

In summary, there are significant gaps in our understanding of the LSA and historical periods of Sierra Leone. Even basic information such as regional chronologies and the extent of potential archaeological resources are almost entirely lacking. The paucity of archaeological sites located is a result of the limited research conducted to date, and the difficulties involved in locating archaeological sites within savannah-forest because of the sheer density of vegetation. Thus, from an archaeological perspective the opportunity for survey within the area of the BHP reservoir represents an opportunity to determine the archaeological potential or otherwise of this area, and to contribute spatial information on the presence/absence of sites and materials within the Northern Province.

Results of Archaeological Survey

The terrain of the reservoir area is mostly hilly and ‘mountainous’ and the entire area is thickly vegetated. The ‘modern’ settlement pattern is characterised by villages/hamlets situated atop hills, and these become progressively more widely spaced to the north. These factors have engendered a palpable sense of isolation between the communities, as many are functionally and, to some extent, socially discrete from their neighbours.

The interviews included a wide range of persons, from chiefs, elders, and householders to family members, farmers, fishermen, shopkeepers and others, and ranged over a wide variety of topics. The results were uniform at all locations in that the interviewees had not recovered or noted any archaeological material during hunting, pastoral, agricultural or any other activities.

The various field investigations yielded similar results. Although almost 10 % of the reservoir area was investigated by field walking, no archaeological sites or materials were detected. The detailed shovel-testing of the mounds at Kasai and Fulatown also revealed no evidence of any occupation or artefacts, suggesting that the ‘mounds’ appear to be entirely natural phenomena. The rock shelter near Kafogo also yielded no material culture or evidence of occupation, although according to villagers it has been used recently as a temporary respite in times of conflict. However, given the shallow overhang of the shelter (which provides little more than a metre of cover) it may have only ever functioned as an ephemeral site of occupation.

During the investigation and interviews it became apparent that the limited number of settlements lying within the scope of the survey were founded around the mid to late 19th century AD. The Bumbuna environs seem to have to been settled by the Limba peoples as part of a southern wave of migration provoked by the contemporaneous expansionist activities of ‘warrior-kings’ such as Almamy Suluku (a Biriwa Limba[9]) and Samori Touré (a Mandingo[10]). The peoples displaced by this migration are likely to have comprised Koranko and Temne ethnic groups. The current Limba people were entirely unaware of the location of any of the areas previously occupied by these groups. Their oral history of the study area ‘begins’ with the arrival of their ‘forefathers’ in the region they currently inhabit. Koranko people interviewed during the survey were unable to provide any further information as their ‘history’ dates from a similar period. This is, however a significant finding, as it seems to suggest that they may not be descended from the Koranko group(s) thought to previously occupy the area.

[9] Biriwa is a Chiefdom area with its headquarters currently situated at Kamabai (see Fig. 3.3.2-3).
[10] The Mandingo people emigrated from the area of Guinea south into Sierra Leone and Liberia over the past 200-300 years.

N.2 Review of Literature Relating to the Archaeology of Sierra Leone

The main ethnic group that will be directly affected by the BHP are the Limba people(s) (Fig. N.1.3-1). In a broad ethnographic study that was typical of the time, Gorvie (1944) posited the existence of ten sub-divisions of the Limba that identified the Limba of Kalansogoia as the Kalantuba Limba. McCulloch’s 1950 ethnographic survey of Sierra Leone reviewed all existing literature on the ethnography of the country. She treated all the major ethnic groups at length depending on available documentation, noting in the process that there was a paucity of appropriate information about the Limba. In light of the available source material and research development, McCullough’s review was not particularly helpful, and did not exceed Thomas (1916) in terms of useful information about the ethnographic make-up of the Sierra Leonean area. Finnegan (1965) wrote the most comprehensive account of the entire Limba group, dealing in greater detail than any other author with history, political system, social institutions (such as clans, kinship groups, marriage, male and female societies), economy (especially agricultural), religion and witchcraft. However, the main focus of her investigation centred on the Biriwa, Wara Wara and Kasunko chiefdoms.

There has been a serious lack of archaeological research throughout the savanna-forest zone of sub-Sahelian West Africa and our knowledge of the Late Stone Age (LSA) and historical periods (e.g. African-European Contact from ca.1440) of this area is therefore extremely patchy and irregular (cf. Alie 1990; Anderson and Rathbone 2000; Fyfe 1962; Lamp 1983; MacDonald 1998; MacDonald and Allsworth-Jones 1994; Shaw et al., 1993; Watson 2004). Archaeological research in Sierra Leone is particularly underdeveloped, partly a result of the devastation of the socio-economic and academic infrastructure caused by civil war (1991-2002), and that a chair or department of archaeology has never been established within the country. This situation is exacerbated by the fact that few systematic excavations or reconnaissance surveys have ever been conducted within Sierra Leone; the limited number of publications that exist present very generalised and unrefined views of the area’s archaeological heritage.

In order to contextualise the archaeology of Sierra Leone it is first necessary to briefly describe the past ecological conditions of the savanna-forest region. The interplay between ecological conditions and human behaviour is highly complex, but the latter is directly influenced - though not necessarily determined - by the potential offered by the environment. Unfortunately, comparatively limited data are available for the past climatic and past environmental conditions of the savanna-forest zone of West Africa, and these relate primarily to the Holocene (a geological/environmental epoch beginning ca. 10, 000bp[11]). The available information concerning Holocene climate and ecology

[11] Radiocarbon dates presented as ‘bp’ refer to years ‘before present’.

(obtained from neighbouring regions, including Ghana, Burkina Faso and Nigeria) suggests that the ecological history of this zone was characterised by a complex series of fluctuations in climate. These switches in climatic regime engendered extremes of environmental conditions, with phases of marked aridity (especially after ca. 2,500bc[12] when ecological conditions began to approach those of the present day) interspersed with more humid phases that seem to have been more conducive to human settlement and demographic movement (cf. Frank et al., 2001; Grove 1993; Lauer and Frankenberg 1980; Lézine 1987; Maley 1996; Neumann et al., 1996; Neumann and Ballouche 1992; Rognon 1976a, 1976b and 1980; Street and Grove 1976; Sowunmi 1981, 1985, 1986, 1999 and 2002; Talbot et al., 1984). Yet in the absence of direct or proxy palaeoecological and the limited archaeological data available (e.g. socio-economic systems and/or settlement patterns) for this area, it is not currently possible to accurately identify the extent and nature of the impact of these palaeoecological fluctuations during human history. However, it is important to recap upon that which is already known about the area so that some general notions of what may be expected in the proposed dam area can be postulated.

A number of LSA (Late Stone Age) hunter-gatherer sites have been found in the Northern and Eastern Provinces (Fig. N.1.3-2) demonstrating that this area was inhabited from at least ca. 2,500BC. The only well documented sites are Yengema cave (thermoluminescence[13] dates of 2200 ± 470BC[14] and 1500 ± 350BC; Coon 1968) and the Kamabai (radiocarbon date of 2560 ± 115BC) and Yagala rock shelters (radiocarbon date of AD 1070 ± 100) (Atherton 1972). While variable to a certain extent, these sites are typically situated on inselbergs[15] and are characterised by the differential occurrence of geometric and non-geometric microlithic[16] (quartz-based) and macrolithic[17] toolkits, double- and single-bladed polished and/or ground stone celts (stone axes predominantly made from dolerite, a coarse grained basalt), and pottery. Similar, but undated, LSA assemblages have been reported from the rock shelter sites of Kakoya and Bunumbu in the Northern Province, which were excavated by Newman (1966). The significance of this data is certainly debateable, given the small number of known sites and the often-basic methods used to excavate and record them, but some general trends are apparent. Sub-Saharan West Africa appears to have been populated by small, mobile and,

[12] Dates presented as 'bc' are uncalibrated, and are derived from subtracting the 'raw' date from AD 1950 (when atomic testing led to elevated levels of radioactive carbon isotopes in the atmosphere). These are approximate dates are equivalent to calendric dates. Whilst 'BC' dates are calibrated against known dendrochronological (tree-ring dating) data and fluctuations in the C14 (radioactive) isotope. These may be understood to represent calendric dates.

[13] Thermoluminescence is a dating method that relies indirectly on radioactive decay (unlike radiocarbon dating which is entirely based on measuring radioactive decay) by measuring the energy generated by a sample (usually ceramic) during heating.

[14] As all radiocarbon dates are expressed as a statistical value the '±' following each date represent the error factor inherent within the date. So the radiocarbon date of 2560 ± 115BC has an error factor of 115 years on either side of the date of 2560BC.

[15] An isolated rocky hill rising abruptly from a flat plain.

[16] Small stone tools usually less than 2-3cm greatest length, and thought to have been hafted for use as composite tools (e.g. a saw).

[17] Any stone tool kit with individual elements (i.e. tools) with greater dimensions that those described in footnote 6.

apparently, isolated bands of hunter-gatherers/fishers moving freely within a vast geographical area consisting of forests, rivers and grasslands (cf. MacDonald 1998; Watson 2004). In Sierra Leone, the differences in the lithic industries found at LSA hunter-gatherer sites (i.e. Yengema yielded a macrolithic assemblage, whilst those from Kamabai and Yagala were microlithic) and their perdurability indicate the existence of either regionally specialised toolkits adapted for the extraction/processing of localised resources, or possibly reflecting the postulated 'isolation' said to characterise individual groups throughout the Holocene. Whatever the cause, this socio-economic adaptation proved to be exceptionally durable throughout the savanna-forest region of West Africa, as hunter-gatherer groups seem to have survived in the area until some time in the 1st millennium AD (e.g. Yagala rock shelter).

The terminal LSA assemblages from Yagala and Kamabai rock shelters were overlain by 'Iron Age' assemblages, consisting of iron tools, different forms of pottery decoration and evidence for iron working (slag and similar by-products of the smelting process). At Kamabai, definite evidence for metallurgy occurs in Level 3 (dated to AD 1360 ± 95) but it has been suggested on the basis of similarities in the pottery decoration between this level and the underlying Level 4 that iron technology was introduced around AD 690 ± 95 to AD 760 ± 95 (Atherton 1972). Intriguingly, there appears to be two different and broad pottery decorative traditions in Sierra Leone. The pottery associated with pre-metallurgical groups (i.e. prior to ca. AD 700 at Yagala, Kamabai and Yengema Cave) consists of potsherds (pottery fragments) predominately decorated with simple punctate or cord-impressed motifs, whilst later assemblages are decorated with a wider variety of motifs and techniques (including earlier forms) and appear to persist until ca. AD 1500 (cf. Atherton 1972; Lamberg-Karlovsky in Coon 1968). Despite the appearance of iron technology at Yagala and Kamabai, relatively large quantities of chipped stone (i.e. stone tools) were associated with 'Iron Age' material culture, indicating the continued use of this technology despite the advent of iron metallurgy (Atherton 1972; cf. Hill 1969).

No attempt was made to recover archaeobotanical remains during any of these excavations and no animal remains were reported. Consequently, we have little understanding of the subsistence economy of these hunter-gatherers or the metallurgical group(s). Equally, we have no data concerning any potential early cultivation of indigenous staples of the savanna-forest/forest (i.e. tree and tuber crops; cf. Andah 1987, 1993; Sowunmi 1981, 1985, 1986, 1999 and 2002; Shaw 1985). It is therefore impossible to determine whether these agricultural economies were indigenous developments, or the result of stimulus diffusion from an adjoining region of West Africa.

Archaeological surveys of the area have generally been sporadic and unsystematic. Ozanne (1966, 1968) conducted archaeological surveys during the course of four and a half weeks in the Western, Eastern and Southern Provinces, but due to time constraints he was unable to visit any sites in the Northern Province. He postulates on the basis of surface finds (principally from Baka in western Sierra Leone) the existence of an apparently widespread "medieval cultural complex" described as the "Beaker Group". This consists of an 'archaeological culture' defined on the basis of the presence of a specific set of artefacts, in this case beaker-shaped pottery. Consequently, it is an abstract, as it does not necessarily relate to a geographically and/or temporally discrete human culture. Dates for this so-called culture range from the late 15th to the early 17th century AD, ascribed on the basis of the co-occurrence of this form of pottery with European trade goods that date to this period. Hill (1969) undertook wide ranging but sporadic surveys around the Bo, Kenema, Kailahun and Kono Districts in the Southern and Eastern Provinces over a total of three months between November 1967 and June 1968. His survey eventually limited itself to the Chiefdoms of Bagbe, Komboya and Baja in the Bo District, where he was able to locate over 100 sites from "contemporary villages with archaeological materials" to defensive structures, a few "purely lithic sites" and a wide range of other archaeological sites yielding scatters of surface material. Subsequent research was undertaken on ceramic seriation of the material collected from the surface of many of these sites (Hill 1970), in an attempt to develop a region-wide typological system (i.e. the organisation of artefacts into types on the basis of shared attributes). Test excavations were conducted by Hill (1969) at two very different sites within the Bagbe Chiefdom. The first excavation took place at a mound site near Mano-Pendobu, which was interpreted as a "ritual deposit of pottery". The other site was the putatively older Joya rock shelter near Gbaama, that yielded "[a] very limited number of stones and pottery artefacts…suggesting only occasional and limited occupation." Newmann (1966), in addition to his excavation of rock shelter sites (see above), also surveyed areas within the Northern Province and located the remains of a few 19th century villages and apparent prehistoric sites. Unfortunately, little information has been published regarding any of these sites.

Speculation surrounds a variety of artefacts that are either unique to Sierra Leone or a found widely distributed across sub-Sahelian West Africa. Atherton (1980; cf. Atherton and Kalous 1970) suggested that double-edged celts found at LSA sites in Sierra Leone were associated with "socioreligious" activities of "prehistoric populations" as they were used for the manufacture of *nomoli* - soapstone figurines found in the southern and eastern parts of Sierra Leone. These figurines are unique to Sierra Leone and may represent ancestors, spirits or, indeed, the peoples known to early Portuguese traders as the "Sapi peoples" (the modern Temne may be their linguistic descendants; Atherton 1980; Atherton and Kalous 1970; Lamp 1983). However, *nomoli* have not yet been recovered from any known archaeological site or context. Instead, they are found, usually by chance, as individual finds or in groups in farm land and/or in sacred sites with which they are associated. Double-edged celts have been found outside the known distribution of the figurines (e.g. Côte d'Ivoire) and may form part of a technocomplex (a group of "cultures" sharing an "interlinked response to common factors in environment, economy and technology"; Clark 1978) specific to the western area of sub-Sahelian West Africa (cf. Atherton 1972, Chenorkian 1983). Consequently, Atherton's (1980) hypothesis regarding the association of *nomoli* and early LSA populations (i.e. from ca. 2500BC) may be incorrect. Indeed, Lamp (1983) dates the beginning of the manufacture of *nomoli* to around the 15th century AD. Atherton (1980) also suggested that *kwes* ("digging-stick weights") found in "diamondiferous" areas might have been used for mining diamonds and/or gold, perhaps for the trans-Saharan trade. However, more prominence has been given to the suggestion that *kwes* - along with 'specialised tools' such as choppers, 'picks' and celts - were associated with forest clearance and incipient vegeculture of yams (but see Watson 2004 for a review of the available evidence).

Megalithic[18] monuments have also been reported from Sierra Leone. Roll (1967) excavated two formations located in the Gaura Chiefdom within the Gola forest: one consisted of two upright stones in an 'L' shape, whilst the other comprised eight upright stones arranged in a circle with a ninth located in its centre. The significance of these monuments to the culture(s) that produced them is currently unknown,

Due in part to the cultures that lived in the area, and the oscillating climatic regime that may have had a destructive effect on preservation, rock paintings are rare in the savanna-forest of West Africa. The only examples reported from Sierra Leone are by Decorse (1988) from the eponymous rock shelter located near Kakoya, a Limba town in the Bafodia Chiefdom. The designs are ovoid with a white outline and series of dots in their interiors. Their significance is unknown, but it has been suggested that they may be related to female excision rituals that still take place amongst the Limba. It is anticipated that the survey of more escarpments, caves and river valleys may provide further information about this currently under-researched area of West African archaeology.

The most recent archaeological research in Sierra Leone was conducted by Dr C. Decorse, comprising a survey of 25 protohistoric[19] and historic defensive sites in the Koinadugu District. These sites have been dated on the basis of European trade goods to the 19th century AD (Decorse 1980, 1981); further historical sites on Bunce Island were also located in 1993, but these are yet to be published (Dr C. Decorse, pers. comm.). Decorse (1989) also conducted a pioneering ethnoarchaeological study of the Limba, Yalunka and Koranko peoples, contiguous 'ethnic groups' resident in the Northern Province, into their ethnic affinity and its expression in material culture. His

[18] Large standing stone monuments such as Stonehenge in Britain.

[19] Early African-European contact period.

comprehensive review was able to demonstrate that contrary to many assumptions in archaeology regarding material culture/technology as media for delineating group identity, such media may in fact be problematic indicators of group affiliation. Despite the self-conscious ethnic identification of these peoples and their propinquity, few differences were evident in their material culture that would serve as archaeological signatures of ethnicity.

The origin of most ethnic groups currently, or recently, resident in Sierra Leone (Fig. N.1.3-1), and the date of their first incursion into the area, has never been accurately established. Indeed, the history of the peoples of Sierra Leone before and during the early historical period is largely based on supposition (cf. Lamp 1983). The historiography of the ‘Limba’, however, is germane to the current assessment survey, as the BHP falls within the modern extent of their settlement of the Northern Province. Despite the paucity of archaeological, historical and ethnographic (especially pre-19th century) data available for Sierra Leone, there appears to be a consensus that the occupation the ‘Limba people’ is of considerable antiquity (cf. Fyfe 1962; Kup 1962). From the 17th onwards, accounts by European visitors to the coast differentiated between the Limba, related groups and others that were believed to have arrived in the recent past (Atherton 1969, 140-141). Archaeologically, we lack the refinement to assess the integrity of this assertion. However, it should be noted that Atherton (1969) argued for continuity on the basis of apparent typological continuity in lithic assemblages from the LSA into the early ‘Iron Age’, thereby arguing that the ‘Limba’ were descended directly from the LSA inhabitants of the area. The importance of testing this theory cannot be overstated, as it has serious implications for the national and historic heritage of Sierra Leone and the surrounding area. It is therefore vital that this hypothesis be re-examined on the basis of systematic excavation of similarly dated archaeological sites in the area, including analysis of material culture and socio-economic data.

In summary, there are significant gaps in our understanding of the LSA and historical periods of Sierra Leone. Even basic information such as regional chronologies and the extent of potential archaeological resources are almost entirely lacking. The paucity of archaeological sites located is, of course, a direct result of the limited research conducted to date, and the difficulties involved in the location of archaeological sites within the savanna-forest zone of sub-Sahelian West Africa (e.g. the sheer density of vegetation in this broad ecological zone). Thus, from an archaeological perspective the opportunity for survey within the area of the BHP reservoir represents an excellent opportunity to determine the archaeological wealth or otherwise of this area, and may at the very least contribute spatial information regarding the presence/absence of sites and materials within the Northern Province.

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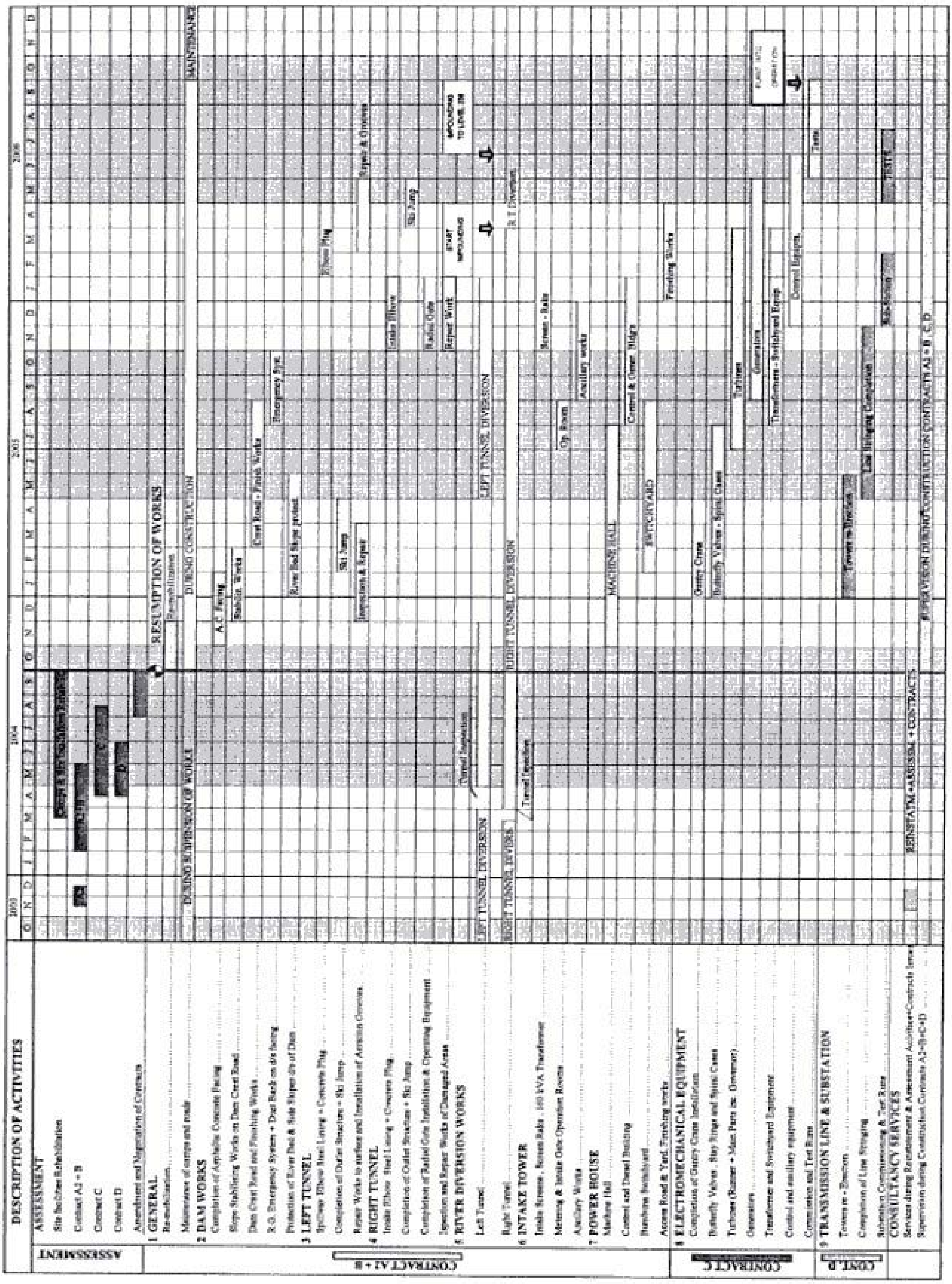
World Bank Operational Policy Note 11.03: Management of Cultural Property in Bank-Financed Projects.

O Remaining Construction

O.1 Programme of Works up to Project Completion (2004-2006)



Source: DRP (2004)

O.2 Summary of Main Activities and Quantities for Project Completion

LIST OF ACTIVITIES	MAIN WORKS and QUANTITIES Description	U.M.	Q.ty
1 GENERAL			
Re-mobilisation	Expatriate Staff (70 pers.), Mobile Plant & Equipment		
Refurbishment of Access roads to site	Makburaka-Bumbuna, Binkolo-Bumbuna	km	81
2 DAM WORKS and SLOPE PROTECTIONS			
Dam Embankment construction	Downstream random fill zone	m3	30000
Completion of Asphaltic Concrete Facing	Milling of weathered material	m2	15000
	Impervious Layer for completion plus reconditioning	m2	21500
	Provide and apply Sealing coat	m2	51000
	Cut-Off Joint	m	450
Slope Stabilising Works on Dam Crest Road	Excavation	m3	500
	Rockfill	m3	5500
	Concrete works	m3	800
Dam Crest Road and Finishing Works	Paved roads	m2	7000
	Concrete works (wave wall, kerbs and cable ducts)	m3	950
	Stone pitched drains	m2	900
	Guardrails	m	940
Protection of River Bed & Side Slopes d/s of Dam on left and right bank	Common bulk excavation	m3	32400
	Rock bulk excavation	m3	12000
	Random fill	m3	43050
	Mass concrete	m3	2505
	Geotexile	m2	14550
	Gabbions and "Reno" Mattressess	m3	5240
	Rockfill and rip rap	m3	23365
Spillways protection	U/S Floating barrier	m	400
3 LEFT TUNNEL			
Spillway Elbow Steel Lining + Concrete Plug	Concrete plug	m3	1800
Completion of Outlet Structure + Ski Jump	Concrete works	m3	1500
Repair Works to surface	Concrete lining repair and finishing	m2	4500
Aeration Grooves	Installation and finish	n	45
4 RIGHT TUNNEL			
Intake Elbow Steel Lining + Concrete Plug	Stoplogs and Concrete plug	m3	2230
Completion of Outlet Structure + Ski Jump	Concrete works	m3	1277
Completion of Radial Gate Installation & Operating Equipment	Side steel linings, top seals, instrumentation and monitoring sys.		
Ispection and repair works of concrete damaged areas	Concrete lining repair and finishing	m2	1600
R.G. Pipelines for Normal and Emergency Opening Systems	Flanged Steel pipes PN 10 D 300 mm, Valves, fittings	m	50
	Flanged Steel pipes PN 10 D 150 mm	m	300
5 RIVER DIVERSION WORKS			
Left Tunnel	inspection and repair works, ski jump and plug	nr	2
Right Tunnel	repair works, ski jump and intake elbow	nr	1
6 INTAKE TOWER			
Intake Screens, Screen Rake, 160 kVA Transformer	Set of 6 screens and cleaning trash rake equipment		
Metering & Intake Gate Operation Rooms	water level metering, inclinometer		
Ancillary Works	Concrete and building works, Structural steel and metal works for upper structure		
7 POWER HOUSE			
Machine Hall	Backfill with selected rock	m3	5000
	Concrete works	m3	3500
	Gres ceramic flooring	m2	650
Control and diesel generators buildings	blockworks, doors and windows, tailing, plastering and painting	m3	1500
Bumbuna Switchyard	earthworks, concrete works, fencing	m2	6600
Access Road & Yard, Finishing works	paved road (chippings and bitumen)	m2	6600
8 ELECTROMECHANICAL EQUIPMENT			
Completion of Gantry Crane Installation	115 ton Main hoist, 15 ton Aux. hoist	nr	1
Butterfly Valves, Stay Rings and Spiral Cases	2500 mm batterfly valve, 1 Mpa des. Pressure	nr	2
Turbines (Runner + Main Parts inc. Governor)	25 MW Francis turbine, vertical axis, design head of 70 m	nr	2
Generators	33.7 MVA 50 Hz vertical axis generator. 13.8 kV. 333.3 rpm	nr	2
Transformer and Switchyard Equipment	33.7 MVA ONAN cooling 13.8 / 170 KV step-up trasformer	nr	2
Control and auxiliary equipment	Distribution boards, inverter and battery equipment, diesel set with accessories, auxiliary MV/LV trasformers. instrumentation and metering equipment and services		
Commission and Test Runs			
9 TRANSMISSION LINE & SUBSTATION			
Towers re - Erection	Condition assessment in progress	nr	40
Completion of Line Stringing	" "	km	130
Substation Commissioning & Test Runs	" "		

Activities_Summary, 30Oct04, POE Rev. 30 Oct 2004 studio pietrangeli - rome

P Catchment Management

P.1 Water and Land Management Practice at Basin Level

P.1.1 Water Quality and Use

Water quality of the Seli River is typical of tropical rivers, characteristically with very low dissolved solid and nutrient levels, and a very low buffer capacity.

It is unlikely that water pollution will be an issue in the short term because of the predominantly rural nature of land and water use. However, should mining operations develop, then safeguards will be needed to protect against pollution from the use of process chemicals, and also from sedimentation from mine washing operations. These conditions will equally apply to the numerous small-scale enterprises and to less numerous medium and larger enterprises.

The presence of growing settlements in the catchment will also require that sewage treatment and disposal and solid waste disposal are carefully controlled.

Similarly, agricultural developments may lead to the use of pesticides or fertilisers, which may harm water quality. Adequate environmental standards concerning water quality and pollution will need to be developed and applied.

Reliable availability of water is critical for the operation of the BHP, and although water availability at certain times of year may be sufficient for other major uses upstream of the dam, during the dry season water will be needed primarily for power generation. There is little scope, therefore, for significant use of irrigation water upstream of the dam. Downstream, water will be available for the Magbas Sugar Project and other small scale irrigation schemes.

Planning of water use, both surface water and groundwater, will be necessary at basin level to ensure provision is made for power generation, agriculture, industry domestic use and other users.

P.1.2 Land use

Land management practice

Rates of soil erosion increase dramatically when the ground is bare of vegetation. According to figures quoted by Goudie for various parts of Africa, erosion (expressed as tonnes/ha/year) for a cropped surface is roughly one order of magnitude, and for bare soil approximately two orders of magnitude greater than for a forested surface.

Equally, the shifting cultivation agricultural practice will frequently result in the exposure of bare earth. This is potentially the most significant factor since the area under cultivation is large and probably increasing. Slash and burn cultivation practices should, in the medium and long term, be replaced by alternatives that are less destructive to soils. Birchall et al. (1979) state that the average fallow period at that time was shorter than 9 years, which is too short for guaranteeing a sustainable use of the soils in the long run. Population density is already too high to allow for longer fallow periods, and the general situation has probably not improved in the meantime, even if some areas show signs of reduced pressure and partially longer fallow periods. Agroforestry seems to be the best alternative, as it allows permanent use of soils without exhausting and destroying them. The land use form proposed for the immediate catchment area can be applied in the whole watershed in places where agriculture is feasible, i.e. in the forest regrowth vegetation type zone. This is based on contour line alley cropping with separating strips of forest in between.

The selection of crops and trees will have to be adapted to the prevailing local conditions, as these may somewhat different across the basin (precipitation, soil, altitude).

The Ministry of Agriculture has some experience with agroforestry, but only small projects were started. Important points are the propagation of oil palms (improved cultivations) together with the planting of other tree species. For the purpose of agroforestry, several species have been utilised successfully, mainly *Acacia mangium, A. auriculiformis, Gliricidia sepium, Albizzia* and *Cassia siamea; Leucaena leucocephala* seems to be less suited and is not recommended for use in Sierra Leone.

In order to be able to assess the importance of erosion under various conditions (different types of vegetation, land use, soil and slope), determination of actual amounts of erosion must be carried out. This would help in identifying conditions, mainly soils and land use practices that present a high erosion risk, and where therefore measures should be taken. The measurement of erosion should be complemented by monitoring the silt load of the rivers.

For soil protection and water retention, very steep slopes (>50 %) should not be used for crop production or as pastures, and the vegetation in these places must be left intact (no cutting, no burning). If erosion prevention is the main or only aim of this measure, it is best to leave the vegetation that develops spontaneously; active reforestation by planting trees would only seem necessary where soils have been degraded and eroded to an extent that makes the spontaneous regrowth of woody vegetation impossible or too slow. Such cases, if they exist in the Seli/Rokel catchment, seem to be the exception, and such reforestation programs will probably not be required. Forests regenerating through natural succession, especially when the original forest has been completely removed, will be slow in building up and therefore not quickly be able to provide other services e.g. timber production. However, they can be suitable habitat for a variety of wildlife species.

Sustainable forestry initiatives

An important means of reducing erosion and at the same time providing benefits for the local communities and for conservation, is through the adoption of sustainable forestry initiatives. For example, natural and semi-natural forests, which are almost exclusively gallery forests along the rivers, should be protected and, if required, enhanced. These forests are important not only for their ability to retain some of the silt brought by the river, but also for the conservation of the biological diversity of the country, as they are a suitable habitat for a large variety of plant and animal species.

Community Forests: Forests planted with the main purpose of producing fuel wood can substantially reduce pressure on the remaining natural forests. In order to be acceptable as fuel wood sources, such forests must be close to settlements. These are the places where competition for other forms of land use, mainly crop production, is highest. Therefore, people are often reluctant for giving land for this purpose. Community forestry can be a way for obtaining such forests. Furthermore, agroforestry using multipurpose tree (MPT) species can, at least to some degree, provide fuel wood at the same time as providing forage for animals and shelter, mulch etc. for food crops.

Poles etc. are needed locally for construction purposes, for fencing etc. Forest plantations with suitable species can serve this purpose. ‘Taungya’, a practice where crop production is combined with reforestation programs, can be an acceptable procedure. Such schemes have given good results in Asia and in Africa, e.g. Tanzania.

Forest plantations for high value timber production: Timber for export can be produced in forest plantations; the best-known species for this purpose is teak (*Tectona grandis*), which has already been planted in small plantations throughout Sierra Leone. However, the lag time from planting to harvesting is rather long (> 15 years), and an infrastructure for harvesting and processing of the timber is required. This makes such projects dependent on foreign investment. For the time being, there do not seem to be favourable conditions for such projects. In the past, forest plantations for timber production were planted in various parts of the country. The main species were teak (*Tectona grandis*), Caribbean pine (*Pinus caribaea*), *Gmelina* and *Terminalia ivoriensis*.

Q Costs for Mitigation and Monitoring

Q.1 Establish and administer the BWMA

	Description	Set Up Unit	Set Up Unit Cost	Set Up Total (US$)	Annual Recurring Unit	Annual Recurring Unit Cost	Annual Recurring Total (US$)
Institutional							
	Organisational development	1	25000	25000			0
Office							
	Refurbisment of premises	1	50000	50000			0
	Communications (satellite e-mail, phone, radio equipment)	1	25000	25000	12	500	6000
	Office equipment (PCs, printers, scanner, furniture etc)	1	40000	40000	1	10000	10000
Staff							
	Executive Director	12	2500	30000	12	2500	30000
	Finance Director	12	2000	24000	12	2000	24000
	Senior Admin	12	1500	18000	12	1500	18000
	Admin	12	1000	12000	12	1000	12000
	Technical programme staff (1)	12	1500	18000	12	1500	18000
	Technical programme staff (3)	24	1000	24000	24	1000	24000
	Trustees (7)	21	500	10500	21	500	10500
	International Inst Dev specialist	2	20000	40000			0
	Staff and Board training (15)		100	0	180	100	18000
Subsistence							
	International Inst Dev specialist	2	1800	3600			0
Transport							
	Vehicle purchase (3)	3	30000	90000			0
	Vehicle running and maintenance			0	3	1000	3000
	International travel	1	4000	4000			0
	Local transport	12	2000	24000	12	2000	24000
Materials							
	Outreach and training	1	20000	20000	1	10000	10000
	Documentation	1	5000	5000	1	2500	2500
	Contingency (10%)	1	50000	50000	1	25000	25000
	Total			**513100**			**235000**

Q.2 Construction measures

Description		One off			Annual Recurring		
		Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
Construction							
	Safe use and storage of toxic materials	0	0	0			0
	Minimise impacts on downstream channel	0	0	0			0
	(both the above are construction good practice)						
Monitor reservoir slopes during impoundment							
	Topographical surveys	5	500	2500			0
	Allow for remedial measures	1	5000	5000			0
	Subtotal			**7500**			
Reservoir water mixing							
	Supply and fix 300 m of perforated pipe and on reservoir floor	1	10000	10000			0
	Construct housing for compressor	1	10000	10000			0
	Supply and install air compressor complete with supply of electricity	1	20000	20000			
	Subtotal			**40000**			
Seismic Monitoring							
	Supply and install seismograph at suitable location at dam site	1	10000	10000			0
	Allow for readings at appropriate periods by a qualified person	12	50	600			0
	Subtotal			**10600**			
Rehabilitation of stream flow gauges							
	Rehabilitate stream flow gauges at Bumbuna and Badela including automatic recorder	2	20000	**40000**			0
	Total			**98100**			

Q.3 Clearing the reservoir area

Description		One off Unit	One off Unit Cost	One off Total (US$)	Annual Recurring Unit	Annual Recurring Unit Cost	Annual Recurring Total (US$)
Supervising Personnel							
	Project Manager	15	1500	22500			0
	Administrators (3)	36	1000	36000			0
Contractors' workforce (4)							
	Group leaders (4)	48	500	24000			0
	Woodcutters (40)	480	250	120000			0
	Assistants (40)	480	125	60000			0
	Helpers (20)	240	100	24000			0
Equipment							
	Power saws	40	2000	80000			0
	Personal	120	100	12000			0
	Miscellaneous	1	20000	20000			0
Set up and operational costs							
	Use and maintenance of plant	4	30000	120000			0
	Office, store and workshop	48	1500	72000			0
	Overheads	48	1000	48000			0
	Contingency (10%)	1	65000	65000			
	Total			**703500**			

Q.4 Baseline bird survey

Not for disclosure

Q.5 Baseline butterfly survey

Not for disclosure

Q.6 Baseline reptile and amphibian survey

Not for disclosure

Q.7 Baseline small mammal survey

Not for disclosure

Q.8 Baseline flora survey

Not for disclosure

Q.9 Baseline limnological study

Not for disclosure

Q.10 Baseline fisheries survey

Not for disclosure

Q.11 Baseline primate survey and monitoring programme

Not for disclosure

Q.12 Baseline archaeological field investigation

Not for disclosure

Q.13 Desk study on Bumbuna conservation area

	Description	Investment Unit	Investment Unit Cost	Investment Total (US$)	Annual Recurring Unit	Annual Recurring Unit Cost	Annual Recurring Total (US$)
Personnel							
	International specialist	2	20000	40000			0
	Domestic expert	2	3000	6000			0
	Field workers	0	200	0			0
Equipment							
	Miscellaneous			0			0
Materials							
	Consumables	1	500	500			0
Administration							
	Communications (satellite e-mail, phone, radio equipment)			0			0
	Communications operating costs	2	500	1000			0
	Office equipment (laptops printers, scanners, etc)	1	500	500			0
	Reporting	1	500	500			0
	BWMA overheads	2	500	1000			0
Transport							
	Vehicle hire	2	2000	4000			0
	Fuel	2	200	400			0
	International air travel	1	4000	4000			0
	Local transport			0			0
Subsistence							
	Consultant perdiem	2	1800	3600			0
	Other staff perdiem	0	900	0			0
	Contingency (10%)	1	6200	6200			0
	Total			**67700**			**0**

Q.14 Community participation and awareness

	Description	Set Up			Annual Recurring		
		Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
Personnel							
	International specialist	3	20000	60000			0
	Domestic community development expert	12	3000	36000	3	3000	9000
	Domestic expert on environmental management	6	3000	18000	3	3000	9000
	Domestic expert on public health	4	3000	12000	2	3000	6000
	Admin assistant	12	1000	12000	3	1000	3000
Equipment							
	Training hardware	1	5000	5000	1	2000	2000
	Audio visual	1	5000	5000	0	0	0
Materials							
	Consumables	1	2000	2000	1	1000	1000
	Dissemination and outreach materials	12	500	6000	12	500	6000
				0			0
Workshops							
	Environmental awareness campaign	12	2000	24000	3	2000	6000
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	5000	5000	1	1000	1000
	Communications operating costs	12	500	6000	12	500	6000
	Office equipment (PCs, printers, scanners, etc)	1	3000	3000	1	1000	1000
	Office running costs	12	1000	12000	12	1000	12000
	Reporting	1	1000	1000	1	500	500
Transport							
	Vehicle hire	12	2500	30000	4	2500	10000
	Fuel	12	500	6000	4	500	2000
	International air travel	1	4000	4000			0
	Local transport	12	500	6000	4	200	800
Subsistence							
	Consultant perdiem	3	1800	5400	8	1800	14400
	Other staff perdiem	22	900	19800	8	900	7200
	Contingency (10%)	1	27800	27800	1	9700	9700
	Total			**306000**			**106600**

Q.15 Establish the Water and Land Management Strategy and Action Plan

		Set Up			Annual Recurring		
	Description	Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
Personnel							
	Strategy and Action Plan Coordinator (BWMA)	0	0	0			0
	International water and land use specialist	4	20000	80000			0
	Domestic environmental management expert	4	3000	12000			0
	Domestic Trainer/Facilitator (3)	12	2500	30000			0
	Administrator	4	1000	4000			0
Equipment							
	Miscellaneous	1	1000	1000			0
Materials							
	Consumables	1	1000	1000			0
	Dissemination and outreach materials	4	500	2000			0
	Mapping/remote sensing	1	2000	2000			0
Workshops							
	Sensitisation and planning	8	2000	16000			0
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	2000	2000			0
	Communications operating costs	4	500	2000			0
	Office equipment (PCs, printers, scanners, etc)	1	2000	2000			0
	Office running costs	4	1000	4000			0
	Reporting	1	500	500			0
Transport							
	Vehicle hire	4	2500	10000			0
	Fuel	4	500	2000			0
	International air travel	1	4000	4000			0
	Local transport	4	500	2000			0
Subsistence							
	Consultant perdiem	4	1800	7200			0
	Other staff perdiem	16	900	14400			0
	Contingency (10%)	1	19800	19800			0
	Total			**217900**			**0**

Q.16 Land and soil management programme

		Set Up			Annual Recurring		
	Description	Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
Personnel							
	Water and Land Management Strategy and Action Plan Coordinator (BWMA)	0	0	0			0
	International water and land use specialist	3	20000	60000			0
	Domestic land management expert	12	3000	36000	6	3000	18000
	Domestic Trainer/Facilitator	12	2500	30000	6	2500	15000
	Field workers	24	200	4800	12	200	2400
Facilities and Equipment							
	Tools	1	5000	5000	1	2000	2000
	Miscellaneous	1	5000	5000	1	2500	2500
	Hire of demonstration tractor and plough	2	3000	6000	1	3000	3000
	Set up/ operate tree nursery	12	500	6000	6	250	1500
	Land survey equipment	1	3000	3000			0
	Stream flow equipment	1	6000	6000			0
Materials							
	Consumables	1	3000	3000	1	1000	1000
	Dissemination and outreach materials	12	500	6000	6	500	3000
	Seedlings	1	10000	10000	1	5000	5000
	Miscellaneous	1	5000	5000	1	3000	3000
Laboratory							
	Water sample testing	200	30	6000	100	30	3000
	Suspended solids sample testing	200	30	6000	100	30	3000
	Transport of water samples	12	25	300	6	25	150
	Channel bed samples	6	150	900	3	150	450
	Bed samples transport	6	25	150	3	25	75
Workshops							
	Promotion of best practice in soil conservation	5	2000	10000	3	2000	6000
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	2000	2000			0
	Communications operating costs	12	500	6000	6	500	3000
	Office equipment (PCs, printers, scanners, etc)	1	2000	2000	0	0	0
	Office running costs	12	2000	24000	6	2000	12000
	Reporting	1	500	500	1	500	500
	BWMA overheads	12	500	6000	12	500	6000
Transport							
	Vehicle hire	12	2500	30000	6	2500	15000
	Fuel	12	500	6000	6	500	3000
	International air travel	1	4000	4000			0

	Local transport	12	200	2400	6	200	1200
Subsistence							
	Consultant perdiem	3	1800	5400	0	1800	0
	Other staff perdiem	24	900	21600	12	900	10800
	Contingency (10%)	1	32000	32000	1	12000	12000
	Total			**351050**			**132575**

Q.17 Downstream fisheries management programme

		Baseline			Annual Recurring		
	Description	Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
Personnel							
	Water and Land Management Strategy and Action Plan Coordinator (BWMA)	0	0	0			0
	International riverine fisheries specialist	3	20000	60000			0
	Domestic riverine fisheries expert	12	3000	36000	12	3000	36000
	Domestic Trainer/Facilitator	6	2500	15000	3	2500	7500
	Field workers	24	200	4800	24	200	4800
Equipment							
	Fishing equipment	1	20000	20000	1	20000	20000
	Miscellaneous	1	2000	2000	1	2000	2000
Materials							
	Consumables	1	2000	2000	1	2000	2000
	Dissemination and outreach materials	12	500	6000	12	500	6000
Workshops							
	Promotion of fisheries best practice	3	2000	6000	3	2000	6000
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	2000	2000			0
	Communications operating costs	12	500	6000	12	500	6000
	Office equipment (PCs, printers, scanners, etc)	1	2000	2000	0	0	0
	Office running costs	12	2000	24000	12	2000	24000
	Reporting	1	500	500	1	500	500
	BWMA overheads	12	500	6000	12	500	6000
Transport							
	Vehicle hire	12	2500	30000	12	2500	30000
	Fuel	12	500	6000	12	500	6000
	International air travel	1	4000	4000			0
	Local transport	12	200	2400			0
Subsistence							
	Consultant perdiem	3	1800	5400	0	1800	0
	Other staff perdiem	18	900	16200	15	900	13500
	Contingency (10%)	1	25600	25600	1	17000	17000
	Total			**281900**			**187300**

Q.18 Reservoir fisheries management programme

		Baseline			Annual Recurring		
	Description	Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
Personnel							
	Water and Land Management Strategy and Action Plan Coordinator (BWMA)	0	0	0			0
	International freshwater fisheries specialist	3	20000	60000			0
	Domestic freshwater fisheries expert	12	3000	36000	12	3000	36000
	Domestic Trainer/Facilitator	6	2500	15000	3	2500	7500
	Field workers	24	200	4800	24	200	4800
Equipment							0
	Fishing equipment	1	20000	20000	1	20000	20000
	Miscellaneous	1	2000	2000	1	2000	2000
Materials				0			0
	Consumables	1	2000	2000	1	2000	2000
	Dissemination and outreach materials	12	500	6000	12	500	6000
Workshops							
	Promotion of fisheries best practice	3	2000	6000	3	2000	6000
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	2000	2000			0
	Communications operating costs	12	500	6000	12	500	6000
	Office equipment (PCs, printers, scanners, etc)	1	2000	2000	0	0	0
	Office running costs	12	2000	24000	12	2000	24000
	Reporting	1	500	500	1	500	500
	BWMA overheads	12	500	6000	12	500	6000
Transport							
	Vehicle hire	12	2500	30000	12	2500	30000
	Fuel	12	500	6000	12	500	6000
	International air travel	1	4000	4000			0
	Local transport	12	200	2400			0
Subsistence							
	Consultant perdiem	3	1800	5400	0	1800	0
	Other staff perdiem	18	900	16200	15	900	13500
	Contingency (10%)	1	25600	25600	1	17000	17000
	Total			**281900**			**187300**

Q.19 Environmental flow sufficiency

		Set Up			Annual Recurring		
	Description	Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
Personnel							
	International HEP hydraulic specialist	3	20000	60000			0
	Domestic river engineering expert	3	3000	9000			0
	Field workers	6	1000	6000			0
Equipment							
	Miscellaneous	1	2000	2000			0
Materials							
	Consumables	1	2000	2000			0
	Software for hydraulic calculations	1	1000	1000			0
Survey and Mapping Services							
	Topographical survey of river channel	1	5000	5000			0
	Mapping/presentation of survey	1	5000	5000			0
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	1000	1000			0
	Communications operating costs	3	500	1500			0
	Office equipment (PCs, printers, scanners, etc)	1	1000	1000			0
	Office running costs	3	1000	3000			0
	Reporting	1	500	500			0
	BWMA overheads	3	500	1500			0
Transport							
	Vehicle hire	3	2500	7500			0
	Fuel	3	500	1500			0
	International air travel	1	4000	4000			0
	Local transport	3	200	600			0
Subsistence							
	Consultant perdiem	3	1800	5400			0
	Other staff perdiem	3	900	2700			0
	Contingency (10%)	1	12000	12000			0
	Total			**132200**			**0**

Q.20 Agroforestry and forestry programme

	Description	Set Up Unit	Set Up Unit Cost	Set Up Total (US$)	Annual Recurring Unit	Annual Recurring Unit Cost	Annual Recurring Total (US$)
Personnel							
	Water and Land Management Strategy and Action Plan Coordinator (BWMA)	0	0	0			0
	International agroforestry and forestry specialist	3	20000	60000			0
	Domestic agroforestry and forestry expert	12	3000	36000	6	3000	18000
	Domestic Trainer/Facilitator	12	2500	30000	6	2500	15000
	Field workers	24	200	4800	12	200	2400
Facilities and Equipment							
	Tools	1	5000	5000	1	2000	2000
	Miscellaneous	1	5000	5000	1	2500	2500
	Hire of tractor and trailer	4	3000	12000	2	3000	6000
	Set up/ operate tree nursery	12	500	6000	6	250	1500
Materials							
	Consumables	1	3000	3000	1	1000	1000
	Dissemination and outreach materials	12	500	6000	6	500	3000
	Seedlings	1	20000	20000	1	10000	10000
Workshops							
	Training in agroforestry and forestry	5	2000	10000	3	2000	6000
	Training of forest guards	2	2000	4000	1	2000	2000
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	2000	2000			0
	Communications operating costs	12	500	6000	6	500	3000
	Office equipment (PCs, printers, scanners, etc)	1	2000	2000	0	0	0
	Office running costs	12	2000	24000	6	2000	12000
	Reporting	1	500	500	1	500	500
	BWMA overheads	12	500	6000	12	500	6000
Transport							
	Vehicle hire	12	2500	30000	6	2500	15000
	Fuel	12	500	6000	6	500	3000
	International air travel	1	4000	4000			0
	Local transport	12	200	2400	6	200	1200
Subsistence							
	Consultant perdiem	3	1800	5400	0	1800	0
	Other staff perdiem	24	900	21600	12	900	10800
	Contingency (10%)	1	31200	31200	1	12000	12000
	Total			**342900**			**132900**

Q.21 Agricultural development programme

	Description	Set Up Unit	Set Up Unit Cost	Set Up Total (US$)	Annual Recurring Unit	Annual Recurring Unit Cost	Annual Recurring Total (US$)
Personnel							
	Water and Land Management Strategy and Action Plan Coordinator (BWMA)	0	0	0			0
	International agriculture specialist	3	20000	60000			0
	Domestic agriculture expert	12	3000	36000	6	3000	18000
	Domestic Trainer/Facilitator	12	2500	30000	6	2500	15000
	Field workers	24	200	4800	12	200	2400
Equipment							
	Tools	1	5000	5000	1	2000	2000
	Miscellaneous	1	5000	5000	1	2500	2500
	Hire of tractor and plough	4	3000	12000	2	3000	6000
Materials							
	Consumables	1	3000	3000	1	1000	1000
	Dissemination and outreach materials	12	500	6000	6	500	3000
	Seeds	1	10000	10000	1	5000	5000
Workshops							
	Training in crop husbandry, farm management	5	2000	10000	3	2000	6000
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	2000	2000			0
	Communications operating costs	12	500	6000	6	500	3000
	Office equipment (PCs, printers, scanners, etc)	1	2000	2000	0	0	0
	Office running costs	12	2000	24000	6	2000	12000
	Reporting	1	500	500	1	500	500
	BWMA overheads	12	500	6000	12	500	6000
Transport							
	Vehicle hire	12	2500	30000	6	2500	15000
	Fuel	12	500	6000	6	500	3000
	International air travel	1	4000	4000			0
	Local transport	12	200	2400	6	200	1200
Subsistence							
	Consultant perdiem	3	1800	5400	0	1800	0
	Other staff perdiem	24	900	21600	12	900	10800
	Contingency (10%)	1	29200	29200	1	11200	11200
	Total			**320900**			**123600**

Q.22 Study and mapping of land use and vegetation

	Description	Set Up			Annual Recurring		
		Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
Personnel							
	Water and Land Management Strategy and Action Plan Coordinator (BWMA)	0	0	0			0
	International land use and GIS specialist	3	20000	60000			0
	Domestic land use and mapping expert	3	3000	9000	3	3000	9000
	Technical assistants (6)	18	1000	18000	3	1000	3000
	Field workers (6)	18	200	3600	6	200	1200
Equipment							0
	Miscellaneous	1	2000	2000	1	500	500
	GPS	10	280	2800			0
Materials							
	Consumables	1	2000	2000	1	500	500
	Mapping, aerial photos and satellite imagery	1	15000	15000			0
	Software for GIS	1	2000	2000			0
	Hardware for GIS	1	5000	5000			0
Mapping Services							
	Field work and data collectionMapping and GIS data	1	5000	5000			0
	Mapping and GIS data			0			0
Training							
	Training of BWMA staff in use of GIS	2	1500	3000	2	1500	3000
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	1000	1000	1	250	250
	Communications operating costs	3	500	1500	3	500	1500
	Office equipment (PCs, printers, scanners, etc)	1	1000	1000			0
	Office running costs	3	1000	3000	3	1000	3000
	Reporting	1	500	500	1	500	500
	BWMA overheads	3	500	1500	3	500	1500
Transport							
	Vehicle hire (4)	12	2500	30000	3	2500	7500
	Fuel	12	500	6000	3	500	1500
	International air travel	1	4000	4000			0
	Local transport	3	400	1200	3	400	1200
Subsistence							
	Consultant perdiem	3	1800	5400	0	1800	0
	Other staff perdiem	21	900	18900	9	900	8100
	Contingency (10%)	1	20100	20100	1	4200	4200
	Total			**221500**			**46450**

Q.23 Ecological and ecotourism survey

	Description	Investment Unit	Investment Unit Cost	Investment Total (US$)	Annual Recurring Unit	Annual Recurring Unit Cost	Annual Recurring Total (US$)
Personnel							
	Water and Land Management Strategy and Action Plan Coordinator (BWMA)	0	0	0			0
	International specialist	2	15000	30000			0
	Domestic ecological expert	6	3000	18000			0
	Domestic ecotourism expert	2	3000	6000			0
	Field workers	6	200	1200			0
Equipment							
	Miscellaneous	1	2500	2500			0
Materials							
	Consumables	1	2000	2000			0
Laboratory							
	Analyses of samples	50	30	1500			0
	Transport of samples	10	20	200			0
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	1500	1500			0
	Communications operating costs	6	500	3000			0
	Office equipment (laptops printers, scanners, etc)	1	5000	5000			0
	Office running costs	6	500	3000			0
	Reporting	1	500	500			0
	BWMA overheads	6	500	3000			0
Transport							
	Vehicle hire	6	2500	15000			0
	Fuel	6	500	3000			0
	International air travel	1	4000	4000			0
	Local transport	6	200	1200			0
Subsistence							
	Consultant perdiem	2	1800	3600			0
	Other staff perdiem	8	900	7200			0
	Contingency (10%)	1	11100	11100			0
	Total			**122500**			**0**

Q.24 Establish and administer the BCA

Description		Set Up			Annual Recurring		
		Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
Set up							
	Communications (phones, radios)	1	10000	10000	1	2000	2000
	Vehicle (1)	1	30000	30000			0
	Motorcycle (1)	1	10000	10000			0
	Office equipment (1 PCs, printer, scanner, furniture, etc)	1	12000	12000	1	1000	1000
	Office rehabilitation (Bumbuna site)	1		0			
	Equipment and materials	1	10000	10000	1	2000	2000
	Land cover inventory & mapping	1	40000	40000			0
	Boundary marking and signage	1	10000	10000	1	2000	2000
	Establish/operate tree nursery	12	500	6000	12	250	3000
	Public meetings/awareness	3	500	1500	1	500	500
	Compensation to occupiers of assets within the BCA	1	50000	50000			0
Annual Recurring							
	Warden salary	12	700	8400	12	700	8400
	Senior Warden (1) and Guards (3) salaries	48	500	24000	48	500	24000
	Administration	12	1500	18000	12	0	0
	Driver/field workers (3) salaries	36	200	7200	36	0	0
	Local transport	12	200	2400	12	200	2400
	Office running costs	12	500	6000	12	500	6000
	Vehicle running & maintenance	12	1000	12000	12	0	0
	Sanctuary Advisory Committee	3	1000	3000	3	1000	3000
	Training (staff & Board)	2	10000	20000	2	10000	20000
	Dissemination and outreach materials	1	4000	4000	1	4000	4000
	Conservation Area maintenance	12	500	6000	12	500	6000
	Contingency (10%)	1	30000	30000	1	8400	8400
	Total			**320500**			**92700**

Q.25 Social and health measures

	Description	Set Up			Annual Recurring		
		Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
BWMA							
	Stimulation of small business enterprises (crafts, tourism, local services) as alternative livelihood means for local population. (not costed)	1	80000	80000	1	50000	50000
	Implement tourism initiative to improve revenue from tourism to local community. (not costed)	1	50000	50000	1	30000	30000
Upper Seli Community Development Initiative							
	Establish regional health protection and information programme in the immediate catchment						
	Construction of health centres (9)	1	208100	208100			0
	Construction of water wells and toilets (7)	1	160000	160000			0
	Implement programme (not costed)	1	300000	300000	1	300000	300000
Ministry of Energy and Power							
	Establish a local health protection and information programme in the project area (not costed)	1	500000	500000	1	300000	300000
BHP Operator							
	Identification and drainage of mosquito breeding areas in reservoir drawdown zone. (not costed)			0	1	30000	30000
	Total			**1298100**			**710000**

Q.26 Technical assistance programme for a project supervision unit in the Dept of the Environment

	Description	First Year			Second Year		
		Unit	Unit Cost	Total (US$)	Unit	Unit Cost	Total (US$)
Personnel							
	Unit Manager - Freetown	12	1500	18000	12	1500	18000
	Bumbuna Site Officer	12	1000	12000	12	1000	12000
Programme Equipment							
	Miscellaneous	1	1000	1000	1	500	500
Programme Materials				0			0
	Consumables	12	200	2400	12	200	2400
	Training materials	12	200	2400	12	200	2400
Training							
	Project life cycle, social, environmental and mitigation issues, EIOA, catchment management, supervision,	2	1000	2000	2	1000	2000
Administration							
	Communications (satellite e-mail, phone, radio equipment)	1	2000	2000			0
	Communications operating costs	12	200	2400	12	200	2400
	Office equipment (PCs, printers, scanners, etc)	1	2000	2000			0
	Office running costs	12	400	4800	12	400	4800
	Reporting	1	500	500	1	500	500
Transport							
	Vehicle purchase	1	30000	30000			0
	Vehicle running costs	12	1000	12000	12	1000	12000
	Local transport	12	200	2400	12	200	2400
Subsistence							
	Perdiems/housing allowance at Bumbuna	12	500	6000	12	500	6000
	Contingency (10%)	1	10000	10000	1	6500	6500
	Total			**109900**			**71900**