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Ministry of Energy and Power

Bumbuna Hydroelectric Project Environmental Impact Assessment

Draft Final Report

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in association with

BMT

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 2 – Main Report.

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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

1 Introduction

1.1 The Bumbuna Hydroelectric Project

The Bumbuna Hydroelectric Project (BHP) site is located near Bumbuna Falls on the upper reaches of the Seli / Rokel river, in the foothills of the Sula Mountains of Tonkolili District, about 200 km northeast of Freetown. The Seli, which is the third largest river in Sierra Leone, drains westward into the Atlantic via a broad estuary to the north of the Freetown Peninsula. The Seli River has a high flow rate in the wet season and a very much lower flow in the dry season, which is typical of the rivers of Sierra Leone.

Bumbuna Falls was first suggested as the site for a hydropower project (then 75 MW) in a 1970/1 UNDP-funded study, which identified 22 potential hydropower development sites in Sierra Leone. The development of the 50 MW Bumbuna project is envisaged as the first phase of a five-stage development of the Seli River, with an ultimate potential of 275 MW (135 MW firm). There are several alternatives of the sequence to optimise the phases, but all schemes involve a first phase dam 2.4 km upstream of Bumbuna Falls.

The Phase 1 Bumbuna project is a large run-of-river scheme consisting of an 88m high asphalt-faced rockfill dam with a 50 MW (2x25 MW) powerhouse at the foot of the dam, connected to Freetown by a 200km 161 kV single circuit transmission line. The reservoir will have a surface area of 21 km^2 and a maximum operating capacity of 350 Mm^3. Apart from power generation, it will be capable of 35 Mm^3 regulation for downstream flood control. The spillways through left and right bank tunnels have a total design discharge of 3000 m^3/s.

Site preparation was conducted during 1982-85, and the main construction works were undertaken between 1989 and 1997, when the 85% complete project was abandoned due to the civil war. The history of the project is described in Chapter 2, and the presently proposed first phase project is described in more detail in Chapter 3. Development of the further four phases of the Bumbuna project is described in Chapter 4.

1.2 The Environmental Impact Assessment

This Environmental Impact Assessment (EIA) report relates to the first phase of the BHP.

As an EIA report it is unusual, being prepared when construction of the project is largely complete. In fact, an original EIA report was prepared by Electrowatt Engineering Services Ltd and Techsult Co. Ltd. in 1996, by which time the project was then largely

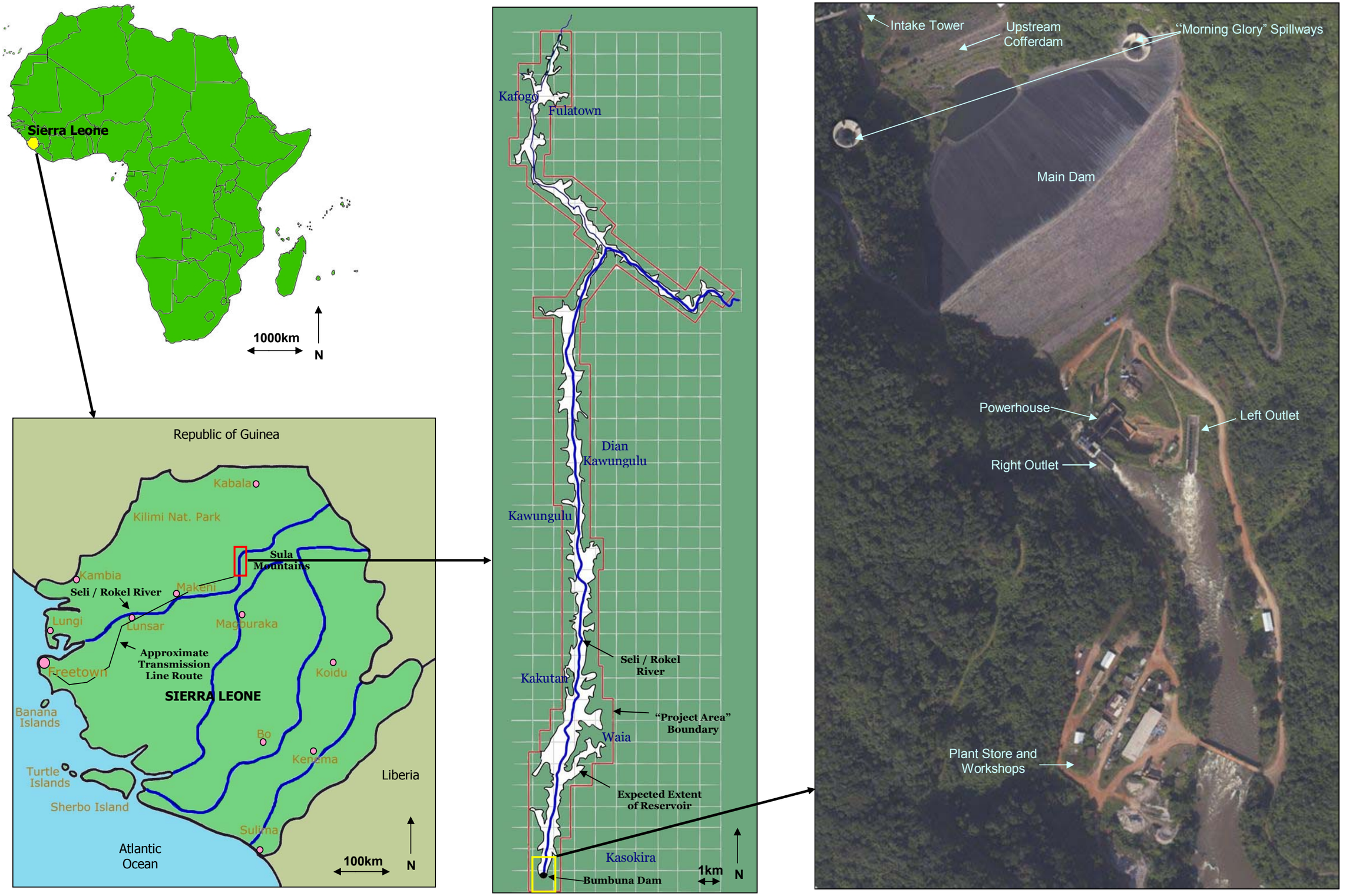


Figure 1-1: Maps Showing Project Location and Details

complete. The project itself is also very unusual in having had such a protracted development period (see Chapter 2 below).

The 1996 to 2002 civil war was a period of considerable disturbance and displacement of communities in the vicinity of the BHP project site and the transmission line. Work to complete the BHP is anticipated to commence in 2005. Since 1996, there has been an increase in international expectations of the scope of EIAs, with a greater emphasis on public consultation / participation, upstream and downstream impacts, regional impacts, catchment management, conservation of biodiversity, etc. Moreover, the EIA requirements of development banks and other multilateral institutions have become more comprehensive, as exemplified by the 'safeguard policies' of the World Bank.

The World Bank will be supporting development of the BHP using the following two instruments, which will be presented for approval by the World Bank Board on the same day:

- A Partial Risk Guarantee (PRG) for a commercial loan of about US$ 20 million, depending on the final project cost estimate. The commercial loan will be used to finance one or two of the contracts for completion of the project. The PRG loan will not be used to finance any of the environmental elements of the project.

- In conjunction with the Government, an IDA Credit will be used to support the financing, where necessary, of the Environment Management Plan (EMP) and the Resettlement Action Plans (RAPs).

For all of the above reasons, the Bumbuna Project Implementation Unit (PIU) decided that, as the project moves into the final stage of construction, the EIA report should be updated to take account of both recent EIA requirements, and the environmental, social and institutional changes that have occurred since the original report was written. Nippon Koei UK Co. Ltd. (NKUK), in association with BMT-Cordah (Cordah) of the UK and the Environmental Foundation for Africa (EFA) based in Sierra Leone, was appointed at the end of July 2004 to conduct a range of additional studies. These studies ultimately consisted of 19 tasks, including field studies in various disciplines, which, along with the original EIA report, constituted the main source of data for the present report.

The object of the present EIA report is to bring together the results of the original EIA, the additional studies and data from a number of other sources to produce an 'omnibus' document. The document corresponds to a standard EIA report, but the style focuses on the main issues and avoids repetition, in order to guide the reader through the considerable amount of relevant material that has been produced on the project over the years. The other sources of information include the following:

- The Resettlement Action Plan (RAP) for the transmission line (Azimut et al, 2005)

- The RAP for the reservoir basin (Electrowatt-Ekono et al, 2005)
- The Bumbuna Retrospective Review / Options Assessment Study (Haas, 2005). See Appendix C.1.
- The Upper Seli Community Development Initiative study (Vincent, 2005)
- The first report of the Bumbuna Environmental and Social Advisory Panel (ESAP, 2004)
- The first report of the Bumbuna Dam Review Panel (DRP, 2004)

2 Project History

2.1 National Background

Sierra Leone presently ranks as the poorest country on the African continent, despite its substantial endowment of natural resources, including abundant freshwater, fertile land, minerals, fisheries, biodiversity and tourism 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). Since 2002, the nation has emerged from the 11 years of armed conflict with the support of a peace process carried out under the auspices and military security of the international community. The general election of May 2002 has been followed by a period of peace and political stabilisation. Nevertheless, more than a decade of rebel conflict has left a legacy of destroyed public and private infrastructure, two million homeless out of an estimated population of 5.8 million (2004), almost half a million refugees, high unemployment and widespread poverty throughout the country.

Since independence in 1961, governance in Sierra Leone has been founded on a constitutional democracy based on English law and the customary laws of indigenous tribes. The country is administratively divided into three provinces (Northern, Southern and Eastern) and further into 61 districts. The Western Area Grid serves the major electricity load centre around the capital city of Freetown, which is located in the Northern Province on the Atlantic coast. Almost two million people (roughly one third of the country's population) live in this area, where much of the country's government, commerce, light industry and non-agricultural employment are concentrated.

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

2.2 Summary of Project History

The BHP has had a very long and complicated gestation period since it was first proposed in the 1970/71 UNDP study. The history of the project has been summarised in

the recent retrospective options assessment study (Appendix C.1 - Haas, L., 2004), which recognises four periods in Bumbuna's long project history, as follows:

Table 2.2-1: Four Periods in the Development of BHP

1970-1985	From the first nationwide hydropower inventory through feasibility study and initial site preparation works.
1986-1997	From final selection of the financing of the project to abandonment in May 1997 when the project was 85% completed.
1998-2002	During the intensified rebel war to its official end in January 2002, during which time no work on the project was undertaken.
2002-present day	From the post-war national election in May 2002, to refinancing discussions and PPF studies that aim to complete and commission the BHP by the end of 2006

Source: Haas (2004)

Figure 2.2-2 overleaf summarises the relevant national and power sector events.

The first phase BHP was originally conceived as a 74m high dam with a 71 MW generating plant utilising the head of both the dam and the 40m Bumbuna Falls by having a 2-km long headrace tunnel from the dam to the power station below the Falls. The most significant point in the history came in 1984 when a scaled-down reduced cost design was prepared. This was achieved by a combination of changes that included:

- Moving the proposed location of the powerhouse upstream to the foot of the dam;
- Conversion of the existing spillway tunnel into a combined spillway and power tunnel;
- Adopting a single 47 MW turbine instead of two units;
- Adopting a single circuit (161 kV) transmission line from Bumbuna to Freetown, instead of a double 132 kV circuit;
- Eliminating the intermediate substations, and;
- Reducing the transmission line by 26 km, by rerouting the Bumbuna-Makeni section.

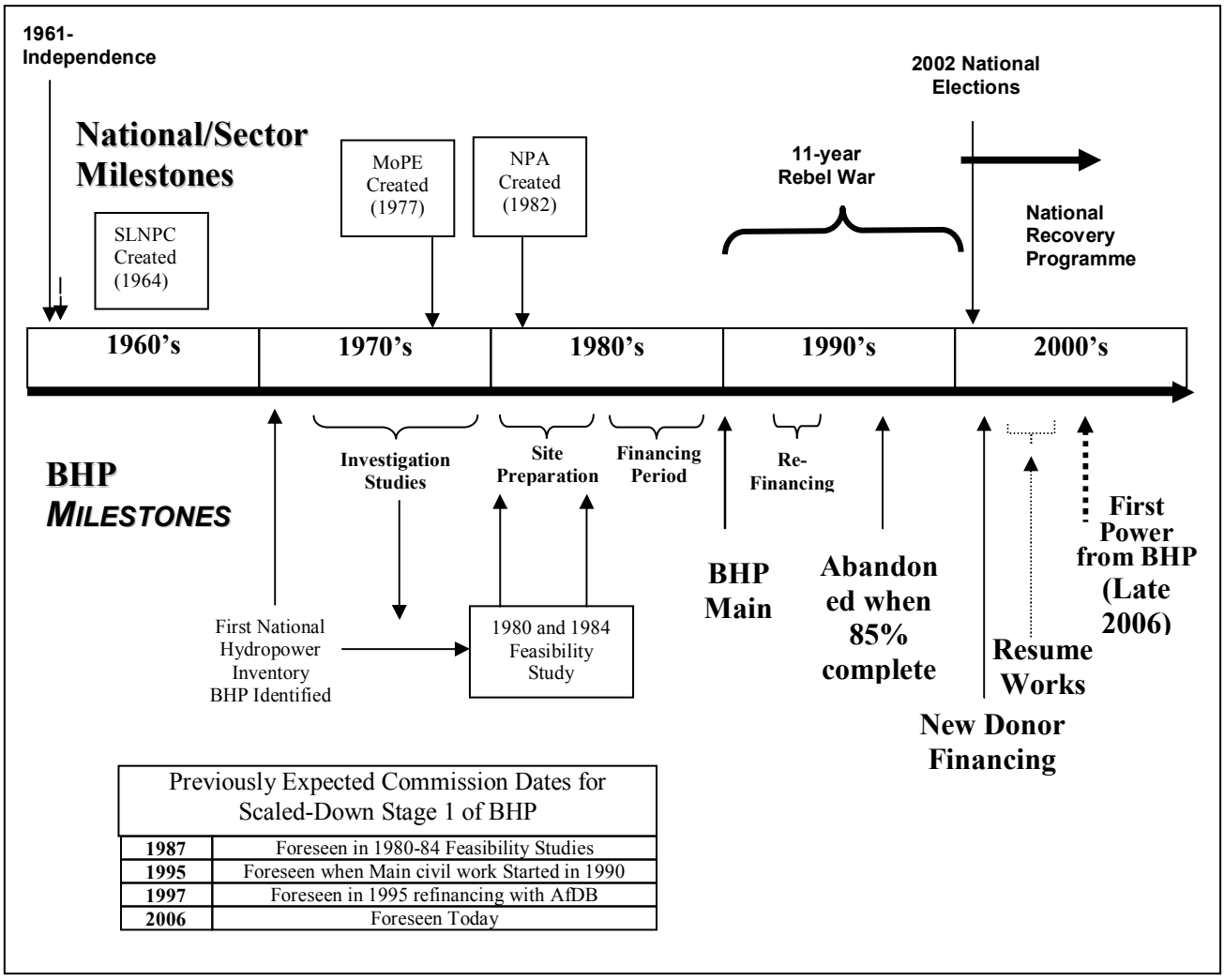


Figure 2.2-2: BHP Development Timeline

Source: Haas (2004)

The design has essentially remained the same since 1984, with the exception of the reversion to two generating units, now of 25 MW each.

The history of construction of the BHP so far can be summarised by the contracts that were let for its implementation in the early 1990s, as shown in Table 2.2-3 below:

Table 2.2-3: BHP Construction Contracts

Contract	Component	Timing and Parties	Foreign Component Financing
Contract A0	Permanent and Resident Engineer Camp	1982-84	GOI ($US 20 Million Eq. Loan for Contracts AO and A1)
Contract A1	Preliminary Works (Excavation of Tunnels)	1982-84 GoSL with Contractor Salini Costruttori (Italy)	GOI (in above)
Contract A2:	Main Civil Works	Signed 1988-GoSLwith Contractor Salini Costruttori (Italy) Came into force Aug 1989	GOI ($US 102.2 million equivalent A2 and B)
Contract B:	Hydraulic Steel Structures	Signed 1988-GoSLwith Contractor Salini Costruttori (Italy) Came into Force Aug 1989	GOI
Contract C:	Electromechanical Equipment	Confirmation of available financing 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 for C, D and Services)
Contract D:	Transmission Line and Freetown Substations	Confirmation of available financing Jan 1989; Signed Jan 1993; Came into force Sept 1993; Supplies: ABB SAE, Saldelmi /ABB and Schaltanlangen	AfDB
	Engineering Services contract C and D and Logistical Support for the PIU	Loan Agreement 1991, Consultant Studio Pietrangeli	AfDB $US 3.1 million

Source: Haas (2005)

2.3 Retrospective Review of Power Supply Alternatives

The retrospective review of the BHP by Haas (2005), with emphasis on the role and application of options assessment, has been referred to in Section 2.1 above. That review has described the supply-demand power crisis in Sierra Leone and the need for a reliable and cheaper power source. It concluded that the decision to proceed with BHP was well grounded in Sierra Leone's national development policy and evolving power sector policy, from the time the project was first identified in 1970-71 to the present. Over 20 years ago, the NPA Act (1982) encapsulated the policy to, " … plan, construct, and operate the Bumbuna HEP and to provide for its integration into the overall electricity supply system in the country".

Table 2.2-4 below summarises the grid supply options considered in the key studies leading to the decision to finance the BHP in 1988-89. For comparison, the options subsequently considered in the 1996 Power Sector Master Plan are included.

Table 2.2-4: Supply options assessed for the Western Area grid in arriving at the decision to develop the BHP. (Source: Haas, 2005)

Study / Timing	Generation Technologies Considered >	ENERGY RESOURCE OPTION								
		Hydro			Thermal		Other Renewable			
		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 Stem (HFO) Imported Coal: Coal-fired steam plant in Freetown	□	■	□	■	■	○	○	○	○
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 Stem (HFO) Biomass (as far as specific energy costs) Solar, Wind , Wave and domestic coal were evaluated but screened out	■ ○	■	■	■	□	□ ○	□ ○	□ ○	□ ○

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

The retrospective review has considered the lessons of the past, the actions in the present, and their application to the future, as follows:

2.3.1 The Past

The project was selected and its design was optimised not as a stand-alone hydropower project, but as the first stage of the larger Bumbuna-Yiben hydropower development scheme that has an ultimate potential in excess of 275 MW. The selection of the Bumbuna site as the first stage was based strictly on economic and financial criteria, with little involvement of stakeholders or locally affected communities, apart from government officials and donor partners supervising the project consultants.

Environmental and social criteria were not applied, or made explicit, either in the site selection or to optimise the economic, social and environmental performance of the project design, layout and operating strategy. The options assessment methods that were acceptable then would not be sufficiently rigorous or participatory to secure project financing from international sources in today's context, or to engender stakeholder ownership and public support for the project.

Decisions on the project (a long-life infrastructure project) were made in the absence of any longer-term basin development plan for the Seli / Rokel River basin.

Notwithstanding past weaknesses, the analysis and decision-making approaches conformed to accepted international practices of the day regarding the assessment of alternatives, stakeholder involvement and risk management (e.g. demonstrated risks concerning diesel power supply and the nation's vulnerability to price fluctuations in international oil markets). Moreover, the BHP was appraised as being the least-cost supply option for the Western Area Grid in all donor-supported studies that led to the Government decision to secure project financing in the late 1980's. The concern then was 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 version of the project to resolve these concerns.

2.3.2 The Present

The post-war decision to complete the Bumbuna project is supported by appraisals prepared by the donors in 2002-03. The recent stakeholder consultations at national and local levels undertaken as part of the present study indicate that there is little doubt that completion of BHP is today widely supported by all segments of society.

Little or no attention has been given to the option of not proceeding with completion of the BHP. Clearly, the expected adverse environmental and social effects set out in Chapter 8 below would not materialise. Similarly, the stated environmental and social benefits would be foregone, including the improved environmental management and capacity-building that are proposed in the present report. In addition, it could be said that the significant adverse environmental and social effects of construction thus far, would

have been experienced without any corresponding benefit. There is a more general lost opportunity and waste of sunk costs, but that is an economic rather than an environmental issue.

The environmental and social studies that started in mid-2004 offer a fresh opportunity to evaluate alternatives for the non-infrastructure (social and institutional) components of the project, with the benefit of full stakeholder participation that was previously absent in the 1990's. Apart from sustainable power services, these choices can enhance overall development effectiveness of the project, its contribution to regional development and its acceptance by the communities "hosting" or affected by the project. These include measures for environmental and social mitigation and enhancement, benefit sharing, institutional arrangements and sustainable financing for the chosen initiatives. In this respect, what is done with the BHP is an important precedent for future power projects in Sierra Leone.

The recent retrospective review of options by Haas (2005) has been conducted in compliance with the requirement for alternatives analysis of a World Bank Category 'A' project.

2.3.3 The Future

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

While the BHP will help to resolve the immediate supply shortages, a clear strategy is needed for the future expansion of power generation capability, the interconnection of isolated provincial networks and rural electrification. 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 key decisions, with more comprehensive approaches to decide matters such as the sequencing of options and interim strategies. Among the challenges is the provision of open, systematic, and participatory processes, as the decisions will affect all sectors of society and the economy. For this it will be important to clarify institutional responsibilities and roles for options assessment in strategic planning at the sector and basin level, as well as at the project level.

The new National Energy Policy and Co-ordination Unit in Ministry of Energy and Power (MEP) can play a key role, as follows:

- 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 generators and power users in the industrial and commercial sectors);

- Capacity can be built, drawing on the considerable body of international practice.

The mobilisation of project financing and diversification of sources of finance is an on-going concern. In this regard, the benefits to be derived from improving the application of options assessment concepts to power planning and development include:

- **Public Sector Financing**: most multilateral and bilateral development agencies, as well as export credit agencies (ECAs) now require explicit and participatory options assessment within strategic and project-level planning, as do World Bank safeguard policies;

- **Private Sector Financing**: in 2002, leading private financing institutions, which account for 70% of infrastructure financing globally, adopted the "Equator Principles", a voluntary industry protocol that links private bank lending policies to IFC and World Bank Safeguard policies. This is an important consideration for the future of public-private financing;

- **Emission Reduction / Carbon Trading:** financing mechanisms currently exist to help developing countries reduce their CO_2 emissions, and new international carbon trading systems will be introduced in future. Apart from assessing power options against such criteria, Sierra Leone's ratification of the Kyoto Protocol would be an important step to enhance eligibility to such financing, not only for hydropower, but to finance biomass and solar alternatives for isolated networks and rural electrification;

In moving to integrated resource management for sustainable development, options assessment can offer the following benefits to power planning:

- It is widely acknowledged that sustainable development requires integrated resource planning and management;

- Options assessment offers a practical and effective tool to foster integrated approaches and participatory processes. These will help to strengthen cross-sector coordination, particularly when adopted "upstream" in strategic planning, and followed through in design and management of selected projects;

- The philosophy of viewing the BHP as a platform to build experience integrating environmental, social and economic concerns in power sector projects can provide positive synergies with other regional development, environment and social policies. For example, national environmental management capacities may be strengthened through the BHP EIA update process and implementation of the Environmental Management Plan;

- Moreover, if development of a hydro-based power system is preferred, 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 also be important to provide capacity and attract resources to meet existing international commitments under conventions such as Ramsar, UNFCCC and CBD;

- The completion and subsequent management of the BHP can provide a basis to pursue a range of opportunities to catalyse sustainable development, not only in the power sector but in other interdependent resource management sectors

3 The Present Project

3.1 General Description

This chapter provides a brief description of the design and operation of the BHP. The environmental and social effects of the project are discussed in Chapters 8 and 9 respectively. All issues related to the associated transmission line between Bumbuna and Freetown are discussed in Chapter 10.

Phase 1 of the Bumbuna project as constructed is a large run-of-river scheme[1] consisting of an 88m high asphalt faced rockfill dam with a 50 MW (2x25 MW) powerhouse at the foot of the dam. The reservoir will have a surface area of 21 km^2 and a maximum operating capacity of 350 Mm^3. Apart from power generation it will be capable of 35 Mm^3 regulation[2] for downstream flood control. The 'morning glory'[3] spillways discharging through left and right bank tunnels have a total design discharge of 3,000 m^3/s. The right bank tunnel will be used as both the power tunnel and also as an auxiliary spillway controlled by a radial gate[4] at its outlet. The intake to the power tunnel is via a 93m high hexagonal tower with a screen protected inlet and a 7.5 m diameter cylindrical gate[5]. The essential elements of the scheme and the modes of operation are illustrated in Figures 3.1-1 and 3.1-2 (from the 1994 Project Summary).

After impoundment, the dam will create a Y-shaped 30 km long reservoir. In the main, narrow, steep-sided river valley, the reservoir width will vary between 0.2 and 1 km. The maximum seasonal drawdown of the reservoir will be about 31 m; the daily fluctuation of reservoir level due to 'peaking'[6] is expected to be 0.1 m during the dry season.

Once completed, the Phase 1 BHP will function as a base load station at its full 50 MW production during the wet season (when the average flow could be as high as 500 m^3/s). During the 3-4 month dry season (when the average flow could be as low as 6 m^3/s), generation would gradually reduce to 18 MW continuous equivalent, at which time thermal generation would be required to meet the load.

The electricity generated at Bumbuna will be supplied to a substation in the Freetown Peninsula via a 200 km 161 kV single-circuit transmission line (see Figure 3.1-3). In the short-term, a low cost method of supplying towns along the line will be employed, using

[1] A hydropower scheme which exploits a head difference, without having a major water storage or river regulating function.
[2] i.e. the ability to hold back this volume of water during flood conditions, in order to moderate downstream flow.
[3] Mouth of the spillway tunnel intake, shaped like a morning glory flower.
[4] Gate with a curved face against the water flow, which is raised and lowered in an arc.
[5] Gate at the foot of the tower, operated by a mechanism at the top of the tower.
[6] Variations in power generation according to variations in demand over the 24-hour cycle.

the shield wire[7] above the 161 kV conductor, until conventional substations are built. This "Insulated Shield Wire Line" (ISWL) system operating at 35.5 kV will supply Makeni from Bumbuna and supply Lunsar from Freetown. This will be a single-phase service limited to 4 MVA capacity. Thus, while BHP will primarily provide power to the Western Area network, it will also connect Bumbuna township in the north and be the grid connection platform for Makeni/Magburaka, Port Loko/Lunsar and Rokupr/Kambia, and Lungi.

[Eventually, full sub-stations would be added along the line and additional circuits will be provided, if and when a subsequent phase of the Bumbuna-Yiben development occurs.]

[7] The earth wire normally used to 'shield' the conductor from direct lightning strikes.

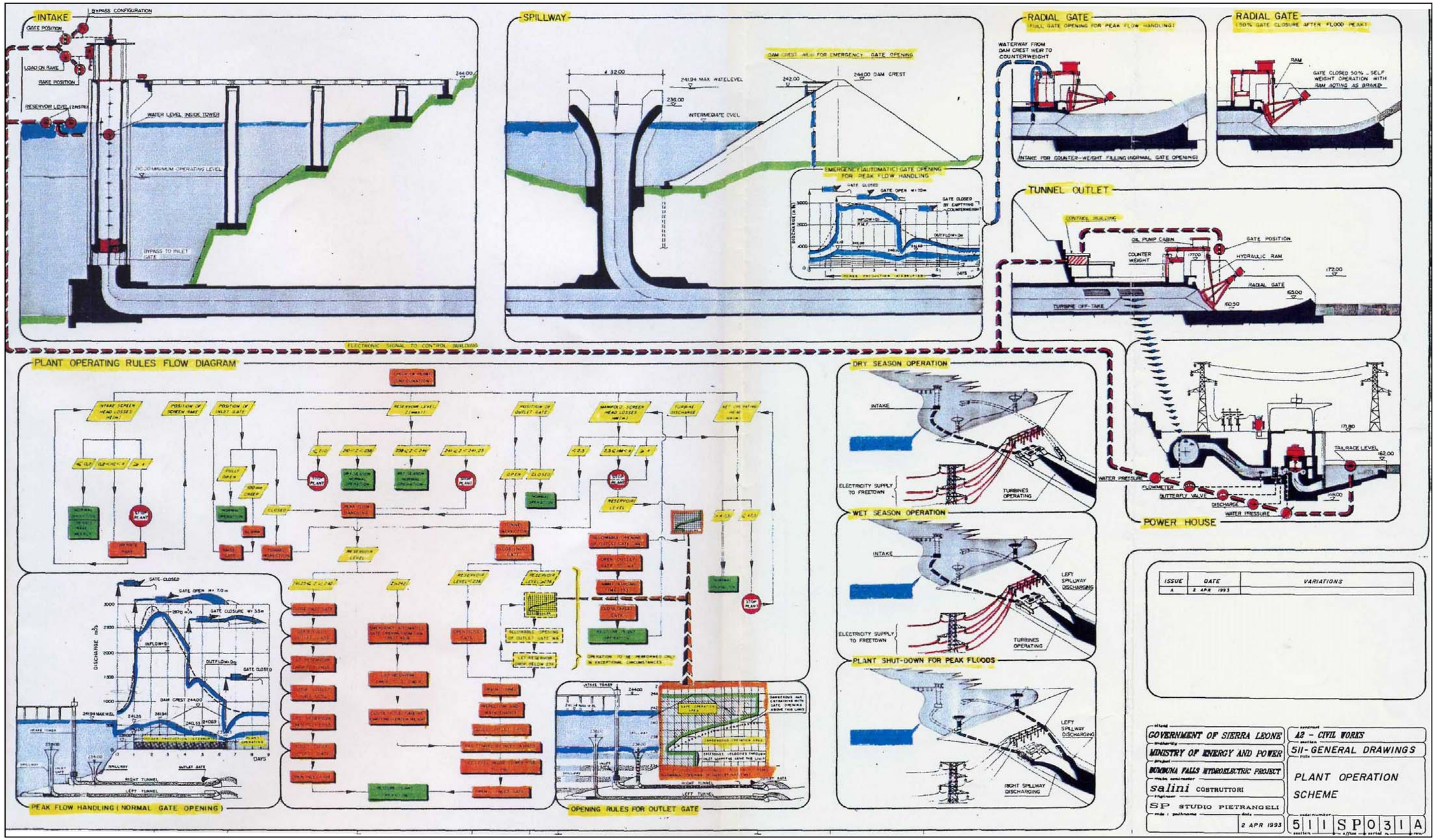


Figure 3.1-1: Plant Operation Scheme

Source: Bumbuna Falls Hydroelectric Project – Project Summary April 1994

Figure 3.1-2: Dam site and Camps Layout

Source: Bumbuna Falls Hydroelectric Project – Project Summary April 1994

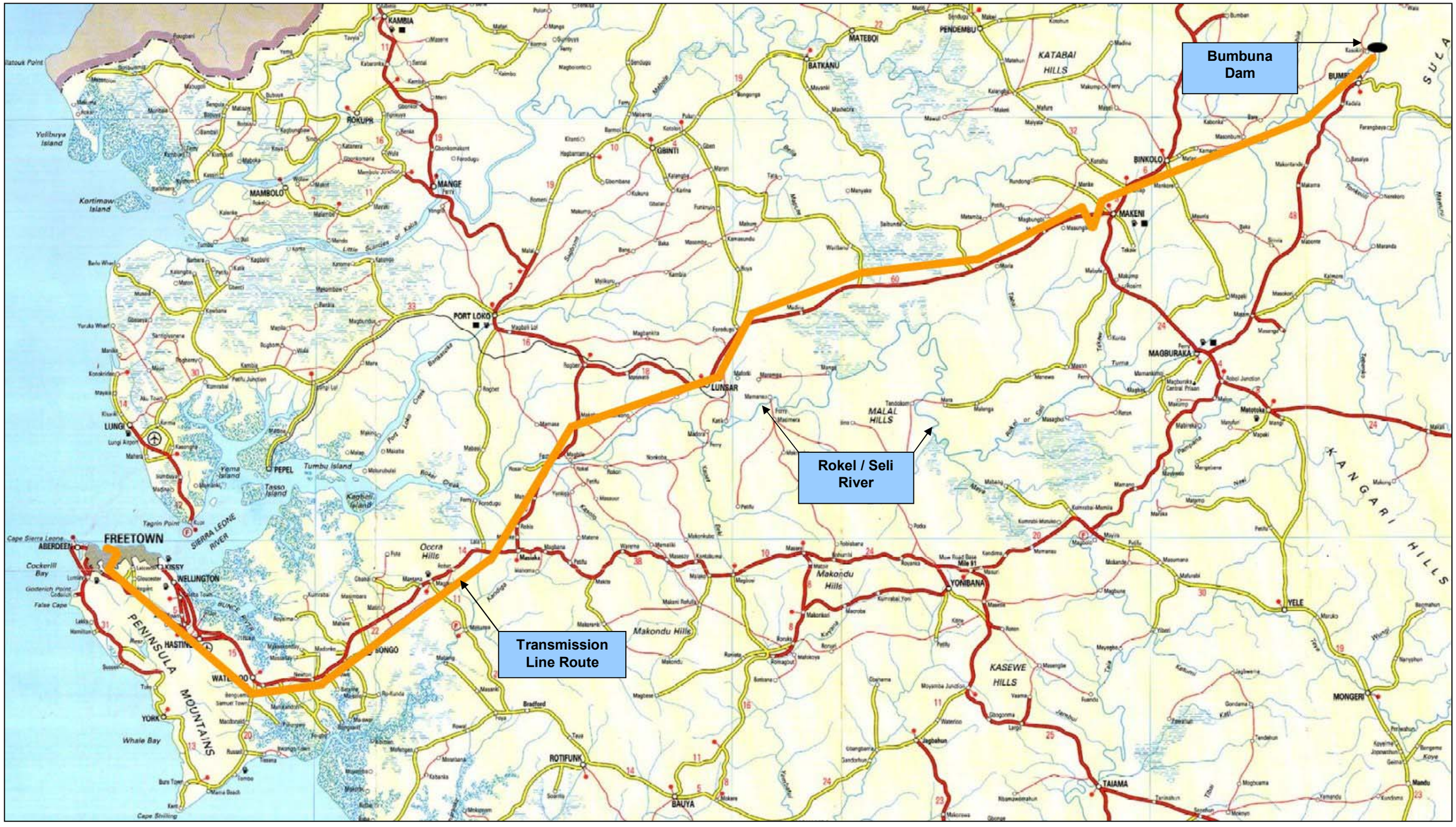


Figure 3.1-3: Map Showing Route of the Bumbuna-Freetown 161kV Transmission Line

3.2 Present Situation of the Project (January 2005)

At the time of the present report, the dam is in place, but the reservoir has not been filled. Water is in free-flow through the 9 m diameter left bank spillway tunnel, which was used as one of the two river diversion tunnels during construction of the dam; the right bank spillway tunnel is also used for diversion during flood flow.

Various studies are under way in preparation for completion of the project e.g. the condition survey of the structures and associated mechanical and electrical equipment. The completion of construction is due to begin in 2005, and the filling of the reservoir and subsequent commissioning are due to start in early 2006.

3.3 Environmental Management Over-sight

All further work on completion of the BHP is being supervised by the Bumbuna PIU, within the Ministry of Energy and Power (MEP), which will have some responsibility for environmental management over-sight. The PIU is recruiting a single environmental specialist, who will fit into the organisation as indicated in Figure 3.3-1 overleaf.

In addition, two panels of experts are providing over-sight of the project, including the work of all consultants; these are the Environmental and Social Advisory Panel (ESAP) and the Dam Review Panel (DRP), which will meet approximately half-yearly. By the end of 2004, the two panels had met once.

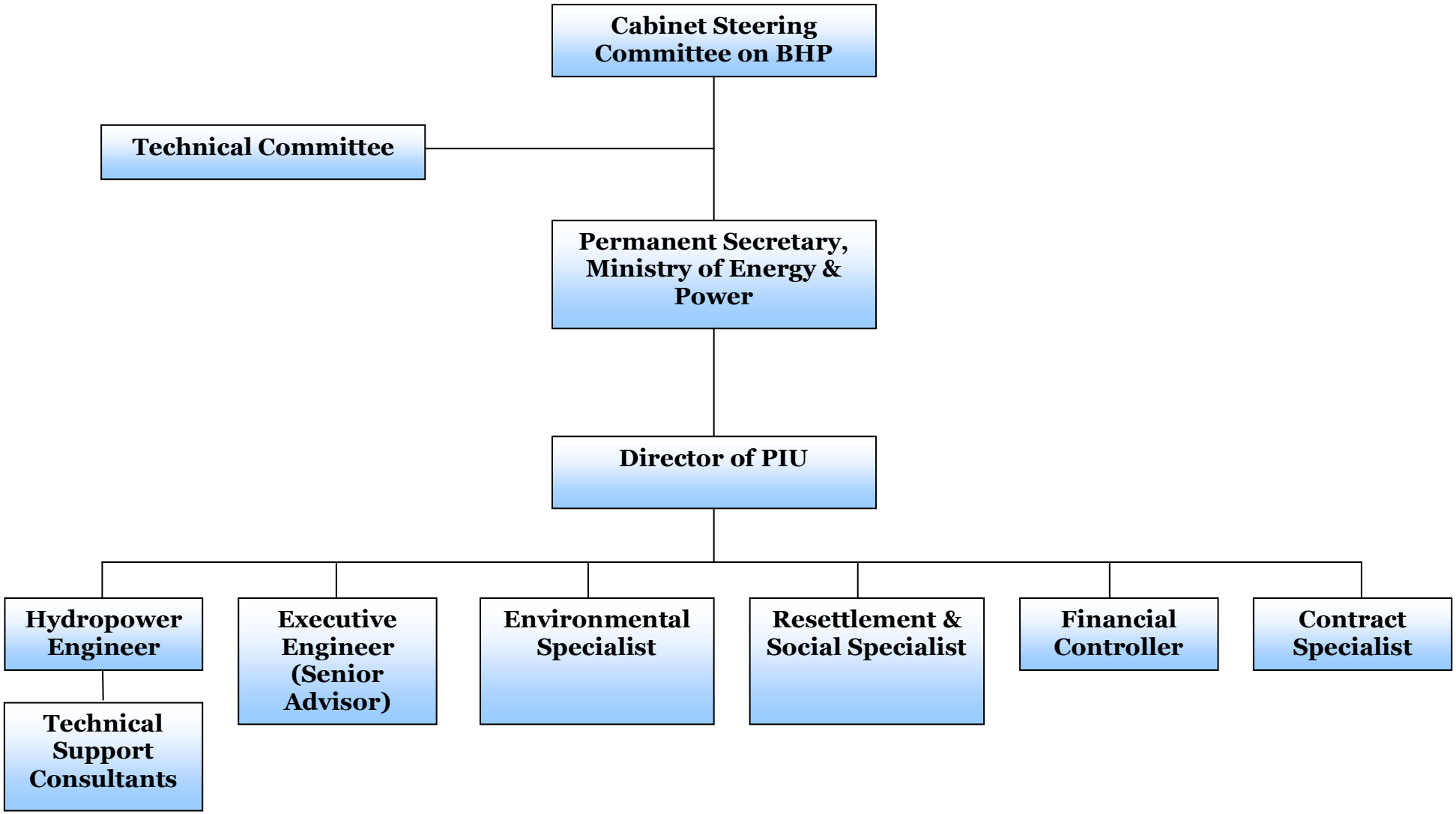


Figure 3.3-1: Organogram for the Bumbuna PIU

3.4 Filling

Various scenarios have been considered for filling the reservoir. If conducted in May-June as originally planned, filling of the reservoir to its minimum operating level would take 40 days, and filling to Full Supply Level (FSL) would take another 30 days. If impoundment were delayed until September, filling to minimum operating level could be achieved in about 3 days, and filling to FSL would take another 16 days. (Both of the above periods assumed a zero release of water from the dam during filling in order to fill the reservoir as quickly as possible.) In fact, it is now most likely that filling will be initiated in the dry season (probably January 2006) in order to avoid the possibility of flood flow during filling. Filling will then proceed slowly to 50% of FSL, at which point it will be interrupted to check for leaks, movement, etc.

If the downstream river flow were to be stopped during the filling period, this would have a range of adverse effects on the downstream aquatic ecology, fish, fisheries and river users; it would also leave a series of pools in the river bed which would very significantly increase mosquito breeding habitat. Such impacts are considered to be unacceptable, and the ESAP has therefore recommended that an amenity flow (= compensation flow or environmental flow) should be released from the dam during filling, even though that would extend the filling period. The ESAP has recommended a minimum downstream flow of 6 cumecs (m^3/s) during the dry season and 100 cumecs during the wet season for both filling and subsequent operation. This recommendation has been accepted by the Bumbuna PIU, and the engineering consultants have agreed to retro-design a left bank low-level outlet to achieve the required amenity flow at all times, including the start of filling.

3.5 Commissioning

It is expected that during commissioning (which could coincide with the period of filling) releases will made from the dam at varying flow rates, as the various elements of electrical and mechanical equipment are tested. In the absence of any operating rules for the reservoir, flows would vary considerably during a period of about two months, which could cause significant environmental disturbance and danger to both ecological processes and river users downstream. Such impacts would also be unacceptable and the DRP has asked the engineering consultants to establish a warning system for downstream users as part of the Emergency Preparedness Plan (EPP), and rules to prevent sudden changes in flow rate (either increases or decreases).

3.6 Operation

As mentioned in 3.4 above, operation of the BHP will be subject to the environmental / amenity flow requirements specified by the ESAP for the wet and dry seasons. Operation of the BHP will result in the following changes to the downstream river flow:

- An increase in river flow to about 33 cumecs during the January–May dry season period (average minimum natural flow in this period is 6 cumecs in March);
- A delay of about five weeks in the onset of flood conditions at the start of the rainy season, as the reservoir is re-filled to FSL;
- Depending upon operating rules for the scheme, possible reductions in flow at night and weekends due to retention of water to meet peak demand;

The environmental impacts of these changes in flow are discussed in Chapter 8.

All of the water released from the dam during operation will flow over the Bumbuna Falls and therefore the aesthetic value of the Falls will not be reduced.

3.7 Resettlement

Resettlement Action Plan (RAP) studies have been conducted for the dam / reservoir area and for the transmission line Right of Way (ROW), which are summarised in Chapters 9 and 10 respectively. The two RAP reports will be disclosed at the same times and places as the EIA report. Consultations will be held on all of these reports with relevant stakeholders.

Infrastructure to support resettlement will also need to be developed over time. Once the plans for resettlement have been completed, an EIA of the proposed resettlement arrangement will be required.

4 Future Seli Power Development Opportunities

The development of the 50 MW Bumbuna project is envisaged as the first phase of a 5-stage power development of the Seli River, with an ultimate potential of 275 MW (135 MW firm). There are several alternatives of the sequence to optimise phasing after Phase 1, but all schemes involve two dams (the existing dam 2.4 km upstream of Bumbuna Falls and a second dam 28 km further upstream at Yiben), and three locations for powerhouses, at the foot of the Bumbuna dam, below the Yiben dam, and downstream of Bumbuna Falls either on the left or right bank.

Table 4-1 illustrates the phasing of the Bumbuna-Yiben development:

Table 4-1: The Five Phases of BHP Development

Phase 1	Completion of the present BHP with a 50 MW powerhouse (2 x 25 MW units) at the foot of the 88m dam. Phase 1 would operate as a run-of-river scheme generating 50 MW in the wet season, reducing to 18 MW continuous (equivalent) in the dry season.
Phase 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 all year round. At that time, alternatives to add additional generation capacity include installing a powerhouse at the Yiben dam (with an initial 17 MW unit, Power Sector Master Plan, 1996), or alternatively, extending the Bumbuna powerhouse with 2x25 MW units to raise its output to 100 MW all year round (after the 1980 Feasibility).
Phase 3a	Envisages raising the Yiben dam (by 15 metres, 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.
Phase 3b	Envisages raising the Yiben dam further (24 metres, 1980 Feasibility) and increasing the Yiben power station to full capacity, or adding capacity at the Bumbuna Falls power station.
Phase 4	Depending on previous stages, this envisages upgrading capacity (additional units) either at the Yiben, Bumbuna or Bumbuna Falls power stations to their full development potential.

The actual size and timing of any subsequent stage of the Bumbuna-Yiben development would depend on integrated optimisation with respect to environmental and social criteria, and a combination of economic factors. These factors would include the attractiveness of competing supply options, the state of the economy and consequent rate of load growth in the Western Area grid, and also, whether transmission interconnection with Guinea is to be pursued (a 114 km transmission would be required).

As shown in Figure 4-1 (extracted from the 1980 Feasibility Study), the reservoir created by the full Yiben dam will be over ten times the volume of the Bumbuna reservoir (209 Mm^3 for the Bumbuna reservoir versus 2,130 Mm^3 of regulation capacity from the Yiben reservoir).

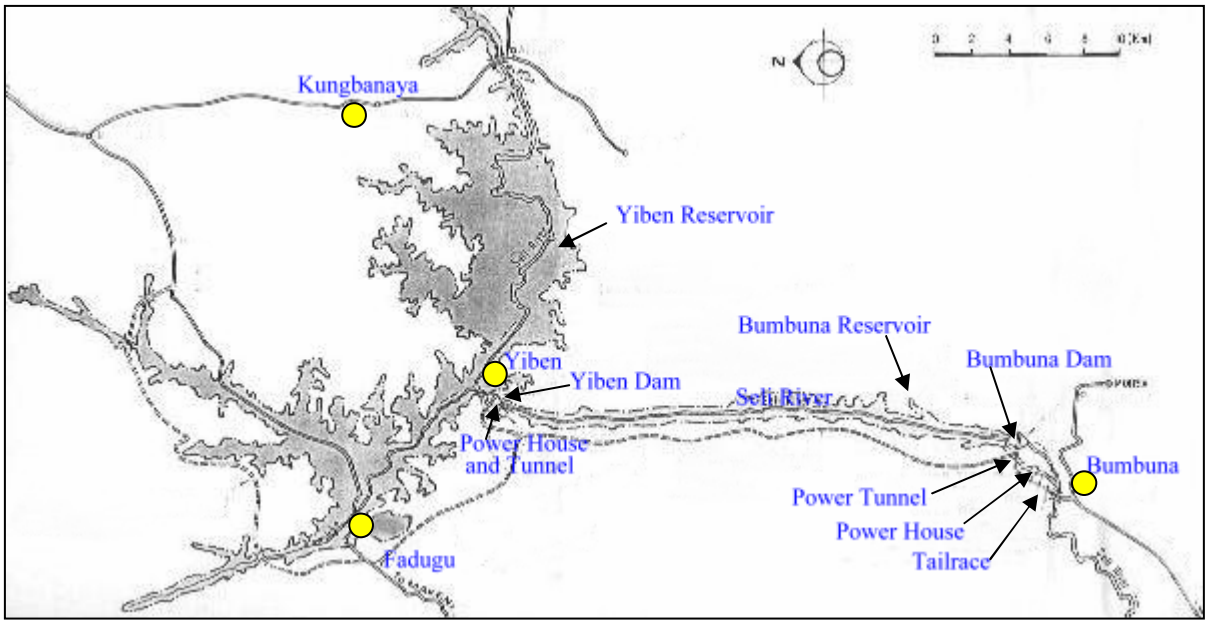


Figure 4-1: Representation of the Reservoir Area for the Full Bumbuna-Yiben Scheme

Source: 1980 Feasibility Study (Note: some aspects have since changed, but the overall scheme remains the same)

If the upstream Yiben reservoir were built, as is projected in the 1996 Master Plan, the Bumbuna reservoir would essentially remain full and the Bumbuna power station would generate to its maximum installed capacity all year round. The minimum regulated flow release i.e. downstream flow in the Seli, would be 80 m^3/s, compared with the 'without-dam' case of natural river flow of 6.4 m^3/s during March and April.

Apparently, the World Bank has no current plans to fund the future phases of development referred to above. However, regardless of Bank involvement, EIAs will be required nationally for any additional development of the scheme (they would also be required by any other financial institution that might be involved).

Any further development of the scheme will require construction of the Yiben Dam as the first step. As indicated in Section 12.5 below, this will have very much greater environmental and social consequences than the Bumbuna Dam. Many of these impacts will be cumulative (e.g. loss of farming land) and some will be synergistic (e.g. impact on wildlife due to loss of habitat). In the circumstances, there is a very strong case for conducting a Regional Environmental Assessment (a type of Strategic Environmental Assessment - SEA) before any further planning or design work. A Regional Environmental Assessment would be required by many international funding institutions, and would in any case be expected as part of international good practice. The nature of the required assessment is outlined in Section 12.5 below.

5 Policy, Legal and Institutional Context

5.1 National Administration of Environmental Management

The administration of environmental management in Sierra Leone has been changed since the end of the civil war. Whilst the resources available are still very modest, the government has made significant steps in establishing a proper administrative framework for the environment. The National Environmental Policy (NEP), originally approved by the cabinet in 1990, has finally been adopted and is now being implemented through the various provisions of its National Action Plan. These include the introduction of new legislation, the principal element of which is the Environmental Protection Act 2000 (EPA), which is itself now being implemented.

The principal administrative body is the National Environmental Protection Board (NEPB), which is charged with, *inter alia*, providing advice, co-ordination, co-operation and collaboration with other arms of government. The NEPB has some important powers, including the review of EIAs required under the Act for certain proposed project types (as in the case of BHP). The preparation and processing of EIAs is required to follow the EIA Procedures, published in July 2002, and the relevant sectoral EIA guidelines (see Section 5.2 below).

The Department of the Environment (EPD) of the Ministry of Lands, Country Planning and Environment, acts as the executive arm of the NEPB, and administers the EIA Procedures, including the requesting, reviewing and approving EIA reports. The NEPB / EPD has a Scientific Committee (otherwise known as the EIA Committee) which provides appropriate technical advice. Following the approval of a major project such as BHP, the staff of the EPD will monitor implementation of the recommendations of the EIA, particularly the mitigation measures and environmental monitoring programme.

The present capacity of the EPD to monitor implementation is very limited. Whilst a major project such as BHP is required to conduct self-monitoring and report the results to EPD, it will still be necessary for EPD to conduct regular field inspections during both construction and operation (in association with other government departments as appropriate).

The EPD HQ staff currently consists of five university graduates (four with master's degrees), i.e. the Director, Deputy Director, two Assistant Directors and one Principal Environmental Officer. In addition, there are four Senior Environmental Officers in the provinces, with a number of Environmental Inspectors in each office.

The EPD does not yet have its own equipment for the sampling and analysis of environmental media. The requirements for capacity-building in EPD are discussed in Chapter 13.

The Wildlife Conservation Branch (WCB) is located in the Forestry and Wildlife Division of the Ministry of Agriculture, Forestry and Food Security. WCB has a responsibility to manage game reserves, wildlife parks, and other protected areas but it appears to lack the capability to do so effectively. According to the analysis in the UNDP-sponsored report entitled Biodiversity Status and Trends in Sierra Leone and the accompanying National Report: Biodiversity Strategy and Action Plan (both 2003), the WCB is "….small, understaffed and ineffective". It lacks suitably qualified staff when compared with the professional forestry staff in the same Ministry. According to the report, WCB 'protected areas' management work is, in effect, conducted by local and international NGOs with donor funding.

5.2 National EIA Requirements

It is particularly important that any EIA should be fully compliant with applicable national EIA requirements and procedures. The original 1996 EIA was conducted before the advent of the Sierra Leone EPA, and publication of the EIA Procedures in 2002. Under those procedures, the BHP is classified as a Class A project, requiring Full Environmental Impact Assessment. The original EIA complies with that requirement retrospectively, in terms of the overall content of its EIA study and its EIA report (= Environmental Impact Statement). The subsequent additional studies in 2004 have also been conducted in compliance with the EIA Procedures, to the extent possible within a largely *post hoc* up-dating process.

The national EIA requirements do not conflict with those of the World Bank (see Section 5.3 below) and are similar in many respects, including project categorisation and the required content of the EIA study and report. The World Bank recommends rather more public consultation at the scoping stage. The national EIA Procedures require rather more public consultation at the EIA review stage. These have both been incorporated in the recent EIA studies.

5.3 World Bank Safeguard Policies

For future funding purposes, it is intended that the present EIA report should reflect the current policies, requirements and guidelines of the World Bank. In particular, the EIA Update studies were designed to comply with the Bank's 'safeguard policies', most of which have been either revised or introduced since the original EIA was prepared. Those safeguard policies that are being triggered by the project are reviewed below, in order to identify their implications for the BHP.

Environmental Assessment (OP 4.01)

Operational Policy (OP) and Bank Procedure (BP) 4.01 on Environmental Assessment (EA) published in January 1999, combine and replace several previous policies, including the Environmental Policy for Dam and Reservoir Projects. OP 4.01 describes the EA screening categories and their requirements, for which the Bumbuna project has already been determined as Category 'A', requiring a full EIA. An annexe of the OP defines the required structure of the EIA report, with which the original and present EIA reports comply. A further annexe defines the structure of the Environmental Management Plan (EMP), with which the present report also complies.

OP 4.01 states that for Category 'A' projects that are highly risky or contentious or that involve serious and multidimensional environmental concerns, the developer should normally engage an advisory panel of independent, internationally recognised environmental specialists to advise on all aspects of the project relevant to the EA. Establishment of the three-man ESAP in October 2004 complies with this requirement. The first visit of the ESAP took place from 1st to 11th November 2004, resulting in a 57-page report, some elements of which (e.g. recommended amenity flow rates for the Seli) have been referred to in the present report. See Appendix A.2 for a summary of the report.

In relation to public consultation, OP 4.01 requires a two-stage process, which was conducted as part of the EIA studies in 2004, viz: (a) shortly after environmental screening and before the terms of reference for the EA are finalised, and (b) once a draft EA report is prepared. (In fact, there were also four consultation public meetings and numerous personal interviews during the original EIA). In addition, the borrower is required to consult with stakeholder groups throughout project implementation as necessary to address EIA-related issues that affect them, as is recommended for various aspects of environmental management in the present EIA report.

Compliance with OP 4.01 will require the following additional future actions:

For consultation after the draft EIA report is prepared, the borrower should provide a summary of the conclusions of the EIA. In addition, for this Category A project, the borrower should make the draft EIA report available at a public place accessible to project-affected groups and local NGOs. (The PIU has agreed to make arrangements for these actions.)

During implementation of the project, the borrower should report on: (a) compliance with measures agreed with the Bank on the basis of the findings and results of the EIA, including implementation of the EMP; (b) the status of mitigation measures; and (c) the results of monitoring programmes.

The future development of the Bumbuna / Yiben project through a further four phases up to a maximum installed capacity of 275 MW is likely to have sectoral and/or regional impacts. When a project is likely to have sectoral or regional impacts, OP 4.01 requires sectoral or regional Environmental Assessment (EA) to be undertaken. A sectoral and/or regional EA will therefore be required before further development of the Bumbuna programme is initiated.

Sectoral and regional Environmental Assessments are types of Strategic Environmental Assessment (SEA), for which the World Bank has no requirement by that name. However, the Bank's Environment Strategy (adopted in July 2001) includes the more systematic use of Strategic Environmental Assessment (SEA) in World Bank operations to promote 'mainstreaming' of environment, by influencing planning and decision-making processes at an early stage.

Cultural Property (OPN 11.03)

OP 4.11 is currently under preparation. Until it is issued, Bank staff are guided by the provisions of Operational Policy Note (OPN) 11.03, which was quoted and acted upon in the original EIA and has guided the more recent field studies.

The United Nations term "cultural property" includes sites having archaeological (prehistoric), palaeological, historical, religious, and unique natural values. Cultural property, therefore, encompasses both remains left by previous human inhabitants (including middens, shrines, and battlegrounds), and unique natural environmental features such as canyons and waterfalls.

The World Bank requires that, before proceeding with a project which may risk damaging cultural property (e.g., any project that includes large scale excavations, movement of earth, superficial environmental changes or demolition), the cultural property aspects of the project site must be determined. If there is any question of cultural property in the area, a reconnaissance survey should be undertaken in the field by specialists.

The original EIA reports on cultural practices and sites within the project area, and acknowledges the potential tourism attraction of Bumbuna Falls and the hydro-electric power station. It also provides the results of an archaeological literature review and archaeological interviews. This information has been supplemented with an archaeological field reconnaissance survey in the vicinity of the project in 2004 (see Chapter 7 for results).

Natural Habitat (OP 4.04)

This OP replaces the previous policy relating to 'wildlands' referred to in the original EIA report. It states that wherever feasible, Bank-financed projects are sited on lands already converted (excluding any lands that in the Bank's opinion were converted in anticipation of the project). The Bank does not support projects involving the significant conversion of natural habitats unless there are no feasible alternatives for the project and its siting, and comprehensive analysis demonstrates that overall benefits from the project substantially outweigh the environmental costs. If the environmental assessment indicates that a project would significantly convert or degrade natural habitats, the project should include mitigation measures acceptable to the Bank. Such mitigation measures include, as appropriate, minimising habitat loss (e.g., strategic habitat retention and post-development restoration) and establishing and maintaining an ecologically similar protected area. The Bank accepts other forms of mitigation measures only when they are technically justified.

The Bank encourages borrowers to incorporate into their development and environmental strategies, analyses of any major natural habitat issues, including the identification of important natural habitat sites, the ecological functions they perform, the degree of threat to the sites, priorities for conservation, and associated recurrent-funding.

Inundation of the reservoir basin will clearly 'convert or degrade' its natural habitat. The question is whether that can be considered 'critical' natural habitat. The World Bank definition of critical natural habitat is as follows:

- Existing protected areas and areas officially proposed by governments as protected areas (e.g., reserves that meet the criteria of IUCN classifications), areas initially recognised as protected by traditional local communities (e.g., sacred groves), and sites that maintain conditions vital for the viability of these protected areas (as determined by the environmental assessment process);or

- Sites identified on supplementary lists prepared by the Bank or an authoritative source determined by the Regional environment sector unit (RESU). Such sites may include areas recognised by traditional local communities (e.g. sacred groves); areas with known high suitability for biodiversity conservation; and sites that are critical for rare, vulnerable, migratory, or endangered species. Listings are based on systematic evaluations of such factors as species richness; the degree of endemism, rarity, and vulnerability of component species; representativeness; and integrity of ecosystem processes.

Given that the area of the reservoir basin is neither an existing nor officially proposed protected area, nor a site identified on any official supplementary list, it does not fall within the World Bank definition of critical natural habitat. The question of whether the natural habitat to be inundated is critical to the endangered chimpanzee population is

discussed below in Chapter 8 of this report, and in detail in the separate Interim Report on Primates previously issued in October 2004, and contained in Appendix J.

Concerning 'feasible alternatives for the project and its siting', the fact that the dam already exists indicates that there is no feasible alternative site, unless the existing site were abandoned and another dam built elsewhere (which would result in a very significant overall increase in the adverse environmental and social effects of the project). Moreover, the retrospective assessment of alternatives (Haas 2004) referred to in section 2.2 above indicates that selection of the current site and design was a reasonable decision.

If an EIA indicates that a project would significantly convert or degrade natural habitats, the project must include mitigation measures acceptable to the Bank. Such mitigation measures may include, as appropriate, minimising habitat loss (e.g., strategic habitat retention and post-development restoration) and the establishment and maintenance of an ecologically similar protected area. The Bank accepts other forms of mitigation measures only when they are technically justified.

The 2004 field studies on primates and forests have been conducted in compliance with the above, as have the resulting mitigation measures relating to the conservation of chimpanzees and 'offset' protected forest areas (see Chapter 8). The required consultation with local people and NGOs concerning the importance / value of affected natural habitats, has been addressed by the recent public consultation activities (see Chapter 6).

The Bank takes into account the borrower's ability to implement the appropriate conservation and mitigation measures. If there are potential institutional capacity problems, the project must include components that develop the capacity of national and local institutions for effective environmental planning and management. Such capacity-building requirements were reviewed, and have been addressed within the EMP of the present EIA report (Chapter 12).

Forests (OP 4.36)

Whilst this OP is principally related to World Bank activities in the forestry sector, it includes policies on the conservation of forest biodiversity, the sustainable management of forest areas, and the participation of local people, all of which may be relevant to BHP, particularly in the management of the surrounding forests and the Seli river basin. The OP emphasises that the management, conservation, and sustainable development of forest ecosystems and their associated resources are essential for lasting poverty reduction and sustainable development.

The OP states that:

- The Bank does not finance projects that, in its opinion, would involve significant conversion or degradation of critical forest areas or related critical natural habitats;

- If a project involves the significant conversion or degradation of natural forests or related natural habitats that the Bank determines are not critical, and the Bank determines that there are no feasible alternatives to the project and its siting, and comprehensive analysis demonstrates that the overall benefits from the project substantially outweigh the environmental costs, the Bank may finance the project provided that it incorporates appropriate mitigation measures.

The second of these statements applies to the BHP. The forest inventory studies and conservation proposals developed as part of the 2004 studies and reported in Chapter 8, represent completion of the required appropriate mitigation measures.

Once the BHP is in operation, it will be necessary to keep the Right of Way (ROW) clear of large vegetation which might either interfere with the transmission line or cause a fire hazard to it. This will be done by the physical cutting of the bush on a regular basis. This maintenance would not be conducted using herbicides, the use of which will be forbidden, so the World Bank policy on Pest Management will not be triggered.

Dam Safety (OP 4.37)

The Bank's requirements in respect of 'Existing Dams and Dams under Construction (DUC)' are relevant to the Bumbuna case, and in particular the following paragraph:

8……. the Bank requires that the borrower arrange for one or more independent dam specialists to (a) inspect and evaluate the safety status of the existing dam or DUC, its appurtenances, and its performance history; (b) review and evaluate the owner's operation and maintenance procedures; and (c) provide a written report of findings and recommendations for any remedial work or safety-related measures necessary to upgrade the existing dam or DUC to an acceptable standard of safety.

This requirement has been met by establishment of the four-man Bumbuna Dam Review Panel, which met for the first time during the period 25th October – 4th November 2004, carried out the activities specified above, and submitted a 60-page report on all aspects of the safety of the dam and its operation. See Appendix A.2 for a summary of the report.

Involuntary Resettlement (OP 4.12)

Any requirement for involuntary resettlement is considered to be one of the most important environmental impacts of a proposed project, and Bank guidance on resettlement and compensation is now very comprehensive and specific, particularly in

relation to the identification, participation and support of project affected persons (PAPs). The policy objectives stated in OP 4.12 are as follows:

- Involuntary resettlement should be avoided where feasible, or minimized, exploring all viable alternative project designs;

- Where it is not feasible to avoid resettlement, resettlement activities should be conceived and executed as sustainable development programs, providing sufficient investment resources to enable the persons displaced by the project to share in project benefits. Displaced persons should be meaningfully consulted and should have opportunities to participate in planning and implementing resettlement programs;

- Displaced persons should be assisted in their efforts to improve their livelihoods and standards of living or at least to restore them, in real terms, to pre-displacement levels or to levels prevailing prior to the beginning of project implementation, whichever is higher.

In the circumstances, the PIU commissioned Electrowatt et al and Azimut et al to prepare Resettlement Action Plans (RAPs) for the reservoir and for the transmission line route respectively. The draft reports for the two RAPs are summarised in Chapters 9 and 10 respectively below.

Other OPs, which are not triggered by the BHP, but which might be considered to be of interest, are as follows:

Projects on International Waterways (OP 7.50)

This OP is not applicable, as the Seli / Rokel River flows exclusively within Sierra Leone throughout its entire length.

Indigenous Peoples (OP 4.20)

This OP provides policy guidance to ensure that indigenous people benefit from development projects, and to avoid or mitigate potentially adverse effects on indigenous people caused by Bank-assisted activities. Special action is required where Bank investments affect indigenous peoples, tribes, ethnic minorities, or other groups whose social and economic status restricts their capacity to assert their interests and rights in land and other productive resources.

The Bank defines "indigenous peoples," "indigenous ethnic minorities," "tribal groups," and "scheduled tribes" as social groups with a social and cultural identity distinct from the dominant society that makes them vulnerable to being disadvantaged in the development process. Whilst the people living in the vicinity of the BHP are from more

than one recognisable tribe (see Chapter 7 below for details), none can be described as indigenous peoples under the above definition.

5.4 International Good Practice

In addition to World Bank safeguard policies, there are numerous other guides to the environmental and social management of the development of major projects, published by bilateral development assistance agencies, multi-lateral development banks, etc. It is not possible to review the BHP in detail with respect to all of these, but the following reviews some of the approaches incorporated in the BHP, as feasible.

Past / Existing Projects

It is normally expected that outstanding compensation issues should be cleared up at the time of related new works. This is being done for BHP within the two RAP studies.

Compensation

It is also expected that stakeholders should have the opportunity to negotiate agreements for compensation, mitigation, resettlement, development and monitoring measures affecting them. Given that there has been no compensation of stakeholders thus far, this has not been done. However, stakeholders were very much involved in discussions of value in the two RAPs undertaken for the reservoir and transmission line route, and will be similarly involved in the subsequent more detailed valuation, compensation and resettlement exercise.

Public Consultation

The relationship between project development and communities should ideally be managed to achieve public acceptance of a project. This will require attention to the linked issues of stakeholder identification, communication, consultation, participation, negotiation, prior consent and dispute / grievance resolution. Whilst it is now too late to involve communities in the major decisions of BHP development (site selection, etc), it is still important that a consultative mechanism should be put into place for the remainder of construction and then for operation. This has been started in the consultation processes for the present study (see Chapter 6 on Public Consultation and Disclosure), and in the RAP studies, and will be continued by the PIU throughout the further development of the project. Chapter 6 below recommends establishment of a Community Liaison Committee and Appendix B.3 contains a grievance and dispute resolution procedure for stakeholders that will be included within the contractors' EMPs (see Chapter 13). A public communication programme will also be required, and this has

been developed by the recently established Bumbuna Communications Unit attached to the PIU.

Benefit Sharing

The World Bank has considered the types of benefit sharing mechanisms that can be employed within dam projects (see Egre, Roquet and DuRocher), as follows:

- Revenue Sharing;
- Development Funds;
- Equity Sharing or Full Ownership;
- Taxes paid to regional and local authorities;
- Preferential electricity rates.

The RAPs have addressed the issue of compensation, and the Upper Seli Community Development Initiative study (December 2004) has addressed the broader community benefits that could be provided as part of the development of BHP, in terms of health centres, schools, sanitation and skills training. Other direct methods of sharing the benefit of BHP are anticipated, e.g. the electrification of Bumbuna village, and the employment of Project Affected Persons (PAPs) in the completion of construction. Like the gaining of public acceptance, these are issues that can best be finalised at local level within the process of improving the relationship between project and community described above. It is expected that a trust fund will be established, in order to utilise income from Bumbuna carbon credits, and it is also recommended in the present report that a fund should be established (possibly the same fund) using, *inter alia,* a small percentage of the electricity tariff, to support land management activities in the immediate catchment of the reservoir.

Analysis of Alternatives

It is now expected that environmental and social issues should be given the same weight as technical and economic considerations in decision-making for major projects. This would normally be done within a comprehensive assessment of alternatives. The BHP was developed before such an approach became the norm, and it is obviously too late to apply such methodology to those stages of the BHP that have already been completed. However, options assessment can be applied to some aspects of completion and to operation of the BHP, and would certainly be a part of the SEA that has been recommended before any of the further four phases of Bumbuna development. A 'Retrospective Review of the Bumbuna Hydroelectric Project, Including Alternatives Analysis' was conducted concurrently with the 2004 EIA studies (Haas, 2004). This reviewed the degree to which options were assessed up to mid-2004, and made

recommendations for options assessment during the completion and operation of the BHP (Phase I).

Downstream River Flows

Most funding agencies require that an adequate downstream environmental flow (= amenity flow or compensation flow) should be defined to maintain downstream species, ecosystems and livelihoods. It is often difficult to determine an appropriate flow rate, but as stated in 3.4 above, the ESAP has proposed minimum wet and dry season flow rates, which have been accepted by the PIU. The need for fish passes is normally considered where migratory fish are involved, but this is irrelevant in the case of BHP, because of the barrier to upstream fish migration that is already presented by Bumbuna Falls.

Contingency Planning

It is expected that any dam project should have contingency plans for emergency drawdown of the reservoir and for dam-break, including arrangements for rapid communication with stakeholders. Improvements in the Emergency Preparedness Plan have been addressed by the DRP, and such plans will also be included in the Emergency Plan to be prepared as part of the O & M contractor's EMP – see Chapter 13 below.)

Strategic Environmental Assessment

SEA, as recommended by the World Bank Environment Strategy, is now widely accepted as the required tool for assessment of programmes of development, such as the further four phases of power development on the Seli River at Yiben / Bumbuna.

Capacity Building

It is also generally accepted that the governments of developing countries should be provided with the training and capacity building needed to adequately monitor and manage the environmental and social issues associated with internationally funded major projects (as discussed in Chapter 13 in relation to BHP).

5.5 Multilateral Environmental Agreements to Which Sierra Leone is Committed

The developers and operators of the BHP (and further hydropower projects in Sierra Leone) should note that the Government of Sierra Leone has signed or ratified the following multilateral environmental conventions, treaties and agreements:

- The Convention on International Trade in Endangered Species of Wildlife, Fauna and Flora (CITES)
- Convention on Wetlands of International Importance (Ramsar Convention)
- The UN Convention on the Law of the Sea (UNCLOS 1982)
- The Convention of the International Maritime Organization 2001

- The Convention covering the protection of the World Cultural and Heritage Sites, UNESCO 1972
- UN Convention to Combat Desertification 1994
- UN Convention on Climate Change 1992
- Vienna Convention for the Protection of Ozone Layer
- Montreal Protocol on Substances that Deplete the Ozone layer 1993
- International Convention for the Prevention of Pollution from Ships 1973
- The Basle Convention on the Control of Trans-boundary Movement of Hazardous Wastes and their Disposal
- Convention on Biological Diversity
- Convention on Biosafety
- FAO code of Conduct on Responsible Fisheries

In addition, the Sierra Leone Government is a signatory to certain regional agreements that may relate to the conservation of biodiversity, including:

- The Convention Establishing a Permanent Inter-state Committee for the Control of Drought in the Sahel
- International Convention for the Conservation of Atlantic Tunas
- African Convention on the Conservation of Nature and Natural Resources
- International Tropical Timber Agreement
- FAO International Undertaking on Plant Genetic Resources
- FAO International Code of Conduct on the Distribution and use of Pesticides

5.6 Power Sector Policy

Sierra Leone's power sector policy framework is discussed in the options assessment study (Appendix C1). This states that hydropower development, particularly the implementation of the BHP is well founded in the national development policy and energy policy framework. Consistent policy themes since the first nationwide hydropower inventory was 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 utilising indigenous renewable energy resources, particularly to develop a hydropower based electricity 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.

6 Public Consultation and Disclosure

6.1 The Public Consultation and Disclosure Plan (PCDP)

Stakeholder consultation is now normal practice when an EIA is conducted for a major project. Stakeholders are individuals, groups and organisations whose interests may be affected by a proposed project, and who may have an ability to influence decisions concerning the siting, construction and operations of the project. For a category 'A' project like BHP, stakeholder consultations will be necessary throughout the EIA process and also during the construction and operation phases.

The Terms of Reference (ToR) for the 2004 EIA studies required that public consultation and disclosure should be in accordance with World Bank policies, specifically (OP) 4.01. A Public Consultation and Disclosure Plan (PCDP)[8] was therefore prepared, and is included as Appendix B.1.

PCDPs are prepared at the beginning of EIA studies, and act as guides to management of the consultation and disclosure programme. They are useful tools for assisting the EIA process and ensuring that work is undertaken effectively and efficiently. The PCDP presents the consultation activities to be implemented, and links them to key stages in the EIA process. The Bumbuna PCDP was prepared taking into account the requirements of the EIA legislation in Sierra Leone and consultations already undertaken during preparation of the original EIA report, and represents a technically and culturally appropriate approach to consultation and disclosure. The goals of the PCDP 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 at the national level;
- These stakeholders are given sufficient opportunity to voice their opinions and concerns;
- These concerns are considered in determining the EIA work and project decision-making.

The PCDP prescribes consultations at four main stages, reflecting World Bank policy and procedural requirements and international best practice. The stages are:

- Consultations on the ToR (known as 'scoping');

[8] Preparation of a PCDP is a requirement of the International Finance Corporation (IFC), a member of the World Bank Group. A PCDP prepared early in the recent study, helped to ensure that adequate and effective consultation occurred within the tight timescale. Particular reference has been made to the 1999 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'* .

- During conduct of the additional EIA studies;
- On the draft EIA omnibus report; and
- During the period when the project is completed, commissioned and begins operation.

The findings of the 'scoping' consultations are reported in section 6.2 below, with particular reference to the focus and content of the 2004 studies. These findings were then used to refine the ToR for the studies.

The PCDP has specified that consultations will be required on the final EIA Report, and this is a requirement under national EIA legislation. These will be implemented under the control of the Department of Environment of the Ministry of Lands, Country Planning and the Environment. Whilst the PCDP outlines the activities required (see Appendix B.1), it will be the DoE (in concert with the PIU) that will determine the details of how such consultations will be undertaken.

6.2 Scoping Consultations

Local (primary) and national (secondary) stakeholders were identified, and meetings held to obtain their views and concerns with respect to the likely impacts of the project. Tables 6.2-1 and 6.2-2 show the target groups for the two sets of local and national stakeholders. Table 6.2-3 lists the individual consultation meetings with details of date, location and attendance.

Table 6.2-1: Primary Stakeholder Target Groups

Women - women's farming association in Bumbuna and women 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 (male and female). **Co-operative associations and/or special interest groups (farmers associations; fishermen)** **Religious leaders** – Muslim imams and the Roman Catholic priest in Bumbuna. **Security personnel** – Police **Acting Principal and Teacher of secondary school** –. Bumbuna **Site Manager of Salcost** – contractor for current phase of the project

Table 6.2-2: Secondary Stakeholder Target Groups

***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 (responsible for reservoir basin RAP)
Azimut (responsible for transmission line RAP)

Table 6.2-3: Scoping Consultation Meetings

Stakeholder(s)	Location	Date	Type of meeting	No. of attendees	No. of women
Acting Provincial Secretary, Northern Province	Makeni	23.08.04	Private	1	Not applicable
Village chief, elders and inhabitants	Kadala	24.08.04	Public	11*	6
Township elders, chiefdom speaker, imams and elders and inhabitants	Bumbuna Town+	24.08.04	Public	20*	1
Village chief, elders and inhabitants	Kasokira	25.08.04	Public	15*	2
Village chief, elders and inhabitants	Gbulia	25.08.04	Public	9*	1
Township senior school pupils, one teacher, one retired teacher	Bumbuna Town^	26.08.04	Private	16 pupils, two teachers	8 female pupils
Police (Officer/commanding, senior CID officer and station sergeant)	Bumbuna Town^	26.08.04	Private	3	Not applicable
Roman Catholic priest	Bumbuna Town^	26.08.04	Private	1	Not applicable
Chief, elders and inhabitants	Kafogo<	26.08.04	Public	18	4
Village chief, teacher and elders	Kakeko<	26.08.04	Public	14	5
Township chiefdom speaker, elders and inhabitants	Fadugu<	26.08.04	Public	31	7
Paramount Chief, Kalansogoia	Bumbuna Town	27.08.04	Private	1	
Women's Agricultural Association	Bumbuna Town	27.08.04	Public	40-50*	40-50
Salcost site manager and two consulting engineers from Studio Pietrangelli	Main contractor camp	27.08.04	Private	3	Not applicable
Paramount Chief, Bombali-Sheboia	Makeni	28.08.04	Private	1	Not applicable
National stakeholder workshop of representatives from Ministries, Parastatals, NGOs and Academic Institutions and the Press	Freetown	03.09.04	Private	20*	4

Notes: * Numbers participating fluctuated during the meeting. Numbers provided are either an estimated average or range.
+ Paramount Chief chaired the meeting.
^ Meetings led by Ron Bisset (NKUK).
< Meetings led by Dr Abdul Karim (NKUK).

As indicated above, various meetings were conducted at the local level (including Makeni), and a scoping workshop was organised in Freetown for the national stakeholder group. The views and concerns of individual stakeholders were noted and then compared separately for local and national stakeholders. The views and concerns were subsequently summarised (as there was considerable repetition of the same issues, but expressed in slightly different ways) again for each stakeholder group. Finally, the summaries were compared with the existing ToR for the EIA Update studies, and refinements were made to ensure that the legitimate concerns of the stakeholders were taken into account.

The scoping consultations, and a full account of results obtained, are described in detail in the Scoping Report presented as Appendix B.2. That appendix includes the consequent additions that were made to the ToRs for the update studies, presented as a series of additional questions. Each of those questions has then been addressed within the present report.

6.3 Consultations During the EIA Update Studies

Three specialist study teams worked in the project area to conduct the additional field studies during August and September 2004. During this work, team members were available for additional consultations as and when the need arose on the part of local stakeholders (not necessarily those consulted during scoping). In addition, the teams actively consulted local people to increase the team's knowledge and understanding of the local environment, key changes since 1996 and current trends. Such discussions provided a context in which stakeholders could voice any new concerns, as well as reinforcing issues and concerns already raised in the earlier consultations.

6.4 Further Consultations

6.4.1 Consultations on the Draft 'Omnibus' EIA Report

In accordance with the requirements of the PCDP, the present report will be subject to consultations, which will be conducted in February / March 2005. The report will be issued in English and placed on the PIU project website, with a facility for comments to be posted (website not operating as of January 2005; expected to be operational in February 2005). The PIU will place some copies of the draft EIA Update report in public locations such as schools and local government offices in Freetown, Bumbuna, Makeni and Fadugu, in order to increase the opportunity for informed stakeholder comment. At the same time, multiple copies of the Executive Summary will be placed in both the same, and additional locations.

Information on the consultation procedures for the draft of the present EIA report will be publicised through the Press, the posting of public notices in local communities, and through the administrative structures of the Paramount Chief of Kalansogoia. Four open public meetings will be held in Freetown, Bumbuna, Fadugu, and in a village in the dam/reservoir area.

The public meetings will be held in the evenings to allow those working to attend. They will be chaired by an independent chairperson from an area not affected by the project, and facilitated by an EIA team member fluent in English and Krio. The meetings will start with a presentation summarising the present report, followed by a 'question and answer session' and a focused discussion.

All comments will be noted, collated, analysed and recorded on a form. This form will enable the PIU/MEP to summarise its responses, and to decide whether the issues need to be taken into account in the final report. The form will also be used by the PIU/MEP to provide feedback to those consulted. Copies of the completed form will be placed on the project website and in the locations used to provide public access to the draft report and executive summaries.

6.4.2 Results of Consultations on the Draft EIA Report

TO BE DRAFTED FOLLOWING THE CONSULTATIONS

This section of the final report will contain an account of the comments received on the draft EIA report, with an indication of how they were analysed and incorporated into the final report.

6.4.3 Consultations on the final EIA Report

The final EIA report will be subject to review and consultation according to the national EIA Procedures. The Department of Environment will be responsible for this process, and the PIU/MEP has agreed to assist by providing the following support to its Director:

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

The consultations on the final report are expected to take place in the first quarter of 2005. The final report, which will be made public both in-country and at the World Bank Infoshop, will replace the previously disclosed draft report.

6.4.4 Consultation during completion, commissioning and operation of BHP

During certain scoping consultations, but particularly at the national stakeholder workshop in Freetown, there was discussion of the principles that should apply to consultation in the post-EIA phase. The suggestions provided have been used as a basis for the proposed consultation framework and mechanisms. The recommended mechanisms are the establishment of a Community Liaison Committee and a Grievance Procedure, the details of which are presented in Appendix B.3. These mechanisms are compatible with the current national and local-level institutional and regulatory context.

A Community Liaison Committee (CLC) is suggested because it is increasingly important that environmental management for large-scale projects should be socially responsive. Experience has shown the important role that can be played by a forum, in which local communities, the project operator, and national and local government agencies can meet regularly to discuss issues and problems, and agree on possible solutions. The need for a CLC is indicated by the history of previous project/community interactions related to the BHP (many of them considered to be adverse by local and national stakeholders), the nature of the issues and concerns expressed during scoping, and the expectations of people locally and nationally in relation to project benefits.

Such a committee can only concern itself with issues that have a community-wide focus and are of medium to long-term duration. 'Community-wide', in this context, refers to settlements or significant community groups and not to individuals. A liaison committee, even one that meets regularly, will not have sufficient resources to deal with issues that pertain only to individuals.

To deal with possible complaints and grievances from individuals, it is necessary to establish a grievance procedure that provides a speedy, transparent and effective mechanism for resolving disputes without recourse to legal redress. The proposed procedure does not reduce or restrict the rights of individuals to resort to judicial means of dispute resolution. In addition to the grievance procedure outlined in Appendix B.3, there is a grievance procedure associated with each of the two RAPs. This is appropriate because the RAPs deal with the very specific issues of land acquisition and compensation, in which disputes will usually concern matters of valuation, payment, etc.

7 Existing Environment

7.1 Introduction

Study Area Boundaries

The following system is adopted in this report to refer to the various parts of the study area:

Seli/Rokel Basin:	The drainage area of the whole Seli/Rokel river, which covers a surface area of 10,620 km^2;
Upper Seli Catchment:	The drainage area of the Seli River upstream of the dam, which covers 3,920 km^2;
Immediate Catchment:	The area upstream of the dam, within the hills immediately east and west of the Seli River. Extends approximately 10 km on each side of the river, covering an area of around 640 km^2, including the new reservoir;
Reservoir area:	The land submerged beneath the 21 km^2 reservoir after impoundment to Full Supply Level (FSL, 241.25 m asl);
Project area:	The area covered by the project structures (reservoir, dam and associated facilities);
Downstream area:	The Seli-Rokel River downstream of the dam, as far as the estuary and river mouth east of Freetown;
Resettlement area:	Area potentially suitable for resettlement of Project Affected Persons (PAPs).

Data Sources

The following description of existing environmental conditions in the area that could be affected by the project is based on data from a variety of sources. These include:

- Existing data (from Government agencies and NGOs, published reports, books, papers, etc) contained in the 1996 EIA report (Electrowatt/Techsult 1996), and additional existing data collected by NKUK, BMT Cordah and EFA in 2004;
- New data from surveys (primates, aquatic and terrestrial flora and fauna, archaeology, public health, socio-economics, etc) carried out by Electrowatt/ Techsult in 1995-96 and by NKUK, BMT Cordah and EFA in 2004;
- Data from other studies related to the BHP, including the Feasibility Study (Bumbuna Hydro-Consultants 1980), Resettlement Action Plans for the

dam/reservoir (Electrowatt-Ekono/Techsult 2005) and transmission line (Azimut/ BGJLR/Infoterra 2005), and the Retrospective Options Assessment (Haas 2004).

The description of the existing environment includes data from all sources, and the text is illustrated with summary tables of data, maps, graphs, photographs, etc. Raw data is presented in Appendices B-N, which also includes more detailed written descriptions of many of the features, to which the reader may refer for further information. The sources of all data are given either in the text below or in the Appendix, and the references of all published data are shown in the Bibliography.

7.2 Physical and Chemical Environment

7.2.1 Climate

Like most of West Africa, Sierra Leone has a tropical savannah climate, with distinct wet and dry seasons resulting from migration of the Inter-tropical Convergence that separates the warm dry air of the Sahara from moist air blowing northwards across the sea.

In Bumbuna the wet season begins in May and ends in October, and is characterised by heavy rain (reaching a maximum of around 600 mm in August), high humidity (70-80%), and air temperatures that are generally below the annual average of 25 °C (Appendices D.1 and D.2). At the height of the wet season rain can fall for several days without interruption, and even on dry days there is little sunshine because of heavy cloud cover. Thunderstorms occur in the transition periods between the two seasons, accompanied by short periods of strong winds and heavy rain.

Rainfall decreases as the dry season progresses, until in February there is virtually no rain at all. Humidity is lower and temperatures are a little above average, at generally around 25-30 °C in the day and 20-25 °C at night. March is the hottest month, when temperatures reach the annual maximum of 35 °C. Conditions are modified by the Harmattan, which is a dry, dust-laden wind, which blows south-west from the Sahara intermittently between December and March, for periods of up to a few days. At such times the sun can be obscured by airborne dust, and temperatures can fall to 16 °C and humidity to 40-70% (Appendix D.2).

7.2.2 Hydrology

Seli-Rokel Basin

The Seli/Rokel River watershed is the third largest in Sierra Leone, with a total length of 380 km and a drainage area of 10,620 km^2. The Seli rises in the north-northeast of the country, near the border with Guinea, and flows south-west across the Interior Plateau for around 100 km (Figure 7.2.2-1). South-east of Fadugu, near Yiben, the river transects the

Sula Mountains and flows out of the plateau across Bumbuna Falls, where it drops around 40 m into the Interior Lowlands. The river is then known as the Rokel, and meanders 350 km across the gently sloping interior lowlands, down to the sea east of Freetown.

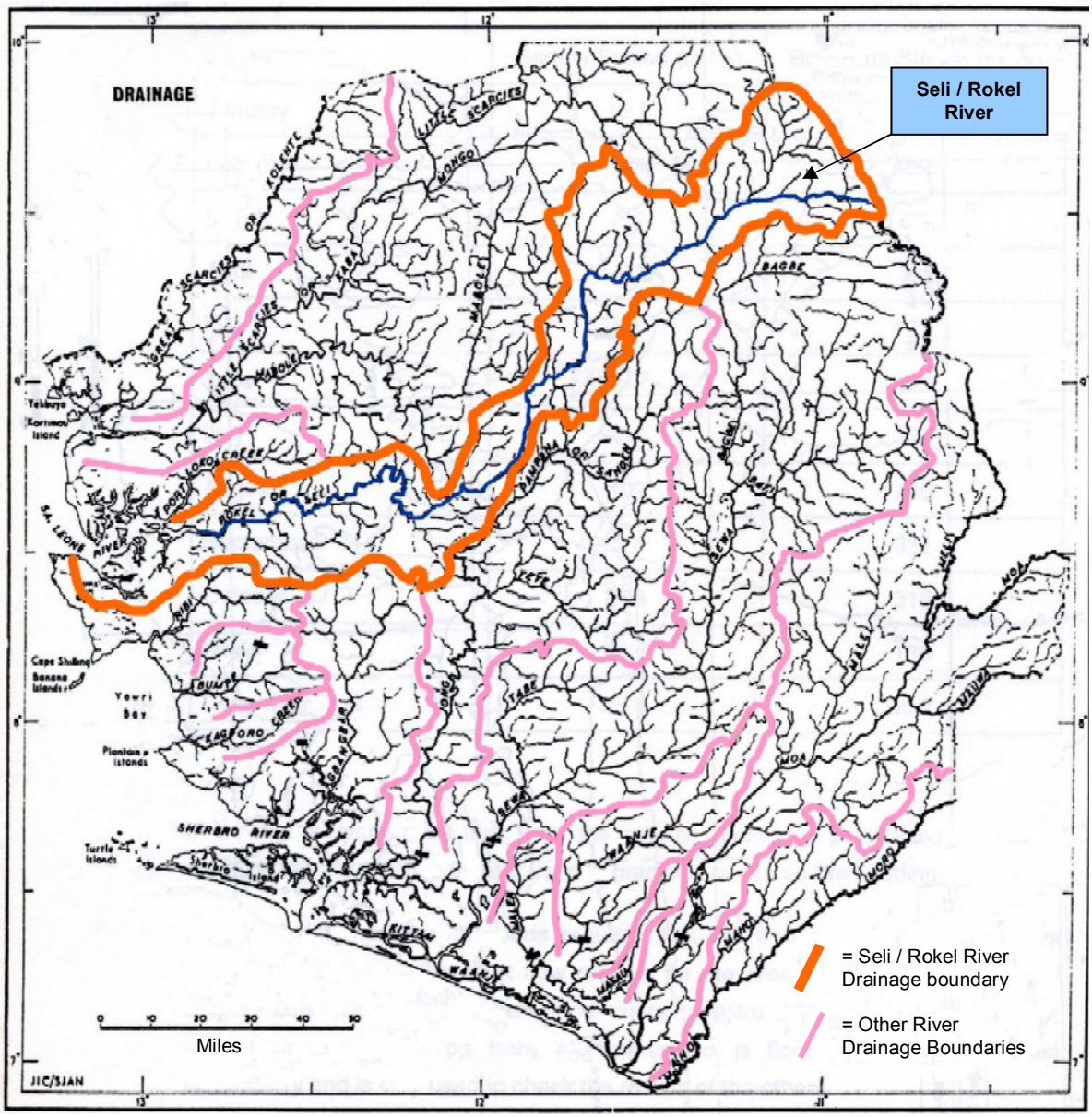


Figure 7.2.2-1: Seli/Rokel River and its Drainage Area

Adapted from: Electrowatt/Techsult (1996)

Rainfall

Appendix E.1 shows mean annual and monthly rainfall, recorded at pluviometric stations in and around the Bumbuna catchment between 1921-78. This shows an average annual rainfall for Bumbuna of 2635 mm, with a maximum of 594 mm in August and a minimum of virtually zero in February. The distribution of mean annual rainfall across

the country is shown in Figure 7.2.2-2, which indicates that rainfall increases from an average of 2000 mm per annum in the north, to 4000 mm at the coast.

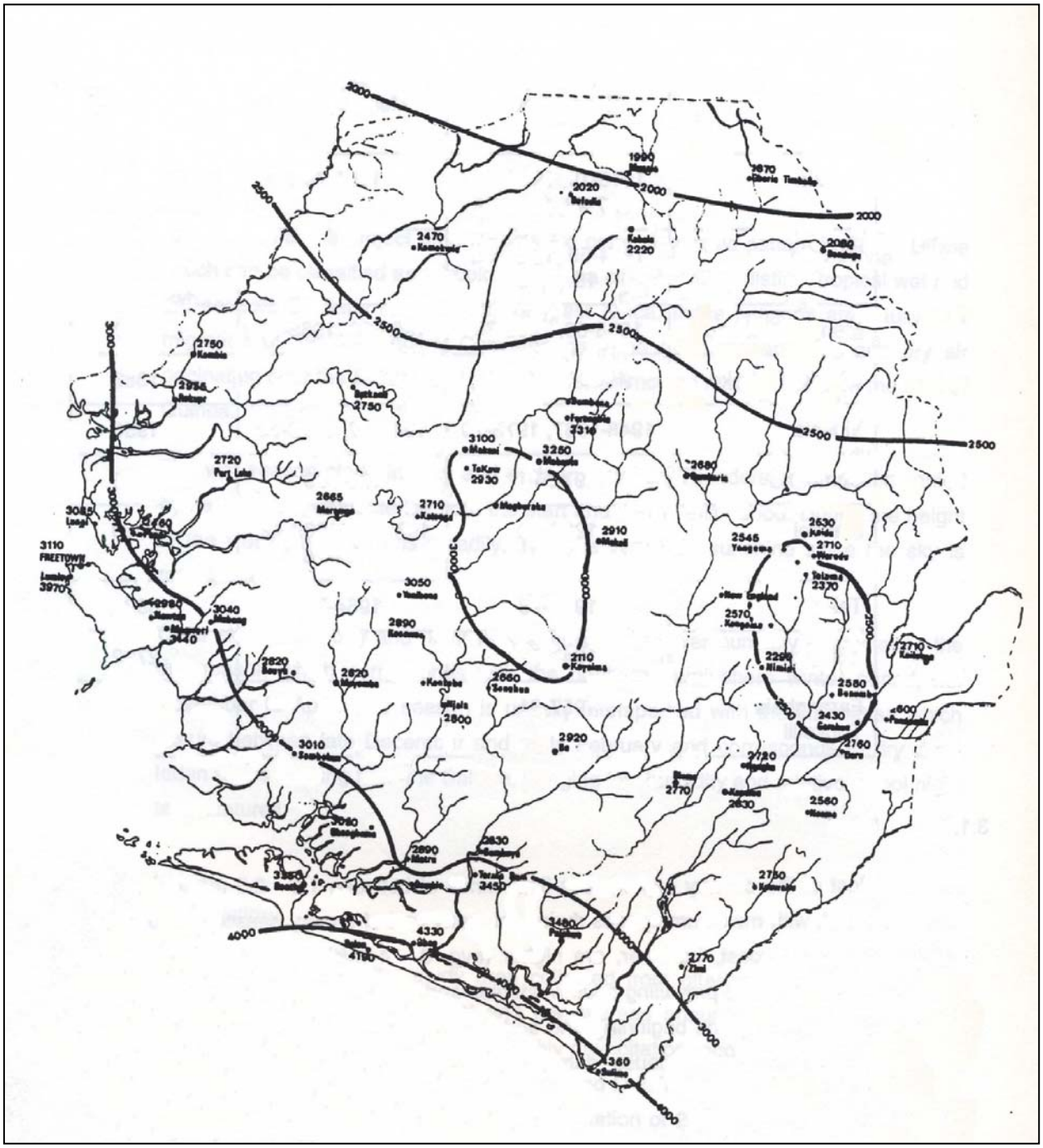


Figure 7.2.2-2: Mean Annual Rainfall Distribution (mm)

Source: Electrowatt/Techsult (1996)

Evaporation

Monthly evaporation from a US Weather Bureau class A-pan at Bumbuna (1972-79) is shown in Appendix E.2. Maximum monthly evaporation generally occurs in March

(average 174 mm), and the minimum in August (66 mm), and the annual total is estimated at 1355 mm.

Evapotranspiration averages around 1400 mm per year, with higher rates in the dry season from December to May, and lower rates from June to November, with a minor peak in October. Although rainfall far exceeds evapotranspiration, the combination of high evapotranspiration and negligible rainfall in the dry season can lead to severe soil moisture stress.

Regime of the Seli River

River flow is dictated by land runoff and baseflow from the catchment, so the flow regime of the Seli follows closely the seasonal rainfall pattern. Table 7.2.2-1 shows data from gauging stations at Bumbuna and upstream at Badela in 1970-79 (see Appendix E.3), which shows a maximum average monthly flow at Bumbuna of 331 m^3/s in September and a minimum of 6.1 m^3/s in March. Peak flows (Appendix E.4) are greatest between July and October (600 to 1200 m^3/s). The mean annual discharge of 113 m^3/s is equivalent to around 890 mm of annual rainfall[9]. Since the estimated mean annual precipitation is 2,300 mm over the catchment, the mean runoff factor is 0.39. Flows at Badela are lower, because the catchment is smaller (2,525 km^2, compared to 3,990 km^2 at Bumbuna).

Table 7.2.2-1: Monthly Average Runoff at Bumbuna and Badela Gauging Stations (1970 - 1979)

Month	Badela Station (m^3/s)	Bumbuna Station (m^3/s)
January	12.1	27.9
February	6.3	13.6
March	2.9	6.1
April	4.0	7.0
May	8.1	19.1
June	50.7	80.8
July	68.7	137
August	109	230
September	175	331
October	168	315
November	59.6	130
December	25.9	55.7
Annual Average	57.5	112.8

Source: Bumbuna Hydro-Consultants (1980)

[9] Calculated by dividing the total volume discharged in a year by the area of the catchment

Design Floods

The frequency of flooding in the downstream area with and without the dam was assessed in the Feasibility Study (Bumbuna Hydro-Consultants 1980). Appendix E.5 shows the unit hydrograph, representing runoff at Bumbuna after 25.4 mm (1 inch) of rainfall within 6 hours over the whole watershed. The estimated peak discharge is 530 m^3/s, reached after 26 hours.

The Bumbuna dam is rock filled, and exceeding the spill capacity could result in failure, which could have catastrophic effects downstream. The dam and spilling structures should therefore be designed to allow the upper limit of flood flows (generally referred to as the Probable Maximum Flood, PMF) to pass downstream. The Feasibility Study determined the PMF through infiltration measurements and analysis of precipitation records south of the catchment. The derived PMF hydrograph shows a peak flow of 2970 m^3/s and a base flow of 750 m^3/s (Appendix E.5), and was used as the basis for design of the structures.

7.2.3 Geology and Mineral Resources

Geology

Figure 7.2.3-1 is a geological map of the study area, and Table 7.2.3-1 summarises the geo-stratigraphic succession of the main formations. This shows that Bumbuna lies on the western edge of a Precambrian curvilinear greenstone belt, which is surrounded by basement granitoids and late kinematic granites, and rises to form the Sula Mountains to the north-east. Residues of weathered granite (laterites) overlie most of the Precambrian rocks and were developed during various orogenic movements (uplifting and warping) of the West African Craton Age since the Paleozoicum.

The basement granitoids and the Sula Group supracrustals have been affected by two major thermotectonic episodes. Around 2900 million years ago a Leonean deformation left an east-west foliation trend with metamorphism, but today only a few remnants outcrop in the Loko Hills near Kamakwi. In contrast most of the rocks bear imprints of the later Liberian thermotectonic episode (~ 2700 million years ago), which left a north/south and north-east/south-western orientated fabric.

Faults along the Seli River to the west of the schist belt transgress the margins into the surrounding granites (Figure 7.2.3-1) and probably resolved stresses built up from the deformation of the schist. Faults with north-south trends are probably from a later stage of this Precambrian period of deformation. At the dam site the right bank of the river consists of granite and granodiorite, whereas the left bank is mainly amphibolites.

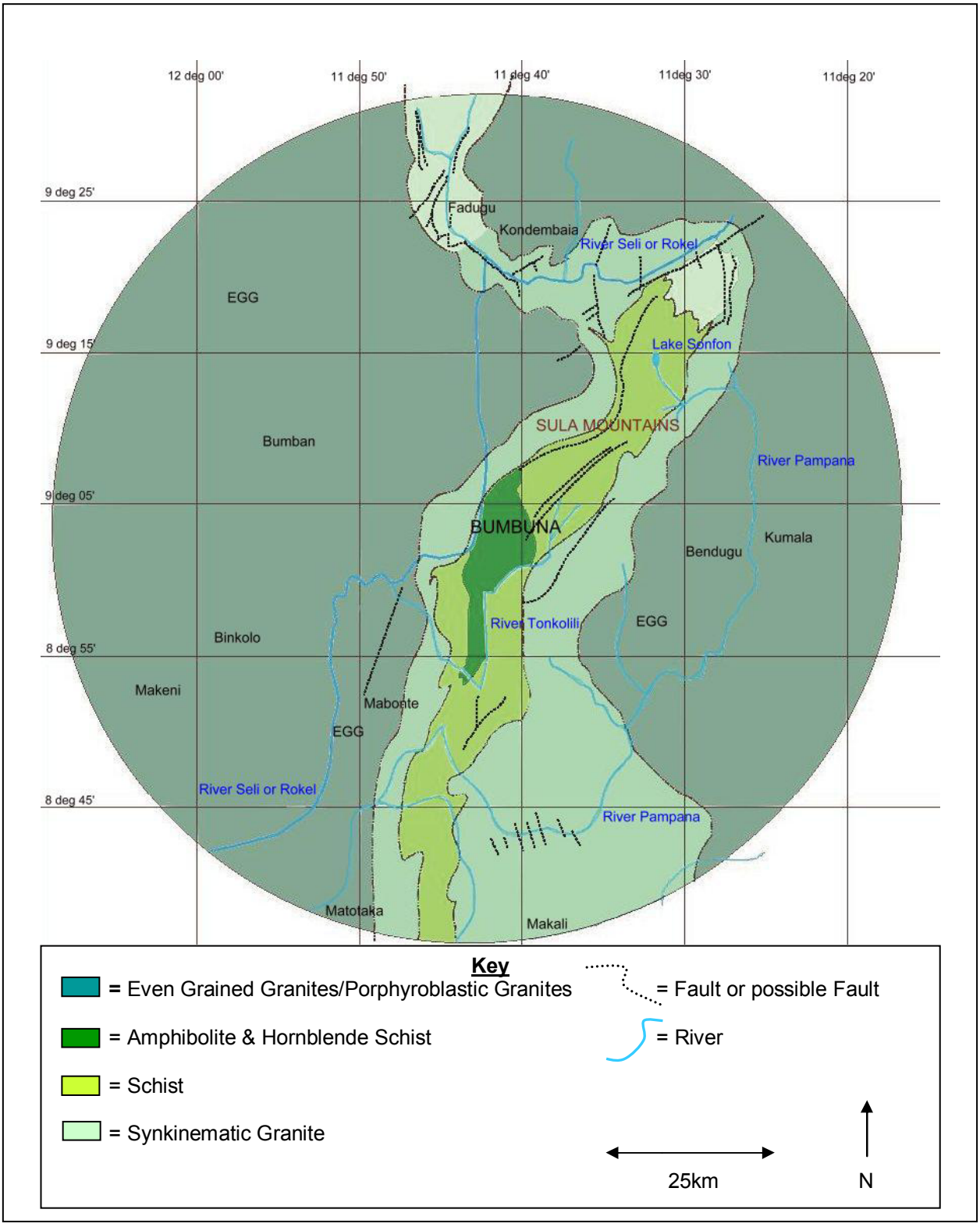


Figure 7.2.3-1: Geological Map of the Study Area

Adapted from: Electrowatt/Techsult (1996)

Table 7.2.3-1: Stratigraphy in the Bumbuna Area and its Immediate Surroundings

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	ca 2700x10^6
			Sonfon	Amphibolites, ultramafics	
	-	-	Synkinematic granite	Quartz diorite, Granodiorite, Migmatitic Gneisses	>2700 (x10^6)

Source: Electrowatt/Techsult (1996)

Contact between these formations occurs via a fault with an almost north-south trend, following the course of the river, west of the Sula Group.

Loose, unconsolidated surface material in the area consists generally of up to 10-15 m thick *in situ* weathered rock sequences or alluvial deposits. The lateritic (clay) profile is not well developed, because of the steep inclination of the mountainous slopes. It is found mainly in the flatter areas such as Kamange, Kamato and Kasukra, where a fragmented gravely and ferruginous hardpan occurs. Alluvial deposits are virtually absent from the hillsides, but are abundant in the Bumbuna valley and downstream. Where the river becomes more braided, alluvial islands and banks of gravel and sand occur. Erosion is the dominant geological process, and the river itself has cut several metres into the alluvial deposits in the Bumbuna valley.

Mineral Resources

Several minerals occur in the project area, including gold, nickel, iron ore, molybdenite, asbestos and talc (Table 7.2.3-2), located approximately as shown in Figure 7.2.3-2.

Gold occurs in the upper catchment and for around 10 km downstream of the dam, and approximately 10,000 kg were mined between 1930 and 1956, mainly from alluvial workings in and around the greenstone belt in the Sula Mountains and Kangari Hills. Alluvial mining is still carried out by small groups panning river gravels, although commercial interest has shifted to primary sources, found by tracing alluvial deposits

back to their origin. Gold-quartz veins occur in the amphibolites and ferruginous schists, and some have been explored by drilling, notably at Baomahun in the southern Kangari Hills, where favourable grades in the range of about 10-30 ppm have been found. In the reservoir area only small quantities of alluvial gold are presently mined as a supplementary source of income, and quantities found are generally small.

Table 7.2.3-2: 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

Source: Garrett and Nichol (1967), Wright *et al* (1985), Electrowatt/Techsult (1996)

Iron ore occurs in banded iron formation in the Kangari Hills - Sula Mountain greenstone belt near Tonkolili. Reserves are estimated to be around 100 million tonnes, at grades of over 55% Fe. Despite extensive investigation between 1930 and 1960 these deposits have not been exploited, mainly because of the distance from port facilities and the lack of suitable infrastructure.

Molybdenite is found in late kinematic granites around Dalakuru, and in the northern Sula Mountains where there is an extensive zone with levels in the range of 1.5-3 ppm. Two linear zones with values in excess of 3 ppm extend away from Dalakuru, with peak concentrations reaching 30 ppm. Molybdenum also occurs in river sediments, at around 1.5 ppm.

Nickel, asbestos and talc are associated with ultramafic rocks, but no worthwhile deposits have yet been found. The asbestos minerals chrysotile and anthophyllite are widespread among the serpentinites of the greenstone belts, where they are sometimes accompanied by talc, so these deposits may be of economic interest in the future. There is also the potential for uranium, which occurs elsewhere in the vicinity of granites, especially where they intersect greenstone belts.Low-value resources should also be exploitable, particularly crushed rock for aggregate and fill, from fresh homogeneous

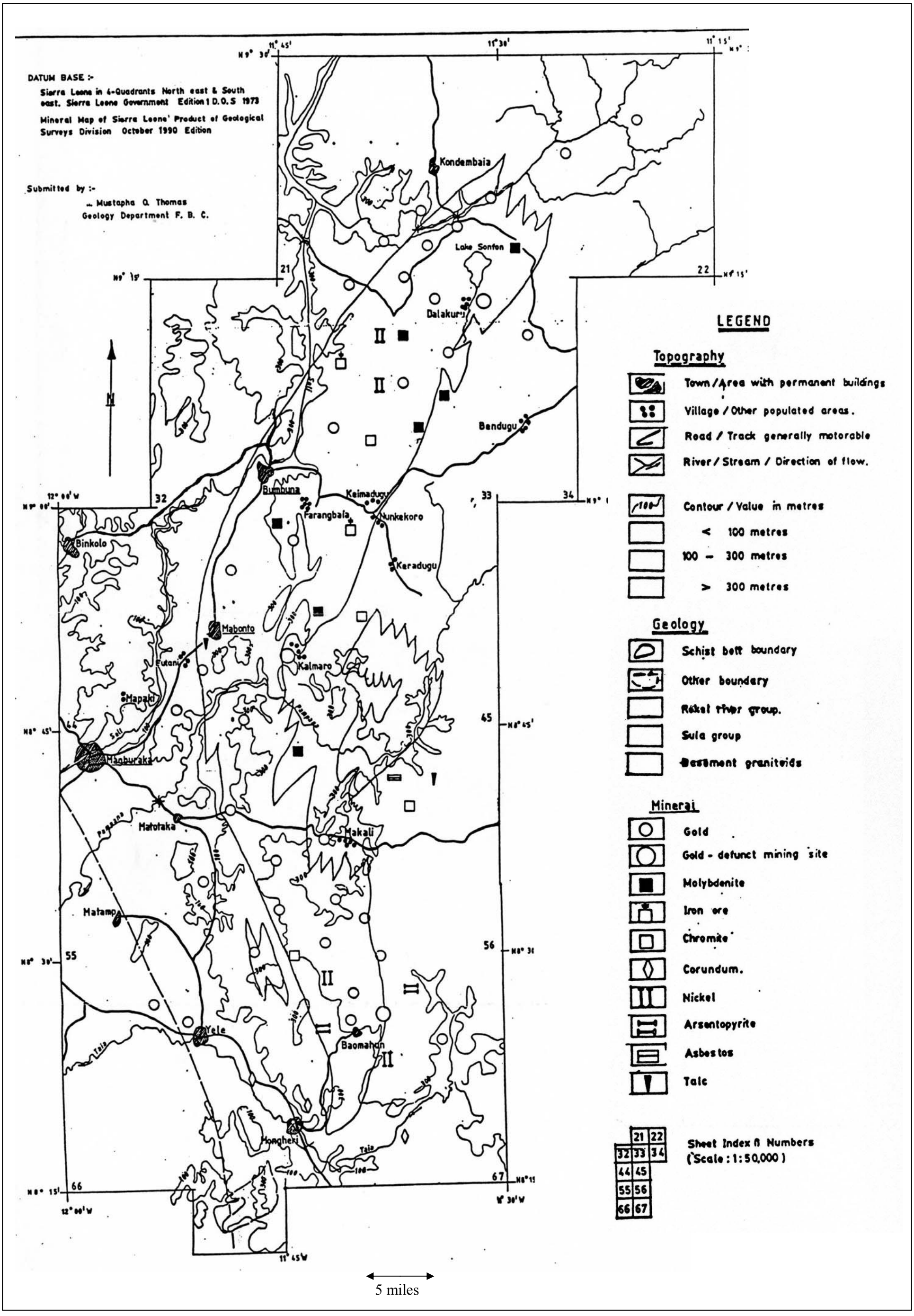


Figure 7.2.3-2: Distribution of Economic Mineral Deposits in the Project Area

Source: Electrowatt/Techsult 1996

granites as used in construction of Bumbuna Dam. Pure grades of quartzite and pegmatite-feldspar could also be found and exploited for glass and ceramic manufacture.

7.2.4 Seismicity

Regional Seismicity

A geological and seismotectonic study of the Dam site was carried out as part of the Feasibility Study to assess seismic risk and determine the earthquake and seismic parameters to be used in the design (Bumbuna Hydro-Consultants 1980). Seismic activity mainly occurs at the boundaries between the earth's crustal plates, which are generally located along continental margins, ridges in the seafloor and rift valley systems. Sierra Leone is far from such areas and is in one of the least seismically active zones in Africa. Only five seismic events were reported in the region between 1947 and 1978, none of which were recorded by the nearest seismological station in Senegal. It is unlikely therefore that their intensity exceeded IV-V on the Modified Mercalli scale.

Locally, the crystalline rocks of the West African Craton that underlie the dam site have been geologically stable since the Pre-Cambrian Age, and the Dam Review Panel concluded that faults in the basement complex do not represent planes of weakness that could be reactivated due to seismic forces (Dam Review Panel 2004). There is no evidence of movement of faults in the craton since the Cretaceous Period some 65 million years ago.

Reservoir Induced Seismicity

The Feasibility Study considered historical records of seismicity created by the weight of water impounded in reservoirs on Pre-Cambrian cratons worldwide (Bumbuna Hydro-Consultants 1980). This concluded that there was some potential for the reservoir to induce such events, and that the dam should thus be designed to withstand an earthquake with a magnitude of 4.5 on the Richter scale, with a hypocentre 5 km from the site.

7.2.5 Soil, Land Use and Agriculture

Soil, Land Use and Agriculture in the immediate catchment were evaluated in 1996 and 2004 on the basis of a variety of studies and surveys, described in full in Appendix H.

Soil

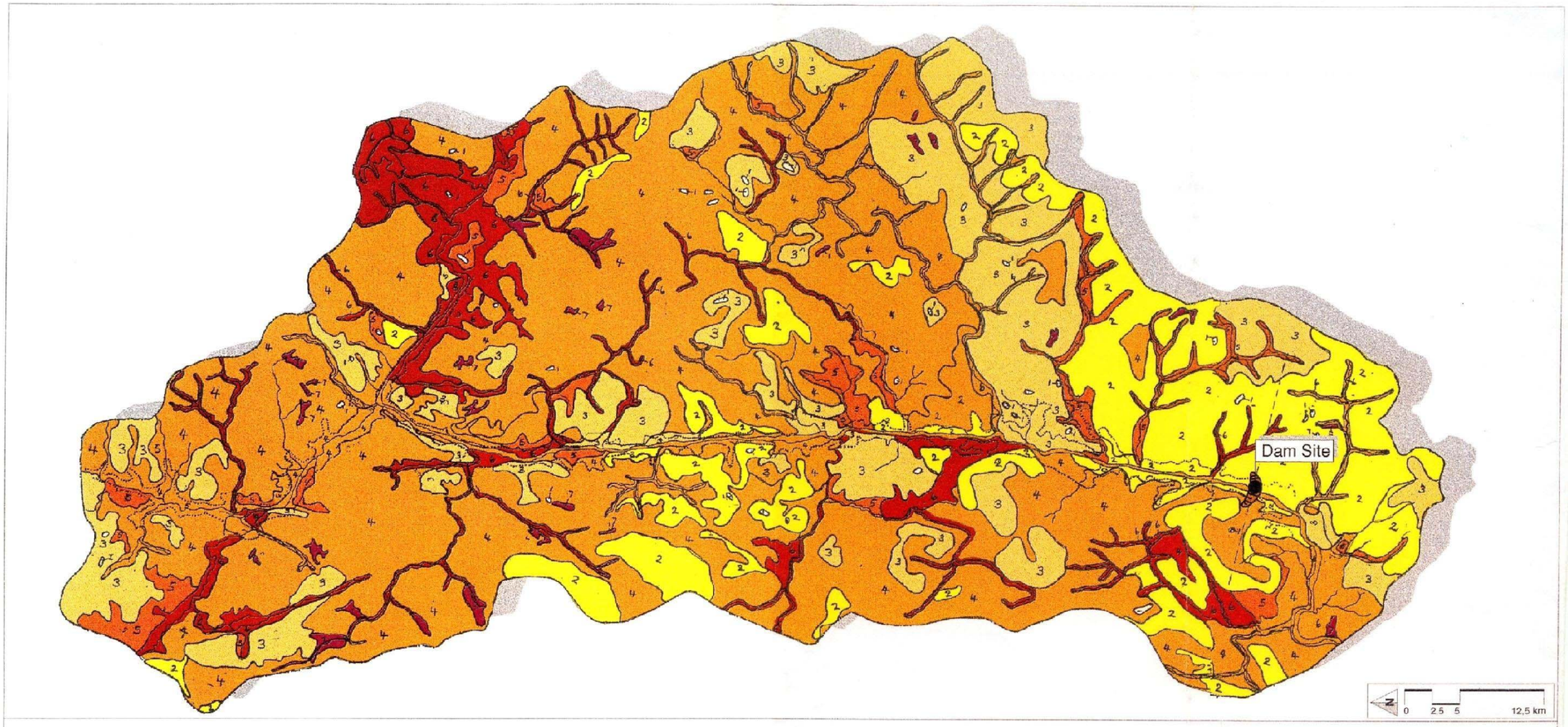
Figure 7.2.5-1 shows the distribution of the main soil types. This shows that the soils are acidic to strongly acidic (pH 4.5-5.5), with high levels of organic matter from decaying vegetation in the upper horizons, and the practice of farmers of leaving land fallow for long periods (see below). However, soil fertility is generally low (< 0.2% total nitrogen

and 3-4 ppm available phosphorus) mainly because of the heavy rainfall, hilly terrain and deforestation of hillslopes (see Figure 7.2.5-2), which results in leaching of soluble components and erosion of soil from upland areas.

Land Use

Land cover is dominated by vegetation, comprising a forest savannah mosaic with a mixture of zones produced by variations in rainfall, altitude, hydrology, topography and land use. Figure 7.2.5-3 shows that most of the area has been cleared by slash and burn for agriculture in the past, and the vegetation is now in various stages of re-growth. Mixed tree savannah (sm) dominates the area upstream of the dam, stretching beyond Fadugu in the north and Karnia in the east, and at the dam site and immediately upstream and downstream the cover is mainly forest thicket and regrowth (r). Surprisingly little of the land (3 %, 22 km^2) is under active cultivation, and the fallow areas are left uncultivated for up to 15 years. Where mixed tree savannah has been severely degraded, grasses have replaced trees, and there are isolated small patches of secondary forest alongside the river and on the slopes and crests of the surrounding hills.

Table 7.2.5-1 shows changes in land use near the dam site between 1975 and 1987. This indicates that there has been a gradual increase in the area of forest regrowth/farmland and a corresponding decrease in mixed tree savannah, largely from an increase in land cleared and then left fallow, rather than an increase in cultivation. There has also been an increase in the transformation of swamp thicket into swamp grassland, as swamps have been cleared, cultivated and then returned to fallow. These changes slowed during the civil war when many people left the countryside and moved into urban areas and there was a significant reduction in farming. This has gradually resumed in recent years with emergency support from the international community, and although farmers will initially clear fallow areas, destruction of mixed tree savannah may increase in the future.



Legend:

- Landform Boundary
- Catchment Boundary
- River / Stream
- Maximum Flood Level of Reservoir
- Dam Site

Mapping Unit Number	Description	Slope Class	Soil Description	Soil Classification	Present Cultivation
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	Unsuitable for agriculture
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	Rice, groundnuts and cassava
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	Rice, gorundnuts, maize and cassava
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	Used for grazing
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		Arable crops (potentially suitable for tree crops)
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	Rice, bananas, potatoes and cassava
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	Paddy rice in rainy season - tubers in dry season

Figure 7.2.5-1: Distribution of Main Soil Types in the Immediate Catchment Area

Adapted from: Electrowatt/Techsult (1996)

Figure 7.2.5-2: Deforested Slopes Upstream of the Dam Site in 1994

Source: Electrowatt/Techsult (1996)

Rice production reached 78% of pre-war levels in 2002, and was expected to return to pre-war thresholds by the end of 2003 (MAFFS/FAO 2003).

Agriculture

Farming is dominated by shifting agriculture where vegetation is cleared by slash and burn to establish rainfed or swamp-based fields, which are used for one or two years, after which the land is left fallow and the farmer moves on to clear another area (of regrowth/fallow vegetation, mixed tree savannah or swamp).

The main crop is rice: both swamp and upland. Yields are reported as a function of the quantity of seed planted, and one bushel (35.24 litres) of seed produces 35-100 bushels of swamp rice, but only 20-30 bushels of upland rice, depending on seed variety and quality, land suitability and preparation, and rainfall. Other crops include groundnut (grown after rice), maize (intercropped with upland rice), millet (in the north of the immediate catchment), cassava and pepper. Garden farms produce a variety of vegetables (beans, etc). Palm is the main economic tree, producing palm oil and palm wine, and others include citrus (orange, lime, grapefruit), mango and localised coffee (eg at Kasasi).

In the immediate catchment, surplus produce is sold in key market towns and villages, including Bumbuna, Fadugu, Badala, Kabala and Kondembaia. Farmers transport their

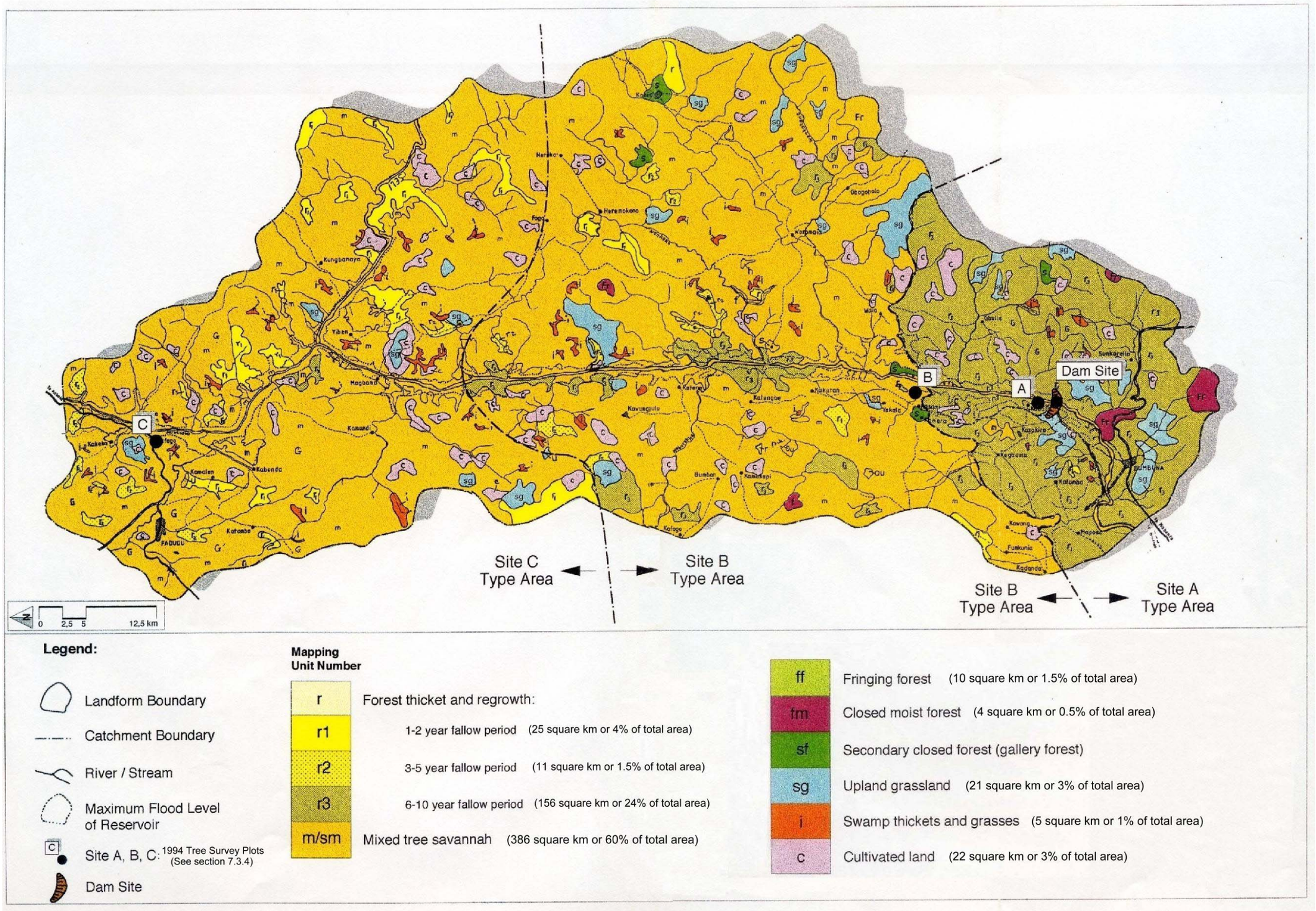


Figure 7.2.5-3: Vegetation and Land Use in the Immediate Catchment Area

Adapted from: Electrowatt/Techsult (1996)

Table 7.2.5-1: Changes in Land Use in the Immediate 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 savannah	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**	

Source: Towler *et al* (1988).

produce and either sell it themselves or through traders, and traders also buy produce at Bumbuna and Fadugu to sell in Makeni and Freetown.

The civil war resulted in the collapse of the agriculture sector. National seed bank centres were looted and household seed stock consumed, and livestock was largely decimated and Fula herders moved north into Guinea. Post-war efforts aim to contribute towards relaunching the economy, as defined in the Sierra Leone Poverty Reduction Strategy Paper (SL-PRSP) (GOSL 2004). 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, and Table 7.2.5-2 shows how cultivated areas and yields have increased since the end of the civil war.

Table 7.2.5-2 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: Technical Committee of the National Recovery Committee (October 2003)

Small-scale farming still faces problems of low and unreliable yields, small and uneconomic farm sizes, lack of fertilizers and other chemicals, and lack of mechanisation and reliance on intensive manual labour. As a result, agriculture alone generally does not provide sufficient income to support a rural family, and this is supplemented by at least one member generating income from other activities (such as gold mining, fishing, production of palm wine and palm oil, etc), or from funds remitted by relatives working in urban areas.

Problems related to Land and Agriculture

There are many other problems in agriculture sector, both in the study area and in the country as a whole. These include:

- **Rural urban migration:** Large numbers of young men and women have moved into towns and mining areas in search of employment and better living conditions, particularly during the civil war. Farms are thus under-resourced and may not be worked by future generations;
- **Pests and diseases** can severely limit production. For example birds and rodents damage rice; squirrels, primates and ants cause incidental damage to groundnuts, cassava, yams and potatoes; and foot and mouth, rinderpest and other diseases can have devastating effects on livestock;
- **Poor health and malnutrition** are features of rural and urban areas, with children in particular suffering protein deficiencies from insufficient meat in the diet;
- **Cultivation of rice instead of other crops**, as favoured by farmers and Government/NGO programmes, is labour intensive (particularly in uplands) and farmers and the sector as a whole would benefit from more diversification into higher yield crops (chilli, cocoyam, potatoes) which require less labour;
- **Lack of storage facilities** and pressure for fees at the beginning of the school year, mean that farmers usually sell their produce at harvest time when prices are low, rather than benefiting from higher prices when the supply is limited;
- **Land tenure:** Land is owned by families and distributed at village level to community members by the owners or chiefs/elders. Farmers are more likely to be tenants than landowners, which does not encourage them to invest in the land;
- **Land degradation:** Land and vegetation of the Seli River catchment is classed as severely degraded in the ESCG report of 1988, because of slash and burn cultivation, farming on hill slopes, and overgrazing and bushfires in the north. Soil is low in fertility and this is exacerbated by recurrent rainfed agriculture. Soil

erodes from recently cleared farms on steep slopes (Figure 7.2.5-4), but may be retained at lower levels if there is forest regrowth and riparian forest;

- **Livestock grazing:** Before the civil war there was conflict between pastoral Fula herdsmen and farmers in the north of the catchment (around Fadugu, Kafogo and Kania) because of damage to crops by livestock and expansion of rainfed agriculture into grazing lands. This is not a current issue as livestock have not returned to pre-war levels, but it could recur in the future;
- **Agroforestry and soil erosion control:** post-war agricultural programmes are focused on re-establishing seed stocks and crop yields of the main staple foods, and provide little guidance on effective upland farming. Farmers continue to cultivate steep slopes without any attempt to control soil erosion by biological means (planted bunds, alley cropping) or physical measures (contour tilling, bunds).

Land Management and Planning

Many of the above problems could be solved by effective land management and planning, via an integrated multi-sectoral and decentralised approach. The framework for such a system is provided by legislation, including:

- Clause 7 of the Forestry Act, 1988, which states that (the Forest Department shall) "Prepare and revise a plan for the management of 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 that "No land between high and low water marks nor any lands above the high water mark at the bank of both sides of waterways (rivers and large streams) extending a distance of 100 feet 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 that "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". The Department is also required to "formulate or promote the formulation of, and monitor the implementation of policies, programmes and projects, standards and regulations relating to environmental projection and management".

Figure 7.2.5-4: Steep Slope Upland Rice Farming with Evidence of Soil Erosion (east of dam site 11.9.04)

However the central level sectoral institutions have insufficient staff and financial resources to undertake work at Provincial, Council and Chiefdom levels, and the only active management of the Bumbuna catchment is through *ad hoc* byelaws issued by Paramount Chiefs. For example 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. The Kalansogoia (Bumbuna) Paramount Chief has banned the burning of grasslands because it is promoting the spread of weeds (e.g. elephant grass) at the expense of possible agriculture.

7.2.6 Water Supply

A survey of water supply in settlements in and around the immediate catchment in 1995 showed that untreated water from streams, collected by bucket or delivered by pipes (gravity-fed or occasionally via small pumps), is the main source of water for domestic use. Groundwater is also exploited to a limited extent, using hand-dug wells with hand pumps or buckets (Electrowatt/Techsult 1996).

Most villages on the west bank (Kamena, Yakala, Kakutan, Kawungulu, Katene) are more than a kilometre from the river, so perennial springs and surface streams are the main source of drinking and irrigation water for the mainly farming population. Further upstream (Kafogo, Fula, Kakeko, Diankafogo) water is collected by hand from the

Mawoloko River, and in Fadugu there is a gravity-fed system bringing stream water to standpipes in the town. In Bumbuna around 85% of the population are supplied by standpipes or house connections, with the source being the nearby Mado stream, in which a small concrete embankment has been built to impound water. The Seli is also used for laundry and bathing, as well as for drinking and domestic purposes, mainly by people living in the vicinity.

Water is collected mainly by women and children, and is normally free of charge, with no restriction on the amount used. The ability to collect seems to be a constraint on use, with per capita daily use being less in larger households.

7.2.7 Groundwater

Groundwater resources in the catchment have not been fully exploited, because of a lack of government initiatives, and because surface supplies provide about 80% of total domestic requirements. There are no major groundwater development schemes, and as indicated above, groundwater exploitation is restricted to townships such as Fadugu and Bumbuna, where shallow hand-dug wells tap into the unconfined aquifer to supplement the more important surface supplies.

The phreatic aquifers are formed by weathered granitic and amphibolitic layers, over the fractured bedrock. The weathered layer is relatively permeable and extends to 10 m or more in flat low-lying areas such as Bumbuna and Fadugu, but can be less than a metre on hillslopes. Groundwater levels depend on effective infiltration (water that reaches the aquifer after soil moisture deficit has been satisfied), and thus vary seasonally with changes in the length and intensity of rainfall. The water table rises in June to October and falls in the dry season, with wells in Bumbuna falling by around 5 m in March

The crystalline bedrock of the Sula Mountains forms the basement of the area, and fracturing in the upper strata reduces to zero within 30-40 m of the surface, so the bedrock can be considered as impermeable with no deep groundwater flow. The gradient slopes steeply towards the river on both banks, so that rainfall, after saturating the upper weathered cover, runs-off as surface and shallow sub-surface flow.

7.2.8 Water Quality

Water quality in the Seli River was determined from data collected by several studies. These were the Feasibility Study in 1980 (Bumbuna Hydro-Consultants 1980), the WHO Oncho Control Programme (Tholley 1992, 1993, 1994), and analyses of water samples taken at five stations upstream of Bumbuna Falls in 1994 (Electrowatt/Techsult 1996) and four stations downstream in 2004 (this study), located as shown in Figure 7.2.8-1. Results of the analyses are given in Table 7.2.8-1.

The data indicate that water quality in the Seli is typical of tropical rivers, and that the main influences are the wide seasonal variations in rainfall and flow, and land use (particularly farming practices) in the catchment.

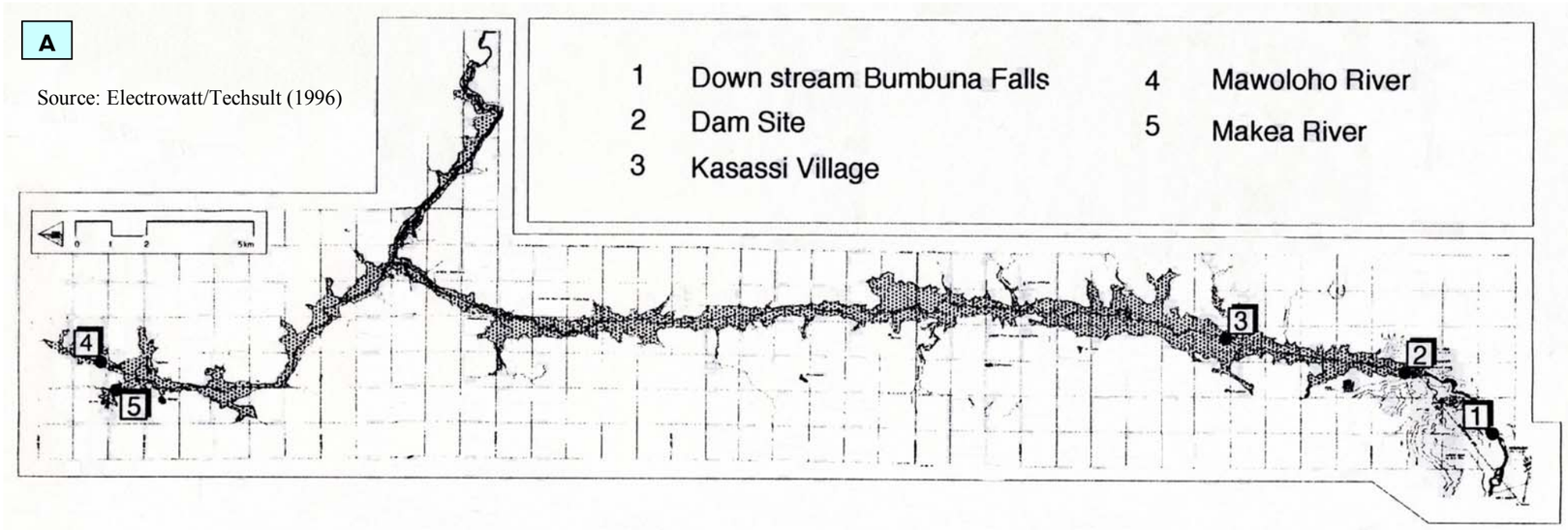
The main characteristics are:

- Low concentrations of dissolved salts (electrical conductivity, calcium, magnesium, bicarbonate, etc);
- Low concentrations of plant nutrients (nitrate, nitrite, phosphate);
- Reasonably high levels of oxygen, and low values of Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD);
- Little evidence of pollution by sewage bacteria (faecal coliforms), organic matter (Dissolved Organic Carbon: DOC), fertilizers, pesticides, etc;
- No major differences in the quality of water upstream and downstream, or over the 24 year period of the observations;

One exception is the level of suspended sediment, which averaged 3 mg/l in 1980, and over 100 mg/l in 2004.

The low concentrations of salts and plant nutrients occur despite heavy runoff in the wet season, because as explained above, land in the catchment is low in fertility, as soluble and insoluble components have been leached out by rainfall and rainfed agriculture, and erosion of soil from areas cleared to provide land for agriculture (see below).

The relatively high levels of oxygen and low levels of BOD, COD and DOC suggest that there are not significant amounts of decaying vegetation or other organic matter in the water. This is mainly because of the relatively low rural population (which decreased further during the civil war), the fact that there are few villages and towns immediately adjacent to the river so the waterway is not greatly used for the disposal of domestic waste or sewage, and because there is no major industrial development in the catchment.



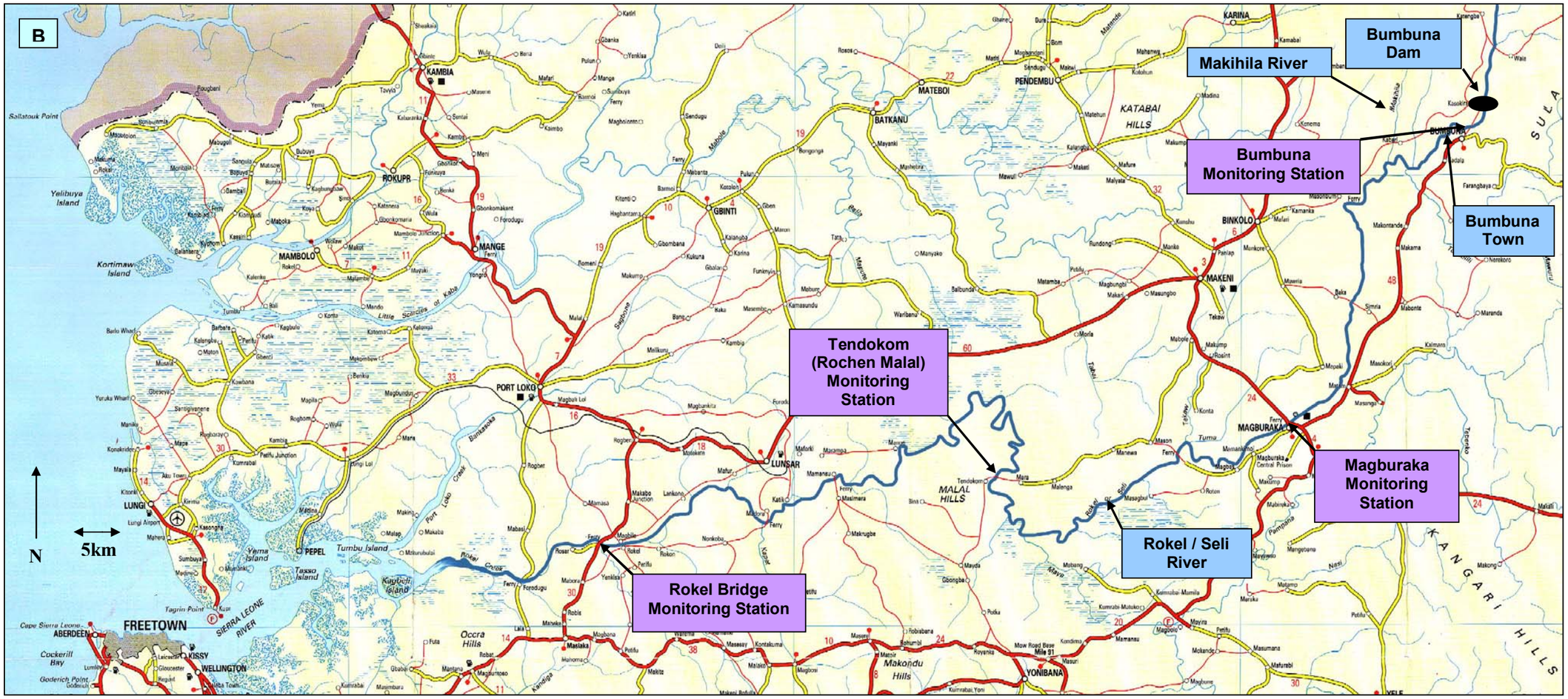


Figure 7.2.8-1: Water Quality and Aquatic Ecology Monitoring Stations, a) Upstream of Bumbuna Falls (1994) and b) Downstream of Bumbuna Falls (2004)

Table 7.2.8-1: Results of Water Quality Analyses Conducted in the Seli River

Parameter	Units	19, 20 Aug 2004 (this study)[1]				May, Oct 1994 (EIA)[2]										Feb 1980 (FS)[3]	
		Bum-buna	*Magb-uraka*	*Tend-okom*	*Rokel Bridge*	*Mawoloko*		*Makea*		*Kasassi*		*Bumbuna Dam*		*Below Bumbuna Falls*		*Bbuna Dam*	*Rokel Bridge*
						May	Oct	May	Oct	May	Oct	May	Oct	May	Oct		
Temperature	ºC					26.5	25.0	30.20	25.0	28.5	25.0	28.5	25.0	28.5	25.0	24.7	25.0
pH		7.6	7.6	7.5	7.7	7.60	7.60	7.20	7.20	7.80	7.80	7.4	7.4	8.1	8.0	6.9	6.9
Oxygen	mg/l					5.85	-	5.40	-	6.90	-	7.2	-	7.8	-	9.8	9.8
Oxygen Sat^{n}	%															121	121
DOC	mg/l															2	<1
BOD_5	mg/l					1.65	-	4.80	-	2.40	-	4.2	-	2.4	-		
COD	mg/l					4.40	2.50	5.00	6.30	4.40	4.20	4.9	3.2	4.8	3.0	9	<3
Susp Solids	mg/l	200.3	164.3	100.0	102.3											3.7	2.4
TDS	mg/l					28.70	13.90	49.85	12.83	64.30	9.90	35.75	34.05	35.1	24.1		
Conductivity	µmho/cm	14.1	28.3	23.6	23.6	50	22	90	21	110	16	60	55	60	39	26	22
Sodium	mg/l	nd	nd	nd	nd											<0.1	<0.1
Potassium	mg/l	0.15	0.20	0.16	0.15											nd	nd
Magnesium	mg/l	0.96	1.09	1.15	0.90	1.22	0.60	0.61	0.90	0.95	0.60	0.61	0.6	1.22	0.6	0.6	0.5
Calcium	mg/l	1.07	0.53	nd	0.53	4.0	3.0	3.0	4.0	5.0	3.0	3.0	3.0	4.0	3.0	3.5	3.4
Iron: diss	mg/l															<0.1	<0.1
total	mg/l	14.17	13.17	16.83	13.50	22.63	10.53	18.42	9.21		6.62	6.58	8.56	11.84	13.1	2.9	1.5
Mn: diss	mg/l															<0.1	<0.1
total	mg/l															<0.1	<0.1
Cu diss	mg/l															0.1	<0.1
Total	mg/l															<0.1	<0.1
Nitrite- N	mg/l					2.07	56.15	nd	6.92	3.68		2.07	0	3.31	3.85		
Nitrate- N	µg/l	8.80	9.09	9.09	9.68	51.33		25.67		218.6		nd	-	30.33	-	<0.1	<0.1
Ammon- N	mg/l					0.00	0.00	0.09	0.00	0.00	0.00	0.24	0.19	0	0.19	0.08	nd
Kjeldahl- N	mg/l															<0.1	<0.1
Phosphate- P	mg/l					2.21	0.04	1.71	1.40	1.21	0.00	0.93	1.0	2.36	0.12	<0.05	<0.05

Total P	mg/l														<0.01	<0.01
Chloride	mg/l	2.84	2.37	2.46	2.37	6.51	0.00	3.55	0.00	4.96	0.00	2.13	0	7.09	0	0.35	0.45
Sulphate	mg/l	0.40	0.39	0.37	0.43											nd	nd
Hardness	dH					0.00	0.20	0.00	0.20	16.03	0.15	16.03	0.25	0	0.1		
Alkalinity	MgCaC O_3/l					22.55	5.50	36.30	3.00	29.7	13.50	32.45	10.00	32.45	18.5		
Faecal Colif	PNC/100ml					0.00	-	7.00	-	90.00	-	0	-	5	-		
Carbonate	mg/l	nd	nd	nd	nd												
Bicarbonate	mg/l	0.53	0.64	0.67	0.48												
Aluminium^{3+}	mg/l	nd	nd	nd	nd												
Hydrogen^{+}	mg/l	0.80	0.87	0.83	0.70												

nd = not detected; - = not measured;

[1] This study (each figure is the average of three samples);

[2] Electrowatt/Techsult (1996);

[3] Bumbuna Hydro-Consultants (1980).

This is supported by the low concentrations of faecal coliforms in the water, and the lack of evidence of other forms of pollution. There is considerable agriculture around the middle reaches of the river (downstream of the dam), but with the exception of the recently recommenced sugar cane operation at Magbas 10 km southwest of Magburaka (Figure 7.2.8-1), most agriculture is subsistence-level and not well organised or funded. There is therefore little application of fertilisers or pesticides, so few residues are washed into the river, as indicated for example by the relatively low levels of the various forms of nitrogen and phosphorus (Table 7.2.8-1).

The high levels of suspended sediment recorded in 2004 are almost certainly produced by the slash and burn agriculture, where trees and shrubs are replaced by crops (or grasses in areas left fallow), which are shallow-rooted with little ability to retain the soil, which then washes into rivers during the rains. The apparently low levels of sediment in 1980 are probably because the samples were taken in the dry season, when the soil becomes loose and dusty, but does not enter rivers in any quantity because of the lack of rain.

Water quality is therefore relatively good in terms of oxygen levels and the lack of pollutants, and the low levels of nutrients could limit the occurrence and productivity of aquatic plants. The high levels of sediment would also limit productivity by reducing light penetration, and could also affect riverside communities that use the water for drinking and other domestic purposes.

The quality of drinking water from hand-dug wells or piped from streams was measured at four locations in the immediate catchment in 1994 (see Appendix I.1). Although the water was untreated, parameters analysed were all within WHO standards for human consumption, and levels of nitrate indicated little contamination. All sources sampled were in areas that are traditionally protected by the local community, and the only risk of contamination is from wildlife.

7.3 Biological Resources

7.3.1 Primates

A survey of the primate populations of the project area was carried out in August-September 2004, and the work and conclusions are described in full in Appendix J. Some standard techniques, such as using camtrackers to photograph and record animals remotely and cutting line transects through the forest, could not be used because of the dense vegetation, hilly topography and fragmented nature of the habitat. Work thus concentrated on reconnaissance ("recce") walks (recording sightings, vocalisation, foot- and knuckle- prints, faeces, discarded food, chimpanzee nests), and informal interviews with local people (recording knowledge and awareness of primates, locations of chimp nests and feeding sites, human/animal issues such as crop-raiding, hunting, and other

factors). Ten recce walks were conducted as shown in Figure 7.3.1-1 and 17 interviews were held with over 60 people. The results are presented in Appendix J.

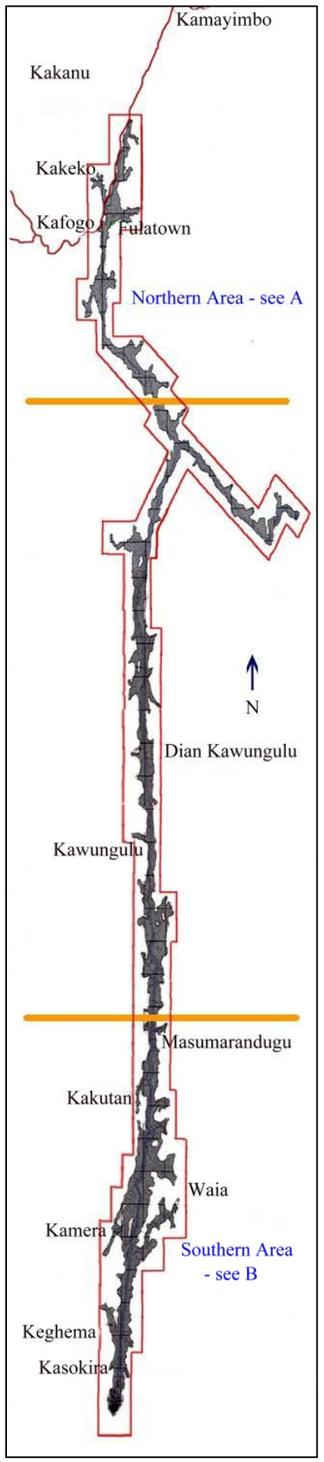
Species and Communities Present

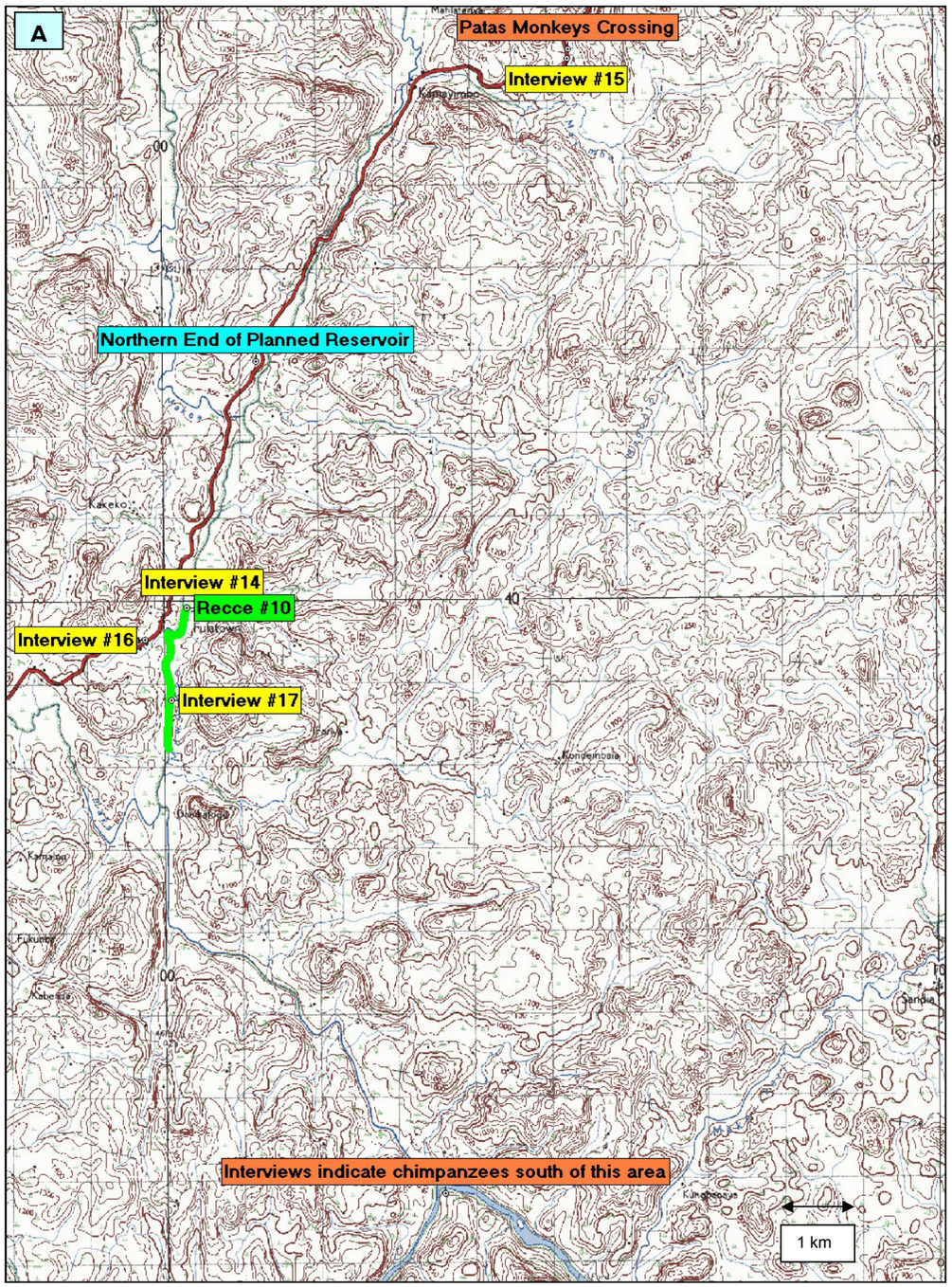
Physical evidence was found of at least three chimpanzee communities living in the south of the project area (Appendix J Tables II and III), and verbal reports suggest at least two additional communities farther north (Appendix J Table IV).

In the south, one community ("Dynamite Community") lives in the forest ridge that runs above the BHP rock quarry and dynamite store on the west bank of the river; another lives west of Kakutan; and nest evidence suggests that another lives north/northeast of Waia. There was no evidence of chimpanzees in the very north of the reservoir, although interviews suggest at least one community in the central portion south/southeast of the confluence of the Seli and Mawoloko Rivers, and a report of a chimpanzee killed at Masumarandugu suggests another community in this area (Figure 7.3.1-1).

This means that there are at least five chimpanzee communities in the study area, plus probably others on the un-surveyed land. Without an assessment of the complete area it is not possible to give an accurate figure for the total population density. Estimates of the amount of similar habitat from recent aerial photographs (Pietrangeli 2004), suggest that there could be as many as 10-15 chimpanzee communities in the project area as a whole, if the habitat is all of similar quality to that in the area surveyed.

A number of other primates were observed or heard vocalising, including species of both sub-families of Old World monkeys (Cercopithecidae): the Cercopithecinae, which store food inside their cheeks and are thus frequent crop raiders, and the Colobinae, which have a chambered stomach and feed mainly on leaves high in the trees. Ceropithecines in the area include vervets, mangabeys, patas, spot-nosed monkeys and Campbell's monkeys, and although Table 7.3.1-1 indicates that none of these are currently threatened or endangered, their status could be overestimated because of the lack of recent surveys. Of the Colobines, interviews reported the black and white Colobus monkey as being present, but none were seen, and as their skin is highly sought after for use in society ceremonies, this could indicate that the species is on the decline in the Bumbuna area. Also of concern is the apparent absence of the endangered bay colobus (red colobus *Procolobus badius badius*), which was formerly present throughout much of northern Sierra Leone, but is now greatly reduced because of hunting pressure.





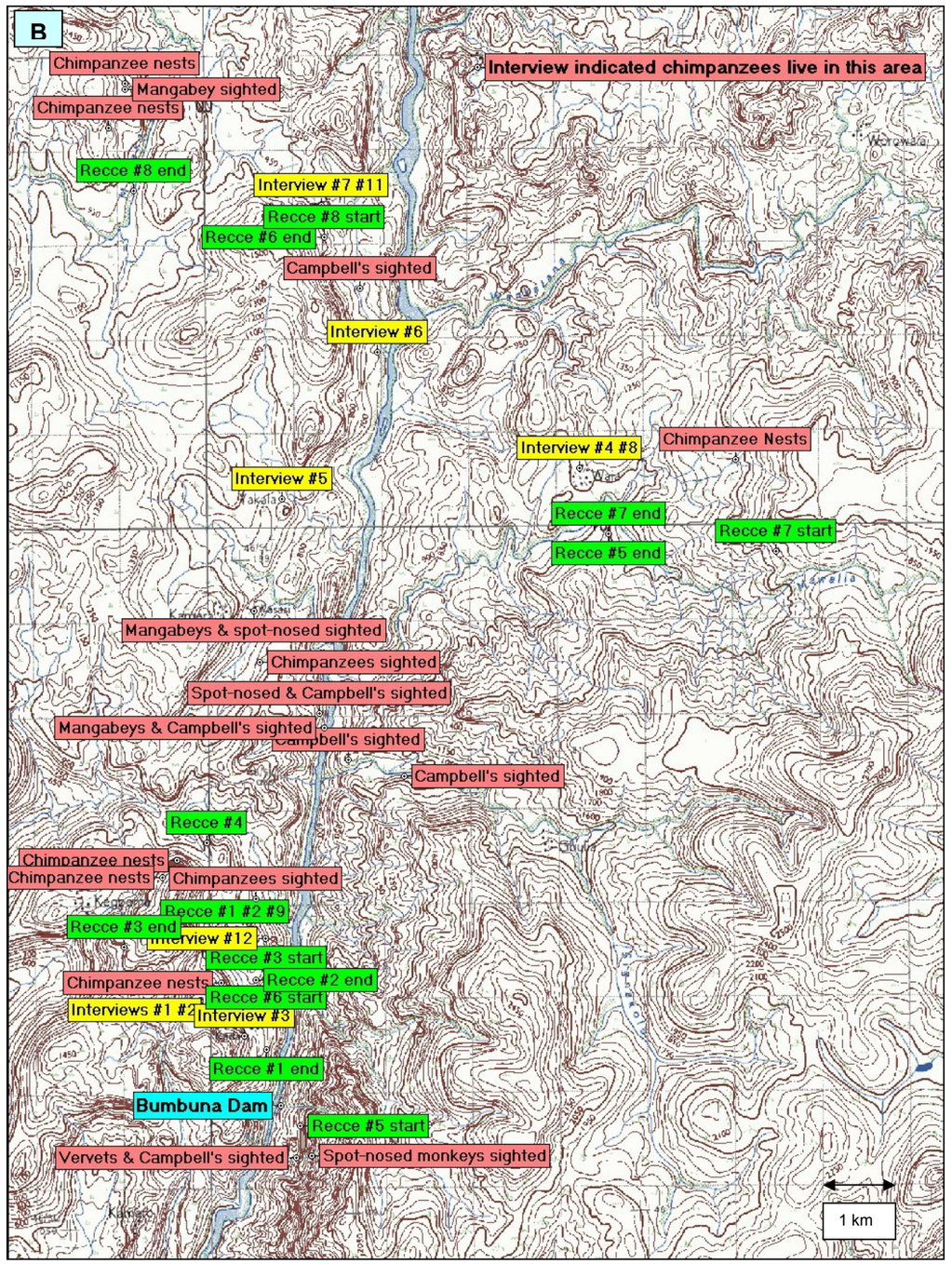


Figure 7.3.1-1: Locations of Primate Surveys and Sightings.

Table 7.3.1-1 Conservation Status of the Primates of Sierra Leone. (*Note: the lack of recent primate surveys may mean that the threat level is underestimated)

Classification and Scientific Name		Common Name	Conservation Status*	In Bumbuna Catchment?
Prosimians				
	Galago senegalensis	Senegal galago	Not threatened	?
	Galagoides demidoff	Demidoff's galago	Not threatened	Yes
	Perodicticus potto	Potto	Not threatened	?
Monkeys				
	Cercocebus atys	Sooty mangabey	Low Risk	Yes
	Cercopithecus aethiops	Vervet monkey (green monkey)	Not threatened	Yes
	Cercopithecus campbellii	Campbell's monkey	Not threatened	Yes
	Cercopithecus diana diana	Diana monkey (Diana guenon)	Endangered	No
	Cercopithecus petaurista	Spot-nosed monkey (spot-nosed guenon)	Not threatened	Yes
	Colobus polykomos	King colobus (black & white colobus)	Low Risk	Yes
	Erythrocebus patas	Patas monkey (red monkey)	Not threatened	Yes
	Papio papio (or P. hamadryas papio)	Guinea baboon (red baboon)	Low Risk	No
	Papio anubis (or P. hamadryas anubis)	Olive baboon	Not threatened	?
	Procolobus badius badius	Red colobus (bay colobus)	Endangered	No?
	Procolobus verus	Olive colobus	Low Risk	No
Apes				
	Pan troglodytes verus	Western chimpanzee	Endangered	Yes

Source: IUCN (2003)

Chimpanzee Population Density

A standard chimpanzee "census" records numbers of nests and other evidence of chimpanzee presence along line transects in a forest block identified from satellite imagery or otherwise known to be relatively intact and homogeneous, so counts can be scaled up to indicate density in the total area. Nest "decay rates" are determined in advance as these vary with habitat, location and season, and full decay can take up to 120

days. This method could not be used in this survey because the fragmented nature of the habitat means that data from selected sites is not necessarily representative of the area as a whole, and nest decay could not be determined accurately in the time available. A complete estimate of the chimpanzee population would therefore require further study, as described in Section 8.6 below. It is however possible to comment upon the potential sizes of the communities on the basis of the data obtained, as follows:

Dynamite Ridge: there were a large number of nests west-northwest of the BHP quarry and dynamite store, ranging from fresh (a total of 10) to rotten. The fresh nests would suggest that the community has at least 12 members, if all were built on the same day, all community members were travelling together, and none of the nests were "day nests". It is however rare for these features to coincide, and it is more likely that the nests were built by a sub-set of a larger community, particularly as the forest along the ridge is substantial enough to support up to 25 individuals.

Near Kakutan Village: many nests were found in the forest northwest of Kakutan, and although none were fresh, seven were "recent" (with some green leaves, probably built in the preceding two weeks). Interviews confirmed a strong presence of chimpanzees and the habitat is very suitable, so the community was probably elsewhere at the time of the recce walk.

Mear Waia Village: only two very old (rotten) nests were seen in this area, and interviews suggest a decrease in chimpanzee sightings over the years. This may mean that there are fewer chimpanzees in the southeast of the project area than should be expected.

Chimpanzees are very seasonal in their diet and ranging patterns, so data collected over a longer period would help to fully ascertain their usage of the project area as a whole. For example there are several trees in the gallery forest near the river at the dam site that bear fruit that is eaten by chimpanzees. However as the fruit does not ripen until March/April, chimpanzees were not recorded in the area during the surveys, although they would probably be there when the fruit is ripe. Human activity could also be a deterrent, as the same types of tree on surrounding hillsides were seen to contain recent nests.

7.3.2 Other Terrestrial Fauna

Biodiversity and Conservation

Sierra Leone's Biodiversity Strategic Action Plan (Government of Sierra Leone 2003) indicates that the flora and fauna of the country has been under threat for many years, mainly from habitat loss and fragmentation from changes in land use. Forest habitats such as those in the Seli catchment are part of the Upper Guinean Rainforest Belt, one of

25 "global biodiversity hotspots" (Meyers *et al* 2000). Particular problems are the reduction of critical wetland, forest, montane and aquatic habitats by agriculture and mining, and uncontrolled hunting which threatens many birds and mammals.

Currently Sierra Leone hosts 178 species of mammal, including 15 primates, of which 7 are threatened and 3 endangered, according to the IUCN "Red List" (IUCN 2003) (Western Chimpanzee, Red Colobus and Diana Monkey, see Section 7.3.1). There are also 18 antelope species, of which 16 are threatened and 9 endangered, including the zebra duiker and Jentink's duiker, which are forest dwellers. Other threatened mammals include the forest elephant, warthog, giant forest hog, red river hog, and the pygmy hippopotamus.

Nine species of globally threatened birds are found in Sierra Leone, of which eight are dependent on forest or savannah. Those that inhabit riparian forests in the north include the rufous-winged illadopsis, Sierra Leone prinia, and black-headed stream warbler. The total number of insect species is not known, but there are 800 species of butterfly and two endemic dragonflies.

To obtain further information on the terrestrial fauna and the presence of rare or endemic species in the immediate catchment, Rapid Biodiversity Surveys were conducted along transect lines and recce walks in August-September 2004 as part of the EIA Update studies (Figure 7.3.2-1). Observations were made of mammals (sightings, calls, tracks, faeces and interviews with farmers and hunters), birds (timed species counts, mist netting and *ad hoc* observations), amphibians and reptiles (*ad hoc* collections and day- and night- time habitat searches).

Mammals

Thirteen mammal species were recorded in the immediate catchment (see Appendix K.1), of which one, the Western Chimpanzee is endangered and was surveyed in detail as described in Section 7.3.1 above. Hoof-prints of the yellow-backed duiker (a vulnerable species) were found in a sacred grove at Fullah Town, outside the reservoir area. Three rodents (the rats *Praomys jacksoni* and *Malacomys* sp and the soft-furred mouse *Praomys tullbergi*) were captured in the reservoir area and downstream, and there is a population of bats (*Taphozous peli*) roosting in the reservoir draw-off tower (Figure 7.3.2-2).

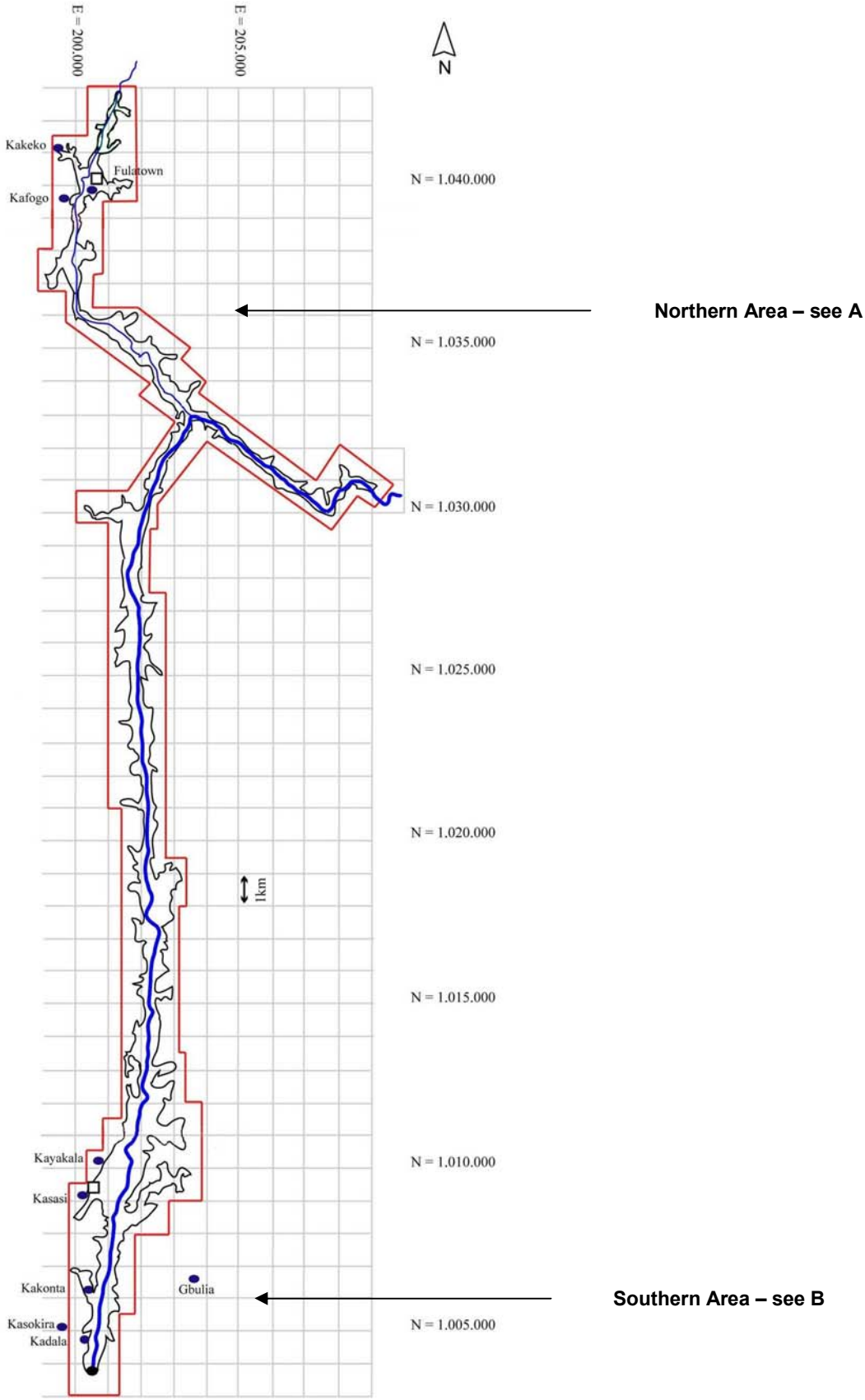


Figure 7.3.2-1: Locations of Transects and Recce Walks used for observations of terrestrial flora and fauna.

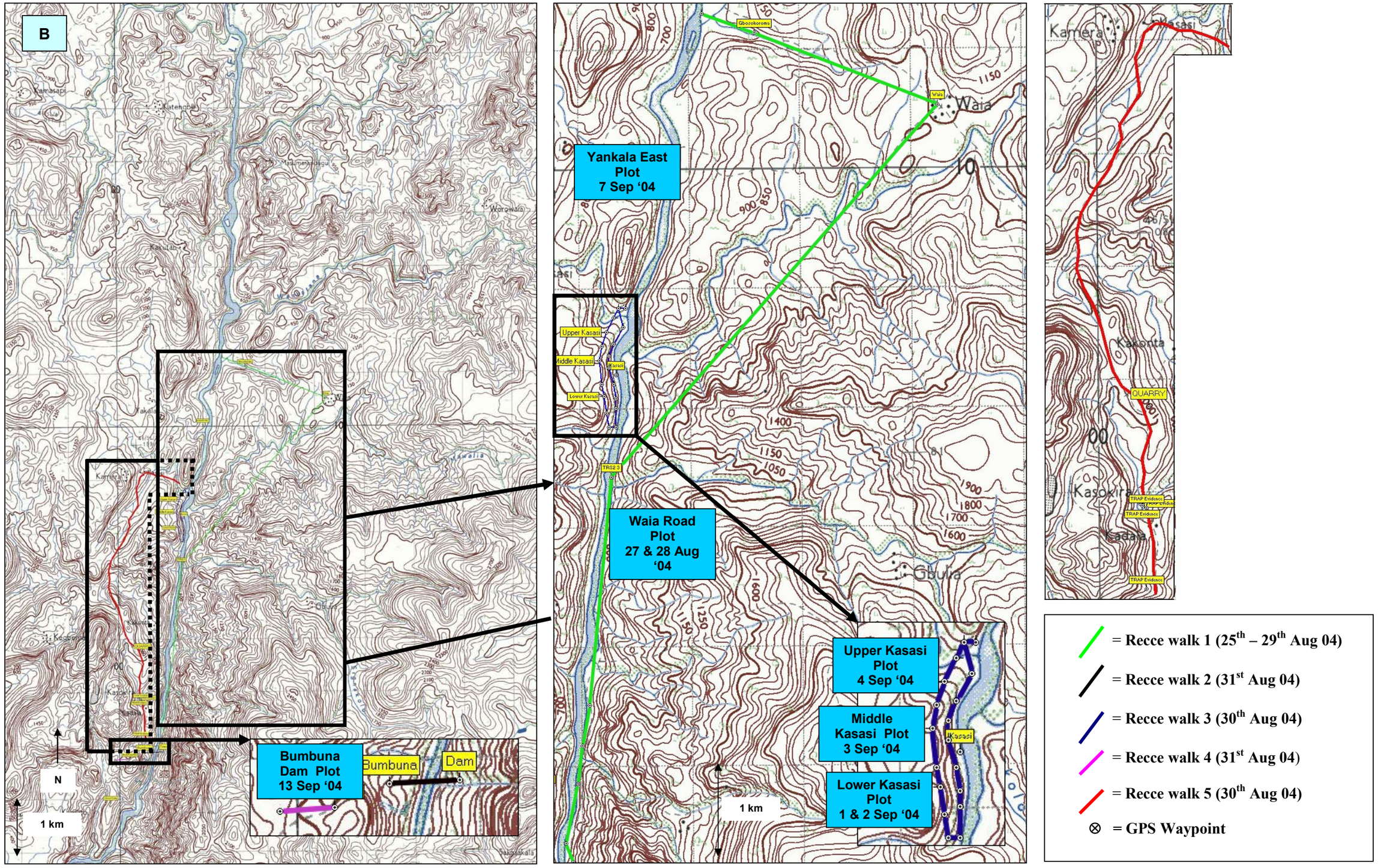


Figure 7.3.2-1 (cont.): Locations of Transects and Recce Walks used for observations of terrestrial flora and fauna.

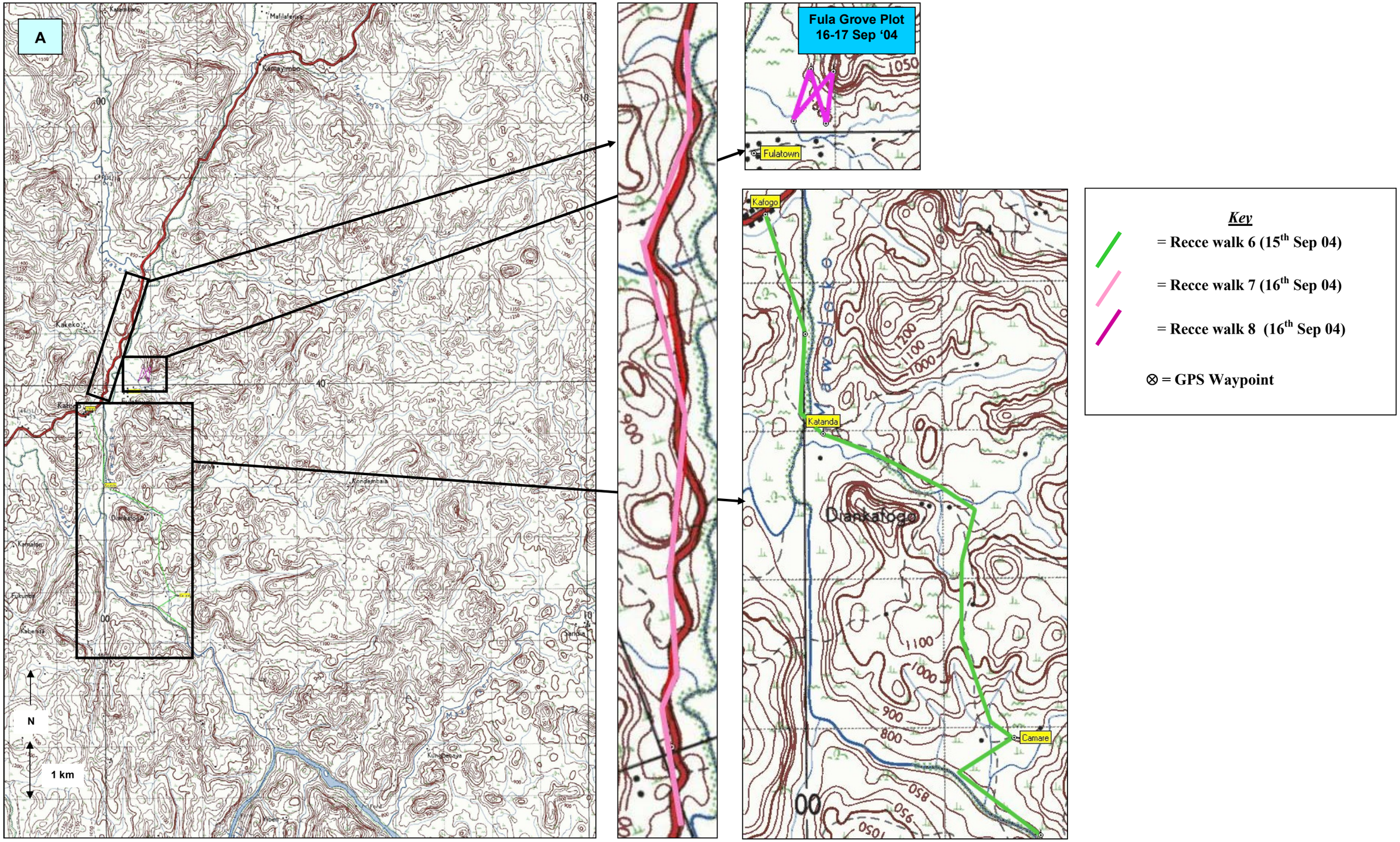


Figure 7.3.2-1 (cont.): Locations of Transects and Recce Walks used for observations of terrestrial flora and fauna

Birds

Appendix K.2 shows the birds recorded in the reservoir area in 1994, and Appendix K.3 shows those observed in the immediate catchment in 2004. A total of 39 species were recorded in 1994 and 128 in 2004, but the difference is likely to be because the recent survey involved more effort and covered a larger area. Two of the species recorded in 1994 are rare (yellow-casqued hornbill, Ussher's dusky flycatcher), and 12 of those recorded in 2004 (fork-tailed drongo, square-tailed drongo, Latham's forest francolin, Baumann's greenbul, golden greenbul, greater honeyguide, yellow-casqued hornbill, African dwarf kingfisher, African golden oriole, square-tailed saw-wing, tiny sunbird, Finsch's flycatcher). Although three globally threatened species are found in riparian forest elsewhere in northern Sierra Leone (rufous-winged illadopsis, Sierra Leone prinia, and black-headed stream warbler), these were not recorded in the study area. One of the species recorded (Baumann's greenbul) is endemic, and also occurs in the nearby Loma Mountains. Most of the other species are forest-dwellers, but also live in farm-bush or forest plantations. Most are widely distributed and fairly common in Sierra Leone.

Appendix K.3 shows the Timed Species Counts, conducted in forest, farm-bush, woodland savannah and riparian forest habitats. 66 species were recorded during these surveys, and the most common were little greenbul, black-crowned tchagr, village weaver, bronze manikin, simple leaf love, Senegal coucal and common garden bulbul.

Herpetofauna

Twelve species of amphibian were recorded, including the toad *Bufo* sp and the frogs *Hylarana albolabris*, *Hyperolius concolor* and *Afrixalus* sp (Appendix K.4 and Figure 7.3.2-3). There were also six reptiles, and combined with data from 1996 this indicates that there are 14 or more reptile species in total. The Nile monitor lizard *Varanus niloticus* was seen at the edge of the river, and other common species, such as *Mabuya carinata* and *Agama agama* were also found. No crocodiles were seen, although residents of Kakeko and Fadugu reported their occurrence in the Mawaloko River, and residents also indicated that pythons are present in the catchment.

Local Endemism

The surveys of taxa other than primates provided a rapid assessment of the fauna only, and more detailed studies conducted over a longer period would be necessary for a more complete inventory of faunal diversity (see Chapter 8 below). However, the area contains no unique features of ecology and geography, so it is unlikely that the fauna (and flora) would differ significantly from those found in similar regions of Sierra Leone. The data suggest that many species are under continuing threat of habitat loss and hunting, but there is no evidence that any are endemic to the immediate catchment or are endangered

requiring immediate protection. All animal species appear to be adapting to changing vegetation zones, although some populations are becoming locally unviable, from the reduction and fragmentation of habitats, caused mainly by the clearance of land for agriculture.

Figure 7.3.2-2: View of Upstream Face of the Dam, 'Morning Glory Spillway', intake and intake tower

7.3.3 Terrestrial Flora

The vegetation of the immediate catchment (between Bumbuna and Waia in the east and Kasasi in the west), plus representative parts of the wider catchment (woodland savannah at Badala, Mawaloko River between Kakeko and Kabendugu) was assessed in August-September 2004 (Figure 7.3.2-1). Walks of 12-16 km per day were made along existing trails and footpaths. Plants were recorded and detailed observations were made in the main habitat types, and herbarium specimens were collected for unidentified species. Additional tree sampling in 1-1.2 ha plots was carried out in the main wooded habitats (see Section 7.3.4).

Immediate Catchment

Figure 7.2.5-3 above shows the distribution and cover of the main habitats in the immediate catchment. This indicates that the vegetation is a forest-savannah mosaic

(Cole 1968, FAO 1978), comprising small patches of closed forest interspersed within large areas of savannah and savannah woodland. The main communities (in terms of quantity present) are mixed woodland savannah and farmbush/forest regrowth, and there are only very small areas of upland grassland (on granite outcrops), riparian forest, freshwater swamp and closed moist forest.

Forest has declined because of logging followed by slash and burn clearance for rice cultivation on the east bank, and tree felling around Bumbuna to prevent surprise attacks during the civil war. There has been little forest management, and the increased dependence on forest lands for rice cultivation has led to reduced areas of bush fallow, and the establishment of small unsustainable rice fields on very steep slopes (Figure 7.2.5-4). The only reminder that the bare slopes that dominate the landscape were once forested, is the presence of tall forest trees (*Amphimas pterocarpoides*, *Parinari excelsa*, *Parkia bicolor*, *Afzelia africana*, *Pentaclethra macrophylla*) in 3-5 m wide strips of gallery forest remaining along tributary streams that flow down the slopes. Closed forests, which previously occurred throughout the swamplands, are now reduced to isolated trees of *Mitragyna stipulosa* in increasingly large areas of swamp rice.

Riparian forest comprises mainly gregarious species like *Gilbertiodendron bilineatum*, which was dominant in two vegetation plots (Appendix L), reaching a basal area of 62.2 m^2 and 59.2 m^2 at Lower and Middle Kasasi. *Monopetalanthus pteridophyllus* was the dominant tree in two other plots, with basal areas of 10.7 and 23.8 m^2 in the Waia Road and Upper Kasasi forests. Tree diversity was high (68-78 species per 1 ha plot), and other common species included *Pentaclethra macrophylla*, *Santiria trimera*, *Pterocarpus santalinoides*, *Parkia bicolor*, *Distemonanthus benthamianus*, *Treculia africana*, *Uapaca guineense* and *Uapaca heudelotii*. These are mostly adapted to grow alongside rivers, and can withstand partial submergence in the wet season. Understorey shrubs include *Massularia accuminata*, *Diospyros heudelotii*, *Microdesmis keayana*, *Acioa scabrifolia* and *Chytranthus* sp

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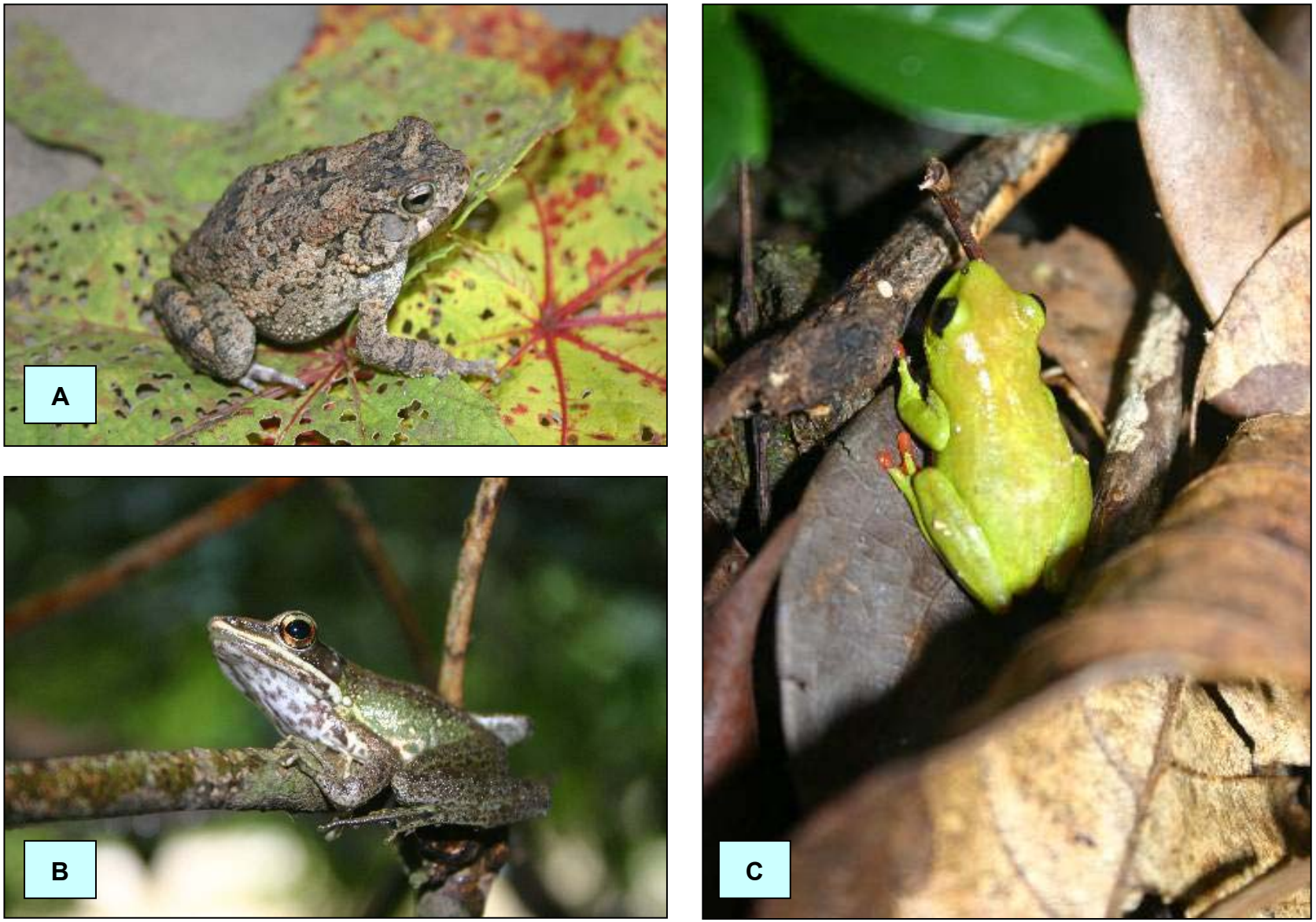


Figure 7.3.2-3: Amphibians Found in the Immediate Catchment: a) *Bufo* sp, b) *Hylorana albolabris*, c) *Hyperolius concolor*.

The degradation of existing forest and the increased use of fires are increasing the area of mixed tree savannah on the hills and plains. Farther north in the upper catchment this vegetation dominates, as fire is both a natural hazard and a land management technique used to encourage the growth of new and palatable grasses for livestock (Figure 7.3.3-1). Burnt savannah is now a dominant part of the landscape, and indicative trees like *Piliostigma thiningii*, *Lophira lanceolata*, *Parkia biglobosa*, *Spondias mombin*, *Pterocarpus erinaecius*, *Millettia zechiana* and *Hymenocardia acida* predominate. Typical grasses and other understorey plants include *Pennisetum purpureum*, *Hyparrhenia* sp, *Andropogon tectorum*, *Panicum maximum*, *Aframomum* sp, and *Anadelphia* sp, often no taller than 3m. Savannah woodland contains a single stratum of low trees with flat-topped crowns and thick, fire-resistant barks on gnarled stumps. There are also savannah grasslands without trees on rolling plateaux, and sedge flora as arborescent shrubs, both limited to areas with little or no topsoil over granitic bedrock.

Figure 7.3.3-1: Area Recently Burned for Recultivation.

Forest regrowth or farmbush occurs in different stages of succession as a result of slash and burn clearance (Figure 7.3.3-2), and extends as isolated forest patches well into the tree savannah. Trees typical of 5-10 year old regrowth include *Samanea dinklagei*, *Albizia adianthifolia*, *Anisophyllea laurina*, *Dichrostachys glomerata*, *Phyllanthus discoideus*, *Harungana madagascariensis* and *Albizia zygia*. Herbs and shrubs include *Cnestis ferruginea*, *Cleria bovinii*, *Tetracera alnifolia*, *Cissus difusiflora*, *Combretum* sp

and *Sabicea vogelii*. Diversity can be high because of early colonising species that disappear as the forest matures. *Funtumia africana*, the dominant pioneer elsewhere in Sierra Leone, is rare, and around Kasasi poles of *Anisophyllea laurina* and *Pentadesma butyracea* are common, many coppicing from previously-cut stems. Farmbush is an important reservoir of forest products including medicinal plants, fruits, ropes and poles for construction work.

Inland valley swamps are cultivated for rice, reducing their species diversity. Less disturbed swamps include the trees *Mitragyna stipulosa*, *Raphia hookeri*, *Raphia palma-pinus*, *Anthocleista nobilis* and *Ficus capensis*, and weeds and herbaceous plants include *Dissotis rotundifolia*, *Urena lobata*, *Clappertonia ficifolia*, *Costus afer* and *Tristemma akeasii*. *Raphia palma-pinus* is an important source of a local beverage, "bamboo wine".

Figure 7.3.3-2: Area with Different Stages of Fallow Regrowth.

7.3.4 Forest

Inventories were conducted of the main forest types in the immediate catchment in 1994 and 2004. In the first survey, 11, 9 and 7 plots of 400 m^2 were sampled at Bumbuna, Kasasi and Kafogo (Sites A, B, C on Figure 7.2.5-3), and for all trees above 6 cm dbh (diameter at breast height) the species, dbh, tree and trunk height, and crown height and width were recorded, and average values were calculated. In 2004, 1-1.2 ha plots were sampled in 5-10 year old farmbush at Bumbuna Dam, mixed woodland savannah at

Fullah Town, and riparian forest at Waia Road, Yankala East, and Lower- Middle- and Upper- Kasasi (Figure 7.3.2-1). All trees and vines above 10 cm dbh were identified and measured (dbh), and relative frequency, density and dominance, and Species Importance Value (SIV) were calculated. Data are presented in Appendix L, and the 2004 data are summarised in Table 7.3.4-1 and Figure 7.3.4-1.

Riparian Forest

Table 7.3.4-1 shows that riparian forest is the most diverse and dense of the wooded habitats in terms of tree cover, containing between 59 and 78 species per hectare plot, with a combined basal area of 80-240 m^2. In terms of the species present and their importance (SIV values, Appendix L), the data suggest that there are possibly two types of association. The first is a community dominated by *Monopetalanthus pteridophyllus*, which frequently also includes such species as *Pentaclethra macrophylla*, *Calpocalyx brevibracteatus*, *Parkia bicolor*, *Hannoa klaineana*, *Dialium guineense*, *Hymenocardia lyrata*, *Amanoa bracteosa*, *Afrosersalisia afzelii* and *Diospyros heudelotii* in relatively high densities. The second is a community dominated by *Gilbertiodendron bilineatum*, which also includes *Monopetalanthus pteridophyllus*, *Amanoa bracteosa*, *Diospyros heudelotii* and *Carapa procera*. The *Monopetalanthus* association occurs at Waia Road, Upper Kasasi and Yankala and the *Gilbertiodendron* association occurs at Middle and Lower Kasasi.

In both communities, around 50% of species occur only once or twice in each hectare plot (Table 7.3.4-1) and are therefore classed as locally rare. Figure 7.3.4-1 also shows that the forest is dominated by small trees, with 35-50% of individuals being in the smallest trunk diameter class (10-20 cm dbh). There were some larger trees of 50-100 cm dbh at each site, but these were very few in number. Several of the species are important for timber (such as *Berlinia confusa*, *Xylopia quintasii*, *Erythrophleum ivorens*, *Newtonia aubrevillei*, *Chlorophora regia* and many others), although most are in low numbers, and only *Hannoa klaineana* and *Daniella ogea* are common.

Young Farmbush

Farmbush is much less diverse than the riparian forest, with only 39 species in the 1.2 ha plot, of which 40% occurred as one or two individuals only (Table 7.3.4-1). *Samanea dinklagei* was the dominant species, covering a basal area of 24.3 m^2, and other important species were *Phyllanthus discoideus*, *Albizia zygia*, *Albizia adianthifolia, Anisophyllea laurina*, *Dichrostachys glomerata*, *Harungana madagascariensis*, *Chlorophora (Milicia) regia*, *Millettia lane-poolei* and *Sterculia tragacantha*. Many of the species are pioneers, able to colonise rapidly after an area is cleared by slash and burn or is left fallow after cultivation. The succession process is also reflected in the size of trees, 90% of which

Table 7.3.4-1: Summary of forest data collected in 2004

Location	Total Species	Total Families	Basal Area	Ten most important species at each site (based on SIV scores); see below for key to species names																				Occurs Once	Occurs Twice
	(No)	(No)	(m^2)	Sp1	Sp2	Sp3	Sp4	Sp5	Sp6	Sp7	Sp8	Sp9	Sp10	Sp11	Sp12	Sp13	Sp14	Sp15	Sp16	Sp17	Sp18	Sp19	Sp20	Sp21	Sp22	(No)	(No)
RIPARIAN FOREST																											
Waia Rd	59	23	80.8	√	√	√	√	√	√	√	√	√	√													17	17
U Kasasi	69	32	175.9	√					√		√		√	√	√	√	√	√	√							17	10
M Kasasi	78	32	195.9	√					√						√		√	√		√	√	√	√	√		27	15
L Kasasi	70	32	196.1	√									√	√	√		√	√	√	√	√			√		23	12
Yankala	74	31	241.4	√	√	√								√	√	√	√			√			√		√	19	7
5-10 YEAR OLD FARMBUSH																											
Bumbuna	39	20	111.2	√	√	√	√	√	√	√	√	√	√													11	5
MIXED WOODLAND SAVANNAH																											
Fullah T	32	16	94.3											√	√	√	√	√	√	√	√	√	√			18	3

Riparian Forest Species

Sp1 *Monopetalanthus pteridophyllus*
Sp2 *Pentaclethra macrophylla*
Sp3 *Calpocalyx brevibracteatus*
Sp4 *Dacryodes klaineana*
Sp5 *Ochna membranacea*
Sp6 *Parkia bicolor*
Sp7 *Pterocarpus santalinoides*
Sp8 *Hannoa klaineana*
Sp9 *Rubiacea* (unidentified)
Sp10 *Dialium guineense*
Sp11 *Hymenocardia lyrata*
Sp12 *Amanoa bracteosa*
Sp13 *Afrosersalisia afzelii*
Sp14 *Diospyros heudelotii*
Sp15 *Diospyros* sp
Sp16 *Diospyros gabonensis*
Sp17 *Gilbertiodendron bilineatum*
Sp18 *Carapa procera*
Sp19 *Syzygium* sp
Sp20 *Drypetes afzelii*
Sp21 *Daniella ogea*
Sp22 *Menispermaceae* (unidentified)

Farmbush Species

Sp1 *Samanea dinklagei*
Sp2 *Phyllanthus discoideus*
Sp3 *Albizia zygia*
Sp4 *Anisophyllea laurina*
Sp5 *Dichrostachys glomerata*
Sp6 *Albizia adianthifolia*
Sp7 *Harungana madagascariensis*
Sp8 *Chlorophora (Milicia) regia*
Sp9 *Millettia lane-poolei*
Sp10 *Sterculia tragacantha*

Mixed Woodland Savannah Species

Sp11 *Elaeis guineensis*
Sp12 *Pterocarpus erinaecius*
Sp13 *Millettia zechiana*
Sp14 *Spondias mombin*
Sp15 *Ficus capensis*
Sp16 *Terminalia glaucescens*
Sp17 *Gmelina arborea*
Sp18 *Piliostigma thonningii*
Sp19 *Ficus exasperata*
Sp20 *Sterculia tragacantha*

were of 10-20 cm dbh only, and in the fact that there was only one timber species, *Chlorophora regia*.

Mixed Woodland Savannah

The data suggest that this is the least dense and diverse of the three wooded habitats, as the 1 ha plot supported only 32 species, covering a basal area of 94.3 m^2. *Elaeis guineensis* was the dominant tree (covering 19.3 m^2), and others of importance included *Pterocarpus erinaecius*, *Millettia zechiana*, *Spondias mombin*, *Ficus capensis*, *Ficus exasperata, Terminalia glaucescens*, *Gmelina arborea*, *Piliostigma thonningii*, and *Sterculia tragacantha*. Several of the species were only recorded in this habitat, and 65% occurred only once or twice in the plot. The community was again dominated by small trees (50% of 10-20 cm dbh).

In total 87 tree species were recorded in 1994 and 155 in 2004, but this does not suggest an increase in diversity, as the recent surveys were more detailed and covered a larger area. One species *Tieghemella heckelii* was recorded in 1994 and not in 2004, and recent information indicates that it is endangered (Poorter *et al* 2004). Four other species were found which are classed as vulnerable (*Entandrophragma utile*, *Lovoa trichilioides*, *Nauclea diderrichii* and *Terminalia ivorensis*), and these occur in other rainforest in the east and southeast of Sierra Leone. Species composition of these areas is similar to the riparian forest of the immediate and upper catchment, which is probably now the northern limit of the once widespread Upper Guinean Rainforest Belt in West Africa.

Farming, logging and bushfires are continuing threats to the forest habitat. Mature moist forests are now rare or absent, and remaining forest areas are continually being degraded. Farms in the immediate catchment extend very close to the river, and only the steepest slopes have been spared. The only extensive area of riparian forest is around Kasasi village.

The Loma Mountains

The Loma Mountains 70 km east of Bumbuna (Figure 1-1) are part of the system of high altitude peaks and plateaux spread across Guinea, Ivory Coast, Liberia and Sierra Leone, which contain much of the remaining Guinean Montaine Forest. This includes many of the species and communities found in the Seli catchment, so mitigation of the impacts of the BHP could include protection and enhancement of Loma habitats to offset damage at Bumbuna (See Section 8.4 below). The flora and fauna was thus investigated in 2004.

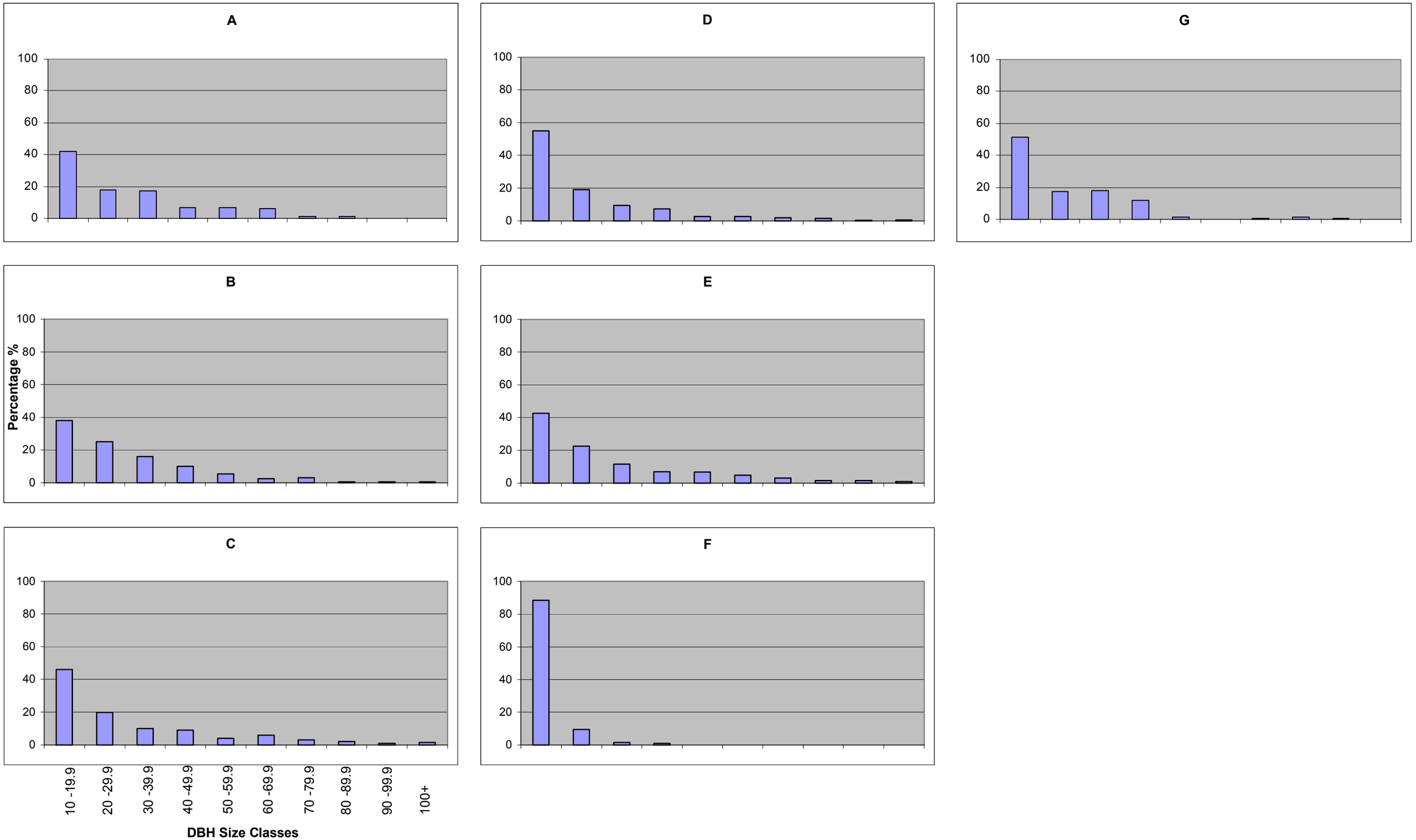


Figure 7.3.4-1 Size Distribution of Trees in Riparian Forest (a-e), 5-10 Year Old Farmbush (f) and Mixed Woodland Savannah (g)

Loma Mountains cover 33,000 ha, and consist mainly of Precambrian granite, with dolorite, gneiss, schist and quartzite insertions. Loma Mansa (Bintumani) reaches 1,945 m, and is the highest peak west of Mount Cameroon. Rainfall is high (over 2,000 mm annually), and several major rivers originate in the area, including the Seli-Rokel and the most westerly tributary of the Niger.

Loma supports many different floral associations and a wide diversity of animals, and was designated as a Non-hunting Forest Reserve in the 1970's, prohibiting hunting without a licence. However hunting remains intense, and as in most other parts of the region, agricultural encroachment has reduced the cover and quality of the habitats. Nevertheless, biodiversity is richer than in the Seli basin, and the habitats are less disturbed and fragmented.

The diversity of the Loma flora is a result of many factors, including geographic isolation, the varied nature of the topography and soils, speciation, climate, and various anthropogenic influences. Biodiversity and endemism are high, and although the area has been incompletely studied, 1,576 plant species have been recorded, from 135 families. Nine species are endemic: *Afrotrilepis jaegeri, Digitaria phaeotricha* var *patens, Dissotis sessilis, Gladiolus leonensis, Ledermanniella jaegeri, Loudetia jaegeriana, Loxodera strigosa, Schizachyrium minutum (S. brevifolium)* and *Scleria monticola.*

The fauna includes ten species of primates, including the endangered Western chimpanzee (reported in high numbers), Diana monkey and Bay colobus, plus several vulnerable mammals such as the leopard, pigmy hippopotamus and Jentink's duiiker. A total of 245 bird species have been recorded, including two near-endemics (the Sierra Leone prinia and the iris glossy-starling), and two that are threatened (the rufous fishing owl and the yellow-headed rockfowl). Many more species are endemic to this ecoregion as a whole, including several small mammals, a leaf-nosed bat, ten species of amphibians and many invertebrates.

Despite the anthropogenic influences, Loma Mountains is one of the few areas in the region with an unbroken sequence of intact habitats. However the ecoregion is not well protected in terms of formal conservation, and at present there are only two Biosphere reserves (Mount Nimba in Liberia, Guinea and Ivory Coast, and Massif du Ziama in Guinea) and two World Heritage Reserves (Mount Nimba in Ivory Coast and Guinea). Loma Mountains has been proposed as a National Park, and priority studies have been identified including rapid biodiversity assessments and analyses of local and ecoregion-wide endemics (Lebbie 2002). Any such actions have been impeded by the civil war and the continuing lack of human and financial resources.

Forest Conservation

Two centuries ago up to 75% of West Africa was covered in tropical rain forest, and today less than 5% remains (Sayer *et al* 1990), of which approximately half is immature and consists of forest re-growth in areas previously cleared for agriculture (Allan 1990). Most forest is now protected by the Forestry Division of the Ministry of Agriculture, Forestry and Food Security, but conservation is ineffective because less than 25% of gazetted Forest Reserves and proposed National Parks have been inventoried, and forest boundaries are unclear, leading to encroachment from slash and burn farmers and developers. There is insufficient technical capacity for managing the approximately 48 Forest Reserves, and in the civil war the breakdown in authority led to increased harvesting of timber, fuelwood, poles, etc. Recent studies have recommended the elevation of several protected areas and forest reserves to the status of National Parks to improve their management (Lebbie 2003).

There are no national protected areas in the immediate catchment of the BHP. The Farangbaia Forest Reserve (south-east of Bumbuna) is part of the Seli catchment but drains downstream of the dam, and the Wara Wara Hills and Loma Mountains Forest Reserves are outside the catchment (see Figure 1-1). To protect the natural forest the Forestry Division has established peri-urban plantations to supply the community with firewood, poles and timber, including 9,700 acres at Kabala, 1,190 acres at Fadugu, 1,220 acres at Mondembaia and 7,000 acres at Bumbuna. However these areas have been subject to the same pressures as the natural forest, and the Farangbaia Reserve has been largely converted to farmland or bush forest, and much of the Bumbuna plantation was cleared by the army on security grounds and has since been encroached by farmers.

7.3.5 Catchment Management

Upper Seli Catchment

The Upper Seli catchment as referred to in this report is all of the land upstream of the dam that drains into the Seli River (see Section 7.1). This is an area of 3,920 km^2, which is approximately 40% of the total Seli-Rokel Basin. As discussed above the catchment supports a forest savannah vegetation mosaic, which has been greatly influenced by anthropogenic activities, particularly farming. There are now only very small areas of natural habitat (such as narrow belts of riparian forest adjacent to the river and the swamps in the north), and the vegetation is dominated by mixed tree savannah and forest/farmland regrowth.

A catchment and its ecosystems provide benefits and services that are vital to rural communities and often have cultural and spiritual significance. These include:

- Provisioning: food, natural medicines and pharmaceuticals, genetic resources, fuel, fibre, water, minerals, etc;
- Regulating: climate regulation, water flow moderation, erosion control, water purification, waste treatment, human disease control, biological control, etc;
- Cultural: cultural diversity and identity, religious and spiritual values, knowledge, aesthetic values, social relations, heritage values, etc;
- Supporting: agricultural production, soil formation, oxygen production, soil retention, pollination, habitat provision, nutrient cycling, etc.

Importantly for the BHP, vegetation and land management practices in the catchment can affect sediment load and river flow regime, and therefore the long-term sustainability of the project. Consequently there is a need to evaluate the environmental services provided by the catchment, and to ensure that critical services are maintained and improved where possible for the benefit of stakeholders, including BHP beneficiaries.

Provisioning

The vegetation of the catchment provides various sources of food, medicine, construction materials and energy. Palm trees are amongst the most economically important plants, mainly as a source of protein-rich cooking oil and palm wine. Herbs, nuts and fruits are used in cooking or consumed raw, and many plants are harvested for use in traditional medicines. Trees provide building poles, timber and roofing materials. These plants are found in all major vegetation zones, including mixed tree savannah, forest regrowth and riparian forest.

The catchment also provides water, extracted from wells, surface streams or gravity-fed communal tap systems. Gold is also mined by individuals or small groups along the river tributaries, and in previous times by commercial operations in the upper catchment.

Regulating

Vegetation in the catchment minimises rainwater runoff, reducing soil erosion and recharging groundwater supplies, as well as purifying used water. These functions could influence the long-term viability of the BHP as the volume of the reservoir could be reduced by sedimentation resulting from soil erosion. The catchment also regulates the local climate by maintaining relative humidity through evapotranspiration, producing localised mist clouds. The vegetation also contributes to Sierra Leone's overall net positive carbon balance by producing oxygen and absorbing carbon dioxide, thus maintaining the country's position as a non-contributor to global warming.

Cultural

The catchment falls within twelve chiefdoms (Table 7.3.5-1), most of which extend well beyond the catchment boundaries. Many areas are culturally important for the Limba and Kalansogia people and each village has sacred sites for men and women, located in areas associated with water and natural vegetation, the sacred groves.

Table 7.3.5-1 Chiefdoms in the BHP Watershed

District	East Bank	West Bank
Tonkolili	Kalansogoia Kafe Simirna Kholifa Kholifa Mabang Malal	Kalansogoia
Bombali		Safroko Limba Parki Masabong Bombali Sebora Makari Gbanti
Port Loko	Marampa Masimera Koya	Marampa Masimera Maforki

Supporting

The catchment performs important supporting functions that are critical for both human inhabitants and wildlife, but this is undermined by the inherent low fertility of the soil, and farming practices that further reduce fertility and promote soil erosion. Shifting subsistence agriculture is dependent on extensification, whereby land is cleared, farmed for one or two seasons and then left fallow so that vegetation regrowth and dieback will replenish soil nutrients. Fallow periods have reduced, and together with inadequate land preparation and management, this reduces soil fertility and productivity.

The vegetation provides habitat for wildlife, which include endangered primates, antelopes and other species, and this function is also threatened by agriculture, specifically habitat loss by conversion to farmland, and reduction of animal populations by hunting. It is clear that, even without development of the BHP, the forest conversion and slash and burn agriculture in the catchment is not sustainable, and that improved farming methods and catchment management are urgently needed. The BHP provides a mechanism through which this can be achieved (see Sections 8.8 and 8.9).

Seli/Rokel Basin

Proposals to manage land and water in the Upper Seli Catchment need first to take into account current land uses in this area and in the wider Seli/Rokel Basin (ie the catchment of the whole river) as these show the present situation and indicate where there are conflicts/problems as well as opportunities for improvement. Land use in the Immediate Catchment (immediately upstream of the dam) was described in Section 7.2.5 above. The major current and planned future land uses in the wider Seli/Rokel Basin were reviewed as part of the EIA Upgrade studies in 2004, and are summarised as follows.

Mining

- Small-scale (artisanal) mining is taking place throughout the catchment, licensed by the Provincial offices;
- In Port Loko District (Seli/Rokel lower catchment), licences have been issued by the Ministry of Mineral Resources for exploration of bauxite in a number of locations for 3-year terms. It is expected that exploration and prospecting will continue for at least another ten years;
- In Koinadugu District (Seli upper catchment), exploration and prospecting licences have been issued for gold deposits, and drilling has been taking place between Bumbuna and Magburaka. If the deposits are found to be viable, operations are expected to be small to medium size;
- There are no current mining leases in the catchment, and a company wishing to apply for a lease must submit a feasibility study for consideration. An EIA has to be carried out, and compliance shown with the environmental regulations of the Ministry of Mineral Resources and other statutory bodies.

In the short to medium term there will be little change in the extent and effects of mining in the Seli/Rokel watershed, since industrial scale activities are 5 – 10 years away. The required procedures for EIA are already in place, and in the long term, if the procedures are enforced and artisanal activities are monitored, the impacts of mining on the watershed should be controllable.

Agriculture

No major national-level agricultural initiatives or studies are at present underway in the catchment. However, at the district level there are initiatives to set up projects and promote agricultural development generally:

- Tonkolili District is attempting to develop the swamplands as areas of sustainable agriculture, by providing tractors for hire, and obtaining combine harvesters for rice, following improvements in infrastructure. There are also proposals to grow root crop vegetables, oil palm and cashew (for which seedlings are available), and citrus, along the periphery of paddy fields. There is also a recognised need to rehabilitate feeder roads;
- A second initiative is for the development of oil palm plantations within a Community Oil Palm Programme, mainly in the inland valley swamps. Land holding would be in accordance with the traditional tenure system, although some of the land is already privately owned;
- In the 1970s the Chinese government set up a valley irrigation and HEP on 116 acres at Makali on a tributary of the Pampani river, that provided irrigation and electricity for the town. This was destroyed in the civil war, and the District is now seeking assistance to rehabilitate the project. It is outside the Seli catchment, but it could be a possible model for replication as an environmentally benign small-scale development for sustainable agriculture, that also supplies power to improve living standards and for cottage industries.

External funding for the financing of these proposals would have to be found, and is being actively sought at district level, and a similar process is underway in the adjacent Bombali District. The present emphasis is on local initiatives with a high level of local participation. At the same time, the process of valley swamp and 'boli' development is supported at national level (bolis are saucer–shaped depressions that are seasonally flooded, and generally confined to the Rokel river catchment). Development usually consists of creating drainage structures and bunded, levelled plots to enhance water control. With the necessary infrastructure, two high yield crops per year can be produced. Since the 1970s swamp development of inland valley swamps to boost rice production has been encouraged. The land is more fertile than uplands, and the intention is to encourage farmers away from upland shifting cultivation to more sustainable agricultural practices in the swamplands. Each District has at least 200 Farmers' Associations working toward swamp development and utilisation. High production technology transfer is available, as rice research has been practiced in Sierra Leone since 1966.

Industrial Sugar Production

The Magbas Sugar Project is a 1,280 ha sugar cane farm and factory adjacent to the Seli/Rokel River a few kilometres downstream of Magburaka. It is the only one of its kind in Sierra Leone, and was set up by the Chinese government and operated under Chinese direction until 1995. When operating fully, each year 850 – 1000 ha was planted,

and 60,000 – 70,000 tonnes per year of cane harvested. The highest production of sugar was in 1984/85 when 8,216 tonnes were produced. Production had fallen to 2,460 tonnes in 1995/96, by which time the equipment was in a poor condition and required rehabilitation. Several hundred tonnes of ethanol were also produced, and an alcoholic drink, Sasma, was produced as a by-product.

The infrastructure was destroyed during the civil war, and towards the end of 2003, the site was leased to a Chinese company and became the Complant Sugar Complex. It is expected that the factory will be operational by February 2005, with a first production of 2,500 tonnes of sugar, and a second production later in 2005 of 5,000 tonnes.

Under the previous operation a pumping station on the Rokel river abstracted 1.8 m^3/s for the peak period 6.00 am to 5.00 pm, and 0.44 m^3/s for the rest of the day. This is likely to be similar when the operation returns to full capacity, and this should not be a large water demand on the Rokel.

Forestry

There are no major forestry initiatives planned at the national level for the Seli/Rokel catchment. Farangbaia is a 1,260 ha Forest Reserve approximately 10km from Bumbuna, which is mainly grassland, though there are a number of sawmills operating. There are no plans to change its current operations or status.

Forestry could become a major activity affecting the management of the catchment, and there is clearly scope for expanding forestry activities in such a way that will provide additional protection to the soils of the catchment.

7.3.6 Aquatic Ecology

The ecology of the river was investigated upstream of the dam in 1994, and downstream in 2004, by taking samples and observations at the same stations as used in the water quality assessments (see Figure 7.2.8-1). Methods included: grab sampling of plants and invertebrates; sweep netting for insects; observations of riparian and aquatic flora and fauna and the main characteristics of the river (channel shape and size, river flow, bed material); discussions with local experts; and review of data and information from published and unpublished sources (e.g. Payne 1986, Iscandri 1990, Findlay 2004).

Physico-chemical Conditions

The Seli originates as a series of hillside streams in the Futa/Jallon Highlands near the Loma Mountains, and is joined by several tributaries as it runs across the upland plateau and escarpment zones in the northeast of the country. These upper reaches are

characterised by steep-sided valleys and sudden changes in topography, which produce fast flowing water and rapids in places. Bumbuna Dam and the nearby Falls are at the southwestern edge of the escarpment, downstream of which the land slopes more gently and the river assumes the morphology of the middle reaches, with a wide channel, slow velocity and meandering course, which runs for over 150 km across the interior lowlands. There is a wide floodplain adjacent to the river in this area, particularly downstream of Magburaka, into which the river flows during the rainy season, forming temporary and semi-permanent swamps (Figure 7.3.6-1). The estuarine lower reach begins around the Rokel Bridge, where saline water first becomes evident, after which the channel becomes wider and merges with the mouths of other rivers east of Freetown (Figure 7.2.8-1).

Water cascades down the steep-sided upland valleys in the rainy season, carrying soil from the surrounding land. Flow reduces at the end of the rains, and in the dry season the river gradually becomes shallower and the edges dry out, until eventually upstream the river flows as a small stream only. The bed is V-shaped and consists mainly of rock in the upper reaches and in the central channel of the middle reach, as fine material is carried downstream and the bed has eroded over time. Sand and gravel collect between rocks in the middle reach (Figure 7.3.6-2), and fine material is deposited on the flatter raised channel edges, where flow is relatively slow even in the rains (Figure 7.3.6-3). The bed becomes a broad U-shape as more fine material is deposited downstream, and silt settles out mainly in the lower reach where freshwater meets inflowing seawater.

There are a number of areas where the presence of large rocks near the surface disturbs and increases the flow of water forming rapids. Bumbuna Falls, 2.5 km downstream of the dam is the largest of these areas, where the water drops 30-40 m vertically over a horizontal distance of around 20 m, forming a spectacular waterfall (Figure 7.3.6-4).

Data presented in Section 7.2.8 indicate that water quality in the river is relatively good, with reasonable levels of oxygen, little decaying organic matter, and no evidence of pollution. This is because the water is aerated and materials are dispersed downstream by the rapid wet season flows, population is low in the countryside so the waterway is not greatly used for the disposal of waste, and there is no polluting industry in the watershed and little application of chemicals by the mainly subsistence farmers. There are however high levels of suspended sediment from erosion of soil from deforested hillslopes and lowlands converted to slash and burn agriculture, but levels of plant nutrients are low because the land is low in fertility, as it is subjected to recurring rainfed agriculture and inadequate preparation and management.

Aquatic Ecology

There is very little truly aquatic vegetation in the river, because of the lack of nutrients and because the marginal areas inhabited by such plants dry out each year. Six aquatic plants are known from the region (*Eichhornia natans*, *Nymphoides indica*, *Ottelia ulvifolia*, *Utricularia* sp, *Nymphaea lotus* and *Ceratophyllum demersum*, Cole (1968)), but only the marsh horsetail (*Equisetum* sp) was found in surveys near the dam. However the banks are heavily vegetated by trees, savannah grass and other plants, which overhang the river and grow in the bed in places (Figure 7.3.6-5), where they perform some of the functions of aquatic vegetation in trapping sediment, which allows colonisation by animals. These include burrowing worms (Oligochaetes and Nematodes), molluscs (snails and bivalves), crustaceans (freshwater crabs and *Macrobrachium* shrimps), amphibians (frogs and toads, including *Xenopus* sp), and insects.

Insects dominate the fauna in terms of numbers of species, and many are found in the shallow margins. These include forms that are entirely aquatic such as water beetles and water-spiders, and others that spend only part of their lives in the river, normally as larvae. The latter include a wide variety of insects, of which the most common in the Seli-Rokel are the Ephemeroptera (mayflies), Plecoptera (stone-flies), Trichoptera (caddis-flies), Odonata (dragonflies), Diptera (midges, mosquitoes and flies), Hemiptera (bugs) and Coleoptera (beetles).

The semi-aquatic fauna includes the vectors of several major human diseases, most notably mosquitoes (*Anopheles*) which carry malaria and dengue fever and lay their eggs in swamps and areas of calm water in the river, and the black-fly *Simulium damnosum* which lays eggs on rocks and vegetation in fast flowing water upstream, and carries the nematode *Onchocerca volvulus* which causes river blindness. Bilharzia is one of the major water-borne diseases, and this is present where bankside vegetation is inhabited by the snails *Bulinus* and *Biomphalaria*, which are the secondary host of the trematode *Schistosoma*, which penetrates the skin of people bathing or swimming in infected water.

Invertebrates are also found in the centre of the river, including temporary inhabitants washed out of the margins during the rains and motile forms that move here as the edges dry in the warmer months, and permanent residents such as mussels on gravelly bottoms, and oysters attached to rocks, including areas near Bumbuna Falls. In general there are more animals in the middle reach than upstream where conditions are more harsh and variable because of the strong flows in the rains and extensive drying in the dry season.

Figure 7.3.6-1: Floodplain Swamps adjacent to the River near Rochen-Malal

Figure 7.3.6-2: River Bed Substrate near Bumbuna

Figure 7.3.6-3: Rainy Season Flow in the Middle Reach of the Seli-Rokel in August 2004

Figure 7.3.6-4: Bumbuna Falls towards the middle of the rainy season in August 2004

Figure 7.3.6-5: River Margins near Magburaka in August 2004

The ecology changes in the lower reach under the influence of saline water. Mudflats at the edge of the channel are periodically uncovered by the tide, and are colonised by mangroves, including *Laguncularia* sp at the head of the estuary and *Avicennia marina*, *Rhizophora racemosa* and others where conditions are more saline. The fauna includes fiddler crabs (*Uca tangeri*) and mudskippers (*Periophthalmus koelreuteri*), which live in burrows and forage on the surface at low tide, and oysters and barnacles attached to the aerial roots of mangroves. These habitats prevail in the large area of creeks and river estuaries inland of Freetown (known as the Sierra Leone River, Figure 7.2.8-1), and are important nursery grounds for a variety of marine fish and crustaceans. However, many of these areas are degraded near the city by fly-tipping, cutting of mangroves and other human activity. Conditions change along the coast where salinity is similar to that of the open sea, and wave action creates sandy beaches that are unsuitable for mangroves and are inhabited by only a few animals such as the ghost crab *Ocypode*.

Fish

The fish and fishery of the river were investigated upstream of Bumbuna Falls in 1994 and downstream in the river and estuary in 2004. Methods were chosen to focus on species that are important to the community as a source of food and income and to collect information on the fishery, as these are areas where impacts of the dam are of local concern (see Public Consultation Scoping Report, Appendix B.2). Methods thus included questionnaire surveys of fishing communities (see Appendix M) and purchases of catches to count and identify the species present. This provided data that are less detailed than studies of other rivers conducted for research purposes (e.g. Payne *et al* 1989), but which nevertheless provide a baseline from which the impacts of the dam on the key issues can be predicted. The spread of observations from upper to lower reaches and across a ten-year interval also provides qualitative information on aspects of fish ecology, including distribution, reproduction and critical habitats.

A total of 36 species were recorded by the surveys, and the data suggest that, as in most African rivers, Cichlidae, Cyprinidae, Mormyridae, Characidae and Clariidae are the most important families (Table 7.3.6-1). As expected, the greatest number of species was reported from the middle reach, 23, compared with 16 in the upper reach and 13 in the lower reach (Table 7.3.6-2). The middle reach is normally the most diverse part of a river, as at different times of the year it can include permanent and semi-permanent residents (fish that live all or most of their lives in this area) and temporary visitors (that live in the estuary or the coast but enter the lower river to breed, or those carried down from the upper reaches by floods in the rains).

In terms of the distribution of individual species, Table 7.3.6-2 shows that seven species were only reported from the upper reach, five appear exclusive to the middle reach, and eight were only found in the estuary. In the middle reach, certain species, such as *Hemichromis bimaculatus*, *Labeo chariensis* and *Petrocephalus simus* are found mainly in upstream areas (around Bumbuna), and others, such as *Hemichromis fasciatus* and *Mormyrus* sp, are present mainly in the centre of the reach (Magburaka and Rochen-Malal, Table 7.3.6-1). Nine species were recorded both above and below Bumbuna Falls (*Hemichromis bimaculatus*, *H fasciatus*, *Tilapia zillii*, *T monodi*, *Lates niloticus*, *Synodontis clarias*, *Petrocephalus simus*, *Clarias anguillaris* and *Labeo chariensis*). The most widely distributed fish are *Hemichromis fasciatus*, *Synodontis clarias* and *Clarias anguillaris,* which were recorded upstream of the dam and as far downstream as Rochen-Malal (see Figure 7.2.8-1), and are species known to adapt to a wide range of environmental conditions. *Hydrocynus* sp and *Hepsetus odoe* were widely distributed downstream, being reported from all stations in the middle and lower reaches.

Although most fish live much of their life within a particular part of a river, many travel out of their normal environment once a year or more frequently to breed. Most reproductive cycles are strongly seasonal, and have evolved so that the young hatch when conditions are most favourable, in a location with a plentiful supply of food. Most tropical species begin to spawn in the early rains, when adults migrate upstream (or more rarely downstream), to specific breeding grounds. In the middle reaches catfish and other species breed in the floodplain swamps that become inundated at this time, and the fry feed on plankton, or organic matter that washes out of the soil. Other species such as *Alestes* migrate into smaller tributaries upstream and lay their eggs on the gravelly bottoms, where the fry feed on detritus washed out of the riverbed or from the surrounding land by the heavier rains.

Fewer fish spawn in the dry season, although this is common amongst the commercially important family Cichlidae, including *Tilapia* and *Hemichromis*. Such species normally spawn more than once per year, and produce small numbers of eggs with large amounts of yolk, so the embryos are independent of an external food supply, which enables them to survive the harsh dry season conditions.

Table 7.3.6-1: Fish present in the study area, from interviews with fishermen in 1994 (Cols 8-12) and 2004 (Cols 4-7)

Family	Species	Common Name (English)	Location								
			Rokel Bridge	Rochen-Malal	Magbur-aka	Bumbuna	Above Falls	Above Dam	Kasassi	Makea	Mawoloko
Cichlidae	*Hemichromis fasciatus*	Banded jewelfish		√	√		√	√			
	Hemichromis bimaculatus	Jewelfish				√	√	√		√	√
	Tilapia spp	Tilapia		√	√	√					
	Oreochromis	Tilapia			√	√					
	Tilapia zillii	Red Belly Tilapia					√	√	√		√
Cyprinidae	*Barbus macrops*	Blackstripe barb		√							
	Labeo chariensis/parvus					√			√		
Mormyridae	*Mormyrus* sp	Cutlass fish		√	√						
	Petrocephalus simus					√	√	√			√
Clariidae	*Clarias anguillaris*	Catfish/Mudfish		√	√	√					√
Characidae	*Alestes* sp		√		√	√					
	Hydrocynus sp	Tigerfish	√	√	√	√					
Hepsetidae	*Hepsetus odoe*	Kafue pike	√	√	√	√					
Mochocidae	*Synodontis clarias*	Red tail syno		√			√		√		
Notopteridae	*Xenomystus nigri*	African knife fish		√							
	Papyrocranus afer	Marbled knife fish		√							
Polynemidae	*Polynemus quadrifilis*			√							
Mugilidae	*Mugil cephalus*	Flat head mullet	√	√							
	Liza sp	Sicklefin mullet	√	√							
Ariidae	*Arius latiscutatus*	Rough head sea catfish	√								

Lutjanidae	*Lutjanus dentatus*	African brown snapper	√								
Gymnarchidae	*Gymnarchus* sp	Aba	√								
Sparidae	*Dentex* sp	Bream/snapper	√								
	Sparus sp	Bream/snapper	√								
	Galeoides decadactylus	Lesser African threadfin	√								
Haemulidae	*Pomadasys jubelini*	Sompat grunt	√								
	Pomadasys perotoei	Parrot grunt	√								
Alestiidae	*Alestes rutilus*	True Big-scale Tetra									√
	Alestes chaperi	Long-finned Characin						√			
Anabantidae	*Ctenopoma kingsleyae*	Tailspot ctenopoma						√			
Centropomidae	*Lates niloticus*	Nile Perch						√			√
Bagridae	*Bagrus docmac*										√
	Chrysichthys nigrodigitatus	Bagrid Catfish or Silver Cat							√		
	Chrysichthys walkeri								√		

Table 7.3.6-2 Comparison of fish species recorded in each of the main river zones

Zone	Total species	Species only recorded in this area
Upper Reach	16	*Ctenopoma kingsleyae*, *Bagrus dogmac*, *Chrysichthys nigrodigitatus*, *Alestes rutilus*, *A chaperi*, *Barilius senegalensis*, *Barbus wurtzi*
Middle Reach	23	*Oreochromis* sp, *Barbus macrops*, *Mormyrus* sp, *Xenomystus nigri*, *Polynemus quadrifilis*
Lower Reach	13	*Arius latiscutatus*, *Lutjanus dentatus*, *Gymnarchus* sp, *Dentex* sp, *Sparus* sp, *Galeoides decadactylus*, *Pomadasys jubelini*, *P perotoei*

A more detailed survey, sampling fish and habitats over a longer period than was available for the studies described above, would be necessary to identify the locations of habitats and areas that are critical to the many fish species in the river, and to determine whether there are any rare or endemic species (which would not feature in fishing catches). However, certain tentative comments can be made from the data collected to date, as follows:

- The severe gradient of Bumbuna Falls (with a drop of 40 m over a horizontal distance of around 20 m), coupled with the extreme force of water during the rainy season (Figure 7.3.6-4) and the very low flows in the dry season, almost certainly prevent upstream migration by fish;
- The fact that nine species were recorded both above and below Bumbuna Falls does not mean that these populations are interconnected and maintained by upstream and downstream migrations. It is more likely that the populations were connected in the geological past when land levels were different than they are today, but have remained separate since Bumbuna Falls were formed;
- In the present day the upstream and downstream populations are likely to be almost completely separate, inter-connected only when individuals (or eggs and larvae) from upstream are washed downstream by the force of water in the rainy season;
- As the reproductive cycles of many species involve at least some upstream migration, the area immediately below Bumbuna Falls is likely to be one of the most important habitats in the river, as it is probably the most upstream area that many fish are able to reach, and is thus the location where they breed. Local fishermen are very aware of this phenomenon, and frequently catch large gravid fish here;
- Other critical habitats for species inhabiting the middle reaches are the large floodplain swamps between Magburaka and Lunsar, where many fish breed in the

mid-late rains, and also the smaller streams feeding the many tributaries that flow into the middle reach of the Seli, where other species breed;

- Species living upstream of the falls migrate farther upstream to breed, and in the absence of a floodplain, critical habitats for spawning in these species are the smaller rivers and streams feeding into the main river;

Other habitats and areas are important for other aspects of the ecology of fish (such as feeding, shelter from predators, etc). Habitat preferences are determined by a wide variety of factors (eg current speed, substrate, vegetation, water quality, the presence of food and/or predators, etc), often vary seasonally and over the much shorter term as these and other features change, and can differ widely between species and even between individuals of the same species. The adaptability of species also means that many can inhabit a range of sub-optimal habitats. Identifying other critical habitats would therefore involve very detailed ecological investigations, which are outside the scope of this study.

Fishing

The questionnaire surveys of fishing communities in 1994 and 2004 indicated that fishing practices and the fishery are similar throughout the river, and have not changed significantly in the past decade.

Fishing methods are essentially the same at all locations, and include:

- Gill nets (which are the main method), mainly fixed by wooden stakes and strung across most of the width of the river;
- Cast nets, employed by single operators, from a boat, the riverbank or when wading through shallow water;
- Hook and line, mainly using multiple hooks (sometimes several hundred), baited with fish flesh and left *in situ* for several hours or overnight;
- Fish traps, with or without fences, employed both in small streams and in the main river;
- Poison, derived from plant materials, which is generally a small-scale activity, used mainly in small streams (there was no evidence of the use of chemical poisons or explosives).

Throughout the river, fishing is carried out mainly in the dry season (September to March) when currents are slow and fish are confined to a small and decreasing volume of water and are thus easier to capture. Fishing is mainly carried out by men, although women also fish in groups in shallow water, using scoop nets (Figure 7.3.6-6). There are

generally a small number of canoes in each village, capable of carrying 1-4 persons, and there appear to be none equipped with outboard motors.

Fishing can be carried out at any time of the day or night, but the afternoons are the preferred time. Fishing trips are generally of relatively short duration (10-12 hours on average), and over relatively short distances (up to around 10 miles), because there is no refrigeration available and because the purpose of fishing is to feed the fisher families as well as generate income. Fishermen therefore generally return to the village with their catch, which is distributed to their families, and the remainder is sold fresh in the village and in surrounding villages or towns the following morning. Any fish unsold at the end of the day is smoked and sold over the next few days.

Catches vary with season, location and effort, but in most villages a canoe full of fish represents a good catch for half a day of fishing, and this could be 30 or more large fish or several hundred smaller fish, weighing 50-100 kg in total.

Figure 7.3.6-6: Scoop Net Manufacture at Mabla Village near Magburaka

The importance of fishing varies between villages, and tends to be less near large towns, because most people are engaged in other activities in the town. In contrast in more remote areas, such as the small villages around Rochen-Malal, between 60 and 100 % of the adults are involved in fishing.

The 1994 survey reported that fishing in the main river upstream of the Dam is carried out only in the dry season, presumably because the velocity of the upland streams makes it a hazardous activity in the rainy season. However the surveys in 2004 showed that downstream communities fish throughout the year, although there is a reduction in effort during the rains when people are more involved in farming. Most villages reported fishing by professional fishermen from outside the area and even outside the country, who use mainly gill nets and long lines with large numbers of hooks, and operate from canoes with outboards. At Bumbuna the Paramount Chief and Elders are considering introducing a levy on such activities, and a system is already operating in places downstream, such as the village of Robonka where visiting fishermen pay a tax to the Local Authority.

7.4 The Human Environment

7.4.1 Data Sources

Data on various aspects of the human environment were collected for the original EIA and are contained in the final report and appendices of that study (Electrowatt/Techsult 1996). However the effects of the civil war and other changes in the intervening period mean that much of this data is now out of date. Several new studies were therefore conducted in 2004 to update information on socio-economics, culture and health, and to cover new topics. These studies included:

- Resettlement Action Plan (RAP) for the Reservoir and Dam Area (Electrowatt-Ekono/Techsult 2005);
- RAP for the Transmission Line (Azimut *et al* 2005);
- The Upper Seli Community Development Initiative (Vincent, 2005);
- An Archaeological Survey of the Bumbuna Reservoir Area (NKUK 2005);
- A Survey of Public Health in Bumbuna and the Surrounding Area (NKUK 2004).

The following account of existing conditions in the human environment of the dam and reservoir area uses information from these sources. Existing conditions along the Transmission Line are described in Chapter 10.

7.4.2 Socio-economic Conditions

The study area for the dam and reservoir RAP was defined as "all that parcel of land on either side of the River Seli, which is upstream of the dam making up the reservoir area, as demarcated by the 800 ft contour line" (Electrowatt-Ekono Techsult 2005). This converts to 243.84 m asl, so the area is slightly larger than the "reservoir area" defined in Section 7.1 above (and used throughout the remainder of this report), which is based on the reservoir full supply level of 241.25 m.

The RAP recorded 59 communities, comprising villages in the reservoir area and villages that were resettled when the project took over land for the quarry, campsite, dam, roads and other facilities. Methods included questionnaire surveys with heads of households, separate focus group discussions with youths, women, men, and chiefs and elders, and consultative meetings with the community. The final report (Electrowatt-Ekono/Techsult 2005) gives the following account of the socio-economics of the area.

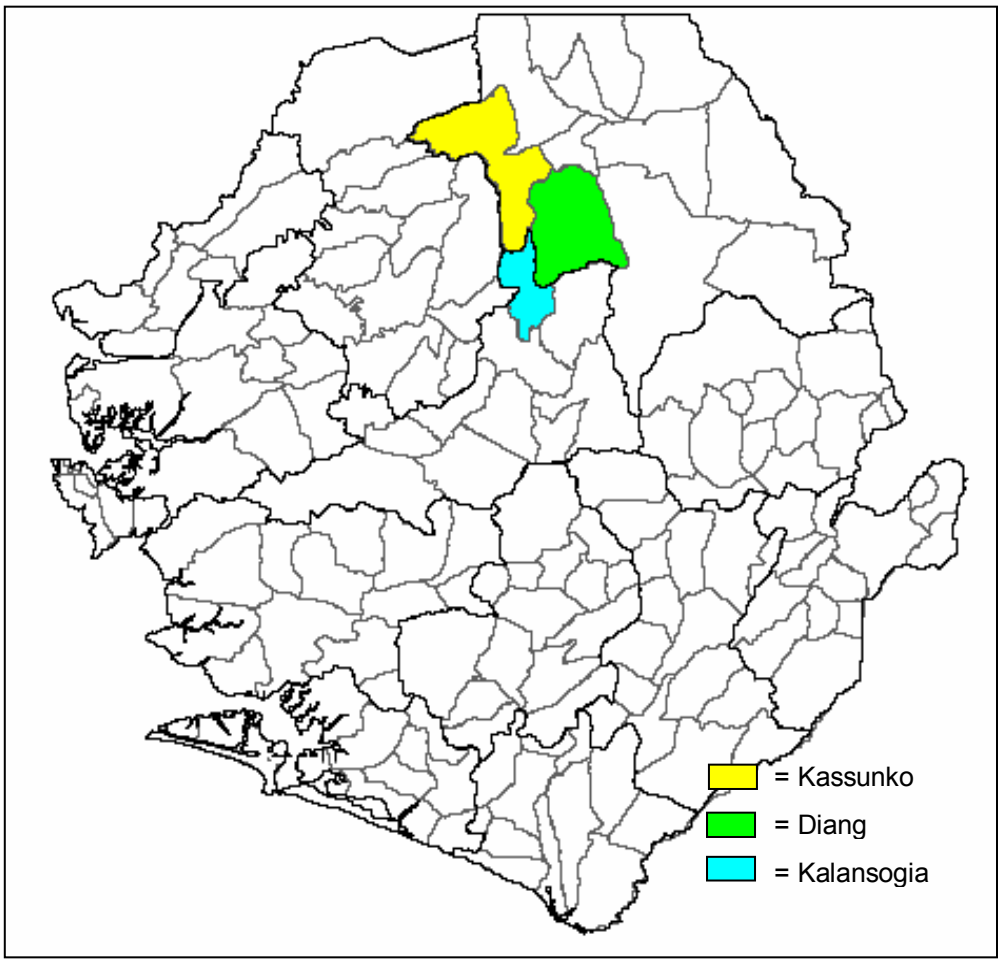


Figure 7.4.2-1: Map of the chiefdoms of Sierra Leone, showing those in the vicinity of the BHP

Source: Electrowatt-Ekono/Techsult (2005)

Settlements

The area around the BHP is relatively isolated and underdeveloped, except for Bumbuna town that has been rebuilt after the war, but still has house structures that could be refurbished. Local and regional infrastructure, road systems, social services and employment opportunities could be improved. Access to the villages is by footpaths and tracks. Footpaths and locally constructed bridges need to be maintained. Bumbuna town has experienced some growth and influx of people who lost their land to the campsite, quarry and dam area. The town now has a police post that ensures a return to security after the war.

Table 7.4.2-1 provides a list of the villages included in the RAP surveys. Of the total of 59 villages, 5 were outside the reservoir area (as defined by the RAP), some were deserted although the land was still cultivated (eg Fula Town), and some were "twin" villages, comprising two villages with the same name, formed recently from the splitting of a larger village (eg Kasasi 2A and 2B, Kabonka I and II, and Kamaniki and Kamaniki II).

Table 7.4.2-1: Villages included in surveys conducted for the Dam and Reservoir RAP

No.	Village	Elev. m asl	Latitude N	Longitude W
	Mawoloko[1] River right bank (N res.)			
1	Heremakono	288	09°28.175	11°41.971
2	Kamayimbo	289	09°27.252	11°42.194
3	Kadubaya	280	09°25.736	11°43.149
4	Kamakea	282	09°25.134	11°43.474
5	Kakekor	295	09°24.266	11°43.780
6	Kafogo	280	09°23.575	11°44.087
7	Kamadonorheh	323	09°22.378	11°44.821
8	Kasoloba	252	09°22.329	11°44.035
9	Kahukumbah	340	09°22.191	11°44.963
10	Kathagburenah	340	09°21.834	11°45°132
11	Kamabandayna (des).	292	09°21.126	11°44.071
12	Kabendugu	354	09°20.666	11°43.505
13	Kagboray	354	09°20.327	11°42.836
14	Kasasi (2B)	327	09°20.061	11°42.419
15	Kasasi (2A)	326	09°20.035	11°42.524
	Mawoloko River left bank (N res.)			
16	Kakumankuru	380	09°25.380	11°42.613
17	Kakuthuhu	289	09°25.320	11°43.050
18	Kamandi (II)	319	09°25.013	11°41.650
19	Kamakaheh	258	09°24.568	11°43.343
20	Kasanday	380	09°24.455	11°42.348
21	Kawayron	289	09°24.077	11°42.663
22	Kamatethe	273	09°23.882	11°43.203
23	Fula Town	273	09°23.806	11°43.688
24	Kamatha	289	09°23.625	11°42.945
25	Kabonka II	304	09°22.883	11°43.637
26	Kabonka I	365	09°22.822	11°43.799
27	Kasokra	273	09°22.408	11°41.483
28	Kamakoseh	273	09°22.215	11°42.135
29	Kamabareh	273	09°21.722	11°43.048
30	Kamaniki II (Kamaselon)	258	09°21.278	11°42.632
31	Kamawayway	319	09°20.928	11°41.552
32	Kamaniki	289	09°20.898	11°42°288
33	Kapamapaheh	380	09°20.359	11°41.802

	Seli River right bank			
34	Kamandi	339	09°18.900	11°43.995
35	Kamagbama	297	09°18.817	11°42.771
36	Katoina	251	09°16.490	11°43.116
37	Kamasepina	253	09°15.588	11°43.180
38	Kawunglu	464	09°13.781	11°43.555
39	Katene	253	09°12.462	11°42.852
40	Katengbeh	315	09°10.856	11°43.294
41	Kakutan	341	09°09.467	11°43.045
42	Kayakala	329	09°07.769	11°43.268
43	Kamerah	294	09°07.331	11°43.421
44	Kasasi	281	09°07.200	11°43.497
45	Kasokiri	278	09°05.174	11°44.000
46	Kadala	251	09°04.808	11°43.473
	Seli River left bank			
47	Yiben[2]			
48	Bombali Dian Kawungulu	241	09°13.547	11°42.313
49	Kulian (Kulayan)	235	09°12.524	11°41.792
50	Matombe	211	09°12.128	11°42.167
51	Kamakweni	230	09°10.366	11°42.060
52	Masamandugu	233	09°10.353	11°42.057
53	Waia	322	09°07.874	11°42.366
54	Gbulia	428	09°05.903	11°42.652
	Outside Reservoir Area[3]			
55	Worowaia			
56	Sonkoni			
57	Kamato old			
58	Kamato new			
59	Bumbuna Town			

[1] Main tributary of Seli River forming north-western arm of reservoir
[2] Due to high river flow, Yiben was not accessible during whole study period
[3] Too far away from reservoir (Worowaia) or in the downstream area

Source: Electrowatt-Ekono/Techsult (2005)

The main ethnic group in the area is the Limba, with smaller proportions of Mende, Fula, and Temne. These ethnic groups have their own traditions but there are broad cultural similarities among them, including the traditional secret societies, use of Krio language, and religion (traditional, Christianity and Islam). The sacred sites of cultural importance include the secret society bush, ancestral cemeteries, shrine bush, stones, etc.

Education levels are low and illiteracy rates are high. There is the inability of families to afford formal and informal school fees and traditional customs may also discourage girls from education.

Slash and burn agriculture is the predominant land use and income source. Almost all farmers are involved in swamp rice farming. Other food crops include upland rice, cassava, sweet potato, yam, and fruits like bananas, pineapples, oranges, grape fruits, mangoes etc. Other sources of income include gold mining, palm wine tapping, fishing, petty trading and hiring out of labourers etc. Bartering is commonly practised when a household has high yields of for example rice and lacks other household essentials.

The level of social services and infrastructure in the area is dismal. None of the local villages have access to the national power grid, though poles have been erected in Bumbuna town, which will benefit from electrification. There is one hospital under

construction at Bumbuna town and this will cater for the villages. At present the seriously sick have to go as far as Magburaka for medical attention. A clinic also exists in Fadugu, but this means that some villagers have to walk about 20 km to get medical help. Some of the villages have at least a hand pump or a water point installed by an NGO, but most villages collect drinking water from communal wells, dams, springs and streams, while water from the river is used for washing. Sanitation facilities (latrines) are rare. Primary schools exist at least in the larger villages. In Bumbuna Town more schools are needed, including a vocational training centre to absorb especially the youth

Only one major motorable road exists in the area in the north, which passes through Fadugu and Kafogo and proceeds north through Kamayimbo, possibly touching the right shore of the future lake. The other place directly connected by road is Bumbuna Town. The two roads meet at Magburaka and Makeni; the road going north lies approximately 25 km west of the Seli river. This fact implies that villages along the future lake can be approached by road only either from the south (Bumbuna) or the north (Fadugu), from where they can be actually reached only by footpaths. A fine network of such footpaths exists, but not all of them can be used during the rainy season.

Figure 7.4.2-2: Village in the project area (Kamakea, 18.09.04)

Source: Electrowatt-Ekono/Techsult (2005)

Connections between villages are not always the shortest possible routes but often go up and down the hills, and resemble rather the bed of mountain brooks than real paths. It goes without saying that reaching these villages often is an arduous journey, which takes a long time and a lot of energy. The villagers are conscious of it, and find it particularly difficult to transport sick people. It is therefore not surprising that sometimes contacts between neighbouring villages are minimal, and exchange of goods even more so.

Household Structure

Household surveys were conducted in the 54 villages in the reservoir area defined by the RAP (Table 7.4.3-1), and data were collected from a total of 872 households. Average HH size is 7.6 persons. Figure 7.4.2-3 illustrates the frequency distribution of HH size classes, which is atypical for the African (or Sierra Leonean) context, especially in a rural population, as there are a number of one-person households.

Questions on the marital status of HH members provided a somewhat confusing picture, as the recorded numbers of women and men, respectively, in polygamous unions did not match.

Two-generation households are the norm in this area. This (emphasised by the very few persons classified as grandparent or grandchild) shows that life expectancy is low, as it is for the whole of Sierra Leone.

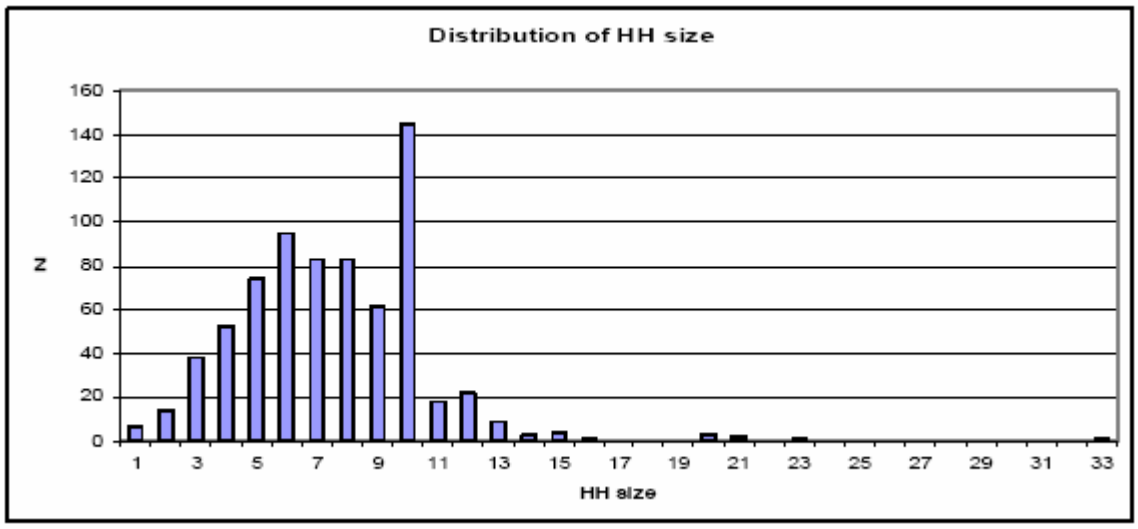


Figure 7.4.2-3: Frequency distribution of households according to size

Source: Electrowatt-Ekono/Techsult (2005)

Village Size

Village size is very variable, ranging from Kamatethe, with 2 HH and 9 persons, to Kafogo, with 764 persons in 84 households. However, most villages are small, as illustrated by the fact that for the 46 inhabited villages (counting "twin" villages as one) average village size is 17 HH, 15 villages have 5-7 HH each, and only three (Kafogo, Gbulia and Waia) have more than 50 HH each

Water Supply

Data on remaining socio-economic indicators were collected for the three chiefdoms adjoining the BHP (see Figure 7.4.2-1) as a whole.

The source of water supply for domestic use is generally unsafe, especially in Diang and Kalansogoia chiefdoms, as seen in Table 7.4.2-2. The situation is much better in Kassunko Chiefdom, where 46.2 % of the population have access to wells with pumps and only 50 % obtain their water directly from rivers or streams.

Table 7.4.2-2: Types of Sources of Water Supply, by Chiefdom

Source of water supply	Chiefdom		
	Diang	Kalansogoia	Kassunko
River/stream/pond	96.4	85.2	50.0
Well with pumps	3.6	2.0	46.2
Well without pumps	-	8.6	3.0
Others	-	4.2	0.8
Total	100.0	100.0	100.0
N	**138**	**418**	**132**

Source: Electrowatt-Ekono/Techsult (2005)

Table 7.4.2-3: Distance to Water Source, by Chiefdom

Distance	Chiefdom		
	Diang	Kalansogoia	Kassunko
Within Homestead	19.6	18.7	66.7
Up to 1 km	68.8	62.2	25.8
1 km and over	11.6	19.4	7.5
Total	100.0	100.0	100.0
N	**138**	**418**	**132**

Source: Electrowatt-Ekono/Techsult (2005)

Table 7.4.2-3 shows that over 60% of all households in Diang and Kalansogoia chiefdoms travel up to one kilometre to their source of water. In Kassunko chiefdom, on

the other hand, two-thirds of the population reported that their water supply is in their homesteads.

Solid Waste Disposal

Sanitation is expressed in terms of method of refuse disposal. Table 7.4.2-4 shows that the most frequently used method of waste disposal involves throwing such refuse into the nearby bush. This is the predominant practice in settlements in all three chiefdoms.

Table 7.4.2-4: Methods of Refuse Disposal, by Chiefdom

Method of disposal	Chiefdom		
	Diang	Kalansogoia	Kasunko
Private pit	26.8	7.5	1.5
Thrown into nearby bush	71.0	88.9	95.4
Communal Pit	-	2.2	0.8
Burnt by household	1.4	0.7	0.8
Buried by household	-	-	1.5
Others	0.8	0.7	-
Total	100.0	100.0	100.0
N	**138**	**418**	**132**

Source: Electrowatt-Ekono/Techsult (2005)

Public Health

Data were collected on the type of medical treatment used in the localities studied, and the results are presented in Table 7.4.2-5.

Table 7.4.2-5: Medical Treatment Types, by Chiefdom

Nature of Treatment	Chiefdom		
	Diang	Kalansogoia	Kassunko
Traditional	38.3	24.9	1.5
Modern	24.6	21.3	54.6
Traditional and Modern	37.0	53.8	43.9
Total	100.0	100.0	100.0
N	**138**	**418**	**132**

Source: Electrowatt-Ekono/Techsult (2005)

The use of modern medical treatment is most common in settlements in Kassunko Chiefdom, and the greatest dependence on traditional treatment is reported in localities in the Diang Chiefdom. All three chiefdoms rely to a considerable extent on a combination

of both traditional and modern methods. This combination is most relied upon in settlements in Kalansogoia. The rather low percentage of households using modern facilities in Diang and Kalonsogoia doubtless reflects the general remoteness of these villages, with long and difficult access to public health facilities.

Attitude to Relocation

Since some settlements will have to be relocated prior to filling of the reservoir, the interviewees were asked whether they had a preferential location for resettlement. The results are presented in Table 7.4.2-6 below. In summary, the majority of inhabitants in Diang and Kalansogoia Chiefdoms, 55.1 and 67.5% respectively, appear to have already made up their mind about possible alternative sites for resettlement. The situation in the settlements in Kassunko, however, is different. There, up to 91.7% of the household heads reported that they have no preferences as yet if they have to be relocated. Only 6.8% of the heads have preferences.

Table 7.4.2-6: Preference for Resettlement Sites

Chiefdom	Locality	Preferences	No preference	Undecided
Diang	Waia	65.7	28.7	3.6
	Diang Kawungulu	57.1	28.6	14.3
	Masamandugu	83.3	16.7	-
	Fula town	100.0	-	-
	Kulian	66.7	-	33.3
	Kamakweni	100.0	-	-
	Matombe	25.0	75.0	-
	Kabonka	14.3	85.7	-
	Kakuthuhu	-	75.0	25.0
	Kamakoseh	16.7	83.3	-
	Kamatethe	-	100.0	-
	Kamaniki	-	100.0	-
Kalansogoia	Kamato I	79.1	18.6	2.3
	Kadala	76.9	23.1	-
	Kasasi	75.0	25.0	-
	Kasokiri	73.3	24.4	0.3
	Kakutan	100.0	-	-
	Katengbeh	100.0	-	-
	Katene	100.0	-	-
	Gbulia	37.7	62.3	-
	Kamasepina	52.8	47.2	-
	Katoina	68.4	31.6	-
	Kawungulu	41.8	55.8	2.4
	Kayakala	83.3	16.7	-
	Kamerah	84.0	16.0	-
	Kamato II	86.7	13.3	-
	Kamabareh	-	100.0	
Kassunko	Kafogo	4.8	94.0	1.2
	Kamagbama	45.5	54.5	-
	Kakekor	-	100.0	-
	Kamakea		100.0	
	Kadubaya		66.7	33.3

Source: Electrowatt-Ekono/Techsult (2005)

Analysis of the perceived criteria for relocation suggests that the two most important factors in the view of the affected persons, are access to better housing conditions and better land for agriculture (Table 7.4.2-7).

Table 7.4.2-7: Perception of the Most Important Factors for Resettlement

Factors	Percentage
Better land	38.2
Family relations	1.3
Better housing	36.9
Access to water	6.0
Access to education	2.0
Access to health	2.9
Overall improved conditions	1.9
Job opportunities	1.3
Maintain present state	1.9
Don't want to move	2.7
Others	0.3
Not stated	2.9
Better roads	1.7
Total	100.0
N	688.0

Source: Electrowatt-Ekono/Techsult (2004)

7.4.3 Culture, History and Archaeology

The culture, history and archaeology of the reservoir and immediate catchment were investigated in 1994 and 2004. The work involved:

- Search and review of published literature on the history and archaeology of Sierra Leone and West Africa in general;
- Shovel testing by digging 1 m pits of 0.5 m diameter at intervals within sampling grids in areas of archaeological interest, identified from interviews with local people and by systematic field walking along transects, mainly 5 m wide and 200 m long;
- Interviews with chiefs, elders and inhabitants of villages in the vicinity of the reservoir area to discuss oral histories and discoveries made whilst engaged in agricultural or other activities.

The results are presented in Appendix N and are summarised as follows.

Culture and History

The area in which the BHP is located is inhabited mainly by people of the Limba, Koranko and Temne ethnic groups (Figure 7.4.3-1), and is at the north of the Tonkolili District in Northern Province, bordered by Koinadugu District in the north and Bombali District in the west (Figure 7.4.3-2). The dam, reservoir and other facilities are in the Kalansogoia Chiefdom, formed in 1953 from the amalgamation of Kalantaba and Dansogoia chiefdoms. Kalansogoia covers around 250 km^2, and consists of seven administrative sections, six Limba and one Koranko.

Settlement patterns, socio-economics and culture have been shaped by the mountainous terrain that dominates much of the area. Settlements developed on hilltops, initially because they were easier to defend, and they have remained isolated by the intervening valley systems, so that even today inhabitants of neighbouring towns separated by only a few kilometres can know little of each other.

The chiefdom headquarters town of Bumbuna has a significant Temne population, but elsewhere inhabitants are mainly from the Limba Kalantaba group, which have distinct dialects, and hard, sturdy features, which distinguish them from other Limbas. Limbas are believed to originate from a common ancestor Tonko Santigi who migrated from Guinea on a hunting expedition and established a small community. Splits because of the slave trade then led to the development of Sierra Leone's other Limba groups.

The chiefdom is the traditional administrative unit of the country, and was adapted to suit modern conditions during colonial times. Paramount Chiefs are subject to the authority of central Government, receive a salary and collect Government taxes, but no longer preside over courts. Decisions are made by the Chiefdom Council, comprising the Paramount Chief, Speaker, Section Chiefs and Chief Elders, and revenue is paid into a Chiefdom Treasury. The Paramount Chief is elected by Chiefdom Councillors (each representing 20 taxpayers) and is subject to confirmation by central Government.

The administrative sections of a chiefdom are led by a Section Chief, also elected by Chiefdom Councillors. Each section comprises towns and villages, most of which originated as small settlements developed by warriors, hunters or farmers on expeditions.

Settlements were often established after battles to annex the land, although land was also acquired peaceably after requests to rulers. New villages expanded rapidly as followers migrated to join the founder, and surrounding forest was then cleared for farming and to build the characteristically modest dwellings (Figure 7.4.2-2). Acquisition and distribution of land within a settlement is mainly on the basis of membership of clans, of

which there are many in the study area (eg Mansaray, Conteh, Kamara, Koroma, Turay, Kanu).

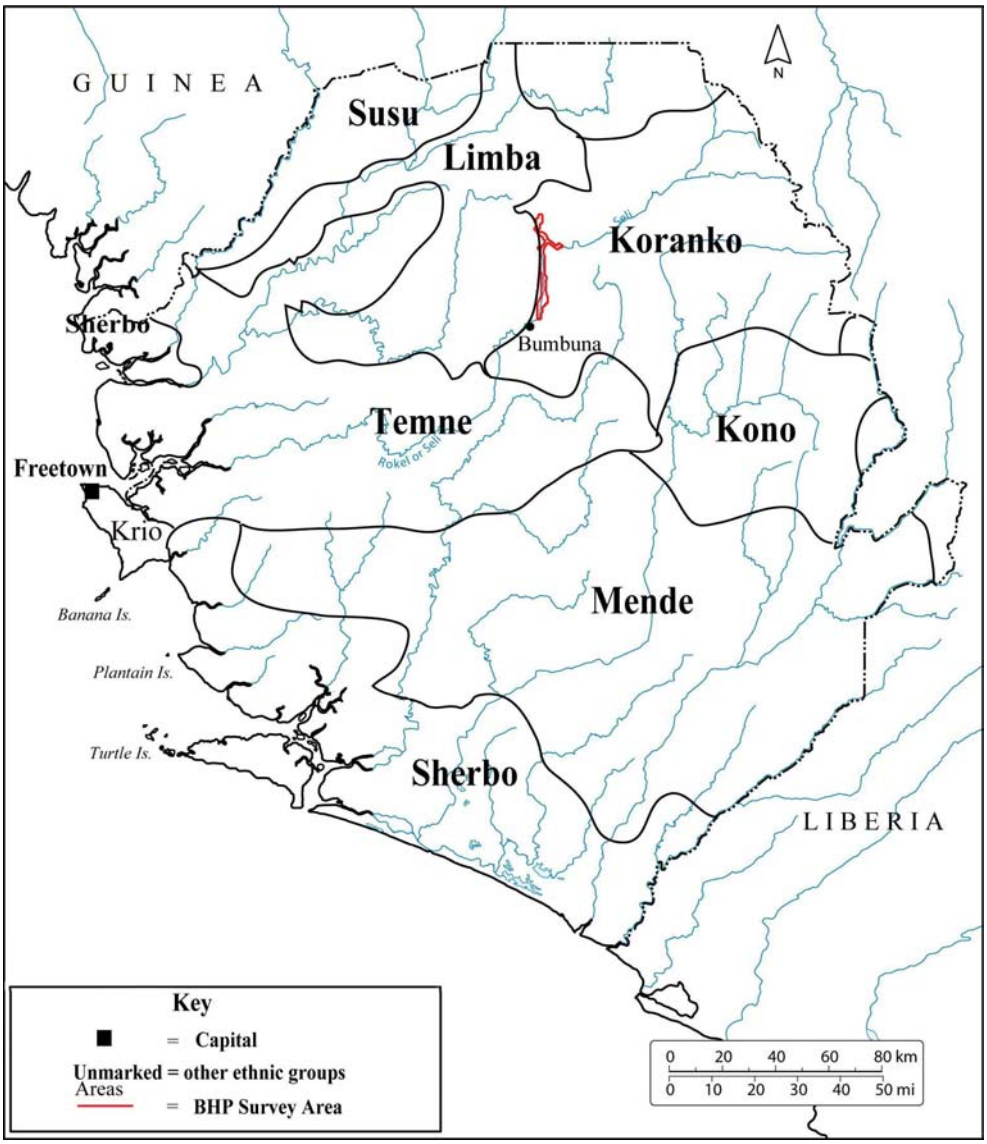


Figure 7.4.3-1: Distribution of the main ethnic groups in Sierra Leone.

Sources: Fyfe (1962), Finnegan (1965), Alie (1990)

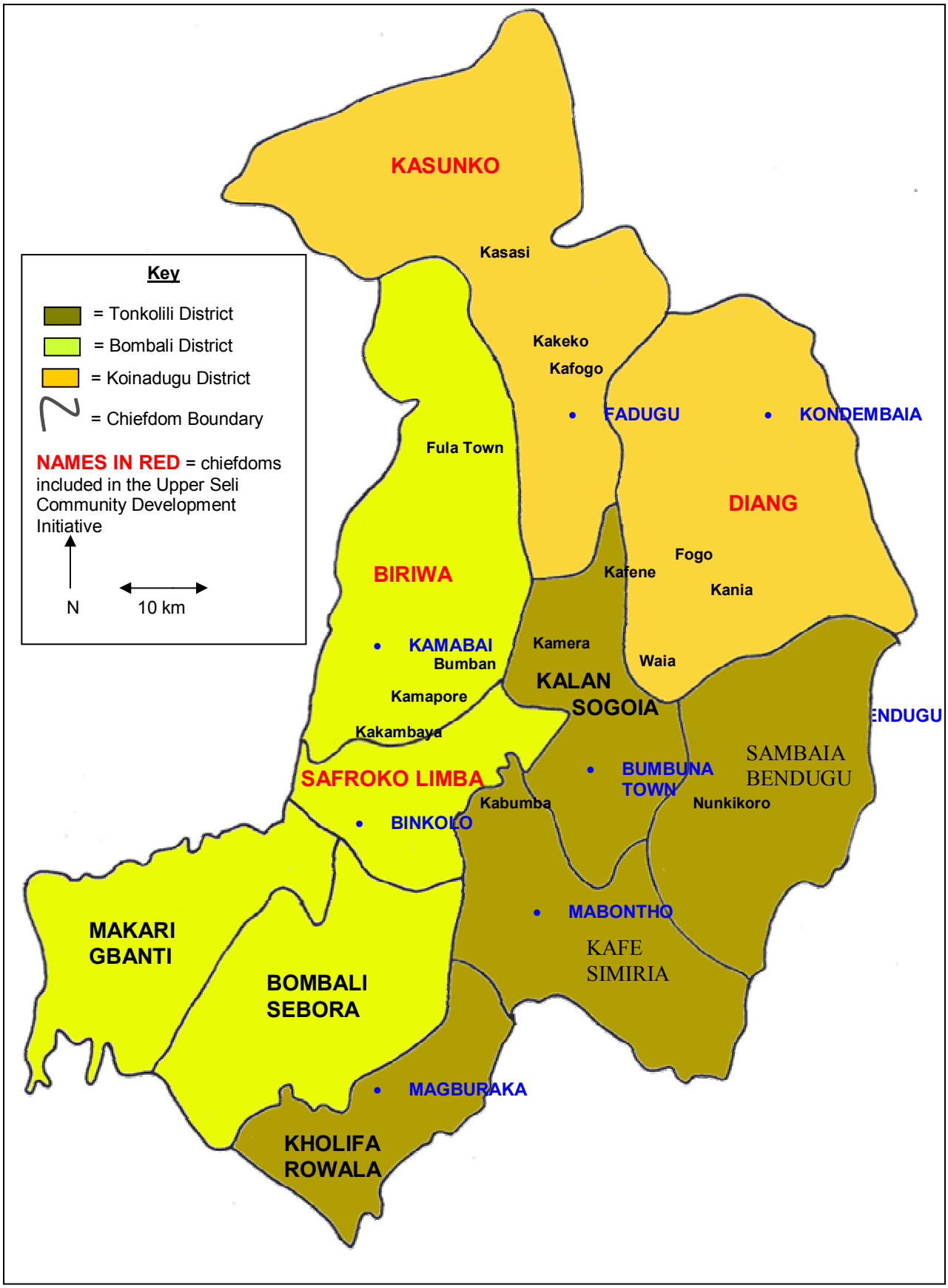


Figure 7.4.3-2: Boundaries of the Kalansogoia and Surrounding Chiefdoms

Source: Vincent (2004)

These are distinguishable by claims to different ancestry, and by different beliefs, taboos and prohibitions; intra-clan marriage is a generally shared taboo.

Social Organisation and Traditions

Most clans in Sierra Leone (including those of the Kalantuba Limba) are patrilineal. These claim decent through the males from a remote ancestor, usually with features and attributes of a great animal found in their environment, which is the totem (emblem) of the clan. Clan names are used as surnames, and these create a strong bond between the men of the clan. Descent is from father to sons, and carries loyalty to the ancestor, which involves observing the conditions and prohibitions of the clan.

Marriage is mainly endogamous, within the clan. Partners are chosen from relatives, with brides often chosen at birth by parents of a potential husband, who then share the maintenance and upbringing of the girl with her natural parents. Marriage ceremonies are simple, involving the performing of rituals and payment of bride prices by the husband.

Within households, social organisation is similar to that of most African communities. The head of the household is normally the male, who may have one or more wives. Other members include children, and relatives of the husband and wives, such as aged parents, brothers and sisters. The head is the legal custodian of all household property, including land, which is passed on to the male offspring. He is the main economic provider, as well as being responsible for protection and security.

Generally each household owns a house, which are mainly of the traditional circular shape, constructed of mud and wattle, with grass roofing (Figure 7.4.2-2). Houses are not normally partitioned internally into rooms, although there may be “barri”, a shed behind the house for cooking and storage of grain. There is little piped water and no sanitary facilities, and people generally defecate in the bush and forest. Some houses in towns are built from locally constructed sand and clay blocks, with corrugated iron roofs (Figure 7.4.3-3), and some of these are supplied with water, piped from streams.

Religion and Sacred Sites

Most inhabitants of the Kalansogoia chiefdom are Christians, and few Limbas follow the Muslim religion, despite centuries of association with Muslim neighbours. Religious teaching and moral/ethical guidance is provided by travelling Christian evangelists who visit from Bumbuna or Makeni, mainly during Christmas and Easter. There are however few permanent church buildings in the villages, and services are mainly held in temporary huts.

Figure 7.4.3-3: Traditional and More Modern Houses in Bumbuna Town

Many people unwittingly follow a mixture of Christian and traditional religious practices, as evidenced by the widespread belief in shrines or sacred groves as abodes of the gods, where people place traditional religious figurines and conduct sacrifices (Figure 7.4.3-4). Most towns and villages have the following sacred sites:

Bembe: A shrine or grove where people, led by the oldest male member of the "Gbangbani" Society (see below), assemble before significant events (marriage, childbirth, naming ceremonies, preparation for war, etc) to feed the spirits and offer sacrifices (sheep, goat or bull). Each stage of the farming process involves these rituals, such as the arrival of the first rains, when farmers visit the bembe to offer rice-bread, cooked rice or livestock to the goddess of the earth and departed ancestors, to ensure a successful harvest.

Nabangere: A sacred stone kept in the grove of the male society, which is fed and offered sacrifices during initiations and other ceremonial rites. Nabangere is believed to protect, and can intercede on behalf of Gbangani members who have offended the spirits of the society.

Kpouki: A sacred stone in the female societal grove, used as a place of worship and sacrifices during female initiation rites, to which sacrifices are offered to grant fertility. A representative stone of the Kpoki is kept on a raised mound of earth in the centre of the village to protect the village and its women and children.

Stream: Most towns and villages have streams nearby, which are given symbolic names (eg "Kamatane", holy water place, in Kakutan). These are used for drinking water (sent by spirits or gods), and as places to worship and offer sacrifices for good fortune and prosperity,

Ceremonial Trees: These are trees thought to be inhabited by the ancestors who founded the town or village, whose responsibilities are to protect it. They are found at the entrance to a village, towards the rear, or in the nearest area of thick bush, and are places of periodic ceremonial worship. Many different trees fulfil this role, although many are cotton trees.

There are many other sacred places specific to particular towns and villages, such as Bumbuna Falls, which is believed locally to be the home of the devil, and a place from where people are thought to have been taken by the devil.

Figure 7.4.3-4: Ancestor Shrine Containing Traditional Figurines

Source: Electrowatt/Techsult (1996)

Secret Societies

Secret societies are a feature of the traditional African way of life, and are very prominent among the Limba people. The main male society is the Gbangbani, which has aggressive features and rituals, and is powerful in the community, although it has no political function. Ceremonies are conducted in groves on the outskirts of towns, or they can encompass the whole area of a small village. Bondo is the main female society, and ceremonies are held on the outskirts of the village, away from the male grove.

Close communities (in terms of location or ancestry) maintain separate societies, and there seems to be little or no merging of societies or rituals. Kadala is one of the most important areas as it houses the oldest society-grove in the area, and is the area to which all lodges travel annually to attend a major festival.

Archaeology

There has been little archaeological research in the savannah-forest of West Africa, and few surveys in Sierra Leone. LSA (Late Stone Age) hunter-gatherer sites in the Northern and Eastern Provinces (Figure 7.4.3-5) suggest that the area has been inhabited since at least 2,500 BC. Yengema cave (Coon 1968) and rock shelters at Kamabai and Yagala

(Atherton 1972) are situated on inselbergs[10] and characterised by microlithic[11] (quartz-based) and macrolithic[12] toolkits, double- and single- bladed polished and/or ground stone celts[13], and pottery. These and similar rock shelters at Kakoya and Bunumbu (Newman 1966) suggest that the region was populated by small, mobile and isolated bands of hunter-gatherers/fishers moving across a vast area containing forests, rivers and grasslands. This existence was exceptionally durable, as hunter-gatherer groups appear to have survived here until the 1st millennium AD (eg Yagala rock shelter).

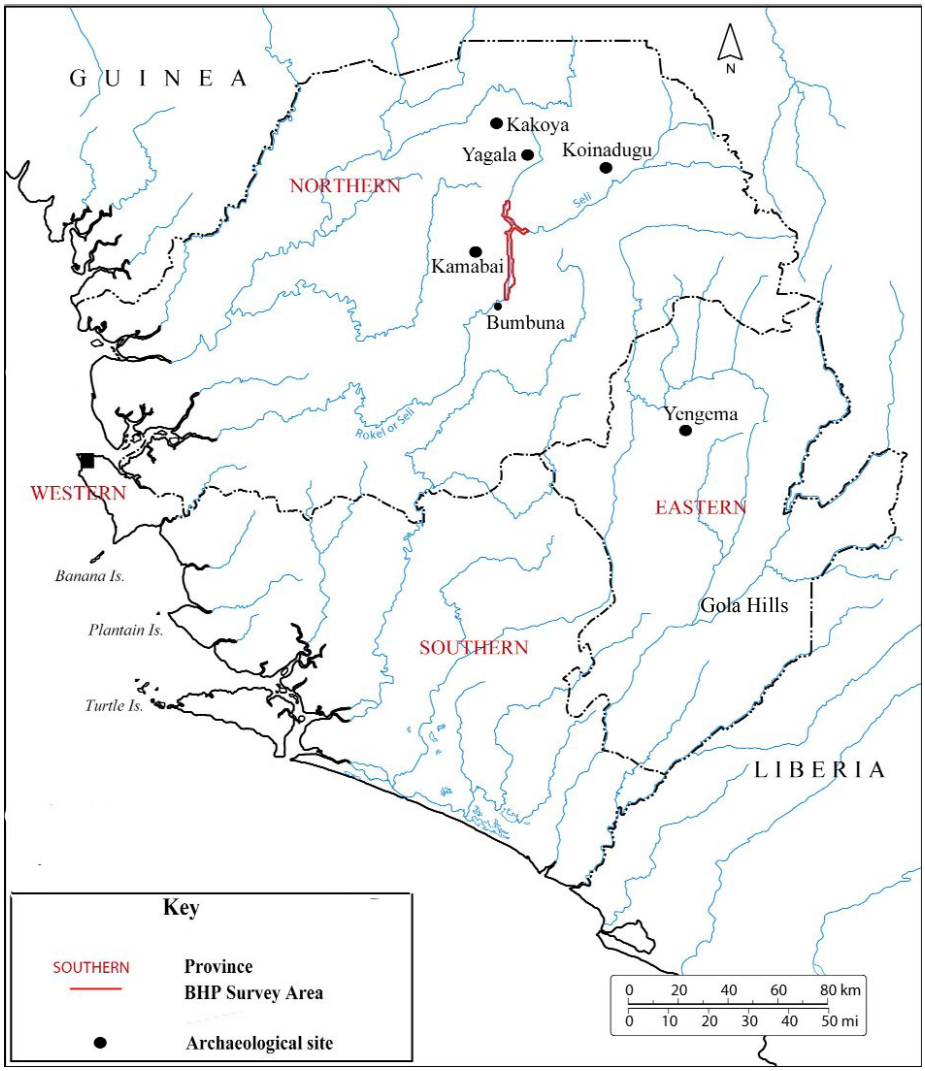


Figure 7.4.3-5: Archaeological Sites in Northern Sierra Leone

Iron Age material at Yagala and Kamabai included iron tools, pottery and slag from smelting, plus quantities of chipped stone that suggest continued use of earlier technologies (Hill 1969, Atherton 1972). There were two pottery traditions, with

[10] An isolated rocky hill rising abruptly from a flat plain
[11] Small stone tools usually less than 2-3 cm long, thought to have been hafted for use as composite tools (eg saws)
[12] A stone tool kit with tools larger than those found in microlithic kits
[13] Stone axes made predominantly from dolerite (a coarse grained basalt)

potsherds (fragments) of pre-metallurgical groups (prior to AD 700) decorated with simple punctate or cord-impressed motifs, and later assemblages (to AD 1500) decorated with a wider variety of motifs and techniques (Coon 1968, Atherton 1972). No data are available on archaeobotany or animal remains, so little is known of the subsistence economy or agricultural practices of the hunter-gatherers or later metallurgical groups.

Regarding more recent ages, surveys of the Western, Eastern and Southern Provinces suggest the existence of an apparently widespread "medieval cultural complex" described as the "Beaker Group" from the beaker-shaped pottery from the late 15th to early 17th century (Ozanne 1966, 1968). Surveys near Bo (Hill 1969) located over 100 sites with a range of materials, and surveys in the Northern Province located remains of 19th century villages plus apparent prehistoric sites (Newmann 1966).

Megalithic[14] monuments have been reported, although their significance is unknown. Roll (1967) excavated two formations in Gola Forest (Figure 7.4.3-5), one comprising two upright stones in an 'L' shape and the other eight upright stones in a circle with a ninth in the centre. Rock paintings are rare, and the only known examples are from the Kakoya rock shelter (Decorse 1988), and consist of ovoid white outlines with dots in the interior, which may have been related to female excision rituals. Decorse (1980, 1981) surveyed 25 protohistoric[15] and historic defensive sites in the Koinadugu District, which were dated to the 19th century from European trade goods.

The occupation of Limba people in the north of Sierra Leone seems to be of considerable antiquity, and Atherton (1969) postulates that Limba are descended directly from the LSA inhabitants of the area. Accounts by European visitors from the 17th century onwards differentiate between the Limba, related groups, and others that were believed to have arrived more recently (Atherton 1969).

The studies in 2004 indicated that the area around Bumbuna was settled by Limba people in the mid-late 19th century as part of a southern wave of migration provoked by the expansionist activities of 'warrior-kings' such as Almamy Suluku (a Biriwa Limba[16]) and Samori Touré (a Mandingo[17]). People displaced by this migration are likely to have been Koranko and Temne. The current Limba people are unaware of the location of any areas occupied by the incoming groups, and their oral history begins with the arrival of their 'forefathers' in the region they currently inhabit. Koranko history dates from a similar period, which suggests that they may not be descended from Koranko group(s) thought to previously occupy the area.

14 Large standing stone monuments, such as Stonehenge in Britain
15 Early African-European contact period
16 Biriwa is a chiefdom with its headquarters currently situated at Kamabai (see Fig 7.4.3-2)
17 The Mandingo people emigrated from Guinea south into Sierra Leone and Liberia over the past 200-300 years

The interviews in 2004 included a wide range of persons, but none had noted any archaeological material during farming, hunting or other activities. The field surveys also yielded no material, despite detailed shovel testing of the mounds at Kasai and Fulatown (which thus appear to be natural formations), the rock shelter near Kafogo, and other locations in an area covering of 10 % of the land that will be inundated by the reservoir. This was not unexpected, given the high proportion of land that has been disturbed by previous agricultural activity, and the inhabitants' lack of appreciation of archaeology, which would not favour the recognition or preservation of any such material.

7.4.4 Tourism and Recreation

Tourism has always been of minor economic importance in Sierra Leone, with the only significant influx of foreign visitors occurring in the few decades before the civil war, in the period when European tourists began to view parts of West Africa as a potential holiday destination. Visitors tended to remain on the Freetown peninsula, where there are hotels, attractive beaches, some entertainment, and historical interest in the small museums, Bunce Island ruins, and colonial architecture in the city. Few visitors ventured into the interior, where attractions include Kilimi and Outamba National Parks in the far north-west, Tiwai Island Nature Reserve in the south-east, diamond mining east of Bo, and Mount Bintumani in the Loma Mountains. Visits to these areas are constrained by the distances involved, the inadequacy of many of the roads, and the lack of quality hotels, or guesthouses of any description outside the main towns.

Although the Government began to support the tourist industry in the 1980s, such developments ceased during the civil war, when many facilities were damaged and destroyed. In the short period since the war visitors have not returned, because the supporting infrastructure has not yet been replaced, and because the security situation is still viewed as uncertain from outside the country. There is however a growth in in-country tourism, with many of the foreign personnel working in Sierra Leone with international aid agencies and NGOs, visiting former resort areas on the coast around Freetown at weekends, and visiting some of the sites in the interior.

At present the only site with any tourism potential in the study area is Bumbuna Falls, which receives small numbers of visitors each year because of its picturesque surroundings and the impressive views of large quantities of water flowing downstream in the rainy season (Figure 7.3.6-4). There is no tourist accommodation in Bumbuna, and with the nearest, low quality hotels being 50 km away in Makeni, visitors tend to be mainly local residents, plus some people from the surrounding towns.

7.4.5 Public Health

Public health in the study area was investigated in 1994 and 2004 by reviewing data and reports produced by the Ministry of Health, other national and international agencies and NGOs, by conducting surveys of the health facilities and related services and infrastructure in the study area, and by holding discussions with health professionals. Surveys were also conducted to determine the presence of the various vectors of water borne diseases. Data from the 2004 surveys is presented in Appendix B.4.

Public Health in Sierra Leone

Health statistics in Sierra Leone are sometimes contradictory, but most indicators show a population suffering many of the diseases and health problems that are prevalent in rural Sub-Saharan Africa, that are associated with poverty and a lack of basic services like water and sanitation, and a public health system that is under-resourced and inadequately developed. This is illustrated by data presented in the original EIA report (Electrowatt/Techsult 1996), shown in Table 7.4.5-1.

The data show a very high incidence of infant mortality during the early years of life, and an average life expectancy in adults (45 years), which is well below current norms for many rural communities living by mainly subsistence farming in remote areas. With women having an average of 6.5 children and the average annual birth rate exceeding death rate by 25 per 1000 people, the population is rising, and is estimated to double every 28 years. The figure of one doctor for every 17,000 people shows the inadequacy of the health system, which means that people in remote areas will not have access to the most basic of health services, and will rely mainly on traditional medicines.

Table 7.4.5-1: Public Health Statistics for Sierra Leone in 1994

Parameter	Sierra Leone Average
Infant Mortality Rate (death in 1st year)	15.4 %
Under Five Mortality Rate	24.5 %
Life Expectancy at Birth	45 years
Maternal Mortality Rate (deaths caused by pregnancy or childbirth)	0.65%
Annual Birth Rate	48 per 1000 population
Annual Death Rate	23 per 1000 population
Annual Population Increase	2.5 %
Doubling time of population	28 years
Total Fertility Rate (TFR)	6.5 births/woman
Contraceptive use	9.8 %

Population per doctor	17,300
Population per hospital bed	963
Access to safe water	Rural 22%, Urban 83% Average 43%
Sanitary disposal of excreta	Rural 35%, Urban 59% Average 43%
Complete immunization by 1st birthday (TB, Diphtheria, Whooping Cough, Tetanus, Polio, Measles)	68%

Source: Electrowatt/Techsult (1996)

Public Health in Bumbuna

Health facilities in the area around the BHP are very limited. In general, facilities exist only in the Chiefdom headquarters towns, and in most cases do not have trained personnel or sufficient (in some cases any) drugs. Information on health facilities collected as part of the present studies is summarised in Table 7.4.5-2 below.

Table 7.4.5-2. Health Facilities in Kalonsogoia and its bordering chiefdoms (2004)

CHIEFDOM	HEALTH FACILITIES	TOWN/VILLAGES
Kalonsogoia	Community Health Centre (CHC) Maternal & Child Health Post (MCHP)	Bumbuna Basainya
Sombaya	MCHP	Rogbaneh
Kafe Simiria	CHC	Mabontor
Safroko Limba	MCHP MCHP	Maselleh Kabonka Binkolo Masongbo Kapeteh Kagbo Kanjassie Town
Biriwa	MCHP MCHP MCHP CHC CHC Community Health Post (CHP) MCHP MCHP	Kamasikie Kagbankuna Manjoro Biriwa Kamabai Kagbameh Bumbaday Bumban Kendehka
Diang	CHP CHC CHP	Yaru Kondembara Kondembaia

Only in Kalansogoia is the situation likely to improve in the near future as two health centres are currently under construction, funded by the National Commission for Social Action (NaCSA).

Infectious diseases are the major health problem in the Bumbuna area, especially those transmitted by insect vectors, or with snail intermediate hosts (Malaria, Onchocerciasis, Schistosomiasis), and/or through contact with unsanitary water (e.g. diarrhoeal diseases, intestinal parasites). The situation with respect to each of these is as follows:

Malaria: Malaria is common in Sierra Leone, although figures may be over-estimated as diagnosis is from symptoms rather than blood tests, as health centres do not have microscopes. In 1994, 23% of patients visiting Bumbuna health centre suffered from malaria, and by 2004 this had increased to 33.8%. Treatment is generally by chloroquin, and resistance is not yet a problem.

Onchocerciasis: River blindness has been common in the area for many years. In 1956, 56% of the inhabitants of 22 villages in Tonkolili were infected, and in 1992, 65% of personnel at the dam site were infected. By 2004, the prevalence of onchocerciasis in Tonkolili villages was similar (Ferengbeya 64.3%, Sonkoni 41.5%, Kulujage 36.3% and Masaka 56.2%). Black flies are common, although the disease reduced prior to the civil war as a result of mass treatment with Ivermectin and spraying of insecticide under the Onchocerciasis Control Programme (OCP). The OCP still distributes Ivermectin annually in all communities along the Seli River that are at risk from onchocerciasis, and also provides entomological surveillance; insecticide spraying has ceased.

Schistosomiasis: There are two forms of Schistosomiasis in the study area: urinary (caused by *Schistosoma haematobium*; intermediate host *Bulinus* snails) and intestinal (*Schistosoma mansoni*; *Biomphalaria* snails). Infection rates in the study area were 11 and 29% respectively in 1994, and both snail hosts were present near the river. In 2003, schistosomiasis was still present in the area, with about 1% of all out-patients (1,329 cases) in the districts of Koinadugu, Tonkolili and Bombali reporting infection. This represented a considerable increase over 2002 (186 cases). Worryingly, there is no specific schistosomiasis control programme in existence or planned.

Others: Other vector-borne diseases are rare in the study area. Lymphatic filariasis occurs in Sierra Leone, but it is not a public health problem. Tsetse flies are present, but there have been no cases of human Trypanosomiasis (sleeping sickness) for many years. The *Aedes* mosquito is also present, but there were no cases of yellow fever or dengue fever in the project area in 2003.

Diarrhoeal Disease: 27% of patients at the Bumbuna Health Centre in 1994 suffered from dysentery and gastro-enteritis; by 2003 this was 8% for Tonkolili district as a whole.

Intestinal Parasites: A survey also in 1994 showed 50% of people infected with hookworm and 39% with Ascaris.

Respiratory Disease: Acute respiratory infections (ARIs) are frequent, with around 6% of patients at Bumbuna Health Centre suffering from pneumonia and 6% from Whooping Cough in 1994. There are no data on Tuberculosis, but in the country as a whole there were 2030 new infections in 1993 (47 in 100,000), and a high incidence of drug resistance. In 2003, an average of 32.5% of out-patients in the three districts reported with ARIs.

STD: Sexually Transmitted Diseases are frequent, but there were no data specific to the study area in 1994. In 2003, an average of 8% of out-patients in the three districts reported with STDs.

Although HIV and AIDS were still at low levels at the time of the original EIA (127 AIDS patients in the country as a whole and 425 HIV positive cases), levels increased significantly during the following decade, particularly during the lawless times of the civil war. 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.

Currently, there is no HIV/AIDS prevention programme in Bumbuna or anywhere else 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 also expected that these communities will benefit from a recently awarded Global Fund grant of about US$ 8.5 million for two years, to scale-up HIV/AIDs interventions in the country.

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

Malnutrition: Despite the predominant agricultural livelihood in the study area, malnutrition is frequent in small children. Around 50% of children under five were below expected weight and height in 1994, both significantly worse than the results of surveys in 1978 and 1989/90. This was thought to be due to inappropriate weaning and feeding habits, and high levels of infections and parasitic diseases. In 2003, only 1.3% of out-patients in the three districts reported with malnutrition, but it is likely that most malnourished people, particularly children, would not visit a health centre.

Health Projects

There were a number of health projects in the study area at the time of the original EIA, including the Onchocerciasis Control Programme (involving weekly spraying with larvicides and mass treatment of people), improved malaria control (prophylaxis for pregnant women, health education, epidemiological surveillance, etc), Mother and Child Health (vaccinations, family planning) and a Primary Health Care Programme (health education, promotion of household latrines, improved drinking water supply). However these ceased during the civil war, during which much of the meagre health infrastructure in the country was damaged and parts were destroyed.

Since the civil war, Sierra Leone has received support from many international agencies, and certain programmes of these organisations have focused on issues related to public health, and the sector has also received some support from central Government. The

Upper Seli Community Development Initiative (Vincent 2005) lists four health related projects in the area at the present time, shown in Table 7.4.5-3.

Table 7.4.5-3: Current Health and Health Related Projects in Chiefdoms near the BHP (2004)

District	Chiefdom	Village	Project and Funding Agency	Period
Bombali	Biriwa		Community Health Post (NaCSA)	2004
	2 Chiefdoms: to be decided		Food Security, Sanitation and Health (NPRDI)	2004 - 2006
Koinadugu	Kasunko	Kagbasia	Community Health Post Construction	2004
	Kasunko	Whole chiefdom	Civil works (Health Centres, School)	
	Kasunko	Whole chiefdom	Construction of wells and sanitation (WATSAN)	
	Kasunko	Kafogo	Rehabilitation of Gravity Water	2004
Tonkolili	Kalansogoia		Gravity water supply in Bumbuna (UK DFID)	2003

Source: Vincent (2004)

8 Environmental Impacts

8.1 Introduction

Table 8.1-1 summarises the potential environmental impacts of the BHP, covering the remaining construction work and plant commissioning (pre-operation) as well as the subsequent operation of the scheme. This identifies the impacts and their likely significance and explains the rationale behind each conclusion (as text in each cell), and indicates the measures required to mitigate the adverse impacts. These have been discussed with the PIU and the World Bank, who have agreed that all measures shown in Table 8.1-1 and taken forward into the Environmental Management Plan (Chapter 13) will be implemented.

This chapter describes the impacts and mitigation for "environmental" issues, Chapter 9 covers "social" impacts (relating to the human environment), and Chapter 10 covers all issues relating to the Transmission Line. Table 8.1-1 shows that there are clearly certain key issues where negative impacts could occur. These are:

- Upstream river effects and reservoir management;
- Slash and burn agriculture and its impacts in the catchment;
- Effects on terrestrial flora and fauna;
- Downstream river hydrology and channel morphology;
- Downstream aquatic ecology;
- Social, displacement and resettlement impacts in communities inhabiting the reservoir area and the transmission line route;
- Cultural and historical issues relating to these communities.

In the following account most attention is paid to these issues and other impacts are discussed in less detail, maintaining the focus of the document on key issues as explained in Section 1.2, so that the EIA can be used as a decision-making tool.

Table 8.1-1 uses coloured shading to indicate the different levels of significance (high and low) of both positive and negative impacts. This simple mechanism enables mitigation priorities to be readily identified, with the first priority being action to address impacts that could be highly negative (red), the second priority action to address impacts that could be negative (yellow) and the third priority being any remaining action (no

Table 8.1-1: Summary of the environmental impacts of the BHP, proposed mitigation, and the priority of each action

Highly Negative | Negative | No Impacts | Positive | Highly Positive

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
Climate		No change in local climate. No effect globally		No mitigation necessary	Generation of electricity by hydropower instead of by thermal or diesel fuel stations will greatly reduce CO_2 emissions	Will contribute to reducing global climate change by reducing CO_2 emissions and maintaining Sierra Leone's positive carbon balance	No mitigation necessary
Hydrology	Above dam	Impoundment is likely to begin in Jan 2006 and continue for several months. Slow flowing dry season river will gradually become a lake	Changes will only affect the reservoir area, which is relatively small. Hydrology upstream of Yiben will be unaltered	No mitigation necessary	A river with wide seasonal changes in flow will become a lake, with a surface area of 21 km^2.	Will only affect a river length of 30 km. Hydrology upstream of Yiben will be unaltered.	No mitigation necessary
	Downstream	As the reservoir is filling a minimum downstream environmental flow of 6 m^3/s will be maintained in dry season, and 100 m^3/s in Sept-Nov. Flows will vary in the final 2 months of impoundment as the scheme is tested (Commissioning).	Downstream flow will maintain natural dry season conditions and provide rainy season flow of less than the average monthly maximum flow (350 m^3/s) if the reservoir is filled in Sept-Nov. An operational rule will be introduced to prevent sudden flow changes during commissioning.	Proposed actions should avoid downstream impacts on hydrology, ecology, human users and other factors. No further mitigation is necessary.	Increased dry season flow (Jan-May) from 6-20 m^3/s to 33 m^3/s. Below normal flow in June-Aug as reservoir refills, delaying flood conditions by 5 weeks. Possible reductions in flow (evening/weekend) to retain water for times of peak demand.	Increases in dry season flow will be beneficial by avoiding severe reductions in river area that occur naturally. Rainy season impacts will not be significant as peak flood flows (Sept-Nov) and downstream inundation will not change. 5-week reduction in onset is also not of major importance with respect to hydrology. Unlikely to be any impact in estuary as changes will be masked by normal flows from the many tributaries downstream	No mitigation necessary
Sediment Load and Channel Morphology	Above dam	River sediment will be retained by dam once impoundment begins	Only small amounts will be retained during the short filling period.	No mitigation necessary	Most sediment in the river upstream will be retained by the dam	Data suggest that sediment carried by the river has increased, so sediment retention in the reservoir could be an important issue.	Will be investigated further by water quality and sedimentation studies and mitigated by improved land management in catchment.
	Downstream	Excavation of riverbed for 300 m below the dam to create the profile necessary to allow safe passage of peak flood flows. Addition of riprap and gabions to protect	Disturbed material could be carried downstream by river flow, but this will be a temporary impact and is thus not greatly significant.		Reduced sediment load will not cause erosion downstream because most flows will not be strong enough to mobilise mainly coarse sediments. May be some erosion in	Erosion and downstream deposition during extreme floods will be infrequent and will decrease with distance downstream because sediment carried by tributaries will provide the normal base load. Any changes in channel will therefore	No mitigation necessary

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
		riverbanks.			extreme floods.	be small and not significant	
Mineral Resources		Farmers pan for gold in the river to supplement income and will be unable to do so as reservoir fills.	Not a major issue during the relatively short period of reservoir filling.	No mitigation necessary in this phase.	Alluvial gold is found on the river bed so panning will not be possible in the reservoir.	Some people will move up- and down-stream to continue panning. However journeys will be too far for people living near the reservoir centre so incomes will be reduced.	Affected people will be included in measures implemented through the RAP to stimulate small business enterprises (crafts, tourism, local services) as alternative livelihood means
Geology	Above dam	Landslips could occur during reservoir filling from soil wetting and lubrication	Landslips are unlikely as reservoir will fill gradually (in dry season) so soils will adjust to changing hydraulic conditions	Reservoir slopes will be monitored during impoundment for early detection of earth movements	Landslips could occur from wave action or by increased pore pressure in fractured rocks during the annual drawdown.	Unlikely to be a major issue as reservoir shape will reduce wave incidence, and drawdown will be gradual not sudden.	Forest will be planted in a 100 m strip along the reservoir border to retain soil.
Seismicity		Little potential for impoundment to induce seismicity because dam is in a stable area with no tectonic structures showing recent activity.	No significant impacts.	Seismograph will be installed near dam to detect any variations in background seismicity to allow remedial action.		No impact	No further mitigation necessary over the longer term.
Agriculture, Soil and Land Use	Above dam	Small-scale changes in land use as remaining buildings, access roads, etc are constructed. Gradual inundation and loss of cultivated and fallow land within reservoir area as impoundment progresses. Likely increase in clearing and agriculture on upper slopes as a result.	No significant impacts as all new structures etc will be within footprint of existing scheme See columns 6 and 7 (right) for impacts of impoundment		Loss of cultivated (250 ha) and fallow land beneath reservoir. Increased forest clearance on slopes above reservoir as farmers move uphill. Loss of soil from deforested areas and reduction in soil fertility. Improved transport of produce to market by reservoir boats.	Loss of land is not significant in terms of agriculture, as affected farmers will be provided with alternative land on which they can continue to farm. However this land is likely to be acquired from existing farmers, increasing the pressure on land by reducing fallow periods, exacerbating existing problems of poor soil fertility and erosion of soil from hillslopes.	Land management and agricultural practices in the immediate catchment will be improved by the creation of a Bumbuna Watershed Management Authority (BWMA), who will prepare and implement a Water and Land Management Strategy and Action Plan. This includes measures to reduce soil erosion and improve soil conservation, fertility and productivity.
	Downstream	No change in existing situation	No impact	No mitigation necessary	Agriculture could expand if some of the increased, reliable river flow is used for irrigation. 20,000 ha of land could be supplied (if controlled).	Potential benefit from an expanded agricultural sector, providing sufficient water remains in the river at all times to maintain a healthy ecology and fishery.	No mitigation necessary
Water Supply	Above dam	No change, as where communities use river			Reservoir will increase availability of untreated	Minor benefit	A community education campaign will be

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
		water for domestic supply this is taken from streams, not the main river			water for domestic purposes		implemented to increase awareness of the risks of drinking untreated water and the benefits of simple treatment, eg by boiling.
	Downstream	Variations in availability of river water during commissioning	Provision of a minimum environmental flow should ensure that water continues to be available for downstream users	No mitigation necessary	Increased dry season flow will increase availability of water for domestic use	Minor benefit	No mitigation necessary
Groundwater	Upstream	Water table will gradually rise in vicinity of reservoir as impoundment proceeds.	No impact on water supply or agriculture as villages will be relocated and new wells and farms will be established at the new sites.	No mitigation necessary	Water table will be higher in vicinity of reservoir	Water supply from new wells in the vicinity could reduce in the dry season as reservoir level drops.	RAP requires that resettled communities are provided with water supplies. Prior investigation will ensure that these are not affected by variations in reservoir.
	Downstream	Environmental flow should ensure that groundwater downstream is not affected	No impact	No mitigation necessary	Increased dry season flow may prevent some swamps from seasonal drying	Not significant with respect to groundwater	No mitigation necessary
Water Quality	Upstream	Poor quality (low oxygen, high BOD and nutrients) from decay of terrestrial vegetation in reservoir and organic matter in flooded soil.	Temporary impact, but could hinder development of aquatic ecology and fishery in reservoir.	Large vegetation will be removed from reservoir area before impounding. Water quality will be monitored and further action taken if necessary.	Because of its shape and lack of water movement the reservoir is likely to become stratified, with a large lower layer, devoid of oxygen because of a lack of mixing.	This could be highly negative as it will limit the development of ecology and the fishery in the reservoir and discharge poor quality water downstream, again limiting the development of ecology and fisheries.	The Dam Safety Panel do not consider that the reservoir will stratify, so a limnological study will be carried out to confirm this, and to determine the most suitable method of artificially circulating the water if necessary. This will then be installed in the reservoir.
	Downstream	Excavation of riverbed and provision of concrete & riprap bank protection downstream of dam could wash soil and other materials into river. Water released from reservoir will be poor in quality because of	Spills of fuels, cement etc could be toxic for aquatic organisms and human users. Increased sediment could affect aquatic plants and animals and make water unsuitable for human use Not of major significance as impact will be temporary and agitation of water by	Spills will be prevented by safe use and storage of materials on site. Excavation and construction in the river will be carried out in the dry season to reduce entry of sediment into water	Improved quality river water as dam will retain suspended sediment	Benefit for aquatic ecology and human users of river water	No mitigation necessary

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
		decaying vegetation.	Bumbuna Falls will raise oxygen level in rainy season	and transportation downstream			
Primates		Chimpanzees and other primates could be stranded in trees as reservoir fills.	Unlikely to be significant as impoundment is likely to occur mainly in the dry season, so water levels will rise slowly and chimpanzees will probably move gradually to higher ground in response.	Removal of trees from reservoir area to maintain water quality will avoid any possibility of chimpanzees being stranded by rising water.	Although the patchy forest mosaic in reservoir is not ideal habitat for chimps, it probably supports several communities at certain times of the year. Loss of these areas will force chimps to move elsewhere to land that will come under further pressure from farmers also displaced from reservoir.	Highly negative impact as chimps are a protected and endangered species. Habitat which several groups use will be lost, and chimps will be forced to move to other areas where they will come into conflict with humans and primates already inhabiting these areas.	Surveys will be carried out for 1 year to determine the number, size and status of all chimp communities in reservoir area. Then mitigation specific to each group will be planned and implemented. This could include: establishing forest ridge as a protected area; reforesting other areas nearby; protecting and maintaining similar habitat elsewhere in Sierra Leone.
Other Terrestrial Fauna		Some animals inhabiting the reservoir area will drown as the area is inundated and others will be exposed to increased predation (including hunting) as they move up the hillside as the impounded water rises.	This could be significant, as it may include rare and endangered primates and duikers, plus many other species.	Vegetation will be removed from the reservoir area systematically before impoundment (S to N; valley floor to upper slopes) so animals will move away in response to the disturbance. Hunting will be banned during this exercise.	Riparian forest alongside Seli River will be lost, causing habitat squeeze as primates, duikers and other animals have to move to other areas. New water body would allow populations of aquatic and semi aquatic amphibians, reptiles, mammals and birds to expand	Negative impact, but not highly significant as these habitats are small, so small numbers of animals will be affected. This can be mitigated by improved land management to increase and improve forest habitat (see below). The reservoir will increase the numbers and diversity of aquatic life, which will be of benefit to the environment and the community Further field surveys to collect baseline data on primates, birds, butterflies, reptiles, amphibians, small mammals and bats will be conducted, as required by ESAP. Work done to date suggests that it is unlikely that riparian forest in the reservoir area supports significant endemic, endangered or otherwise special species or populations.	Conservation of these species will be improved by the BWMA implementing the Water and Land Management Strategy and Action Plan. This contains measures to: strengthen protection of all remaining forest via community education; raise awareness of effects of hunting and bushmeat consumption; establish a protected area in the immediate catchment; extend community based arms collection
Terrestrial Flora					Riparian forest in the Upper Seli catchment is probably the most northerly remaining area	Although riparian forest exists as a strip only 10-25 m wide along riverbanks, given its reduction over the whole of Sierra Leone and	The Water and Land Management Strategy and Action Plan includes measures to compensate for

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
					of Upper Guinean Rainforest. Part of this will be lost, together with other closed moist forest and forest regrowth as resettled farmers clear new land.	elsewhere, this loss would be highly significant. Further field surveys to collect baseline data on trees and other plants will be conducted, as required by ESAP.	these losses. These are to: protect remaining riparian forest in the Upper Seli catchment by raising awareness; set up a fund and promote community forests & reforestation-afforestation programmes; allow plants to regenerate in Bumbuna quarry; establish funding to implement the National Biodiversity Strategy & Action Plan to safeguard critical habitats elsewhere in Sierra Leone
Forest		Clearing vegetation from reservoir will remove 1570 ha of forest, including 380 ha of riparian and 450 ha of mixed tree savannah, including commercially valuable trees with trunk volume of >500,000 m^3.	Loss of timber will have a negative impact on local communities who use the resource for fuel, building, manufacture, etc.	The Contractor appointed to clear vegetation from the reservoir before impoundment will be required to employ local labour and provide timber to the community free of charge.	Loss of vegetation in reservoir will increase pressure on remaining tree and forest resources in the catchment, causing further loss of soil and land degradation.	Loss of forest within and outside the reservoir would be significant in an area in which the resource is already greatly depleted. Associated soil loss and land degradation would exacerbate existing problems.	The Water and Land Management Strategy and Action Plan will compensate for losses by initiating community forestry in the immediate catchment to manage existing forest and promote reforestation and afforestation.
Catchment Management					Increased conversion of forest to cultivated land by resettled farmers, particularly on hillslopes, will increase soil erosion and further reduce soil fertility	Further soil degradation could be very significant because as well as reducing agricultural productivity, any increased sediment carried by rivers upstream will increase the sediment retained by the reservoir.	The Water and Land Management Strategy will address these and other problems caused by inappropriate land use and management practices (see above)
Aquatic Ecology	Upstream	If terrestrial vegetation is not removed, poor water quality will severely limit the ecology of the lake, as few organisms will survive in conditions of low oxygen. If vegetation is removed, lake flora and fauna will	If vegetation were not removed ecological impacts would be very negative as it would prevent development of a healthy ecology and fishery. Removal of vegetation will allow the development of	As much vegetation as possible will be removed from the reservoir area before impoundment.	Action will be taken to prevent stratification of the water column if necessary, and as water quality stabilises, a slightly impoverished lake community will develop (eg the periodic drying of reservoir edges	Reservoir will have positive impacts by providing a lake habitat in an area where no lakes exist naturally. Benefits could increase if fish populations developed enough to support viable fisheries. The dam will not significantly affect fish migration, as Bumbuna Falls prevents migration beyond this	The water column will be artificially mixed if necessary, and this will ensure positive impacts by allowing aquatic communities including fish to develop. The Water and Land Management Strategy will enhance beneficial

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
		develop gradually, with initial population fluctuations, as washout of organic matter from soil will cause eutrophic conditions.	new aquatic habitats and communities. This will be a positive impact.		will prevent significant growth of attached macrophytes).	point. Further field surveys to collect baseline data on fish and their habitats will be conducted, as required by ESAP. Work done to date suggests that no endemic, endangered or otherwise special species or populations will be found	impacts by monitoring development of aquatic communities and managing the reservoir to develop fisheries plus habitats and organisms (eg birds) to attract tourists. BWMA will provide equipment and training to local people for reservoir fishing.
	Downstream	Excavation of riverbed and provision of bank protection downstream of dam will remove flora and fauna. Downstream flora and fauna could also be affected by sediment and spilled materials if they enter water. Downstream aquatic ecology will not change greatly during reservoir filling as environmental flows will be the minimum natural flow in dry season (6 m^3/s), and discharges during commissioning will be similar to those that occur naturally at the same time of year (in the early rains). The flora and fauna should therefore not experience unusual harsh conditions.	Direct losses by excavation will affect a relatively small area and thus be of little significance. Depending on quantities spilled and toxicity of materials, site spillages could have more damaging impacts over a wider area No significant impacts on most aquatic flora and fauna during reservoir filling.	Spills will be prevented by safe use and storage of materials on site and work will be carried out in the dry season to reduce entry of sediment into water and transportation downstream.	Increased dry season flow should allow plants and animals to inhabit river margins permanently, so habitat and populations will increase. Fish reproduction could be disrupted by the less-than-normal flows in the early rainy season, which could disturb cues in the environment that stimulate gonad development and spawning migrations.	If plants and animals establish permanent communities at river margins this will be a significant increase in habitat and populations. This will include fish so catches and incomes could increase. This will not occur however if reservoir discharges reduce significantly at evenings or weekends to retain water. Reduced breeding success in fish could be highly negative in terms of ecology, biodiversity, the fishery and the community, if it caused populations to decline. These changes would probably not be significant in the estuary where flow from upstream of the dam is a relatively minor component of the total volume. Further field surveys to collect baseline data on fish and their habitats will be conducted, as required by ESAP. Work done to date suggests that no endemic, endangered or otherwise special species or populations will be found	Studies will be conducted to devise an operating rule that maintains a downstream flow sufficient to cover the whole riverbed at all times. Downstream fish populations and catches will be monitored during 1st year of operation, and the BHP operator will compensate fishers if breeding, catches and income are reduced. An ichthyological survey will determine whether the river supports rare or endemic species, so that conservation measures can be devised if necessary.
Socio-economics	Dam and Reservoir	Some employment opportunities for local unskilled labour during	Small scale socio-economic benefits from increases in income in the local	See column 8	Permanent inundation and loss of 1 village housing an estimated 135	This would be a very highly negative impact if affected people were not resettled, as one village	A Dam and Reservoir Area Resettlement Action Plan has been prepared, which

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
		2005 when the remaining construction is completed. Gradual inundation of farmland, houses and other areas and assets. Current estimates indicate that 1 village will be inundated completely and 26 others will lose land in the reservoir area, located below FSL	community See column 7		people. Loss of assets in 26 other villages (farmland, crops, timber and fruit trees, village land, footpaths, etc). An estimated 3648 people in 499 households will lose between 20 and 60% of their land. The BHP will provide electricity to several major towns and substantial parts of Freetown, inhabited by upwards of two million people.	would be destroyed, 135 people would lose their homes, and 3648 others would lose land and assets. Living conditions will improve significantly for those people who receive and are able to afford the new supply of electricity.	will provide new housing, farmland and other facilities (schools, markets, etc) at an alternative location (to be determined), and includes assistance with alternative livelihood strategies in agriculture, fisheries, etc. This will be agreed with the communities, who will then be resettled.
	Transmission Line Route	Displacement of people inhabiting land along the Transmission Line, to allow access for reconstruction and avoid potential health and safety impacts to people living near the transmission line. Currently 4168 persons, in 367 households are located in the 30 m wide Right of Way and 35% of these fall within the Exclusion Zone so will need to be relocated.	This would be a very highly negative impact if affected people were not resettled, as significant numbers of people would be displaced and denied acces to their homes, farms and other assets.	A Transmission Line Resettlement Action Plan has been prepared, through which PAPs will be provided with land outside the ROW and financial and technical assistance which they may use to construct improved housing. Financial compensation will also be provided for loss of assets.	The BHP will provide electricity to several major towns and substantial parts of Freetown, inhabited by upwards of two million people.	Living conditions will improve significantly for those people who receive and are able to afford the new supply of electricity.	Alternatives to relocation are also being actively considered where appropriate, including re-routing parts of the line to avoid areas of major inhabitation, and raising electricity pylons so that electromagnetic fields do not impinge upon people at ground level. If implemented this would reduce considerably the number of people to be resettled.
Culture, History, Archaeology	Dam and Reservoir	Gradual inundation of sacred shrines, other sites and artefacts, plus any archaeological material.	See column 7	See column 8	Inundation and loss of sacred shrines, other sites and artefacts, and loss of access to any as yet undiscovered archaeological sites or material.	This would be a highly negative impact if no preventative action were taken, as such sites are of considerable cultural and religious importance and their destruction could affect people psychologically and in other ways, and cause dissatisfaction and social unrest	Through the RAP, affected communities will be provided with financial compensation for loss of sacred sites, and they will be able to hold ceremonies to relocate sites and artefacts to the new village sites. Recent archaeological

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
							surveys were constrained by the density of the vegetation and soil and other conditions in the rains, so additional surveys will be carried out in the dry season when the land is cleared of vegetation, to determine the area's full archaeological potential.
	Transmission Line Route	If people are resettled to sites outside the ROW they will still be able to visit sacred shrines and other sites and artefacts within the ROW. Re-stringing the towers will not involve significant ground disturbance, so there should be no damage to any undiscovered archaeological material	No impact	No mitigation necessary	In the long-term, resettled people will probably establish new sacred sites near their new houses, so visits to sites in the ROW will probably diminish.	No impact	No mitigation necessary
Tourism and Recreation	Dam and Reservoir	Bumbuna Falls would experience variable flows during Commissioning	Not a significant impact as Bumbuna Falls is not a major tourism site, and there are no other sites of tourism interest in the study area	No mitigation necessary	Bumbuna Falls will receive increased river flows in the dry season, and reduced wet season flow in July-August. BHP will create new features of potential tourism interest including the dam and reservoir and possible nature reserve to protect chimp habitat.	Increased dry season flow will extend the period in which Bumbuna Falls is an attractive waterfall. This plus the other water and landscape features (reservoir and dam) could create socio-economic benefits for the local community if action was taken to stimulate tourist interest in the area.	The BWMA will encourage and fund tourism initiatives by the local community (including provision of accommodation and infrastructure) to increase visitor numbers and provide new revenue for the community.
	Transmission Line Route	No sites with any tourism potential along ROW	No impact	No mitigation necessary		No impact	No mitigation necessary
Public Health	Dam and Reservoir	The fast flowing river will gradually change to a relatively static and expanding water body as impoundment proceeds.	30 km of fast flowing river that was suitable for egg laying by blackfly will be lost. This will be a positive impact, as it will prevent	See Column 8 (right) for mitigation of increased incidence of malaria.	Permanent loss of 30 km of fast flowing water suitable for egg laying by blackfly. Creation of a small area of new similar	The permanent removal of blackfly habitat will be a highly significant benefit as it will reduce the incidence of river blindness in the community. The small increase in	A health protection programme will be implemented in the immediate catchment through the Upper Seli

		REMAINING CONSTRUCTION & PRE-OPERATION			OPERATION		
Issue	**Location**	**Impact**	**Significance**	**Mitigation[1]**	**Impact**	**Significance**	**Mitigation[1]**
			new incidents of river blindness. However the edges of the filling reservoir may be suitable for mosquito breeding so there could be a short-term increase in the incidence of malaria during impoundment.		habitat at the power station outlet (through which water will flow rapidly). The reservoir will also provide new areas that are suitable for mosquito larvae, at the edges, and particularly in pools that will form during drawdown periods. The presence of a lake may result in more people coming into contact with slow moving water.	habitat at the discharge point is not significant in comparison, but action should be taken to protect workers and the community from Onchocerciasis. An increase in the mosquito population will be highly negative as it will increase the incidence of malaria. Increased contact with slow moving water by swimming, bathing, washing clothes, etc, may increase both urinary and intestinal Schistosomiasis, especially the latter. This would be a significant negative impact	Development Initiative, with additional support from the BHP operator and BWMA. This will include: functioning and well equipped and staffed health centres providing free healthcare; identification and removal by flattening or improved drainage of all pools of standing water in the draw down area; public education on water borne diseases and prevention of infection; action to break the parasite-host cycle including removal of aquatic vectors and public health treatment (this will cover all main diseases, including Schistosomiasis, Onchocerciasis & Malaria)
	Transmission Line Route	Remaining construction and pre-operational testing will not affect river flow or drainage of swamps	No impact	No mitigation necessary	People living beneath the transmission lines may be exposed to electromagnetic radiation, about which there are human health concerns.	As yet there is no widespread agreement on whether electric and electromagnetic fields cause cancer and other health problems in humans as has been claimed. These would be highly negative impacts, if they occurred so irrespective of whether or not they are likely, mitigation should be implemented	Implementation of the RAP to resettle people from the Transmission Line will avoid potential or actual impacts on human health and reassure the public as to the safety of the BHP. Alternative action is also being considered, such as raising pylons so that electromagnetic radiation is not significant at ground level.

[1] All mitigation measures have been discussed and agreed with the PIU and the World Bank and will be implemented as described in this table and the accompanying text (Chapter 8). All measures are included in the Environmental Management Plan (Chapter 13).

colour). Many of the measures relate to improving the management of land and water in the Upper Seli catchment and also in the Seli/Rokel basin as a whole, and the proposed mechanism for managing these activities is discussed in Sections 8.7-8.9.

8.2 Remaining Construction

Given that construction of BHP was 85% complete when the project was suspended in 1997, then most of the impacts of the construction process (such as loss of habitats and displacement of people at the dam site) have already occurred. Appendix O shows the programme for the remaining construction work, which indicates that the majority will be completed in 2005. The main activities are summarised in Table 8.2-1.

Table 8.2-1 Summary of the main remaining construction activities

Activity	Main Works	Brief Description
Dam works and slope protection	• Construction of dam embankment	Excavation of rock from quarry, transport to site on trucks, tipping into random fill zone
	• Completion of asphaltic concrete facing	Milling of existing weathered material, application of impervious layer and sealing coat
	• Stabilising & finishing dam crest road	Excavation of foundations and drains along dam crest, application of rockfill, concrete and paving, erection of guard rails, etc
	• Protection of river bed and dam slopes on left and right bank	Excavation of riverbed 300 m downstream; installation of gabions, reno mattresses, rockfill, rip rap, concrete along river banks
	• Protection of spillways	Installation of floating barrier upstream
Left and right tunnels and river diversion	• Completion of spillways, outlet structures, ski jumps, radial gate (right tunnel)	Application of concrete to form plugs and other structures
	• Concrete repair works to damaged areas	Repair by application of concrete
Intake tower	• Installation of screens, water level metering, gate operation rooms	Provision and set up of equipment and meters
	• Ancillary works	Concrete and other building work, including use of structural steel and metal components
Power house	• Completion of buildings for machine hall, diesel generators, switchyard	Earthworks, rockfill, concrete and block-works
	• Finishing access road and yard	Application of chippings and bitumen
Electromechanical equipment	• Completion of gantry crane, butterfly valves, turbines, generators	Provision and set up of mechanical and electrical equipment, meters, etc
	• Installation of control and ancillary equipment	
Transmission Line and Substation	• Re-erection of at least 29 towers	Concreting to repair foundations if necessary; replacement of metal structures
	• Re-stringing entire transmission line	Replacement of electrical cables
	• Re-routing certain sections	Excavation, concreting new foundations, building metal pylons and stringing cables
Staffing	• A maximum of 45 expatriates and 200 skilled and 200 unskilled Sierra Leoneans will be employed in early 2005	Expatriates will live in the existing Salcost camp and local staff will be recruited from surrounding villages, so will live at home or in rented accommodation in Bumbuna

Source: DRP (2004)

This shows that activities at the dam and reservoir site are mainly small in scale, involving repair of equipment and structures damaged in the civil war, completion of structures that had not been finished when work ceased in 1997 (such as the dam crest road), and provision or replacement of items of mechanical and electrical equipment.

Activities such as installation of equipment and repair of damage will not cause significant impacts because they are small in scale, involve little in the way of machinery (including delivery, which will require few lorry journeys), and occur in areas where buildings and other structures have already been built. Even creation of the dam embankment, crest road, and power house and other new buildings will not have major impacts because the structures are in the existing footprint of the scheme, and involve relatively small-scale construction, requiring few materials, certainly compared with the amounts used in construction of the dam. Materials will be obtained from existing sources (such as the previous site quarry), and will be transported along site roads, so will not pass close to inhabited areas.

The only exception is the construction in the riverbed and along the banks downstream of the dam to create the plunge pool, ski jump and bank-side protection. This is larger in scale and invasive, with the potential to affect the ecology of the river, the quality of water, and the morphology of the channel. These aspects are discussed in Sections 8.5 and 8.6 below, and the Transmission Line impacts shown in Table 8.2-1 are discussed in Chapter 10.

8.3 Positive Impacts

Table 8.1-1 shows that construction, and particularly operation of the BHP, will produce a number of major benefits locally and nationally, by improving the social conditions of people who are supplied with and can afford the new reliable source of electricity, and improving livelihoods and health in the Bumbuna area by providing employment and reducing the incidence of certain river-borne diseases. These are discussed with other impacts on the human environment in Chapter 9 below.

Positive impacts on the natural environment include expanding the coverage and diversity of aquatic habitats upstream and downstream, and potentially providing a major new fishery in the reservoir, and these and other benefits are discussed in the remainder of this chapter below. The other major positive impact is the contribution that Sierra Leone will make to reducing global greenhouse gas emissions by adopting hydropower as its main means of electricity generation instead of the present inefficient and largely ineffective system of thermal generation powered by diesel fuel.

As explained in Appendix D.3, a fossil fuelled power station generates carbon dioxide throughout is operational life in quantities proportional to its electrical power output. CO_2 is the major greenhouse gas, so the adoption of alternative methods of energy generation is one of the principal methods of reducing global warming. This is tempered somewhat in schemes where land is flooded to create a reservoir, because decomposition in the sediment and anoxic lower parts of the water column is anaerobic, liberating CO_2 and methane, the latter being an even more significant greenhouse gas.

Appendix D.3 calculates that the BHP reservoir will emit approximately 2.1 and 2.2 tonnes/day of CO_2 and methane respectively, which equates to 48 tonnes/day of CO_2 equivalents (17,000 tonnes/year), as methane is 21 times more effective at absorbing long wave infra-red radiation. Compared with CO_2 emissions of 180,000 tonnes per year from an equivalent thermal power station, the BHP scheme driven by the reservoir thus shows a net annual 'saving' of around 163,000 tonnes of carbon dioxide.

8.4 Minor Impacts

As well as the major issues identified in Sections 8.1 and 8.3 above and discussed in Sections 8.5-8.13 below, Table 8.1-1 shows that there are a number of other impacts that are less significant, where impacts can be mitigated by straightforward measures, or where there will be no impacts, so no mitigation is required. Although these are not critical components of the decision-making process they are integral to the environmental assessment, as they indicate those fields that will not be affected by the scheme. They thus need to be recognised, and are described below.

8.4.1 Climate

As noted above the activities involved in completing construction are all very small-scale and localised, and do not involve significant changes in the landscape, emissions to the atmosphere, or other actions that could influence the climate of the area. Creation of the reservoir is also unlikely to change the climate during the pre-operation period, which at most will last 2-3 months if impoundment occurs in the dry season.

When the BHP is operating, the presence of a large water body, which changes temperature more slowly than the surrounding air, could influence climate in the vicinity by moderating air temperatures. Temperatures might thus be slightly lower than elsewhere in the dry season and slightly higher in the rains, this being similar to the way in which the sea modifies the climate at the coast. However because the

reservoir is so small in comparison, any such changes will be very small, and might not even be noticed by local inhabitants. They should however benefit from a cooling breeze blowing across the water surface, particularly when temperatures fall at night.

8.4.2 Hydrology

The hydrology of the area immediately upstream of the dam will change quite dramatically during impoundment. If this occurs in the dry season as planned, the river will be flowing slowly at an average of around 6-20 m^3/s (see Figure 8.8-1 below) in a narrow channel in the bed. Once impoundment begins the water body will gradually expand, to eventually form a large lake. Although this will be a major change in this area, it will only affect 30 km of the river, which overall is more than 300 km in length from the source to the mouth.

When the BHP is operating the hydrology upstream of the reservoir will be unaltered, and hydrology downstream will be modified as described in Section 8.8. Considering hydrology alone these changes are only significant locally and should therefore not require mitigation beyond that already provided by the reservoir operating rules to maintain downstream flow, described below.

8.4.3 Mineral Resources

People routinely pan for gold in the Seli/Rokel and in other rivers in the north and east of Sierra Leone, to supplement their income from farming. This occurs mainly in the dry season when more of the riverbed is accessible, and when income is at a seasonal low before the onset of the rains provides new produce. These activities will become more difficult in the reservoir area as the river expands, and will be impossible once the water level rises above the normal river channel, as it is the long-term action of the river on the bed substrate that reveals the mineral deposits.

As the reservoir will be 30 km in length and located in an area that is sparsely populated, then the fact that this area will not be suitable for alluvial panning when the BHP is operating will affect relatively few people. However those that are affected could experience hardship if this source of income is removed, so this will need to be ameliorated. Chapter 9 discusses measures included in the Reservoir RAP to provide alternative livelihoods for PAPs, through encouraging small business enterprises in tourism, traditional crafts, service provision such as blacksmithing, boat transport across the reservoir, etc. Farmers and their families who rely on seasonal mineral exploitation as a supplementary source of income will be included in these activities.

8.4.4 Geology

Once the topography, geology and other physical characteristics of an area have been confirmed as suitable for the retention of a large body of water behind a dam, the main geological issue is the likelihood of occurrence of landslips. These can affect surrounding hillsides where soil is lubricated by the elevated water table, and can have catastrophic consequences if they occur near the dam, causing the structure to fail. Such events are generally associated with sudden changes in water depth, such as may occur during extreme floods or rapid dry season drawdown, where pressure in the soil and rocks becomes unbalanced, generating movements in weak areas.

Avoidance of these conditions is a key element in reservoir design and operational planning, and they have already been taken into account in the BHP scheme. Hydraulic changes will be gradual, both during first filling and during annual drawdown in the dry season, so there will be no sudden changes in pressure, and conditions in the underlying and surrounding soils and rocks will adjust gradually. The capacity of the spillways to discharge floodwaters downstream when the reservoir is at its full operating level, will avoid sudden changes in the rainy season. To prevent excessive soil eroding from the steep slopes in the immediate catchment and washing into the reservoir, and to create new riparian forest habitat (see Section 8.7 below), native trees found in these areas at present will be planted in a 100 m wide strip around the entire edge of the reservoir, above FSL.

8.4.5 Seismicity

The ability to withstand seismic events is another very important aspect of dam and reservoir design, and as explained in Section 7.4.2 the BHP dam has been designed to withstand an earthquake with a magnitude of 4.5 on the Richter scale, which is far above the scale of any event recorded in Sierra Leone or the surrounding countries.

Reservoirs can also induce seismicity, primarily from the weight of impounded water acting on tectonic-related faults in the underlying strata. This is highly unlikely in the case of the BHP because Sierra Leone is in one of the least seismically active zones in Africa, and there is no evidence of movement in the underlying West African Craton since the Pre-Cambrian Age, 65 million years ago. Normal precautions involve installation of a seismograph near the dam to detect any variations in background seismicity during and after reservoir filling, and that will be the case here. Checking the stability of the dam is another very important aspect of the commissioning procedures, which allows remedial action to be taken in the unlikely event of instability being detected.

8.4.6 Water Supply

This study and the Reservoir RAP confirmed that many rural communities upstream and downstream of the dam rely on the river as a source of domestic water, either collected daily from the river itself, or piped into communal taps in villages from small streams and tributaries. There is no prior treatment, even before drinking, and there is little appreciation of the health risks, and few alternative supplies, except for a limited use of groundwater via wells, often provided by NGOs.

During reservoir filling there will be little change in the supply of water from the river upstream as the piped systems mainly source water from small upland streams rather than the river itself. There will however be reductions in flow downstream when the reservoir is filled, and variations (increases and decreases) during the subsequent 1-2 month commissioning period when the functioning of the BHP is tested under different operating conditions. However, as explained in Section 8.9.1 below, the ESAP have indicated that there must be a minimum flow of 6 m^3/s in the river downstream at all times, and this should mean that water continues to be available for downstream users.

When the BHP is operating there will be increased supplies of river water available for domestic use both upstream (from the reservoir) and downstream, where discharges resulting from power generation will be greater than the natural flow in the dry season. The scheme will thus provide indirect benefits to these communities. These will be enhanced by a community education programme to increase awareness of the health risks of consuming untreated water, and the benefits of simple treatment methods, such as boiling.

8.4.7 Groundwater

When the reservoir is filled the water table in the vicinity will rise gradually, but this will not have significant effects on agriculture or the supply of water from wells, as inhabitants will be relocated from this area before impoundment begins. Once the BHP is operating the water table in the immediate vicinity will fluctuate seasonally with the level of water in the reservoir, so wells could dry out during the dry season drawdown. If under implementation of the RAP, communities are resettled into areas around the reservoir, studies will be conducted in advance to ensure that water supplies (piped or from wells) are not affected by seasonal changes in reservoir levels.

Downstream there will be no major changes in groundwater because as explained in Sections 8.8 and 8.9, the reservoir operating rules will ensure that there is a flow of water in the river at all times (including during reservoir first filling and the annual

refilling), at rates which are broadly similar to natural flows. When the BHP is operating, flow in the dry season will be greater than the natural flow, which may increase groundwater levels in some places, and could bring ecological and agricultural benefits by preventing the seasonal drying of some swamp areas that occurs each year at present.

8.5 Upstream River Effects and Reservoir Management

8.5.1 Reservoir Formation and BHP Operation

As indicated in Section 3.4 above, under the present construction and testing programme it is likely that impoundment will commence in January 2006 and continue slowly throughout the dry season to avoid sudden surges in flow as occur once the rains begin. The left bank tunnel will be altered to allow the minimum downstream environmental flow required by the ESAP during the filling period, that is a minimum of 6 m^3/sec throughout the dry season, and 100 m^3/s if the programme were delayed and filling occurred during September-November.

The reservoir will begin to form once the gates on the outlet tunnels start to close, and under dry season river flows the water will rise gradually over a period of several months. Once 50% FSL is reached, filling will pause to enable checks for leaks and other aspects to be carried out. Impoundment will then continue to FSL, and during this latter period the generating plant will be commissioned. This will continue for several weeks and could result in variations in downstream flow as the plant is tested under different conditions of head and flow. The BHP will begin to operate shortly after the end of commissioning.

At FSL the reservoir will have a surface area of 21 km^2, and once this level is reached in the rainy season, excess inflow will be discharged downstream through the morning glory spillways. Electricity generation will continue in the dry season, and this will draw the reservoir down around 31 m vertically each year. Refilling will recommence with the onset of the rainy season, and FSL will be reached towards the middle of the year (July-August).

These changes will have a variety of effects on the environment upstream of the dam, of which the most obvious will be the creation of a 21 km^2 lake from a 30 km stretch of relatively fast flowing river, and the inundation of a substantial area of land that supports natural vegetation and wildlife, and is also extensively used for farming. Table 8.1-1 shows that the sectors in which there could be negative impacts are: sediment flow; agriculture, soil and land use; water quality; terrestrial flora and fauna (including primates and forest); catchment management; and aquatic ecology. These

are dealt with in Sections 8.5 - 8.7, and downstream impacts are covered in Sections 8.8 and 8.9.

8.5.2 Water Quality

Appendix I.2 contains the assessment of the likely quality of water in the reservoir during and after impoundment, as presented in the original EIA (Electrowatt/Techsult 1996), and Appendix I.3 contains a technical discussion of the limnological implications of creating the reservoir, prepared for this study.

Results from the various analyses (Table 7.2.8-1) show that water quality in the river is relatively good throughout its length, with the main characteristics being low concentrations of dissolved salts and plant nutrients, relatively high levels of oxygen, and no evidence of pollution by organic matter or other substances. However Appendices I.2 and I.3 show that this will not be the case in the new reservoir, because organic matter in the soil will wash into the water once impoundment begins, and vegetation on the inundated hillslopes will die and biodegrade. The reservoir water will therefore be of poor quality initially, with low levels of oxygen from the mainly aerobic breakdown of vegetation, high values of BOD and COD, and high levels of organic matter, nitrates, phosphates and other nutrients. These conditions will encourage plant growth, so there are likely to be blooms of phytoplankton and possibly also floating macrophytes, the death of which as conditions change, will add further to the organic and nutrient loading.

If filling occurs in the dry season there will be no large inputs of fresh water to dilute the nutrients and increase oxygen, and little water movement to create vertical mixing. The water column will therefore become stratified, and lower levels where the decaying material collects will become devoid of oxygen. Given the density of the vegetation and the fact that it includes large mature trees, it could take several years for a “normal” water quality to become established.

The limnological study in Appendix I.3 suggests that the mature reservoir will also be stratified because the elongated shape means that the momentum of inflowing water will be dissipated rapidly, and little energy will be imparted by wind action on the surface. There will thus be insufficient water movement to counter the heating effect of the sun, which inhibits vertical mixing by warming the upper layers. The upper epilimnion will therefore be well oxygenated, with probably normal levels of nutrients and other constituents. However dead material will sink to the bed, so the hypolimnion will be anoxic because of the decay processes, and because oxygen is not replenished from above. This will have implications for the development of the ecology (and fishery) of the reservoir, and for the maintenance of aquatic ecology

downstream, given that the discharge outlet is a few metres from the reservoir bed, and is thus in the hypolimnion.

Clearly action is necessary both during impoundment and when the BHP is operating, to maintain the quality of the reservoir water, and of the water flowing downstream. The high levels of nutrients and organic matter and the likely anoxia of the water in the initial period are mainly related to the presence of large amounts of terrestrial vegetation on the inundated hillslopes. This will therefore be avoided by removing as much vegetation as possible before impoundment begins, concentrating on trees, as these take much longer to decay than grasses and shrubs. A contractor will be appointed for this purpose, and will be required to employ local people in the workforce and to provide the resulting timber to neighbouring communities free of charge, for domestic and community use, or for onward sale. These actions will help to compensate for the disruption of relocation, and reduce the pressure on natural habitats somewhat, by delaying the collection of wood in the resettlement areas.

As explained in Appendix I.3, the reservoir is likely to become stratified, so the water will probably need to be mixed to maintain water quality. A free air mixing system is the most appropriate method, which involves anchoring a horizontal perforated pipe to the bed of the reservoir, connected to a supply of air from a compressor at the surface. As the air bubbles rise they draw in water from the surrounding area, which sets up large counter-rotating cells in the adjacent water column. If the pipework was set up in the dry before impoundment begins this would provide a simple and inexpensive means of preventing stratification and maintaining water quality, which has been widely used in reservoirs elsewhere. The Operator monitors water temperature and oxygen each week to determine whether stratification and de-oxygenation are developing, and an operating rule requires the compressor to be switched on whenever there is a 1°C difference between the surface and bed.

The ESAP require limnological studies to be conducted before any such system is considered, to confirm that the reservoir is likely to become stratified. This will be carried out in March-May 2005 and will involve:

- Desk studies of the many lakes and reservoirs in tropical latitudes in which thermal stratification has occurred, and to obtain typical BOD values for green vegetation and soil organic matter;
- Analysis of LIDAR survey data to produce valley cross section profiles along the reservoir;
- Analysis of climatological data to determine solar radiation input, air temperatures and wind velocities;

- Site visit to confirm physical conditions around the reservoir and examine the nature of the bed;
- Estimation of the risk of thermal stratification and hypolimnetic oxygen consumption rates.
- If these studies confirm that stratification is likely and artificial mixing is necessary to maintain water quality, systems used at reservoirs elsewhere (as described in Appendix I.3) will be reviewed and the most appropriate will be recommended. The system will then be installed prior to impoundment.

8.5.3 Aquatic Ecology

Once the reservoir begins to form after the initial impoundment, organisms inhabiting the river will move into the newly inundated areas along the sides of the reservoir or in the deepening water column. Motile animals such as fish, insects, etc will be the first to occupy such areas, and it will take longer for aquatic plants to become established, at the margins and also floating on the surface. As noted in Appendix I.3 there will be an initial period of instability, when populations expand and decline as they adjust to the new conditions; prey species for example may increase in numbers if they occupy new areas where predators are unable to follow.

In normal circumstances this process continues over a sometimes-lengthy period until a stable community is formed in which the populations are at equilibrium with each other and with conditions in the environment. In this case the natural process will be disrupted and the adjustment period extended, as despite the removal of trees and large vegetation before impoundment, water quality will still be poor initially, from the decay of the remaining vegetation, and because organic matter and nutrients will wash out of the soil. This will create eutrophic conditions, in which there will be blooms of phytoplankton and possibly also macroscopic plants, which then reduce oxygen further when they die and decay as the supply of nutrients is exhausted or light penetration is reduced by the density of plant material. These events can have negative impacts on animals, which can be harmed or even killed by toxins released by blooming algae, or by the subsequent reductions in oxygen.

The removal of terrestrial vegetation and provision of artificial mixing if required will reduce the amount of organic matter in the reservoir and promote aerobic decay respectively. Although this will not prevent negative impacts on water quality and the developing ecology, it will ensure that there will be fewer perturbations over a shorter period than if trees were simply left in place to degrade.

Not all river species are able to survive in a lake environment, so the community that develops will be somewhat impoverished, with fewer species than occur in a natural lake. The seasonal drawdown for example will limit the development of aquatic plants in the margins, and there will be few shallow flat areas so species that live in such locations may also be absent. Crocodiles for example are unlikely to survive long-term, as they require shallow sandy areas in which to lay their eggs. Other species may not be able to survive the initial period of organic enrichment and low oxygen as the vegetation decays.

Development of the reservoir fishery is particularly important, as this could provide a significant benefit to local communities by improving both their livelihoods and their health (through improved nutrition). This is a further reason for action to be taken to avoid stratification of the water column, as fish will be unable to survive long-term in an anoxic hypolimnion, so this would prevent the fishery reaching its full potential. The fishery will be managed to enhance its development, and this is a task that will be undertaken by the agency established to improve the management of water and land in the catchment (The Bumbuna Watershed Management Authority, BWMA) as described in Section 8.12 below. Fishery management will not include the artificial introduction of non-native species, which has caused considerable ecological disruption where it has been attempted elsewhere. Instead a fishery study will be conducted (through the BWMA) to plan the development and sustainable exploitation of the fishery, based on naturally occurring fish. Equipment and training will also be provided to local fishers, who will not have fished in a lake before.

The ecology of the reservoir could provide further benefits locally if management measures were introduced to provide habitats and organisms (birds for example) that attract tourists. The BWMA will therefore conduct a study of the developing ecology, including a habitat management feasibility study and planning exercise. If appropriate the BWMA will implement measures recommended by these studies within a wider initiative to assist the community in developing eco-tourism enterprises, which will include important supporting actions such as the provision of suitable accommodation and infrastructure.

8.6 Land Use, Agriculture and Catchment Management

Table 8.6-1 shows the main categories of vegetation and land use in the reservoir area in 1994. This shows that at this time an estimated 12% of the land was under

Table 8.6-1 Vegetation and Land Use in the Reservoir Area in 1994

Land Cover	Area (ha)
Forest regrowth (fallow)	630
Cultivated land	250
Mixed tree savannah	510
Upland savannah grassland	10
Fringing (Riparian) forest	450
River	250
Total	2100

Source: Electrowatt/Techsult 1994

cultivation (250 ha), with the main crops being upland and swamp rice, groundnuts, maize, cassava and sweet potato, and the economic trees palm and kola. A much larger area (630 ha) was in various stages of re-growth, having been left fallow after clearance for previous farming. Estimates on the basis of the surveys in 2004 suggest that there has been approximately a 15% decrease in the amount of riparian forest since 1994 as a result of slash and burn practices, and much of this land is now fallow. These areas will all be inundated and lost once the reservoir fills, but compensation for these impacts will be delivered through the Resettlement Action Plan, whereby affected people will be provided with alternative land in the resettlement area(s) where they will be able to continue farming (Electrowatt-Ekono/Techsult 2004).

However, to avoid further destruction of forest, land for resettled farmers is likely to be acquired from areas that are already farmed or are being left fallow. This will reduce fallow periods and expand the area subjected to current agricultural practices, which involve inadequate ground preparation and few measures to improve fertility or soil conservation. This will exacerbate many of the problems noted in Section 7.2.5 above, and is likely to further degrade land and erode soil, increasing the quantities of soil and nutrients washing into the river.

Natural vegetation will also be lost through inundation in the reservoir area, which in 1994 contained an estimated 1,590 ha of forest re-growth, mixed tree savannah and riparian forest (Table 8.6-1). These areas contribute to the livelihoods of local communities, who rely on the natural and semi-natural forest for firewood, timber, medicinal products, etc. Impacts will again be mitigated by resettling communities into areas where such habitats are available, but this will then increase the damage of natural habitat, with ecological consequences as discussed below.

The BHP will provide electricity to some rural communities, as well as offering a limited amount of new employment. It will also generate other benefits through development of the reservoir fishery, improving transport links across the reservoir, and providing improved living conditions in the relocated communities. With the Sierra Leone economy expected to expand over the next few years, in time socio-economic improvements should reach the rural areas. These developments will increase the pressure on land in the catchment, as population increases and slash and burn agriculture expands, removing yet more natural vegetation, destroying plant material that could fertilize the soil, increasing erosion by replacing trees and shrubs with shallow-rooted crops, and moving agriculture farther up the hillsides to areas with even shallower, less fertile soil. As well as reducing the productivity of land and the agriculture sector and providing farmers with an even smaller income, this would also increase the amount of sediment settling in the reservoir and thus impinge upon the BHP itself.

Rather than being viewed as inevitable consequences of a scheme that will provide major benefits, these impacts and the way in which they are mitigated are being seen by the BHP PIU and the World Bank as an opportunity to manage land and water in the catchment to maintain its benefits and services and allow anthropogenic uses to continue and even expand, in a sustainable way. A Water and Land Management Strategy and Action Plan has therefore been developed, which will be implemented by the Bumbuna Watershed Management Authority, the organisation that will be established to improve the management of land and water in the catchment, and to deliver much of the mitigation identified by this study (see Section 8.12). A key element of the Strategy is implementation by the main stakeholders involved in the use and management of the catchment. This will address negative impacts of slash and burn agriculture and other land uses, and take action to mitigate negative impacts of the BHP and current practices (eg hunting and fishing) that threaten biological resources (wildlife, vegetation, aquatic flora and fauna). This approach will foster a more holistic, integrated and coordinated approach to the management of land, water and their natural resources.

8.7 Terrestrial Fauna and Flora

8.7.1 Chimpanzees

Creation of the reservoir could affect chimpanzees in a very obvious way, as individuals or even groups could drown if they are stranded in trees by the rising water. However the plan to fill the reservoir during the dry season should avoid this, as the water will rise slowly, so chimpanzees (and other animals) should simply move

gradually to higher ground. The removal of trees to maintain water quality will be a further safeguard, as chimps will move away in response to the disturbance, and there should be no strandings in the absence of trees.

A much more significant issue is the inundation and loss of habitat in the impounded area, which as discussed in Section 7.3.1, probably supports chimpanzees at certain times of the year as it contains fruit trees on which they feed, and the surveys in 2004 recorded several chimpanzee groups in the surrounding area above FSL.

World Bank policy (OP 4.04 Annex A) applies the following definitions to natural habitats:

Natural Habitats: areas where (i) the ecosystem's biological communities are formed largely by native plant and animal species, and (ii) human activity has not essentially modified the area's primary ecological functions.

Critical Natural Habitats: existing or proposed protected areas recognised by government or by local communities, or sites identified on supplementary lists prepared by the Bank or by an authoritative source determined by the Regional Environment Division. This can include areas with known high suitability for biodiversity conservation, and sites that are critical for rare, vulnerable, migratory or endangered species.

OP 4.04 states that:

- The Bank does not finance projects that, in its opinion, would involve significant conversion or degradation of critical natural habitats; and

- If a project involves the significant conversion or degradation of natural habitats that the bank determines are not critical, and the Bank determines that there are no feasible alternatives to the project and its siting, and comprehensive analysis demonstrates that the overall benefits from the project substantially outweigh the environmental costs, the Bank may finance the project provided that it incorporates appropriate mitigation measures.

The reservoir area as a whole cannot be considered as critical natural habitat because the vegetation has been greatly altered by man and natural habitats remain as small isolated fragments within an expanse of cultivated and fallow land, and as yet there are no designated or proposed protected areas recognised by the community, the Sierra Leone Government, or the World Bank. The small areas of gallery or riparian forest alongside the river are also not critical habitat as they are not protected,

although they could be considered as natural habitat, despite some disturbance by humans, collecting timber, fuel wood, etc.

The Retrospective Review of the BHP (Haas 2004, Appendix C.2) does not propose suitable alternative methods of power generation or locations, and it can be assumed that these would not be cost effective even if available, as construction of the project was already 85% complete when work ceased in 1997.

The reservoir area therefore does not contain critical natural habitat, but does contain areas of natural habitat, but there are no feasible alternatives to the project or the Bumbuna location. Thus according to OP 4.04 the Bank would be able to support the project, providing that appropriate mitigation for the loss of habitat is provided. Such measures are described below.

Chimpanzees are endangered, and it has recently been proposed that the species should be raised to critically endangered, based on major declines of great apes in Central Africa (Walsh *et al* 2003). Chimpanzees are already under pressure in the Bumbuna immediate catchment, from damage to their habitat by unmanaged farming that has converted the once-forested hillsides to patchy mosaics of forest fragments, cropland and fallow cropland covered with tall grass. This pressure will increase once the reservoir is filled, because as less land is available for human use, farming will increasingly encroach upon the remaining forest fragments, resulting in less useable space for chimpanzees and unavoidable clashes with humans.

Human-wildlife conflict is ubiquitous in primate habitats (Marsh *et al* 2003), and there is good evidence that primates in the immediate catchment are hunted for their meat, and in some cases their skins. Despite claims that few guns are still owned by Sierra Leoneans, the surveys confirmed their continuing use, through spent cartridges, a gunshot, and reports of two recent killings of chimpanzees. More often hunting involves the use of wire snares, of which countless examples were encountered in both riparian and upland forest. When adult primates are killed their young are often taken alive to keep or sell, producing the additional health and sanitation problems of keeping primates as pets.

Conflict with chimpanzees can also affect humans, and there are reports of babies being snatched while mothers tended fields, and of young children being “mugged” by chimpanzees while walking through the forest (Richards 2000). There are no reports of such incidents in the study area, but their likelihood will only increase if humans and chimpanzees are forced to share a shrinking habitat.

The nature of the habitat and the time available for fieldwork did not allow a full examination of the chimpanzees using the reservoir area, so the number, size and social organisation of such groups is not yet known. This needs be determined before mitigation can be planned in detail, as different groups may need to be treated differently. This will require a census over at least a full year, as range and habitat use changes seasonally. The majority of the work will be carried out before impoundment begins, and will involve:

- Analysis of aerial photographs of the immediate catchment from the LIDAR survey to assess the habitat and identify sites for surveys by modified line transects;
- Two field teams working simultaneously on either side of the river, calculating population densities from nest counts after initial determination of decay rates;
- Training survey personnel in census data collection, use of field equipment, health monitoring, and the recording of behavioural observations;
- Establishing a base of operation at the Salcost camp for all survey personnel, with teams working from mobile field camps in the dry season to maximise survey time;
- Implementing an education programme to increase residents' awareness of wildlife and conservation issues.

This work will be conducted from March 2005 to March 2006, and will then be continued for three years after commencement of BHP operation, to determine the impacts of the scheme and the success of mitigation, and to assess whether further measures are necessary. The post-operation work will be integrated into the Water and Land Management Strategy and Action Plan described in Section 8.12, which includes strategic habitat retention and post-development restoration as per World Bank OP 4.04.

Once a full year of information is available from the chimpanzee and other flora and fauna surveys (see Sections 8.7.2 and 8.7.3), mitigation specific to each chimpanzee group will be planned and implemented. Measures will be decided at that time, and could include:

1. Establishing a protected area in the immediate catchment to secure important chimpanzee habitat from further encroachment and offset the loss of habitat at the reservoir site. The suitability, location and dimensions of such an area will be determined by the detailed studies, and it could include the forest ridge near the campsite, where the "Dynamite Community" was seen;

2. Rehabilitation of these and other chimpanzee habitats in the immediate catchment by reforestation, after suitable areas and tree species are identified. This could include planting corridors to join tree patches, working with local people to confer additional benefits and ensure long-term viability of the scheme;

3. Usage of part of the Salcost camp post-construction as a satellite campus of the University of Sierra Leone, operating as a field station, offering courses in environmental science, conservation biology and animal behaviour. The proximity of primates, other animals and increasingly rare flora and habitats provide excellent opportunities for research and education. A portion of the site will also be offered for ecotourism use, which the BWMA will control and develop in sympathy with the environment, ensuring that the main beneficiaries of associated revenues are the local community.

   There are also opportunities to enhance the conservation of biodiversity in Sierra Leone by improving the management of national parks and protected areas containing chimpanzee habitat (following the principles of OP 4.04). The Goma Mountains and Loma Mountains have been suggested as suitable locations, so these will be surveyed in detail so that additional management and protection can be designed and implemented if appropriate.

8.7.2 Other Fauna

As noted above, very little mature forest remains in the reservoir area, and such habitats now occur only as narrow strips along the edge of the river. This does support some important species, including the sooty mangabey, spot-nosed monkey and Campbell's monkey, possibly chimpanzees at times, plus the duikers *Tragelaphus scriptus* and *Cephalophus monticola*. These animals will probably respond to impoundment in the same way, by moving gradually to higher ground as the water level rises. This should avoid direct losses, although they could be subject to increased hunting, particularly if the community is involved in clearing trees prior to impoundment. There will also be direct losses of smaller less mobile animals in the inundated area.

Animals that relocate will experience "habitat squeeze" in the new areas, where, as described above for chimpanzees, animals are forced to live in a shrinking area of habitat, in closer proximity to humans. The animals and habitats will thus be under increased pressure, and may suffer as a result.

The inundated area does not contain critical natural habitat as defined by the World Bank, but despite the fact that endangered animals were not encountered during the surveys, as explained above, parts of the area are likely to support chimpanzees at certain times of the year. Because of this, and the fact that several of the vegetated areas meet the Bank definition of natural habitat, these losses and the effects of habitat squeeze should be mitigated. This should include controls on hunting, plus habitat protection and community education measures that link to the proposals for chimpanzees described above. The following actions have therefore been included in the Water and Land Management Strategy and Action Plan:

1. A study to determine the viability of establishing a protected area in the immediate catchment to conserve and improve riparian forest and other habitats such as mixed tree savannah, to offset the loss of habitat in the reservoir area. If this is shown to be appropriate, the boundaries and management of the area will also be determined;

2. Strengthening protection of the remaining forest in the Upper Seli catchment by engaging NGOs to conduct outreach community programmes, increasing the sensitisation of chiefs, elders and community organisations by emphasising the benefits that accrue from nature conservation and the sustainable use of natural resources;

3. Implementation of community education programmes to increase awareness of the negative effects of bushmeat consumption and the trapping of endangered species for use in initiation ceremonies and other rituals;

4. Extension of the community-based arms collection programme in the project area, engaging the assistance of local chiefs to prohibit hunting in the immediate catchment and to ensure that the ban is enforced.

There is also an opportunity to help to safeguard Sierra Leone's natural heritage by establishing a long-term financing mechanism to implement the priority actions of the National Biodiversity Strategy and Action Plan.

8.7.3 Vegetation and Flora

Many of the impacts of the BHP on vegetation and flora have been noted above, with the most significant being the loss of vegetation in the reservoir, and the increased pressure to which the remaining habitats will be subjected.

The riparian forest in the reservoir area is probably a remnant of the most northerly area of Upper Guinean Rainforest, which has been extensively damaged over the years by exploitation, and now exists in small patches only, adjacent to the river. As

well as its obvious floral importance, this vegetation also provides habitat for some large and small mammals, amphibians, reptiles, birds and other animals, as well as retaining sediment that washes down the hillsides.

The remaining and resettled communities can be expected to compensate for the loss of agricultural land in the reservoir by farming other land in the immediate catchment. This is a further squeeze effect, which will reduce the areas of forest re-growth and probably also the closed moist forest patches. As noted elsewhere this could then have the knock-on effect of increasing soil erosion and land degradation around the reservoir.

Other impacts on vegetation and flora are less significant and include:

- Damage of some vegetation at the dam site by the remaining construction work (excavation, spoil disposal, etc);
- Reduced absorption of carbon dioxide because of the loss of plants, and increased release of CO_2 when vegetation is burned to provide new farmland.

As explained in Sections 8.2 and 8.3 above, these are of little significance because: a) 85% of the scheme has been constructed and the remaining work is relatively small-scale, so there will only be minor loss of additional vegetation, and b) any increase in CO_2 emissions will be inconsequential compared with the savings gained by generating electricity by hydropower instead of through burning fossil fuels.

Because vegetation, faunal habitats, land use and agriculture are all inter-linked, the measures required to reduce the effects of vegetation loss and increased pressure on remaining habitats, are the same or similar to those proposed elsewhere. The Water and Land Management Strategy and Action Plan includes the following measures aimed specifically at mitigating impacts on vegetation and flora:

1. Improving protection of the remaining forest within the Upper Seli catchment by raising local awareness of the roles and importance of such areas;
2. Promoting the development of Community Forests and reforestation-afforestation programmes by village associations (see below), and establishing a fund providing grants to support such initiatives;
3. Allowing plants to regenerate naturally in the former Bumbuna Quarry;

   Again there is also an opportunity to contribute to the conservation of forest, floral and faunal biodiversity in Sierra Leone by establishing a long-term funding mechanism to support measures contained in the National Biodiversity Strategy and Action Plan. Sites where viable habitats and populations similar to those in the

reservoir area could be maintained if effectively managed include: Outamba-Kilimi National Park; Gola Forest Forest Reserve; Loma Mountains Forest Reserve (proposed as a National Park); Tingi Hills Forest Reserve (proposed as a Game Reserve), Tiwai Island Wildlife Sanctuary; and the Western Area Forest Reserve (proposed as a National Park).

8.7.4 Forest

Table 8.6-1 shows that in 1994 the reservoir area contained 1,590 ha of forest, of which approximately 450 ha was riparian forest, 510 ha mixed tree savannah and the remainder (630 ha) was farmbush/forest re-growth in previously cleared areas. The assessment of trees of timber value in 2004 (Table 8.7.4-1) showed that trunk volume ranges from 350 m^3/ha in mixed forest savannah, to an average of 970 m^3/ha in riparian forest. Combining these figures gives a very rough estimate of a total trunk volume of over 600,000 m^3 for trees of commercial value in the reservoir as a whole, comprising 440,000 m^3 in riparian areas and 180,000 m^3 of re-growth.

Table 8.7.4-1: Trunk volume in the main forest types in the reservoir area (2004)

Location	Forest type	Total wood volume (m^3/ha)	Trunk volume for trees >30 cm dbh (m^3/ha)
Waia Road	Riparian Forest	579.8	478.7
Upper Kasasi	Riparian Forest	1345.2	1087.4
Middle Kasasi	Riparian Forest	1413.4	1147.0
Lower Kasasi	Riparian Forest	1546.9	1114.1
Yankala East	Riparian Forest	1264.6	1040.9
Fullah Town	Mixed Woodland Savannah	490.9	352.9

The inundation of these trees would represent a significant loss of potential income for the local community, and it would further increase the pressure on the remaining tree and forest resources in the catchment. This will be mitigated by providing timber from trees that are felled and removed prior to inundation, to the local community to use for their own purposes or to sell on. This should produce substantial income for the community, and generate goodwill towards the BHP.

As an additional measure, to replenish and expand the forest resource, through the Water and Land Management Strategy and Action Plan the BWMA will establish forestry programmes in the immediate catchment (in particular community forestry), to manage existing closed moist forest, riparian forest and mixed tree savannah, and promote reforestation and afforestation.

8.8 Downstream River Hydrology and Channel Morphology

8.8.1 Hydrological Regime

Reservoir First Filling and Plant Commissioning

The Dam Review Panel has determined that initial filling of the reservoir should occur in two stages, so that dam safety checks can be carried out during impoundment. The first stage will be to 40–50 % of dam total height, and should preferably take place in the dry season. This will ensure that the rise in level will not be rapid, and will provide time for the dam safety data to be gathered and analysed (DRP 2004).

The Environmental and Social Advisory Panel has stated that at no time should downstream flow be reduced to zero, and that there should be a minimum flow ('environmental flow') of 6 m^3/s, except during September, October and November when the minimum flow should be 100 m^3/s (ESAP 2004). Without such measures, during impounding there could be severe ecological stress downstream, and human users could be deprived of the benefits normally provided by the river.

Once the water level reaches 210 m then in theory the generating plant may be commissioned, which would in practice result in variable outflows, depending on which items of plant were being tested and the specific conditions of head and flow. For turbine commissioning, flows would vary from around 33 m^3/s at firm power output (18MW), up to 80 m^3/s or more. For commissioning of the radial gate on the right bank tunnel, flows might vary rapidly from zero up to hundreds of cubic metres per second. For the periods when plant is not being commissioned, at night for instance, downstream flow is likely to revert to 6 m^3/s.

In practice, the operations during impounding will be governed by an Impoundment Plan and an Impoundment Instruction Manual, prepared as recommended by the Dam Review Panel. These documents will include measures to provide the minimum flows and avoid sudden wide flow variations, and to ensure that appropriate safety procedures are followed when high flows need to be released during commissioning.

Normal Reservoir Operation

Reservoir operation will regulate flow in the river, which will alter the hydrological regime downstream. In broad terms there will be an increase in flow during the dry season, and a flow for the first few weeks of the rainy season that is lower than the natural rate, as water is retained to refill the reservoir.

There are no reliable hydrological data for the Seli downstream of Bumbuna, so it is not possible to quantify water level reduction or flow rate during the wet season, or the increase during the dry season. Some run-off data are available for Magbaraka for 1991-97 from the WHO Onchocerciasis programme in Burkina Faso, but the original source is unknown, there is no information on the rating curve used for conversion of gauge readings, and the results are intermittent. The data are therefore not regarded as reliable, and have not been used. Notwithstanding this it is possible to make qualitative assessments of the impacts of the changes, as follows.

Table 8.8.1-1 and Figure 8.8.1-1 show the distribution of downstream flows throughout the year for two alternative flow regimes, with a Minimum Turbine Discharge of 40 m^3/s and 33 m^3/s, to provide the Firm Power output of 18 MW. The inflow values are 'measured' monthly average flows for the period 1970–79 at the Bumbuna gauge. The daily flow regime may vary, depending on the peak load requirements, but overall the data shows that between January-May there will be an increase in downstream discharge to 33–40 m^3/s, compared with the natural runoff of 6-20 m^3/s. Flows will then be below the natural flow between June and August as the reservoir refills, which will delay the onset of flood conditions by about 5 weeks. In the period of highest flows (September-November) outflow is the same as inflow, so peak flows are not reduced and the falling regulated flood corresponds with the natural flood.

Further downstream, as unregulated flow enters the river system from tributaries, the effect of the regulation of the dam outflow will decrease. When total stream flow has doubled, the maximum reduction in flow in June in the example in Figure 8.8.1-1 of 63 m^3/s will have the effect of delaying the onset of the floods by only 1 – 2 weeks.

The difference between regulated and natural flows under normal BHP operation is thus generally not significant in terms of flow alone, although there could be resulting impacts on channel morphology and ecology downstream, as described below.

Table 8.8.1-1: Estimated Reservoir Operation Characteristics and Downstream Flow Regime

Case 1: Minimum Turbine Discharge 40 m^3/s

Month	Seli River		Turbine		Spillway		Downstream	Downstream	Reservoir		
	Monthly Average Discharge	Monthly Flow	Monthly Average Discharge	Monthly Flow	Flow	Volume	Flow Difference	Flow Regime	Volume	Area	Level
	m^3/s	Mm^3	m^3/s	Mm^3	m^3/s	Mm^3	m^3/s	m^3/s	Mm^3	km^2	m
Dec	56	149.19	60	160.70	0	0	4.3	60	433	19.2	240
Jan	28	67.50	40	107.14	0	0	12.1	40	394	17.5	238
Feb	14	36.43	40	95.77	0	0	26.4	40	334	14.8	234
Mar	6	15.51	40	107.14	0	0	33.8	40	242	11.7	225
Apr	7	18.75	40	103.68	0	0	33.0	40	157	8.7	218
May	19	49.51	40	107.14	0	0	20.9	40	100	6.0	212
Jun	81	216.41	65	158.48	0	0	-15.5	65	148	8.0	217
Jul	137	354.59	70	167.49	0	0		70	315	14.3	233
Aug	230	616.57	75	200.88	107	285		182	445	20.0	241
Sept	331	856.56	80	207.36	251	645	0.0	331	445	20.0	241
Oct	215	842.89	80	214.27	235	625	0.0	315	445	20.0	241
Nov	130	336.70	80	207.36	50	125	0.0	130	445	20.0	241
Dec	56	149.19	60	160.70	0	0	4.3	60	433	19.2	240

Case 2: Minimum Turbine Discharge 33 m^3/s

Month	Seli River		Turbine		Spillway		Downstream	Downstream	Reservoir		
	Monthly Average Discharge	Monthly Flow	Monthly Average Discharge	Monthly Flow	Flow	Volume	Flow Difference	Flow Regime	Volume	Area	Level
	m^3/s	Mm^3	m^3/s	Mm^3	m^3/s	Mm^3	m^3/s	m^3/s	Mm^3	km^2	M
Dec	56	149.19	60	160.70	0	0	4.3	60	-12	19.2	240
Jan	28	67.50	33	88.39	0	0	5.1	33	-32	18.0	238
Feb	14	36.43	33	79.63	0	0	19.4	33	-75	16.2	236
Mar	6	15.51	33	88.39	0	0	26.9	33	-148	13.5	232
Apr	7	18.75	33	85.54	0	0	26	33	-215	11.2	226
May	19	49.51	33	88.39	0	0	13.9	33	-254	9.7	222
Jun	81	216.41	60	155.52	0	0	-20.8	60	-193	11.8	227
Jul	137	354.59	70	187.49	0	0	-66.5	70	-26	16.5	239
Aug	230	616.57	80	214.27	140	376	-9.7	220	0	20.0	241
Sept	331	856.56	80	207.36	251	649	0.0	331	0	20.0	241
Oct	315	842.89	80	214.27	235	629	0.0	315	0	20.0	241
Nov	130	336.70	80	207.36	50	129	0.0	130	0	20.0	241
Dec	56	149.19	60	160.70	0	0	4.3	60	-12	19.2	240

Source: Electrowatt/Techsult (1996)

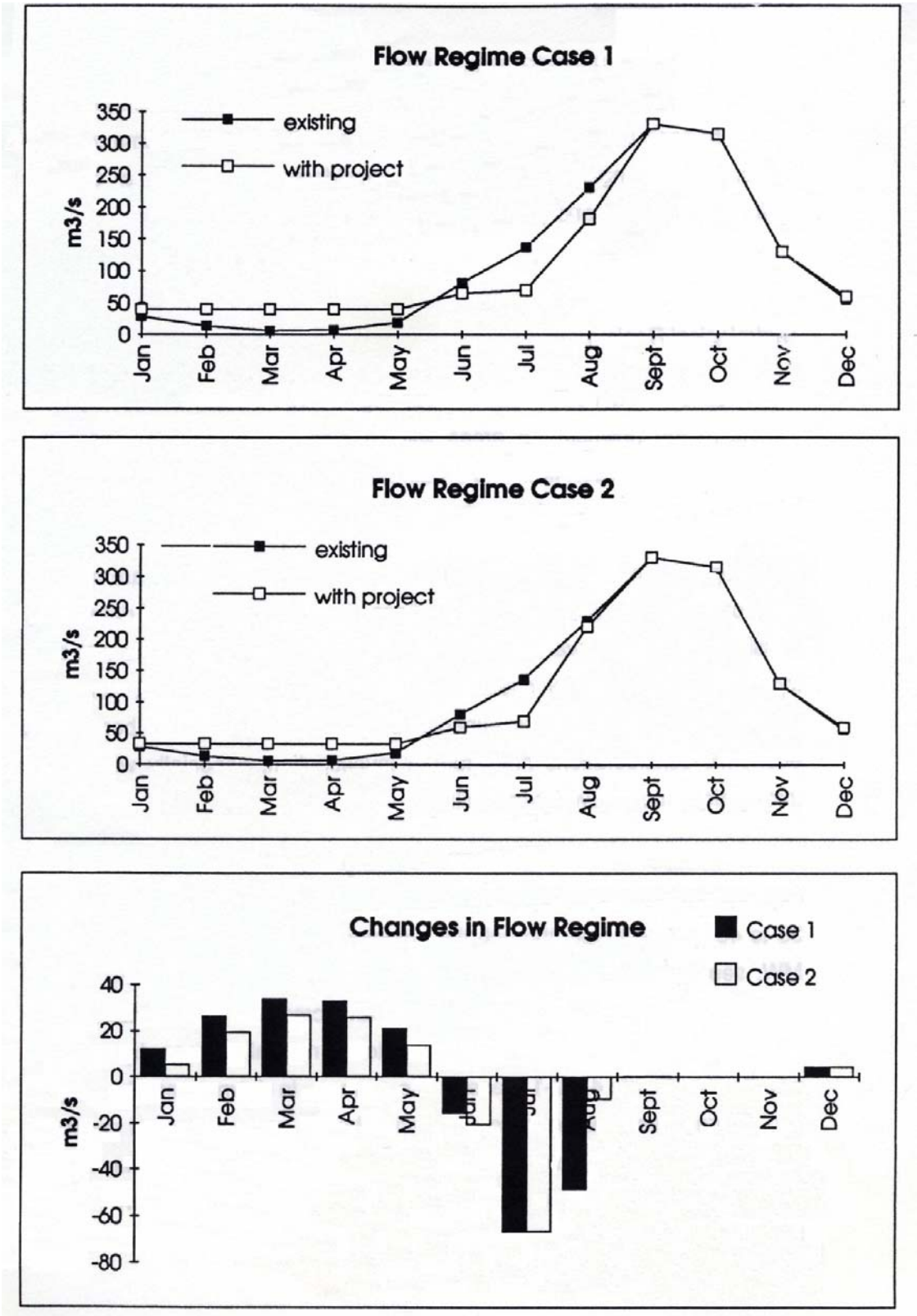


Figure 8.8.1-1: Changes of the Downstream Flow Regime for two Reservoir Operation Scenarios

Source: Electrowatt/Techsult (1996)

Peak Flow Operation

Already established operating rules for the BHP require that when the reservoir level reaches 241.25 m, the inlet gate on the right tunnel will be closed and the outlet gate fully opened. In the case of the Probable Maximum Flood (PMF) of 2950 m^3/s, when the outlet gate is fully open the total discharge will be 2500 m^3/s, rising to 2870 m^3/s maximum about ½ day after the arrival of the flood peak. As the reservoir level falls, at around 2.2 days after the peak inflow, the outlet gate will be closed to 50%, and a further two days later it will be totally closed. The slope of the falling outflow curve is roughly the same as the inflow curve until, at about 5½ days after the arrival of the flood peak, the outflow equals inflow (Pietrangeli 1994).

The net effect of the reservoir and peak flow operations will be to reduce by around 3% the magnitude of the PMF (80 m^3/s), delay the peak outflow by around ½ day, and extend the outflow duration by ½ day. The impacts of regulation of peak flows are consequently not likely to have any significance at all downstream.

8.8.2 Sediment Load and Channel Morphology

Channel morphology could be affected by changes in downstream flow and sediment loading caused by some of the remaining construction work, as well as changes that occur during BHP operation.

Design and Construction of Energy Dissipation Works

The works downstream of the tunnel outlets will consist of an energy dissipator in the form of a plunge pool, and channel protection constructed principally using rip-rap, gabions and reno mattresses (see Table 8.2-1). The plunge pool will erode at the point of impact of the jet from the ski jump. The Consulting Engineer estimates that the plunge pool should not extend to more than 15 m deep for flood flows of around 400 m^3/s. The Probable Maximum Flood (PMF) of 2950 m^3/s will need to be passed safely (i.e. without danger to the integrity of the dam structures), as will a full range of lower flows, so that damage does not occur to the channel.

The energy dissipator has been designed using computer software that simulates the hydraulic conditions in the channel for flows up to and including the PMF, and the design will include adequate protection to the downstream channel. Although downstream erosion and deposition may still occur, such damage events will be rare.

During construction of the protection works there will be blasting of the channel section to create the required profile. Excavated rock will be used in the works, and any additional rock will be taken from the existing quarry, which will be reopened.

There will be works on the channel for a least 300 m downstream of the dam, which will carry the risk that material stored or disturbed in the channel bed will be mobilised in channel flows and carried downstream.

The period of construction is likely to be several months, and unconstrained working on the protection works would have a considerable impact on aquatic ecology and on users of the river downstream. Mitigation measures will therefore be required to eliminate or at least minimise the risk of material entering channel flows (see below).

Design and Construction of Dam Infrastructure

Most of the infrastructure such as roads and services associated with the dam and power generation was completed some years ago, so the remaining works should cause no major impacts, considering the current stability and maturity of the construction and the apparent satisfactory functioning of the facilities.

Installation and Operation of Dam Temporary Works

The camps and other temporary works were completed long ago, and although refurbishment has taken place in preparation for the resumption of construction, this process will not have caused significant impacts. Once construction work resumes it will be on a small scale compared with the works already completed, consisting of installation of the mechanical and electrical plant, completion of the asphaltic membrane, concrete plugging of the tunnels, and the construction of the downstream channel works (Table 8.2-1). There is not expected to be further development of the temporary works, except perhaps the quarry and spoil disposal areas should these be needed for the river protection works. The small scale of these operations should ensure that there are no significant environmental impacts.

Normal Reservoir Operation

The Bumbuna dam effectively isolates sediment sources in the river from the channel downstream, and sediment load leaving the reservoir will be practically zero. A major reduction in the sediment load in relation to the change in flow regime would normally be expected to cause scour of the channel bed immediately below the dam, and the eroded material would be transported farther downstream. However that should not be the case in the Bumbuna situation.

Sediment loads in the river in 1978–79 (Annex IV–2/24 in Bumbuna Hydro-Consultants 1980) were very low even during the wet season, and analyses in August 2004 showed a tenfold increase in suspended solids (Table 7.2.8-1). However although this may indicate an urgent need for catchment management, the values are

not significant in terms of potential changes to channel morphology. The channel between the dam and Bumbuna Falls is on bedrock, and although there are alluvial deposits downstream, coarse superficial materials have produced a natural 'armoured' layer. The majority of regulated discharges will not be sufficient to suspend this material so the channel will not erode in 'normal' situations. It is only likely to be more extreme, longer-term events that will exceed the threshold resistance of the channel boundary materials and mobilise bed load. Following construction of the dam, upstream bed load will be trapped by the reservoir, so there will be an initial phase of downstream erosion and readjustment of channel morphology. Several alternating phases of erosion and deposition may occur as the channel adjusts to the new conditions of flow and sediment supply.

The effect of the impoundment in reducing the magnitude of flood flows has been shown to be negligible, and the change in duration of peak flows is relatively small. Therefore the modifications to channel morphology that typically would be induced when regulated flood flows are reduced in magnitude and frequency (reduced channel depth and width) will not occur at Bumbuna.

Under normal operation and non-extreme flood conditions, the effects of impoundment and regulation on channel morphology are therefore likely to be insignificant. However, for extreme events where bed sediments are mobilised, there will be increased bed scour followed by deposition downstream. These effects are therefore likely to be seen only in the long-term. Any such effects will also decrease as the contribution of non-regulated run-off increases. When the impounded catchment area forms no more than 35% of the total drainage area, the effect of reservoir regulation should be insufficient to induce an adjustment of channel morphology (Petts 1980). The Bumbuna dam catchment of 3,920 km^2 represents 37% of the total Seli/Rokel catchment of 10,600 km^2, so the effects may be expected to be felt over the whole basin, but decreasing to zero at the lower end.

Reservoir First Filling and Plant Commissioning

Reservoir first filling during the dry season will have an insignificant effect on sediment loads and channel morphology, since channel flows will be very low, will carry only small amounts of suspended material and will be unable to mobilise sediment.

However, if impoundment were to occur during the wet season, there may be induced changes to channel morphology. Under these conditions non-regulated tributaries will provide a sediment source that may be significant in relation to the reduction in flood magnitude and the capacity of the mainstream flow to carry this introduced sediment.

Sediment discharge may also be increased by the induced erosion caused by the lowering of tributary base-level during the period of mainstream flow reduction. Deposition of suspended material may then occur if the capacity of the mainstream flow is reduced to below that required to transport the tributary supply of sediment. Redistribution of deposited sediments may occur during the testing of the radial gate, as large flows are capable of being released. These effects may be quite marked, but would only be transitory.

8.8.3 Bumbuna Falls

The ESAP requirement for a minimum amenity/environmental flow during initial filling of the reservoir and the annual refilling will maintain a flow of water across the Bumbuna Falls which is broadly similar to the natural flow. This measure and the fact that water will be discharged from the reservoir at the outlets of the powerhouse and tailrace at the toe of the dam and thus well above the Falls, should ensure that the aesthetic value of the Falls will not be changed either before or during BHP operation.

8.8.4 The Seli/Rokel River Estuary

The limited change in the hydrological regime will have no effect on the lower reach of the Seli/Rokel River. Freshwater flowing into the estuary limits the influx of seawater from the ocean, and reversing currents caused by the tides initiate some vertical mixing with a resulting increase in salinity towards the ocean. Following impoundment, the freshwater flow will remain continuous, and so there should be no effect on the location of the mixing zone. At most, salinity in the estuary will be reduced to some extent, as the higher dry season runoff will lead to a less marked tidal influx of sea water.

8.8.5 Mitigation Measures

In the case of reservoir first filling and plant commissioning, major adverse ecological and social impacts will be avoided by adoption and implementation of the operational rules required by the two Advisory Panels, so no further mitigation is required.

For the remaining construction activities that affect the river downstream, namely the protection works in the channel below the tunnel outlets, mitigation to limit sediment transport downstream is included in the Environmental Management Plan (Chapter 13) under the contractors' and operators' responsibilities.

No mitigation measures are proposed for modifying the hydrological regime in the river for normal or peak flow operations. In the reservoir area no measures would

prevent the change of the river into a seasonally semi-static water body, except dramatic changes in the design reducing the HEP to a full run-of-river power plant. Since the increase of the dry season flow regime downstream of the dam is expected to prove largely beneficial, no measures are required there either.

8.9 Downstream Aquatic Ecology

8.9.1 Environmental Flow

The first report of the Environmental and Social Advisory Panel observed that the original intention to fill the reservoir as quickly as possible by cutting off all flow to the river downstream, was unacceptable and did not conform to international practice (ESAP 2004). The panel indicated that during initial filling and also the annual re-filling after the dry season drawdown, a minimum water flow must be provided to the river downstream of the dam to avoid dangerous consequences for aquatic life. They stated that they require a minimum flow of at least 100 m^3/s in September, October and November if filling takes place in the wet season, and a minimum of 6 m^3/s in the dry season, this being the average minimum natural flow in this period. The minimum flow of 6m^3/s will be guaranteed during all phases of operation, and in no circumstances will river flow be completely halted and the riverbed allowed to dry out downstream of the dam.

These requirements have been accepted by all parties, and as explained above the initial filling is now planned for the dry season, most likely commencing in January 2006, and outlet designs have been revised to provide the minimum flow of 6 m^3/s. The following section assesses the ecological impacts of these changes in the river downstream.

8.9.2 Aquatic Ecology

Under natural conditions river flow reduces rapidly from an average of around 350 m^3/s in October to <50 m^3/s in December, after which it falls more gradually to an average minimum of 6 m^3/s in April (Figure 8.8.1-1 and Table 8.8.1-1). The river edges slowly dry out between January and April, and below the dam the river flows as a small stream at the centre of the channel. Fish and certain other animals living in the marginal areas move into the centre of the channel at this time, but plants and less motile animals are unable to do so and desiccate and die. This means that the populations of these areas are temporary, becoming established each year as the river rises in the rains, and then dying out in the dry season. The drying area becomes less with distance downstream, because of the inputs from the many tributaries. However

even in the lower reaches some parts of the riverbed become exposed in the dry season.

Allowing a downstream flow of 6m^3/s from the start of impoundment in January to the completion of filling several months later would maintain the ecology of the river close to its normal state for this time of the year, were it not for the fact that the water will be of poor quality, as the reservoir will be high in nutrients and low in oxygen from the breakdown of terrestrial vegetation and the organic matter washed out of the inundated soil. Organisms downstream would be subjected to physiological stresses by being exposed to this water, and some could die from the low levels of oxygen. This impact would be reduced by the use of compressed air to circulate the water (as suggested in Appendix I.3 and Section 8.5.2), because as well as mixing the reservoir this would aerate the water, raising oxygen levels and promoting more rapid aerobic decomposition of the material. The need to maintain downstream water quality will be taken into account in the limnological study described in Section 8.5.2, and action will be taken to improve the quality of the reservoir water if necessary. This measure and the maintenance of a minimum downstream flow should thus ensure that there are no impacts on downstream ecology during impoundment.

Commissioning the various parts of the BHP will probably commence towards the end of impoundment, and during this phase downstream flows will vary as the power generation components need to be tested under a range of conditions of head and flow. The potential impacts of these changes have been reduced by the ESAP requirement for a minimum flow of 6 m^3/s at all times, and the DRP recommendation that an operating rule be applied to prevent sudden wide changes in flow. As a result commissioning discharges will mainly be increases over the base flow of 6 m^3/s, and conditions should thus approximate to those that normally occur at around this time, when there can be flushes of increased flow in the early rains, followed by reductions if there is then no further rainfall for a few days. The Panel requirements should thus maintain the ecology of the river downstream in a relatively normal state.

When the BHP is operating the increases in river discharge to an average of 33 m^3/s during the dry season should bring significant ecological benefits, as a far larger area of the riverbed will retain a permanent covering of water. There will therefore be much less drying of the river margins, so many more plants and animals should survive in these areas, and permanent populations may become established, thus expanding biodiversity, habitats and ecosystem productivity. This will not happen however if, as has been suggested, discharges are reduced in the dry season at times of lower electricity demand (such as evenings and weekends), to conserve water for power generation in peak periods. Reductions at these times to the minimum

environmental flow of 6 m^3/s would prevent plants and animals becoming established at the edges of the channel, as most are unable to withstand being uncovered for more than a few hours.

The ecological benefits produced by the dry season increase in flow allowing animals and plants to establish permanent populations at the river margins would be maintained if it were possible to devise an operating rule that provided a minimum flow during BHP operation that maintained at least a thin covering of water over the whole riverbed at all times. A study will thus be conducted before impoundment begins to determine the feasibility of providing an enhanced level of environmental flow in the dry season, whilst still meeting power demands. This will involve:

- Topographic surveys of the channel in cross section at intervals between the dam and the first major tributaries 10 km downstream;
- Hydraulic studies to calculate the volume of water necessary to cover different proportions (percentages) of the river bed and the rate of discharge from the reservoir that would provide these flows;
- Analyses of predicted fluctuations in reservoir levels during the dry season under typical power demands to determine whether reservoir operation can be adjusted to maintain sufficient water to satisfy power needs as well as the proposed additional downstream flow;
- If this shows that it is feasible to provide an enhanced level of environmental flow, an Operational Rule Curve will be designed through which releases from the reservoir will be managed.

The period in July-August when river discharge increases, but to levels that are below those that occur naturally as water is retained to allow the reservoir to refill after the drawdown in the dry season, should not result in the death of animals and plants downstream, as no parts of the river will dry out. There could be more subtle changes, in growth, reproduction, etc of plants and animals from the variations in environmental conditions, particularly the delay in the onset of the normal flood, which stimulates seasonal cycles of many aquatic organisms. These changes can produce variations in population density and the composition of communities, which are difficult to predict without detailed research. These should not be of great significance in the majority of aquatic organisms, as fluctuations would be in the range of those that occur naturally throughout the seasons, and from year to year. As explained below they could be more significant in the case of fish, because of their importance to the local community.

8.9.3 Fish and Fisheries

Fish respond to the natural reductions in river flow in the dry season by moving into the centre of the channel as the margins dry, and many also migrate downstream in the late rains and early dry season, to areas where the changes in the water body are less extreme. The timing of these cycles may change during reservoir impoundment because the river bed may dry earlier than usual, but it is unlikely that fish numbers or their state of health, etc will change significantly.

The onset of the rainy season provides major environmental cues for many tropical freshwater fish, as the increases in flow and reductions in water temperature that occur after the first heavy rainfall stimulate many species to begin their migrations upstream to breed. If the commissioning releases occur during the early rains as currently seems likely, then conditions should be similar to those that occur naturally, as flows vary during the early rains as rainfall fluctuates. It is reasonable to expect therefore that upstream migrating species will receive relatively normal environmental cues, so they should not be significantly affected. Species that spawn in floodplain swamps are stimulated by factors that occur somewhat later, such as the stronger flows and increased water depths of the peak floods. These should still occur, as by this time commissioning should have finished and the reservoir will have returned to FSL, so flood discharges will flow downstream through the morning glory spillways, mirroring the normal cycle.

During BHP operation, like other aquatic organisms fish should benefit from the increase in dry season discharges, as species that live in the margins will be able to occupy these areas permanently so their populations should expand. There could then also be increases in the larger predators that live in deeper water and venture into the margins in search of food, if their prey species are present in greater numbers. These changes would be of considerable benefit to the community if they affect exploited species, which is very likely in the case of the larger predators. Catches should therefore increase and incomes could also rise, as there would be more surplus fish to sell in the markets. As with the ecological improvements described above, these benefits will not occur if discharges are reduced to the minimum of 6 m^3/s to conserve water during low demand periods, so this is further justification for an enhanced environmental flow that provides a coverage of water over the whole river bed at all times, if this is feasible.

The annual period of lower than normal flows during June-August will delay the onset of normal flood conditions by an estimated 5 weeks, and this could have significant impacts on fish by delaying the appearance of the environmental cues that stimulate

breeding. This could delay the maturation of gonads and the commencement of the upstream migrations, which has a number of implications. These are that:

- Some fish may be unable to reach their preferred spawning grounds if they migrate later, as this may coincide with the stronger flows of the peak flood period;

- Some may arrive at the spawning grounds with unripe gonads, so the numbers of fertilized eggs may be reduced;

- There may also be fewer viable larvae returning to the adult population if they hatch when conditions are less than optimum, for example if food supplies are inadequate, river flows are too strong, or predators are present in high numbers;

These factors will not affect all species and individuals, and it is unlikely that the later breeders will be affected at all as flows will return to normal after August. However the disruption could affect sufficient fish for reductions in populations caused by reduced breeding success to be significant in terms of ecology, the fishery and local fisher communities.

Given the variability of these various factors and the resulting uncertainty regarding the likely impacts of the flow changes, mitigation should not be attempted until the nature and extent of any changes in fish populations and the fishery have been determined. This will require a baseline survey of a year to establish existing conditions, followed by one year of monitoring to identify the impacts that have occurred and their significance. Additional data on critical habitats, migration and the occurrence of endemic species required by the ESAP will also be collected. The following surveys will thus be conducted:

- A one-year baseline survey of fish throughout the river under natural conditions (before reservoir impoundment), to determine species present, and the population sizes and principal habitats of the major species and any endemic or otherwise rare species. The timing, nature and extent of spawning migrations will also be determined, as well as the extent of any migration upstream and downstream of Bumbuna Falls. Spawning and nursery grounds will be identified, together with the location of any other critical habitats. Catches taken by fishers will be recorded to determine species, catch sizes, and variations with season and location;

- A one year survey of fish downstream of the dam during the first year of BHP operation to determine species present and population sizes, and the timing, nature and extent of spawning migrations. Species and catches take by local fishers will also be recorded, and all methods will be the same as those employed in the baseline survey. The results of the two surveys will then be compared to identify and assess the significance of the impacts of BHP operation, and to determine the need for and nature of any mitigation.

Mitigation will then be provided if necessary, and this could include such measures as:

- Providing financial compensation to fishers and their communities to mitigate reductions in catches and incomes;
- Providing downstream communities in the vicinity of the dam with transport, equipment and training to enable them to move their fishing operation into the reservoir to take advantage of the developing fishery there;
- A management study of the downstream fishery to devise measures to increase populations and thus returns from the fishery;
- A study of any rare species to devise measures to enhance habitats to conserve and expand populations if appropriate.

8.10 Catchment Management Planning

A number of major issues and potential impacts on the environment and local communities resulting from the construction and operation of the BHP have been discussed above. These relate to water flows and water quality, hydrology, morphology and aquatic ecology of the river and its channel, agriculture and land use, and the protection of fauna and flora. The activities taking place in the catchment area of the reservoir that may affect the operation and sustainability of the project, in particular systems of land use, erosion and sedimentation, as well as downstream benefits and services, have also been discussed.

Effective measures to address these issues and mitigate impacts will clearly be required at the local level of the reservoir and upper catchment. Management measures will aim initially to maintain and then to improve the environment around the reservoir and within the upper catchment. These measures will be complemented by a community awareness and participation programme, institutional strengthening, development of local regulations, training and capacity building, technical programmes and identification of funding. Implementation of the measures will be followed by appropriate monitoring. Where required, further studies will be carried out to provide the information needed to enable considered decisions to be made on mitigation issues.

An institution, referred to as the Bumbuna Watershed Management Authority (BWMA), will be established to manage the reservoir and upper catchment. It will focus on the implementation of a Water and Land Management Strategy and Action Plan (WLMSAP) that will work towards ensuring that in the long term the resources of the Bumbuna catchment will be able to support the BHP, maintain the services provided from land and water, and sustain its fauna and flora. The BWMA will be

established in the pre-impoundment phase to ensure that the issues arising from the construction and operation of the Bumbuna HEP project are dealt with swiftly.

To support the functioning of the BWMA and the processes and activities that will take place in the upper catchment area, an existing organisation, the Seli River Development Authority (SRDA) will be revived. This will provide the strategic overview for the delivery of a programme of integrated land and water management at the level of the Seli/Rokel basin, and will establish planning, institutional and legal frameworks to enable effective and efficient co-ordination and implementation of the mitigation and monitoring plans at both national and local levels. It will serve as the planning body for the allocation of the basin's resources across the regions and sectors. It will coordinate the provision of training, capacity building and institutional strengthening, and assist in the provision of funding for the local-level catchment management organisations. The SRDA will thus provide both direct and indirect support to the BWMA.

The relationship and operation between the SRDA and its local catchment bodies such as the BWMA will be as shown in Figure 8.10-1.

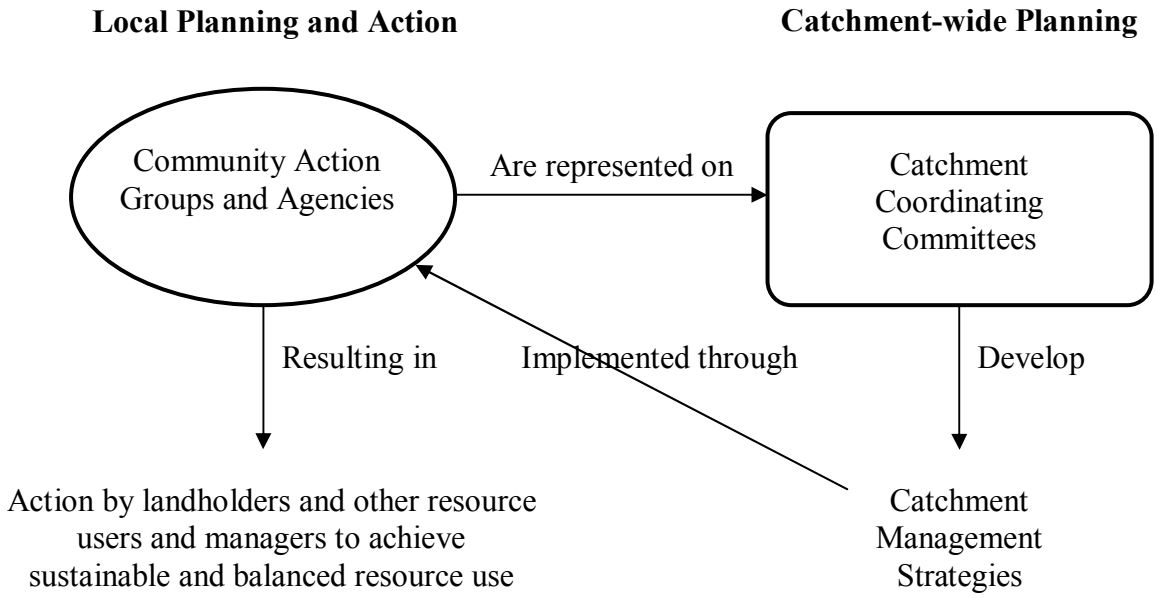


Figure 8.10 – 1: Relationship between the catchment coordinating committee and land users

Source: Queensland Government (1999)

The Seli River Development Authority is already in existence, albeit dormant, and is considered to be the appropriate vehicle to safeguard the products and services that can be provided by the Seli/Rokel basin. As it will be a principal promoter of the

establishment of the BWMA, it will be revived as soon as is feasible during the pre-impoundment period.

8.11 Seli/Rokel Basin Management

8.11.1 Seli River Development Authority

The SRDA will have a small full-time executive consisting of experts in finance and administration, economics, water and land management, planning and legislation. Other part-time experts will be available in *inter alia* institutional strengthening, training and capacity building, ecology, agriculture, forestry and fisheries.

The executive will be responsible to a basin management committee with representatives from the various line ministries, Provincial and District councils, and community groups.

The main activities of the SRDA will be to:

- Establish a comprehensive strategy on integrated water and land management that can be implemented at the local, regional and national level. This will be co-ordinated with the relevant authorities in central and local government and with catchment management organisations, and will be structured in a way that will encourage the responsible bodies to implement the tasks allocated to them;

- Establish planning policy and guidelines on the allocation of the basin's resources and services across the regions and sectors (e.g. irrigation, hydro-electric power generation, mining and other industry, and domestic use);

- Provide policies and guidelines, and when necessary promote legislation to facilitate sustainable and community-based best practice in agriculture, forestry, land use, fisheries, and conservation of habitats and species, and establish environmental standards;

- Where the local administrations lack the required institutional and skills base, promote and facilitate the setting up a programmes of institutional strengthening and capacity building, involving legislative planning processes, financial management, strategic planning, technical training, human resources, gender issues and community development;

- Direct and co-ordinate research activities applicable at basin level, for example on suitable species of trees and grasses to grow on exposed slopes, grass fires, agro-forestry, and provide support for research at local catchment level.

Some of the technical issues, practices and requirements concerning land and water management are discussed further in Appendix P.

8.11.2 Community Participation

The participation of local communities is essential to the success of catchment management, and local community groups will be represented at both the basin level (SRDA) and at the local level (BWMA). The local people are the prime users of the catchment, mainly through agriculture, grazing and forestry activities, but also through smaller-scale activities such as mining. Improvements to current practice cannot be imposed from above by regulations or legislation. It is important that changes are brought about through consultation with local people, allowing them to provide their own solutions. It will be up to the local communities themselves to implement the changes, supported by the administration and the planning processes, through training and technical extension schemes, and where necessary, with material and financial assistance.

8.11.3 Preliminary Measures

As one of its first tasks the SRDA will promote the establishment of the BWMA and a programme for management of the Seli upper catchment.

The first tasks of the SRDA will therefore be to:

- Review its own Terms of Reference, structure, representation and funding sources, and set up an initial programme of activities;
- Establish the BWMA, confirm its Scope of Work, ascertain staffing and implementation arrangements, and secure the initial funding;
- In conjunction with the BWMA, approve the objectives and measures of the Water and Land Management Strategy and Action Plan (WLMSAP) devised by this study as the mechanism to manage the upper Seli catchment (see Section 8.12 below), and support its implementation;
- Establish and implement a programme of capacity building and training to strengthen its own capability, and that of participating government staff and the BWMA. Conduct an initial needs assessment to determine specific requirements of staff and training topics (which in the first instance should include community development, catchment management, and project management);
- Set up a programme of working with local communities and groups, firstly to establish needs and aspirations, and follow up with training and extension work, and material and financial assistance. Community representatives should be prepared for joining the basin management committee, and in the long term to take on responsibilities in local catchment management. The programme would in time be devolved to the local catchment bodies such as the BWMA;
- Establish funding streams to meet the expected costs of the BWMA and its programmes.

- Establish a research programme and engage researchers to provide information on and analyses of the issues of catchment management. Research should be directed at basin-wide issues, but should also support specific local catchment issues where necessary to promote the work of for example the BWMA.

- Establish the required guidelines and standards, and promote legislation and regulation to support the catchment management programmes.

8.11.4 Funding

The expected costs of establishing the SRDA are presented in Appendix Q and summarised in Table 12.2-1.

Funding to support the investment and recurrent costs related to the SRDA is expected to come from central government, via the Ministry of Agriculture, Forestry, and Food Security, the Ministry of Power and Energy, the Ministry of Mineral Resources, and the Ministry of Health and Sanitation, as each of these ministries has an interest in the development of the Seli basin. A funding mechanism will need to be established between the various ministries.

8.12 Upper Catchment Management

8.12.1 Bumbuna Watershed Management Authority

As noted above the BWMA will be established to serve as the facilitator for the delivery of the catchment management plan as set out in the WLMSAP (See Table 8.12.2-1). BWMA will ensure that in the long term the resources of the Bumbuna catchment will be able to support the BHP Project, maintain the services provided from land and water, and sustain its fauna and flora.

The key institutional elements of the BMWA, which reflect international practice, will include:

- A Board of Trustees, (7 to 9 members) made up of individuals having expertise and experience in at least one of the following areas: grant-making systems, finance and administration, biodiversity conservation, land/watershed management, organisation and management, development, law and forestry;

- A small secretariat consisting of an Executive Director, Finance and Administration Director, and no more than five additional technical programme and administration staff. The technical staff will be properly skilled in catchment management.

The BWMA will either be established as a non-governmental civil society organisation or a parastatal. The decision will be based on a legal assessment of the options conducted by SRDA.

BWMA will be responsible for coordinating and implementing the following key activities:

- Sensitisation of stakeholders regarding problems and issues affecting the Bumbuna catchment;
- Information sharing and consultative meetings with catchment stakeholders to develop the Water and Land Management Strategy and Action Plan (WLMSAP);
- Organising necessary finance and resources to support implementation of the WLMSAP;
- Facilitating adoption of the WLMSAP by key stakeholders through a participatory process;
- Implementation and monitoring of the WLMSAP;
- Lesson learning and revisiting the WLMSAP (after 3 – 5 years);
- Ensuring the provision of adequate training for stakeholders and for trainers.

BWMA will take the lead in co-ordinating implementation of the WLMSAP with key stakeholders (see section 8.12.2). These would include, *inter alia*, Paramount Chiefs, Village Chiefs, representatives of elders' council, women's and youth groups, District Councils, line ministries, NGOs/CBOs, and the Community Liaison Committees.

Implementation of the programmes within the Water and Land Management Strategy will be co-ordinated by BWMA, to ensure integration with other components of the overall strategy and the wide range of stakeholders. The BWMA may contract out services for development, implementation and monitoring activities to service providers such as qualified NGOs or academic institutions, with the assistance of government ministry staff, in particular in Northern Province. Training of trainers within government and NGOs may also be contracted out. Service agreements will stipulate performance related targets (e.g. establishment of Community Forests, etc.) with renewal subject to performance. BMWA will also advance its programme by issuing grants to institutions to take forward initiatives according to set TORs and contracts.

The BWMA will establish a small Advisory Committee (5-7 people) consisting of individuals from Government and civil society with expertise and experience in

conservation, to advise and guide BWMA on the criteria for selection of suitable work. An annual call for proposals against agreed objectives and criteria will be issued by BWMA, and the Advisory Committee will review submitted proposals and recommend a short-list for funding.

BWMA establishment and investment costs will be incorporated in the BHP financing costs, and its recurrent costs will be covered by a contribution from the electricity tariff in return for improvements in the catchment delivered by the WLMSAP. Further details on the costs and financing of BWMA are given in Section 8.12.9.

8.12.2 Water and Land Management Strategy and Action Plan.

The impact of the dam and reservoir on agriculture and land use will be relatively minor, namely the loss of approximately 250 ha of cultivated land and 630 ha of forest regrowth (fallow land/farmbush) (1994 figures, Table 8.6-1). However, land use within the catchment: 1) will also be indirectly affected owing to increased land pressures on the immediate catchment; and, 2) could affect the long term economic viability of the BHP, taking account of:

- The existing land degradation in the vicinity of the BHP;
- The likelihood that degradation will increase; and
- The need to protect the reservoir from sedimentation.

The development aspirations of the communities living within the Bumbuna catchment should be partially met from improved land management. As described in Chapter 9 below and in the Dam and Reservoir RAP (Electrowatt-Ekono/Techsult 2004), the positive impacts on livelihoods for communities living with the watershed are limited.

Catchment management will generally require management of the processes directly affecting water quality (pollution and sediment), water quantity and flow (availability and alternative uses such as water supply and irrigation), and soil erosion. These are the main factors that affect the long-term ability of the land to provide the water resource and other benefits such as trees, crops and domestic animals. Management should also ensure the long-term protection of important habitats, fauna and flora.

The Water and Land Management Strategy therefore not only addresses water and land use and agriculture, but also takes into account mitigation measures recommended to address negative impacts on the biological resources (wildlife, vegetation, aquatic flora and fauna, etc.). The strategy must also be accepted and

practiced by the local communities and administrations and it will be the responsibility of the BWMA to ensure that this is the case.

The WLMSAP consists of five separate components, four related to the required outcomes, and the fifth specifying monitoring:

Component 1: Assurance of stakeholder awareness and participation;

Component 2: Maintenance of water quality and use, and ecological conditions;

Component 3: Improvement of land systems and benefits obtained;

Component 4: Maintenance of ecosystems to benefit conservation and communities;

Component 5: Monitoring of physical, ecological and socio-economic impacts and benefits of the strategy and action plan.

WLMSAP has a multi-sectoral approach, so no central line ministry should take the lead to co-ordinate its implementation. Similarly, the Bumbuna catchment is shared between three Districts, so no single District Council could take on this co-ordination role. Although NPA is the principal interested body it also does not have either the mandate or capacity to co-ordinate WLMSAP.

The purpose of WLMSAP is to guide co-ordinated management actions by involved stakeholders to achieve collectively the intended goal of addressing the issues and mitigating the impacts of BHP construction and operation. The Strategy will be implemented through its Action Plan, by applying a time-bound detailed activity programme.

In the first instance WLMSAP promotes a process approach, with stakeholder participation, to set out the land management principles and objectives (i.e. the Strategy). These then inform the setting of legislation and mechanisms for its application, which are part of the Action Plan.

In order for the Strategy to become a living process resulting in change, it is essential that all key stakeholders who are affected by or have an effect on the issues and impacts, should collectively engage in its formulation and subsequent implementation. This process will stimulate 'ownership' of the Strategy not only by the institution(s) responsible for its implementation but also all stakeholders who have both a role in its implementation and benefit from its successes.

The WLMSAP is outlined in Table 8.12.2-1 below. It encompasses all the elements that constitute a catchment management plan, including: the management of land, water, agriculture and ecological resources; the development and delivery of a

Table 8.12.2–1: Water and Land Management Strategy and Action Plan

STRATEGY LOGIC	MILESTONES / TARGETS	MEANS OF VERIFICATION
Objective: The Bumbuna upper catchment ecosystem will, in the long term and with the active participation of its communities, support the BHP Project, maintain the services provided from the land and water, and sustain its fauna and flora.	• By 2055, Bumbuna reservoir storage capacity has not reduced by more than 10% due to siltation. • By 2025, vegetation cover is maintained at 2005 baseline level. • By 2025, economic benefits from the resources of the Seli upper catchment have increased by at least 50% from 2005 baseline level. • By 2010, conservation measures for flora and fauna are fully operational and supported by local communities	• Bumbuna Dam reports • Bumbuna Watershed Management Authority (BWMA) reports • District reports • Ecological monitoring reports
Outcomes:		
1. **Stakeholders demonstrate awareness and action to safeguard environmental services** (community informed participation on environmental issues, fisheries and agricultural and forestry best practice)	• By 2005 Community Liaison Committees (CLCs) are established and actively participating in environmental and catchment management affairs. • By 2007 an improvement in conservation measures, forest and soil management and a reduction in waterborne disease.	• BWMA reports • District reports • CLC reports
2. **Maintain reservoir function, water quality and aquatic systems** (reduce sediment load, manage fisheries, control water pollution, maintain water quality, maintain environmental flows, manage and enhance habitats)	• By 2007, byelaws introduced for water and land use in immediate catchment. • By 2008, regulate reservoir fisheries and establish management plan, and by 2010 introduce fisheries enterprises. • By 2008 manage reservoir habitats to provide ecological and tourism benefits • By 2005, environmental flows for reservoir impounding and operations agreed. • By 2006 artificial mixing and aeration of reservoir established if necessary.	• BWMA reports • Ecological monitoring reports • Water quality monitoring reports • Fisheries development reports
3. **Land systems improved and sustainable benefits obtained** (agro-forestry policy, community forests, improved land and forest use, improved yields)	• By 2010, there is a 5% decrease in the area of recent fallow land, followed by a further 10% per ten-year cycle until 2055. • By 2015, community forests with an area of 1% of the catchment area have been established, followed by a further 1% per ten-year cycle until 2055.	• BWMA reports • Ecological monitoring reports • Forestry development reports

4. Maintain ecosystems for the benefit of fauna and flora and local communities (community awareness of conservation issues, establish protected areas, provision for conservation offset, manage and improve downstream fishery)	• By 2010, a reduction in the hunting of protected animals from 2005 levels. • Bumbuna Dam Conservation Area established no later than end of 2006. • In 2007, the management plan for the Bumbuna Dam Conservation Area is prepared, and implemented henceforth. • By 2010, riparian forests within catchment are not less than 2005 baseline area. • By 2025, riparian forests have increased to above 2005 baseline area. • By 2006, NBSAP financing mechanism established and management improved in national parks/conservation areas elsewhere in Sierra Leone. • By 2008 regulate downstream fishery and implement management plan.	• BWMA reports • Reports from chiefdoms. • Results of ecological monitoring • Bumbuna Dam Conservation Area management plan and progress reports. • Fisheries development reports
Action Plan Components *(to achieve the four Outcomes above)*		
1.1 Set up CLCs. Undertake training and capacity building measures for members of CLCs and the local administration. Training of trainers	Establish CLCs during 2005. Training sessions/workshops held at least every six months for 25 participants.	
1.2 Formulate and implement an environmental awareness campaign addressing hunting, bushmeat trade, forest management, soil and water conservation, fishing, water pollution, waterborne diseases.	Environmental awareness campaign launched in 2006. School-based environmental groups established starting from 2007.	
2.1 Formulate and implement water and land use byelaws to be effected by the Paramount Chiefs and supported by District byelaws, with the aim of promoting suitable vegetation cover including community forests, limiting agriculture in the immediate catchment area, water conservation, regulating fisheries, and preventing water pollution.	Byelaws to regulate water and land use within the immediate catchment introduced by 2007. Land and soil stabilisation measures on reservoir margins by 2008 Byelaws to regulate fisheries introduced by 2008.	
2.2 Formulate and implement a fisheries management plan and programme in Koinadugu and Tonkolili Districts to promote sustainable fishing on the reservoir and provide support for fishers.	Work with local fishers to establish the fisheries management plan with self-regulation of catches by 2008. Operate small-scale fisheries enterprises by 2010 with technical and financial assistance.	
2.3 Design reservoir operating rules that take account of Environmental Flows, and monitor flows released. Take action to maintain reservoir water quality if necessary.	Operating rules approved and in force before first impounding in 2006. Artificial mixing and aeration system in place if necessary, before first impounding in 2006.	

2.4 Prepare and implement an ecological management plan for the reservoir that *inter alia* provides native habitats and species that are attractive to tourists.	Reservoir ecological management plan in operation by 2008	
3.1 Implementation of an agro-forestry programme in Bombali. Koinadugu and Tonkolili Districts including soil conservation, alley-cropping techniques, community forestry, and planting of economic trees. Requires training of trainers and establishment of on-farm demonstration plots.	Agro-forestry support programme commenced by 2006, and resulting in increased productivity, vegetation cover and reduced soil erosion potential by 2010.	
3.2 Application of the Forestry Policy and Regulations within Bombali, Koinadugu and Tonkolili, with particular emphasis on supporting village associations to establish tree nurseries, Community Forests, protection of riparian forest, and afforestation initiatives.	Village associations/interest group operating during 2006 to set up tree nurseries and community forests, and engaged in other forestry initiatives.	
3.3 Implementation of an agricultural programme in Bombali, Koinadugu and Tonkolili Districts based on crop diversification and husbandry, farm management, post-harvest techniques and land management. Requires training of trainers and establishment of on-farm demonstration plots.	Improved agricultural methods in evidence by 2010, with annual improvements thereafter.	
3.4 Conduct mapping of present land use and vegetation types.	Establish current vegetation cover and land use and store information on GIS by 2006. Develop and implement plan for better management of pastures by 2007.	
4.1 Establish the Bumbuna Dam Conservation Area as an environmental offset, through a consultative process engaging local stakeholders, Wildlife Dept, NGOs and University. Establish ecological baselines and prepare management plan.	Agreement by land-owning families and Paramount Chief on the establishment of the Bumbuna Dam Conservation Area by the end of 2005.	
4.2 Protection of riparian forest	Riparian forests on the upper Seli catchment protected by bylaws, increased awareness and effective management. Evidence of maintenance of riparian forest during 2007.	
4.3 Fishery Management	Downstream fishery regulated and managed by 2008 and showing evidence of increased catches by 2010.	

programme of institutional strengthening, capacity building and training; monitoring of impacts; and direction and co-ordination of research activities required to further the implementation of the Strategy.

An important element of WLMSAP is the formulation and application of land use regulations and agro-forestry development. Land use regulations aim to protect the vegetation cover and soils of the immediate catchment, to safeguard the reservoir from sedimentation. The promotion of agro-forestry will contribute to maintenance of vegetation cover, replenishment of soil nutrients, crop diversification and agricultural intensification.

The formulation of land use regulations and agro-forestry development will require consultations with stakeholders to achieve a consensus on the purpose and benefits. In order to ensure a change in land use that fosters improved agricultural, forest and land management while safeguarding the environmental services provided by the catchment, there will be a process whereby key landowners and users, and decision makers are informed and agree on the need to take action. The simple introduction of new regulations will not result in change, if those affected by the proposed regulations are not consulted on the need, purpose and benefits of the regulations. Moreover, such a 'legislative' approach would be dependent on effective enforcement, which is often costly and unrealistic in rural situations.

A monitoring programme will be established early to begin data collection *inter alia* on land use, vegetation cover, sediment loading of streams, and water use and quality. The topic is dealt with in section 8.14, Monitoring Plan.

Costs for the delivery of the Water and Land Management Strategy and Action Plan are presented in Appendix Q and Table 12.2-1 below.

8.12.3 Community Participation and Development

Community participation in the process of developing and implementing the WLMSAP will be fundamental to its success. An outcome of the Strategy is that stakeholders will demonstrate awareness and action to safeguard environmental services, which requires community informed participation on environmental issues, fisheries, and agricultural and forestry best practice.

The process of engagement will include the following key actions:

- Sensitise stakeholders as to problems and issues affecting the Seli upper catchment;

- Ensure information sharing and hold consultative meetings with catchment stakeholders to develop the WLMSAP;
- Carry out a needs assessment for stakeholders to identify capacity and knowledge issues, and provide the necessary awareness and training;
- Sensitise local communities on conservation needs, compensation issues associated with a conservation area and potential socio-economic and catchment benefits;
- Consult stakeholders and decision-makers and obtain agreement on regulations for wise and sustainable use of water, land and natural resources;
- Implement and monitor the WLMSAP;
- Hold stakeholders' fora to validate perceived issues and impacts, identify potential issues, and clarify inter-relationships.

It is important that an early initiative is a community-based programme. It will follow initial consultation, and should provide quick results with some early benefits, to show that benefits really can be obtained through WLMSAP and provide confidence in the BWMA's ability to deliver.

To facilitate community participation and development, Community Liaison Committees will be established. Representatives from the committees will have the opportunity to receive training, and should in time have membership of the BWMA and SRDA.

Monitoring of the advances in community participation will be carried out, to include an assessment of the success of consensus measures for the regulation of improved practices in agriculture, forestry and land use.

8.12.4 Water Quality and Use

WLMSAP will aim to maintain reservoir function, water quality and aquatic systems. These outcomes will require action to reduce soil erosion and sediment load in the river, control water pollution including eutrophication of the reservoir, maintain environmental flows in the river downstream of the dam, and manage the reservoir. A programme of monitoring will be set up and implemented.

Implementation of the water quality and use programme will be co-ordinated by BWMA though the various components may be contracted out through service agreements. Training of trainers within government and NGOs may also be envisaged.

Detailed measures are as follows:

(i) Soil conservation measures to reduce soil erosion, sediment load and potential for landslips into the reservoir (important for the long-term viability of the BHP):

- Encourage best practice in agriculture, in particular the avoidance of cultivation on steep slopes;
- Promote agro-forestry (e.g. alley cropping, community forestry);
- Identify problem areas, i.e. areas that have already been damaged by erosion and areas that are erosion prone, and implement remedial action;
- Implement forest cover measures along reservoir edges and riverbanks.

(ii) Pollution prevention and control

- Remove trees from the reservoir area to reduce the potential for eutrophication of reservoir water on filling;
- Artificially mix and aerate reservoir water if found to be necessary;
- Remove any excessive amounts of floating water plants to safeguard reservoir operation and water quality if necessary;
- Ensure the adoption of safeguards on domestic and agricultural pollution of river and reservoir waters. Measures will include awareness of issues and regulations, suitable treatment and disposal of domestic solid and liquid waste, and appropriate use and disposal of agricultural pesticides.

(iii) Water use measures

- Water flow management (turbination) in the initial filling phase. If possible, reservoir filling should be slow to promote the throughflow of nutrients and thus reduce the potential for reservoir eutrophication;
- Fisheries management. Formulate and implement a fisheries management policy and programme to assist local communities to maximise benefits. Promote best practice (through consensus and regulation) to achieve sustainability in the fisheries programme;
- Awareness, training and fisheries extension. Support measures to be provided to promote fisheries development in the reservoir. Training of trainers programme;
- Habitat management. Prepare and implement a programme of ecological management to provide native habitats and species in the reservoir that may be attractive to tourists;

- Devise and operate reservoir operating rules and an Operational Rule Curve that provide an appropriate minimum environmental flow in the river downstream of the dam, at all times.

(iv) Policy and regulations

Formulation and implementation of water and land use byelaws to be effected by the Paramount Chiefs and supported by District byelaws, with the aim of promoting suitable vegetation cover including community forests, limiting agriculture in the immediate catchment area, water conservation, regulation of fisheries, and prevention of water pollution.

(v) Monitoring and further studies

The monitoring programme will include water quality, sediment loading, downstream flow, erosion control, fish production, aquatic/marginal habitats and species, and land use practice. Details are given in section 8.13. .

8.12.5 Agriculture and forestry

WLMSAP aims to improve land use systems and the sustainable benefits arising from agriculture and forestry. These outcomes require action to improve agricultural techniques and improve yields, introduce agro-forestry methods, establish community forests, and improve forest use. A programme of monitoring will be set up and implemented.

In order to mitigate against the extension of slash and burn agriculture, the increasing pressures on land, and potential increase in land and soil degradation, improved agricultural, forestry and vegetation management methods form an important element of the land management strategy.

Implementation of the agriculture and forestry programme will be co-ordinated by BWMA though the various components may be contracted out through service agreements. Training of trainers within government and NGOs may also be envisaged.

Detailed measures are as summarized below.

(i) Agricultural improvement

Slash and burn cultivation practices will be replaced in the medium and long term by alternatives that are less destructive to soils. Birchall *et al* (1979) state that the average fallow period at that time was shorter than nine 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 will be made worse by the loss of land to the reservoir. Measures that will be developed are:

- Crop husbandry techniques;
- Basic farm management;
- Crop diversification;
- Harvesting and post-harvest techniques;
- Use and care of farm tools;
- Improvement in management techniques to reduce bush fires and enhance pasture quality.

These measures will be promoted through a combination of *inter alia*, awareness materials, extension worker inputs, and on-farm demonstration plots.

(ii) Agro-forestry

A further component of agricultural and land management improvements will be to promote agro-forestry, which allows permanent use of soils without exhausting and destroying them. As well as providing a crop they can be used to protect areas prone to soil erosion such as steep slopes. Measures include:

- Alley cropping along contours, contour line alley cropping with separating strips of forest in between;
- Perennial tree crops. Production of timber for local use, e.g. poles for construction, fencing etc. Forest plantations with suitable species can serve this purpose. Taungya, a practice where crop production is combined with reforestation programmes, can be an acceptable procedure. Such schemes have given good results in Asia and in Africa, e.g. Tanzania;
- Fuel wood agro-forestry using multipurpose tree (MPT) species. This practice 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.

(iii) Forestry

There are a number of different approaches to forestry that depend on the circumstances and required outcomes:

- Forest protection. The remaining forests within the catchment are almost exclusively riparian gallery forests along the rivers, and these have to be protected, and if possible enhanced. These forests are important not only for their ability to retain silt carried by overland flow, but also for the conservation of

biodiversity, as they are a suitable habitat for a large variety of plant and animal species. The permanent protection and improvement of such forests is one of the most important mitigation measures for the impact on fauna and vegetation caused by the impoundment of the Bumbuna reservoir;

- Production of fuel wood. 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, and obtaining land for this purpose may be problematical. Community forestry can be a way for obtaining such forest lands;

- Reforestation. Re-establishing forests can serve different purposes, including soil protection through erosion prevention, enhancing water retention, providing habitat for wildlife (including chimpanzees), production of fuel wood, production of secondary forest products (fruits etc), production of timber for local use (poles etc) and for export. The kind of forest to be planted or protected will be chosen according to the objective;

- Soil protection. Especially steep slopes (>50°) should not be used for crop production or as pastures, and the vegetation in these locations must be left intact (no cutting, no burning). If erosion prevention is the main or only objective, 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 re-growth of woody vegetation impossible or too slow. Such cases, if they exist in the Bumbuna catchment, seem to be the exception, and such reforestation programmes 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 will not provide other services (eg timber production) quickly. However, they can be suitable habitat for a variety of wildlife species during the succession process.

The following key supporting measures of the forestry and agro-forestry programme will be implemented:

- Training of Forestry Guards and District staff in Tonkolili, Bombali and Koinadugu;

- Sensitisation of Chiefs and communities with respect to the Forestry Act (1998);

- Promotion of the establishment of community forests, and guidance to Community Liaison Committees and local interest groups on forest management and reforestation/afforestation;

- Explore and implement opportunities for community-based reforestation and afforestation initiatives that could generate benefits under carbon sink initiatives (Kyoto protocol);

- Establish incentive payment schemes for communities and interest groups successfully protecting riparian forests and managing community forests;

- Assist with the selection of tree species and crops for alley-cropping, which should be adapted to the prevailing local conditions.

(iv) Policy and regulations

Land management policies, procedures, and regulations concerning agricultural, forestry and land use practice in the upper Seli catchment will be established by consensus or where necessary through the use of by-laws.

Recommendations for appropriate land use and agro-forestry practice to protect the immediate catchment on four slope classes are set out in as options in Figures 8.12.5-1 to 8.12.5-3. The main considerations in the presented options are distance to the reservoir and the general slope of the adjacent hillsides.

- Slope gradient: 0-5 % (Figure 8.12.5–1). Install a forest strip 50 m wide along the reservoir area, followed by alternating strips of alley-cropping (600 m wide) and agro-forestry (50 m wide);

- Slope gradient: 5-25% (Figure 8.12.5–2). Create a forest strip 100 m wide adjacent to the reservoir area, followed by alternating strips of alley cropping (300 m wide) and agro-forestry (50 m wide);

- Slope gradient: 25-50% (Figure 8.12.5–3). Create a forest strip 200 m wide adjacent to the reservoir area, followed by two sequences of alternating strips of alley-cropping (200 m wide) and agro-forestry (100 m). Further sequences will be 400 m/100 m width respectively;

- Slope gradient > 50%. The proposed policy would be to prohibit cultivation in such areas. Under present 'slash and burn' practices, slopes of up to 70-80% are being cultivated.

Programmes of education, training, extension and demonstration will be provided under WLMSAP, and the above land use patterns will be implemented around the periphery of the reservoir.

(v) Monitoring and further studies

Monitoring measures are set out in Section 8.13 and are summarised as follows:

- Effectiveness of improved land use practice in controlling erosion;

- Progress in the introduction of improved agricultural practices and reduction in 'slash and burn';

- Progress in the introduction of improved forestry practices, and success in setting up of community forests and agro-forestry schemes;
- Trends and changes in land use patterns.

Further studies will be carried out as follows:

- Vegetation and land use map. An early study will be the establishment of a map of the present vegetation and land use types. This will go into more detail than the presently available maps of the area, and will reflect the actual land use. It is especially important that data on the amount of land cultivated, on cultivation methods used, and on the extent of annual grass fires be made available. Fieldwork in combination with the analysis of recent aerial photographs and satellite imagery will be required. A GIS should be used to record and store the mapping and data.
- Mapping of present land use and vegetation types. This mapping will be based on fieldwork in combination with analysis of aerial photographs produced by the recent LIDAR survey (Pietrangeli 2004), and comparisons will be made with 1975/76 aerial photographs to assess land use change in the past 30 years.
- Grazing will increase as farmers gradually replenish livestock looted and destroyed during the civil war. The carrying capacity of land used as pasture will be determined, and a land use form will be found which will allow a substantial reduction in grass fires. Careful management of pastures can improve their quality and can in this way contribute to the reduction of grazing pressure on this resource.
- The yearly rise and fall of the reservoir will create an area that will to a great extent be devoid of vegetation, which is repeatedly exposed to wave action and run-off on steep slopes, and so will be particularly prone to erosion. Research on Lake Kariba shows that certain highly specialised grasses may find an ecological niche and colonise these drawdown zones. Research will thus be conducted to assess whether native plants will grow in this area, as these could provide erosion protection and retain sediment washed from hillsides.

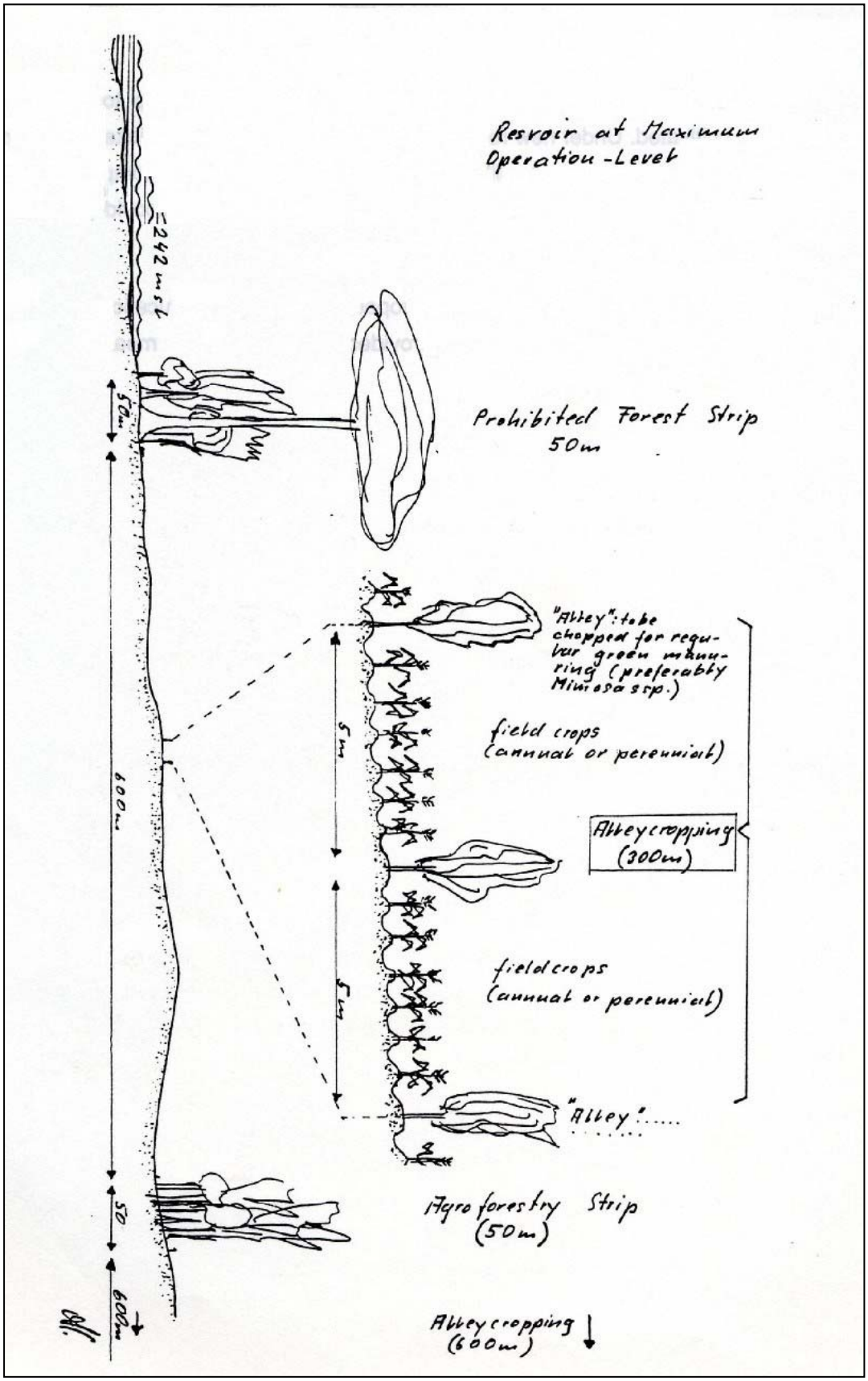


Figure 8.12.5–1: Land Use Legislation; Proposed Land Use Pattern on Slopes 0-5%

Source: Electrowatt/Techsult (1996)

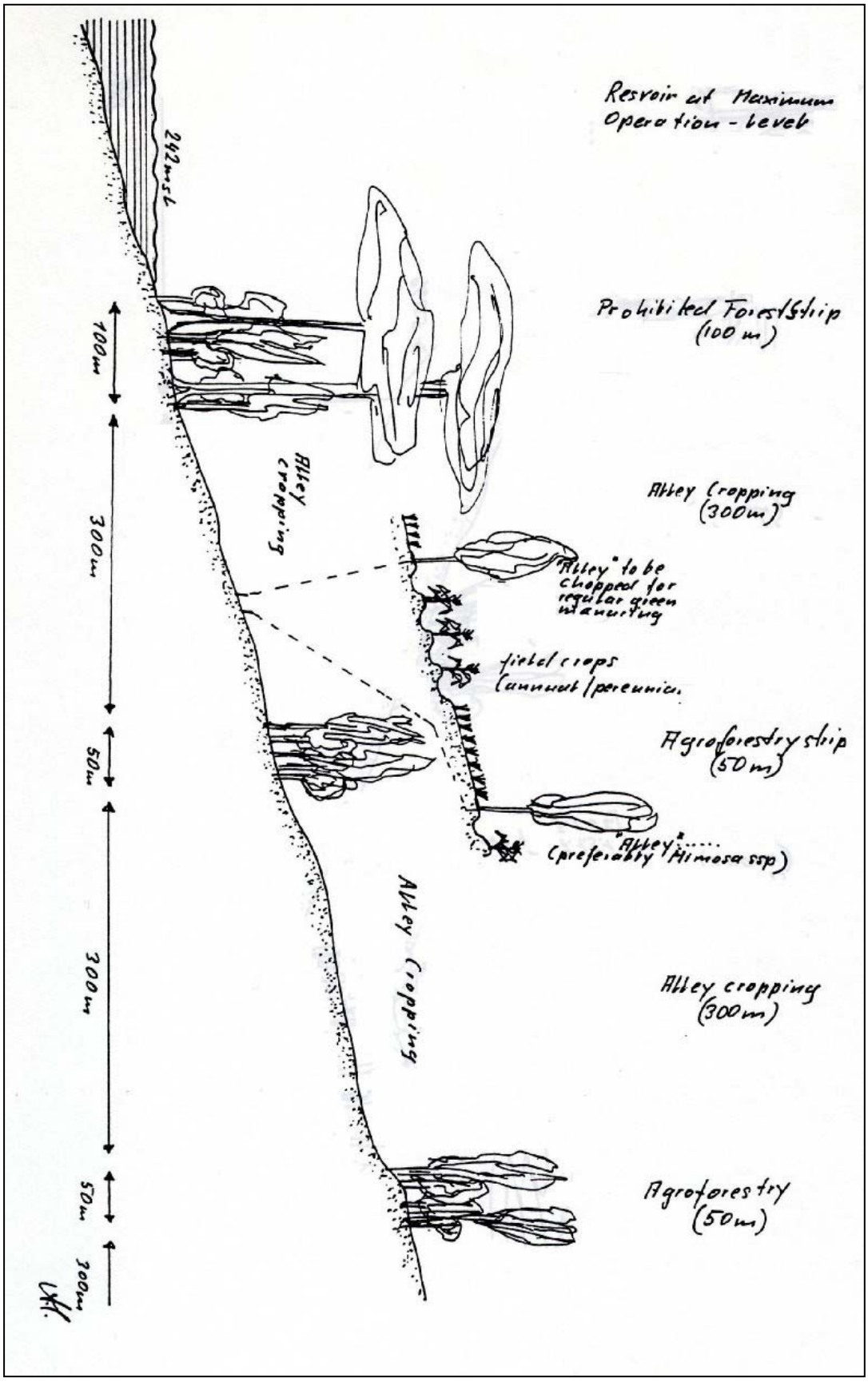


Figure 8.12.5–2: Land Use Legislation; Proposed Land Use Pattern on Slopes 5-25%
Source: Electrowatt/Techsult (1996)

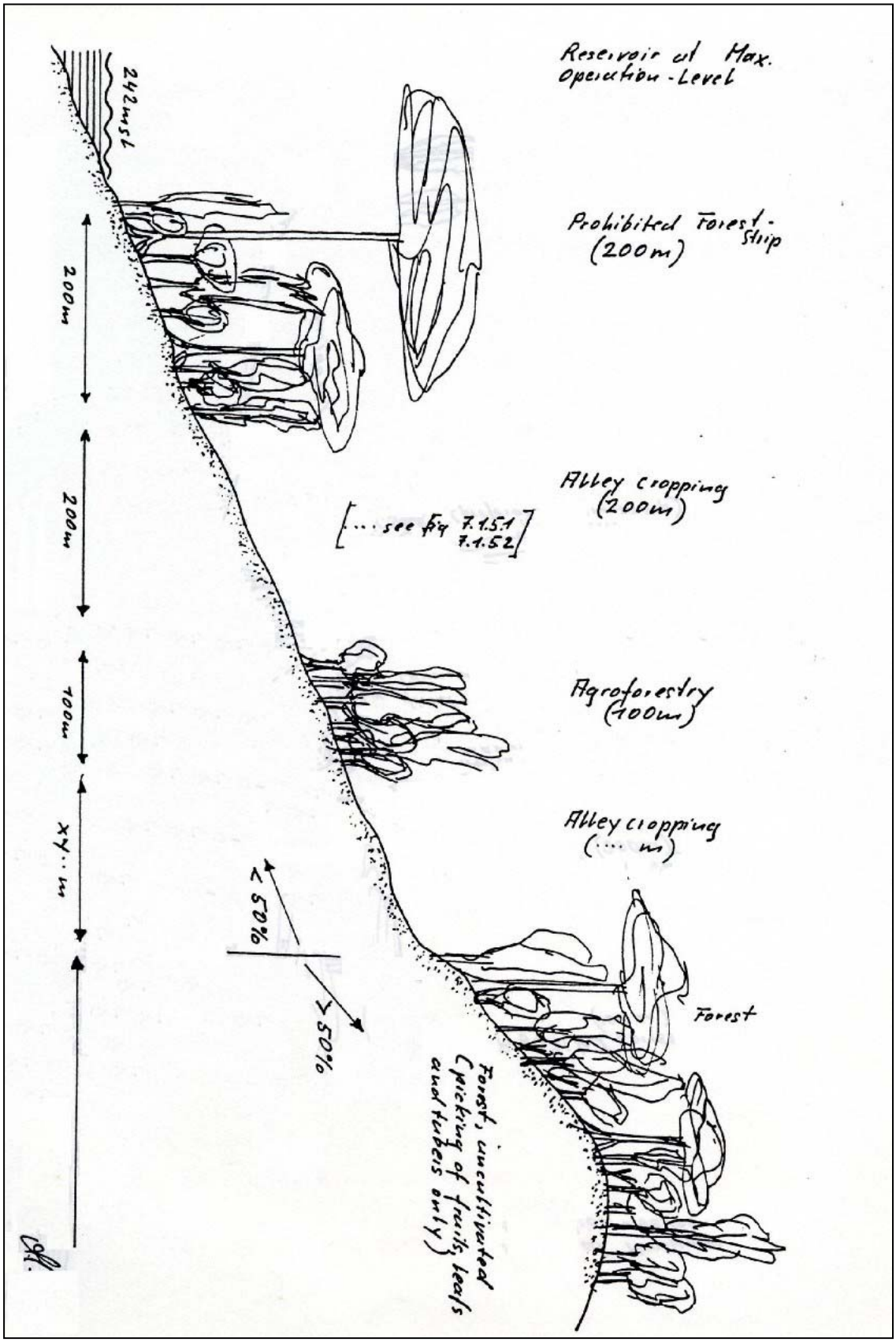


Figure 8.12.5–3: Land Use Legislation; Proposed Land Use Pattern on Slopes 25-50%

Source: Electrowatt/Techsult (1996)

- The yearly rise and fall of the reservoir will create an area that will to a great extent be devoid of vegetation, which is repeatedly exposed to wave action and run-off on steep slopes, and so will be particularly prone to erosion. Research on Lake Kariba shows that certain highly specialised grasses may find an ecological niche and colonise these drawdown zones. Research will thus be conducted to assess whether native plants will grow in this area, as these could provide erosion protection and retain sediment washed from hillsides.

8.12.6 Habitat and Species Protection

The WLMSAP will aim to maintain ecosystems to conserve fauna and flora and benefit local communities. These outcomes require action to safeguard habitats, including the establishment of protected areas, setting up of conservation offsets, the institution of practices to conserve fauna and flora, and working successfully with local communities to obtain a consensus on all the measures taken.

Detailed measures are as summarised below.

(i) Environmental Offset: Bumbuna Conservation Area

A study will be conducted in 2005 to assess the merits of establishing a Bumbuna Conservation Area as an offset to compensate in part for the loss of habitats and species in the reservoir area, and if appropriate to determine the appropriate location, boundaries and management measures. Such an area would serve principally to protect chimpanzee populations and other wildlife in the vicinity of the dam and reservoir, and will include examples of most forest zones found within the catchment, including the downstream riparian forest, forest re-growth, closed forest patches and mixed tree savannah. It would also conserve some remaining riparian forest, and foster the regeneration/emergence of new riparian forest on the reservoir margins immediately upstream of the dam.

The management objectives of the Conservation Area are:

- Conservation of flora;
- Conservation of fauna, in particular endangered chimpanzee populations;
- Collection of ecological data through the monitoring of flora and fauna;
- Promotion of eco-tourism and tourism to the BHP site.

The main steps and inputs required for its establishment are:

- Sensitisation with local communities on land and conservation needs, compensation costs associated with the acquisition of land, and potential socio-economic and catchment benefits;

- Detailed inventory and mapping of vegetation, and inventory of fauna;
- Development of management objectives and an initial 3 year management plan;
- Establishment of a detailed and multi-year primate monitoring programme;
- Establishment of management structures that take into account local stakeholders' interests. The area will be managed by a locally registered institution with a small number of staff responsible for managing the site, overseen by a Management Committee headed by the Paramount Chief and including representatives from NPA, the BHP operator, the Wildlife Department, a conservation NGO and Tonkolili District Council;
- Reforestation (where necessary) using indigenous trees characteristic of the upper Guinean moist forest zone. The cost of establishing a tree nursery at the Bumbuna site is incorporated in the establishment and operating costs of the Conservation Area;
- Implementation of a compensation programme if farmland is relocated to areas outside the boundaries, and economic trees are lost.

The investment and recurrent costs for establishing and managing the Bumbuna Conservation Area are presented in Appendix O and Table 13.2-1.

All the areas of land used at the BHP site (for excavation, borrow, spoil disposal, etc.) are likely to fall within the proposed Bumbuna Conservation Area, so most mitigation measures will therefore be in the context of the stated management objectives. Proposed mitigation measures include allowing for the natural regeneration of vegetation in the quarry and all previously cleared land areas, and livestock grazing or farming will be prohibited. The current regeneration of grasses, herbs and amphibian populations in the quarry area demonstrates the ability for natural regeneration, so replanting will not be necessary.

The size and designation of the proposed conservation area needs further discussion at national and local level. It could be declared a Wildlife Sanctuary, which is an existing formal category of protected area in Sierra Leone. However if a larger conservation area is deemed practical/appropriate it could be referred to as a protected landscape. Given the tenure situation, much will depend on the goodwill and co-operation of the communities which currently utilise the area, and which must participate in the further planning of such a protected area. Ensuring community participation and commitment will thus be one of the main actions during the planning phase.

(ii) Riparian forest

The loss of the riparian forest within the reservoir area results in the loss of the most important vegetative zone within the watershed. Although not likely to be a critical habitat for endangered primate populations within the catchment, the loss of plant diversity and habitat function for small mammals, amphibians, reptiles and avifauna is significant within the catchment and for the country. Recommended mitigation measures for the loss of the riparian forest are as follows:

- Protection of the remaining riparian forest within the BHP catchment, namely along the Seli and Mawoloko rivers and their tributaries, by legal measures and a community education programme. Their protection is already required under the Forestry Act (1989);

- Village chiefs and communities will be further encouraged to maintain and, where appropriate, reforest riparian forest areas, for which an annual payment will be made by the BWMA (subject to riparian forest within village boundaries being maintained). See costing under Section 8.12.9;

- Conservation Offset arrangements will also act in mitigation for the loss of riparian forest (see Section 8.12.7).

(iii) Protection of other representative habitat

There is an urgent need to protect areas in the immediate catchment where there are other types of habitat that will be lost in the reservoir area. In particular this should include areas where chimpanzee populations were observed during fieldwork for this study (eg 'Dynamite Ridge'). The mixed tree savannah on escarpments immediately west of the dam site will therefore be protected to safeguard the chimpanzee population there. This will be done by including this area in the Bumbuna Dam Conservation Area, or as a separate exercise. Protection will extend down to include the quarry and the reservoir shoreline. Much of this area consists of old (5 to 10 years) farm bush, which although not currently of high ecological value, does constitute a fairly well established forest area providing an important habitat for small mammals, which over time could develop into an important forest area.

(iv) Policy and Regulations

The protection of riparian forest and other representative habitat will require the agreement of the local administration and the local community. An education and awareness programme will first be carried out to sensitise stakeholders on conservation issues and the need to provide protection to fauna and flora, and the costs and benefits of the proposed protected area(s). Formal agreement between the BWMA and stakeholders will be obtained on the degree of protection to be afforded to the wildlife and vegetation in the sanctuary and elsewhere, and on the compensation to be given for

loss of use and benefits obtained from the land and its resources. This will take the form of a set of regulations and the means of enforcement that will be in accordance with local custom. The BWMA may wish to enlist the assistance of the Wildlife Department and appropriate NGOs in accomplishing these tasks.

(v) Monitoring and further studies

Monitoring proposals are generally set out in 8.13 Monitoring, and are summarised as follows:

- Prepare a detailed inventory and mapping of vegetation, and census of fauna within the proposed area of the Bumbuna Dam Conservation Area and other areas proposed for protection;
- Update ecological data through the monitoring of flora and fauna;
- Establish a detailed and multi-year programme of primate monitoring.

8.12.7 Biodiversity Conservation

Notwithstanding the mitigation measures to minimise habitat loss in the immediate catchment, the BWMA, through the WLMSAP will also make annual contributions towards the conservation and management of similar critical habitats in Sierra Leone within the context of the National Biodiversity Strategy and Action Plan (NBSAP) and annual priorities established by the Board of Trustees of the BMWA. This will be in accordance with the World Bank's policy of 'establishing and maintaining an ecologically similar protected area' (OP 4.04). NBSAP priorities include strengthening the management and protection of the Loma Mountains and Tingi Hills complex and the Sula Hills, in recognition of their high biodiversity conservation value. These montane ecosystems host similar habitats to those found in the Bumbuna catchment. International funding may also be sought to support these activities.

The BWMA will issue grants annually to institutions in Sierra Leone (Government and/or civil society) that are engaged in undertaking research and management action towards safeguarding the country's natural heritage and biodiversity, as reflected in the NBSAP.

8.12.8 Forest clearance

The 21 km^2 area of the future reservoir needs to be cleared of trees to reduce biomass decomposition in the reservoir and the potential for eutrophication of reservoir waters. Table 8.6-1 shows that this includes approximately 450 ha of riparian forest containing both commercial and non-commercial trees, 510 ha of mixed tree savannah and 630 ha

of forest regrowth areas, that is 1590 ha in total. One or more contractors will be employed for this purpose, and to ensure that benefits are passed on to the local community to help compensate for the disruption they will experience through having to relocate, and to protect remaining forest from further damage, contracts will require the company to:

- Employ at least 80% of the workforce from the local community;
- Provide all timber produced by the exercise to the local community free of charge;

Timber will be provided through the Paramount Chief to ensure an equitable distribution, and recipients will be free to use the products for their own purposes, or to sell to third parties if they wish. Clearance will commence during 2005, and will be completed before impoundment. By beginning clearance early, nutrients from brush that is burned or left to decompose will have the maximum time to be washed away, reducing amounts accumulating in the reservoir.

These arrangements for clearing the forest are based on the following principles and assumptions:

- As owners/custodians and users of the forest resources in the reservoir area, the local communities should be the beneficiaries of the forest products;
- Since the clearing of the reservoir is required for the benefit of the BHP, the costs will be met by the BHP;
- The transformation of trunks into planks will be undertaken on site, as off-site transport of logs for processing would be prohibitively expensive;
- Although a high proportion of the workforce will be members of the local community, experienced timber contractors will also be required to supervise and undertake critical tasks.

8.12.9 Funding

The expected costs of establishing the BWMA are presented in Appendix O and Table 12.2-1.

An innovative funding mechanism will be established to support the investment and recurrent costs related to:

- Bumbuna catchment management activities;
- Implementation of the WLMSAP;
- The proposed Forestry and Wildlife Conservation Offset;

It is proposed that the BWMA would be financed and hold funds from the following sources:

- A levy on electricity generation as payment for the benefit of environmental services from the Bumbuna catchment. The total annual power generation from BHP is expected to reach a maximum of 315 Gigawatts (315,000,000 kW). An environmental service levy of US$ 0.005 (half a cent) per kilowatt-hour will be applied. This will be equivalent to 3% of a possible customer tariff of US$ 0.16 per kilowatt-hour. This would generate a maximum of US$ 1,575,000 per annum.

- An application for funds will be prepared, through the World Bank, to seek support as part of the environmental measures related to the BHP. Funds generated by the environmental service levy would constitute matching funds, so the levy may attract other funding to Sierra Leone for biodiversity conservation and environmental management that might not otherwise be available.

- Depending on its programme costs, BWMA could also raise funds from private sector institutions active in Sierra Leone.

Costs for each of the programmes are presented in Appendix Q, and are summarised in Table 13.2-1, together with possible sources of funding.

8.13 Monitoring Plan

8.13.1 Introduction

Monitoring will commence as soon as possible in the pre-impoundment phase to assess progress towards achieving the objectives and outputs of the WLMSAP. This will begin with the collection of baseline data, via a number of surveys described in Section 8.14 below, which will establish existing conditions prior to impoundment and BHP operation. Details of performance indicators, information requirements, specific monitoring methods, sampling frequency and institutional responsibilities can only be established once the WLSAP has been completed in discussion with key stakeholders. Monitoring will include the measures set out below.

The BWMA should contract out land and wildlife monitoring services to NGOs or technical institutions with a good track record in water and land use, ecological and socio-economic monitoring. The monitoring contractors should establish a base of operations at Bumbuna. The resulting monitoring reports will be fed back into the Strategy to ensure that necessary adjustments are made to the activities. They will also be copied to all relevant stakeholder groups for comment and feedback. Activities in the monitoring plan are summarised in Chapter 12.

8.13.2 Stakeholder Awareness and Participation

The BWMA will monitor the advances in community participation, to assess the success of consensus measures for the regulation of improved practices in land use and conservation within the upper Seli catchment. This will include monitoring of the following key elements:

- Establishment of Community Liaison Committees and their participation in WLMSAP;
- Improvements brought about by community awareness and participation, in protection of water resources, forest and soil management, and wildlife conservation.

Monitoring will be an ongoing measure, and may be carried out as an internal exercise by BWMA.

8.13.3 Reservoir and Aquatic Systems

The monitoring programme will include:

- Water and land use regulations. Progress in instituting byelaws and other measures for regulating fisheries, and water and land use within the immediate catchment. This will be an internal exercise by BWMA;
- Water quality. A programme of water sampling and physico-chemical analysis to monitor *inter alia*: pH, dissolved oxygen, nitrate, phosphate, BOD, COD, DOC to indicate the quality of water in the reservoir and downstream, the occurrence of eutrophication and any other adverse conditions, and the need for and performance of any ameliorative measures, such as artificial mixing, both during impoundment and BHP operation;
- Erosion. Analysis of the quantities of soil eroding at different locations under different land use practices, to identify conditions and locations where further preventative measures are needed;
- Sediment loading and stream flow. An erosion monitoring programme will record sediment loads in the reservoir and the major inflowing rivers (the Seli and Mawoloko), plus stream flow gauging data and loss of soil from susceptible areas and locations of remedial measures, to provide a total analysis of sediment flow;
- Environmental flows. Flow measurements at the tailrace and measurements and observations downstream will verify the provision of required environmental flows and their performance in terms of meeting the needs of downstream ecosystems and human users as well as achieving the desired coverage of the river bed;
- Fisheries management. Development of the upstream (reservoir) and downstream fisheries and the success of management measures will be assessed by fish

population surveys and analyses of catches both before and during BHP operation;

- Ecological management. Aquatic habitats and species will be monitored in the reservoir to determine the success of measures intended to develop a diversity of native habitats and species of potential interest to tourists (eg waterbirds);

Monitoring will be conducted by experts in the appropriate fields, supported by experienced field assistants. In all cases monitoring will be conducted before impoundment begins to establish existing conditions, and will be continued during impoundment and when the BHP is operating to determine the impacts of these activities and the success of mitigating measures in reducing impacts as intended (as described in this document). The BWMA will then review the results as presented in monitoring reports and will make informed decisions as to whether further action is required to address any unforeseen impacts, or in the event of any measures not providing the desired outcomes. Monitoring will be a long-term activity, although over time the intensity may be reduced in areas where no problem areas have been detected over a long period.

8.13.4 Agriculture and Forestry

Monitoring will include:

- Progress in establishing an agro-forestry support programme with village associations/user groups, in the introduction of improved forestry practices, and the success in setting up of community forests and agro-forestry schemes;

- Progress in the introduction of improved agricultural practices and reduction in 'slash and burn';

- Trends in forest and vegetation cover within the immediate catchment and watershed, with particular attention to riparian forest zones and reservoir margins;

- Trends in bush fires including frequency, extent and location;

- Trends in agricultural land use, including soil conservation practices, agro-forestry, and intensification. Information about a momentary state of land use in an area is not sufficient for the purposes of catchment management. Trends and changes in land use patterns have to be monitored in order to know at an early stage if a non-desirable development is starting to take place, and to take corresponding and appropriate correcting measures.

This monitoring will also be an on-going process, intensive at first in order to establish a reliable and detailed baseline and to detect and report improvements in the first few years of the WLMSAP, so that the BWMA can provide early evidence of success that will be disseminated to stakeholders through the ongoing community education

programmes. Reviews at three-year intervals will allow adjustment of monitoring programmes to focus on ongoing problem areas and any locations and activities in which further mitigation has been necessary, and reduce monitoring effort where results have been routinely acceptable.

8.13.5 Habitat and Species Protection

Monitoring will include:

- Bumbuna Conservation Area. Preparation of a detailed inventory and mapping of vegetation, and census of fauna within the Conservation Area and other protected areas each year. This will record the continued presence of species and the expansion of populations and coverage, and will allow early detection of any problem areas and ingress from other land uses such as agriculture so that action can be taken through the community mechanisms;

- Primates. A detailed and multi-year primate monitoring programme will be conducted within the Bumbuna Conservation Area and the immediate catchment, to record the status of the communities and the performance of mitigation measures in protecting and enhancing the populations, and to ensure that measures can be adjusted to provide further benefits in the future to ensure continued protection;

- The natural regeneration of the quarry and other parts of the BHP site will also be monitored, to record the gradual development of natural habitats and inhabiting species.

8.13.6 Expertise, Effort and Budget

The envisaged level of expertise and effort for each of these surveys, and the likely costs, are shown in detail in Appendix Q in individual costing tables. These are included in the Environmental Management Plan described in Chapter 12, and shown in consolidated form in the summary EMP in Table 12.2-1.

8.14 Additional Baseline Studies

At various points in Chapters 7 and 8 a need has been identified to conduct additional studies and surveys to collect further data, to describe aspects of the existing environment in more detail, to enable mitigation of impacts to be planned, or to provide the baseline of existing conditions against which future changes can be assessed. Certain surveys have also been required by the ESAP. This has been discussed with both the World Bank and the PIU, who have agreed that the following additional studies will be conducted during 2005, before reservoir first filling commences.

The results of these studies will be incorporated into a revised EIA document, which will be disclosed by the Bank, and subject to public consultation in Sierra Leone. The

results of the public consultations will then be incorporated into the final version of this EIA. Many of the surveys will then be continued during impoundment and BHP operation, as part of the monitoring programme described above.

The studies are as follows:

a. A one-year fish survey throughout the river to identify spawning and nursery grounds and the location of any other critical habitats upstream and downstream, to determine the extent of any migration upstream and downstream of Bumbuna Falls, and to determine whether the Seli/Rokel supports any rare or endemic fish species. The final report will be available in March 2006.

b. A two-month limnological study to determine whether thermal stratification will occur in the reservoir, and identify and plan how it should be mitigated. This will involve desk studies of reservoir stratification, analysis of topographic and climatological data, field assessment of physical conditions, and estimations of the risk of stratification and hypolimnetic oxygen consumption. The final report will be available in May 2005.

c. A one-year study of chimpanzees and other primates in and around the whole reservoir area to determine the number, size, social organisation, habitat requirements and range of all primate groups, so that mitigation measures for each group can be planned in detail and implemented prior to reservoir filling. The final report will be available in March 2006.

d. A three-month survey of birds in the riparian forest of the reservoir area and in the Loma and Sula Mountains to identify the species and numbers present and their dependence on the forest, and to determine whether the same species are present in Loma and Sula. The final report will be available in July 2005.

e. A three-month survey to catalogue the butterfly species present in the various vegetation types in the reservoir area and the Loma and Sula Mountains. The final report will be available in July 2005.

f. A three-month survey of reptiles and amphibians in the reservoir area and in the Loma and Sula Mountains to produce a complete inventory of species, estimates of population densities, and an analysis of habitat types and preferences. The final report will be available in July 2005.

g. A three-month survey of small mammals and bats in the reservoir area and in the Loma and Sula Mountains to produce an inventory of species, estimates of

population densities, and an analysis of habitat types and preferences. The final report will be available in July 2005.

h. A six-months survey of trees, flora and plant communities/habitats in and around the reservoir area and in the Loma and Sula Mountains, comparing their species, quality and importance with those of similar areas elsewhere in West Africa. The final report will be available in September 2005.

i. A two-month desk study using data collected by the above surveys, to assess the merits of establishing a Bumbuna Conservation Area as an environmental offset, and if appropriate to determine its location, dimensions and management. The flora, fauna and habitats of the Loma and Sula Mountains will also be assessed and biodiversity conservation measures will be planned if appropriate. The final report will be available in November 2005.

j. A two-month field investigation to determine the archaeological potential of the reservoir and resettlement areas, to be carried out in the dry season once land in the reservoir area has been cleared of vegetation. This will be followed by a desk study to plan mitigation to protect archaeological remains, if this is found to be necessary. The final report will be available in November 2005.

9 Social and Cultural Impacts

9.1 Introduction

The most important social issue with respect to the development of BHP is the resettlement and/or compensation of people who will lose houses, land or other assets. Separate Resettlement Action Plans (RAPs) have been conducted for the dam / reservoir area and for the route of the transmission line, the initial results of which are summarised in section 9.2.4 and chapter 10 respectively. It can be concluded that plans are in place to resettle and/or compensate Project Affected Persons (PAPs), but much more detailed fieldwork will be required to implement the two RAPs. Given the schedule for project completion, this work must be progressed promptly.

Arrangements for communication and consultation with PAPs during the completion of construction and then operation will be through the medium of Community Liaison Officers, a Community Liaison Committee and a Grievance Procedure, which are briefly referred to in this chapter, but have been described in section 6.4.4 above.

In addition to the two RAPs, a development planning study (Vincent, 2005) has been conducted for a wider area around the BHP (the six chiefdoms that surround the core chiefdom of Kalansogoia based in Bumbuna). This Upper Seli Community Development Initiative, which is briefly described in section 12.2, is intended to bring development benefits to a broader spectrum of communities in the vicinity of the BHP. Other options and proposals for benefit sharing within the BHP are discussed briefly in section 9.5 below.

The development and operation of BHP could have significant impacts on the health of the 'host' communities, particularly in relation to vector borne diseases. These effects are discussed in section 9.7 below. The potential effects of electric and electro-magnetic fields created by the transmission line have been referenced within the transmission line chapter (10) below.

Other cultural impacts on the communities of the BHP area of influence are discussed in 9.8 below.

9.2 Social Impacts

The remaining construction work will be largely restricted to the existing project sites (quarry, dam, power station, tailrace); similarly, most of the construction traffic will be on the internal site roads, and on the road between the site and Bumbuna village for the transport of labourers. Therefore, whilst construction is being completed, the main social impact will be the health and cultural implications of having a relatively large

itinerant workforce stationed within, or in close proximity to, the village of Bumbuna. The mitigation of these issues is addressed in the contractors' EMPs (see chapter 13).

During the completion of construction, the maximum workforce will be 400 Sierra Leoneans and 45 expatriates. By comparison, the peak construction workforce in 1996 was 1,200 Sierra Leoneans and 85 expatriates, and at the end of 2004 the figures were 150 and 24 respectively. No new accommodation will be required at the construction site, and it is expected that the largely local labour force will be accommodated in existing housing within Bumbuna village. As the completion of construction gets under way, project drivers will need to be advised of the danger of accidents involving pedestrians between the village and BHP, particularly children.

Given that construction of the BHP is already almost complete, the major social issues of the project are related to the displacement and resettlement of people from the reservoir basin prior to inundation, along with some small impacts of operation.

Physical resettlement and other support measures are discussed under 9.4 below, but the social effects will be more wide-ranging. Of particular concern is the risk of exacerbating poverty due to the fact that the riparian communities will be supported by a reduced area of natural resources (see 9.3 below). There will also be raft of adverse socio-cultural effects involving

- Changes to inter-community relations due to resettlement in new locations
- Interruptions of existing lines of communication and inter-community relationships due to the presence of the reservoir.
- Impacts on traditional sacred sites and associated ceremonies (see also 9.8 below).
- Changes in the status of communities and families due to differences in the amounts of compensation received.
- Arrival of internal migrants to take advantage of new fishery opportunities and easier access (by water) to other natural resources.

In addition there will be adverse socio-economic effects, such as:

- Changes to income due to loss of access to resources and/or changes in crops.
- Marketing problems due to severance of existing transport routes.
- Reduced productivity due to reduced fallow period on smaller area of farmland.
- Marked reduction in paid labouring opportunities at the completion of construction.

- Potential increases in malaria, bilharzia and gastro-enteritis.

Against these social problems there will be certain benefits, such as:

- Improved health and education status due to new facilities to be provided as part of resettlement and the Upper Seli Community Development Initiative.
- New opportunities for fishing in the reservoir
- New opportunities to earn incomes from tourism
- Some improvements to transport due to water transport on the reservoir and new tracks to be built as part of resettlement.
- Improved skills due to training elements of Upper Seli Community Development Initiative.
- Opportunities to buy new equipment (tools, fishing gear, etc) for livelihood support using compensation.
- Availability of electricity in Bumbuna and towns along the transmission route.

It is impossible to quantify these potential social impacts, and therefore it will be critical to monitor the communities in the area of influence of BHP, in order to take early corrective action if problems arise. One encouraging observation to come from the RAP field studies is that the people of the project area seem to be quite flexible, many having relocated and re-established their livelihoods in recent years, for reasons other than the civil war. The main reason for spontaneous relocations of villages is to gain proximity to agricultural land or to a road. Such movements do not necessarily comprise the whole village; new offshoots are established from older villages. This shows that, at least within a certain distance (mainly defined by the limits of the chiefdom), there is not a cultural barrier to relocating villages.

9.3 Risk Assessment

Development and operation of the BHP will inevitably involve certain social risks. The philosophy of resettlement is that Projected Affected Persons should be no worse off as a result of the project, and preferably better off. There is, however, the risk of impoverishment, even given the financial support initially provided for in the RAP. Difficulties in re-establishing farming in a new location, loss of access to natural resources of seasonal importance (in this case including gold-panning sites), increased costs of transport and other services, and social disruption, can all lead to a downward spiral of impoverishment. An impoverishment risk assessment has not been conducted for the BHP, which emphasises the importance of the social monitoring referred to above, particularly in relation to the restoration of incomes and livelihoods.

Another risk is that the RAP will not be adequately implemented, in terms of either promptness, effectiveness or continuity. In relation to promptness, it is critical that the PAPs should move well in advance of reservoir filling, and that the planning, organisation and management should be established well in advance of the physical resettlement (see 9.4 below). Again, monitoring of the various mitigation measures within the RAP for implementation and effectiveness will be most important.

A major benefit of the BHP will be provision of a reliable source of power, and the distribution of power to an increased clientele along the transmission line route. There is a risk that this socio-economic benefit may not be achieved, due to lack of either connection or affordability. Connections in Bumbuna are due to be made free of charge, but connections in other towns along the transmission line are not expected to be free. The unit charge for electricity is due to be reduced once BHP is commissioned, so affordability by existing customers in Freetown is not in question. Affordability by new customers in Bumbuna and along the transmission line has apparently not been studied.

9.4 Resettlement Action Plan for the Reservoir Basin and Dam Area

[See Chapter 10 for summary of the RAP for the transmission line]

Electrowatt-Ekono initiated field studies of resettlement requirements in the vicinity of the BHP dam and reservoir on 9th August 2004, and the resulting Resettlement Action Plan (RAP) was published on 13th December 2004. Further revisions are expected following completion of the LIDAR survey of the reservoir area. The following text has been abstracted from the Summary of the RAP.

The main purpose of the RAP is to formulate a plan for resettling people and compensating them for losses incurred due to the BHP having encroached on their dwellings and resources, and altered their livelihoods. The RAP is intended to be in compliance with World Bank OP 4.12, which aims to ensure adequate compensation for PAPs, and their integration in the process of resettlement planning and implementation. Resettlement planning for a hydropower project is usually conducted during the feasibility and detailed design phase of the project. Implementation of the resettlement can then be carried out in parallel with the construction activities, which, may last for several years. BHP is very unusual in that the dam and main structures were built before the RAP studies were conducted.

Implementation of the RAP requires an adequate institutional set-up. The main actors will be as follows:

- The **Project Implementation Unit (PIU)** will be responsible for implementing the RAP. This unit already exists, and will receive additional staffing and institutional strengthening.

- Implementation will be contracted out to a **Resettlement Unit (RU)**, staffed and equipped to carry out the work. This RU should have offices in Bumbuna and Kafogo to deal directly and on a local basis with all issues at hand, and a co-ordinating office in Freetown. This unit will have to be created and the required personnel hired.

- A whole parcel of activities, the **LAIR** (Livelihood Assessment and Income Restoration) programme, should be carried out by an **NGO** qualified for such work. One such organisation has been identified, but further analysis will be required.

- An estimated total of 15 **Resettlement Officers (RO)** will be required, each of them dealing with 4 to 5 villages in the project area.

- **Legal counsel** to PAPs will be provided continuously throughout the process. The Lawyers Centre for Legal Assistance (LAWCLA) is an appropriate organisation for this task.

- **Village Resettlement Committees (VRC),** one per affected village, will be organised for direct representation of the PAPs. It is important that representatives of vulnerable groups (especially women and young people) are adequately represented.

- The role of a steering committee will be assumed by the **Resettlement Advisory Group**, in which all stakeholders will have to be represented.

- **Monitoring** will be an important part of the follow-up work. Different tasks within monitoring can be carried out by different actors, the main ones being the **RU** itself (for routine day-to-day monitoring), a **Witness NGO** for witnessing and monitoring specific activities, e.g. compensation payments or signing of agreements, and a **Panel of Experts** (the existing ESAP) for periodic external monitoring.

Following the fieldwork carried out, the villages in the study area have been grouped into the following six categories:

A Village not affected, no loss caused by the project.

B Built-up area of village not affected, but community loses a small part of its land (< 20%).

C Built-up area village not affected, but community loses a considerable part of its land (about 40%).

D Village at a critical elevation, might have to be moved at least partly, and loses a considerable part of its land.

E Village submerged, will have to be relocated.

F Village outside reservoir area or downstream of dam, which lost land to dam construction.

The following Table 9.4-1 shows the villages in each of these categories.

Table 9.4-1: Villages according to compensation categories

A	B	C	D	E	F
not affected	>20% land lost	~40% land lost	critical elevation	submerged	lost land for dam
1. Heremakono 2. Kamayimbo 3. Kadubaya 4. Kamakea 5. Kakekor 6. Kafogo 7. Kamadonorheh 9. Kahukumbah 10. Kathagburenah 11. Kamabandayna 16. Kakumankuru 17. Kakuthuhu 18. Kamandi 19. Kamakaheh 20. Kasanday 21. Kawayron 22. Kamatethe 23. Fula Town 24. Kamatha 27. Kasokra 28. Kamakoseh 34. Kamandi	8. Kasoloba 12. Kabendugu* 13. Kagboray* 14. Kasasi 2B* 15. Kasasi 2A* 25. Kabonka II* 26. Kabonka I' 29. Kamabareh 31. Kamawayway* 33. Kapamapaheh 35 Kamagbama 38. Kawungulu* 40. Katengbeh* 45. Kasokiri 47. Yiben[2] 54. Gbulia 55. Worowaia	30. Kamaniki II 32. Kamaniki I 36. Katoina 37. Kamasepina 39 Katene 41. Kakutan 42. Kayakala 43. Kamerah 44. Kasasi 46 Kadala 48. Bombali Dian Kawungulu 49. Kulian 51. Kamakweni 52. Masamandugu 53. Waia[3]		50. Matombe	56. Sonkoni 57. Kamato old 58. Kamato new 59. Bumbuna Town

Source: Electrowatt – Ekono (2005)

The following Table 9.4-2 (Source: Electrowatt – Ekono (2005)) indicates the number of households and population for each village, so that the number of people in each category can be determined.

Table 9.4-2: Villages: location and population

No.	Village	Elev. m asl	Latitude N	Longitude W	Households	Persons	Persons per HH
	Mawoloko River right bank (N res.)						
1	Heremakono	288	09°28.175	11°41.971	33	263	8.0
2	Kamayimbo	289	09°27.252	11°42.194	24	177	7.4
3	Kadubaya	280	09°25.736	11°43.149	3	23	7.7
4	Kamakea	282	09°25.134	11°43.474	12	99	8.3
5	Kakekor	295	09°24.266	11°43.780	23	188	8.2
6	Kafogo	280	09°23.575	11°44.087	84	749	8.9
7	Kamadonorheh	323	09°22.378	11°44.821	6	41	6.8
8	Kasoloba	252	09°22.329	11°44.035	8	65	8.1
9	Kahukumbah	340	09°22.191	11°44.963	1	7	7.0
10	Kathagburenah	340	09°21.834	11°45°132	n.a.	n.a.	n.a
11	Kamabandayna (des).	292	09°21.126	11°44.071	0	0	0.0
12	Kabendugu	354	09°20.666	11°43.505	9	67	7.4
13	Kagboray	354	09°20.327	11°42.836	9	51	5.7
14	Kasasi (2B)	327	09°20.061	11°42.419	0	0	0.0
15	Kasasi (2A)	326	09°20.035	11°42.524	7	55	7.9
	Mawoloko River left bank (N res.)						
16	Kakumankuru	380	09°25.380	11°42.613	5	32	6.4
17	Kakuthuhu	289	09°25.320	11°43.050	4	26	6.5
18	Kamandi (II)	319	09°25.013	11°41.650	20	164	8.2
19	Kamakaheh	258	09°24.568	11°43.343	5	42	8.4
20	Kasanday	380	09°24.455	11°42.348	6	38	6.3
21	Kawayron	289	09°24.077	11°42.663	7	43	6.1
22	Kamatethe	273	09°23.882	11°43.203	2	9	4.5
23	Fula Town	273	09°23.806	11°43.688	1	12	12.0
24	Kamatha	289	09°23.625	11°42.945	0	0	0.0
25	Kabonka II	304	09°22.883	11°43.637	0	0	0.0
26	Kabonka I	365	09°22.822	11°43.799	7	43	6.1
27	Kasokra	273	09°22.408	11°41.483	7	40	5.7
28	Kamakoseh	273	09°22.215	11°42.135	5	42	8.4
29	Kamabareh	273	09°21.722	11°43.048	10	56	5.6
30	Kamaniki II (Kamaselon)	258	09°21.278	11°42.632	0	0	0.0
31	Kamawayway	319	09°20.928	11°41.552	6	43	7.2
32	Kamaniki	289	09°20.898	11°42°288	3	20	6.7
33	Kapamapaheh	380	09°20.359	11°41.802	5	47	9.4
	Seli River right bank						
34	Kamandi	339	09°18.900	11°43.995	n.a.	n.a	0.0
35	Kamagbama	297	09°18.817	11°42.771	11	97	8.8
36	Katoina	251	09°16.490	11°43.116	19	154	8.1
37	Kamasepina	253	09°15.588	11°43.180	36	215	6.0
38	Kawunglu	464	09°13.781	11°43.555	19	154	8.1
39	Katene	253	09°12.462	11°42.852	20	150	7.5
40	Katengbeh	315	09°10.856	11°43.294	31	197	6.4
41	Kakutan	341	09°09.467	11°43.045	31	150	4.8
42	Kayakala	329	09°07.769	11°43.268	6	30	5.0
43	Kamerah	294	09°07.331	11°43.421	25	188	7.5
44	Kasasi	281	09°07.200	11°43.497	12	76	6.3
45	Kasokiri	278	09°05.174	11°44.000	45	306	6.8
46	Kadala	251	09°04.808	11°43.473	13	94	7.2
	Seli River left bank						
47	Yiben[2]				n.a.	n.a.	0.0
48	Bombali Dian Kawungulu	241	09°13.547	11°42.313	7	64	9.1
49	Kulian (Kulayan)	235	09°12.524	11°41.792	3	18	6.0
50	Matombe	211	09°12.128	11°42.167	16	135	8.4
51	Kamakweni	230	09°10.366	11°42.060	5	41	8.2
52	Masamandugu	233	09°10.353	11°42.057	6	55	9.2
53	Waia	322	09°07.874	11°42.366	80	612	7.7
54	Gbulia	428	09°05.903	11°42.652	69	565	8.2
	Outside Reservoir Area[3]						
55	Worowaia				n.a.	n.a.	
56	Sonkoni				n.a.	n.a.	
57	Kamato old				43	294	6.8
58	Kamato new				15	109	7.3
59	Bumbuna Town				n.a.	n.a.	
	Total				**824**	**6'146**	
	Average				**15.5**	**116**	**7.5**

The overall number of villages, households and people that will be affected, along with the areas of land and numbers of trees to be lost, is summarised in Table 9.4-3 below. (The total of five villages and 308 people to be resettled is subject to confirmation or amendment following a revision of the topographic survey data.) The fact that only a relatively small number of villages will be inundated is due to the settlement pattern in this area, with most villages being located some distance away from the river, on hills or small plateaux. The consequently modest resettlement programme can be achieved in the period before reservoir filling is due to begin in early 2006.

Table 9.4-3: Number of affected villages, households and persons

Cat.	Impact	Villages	HH	Pers.	Land		Trees	
		N	N	N	cult. ha	lost ha	present N	lost N
B	Up to 20% land lost	17	236	1'786	715	115	16'680	2'678
C	Up to 40% land lost	8	186	1250	484	194	10876	4350
C+	About 60% of land lost	1	80	612	374	225	4'678	2'800
D	Possibly partly to be relocated	0	0	0	0	0	0	0
E	**To be resettled**	**1**	**16**	**135**	**43**	**35**	**749**	**1'580**
Total affected by reservoir impoundment		33	518	3'783	1616	569	32983	10428

Note: C+ refers to Waia, which is well above FSL, but has 60% of its farmland below FSL

Compensation packages will be provided as follows:

Category B - Individual householders will be compensated for lost fruit trees, and an overall compensation for the lost land will be negotiated with the community. Since the amount of land lost is small, compensation does not necessarily have to be on a land-for-land basis, it could be anything else of equivalent value that the community considers as a priority (e.g. improved access, farming tools, etc.).

Category C - The question here will be whether the agriculture of the village will be sustainable on the remaining amount of land. In addition to the compensation measures mentioned for Category B, the following options will have to be considered: (i) support for the development of presently unused land within the community, (ii) development of stabilised agriculture on available land, including an appropriate extension programme, (iii) development of alternative livelihood strategies according to the options described below, and (iv) acquisition of land in a neighbouring community. These four possibilities are not mutually exclusive.

Category E - In addition to the compensation package outlined for Category C, a resettlement programme will be required. It seems that this village can be relocated a short distance from the present site, at a somewhat higher elevation, on land belonging

to the village. A reconstruction site has already identified, and the community is convinced that there is enough land for cultivation.

Category F – These villages will get retrospective compensation at community level rather than by individual households, in direct relation to the value of the land lost (as for Category B). The nature of this compensation will be negotiated with the community.

For Category C villages (and others as appropriate) a number of possibilities have been developed for alternative livelihood strategies, as follows:

- **Stabilised agriculture:** this is probably the most important of the strategies. Agriculture is the livelihood for almost the entire population. On the other hand, the area has reached its carrying capacity, and slash-and-burn cultivation is no longer sustainable. For these reasons, alternatives will have to be developed. The problem to be faced here is the fact that there is apparently no experience so far with such initiatives in Sierra Leone.

- **Fish ponds**: such ponds could be installed in a number of villages, and they could provide a source of income to individual families. Fish farming could also be developed in the reservoir once the water quality has stabilised. Fish is an important part of the diet in Sierra Leone, not only in coastal areas.

- **Boat service on the reservoir, ferry crossings**: This would serve the entire population, and could create income for a number of families.

- **Blacksmiths**: they play an important part in rural communities. The strategy aims at improving skills and performance, and possibly to train additional people.

- **Improving local markets**: this would be less an alternative livelihood, but rather an opportunity for a larger number of families in the project area to create an additional income. This has to be seen in relation to improved access (e.g. by boat).

- **Improving footpaths**: access is vital for the remote villages, and improved access could be a part of the compensation package for some of them. Ideally, construction of these paths should be undertaken by the villagers themselves.

In addition to the above, a number of possibilities either need further studies for assessing their potential (e.g. tourism, reservoir fisheries, drawdown area cultivation, and vocational training for masons and carpenters), or which could be chosen by interested individuals and would then have to be developed (e.g. production of handicrafts, agroforestry, herbs and medicinal plants, non-timber forest products, etc.). One important possibility for income generation for the local community, albeit for a limited period, is implementation of the RAP itself. A considerable amount of physical

labour will be required (reservoir area clearing, land preparation, construction of houses and footpaths, etc.), and priority should be given to the local population for this work.

The $ 1.14 million Upper Seli Community Development Initiative (see 9.5.7 below) includes a similar set of alternative livelihood strategies.

A resettlement budget has been made based on the information obtained so far. The main items of this budget are shown in Table 9.4-4 below.

Table 9.4-4: Budget for Bumbuna HEP Resettlement

Item		Costs in US$			Total US$	Total SLL
		Year 1	Year 2	Year 3		
	Inst. setup (RU)					
	RU salaries and fees	645'200.00	630'200.00	630'200.00	1'905'600.00	5'335'680'000.00
	RU expenditures	558'600.00	300'500.00	255'500.00	1'114'600.00	3'120'880'000.00
	Compensation costs[1]	352'409.85	1'057'229.56	352'409.85	1'762'049.27	4'933'737'951.00
	LAIR activities	196'000.00	144'200.00	184'100.00	524'300.00	1'468'040'000.00
	Stabilised agriculture	397'000.00	497'000.00	355'000.00	1'249'000.00	3'497'200'000.00
	Total	**2'149'209.85**	**2'629'129.56**	**1'777'209.85**	**6'555'549.27**	**18'355'537'951.00**

1 Compensation: preparation (0.2) in year 1, main work (0.6) in year 2, finishing (0.2) in year 3.
Compensation costs are those which are required for the specific compensation packages required for individual villages.
Source: Electrowatt-Ekono/Techsult (2004).

9.5 Benefit Sharing

9.5.1 Introduction

A World Bank desk study on the sharing of benefits from dam projects (Egre, Roquet and Durocher, 2002) has considered the benefit sharing mechanisms in a number of cases studies (which include power, irrigation and water supply). Five types of mechanism were identified, and for any given project, more than one type of mechanism can be used. These five mechanisms are discussed below, followed by their potential application to the BHP.

9.5.2 Revenue Sharing

In the case of revenue sharing mechanisms, part of the revenues are redistributed to local or regional authorities in the form of royalties tied to power generation or to water charges. Such mechanisms may be the result of negotiations between local or regional authorities and the promoter, or may be defined in legislation. In the latter case, the

percentages of revenues that must be transferred to regional or local beneficiaries, and the destination of the proceeds, are generally specified.

9.5.3 Development Funds

Developments funds financed from power sales, water charges or government may be established to provide seed money for fostering economic development in the project affected area. As with revenue sharing mechanisms, the objectives, structure and duration of development funds may be the result of negotiations between local or regional authorities and the promoter, or may be defined in legislation. Projects to be financed by the development funds may be specified or not. They may include, for example, community facilities, training programmes or job creation in industrial or commercial projects.

9.5.4 Equity Sharing or Full Ownership

A variety of mechanisms may allow local or regional authorities to partly or fully own a dam project. Local authorities thus share the risks of the venture, but also its profits, if any. Moreover, they may in certain cases gain a degree of control over the design and operation of the project.

9.5.5 Taxes Paid to Regional and Local Authorities

Two main types of tax paid to regional and local authorities can be considered. In some countries, the State allows local or regional authorities to directly tax dam owners (e.g. hydropower corporations) on the property value of the project or other bases. This mechanism is not linked to revenues, since the tax applies whatever the level of power generated or water supplied by the dam operator. However, it represents a fixed charge for the producer, which has a direct impact on profits. Taxes to be paid to regional and local authorities can also be defined in State legislation, sometimes as a percentage of project sales or net income. In the latter case, this mechanism is similar to revenue sharing.

9.5.6 Other Project Related Fees

Local or regional authorities may negotiate free energy or preferential electricity rates with the hydropower producer, which benefits all electricity consumers in their constituency and contributes to local and regional economic development. This mechanism is a form of revenue sharing, since it results in the receipt of less revenues for the dam owner, and avoided costs for beneficiaries.

9.5.7 Bumbuna

In the case of Bumbuna, it is expected that **development funds** will be made available, as defined in the Upper Seli Community Development Initiative (Vincent, 2004). The objective of this $ 1.14 million initiative is to widen the benefits of the BHP to its broader area of influence, i.e. those areas where some positive and adverse social impacts may be experienced, but which will not receive of funds directly for resettlement and compensation. These funds will pay for infrastructure such as education and health facilities, and for vocational training and other capacity-building activities. As mentioned in section 12.2 above, seed funding has been acquired to prepare a proposal to fund the initiative under the Japanese Social Development Fund, which is managed by the World Bank.

In addition, a type of **revenue sharing** has been proposed, in that it has been suggested in the present report that a portion of the electricity tariff should be paid into a Watershed Management Fund, which will support the activities of the proposed Watershed Management Authority. (This has been accepted in principal by the Bumbuna PIU, but the details will depend upon the nature of the contracts between the MEP and both the future BHP operating company and the new power distribution company.) It is likely that the BHP will also be in receipt of carbon credit funds from the GEF. These funds will probably be credited to a Trust Fund, which may or may not be the same fund.

Finally, **other project related fees** will effectively be transferred to local beneficiaries on a one-time basis by the electrification of Bumbuna village. Village houses are expected to be connected to the power supply free of charge, but householders will have to pay for the electricity consumed.

9.5.8 Social Infrastructure

Some **social infrastructure projects** that are recommended as mitigation measures, will also become significant benefits for the host community. These include:

- A replacement footbridge downstream of the dam to be built after removal of the existing construction bridge.
- A ferry boat to provide a transport service across and along the reservoir.
- Floating pontoons or long jetties (probably two) on the reservoir to act as catch landing points for fishermen.
- New access tracks to provide vehicular access to resettlement locations.

9.6 Project - Community Relations

During both the completion of construction and the many years of future operation, there will be interaction between BHP and its 'host' community. It is essential for all parties that good relations are maintained. As specified in the EMP (13.3.2 above), the construction contractors and the operating company will each be required to employ a **Community Liaison Officer**. In addition, a **Local Consultative Committee** will be formed to act as the forum for all stakeholders, as described in 6.4.4.above. Finally, as also mentioned in 6.4.4, a **Grievance Procedure** has been devised to deal with problems or complaints that cannot be resolved by the other two means.

9.7 Health Impacts

The construction and operation of the BHP may potentially influence the health of the surrounding communities in the following ways:

- changes in the incidence of vector borne diseases, due to changes in vector habitat
- social impacts resulting in the increased incidence of Sexually Transmitted Diseases (STDs),
- gastro-intestinal problems due to changes in water quality and water use.

Whilst these are three separate types of health impact, they are addressed together below because in the remote area of the project site, the health of communities can best be monitored and treated by a single primary health care programme (with the addition of specialist treatments / programmes where needed).

The specific issues to be addressed are as follows:

- Malaria - Malaria is already by far the most prevalent identifiable disease of children and adults in all districts of the Northern Province, with 32% of all out-patients reporting malaria in 2003. The new reservoir will create additional breeding sites for the mosquito vectors of malaria. This could be particularly prevalent during drawdown, which can be expected to leave a number of small isolated pools of water. In addition, some of the villages that are presently not near the river will be within mosquito flying distance of the reservoir after impoundment. Downstream of the dam, the discharge during the dry season will increase. This is likely to eliminate some of the pools of stagnant water which form in the river bed under present conditions during the dry season.
- Schistosomiasis (Bilharzia) – Schistosomiasis is also prevalent in the project area The slow-moving water at the margins of the reservoir will create new habitat for the snails that are the intermediate hosts of schistosomiasis. The existing schistosomiasis problem in the three districts around Bumbuna is already worrying, as there is currently no national schistosomiasis control programme and there are no immediate plans to introduce one.

- Onchocerciasis (River Blindness) - Filling the reservoir will inundate various river rapids which create the 'white water' breeding sites used by *Simulium* blackflies, the vector of onchocerciasis. The project will therefore lead to a reduction of river blindness along the 30 km reservoir. On the other hand, at the tailrace of the power plant, the agitated water can be expected to create a new *Simulium* breeding site. However, the reduction of white water will be far greater than this small increase. (The prevalence of onchocerciasis among the villages of the project area averaged 48% in 2002. However, the Onchocerciasis Control Programme now provides once yearly community distribution of Ivermectin and entomological surveillance.)

- Public Health - The construction and operation of the power plant will attract people into the project area. They might settle in temporary housing having unsanitary living conditions and may not have access to proper health care. Once the reservoir is filled, communities that have not previously had river access, will find themselves adjacent to a very large water body. This will be very tempting both as a source of water and a site for washing, defaecation, waste disposal, etc. This will demand a strenuous effort in public awareness to prevent the transmission of both gastro-intestinal disease and bilharzia. Moreover, the resettlement of PAPs in new locations with unfamiliar sources of food and water, will also expose people to new health risks. Proper water supply and sanitation will therefore need to be provided at resettlement sites.

- Sexually Transmitted Diseases - HIV/AIDS is nationally on the increase. 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. HIV/AIDS and other STDs are classically spread by migrant workers, truck drivers and other itinerant or temporary labourers at construction sites. Awareness, prevention measures and access to care must be provided in the BHP project area. (This issue is also addressed in chapter 13 within the contractors' EMPs.)

Up-to-date information on health status and health facilities in the project area is provided in Appendix B.4. The health infrastructure is very weak and functions badly. It needs to be strengthened to assure access to primary health care for the whole population, to guarantee proper treatment for common diseases and injuries, and to warrant for timely referral of complicated cases. Even without the BHP, implementation of most public health programmes in the project area needs to be strengthened, especially:

- Provision of improved Mother and Child Health Services, including Family Planning (MCH-FP).

- Expanded Programme on Immunisation (EPI).

- Promotion of safe drinking water supply and sanitation; including latrines and refuse disposal.

- Health education, including education on nutrition and childcare.

The potential health impacts referred to above cannot be quantified, so the approach must be to plan for their minimisation by both **health services** and **engineered mitigation** measures. Given the weakness of existing health facilities referred to above, it will be necessary for the project to take the initiative for appropriate improvements in co-operation with the Ministry of Health and donor health programmes operating in the area.

Prior to the completion and operation of the BHP, the following **health service improvements** must be envisaged:

- Rehabilitation and proper staffing of the existing health infrastructure, especially the Community Health Centre in Bumbuna. This poorly equipped facility, which is headed by a Maternal & Child Health Aid (MCH-Aid), is currently the only clinic serving the entire Kalonsogoia chiefdom.

- Establishment of new rural health facilities in remote areas, particularly in relation to resettlement areas (which had not yet been identified at the time of writing). See section 7.4.5 above for a listing of existing health facilities in the vicinity of the project, which indicates that facilities are both sparse and inequitably distributed.

- Malaria control in collaboration with the Malaria Control Programme of the Ministry of Health & Sanitation, including monitoring, improved case management, chemoprophylaxis for pregnant women, promotion of impregnated bed nets, and health education.

- Onchocerciasis control in collaboration with the Onchocerciasis Control Programme (Ivermectin treatment as may be recommended by the programme from time to time, along with entomological surveillance).

- Schistosomiasis control in collaboration with the Schistosomiasis Control Programmme (health education, monitoring, proper diagnosis and treatment, and sanitation).

- Implementation and strengthening of other national public health programmes, especially immunisation and the Mother-and-Child-Health (MCH) programme, which includes also Family Planning.

- Monitoring and control of diarrhoeal diseases and intestinal parasites by promotion of safe drinking water, promotion of sanitary latrines, and application of oral rehydration therapy (ORT).

- AIDS prevention by health education, condom promotion, and proper treatment of sexually transmitted diseases.

- Tuberculosis monitoring and control by proper diagnosis and treatment.

- Water supply and sanitation - all the villages requiring resettlement will be provided with an adequate supply of clean drinking water (piped from secure springs, or covered dug wells with hand pumps). Sanitary facilities (VIP latrines) and waste disposal facilities must also be installed.

- Health education and promotion - to ensure that health education messages really reach the people, the entire health staff, village health workers, health committees, administrators and school teachers must participate in health education efforts.

The health education messages must include, *inter alia*, the following points:

- Nutrition: proper nutrition for children, weaning, importance of breast-feeding.

- Importance of immunisations.

- MCH: antenatal care (ANC) and child spacing.

- Malaria control: importance of early treatment, chemoprophylaxis for pregnant women, and promotion of impregnated bed nets.

- Schistosomiasis control: avoidance of infested water sites, treatment for patients with haematuria.

- Onchocerciasis control: importance of regular Ivermectin mass treatment.

- AIDS prevention: risks of multiple sexual partners, condom promotion.

- Latrine promotion.

- Promotion of safe drinking water.

- Oral rehydration therapy.

For each village to be relocated in the vicinity of the reservoir, the RAP has made a standard provision of $ 8,000 for a new health centre. As the RAP is further developed, a more detailed costing will be required to include initial staffing and running costs, along with plans for the ultimate transfer of responsibility to the Ministry of Health. The Upper Seli Community Development Initiative includes a budget for health and sanitation. This consists of $ 208,000 for nine new health centres and $ 160,000 for seven well and toilet projects.

Environmental engineering for vector control. While engineering methods may not be sufficient for disease prevention by themselves, they may provide a significant

element of mitigation. The most important measures will probably consist of the drainage of depressions in the drawdown area, where such places exist in proximity to settlements, to prevent the formation of breeding places for mosquito larvae. The drainage of larger depressions can be by mechanical means, whilst smaller local drainage ditches can be dug by hand. Small swamps created along the lake shoreline and close to villages, may be filled or drained to prevent them from becoming habitats for water snails and therefore risk areas for schistosomiasis infection. As the lake shoreline is so long, it cannot be envisaged to apply such measures to the whole of it. However, to reduce risk it will be sufficient to do so within distances of 1 to 1.5 km from settlements.

It is important to ensure that all health mitigation measures are continued into the operation of BHP and are maintained. Their chances of sustainability can be increased by the following measures:

- Community participation in the planning, preparation and implementation of the mitigation measures.
- Strengthening not only the infrastructure of health facilities, but also the capability of personnel, in order to maintain dialogue between the health system and the local population.
- Implementation of the mitigation measures, taking into consideration national health guidelines and health policy.
- Implementation of the mitigation measures as far as possible by the Ministry of Health and the official public health programmes.

9.8 Cultural Impacts

9.8.1 Local Culture

The field study in the original EIA (1996) provided valuable information for evaluating and assessing the reaction of local people to the entire project. This information was updated by information collected during the consultations for the present study (2004) as summarised in chapter 6 above.

The main adverse cultural impact of the project, which cannot be valued in monetary terms alone, is the destruction of religious sites and places of spiritual or ancestral worship. Cultural sites are an integral part of society, with some settlements having an array of these relating to the many male and female "secret societies" in the villages of the project area. Sacred sites of various kinds occur in most of the villages that will be affected by the project. Some of these sites were destroyed during the site preparation and construction works more than a decade ago, which caused considerable upset at the

time. These works involved massive earth moving processes, which were mainly undertaken in three sectors:

- the construction of access roads from Bumbuna village to the dam site and its environs,
- the construction of the dam, power station and auxiliary works,
- quarrying in the vicinity of Makali, one of the villages heavily affected by construction activities.

Other sacred sites will have to be located before the reservoir is filled, and the people have stated that these sites can moved if necessary, when instructed by the government. Cultural sites were identified as part of the recent (2004) RAP studies for the dam and reservoir area. For example, at Worowaia, four male and one female secret society shrines were identified. At the village of Kamakweni, three male and three female secret societiety shrines were found. Kamakea* has three male and one female secret societies. At Kamabareh and Kamakoseh*, one each of male and female secret society sites were found. In total, there might be thirty such sites that will have to be relocated. However, according to information obtained during focus group discussions, the relocation of such sites is always possible, provided that ceremonies can be held at the appropriate time. Compensation will have to be paid for the holding of these relocation ceremonies, as indicated in the RAPs.

As also indicated in the RAPs, trees are among the assets for which compensation will be payable. Among the Limba people, palm-trees are considered to be the most valuable and culturally important trees, which they fondly refer to as "the trees of life". They obtain two valuable items from the palm-tree; palm oil and palm-wine, which is used both for consumption and for sale as a important source of revenue.

Another cultural issue is the need to keep people properly informed about the project through traditional channels. Chiefdom authorities are the normal point of access to information; if they do not have access to official information on the project work programme, they are unable to provide adequate explanations to their people.

A further cultural impact of the project has been the rapid increase in the size of the population of Bumbuna. This situation was largely responsible for some ethnic conflict between the indigenous Limba inhabitants and the migrant construction workers

* Unaffected

moving into the area. A related development was the rapid increase in small-scale trading within the area. The increase in the number of people being salaried or wage labourers increased people's purchasing power. This encouraged business people to move into the area in order to benefit from the new market created.

9.8.2 Archaeology

Field studies in the area of the future reservoir conducted for the original EIA (1996) and for the EIA Update (2004) did not identify any archaeological sites or artefacts (see also section 7.4.3 above and its related appendix). The latter studies were limited by the time available, the wet weather and the field conditions. However, local informants interviewed during the EIA Update studies were also unable to provide any information about potential archaeological sites or materials, or any relevant local history. It is entirely probable that archaeological "cultural property" can exist without the knowledge of local inhabitants, who may not recognise an object as an archaeological artefact (e.g. microlithic stone tools), or recognise that features within the landscape may constitute the remains of ancient occupation sites. Conversely, if it is assumed that modern agriculturalists exploit arable areas that may have been regarded as suitable by previous farming communities, then the current lack of familiarity with archaeological sites/material is highly suggestive that none exist. Even speculation regarding the possible existence of archaeological sites (also settlement patterns, dating and socio-economic adaptations) is difficult, due to the limited volume of previous research conducted in Sierra Leone. Nevertheless, sufficient evidence was collected from the review of published literature and from the various surveys conducted during the EIA update to conclude that:

- The local inhabitants' lack of familiarity with archaeological remains, along with the absence of remains at any of the field sampling sites, suggests that the BHP reservoir area has little archaeological potential;

- On the basis of the data available, it appears that no significant archaeological remains will be affected by the implementation of the BHP.

- The certainty of these conclusions could be improved by additional survey work, but this should not be attempted until the pre-inundation clearance of vegetation has been completed.

Given the above situation, no immediate mitigation measures are presently proposed for the protection of any archaeological sites. However, a further two-month field investigation will be conducted once trees have been cleared from the reservoir area. There is also the possibility that archaeological material could be uncovered during the

final stage of construction, or during operation (particularly along the reservoir margins). For this reason, instructions should be included within the contractors' EMPs to anticipate this situation, in order to protect or preserve any such materials (see section 13.3.2).

10 Transmission Line Issues

10.1 The Transmission Line

The 161 kV single circuit transmission line, 203 km in length, was constructed between Freetown and Bumbuna during the period 1994-96 (see Figure 3.1-3). By the cessation of construction, most of the towers (540) had been constructed and approximately 80 km of the line had been strung. By the end of hostilities, 29 of the towers had been destroyed. These will have to be rebuilt and some others will need restoration work. In addition, the whole of the line will have to be restrung with new cables. A small number of additional towers may be built during the restoration work, in order to detour around some areas of housing that have been constructed in the intervening years.

The line design consists of 400 mm^2 conductors, shielded by two shield wires. In order to supply electricity to Makeni and Magburaka, the two shield wires between the Bumbuna Switchyard and Makeni will be insulated and energised at 34.5kV at Bumbuna. Similarly, to supply electricity to Lunsar and Port Loko, the shield wires between Freetown and Lunsar will be insulated and energised at 34.5kV from the Freetown Substation.

The Freetown substation is located near the existing Kingtom Thermal Power Station, which will facilitate connection of the supply from Bumbuna into the existing Freetown distribution network. Similarly, a new sub-station is planned on the site of the former Makeni diesel generating station.

10.2 Environmental and Social Impacts of the Transmission Line

10.2.1 Construction

Environmental Impacts

The transmission line was virtually complete at the termination of construction in 1996, and therefore any environmental effects of construction occurred a decade ago. The main impact at that time would have been the clearance of vegetation from the ROW and the access tracks to it. However, the transmission route passes through cultivated swamps, farm-bush and human settlements, all of which are ecologically unremarkable. Vegetation along the route is typical of disturbed areas, with fast-growing pioneer and exotic species. Typical plant species composition includes *Harungana madagascariensis, Cassia sieberiana, Spondias mombin, Alchornea cordiflolia, Albizia adianthifolia, Panicum sp.* and *Anisophyllea laurina*. Exotic species include *Bambusa vulgaris* and *Gmelina arborea*, while cultivated plants included cashew, pineapples, palm, potatoes, sugar cane, cassava and rice. Regenerating timber species growing

along the transmission route included *Canarium schweinfurthii, Antiaris africana, Ceiba pentandra* and *Daniella thurifera*.

The line passes over three transmission towers in the Occra Hills Forest Reserve, 7-8 km from Masiaka along the Waterloo - Masiaka road. This is a production reserve designed to protect the steep hill slopes from erosion, and is planted with several exotic species, the dominant ones being *Cordia alliodora* and *Gmelina arborea*. Additional plant species found in the reserve include *Ochthocosmus africanus, Anisophyllea laurina, Anthocleista vogelii* and *Phyllanthus discoideus*. The exotic species *Chromolena odorata* grows along the paths leading into the reserve. Human disturbance in the reserve is high due to the gathering of fuelwood, the cutting of poles and hunting for bushmeat.

None of the transmission line passes through the Western Area Reserve, located on the mountain chain of the Freetown Peninsula. Most of the transmission towers are located on the lower slopes of the mountain chain, in areas that have already being degraded and deforested.

Social Impacts

Construction of the transmission line involved the demolition of some buildings and the loss of economic trees within the 30m wide ROW (see Figure 10.2.2-1 overleaf). At the time, a valuation exercise was carried out and plans made for compensation of the affected people. However, no compensation was ever paid, which is a source of continuing disquiet. This issue has been addressed in the recent Resettlement Action Plan (RAP) for the transmission line, so that compensation may be made retrospectively (see 10.2.2 below).

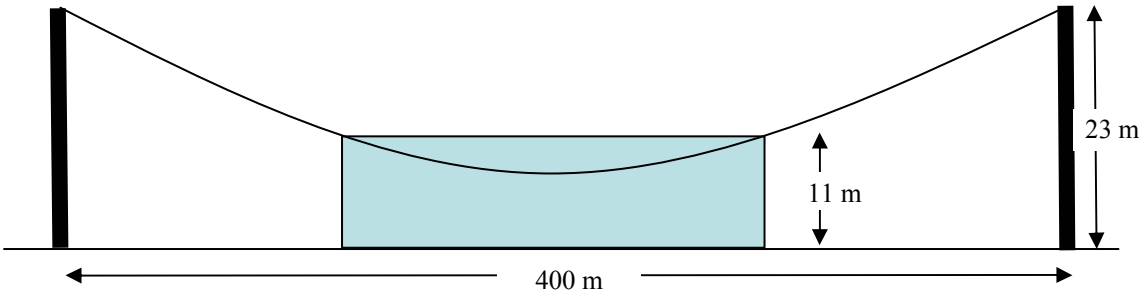
10.2.2 Restoration and Operation

Environmental Impacts

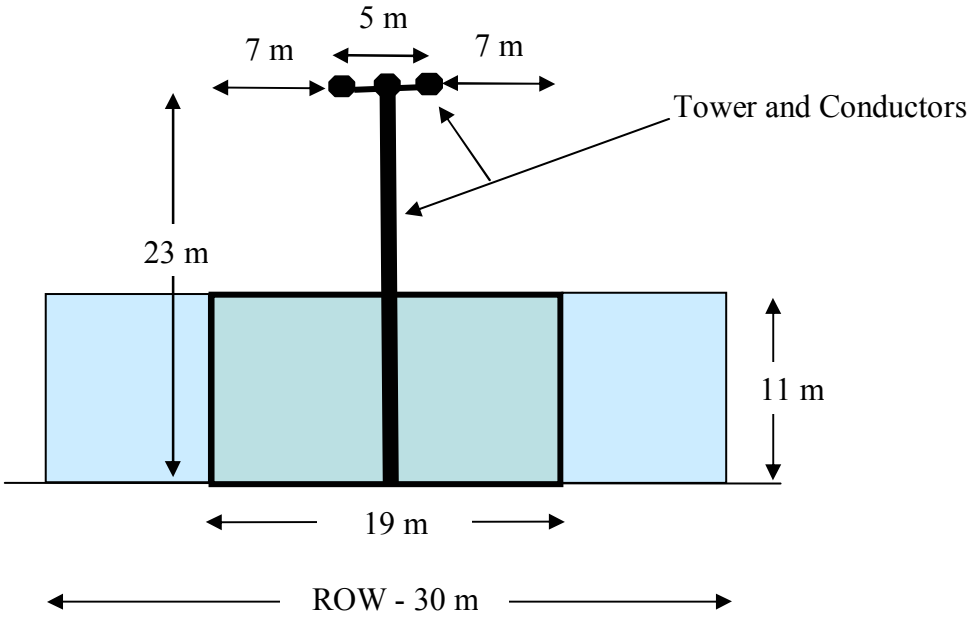
The restoration of the transmission line will require engineering access to all of the tower sites. In almost all places, the track along the Right of Way (ROW) has continued to be used by local people. Similarly, the original access tracks from roads to the transmission line have been kept open by local use. Rehabilitation of the transmission line will therefore not cause any adverse effects on flora and fauna additional to the original effects of its construction. Vegetation will be cleared mechanically where necessary, and herbicides will not be used.

Social Impacts

Restoration of the ROW could theoretically require the resettlement of those people who have settled within the 30m wide exclusion zone since the line was first



Sketch A. **Longitudinal Profile** along centerline of ROW showing horizontal separation of towers (400 m), sag of conductors (Hyperbolic Cosine), and vertical Exclusion Zone height of 11 m: 7 m (EMF) plus 4 m (average height of all structures in the ROW). The horizontal length of the Exclusion Zone is calculated as 220 m (55 %) of the distance between towers based on the equation describing the shape of the sag in the conductors. This length is a good approximation for both horizontal and inclined surfaces. Sketch not to scale.



Sketch B. **Transverse Profile** perpendicular to centerline of ROW showing horizontal dimension of Exclusion Zone (19 m) that includes separation between conductors (5 m) and setback distance (7 m) on either side of the outer conductors. The vertical dimension of the Exclusion Zone remains the same (11 m). The ROW is 30 m wide. Sketch not to scale.

Figure 10.2.2-1: Diagrams of the Transmission Line showing ROW and Exclusion Zone

Source: Azimut *et al*. (2005)

constructed, and the RAP study has therefore surveyed and recorded all such properties and people. However, existing structures are now acceptable within the ROW, with the exception of those which are within 7 m of an electrical conductor. This is recognised as a safe separation distance for this type of power line in Europe, America and other developed countries. This clearance also meets the most recent and stringent Electromagnetic Field (EMF) exposure standard of 3 μT (micro-tesla) just under the conductors, applied by the Government of Italy (which is the strictest in the EU).

On the basis of this minimum distance, a new Exclusion Zone has been defined from which occupants will be resettled and compensated. The Exclusion Zone is described as a series of solid rectangular boxes that are 11m high, 19m wide and 220m long between each set of towers, as demonstrated in Figure 10.2.2-1. These dimensions were derived as follows:

Height is the minimum distance relative to the 7 m standard + the average height of all structures in the ROW (4.025 m) = 11.025m.

Width is the distance between conductors (5 m) + 2 X minimum required separation distance (7m) = 19m.

Length is the length of the sagging conductor that is within 11 m of the ground surface, assuming that the average distance between towers is 400m, i.e. 220m

The structures requiring resettlement from the Exclusion Zone are houses, sheds, shacks, wells, fences, walls, poles and any other type of constructions, temporary or permanent. Other unacceptable activities include tree-planting for whatever purpose. However, gardening, crop production and cattle raising are all allowable in the ROW, as long as no structures other than small fences are erected. This will reduce the social impact of ROW. PAPs will be issued with restricted leases which will specify the limits and conditions of land use.

Resettlement has been addressed in detail in the RAP for the transmission line. In a few cases, the construction of small detours of the transmission line may be made to avoid the need for resettlement (e.g. between Kissy Cemetery and Fourah Bay College in Freetown). The numbers of households and people within the ROW are as follows:

Table 10.2.2-1: Numbers of Households and People within the Transmission Line ROW

Transmission Line Sections	Households	Individuals
Kingtom to Hill Cut Road, Freetown	119	1,574
Hill Cut Road to Bumbuna (except Makeni)	141	1,342
In Makeni	107	1,252
Total	367	4,168

Of the 367 households in the ROW, only 129 (35%) are within the Exclusion Zone, so the social impacts will be much reduced. Almost all of the structures are used for residential purposes. During the day, some are used for commercial purposes (restaurants or shops), especially in the towns. The large majority of the households to be relocated will require BHP assistance to physically move them. They will require in-kind compensation and will accept to proceed on their own to a new location of their choice.

In rural areas, if houses must be demolished, resettlement will largely be achieved by providing replacement houses a short distance from the ROW, in many cases on contiguous land owned or occupied by the household to be moved, so the social disruption of resettlement will be slight in these areas.

The table above indicates that about 60% of households in the transmission line ROW are in the two urban areas, about half of them in the 1.5 km between Kingtom and Hill Cut Road in Freetown, and the other half in Makeni. Consultations for the RAP indicated that resettlement from the mixture of temporary and permanent structures along the Kingtom-Hill Cut Road line would be a considerable task. It would also be preferable to avoid resettlement from the urban area of Makeni if possible. However, the reason for keeping the ROW clear of people is to address health and safety concerns.

This issue has been considered by the PIU and the ESAP, and the following solutions have emerged.

Makeni - The 161 kV transmission route passes into the town, in order to connect with the new 35.5 kV sub-station, which is planned to be constructed on the site of the former diesel power station. If the line were diverted through open countryside to the north of the town, the resettlement requirements would be negligible. This would involve moving 15 of the existing towers and locating the new sub-station on the north side of

the town. At the time of writing in January 2005, this alternative is under active and positive consideration.

Freetown – For the urban area of Freetown, the following alternatives to clearing the Exclusion Zone have been considered, in order to minimise resettlement:

- Relocation of the end-of-line 161 kV sub-station from the Kingtom power station site to a new location in the Lester Peak area (or Wilberforce), close to the perimeter of the city on the existing alignment. (This alternative has subsequently been discounted on cost grounds.)

- Raise the towers at critical sections where public health issues may be a concern (i.e. to reduce exposure to transmission field effects to below the international guidelines), and in parallel, adopt measures to mitigate hazards or perceptions of hazard.

The factors to be considered in relation to these alternatives include the following:

- Pubic safety around transmission lines
- Public health risk avoidance in relation to electrical field effects
- Line maintenance and access
- Sustainability
- Relative cost and affordability
- Views of the affected communities
- Future investment in transmission, distribution and system reliability
- Accepted international practice

While the initial concern was that EMF effects may be the critical criterion, preliminary analysis has concluded that an additional key issue is to demonstrate adequate provision of public safety and access to the towers for routine maintenance and emergency repair.

This issue had not been finalised by January 2005. As part of the normal PAP consultation on the completed draft final report of the Transmission RAP, PAP feedback will be obtained on the overpass alternative, with the option of raising critical towers.

However, it can be concluded that satisfactory mitigation options are available to either resettle people from the Exclusion Zone, or design an engineering solution that would provide an adequate level of safety and health protection for any people remaining within the ROW.

10.2.3 Cost of Resettlement and Compensation

The costs of resettlement are summarised in the five tables below. The valuation methods used were intended to be equitable and fair to all PAPs, with the same policies

applied in the Western Area and the Provinces. The average cost of **substitute land**, purchased with or without title, is $20 per square metre. Notwithstanding this, the basic approach will be to compensate the loss of land with new land (land-for-land). The **cost of construction** of a permanent structure is estimated $100 per square metre. At the implementation stage, the value will be fixed according to the type of structure. The project will disturb some **small businesses** in the ROW, which will experience loss of income during the resettlement activities. They will be compensated on a case-by-case basis. **Removal cost** will be reimbursed by a fixed payment per household and business.

Table 10.2.3-1: Estimated Cost of Reconstruction of Structures

161 kV Transmission line	Area (m^2)	Value (Area x $100)	$ Value in Exclusion Zone (35%)
Kingtom to Hillcut Road	15 230	1 523 200	533 050
Hillcut to Bumbuna (excepting Makeni)	13 027	1 302 700	455 945
Makeni	19 699	1 969 900	689 465

Source: Azimut *et al* (2004)

Table 10.2.3-2: Calculated Value of Land

161 kV Transmission line	Area (m^2)	Value (Area x $20)	$ Value in Exclusion Zone (35%)
Kingtom to Hillcut Road	30 460	609 200	213 220
Hillcut to Bumbuna (excepting Makeni)	53 112	1 062 240	371 784
Makeni	55 907	1 118 140	391 349

Source: Azimut *et al* (2004)

As land-for-land compensation will be provided by GOSL, the above values are an indicator and do not require specific funding.

The value-added for land improvement below is calculated at 10%.

Table 10.2.3-3: Calculated Value-added for Land Improvement

161 kV Transmission line	Area (m^2)	Value (Area x $20 x 10%)	$ Value in Exclusion Zone (35%)
Kingtom to Hillcut Road	30 460	60 920	21 322
Hillcut to Bumbuna (excepting Makeni)	53 112	106 224	37 178
Makeni	55 907	111 814	39 135

Source: Azimut *et al* (2004)

The **total estimated cost** of resettlement and compensation, excluding land-for-land compensation, is presented below.

Table 10.2.3-4: Total Cost of Resettlement and Compensation

161 kV Transmission line	$ Value of Structures	$ Land + Value-Added	$ Total in ROW	$ Total in Exclusion Zone (35%)
Kingtom to Hillcut Road	1 523 000	670 120	2 193 120	767 592
Hillcut to Bumbuna (excepting Makeni)	1 302 700	1 168 464	2 471 164	864 907
Makeni	1 969 900	1 229 954	3 199 854	1 119 949
Total		**$**	**7 864 138**	**2 752 448**

Source: Azimut *et al* (2004)

Losses of crop and tree assets were evaluated in 1994, and agreements were signed for compensation, although this was not paid at the time. These consisted of 448 cases with a total value of Le 1,148,656,443, i.e. $ 1,276,331 at the 1994 exchange rate of Le 900 per $1. These compensation amounts have been inflated by the average prime interest rate of the National Bank of Sierra Leone for each of the intervening years cumulatively up to 2005. This gives a current total of $ 3,641,389, which will compensate the loss of the affected persons resulting from not being paid their due during the period 1994-2005.

The total budget required for **complete implementation** of the RAP for the transmission route is shown in Table 10.2.3-5 below. It incorporates the cost of compensation and resettlement for all affected people of all categories, together with the

cost of the implementation organisation, monitoring, evaluation and assistance to vulnerable people. An additional 10% is included for contingencies.

Table 10.2.3-5: Budget for Complete Implementation of RAP for Transmission Line.

Item	$ Entire ROW	Exclusion Zone (35% of ROW)
COMPENSATION		
Lost Structures Compensation: Kingtom to Hillcut Road *Note 1*	$1,523,000	$533,050
Lost Land Compensation: Kingtom to Hillcut Road *Note 1*	$609,200	$213,220
Land Improvement Compensation: Kingtom to Hillcut Road	$60,920	$21,322
Lost Structures Compensation: Hillcut Road to Bumbuna, except Makeni *Note 2*	$1,302,700	$455,945
Lost Land Compensation: Hillcut Road to Bumbuna, except Makeni	$1,062,240	$371,784
Land Improvement Compensation: Hillcut Road to Bumbuna, except Makeni	$106,224	$37,178
Lost structures Compensation: Makeni *Note 2*	$1,969,900	$689,465
Lost Land Compensation: Makeni *Note 2*	$1,118,140	$391,349
Land Improvement Compensation: Makeni *Note 2*	$111,814	$39,135
1994 Compensation Files *Note 3*	$3,300,000	$1,155,000
Compensation for Transmission Tower Land *Note 4*	$225,000	$78,750
Lost Business Compensation	$102,000	$35,700
Cultural Property Compensation	$20,000	$7,000
Forest Asset Compensation *Note 6*	$10,000	$3,500
Crop Loss Compensation *Note 6*	$10,000	$3,500
Disturbance Compensation (10 %)	$1,153,114	$403,590
Sub-Total Compensation	$12,684,252	$4,439,488
IMPLEMENTATION		
Implementation Organization	$620,000	$620,000
Substitute Land Development *Note 5*	$195,271	$68,345
Cost related to Vulnerable People	$40,000	$40,000
Compensation Commission & NGO Witness	$20,000	$20,000
Legal Counsel	$20,000	$20,000
Final Evaluation & Compensation Contract	$20,000	$20,000
Monitoring	$20,000	$20,000

Sub-Total Implementation	$935,271	$808,345
Total	$13,619,522	$5,247,833
Contingencies 10%	$1,361,952	$524,783
GRAND TOTAL	**$12,191,895**	**$4,796,263**

Source: Azimut *et al* (2004)

- **Note 1**: An alternative option of raising the towers in the densely populated Freetown section of the line is under active consideration; this could lead to a major reduction of the resettlement costs in this section of the line.
- **Note 2**: Resettlement costs in the densely occupied area of Makeni could be largely avoided by re-routing the line to the north of the town.
- **Note 3**: Compensation for 1994 losses is limited to loss of crops and trees in the ROW.
- **Note 4**: The area of the transmission towers was not included in the calculation of Lost Land Compensation.
- **Note 5**: These nominal amounts are included to compensate for crops and tree loss that may not have been recorded in the 1994 field survey.
- **Note 6:** A standard rate of 7 % as charged by Real-estate Agents was calculated, based on the actual Lost Lands Value to be substituted.

10.2.4 Implementation of Transmission Line RAP

This RAP complies with national requirements, the Constitution, National Laws and Acts applicable to the transmission line rehabilitation project. The RAP and its implementation methodology have followed the World Bank Involuntary Resettlement guidance, so that Bank policies and guiding principles will take precedence. This has been structured in the RAP such that no prejudice or precedent will be created.

The Ministry of Energy and Power and its Bumbuna PIU is the sponsor of the BHP and is responsible for the implementation of the RAP, with the assistance of the following organisations and institutions:

- An independent legal counseling firm;
- An independent Non Governmental Organization of Sierra Leone.
- A Freetown financial institution.
- The Government of Sierra Leone.
- A National Compensation Commission (NCC) which will include the above mentioned groups.

The NCC will be responsible for the identification of the land users and for ensuring that each payment is made in a secure way to each Project Affected Person. A contract between the PIU and each household will be signed, allowing the disbursement of compensation. Preference will be given to in-kind compensation. As part of the

compensation, residents will be able to sign leases which will allow them to continue to use the ROW land under strict conditions.

The Project Affected Persons (PAPs) are all land owners, land occupiers, squatters and others who will lose assets or lose the benefit or the use of assets resulting from the project, whatever the extent of the loss. Loss of assets includes the loss of land use, structures, crops, or a combination of these. Not all PAPs will have to be relocated, as in some cases only a narrow strip of the concerned asset will be encumbered. In such instances, they will receive cash or in-kind compensation for their loss. Eligibility to resettlement and compensation is based upon the survey executed at each site. Any household that has been identified during the survey as having interests affected by the project, is eligible to compensation and/or resettlement in proportion to the impacts.

The construction of a replacement house will be offered wherever the existing building has to be removed. This may be either on the remaining part of the plot if it is viable and the affected household agrees to such a solution, or on another resettlement plot of the household's choice if the remaining area is not adequate. Replacement land will be offered in cases where the area outside the ROW and setbacks are not viable. Replacement land will be equivalent in area and of the same potential use as the original land. The household will be consulted on the location and characteristics of this land. Secure and legal land titles will be given to all re-settled families. In-kind compensation will be offered preferentially against encumbered or acquired assets when they are in the ROW. Consultation with the affected persons in each household will ensure that the final compensation / resettlement package is appropriate for the needs and expectations of the affected household. Consent of spouse and children will be complied with wherever applicable. Because the ROW is a linear strip of land with little broad impact on communities as such, no group resettlements are anticipated. Resettlement land sites will be identified in the neighborhood of the affected household or, in some cases, at another site of choice. For this reason, no significant impact on host communities is expected.

The choice of resettlement sites will be determined by mutual consent between the PIU and the household. It is estimated that more than 75% of households will require resettlement support in the vicinity of the ROW, and the remaining 25% will request resettlement elsewhere. The implementation team will analyse the compensation request, in order to assist with resettlement and to ensure that people receive compensation for housing, land, land title, and loss of economic activity.

Construction will be undertaken by the individual owner or by a contractor, and this will be determined at the beginning of the implementation stage. The type and quality of

houses will be better than the original. Technical advice will be provided to each household, and plans will be prepared in consultation between the beneficiary of the compensation and the engineer of the implementation team. To favour the employment of PAPs, they will be encouraged to be active in the construction work. The budget for reconstruction will remain the same, but will directly benefit the affected people.

The low population density along most of the line will allow construction to respect the urban and rural environment of the resettlement site. (with respect to the size of plot, stability of soil, surface water drainage, sewage system, access, minimal bush cutting and natural effects, neighborhood and general social acceptance of the construction.)

The PIU has taken steps to minimise the potential for disputes. Valuation is made by independent surveyors. Legal Counsel will be available to advise the Project Affected People on legal issues, and all survey and valuation results are cross-checked by community members and the asset owner. The potential heirs of land owners have already been identified during the field census, in case the landowner dies during the compensation-resettlement process. Aggrieved persons will have a right of access to the court as guaranteed by the constitution and laws. If property disputes occur, the PIU team will encourage aggrieved persons to find a mutual understanding and come to an applicable solution. In the case of a persistent dispute, it may be brought to the local magistrate. If it cannot be resolved in this way, the case can be brought to a higher court.

It is estimated that implementation of the RAP will require a period of one year. No construction work will take place before the compensation-resettlement measures are completed.

Monitoring and Evaluation are key components of the RAP under the responsibility and obligations of the Ministry of Energy and Power and the PIU. The monitoring and evaluation procedures will have the following general objectives:

- Evaluation of the compliance of the actual implementation with the objectives and methods set out in the RAP, and of the impact of the compensation and resettlement programme on incomes and living standards.

- Monitoring of specific situations of economic and social difficulty arising from the compensation-resettlement process.

11 Development Context

11.1 Negative and Positive Impacts

The project design and the landform, geographical and meteorological conditions at the Bumbuna site endow it with a number of natural advantages, such that the negative impacts of BHP (first phase scheme) are relatively modest when compared with many other hydropower schemes. For example, any effects of this run-of-river scheme on the downstream river and its associated flora, fauna, fisheries, wetlands and water resources will be slight, because there will be relatively little change in the river flow regime.

The work of the original EIA tended to concentrate on the negative direct impacts of the BHP. Chapter 8 of the present report provides a more complete account of the expected adverse and beneficial environmental effects of the project.

In addition, there will be a number of broader direct and indirect benefits of the BHP scheme, which are of relevance to development and poverty reduction. These can be classified under economic, environmental and social categories, as follows:

Economic (the following is not intended to be an economic evaluation of the BHP project, which is outside the scope of the present report.)

- Given the present high prices of oil products, which are expected to be maintained in the medium term, the saving of foreign exchange due to the reduction of oil imports can be expected to be very much greater than predicted. The growing expenditure on fuel for large numbers of individual generators would also be saved. (As NPA service has deteriorated, this has become a significant element of expenditure for an increasing number of households.)

- Given the current growth rate and power demand in the capital, output from the 50MW first phase of Bumbuna will be rapidly taken up by Freetown. However, the future phases of Bumbuna development up to 275MW could supply other parts of the country and/or be exported to neighbouring countries of the region. The scheme would then contribute to national and West African regional development, with a valuable foreign exchange income in the latter case. (As noted earlier, the conduct of a Strategic Environmental Assessment (SEA) of the remaining four phases of the Bumbuna scheme is strongly recommended to comply with World Bank and other guidance.)

- New / foreign investment in manufacturing, service industry and tourism facilities is unlikely without reliable power, so commissioning of the BHP should contribute significantly to the recovery and growth of those sectors of Sierra Leone's economy.

- No major industrial, mining or agricultural projects are planned for the Seli / Rokel valley region. However, the provision of power to Makeni will make a step change in the recovery of this district centre, which previously had a functioning

mains electricity distribution system. Part of the poverty reduction strategy of Sierra Leone envisages increased agricultural production for food security, combined with agro-processing in rural growth points such as Makeni. The provision of a reliable power supply in Makeni will facilitate the growth of agro-processing and other small-scale rural industries, with an associated reduction in poverty.

- As indicated earlier, it can be expected that creation of the Bumbuna reservoir will have a fishery benefit. The productivity of the water body will be somewhat limited by the rapid turnover of water and therefore loss of nutrients. Nevertheless, this fishery will be of direct economic (and nutritional) local benefit to those riparian communities which will lose land due to inundation.

- The reservoir will also provide a small but important local economic and social benefit in terms of water transport, both cross-river transport and longitudinal transport providing access to previously inaccessible villages of the Seli valley.

- There will be a significant increase in the Seli River flow rate downstream of Bumbuna during the dry season (January – May). This could potentially be used for irrigation to extend the growing season, with economic benefits to the agricultural sector.

- Tourism in Sierra Leone is in a parlous state due to the damage to the infrastructure and reputation of the country caused by the recent civil war. However, the hydropower project at Bumbuna represents a significant opportunity for tourism development, as discussed below.

Environmental

- The corollary of fuel cost saving, is the saving in local air pollution and global carbon emissions compared with thermal power generation. The annual energy production of the 50 MW first phase BHP scheme will be 315 GWh, which would produce 179,600 tonnes of carbon dioxide (CO_2) if it were generated by a standard thermal power station. Taking account of the greenhouse gases that may be generated within the reservoir (methane equivalent to 55,480 tonnes of CO_2), there is calculated to be a net carbon dioxide benefit of 124,120 tonnes of CO_2 from the operation of BHP (see Appendix C.3).

- The more immediate environmental benefit of providing reliable power supplies to Freetown, Makeni and other towns is the reduction of local air pollution, noise and disturbance due to individual petrol and diesel generators. This benefit is unquantifiable, but the use of generators has proliferated since the end of the civil war, due to both improving economic conditions and the continuing deterioration of the existing NPA systems for power generation and distribution.

- The immediate catchment of the reservoir is currently being farmed using unsustainable practices, both the slash and burn shifting cultivation and the tillage of extremely steep slopes, which will rapidly lose soil during rain. Measures for improved soil conservation, land use and watershed management are recommended within the present report, *inter alia*, to protect the power station and reservoir from the effects of suspended solids and sedimentation. If these

measures are implemented this will be a very considerable indirect environmental benefit of the BHP.

- Given the loss of forest in the reservoir basin, improved forest protection and management is proposed in the present report, both in the vicinity of the reservoir basin and via an 'offset' mechanism to support forest reserve(s) elsewhere. The project will also provide an opportunity to improve protection of the remaining chimpanzee population around the reservoir and within the offset area(s). These are environmental benefits which would probably not have been achieved without the advent of the BHP.

- Whilst the filling of the reservoir will destroy some forest habitat, it will also increase habitat diversity by creating a lake where previously there had only been a river environment. This will lead to an increase in overall aquatic biodiversity (which will also enhance the fishery benefit mentioned above).

Social

- Construction of the BHP has created and will create direct employment. At its maximum in 1996, BHP was employing 1,200 Sierra Leoneans. At the halt of construction in 1997, the project had been employing 750 Sierra Leoneans and 85 expatriates. In August 2004, 150 Sierra Leoneans and 24 expatriates were employed at the construction site. The peak of employment in the completion of the BHP will be 400 Sierra Leoneans and 45 expatriates in early 2005. All of the unskilled labour (200 Sierra Leoneans) will be recruited from Bumbuna and neighbouring villages. However, the latter is of low value (c. Le 5,000 per day) and the number required will be dramatically reduced at the end of construction.

- The BHP has also created indirect employment in services in Bumbuna village. Moreover, it has provided an opportunity to build local capacity in the skilled trades such as plumbing, building, mechanics and electrics. Employment in these skills will be more transferable and therefore more sustainable than employment in labouring.

- Most of the engineering work on BHP has been conducted by foreign specialists, principally from Europe, but also from other African countries. The completion of construction and subsequent operation of the BHP will hopefully act as a vehicle for Sierra Leone to build its own capacity in hydropower engineering, thus reducing reliance on the use of foreigners for the future hydropower projects under consideration.

- Finally, the successful completion and commissioning of the BHP should provide a boost to national morale, which will help the important post-conflict process of nation building.

11.2 Development Initiative for the BHP Vicinity

BHP Project Affected Persons (PAPs) will be compensated and/or resettled according to the recommendations of the two Resettlement Action Plans, and it is intended that these

PAPs should be net beneficiaries of the project. In addition, there is the intention that the BHP should also benefit a broad community of people living in the vicinity of the project. A study was therefore conducted in September and October 2004, of development problems and opportunities in the area of influence of BHP, with the objective of preparing the Upper Seli Community Development Initiative (Vincent, 2004).

The BHP is located in the Northern Province, and its main infrastructure is located in Kalansogia Chiefdom (HQ in Bumbuna village) in Tonkolili District. Six chiefdoms in three districts surround this 'core' chiefdom, viz:

- Koinadugu District – Kasunko and Diang Chiefdoms
- Tonkolili District – Sambaia Bendugu and Kafe Simiria Chiefdoms
- Bombali District – Safroko Limba and Biriwa Chiefdoms

These six chiefdoms (see Figure 12.2-1) are the focus of the Development Initiative. (Of these, Kasunko and Diang will have some direct impacts due to inundation of the reservoir basin.)

The total cost of the proposed Development Initiative is $ 1.14 million, and seed funding has been acquired to prepare a proposal to fund the initiative under the Japanese Social Development Fund, which is managed by the World Bank.

The development study conducted consultations and Participatory Rural Appraisal (PRA) techniques in the above six chiefdoms to identify and rank problems and opportunities. The outcome was a number of recommendations for infrastructure improvements (roads, electrification, health and educational facilities) and a series of proposals for village-level community sub-projects in each of the chiefdoms. The latter consist of physical projects (schools, clinics, water supply, etc.) and socio-economic support projects (training, micro-credit, trading, agriculture, tourism etc).

There is now the need to build the results of the study into a properly costed programme, and to identify / confirm the source of funds from within the BHP budget.

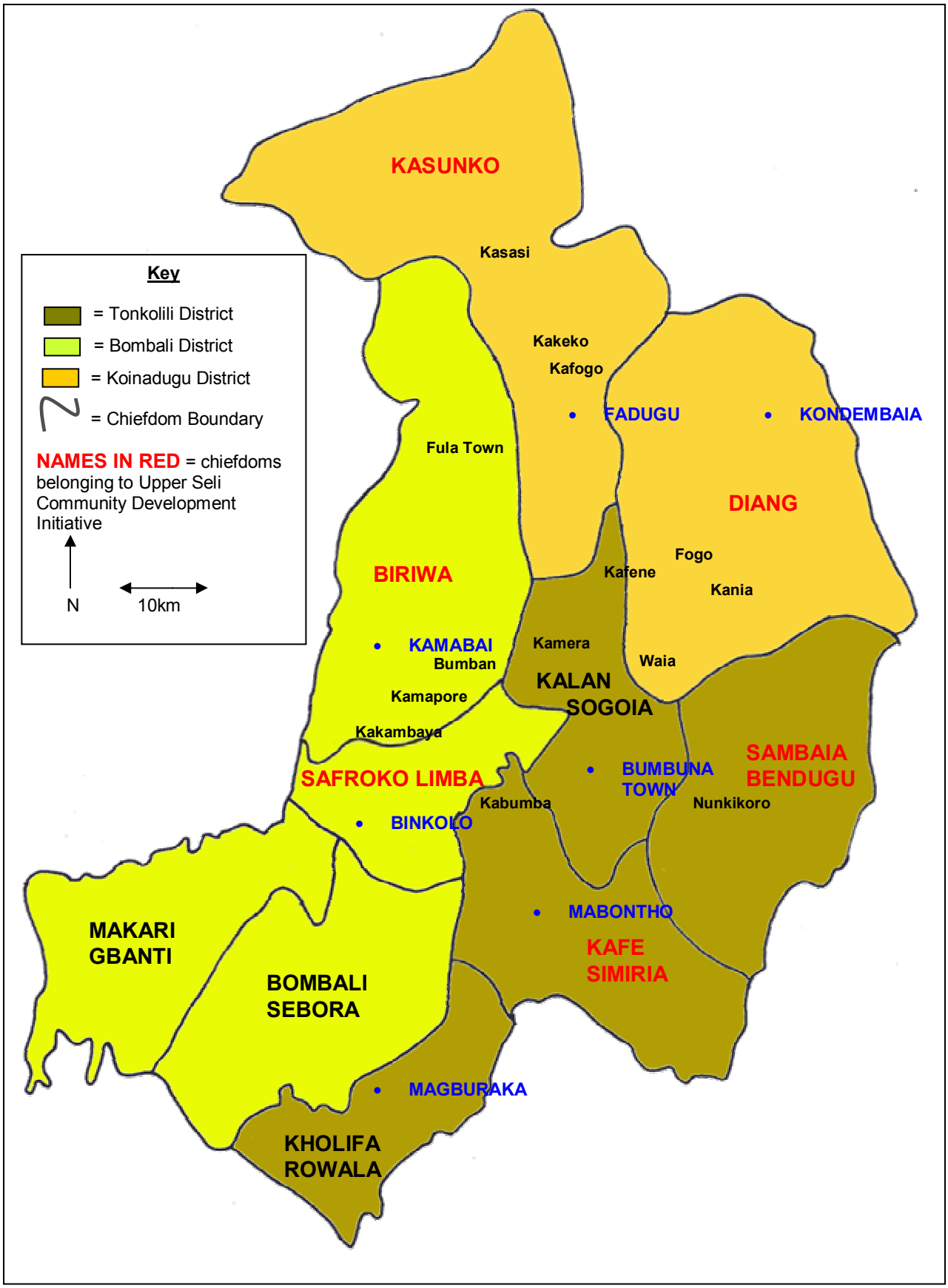


Figure 12.2-1: Map showing Kalansogoia & Surrounding Chiefdoms

11.3 Tourism

The original EIA identified some tourism benefits of BHP, and the ways in which such opportunities might be enhanced. The tourism resources to which this referred were the spectacle of Bumbuna Falls itself, the technical interest of the hydro-power station, and the after-use of the construction camp as hotel accommodation.

However, it can now be envisaged that environmental management for the BHP will include catchment management with the combined objectives of forest conservation, chimpanzee conservation and reservoir water quality protection. This will include the establishment of a wildlife sanctuary to improve the conservation of chimpanzees and other wildlife. In the circumstances, the Bumbuna area could potentially offer very much more in the field of ecotourism. In addition to visits to the Falls and the power station, there could be controlled chimpanzee tracking, bird watching, forest walks, boat trips for wildlife viewing, sport fishing, etc. It has also been suggested that part of the existing camp could be converted into a university affiliated primate research facility and a field station for the teaching of the environmental sciences, training of conservation staff, scientific conferences, etc., which would further enhance tourism interest.

The Bumbuna area could therefore become a valuable tourism asset, initially for internal tourism. Once the tourism industry regains confidence in the long-term safety of Sierra Leone, Bumbuna could become a destination for international ecotourism.

The Six Chiefdoms study has made recommendations as to how the local communities might prepare themselves to benefit from this tourism, in terms of crafts, fishing, food production, and training for guides, etc.

11.4 Induced Regional Impacts

The BHP is being developed in a part of Sierra Leone that is relatively remote and lacking in other development initiatives. In fact, as discussed in Chapter 8 above, few development initiatives are anticipated for the whole Seli / Rokel valley. In the circumstances, the induced impacts of Bumbuna/Yiben power development programme could be of considerable regional significance. The first phase of the BHP is a relatively small scheme, but the further phases will ultimately increase BHP power output by six times. Construction of the further phases will be a significant economic driver for the north of the country, and the availability of power thereafter will give the opportunity for further development in the north.

The following induced impacts of BHP can be anticipated for the first phase:

- Slightly improved standard of living in the greater project area due to BHP compensation payments and inputs from the associated Upper Seli Community Development Initiative.

- Increased pressure on forest and other natural resources as some compensation is used to purchase chainsaws, outboard motors and other equipment / tools.

- Development of small-scale riparian irrigated agriculture in the middle reaches of the Seli during the dry season.

- In-migration of existing fishermen from other parts of Sierra Leone to take advantage of the fishery in the reservoir.

- Development of presently remote villages, and exploitation of their natural resources, as the reservoir makes them accessible by water transport.

- Light industrial and commercial development can be envisaged for the towns that will be supplied by the shield-wire system along the transmission line route (Makeni, Magburaka, Lunsar, Port Loko, Masiaka and Kembia), which will have poverty reduction benefits. This infers that subsequent to electrification there will be some physical growth of these towns, which should be properly planned and controlled, in order to avoid consequent environmental and social degradation.

- Growth of small commercial enterprises along the Freetown – Bumbuna road corridor, to serve increasing numbers of travellers associated with engineering, tourism and research in the Bumbuna area.

11.5 Strategic Environmental Assessment

As discussed in Chapter 4, the present BHP is conceived as the first of five phases of power development on the upper Seli, with an ultimate maximum installed capacity of 275 MW. Completion of this programme will have very much greater environmental and social impacts, over a very much wider area, than the first phase project. Moreover, the direct impacts will be cumulative and possibly synergistic, and the overall development will induce impacts that are extensive in space and time. This is the type of development programme for which the World Bank Environment Strategy and other authorities recommend the conduct of a Strategic Environmental Assessment (SEA) at an early stage. The requirement for a Regional Environmental Assessment (a type of SEA) is specifically derived from the World Bank OP 4.01, and the ESAP has concurred that this is needed before the planning of any further phases of the Bumbuna / Yiben power development programme.

A Regional EA will improve and underpin the development planning process by:

- early identification of important issues
- evaluation of alternatives
- assessment of cumulative impacts

- assessment of risks

Conduct of the Regional EA will be a participatory and iterative process, which will include those elements of options assessment that were absent from the early stages of planning the first phase of BHP. The required studies envisaged for the study are as follows:

- Review of the existing environment, its importance, values and sensitivities within the 'area of influence' of the power development programme (including transmission line corridors). This would include the collection of new data over a relatively large area, and the initiation of long-term monitoring.
- Stakeholder analysis. Preparation of consultation plan.
- Regional social, cultural and economic review.
- Review of proposed power development programme, including all four phases, alternative options for each phase, and permutations of the most promising / likely options. (The alternative options would include a careful analysis of dam height v. area of inundation for each phase that includes construction or raising of Yiben dam.)
- Stakeholder consultations. Review of hopes, aspirations and fears.
- Assessment of environmental effects of each alternative.
- Assessment of social effects of each alternative.
- Assessment of resettlement requirements for each alternative.
- Assessment of cumulative, synergistic and induced impacts.
- Review of environmental and social constraints and opportunities.
- Comprehensive options assessment
- Review of opportunities for benefit sharing and community development programme.
- Design of mitigation measures, including any proposed offset.
- Design of environmental management programme, to include monitoring programme.
- Review of institutional structure and capacity for environmental management of power development programme, at national regional and project / programme level.

- Further stakeholder consultations.

The results of this process will need to be presented in a report. There is no 'standard' framework for SEA reports, as the process is still relatively young. The report structure would be expected to be along the following lines (derived from the EU Directive on SEA):

- Outline of the contents, main objectives of the programme and relationship with other relevant plans and programmes in the region;
- Relevant aspects of the current state of the environment and the likely baseline without implementation of the programme;
- Environmental characteristics of areas likely to be significantly affected;
- Existing environmental problems which are relevant, in particular those relating to any areas of particular environmental importance;
- Environmental protection objectives, which are relevant to the programme, and the way the objectives and any environmental considerations have been taken into account;
- Likely significant effects on the environment (biodiversity, population, human health, fauna, flora, soil, water, air, climatic factors, material assets, cultural heritage, landscape and the interrelationship between the above factors) including secondary, cumulative, synergistic, short, medium and long term, permanent, temporary, positive and negative effects;
- Measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment as a result of the programme;
- Description of the measures envisaged concerning monitoring; and
- Non-technical summary (summary that would be understood by an average reader).

12 Environmental Management Plan

12.1 Introduction

It is expected that the Environmental Management Plan (EMP) for a Category A project should consist of the set of mitigation, monitoring, and institutional measures to be taken during construction and operation, to eliminate adverse environmental and social impacts, offset them, or reduce them to acceptable levels, and the actions needed to implement these measures.

The present report is an issues-based omnibus EIA report, in which the physical mitigation, monitoring and institutional measures have been described under Chapter 8 above, and the social measures have been described in the two RAPs, as summarised in Chapter 9 above. The purpose of the present chapter, therefore, is to bring these measures together in a single table indicating actions, responsibilities, timing and costs. In addition, outline EMPs are provided for the construction and operation contractors. These are followed by the capacity-building that will be required for the several institutions that will be responsible for implementation of the various mitigation measures in the EMP.

12.2 EMP Summary

12.2.1 Introduction

The measures set out below accompany the environmental management and monitoring processes summarised in Table 12.2-1. Further details are provided in sections 8.12 Upper Catchment Management and 8.13 Monitoring Plan.

Costs are also summarised in Table 12.2-1; the cost breakdown is provided in the tables in Appendix Q.

Table 12.2-1: EMP Summary

Impact/Issue	Mitigation/Activity	Responsibility	Timing/ Duration	Cost US$		Source of funding
				One-off	Annual	
Management of the Upper Seli catchment	Establish Bumbuna Watershed Management Authority (BWMA)	Seli River Development Authority (SRDA)/ Ministry of Energy and Power - PIU	2005	513,100		Private sector BHP/Watershed Management Fund
	Administer BWMA	BWMA	Annual		235,000	Electricity surcharge of US 0.005c/kWh
Integrated Water and Land Management	Establish Water and Land Management Strategy and Action Plan	BWMA/ SRDA/ Ministry of Energy and Power - PIU	2005	217,900		BHP
Construction Measures	Safe storage and prevention of spillage into the river channel of chemicals and toxic materials.	BHP construction contractor	2005 onwards	0	0	BHP
	Works in downstream river channel to be carried out in the dry season to minimise impacts downstream.	BHP construction contractor	2005	0	0	BHP
	Monitoring of reservoir slopes during impoundment for detection of instability.	BHP construction contractor	2006	7,500		BHP
	Set up free air mixing system to prevent stratification and eutrophication if shown to be necessary from limnological study.	BHP construction contractor	2006	40,000		BHP
	Installation of seismograph near dam site before impoundment for detection of seismic activity following impoundment.	BHP construction contractor	2006	10,600		BHP
	Rehabilitation of river flow gauges at Bumbuna and Badela.	BHP construction contractor	2005	40,000		BHP
Additional Baseline Studies and Surveys	Two month limnological survey to determine likelihood of thermal stratification and means of mitigation.	BWMA/ Service providers	By May 2005	Not for disclosure		BHP
	Three month survey of birds in the riparian forest of the reservoir area and in the Loma Mountains and Sula Hills.	BWMA/ Service providers (NGOs, academic institutions, private sector)	By Jul 2005	Not for disclosure		BHP

				Cost US$		
	Three-month survey of butterfly species present in the reservoir area and the Loma Mountains and Sula Hills.	BWMA/ Service providers	By Jul 2005	Not for disclosure		BHP
	Three-month survey of reptiles and amphibians in the reservoir area and in the Loma Mountains and Sula Hills for species inventory.	BWMA/ Service providers	By Jul 2005	Not for disclosure		BHP
	Three-month survey of small mammals and habitats in the reservoir area and in the Loma Mountains and Sula Hills for species inventory.	BWMA/ Service providers	By Jul 2005	Not for disclosure		BHP
	Six-month survey of trees and plant communities/habitats in the reservoir area and in the Loma Mountains and Sula Hills.	BWMA/ Service providers	By Sep 2005	Not for disclosure		BHP
	One year fish survey upstream and downstream to identify spawning and nursery grounds, critical habitats, migration, and endemic species.	BWMA/ Service providers	By Mar 2006	Not for disclosure		BHP
	One year primate study in reservoir area to determine data on groups and implement mitigation measures prior to reservoir filling.	BWMA/ Service providers	By Mar 2006	Not for disclosure		BHP
	Two-month field survey on the archaeological potential of the reservoir and resettlement areas, followed by a desk study to plan mitigation measures if required.	BWMA/ Service providers	By Mar 2006	Not for disclosure		BHP
	Two-month desk study on the creation and management of a Bumbuna Conservation Area.	BWMA/ Service providers	By May 2006	Not for disclosure		BHP
Community participation and awareness	Set up and administer Community Liaison Committees (CLCs) including training and capacity building.	BWMA/ Districts/ Service providers (NGOs, academic institutions, private sector)	2005 and for three further years	306,000	106,600	BHP
	Formulate and implement an environmental awareness campaign for local communities, schools, and local administration addressing hunting, bushmeat trade, forest management, soil and water conservation, fishing, water pollution, waterborne diseases and prevention.	BWMA/ Districts/ Service providers (NGOs, academic institutions, private sector)	2006 and annually for three further years			BHP

				Cost US$		
Water quality and use	Clear trees from reservoir area: - Contracts to clear trees up to 35 cm dbh - To include provision for community benefits from employment and use of timber products	BHP construction contractor BWMA	2005	703,500		BHP
	Raise awareness in local communities of issues and regulations and adoption of safeguards on pollution of river and reservoir waters.	BWMA/ Service providers (NGOs, academic institutions, private sector)	2006 and annually for three further years	included	included	BHP
	Set up and implement land and soil conservation programme of measures for reservoir margins.	BWMA/ Districts/ Service providers	2007 and a further three years	351,050	132,575	BHP
	Implement a downstream fisheries mitigation programme if appropriate: - provide financial compensation to fishers to mitigate reductions in catches and incomes - provide fishers with support to take advantage of the reservoir fishery - management study of the downstream fishery - study of rare species for measures to enhance habitats to conserve and expand populations.	BWMA/ Districts/ Service providers	2006 and a further three years	281,900	187,300	BHP
	Set up and implement a reservoir fisheries management programme to maximise benefits to local communities: – fish population study upstream – training in fishing techniques and management - extension activities - financial support for fishers and equipment - training of trainers programme	BWMA/ Districts/ Service providers	2008 and a further three years	281,900	187,300	BHP
	Feasibility study to determine whether environmental flow can be provided during BHP operation that will maintain coverage of water on river bed at all times.	BWMA/ Service providers	2005 - 2006	132,200		BHP

				Cost US$		
Agriculture, forestry and land use	Set up and implement an agroforestry development programme: - training in alley-cropping, economic forestry, forest conservation - training of forest guards - extension activities - financial support for nurseries, Community Forests	BWMA/ Forestry Dept/ Districts/ Service providers (NGOs, academic institutions, private sector)	2006 and a further three years	342,900	132,900	BHP
	Set up and implement an agricultural development programme: – training in crop husbandry, farm management, post-harvest techniques, land management - extension activities - financial support for improved agriculture	BWMA/ Agriculture Dept/ Districts/ Service providers (NGOs, academic institutions, private sector)	2006 and a further three years	320,900	123,600	BHP
	Mapping of present land use and vegetation types	BWMA/ Service providers	2005 - 2006	221,500		BHP
Habitat and species protection	Survey of developing ecology in reservoir - feasibility study and planning exercise for development of habitats and species to attract tourists	BWMA/ Service providers (NGOs, academic institutions, private sector)	2005 - 2006	122,500		BHP
	Establish the Bumbuna Conservation Area as a Conservation Offset if studies show this is appropriate. Determine Conservation Area boundaries and resolve occupation issues.	BWMA/ Wildlife Dept/ local stakeholders and administration/ NGOs/ academic institutions/ private sector	2006	320,500	92,700	BHP
	Outreach community education to improve forest protection and improve awareness of impacts of bushmeat and endangered species. To be included in Community participation and awareness programme.	BWMA/ Service providers (NGOs, academic institutions, private sector)	2006 and a further three years	included	included	BHP
	Two year Technical Assistance programme for training and capacity building for Dept of the Environment	Ministry of Power and Energy - PIU	2006 - 2008	109,900	71,900	BHP

				Cost US$		
Social and health measures	Stimulation of small business enterprises (crafts, tourism, local services) as alternative livelihood means for local population.	BWMA/ local administration/ Service providers (NGOs, academic institutions, private sector)	2006 and a further three years			BHP
	Tourism initiative to improve revenue from tourism to local community.	BWMA/ Service providers	2006 and a further three years			BHP
	Regional health protection and information programme to be established in the immediate catchment through the Upper Seli Community Development Initiative .	Upper Seli Community Development Initiative	From 2006	1,298,100	710,000	Upper Seli Community Development Initiative funds
	Local health protection and information programme to be established in the project area.	Ministry of Energy and Power/ Ministry of Health/ BWMA	From 2006			BHP
	Identification and drainage of mosquito breeding areas in reservoir drawdown zone.	BHP Operator/BWMA	2006 for one year			BHP
Resettlement Action Plans	Replacement in accordance with RAP of farmland, houses and other assets inundated by the reservoir and assistance with alternative livelihoods.		From 2006	Included in Reservoir RAP budget of $8,012,760		BHP
	Financial compensation in accordance with RAP for loss of sacred and cultural sites to reservoir.		2006			BHP
	Provision in accordance with RAP of new water supplies for persons displaced by the reservoir and the transmission line.		From 2006	Included in Trans line RAP budget of $7,864, 138		BHP
	Relocation in accordance with RAP of persons displaced by the transmission line.		2006			BHP
	Measures to re-route and modify transmission line to avoid social and health impacts on people in accordance with RAP.	BHP through transmission line contract	2005			BHP
Mitigation Programme Monitoring	Monitor advances in stakeholder awareness and participation	BWMA (internal)	2007 -2010		included	BHP

				Cost US$		
	Monitor progress in instituting water and land use regulations	BWMA (internal)	2008 –2011		included	BHP
	Monitor water quality, erosion and sedimentation, stream flow	BWMA/ Service providers (NGOs, academic institutions, private sector)	2007 -2010		included	BHP
	Monitor downstream fisheries development progress	BWMA/ Service providers	2007 -2010		included	BHP
	Monitor reservoir fisheries development progress	BWMA/ Service providers	2009 -2012		included	BHP
	Monitor environmental flows and downstream channel aquatic ecology	BWMA/ Service providers	2007 -2010		included	BHP
	Monitor agroforestry support programme progress	BWMA (internal)	2007 -2010		included	BHP
	Monitor improved agricultural practice progress	BWMA/ Service providers	2008 –2011		included	BHP
	Monitor trends in forest cover, bush fires and agricultural land use	BWMA/ Service providers	2008 -2011		46,450	BHP
	Three year monitoring of chimpanzees to determine the impacts of the scheme and success of mitigation, and assess on further measures.	BWMA/ Service providers	2007 -2010		185,900	BHP

12.2.2 Management of the Upper Seli Catchment

1. Establish Bumbuna Watershed Management Authority (BWMA)

The Bumbuna Watershed Management Authority (BWMA) will be established to serve as the facilitator for the delivery of the catchment management plans and a number of the mitigation measures included in the Environmental Management Plan. It will be set up by the Seli River Development Authority (SRDA) in conjunction with the Ministry of Energy and Power – PIU. Initial requirements of the SRDA will be to confirm the BWMA's Scope of Work, ascertain staffing and implementation arrangements, and secure the initial funding. The BWMA will be set up during 2005 as a civil society organisation (NGO) or a parastatal.

2. Administer BWMA

The administration of the BWMA will be carried out by its own Board of Trustees and the secretariat consisting of an Executive Director, Finance and Administration Director, and no more than five additional technical programme and administration staff. It will be responsible for its annual financing and resourcing plan to provide for implementation and will make use of service providers (NGOs, academic institutions, private sector) for carrying much of its programme with the assistance of a small Advisory Committee consisting of individuals from Government and civil society with expertise and experience in conservation.

12.2.3 Integrated Water and Land Management

Establish the Water and Land Management Strategy and Action Plan

The Water and Land Management Strategy and Action Plan will address water, land use and agricultural issues, as well as implement mitigation measures identified by the EIA to address negative impacts on wildlife, vegetation, aquatic ecology etc.

The BWMA will take the lead in co-ordinating implementation of the Strategy with key stakeholders to ensure integration of all components of the Strategy and the wide range of stakeholders. It will however receive support of the Ministry of Energy and Power – PIU, particularly in respect of measures that involve the participation of the BHP.

The Water and Land Management Strategy and Action Plan recommended for the Seli upper catchment includes specific mitigation measures related to community participation; institutional measures; water quality and use; agriculture, forestry and land use; habitat and species protection; and social and health measures, as well as monitoring of impacts and direction and co-ordination of research activities required to further the implementation of the Strategy.

12.2.4 Construction measures

Provision must be made in the construction contracts for the remaining works for the mitigation measures outlined below:

1. Storage and handling of chemicals and toxic materials

Downstream flora and fauna could be affected by spilled chemicals and toxic materials if they enter water, and depending on quantities spilled and toxicity of materials, site spillages could have more damaging impacts over a wider area. Spills must be prevented by safe use and storage of such materials on site.

2. Works in downstream river channel

Work on the channel protection works downstream of the tailrace and spillway outlet will be carried out in the dry season to minimise impacts downstream, specifically to reduce entry of sediment into the channel.

3. Monitoring of reservoir slopes during impoundment for detection of instability

The occurrence of landslips in the reservoir area may increase as a result of impoundment and subsequent drawdown. Monitoring of reservoir slopes must be undertaken to give advance warning so that remedial measures may be taken if deemed necessary. Monitoring will consist of regular visual inspection in the first instance (say once per month) and provision for local detailed topographic survey and monitoring if the initiation of slips is detected.

4. Installation of seismograph near dam site

Before impoundment, a seismograph must be installed near to the dam for the detection of seismic activity following impoundment. Provision will be made

for setting up and taking baseline readings, followed by daily readings during the impoundment and post-impoundment period.

5. Rehabilitation of stream flow gauges

The gauges at Bumbuna and Badela will be rehabilitated so that environmental flows may be monitored and to enable estimates of sediment loading to be determined per unit of river flow.

12.2.5 Additional Baseline Studies and Monitoring

1. Bird survey

A three-month survey of birds in the riparian forest of the reservoir area and in the Loma Mountains and Sula Hills will identify the species and numbers present and their dependence on the forest, and to determine whether the same species are present in the different locations. The final report will be available in July 2005.

2. Butterfly survey

A three-month survey will catalogue the butterfly species present in the various vegetation types in the reservoir area and the Loma Mountains and Sula Hills. The final report will be available in July 2005.

3. Reptile and amphibian survey

A three-month survey of reptiles and amphibians in the reservoir area and in the Loma Mountains and Sula Hills will provide an inventory of species, estimates of population densities, and an analysis of habitat types and preferences. The final report will be available in July 2005.

4. Small mammal survey

A three-month survey of small mammals and bats in the reservoir area and in the Loma Mountains and Sula Hills will provide an inventory of species, estimates of population densities, and an analysis of habitat types and preferences. The final report will be available in July 2005.

5. Flora survey

A six-month survey of trees, flora and plant communities/habitats in and around the reservoir area and in the Loma Mountains and Sula Hills will be conducted, comparing the species, and quality and importance of habitats with

similar areas elsewhere in West Africa. The final report will be available in September 2005.

6. Limnological study

A two-month limnological study will determine whether thermal stratification will occur in the reservoir, and identify and plan how it should be mitigated. This will involve a field visit, data collection and a desk-based analysis. The final report will be available in May 2005.

7. Fish survey

A one-year fish survey throughout the river will identify spawning and nursery grounds and the location of any other critical habitats upstream and downstream, will determine the extent of any migration upstream and downstream of Bumbuna Falls, and whether the Seli/Rokel supports any rare or endemic fish species. The final report will be available in March 2006.

8. Primate study

A one-year study of chimpanzees and other primates in and around the whole reservoir area will determine the number, size, social organisation, habitat requirements and range of primate groups, so that mitigation measures for each group can be planned in detail and implemented prior to reservoir filling. The final report will be available in March 2006.

9. Archaeological field investigation

A two-month field investigation will determine the archaeological potential of the reservoir and resettlement areas. It will be carried out in the dry season once land in the reservoir area has been cleared of vegetation, and will be followed by a desk study to plan mitigation to protect archaeological remains, if this is found to be necessary. The final report will be available in March 2006.

10. Desk study on environmental offset and establishment of a Bumbuna Conservation Area

A two-month study will be conducted on completion of the above surveys, to assess the suitability of the Loma Mountains and Sula Hills as areas for potential environmental offset to compensate for losses at Bumbuna, to assess the merits of establishing a Bumbuna Conservation Area, and its appropriate

location, dimensions and management. The final report will be available in May 2006.

12.2.6 Community participation and awareness

1. Community Liaison Committees (CLCs)

Community participation in the process of developing and implementing the Water and Land Management Strategy will be fundamental to the Strategy's success. To facilitate this participation it will be necessary to set up and administer Community Liaison Committees (CLCs), including training and capacity building. These tasks will be the responsibility of the BWMA, working with the District administration and service providers.

The process of engagement will require the sensitisation of stakeholders and decision-makers on problems and issues affecting the Seli upper catchment, and consultation to obtain agreement on regulations for wise and sustainable use of resources.

It is expected that the CLCs will be established during 2005.

2. Community environmental awareness campaign

An outcome of the Strategy is that stakeholders will demonstrate awareness and action to safeguard environmental services, which requires community informed participation on environmental issues, fisheries, agricultural and forestry best practice.

The BWMA, again working with the District administration and service providers, will formulate and implement an environmental awareness campaign for local communities, schools, and local administration to address hunting, the bushmeat trade, forest management, soil and water conservation, fishing, water pollution, waterborne diseases and their prevention. During 2006 the BWMA will:

- Ensure information sharing and hold consultative meetings with catchment stakeholders to develop the Strategy and Action Plan.
- Sensitise local communities on conservation needs, compensation issues associated with a wildlife conservation area, and potential socio-economic and catchment benefits.
- Hold stakeholders' fora to validate perceived issues and impacts, identify potential issues and clarify inter-relationships.

Monitoring of the advances in community participation will be carried out, to include an assessment of the success of consensus measures for the regulation of improved practices in agriculture, forestry and land use.

12.2.7 Water quality and use

The Strategy and Action Plan will aim to maintain reservoir function, water quality and aquatic systems. These outcomes will require action to reduce soil erosion and sediment load in the river, control of water pollution including eutrophication of the reservoir, the maintenance of environmental (minimum) flows from the reservoir, and management of the reservoir. A programme of monitoring will be set up and implemented.

The priority action will be the clearance of trees from the reservoir area. This will form part of the BHP construction contract, though it is expected that the clearance will be carried out by a specialist timber contractor.

Implementation of the water quality and use programme will be co-ordinated by BWMA though the various components may be contracted out through service agreements. Training of trainers within government and NGOs are also envisaged.

1. Clear trees from reservoir area:

Contracts will be let and completed during 2005 and early 2006 to clear trees up to 35 cm diameter at breast height (dbh). To ensure that wildlife will not be trapped in isolated areas of forest, clearance will be south to north, valley bottom to top. Provision will be made for community benefits from employment and the use of timber products. The BWMA will advise on community aspects of the clearance and will provide the liaison with the CLCs, community groups and the local administration.

2. Set up free air mixing system to prevent stratification and eutrophication

If the decision following the limnological study is that measures will be needed to eliminate stratification and an air mixing system will be the most appropriate method, then perforated pipework and fixtures will be laid in the reservoir bottom near to the dam and connected to a dedicated air compressor to blow air through the pipework and into the water column. The turning over of the water will improve the oxygen uptake of the water and reduce the formation of ammonia, hydrogen sulphide and methane.

Responsibility for design will rest with the BHP, and installation and commissioning by the construction contractor.

3. Awareness of pollution issues and regulations

The BWMA will ensure the adoption of safeguards to minimise domestic, industrial and agricultural pollution of river and reservoir waters. Measures will include awareness of issues and regulations, of suitable treatment and disposal of wastewater, and appropriate use and disposal of agricultural pesticides. In cases of non compliance by people or organisations in the catchment, the BWMA will report to the appropriate government body.

4. Land and soil conservation programme

Land and soil conservation are important for the long-term viability of the Bumbuna HEP. Soil conservation measures to reduce soil erosion, sediment load and the potential for landslips into the reservoir will include:

- Adoption of best practice in agriculture to reduce erosion
- Promotion of agroforestry (e.g. alley cropping, community forestry)
- Implementation of riparian forest cover measures

5. Downstream fisheries management and monitoring programme

A baseline survey of a year to establish existing conditions will followed by one year of monitoring to identify the impacts that have occurred and their significance. Mitigation will then be provided if necessary, and this could include such measures as:

- Providing financial compensation to fishers and their communities to mitigate reductions in catches and incomes
- Providing downstream communities in the vicinity of the dam with transport, equipment and training to enable them to move their fishing operation into the reservoir to take advantage of the developing fishery there
- A management study of the downstream fishery to devise measures to increase populations and thus returns from the fishery
- A study of any rare species to devise measures to enhance habitats to conserve and expand populations if appropriate.

6. Reservoir fisheries management programme

Set up and implement a fisheries management programme to include:

- Implementation of a one year fish population study upstream
- Establish management policy and programme to maximise benefits to local communities from fishing.
- training in fishing techniques and management
- Promotion of best practice through consensus and regulation to achieve sustainability
- Extension activities
- Financial support for fishers including provision of equipment.

7. Sufficiency of environmental flow

A study will be conducted before impoundment begins to determine the feasibility of providing an enhanced level of environmental flow in the dry season, whilst still meeting power demands. This will involve:

- Topographic surveys of the channel in cross section at intervals between the dam and the first major tributaries 10 km downstream;
- Hydraulic studies to calculate the volume of water necessary to cover different proportions (percentages) of the river bed and the rate of discharge from the reservoir that would provide these flows;
- Analyses of predicted fluctuations in reservoir levels during the dry season under typical power demands to determine whether reservoir operation can be adjusted to maintain sufficient water to satisfy power needs as well as the proposed additional downstream flow.
- If this shows that it is feasible to provide an enhanced level of environmental flow, an Operational Rule Curve will be designed through which releases from the reservoir will be managed.

12.2.8 Agriculture, forestry and land use

The Strategy and Action Plan will aim to improve land use systems and the sustainable benefits arising from agriculture and forestry. These outcomes will require action to improve agricultural techniques and improve yields, introduce agroforestry methods, establish community forests, and improve forest use. A programme of monitoring will be set up and implemented.

In order to mitigate against the extension of slash and burn agriculture, the increasing pressures on land, and potential increase in land and soil degradation, improved agricultural, forestry and vegetation management methods will form an important element of the land management strategy.

Implementation of the agriculture and forestry programme will be co-ordinated by BWMA though the various components may be contracted out through service agreements. The BWMA will work closely with the District administration and the government Forestry and Agricultural departments. Training of trainers within government and NGOs is also envisaged.

Measures are summarized below.

1. Agroforestry and forestry programme

Set up and implement an agroforestry and forestry programme, to include:

- Training in alley-cropping, economic forestry, forest conservation
- Training of forest guards
- Extension activities
- Financial support for nurseries and Community Forests

2. Agricultural development programme

Set up and implement an agricultural development programme, to include:

- Training in crop husbandry, farm management, post-harvest techniques and land management
- Extension activities
- Financial support for improved agriculture

3. Study and mapping of present land use and vegetation types

An early study will be to provide a map of the present vegetation and land use types across the reservoir catchment area, to reflect the actual land use and provide the data on the amount of land cultivated, on cultivation methods used, and on the extent of annual grass fires. Mapping will be based on fieldwork in combination with satellite imagery and/or analysis of recent aerial photography. A GIS will be used for the task of recording and storing the mapping and data.

12.2.9 Habitat and species protection

1. Survey of developing ecology in reservoir and planning for development of eco-tourism

The ecology of the reservoir could provide further benefits locally if management measures were introduced to encourage habitats and organisms (birds for example) that attract tourists. The BWMA will therefore conduct a study of the developing ecology, including a habitat management feasibility study and planning exercise. If appropriate the BWMA will implement recommended measures within wider initiatives to assist the community in developing eco-tourism enterprises, which will include important supporting actions such as the provision of suitable accommodation and infrastructure. Service providers would likely be employed for the study. The survey will have a duration of 6 months over a period of one year.

2. Establish the Bumbuna Conservation Area (BCA) as a Conservation Offset

The establishment of a Bumbuna Conservation Area as a Conservation Offset, if the conclusions drawn from the earlier study show it to be appropriate, would serve principally to protect chimpanzee populations and other wildlife in the vicinity of the dam and reservoir. It would also serve to conserve and extend riparian forest within its boundaries and on the reservoir margins immediately upstream of the dam.

The setting up of the Bumbuna Conservation Area and the resolution of all issues will be coordinated by the BWMA working with the Wildlife Department, local stakeholders and administration, with service providers supporting as necessary.

The main steps and inputs required for its establishment are:

- Sensitise local communities on land and conservation needs, and socio-economic issues.
- Provide a detailed inventory and mapping of vegetation, and inventory of fauna.
- Develop management objectives and an initial management plan
- Establish a detailed and multi-year primate monitoring programme
- Establish management structures that take into account local stakeholders' interests.

3. Determine BCA boundaries and resolve occupancy issues.

The size and designation of the proposed conservation area will be recommended following the earlier study, and will be further discussed at national and local level. Its establishment will depend on the goodwill and co-operation of the communities that currently utilise the area, and who must participate in the further planning of such a protected area. A compensation programme will be implemented if farmland is relocated to areas outside the boundaries, and economic trees are lost.

4. Opportunities for biodiversity conservation

The GEF will make financial contributions towards the conservation and management of similar critical habitats in Sierra Leone within the context of the National Biodiversity Strategy and Action Plan (NBSAP).

NBSAP priorities include strengthening the management and protection of the Loma Mountains and Tingi Hills complex and the Sula Hills, in recognition of their high biodiversity conservation value. These montane ecosystems host similar habitats to those found in the Bumbuna watershed.

It is therefore proposed that the GEF would issue grants annually to institutions in Sierra Leone (Government and/or civil society) that are engaged in undertaking research and management action towards safeguarding the country's natural heritage and biodiversity, as reflected in the NBSAP.

5. Outreach community education

Outreach community education to improve forest protection and improve awareness of impacts of bushmeat and endangered species will form a part of the community participation and awareness programme to be implemented by the BWMA.

6. Technical Assistance to Department of the Environment

A two yearTechnical Assistance programme will be provided for two staff members of the Department of the Environment to receive on-the-job training and capacity building. The TA will be set up by the Ministry of Energy – PIU for funding by the World Bank. Further details are provided in section 12.4 Capacity Building.

12.2.10 Social and health measures

1. Stimulation of small business enterprises

Training and capacity-building workshops will be conducted to stimulate small business enterprises (crafts, tourism, local services) as alternative livelihood means for persons displaced from the reservoir area or wishing to diversify in employment. The BWMA will be responsible, working with the local administration, service providers and the local community.

2. Tourism initiative

Tourism initiatives will be set up to improve revenue from tourism to the local community. The BWMA will be responsible, working with the local administration, service providers and the local community.

3. Regional health protection and information programme

A health protection and information programme will be established in the immediate catchment through the Upper Seli Community Development Initiative. The Upper Seli Community Development Initiative will be responsible, working with the BWMA, the Ministry of Health, the local administration and the local community.

4. A local health protection and information programme will be established in the project area. The Ministry of Energy and Power will be responsible, working with the BWMA, the local administration and the local community.

5. Identification and drainage of mosquito breeding areas in reservoir drawdown area

Where specific locations close to human habitations responsible for mosquito proliferation or other insect hazard or nuisance are identified in the drawdown area, the BHP operator will where practicable drain or level the problem areas with a view to reducing or eliminating the hazard or nuisance.

12.2.11 Resettlement Action Plans

The following mitigation is all detailed in the two Resettlement Action Plans.

1. Replacement of farmland, houses and other assets inundated by the reservoir and assistance with alternative livelihoods.

2. Provision of new water supplies for persons displaced by the reservoir and the transmission lines.

3. Resettlement of persons displaced by the transmission line.

4. Measures to re-route and modify transmission line to avoid social and health impacts on people.

5. Financial compensation for loss of sacred and cultural sites in the reservoir basin.

12.2.12 Mitigation Monitoring Programme

1. Stakeholder awareness and participation

The BWMA will carry out monitoring of the advances in community participation, to assess the success of consensus measures for the regulation of improved practices in land use and conservation within the upper Seli catchment. The monitoring will include:

- Establishment of the Community Liaison Committees and their participation in the Strategy and Action plan.
- Improvements brought about by community awareness and participation, in protection of water resources, forest and soil management, and conservation measures.

2. Water and land use regulations

Progress in instituting byelaws and other measures for regulating fisheries, and water and land use within the immediate catchment will be monitored. This will be an internal exercise by Bumbuna Watershed Management Authority in concert with the chiefdoms

3. Water quality

A programme of water sampling and physico-chemical analysis will monitor the occurrence of detrimental effects such as eutrophication of the reservoir on first filling and water pollution, through water quality measurements, particularly of nutrient levels and dissolved oxygen.

4. Erosion, sediment loading and stream flow

Soil erosion will be monitored to assess the importance of erosion under various conditions (different types of vegetation, land use, soil and slope). This will help in identifying conditions that present a high erosion risk, mainly land use practices, and where measures should be taken to reduce erosion.

Sediment loads of rivers entering the reservoir, in particular the Seli and Mawoloko rivers, will be monitored. Measurements will complement an

erosion monitoring programme, whereby susceptible areas of land and any remedial actions are monitored, as well as stream flow gauging to allow calculations to be made of total sediment inflow to the reservoir. The gauges at Bumbuna and Badela will be rehabilitated under the construction contractor's programme.

The water and land management measures will be carried out by a catchment management specialist with three months' input over each year.

5. Environmental flows and downstream river ecology

Flow measurements will verify flows permitted under power station operating rules. The ecological health of the downstream river will be monitored by an aquatic ecologist, who will have two months' input over a one year operation period.

6. Downstream fisheries development progress

A one year survey of fish downstream of the dam will be undertaken during the first year of BHP operation to determine species present and population sizes, and record information on spawning migrations. Species and catches take by local fishers will also be recorded, using the same methods employed in the baseline survey.

7. Reservoir fisheries development progress

Progress will be monitored in the development of the upstream fisheries programme, including fish production, for the reservoir area. The fisheries expert carrying out the fisheries management programme will also undertake the monitoring.

8. Improved agroforestry and agricultural practice progress

Progress will be monitored in establishing an agroforestry support programme with village associations/user groups, in the introduction of improved forestry practices, in the success in setting up of community forests and agroforestry schemes, and in the introduction of improved agricultural practices and reduction of 'slash and burn'.

9. Forest cover, bush fires and agricultural land use

Trends will be monitored in:

- Forest and vegetation cover within the immediate catchment and watershed.

- Bush fires including frequency, extent and location.
- Agricultural land use, including soil conservation practices, agroforestry, and intensification. This monitoring must be an on-going process.

The monitoring of the introduction of good practice and trends will be carried out over 3 months annually for three years from 2007 by a land use expert experienced in agricultural, agroforestry, forestry and with community participation.

10. Chimpanzees

To follow up the full year study, monitoring of chimpanzees will continue for three years after commencement of BHP operation, to determine the impacts of the scheme and the success of mitigation, and to assess whether further measures are necessary. Two field teams will work simultaneously on either side of the river, calculating population densities from nest counts after initial determination of decay rates;

12.3 Environmental Management Plans for Construction and Operation of the BHP

12.3.1 Introduction

There are still some significant engineering works and operations to be undertaken for completion of the BHP. These include construction of the remainder of the powerhouse, installation of the mechanical and electrical generating equipment, replacement of 29 transmission towers, restringing of the powerline, clearance of the reservoir basin, filling of the reservoir and finally commissioning of the power plant.

Environmental Management Plans (EMPs) will therefore be needed for the activities of the civil construction contractor, the transmission line contractor and the O&M operation contractor. These parties traditionally prepare their own EMPs, for approval by the project client / owner. Recommendations for the preparation of these Environmental Management Plans are provided below. This is in the form of an outline master EMP, but it is important that each of the contractors and sub-contractors working for the BHP should prepare their own daughter EMPs, which take account of their specific activities. Indeed, contractors should not be allowed to work on BHP until they have in place an EMP that has been approved by the PIU. (Depending

upon the previous experience of the PIU Environment Officer, it may be appropriate for the PIU to use TA to have these EMPs reviewed by an international specialist.) This requirement should be applied to all contractors and major suppliers whether or not they are working at the Bumbuna site itself (e.g. transport contractors, waste management contractors, timber suppliers, and fuel suppliers must all have approved EMPs). The EMP must be brought to the attention of each of the contractor's employees working on the BHP, and they must be provided with a verbal explanation of the provisions of the EMP and an insight into the potential adverse impacts of their work.

Most contracting companies have Health and Safety (H&S) Management Plans. There are links between the disciplines of H&S management and environmental management, so where H&S is already well managed, some contractors may find it convenient to combine the two in a management plan for Environment, Health and Safety (EHS). It should be noted, however, that the environmental management function will require additional and different skills from those of H&S management.

The EMPs of the main civil construction contractor and the O&M operation contractor should be implemented within a company Environmental Management System (EMS). This should be certified to ISO 14001, or capable of being so certified in future. Each sub-contractor should also have an EMS, but this would not need to be ISO 14001 certified.

12.3.2 Outline Master EMP

It is recommended that the EMPs should include the following elements:

(i) Environmental Policy

Each EMP must start with a statement of Environmental Policy. This should be a simple statement of the contractor's intent with respect to the environment and the management of environmental affairs, which can guide all other aspects of the plan.

(ii) Management Responsibility

The policy should be followed by a statement of management responsibility for environmental affairs. This should name the most senior manager in the contracting company or at their Bumbuna site as having overall responsibility for environmental management, with an explanation that such responsibility is

also delegated down to each level of management. In addition, it should name the **Environmental Manager** who will be responsible for day-to-day environmental management, supervision and monitoring, and will have company authority to stop construction works or operations if environmental non-compliance is observed. At each active construction site (including the quarry) there must be at least one named person with delegated responsibility for environmental management on each shift. This person may also be responsible for Health & Safety issues, and would then be referred to as the Environment, Health & Safety Officer (EHSO).

Environmental affairs include social issues. The principal contractors for dam / power station construction, for transmission line construction, and for operation should therefore each have a named **Community Liaison Officer** to deal with relations with people who may be affected by construction, commissioning or operation of the BHP.

(iii) Management Contacts

The office and home telephone / radio contacts should be listed for all named persons having environmental management responsibility.

(iv) Mitigation Measures

In cases where contractors are responsible for implementation of any of the specific mitigation measures proposed in the EIA, these should be stated in the tender offer documents, along with indicators of their successful application / completion.

(v) Management Measures

1. Construction and Commissioning

(a) Management of Construction Sites and Camp(s)

- A drained concrete area must be provided for vehicle washing; the drainage of which should have an oil interceptor and a sediment trap.
- All liquid fuel and lubricant storage tanks must be bunded to retain the entire contents of the tank.
- Active construction sites must be watered to suppress dust whenever appropriate during the dry season. Water tankers should be permanently available for this task.

- All site drainage water must be passed through a sediment trap.
- All sewage must be treated before discharge, e.g. using septic tanks.
- All effluents must comply with local or international environmental standards (see below).
- All emissions (e.g. from engines, crushers, and batching plants) must comply with local or international environmental standards (see below).
- All motor-driven generators, compressors, pumps, etc., must be properly silenced.
- The running of machinery and lighting in the vicinity of housing must be limited to normal working hours.
- All solid wastes must be properly disposed of (see 1 (b) below).
- Proscribed toxic and hazardous substances must not be used or disposed of (see below).
- All plant, equipment and wastes must be removed at the end of construction, and each site must be restored to its original condition where possible.
- A **Code of Practice** must be issued to all construction workers. This should specify required behaviour, e.g.:
  - No unauthorised cutting of trees or branches.
  - No lighting of fires.
  - No hunting or fishing.
  - No disposal of any kind of waste into water courses
  - Behaviour to comply with defined local cultural and religious sensitivities.
  - No unauthorised entry onto private property
  - Recommended health protection measures (see also (f) Health and Safety below).

Environmental Standards – Contractors must comply with national environmental standards that may be made from time to time by Statutory Instrument as Regulations under the Environmental Protection Act 2000. In the absence of relevant national standards, international standards should be applied, e.g. as published in the World Bank Pollution Prevention and Abatement Handbook.

Toxic and Hazardous Materials – Contractors must not use activities or substances which may be proscribed by the Minister of Environment from time to time under the Environmental Protection Act 2000, or which are internationally banned.

(b) Management of construction solid wastes and toxic wastes

- Waste generation is to be minimised. The treatment of waste should follow the hierarchy: Avoid > Minimise > Reuse > Recycle > Treat > Dispose.

- All domestic refuse is to be disposed of to a recognised and properly managed waste disposal site, i.e. a landfill site with daily covering of the working face with sand or soil. Where a market exists for recycled materials (e.g. glass, cans, plastics, paper) these should be separated and recovered. Vegetable waste should be composted.

- Toxic and hazardous waste must be either returned to its source, or stored and disposed of separately in consultation with EPD; this includes oil filters, empty paint cans and the packaging of toxic materials.

- The empty containers of toxic or hazardous liquids must be punctured or crushed to avoid them being used subsequently for drinking water.

- Waste lubricating oil is to be stored and sold to an oil recycling company or refinery.

- Vehicle batteries are to be stored and sold to a battery recycling company.

- Vehicle tyres are to be stored and sold to a tyre recycling company.

- Wood, paper, glass bottles, cans, plastic and other recyclables for which there is a market are to be separated and recycled.

- No waste is to be burnt.

(c) Management of Land

- Topsoil must be removed and stored for future use, before any further excavation work.

- In the case of temporary land take in agricultural areas, the positions of all walls, fences and hedges should be recorded, and they should be replaced at the end of construction.

- All land used temporarily during construction must be restored to its pre-construction condition.

- Cut and fill volumes must be planned to minimise the generation of spoil.

- Spoil must only be disposed of in the planned spoil disposal sites. Completed spoil heaps must be profiled, covered in topsoil and grassed to maintain stability.

- The gradients of cuttings and embankments must not exceed the stable maximum for the given medium. All completed cuttings and embankments must be covered with topsoil and grassed. Where soil stability is likely to be a problem, the soil surface should be reinforced, e.g. using coir netting pegged to the slope surface.

- All excavations below ground level should be bunded to prevent water inflow or outflow.

- Water pumped out of excavations should be passed through a settlement facility before disposal.

- The use of heavy machinery should be minimised to avoid soil compaction.

- Arrangements must be made for the halting of work and the consultation of specialists from the National Museum, in the event that any potential archaeological remains are uncovered during excavation.

(d) Management of Transport

- All vehicles must be in a safe and legal condition with respect to all of their systems.

- All vehicles must comply with Sierra Leone regulations on emissions and noise.

- All drivers must be properly licensed for the class of vehicle they are driving.

- All vehicles must carry a fire extinguisher and first aid kit.

- All construction vehicles must have upward facing exhaust pipes.

- All vehicles must have audible indicators for reversing.

- Public roads must be promptly cleaned if affected by material loss.

- Truckloads of construction materials must be covered to prevent dust or losses.

- Where public roads are to be used, an official ‘construction route’ is to be defined, avoiding settlements as much as possible, and this route should be marked with road signs.

- Unsurfaced haul roads must be watered to suppress dust whenever appropriate during the dry season. Water tankers should be permanently available for this task.

- Washing of vehicles must only be conducted in proper places (see 1 (a)), and not in rivers.

(e) Community Facilities

- Consultation is required with all relevant individual communities before the start of further construction, to identify any notable features or issues of local concern.

- Features that are to be protected during construction (cemeteries, mature trees, sacred places, buildings) should be marked with brightly coloured tape.

- Excavation works below ground level in the vicinity of settlements should be marked with posts and tapes for safety.

- Temporary bridges or diversions must be provided wherever existing footpaths, tracks or roads are to be cut by construction works.

- Temporary water supplies are to be provided where either an existing water source is to be interrupted by construction, or access to the existing supply is severed.

(f) Health & Safety

- All construction workers must be given a medical examination (including sight and hearing tests) before being accepted for employment. This must be repeated annually. The results of these medical examinations must be kept by the contracting company.

- All employees must be given printed information on the health implications of their work and how to avoid problems. This should incorporate advice in the field of sexually transmitted diseases (STDs), including HIV / AIDS.

- All construction workers must be given H & S training.

- All construction workers must be provided with a set of protective clothing and equipment (hard hat, hard boots, leather gloves, ear defenders and dust mask). Certain workers may need additional safety equipment e.g. harnesses for working at height and respirators for working in enclosed spaces. Workers are required to wear appropriate protective equipment before being allowed on active construction sites.

- A 'permit to work' system is to be instituted for all work in enclosed spaces or other hazardous locations.
- All excavations below ground level should be marked with posts and tape.
- Drinking water, toilet and washing facilities must be provided at each active site.
- Each active site must be equipped with a comprehensive First Aid kit and eyewash bottle.
- All vehicles must carry a fire extinguisher and first aid kit.
- Explosives must be stored in accordance with Sierra Leonean regulations.
- All (legal) toxic or hazardous materials (e.g. water chlorination agents) must be stored in a locked, waterproof, ventilated enclosure.
- All compressed gas bottles must be stored, chained in the upright position, in a locked ventilated enclosure.
- During commissioning, timely public warnings must be issued concerning operations which may affect the public, e.g. sudden releases of water from the dam, or pollution incidents.
- International occupational health standards must be applied to all contractors' workplaces. Small contractors who do not have existing H&S Management Plans should consult the World Bank / IFC General Health and Safety Guidelines, which are reproduced as Annexe B.5 to this report.
- More generally, contractors should also be guided by the World Bank Pollution Prevention and Abatement Handbook (World Bank, 1997).

(g) Emergency Plan

An Emergency Plan must be prepared for each active site to cope with accidents, emergencies and upset conditions. Most Probable Accidents should be identified. This plan should include contact details for all emergency services, hospital / clinic and senior management. Actions in case of fire, flood or accident must be specified. It must include an evacuation plan / route for the site. Emergency procedures should be practiced occasionally.

2. Operation

Environmental management during the operation of BHP and its associated powerline and transformer stations will largely consist of regular management and monitoring tasks, examples of which are as follows:

- Monitoring the revegetation of cut, fill, spoil and other former construction areas, and undertaking further restoration where needed.
- Management and monitoring the disposal of wastes generated during operation, e.g. lubricating and cooling oils, oil filters, batteries, domestic refuse, sludges, waste toxic and hazardous materials and their containers.
- Monitoring the storage, use and disposal of any (legal) toxic or hazardous materials.
- Management and monitoring public safety issues. This would include the timely issuing of public warnings of emergencies or operations which may affect the public, e.g. releases of water from the dam (both during floods and for operational drawdown of the reservoir). The public downstream must also be informed of any water pollution incidents that take place at the reservoir or generating station.
- Management and monitoring of workforce health and safety issues, including the annual medical examinations.
- Management of any operations required in the catchment of the Bumbuna reservoir (in liaison with the authority having overall responsibility for catchment management).
- Management of any operations that may affect the fishery of the Bumbuna reservoir (in liaison with the Fisheries Department).
- Monitoring water quality in the Bumbuna reservoir.
- Monitoring water quality in the river downstream of the BHP.
- There is always the possibility that archaeological remains may be revealed on the margins of the reservoir due to the erosive effect of cyclical drawdown and refilling. Prior arrangements must be made for the consultation of specialists from the National Museum, in the event that this occurs.

Operating Rules must be elaborated for operation of the scheme, in particular guaranteeing the minimum environmental flow (= amenity flow, compensation flow) to be released from the dam throughout the year. If the

operator ultimately decides to store water daily or weekly during the dry season (to correlate output with demand), the minimum flow rates must be defined on an hourly and daily basis by reference to an agreed flow curve. Development of this curve must include reference to the minimum flow rates defined by the ESAP (i.e. 6 cumecs during the dry season and 100 cumecs during the wet season).

An **Emergency Plan** must be prepared for operation of the BHP to cope with accidents, emergencies and upset conditions. Most Probable Accidents should be identified. Arrangements for the emergency drawdown of the reservoir should be specified, along with arrangements for any other emergency that can be anticipated, such as a river pollution incident. This plan should include contact details for all emergency services, hospital / clinic and senior management. Actions in case of fire, flood or accident must be specified. It must include evacuation plans / routes for buildings and structures within the power generation site. Emergency procedures should be practiced from time to time. (The recently published (October 2004) Emergency Preparedness Plan within the Dam Safety Programme has addressed most of these issues in relation to the dam / reservoir, but has not yet included the required details of contacts and communication. The DRP has also made recommendations for greater attention to non-failure emergency conditions, and the organization and logistics required for the operation of warning systems.)

A **Decommissioning Plan** must ultimately be prepared to plan for the ultimate dismantling and removal of the BHP at the end of its operational life. At an earlier stage, plans must be made for the safe removal and disposal of major items of plant which may need to be replaced during the normal life of the project, e.g. transformers.

(vi) Monitoring

1. Construction

As outlined above, a comprehensive monitoring programme is needed for the BHP scheme once it is in operation. However, environmental monitoring of the construction works and their surrounding environment must also be conducted throughout the remaining construction period. The contractors will be responsible to conduct the monitoring of their works, and will be required to prepare a detailed Monitoring Plan for approval by the Client. Arrangements for such monitoring must be included in each of the

contractors' EMPs, which will be submitted to the PIU for approval. The results of monitoring must be regularly reported to the government body responsible for supervision and environmental compliance, i.e. the EPD.

Recommended example monitoring criteria to be included in the contractors' EMPs are as follows:

- Regular inspection to determine compliance with stated mitigation measures with respect to excavation, spoil disposal, treatment and revegetation of land.
- Regular inspection to determine compliance with mitigation measures with respect to community facilities, land acquisition, compensation and resettlement.
- Regular inspection to determine compliance with defined truck routes.
- Sampling and analysis of river water upstream and downstream of any construction works, quarry / borrow areas or effluent discharges (see Table 13.3-2 below).
- Sampling and analysis of effluents and drainage discharged from construction sites and camps (see Table 13.3-2 below).
- Sampling and analysis of drainage water from quarry (see Table 13.3-2 below).
- Air quality monitoring (TSP) at active construction sites.
- Noise monitoring at active construction sites near to settlements or noise sensitive receptors.

Table 13.3-2: Recommended water quality monitoring parameters for the Bumbuna Reservoir, Seli River and drainage or effluent waters.

1. Physical Indicators
Water temperature ^{0}C
Turbidity or Secchi depth m
Suspended solids, mg/l
Conductivity
2. Chemical Indicators
pH
Alkalinity
Dissolved Oxygen mg/l or % satn.
Ammonia N, mg/l
Nitrite N, mg/l
Nitrate N, mg/l

Phosphate P mg/l
BOD mg/l
COD mg/l
Oil mg/l
3. Biological Indicators
Faecal coliforms (Prob. No./100 ml)
Chlorophyll C mg/l

The detailed Monitoring Plan in each contractor's EMP should define the locations, parameters and frequency of monitoring. Sampling should generally be at monthly intervals, but 'spot' sampling should also be undertaken whenever non-compliance is apparent, or when a complaint is received from a member of the public.

2. Operation

The EMPs for the O & M contractor and any sub-contractors will need to include Monitoring Plans. The content of these plans will be largely the same as indicated in the list of environmental management and monitoring activities above.

(vii) Auditing

Arrangements must be defined for **environmental auditing** at the end of construction and the reporting of the results, as required under the official EIA Procedures. (The date of the audit is normally specified in the Environmental Approval.) Detailed arrangements should be made between the PIU, the contractors and the EPD. In outline, the procedure should be as follows:

- Main construction contractor appoints independent environmental auditors.
- PIU approves choice of auditor and ToR for the audit.
- Auditors inform PIU and EPD of the audit timetable.
- Environmental audit is undertaken (with EPD in attendance if it wishes).
- Environmental audit report submitted to PIU
- PIU submit audit report to EPD
- EPD approves audit report following consultation with the Working Group.

Arrangements must also be defined for periodic (annual or biennial) environmental auditing and reporting during the operational life of BHP.

(vii) Training

All contractors' EMPs must include defined arrangements for dissemination of the EMP within the workforce, and any staff training necessary for their effective implementation. Where contractors do not have existing environmental management staff, arrangements must be made for adequate capacity-building within the company. For the primary contractors, that will include arrangements for the induction of their newly appointed Environmental Manager and Community Liaison Officer.

(vii) Implementation

All contractors' EMPs must include defined and costed arrangements for their implementation.

12.4 Capacity Building

Once the BHP has been commissioned, professional environmental management will be required at several levels. Capacity building for environmental management will be needed at each level, as described below.

BHP Operation

Environmental management during operation will concentrate on the mitigation and monitoring of the operational impacts of BHP, including effects on local stakeholders. The aim will be to continuously act to maximise the benefits of the BHP and minimise any adverse consequences.

There has been a change in the proposed mechanism for operation of the BHP, which was previously planned to be a function of the National Power Authority. It is now the intention of Government to follow an international bidding procedure to contract a private sector entity, which will operate the BHP and deliver power to another entity or entities responsible for transmission. The operator will be answerable to the regulator, i.e. the Ministry of Energy and Power.

The responsibility for environmental management at BHP level will then lie with the O & M operator. As discussed in relation to the contractors' EMPs, if the contractor appointed does not have existing adequate environmental

staff, then recruitment, training and induction will be required. (When it comes to the selection of an operating company, MEP / PIU could declare that the adequacy of the proposed EMS, EMP and environmental staffing will be one of the selection criteria. This would be normal practice in many countries.)

Bumbuna Watershed Management

Environmental and land use management of the immediate Bumbuna watershed will aim to maintain and then improve the environment of the immediate catchment around the reservoir. This improvement will both benefit a variety of stakeholders and help to protect the reservoir from suspended solids and minimise nutrient inputs.

The simple institutional arrangements for watershed management proposed in the EIA update studies are as follows:

An institution referred to as the Bumbuna Watershed Management Authority (BWMA) will be established. This will be a small organisation responsible for implementation of the Land Management Strategy and Action Plan, largely by contracting out various activities funded by the Watershed Management Fund, and overseen by a small Board of Trustees. It would keep very close links with the Community Liaison Committee.

The BWMA will have a small number of technical staff. It is important that these people are properly skilled in watershed management. Given the recent history of Sierra Leone, it is possible that it will be difficult to find people with sufficient practical experience in modern watershed management. In that case, an initial task of BWMA will be to provide training for its own professional staff, probably by attachments and short courses overseas (not one-year M.Sc. courses). This may create a paradox that is common in developing countries, i.e. small institutions may have such a proportion of their staff in overseas training that the institution is unable to function effectively. This is a situation that must be managed by the BWMA such that staff can only be away one at a time.

The capacity-building for BWMA should include the management of conservation areas, for which they will be responsible in concert with the Wildlife and Conservation Branch (see below).

Seli Catchment Management

Whilst watershed management activities have been proposed for the catchment of the reservoir, with a focus, *inter alia*, on the protection of water quality, there is also a need for management of the whole Seli catchment, particularly given that further power development is expected upstream, and future agricultural development can be anticipated downstream. Establishment of the BWMA is seen as an immediate requirement, whilst broader Seli catchment management can be developed at a more measured pace.

The Seli River Development Authority is already in existence, albeit dormant, and is considered to be the appropriate vehicle to facilitate improved management at the Seli catchment level. The Authority will have to be rejuvenated and provided with a small executive. Again, a 'lean' institution is proposed. This institution will need the same capacity building approach as is proposed above for the BWMA, and there would be benefit in integrating the capacity building activities of the two institutions. There would, however, be a difference in character between the two institutions, in that BWMA needs to be involved in immediate 'hands-on' watershed management, whilst the Seli River Development Authority will initially be involved in planning issues, particularly in relation to the SEA of the Bumbuna / Yiben power development programme.

Department of the Environment

The Department of the Environment is responsible for monitoring the environmental impacts of new projects. It has limited experience of this work and few resources to conduct it effectively. The capacity of the Department therefore needs to be built up in readiness for the completion and operation of the BHP.

So far, the Department of the Environment has rightly avoided the temptation to create an externally funded Environmental Protection Agency, which in the experience of several other African countries becomes unsustainable once project funding ends. However, given the urgent need to build capacity in relation to BHP, it is recommended that the Government should enter into discussions with the World Bank to design a focussed capacity-building programme for the Department. (This project would need to fit with current Bank-supported initiatives, e.g. the 'Institutional Reform and Capacity Project' aimed at government decentralisation.) The proposed programme

would aim at creating a Project Supervision Unit in the Department. It should be designed according to current 'best practice' for such capacity building initiatives, with a clear exit strategy for the withdrawal of external support, whilst ensuring that the Unit continues to function effectively and sustainably.

The BHP would be the main 'vehicle' for capacity-building within the Department, since capacity-building is more effective if it is based on the principle of 'learning by doing'. Indeed, it would be appropriate for this to be achieved by Technical Assistance, funded under the BHP. Staff will continue to discharge their responsibilities as they learn. A combination of classroom training and on-the-job mentoring will support learning.

The Unit should be established with two new staff members, one being the Unit Manager based in Freetown, and the other the on-site Bumbuna Officer. (This on-site officer could be drawn from the existing district DoE inspectors, if suitably qualified and given adequate training.) Initial actions needed to develop the Unit would be to:

- Draft Terms of Reference for the new posts of Unit Manager and Bumbuna Officer;
- Determine office, transport and back-up facilities needed for the officers to be effective in the fulfilment of their duties and provision of same;
- Recruit new senior staff member to fill the two posts;
- Design a capacity- building programme; and
- Develop a schedule for further recruitment in line with expected workload.

The Unit Manager and Bumbuna Officer will require training. This training should use the BHP as the 'living case study'. The training will need to focus upon:

- The project life-cycle and the environmental tools that can be used to predict/mitigate and manage project-environment interactions;
- The technical environmental issues involved in the operation of a major project such as BHP,
- The social issues involved in the operation of a major project such as BHP,
- EIA with emphasis on the role of Environmental Management Plans (mitigation, monitoring, performance evaluation and revision);

- Governmental supervision of projects (procedures, tools and techniques); and
- Watershed management principles and practice.

In accordance with the government policy of decentralisation, and the environmental management framework being put in place for the BHP, it is recommended that any training courses conducted as part of the capacity building programme should be open to selected local individuals, including district council officers, Paramount and Section Chiefs.

In addition to training, there will be a need for preparation of documents to be used in the day-to-day activities of the Unit. Such documents are likely to include Procedural Manuals (with focus on data acquisition, management and storage) and various Environmental Management Guidelines.

During the course of this capacity-building programme, other new development projects will come under the supervision of the Unit, and additional staff will be required. Such projects can be included in the delivery of the training, to make it more relevant and to widen the learning experience and knowledge acquisition. By the time the BHP is completed, a fully functioning and experienced Unit should be in place.

Wildlife and Conservation Branch

The proposed environmental offset arrangements will need to be properly managed. Currently, the Wildlife Conservation Branch (WCB), located in the Forestry and Wildlife Division of the Ministry of Agriculture, Forestry and Food Security, has responsibility for managing game reserves, wildlife parks, and other protected areas. It is likely that it may play a role in the proposed environmental offset arrangements. However, according to the analysis in the UNDP-sponsored report entitled *Biodiversity Status and Trends in Sierra Leone* and the accompanying *National Report: Biodiversity Strategy and Action Plan* (both 2003) the WCB is, "….small, understaffed and ineffective". As a result of this lack of capacity, its 'protected area' work is undertaken by local and international NGOs with donor funding.

It is clear that the institutional location of the WCB needs to be changed to improve its effectiveness in influencing both policy and its 'day-to-day' regulatory and managerial activities. Without such a change, there is a high likelihood that the measures proposed below will be ineffective. The

Government should consider removing the WCB from its location within the Forestry and Wildlife Division and giving it 'Division' status within the Ministry.

Specialists may need to be recruited and trained, and such capacity development should be related to BHP implementation. It is perhaps premature to recommend specific capacity building measures, as the UNEP-sponsored Capacity Assessment Study for Sierra Leone, partly focusing on biodiversity issues, has not yet reported. However, it is recommended that representatives of the WCB should be invited to participate in training events linked to the proposed capacity building programme for the Department of the Environment referred to above.

Bumbuna Project Implementation Unit (PIU)

The PIU will have certain environmental management oversight responsibilities and legal obligations, and at least one Environmental Specialist is being recruited to take responsibility for these issues. It is recommended that this person should also attend the training events of the proposed DOE capacity-building programme. This will mean that there will be a cohort of officials related to BHP, who will have all had the same experience of capacity-building in environmental management and will thus be able to understand and communicate with each other on technical issues as they arise.