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EXECUTIVE SUMMARY

The health component of the Instream Flow Requirements investigation aimed to identify the current health dynamic of the downstream human communities. Thereafter, using the potential impacts of the proposed Lesotho Highlands Water Project dams on the downstream rivers as identified by the bio-physical specialists, this study assessed the potential impacts on the health and welfare of the people living along the study rivers.

The study area consisted of the Matsoku River downstream of the proposed Matsoku Weir, the Malibamatso River downstream of the Katse Dam, the Senqu River from the confluence with the Malibamatso to the border with South Africa and the Senqunyane River downstream of the proposed Mohale Dam.

The eight sections comprised the following river reaches:

1 The Matsoku River from just downstream of the Matsoku Weir to the confluence with the Malibamatso River;
2 The Malibamatso River downstream of the Katse Dam to the confluence with the Matsoku River;
3 The Malibamatso River between the confluence with the Matsoku River to the confluence with the Senqu River;
4 The Senqu River between the confluence with the Malibamatso River to the confluence of the Tsoelike River;
5 The Senqu River between the confluence of the Tsoelike River and the confluence with the Senqunyane River;
6 The Senqu River between the confluence of the Senqunyane River and the South African border;
7 The Senqunyane River between the Mohale Dam and the confluence with the Lesobeng River;
8 The Senqunyane River between the confluence with the Lesobeng River and the Senqu River.

Diseases related to inadequate water supply and defective sanitation include communicable diseases, which may be water-borne (spread through water supply), water-washed (lack of water for personal and food hygiene) or water-based, as well as non-communicable diseases due to water-borne toxins. Water-related insect vectors transmit water-vectored diseases.

A literature review revealed the following:

- The percentage of the population in Lesotho with access to safe water in 1995 was 52%. The estimate of sanitation coverage levels in rural areas of Lesotho based on 1995 figures indicated that 8% of the rural population had adequate sanitation (VIP or flush toilets).

- By studying total coliforms and *Escherichia coli* concentrations, the Lesotho Highlands Health Survey in 1993 demonstrated that the potability and safety of most domestic water supplies in the Katse catchment area were compromised. All “unimproved’ and “semi-improved” sites were contaminated with significant implications for diarrhoeal disease prevalence.

- According to the 1993 Lesotho Health Profile based on data collected between 1988 and 1991, water-related diseases were among the most common illnesses reported by outpatients in health centres. Skin diseases, digestive diseases, diarrhoeal disease, and intestinal parasites were highest among children between 0 - 4 years.

- A parasitology survey was conducted among people in the Katse and Muela catchment areas in Lesotho in 1993. Of 654 faecal specimens examined, *Entamoeba coli* was found in 53.2%. The infection rate with *Giardia lamblia* was 4.1%. The percentages of parasites found gave an indication of the extent of contamination of food and water in the community studied.

- Prinsloo and Van Eeden undertook comprehensive surveys for freshwater snails in Lesotho during the period January 1968 to February 1969. The collections contained no human *Schistosomiasis* intermediate host snail species. The physiological indication was that the intermediate snail hosts would not survive, nor would the parasite develop, in the low temperatures in the water-resource development area.

- The most important conclusion from the Lesotho Highlands Development Authority Phase 1 A Nutrition study of the Katse and Muela catchment, was that the study population was extremely vulnerable from a nutritional point of view. Furthermore food security (dietary quality and quantity) was found to be closely linked to risk and severity of malnutrition.

- In the population of the Mohale Dam catchment area all the age groups reported having regular meals, but qualitative analysis revealed a low diversity in the diets, with an irregular intake of protein rich foods and milk. In addition, quantitative data on three to five year olds showed that micronutrient intakes were low and that the energy intake of these children was inadequate.

Studying the population at risk (PAR) revealed the following:

- The PAR (the statistical population within the 5-km corridor on either side of the river) consisted of 50.1% males and 49.9% females. The age distribution of the PAR showed a high dependency ratio, with 50.7% of the population below the age of 21.

- The area was burdened by a high illiteracy rate with 29.7% of the population having no formal education well in excess of the 19% calculated in 1995 for Lesotho as a whole. In addition, 70.6% of the population had no formal income and 40.6% was unemployed.

- High levels of childhood infectious diseases related to water throughout the study area were found, ranging from 19% of diagnoses with which 0-5 year olds presented to Marakabei clinic to 50% of all diseases in this age group recorded at Holy Cross clinic. Among these were water-borne diseases causing gastroenteritis and water-washed diseases causing skin diseases and eye infections. Diarrhoeal disease was the second most common disease that households suffered from during the two months prior to the household baseline health survey done for the socio-economic survey in 1999.

- An average of 27% of households relied on uncovered springs for domestic water all year round. An average of 11.78 litres/capita/day water consumption was used by these households (WHO recommendation 35 litres/capita/day). Moderate levels of river water were consumed, especially in the summer months and during drought periods when alternative sources were unreliable.

- The results of the field testing of 100-ml water samples showed that the river was not contaminated with coliforms during the high flow months of January to April 1999. Isolated positive findings were in a range where negligible risk of microbial infection exists. Only during April 1999 (low flow month) at IFR Site 8 were the levels recorded indicative of a risk of humans contracting diarrhoeal disease as a result of continuous exposure.

- *Giardia lamblia* was sampled from the rivers. The concentration of cysts found, indicated a high risk of contracting diarrhoeal disease from drinking the river water where the cysts were consistently found. The risk would have been high even if a small amount of water were consumed.

- The comparison of the water chemistry observations at individual IFR sites revealed limited differences. Except for isolated elevated measures during the high-flow summer period, the chemical composition of the rivers indicated safe levels for human consumption.

- During 1966 and 1996, Anthrax epidemics were recorded in the vicinity of IFR Sites 1,2,3,4 and 7. The mortality rate for inhalation Anthrax approaches 100% making a strong case for prevention. Food is scarce and the communities cannot afford to discard meat, even if the animal died from unnatural causes. In addition, more than 50% of households surveyed owned animals and more than 50% used river water for watering their animals during drought periods. Anthrax infected animals bleed from the mouth and nose and contaminate drinking places with spores that can persist in the environment. With low flows, spores can remain in the environment longer.

- Maize and sorghum were grown by a maximum of 27% of households. Fish, a potentially important source of protein, was caught by 15% of households. These households then sold fish to the rest of the corridor community. Trout, Smallmouth Yellowfish and Rock Catfish were commonly caught and eaten, whereas the Orange River mudfish was more difficult to catch. Wild vegetables formed a large part of the diet. Children under six years consume very little fish in households where fish was part of the diet.

- The impact of both the Treaty and Design Limitation Scenarios on river resources, river flow, public and animal health were analysed and the impacts quantified. Under the Treaty scenario, severe to critically severe impacts are expected for diarrhoeal disease and nutrition. Minimal impact is expected for Malaria and Schistosomiasis. Under the Design Limitation scenario, minimal to moderate impacts are expected for diarrhoeal disease and nutrition. Minimal impact is expected for Schistosomiasis and Malaria.

- The baseline situation with respect to diarrhoeal disease and nutrition requires immediate mitigation and the potential for mitigation varies from moderate to good for diarrhoeal disease to minimal to moderate for nutrition under the Treaty Scenario. This is because the baseline health condition of the people in the corridor communities is already poor. Under the Design Limitation scenario, because of the minimal changes expected ecologically, the potential for mitigation varies from good for diarrhoeal disease to moderate for nutritional interventions.

- For Anthrax, Malaria and Schistosomiasis, there are currently no cases recorded in the area. No Malaria or Schistosomiasis is expected, although ecological changes under the Treaty Scenario warrant periodic monitoring. For Anthrax, the potential for mitigation is minimal when the disease does occur.

- The primary limitations of the study relate to logistical and time constraints, which limited the amount of primary research that could be undertaken. In addition, a degree of uncertainty surrounds population projections for Lesotho. The reliance on secondary data may have introduced certain biases, although every attempt was made to verify and assess the plausibility of information obtained.

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GLOSSARY OF TERMS

Fertility rate	The number of children borne to a woman if she were to live to the end of her child bearing years.
Gastro-enteritis	Diarrhoeal disease characterised by diarrhoea, nausea and vomiting.
Health Impact Assessment	A comprehensive assessment of the health effects of development projects focussing on health status, determinants of good health, health services and health promotion.
Infant mortality rate	Number of infants less than one year old who die per every 1000 live births.
Instream flow requirements	Requirements of flow for the river downstream of a dam impoundment based on the effects on the riparian communities.
Intervention	A specific activity meant to reduce disease risks, treat illness, or palliate the consequences of disease and disability.
Maternal Mortality rate	The number of mothers that die while giving birth per 100 000 live infant births.
Mitigation	Actions taken to lessen the severity of negative impacts or increase the potential of positive impacts.
Primary data	Data collected by the project team for the purposes of this project.
Secondary data:	Data already collected and analysed, either routinely or during other projects
Sub-saharan Africa	Comprises all countries south of the Sahara, including Madagascar and South Africa, but excluding Mauritius and Seychelles.
Under 5 mortality rate	The probability of dying between birth and age five, expressed per 1000 live births.

LIST OF ABBREVIATIONS

AIDS:	Autoimmune deficiency syndrome
ARI:	Acute Respiratory Tract Infection
ENT:	Ear, Nose and Throat
FDI:	Foreign Direct Investment
GDP:	Gross Domestic Product
GNP:	Gross National Product
HIV:	Human Immunodeficiency Virus
MRC:	Medical Research Council
NGOs:	Non Governmental Organisations
OECD	Organisation for Economic Co-operation and Development
PAR	Population at Risk
PID	Pelvic Inflammatory Disease
SIDA:	Swedish International Development Agency
SSA :	Sub-Saharan Africa
STD:	Sexually Transmitted Diseases
TB:	Tuberculosis
TSS:	Total Suspended Solutes
UN:	United Nations
UNDP:	United Nations Development Programme
UNICEF:	United Nations Children's Fund
URTI:	Upper Respiratory Tract Infection
VIP:	Ventilated Improved Pit Latrine
WHO:	World Health Organisation

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SECTION A: INTRODUCTION AND STUDY METHODOLOGY

1 INTRODUCTION

It is being increasingly recognised that health-producing interventions are often outside the traditional domain of health services (Drummond and Stoddart 1995). Infrastructure and development have the potential to improve health through the provision of services, the generation of employment and economic activity. But the solution to one problem often causes or aggravates another. Hydroelectric power, for example is clean energy that causes no air pollution. But large dams and their reservoirs take up land and can damage ecosystems (World Resource 1998/99).

The negative impacts of large-scale developments can include the destruction of the natural environment, resettlement and migration, increases in communicable disease and the exacerbation of poverty (Faechem and Jamison 1991). The failure to foresee the health consequences of development limits the potential for ensuring that infrastructure is health promoting (Cooper-Weil *et al*., 1990).

The impact on people's health constitute one of the best measures of the success (or failure) of infrastructure and development (Lerer and Yach, 1995). In 1985, the feasibility study for the Lesotho Highlands Water Project (LHWP), concluded that the project would cause serious adverse health effects from the disruption of the natural and social environment (Lahmeyer MacDonald Consortium, 1986). This conclusion was supported by subsequent environmental impact assessments (Tshabalala and Turner 1989).

Serious impacts were anticipated with respect to water-related diseases, health and social problems resulting from a large workforce and population resettlement. The subsequent inability of the health system to cope with the population growth and increased disease prevalence was also anticipated.

As part of the Instream Flow Requirements investigation (LHDA 648), it was realised that an inter-sectoral approach to conducting IFRs would require a concurrent Health Impact Assessment (HIA) grounded in the principle of “people-centred” development. As IFRs move towards a more holistic approach that encompasses people, their social, economic and biophysical environment, there could not be a more opportune time for a sustainable and equitable partnership with public health.

The approach used in this public health study, that of a Health Impact Assessment (HIA), aims to enrich the IFR process and provide realistic, implementable and cost-effective avenues for ensuring that the Lesotho Highlands Development project is “health promoting”. We have attempted to ground this work in the social, political and economic context of Lesotho, in recognition of the fact that most of the determinants of health status lie outside the health sector.

2 METHODOLOGY

2.1 Study Objectives

Using a HIA methodology (Scott-Samuel 1996; Strauss and Lerer 1996), the health component of the Instream Flow Requirements of the rivers downstream from the LHWP Dams aimed to identify the current health dynamic of the downstream human communities. Thereafter, using the potential impacts of the proposed LHWP dams on the downstream rivers as identified by the bio-physical specialists on the IFR team, this study assessed the potential impacts on the health and welfare of the people living along the study rivers.

2.2 The study area

2.2.1 The IFR biophysical component sampling sites

The study area consisted of the Matsoku River downstream of the proposed Matsoku Weir, the

Malibamatso River downstream of the Katse Dam, the Senqu River from the confluence with the Malibamatso to the border with South Africa and the Senqunyane River downstream of the proposed Mohale Dam.

The rivers were divided into eight representative sections, taking into account the most important tributaries where effects on the river characteristics may be expected as well as the sites of existing and proposed dams and weirs. Within each reach, an IFR site was selected which described the characteristics of the reach.

2.2.1.1 Location of the river reaches

The eight sections comprised the following river reaches:

- The Matsoku River from just downstream of the Matsoku Weir to the confluence with the Malibamatso River;
- The Malibamatso River downstream of the Katse Dam to the confluence with the Matsoku River;
- The Malibamatso River between the confluence with the Matsoku River to the confluence with the Senqu River;
- The Senqu River between the confluence with the Malibamatso River to the confluence of the Tsoelike River;
- The Senqu River between the confluence of the Tsoelike River and the confluence with the Senqunyane River;
- The Senqu River between the confluence of the Senqunyane River and the South African border;
- The Senqunyane River between the Mohale Dam and the confluence with the Lesobeng River; and
- the Senqunyane River between the confluence with the Lesobeng River and the Senqu River.

2.2.1.2 Description of sites

IFR Site 1 (Matsoku)
The site was located on the Matsoku River, upstream of the village of Ha Nang and downstream of the proposed Matsoku diversion weir. The site was considered to be a representative sampling point for this section of the river as there were no major tributaries between the site and the confluence with the Malibamatso River.

IFR Site 2 (Katse)
The site was located on the Malibamatso River approximately 4km downstream of Katse Dam and 2 km downstream of Katse Bridge. The site was in a transition zone where the effects of Katse Dam on water quality were moving to equilibrium with natural river processes.

IFR Site 3 (Paray)
The site was located on the Malibamatso River adjacent to the Department of Water Affairs gauging station, which was approximately 2 km downstream of the gauging weir. The site was considered to be a representative sampling point for this reach of river as it was far enough downstream from the confluence with the Matsoku River for complete mixing to occur and there were no major tributaries until the confluence with the Senqu River.

IFR Site 4 (Sehonghong)
The site was located on the Senqu River next to the town of Sehonghong, approximately 20km downstream of the Department of Water Affairs gauging station at Koma-Koma. The site was far enough downstream of the confluence with the Mashai River (15 km) for complete mixing to occur.

IFR Site 5 (Sekake)
The site was located on the Senqu River between the confluence with the Tsoelike and Senqunyane Rivers, just upstream of the village of Sekake. The site was far enough downstream of the Tsoelike River for complete mixing to occur.

IFR Site 6 (Seaka)
The site was located on the Senqu River just downstream of the old Seaka Bridge and the Department of Water Affairs gauging station and upstream of the new bridge on the Mohale's Hoek to Quthing Road. The site was far enough downstream of the confluence with the Senqunyane River for complete mixing to occur.

IFR Site 7 (Marakabei)
The site was located on the Senqunyane River approximately 2 km upstream of the Department of Water Affairs gauging weir. It was considered to be representative of the reach from the Mohale Dam to the confluence with the Lesobeng River. However, with the construction activities at the Mohale Dam site, the water quality may be expected to deteriorate more noticeably than locations on this reach further downstream, i.e., at a greater distance from the construction site (Skoroszeski, 1999). Similarly, the water quality at the stretch of river upstream of this site (closer to the construction site) may be expected to be more impacted (Skoroszewski, 1999).

IFR Site 8 (Lower Senqunyane)
The site was located on the lower Senqunyane River, approximately 3km upstream of the confluence with the Senqu River. The contribution of natural flow at this site originating from the catchment of Mohale Dam is approximately 70% compared to 85% at Marakabei (Skoroszewski 1997).

2.2.2 The socio-economic study sites

The socio-economic study consisted of two distinct phases. The first phase, the pilot study, was designed to identify at a fairly coarse level the following (Report 648-F-08):

- the extent to which the villagers living alongside the study rivers made use of river resources;
- the extent to which they use the rivers for cultural activities;
- problems related to the study rivers;
- the general feelings that they have toward the study rivers;
- any health problems associated with the study river (this included both human and animal health).

The second phase of the study, the detailed survey, was designed to quantify usage of riparian resources as identified during the pilot study among a precisely defined population of river users (Report 648-F-08). The detailed study also aimed at determining the economic value of the river resources used, and at identifying river-related aspects of public and animal health. These studies by the socio-economic team were complemented by a health centre survey from the public health team that identified the diseases with which people within the study corridor presented. The socio-economic team surveyed communities within the same river reaches that the IFR sites were located.

2.2.3 Health centre survey sites

The health centre survey was conducted at health facilities within the same river reaches that the socio-economic and biophysical teams surveyed.

2.2.3.1 Location of clinics

The locations of the clinics and Paray hospital in relation to the IFR sites are described below. The villages served by each clinic are given in brackets after the clinic name.

Seshote Clinic (Villages: Kalakatana, Khopung, Khubetsoana, Leferefere, Leohla, Maieane, Mathabela, Moses, Ranthoto, Ranthebe, Sekhutla, Seshote, Tsehla)
The clinic is close to IFR Site 1 on the Matsoku River.

Khohlo-Ntso Clinic (Village: Ha Soai)
Ha Soai, the village served by Khohlo-Ntso Clinic, is a medium sized village with easy access to the health service. This clinic is located near to Katse Dam and IFR Site 2. The community at Ha Soai already experience impacts related to the construction of LHWP dams.

Mohlanapeng Clinic (Village: Koma-Koma)
Mohlanapeng Clinic is located in the upper Senqu River valley. Koma-Koma, the village served by the clinic, is a medium-sized village approximately 45 minutes walk from the Senqu River Bridge.

Paray Hospital (Villages: Ha Clarke, Ha Soai, Khoma ea molo, Koma-Koma, Tloekeng.)
Paray Hospital was the only hospital visited during data collection. It is located close to IFR Site 3 on the Malibamatso River.

Sehonghong Clinic (Villages: Ha Clarke, Ha Fusi, Ha Poko, Kgomo, Khoma ea molo, Tloekeng)
The IFR site closest to this clinic is IFR Site 4 on the Senqu River between the confluence with the Malibamatso River to the Tsoelike River.

Holy Cross Clinic (Villages: Ha Phatalla, Ha Ramatlalla, Seaka)
The river closest to this clinic is the Senqu River and the closest IFR site is IFR Site 6 at Seaka Bridge. The area, close to the South African border, is a typical lowland area.

Sekake Clinic (Villages: Pathela, Sekake, Setofolo)
The Sekake Clinic serves communities on both sides of the Senqu River. Whereas Sekake is a large settlement, resembling a town, the other villages are rural in nature with very high dependency on the river.

Marakabei Clinic (Villages: Ha Noha, Ha Tsitso, Marakabei)
The clinic is close to the Sengunyane River at IFR Site 7. The Mohale Dam site is also located in this area. Marakabei and Ha Noha are situated on opposite sides of the Senqunyane River.

Mount Moorosi Clinic and Phamong Clinic (Villages: Ha Koali, Ha Seletara, Phamong)
The clinics are located on opposite sides of the Senqu River from one another, halfway between IFR Site 6 at Seaka Bridge and IFR Site 8 on the lower Senqunyane River. Both clinics were selected for data collection, so that patients' records on both sides of the
Senqu River would be captured.

2.3 Scientific methods

2.3.1 Data sources and data management

The Public Health assessment was done in two parts, *viz.*:

Part 1: a review of available secondary documentation.

Part 2: collection and analysis of additional data required to assess likely flow related changes.

2.3.1.1 Part 1: Review of available secondary documentation

The first part of the public health assessment was based on a review of available secondary documentation. Where possible, original data were re-analysed, especially in the case of the distribution of morbidity and mortality. Secondary data sources included available Lesotho health-related records and previous studies, especially the Phase 1A and Phase 1B LHWP cross-sectional studies (Consortium for International Development 1993;Medical Research Council 1996), and international literature on issues of public and environmental health as they relate to freshwater-development projects.

Evaluation of vital registration data (where available) was undertaken for the estimation of morbidity and mortality.

The 1992 Phase 1A study area was conducted among those communities living within the Katse and Muela local catchments (Tshabalala 1989). The surveys reviewed in this study were:

- the review of the demographic and vital statistics for Phase 1A and Lesotho;
- the nutrition survey;
- the prevalence and intensity of vectors of human disease;
- the prevalence and intensity of human
- communicable or infectious disease;
- the availability of medical facilities and their usage,
- knowledge/attitudes/practices regarding health;
- and a future monitoring and audit programme.

The 1993 Phase 1B study was conducted in the proposed Mohale catchment area, which comprised the basin formed by the Senqunyane River and several of its tributaries (Medical Research Council 1996). This area lies about 70 km east of Maseru, within the Maseru and Thaba-Tseka Districts. The population studied consisted of all people living in the 83 villages in this demarcated area. The surveys reviewed were:

- the community-based epidemiological survey;
- the review of human health, demographic and

vital statistics for Phase 1 B area;
- the knowledge, attitude, practices survey;
- the nutrition survey;
- prevalence and intensity of vectors of human communicable disease;
- the prevalence and intensity of human communicable disease;
- the health and medical services survey;
- a future monitoring and audit programme.

2.3.1.2 Part 2: Primary data collection

The second part of the assessment drew on work done during the socio-economic study as well as that done by the biophysical IFR specialists, especially the water quality and the macroinvertebrate studies. Part 2 also comprised health-related primary data collection and additional water microbiology and parasitology sampling.

Primary data collection included data collection at the local health centres that serve the PAR by the public health team. A public health specialist and research assistants examined the health centre outpatient record books and collected data on each patient focussing on the following:
- date;
- clinic;
- village of residence;
- age of patient;
- gender of patient;
- diagnosis.

A total of 4169 patient records was collected from the clinics and analysed for the period 01 July 1998 to 30 June 1999. The data were collated and entered into a database created on Microsoft Office Excel 97. The data were grouped further for analysis. As 62 different diagnostic groupings were identified, the totals per grouping were too low to draw statistical inferences from the data. Any attempts to further group diseases into smaller diagnostic groups would have resulted in bias being introduced. Because people do not always present to the health centre for certain disease groups and because of the possibility of wrong diagnoses, these figures are not necessarily an accurate reflection of disease prevalence in the study area. For that reason, general trends and percentages are used as the unit of analysis.

Water microbiological and parasitological quality assessment at all eight IFR sites by the water-quality specialist in the biophysical team. The river water was tested for total coliforms, *Giardia lamblia* and *Entamoeba coli.* The methodology used is included as Appendix A.1.

2.3.2 Methodology

The purpose of this study was to evaluate the downstream health impacts of dam construction by examining the interaction between socio-demographic and biophysical factors. The relationship between water-related diseases and water consumption was also explored.
The socio-demographic component of the health impact equation included:
the size and health of the exposed population; and
the nature of their exposure (water use patterns).

The biophysical component of the health impact equation included:
the quality of the river water; and
the health consequences of low flow scenarios.

The core components contained in this study are:
- Demographic, social and economic profile.
- Health status and priority health issues.
- Health status indicators.
- Determinants of health status.
- Health outcomes (HIA results and biophysical impacts).

These are explained in more detail below.

2.3.2.1 Demographic, social and economic profile

The demographic, social and economic profile focused on the collation of existing data on population demographics, both nationally and locally. These data were collated for the downstream communities and areas that may be reasonably extrapolated in order to quantify the PAR, and to explore how interaction with the rivers influences health. These included data on: socio-economic indicators; river utilisation patterns;

health system utilisation; education;, geographical factors; agriculture, nutrition; household health production and; other macro-economic development activities.

2.3.2.2 Health status and priority health issues

The Health Status Assessment aimed to provide accurate baseline data on health status to assist in determining health needs and to provide a relatively unbiased indicator of the effects of development. A wide range of health indicators was used, subject to availability, including measures of morbidity and priority diseases. These are discussed below.

Health status indicators
A review of the important causes of morbidity and mortality, focusing mainly on water-related diseases on a global, national and local scale. These included infant mortality rate, perinatal mortality rate, under-5 mortality rate, fertility rate, nutritional status, incidence of water-related diseases, and other infectious disease prevalence. These allowed further analysis of the interaction of the people with the river system and in turn, the river system's influence on people's health. Environmental determinants of health status have a strong cross-sectoral component. A review of environmental health issues including water supply, sanitation, and freshwater quality was done for the study area.

2.3.2.3 Health outcomes (HIA results and biophysical impacts)

The aim of this activity was to identify and roup the health outcomes and to describe and quantify the impact of the biophysical consequences for the different scenarios to aid the design of a surveillance system to clarify emerging health threats.

2.3.3 Ethics

The HIA was conducted within the ethical guidelines for biomedical research of the South African Medical Research Council (MRC 1993). The epidemiological research activities of the assessment follow the Guidelines on Studies in Environmental Epidemiology (Fuggle and Rabe 1992). All secondary data, if copied, have been retained in safe storage by the MRC, and copies will be supplied to LHDA on completion of the study.

2.3.4 Limitations

The primary limitations of the study relate to logistical and time constraints, which limited the amount of primary research that could be undertaken. In addition, there a degree of uncertainty surrounds population projections for Lesotho. The reliance on secondary data may have introduced certain biases, although every attempt was made to verify and assess the plausibility of information obtained.

SECTION B: ESTABLISHING THE PUBLIC HEALTH CONTEXT: REVIEW OF DOCUMENTARY SOURCES AND BIOMEDICAL LITERATURE

3. WATER – A RESOURCE AT RISK

3.1 Introduction

The world is faced with a fundamental challenge of supplying freshwater that is adequate in quality and quantity for all people. It is being increasingly recognised, moreover, that the achievement of this goal may be undermined by a disruption in the water supply of those already enjoying access. As affirmed in the Dublin Statement on Water and Sustainable Development, "Scarcity and misuse of freshwater pose a serious and growing threat to sustainable development and protection of the environment. Human health and welfare, food security, industrial development, and the ecosystems on which they depend, are all at risk, unless water and land resources are managed more effectively in the present decade and beyond than they have been in the past" (World Economic and Social Survey 1996).

3.2 Freshwater ecosystems, development and health

Freshwater for human use is a fragile, finite resource that is not only disproportionately distributed among and within regions and countries, but is also frequently unreliable. countries, depend on fish as their primary source of protein (World Resources, 1996). Environmental Freshwater environments play a vital role in the lives of many people, providing them with a source of water, food and employment. For example, an estimated 950 million people, mostly in developing countries depend on fish as their primary source of protein (World Resources 1996).

Environmental change is an inevitable consequence of economic development and people's desires to improve their quality of life. In pursuit of a better life, waterways are dammed and diverted and forests and grasslands are converted into farms, homes and commercial spaces (VanDerslice and Briscoe 1995).

Environmental change can degrade health, either directly by exposing populations to harmful agents or indirectly by disrupting the ecosystems that sustain health as indicated in Table 3.1.

Table 3.1 Environmental change and health effects.

Effects on the ecosystem from environmental change	Resultant health effects
• Vectors and infective parasites change in distribution and activity.	• Changes in the geographic ranges and incidence of water-related diseases.
• Water-related and food-borne infective agents change in distribution and abundance patterns	• Changes in the incidence of diarrhoeal and other infectious diseases.
• Food (especially crop) productivity along riverbanks changes due to changes in water flows, and associated pests and diseases	• Malnutrition and hunger, and consequent impairment of child growth and development.

(Adapted from World Resources 1998/99).

3.3 Dams and channelisation, and their effects on health - global trends

Dams and channelisation remain the two most pervasive threats to freshwater ecosystems today, with dramatic effect on species abundance and diversity. In 1950 there were 5270 large dams in the world. Today there are more than 36,500 (The Economist 1997). Many examples illustrate how the freshwater ecosystems have been threatened over the years with effects on food production and health. More than 100 years of channelisation and riverside of its original flood plains and the native salmon run has nearly disappeared (World Resources 1998/99).

Since 1970, when Egypt's Aswan Dam came into operation, the number of fish species on the Nile has dropped by nearly two thirds and the sardine catch in the Mediterranean has dropped by nearly 80% (McCully 1996). After the Pak Mun Dam was built in the 1990s on the Thailand's Mun River, all 150 fish species that had inhabited the river have virtually disappeared (World Resources 1998/99).

There are a few reports that demonstrate a definite association of an epidemic of gastrointestinal disease with the presence of a dam. In the Bulletin of the Pan American Health Organization, Teixeria and his colleagues described an epidemic of severe gastroenteritis in the Paula Afonso region of Brazil associated with the filling of the newly-constructed Itaparica Dam in 1988 (Teixeria 1996). Over 2,000 cases of gastroenteritis were reported over a 42-day period. An epidemiological investigation revealed that the source of the outbreak was the impounding of a large body of water by the dam. The causative agent was a toxin produced by cyanobacteria as a result of the decomposing biomass and other conditions prevailing in the newly flooded reservoir area (Teixeira 1996).

Large bodies of water can serve to distribute intestinal parasites as well as other infectious diseases. Temcharoen and his colleagues described a prevalence of parasites in workers at three dams controlled by the Electricity Generating Authority of Thailand. They cautioned that, because of the proximity of the people living close to these large bodies of fresh water, measures should be taken to eradicate the parasitic infections among them in order to prevent the spread in the water (Temcharoen 1987).

Two diseases - Schistosomiasis and Malaria - seem most closely related to water-development projects. Construction of the Low Dam at Aswan in the 1930s was followed by an increase of Schistosomiasis with community prevalence levels rising from 2-11% to 44-75% (Lim 1987). A Malaria epidemic in 1942/43 which occurred in Upper Egypt and caused 130,000 deaths, was due to the invasion of *Anopheles gambiae* from the Sudan and must be seen as a consequence of water development.

In Ghana, large-scale surveys for urinary Schistosomiasis were undertaken prior to the building of the Akosombo Dam in the 1960s. Low disease prevalences (5-10% in children) were found (UNDP/WHO 1979). Within a year of the lake reaching its maximum level, prevalences of up to 90% were found in lakeside communities. About 150,000 people were living along the lakeshore. Prevalence of Schistosomiasis gradually decreased with distance from the lake and there was a direct relationship between prevalence of Schistosomiasis and dependence on the lake for domestic water needs (UNDP/WHO 1979). Reports of increased Schistosomiasis prevalence following the construction of a large dam have also been noted in Nigeria, Sudan, and Mali (Hunter 1982).

In Kenya, mosquito surveys in the irrigated and non-irrigated areas of the Kano Plain Project showed a reduction in the number of species and a change in the composition of the mosquito population, with a 4-fold increase in household entry. It was expected that, following settlement of this area, an increase in Malaria transmission would occur (Hunter 1982).

With the water-development project on the Senegal River and the building of an upland hydroelectric dam, ecosystem changes in the river basin occurred. The net impact of the development on people's health has thus far been negative, with Schistosomiasis, diarrhoeal disease and Malaria increasing, in some cases dramatically. Malnutrition also increased as a result of the interruption of the annual floods by the building of the dam, causing a reduction in traditional agricultural practices as well as a reduction in the fish catch in the basin area (World Resources 1998/9).

3.4 Water degradation

Water degradation, be it pollution of groundwater, surface water or coastal water, is regarded as one of the most serious environmental problems because it can directly or indirectly damage human health and economic activities, as well as plant, animal and aquatic plant communities. Microbial pollutants of water are a major cause of health and economic problems and water and its related problems have moved to the front of international environmental and health policy agendas (WHO 1992).

3.4.1 Water supply, sanitation and health outcomes

Research conducted in Lesotho over a ten-year period suggests that the introduction of clean water systems only have a positive health impact if households are persuaded to make exclusive use of the improved supply, use increased quantities of water, improve their hygiene practices and use Ventilated Improved Pit (VIP) latrines. (Esray 1992).

Since the lack of sanitation precludes the proper treatment of human waste, which is in turn one of the main sources of unsafe water, water supply and sanitation issues are intertwined.

Diseases related to inadequate water supply and defective sanitation include communicable diseases, which may be water-borne (spread through water supply), water-washed (lack of water for personal and food hygiene) or water-based, as well as non-communicable diseases due to water-borne toxins. Water-related insect vectors transmit water-vectored diseases. Table 3.2 provides a classification of diseases associated with water according to the various aspects of the environment that human intervention can alter.

According to the World Health Organisation (WHO, 1992), a third of the world'spopulation suffers from diseases derived from contaminated drinking water. Every year about 13 million people die from water-related infections, of which two million are children. The health impact is particularly severe in developing countries, where water-related infectious diseases affect more people than any other health problem (WHO 1997). In 1992, the WHO estimated the impact of water-related diseases on mortality and morbidity, as well as the size of the PAR (Table 3.3)

Infants and children are most affected by inadequate water supply and of sanitation-related diseases. It is estimated that safe and sufficient water supplies and adequate sanitation would reduce infant and child mortality by more than 50 % and prevent 25 % of all diarrhoeal diseases (WHO 1992).

A review of the literature pertaining to water and sanitation and diarrhoeal disease in Lesotho revealed the following:

- The percentage of the population in Lesotho with access to safe water in 1995 was 52 % (Water Resource Management 1995).
- In 1995 the Department of Rural Water Supply in Lesotho conducted a national inspection of the Rural Water Supply Project. The following results were obtained (Water Resource Management 1995):
    a) Coverage was estimated at 56% of the rural population. However, it was much higher in the Lowlands (78%) than in the Mountains (22%), Foothills (33%) or Senqu River Valley (44%). Coverage was lowest in Thaba Tseka near IFR Site 3 on the Malibamatso River.
    b) Thirty-five percent of the improved systems were meeting the litres per capita per day (l/c/d) standard of 35 litres recommended by the WHO (Water Resource Management 1995). Nineteen percent were delivering less than 7 l/c/d, 31% had to be rationed during drought and 4% of the projects had no water at all. Projects in the larger Lowland villages were more likely to have

inadequate water supplies than those serving smaller villages in the mountains.

c) In about one third of the villages, up to 25% of the households were 150 m or further away from a water collection point.

d) In rural areas, 21% of those households using unimproved sources suffered from water-related diseases in the month prior to the investigation, compared to 11% of those using some improved source.

e) When the quantity of water used was considered, some interesting results emerged. Those who used less than 7 l/c/d had a 14% incidence of water-related diseases while those using more than 25 l/c/d had only a 2% incidence.

f) People who collected water from the public systems consumed 11.78 l/c/d as compared to those with a tap in the yard who consumed 671 l/c/d.

Table 3.2 Classification of diseases associated with water.

Water-borne diseases	These arise from the contamination of water by human or animal faeces or urine infected by pathogenic viruses or bacteria, which are directly transmitted when the water is drunk or used in the preparation of food. Cholera and typhoid are the classic examples. Other diseases such as leptospirosis may be acquired through contact of abraded skin with infected water. Other examples are diarrhoeas, dysenteries, polio, hepatitis A amoebiasis, and giardiasis.
Water-washed diseases	Scarcity and inaccessibility of water make washing and personal cleanliness difficult and infrequent. Where this is so some diarrhoeal diseases and contagious skin and eye infections are prevalent. This category of diseases also includes infestation with lice or mites, which are vectors of various forms of typhus. Water-washed diseases diminish whenever an adequate supply of water is available and used. Here, distance to the water source is of the utmost importance, as is the promotion of positive water–use behaviour. Examples are trachoma, conjunctivitis, scabies.
Water-based diseases	Water provides the habitat for intermediate host organisms in which some parasites pass part of their life cycle. These parasites are later the cause of helminthic diseases in people as their infective larval forms in fresh water find their way back to humans by boring through wet skin (Schistosomiasis), being ingested with water plants, crustaceans or fish that are eaten raw or inadequately cooked (liver and lung flukes), or by infecting a minute water crustacean and being swallowed (dracunculiasis).
Water-vectored diseases	Water may provide a habitat for water-related insect vectors of disease. Mosquitoes breed in water and the adult mosquitoes may transmit Malaria, filariosis and various infections such as dengue, yellow fever and Japanese encephalitis (WHO 1992). Inadequate sanitation can also result in the spread of intestinal parasites through contact or ingestion of soil contaminated by human faeces. As the transmission of many of the above diseases depend on access of human wastes to water or people's mouths, the chain of transmission can be broken by the safe disposal of excreta, personal and domestic hygiene, improving water quality and preventing the recontamination of water supplies. Examples are hookworm, ascariasis, trichuriasis, taeniasis.

- The estimate of sanitation coverage levels in rural areas of Lesotho based on 1995 figures indicated that 8% of the rural population had adequate sanitation (VIP or flush toilets) in 1995 (Department of Rural Water Supply 1995). In 1996 this figure rose to 12%. Although the VIP designs of NRSP are popular they are also expensive thus excluding a large proportion of the population who build cheaper models that do not provide the protection from diseases afforded by a VIP.

By studying total coliforms and *E. coli* concentrations, the Lesotho Highlands Health Survey demonstrated that the potability and safety of most domestic water supplies in the Katse catchment area were suspect.

Table 3.3 Examples of water-related infections with estimates of worldwide morbidity, mortality and PAR.

Disease	Morbidity per annum	Mortality per annum	PAR
WATER-BORNE AND WATER-WASHED DISEASES			
Cholera	No figures available		
Diarrhoeal diseases (include salmonellosis, shigellosis, Campylobacter, *E. coli*, rotavirus, amoebiasis and giardiasis)	>1 500 million episodes in children under 5 years	4 million in children under 5 years	> 2 000 million
Enteric fevers (paratyphoid, typhoid)	500 000 cases; 1 million infections (1977-78)	25 000	
Poliomyelitis	204 000 (1990)	25 000	
Ascariasis (roundworm)	800-1 000 million cases; 1 million cases of disease	20 000	
Leptospirosis (Weil disease) Trichuriasis (whipworm)	No figures available No figures available		
WATER-WASHED SKIN AND EYE INFECTIONS			
Trachoma	6-9 million people blind		500 million
Leishmaniasis	12 million infected; 400 000 new infections/year		350 million
Other			
Relapsing fever	No figures available		
Typhus fever (rickettsiosis)	No figures available		
WATER-BASED			
Penetrating skin			
Schistosomiasis (bilharzia)	200 million	200 000	500-600 million
Ingested			
Dracunculiasis (guinea worm)	>10 million		>100 million
WATER-RELATED INSECT VECTORS			
Biting near water			
African trypanosomiasis (sleeping sickness)	20 000 new cases annually		50 million
Breeding in water			
Lymphatic filariasis	90 million		900 million
Malaria	267 million	1-2 million	2 100 million
Onchocerciasis (river blindness)	18 million	20 000-50 000	85-90 million
Yellow fever	10 000-25 000		
Dengue fever (breakbone fever)	30-60 million infected		

Source: WHO (1992).

All "unimproved' and "semi-improved" sites were contaminated with significant implications for diarrhoeal disease prevalence (Consortium for International Development 1993).

- According to the 1993 Lesotho Health Profile based on data collected between 1988 and 1991 (Sechaba Consultants 1993), water-related diseases were among the most common illnesses reported by outpatients. Skin and subcutaneous infections were the most common diseases. At 36.4 per 1000 attendees, diarrhoea without dehydration was the 9th most common ailment. Intestinal parasites which may be water borne, were 22nd on the list at 9.3 per 1000 attendees. Skin diseases, digestive diseases, diarrhoea with and without dehydration, and intestinal parasites were highest among children between 0 - 4 years.

- As part of the above study, 2300 interviewees were asked to recall what water-related illnesses members of the households had suffered from in the last month. Overall 15% of rural households had experienced some illness that they believed was related to water use in some way (Gay *et al.* 1993).
- In the same Lesotho Health profile study, it was found that the incidence of typhoid was relatively low in comparison with other water- related diseases from 1988 to 1991 (0.8 per 1000 attendees). These results are deceiving, however, because two years later, in 1994, the Ministry of Health and Social Welfare (Ministry of Planning and Economic Development 1994) reported a total of 353 cases of typhoid, while 1327 cases were reported in 1995. The number of cases reported from rural areas only was not recorded. Outbreaks also fluctuated between seasons, with most of the cases occurring during the summer months of December, January and February. A similar pattern was identified for diarrhoeal disease.
- The effect of improved sanitation practices in the Mohale's Hoek area was evaluated in a case study by Daniels *et al.*, who found that under-5-year-old children from households with a latrine may experience 24% fewer episodes of diarrhoea than children from households without a latrine (Daniels 1990).

3.4.2 Other infectious diseases related to water supply and sanitation

3.4.2.1 Water-borne and water-washed diseases

Enteric viruses

Enteric viruses that occur in polluted water include adenoviruses, reoviruses, rotaviruses, hepatitis A and the Norwalk virus. These viruses cause diseases such as gastro-enteritis, pneumonia and viral hepatitis. As few as one to ten viruses can initiate an infection. This implies that even at low levels of viral pollution, a high risk of infection exists (Grabow 1991). In the USA, viruses are known to have been responsible for at least 12% of reported waterborne disease outbreaks in the US in the period 1946 to 1980. It has been suggested that this may be as much as 64% of the total cases of waterborne diseases (Craun 1986).

Giardia, Cryptosporidium and Entamoeba coli

The infective dose for these parasites is extremely low. *Giardia* and Cryptosporidium are protozoan parasites with several lifecycle stages. The species that infect humans are *Giardia lamblia* and *Cryptosporidium parvum*.

Cysts (Giardia) and oocytes (Cryptosporidium) are part of the lifecycle of these protozoan parasites and are infective to humans. Infection occurs by ingestion of the cysts or oocytes and disease takes the form of gastroenteritis, diarrhoea, vomiting and anorexia. Acute, chronic and asymptomatic manifestations of infections are known. *Giardia lamblia* was identified as one of the most common causes of waterborne disease outbreaks in South Africa in studies done in 1991 (Casemore 1991, Rose *et al.* 1991).

A review of the literature pertaining to *Giardia lamblia* and *Entamoeba coli* in Lesotho revealed the following:

- Esray *et al*. (1989) examined pre-school children in Lesotho and found *G. lamblia* (23.6%) and *Entamoeba. coli* (2.6%) in faecal samples.

- A parasitology survey was conducted among people in the Phase 1A area in Lesotho in 1993. Of 654 faecal specimens examined, *Entamoeba coli* was found in 53.2%. The infection rate with *Giardia lamblia* was 4.1%. The percentages of *Entamoeba coli* found gave an indication of the extent of contamination of food and water in the community studied.

3.4.2.2 Defective sanitation

Worm Infestations

Among the food-, water-, and soil-borne diseases, those caused by parasitic worms are noted for the debilitation they cause. At any one time, roughly 3.5 billion people in the world are infected with one or several species of parasitic worms (WHO 1997), making these among the most prevalent human infections. Some 450 million people are ill as a result of these infections (WHO 1997).

Rarely fatal, worm infections nonetheless exact a tremendous and diverse toll. Infection takes place repeatedly, and the disease becomes more serious as the worm burden in the body increases. The most vulnerable are school-aged children, who may harbour multiple infections simultaneously. The effects in children are especially pernicious because chronic infections impair both physical and intellectual growth and development.

A review of the literature pertaining to helminth infestations in Lesotho revealed the following:

- Esray *et al.* 1989 demonstrated a low prevalence of helminth infestations in pre-school children in rural Lesotho. Most species were absent or identified in less than 2% of individuals (Esray *et al*. 1989).

3.4.2.3 Water based diseases

Schistosomiasis

Schistosomiasis kills some 20 000 people a year and causes chronic ill health among hundreds of millions more. WHO estimates that about 200 million people in tropical countries have acquired the disease from bathing or wading in infected rivers, lakes and irrigation systems, and 500 - 600 million more are at risk. Schistosomiasis is on the increase in developing countries, in part because it spreads to previously unaffected areas through water-development projects.

Transmission of *Schistosomiasis haematobium* along a water course has been established to be focal and generally confined to warm, calm, slower flowing, and shallow water (Appleton and Bailey 1990). In Southern Africa, the intermediate snail host is *Bulinus africanus*. Fluctuations of *B. africanus* populations and snail infection with *S. haematobium* are associated with periods of seasonal transition, either at the beginning or end of a dry season. Perennial rivers have been found to contain fewer numbers of snails (Noda 1988). With impoundment of water, a milieu for associated *B. africanus* populations may be created.

A review of the literature pertaining to Schistosomiasis in Lesotho revealed the following:

- Prinsloo and Van Eeden (1973 1974) undertook comprehensive surveys for freshwater snails in Lesotho during the period January 1968 to February 1969. These surveys were planned to ensure a proportionate coverage of the entire country in five “snail regions”. The collections contained no human Schistosomiasis intermediate host snail species. Sharp *et al.* (1993) reviewed the results of the Phase 1A Baseline Epidemiological Survey and concluded that it was improbable that the disease would become established. Their reasons for this were the historical lack of evidence of Schistosomiasis transmission in Lesotho, and the physiological indication that the intermediate snail hosts would not survive, nor the parasite develop, in the low temperatures in the water-resource development area. They also recommended that ongoing monitoring for the intermediate hosts could not be justified and would not be cost-effective.

3.4.2.4 Water vectored

Malaria

Malaria is the most deadly of the insect borne diseases, claiming the lives of some one to three million people each year – 90% of them in Africa, and most of them children (Faechem and Jamison 1991). The WHO estimates that 300 to 500 million cases of Malaria occur each year and that 40% of the world’s population is at risk of contracting the disease (WHO 1997).

A review of the literature pertaining to Malaria in Lesotho revealed the following:

- There are no records of Malaria ever having occurred in Lesotho. As a result of Malaria control in South Africa, the borders of Lesotho are even further removed from the Malaria transmission distribution zone than they would have been historically. Hence the threat of Malaria in the region has diminished over time.
- Sharp *et al.* (1993) concluded that, given the historical absence of the vector and the disease from Lesotho and the surrounding areas, it was unlikely that Malaria could become established. The WHO, who reported that there were no cases of Malaria reported in Lesotho in 1995, further supports this (WHO 1997).

4 THE GEOGRAPHY OF RISK

The complex relationships among habitat modification, the functioning of ecosystems, and the transmission of disease mean that it is difficult to predict exactly how land-use changes will affect disease rates. This is especially so since the vulnerability of exposed populations varies widely with income, access to health care, and level of nutrition. Indeed many environmental health problems are associated with poverty and a lack of essential resources, prompting the WHO to call poverty “the world’s biggest killer” (WHO 1997).

4.1 Macro-economic factors influencing health

Poverty is multifaceted and often self-perpetuating. The poor tend to lack education, adequate health care, access to credit, and such basic assets as land. Many of these problems are linked. Gaps in knowledge and information also force the poor into economic relationships that limit their productivity. Given the dire consequences of sudden income shocks, the poor naturally avoid risk when they can. But often this can lock them into a vicious cycle of low risk, low return activities that keep them in poverty (Murray and Lopez 1996).

The 1996 UN Human Development Report (UNDP 1996) presents a salutary picture of growing global inequalities in wealth. The report reveals that the incomes of approximately 1,6 billion people have declined since 1980. Not only the quantity, but also the quality of growth is of concern, as the benefits of economic activity do not automatically trickle down to the poor (Economist 1996). About 1,3 billion people live in abject poverty, and women and children are over-represented in this group. A growing body of evidence shows that regions, countries and even communities with large income inequalities, have high levels of ill-health, and that income inequality is related to excess mortality. (Davey and Smith 1996). According to the WHO and the World Bank, environmental improvements at the household and community level would make the greatest difference for global health (World Bank 1994a). Specifically, the World Bank has calculated that improvements in local environmental conditions facing the poor could lower the incidence of major killer diseases by up to 40% (WHO 1997).

In short, health suffers most where economies have failed to secure adequate income levels for all, where social systems have failed, and where environmental resources have been poorly managed.

A review of the literature pertaining to the economic situation in Lesotho revealed the following:

- Lesotho with a population of two million people, is a low income country economically-linked to its neighbour, South Africa. With a shortage of arable land and no minerals to explore, the country depends to a large extent on migrant labour to South Africa (Sechaba Consultants 1994).
- In Lesotho, the GNP in 1997 was 1.4 billion dollars. The GNP per capita in 1997 was 670 dollars which ranked it 88th in the world with Switzerland ranked 1st and South Africa ranked 45th (IMF 1998).

- Gross domestic saving in Lesotho for 1997 was quoted as -2 % of GDP. The equivalent figure for South Africa is currently 15% of GDP (Financial Mail 1999).

- Lesotho has received low investment inflows as a percentage of gross fixed capital formation in absolute terms (United Nations Conference on Trade and Development 1998). It has however, hosted higher FDI stocks as a percentage of GDP, suggesting that over a period of time, their inward FDI flows relative to their size have been comparable to or even higher than those of the larger African economies. In 1996 Lesotho ranked 14th, with inward FDI stock making up 22% of GDP (United Nations Conference on Trade and Development 1998). Much of the foreign direct investment inflows into Lesotho in recent years have been for the development of the Lesotho Highlands Project; as this nears completion, flows are expected to decline.

Table 4.1 Income distribution in Lesotho 1994 (Sechaba Consultants 1994).

Monthly income in Maluti	Distribution by Regions (%)			
	Mountains	Foothills	Senqu River Valley	Lowlands
<50	77.5	71.9	86.4	84.5
50 -99	17.5	16.9	9.1	9.7
100 -149	3.3	6.7	2.7	3.9
150 -199	0.8	2.2	0.9	0
200 - 249	0	0	0.9	0
250 - 299	0.8	1.1	0	1
300 - 349	0	1.1	0	1
350 - 399	0	0	0	0
400 - 449	0	0	0	0

4.2 Demographic and social factors influencing health

4.2.1 Introduction

Throughout the developed world, improvements in health status and health care, associated with economic growth, have led to a number of demographic changes (World Bank 1993). Increased life expectancy, lower mortality rates, rapid population growth, reduced fertility and population aging now pose challenges for the future. Yet developing countries, like Lesotho, which are predicted to still have rapid population growth, are often least equipped to deal with urbanisation, poverty and health.

A review of the literature pertaining to the socio-demographic situation in Lesotho revealed the following:

- In 1997, Lesotho had two million people with an average 1995 to 2000 growth rate of 2.5%. One million of those were part of the labour force with women contributing 37% and children aged 10 to 14 contributing 22%. Informal employment makes up 31% of the labour market. Of all the households, 49% are considered poor. Females head 23% of all households and of these 59% are considered to be poor (International Monetary Fund 1998).
- It is estimated that by the year 2000, 41% of the Lesotho population will be under the age of 15 years, 55% will be between 15 and 65 and 4% will be over 65 years of age. This age distribution points to a high dependency ratio, with a large percentage of the population under the age of 15 (WHO 1997).

4.2.2 Education, Fertility, Infant Mortality Rate and Maternal Mortality Rate

Education, vital to the adoption and effective use of health knowledge, has expanded in almost every country in the world. Many studies reveal that the education levels attained by girls and women is an important determinant of children's health (Herz 1991).A study of 45 developing countries found that the average mortality rate for children under 5 was 144 per 1000 live births when their mothers had no education. With primary education this figure dropped to 106 per 1000. By contrast, 68 per 1000 children died when their mothers had some secondary education (Filmer and Pritchett 1997).

The extent to which family planning is promoted and used is largely responsible for the differences in fertility between countries. There is a strong negative correlation between fertility and the prevalence of contraceptive methods, and the continued decline in fertility rates will depend on the increasing use of such methods. Reductions in fertility rates also depend on reductions in the number of children desired (WHO 1992). Lower fertility rates not only result in lower population growth rates, but also in improved health among women, lower maternal mortality rates and lower infant mortality rates.

One of the most dramatic and significant changes in the human health condition over the last two to three decades has been the sharp and sustained decline in infant mortality. The world infant mortality rate is currently estimated to be 57 deaths per 1 000 live births, down from 118 during the early 1960s (World Resources 1998/99). It is expected that this declining trend will continue worldwide for the next three decades. Less developed regions have experienced the largest improvements in infant mortality rates.
Although infant mortality rates in Africa will have declined significantly between the period 1960-1965 and 1995-2000, the current rate of 85 is still considerably higher than in the rest of the world. In some countries with a high prevalence of AIDS, the decline in infant mortality has been halted or reversed (WHO/UNICEF 1996).

Perinatal (late pregnancy, birth and the first week of life) and neonatal (first four weeks of life) mortality reflect both the effectiveness of measures to improve women's health status and the quality of obstetric and paediatric care. It is estimated that over 90% of the over seven million annual peri-natal deaths occur in less developed countries (WHO/UNICEF 1996).

In summary, the general socio-economic environment of the family influences infant mortality, by the availability and use of health services and the educational standard of the mother. Literate women with a secondary education are much more likely to take advantage of family planning and maternal and child health care facilities than illiterate women with little or no education. Therefore, by raising the educational level of women, infant mortality will decline even further.

A review of the literature pertaining to education, infant and maternal mortality in Lesotho revealed the following:

- In Lesotho in 1995, public expenditure on education was 5.9% of GDP. The net enrollment ratio in primary school was 65%, while that for the secondary school was a mere 16%. The adult literacy rate was 81% for men and 62% for women in 1995 (World Bank 1998).
- In Lesotho the contraceptive prevalence rate for women aged 15 - 49 from 1990 - 1996 was 23% (World Bank 1998).
- The total fertility rate in Lesotho, calculated as births per woman, in 1996 was 4.6. Compare this with a fertility rate in developed regions of 2.1 births per woman (WHO/UNICEF 1996).
- The maternal mortality rate per 1000 live births in 1990 was 61 (Ministry of Planning, Economic and Manpower Development 1994).
- Infant mortality rate in Lesotho for 1996 was 74 per 1000 live births. The under-5 mortality rate (1995) was 154 per 1000 live births (WHO/UNICEF 1996).

4.2.3 Nutrition and Health

The production and distribution of food affects health as it influences people's nutritional status and, thus, resistance to disease. So far, agricultural development has permitted world food production to grow faster than the world population. Although there is theoretically more than enough food to feed everyone on earth, almost 840 million people, including 200 million children, suffer from hunger and malnutrition (Bender and Smith 1997).

In addition, millions of people, in particular children and pregnant women, are affected by more specific forms of nutritional deficiencies such as lack of iodine, iron and vitamin A. This is because the world's food supply is distributed unequally within and between countries (United Nations World Food Council 1992).

Malnutrition results in poor physical and cognitive development, exacerbating the cycle of poverty and deprivation. Malnutrition is the single most important risk factor for death and disability world wide, accounting for about 16% of the Global Burden of Disease (de Onis 1996; Murray and Lopez 1996).

A review of the literature pertaining to nutrition in Lesotho revealed the following:

- Gay *et al*. (1991) found that nutritional diseases, particularly in women and children, reflect seasonal patterns of agricultural activities and food availability and geographic patterns of malnutrition. There was a higher prevalence of these diseases in the mountains of Lesotho, where farming conditions are harsher and food scarcer (Gay *et al*. 1991; Ministry of Health and Ministry of Agriculture 1992).
- In 1993, after the 1991 – 1992 drought, the prevalence of chronic malnutrition in children under five years of age was 30% in the highlands (Jooste *et al.* 1997).
- According to the United Nations Children Fund (1994), the percentage low birthweight infants (1990 -1994) in Lesotho was 11%. The percentage of children under-5 underweight was 21%, wasting was 2% and stunting 33% (1990 – 1996) (Ministry of Planning, Economic and Manpower Development 1994).
- It is estimated that 29% of child deaths in Lesotho are attributable to the potentiating effects of malnutrition on infectious diseases. Lesotho falls in the middle third of 53 developing countries ranked by this parameter (range 13 – 67%; weighted average 56%) (Pelletier *et al*. 1995).

- The most important conclusion from the LHDA Phase 1 A Nutrition Survey (Consortium for International Development 1993), was that the study population was extremely vulnerable from a nutritional point of view. Furthermore food security (dietary quality and quantity) was found to be closely linked to risk and severity of malnutrition. These conclusions were supported by the following evidence:
  a) Household food insecurity was highly prevalent. Food shortages were reported by more than 60% of households in winter and 77% in summer, with diets of women and children generally poor in legumes and meat.
  b) Undernutrition was highly prevalent in the population, and afflicted all sectors of the population. Stunting in older children indicated that there was an absence of catch-up growth to mitigate the effects of infant stunting.
  c) Risk of being underweight was also found to be higher in older adults (>45) than in 30 to 45 year olds, a finding characteristic of populations under nutritional stress.
  d) Iodine deficiency was found to be endemic in the area, affecting the entire population, with the highest prevalence of visible goitre in women.
  e) If the dependence on maize increases among the poorest households, clinical malnutrition is expected to increase.
- A cross-sectional study was carried out to evaluate the nutritional status of the population of the Mohale Dam catchment area before construction of the dam commenced. Dietary evaluation of children under 15 years from 395 households revealed the following (Jooste 1997):
  a) High initiation rates of breastfeeding as well as a long duration of breastfeeding were

maintained. However, complementary foods were introduced at an early age resulting in low exclusive breastfeeding rates.

b) All the age groups reported regular meals, but qualitative analysis revealed a low diversity, with an irregular intake of protein rich foods and milk.
c) Quantitative data on three to five year olds showed that micronutrient intakes were low and that the energy intake of these children was inadequate.
d) Very low urinary iodine excretion (median 1.3 µg/dL) was found in children indicating a biochemically severe iodine deficiency.
e) A goitre prevalence of 17.5% was observed in 10 to 14 year old children (Jooste 1997).

4.3 Infectious diseases affecting baseline health conditions of communities

4.3.1 Tuberculosis

Tuberculosis (TB) has surpassed Malaria as the prime cause of adult mortality in the world (WHO 1996a). In 1996, an estimated 3 million people died while 7.5 million others developed the disease. An estimated 95% of all TB sufferers live in the developing world and approximately 7% of all deaths in developing countries can be attributed to tuberculosis. Without the appropriate chemotherapy, the case fatality rate approaches 50%.

Sub Saharan Africa has the highest annual TB incidence and TB related mortality rates, with the death rate estimated at 104/100 000 population (WHO 1996a). In addition, the HIV epidemic, besides causing an increasing burden on health and social services, is associated with an increase in TB prevalence.

A review of the literature pertaining to Tuberculosis in Lesotho revealed the following:

- In Lesotho, the smear positive incidence of TB in 1992 was 66 per 100 000 and the overall incidence 224 per 100 000. (Corcoran and Makakole 1992). In 1995, the WHO reported 236 TB cases per 100 000 population in Lesotho (WHO 1996a).
- A study of 311 consecutive TB admissions at Queen Elizabeth II Hospital in January 1992 revealed 11% to be HIV positive (Kravitz 1995).

4.3.2 STDs and HIV/AIDS

Sexually transmitted diseases are the most common notified infectious disease in the world (World Bank 1998/99). The “epidemiological synergy” between STDs and HIV is a source of concern. HIV is responsible for a major increase in adult mortality in many parts of the world, and in some parts of SSA, about half of all adult mortality is already attributable to this disease (Kravitz 1995).

Available models indicate that HIV will approximately halve the total life expectancy by birth cohorts in the less-developed world. Whilst the effects of HIV on population growth may be limited, there is growing evidence of its impact as economically active groups in less developed countries are decimated (Mertens and Piot 1996). Mertens and Burton (1996) note that the recognition of the ever changing character of the epidemic (due to socio-demographic, epidemiological and prevention related factors) through surveillance, will permit the design of holistic interventions.

A review of the literature pertaining to STDs and HIV/AIDS in Lesotho revealed the following:

- HIV/AIDS has the potential to impose a major economic impact on Lesotho. The total long run economic impact between the years 1993 and 1998 is estimated to total M522, 035,686 in constant 1992 prices. This figure includes the total direct medical costs (M66, 497,825), the total direct non-personal costs (M48, 460,020), and the total indirect costs (M437, 077,840). With the rapid increase in HIV infection in Lesotho, the cost of the pandemic promises to spiral, impacting the health care sector as well as other sectors of the Lesotho economy (McMurchy 1994).
- Lesotho Ministry of Health data from 1983 through 1991 indicate that STDs account for 63 – 89/1000 outpatient visits, or 12 13 % of all

outpatient visits (Sechaba Consultants 1993). Such statistics however underestimate the total STD prevalence, as the majority of women may be asymptomatic or report to traditional healers.

- Since 1986, when HIV was first identified in Lesotho, reported cases doubled every year until 1991 (Kravitz 1995). Data for 1992, however, showed an increased incidence of 386%. (Kravitz 1995).
- Kravitz *et al.* (1995) reported that among construction workers at the Katse Dam in Lesotho there was an HIV seroprevalence rate of 5.3% compared to 0.8% in a similar age group in nearby villages surrounding the dam. The investigators expressed "grave concern" that Lesotho was destined to experience a rapid rise in HIV seroprevalence as a result of workers at the Katse Dam infecting the surrounding population. Now, several years later, the community rate of HIV seroprevalence has increased, but this increase could be attributable to a number of other factors as well (such as the return of Lesotho migrant workers), rather than importation by the Katse Dam workers alone (Kravitz 1995).

4.3.3 Acute Respiratory Tract Infections

Acute Respiratory Tract Infections (ARIs) kill more than four million people per year and are the leading cause of death among children under age five (Faechem and Jamison 1991). ARIs and diarrhoea together cause approximately 60% of all deaths in childhood in developing countries. Pneumonia unassociated with measles causes 70% of ARI associated deaths and post measles pneumonia is responsible for 15% (Filmer and Pritchett 1997). Pertussis and viral bronciolitis account for a further 15%. Caused by different viruses or bacteria, ARIs are closely associated with poverty. Overcrowding and unsanitary household conditions favour the transmission of the disease. Death most often strikes those children already weakened by low birth weight, other infections, and malnutrition. Many people in the developing world, mostly in rural areas, rely on biomass fuels for cooking or heat, which exacerbates the disease.

A review of the literature pertaining to ARIs in Lesotho revealed the following:

- The high altitudes of most of Lesotho, the resultant cold weather and the absence of alternatives to in-door fires for heating leads to very high indoor pollution levels and consequently to high prevalence of ARIs.

4.4 Immunisations

Immunisation of children against communicable disease is a key element of primary health care.

The WHO Expanded Programme of Immunisation set its goals for the 1990s as follows:

- Maintenance of a high level of immunisation coverage (at least 90% of children under one year of age by the year 2000) against diphtheria, pertussis, tetanus, measles, poliomyelitis and tuberculosis, and against tetanus for women of childbearing age.
- Reduction by 95% of measles deaths and reduction by 90% of measles cases compared to pre immunisation levels by 1995.
- Elimination of neonatal tetanus by 1995
- Global eradication of poliomyelitis by 2000.

A review of the literature pertaining to child immunisations in Lesotho revealed the following:

- For Lesotho from 1992 to 1995, the percentage of 1-year olds immunised against Tuberculosis was 59%, Dipthteria, Pertussis and Tetanus 58% and Poliomyelitis 59%. The percentage of pregnant women immunised against tetanus (1992 - 1995) was 12% (WHO and United Nations Children's Fund 1996).
- For 1997 and 1998, vaccination coverage in Lesotho was reported as marginally better at 67 and 65% respectively (WHO 1998).

4.5 Health services

Inequalities in access to health services (especially primary health care) have a profound health impact (Anker 1993). The WHO/SIDA publication, Equity in Health and Health Care (WHO 1996a), highlights disparities between class, gender, race, geographical location and age in health care access.

The provision of health services is hampered by four concerns (World Bank 1994b):

- Misallocation: Public money is spent on health interventions of low cost-effectiveness, such as transplants, while critical and cost-effective interventions such as treatment of tuberculosis, remain under funded.
- Inequity: High-quality basic health services are unavailable to all segments of the population.
- Inefficiency: Poor management leading to inefficient operations: brand name drugs are purchased instead of generic ones, health workers are poorly supervised and deployed, hospital beds are under-utilised.
- Exploding costs: In some middle-income developing countries health expenditure is growing much faster than income.

A review of the literature pertaining to the quality and availability of health services in Lesotho revealed the following:

- From 1990 to 1995, public expenditure on health in Lesotho was 3.5% of GDP. Percentage of births attended by trained personnel (1990 - 1996) was 40%. Oral Rehydration Therapy use (1990 - 1996) was 42%. The population per doctor (1990 - 1993) was 1: 24 095, while the population per nurse ratio for the same period was 1: 2040 (World Resources 1998).
- The Lesotho WHO Country team investigated the financial strength of the public health system in Lesotho. They concluded that there is poor absorptive capacity in the public sector and resources are frequently misdirected. Hospitals maintained by the Private Health Association of Lesotho appear to be suffering most from the financial strain. They concluded that on the whole, health is not underfinanced in Lesotho. In actual fact, the resources are not utilised to their full potential (Lesotho WHO Country Team 1994).

4.6 Conclusions

Health suffers most where economies have failed to secure adequate income levels for all, where social systems have failed, and where environmental resources have been poorly managed. The vulnerability of exposed populations varies widely with income, access to health care, and level of nutrition.

As the PAR (the exposed population) in this study forms part of the Lesotho community, the findings in the literature apply equally to them.

Lesotho is a poor country with low GDP and very little foreign investment to boost the economy. Because of the low incomes and general poverty, the savings rate is low. People are thus unable to plan for the future and literally live from hand to mouth. Rural communities are more severely affected than peri-urban communities.

A large number of the population is under 15 years. These members of society are potentially productive in the future, but presently are still dependent on adults for their livelihoods. They thus do not currently contribute actively to the economy, but rather consume resources. This leaves a small workforce with the task of maintaining and growing the economy.

High fertility rates, low contraceptive usage and high illiteracy rates combine to keep people in poverty and poor health. Households are large, food is scarce and incomes are low. Overcrowding and unsanitary household conditions favour the transmission of the disease. This keeps people in poverty and does not allow them to focus on their health, when issues of security are more important.

The production and distribution of food affects health as it influences people's nutritional status and, thus, resistance to disease. It was found that nutritional status was linked to seasonal patterns of agriculture and food availability. Both children and adults were under nutritional stress.

Tuberculosis, STDs and HIV/AIDS as well as ARIs were prevalent throughout Lesotho. This contributes to both the nutritional and the health vulnerability of communities. Immunisation coverage was poor, making children even more vulnerable to contracting diseases that could have been prevented.

The health services in Lesotho operate on a small budget and are fragmented. Their ability to serve the communities at large is thus hampered.

The above findings give a general indication of the health and welfare expected in the study population. The next sections examine the PAR, their general health and their dependence on and interaction with the rivers.

SECTION C: SOCIO-DEMOGRAPHIC COMPONENT OF HEALTH IMPACT EQUATION

5 THE DEMOGRAPHIC AND SOCIO-ECONOMIC PROFILE OF THE POPULATION AT RISK

5.1 Introduction

The availability of water has always strongly influenced where people settled in Lesotho. High levels of rainfall and the mountainous terrain contributed to the widespread availability of perennial springs (Sechaba Consultants 1995). This contributed to a more dense pattern of settlement in the mountains than that to be found in the more arid, low lying regions to the west of the present border with South Africa. In 1997, 74% of Lesotho's population still lived in rural areas. It is estimated that by the year 2000, this figure would have declined by 2% only (IMF 1998).

5.2 The population at risk

The first step in determining the effects of the downstream river flow changes on the communities downstream from the LHWP dams is to ascertain the number of people that could potentially be affected.

As part of Task 5, the PAR was calculated using a 5-km corridor on either side of the river, as this is the maximum distance people would cover to reach the river for harvesting riparian resources (Report No 648-F-08). This 5-km corridor was further divided into primary and secondary corridors. The primary corridor consisted of the villages which have the right of access to both controlled and 'free riverine' resources. Water for domestic use, watering animals, fishing, sand mining, washing, performing ceremonies and leisure activities are considered 'free' resource use. Both the free and the controlled resources are provided in Report No 648-F-08. The secondary corridor consisted of villages where access to controlled riverine resources was prohibited. The populations resident in each of these corridors are presented in Table 5.1.

Table 5.1 The primary and secondary corridor population within a 5-km radius of the rivers.

IFR Section	River Section	1999 Population figures	Primary corridor population	Secondary corridor population
1	Matsoku River between Weir and Malibamatso confluence	7,462	7,138	324
2	Malibamatso River between Katse Dam and Matsoku confluence	2,879	2,879	0
3	Malibamatso River between Matsoku confluence and Senqu River	15,367	15,343	24
4	Senqu River between Malibamatso confluence and Tsoelike River confluence	26,719	26,719	0
5	Senqu River between Tsoelike confluence and Senqunyane River confluence	27,749	27,595	154
6	Senqu River between Senqunyane River confluence and the South African border	60,104	59,363	741
7	Senqunyane River between Mohale Dam and Lesobeng River confluence	10,819	10,306	513
8	Senqunyane River between Lesobeng River confluence and Senqu River confluence	3,488	3,321	167
Total		154,587	152,664	1,923

5.3 Demographics of the study population

The demographic and socio-economic profile of the statistical population within the 5-km corridor on either side of the river of the rivers was ascertained through the household interviews done during the detailed socio-economic survey (see Section 2.2.2).

The PAR consists of 50.1% males and 49.9% females. Single people account for 57.3% of the population, while 32.2% of the adult population are married. The other 10% are made up of divorced, separated or widowed people.

The age distribution of the PAR is as follows:

0-5 year olds	13%
6-20 year olds	38%
21-45 year olds	29%
46-70 year olds	17%
> 70 years old	3%.

Here again, as in the rest of Lesotho, a high dependency ratio is found, with 50.7% of the population below the age of 21. Thirty percent of the PAR has no formal education; 21.7% had 1-3 years of schooling; 36.8% had 4-7 years of schooling; 8.8% had 8-10 years of formal schooling, while only 3% had ten or more than nine years of formal education. The area is burdened by a high illiteracy rate well in excess of the 19% calculated in 1995 for Lesotho as a whole. In addition, 70.6% of the population has no formal income and 40.6% is unemployed.

Of the employed members of the PAR, 24% are schoolchildren, 11% reported to be farmers; 5.1% work as shepherds; 4.4% are self-employed; 3.3% are casual labourers; 2.3% are migrant mine workers away from home for an average of ten months, while only 1.4% are formal wage workers (Report No 648-F-08).

6. HEALTH STATUS INDICATORS BASED ON STUDY AREA HEALTH CENTRE DATA

6.1 Introduction

As part of the study reported on here, 4169 patient records were analysed by the Public Health Team to determine the health status of the PAR. The results for each health centre are divided into 0-5 year, 6-15 year and all age groups. The frequencies of the five top diseases by percentage are presented for the period 01 July 1998 to 30 June 1999. The diseases likely to be impacted by changes in flow regimes have been highlighted.

6.1.1 Seshote Clinic

Seshote Clinic is linked to IFR Reach 1. The clinic serves the communities of Kalakatana, Khopung, Khubetsoana, Leferefere, Leohla, Maieane, Mathabela, Moses, Peni, Ranthoto, Ranthebe, Sekhutla, Seshote and Tsehla. Pneumonia and URTI together accounted for 51% of diagnoses in the 0-5 year age group with gastroenteritis and skin diseases collectively accounting for 24%. In the 6-15 year age group, skin infections made up 14% of diagnoses, while pneumonia and URTI together accounted for 21% of diagnoses with which this age group presented to the health service.

Table 6.1: Top diseases by percentage for different age groups presenting to Seshote Clinic.

Seshote Clinic					
Villages: Kalakatana, Khopung, Khubetsoana, Leferefere, Leohla, Maieane, Mathabela, Moses, Peni, Ranthoto, Ranthebe, Sekhutla, Seshote, Tsehla					
TOP DISEASES BY PERCENTAGE					
0-5 years		6 – 15 years		All ages	
Pneumonia	30	**Skin**	14	STDs	13
URTI	21	Epilepsy	11	Aches	9
Gastro	13	Pneumonia	11	URTI	8
Skin	11	URTI	10	**Skin**	7
ENT	4	**ENT**	10	Hypertension	7
Eye	4	Injury	9	**ENT**	5

6.1.2 Khohlo-Ntso Clinic

Khohlo-Ntso Clinic is linked to IFR Reach 2. It serves the community of Ha Soai. The pilot socio-economic survey encountered a perception within the community in Ha Soai that the construction of Katse Dam had adversely affected the river water quality with resultant negative health impacts (Sechaba Consultants 1998). The health data revealed that for the 0-5 year age group, water-related diseases (gastroenteritis, skin diseases and eye infections) accounted for 50% of the disease diagnoses. URTI was the most common disease among attendees of all ages. Fourteen percent of the diseases in all age groups are made up of water-related diseases (gastroenteritis and skin diseases).

Table 6.2 Top diseases by percentage for different age groups presenting to Khohlo-Ntso Clinic.

Khohlo-Ntso Clinic					
Villages: Ha Soai					
TOP DISEASES BY PERCENTAGE					
0-5 years		6 – 15 years		All ages	
URTI	40	URTI	20	URTI	17
Gastro	20	Chicken pox	20	Aches	17
Skin	20	Injury	20	**ENT**	8
Eye	10	**ENT**	10	**Gastro**	7
Chicken pox	10	**Skin**	10	**skin**	7

6.1.3 Mohlanapeng Clinic

Mohlanapeng Clinic is linked with IFR Reach 4. The community of Koma-Koma visits the Mohlanapeng clinic. URTI and pneumonia together cause disease in 45% of the 0-5 year old clinic attendees. Water-related diseases (skin diseases and gastroenteritis) account for 25% of diagnoses in this age group. In the 6-15 year age group URTI is the most common disease at 30% followed by skin diseases at 20%. For all age groups skin diseases were more common than URTIs.

Table 6.3 Top diseases by percentage for different age groups presenting to Mohlanapeng Clinic.

Mohlanapeng Clinic					
Villages: Koma-Koma					
TOP DISEASES BY PERCENTAGE					
0-5 years		6 – 15 years		All ages	
URTI	34	URTI	30	**Skin**	11
Gastro	14	**Skin**	20	URTI	9
Pneumonia	11	**ENT**	20	Aches	8
Skin	11	**Pellagra**	20	PID	7
ENT	9	Injury	10	**Gastro**	6

6.1.4 Paray Hospital

Para Hospital is linked with IFR Reach 3. Paray Hospital is the only secondary health facility included in the analysis. The record keeping at this facility was very poor with most of the patient records having no disease diagnosis shown on their records.

Table 6.4 Top diseases by percentage for different age groups presenting to Paray Hospital Clinic.

Paray Hospital					
Villages: Thaba Tseka, Ha Clarke, Ha Soai, Khoma ea molo, Koma-Koma, Tloekeng					
TOP DISEASES BY PERCENTAGE					
0-5 years		6 – 15 years		All ages	
Eye	100 (2 cases)	Unknown	45	Unknown	35
		URTI	27	Diabetes	8
		Asthma	9	URTI	7
		Injury	9	Injury	7
				PID	5

6.1.5 Sehonghong Clinic

Sehonghong Clinic is linked with IFR Reach 4. The clinic serves Ha Clarke, Ha Fusi, Ha Poko, Kgomo. Khoma ea molo and Tloekeng. URTI is the most common disease with which all age groups present to the health service. Water-related diseases (gastroenteritis, eye infections and skin diseases) account for 28% of the diseases suffered by 0-5 year old patients, whereas they account for 21% in the 6 to 15 year age group. Hypertension and sexually transmitted diseases rank third and fifth amongst all age groups.

Table 6.5 Top diseases by percentage for different age groups presenting to Sehonghong Clinic.

Sehonghong Clinic					
Villages: Ha Clarke, Ha Fusi, Ha Poko, Kgomo, Khoma ea molo, Tloekeng					
Top Diseases by percentage					
0-5 years		6 – 15 years		All ages	
URTI	39	URTI	23	URTI	16
Gastro	10	**ENT**	19	**ENT**	7
Eye	9	**Skin**	15	Hypertension	7
Skin	9	**Worms**	6	Psychiatric	7
Pneumonia	8	Allergy	6	STD	7
Allergy	4	Injury	6	**Skin**	5

6.1.6 Holy Cross Clinic

Holy Cross Clinic is linked with IFR Reach 6. It serves the communities of Ha Phatalla, Ha Ramatlalla and Seaka. URTI is the most common disease in all age groups. Water-related diseases (gastroenteritis, skin diseases and dysentery) together account for 34% of disease diagnoses in the 0-5 year age group. 24% of diagnoses on the 6 – 15 year age group can be attributed to water-related diseases (skin diseases and eye infections). For all age groups hypertension and sexually transmitted diseases ranked second and third respectively.

Table 6.6 Top diseases by percentage for different age groups presenting to Holy Cross Clinic.

Holy Cross Clinic					
Villages: Ha Phatalla, Ha Ramatlalla, Seaka					
TOP DISEASES BY PERCENTAGE					
0-5 years		6 – 15 years		All ages	
URTI	49	URTI	33	URTI	19
Gastro	18	**ENT**	14	Hypertension	12
Dysentery	11	**Skin**	14	STDs	11
Skin	5	**EYE**	10	Aches	9
Allergy	5	Unknown	10	**Dysentery**	5

6.1.7 Sekake Clinic

Sekake Clinic is linked with IFR Reach 5. The clinic serves Phatela, Sekake and Setofolo in the study area. Skin diseases account for 32% of diagnoses among the 0-5 year age group. Pneumonia and URTI account collectively for 36% of diagnoses in this age group. Gastroenteritis and eye infections together make up 16% of diagnoses. In the 6 – 15 year age group, URTI is the most common disease at 29%, with water-related diseases (skin diseases and gastroenteritis) making up 21%. Sexually transmitted diseases accounted for 8% of diagnoses in all age groups. Many of the diagnoses made at this clinic were recorded as check ups or as ill-defined.

Table 6.7 Top diseases by percentage for different age groups presenting to Sekake Clinic.

Sekake Clinic					
Villages: Pathela, Sekake, Setofolo					
TOP DISEASES BY PERCENTAGE					
0-5 years		6 – 15 years		All ages	
Skin	32	URTI	29	Ill-defined	9
Pneumonia	20	Check up	25	**Skin**	9
URTI	16	**Skin**	13	STDs	8
Gastro	8	**Gastro**	8	**Gastro**	8
Eye	8	Aches	8	Aches	5
Ill-defined	8	Ill-defined	8		

6.1.8 Marakabei Clinic

Marakabei Clinic is linked with IFR Reach 7. It serves the communities of Marakabei, Ha Noha and Ha Tsitso. Pneumonia and URTI account for 37% of diseases among the 0-5 year olds. Water-related infections account for 19% of diseases. In the 6-15 year age group, 19% of diagnoses can be related to water. For all age groups, hypertension and sexually transmitted diseases are most common at 13 and 11% respectively.

Table 6.8 Top diseases by percentage for different age groups presenting to Marakabei Clinic.

Marakabei Clinic					
Villages: Ha Noha, Ha Tsitso, Marakabei					
TOP DISEASES BY PERCENTAGE					
0-5 years		6 – 15 years		All ages	
Pneumonia	19	Epilepsy	27	STDs	13
URTI	18	**Skin**	13	Hypertension	11
Gastro	10	Injury	13	**ENT**	8
Skin	9	**ENT**	8	Epilepsy	8
		Gastro	6	Injury	6

6.1.9 Mount Moorosi Clinic

Mount Moorosi Clinic is linked with IFR Site 6. It serves the villages of Ha Koali, Ha Seletara and Phamong. For the children between 0 and 5, URTI accounts for 28% of diseases. Water-related diseases (skin diseases and gastroenteritis), the disease groups that are related to water and sanitation issues, together account for 36% of the diseases in this age group. In the 6 to 15 year age group URTI is also most common, while water-related diseases accounted for 16% of diagnoses. When adults are added to the patient numbers, hypertension (31%) and sexually transmitted diseases (16%) rank first and third in importance, respectively.

Table 6.9 Top diseases by percentage for different age groups presenting to Mount Moorosi Clinic.

Mount Moorosi Clinic					
Villages: Ha Koali, Ha Seletara, Phamong					
TOP DISEASES BY PERCENTAGE					
0-5 years		6 – 15 years		All ages	
URTI	28	URTI	20	Hypertension	31
Skin	20	Injury	20	URTI	17
Gastro	16	**Gastro**	9	STDs	16
Ill-defined	7	**Skin**	7	Injury	12
ENT	5	Chicken pox	6	**Skin**	11

6.1.10 Phamong Clinic

Phamong Clinic is linked with IFR Reach 6. It serves the same villages as Mount Moorosi clinic, but from the opposite bank of the Senqu River. The disease distribution for both these clinics is very similar to that of Mount Moorosi, with URTI ranking top in disease frequency for both the 0-5 and 6-15 year age groups. Water-related diseases account for 36% of diseases in the 0-5 year age group, but only 16% in the 6-15 year age group. Here again, as in Mount Moorosi, hypertension and sexually transmitted diseases become more important as diagnoses when all patients are taken into account.

Table 6.10 Top diseases by percentage for different age groups presenting to Phamong Clinic.

Phamong Clinic					
Villages: Ha Koali, Ha Seletara, Phamong					
TOP DISEASES BY PERCENTAGE					
0-5 years		6 – 15 years		All ages	
URTI	37	URTI	18	Hypertension	13
Gastro	28	Injury	18	Unknown	13
Skin	7	Aches	14	STDs	11
Fever	5	Chickenpox	14	URTI	10
Unknown	5	**Skin**	9	**Gastro**	7

6.2 Overall trends and differences across the whole study area

High existing levels of childhood infectious diseases related to water were found throughout the study area. These ranged from 19% of the diagnoses with which 0-5 year olds presented to Marakabei clinic to 50% of all diseases in the same age group recorded at Holy Cross clinic. Among these were water-borne diseases causing gastroenteritis and water-washed diseases causing skin diseases and eye infections. For the 6 – 15 year age group, water-related diseases are still prevalent, but not as important as with the 0-5 year olds. For all the age groups combined, the effect of diseases of lifestyle (hypertension) and sexually transmitted diseases become more prevalent.

7. THE NUTRITION OF THE PAR AS IT RELATES TO THE STUDY RIVERS

7.1 Introduction

Food production and food security affects health, as it influences people's nutritional status and resistance to disease. It is thus important to evaluate household food production as it relates to the study rivers. During the pilot and detailed socio-economic surveys, evaluations of agricultural activity, fish and wild vegetable collection and consumption were done (Report No 648-F-08).

7.2 Agriculture within the riparian zone

Communities grow maize and sorghum grown in family plots and small fields along the riparian zone. In addition, vegetables are collected from the riparian zone. These fields yield crops faster than field outside the riparian zone, because they have better quality soil as a consequence of flood-transported sediments, a higher moisture content and ambient temperature is generally higher in the river basin. In the highland areas, fields are cultivated wherever the topography permits. In the lowland areas fields are larger, yielding more maize and sorghum. Vegetable gardening along the river was only practised at Motenalapi at IFR Site 7.

For the different river sections, the percentage of households who own agricultural fields within the riparian zone was calculated. Next to the Matsoku River (IFR Site 1), 23.7% of households own fields and on the Malibamatso River surrounding the Katse Dam (IFR Site 2), 21,9% of households own fields. At IFR Site 7, the highest percentage of households (27.2%) owns fields next to the Senqunyane River. These areas have low population numbers within the primary corridor: 7138 at IFR Site 1, 2,879 at IFR Site 2 and 10,306 people at IFR Site 7. By contrast, at IFR Sites 3 to 6 between 5.1 and 15.3% of households own fields, yet the population ranges from 15,343 at IFR Site 3 to 59,363 at IFR Site 6. The variation in percentages of households owning fields next to the river can be attributed to topographical differences in the suitability of the riparian areas for agriculture with highland sites supplying better opportunities for agriculture.

7.3 Catching fish

Fish is an important source of protein for poor communities where nutrition is frequently compromised. Although the villagers questioned during the pilot socio-economic survey generally considered fish an important river resource, it did not form a significant part of their diet (Report No

648-F-08). Most households (84,4%) had not caught fish during the previous 12 months. The percentage of households who had fished over the last 12 months ranged from 10% at IFR Site 8 on the Senqunyane River to 22% at IFR Site 4 on the Senqu River. Only in households where a member of the family caught fish, were fish consumed on a regular basis.

People fish mainly during the summer months from October to March. During the winter months, fish numbers are low. Villagers claimed that fish disappeared due to the low temperatures, hide under big rocks or die because of algae or ice on the river. The overall abundance of fish was said to be high and unaffected by LHWP dams, except along the Malibamatso River, where Katse Dam was said to have affected seriously the number and size of fish (Report No 648-F-08).

The most important fish species caught were the Smallmouth Yellowfish, the Rock Catfish and the Rainbow Trout. The Smallmouth Yellowfish was the fish most commonly caught at all sites. The Rock Catfish was generally caught for household consumption. Rainbow Trout was caught for sale only on the highland. Sharptooth Catfish was popular for household consumption, but was caught only occasionally.

Catches of the Smallmouth Yellowfish were lowest at IFR Sites 1 and 2. IFR Site 1 presented marginal habitat for the Smallmouth Yellowfish, while Katse Dam affected IFR Site 2. Large numbers of Rock Catfish were caught from the lower Senqu River. The Rainbow Trout, a typical highland fish, was not caught from the lower Senqu River, but was caught regularly at IFR Sites 4,5,7 and 8.

7.4 Wild vegetables collected for household consumption.

More vegetables were harvested in summer than in winter (Report No 648-F-08). The percentage of households harvesting wild vegetables along LHWP-affected rivers varied considerably throughout IFR 1-8 (Table 7.1). The highest number of households that harvested wild vegetables from the river were located along the IFR Site 1 corridor. These high yields were attributed to the ease of access and relative abundance of wild vegetables along this stretch of river. The lowest percentages were recorded at IFR Sites 2, 3, 5 and 8 where access was more difficult. The environments of IFR Site 2 and 3 were considered to have been seriously affected by the effects of Katse Dam. However, a significant proportion of the PAR at IFR Site 3 live in Thaba Tseka, a rapidly developing town where dependence on riverine resources is minimal.

Table 7.1 Wild vegetables collected for household consumption.

	Percentage of households harvesting vegetables	Mean number of plastic bags per week - summer	Mean number of plastic bags per week - winter
IFR1	66,9	4,45	2,22
IFR2	34,4	3,40	1,82
IFR3	31,2	4,29	2,42
IFR4	61,1	4,88	2,44
IFR5	30,7	3,07	1,76
IFR6	43,6	2,95	1,81
IFR7	36,4	4,79	2,94
IFR8	29,1	2,82	2,10
Total	43,1	3,78	2,12

Source: Report No 648-F-08.

7.5 Wild vegetable and fish consumption patterns

Table 7.2 shows the wild vegetable and fish consumption patterns of households without children under 6 years (63.3% of all households). Vegetables were more important component of the diet of these households than fish. However, fish were more likely to be sold. The sale of vegetables was more widespread in the highlands than in the lower Senqu River valley (IFR Site 6). More fish were sold along the Senqunyane River than along the other LHWP-affected rivers

Table 7.2 Mean proportions of vegetable and fish utilisation in households without children under the age of 6.

	Vegetables sold (units)	Percentage of vegetables eaten by household members 6+ of age	Fish sold (units)	Percentage of fish collected eaten by household members 6+ of age
IFR1	10,65	89,16	27,22	72,78
IFR2	5,83	94,17	32,83	67,17
IFR3	13,33	86,67	36,25	63,75
IFR4	5,38	94,34	45,33	54,67
IFR5	---	100	20,91	79,09
IFR6	---	100	30,34	68,97
IFR7	8,84	90,23	53,33	46,67
IFR8	1,60	98,00	55,00	45,00
Total	3,67	96,17	34,38	65,27

Source: Report No 648-F-08.

Table 7.3 shows that the dietary importance of vegetables and fish among those households with children (36.7% of all households) under the age of six resembled that of households without children of that age. Vegetable sales and fish consumption by adults compared well with households where there were no children under six years of age. However, fish sales and vegetable consumed by adults in households with small children were lower than their counter parts without small children.

Table 7.3 Mean proportions of vegetable and fish distribution in households with children under the age of six.

	Vegetables sold (units)	Percentage of vegetables eaten by household members 0-6 of age	Percentage of vegetables eaten by household members 6+ of age	Fish sold (units)	Percentage of fish eaten by household members 0-6 of age	Percentage of fish collected eaten by household members 6+ of age
IFR1	5,14	12,25	82,61	32,35	11,76	55,88
IFR2	5,77	14,62	79,62	38,46	8,46	53,08
IFR3	6,86	15,82	77,32	32,31	9,23	58,46
IFR4	4,31	10,49	85,20	34,00	7,67	58,33
IFR5	---	9,13	90,87	10,33	6,00	83,67
IFR6	3,00	12,37	84,63	20,00	8,89	71,11
IFR7	12,33	16,73	70,93	26,92	9,23	63,85
IFR8	2,40	11,80	85,80	35,00	15,83	49,17
Average	4,15	12,10	83,75	24,12	8,27	67,60

Source: Report No 648-F-08

8 PUBLIC HEALTH ASPECTS OF ANIMAL HEALTH COMPONENT

8.1 Introduction

In many of the rural areas of Lesotho, including those in the study area, animals are not vaccinated. In addition, the pilot social survey recorded that people in the study area consumed the meat of dead animals unless the animal was overtly ill (Report No 648-F-08). The IFR animal health specialist, Dr Daniel Phororo (personal communication, Phororo DR 1992), has confirmed this.

Except for those communities within the river utilisation corridor represented by IFR Site 4, households owning animals exceeded 50%. Nearly 80% of households along the Matsoku River (IFR Site 1) owned animals. There was a very high dependency on the river for watering during drought periods (>50% at all sites). IFR Site 1,3,4 and 7 rivers were also used frequently during the dry season.

Table 8.1: Animal ownership and watering patterns within the study area.

	% Households owning livestock	Dependent on river during dry season	Dependent on river during drought
IFR1	79,6	64,1	80,8
IFR2	67,0	23,8	55,8
IFR3	47,9	48,4	59,5
IFR4	58,4	44,7	64,6
IFR5	57,7	22,8	59,1
IFR6	66,5	20,8	53,8
IFR7	73,3	41,5	65,5
IFR8	62,1	27,7	55,3
Average	62,5	31,5	56,0

Source: Report No 648-F-08.

There are several diseases that affect livestock that can be transferred to humans. The most significant of these is Anthrax, which is discussed in more detail below.

8.2 Anthrax

Anthrax is an acute bacterial infection caused by *Bacillus anthracis* that occurs most frequently in herbivorous animals, including cattle, horses, sheep and goats. Grazing animals become infected when foraging for food in areas contaminated with *B. anthracis* spores. Humans become infected when spores are introduced into the body by contact with infected animals or contaminated animal products, insect bites, inhalation, or ingestion. The mortality rate of inhalation Anthrax approaches 100%. The mortality rate in treated gastro-intestinal Anthrax acquired through the consumption of contaminated meat products is 50% (Isselbacher *et al.* 1994).

In the study area, there are records of animals having been infected by Anthrax and people having died as a consequence (Table 8.2). Terminally-ill animals often bleed from the mouth and nose thereby contaminating watering places with the organisms that can potentially sporulate and persist in the environment (Wilson *et al.* 1996). Under drought conditions, the opportunity for spores to persist in the environment increases dramatically.

Table 8.2 indicates the outbreaks of Anthrax that has been recorded in the study area as well as the rest of Lesotho over the past 35 years. (Phororo, DR 1999 personal communication)

Table 8.2 Anthrax outbreaks in Lesotho for the period 1966 to 1996.

Area	Year	Animal Deaths	Human deaths	Humans treated
IFR Sites 1,2,3,4 Pelaneng to Koma Koma	1966	220 cattle 56 sheep 43 goats 4 horses 2 donkeys	8 adult males	35 men, 10 women
IFR Site 7 - by association - animals graze at this site	1969	4 cattle 3 sheep 2 goats 1 horse 1 donkey	Not recorded, but deaths did occur (personal communication, Dr D Phororo)	6 people
	1996	63 cattle 4 sheep 8 goats 2 horses 1 donkey 1 pig	None (personal communication, Dr D Phororo)	People were treated, but the numbers were not recorded

9 UTILISATION OF RIVER WATER

9.1 Introduction

Communities within the study area make more use of the water in the river under the following circumstances:

- lack of reliable alternative water source;
- lack of reliable tributaries;
- easy access to the rivers;
- lack of infrastructure, services and jobs;
- lack of roads and bridges;
- A high dependency on natural resources;
- a frequent need to cross the rivers;
- lack of alternative resources.

It is important to understand the nature of the communities' interaction with the rivers in order to link their health and well-being to changes in flow dependent river water quality. River water can be consumed accidentally or deliberately. Accidental water consumption occurs during leisure activities, while deliberate consumption occurs either casually when other activities at the river are performed, or when water is collected from the river for the purposes of household consumption. These were further investigated during the socio-economic survey (Report No 648-F-08). The results are discussed below.

9.2 Casual drinking

The percentage and frequency of casual drinking from the rivers are presented in Table 9.1 below. Except at IFR Site 2 and 3, more than 50% of households drank water from the river, usually while conducting other tasks, such as collecting firewood or vegetables, fishing, washing clothes or while working in fields close to the river. Women and herdboys most frequently spend time at the river and are thus the groups who most frequently drink river water. At IFR Site 2, below Katse Dam, people had changed their behaviour in response to the perceived deterioration in water quality. Only 19.5% of households drank from the river at this site. The low percentage of casual drinking at IFR 3 can be explained by the low dependence on the river displayed by residents of Thaba-Tseka. River resources were most frequently used at IFR Site 4. A casual drinking percentage of 71,2 is thus not surprising. The same applies to IFR Site 1 and 7.

Table 9.1 Percentage and frequency of casual drinking from the river reaches.

	% of Households using the river for casual drinking	Average / Frequency / Month	
		Summer (7 months)	Winter (5 months)
IFR1	58,8	19,55	11,80
IFR2	19,5	15,59	7,13
IFR3	40,0	14,55	8,48
IFR4	71,2	16,72	7,22
IFR5	49,8	13,06	8,80
IFR6	50,4	15,83	9,07
IFR7	57,1	22,35	14,24
IFR8	51,5	15,78	8,68
Average	53,1	16,17	8,97

Source: Report No 648-F-08.

9.3 Water for domestic use

Water for domestic use has to be distinguished from casual drinking in that it constitutes the water specifically collected for use in the household. The pilot socio-economic survey determined that people used varying quantities of water, ranging from 7 l/c/d to 20 l/c/d. The WHO recommendation is 35 l/c/d (DWAF 1996).

As indicated in Table 9.2 below, uncovered springs with their high disease-transmission potential are frequently used in the study areas. At IFR Sites 1,2,3,7 and 8, uncovered springs were the most important source of drinking water (Report No 648-F-08). In the remainder of the study area, these were the second most common source of drinking water after taps (Report No 648-F-08).

A low percentage of households (1.1%) used river water throughout the year. This percentage increased during the dry season and during drought periods. At IFR Sites 6 and 7 the increase in usage during dry periods was quite marked. Thirty-three percent and 23.5% of households, respectively, used river water during drought periods, as compared to 0.4 and 9.2% elsewhere in the study area. This suggested a lower degree of reliability of village water supply systems and springs in the lowland areas during the dry season. During this time the importance of the Senqu River as a source of drinking water increased.

Table 9.2 Main water supply systems for domestic purposes reported as a percentage of the total number of households in each area.

	Those using taps	Those using covered springs	Those using uncovered springs	Those using the rivers	Those using the rivers during the dry season	Those using the river during drought
IFR1	30,6	27,8	30,6	2,8	12,2	4,9
IFR2	24,2	18,6	40,0	0,5	2,3	14,0
IFR3	25,6	24,2	31,6	0,5	---	0,5
IFR4	41,6	9,3	35,4	0,4	1,3	1,3
IFR5	53,0	2,3	33,5	---	0,5	2,8
IFR6	51,3	6,4	12,7	0,4	11,9	33,1
IFR7	---	29,5	42,9	9,2	8,3	23,5
IFR8	2,4	18,9	61,7	0,6	2,9	8,7
Average	41,2	11,0	26,5	1,1	6,2	16,4

Source: Report No 648-F-08.

9.4 Accidental water consumption

Thirty-two percent of all respondents reported to have used the river for leisure purposes, mainly swimming and exercising. The low percentages at IFR Site 2 (21.4%) and 3 (23.7%) could be attributed to peoples' fear of contaminated water below Katse Dam (Report No 648-F-08).

9.5 Overall trends and differences across the whole study area

The area is burdened by a high illiteracy rate (29.7%), high dependency rate (50.7% of community members are under 21 years), high unemployment (40.6%) and low formal incomes (29.4% of all households in the study area). Under such circumstances, it is expected that household food insecurity would be highly prevalent.

At IFR 7, along the Senqunyane River, the largest percentage of maize and sorghum are grown (27% of households). Fish, a potentially important source of protein, is caught by only 15% of households. These households then sell fish to the rest of the corridor community. Children under-6 years consume very little fish, even in households where fish is part of the diet. Trout, Smallmouth Yellowfish and Rock Catfish are commonly caught and eaten, whereas the Orange river Mudfish is more difficult to catch. Wild vegetables form a large part of the diet.

An average of 27% of households rely on uncovered springs for domestic water all year round. An average of 11.78 l/c/d water is consumed by these types of users, while the WHO recommends 35 l/c/d.

SECTION D: BIOPHYSICAL COMPONENT OF HEALTH IMPACT EQUATION

The biophysical components of LHDA 648 are reported on in detail in the biophysical specialist reports (Report Nos 648-F-12 to 19). The exception to this is the microbiology of the river water, which is presented in Appendix A.1 of this report. Only those aspects of particular significance to the health of the PAR are reported on here.

10 WATER QUALITY OF THE RIVERS DOWNSTREAM OF PROPOSED AND EXTANT LHWP DAMS

10.1 Changes in the microbiology of the water in the rivers

The water quality team collected water samples at the eight IFR sites from January 1999 to June 1999. The samples were analysed for the presence of coliforms and the protozoan parasites, *Giardia lamblia* and *Entamoeba coli*. The results are presented in Appendix A.1.

Please note: The coliforms were analysed in number of counts per 100 ml water and the protozoan parasites in number of cysts per 100 litres of water.

10.1.1 Total Coliforms

Most pathogens in drinking water are faecal in origin. Thus the coliform bacteria, which are always present in the digestive systems of humans and animals, are commonly used as indicators of water-supply contamination (Ronchi and Wald 1999). Total coliforms comprise a heterogeneous group that includes bacteria from the genera *Escherichia*, *Citrobacter*, *Enterobacter*, *Klebsiella*, *Serratia* and *Rahnella*.

The risk of a person becoming infected by microbial pathogens increases with the level of contamination of the water and the quantity of contaminated water consumed. Higher concentrations of coliforms in drinking water will indicate a higher risk of contracting waterborne diseases, even if the quantities consumed are small. With a Total Coliform range of 0 - 5 counts/100 ml, negligible risk of microbial infection exists. With levels of 5 to 100, there is a risk of infectious disease transmission with continuous exposure and a slight risk with occasional exposure. With levels exceeding 100 counts / 100 ml, there is significant and increasing risk of infectious disease transmission (Payment *et al*. 1991).

Measurements of total coliforms can detect most bacterial pathogens, but cannot detect certain bacteria, viruses and protozoan parasites. For example, the deadly *Escherichia coli* 0157 may be present even if faecal coliform measurements are nil (Ronchi and Wald 1999).

The results of the field testing of 100-ml water samples showed that the river was not contaminated with coliforms during the high flow months of January to April 1999. Coliforms were recorded in January at 2 sites (IFR Sites 2 and 6), and in April at IFR Site 8. However the levels constituted a negligible risk of diarrhoeal disease, even with continuous exposure to infected water (Appendix A.1).

During May 1999, low coliform counts were recorded at IFR Site 3 (Paray), IFR Site 7 (Marakabei) and IFR 8 (lower Senqunyane), indicating negligible disease risk. The June records from IFR Site 4 constituted an increased risk of infectious disease transmission if the water was consumed continuously. The counts at the other IFR Sites were low, and the risk of contracting disease would have been negligible even if large amounts of water were consumed.

Samples were not collected for July to December.

10.1.2 *Giardia lamblia* and *Entamoeba coli*

People defaecate in dongas close to the rivers' edge. Rain allows seepage into the river. Unnatural low flow conditions in the study rivers during the wet season, as a result of upstream dams, could allow protozoan parasites to persist in the water.

Increased fine sediments further facilitates the persistence of these organisms. It has been established that communities use the river water for leisure and cultural activities as well as for drinking water. In dry periods, the sources of clean potable water in the communities become unreliable, and the river becomes a source of drinking water. There is thus ample opportunity for organisms to be transmitted to people when they consume river water, whether accidentally or as drinking water. These organisms cause diarrhoea.

The infective dose for *Giardia* and *Entamoeba coli* is extremely low. Theoretically, one cyst or oocyte is sufficient to cause infection, and an infective dose of ten Giardia cysts has been demonstrated. *Giardia lamblia* has been identified as one of the most common causes of water-borne disease outbreaks in Southern Africa (Rose *et al*. 1991).

Results of the *Giardia lamblia* analysis revealed that water at IFR Site 1 at Matsoku was contaminated in four of the six months sampled (Appendix A.1). This indicates human faecal contamination from a source close to the river. The samples taken at Katse Dam (IFR Site 2) were contaminated during January and June, which indicated isolated faecal contamination. No contaimination was recorded at IFR Sites 3, 4, 5 or 8. At IFR Site 7, infective doses of *Giardia lamblia* were found during the wet season (Jan and March). The highest concentration of cysts was found in the samples collected at Seaka (IFR Site 6), also in the wet season (January and February). Thus, in every case where *Giardia lamblia* was recorded, it was during the wet summer period. This is unsurprising: runoff is highest during the wet season, and faeces are presumably washed off the surrounding areas into rivers during times of rain.

In each case where cysts were recorded, the levels were high enough to constitute a high risk of contracting diarrhoeal disease from ingesting even a small amount of the river water.

As is the case with *Giardia*, the infective dose for *Entamoeba coli* is extremely low. However, *Entamoeba coli* was recorded only twice, once at IFR Site 2 in January and once at IFR Site 3 in February. The levels recorded on these two occasions were very high indicating either post collection contamination or the presence of an isolated infective focus close to the sampling points.

It should be noted, however, that because of the high mud/sediment content of the water samples collected, filtered and analysed, it is feasible that a large numbers of cysts and oocytes were present but not detected through the analysis process. Thus, it is possible that Entamoeba was present in other sites and months.

10.2 Changes in the physico-chemistry of the river water

Monthly sampling of a full spectrum of physical and chemical water quality variables at each IFR site was done for the period January 1998 to September 1999. The results of this component of the IFR study are presented in Report No 648-F-15.

10.2.1 Chemistry

Except for isolated elevated measures during the high-flow summer period, the chemical composition of the rivers indicated safe levels for human consumption (Casemore *et al*. 1991; Department of Water Affairs and Forestry 1996, Report No 648-F-15).

- Total Phosphorus (Tot-P) and Total Nitrogen (Tot-N) concentrations varied significantly in response to changes in flows;
- Tot-N was less than 800 μgl^{-1}at all IFR sites. Total organic carbon was less than 8 mgl^{-1}, with no significant differences between the sites;
- dissolved oxygen was between 80 and 110 % saturation at all sites;
- the concentrations of the base ions, sodium and potassium were less than 6 and 2 mgl^{-1} respectively;
- the concentrations of calcium and magnesium were less than 28 and 10 mgl^{-1} respectively;
- the concentrations of sulphate and chloride levels were less than 11 and 6 mgl^{-1} respectively;
- the concentrations of iron and manganese were generally less than 3000 and 500 μgl^{-1} respectively. The highest levels recorded were associated with high flows at all sites;

- temperature showed natural seasonal variation.

10.2.2 Turbidity

Turbidity in water is caused by the presence of suspended matter, which usually consists of a mixture of inorganic matter, such as clay and soil particles, and organic matter. The latter can be both living matter, such as microorganisms, and non-living matter, such as dead algal cells and vegetal debris. The consumption of turbid water *per se* does not have any direct health effects, but associated effects due to microbial contamination can occur when infectious disease agents become adsorbed onto particulate matter. At a turbidity range of 1 - 5 NTU, no turbidity is visible, although a slight chance of infectious disease transmission does exist. At a level of 5 – 10 NTU, turbidity is visible and may be objectionable to users. Some chance exists for the transmission of disease by micro-organisms associated with particulate matter, particularly for agents with a low infective dose such as viruses (e.g., Hepatitis A) and protozoan parasites (e.g., *Giardia*). At levels exceeding 10 NTU, a chance of disease transmission at epidemic levels exists (Department of Water Affairs and Forestry 1996).

An evaluation of the turbidity data indicated that the water in the Lesotho rivers has a great potential for carrying micro-organisms that can cause human disease. Parasites (e.g. *Giardia lamblia*) and viruses (e.g. Hepatitis A) would be the organisms most likely to be associated with the turbidity levels found. The highest turbidities (> 1000 NTU) were found at IFR Site 4 at Sehonghong and IFR Site 6 at Seaka on the Senqu River. These values were recorded at times of high flow in the summer months. (Report No 648-F-15).

10.3 Changes in the abundance and composition of riparian and aquatic vegetation

10.3.1 Increases in the incidence of algae

Algae refer collectively to a wide range of pigmented, oxygen producing, photosynthesising organisms often present in surface waters. Of the algae, blue green algae are often responsible for toxic algal blooms in fresh waters (Department of Water Affairs and Forestry 1996). In South Africa, *Microcystis* is the most common bloom-forming cyanobacterial toxic species.

Health problems arise from the accidental swallowing or inhalation of water containing these blooms. Effects have ranged from mild (skin irritation, mucosal membrane irritation, sore eyes) to severe (skin blistering, stomatitis, and severe pulmonary consolidation; Turner *et al.* 1990; Pilotto *et al.* 1997). Severe gastro-enteritis, vomiting and liver-function impairment in populations supplied from water bodies dominated by blue-green algae have also been noted. There is also limited evidence of an increased incidence of liver cancer in populations exposed to low concentrations of hepatotoxins in untreated surface water over an extended period of time. No-one is known to have died from recreational exposure (e.g., swimming) to these blooms (Dr W.R. Harding, Southern Waters Ecological Research and Consulting, pers. comm.).

In the lowflow winter months, algal growth was observed at all IFR sites along the river. However, high flows in the summer months and subsequent flushing of the riverine system prevented algal blooms from occurring during this period. Lack of these flushing flows could considerably increase the risk of algal blooms (for detailed predictions, see Report Nos 648-F-04-07). Indeed, there is at least one confirmed record of blooms developing in a Lesotho river during a summer drought in 1991 (Department of Water Affairs and Forestry 1996).

10.3.2 Changes in the abundance of riparian plants

In poor communities, where meat is rare and food security is low, carbohydrate foods in the form of freely available wild vegetables and plants form the basis of the diet. As people do not frequently save money or store food in these areas, it becomes all the more important that free resources be available at all times. If not the case, nutrition suffer, because there is little other free or cheap alternatives to choose from.
In addition, changes in the vegetation along the banks of the river may create a habitat conducive to the establishment of mosquitoes (see 10.4.5).

10.4 Changes in the abundance of key macroinvertebrates

Aquatic invertebrates are an essential component of the riverine ecosystem. Functionally they are important processors of transported organic matter in rivers. They purifying the water in the river and they provide a valuable food resource. However, macroinvertebrates have also been linked to illness, especially of human communities close to the river and those individuals who use the river.

The aquatic invertebrates were sampled at the 8 IFR sites as part of this IFR study. Most species collected had a fairly wide distribution throughout the rivers surveyed (Report No 648-F-17). The macroinvertebrates that could cause illness in humans are discussed further here (see Table 10.1).

Table 10.1 The incidence of potential disease-causing macroinvertebrates found at the IFR sites. P = Recorded during the study.

Taxa	Sample	IFR SITES							
		1	2	3	4	5	6	7	8
Nematoda (roundworms)	*Nais* sp Mermithidae	P 0	P 2	P 2	0 0	P 0	0 0	P 0	P 0
Diptera (True Flies)	*Simulium* sp (black flies) Simulium juveniles *Anopheles*	P P 0	P P 0	P P 0	P P 0	P P 0	P 0 0	P P 0	P 0 0
Coleoptera (beetles)	Elmid larvae Gyrinidae Hydraenidae	7 2 P	0 0 P	0 P 0	0 0 0	0 P P	0 P P	P P P	0 P 0
Mollusca (snails)	*Bulinus* sp	0	0	0	0	0	0	0	0

10.4.1 Nematodes

Nematodes are roundworms that potentially act as intermediate hosts for tapeworm. Except for IFR Sites 2 and 6, (where their numbers were high enough to be of concern) these roundworms were located in only in low numbers throughout the survey area.

10.4.2 *Simulium* species

Four species of blackfly were recorded in the area. Of these, *Simulium nigritarse* and *Simulium adersi* are likely to become more common and abundant with decreased discharges (see Report Nos 648-F-04 to 07). *Simulium adersi* bites humans and can thuse cause a general reduction in the quality of life when intense swarms plague human settlements. *S. adersi* has not been recorded to cause any disease, however. Large numbers were recorded at all sites, except for IFR Sites 6 and 8 where substrates for simuliid colonisation were not suitable. Because blackflies can migrate quite far from the river, they can become disease transmitters by carrying disease from faeces to utensils to humans (faecal – oral route). The blackfly that causes Onchocerciasis, *Simulium damnosum* and its subspecies, found in many parts of Africa, has not been recorded in Lesotho.

10.4.3 Coleoptera

Beetles were found in very small numbers in the river during times of low flow. Although not disease causing, they do secrete an acid, which can irritate the eyes. This can happen with people swimming or washing in the river, as well as when clothes are washed and the beetles become attached to the clothes. Beetles were found at all the IFR sites, except IFR Site 4.

10.4.3 *Bulinus* snails

No *Bulinus* snails, the intermediate hosts of *Schistosomiasis*, were recorded during the study (Report No 648-F-17). However, there is a possibility that flow-related biophysical changes may result in conditions conducive to these snails. This was considered in the biophysical consequence reports (Report Nos 648-F-04 to 07).

In addition, *Lymnaea*, the snail that acts as the intermediate host of the liver fluke or *Fasciola hepatica* in animals could also become established.

10.4.5 *Anopheles* mosquitoes

No *Anopheles* mosquitoes, the intermediate hosts of Malaria were recorded during the study (Report No 648-F-17). It is unlikely that these mosquitoes will become established in the study rivers.

10.5 Changes in fish abundance

In poor communities, carbohydrate foods in the form of cereal staples form the basis of the diet. There is very little consumption of protein in the form of meat and dairy products, especially in children where it is important for their growth and health. In such circumstances, the little protein that they do consume in the form of fish, can make the difference between displaying the effects of protein-energy malnutrition or not. It thus follows that any reduction in fish numbers has implications for the nutritional status of the communities, especially the children.

10.6 General physical changes to the river channel

10.6.1 Changes in productivity of riparian fields

"Out of channel flows" inundate the floodplain. These flows are vital for maintaining river-floodplain connectivity and the transfer of sediment, nutrients and carbon between river and floodplain environments. Without these flows there would be a reduction in the productivity of the river flats and agricultural lands at the edge of the river because of a lack of nutrients supplied by silts deposited during floods. Many annuals are used as food or for medicinal purposes. The growth of annuals and perennial herbs is also dependent on silt deposition and without "out of channel" flows, their reduction is also anticipated.

10.7 Increases in the abundance of the multimammate mouse

These rodents can increase to pest proportions in the absence of flood events to control their numbers. These mice can cause extensive damage to riparian croplands.

10.8 Changes in the abundance of animals and plants used for traditional medicine

The biophysical components of this study (LHDA 648), in conjunction with the sociological components, identified a number of plants and animals that have either traditional medicinal or magical properties. The predicted changes in the abundance of these animals and plants is given in the biophysical consequences of the four IFR scenarios (Report Nos 648-F-04 to 07). However, the impacts of the abundance changes in these animals and plants have not been quantified in the public health report.

SECTION E: METHODS AND ASSUMPTIONS USED TO PREDICT PUBLIC HEALTH IMPACTS FROM CHANGES IN THE BIOPHYSICAL ASPECTS OF THE STUDY RIVERS LIMITATIONS SCENARIOS

11 CONVERTING BIOPHYSICAL CHANGES TO HEALTH-RELATED CHANGES

The links between the river and people's health are complex, often indirect and confounded by factors that are not necessarily river-related, such as income levels, access to clean drinking water and proper toilet facilities. The relationships between health of the PAR and the study rivers are explained in detail in the earlier Sections of this report. The predicted impacts on health for each of the scenarios took into consideration:

- the wide range of factors influencing health in the study communities;
- data on the extent of the river use by members of those communities collected during the social surveys;
- predicted biophysical changes for aspects of the river that could influence health.

In addition, in order to determine the increased risk of contracting a disease, it was necessary to assume certain levels of activity for each type of use. These assumptions are discussed in more detail in Section 11.2.

11.1 Determining the level of impact

Table 11.1 provides an outline of the considerations that were used to create the link between the biophysical changes and each of five key flow-related conditions in the rural populations. The level of importance in Table 11.1 provides an indication of the weighting given to each ecological link, when determining the implications of biophysical changes for public health.

11.2 Assumptions

In order to determine the increased risk of contracting a disease, it was necessary to assume certain levels of activity, since the health risks will be dependent on the level of contact with the river. The communities' river-use patterns were thus used in conjunction with the predicted biophysical changes and the links described in Table 11.1 to determine the future risk. For instance, the risk of contracting diarrhoea from infected water is far less if a little water is ingested accidentally, than if the water is drunk often on purpose. Table 11.2 provides a summary of levels of river use by the communities that were assumed when determining the health implications.

11.3 Determining the public health impacts

The biophysical components of the study provided information on the main changes in key species, communities and features in the study rivers as represented by the eight IFR sites. This information has been used to predict the likely impacts on public health using the links described in Table 11.1. It should be noted that making such a link is new and largely untested at the global level, and no methods were available to aid the process. It is a relatively new venture for health specialists to assess biophysical data on predicted changes rivers at this fine resolution and use them for the purposes of predicting the risks to public health. To a large extent the appropriate kinds of data do not exist, as public health specialists usually collect their data for quite different purposes. So, as with the biophysical specialists, new kinds of data collection and analyses will have to evolve to enhance the predictions of impacts of river changes on health. This will take time. For this project, the available data have been synthesised in this report.

The sequence followed to predict the future public-health risks attached to each scenario was:

- for each social reach the health risks were assigned severity ratings from nil to severe based on the present day level of disease or illness among the PAR;

- future health risks were predicted using expert opinion and consideration of all the presented information for those biophysical components that were deemed to link to public health, and taking into account the levels of the level of exposure of people living alongside the river to those biophysical components.

The predicted impacts on public health for each of the four scenarios are reported in detail in the Social Impact Report (Report No 648-F-21) and summarise in Section F.

Table 11.1 Link between biophysical river condtion and publich health and reasoning used in determining the importance to public health.

Disease/health risk	**Ecological link and reasoning**	**Level of importance for public health**
Diarrhoeal disease and skin and eye diseases	Colloids: An increase in colloidal material allows diarrhoeal disease-causing organisms such as Giardia to remain in the river for longer, thus increasing the chances of people becoming infected either through contact (skin and eye infections) or consumption (diarrhoeal disease).	High
	TSS magnitude: The consumption of turbid water with high TSS levels *per se* does not have any direct health effects, but associated effects due to microbial contamination can occur when infectious disease agents become adsorbed onto particulate matter and remain within the river system for an extended period of time.	High
	Algal blooms: In the lowflow winter months, algal growth was observed at all IFR sites along the river. However, high flows in the summer months and subsequent flushing of the riverine system prevented algal blooms from occurring during this period. Lack of these flushing flows could considerably increase the risk of algal blooms which result in adverse health effects from the consumption of algal bloom contaminated water	High
	Black flies: Increases in numbers can result in an increase in irritation caused by these biting flies. Because blackflies can migrate quite far from the river, they can become disease transmitters by carrying disease from faeces to utensils to humans (faecal – oral route) if their numbers increase dramatically.	Low

Disease/health risk	Ecological link and reasoning	Level of importance for public health
Anthrax	General reductions in flow, linked to drought conditions: If an Anthrax-infected animal dies along the river bank and severe lowflow conditions exist in the study rivers, then there is a risk that the Anthrax spores will remain exposed. They then spread to other animals and humans who can contract the disease through either eating the meat or breathing in the spores. The risk of Anthrax is increased when drought conditions prevail in the surrounding catchment, since animals will travel down to the river for water more frequently during drought than at other times. Thus, the chance of an animal with Anthrax dying at the study rivers is greater in drought. Having said this, the dams on the study rivers will not create drought conditions, in the surrounding ctachments, only low flows in the study rivers, this they are not expected to seriously affect the incidence of Anthrax.	High
Malaria	*Anopheles* mosquitoes: Under the right temperature and altitude conditions, *Anopheles* mosquitoes can become established. Both conditions are however absent in the Lesotho environment, and predicted to remain so in the four scenarios considered.	High
Schistosomiasis	*Bulinus* snail: The predicted increase in *Bulinus* snails (disease causing snails) was used as an indication of the increased risk of Schistosomiasis.	High
Nutritional changes	Floodplain inundation: In many areas loss of high flows would result in a reduction in the productivity of the river flats and agricultural lands at the edge of the river because of a lack of nutrients supplied by silts deposited during floods. However, it has been determined that in Lesotho, the loss of flood events should not significantly affect the productivity of riparian fields, since much of the nutrient supply to these fields comes from runoff from the surrounding slopes.	Low
	Fish: Trout, Smallmouth Yellowfish and Rock Catfish are commonly caught and eaten. Because commuities are poor, their staple diets consist mainly of carbohydrate type foods (maize and sorghum). Protein in the form of meat and dairy products is not frequently consumed. Fish is thus a very important source of protein and nutrition.	High
	Wild vegetables: Wild vegetables form an important part of the diet. A reduction in plants such as *Chenopodium album* and *Chenopodium ambrosioides* and other less important food sources, could severely affect the nutrition of the people who depend on them.	High
	Wild animals: Wild animal meat is infrequently consumed	Low

Table 11.2 Assumptions made with respect to the communities' river use patterns.

Disease	**Assumptions made based on river use patterns**
Diarrhoeal disease	• People drink river water accidentally when they perform leisure activities • People collect river water for household consumption during times when the village water source is unreliable
Skin and eye diseases	• People swim in the river or wade in the water during leisure activities and rituals and their skins come into contact with contaminated water
Anthrax	• Animals drink from the river during times of drought • Anthrax infected animals could die along the river • People consume the meat of animals which die from unnatural causes
Malaria	• People spend time along the river bank or in the river whether it is to swim, to catch fish or for cultural activities
Schistosomiasis	• People spend time in the rivers, whether for cultural or leisure or household activities. If *Bulinus* is in the river, it can transmit Schistosomiasis to people.
Nutrition	• The river is an important source of nutrients. These nutrients can be in the form of fish, wild vegetables or through maintaining the productivity of agricultural lands close to the rivers.

SECTION F: HEALTH IMPACTS OF THE TREATY, DESIGN LIMITATION AND FOURTH IFR SCENARIOS

12 HEALTH IMPACTS

Please note: The details of the health impacts are provided in Report No. 648-F-21: Sociological impacts of the Four IFR Scenarios. The health impacts are, however, summarised below.

12.1 The four scenarios

The likely impacts on the health of the PAR of the four IFR Scenarios are discussed and quantified in the light of the results from the biophysical components of the study. The four IFR scenarios are:

- Minimum Degradation Scenario;
- Treaty Scenario;
- Design Limitation Scenario; and
- Fourth Scenario.

Details of the biophysical consequences for these four scenarios are provided in Report Nos 648-F-04 to 07, and are summarised in the Final Report (Report No 648-F-02). The methods used in deriving these results are given in Report No 648-F-03.

12.2 Public health implications

The public health implications of the four scenarios are summarised below. For each type of impact, a baseline disease level (i.e., the present-day probability that someone in the community will contract the disease or face the health risk), and a level of scenario impact are identified using the following scale:

Nil:	0% probability;
Minimal:	1-20% probability;
Moderate:	20-40% probability;
Severe:	40-80% probability;
Critically Severe:	80-100% probability.

The above values are for both present and predicted future probabilities of contracting the disease. Thus, if before the dams, the probability was moderate (20-40%) and the dams will make little difference, then the future probability will also be moderate (20-40%). Further, if the dams are expected to make a difference, this difference will be reflected by adding the extra probability to the baseline probability. Thus, the scenario impact value will be the full future probability. For instance, it may increase from moderate (20-40%) to severe (40-80%), which should be interpreted as the pre-dam chance (20-40%) of contracting the disease has now increased with Scenario "X" to (40-80%).

12.2.1 Baseline disease/illness levels

The baseline health condition of the PAR with respect to diarrhoeal disease and nutrition is poor. For Malaria and *Schistosomiasis*, there are currently no cases recorded in the area, thus the baseline condition is good. For Anthrax, although incidents of the disease have not been recorded in the clinic records in the study area, it is does occur in Lesotho (see Table 8.2) and is currently a health risk in the area.

On the basis of the data obtained during this study, the following baseline levels of risk were assigned:

Diarrhoeal diseases:	Moderate (20-40% probability);
Malaria:	Nil (0% probability);
Schistosomiasis:	Nil (0% probability);
Anthrax:	Minimal (1-20% probability).

These probabilities can be used to assess the *increased* chance of contracting the disease as a result of the biophysical changes anticipated under any one of the IFR scenarios.

12.2.2 Minimum Degradation Scenario

The Minimum Degradation Scenario was expressly designed to provide a flow regime for the study rivers that would result in minimal if any changes to the biophysical characteristics of the study rivers (Report No 648-F-04). Thus, for the Minimum Degradation Scenario, the impacts on health would also be minimal, and have been assigned a scenario impact level of 0%. The Minimum Degradation Scenario is not discussed further in this report.

12.2.3 Treaty, Design Limitation and Fourth Scenarios

Summaries of the expected health-related impacts for the Treaty, Design Limitation and Fourth Scenarios are presented below. The detailed impacts are provided, along with the other sociological impacts and the implications for animal health, in the Social Impact Report (Report No 648-F-21).

Briefly, for all sites:

Treaty Scenario

Severe to critically severe impacts are expected for diarrhoeal disease and nutrition. Moderate impacts are expected in the reaches downstream of the dams for Schistosomiasis, and the impacts to skin and eye diseases for those reaches is expected to be severe. Minimal impact is expected for Malaria and Anthrax.

Design Limitation Scenario

Minimal to moderate impacts are expected for diarrhoeal disease and nutrition, although nutrition impacts could be severe immediately downstream of the dams. Minimal impact is expected for Schistosomiasis, Malaria and Anthrax.

Fourth Scenario

The expected impacts are similar to those for Design Limitation, except for Reaches 2 and 7, where it is anticipated that the risks of diarrhoeal disease, skin and eye infections and nutritional deficiencies are expected to be greater than those for Design Limitation (i.e., severe to critically severe).

SECTION G:
MITIGATION MEASURES

13. MITIGATION MEASURES

13.1 Introduction

In this section, priority actions required to ameliorate present-day (baseline) health risks and mitigate predicted significant impacts related to change in river flows are discussed. The measures discussed here focus on health issues linked directly to the study rivers.

As some health impacts only manifest themselves years after the completion of the project, it is important to maintain surveillance and mitigation capacity for the longest possible period. Furthermore, the uncertainty of time horizons and infectious-disease transmission geographic boundaries, as they relate to public health, motivates for health to be one of the priority issues to be addressed in any future monitoring programme.

It is important to realise that the mitigation measures recommended cannot be addressed in isolation. They need to be integrated as part of Lesotho's national economic development plan. For the long-term sustainability of implementation to be successful, it is essential that the Government of Lesotho and LHDA collaborate to improve the health and welfare of the affected communities.

Possible mitigation measures can be divided into four categories, namely:

- *Disease Control*: Water borne and water washed diseases, animal health (Anthrax), Malaria, Schistosomiasis.
- *Nutrition:* Food security and diversity of diet.
- *Environmental Health*: Rural water supply and sanitation
- *Formal Education*

It must be noted that in the case of diarrhoeal diseases, skin and eye diseases and nutrition, the poor baseline health condition of these communities make compelling arguments for immediate mitigation even in the absence of IFR-related impacts. These issues are discussed further below. From the perspective of this study, it is recommended that the predicted impact of reduced flows on public health is monitored in order to determine:

1) The degree to which the predicted increases in health risks are accurate, and;
2) the extent to which the LHWP should be expected to contribute towards programmes for the improvement of nutrition and hygiene in the PAR.

In addition, it is anticipated that were the present situation to be properly mitigated, then the impact of the four IFR scenarios would be less than predicted at in this project. However, where IFR impacts are expected to be minimal, it is still important that monitoring be done to detect any change in the baseline situation.

13.2 Illness-control measures

The PAR along the study rivers already faces many health risks, as documented in this report. The following suggested mitigation measures recognise this, and suggest illness-control measures that should be aimed for irrespective of the possible additional impacts of LHWP dams. Monitoring of the future health profile of the PAR is strongly recommended, and will inform, inter alia, on an appropriate proportion of the costs of the control measures that should be borne by the LHWP.

13.2.1 Water-borne and water-washed diseases

Objectives:

1 To instill a culture in the communities of: making exclusive use of improved water supplies; increasing the quantities of water they use;

improving their hygiene practices, and; using VIP latrines.

- To reduce the prevalence of water-related disease and in the episodes of diarrhoeal, skin and eye disease by 10 –20% from the current level.

2 To increase immunisation coverage for tuberculosis, tetanus, diphtheria, pertussis and poliomyelitis to 100% as compared to the 67% recorded in 1997 and 1998.

3 To reduce or prevent the outbreak of infectious disease epidemics.

Mitigation measures:

1 Improve hygiene practices through increasing the rural water supply and increasing the number of VIP latrines in the communities and schools. This should be linked to an education programme that aims to minimise the practise of drinking river water and of using defecation sites close to the edge of any drainage line.

2 Ensure prompt and effective treatment of infection when the child presents to the health service. This could be facilitated by reducing the time between the onset of disease and treatment by making the health services more accessible to the project area inhabitants.

3 Increase community use of oral rehydration therapy from the current Lesotho level of 42% to 80%.

4 Increase the children's resistance to infections by ensuring full immunisation.

Personnel required:
Environmental Health Team
Rural Water Supply Team
Health Promotion Team
Staff for health centres in the areas inhabitated by the PAR
Village health workers.

Activities:
A Health Promotion Team should work with village health workers and the health-centre staff to educate people about hygiene practices, water usage and the recognition of symptoms of illness. The Health Promotion Team and village health workers should provide health education talks within the community on issues such as breastfeeding, controlling a child's fever and orally rehydrating a child. The same activities should be performed at clinics.
Village health workers, health centre staff and the Health Promotion Team should monitor the trends in water-related illness in the various age groups.

Equipment:
Construction materials for water and sanitation provision
Saline solutions, nasogastric tubes for rehydration when oral rehydration fails.
Pharmaceuticals (antibiotics, anti-helminthics)

Project duration:
5 years.

13.2.2 Anthrax

Objective:
No *Bacillus anthacis* affecting humans.

Mitigation method:

1 Ensure all livestock are vaccinated against Anthrax.

2 Bury or cremate carcasses of animals that succumb to the disease.

3 Avoid necropsies or butchering of infected animals as sporulation of *B anthracis* occurs in the presence of oxygen.

Personnel:
Health Promotion Team
Ministry of Agriculture – Department of Livestock Services.

Activities:
The Department of Livestock Services should ensure that all animals are vaccinated and keep a record of animal ownership and vaccination status. The Health Promotion Team should educate people about the dangers of consuming the meat of animals who died of unknown causes.

Equipment:
Animal vaccination kits.

Time Period:
The education programme could be linked with that described in 13.2.1 (i.e., lasting 5 years). Vaccination programmes should be ongoing.

Comment:
B anthracis is a very virulent organism that infects, kills and spreads rapidly. Once contamination of one individual has taken place, the disease will soon reach epidemic proportions with little chance of cure, especially in far-removed rural areas. It is thus essential that an outbreak of Anthrax be prevented, even if the probability of the disease occuring is low.

13.2.3 Malaria

No mitigation required.

13.2.4 Schistosomiasis

No mitigation required.

13.3 Nutrition measures

The major flow-related mitigation measures for the PAR are related to the potential loss of nutirtional river resources. These are listed in the Sociological Report (No. 648-F-08) and costed in the Economic report (Report No. 648-F-22).

13.3.1 Food security and diversity of diet

Food security and diversity of diet within the PAR could be adversely affected by changes in river resources that are used as food, most particularly fish and vegetation. The cost and mitigation of this loss is covered under direct-resource utilisation in the Sociology Report (Report No. 648-F-08). Data collected during this study suggest that the provisions made for replacing or augmenting these resources should reduce the impact of the flow-related changes to food availibility. Nonetheless, even without these flow changes (or even if they are fully mitigated) the nutritional status of the PAR, particularly the children, should be given urgent attention by the Lesotho authorities. It is for this reason that a comment on nutrition is included here.

Objective:
An improvement in food security and a general increase in the level of nutrition within the community, starting with the children.

Comment:
Although losses of, *inter alia*, riparian vegatation and fish may impinge on the general nutritional status of the PAR, nutrition is clearly not an issue that is confined to flow-related aspects and as such does not fall solely under the ambit of the IFR programme. There is however an urgent need to improve the nutritional status of the PAR through poverty alleviation as this will have positive spin-offs for their health. An education programme to encourage dietary diversity should be started. It is anticipated that the nutritional status of these people will not be markedly improved in the short to medium term as the poverty in these communities is multifaceted and often self-perpetuating.

13.4 Rural water supply and sanitation

Objectives:

- To improve the hygiene of the communities and thus reduce the incidence of diseases related to poor hygiene practices.

Mitigation measure:
Provision of basic water supply and sanitation to affected communities. Provision of all schools and clinics with VIP latrines.

13.5 Formal education

Objective:

- To improve the effective use of health knowledge and services by improving the literacy of the community, especially that of the women and girls.

Comment:
The study area was burdened by a high illiteracy rate with 29.7% of the population having no formal education well in excess of the 19% calculated in 1995 for Lesotho as a whole. Many studies reveal that the education levels attained by girls and women is an important determinant of children's health (Herz

1991). The general socio-economic environment of the family influences infant mortality, by the availability and use of health services and the educational standard of the mother. Literate women with a secondary education are much more likely to take advantage of family planning and maternal and child health care facilities than illiterate women with little or no education. By raising the educational level of women, infant mortality will decline even further. There needs to be an investment in raising the quantity and quality of formal education to improve the effective use of health knowledge and to assist in building the country's human capital both within the study area as well as nationally.

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SECTION I - APPENDIX A1: REPORT ON MICROBIOLOGICAL DATA COLLECTION

By Robert Skoroszeweski

A.1 INTRODUCTION

An investigation of the microbiology and parasitology of the water in the study rivers was added to the water quality component of LHDA 648 as part of Variation Order 1. This was done to support the public health component of the project and was concerned primarily with indications of faecal pollution associated with human activity.

Total coliforms were used as a general indicator of faecal contamination. Although not specific to humans, it is generally considered to be a good general indicator as it includes all coliforms (including faecal). 'Total coliforms' is a general term that includes all coliforms (both animal and human). The level of total coliforms indicates the general risk of contracting waterborne diseases.

The parasites tested included *Giardia*, *Cryptosporidium* and *Entamoeba histolytica* each of which cause diarrhoea in humans.

Giardia lamblia is an intestinal protozoan parasite. It inhabits the upper part of the small intestine where they attach themselves to the surface of the mucosal cells. They are the only intestinal protozoan that cannot be cultured in artificial media. Infection with *Giardia* can cause in some patients abdominal discomfort, headache, and diarrhoea alternating with constipation. In other cases however no symptoms are evident. Infection is caused through drinking contaminated water or through contact with infected faeces.

Cryptosporidia are protozoan parasites, which inhabit the small intestine and causes diarrhoea. The life cycle includes sporozoites when in the intestine, which develop into oocsyts, which are passed out in the faeces. The oocyts can survive for several months in water. On ingestion the sporozoites exit from the oocysts and cause infection of the host.

Cryptosporidium first emerged as a common cause of diarrhoeal illness in the late 1970's in immuno-compromised patients, such as those suffering from AIDS or in newly born babies.

A.2 STUDY AREA

See Section 2.2.

A.3 METHODOLOGY

The water samples used were collected as part of the water-quality sampling programme. The samples for the microbiological analysis were tested on site whereas the samples for the parasitological analyses were first filtered in the field before being sent to Aquadoc cc in Pretoria for analysis.

The procedures used for sampling and analysis are as follows:

(a) Total coliforms

- At the site, one ampule of agar medium was poured into each of five millipore petri dishes (65 mm in diameter). This medium is liquid and adsorbs onto the filter pads which are an integral part of the petri dishes. Any excess medium that isn't fully absorbed after one minute is poured away.
- Millipore membranes (47 mm, 0.45μm pore size) were removed from their packing using forceps sterilised with 90% alcohol, and placed on the membrane seat of the filter apparatus (the grid lines face upwards).
- A sterilised plastic funnel was then removed from it's wrapping and placed over the membrane.

- 100 ml of river water was then poured into the funnel and a syringe was used to draw this water through the membrane.
- After all of the water had passed through the membrane, the membrane was removed using the sterilised forceps and placed into one of the petri dishes. The petri dish was then placed into a portable incubator, which was set at 37ºC.
- This was repeated to give five replicates.
- After 24 hours, the petri dishes were examined and the number of metallic-green colonies (which indicate total coliforms) in each dish was recorded.

(b) Parasites (*Giardia*, *Cryptosporidium* and *Entamoeba histolytica*)

The methods used were adapted from Standard Methods (1989).

- The filtering apparatus included a submersible water pump, a filter holder, a water meter, and a portable generator with connecting hoses. The water pump was placed in a large plastic bowl and fully submerged in the river. A large plastic bowl was used to prevent the pump drawing in river sand or mud, which would otherwise clog the filter. The pump is connected to the portable electrical generator.
- The water is drawn up by the pump and passes into the filter holder, into which a 1 µm yarn wound filter has been placed. The water then passes through a water meter and then an exit pipe back into the river.
- At the start of the filtering operation the reading on the water meter is taken and the filtering continued until 100 l has been filtered. The filter is then removed and kept moist until it has been transported to Aquadoc cc in Pretoria.
- At Aquadoc cc, the filters were scrubbed to remove all of the filtered material and the filtrate centrifuged to leave a small plug. A sub-sample of this plug (0.5 ml) was then centrifuged using a sucrose solution (floatation). Following centrifugation the upper layer is collected and stained with monoclonal and fluorescent antibodies. The numbers of *Giardia* and *Cryptosporidium* cysts were counted. *Entamoeba* cysts were identified using a light microscope.
- Sampling was undertaken on a monthly basis between January and June 1999.

A.4 RESULTS

This part describes the results of the microbiological and parasitological analysis of the water at the IFR sites.

A.4.1 Total coliforms

The data are summarised in Table A.1. The results showed that no total coliforms were detected in February and March 1999, which were relatively high flow months. The highest incidence of detection occurred in June 1999, which had the lowest flow of the sampling period.

Total coliforms were detected at all IFR Sites with the exception of IFR Site 1 (Matsoku).

Parasites

In the high flow months (January to April 1999) there were high levels of suspended solids being transported (Report 648 No:13), particularly at the sites on the Senqu River (IFR Sites 4 (Sehonghong), IFR Site 5 (Whitehills) and IFR Site 6 (Seaka). This resulted in large centrifugal plugs, which were sub-sampled. This inevitably resulted in an under-detection of all of the parasites tested.

Where a positive result was recorded, this means that the parasites were present. Where no parasites were recorded, this only means that they were not detected, and not necessarily that they were not present.

A.5.2.1 *Giardia*

The data are summarised in Table 5.2. *Giardia* cysts were detected at IFR Site 1 (Matsoku), IFR Site 2 (Katse), IFR Site 6 (Seaka) and IFR Site 7 (Marakabei). No cysts were detected at any sites in April and May 1999.

Cryptosporidium

The data are summarised in Table A.3. *Cryptosporidium* cysts were detected at IFR Site 1 (Matsoku), IFR Site 2 (Katse), IFR Site7 (Marakabei) and IFR Site 8 (Lower Senqunyane River). The highest incidence of cyst detection occurred at IFR Site 1 (Matsoku).

Table A.1 Summary of the detection of total coliforms at each IFR site for each month of sampling. nd = not detected, - = not sampled

IFR Site	**Month of Sampling**					
	Jan 99	Feb 99	Mar 99	Apr 99	May 99	Jun 99
1	nd	nd	nd	nd	nd	nd
2	detected	nd	nd	nd	nd	nd
3	nd	nd	nd	nd	detected	nd
4	nd	nd	nd	nd	nd	detected
5	nd	nd	nd	nd	nd	detected
6	detected	nd	nd	nd	nd	detected
7	nd	nd	nd	nd	detected	detected
8	-	nd	nd	detected	detected	detected

Table A.2 Summary of the numbers of *Giardia* cysts counted per 100 l at each IFR site for each month of sampling. nd = not detected, - = not sampled.

IFR Site	**Month of Sampling**					
	Jan 99	Feb 99	Mar 99	Apr 99	May 99	Jun 99
1	40	70	25	nd	nd	40
2	80	nd	nd	nd	nd	100
3	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd
5	nd	-	nd	nd	nd	nd
6	380	180	nd	nd	nd	nd
7	40	nd	90	nd	nd	nd
8	-	nd	nd	nd	nd	nd

Table A.3 Summary of the detection of *Cryptosporidium* at each IFR site for each month of sampling. nd = not detected, - = not sampled.

IFR Site	**Month of Sampling**					
	Jan 99	Feb 99	Mar 99	Apr 99	May 99	Jun 99
1	400	70	175	80	nd	20
2	640	nd	nd	nd	60	150
3	nd	nd	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd
5	nd	-	nd	nd	nd	nd
6	nd	nd	nd	nd	nd	nd
7	320	nd	60	nd	30	50
8	-	nd	40	nd	25	40

A.5.2.2 *Entamoeba hisotlytica*

The data are summarised in Table A.4. *Entamoeba histolytica* was only recorded on two occasions. These were in January 1999 at IFR Site 2 (Katse) and in February 1999 at IFR Site 3 (Paray).

Table A.4 Summary of the detection *Entamoeba hisotlytica* at each IFR site for each month of sampling. nd = not detected, - = not sampled.

IFR Site	Month of Sampling					
	Jan 99	Feb 99	Mar 99	Apr 99	May 99	Jun 99
1	nd	nd	nd	nd	nd	nd
2	800	nd	nd	nd	nd	nd
3	nd	600	nd	nd	nd	nd
4	nd	nd	nd	nd	nd	nd
5	nd	-	nd	nd	nd	nd
6	nd	nd	nd	nd	nd	nd
7	nd	nd	nd	nd	nd	nd
8	-	nd	nd	nd	nd	nd

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