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SECTION 1: TERMS OF REFERENCE

1 TERMS OF REFERENCE

The contract for the consulting services for The Establishment and Monitoring of Instream Flow Requirements (IFR) for River Courses Downstream of LHWP Dams (Contract LHDA 648) was awarded to "Metsi Consultants", by the Lesotho Highlands Development Authority (LHDA).

Metsi Consultants is a joint venture between Southern Waters of South Africa (SW) and SMEC International of Australia (SMEC).

The Terms of Reference presented below are taken directly from the Request for Proposals for LHDA 648.

1.1 Contract title

CONTRACT LHDA 648: THE ESTABLISHMENT AND MONITORING OF INSTREAM FLOW REQUIREMENTS (IFR) FOR RIVER COURSES DOWNSTREAM OF LHWP DAMS

1.2 Objectives of the study

Broadly, the objectives of the study as stated in the scope of services of the RFP are:

- to assess the instream flow requirement of the Senqu, lower Senqunyane, lower Malibatso, and lower Matsoku Rivers;
- to assess the long-term impacts of the modified flow regimes resulting from the construction of the proposed Lesotho Highland Water Project (LHWP) dams on the ecosystems of the study rivers, and to provide recommendations for mitigation against, and compensation for, significant impacts linked with the proposed projects;
- to recommend a long-term programme to monitor the efficacy of the IFR releases, the results of which can be used to adjust the IFR as required.

1.3 Task 1: IFR methodology, parameters and sites

- (a) The study team shall review all currently accepted methodologies for determining IFR. Particular reference shall be given to the methods used for determining IFR in southern Africa and similar environments. Particular efforts shall be towards use of comprehensive flow regimes that cater for all river ecosystem components, such as, fish, aquatic invertebrates, water quality, riparian vegetation and the abiotic environment. The advantages and disadvantages of each method shall be identified and pertinently reviewed. The study team shall provide a description of variables to be measured for each methodology selected and provide full justification for its application on a long-term basis to the LHWP. Review and approval of the proposed methodology shall be obtained from the Panel of Experts before proceeding to the subsequent tasks.
- (b) The study team shall conduct a preliminary reach analysis of each river based on air photo interpretation, satellite imagery and any other accepted method. Classification shall take into account flow characteristics, tributary inflows, geomorphology and geology, land-use, riparian characteristics, scenic resources and other defined characteristics. Reach classification shall be confirmed by field reconnaissance.
- (c) The salient factors exerting a dominant influence on each reach, including morphological, hydrological, land use or other factors, shall be identified and described.
- (d) Hydrological characteristics of each reach shall be described and quantified to the extent possible in each of the rivers over the full range of natural conditions including very wet years and very dry years.

- (e) Appropriate 'IFR' stretches/sites shall be selected for each river reach. These will be referred to as IFR sites or reaches. These will be described in detail and their locations marked in the field and on reference maps.

1.4 Task 2: Field data collection

- (a) All relevant data required for the IFR determination shall be collected at each designated river stretch, under full range of flow conditions to cover one full hydrological cycle initially.
- (b) At each river stretch suitable measurements shall be made for the following, whether they are required for immediate IFR estimation or not. It is mandatory that event based water quality sampling will be done. Such data will be compiled and utilised for long-term monitoring and assessment (and for subsequent IFR validation if required). Standard methodologies shall be utilised to the extent possible. The following data shall be collected:
- aquatic habitat characteristics;
 - macroinvertebrate assemblage structure;
 - fish population structure (with particular reference to rare or endangered species);
 - water chemistry;
 - riparian vegetation community structure and phenology;
 - wildlife;
 - threatened species;
 - incidence and abundance of known potential pest species (e.g. *Simulium*);
 - local land-use patterns;
 - community use of rivers and related socio-economic impacts;
 - water quantity/discharges;
 - flood estimations (extent of flooding and return period of different-sized floods);
 - sediment dynamics;
 - fluvial geomorphology.

Flow routing analyses shall be carried out to provide a basis for determining modified flow regimes. The Consultant shall use a Computer model of river systems and dams to estimate flows at each selected river stretch.

1.5 Task 3: IFR determination

- (a) Based on the accepted methodology, an IFR must be determined for each of the four rivers. The Desired State of each stretch of each river shall be stated and explained. The IFR for each stretch of river will describe the recommended minimum flow regime to be maintained in each river in order to meet the Desired State. These recommended flows will encompass different seasonal baseflows to mimic natural variability and higher flows for ecological or geomorphological functioning.
- (b) A release schedule for the various dams/weirs shall be provided which will describe the recommended in-stream flows.

1.6 Task 4: Impact and risk assessment

- (a) Based on the data and information available from Tasks 2 and 3 and any other relevant sources, an assessment shall be provided of the likely impacts to aquatic and riparian habitats and ecosystems, and any associated socio-economic systems and /or land uses, of flow modification by the LHWP dams as per Treaty specifications. The likely duration, timing, severity, spatial extent and significance of such impacts shall be indicated. The ecological and social risks to the downstream systems shall be identified and quantified to the extent possible.
- (b) Any mitigation measures and/or environmental enhancement opportunities, which may be applied to reduce impacts or enhance beneficial effects, shall be identified. Such measures should be linked to a range of releases that are less in total volume than the recommended IFR. All practical mitigation and/ or enhancement

measures shall be identified and described. Any mitigation programme should be costed and a preliminary implementation programme suggested.

1.7 Task 5: Mitigation and compensation

- (a) Based on the study findings and other sources of information, the Consultant will advise the Employer on costs/benefits of meeting, or not meeting, the IFR in the context of current Treaty requirements and appropriate mitigation and compensation measures if it is found that the IFR cannot be satisfied.

1.8 Task 6: Monitoring Programme and refinement of IFR estimations

The Consultant will continue with data collection for a second hydrological year to train LHDA personnel in the process that is to be continued in the long-term. A long-term monitoring programme shall be provided which shall indicate:

- parameters to be observed;
- locations of monitoring;
- timing and scheduling of field monitoring personnel;
- personnel requirements;
- equipment requirements, including any new or additional flow gauging stations required;
- budget.

SECTION 2: THE LESOTHO HIGHLANDS WATER PROJECT

2 PROJECT BACKGROUND

The Lesotho Highlands Water Project (LHWP) is one of the most ambitious water schemes being undertaken in the world (Figure 2.1). Its prime purpose is to transfer water from the highlands of Lesotho to the Vaal River catchment in South Africa. This water will be used to supply water demands in Gauteng and environs.

The LHWP is to be developed in four phases. The first phase consists of two parts (Phase 1A and 1B). At present, Phase 1A is under construction and involves:

- A 185-m high, double-curvature concrete arch dam at Katse on the Malibamatšo River.
- A 89-m high, freestanding intake tower structure located in the Katse reservoir.
- A 45-km long Transfer Tunnel with a finished diameter of 4.35 m from the Katse intake structure to the 'Muela generating station.
- A 72-MW, three unit, underground hydraulic generating station and associated works located at 'Muela in the Nqoe Valley.
- A generating station bypass tunnel and associated works.
- A 55-m high, double-curvature arch dam located on the Nqoe River that impounds the generating station tailrace and forms the head pond for the water delivery tunnel.
- The delivery tunnel intake works at 'Muela Dam.
- A 37-km long delivery tunnel with a finished diameter of 4.5 m. LHDA is responsible for a 15-km portion of this tunnel, from 'Muela to the Lesotho border at the Caledon River.
- Supporting infrastructure.

Phase 1A is complete.

Phase 1B is in the design stage and involves construction of the following works:

- A 145-m high, concrete face rockfill dam at Mohale on the Senqunyane River, approximately 30-km southwest of the Katse Reservoir.
- A 32-km long, 4-m finished diameter, interconnecting tunnel from the Mohale Reservoir to the Katse Reservoir.
- The Mohale tunnel intake and outlet works.
- An approximately 19-m high diversion gravity weir located close to 6 km east of the Katse Reservoir on the Matsoku River.
- A 6.4-km long, 3.8-m finished diameter, interconnecting tunnel from Matsoku Reservoir to the Katse Reservoir.
- The Matsoku tunnel inlet and outlet works.
- Supporting infrastructure.

Construction of Phase 1B is scheduled for completion in 2003.

Four further phases are envisaged for the LHWP. These include the construction of the Mashai Dam (Phase 2), the Tsoelike Dam (Phase 3) and the Ntoahae Dam (Phase 4) on the Senqu River, and the Malatsi Dam (Phase 5) on the Senqunyane River. Construction of the Phases 2, 3 and 4 is scheduled for completion by 2020.

Contract LHDA 648 is focused on all four phases of the LHWP.

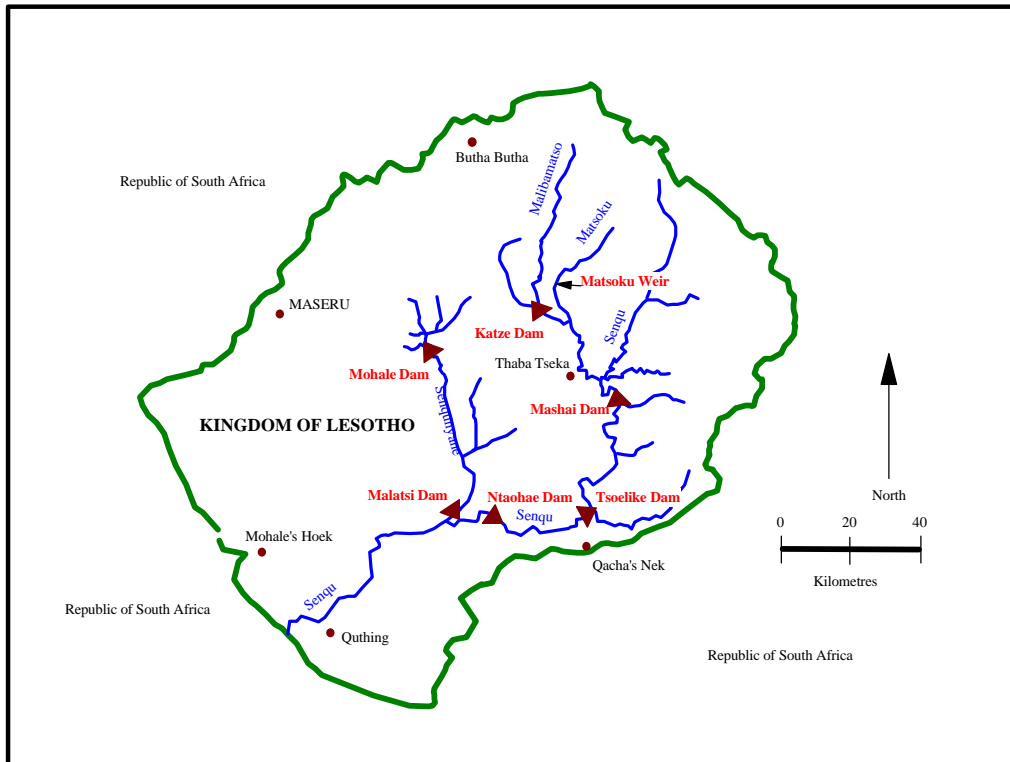


Figure 2.1 Location of the proposed and extant LHWP impoundments

SECTION 3: STUDY AREA

3 STUDY AREA

The study area for Contract 648 consisted of the following river stretches (Figure 2.1):

- (i) Malibamatso River downstream of the Katse Dam (LHWP Phase 1A) to the confluence with the Senqu River.
- (ii) Matsoku River downstream of the proposed diversion weir (LHWP Phase 1B) to the confluence with the Malibamatso River.
- (iii) Senqu River from the confluence with the Malibamatso River to the Lesotho/RSA border.
- (iv) Senqunyane River downstream of the Mohale Dam (LHWP Phase 1B) to the confluence with the Senqu River.

Within this broad study area, the areas actually addressed were delineated differently in the social and biophysical portions of the study. To avoid confusion the following terminology was been used through-out the study.

IFR sites: For the collection of biophysical data. IFR sites were c. 1 km long sections of rivers that were considered representative of the river reach on which they were situated. The IFR sites extended to the 1:100 year flood line on either side of the river.

Social villages: For the collection of sociological data. The surveys were in fact conducted at the level of the household, but the villages assist in defining the geographical cover of the social study.

Clinics: For the collection of public health data.

The villages and clinics used in the social study were each linked a reach of river represented by one IFR site.

4 BIOPHYSICAL SITES

4.1 Number of IFR sites

The IFRs were determined independently for eight IFR sites, each of which represented a longer stretch (or reach) of river. Between them, the eight IFR sites represented all river lengths in the study area.

4.2 Type of IFR sites

The size of the study area and the logistical difficulties of operating in the rural parts of Lesotho are such that the task of collecting a comprehensive data set at each of these sites was enormous. Furthermore, sufficient samples to allow meaningful statistical analyses to be conducted could not be collected at all eight sites, even though a year's sampling preceded the IFR assessment. Therefore, the field sampling programme made provision for two types of IFR sites:

Eight **"Routine" IFR sites** at which routine monitoring and distribution data were collected.

Three **"Super" IFR sites** at which data on channel morphology, habitat utilisation by macroinvertebrates and fish, and event-related water quality changes, were collected. IFR Sites 3, 5 and 7 were chosen as "Super" IFR sites (see below).

4.3 Location of IFR sites

IFR sites were selected in parts of the system with distinctly different hydrological and geomorphological characteristics. Such distinctions included major differences in flow volume, seasonal flow patterns, degree of perenniality or a confluence with another major river system. The following criteria were used to select the IFR sites:

- proximity to a DWA gauging station with a high-quality daily flow record;
- accessibility;
- proximity to human communities that depend on the river ecosystem for sustenance;
- degree of disturbance. The sites selected were as undisturbed as possible, so that clues on required flow regimes could still be gleaned from the natural distribution patterns of aquatic plants and animals;
- suitability for accurate hydraulic modelling of the full range of flows, but particularly of low flows;
- presence of critical habitats (those necessary for completion of life cycles) for riverine biotas, or flow-sensitive habitats such as riffles.

4.4 Description of the IFR sites

The locations of the IFR sites are shown on Figure 4.1 and the co-ordinates for each are provided below.

IFR SITE 1: Matsoku River at Seshote

This site represented the Matsoku River, downstream of the proposed Matsoku diversion weir to the confluence with the Malibamatso River.

Code: IFR Site 1.

Location: The reach was located upstream of Ha Nang village and slightly upstream of the footbridge crossing the river at this point.

General description: The reach was located in a steep valley, on a bend in the Matsoku River.

Co-ordinates: 29° 15' 21" S, 28° 33' 51" E.

Date of first visit: 27.11.97.

Substratum: The site was dominated by bedrock

protrusions, which in many cases extended across the full width of the macro-channel. Boulders and small to medium cobbles were scattered on top of the bedrock and between the protrusions. There were also occasional in-channel bars of very fine black sand. The banks of the macro-channel were composed mainly of bedrock and/or sand.

Canopy cover: None.

Channel shape: The channel was laterally confined by steep valley side walls. The channel was single, with a macro-channel of c. 20-m wide.

Bank shape: Stepped.

Predominant biotopes: Riffle/run sequences and occasional pools.

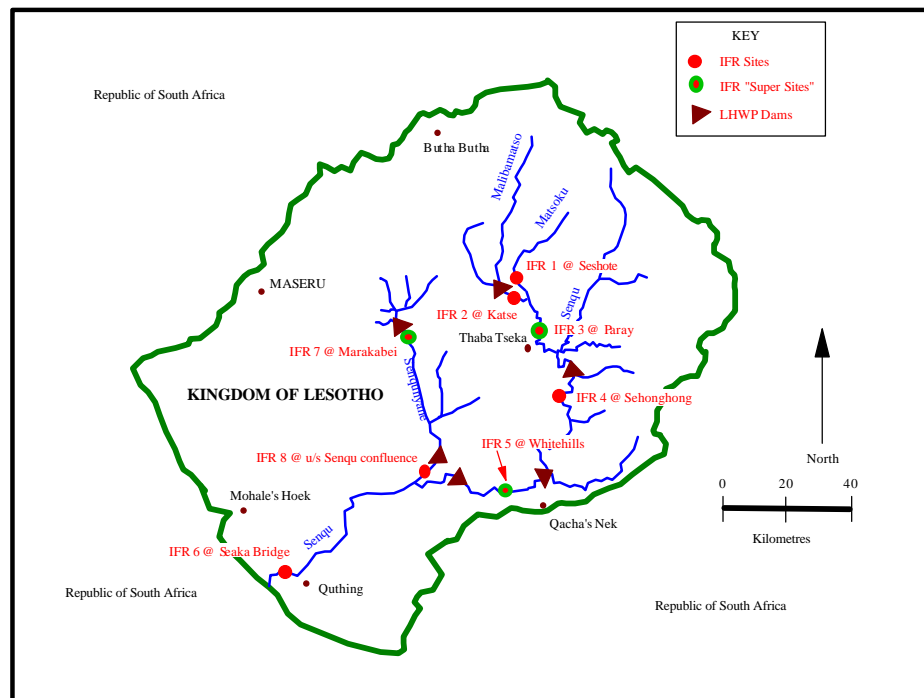


Figure 4.1 Location of the study rivers and the IFR sites for Contract LHDA 648

Instream vegetation: Algae and some floating rooted vegetation.

Riparian vegetation: The riparian vegetation was sparse, with only a few trees (*Salix* sp.) on the northern bank, which was the inside bend of the river. On the outside bend (southern bank), the banks had slumped. These slumped banks were topped with grass.

Water on 27 November 1997: Slightly turbid, with turbidity increasing during the visit. The main

source of the increased turbidity was later identified as an upstream culvert, draining an area where some construction work was being undertaken.

Major perturbations: The land on the northern bank was cultivated to within c. 10 m of the macro-channel. The entire catchment appeared to be very heavily grazed. There were also some localised perturbations as a result of ongoing construction activities on the Katse-Ficksburg road.

General land use: Cattle, sheep and goat farming.

Reasons for choosing this reach:

- It will be downstream of the proposed Matsoku Weir and upstream of the confluence with the Malibamatso River.
- Access to the Matsoku River downstream of this reach was extremely difficult during heavy rains.
- There was a footbridge within the reach, which allowed access to both banks during high flows.

IFR SITE 2: Malibamatso River at Katse Bridge

This site represented the Malibamatso River, downstream of Katse Dam to the confluence with the Matsoku River.

Code: IFR Site 2.

Location: The reach was located c. 1 km downstream of Katse Bridge and c. 2 km downstream of the Katse Dam wall.

General description: The reach was located in a steep valley, on a fairly straight section of the Malibamatso River.

Co-ordinates: 29° 21' 08" S, 28° 31' 32" E.

Date of first visit: 26.11.97.

Substratum: Boulder and cobble substratum. Also some fine sediments along the sides of the river and coating the boulders and cobbles.

Canopy cover: None.

Channel shape: The channel was laterally confined by steep valley side walls. The channel was single, with a macro-channel of c. 30-m in width.

Bank shape: Convex.

Predominant biotopes: Riffle/pool sequence.

Instream vegetation: Algae and *Phragmites australis*.

Riparian vegetation: The riparian vegetation was sparse.

Water on 27 November 1997: Turbid.

Major perturbations: There was some cultivation alongside the river. Also the effects of Katse Dam were very noticeable at this site, most particularly through the high sediment loads in the river, which were probably the result of erosion from the Katse Dam construction area. There were also definite signs of a reduction of water level at the site. For instance, some of the marginal vegetation had died and there was a c. 20-cm gap between the wetted channel and the inner edge of the riparian

vegetation. This gap had been partially colonised by annual plants.

General land use: Cattle, sheep and goat farming.

Main reasons for choosing this reach:

- It was downstream of Katse Dam.
- It was easily accessible and provided an excellent opportunity to study the immediate effects of Katse Dam on the river.
- The riparian vegetation was in fairly good condition and provided an excellent baseline dataset for monitoring the response of the vegetation to dam-related changes.

IFR SITE 3: Malibamatso River at Paray (SUPER SITE)

This site represented the Malibamatso River, between the confluence with the Matsoku River and the confluence with the Senqu River.

Code: IFR Site 3.

Location: The reach was located immediately downstream of the DWA gauging tower at Paray and c. 1 km downstream of the footbridge that crosses the river at Paray.

General description: The reach was located in a steep valley, on a fairly straight section of the Malibamatso River.

Co-ordinates: 29° 29' 52" S, 28° 39' 04" E.

Date of first visit: 25.11.97.

Substratum: There were two distinct stretches within the reach. The first (upstream of the DWA Tower) had a predominately sand substrate. The second (downstream of the DWA Tower) was dominated by bedrock, with some boulders and cobbles. The cobble in the downstream section was embedded in fine sediments. Both stretches were included in all subsequent data collection.

Canopy cover: None.

Channel shape: The channel was laterally confined by steep valley side walls. The channel was single, with a macro-channel of c. 40-m in width. There was evidence of an old flood channel c. 500 m upstream of the DWA gauging tower.

Bank shape: Shallow and convex.

Predominant biotopes: The reach offered a range of habitats, including sand runs and in-channel bars, riffles, rapids and pools.

Instream vegetation: Algae.

Riparian vegetation: Very few riparian trees. However some of the smaller species (such as the

shrub, *Rhus* sp. and the sedge, *Scirpus* sp.) could be used for studying flow-related aspects of the vegetation component of the study.

Water on 25 November 1997: Slightly turbid.

Major perturbations: There was some cultivation alongside the river.

General land use: Cattle, sheep and goat farming.

Main reasons for choosing this reach:

- It was downstream of the confluence between the Matsoku and Malibamatso Rivers.
- DWA collect hydrological data here.
- Although access was extremely difficult, the surrounding catchment at Paray and the reach itself appeared to be less impacted than an alternative site near Ha Leoka.
- The riparian vegetation was in fairly good condition.

IFR SITE 4: Senqu River at Sehonghong

This site represented the Senqu River, from the confluence with the Malibamatso River to the confluence with the Tsoelike River.

Code: IFR Site 4.

Location: The reach was located downstream of the footbridge crossing the Senqu River at Sehonghong.

General description: The reach was located in a steep valley, on a fairly straight section of the Senqu River. The surrounding catchment had far fewer bushes and trees than seen in the north of the study area.

Co-ordinates: 29° 44' 20" S, 28° 45' 19" E.

Date of first visit: 26.11.97.

Substratum: Sand, with small sections of cobble and boulders associated with the mouths of the small tributaries entering the main river.

Canopy cover: None.

Channel shape: The channel was laterally confined by steep valley side walls. Although the selected reach was situated on a fairly straight section of the Senqu River, in general the river is sinuous, winding between high hills. In the upstream parts of the reach, the channel was wide (c. 60 m), with numerous in-channel sand bars, which appear to be a feature of this section of the river. In the downstream sections of the river, the macro-channel was narrower (c. 40 m) and there was a wide (c. 50 m) flood channel on the eastern side of the river.

Bank shape: Stepped.

Predominant biotopes: The reach was dominated by slow sand runs, which flowed between wide sandbanks. There were, however, small sections of riffle associated with the tributaries.

Instream vegetation: None.

Riparian vegetation: The riparian vegetation in this reach was very sparse, although there were small patches of shrubs and trees associated with the numerous tributaries, which joined the main river.

Water on 26 November 97: Turbid.

Major perturbations: There was some cultivation alongside the river and the entire catchment had been very heavily grazed. There was also a considerable quantity of litter strewn along the river.

General land use: Cultivated fields. Cattle, sheep and goat farming.

Main reasons for choosing this reach:

- It was downstream of the proposed Mashai Dam.
- It was easily accessible and appeared to be representative of the Senqu River downstream of its confluence with the Malibamatso River. A reach further upstream, near Taung/Koma Koma, was rejected because it was dominated by bedrock protrusions, which appeared to be uncharacteristic of this section of the river as a whole.
- There was a footbridge to facilitate crossing the river during high flows.

IFR SITE 5: Senqu River at Whitehills (SUPER SITE)

This site represented the Senqu River, downstream of the proposed Tsoelike Dam to the confluence with the Senquyane River.

Code: IFR Site 5.

Location: The reach was located on the Senqu River alongside the road, downstream of Tebellow and upstream of Sekake.

General description: The reach was located on a curve in the river, between two small tributaries. The reach was very similar in character to that at Sehonghong.

Co-ordinates: 30° 03' 56" S, 28° 24' 28" E.

Date of first visit: 28.11.97.

Substratum: Sand, with small sections of cobble and boulders.

Canopy cover: None.

Channel shape: The channel was laterally confined by steep valley side walls. The channel was single, with a macro-channel of c. 30-m in width.

Bank shape: Steep and stepped.

Predominant biotopes: Riffle/pool sequence.

Instream vegetation: None.

Riparian vegetation: The riparian vegetation was sparse, however, there were several sections of reeds and some larger trees.

Water on 26 November: Turbid.

Major perturbations: There was some cultivation alongside the river and the entire catchment had been very heavily grazed.

General land use: Cultivated fields. Cattle, sheep and goat farming.

Main reasons for choosing this reach:

- It will be downstream of the proposed Tsoelike Dam.
- It appeared to be representative of the river in this section.
- There was a short riffle within the reach.
- It was accessible.

IFR SITE 6: Senqu River at Seaka Bridge

This reach is intended to represent the Senqu River, downstream of the confluence with the Senqunyane River to the Lesotho-South African border. It is downstream of all the LHWP Dams.

Code: IFR Reach 6.

Location: The reach was located on the Senqu River alongside the dirt road leading to Seaka Bridge.

General description: The reach was located on a relatively straight section of the river, within a very wide valley.

Co-ordinates: 30° 22' 11" S, 27° 34' 21" E.

Date of first visit: 27.11.97.

Substratum: Sand.

Canopy cover: None.

Channel shape: The channel was entrenched within a wide, flat valley floor. The channel was single, with a macro-channel of c. 100-m in width, with nearly vertical banks. The in-channel sandbanks were sparsely vegetated with grass.

Bank shape: Near vertical, c. 15 m high.

Predominant biotopes: Deep, slow runs.

Instream vegetation: None.

Riparian vegetation: Patches of dense shrubs and trees.

Water on 27 November 1997: Very turbid (dark red).

Major perturbations: There was some cultivation along the eastern bank and the entire catchment had been very heavily grazed. There was a road running along the western bank – above the flood line.

General land use: Cultivated fields. Cattle, sheep and goat farming.

Main reasons for choosing this reach:

- It will be downstream of all the proposed LHWP Dams.
- It appeared to be representative of the river in this section.
- There was bridge to facilitate crossing the river at high flows.
- There was a DWA gauging weir at Seaka Bridge.
- It was accessible.

IFR SITE 7: Senqunyane River at Marakabei (SUPER SITE)

This site represented the Senqunyane River, downstream of the proposed Mohale Dam to the confluence with the Lesobeng River.

Code: IFR Reach 7.

Location: The reach was located on the Senqunyane River c. 1 km upstream of the DWA gauging weir.

General description: The reach was located on a curve in the river, within a narrow, steep valley.

Co-ordinates: 29° 32' 09" S, 28° 09' 15" E.

Date of first visit: 24.11.97.

Substratum: Small and medium cobbles. Some bedrock slabs extending across the river. Occasional beaches of fine sand. The cobble was also quite embedded and a fine layer of sediment coated the boulders and cobbles.

Canopy cover: None.

Channel shape: The channel was laterally confined by steep valley side walls. The channel was single, with a macro-channel of c. 30-m in width. Two major seeps entered from the western bank. On the western bend of the river were remnants of a secondary or flood channel.

Bank shape: The banks were predominately convex. There were occasional small cliffs along the western bank. The eastern bank was shallow, with cultivated field extending into the floodplain in places.

Predominant biotopes: Riffles alternating with pools and runs.

Instream vegetation: Some submerged sedges.

Riparian vegetation: Clear sedge (e.g. *Scirpus* sp.), shrub (e.g. *Rhus* sp.) and tree bands (e.g. *Salix* sp.), which provided excellent clues for predicting/monitoring flow-related changes in vegetation.

Water on 24 November 1997: Slightly turbid.

Major perturbations: There was some cultivation along the eastern bank and the entire catchment had been very heavily grazed.

General land use: Cultivated fields. Cattle, sheep and goat farming.

Main reasons for choosing this reach:

- It was downstream of the proposed Mohale Dam.
- It was representative of the river in this section.
- There was a bridge to facilitate crossing the river at high flows.
- There was a DWA gauging weir at Marakabei Bridge.
- It was accessible.

IFR SITE 8: Senqunyane River near confluence with the Senqu

This site represented the Senqunyane River, downstream of the confluence with the Lesobeng River to the confluence with the Senqu River.

Code: IFR Reach 8.

Location: The reach was located on the Senqunyane River c. 1 km upstream of the confluence with the Senqu River.

General description: The reach was located on a curve in the river, within a narrow, steep valley.

Co-ordinates: 30°02'11"S, 27°34'21"E.

Date of first visit: 24.04.98.

Substratum: Sand and small cobbles.

Canopy cover: None.

Channel shape: The channel was laterally confined by steep valley side walls.

Bank shape: The banks were gentle except on the outside of the river bend, where they were almost vertical.

Predominant biotopes: Runs, alternating with pools and occasional riffles.

Instream vegetation: None.

Riparian vegetation: Sparse.

Water on 24 April 1998: Clear.

Major perturbations: There was some cultivation along the eastern bank and the entire catchment had been very heavily grazed.

General land use: Cultivated fields. Cattle, sheep and goat farming.

Main reasons for choosing this reach:

- It was downstream of the proposed Mohale Dam.
- It was representative of the river in this section.
- It was accessible except during high flows and/or rain.

5 SOCIAL VILLAGES/REACHES

The socio-economic study comprised four inter-linked data collection exercises, namely:

- 1 a pilot sociological and anthropological survey of eight villages to delineate the Population at Risk (PAR) along the study rivers;
- 2 a detailed survey consisting of 1,680 household interviews, distributed over 32 clusters, each represented by one the eight IFR river reaches, to quantify all recognised aspects of river-use and concern as well as public and animal health issues;
- 3 an assessment of the records of nine clinics and one hospital.
- 4 a survey of woolsheds in the study area.

5.1 Pilot study

The eight villages surveyed in the pilot sociological survey were (see Report No. 648-F-08):

- Ha Soai at the confluence of the Matsoku and Malibamatso Rivers;
- Koma-koma village on the Senqu River (north);
- Ha Noha village (Marakabei) and Ha Motenalapi village (Semonkong) on the Senqunyane River;
- Auplaas village, Ha Sekake, Ha Koali village (Mt Moorosi) and Ha Ramatlalla village (Alwynskop) on the Senqu River (south).

5.2 Detailed study

For the detailed socio-economic study, the study area was divided into the same eight river reaches as for the biophysical study (see Section 4). A corridor of 5-km either side of the river (i.e., a total of 10 km width) was demarcated for each river reach and randomly-selected villages within this corridor were visited. Two hundred and ten household responses were gathered from villages within each reach. In total 144 villages were visited during the socio-economic survey, and

1680 responses to the questionnaires were gathered. For further details see Report No. LHDA 648-F-08.

5.3 Clinics

The nine clinics and one hospital used in the public health survey were (see Report No. 648-F-09):

- Seshote Clinic (near IFR 1);
- Khohlo-Ntso Clinic (near IFR 2);
- Paray Hospital (near IFR 3);
- Mohlanapeng Clinic and Sehonghong Clinic (near IFR 4);
- Sekake Clinic (near IFR 5);
- Mount Moorosi Clinic, Phamong Clinic, Holy Cross Clinic (near IFR 6), and;
- Marakabei Clinic (near IFR 7).

6 LOCATION OF THE GAUGING WEIRS IN RELATION TO IFR SITES

The location of reliable hydrological gauging stations was at least as important a consideration as the location of IFR sites and villages. This is because the biophysical data collected during the study had to be linked to flow in the rivers, either directly or indirectly. Table 6.1 provides a list of the hydrological gauging weirs that were used, an indication of the reliability of the data from each weir, and the biophysical IFR sites to which they were linked. For further details see Report No. LHDA 648-F-13.

7 THE LHWP DAMS THAT WILL AFFECT EACH OF THE IFR SITES, SOCIAL REACHES AND CLINICS

The proposed LHWP dams, their location, proposed date of completion and the IFR sites (and the reaches they represent) and social reaches that each will affect are provided in Table 7.1.

Table 6.1 Gauging weirs located near to IFR sites, and an indication of the quality of the data obtainable from those weirs.

Site	Gauging weir number	Reliability of the data
IFR 1	G42 (Seshote)	Good
IFR 2	G41 (Bokong) and Katse Dam	Fair
IFR 3	G08 (Paray)	Good
IFR 4	G05 (Koma-koma)	Good
IFR 5	G04 (Whitehills)	Good
IFR 6	GO3 (Seaka)	Fair
IFR 7	G17 (Marakabei)	Good
IFR 8	G32 (Nkhaus).	Very poor

Table 7.1 The proposed LHWP dams, their location, proposed date of completion and the IFR sites, social reaches and clinics that each will affect.

Proposed dam	LHWP Phase	River	Proposed date of completion	IFR sites/Reaches affected	Social reaches	Study clinics affected
Katse (extant)	Phase 1a	Malibamatso	Completed 1995	IFR 2, 3, 4, 5 and 6	1/2/3; 4/5 and 6	Khohlo-Ntso, Paray Hospital, Mohlanapeng, Sehonghong, Sekake, Mount Moorosi, Phamong and Holy Cross
Matsoku	Phase 1b	Matsoku	2000	IFR 1, 3, 4, 5 and 6.	1/2/3; 4/5 and 6	Seshote, Paray Hospital, Mohlanapeng, Sehonghong, Sekake, Mount Moorosi, Phamong and Holy Cross
Mohale	Phase 1b	Senqunyane	2005	IFR 7, 8 and 6. Also may affect IFR 5 reach.	7 and 8	Marakabei, Mount Moorosi, Phamong, Holy Cross and Marakabei
Mashai	Phase 2	Senqu	2008	IFR 4, 5 and 6. Also would inundate IFR 3 and 2.	4/5 and 6	Mohlanapeng, Sehonghong, Sekake, Mount Moorosi, Phamong and Holy Cross
Tsoelike	Phase 3	Senqu	After Phase 2	IFR 5 and 6. Also would inundate IFR 4.	4/5 and 6	Sekake, Mount Moorosi, Phamong and Holy Cross
Ntaohae	Phase 4	Senqu	After Phase 3	IFR 6. Also would inundate IFR 5.	6	Mount Moorosi, Phamong and Holy Cross
Malatsi	Phase 5	Senqunyane	After Phase 4	IFR 6. Also would inundate most of IFR 8.	6	Mount Moorosi, Phamong and Holy Cross

**SECTION 4:
HABITAT INTEGRITY ASSESSMENT**

8 HABITAT INTEGRITY ASSESSMENT

The term *Habitat Integrity*, as used here, refers to a measure of the number and severity of anthropogenic perturbations on a river and the damage they potentially inflict on the system. These disturbances include abiotic factors, such as water abstraction, weirs, dams, pollution and dumping of rubble, and biotic factors, such as the presence of alien plants and animals. Habitat Integrity is defined as the ability of a river to support and maintain a balanced, integrated composition of physical, chemical and other habitat characteristics (Kleynhans 1996). An assessment of Habitat Integrity is made at the beginning of an Instream Flow Assessment to provide the IFR specialists with a general overview of the condition of the study rivers.

8.1 Habitat Integrity assessment method

The procedure used here, in the collation and interpretation of data and the final assessment of Habitat Integrity of the Lesotho rivers, is essentially that of Kleynhans (1996). The procedure involves the following steps:

1. Separate assessments of Instream Habitat Integrity and Riparian Zone Habitat Integrity of each site are made according to a number of key impacts (Table 8.1).

2. An assessment of the severity of each impact is made on an eleven-point (0-10) scale with 0 indicating no impact, and 10 an extremely severe impact (Table 8.2).
3. A rating system (Table 8.1) based on differing weights for each impact (according to its perceived impact on Habitat Integrity) is used to assess the Habitat Integrity for the instream and riparian components of the river.
4. The final value assigned to each impact is calculated as follows:

$$\frac{\text{score}}{\text{maximum value}} \times \text{weight (\%)}$$

where the maximum value in this case = 10.

5. The sum of these ratings is used to classify the instream and riparian components according to a descriptive Habitat Integrity class (Table 8.3).
6. The Overall Habitat Integrity is determined by averaging the results for the instream and riparian components.

Table 8.1 Weights of impacts used for the assessment of instream and riparian zone Habitat Integrity. Highest weights are given to impacts deemed to have the most deleterious impacts.

Instream impacts	Weight	Riparian zone impacts	Weight
Water abstraction	14	Indigenous vegetation removal	13
Flow modification	13	Exotic vegetation encroachment	12
Bed modification	13	Bank erosion	14
Channel modification	13	Channel modification	12
Water quality	14	Water abstraction	13
Inundation	10	Inundation	11
Exotic macrophytes	9	Flow modification	12
Exotic fauna	8	Water quality	13
Solid waste	2		

Table 8.2 Summary of the scores used to describe the severity of each impact.

SCORE	RATING	DESCRIPTION
0	None	no discernible impact, or the factor is located in such a way that it has no impact
1-2	Small	the factor is limited to a few localities and the impact is also very small
3-4	Moderate	the factor is present at a small number of localities and the impact is limited
5-6	Large	the factor is generally present with a clearly detrimental impact; large areas are, however, not influenced
7-8	Serious	the factor is frequently present and almost the whole of the defined section is impacted; only small areas are not influenced
9-10	Critical	the factor is present over the whole of the defined section with a high intensity; the whole of the defined section is detrimentally influenced

Table 8.3 Habitat Integrity assessment classes.

Class	Description	Score (% of natural)
A	Unmodified, natural	100
B	Largely natural with few modifications. A small change in natural habitats and biota may have occurred but ecosystem functions appear unchanged.	80-99
C	Moderately modified. A loss and change of natural habitat and biota have occurred but the basic ecosystem functions are still predominately unchanged.	60-79
D	Largely modified. A loss of natural habitat, biota and basic ecosystem functions are assumed to have occurred.	40-59
E	The loss of natural habitat, biota and basic ecosystem functions is extensive.	20-39
F	Modifications have reached a critical level and the river has been modified completely with an almost complete loss of natural habitat and biota. In the worse instances, basic ecosystem functions have been destroyed and the changes are irreversible.	0-19

8.2 Information used in the Habitat Integrity assessment

The following information sources were used in compiling this report:

- a video filmed during a low-level helicopter survey conducted by Southern Waters in May 1992. This survey was based on numbered 5-km sectors of the study rivers and was conducted in a downstream direction. The following sections of rivers were filmed:
 - Matsoku River from the village of Seshote to the confluence with the Malibamatso River;
 - Malibamatso River from Katse Dam to the confluence with the Senqu River;
- Senqu River, from the confluence between the Malibamatso and Senqu Rivers to the Lesotho-South African border;
- Senqunyane River from upstream of the proposed Mohale Dam to the confluence with the Senqu River.
- notes taken during the above and another later helicopter flights along the study rivers;
- field notes and observations during the preliminary IFR Reach selection trip in November 1997 (see Task 1 Report);
- preliminary results from the water-quality sampling programme, used to rate the water

- quality in the study rivers in terms of the deviation from natural;
- previous studies of the rivers associated with the LHWP, used to assess the condition of the rivers within the study area;
- the CSIR/ARC National Landcover Database.

Opinions and general information on the condition of the rivers were also obtained through discussions with Dr C. Boucher (University of Stellenbosch), Ms. J. Hughes (Afridev subconsultant), Mr T. Lepono (Senqu Consultants), Ms. V. Queku (LHDA), Dr H. Sabet (Metsi Consultants), Mr R. Skoroszewski (Senqu Consultants), and Ms. S. Tlale (Senqu Consultants).

8.3 River reaches assessed

Usually, habitat integrity assessments are based on the rating of individual 5-km sectors (Kleynhans 1996). This approach allows the identification of particular problems in a specific 5-km sector. In the case of the Lesotho Rivers, however, the length of the rivers and the relative paucity of information on them made it more feasible to do the assessment according to specific river reaches. The Habitat Integrity (HI) reaches chosen correspond with the IFR Reaches. The following HI reaches were identified:

- HI Reach 1: **Matsoku River** from the village of Seshote to the confluence with the Malibamatso River;
- HI Reach 2: **Malibamatso River** from Katse Dam to the confluence with the Matsoku River;
- HI Reach 3: **Malibamatso River** from the confluence with the Matsoku River to the confluence with the Senqu River;
- HI Reach 4: **Senqu River** from confluence with the Malibamatso River to the confluence with the Tsoelike River;

HI Reach 5: **Senqu River** from the confluence with the Tsoelike River to the confluence with the Senqunyane River

HI Reach 6: **Senqu River** from the confluence with the Senqunyane River to the Lesotho/South African border;

HI Reach 7: **Senqunyane River** from Mohale Dam to the confluence with the Lesobeng River. The current construction activities in the vicinity of Mohale have had an impact on the river, and are assessed separately (as Reach 7a) from the remaining parts of the reach (Reach 7b) in Tables 8.4 and 8.5.

HI Reach 8: **Senqunyane River** from the confluence with the Lesobeng River to the confluence with the Senqu River.

8.4 Results

Scores for the perceived impact of various instream and riparian modifications to Habitat Integrity are provided in Tables 8.4 and 8.5, respectively. The overall Habitat Integrity classes for each reach are listed below. These assessments are subjective and are intended only to provide a first estimate of the condition of the rivers within the study area.

HI Reach 1: Matsoku River from the village of Seshote to the confluence with the Malibamatso River

Length of river described by HI Reach: 30 km

Instream Habitat Integrity: CLASS B

Riparian Habitat Integrity: CLASS B

Overall Habitat Integrity: CLASS B.

Table 8.4 Subjective scores for the impact of various instream modifications to Habitat Integrity. Impact are scored from 0 – 10, with 0 = most natural.

Reach	Instream Habitat Integrity	Abstraction	Water Quality	Altered Floods	Altered lowflows	Bed modifications	Channel modifications	Extent of unnatural inundation
Reach 1	95.6 %	0	2	0	0	0	0	0
Reach 2	43.0 %	10	5	10	10	0	5	8
Reach 3	71.0 %	8	3	8	8	0	0	0
Reach 4	78.6 %	5	4	5	5	0	0	0
Reach 5	80.1 %	4	4	4	4	0	0	0
Reach 6	83.1 %	3	4	3	3	0	0	0
Reach 7a	88.6 %	0	4	0	0	1	1	0
Reach 7b	92.6 %	0	3	0	0	0	0	0
Reach 8	92.6 %	0	3	0	0	0	0	0

Table 8.5 Subjective scores for the impact of various riparian modifications to Habitat Integrity. Impact are scored from 0 – 10, with 0 = most natural.

Reach	Riparian Habitat Integrity	Waste	Removal	Encroach-ment	Floods	Lowflow	Channel	Inundation	Abstraction	Erosion
1	83.1 %	0	4	3	0	0	0	0	0	4
2	35.6 %	0	5	3	10	10	8	8	8	4
3	59.8 %	0	5	3	8	8	0	0	8	4
4	73.2 %	0	4	4	5	5	0	0	2	4
5	74.7 %	0.5	5	4	4	4	0	0	0	4
6	75.4 %	0	5	3.5	3	3	0	0	0	5
7a	78.6 %	0	5	3	0	0	1	0	0	5
7b	83.1 %	0	4	3	0	0	0	0	0	4
8	86.2 %	0	3	3	0	0	0	0	0	3

HI Reach 2: Malibatso River from Katse Dam to the confluence with the Matsoku River

Length of river described by HI Reach: 20 km

Instream Habitat Integrity: CLASS D

Riparian Habitat Integrity: CLASS D

Overall Habitat Integrity: CLASS D.

HI Reach 3: Malibatso River from the confluence with the Matsoku River to the confluence with the Senqu River

Length of river described by HI Reach: 35 km

Instream Habitat Integrity: CLASS C

Riparian Habitat Integrity: CLASS C

Overall Habitat Integrity: CLASS C.

HI Reach 4: Senqu River from confluence with the Malibatso River to the confluence with the Tsoelike River

Length of river described by HI Reach: 125 km

Instream Habitat Integrity: CLASS B

Riparian Habitat Integrity: CLASS C

Overall Habitat Integrity: CLASS C.

HI Reach 5: Senqu River from the confluence with the Tsoelike River to the confluence with the Senqunyane River

Length of river described by HI Reach: 85 km

Instream Habitat Integrity: CLASS C

Riparian Habitat Integrity: CLASS C

Overall Habitat Integrity: CLASS C.

HI Reach 6: Senqu River from the confluence with the Senqunyane River to the Lesotho/South African border

Length of river described by HI Reach: 140 km

Instream Habitat Integrity: CLASS C

Riparian Habitat Integrity: CLASS C

Overall Habitat Integrity: CLASS C.

HI Reach 7a: Senqunyane River from Mohale Dam to Ha Mohau

Length of river described by HI Reach: 10 km

Instream Habitat Integrity: CLASS B

Riparian Habitat Integrity: CLASS C

Overall Habitat Integrity: CLASS B.

HI Reach 7b: Senqunyane River from Ha Mohau to the confluence with the Lesobeng River

Length of river described by HI Reach: 80 km

Instream Habitat Integrity: CLASS B

Riparian Habitat Integrity: CLASS B

Overall Habitat Integrity: CLASS B.

HI Reach 8: Senqunyane River from the confluence with the Lesobeng River to the confluence with the Senqu River

Length of river described by HI Reach: 40 km

Instream Habitat Integrity: CLASS B

Riparian Habitat Integrity: CLASS B

Overall Habitat Integrity: CLASS B.

8.5 Discussion

Apart from the impacts of Katse Dam, which appeared high, particularly in the stretch of river immediately downstream of the dam, the rivers within the study area were relatively undisturbed. There was considerable evidence of cultivation alongside the rivers, but this was usually of a low intensity and usually was not associated with any irrigation system, as water abstraction from the main rivers is negligible. Thus, as a first impression, apart from Katse Dam, the three primary impacts on the habitat integrity of the rivers appeared to be:

- erosion from the surrounding catchments;
- removal or cutting of riparian trees; and
- the presence of alien fish species in the systems.

In some places, e.g., Sehonghong, tributaries of the main rivers were used for waste disposal. This resulted in household and other litter being washed into the main rivers during floods. However, for the most part the rivers were free of litter and other visible waste materials.

Finally, it is stressed that this assessment was a preliminary one, based on subjective assessments of available information. It was intended only to provide initial orientation of the relative condition of different rivers within the study area.

SECTION 5: STUDY TEAM AND ORGANISATION

9 PROJECT TEAM AND ORGANISATION

9.1 Project management

The management team from Metsi Consultants consisted of the following members:

Dr Jackie King	Project Director;
Dr Hossein Sabet	Project Manager;
Dr Cate Brown	IFR Process Coordinator.

9.2 Office support

Administrative support was provided by the following people:

In Maseru, Lesotho:

Ms Elizabeth Mohale	Accountant;
Ms Mary Moletsane	Receptionist/Typist;
Mr Maphathe Mahasane	Driver;
Ms Esther Ratia	Office Orderly;
Ms 'Maneo Qheku	Office Orderly.

In Cape Town, South Africa:

Ms Rosalyn Townsend Office manager.

In Cooma, Australia:

Mr Tony Mcleod

9.3 Specialist team

The disciplines represented on the LHDA 648 team, and the names, organisations and email addresses of the specialists that were responsible for each discipline are provided in Table 9.1.

Each of the biophysical disciplines was undertaken by two specialists, which allowed for a cross-pollination of ideas and experience. Where possible and appropriate, specialists with extensive experience in environmental flow assessments were linked with local specialists in the same field, who had experience and knowledge of Lesotho rivers.

9.4 Metsi Internal Advisor

Prof. Barry Hart from Monash University in Australia was appointed by Metsi as the Internal Advisor. Prof. Hart participated in all phases of the biophysical study, reviewed all the draft reports produced during the study

and attended the major meetings of the specialist team. His advice was also sought before major decisions were made on technical and scientific aspects of the project.

9.5 Team communications

In order to facilitate communication between team members, an email circuit was set up for the duration of the project. The circuit was used to distribute project updates and general information. During the 25 months of the project, a total of:

- 16 update letters;
- 2 information packages;

were sent to the project team. In addition, the team received drafts of all the relevant reports for comment.

10 INTERFACE WITH LHDA

10.1 LHDA project supervision

Mr David Nkalai was the Designated LHDA Supervisor for Contract LHDA 648. Dr Stan Hirst was the Interim Technical Supervisor, and the main channel of communication between LHDA and the Consultant. However, Dr Hirst left LHDA mid-way through the project and Mr Nkalai assumed his duties. The Steering Committee, which was responsible for overseeing the project implementation, includes representatives of:

- GM Highlands Services Group (Chairman)
- South African Department of Water Affairs and Forestry
- National Environmental Secretariat, Lesotho
- Joint Project Technical Commission LHDA, Operation and Maintenance Group
- LHDA, Engineering Group.

10.2 Staff secondment from the Employer to the Consultant

LHDA seconded the following staff members to the Consultant from time to time:

Ms Victoria Qheku	Limnologist.
Mr Mahase Thokoa	Biologist.
Mr Ndamase Matshikiza	Hydrologist.

Table 9.1 Disciplines represented on the IFR Team and the names, organisations and contact addresses of the specialists that were responsible for each discipline

Disciplines	Specialists	Institution/Company	Country	Email address
Project Director	Dr J.M. King	Southern Waters	SA	Jking@botzoo.uct.ac.za
Project Manager	Dr H. Sabet	SMEC	Australia	Smec@lesoff.co.za
IFR Process Co-ordinator	Dr C. Brown	Southern Waters	SA	Cbrown@botzoo.uct.ac.za
Internal Advisor	Prof. B Hart	Monash University	Australia	Barry.Hart@sci.monash.edu.au
IFR Data Management	Dr E. Day R. Tharme G. Howard P. Jansens	Southern Waters Southern Waters Ninham Shand SoftCraft Systems	SA SA SA SA	Cbrown@botzoo.uct.ac.za Rtharme@botzoo.uct.ac.za Gjh@iafrica.com Pierre@softcraft.co.za
Hydrology (incl: Yield analysis)	Dr H. Sabet S. Yance	SMEC SMEC	Australia Australia	Smec@lesoff.co.za Hywtr@smec.com.au
Hydraulics	A. Birkhead Dr V. Alavian	Streamflow Consultants RANKIN	SA USA	streamflow@icon.co.za Rankin@usit.net
Sedimentology Geomorphology	Prof A. Rooseboom Dr M. Thoms	Stellenbosch Univ. Canberra Univ	SA Australia	Ar2@maties.sun.ac.za Thoms@science.canberra.edu.au
Habitat Integrity	Dr C. Brown	Southern Waters	SA	Cbrown@botzoo.uct.ac.za
Habitat Mapping	Dr J.M. King	Southern Waters	SA	Jking@botzoo.uct.ac.za
Chemistry (water quality)	R. Skoroszewski Dr C. Palmer	Senqu Consultants Rhodes University	SA SA	Robskoro@iafrica.com Tally@iwr.ru.ac.za
Botany	Dr C. Boucher S. Tlale	Stellenbosch University Senqu Consultants	SA Lesotho	Cb@land.sun.ac.za senqu@ilesotho.com
Macroinvertebrate ecology	Dr F. de Moor R. Skoroszewski	Albany Museum Senqu Consultants	SA SA	Amfd@warthog.ru.ac.za Robskoro@iafrica.com
Ichthyology (fish)	Prof. A. Arthington J. Rall M. Kennard	Griffith University Ecosun Griffith University	Australia SA Australia	A.Arthington@mailbox.gu.edu.au Rall@global.co.za Kennard@mailbox.gu.edu.au
Wildlife ecology	Dr S. Ferreira	Private Consultant	SA	sferreira@doc.govt.nz
Herpetofauna	Dr N. Jacobsen	Private Consultant	SA	P.O. Wilderness, Cape.
Sociology	C. Boehm J. Gay	Sechaba Consultants Sechaba Consultants	Lesotho Lesotho	Sechaba@lesoff.co.za Sechaba@lesoff.co.za
Public Health	Dr R. Phillips	Medical Research Council	SA	rose.phillips@mrc.ac.za
Animal Health	Dr D. Phororo	Private Consultant	Lesotho	
Water Supply	S. Yance	SMEC	Australia	Hywtr@smec.com.au
Economics	Dr M. Majoro	University of Lesotho	Lesotho	Majoro@econ.nul.ls

10.3 Interface with the LHDA Panel of Experts

A three-member international Panel of Experts (POE) was appointed by LHDA specifically to review Contract LHDA 648. The members of the POE were:

Dr Jane Doolan Australia;
Prof. Tom McMahon Australia;
Dr Mike Mentis South Africa.

The POE interfaced with the Consultant at various stages of project implementation. These interactions included the following:

- The POE attended a presentation of the Inception and the Task 1 Reports in January 1998.
- Dr Mike Mentis attended the IFR Planning Meeting in April 1998.
- The POE attended the IFR workshop in April 1999.
- Dr Jane Doolan and Dr Mike Mentis attended the socio-economic scenario workshop in September 1999.

- Dr Jane Doolan and Dr Mike Mentis attended the monitoring workshops in September 1999.
- The POE received copies of all reports produced during the project, including all internal team documents (see Section 5), and provided comment to the Consultant on all of these.

In addition to the IFR Panel of Experts appointed for the contract, the LHWP has a permanent Panel of Experts comprising international experts from the various field represented in the project. This panel, of which Dr Mentis is a member, regularly reviews all aspects of the LHWP. The panel includes environmental, social, engineering and economic experts. This project, LHDA 648 benefited greatly from the advice of members of the LHWP Panel of Experts, most particularly that of Prof. Ted Scudder.

SECTION 6: OVERALL PROJECT STRUCTURE AND PROGRAMME OF EVENTS

11 THE OVERALL PROJECT STRUCTURE

A schematic showing the overall plan adopted for LHDA 648 is presented in Figure 11.1. Each of the numbered steps in Figure 11.1 is detailed in one of the project reports, as follows:

1. Identification of the Population At Risk (PAR): Determined through a pilot social and anthropological survey – Report No. 648-F-08.
2. Qualification and quantification of river resources being used by the PAR: The qualification of the resources was partially completed through a pilot sociological survey and confirmed and quantified through a detailed survey – Report No. 648-F-08.
3. Social input on river resources being used. This information is detailed in Report No. 648-F-08. However, in order to facilitate the fast-tracking of information, sociological specialists attended the IFR Workshop (see Step 11), where they gave input on the uses being made of the river, and ensured that the biophysical specialists addressed all issues of social concern.
4. Health Impact Assessment for PAR: - Report No 648-F-09.
5. Public Health and Animal Health input of health issues related to river regulation. These are detailed in Report Nos 648-F-09 and 10. However, as explained in 3 above, the specialists attended the IFR Workshop.
6. Water use and supply: Report No 648-F-11.
7. Economic assessment of current value: This was accomplished using information from the detailed social survey, but is reported on in Report No 648-F-22 (and see point 14 below).
8. Preliminary characterisation of rivers and selection of eight IFR sites: This report.
9. Representativeness of and extrapolation from IFR sites: Developing predictive capacity: Each component of the riverine ecosystem was addressed individually. Data were collected over a full hydrological year. Results and conclusions from all the biophysical specialists are provided in Reports No 648-F-12 to 19.
10. IFR Workshop to identify ecosystem consequences for different flow regimes: The methods using in the Biophysical IFR Workshop

are detailed in Volume 2 of this report – Report No 648-F-03.

11. Development of four scenarios each linking an alternative flow regime with ecosystem condition: The methods used to develop the scenarios are detailed in Volume 2 of this report – Report No 648-F-03. The biophysical consequences of each scenario are given in Reports No 648-F-04 to 07.
12. Social consequences of each scenario (including mitigation where possible): The social consequences were determined independently by the specialists and then verified at the Sociological Scenario Workshop – Report No 648-F-21.
13. Yield analysis: - Report No 648-F-20.
14. Economic assessment of each scenario, if necessary with mitigation and/or compensation: - Report No 648-F-22.
15. Design of the Monitoring Programme: The Monitoring programme was designed at the Monitoring Design Workshop – Report No 648-F-23.
16. Final Report: The Final Report contains a summary of the salient details of the other project reports - Report No 648-F-02.

The final products of Contract LHDA 648 are four flow scenarios for the study rivers, each of which details (see Report No 648-F-02):

1. A *modified flow regime* for the aquatic ecosystem.
2. The *biophysical changes* expected in the aquatic ecosystem with the flow regime.
3. The *social impacts* expected as a result of the predicted biophysical changes
4. The economic implications of the *social impacts*.
5. A list of other concerns, which should include a description of the intrinsic or intangible values of the aquatic ecosystem of concern.

The decision by LHDA on which scenario to implement and further input by the study team on dam design and monitoring falls outside the TOR for LHDA 648.

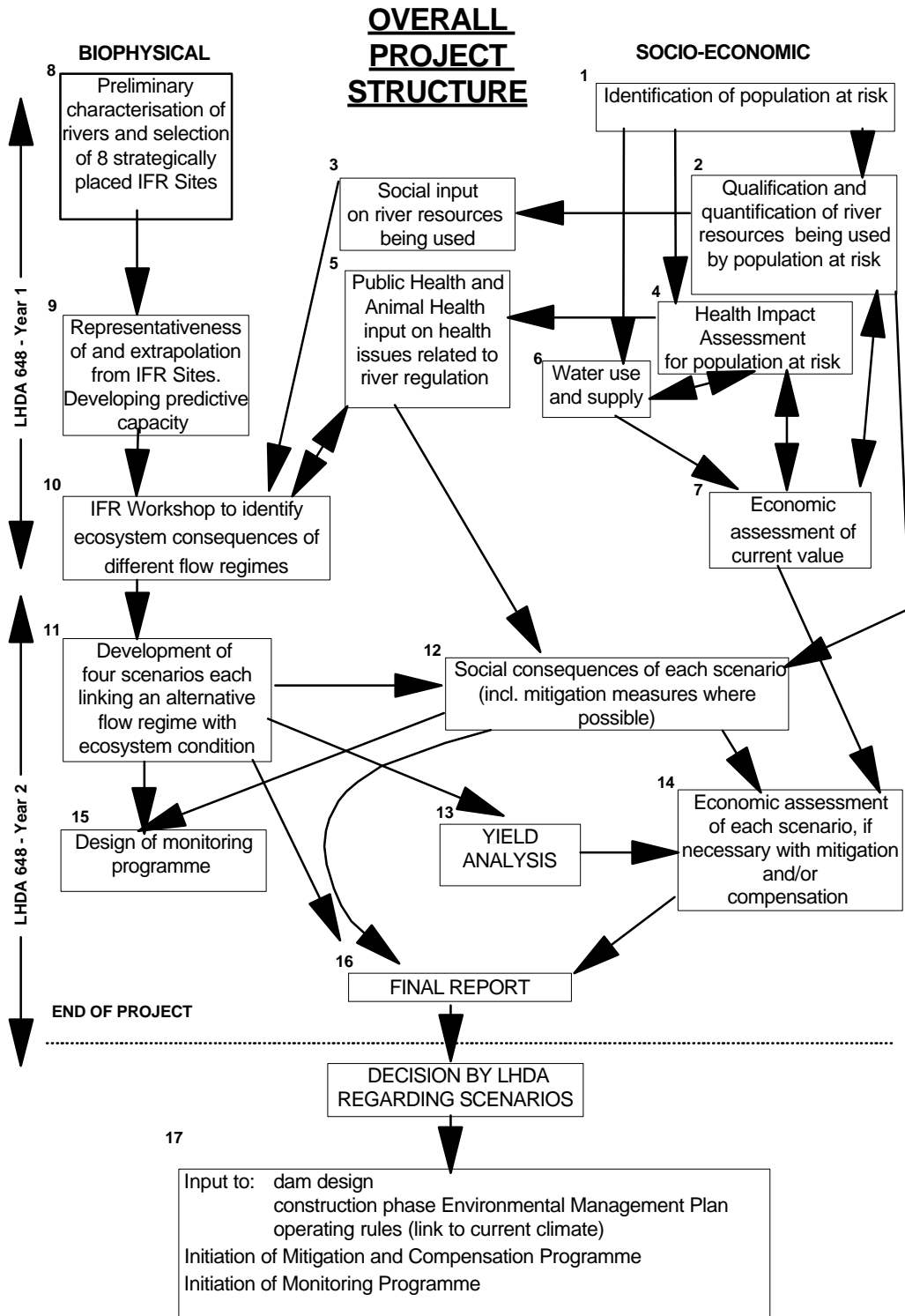


Figure 11.1 Schematic showing the overall plan adopted for LHDA 648.

12 DATES OF SIGNIFICANT ACTIVITIES

The significant activities during the project and the dates on which they occurred are listed below:

- October 1997: Project commencement.
 October 1997-October 1999: Bi-monthly progress reports.
 October 1997: Commencement of water-quality data collection.
 November 1997: Initial site visits and preliminary reach selection.
 November 1997: Commencement of vegetation data collection.
 January 1998: Presentation of Inception and Task 1 Reports to POE.
 April 1998: Planning Meeting and initial data collection exercise (commencement of biophysical [other than water-quality and vegetation] data collection).
 November 1998: Socio-economic Planning Meeting.
 February 1998: End of biophysical data collection, except for water-quality.
 April 1999: IFR Workshop.

September 1999: Socio-economic Scenario Workshop.

September 1999: Monitoring Workshop.

September 1999: End of water-quality sampling.

October 1999: Hand over of water quality sampling sites to LHDA.

14 REPORTS PRODUCED FOR CONTRACT LHDA 648

13.1 Draft reports

Table 13.1 is a list of the draft reports produced for Contract LHDA 648.

13.2 List of final reports

When the set of final reports for Contract LHDA 648 was compiled, the draft reports produced during the course of the study were streamlined to reduce repetition, and to ensure that the final report series read as a comprehensive whole. Thus, some of the draft reports were combined into a single final report. Table 13.2 is a list of the final reports for Contract LHDA 648.

Table 13.1 A list of the draft reports for Contract LHDA 648.

Report Number	Title	Date
648 - 01	Inception Report	December 1997
648 - 02	Task 1 - Report IFR Methodology and Parameters	December 1997
648 - 03	IFR Planning Meeting Working Document	April 1997
648 - 06	Planning Meeting and Feedback Reprt	June 1998
648 - 09	Main Hydrology Report	October 1998
648 - 10	Task 2 - Introduction & Description of the Workshop Process	March 1999
648 - 10	Social Planning Meeting Working Document	October 1998
648 - 11	Task 2 - River Hydraulics	March 1999
648 - 12	Task 2 - Geomorphology/Sedimentology	March 1999
648 - 13	Task 2 - Water Quality Study	January 1999
648 - 14	Task 2 - Riparian and Instream Vegetation and Sociological Vegetation	March 1999
648 - 15	Study Aquatic Habitat Mapping	January 1999
648 - 16	Task 2 - Fish Study/Ichthyofauna	March 1999
648 - 17	Task 2 - Macroinvertebrate Study	March 1999
648 - 18	Task 2 -Mammals and Birds	March 1999
648 - 19	Pilot Study for Sociology /Anthropology component	January 1999
648-22	Task 3 - Proceedings of the IFR Workshop Volume 1- Methods	July 1999
648 - 22	Volume 2 Biophysical Consequences of the Minimum Degradation Scenario	July 1999
648 - 22	Volume 3 Biophysical Consequences of the Treaty Scenario	July 1999
648 - 22	Volume 4 Biophysical Consequences of the Design Limitation Scenario	July 1999
648 - 22	Volume 5 Biophysical Consequences of the Fourth Scenario	November 1999
648 - 23	Sociological Consequences of the four IFR Scenarios	December 1999
648 - 25	Socio-Economic Survey	September 1999
648 - 26	Water Demand and Supply at IFR sites	October 1999
648 - 27	Animal Health and Production Report	December 1999
648 - 28	Public Health Assessment	December 1999
648 - 29	Yield Analysis	December 1999
648 - 30	Monitoring Protocol	December 1999
648 - 31	Economic Consequences of the four IFR Scenarios	January 2000

Table 13.2 A list of the final reports for Contract LHDA 648.

Tasks	Report number	Report Name
All	LHDA 648-F-01	EXECUTIVE SUMMARY
All	LHDA 648-F-02	FINAL REPORT
1	LHDA 648-F-03	Volume 1: TERMS OF REFERENCE, STUDY AREA, STUDY TEAM AND PROGRAMME OF EVENTS Volume 2: IFR METHODOLOGY
3, 4 and 5	LHDA 648-F-04	BIOPHYSICAL CONSEQUENCES OF THE MINIMUM DEGRADATION SCENARIO
3, 4 and 5	LHDA 648-F-05	BIOPHYSICAL CONSEQUENCES OF TREATY SCENARIO
3, 4 and 5	LHDA 648-F-06	BIOPHYSICAL CONSEQUENCES OF THE DESIGN LIMITATION SCENARIO
3, 4 and 5	LHDA 648-F-07	BIOPHYSICAL CONSEQUENCES OF THE FOURTH SCENARIO
2	LHDA 648-F-08	SPECIALIST REPORT – SOCIOLOGY
2	LHDA 648-F-09	SPECIALIST REPORT – PUBLIC HEALTH
2	LHDA 648-F-10	SPECIALIST REPORT – ANIMAL HEALTH
2	LHDA 648-F-11	SPECIALIST REPORT – WATER SUPPLY
2	LHDA 648-F-12	SPECIALIST REPORT – Volume 1: HYDRAULICS Volume 2: AQUATIC HABITAT MAPPING
2	LHDA 648-F-13	SPECIALIST REPORT – HYDROLOGY (6 Volumes)
2	LHDA 648-F-14	SPECIALIST REPORT – Volume 1: SEDIMENTOLOGY Volume 2: GEOMORPHOLOGY
2	LHDA 648-F-15	SPECIALIST REPORT – WATER QUALITY
2	LHDA 648-F-16	SPECIALIST REPORT – Volume 1: RIPARIAN VEGETATION Volume 2: SOCIAL VEGETATION
2	LHDA 648-F-17	SPECIALIST REPORT – MACROINVERTEBRATES
2	LHDA 648-F-18	SPECIALIST REPORT – FISH
2	LHDA 648-F-19	SPECIALIST REPORT – Volume 1: WILDLIFE AND BIRDS Volume 2: HERPETOFAUNA
5	LHDA 648-F-20	SPECIALIST REPORT – YIELD ANALYSIS
3, 4 and 5	LHDA 648-F-21	SOCIAL IMPLICATIONS OF THE FOUR IFR SCENARIOS
5	LHDA 648-F-22	SPECIALIST REPORT – ECONOMICS
6	LHDA 648-F-23	MONITORING PROTOCOL

SECTION 7: REFERENCES

KLEYNHANS, C.J. 1996. A qualitative procedure for the assessment of the Habitat Integrity status of the Luvuvhu River (Limpopo System, South Africa). *Journal of Aquatic Ecosystem Health* 5: 41-54.