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NVE
NORWEGIAN
WATER RESOURCES AND
ENERGY ADMINISTRATION

EXPERIENCES AND FINAL REPORT FROM THE IMPLEMENTATION OF MANTSONYANE AND SEMONKONG SMALL HYDRO ELECTRIC SCHEMES IN LESOTHO

NVE
NORWEGIAN
WATER RESOURCES AND
ENERGY ADMINISTRATION

NORAD
NORWEGIAN AGENCY
FOR DEVELOPMENT
COOPERATION

Title	*No*
Experiences and Final Report from the Implementation of Mantsonyane and Semonkong Small Hydro Electric Schemes in Lesotho.	*6-91*
Executive Officer(s) *Ove Rusten (NORPLAN)* *Per Bang Rolfsen (NOREMCO)* *Torodd Jensen (NVE)* *Steinar Grongstad (NVE)*	***Date*** *June 1991*

Abstract

The report summarises the experiences gained from the imlementation of Mantsonyane and Semonkong small hydro schemes in Lesotho. Information has been gathered from involved personnel at all levels in both Norway and Lesotho.

It is the hope and intention that these experiences can be useful for the planning and implementation of new small hydropower projects in the future.

The executive summary in this report is prepared by NVE, and provides NVE's independent views on the experiences gained.

Subject Terms

Lesotho
Hydropower Development
Experiences

Project Co-ordinator

Egil Skofteland

NVE
Norwegian Water Resources and
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NORAD
Norwegian Agency
for Development Cooperation

MANTSONYANE AND SEMONKONG HYDROPOWER PROJECTS

EXECUTIVE SUMMARY

OF

FINAL REPORT

AND

EXPERIENCES FROM THE IMPLEMENTATION OF THE PROJECTS

JUNE 1991

EXPERIENCES FROM IMPLEMENTATION OF MANTSONYANE AND SEMONKONG; MAIN CONCLUSIONS AND RECOMMENDATIONS

I ***Socioeconomic and environmental issues:***

Socioeconomic and environmental studies for small hydropower (SHP) plants should be included in the (pre)-feasibility studies, normally with emphasis on socioeconomy.

II ***Training and transfer of technology:***

* *(Pre) feasibility study phase:*

A study on possibilities for recruitment of qualified personnel, use of locally and regional training centra, schools and workshops should be carried out as part of the feasibility study for the scheme.

The design work for the technical scheme should insofar as possible be adapted to local technical knowledge in order to allow the participation of local industry and contractors.

* *Implementation phase:*

Separate budget and guidelines for all training activities should be included in contracts.

During the electrical/mechanical erection period, the supervisors should supervise only, and let the trainees do most of the work.

At the end of each project, follow-up courses with exams for the construction personnel and the operation personnel should be held according to course programme specified in the contract.

At least twice the number of trainees needed for operating of the plants should be available when the training course starts.

III ***Tender documents:***

For SHP plants, bidders on electro/mechanical equipment should be allowed to propose their own solution. Comprehensive tender documents will increase the cost.

IV ***Management contracts:***

The idea of management contracts should be followed up for SHP projects. They reduce design work and costs and are more flexible to training activities than ordinary contracts. If necessary the clients organization should be strengthend to secure the need for control.

V ***Proposed new follow up projects:***

* *Mantsonyane; Rehabilitation of the central transmission line from Roma to Thaba Tseka.*

* *Semonkong; Installation of the second hydro power generating unit and construction of a reservoir in the catchment area.*

CONTENTS

MANTSONYANE AND SEMONKONG HYDROPOWER PROJECTS
EXECUTIVE SUMMARY OF EXPERIENCES AND FINAL REPORT
FROM THE IMPLEMENTATION OF THE PROJECTS

MANTSONYANE AND SEMONKONG HYDROPOWER PROJECTS

EXECUTIVE SUMMARY OF EXPERIENCES AND FINAL REPORT FROM THE IMPLEMENTATION OF THE PROJECTS

1. INTRODUCTION

1.1 General

This executive summary is a brief summary of the report dealing with experiences from the implementation of two small hydro-electric power plants in Lesotho. The summary also includes comments on two review reports and the evaluation report prepared for NORAD. The comments and recommendations in this summary are NVE's, and does not necessarily express the opinion of NORPLAN, NOREMCO, or the client.

The Mantsonyane and Semonkong Hydropower Projects are the first hydro electric projects in Lesotho. They are funded by Norwegian bilateral development assistance through SADCC.

In Annex 1 to the Project Agreement the objectives for the projects are described. These are to promote Lesotho's independence from import of energy, to stimulate village development and to promote manpower development and training within the hydropower sector. The schemes were intended to serve as pilot schemes for the SADCC region.

1.2 Semonkong

Semonkong hydropower station will supply the village Semonkong which, according to Lesotho's energy master plan, in foreseable future will not be connected to the national grid.

The main project components are a concrete weir creating a pond in the river, underground penstock, a powerstation built for 2 hydro generator units (200 KW each, only 1 installed in this phase 1), 1 diesel generator (200 KW) to give sufficient power in dry periods and necessary transmission- and distribution lines within the Semonkong area.

1.3 Mantsonyane

The Mantsonyane hydropower station is the first hydroelectric plant connected to the main grid in Lesotho.It is located on the Mantsonyane river in central Lesotho and designed to be operated at full output for a few hours when the Lesotho grid approaches peak demand, as a "peak-lopping" plant, to reduce the monthly peak charge from ESCOM in South Africa.

Main project components are a rockfill dam with asphaltic core creating a reservoir for daily peak operation, tunnel leading the water to the underground station which is equipped with 2 synchronous hydro generating units; 650 kVA and 1900 kVA. Part of the project is a road from Mantsonyane village to the plant, also serving other villages, and a high voltage transmission line to Mantsonyane village for connection to the main grid.

The power station is connected to the existing 33 kV line from Roma to Thaba-Tseka which was planned for upgrading before the commissioning of the project.

2. ASSESMENT

2.1 General

During the implementation of the project there have been two reviews of the schemes, one focusing on socioeconomic and environmental aspects and the other focusing on the training and technology transfer aspects. After commissioning, the Center for Development and Technology, University of Trondheim, has carried out an evaluation of the projects. Some important background information and comments on the reviews and evaluation reports are given below.

2.2 Socioeconomic and environmental aspects

The socioeconomic and environmental comments presented in June 1987 by Arne Martin Clausen recommended that these kind of studies should be carried out in parallell to technical-/economic feasibility studies. NVE agrees in general with this, but would like to point out that for the small hydropower case of Lesotho only socio-economic studies are needed.

The report by A.M. Clausen has comments on the projects which clearly show that all information made available has not been used; Information such as socioeconomic studies by German experts in the Semonkong area connected to German projects (water, workshops, road, forestry) and description of the environmental impact from the hydropower plants.

The lesson from this is that if socioeconomic studies are to be carried out at the pre-feasibility stage, cooperation with donors from other countries operating in the same area should be asked for.

The projects have negligeable effect on the environment. A total of 16.000 m2 have been inundated or swamped. 9.000 m2 of these are an area where willowtrees are planted with funds from the project. There is no-one living along the developed part of the rivers. The intermittent operation of the power plants in low flow periods will cause negligeable problems for downstream use of water. At Semonkong downstream weirs have been constructed for reregulating of the intermittent flow where people are using water for washing and bathing. At Mantsonyane the riverbed itself will reregulate the water several km upstream from where people live. In Norway the projects would be ranked on top for implementation in the Master Plan for Water Resources administrated by the Ministry of Environmental Protection.

2.3 Review of training and technology transfer aspects

The schemes have been reviewed by a team headed by Stein Kristiansen, Agder College, Kristiansand as part of a research project financed by NORAD and presented in a conference paper at NAI's seminar on Paradigms in Developing Thinking and Strategies, May 1991.

The paper has an important recommendation NVE fully agree with. The need for a separate budget and guidelines for all training activities are very important, and should be included in contracts for similar schemes in the future.

The paper includes comments presented as the client's (LEC and WEMMIN) on training of operation personnel and the use of sophisticated equipment which is the opposite of what the client presented to NVE. The paper does not mention that operators actually have been trained according to the intention in the contract and does not discuss the possibilities available for training of civil engineers and construction personnel.

A discussion on the technical knowledge which should be present in Lesotho for local manufacturing of equipment is missing. This part can only be explained by the fact that the research team had no experienced hydro power engineer among its members.

2.4 Comments on the evaluation of the power plants

2.4.1 General

The Center for Development and Technology, University of Trondheim, has carried out an evaluation of the projects (July 1990). In the report it is stated that the projects are constructed with high quality solutions. Training aspects which were important have not been fully discussed as would be expected. Negative comments on costs and organization between the consultant and contractor have been made.

2.4.2 Comments on costs

The initial budget for implementation of the two schemes was NOK 57 million (1985). The consultant had little experience with similar projects in Lesotho, hence the budget was based on general experiences from small hydro power development.

The total costs for the project (including the expatriate who stayed for three years at LEC) reached 81.5 million NOK (1989), which gives a 43 % cost increase. Excluding NOK 3.0 million payed by an insurance company and approximately NOK 4 million in other costs because of dambreach and the cost for the expatriate at LEC give total costs of approximately 71 million NOK and a 25 % cost increase if the dambreach had not occured.

The increased cost has several causes. The most important are the dambreach, an underestimated need for expatriates and the price of electro/mechanical equipment.

As a whole the cost estimate and the progress schedule were too optimistic from the beginning. The project was a pilot project in a developing country in southern Africa with a heavy training component, and with occasional weather conditions which caused stoppage of the work and transport in the Maluti mountains.

It is the opinion of NVE that the encreased cost had little to do with the cost control. The cost control was acceptable for the total control, but for evaluation afterwards, the system was insufficient to acquire accurate figures for the cost of the different activities.

The table summarises the total costs:

Activity/ product	Budget NOK 1000	In-curred 1000 NOK	Diffe-rence 1000 NOK	%	M %	S %
1. Professional Services	18,153	25,560	7,407	40.8	78.1	21.9
2. Equipment from Norway	13,300	20,196	6,896	51.8	66.5	33.5
3. Locally manu-factured equipm	700	1,387	687	98.1	83.6	16.4
4. Transmission and Distrib. Lines	1,900	1,376	- 524	-27.6		
5. Civil engineer-ing constr. costs.	20,397	32,610	12,213	59.9	79,7	20.3
6. Contingencies	2,550	406	-2,144	-84.1		
Total	57,000	81,534	24,534	43.0	75.7	24.3

M: Mantsonyane, percent of total cost
S: Semonkong, percent of total cost

1 *Includes expatriates from NORPLAN and NOREMCO and the Norwegian electrical engineer at LEC (approximately NOK 3.5 mill). The consultants (NORPLAN) professional cost is approximately NOK 10 mill., which is 12 % av the total cost. This is less than normal for SHP plants. The main reason for the overexpenditure in professional services is the delayed termination of the project itself and an underestimate on the need for expatriates.*

2 *Equipment from Norway includes pipes at Semonkong and gate and station crane at Mantsonyane in addition to the main electro-mechanical equipment package.*

The main contribution to the cost increase of 4.9 million NOK compared to the original budget can be found in a Norwegian price increase on electro-mechanical equipment, and the fact that the tender documents were too comprehensive leaving very little alternative choice of solution for the supplier.

The question is open as to whether the equipment for Mantsonyane and Semonkong could have been cheaper if international tenderening had been carried out based on the available tender documents. Especially the equipment for Semonkong power plant could have been much cheaper with less advanced solutions. Simpler solutions could, however, have had negative influence on the training of operators and the mixed operation of the turbine and the diesel unit. A discussion of these problems were never carried out, and the tender documents with their solution is considered the main reason.

3/4 *Locally manufactured equipment was almost doubled compared to the original budget. A lot more steel-equipment was manufactured locally (most at Lesotho steel) than estimated. The only reason for this over-expenditure was underestimation of the work involved. The contribution from Lesotho is therefore not more than planned. All work with the transmission lines was satisfactorily carried out by LEC.*

5/6 *The main contributor to the increase is sub-item "Vehicles and construction equipment". In the budget secondhand construction equipment and spare parts from Norway were included, but six months after construction start the original budget was spend. Before the project was completed, the accumulated costs had reached 12.3 million NOK or 223% more than in the original budget. The original budget was far too optimistic, and the working conditions in Lesotho proved to be very hard on the equipment.*

The second hand equipment functioned satisfactorily but required more repair and maintenance than new equipment. This caused at times a bottleneck regarding both to the use of expatriates and in getting spare parts.

A better planning for need of spare parts and training at the workshop could have reduced or eliminated the problems. It is recommended, however, that for projects where the total mobilization and construction time is more than 2 years, one should consider purchasing new equipment from the very start.

2.4.3 Organization between consultant and contractor

The management contract between NORPLAN and NOREMCO was selected because it would allow the detailed planning to follow the construction. This would reduce planning and investigation costs for preparation of tender documents and allow a counterpart to be trained in civil engineering during the whole implementation period. It would also allow the contractor to recruit a local workforce and perform training during the construction period.

Ordinary contracts will require a lot more basic investigations for preparation of tender documents. This is costly for SHP plants. The bidders will sign a contract with a time schedule and fix prices which can be altered (and normally will) because something always happens which is not described in the tender documents. Normally these kind of changes are costly.

The evaluation report has recommended not to use similar contracts in future projects. Similar comments are given by Lesotho officials. The Lesotho officials are well acquainted with handling of projects according to traditional international tender procedures. The reactions from Lesotho officials to this particular contract arrangement is in short that:

- they find the contract unusual
- they have difficulties to distinguish between the Consultant and the Contractor
- they feel that too close cooperation between Consultant and Contractor may affect the quality control

Lesotho officials confirmed that the management contract did secure the priority to Basuto workers on the project. Experiences with traditional internatial tender procedures for projects in Lesotho, like the Lesotho Highland Water Project and two French SHP projects have shown problems for Basuto workers even if the tender documents stressed the use of them.

NVE has the following comments:

Quality control:
This problem and the problems connected with the changes in the Client's organization during the project period could possibly have been avoided or reduced if WEMMIN had been strengthened by another expatriate engineer during the project period.

Mixing of functions:
A similar management contract should provide for a resident manager which has the overall responsibility for the whole project and all the personnel involved.

Penalties:
Some of the delays in the construction works would most likely have been shorter under standard contract conditions where penalties are used to avoid missing of important deadlines.The priority to employing Basuto workers and the training aspect would, however, definitely have suffered.

NVE recommends the use of similar contracts for civil engineering works for SHP projects where training is a heavy component. The reasons are the following:

- It is impossible to include all training aspects in the tender documents for normal conditions, and even if they are included, stress on time and money factors will make the training difficult.

- Hydropower projects in general are "long structures" were a successful implementation is more dependent on weather conditions and knowledge from basic investigations than most other structures. A flexible contract arrangement can give considerable savings on basic investigations and reduce the consultants planning cost.

- A non-profit system on construction costs will make it easier for the contractor to satisfy labour intensive construction methods.

2.4.4 Economic viability

Semonkong:
The utilization of local hydropower resources was compared with the construction of transmission lines and diesel generating. The power plant was found viable, but the increased cost has reduced its viability. It should be stressed, however, that all electric energy in Lesotho must be purchased from SAA, and that a transmission line over the mountainous country can give unreliable electricity supply. When evaluating the scheme it should also be taken into consideration that it includes investment for the preparation of a second hydro generating unit, mixed operation with a turbine and a diesel unit and necessary high and low voltage transmission lines in the Semonkong area.

Mantsonyane:
The project is intended to act as a peak power plant, and thus save foreign exchange for Lesotho which is dependent on electric power from SAA. Unfortunately, Mantsonyane cannot be reliable in fulfilling its objectives as the 33 KV transmission line between Roma and Thaba Tseka to which it is connected is not in a satisfactory state. Improvements of this line were planned by Lesotho before the construction started, but the funds for construction could not be raised.

2.5 TRAINING

2.5.1 General

Training was focused on from the first contact between NORAD and the consultant. Experiences from Lichinga in Mozambique were to some extent used. It was, however, little information available which introduced guidelines for training components related to SHP development in a country like Lesotho.

The Terms of Reference for the pre-feasibility study period, which started 3 years before the construction period should have asked for a study on local schools, workshops etc. and regional training centres to give information on knowledge and possible cooperation related to hydro power activity which could have been used or developed. This study should have included a specific information for recruitment specifications and practical circumstances related to premises for successful training.

Some of the problems of recruiting personnel and their lack of education would have been known and perhaps solved if these investigations had been given as much attention as the design and solution of the different schemes.

This information could have reduced the problems concerning the operators and in addition allowed a combination of theoretical and "on the job" training during the construction period with tests and exams adapted to the country's educational system.

2.5.2 Civil engineering works

In spite of lack of a more defined training programme, practical onsite training was continuously carried out on various categories of construction works;

1) Carpentry including formwork and concrete works.
2) Shotcreeting and grouting.

3) Rock blasting.
4) Plant mechanics.

Results of the training:

1) Carpentry; about 10 employees can work as foremen and team leaders in the future.

2) Shotcreeting and grouting have only been carried out a short period, and therefore only 2 of the employees are well trained.

3) Rockblasting was one of the major fields of training, with blasting of tunnels, powerhouse, caverns and the spillway. Around 10 of the employees should be well qualified for tunnel drilling and blasting, and also blasting of quarries similar to the spillway.

   3 tunnel miners received approved Blasting Licences from Department of Mines based on the training received on the project.

4) Plant mechanics training has been going on since the construction start-up, and 5 of the employees are now well qualified mechanics.

Today some of the trained personnel are still with NOREMCO, while others have jobs connected to the implementation of the first phase of Lesotho Highland Water Project. Some are acting as foremen on the tunneling and rockfill dam work.

No special training courses leading to exams and training certificates have been held.

Courses in the following areas/subjects to be held after completion of the project were proposed to NORAD during the implementation period:

Rockblasting
Earthmoving
Carpentry
Plant Mechanics

The courses should include both practical and theoretical training tailored to the relevant level of experience.

The suggested courses were based on cooperation with local institutions such as AECI Explosive Factory, Maluti Tractors (Caterpillar dealer), Atlas Copco (Rock drills) and Department of Mines.

Department of Mines expressed interest in a more advanced level rockblasting course in addition to the suggested course for workers from the project.

The carpentry courses were based on an existing course programme previously used in Tanzania by NOREMCO.

Funds were, regrettably, not made available for the follow up courses at the end of the project.

2.5.3 Electro/mechanical erection period

According to the contract 5 LEC operators were to be trained during the erection of the mechanical and electrical equipment. The main purpose was that the operators should to become familiar with their own power station from the very beginning.

The LEC trainees had quite good theoretical background, but lacked practical experience and had very little knowledge about hydroelectric power stations. The supervisors had a wide experience from similar projects in Norway, but lacked experience in conducting training in Africa. They had high expectations for the trainees' knowledge and became from the beginning a bit concerned about the training possibilities.

There were no real plan or guidelines for the training component and both the trainees and the supervisors were uncertain as to how the training should be conducted. Where supervisors also have a tight time schedule, the training component suffered. Each of the supervisors had their own approach to the training component and no "scarlet thread" was followed.

At Semonkong the supervisors explained the type of work, but carried out almost all the work themselves. This practice reduced the trainees eagerness and willingness to participate.

At Mantsoyane, another approach was tried. The trainees were allowed to do almost all the connection work under supervision. When the commissioning period started, many faults were detected.

The 5 LEC trainees were appointed before the mounting works started at Semonkong and Mantsonyane in October 1987 and they have therefore followed the installation of the equipment, the testing period and the final theoretical/ practical training leading to the exams and certificates in February 1989.

The conclusions from training connected to the erection work are the following:

The training component should be clearly defined in the contract, including guidelines for the training.

Direct guidelines describing both the electro/mechanical equipment and the erection work should be available for both the supervisors and the trainees.

The supervisors should supervise only. The trainees should themselves do most of the work. Supervisors should then control the work and the trainees should themselves correct any faults detected.

2.5.4 Power Plant Operation

Lesotho Electrical Cooperation (LEC) has established an organizational unit, the Generation Department, to take care of the daily operation of the power generation installations. The responsibility comprises operation and maintenance of small hydropower stations, and maintenance of a number of diesel power stations.

The Norwegian senior engineer, assigned to Lesotho Electricity Corporation from 1st September 1986 until 13th September 1989, has been a central person in establishing the new Generation Department in LEC. He was also responsible for training of operators and counter-part personnel in LEC, and as a consequence of shortage of operators he is for the moment attached to a second training programme made available by additional funds from NORAD.

One Basuto was trained in Norway for 6 months. Experiences have shown that there should have been at least two following the same scheme. A detectable weak spot here is definitely the language aspect. The personnel with whom the trainee needed most professional contact with regard to explanations and detailed instructions, had also the poorest command of English. This detail should be considered more important.

When the commissioning started in April 1988, the commissioning engineers observed that the trainees still had very little knowledge on the hydroelectric power stations; how they were functioning, how the water was flowing, etc.

The training content is not specifically defined in the contracts or any other additional formal documentation, but has been subject to continuous monitoring and adjustment whenever considered necessary. Apart from the number of trainees, and that the training should continue throughout the assembling of the electro-mechanical equipment, testing and commissioning periods, no direct guidelines and syllabus have been available. This training procedure gave oppertunity to adjustments and additional training. On the other hand, however, the lack of guidelines put more strain on the different parties involved to get the best possible result.

The number of personnel trained has definitely been too small when taking into consideration that this personnel was the only and the first hydroelectric operation personnel in the country to be trained. Two qualified operators for each station plus one for maintenance (5 altogether), are an absolute minimum regarding the location of the stations and the regulations that have to be followed. Experience showed that twice the number of trainees should have been used. This will require more expatriates or a prolonged erection period and thus increase costs in future projects. It can also introduce a problem for the client of paying vages to the trainees during the training period and employing them afterwards.

As a reflection over the experiences gained, there should from the beginning have existed a principal syllabus where also both practical and theoretical training were defined. A stricter description on a contractual basis would have made evaluation easier, measuring of results better, and would definitely have given more specific information to outside parties and to the trainees themselves.

The testing of the trainees did, however, show relatively good results which indicate that the training has given what it was supposed to give, but not necessarily that the training was efficient taking into consideration time and money.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 General recommendations

1. Projects on small hydropower should include socio-economic and environmental studies with emphasis on socioeconomic studies connected to the pre-feasibility studies for the technical scheme.

2. The tariff structure for purchase of electricity should be simple to administer and easy for the consumer to understand. Fixed charges should be introduced being the same for all consumers. Connection fees should be low and different for households and private enterprises.

3. A development programme to utilize the electric energy should be considered whenever appropriate.

3.2 Training

If training is considered a main issue, there should be a separate budget for training expences to prevent that training suffers when the budget gets tight. Specific information related to training should be available and asked for in the Terms of Reference for the pre-feasibility reports.

The Terms of Reference for this period should include investigations on local and regional schools, workshops etc. Recruitment specifications and practical circumstances related to premises for successful training should be made available.

The following general comments can be given:

The training budget should cover extra expatriate time, accommedation for the trainees suitable for studying, necessary transport etc.

At the end of each project, follow-up courses for the civil work personnel and the operation personnel should be held according to a course programme specified in the contract. This is crucial for a sucessful implementation of the project in the long run and should be included in the budgets.

Course certificates should be issued to participants.

In future contracts more attention should be paid by the donors to assigning a counterpart engineer with adequate education and experience to the project from the beginning to completion. This is especially important if the client has few competent persons and at the same time other large projects under development.

At least twice the number of trainees needed for operation should be available when the training course starts, and emphasis should be put on the number needed for the operation after completion if the premises of regular operation, good maintenance and future self-training are to be met.

Specific conclusions and recommendations for operating personnel:

- To get well qualified personnel with adequate background, recruitment, specification and testing of personnel is important. Use of regional training schools should be considered.

- Recruitment of personnel from the contractor with experience of training from the relevant country is important, but a positive attitude to the training and the trainees is most important.

- When supervisors with limited experience of training in 3rd World countries are engaged, direct guidelines should be available.

- When experienced supervisors are engaged, flexible training programmes are to be preferred.

- During the erection period, the supervisors should supervise only, and let the trainees do most of the work.

- The commissioning period should be followed by a comprehensive training period in various operational drawing, maintenance work, fault finding, etc.

- A final test should be organized with training certificates awarded to the participants.

3.3 Contracts

Contracts for implementation of small hydroelectric projects where training aspects is one of the main issues must include possibilities for focusing on the training aspects. A management contract as described in this report enables the different aspects connected to training to be included in a better way than ordinary contracts, especially when unexpected design alterations or circumstances occur.

It should be mentioned, however, that this special kind of contract require knowledge within the clients organisation. An expatriatre should be assigned to the client if this knowledge or capacity is not present. This will enable the follow up work from the clients side and also enable institutional building or training of counterparts to do this work in the future.

NVE therefore recommends to follow up the idea of a management contract. The comments given in this report should be taken into consideration for later use of this special contract form.

Management Contracts for implementation of small hydropower projects in developing countries, will also in future be a favourable alternative if the following conditions are met:

1. The client wishes to implement the project by use of his own manpower.

2. Training is considered an important element in the development process.

Some important aspects regarding management contracts:

1. The traditional consultancy services should not be mixed up with contractors responsibilities.

2. Special care should be taken in order to avoid doubt about the consultants supervision and quality control element, and a detailed quality plan should be part of the contract. An expatriate assigned to the client may solve this problem.

3. The project should have a decentralized organization and experienced senior management should be used for functions in the developing country. This involves that detailed structural design should be carried out as part of the training process in the developing country.

4. The training elements in the development contract should be defined by special Terms of Reference and budget both for consultancy as well as construction work.

5. The non-profit system for construction costs, i.e., construction costs are refunded on actual cost basis, is a sound system for projects based on terms listed initially under this chapter.

3.4 Budget/costs

To enabel the bidders to reduce costs, tender documents for electro/mechanical equipment for small hydro should not be comprehensive. Only basic data should be included to allow the bidders to propose their own solutions. The proposals should be evaluated by neutral professionals.

Advanced solutions may be the appropriate technical solution for a SHP plant. It should, however, be discussed in each case.

The cost control should include a system which allows monitoring of important components during implementation and an evaluation after completion.

3.5 Support of new projects

To enable use of Mantsonyane as a cost reduction plant for peak power, it should be considered to support the rehabilitation of the central transmission line from Roma to Thaba Tseka.

As the demand has increased in Semonkong, it should be considered to support the installation of the second turbine in the power station and at the same time the construction of a reservoir in the catchment area.

MANTSONYANE AND SEMONKONG HYDROPOWER PROJECTS

I EXPERIENCE FROM IMPLEMENTATION OF THE PROJECT

II FINAL HISTORY REPORT

June 1991

I **EXPERIENCE FROM IMPLEMENTATION OF THE PROJECT**

II FINAL HISTORY REPORT

Appendices

PART

I

EXPERIENCE FROM IMPLEMENTATION

OF THE PROJECTS

1. INTRODUCTION

1.1 Scope of Report

This report is split into two parts; I - Experience from Implementation of the Projects" followed by; "II - Final History Report"

The first part discuss the experience gained from the project. Discussions have been held with involved personnel at all levels both in Norway and Lesotho.

Part II provides a brief overview covering main project planning- and implementation activities and the main project data.

Our hope and intention is that experience from implementation of Mantsonyane and Semonkong Hydropower Projects can be used on new small hydropower projects in the future.

1.2 General

The Mantsonyane and Semonkong Hydropower Project development is the first project in Lesotho funded by Norwegian bilateral development aid through SADCC.

In Annex 1 to the Project Agreement the objectives were to promote Lesotho's independence from import of energy, to stimulate village development and to promote manpower development and training within the hydropower sector. The schemes are intended to serve as pilot schemes for the SADCC region.

Being a completely new working area for Norwegian development workers, the experience from the project will to some extent reflect the lack of practise and know-how from the Southern Africa area. On the other hand it is also an experience from the two mini-hydro projects in the Lesotho highlands that Norwegian Construction personnel are better fit than others to keep work in progress during winter conditions in the mountain areas of Lesotho.

Lesotho is likely to be the country in Africa having most similarities to Norway both climatically and with regards its terrain. The project period included both winter conditions and flood periods regarded as abnormal conditions in the area.

The special contract arrangement used for the project will be discussed in this Experiences Section of the Final history report.

The implementation of the Semonkong and Mantsonyane hydropower projects in Lesotho as a pilot project for Norwegian development aid in the area has contributed with valuable experiences from both countries point of view.

The final conclusion on all aspects of the projects cannot be determined at this point in time, but the overall impression is that the basic goal with the project will be fulfilled and that the implementation process, despite serious budget overruns, has been carried through according to the intentions of the Donor and to the satisfaction of the Client.

2. CONTRACTS

2.1 General

Why the Management Contract concept was used:

Savings on ground investigations	Hydropower projects are in general "long structures" with more contact area to the ground than most other building objects. Extensive ground investigations covering all contact areas are expensive to carry out. Variation orders during the construction period caused by design modifications are therefore more frequent on hydropower projects than on other projects. A flexible contract arrangement can give considerable savings on ground investigations. This facts have in some professional forays led to the conclusion that a Turn-key based concept is a favourable contract solution particularly for smaller hydro power projects.
New area	NORAD projects in new geographical areas will involve uncertainty due to lack of experience from the area. This will require additional overhead charges if all risks should be carried by the Contractor according to normal tender procedures.
Include training	One important intention of a NORAD financed project is to include training activities in all elements of the implementation process. This is difficult under normal contract conditions due to stress on time and money factors.
Short order lines	NORAD's administration wished to have as simple as possible procurement procedures for the project.
Labour intensive methods	NORAD also wanted to give preference to labour intensive construction methods whenever possible. The non-profit system on construction costs, made it easier for the contractor to satisfy this intention.
South African construction staff	Both NORAD and Lesotho wanted to avoid that South African labour were used on the project. More skilled South African construction staff is very often preferred by companies working under ordinary tender conditions in Lesotho.

The Client had limited capacity

The Client WEMMIN did not at that time have sufficient capacity to follow up the project properly. Reorganization of Government functions because of Highland Water Project was in progress and the Client therefore preferred a self-contained contract arrangement.

The above are the background reasons behind the choice of contract arrangement for the development of the Mantsonyane and Semonkong hydropower projects in Lesotho.

The Management Contract for Mantsonyane and Semonkong

In outline, the concept was based on the following:

1) NORPLAN's contract with WEMMIN covered the complete development process including:

   Project Management
   Design
   Supervision and
   Construction

2) The Electromechanical supplier NEBB/Sørumsand signed a separate contract with WEMMIN, but coordination of the services from this contract was included under NORPLAN's management responsibilities.

3) The construction work was subcontracted by NORPLAN to NOREMCO CONSTRUCTION. The parties also formed a Joint Venture which should be the executing body for the implementation of the projects in Lesotho. Responsibilities between NORPLAN and NOREMCO CONSTRUCTION should follow the traditional contract pattern, i.e.,:

   NORPLAN should be the Consultant responsible for:

   Liaison with Client
   Design and
   Supervision

   NOREMCO should be the Contractor responsible for:

   Construction works, including all necessary mobilization arrangements in Maseru and on site. NOREMCO employed the labour force.

   The Joint Venture agreement included however, also a clause about flexible management cooperation between the Consultant and the Contractor. The intention was to achieve savings on management manpower. This was utilized particulary during vacation periods.

4) Construction costs including labour, materials, transport, etc. were refunded on actual costs based on detailed documentation. There were no profit or overhead charge added to the vouchers.

5) The expatriate manpower used in the Contract was paid for by the Client by ordinary NORAD rates for consultancy services and all profit both for Consultant and Contractor was included in these rates and limited to this post in the budget.

6) The Agreement between NORPLAN and NOREMCO was part of NORPLAN's contract with WEMMIN.

2.2 Government of Lesotho - Experience

Lesotho is as a result of its location integrated in the South African business area, where development of projects normally are based on traditional tender procedures. Lesotho also has cooperation with a considerable number of international Donor Agencies from all over the world, and the Lesotho officials are therefore well acquainted with handling of projects according to traditional international tender procedures. The reactions from Lesotho officials to this particular contract arrangement is in short terms that:

- they find the contract unusual

- they have difficulties to distinguish between the Consultant and the Contractor

- they feel that too close cooperation between Consultant and Contractor may effect the quality control

- Lesotho officials confirmed that the Management Contract did secure the priority to Basuto workers on the project.

- although the Government officials stress that they have no serious objections to the way the management team from NORPLAN and NOREMCO actually carried out the work on the project, they prefer not to have the same contract form repeated on a new project.

2.3 NORPLAN/NOREMCO Joint Venture Experience

The following are viewpoints on the contract arrangement from NORPLAN/NOREMCO J.V. point of view:

A different working form

1) A successful cooperation based on the terms laid down in the Agreement between NORPLAN and NOREMCO is dependant on the individuals involved. This is true for all kind of working relations, but the actual form of relationship requires ability to distinguish between important and less important conflicts of responsibility.

Quality control

2) In this kind of Contract there is a close relationship between the design/control part (consultant) and the implementation part (contractor) of the Management Team.

The expatriate team is not split along the usual lines of Consultant and Contractor as in a traditional civil engineering contract. This gives potential for savings in manpower as well as high efficiency of the management team. However, this will also raise the question of whether the quality control is good enough. A definite answer cannot be given, but it is the responsibility of the management team that all the works are up to the required standard throughout the construction period.

As far as NORPLAN/NOREMCO JV. is concerned, all works are in conformity with such a standard.

Savings on modi-fications

3) The project did definitivaly benefit from the contract arrangement on one field:
Design modifications were discussed openly between the parties and implemented without further formalities when accepted by the Consultant. Savings achieved by design modifications did automatically result in savings in the budget because of the non-profit system on the construction costs. If a design modification resulted in increased construction costs, the Client paid only the actual marginal cost increase.

There is no doubt that considerable savings of this nature were achieved as a result of the contract.

Training

4) Even if the site training suffered due to forced programmes caused by delays during some periods of the construction time, it would have been far more difficult to give priority to site training under ordinary tender conditions, where profit making is part of the process all the time.

5) It has been stressed by the Client that they found it unusual that the Consultant communicated issue on behalf of NORAD. From the Joint Ventures point of view, these objections are not originated from the contract form as such, but from the fact that NORAD did not have a representative in Lesotho. Communication was therefore of purely practical reasons unofficially communicated through the Consultants representative.

Relation NORAD/ Client

This problem and the problems combined with the changes in the Clients organization during the project period could possibly have been avoided or reduced if the NVE/NORAD representative associated to the project had been engaged as part of WEMMIN staff in Lesotho during the project period or alternatively: that WEMMIN had been strengthened by another expatriate engineer during the project period.

6) The mixing of functions and personnel between the Contractor and the Consultant was a condition in the contract. This is a difficult part of the concept and only possible when the personnel in question are able to cooperate in an extremely flexible manner.

Mixing of functions

7) Some of the delays in the Construction works would most likely have been less under standard contract conditions where penalties are used to avoid overrun of important deadlines. The priority to Basuto workers and the training aspect would however definitively suffer.

Penalties could have reduced delays

8) The budget for expatriate supervision staff proved, as stressed elsewhere in this report, to be underestimated from the beginning, and local recruitment of a sufficient number of qualified Basutho foremen and supervisors appeared not to be successful (impossible). This budget shortage affected the project negatively both on the side of consultancy services and on construction works.

Under-estimated expatriate budget

9) A general and definitely positive experience from the implementation process is however from the Joint Venture point of view that a close and fruitful cooperation with Lesotho officials and workers were achieved under the existing contract conditions.

Good Cooperation with Lesotho officials

2.4. Electromechanical Contractor's Experience

The contract for delivery of the electro-mechanical equipment between the consortium Sørumsand Verksted/NEBB and the Ministry of Water, Energy and Mining (WEMMIN) was signed in 1986. Sørumsand Verksted was the leader of the consortium.

The contract included delivery of two turbines, valves, regulators, generators, transformers and auxiliary equipment for Mantsonyane Hydropower station and ditto 1 pc for Semonkong Hydropower station. The contract also included supervision through the erection period and commissioning of the equipment.

The general contractual terms were based on AKB-52 but with some "standard" alterations. The contract price for the entire delivery was fixed, but with an agreed sliding scale for adjustments of wages and material prices. Exchange rate adjustments were also included for the larger, sub-contracted components. Freight costs were to be billed according to actual costs. Liquidated damages for delay was linked to the shipping date from Norway. The original specification from the Client was very comprehensive and would have resulted in a much higher price for the equipment. During contract negotiations, the specifications were modified to allow for standardised equipment which resulted in considerably lower prices.

The contract stipulated the amount of time necessary to complete erection and commissioning work. Dayrates were agreed upon to be paid in the case where additional work was necessary so long as the delays were not caused by the consortium.

Production and shipping of the equipment went as scheduled, but due to severe weather conditions and flooding at the power station site, the erection was delayed. New components also had to be made to replace those which had been damaged during the flood. It proved difficult to obtain a full acceptance of the additional costs incurred by the consortium under these circumstances, and the project's turnover was therefore considerably reduced. Another drawback was that the quality of the helpers the Client provided was not always good enough. These situations, for different reasons, were not always mentioned and followed-up which resulted in inefficiency and delay.

Cooperation between NORPLAN and the consortium went well, and NORPLAN's local office and resident management was of great help to our people. All communication with the Client usually went via NORPLAN.

The commissioning period went basically as planned, but due to faults in some of the sub-contracted equipment (generators and valves), the take-over date was further delayed. The equipment was ready for commercial operation and take-over by the Client in November 1988 and February 1989 for Semonkong and Mantsonyane respectively.

During the commissioning period, our personnel also held training courses in operation and maintenance of the equipment. The training courses were well received and gave good results. However, the Client seems to have a problem obtaining a reliable and stable work-crew and the training has had to be repeated.

3. TRAINING

3.1 Office personnel

The office in Maseru was manned by the following personnel recruited in Lesotho:

1 Combined Clerk/Driver and Wages Accountant
1 Secretary/Ass. accountant
1 Maid
1 Garden worker and Driver

General office management and company accounts were partly carried out by the locally engaged office staff. The detailed accounting system introduced for the project, required however considerable assistance from the expatriate management team.

The Clerk/Driver and Wages Accountant was trained in some of his work disciplines from previous jobs. The combined functions he covered on this project developed his experience and he became a key person in the project administration.

He is still a valuable Administration Officer at Noremco's office in Lesotho.
Both the Maid and the Gardener are still keeping the same positions at Noremco's office in Lesotho.

The secretary resigned after the project was completed due to personal reasons. She did however, also increase her experience considerably during the project time and is now qualified for well paid positions.

A Civil Engineer trainee should have been assigned to the project from the beginning, but the Client faced difficulties in finding a suitable candidate and the Civil Engineer trainee started working with the project only from March 1987. The candidate had a diploma in Civil Engineering from Lerotholi Technical College in Lesotho.

Unfortunately the lack of sufficient supervision capacity and the stressed working situation which developed during the project, resulted in a situation with only marginal capacity to follow up his training programme. The trainee's qualifications and experience did not quite satisfy the desired requirements for a hydropower engineer trainee on this project.

In future contracts it must be an absolute condition from the Donors side that a counterpart Engineer with adequate education and experience is assigned to the project from beginning to completion. The Counter-part Engineer should have joined the team already on the Feasibility Study level, and funds should have been available for such training.

Report from the Civil Engineer trainee:

QUOTE

I did civil engineering diploma in 1980. I was employed by WEMMIN in 1987 and seconded to NORPLAN NOREMCO for training on many fields in Mini Hydro Power. I was the counterpart of Resident Engineer.

1) I was trained to do the setting out of the dam using the theodolite and distance meter. Before then I was not familiar with that but now I am confident.

2) I did the calculations of the materials to be used, i.e., aggregates to be mixed with bitumen, sand and the cloth for filter media and steel for formwork of the dam core.

3) What helped me to do the calculations was levelling and drawing longitudinal and cross sections.

4) I did controlling and site supervision.

5) I also learned rock excavation, i.e., drilling and blasting. I am now working at Water Branch. We are doing the construction of Europa Trunk Sewer. I did the setting out. I am doing the inspection and levelling. All that I learned in Mantsonyane is very easy here.

I has been promised a scholarship to UK this year for B.SC. Engineer.

PROBLEMS

1) Problems that I encountered were that the accommodation was not good especially for studying. Caravans are the best.

2) We did not have site meeting to solve problems.

3) I did not have communication with the Resident Engineer because he had too much work.

4) I still need further training, i.e., short term courses.

5) When I left NORPLAN NOREMCO I was out of job for three months. The Director of Water Affairs denied me until I got an offer from Water & Sewerage Branch. That I would suggest is that trainees should have security and they should be trained from the feasibility studies and design so that they have the whole scope of the project.

UNQUOTE

3.2 Civil works

On-the-job training was a continuous process during the construction programme. A successful result is to a great extend dependent of the expatriate supervisors ability to give the training aspect priority in the daily working process.

Noremco Construction used foremen with experience from work in developing countries and the effect of the on-the-job training was reasonably satisfactory.

A number of trainees from the Mantsonyane and Semonkong projects are now valuable team leaders in Noremco's construction staff in Lesotho and others are in well paid positions with other contractors.

3 tunnel miners received approved Blasting Licences from Department of Mines based on the training received on the project.

The Contractor does however, feel that the training effect could have been better if the training was a more defined part of his work.

The training programme should at the end of the project be completed with organized training courses for a number of candidates selected from the working crew on the projects.

The Contractor suggested courses for the following disciplines to be held after completion of the project:

Rockblasting
Earthmoving
Carpentry
Plant Mechanic

The courses should include both practical and theoretical training tailored to the actual level of experience.

The suggested courses were based on cooperation with locally available institutions such as AECI (Explosive factory), Maluti Tractors (Caterpillar dealer), Atlas Copco (Rock drills) and Department of Mines.

Department of Mines expressed interest in a more advanced level rockblasting course additionally to the suggested course for workers from the project.

The Carpentry courses were based on an existing course programme previously used in Tanzania by NOREMCO.

Funds were however, not available for the follow up courses at the end of the project.

3.3 Electro-Mechanical Works

According to the contract 5 LEC operators should be trained during the erection period of the mechanical and electrical equipment. The main purpose was that the operators should learn to know their own power station from the very beginning, to become familiar with the power station.

The LEC trainees had quite good theoretical background, mostly university degrees, but lacked practical experience and had very little knowledge about hydroelectric power stations. The supervisors, when they arrived, had quite high expectations of the trainees' knowledge and became from the beginning a bit concerned about the training possibilities. The supervisors were well qualified, with a wide experience from similar projects in Norway, but lacked experience in conducting training in Africa.

There was no real plan or guideline for the training component and both the trainees and the supervisors were uncertain as to how the training should be conducted. Each of the supervisors had their own approach to the training component and no "scarlet thread" was followed.

At Semonkong the supervisors showed and explained the type of work to be done, but carried out almost all the practical work themselves. The trainees were present and watched the work but were rarely directly involved and their eagerness and willingness to participate diminished. On the other hand, the erection work was of very high quality and there were few faults that needed correction later on by the commissioning engineers.

When the work continued at Mantsoyane, another approach was tried. The trainees were allowed to do almost all the connection work under supervision. When the commissioning period started, many faults were detected by the commissioning engineers so the supervision had not been satisfactory. Other problems that developed were LEC related, for example, transport, living conditions, absence from work, etc. In periods, the trainees lacked transport, stayed far from the power plant and therefore attended the training late or not at all. Some personnel problems also developed, perhaps due to the fact that they were living close together for a long period of time before they were allowed to take a weekend off in Maseru.

On this project, the lack of direct guidelines for the training made both the supervisors and the trainees insecure in conducting the training component parallel with the erection work. When supervisors also have a tight time schedule to follow, the training component will suffer. The training component should therefore be clearly defined in the contract, also with guidelines for the training. Unexpected situations (ex. dam breach) also developed which caused the supervisors to attend to other matters.

It was the supervisors' point of view that their experience had shown that the best way to conduct the training was by supervision only. The trainees should do most of the practical work after instructions in the work had been given. Supervisors should then control the work closely and the trainees should themselves correct any faults detected.

3.4 Power Plant Operation/Commissioning

When the commissioning started in April 1988, the commissioning engineers observed that the trainees still had very little overall knowledge about the hydroelectric power stations; how they were functioning, where the water was flowing, etc.

The commissioning period was also split into commissioning work and training, but with rather limited knowledge obtained from the erection period, the combination was difficult in the beginning. The trainees should have been present every day, but due to the same reasons as mentioned in 3.3 (transport/accommodation), this was not always the situation. The problem was solved when the LEC personnel moved into the staff houses next to the power stations. The commissioning and training side by side went quite smoothly as long as normal routines were followed. In the periods when sophisticated fault-finding took place, the engineers could not keep the trainees occupied all the time. At such times it had been better if LEC could have engaged the trainees in other, meaningful work.

Unfortunately, during the testing and operational training period some unexpected demands on LEC side came up, which introduced practical problems in the training process. Testing and operational training could only take place when special arrangements with LEC personnel at the 33 kV network substations had been organised.

Despite the problems mentioned, at the end of the programme, the trainees had obtained good knowledge about the power stations, the equipment and operation, and were able to operate the power stations quite well. The final theoretical and practical tests proved the knowledge gained by the trainees.

Conclusions and recommendations:

- Number of trainees should have been higher from the beginning, e.g., 8-9 persons.
- To get well qualified personnel with adequate background, specifications, recruitment and testing of personnel is important.
- Necessary allowances and requirements to ensure efficient training should be made in Terms of Reference and the financial budget for the Project.
- Recruitment of personnel from the contractor with experience of training in Africa is important, but a positive attitude to the training and the trainees is most important.
- When supervisors with limited experience of training in 3rd World countries are engaged, direct guidelines should be available.
- When experienced supervisors are engaged, flexible training programmes are to be preferred.
- During the erection period, the supervisors should supervise only, and let the trainees do most of the work.
- Commissioning period should start with basic explanations and training in how a hydroelectric power station is constructed and functions.
- The basic training is followed by commissioning work where the commissioning engineers should supervise only. The trainees should do the fault finding, read drawings, see the result from the previous erection work and do the test runs.
- The commissioning period should be followed by a comprehensive training period in various operational situations, maintenance work, fault finding, etc.
- Final test with Training Certificates to the participants.

3.5 LEC - Experience

The training content is not specifically defined in the contracts or any other additional formal documentation, but has been subject to continuous monitoring and adjustment whenever considered necessary. Apart from number of trainees, and that the training should continue throughout assembling of the electro-mechanical equipment, testing and commissioning periods, no direct guidelines and syllabus have been available. This flexibility in the arrangements has definitely positive components, which during the different stages have given opportunity to adjustments both in content of the training as well as additional training in areas requiring extra efforts. It has also made it easier to utilize problems with equipment (reference to Mantsonyane) as a training component.

On the other side the lack of guidelines put more strain on the various parties involved to get the best possible result, and monitoring and contact on more regular basis has been necessary. A stricter description on contractual basis would also have made evaluation easier, measuring of results better, and would definitely have given more specific information to outside parties and to the trainees themselves. The same can be said about the reporting side and the responsibilities, especially on the daily supervision side, where personal contact between LEC, supervisors and trainees on more regular basis has been a necessary substitute.

However, as a reflection over the experiences gained, there should from the beginning have existed a principal syllabus where also both practical and theoretical training were defined. Weak spots would be easier and earlier detectable, and the final result more valuable. Written and practical tests both on the theoretical and the practical side were unavoidable in this situation. The test of the trainees did, however, show relatively good results which indicate the training has given what it was supposed to give, but not necessary that the training has been efficient taking into consideration time and money.

Regarding training of the one engineer in Norway for 6 months, there should most probably have been at least two following the same scheme. Two for three months would definitely have been more efficient taking into consideration LEC needs, than one for 6 months. A detectable weak spot here is definitely the language side. The personnel the trainee needed most professional contact with regard to explanations and detailed instructions, had also the less command of English. This detail should be considered more important.

A real strain during the training period has absolutely been lack of transport. In spite of the utmost done by all parties to meet the problems, periodical problems of importance for the training efficiency have not been possible to eliminate. 1-2 vehicles should have been available for LEC through the project from the start of the training.

An evaluation of practical circumstances should should have been done beforehand, and necessary funds made available in the contract. In this case, the problem showed to be lack of transport.

Number of personnel trained has definitely been too small when taking into consideration that this personnel was the only and the first personnel in the country to be trained. Two qualified operators for each station plus one for the maintenance side, was and is an absolute minimum regarding the location of the stations and regulations that have to be followed. Necessary ordinary or extraordinary leave, or operators leaving the Corporation will immediately endanger the possibility of keeping the station in normal operation and good maintenance condition. This situation has to be considered as a reasonable possibility from the very beginning, and the present reality is critical because disciplinary incidents have made it unavoidable to expel 2 of the original 5 from duty. The Generation Department of LEC is now left with 3 trained operators and 1 partly operator trained counterpart to the expatriate engineer. At least the double number of well-trained operators must be available in near future if the premises of regular operation, good maintenance and future self-training shall be possible to meet.

As an overall conclusion on the training quality, it can be said that the training given has met the expectations and the requirements of LEC, but the quantity of trained personnel is too small. After some time of gaining experience with the operation and maintenance, the operators should also be given opportunities for further training in this field to prepare them for extended responsibilities and more knowledge especially on the theoretical side, for example hydro power operation on a higher level, and additional responsibility on the training side as trainers.

Normally in this context, projects are underestimated as far as the operation/maintenance side is concerned. The hard "life" on the "receiver" end starts when commissioning is completed. A "post-project" follow-up programme should normally be part of agreements/contracts. The additional funds made available for the post-project operation in training, and the follow up from the Norwegian side on the operational problems, has shown crucial for an successful implementation of the project in the long run.

4. CIVIL WORKS

4.1 Mobilization

Preparations for the project was started in Norway prior to the official signing of the contract.

The Consultant and the Contractor carried out a reconnaissance trip to Lesotho in May 1985 together with NORAD's project assigned representative from NVE. Discussions and rearrangements for start-up of the project was done with the Client, LHWP unit, LEC, LCU, Mines Department and other institutions. Both construction sites were visited.

The trip was very useful and contributed to a quick mobilization when the management team arrived in August 1985.

The Contractor used the time between May and August 1985 to procure construction equipment in Norway and organize the shipment to Lesotho.

Immediately after arrival to Lesotho the mobile house units for Mantsonyane camp were procured and transported to site. The construction equipment arrived in September 1985. Staff vehicles and 2 Mercedes 4WD tipper trucks were booked at arrival in August 1985.

Noremco Construction was mobilized for the first construction works at Mantsonyane from October 1985. Houses in Friebel Estate for the expatriates were booked during the reconnaissance trip in May 1985 and office work were in the beginning carried out from the private houses.

NORPLAN organized the office facilities in Maseru. The office was operative from January 1986.

The mobilization period was altogether efficiently completed according to time schedules.

4.2 Construction Period

The construction works at Mantsonyane began with the access road from Mantsonyane village immediately after the erection of St. James Camp was completed.

Inspection of the site at Semonkong was carried out at an early stage. The conclusion was however that it would not be advisable to start works at Semonkong before the rainy seasons was through.

Works on a new access road to Semonkong was also in progress and would later on improve the access to the site. A one way trip to Semonkong with 4WD vehicle took 8 hours from Maseru before the new road was build. Several road crossings on the access were flooded for long periods, and integrated design questions for the weir at Semonkong had to be sorted out with the Semonkong Project and LCU before construction works could be started.

At Mantsonyane LCU (Labour Construction Unit from Ministry of Works) was given a subcontract for the access road. It was, after a while necessary to limit LCU's engagement only to upgrade the access track to Aurey Mission.

Noremco Construction did the roadwork between Aurey and the dam site where heavy rockblasting was required. It caused some difficulties to be dependant of LCU even on the first portion of the access road, and Noremco Construction had to do portions of LCU's road contract in order to avoid serious delays.

All together the construction works for Mantsonyane was completed according to the original plans as far as access to the Dam site and the Power Station is concerned. The reasons for delay afterwards are reflected in the Final History Report under Part II, 4.8.5 Tunnels and 4.8.6 Power Station.

Lesotho has a considerable number of workers with experience from mining both from mines in RSA and Lesotho.

A considerable number of the workers on the project were recruited from the Mantsonyane and Semonkong areas. Despite of previous experience, the requirement of intensive supervision was disclosed when the actual tunnel driving started.

The supervisory staff from Noremco was insufficient in number during the construction period and the expatriates had to work continuously on 1 1/2 shift over longer periods.

Some skilled and very capable plant operators were available in Lesotho. Also truck drivers and mechanics were available in limited numbers.

The flood accidents and the dam breach at Mantsonyane were serious drawbacks for the construction works.

4.3 Construction Equipment

2nd hand construction equipment was purchased in Norway and locally for use on the project. The budget for construction plants were not sufficient for purchase of new equipment. Only the staff vehicles and the tipper trucks were purchased new.

Most of the equipment functioned satisfactory but 2nd hand equipment require more repair and maintenance capacity than new equipment.

This was in periods a bottle neck and caused delays at times. The fact that the expatriate mechanic had to share his time between his workshop duties and supervision of construction work in the tunnel and spillway quarry, was a serious disadvantage. For some of the equipment, spare parts were not available in Lesotho and had to be ordered from Norway. This also caused some delays.

Additional to the problems caused by ordinary breakdown which were nearly normal for the equipment in question, some of the construction units were wrecked due to misuse and accidents. This was partly caused by the terrain conditions. Allowance for accidental breakdowns should be included in future construction equipment budgets.

The choice of equipment units proved to be suitable for the project purposes but to increase the capacity in periods, additional equipment had to be purchased or hired. In the end there was a considerable cost overrun on vehicles and construction equipment.

For projects where the total mobilization and construction time is more than 1 1/2 - 2 years, new equipment should be purchased from the beginning. In hard, mountain conditions the equipment is the key factor when tight time schedules must be kept. New equipment will most likely also give lower total costs in the end.

4.4 Material and Supply

Construction material was available from suppliers in Lesotho.

The supply situation was however, sometimes a problem due to the difficult transport road to Mantsonyane. In winter periods and periods with heavy rains, the access to Mantsonyane was closed for longer periods.

The access to the Power Station area was an additional local access problem. The river had to be crossed in a ford upstream the dam and this river crossing was at times blocked by flood for longer periods and was not passable at all with ordinary small vehicles during longer periods of the rainy season.

People and equipment were for periods ferried across with wheelloaders, but at times even the wheelloaders could not pass. The only remaining alternative to reach the Power Station was in such cases to walk across the mountain where an alternative but more expensive access road alternative is available.

4.5 Design modifi tions

Due to a limited budget for site investigations during the feasibility study some modifications of the design was expected to be necessary. For example the correct level of good solid rock was some places deeper than anticipated.

Semonkong.

At Semonkong the major design-modifications were results of good solid rock at deeper levels than expected.

- The retaining walls at both sides of the concrete weir had to be extended because the solid rock level were deeper than expected.

- The surge-chamber was designed 40 m long in solid unlined rock. During the blasting and excavation of the trench and widening for the surge-chamber, the rock was found to be weathered rock which could not keep the water in place. The surge-chamber was shortened to 10 m as agreed with the electro-mechanical engineers, but had to be lined with concrete in the bottom and all four walls.

Mantsonyane

The major design-modifications at Mantsonyane were caused by various matters, as change in mechanical equipment, engineering equipment available, rock-conditions, etc.

- The cross-section of the tunnels were increased from 9 m2 to 12-15 m2, to be adjusted to the construction plants available, also suitable for other type of work.

  Caterpillar 950 was used for "load and carry" excavation.

- Due to change in design of the turbines (draft-tubes) the whole power-station had to be extended both in height and length. The work at the power station had to stop for about 3 weeks before the new design was ready, and the blasting could resume again.

- Due to the floods in the period September 1987 to April 1988 the bottom-level in the river outside of the power-station had been elevated. This made it necessary to construct a retaining wall against the river just outside of power station entrance.

- The spillway was changed from a design with side-overflow and a narrow but steep canal, to a straight overflow with a wide canal.

- The design of the intake/scour gate had to be changed due to extensive scaling and cleaning works, and a new location of the scour gate was necessary. The new location required more concrete works.

  Table 4.1. shows a list of some of the measured main quantities for the two projects compared with the figures from the Bills of Quantities.

TABLE 4.1

MAJOR ITEMS	Calculated QTY	Total QTY	Difference %
MANT SONYANE			
Dam			
Scaling/cleaning	700 m2	1700 m2	240%
Foundation grouting	5 t	3.25 t	65%
Filling	40,000 m3	69,000 m3	172%
Concrete retaining wall	-	80 m3	-
Concrete slab	-	150 m3	-
Spillway:			
Scaling/cleaning	300 m2	500 m2	160%
Blasting/Excavation	55,000 m3	75,000 m3	136%
Concrete weir	80 m3	180 m3	223%
Tunnels:			
Scour tunnel	90 m	108 m	135%
Headrace tunnel	712 m	712 m	100%
Tailrace tunnel	-	23 m	-
Power Station			
Blasting/Excavation	1500 m3	2600 m3	175%
Concrete works	187 m3	360 m3	192%
Retaining wall	-	30 m3	-
Intake/Scour gate			
Concrete works	63 m3	330 m3	524%
SEMONKONG			
Dam:			
Scaling/cleaning	180 m2	280 m2	156%
Concrete weir	320 m3	320 m3	100%
Intake/Retaining wall:			
Scaling/cleaning	160 m2	200 m2	125%
Concrete works	195 m3	215 m	110%
Penstock/Surge chamber:			
Blasting/Excavation:	2200 m3	4000 m3	180%
Pipes :	460 m	460 m	100%
Concrete surge-chamber :	15 m3	55 m3	367%
Power Station:			
Scaling/cleaning :	130 m2	150 m2	115%
Blasting/Excavation:	165 m3	195 m3	118%
Concrete works :	90 m3	150 m3	167%

5. ELECTRO-MECHANICAL EQUIPMENT

5.1 Transport and Shipment

All the electro-mechanical equipment was contracted delivered to site by the supplier. The shipment left from Oslo in July 1987, about 2 weeks delayed due to cancellation of a departure from Norway.

When the shipment arrived at site in September, another 2 weeks delay was added, mostly caused by slow costume clearing in Durban.

The supplier was responsible for transport to site, but the Resident Management in Lesotho helped to take care of preparations in Lesotho and cooperation with, and "pushing" of the local Freight Agent. This is also quite normal since the Resident Management is more familiar with the conditions in the receiving country, and can therefore easier handle the situation. The main problem proved to be the distance to the Freight Agent's office, which could only be reached by telex, telefax or telephone.

The transport of heavy loads up into the Lesotho mountains on narrow, steep gravel roads is always risky. Seasonal weather-variations are also an important factor, and the delay of 4 weeks could have been a serious problem, but the rain started only on the very last day of transportation.

The transportation from Maseru to Mantsonyane and Semonkong took about one week and went quite smoothly.

The packing was quite satisfying, but due to friction between the station-transformer and the container-wall a small hole in the transformer casing was made.

5.2 Site Erection, Testing and Commissioning

When the erection work started at Semonkong in September 1987 the hydropower station was completed for mechanical and electrical erection work, and floor and walls had received one layer of paint.

The erection work took much longer time than estimated in the contract, while the electrical installation was completed almost on time. It is hard to find any reason for the delay, since the power station also was completed as agreed with the contractor beforehand.

The helpers held by LEC were "skilled" electromechanical personnel and future operators, but there skill were not as good as anticipated beforehand, and comprehensive training was necessary. This additional training could have contributed to some of the delay. The training aspect is further discussed in item 3.4 and 3.5.

Due to transport-problems the LEC personnel was absent from work some days, but this could not have hampered the work that much.

The installation work was completed in December 1987.

The testing period at Semonkong was postponed until April 1988, so the testing and commissioning engineers could continue to Mantsonyane on the same trip from Norway.

The testing work at Semonkong also proved to be time-consuming. Faults were found and some reprogramming of the control-system had to take place. A severe fault on the generator unit was detected when the test runs started and no power was generated. The generator had to be opened for repair, and an engineer from the subcontracted german company Reliance arrived to do the job, but without necessary special tool to take off the flywheel and the rotor.

When such unlucky situations occur in remote areas far from the supplier, the repair work will take longer than usual, but discussions between the main contractor and sub-contractors should not delay the repair work as happened at Semonkong. The fault was reported the 26th April and was only repaired the 7th May.

All Reliance generators are tested at the factory and certificates are issued, and it is therefore very strange that such a fault can occur. The reason seem to have been a bad soldering joint that had broken during transport.

Semonkong Hydropower Station is connected to an isolated network. Very few consumers were connected when the test runs started and necessary load had to be provided from elsewhere. At Semonkong, 2 resistive load-banks had to be hired, one connected by the power-station and one further out on the network. This gave quite good testing conditions, but cannot fully substitute normal variations in future loads on the grid. In remote districts hire of load-banks have to planned and booked long time beforehand, and any delays prior to the use of loadbanks cannot be tolerated.

When the final taking over tests took place in October 1988, another resistive load-bank was hired at considerable transportation costs.

Due to the flood situation in September 1987, the civil construction work at Mantsoyane had fallen behind time-schedule but the mechanical erection of draft-tubes and turbines could start as planned in January 1988. Some of the civil-construction work therefore had to be carried out in parallel with the electro-mechanical erection work. This situation may have hampered the installation work, but parallel working is quite normal, since draft tubes, turbines, etc., are to be embedded in concrete.

Another setback for the installation work was the flood-situation in March, that inundated some of the already installed equipment. This flood delayed the installation work, and cleaning, drying an testing of equipment had to take place. The installation work was completed in the first part of June, and the testing and the commissioning started immediately. The first phase of the testing included all "dry-testing" and also test runs of both units connected to the local grid and at the end connected to the main grid. Many minor faults had to be corrected, but this is also quite normal since the trainees from LEC had actually done a lot of the cable connection work.

The test run was successfully carried out. The second phase of the testing and commissioning took place mainly in October, with both mechanical and electrical Norplan experts present for 1 week.

LEC did not allow Mantsonyane Hydropower Station to be connected to the main grid, and special arrangement with LEC had to be agreed every time test runs on the grid should take place. This situation hampered the testing work and gave very difficult working-conditions for the supplier. (LEC only connected Mantsonyane Hydropower Station permanently to the main grid in February 1991 after an independent consultant had looked into the matter).

During the final testing in October 1989, two severe faults were detected. The bigger valve (1400 mm) could not be operated and had to be dismantled and repaired abroad. The smaller generator gave signals indicating over-heating and the smaller generator therefore fell out, and the German expert once again had to be called upon. A lot of fault-finding work on very high technical level had to be carried out, and the supervisors had a hard time keeping the trainees occupied. Another problem, both at Semonkong and Mantsonyane, has been unsteady signals from the intake to the power station. This problem have still not been sorted out and the supplier is still working on this and have extended the guarantee-period.

It is very unusual that so many severe faults occur on one hydropower project, and we cannot find any good reason for this. Normal control and testing procedures have been followed.

6. COSTS

The total costs for the project are given in part II, table 7.1. As can be seen there has been a considerable cost-overrun from the original budget in 1985, mainly on professional services, equipment from Norway and civil engineer construction costs, giving a total cost-overrun of 24.5 mill. NOK or 43% from the original budget.

6.1 Professional services

The professional services includes all costs for both the Consultant and the Contractor. The costs for Electric Engineer seconded to LEC for 3 years are also included. Professional Services contributed with about 31% of the total costs (27.5% when the electric engineer is excluded).

The distribution of the Professional Services costs between the Consultant and the Contractor was about 50 percent each, including the Electrical Engineer as a member of the Consultant team.

The Professional Services for the Consultant alone (exl. Electrical Engineer) count for about 12-13 percent of the Total Project Costs.

When we look further into the figures for professional services, table 7.4.2 in part II, we can see that professional fees count for almost all the increase with a smaller contribution from travel, subsistence and accommodation, and Maseru project office.

The main reason for the cost-overrun in professional services is the delayed termination of the project itself, which again made it necessary to prolong the expatriates stay in Lesotho. According to the original construction-schedule for the project the construction should have been completed in November 1987, but was more than 1 year delayed. The Electrical engineer seconded to LEC also extended his stay with 1 year.

The budget for the professional services was 18.15 million NOK, and at the end of 1987 the accumulated costs were 17.37 million NOK. This shows that professional services costs are almost proportional with the time. When projects are delayed the professional services will have to be prolonged with the same apparatus involved; fees, project office, accommodation, etc.

On this project the need for expatriates were underestimated, and when the project fell behind the construction schedule, more expatriates had to be recruited for shorter or longer periods. It is very important to have a sufficient number of expatriates to have a good start to the project, and to follow the construction schedule from the beginning. When working in developing countries expatriates are necessary throughout the whole project, and the costs will therefore be proportional with the total construction-time.

The project included a heavy training component, which again required a high number of qualified expatriates. It is difficult to estimate how much "on-the-job" training hampered the progress, but it is clear that work could have been forced by using skilled workers from abroad (South Africa). Fortunately this type of contract gave the contractor a chance to keep up with the training-component, but the budget was too limited.

6.2 Equipment from Norway

The figures for the equipment from Norway are shown in tables 5.1, 7.1.1, 7.1.2 and 7.3.1 in part II. The total cost-increase was 6.9 million NOK, or 55.2% increase from the original budget of 12.5 million NOK.

The main contribution to the cost-increase came already in 1986 when the contract for the electro-mechanical equipment was signed with a price-increase of 4.9 million NOK compared to the original budget. The budget was based on international price quotations, and international tendering was proposed, but not accepted by NORAD. Only Norwegian suppliers were invited, and the tenders were far above the international quotations. Negotiations were held with Sørumsand Verksted A/S (Later Kværner Eureka) as consortium leader, and EB-Energy as the electro-technical supplier.

The tender was 9.65 mill. NOK (77,2%) higher than the budget prices of 12.5 mill. NOK, and the final contract price was reduced to 4.92 mill. NOK (39.4%) higher than the budget price.

Obviously it is difficult to negotiate contracts from an original tender of 22.15 million NOK, down to 17.42 million NOK, and it is also clear that "some" had to be given away to achieve a reasonable contract price.

When a tender-price is hard pressed during negotiations, it will be difficult to keep the final price low, because small adjustments or irregularities from the contract will raise the price again. At Mantsonyane and Semonkong the erection work took much longer than estimated in the contract, and additional training of operators was required throughout both the erection period and the commissioning period.

At completion of the project the final price was 19.23 million NOK, 1.81 mill. NOK above the contract price, but still 2.92 below the tender, with the same input both on the equipment, engineering services and training as included in the original tender.

In addition to the electro-mechanical equipment GRP pipes were included in the budget of 13.3 million NOK. Gates, trashracks and station-cranes were originally budgeted for in the "locally manufactured equipment", but later the scour-gate and the Mantsonyane station crane were added to "equipment from Norway". The total cost-increase was therefore added up by increased electromechanical equipment and additional equipment.

"Locally manufactured equipment" was also almost doubled compared to the original budget. A lot more steel-equipment was manufactured locally (most at Lesotho steel) than estimated. The only reason for this cost-overrun was too optimistic budgeting.

6.3 Civil Engineering Construction Costs

The civil engineering construction costs are given in tables 7.1.1, 7.1.2 and 7.2.1 in part II. As shown there has been a considerable cost-overrun with 12.2 million NOK or almost 60% from the original budget of 20.4 million NOK.

The main contributor to the increase is sub-item "Vehicles and construction equipment". In the budget secondhand construction equipment and spare-parts from Norway was included, but only six months after construction start the budget figure was reached, and before the project was completed, the accumulated costs had reached 12.3 million NOK or 223% more than in the original budget. The original budget was far to optimistic, and the working conditions in Lesotho proved to be very hard on the equipment.

Most of the equipment was second hand equipment from Norway, but some equipment was also purchased new in Lesotho from the beginning and necessary replacements took place throughout the project, see item 4.3 part 1. Due to lack of sufficient equipment and break-down of secondhand equipment, equipment also had to be rented for quite long periods. For the dam-construction 4, 6 wheel-drive tipper trucks were hired for quite a long period together with a heavy bulldozer and additional excavator. Due to the dam-breach the equipment had to be rented for a longer period, and to force the working-programme some additional equipment had to be purchased and hired.

After completion of the project, all the equipment was sold by WEMMIN to Noremco Construction A/S, and the income was used on the project.

The sub-item 5.3 "Labour and material" also reached a cost-overrun from budgeted 14.2 mill. NOK to 19.1 million NOK or 35%. (Item 5.4 staff-houses also included). The main reason for this cost-overrun is underestimated amount of work after the dam breach in September 1987, and a prolonged working period. As described in item 4.5 part 2 we had an increase in work compared to the amounts included in the Bills of Quantities, and for example additional cement, steel, crushed stone had to be purchased. The dam-breach made it necessary to replace material, bitumen, filter-cloth, steel shuttering, etc. Due to the prolonged working-period additional wages are included in this item.

6.4 Total costs

The three main contributors to the cost-overrun are commented on above, and as can be seen there were various situations that together gave this considerable cost-overrun. As a whole the cost-estimate and the progress-schedule seem to have been too optimistic from the beginning. The project was a pilot project in a developing country in Southern-Africa with a heavy training component, and with severe weather-conditions to be in Africa. Abnormal weather-conditions with snow and rain in the mountains caused stoppage to the work and transport in the Maluti mountains.

At the same time the first Civil-works Contracts for the Lesotho Highlands Water Project started, and the Conractors had the same type of experience working in the Maluti mountains. When new Contracts were tendered for, Contractors without experience from the Maluti mountains had the lowest tender and Contractors who already had gained experience from the mountains had increased their rates to include the hard working conditions.

When budgeting for construction work in developing countries the time-schedule should be prolonged compared to similar projects in Norway and the contingencies should be increased to cater for all unforeseen additional work.

The goal is to find an ideal middle way where unforseen situations and training are included while idle periods due to a budget that is too wide are excluded.

The type of contract used on this project ("Project Management Contract") requires considerable input from the Consultant. This also includes work normally carried out by the Client on "standard" contracts.

NORAD has made funds available for additional training of LEC personnel and the training will be carried out in 1990/91.

The total finance for the project is shown in table 6.1.

Table 6.1. TOTAL FINANCE FOR PROJECTS.

Agreement Lesotho-Norway, dated October 1985	57.0 mill.NOK
Addendum No. 1, reg. 032, to agreement dated September 1987	9.5 mill. NOK
Addendum No. 2, reg. 032, to agreement dated March 1988	9.0 mill. NOK
Paid by Government of Lesotho, February 1988	2.0 mill. NOK
Insurance claim	3.0 mill. NOK
Government of Lesotho, February 1989	1.12 mill. NOK
	81.62 mill. NOK

Addendum No. 3, reg. 032, to agreement dated July 1990 "Operational Training and Mangement Support"	1.25 mill NOK

7. RECOMMENDATIONS

7.1 Rural Electrification

Already when the rural electrification programme took off in 1984, discussion about connection fees, tariff structures, etc., started, and the responsible departments and parastatels have been involved. The issue have also been dealt with in various studies since then, including a comprehensive tariff study financed by the World Bank.

The issue was discussed at all 6 Advisory Group meetings held throughout the implementation period of the project. Conclusions were drawn and recommendations were made, but the recommendations were never put into operation. (Avaiting conclusions from the tariff study in connection with the Highlands Water Project).

The current situation, e.g., at Semonkong, has been that the consumer has to pay the actual cost for the new line. Many of the future consumers could not afford the connection fees, which in some cases raised to more than ten thousand maloti (double of an average annual wage). Another problem has also been that LEC could not approve existing wiring inside some of the houses, and necessary rewiring of houses has therefore hampered the connection of more consumers. Recent information however indicates that the demand now has reached the level, where extension with unit number two is needed.

Recommendations for rural electrification
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1. Discuss various strategies to supply electricity to business activities and private households, e.g., loans, grants, subsidies, etc.

2. Uniform tariff for both urban and rural areas, which should be acceptable from political, technical and economic point of view.

3. The tariff structure should be simple to administer and easy for the consumer to understand.

4. A flat rate of connection fee for all household and smaller industrial/commercial consumers.

7.2 Contracts

The form of Management Contract used for Mantsonyane and Semonkong hydropower projects was not ideal in all respects.

The viewpoints from the Client in Lesotho should be considered seriously when new projects are discussed based on similar principles, and it should be stressed that there is no difference in the contractual status of the members of the management team, even if the construction management team is recruited from a contractor company and the design/quality control team is provided by a consulting company.

Management Contracts and Turn Key concepts for implementation of hydro power projects and other projects in development countries, will also in future be a favourable alternative when some of the following conditions are present:

1. The Client wishes to implement the project by use of his own manpower.

2. Training is an important element in the development process.

3. The project is a pilot project in a new area.

4. It is advantageous to commence the implementation of the project at an early stage based on a preliminary design, and to carry out the detailed design as part of a training programme as the development takes place (when such training is required).

Recommendations for contract lay outs:
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1. The traditional Consultancy services should not be mixed up with Contractors responsibilities.

2. Special care should be taken in order to avoid doubt about the Consultants supervision and quality control element, and a detailed Quality Plan should be part of the contract.

3. The project should have a decentralized organization and experienced senior management should be used for functions in the development country. This involves that detailed structural design should be carried out as part of the training process in the developing country (when such training is required).

4. The training elements in the development contract should be defined by special Terms of Reference and budget both for consultancy as well as construction work.

5. The non-profit system for construction costs, i.e., construction costs are refunded on actual cost basis, is a sound system for projects based on terms listed initially under this chapter.

6. Most of the feedback we received from Lesotho officials was quite positive, however, they preferred separate contracts to be signed with the Consultant and the Contractor.

   Two contracts will require more attention from NORAD but we assume that this also could have been handled through the cooperation with NVE when it is a question of a hydropower project.

   Norplan and Noremco have few objections to the type of contract used here and therefore very few reasons to advise against it. What is important is to stress the fact that the Contractor is a full member of the management team and is therefore the Client's partner in the same way as the Consultant.

7.3 Implementation

See para 7.2, recommendations for Contracts.

7.4 Training

The planning of the training component should be incorporated in the feasibility study. This study should include clarification of the requirements of the Client including goal and level of the training. It is of great importance to know if management training or specific training in hydropower design is preferred. When the latter is preferred detailed design should be carried out as part of the training process in the developing country.

Training and tight time schedule is not a lucky combination. Projects will, however, normally wind up with tight time schedules for periods. The training aspect should therefore in a development contract be well defined and detailed.

At the end of each project, follow-up courses should be included and budgets for carrying out the course programme specified in the Contract.

Course Certificates should be issued to participants.

On-the-job-training

"On the job training" is a commonly used phrase, describing a more intensified form for supervision of construction works. The goal is to achieve a better training effect than under ordinary construction works when instructions are given only to the extent necessary to carry out the works satisfactory.

NVE/NORAD has requested that the on the job training aspect is given special attention in this report. When on the job training is incorporated as a condition of contract, the meaning of the word should be defined and necessary allowances for increased time and cost should be included for in the time schedule and the budget.

The following types of training concepts for construction works are recommended:

I Full scale training project
II Training motivated project
III Training courses

I <u>Full Scale Training Project</u>

All construction works included are carried out as a practical training course. This will require careful preplanning of the construction works involved for each element or structure selected as a training piece.

The working crews should be selected as early as possible and follow the work from start to completion of the construction piece.

The work should be carried out under close supervision from a well qualified foreman keeping record of the achievement and progress for each trainee.

A full scale training project should not be too big or complicated.

Semonkong Hydropower project where the construction elements are relatively well surveyable could be a project fitted for the concept.

Mantsonyane Hydropower project would, however, not be fitted for full scale training. The complications combined with floodwater and the nature of some of the structures like tunnels, intake etc would make it difficult to follow a strictly preplanned training programme.

Some of the construction elements at Mantsonyane could, however, be carried out as training pieces. Mixing in special training objects in a normal construction project is, however, difficult because of the risk that manpower and equipment are "borrowed" from the training crew when other construction works in the same area are having shortages.

It will therefore be the best alternative that <u>all works</u> on a project can be split up in training pieces and carried out according to the same system, i.e., as a "full scale training project".

Compared to an ordinary construction contract on tender basis, the following should be included in a contract:

1. Time schedule

   The time schedules should be flexible and include additional compared to normal.

2. Supervisors/instructors

   The number of supervisors or instructors should be increased compared to normal.

   The expatriate supervisors should be paid on time-rate basis, including ordinary overhead charges for consultancy services.

3. Construction costs

   The contract should be based on non profit on construction costs, i.e., the contractor should be refunded actual costs for labour, material and transport.

II <u>Training motivated project concept</u>

This is a project concept very much similar to the one actually used for the Mantsonyane and Semonkong Hydropower projects, where it was a priority in the contract to include on-the-job training as part of the work on the project.

For projects implemented according to this concept the following should be conditions of contract:

1. The <u>training aspect</u> should be stressed in the contract conditions.

2. <u>The expatriate staff</u> working as supervisors on the project should preferably have experience from developing countries and be motivated to supervise the work in an educational manner. If possible the personnel selected to work on the project should be trained as instructors.

   The expatriate teams should be paid for on time based rates including normal overhead for consultancy services.

3. <u>Time schedules</u> should be increase by about 20% compared to normal.

4. <u>Construction costs</u> should be based on non-profit terms in the contract, i.e., labour, material and transport costs, etc., should be refundable on actual cost basis.

5. <u>Training courses</u>

Towards the end of the project period training courses should be arranged. If possible the courses should be held in cooperation with a locally based training college.

The training courses should cover subjects relevant to the experience from the work on the project. The trainees should be picked from the working crew of the project. Training courses should have a separate budget and Terms of Reference in the contract.

III Training courses

As previously suggested (3.2. page 12) training courses should be part of the training concept also for construction works.

Under the "Training motivated" project concept described under para II above, special follow-up courses are suggested towards the end of the project. The importance of having special TOR and Budgets for training courses as stressed above is of decisive importance.

Training courses should preferably be organized in close cooperation with a local training institution. This will give valuable impulses and promotion to the local training institution.

In Maseru, The Lerotholi Technical Training College is an institution which could be approached in this connection.

Practical training for students from the college could be organized as part of the construction work on the project. If the project is carried out according to the "Full scale Training Project" concept (para I under this chapter) it would be possible with a local training institution in the fields of practical training.

To be able to keep the construction work in continuous progress, the trainees have to be organized in 2 groups alternating between theoretical training at the college and practical training on one of the construction pieces picked out as training object on the project.

PART

II

FINAL HISTORY REPORT

1. INTRODUCTION

1.1 General

This second part; "Final History Report" provides a historic overview from the early planning of several small hydropower projects in Lesotho, to the commissioning of Mantsonyane and Semonkong Hydropower Project.

The main data for the projects are listed in Appendix 2.

1.2 Contracts

On request from the Government of Lesotho the Norwegian Government in 1983 provided funds for the study of small scale hydropower development in Lesotho. The Norwegian Agency for International Development (NORAD) commissioned consultants NORPLAN A/S to carry out a review study, feasibility study and design to tender documents for several projects. The final design documents and tender documents for electrical and mechanical equipment for the Mantsonyane and Semonkong projects were presented to the Client, Ministry of Water, Energy and Mining (WEMMIN) in December 1984.

The main Contract for implementation of these projects is "Contract for Project and Construction Management Services between The Ministry of Water, Energy and Mining and Norplan A/S", dated September 1985. This Contract included a sub-contract for Construction Management between Norplan A/S and Noremco Construction A/S.

1.3 Organisation Plan

The Project Organization Chart is shown in Appendix 1.

Norplan's Project Management was based in Oslo/Norway and was responsible for all aspects of the contract. The Project Management had close contact with the activities in Lesotho, through frequent visits to the country.

Norplan's Resident Manager in Lesotho was overall responsible for all activities and aspects of the contract in Lesotho. Noremco Construction was subcontracted by Norplan to provide the Construction Site Team in Lesotho and was responsible for the Civil Engineering Construction work reporting to the Resident Manager. An Advisory Group with members from Ministry of Water, Energy and Mining (WEMMIN), Central Planning Development Office (CPDO), Lesotho Electricity Corporation (LEC), NORAD and NVE was established to monitor the implementation of the project. Norplan covered the secretarial function. In addition to participation in the Advisory Group NVE also acted as NORAD's technical advisor throughout the whole project.

1.4 Scope of Works

The Contract of September 1985 called for the following services;

A. Project Management Services.

A1 Engineering

- Planning and design of physical structures
- Advising on changes in the design, specifications and construction methods.
- Preparations of tender documents for equipment deliveries/subcontracts.
- Evaluation of received tenders and advice Client on which tenders to be selected, signing of contracts on behalf of client after having obtained his approval.
- Administrative and financial control. Project accounting and preparation of budget estimates and periodical reports.
- Continuous quality assurance.
- Preparation of as-built drawings.
- Preparation of commissioning instructions, operational manuals and maintenance procedures.
- Liaison with all bodies whose interest may be affected by the project.

A2 Procurement

- Preparation of contract documents and assistance to Client.
- Purchasing and expediting of material and equipment.
- Material control, logistics and inspections.

A3 Technical supervision

- Continuous examination of field work, quality and quantity and certifications.

A4 Commissioning

- Handing-over and final inspections and instruction of equipment and work and supervision of any remedial work during the maintenance period.

- Training of operating personnel and start-up assistance.

B Construction Management and Civil Engineering Construction Works.

- Management of all works involved, including plant, labour, materials and all subcontracts for civil works.

- Report on quantity measurements.

- Verifications of time and cost measurements, progress claims and payments.

- Payment for and invoicing of the Client for all plant labour and materials.

- Inspections and supervision of work methods, manpower planning and utilization.

- Safety and security.

- All Civil engineering construction works.

2. PROJECT SUMMARY

2.1 Brief description of the Project
See Appendix 2 for Main Project Data

Semonkong

The hydropower plant is located on the Maletsunyane river at the Semonkong Falls, some 2 km north of the centre of the village Semonkong, see Appendix A.3.1.

The main project components are intake, dam/spillway, concrete pipes, surge chamber, glassfibre penstock, power-station, 11 kV transmission line, 380 V distribution lines, and staff-houses, see Appendix A.3.2.

The hydropower project will supply the village Semonkong which, according to Lesotho's energy master plan, in foreseeable future will not by connected to the national grid.

The intake-structure is a 2.5-3 m high combined concrete gravity dam and spillway with a crest length about 60.5 m.

The retaining wall on the intake side is about 30 m long with a maximum height of 6.5 m.

Upstream of the dam/wall on the north bank of the river an intake-channel about 40 m long takes the water to the intake. A scour-arrangement is located next to the intake, to keep the intake channel free from sand and silt deposits.

The headrace concrete pipes with internal diameter 1350 mm, are buried and takes the water to the surge-chamber. The surge-chamber is also equipped with trash-rack and a 300 mm valve for scouring of sand and silt.

From the surge-chamber buried glassfibre pipes, internal diameter (1200 and 1000 mm) brings the water down to the power-station.

The power-station is located down by the Maletsunyane river. The station is built on bedrock foundation and is well above the highest tailwater level. The power station is built for 2 turbine generator units (200 kW each), and 1 diesel-generator (190 kW) to give sufficient power in dry periods. Only 1 turbine/generator unit and the diesel-generator are installed in phase 1.

The principal support system is a steel structure and the walls are filled in with concrete blocks and surfaced with natural stone. The roof is made of corrugated steel on girders and covered with thatch. The power station fits nicely into the landscape and the local environment.

The transformer section is located out-doors just outside of the power-station. Included in the project is also 11 kV transmission and 380 kV distribution network.

Mantsonyane

The Mantsonyane hydropower project is located on the Mantsonyane River some 6 km south of the village of Mantsonyane in central Lesotho, see Appendix A.3.1.

The main project components are 13 km Access road from Mantsonyane Village to the power-station, intake, dam spillway and bridge-crossing, headrace-tunnel, scour tunnel, power-station, transformer-hall, tailrace tunnel, staff-houses, 33 kV overhead line to Mantsonyane village which branches off to Auray Mission and the St. James Hospital. See Appendix A.3.2 for overall layout of the project.

The power-station is connected to the existing 33 kV line from Roma to Thaba-Tseka, and Mantsonyane is the first hydroelectric plant connected to the main grid in Lesotho.

The intention is to run the power-plant at full output for a few hours when the Lesotho grid approaches peak demand, as a "peak-lopping" plant, to reduce the monthly peak charge from ESCOM in South Africa.

The dam is a 18.5 m high rockfill dam with a bituminous core and a downstream toe. The crest length is 120 m.

The spillway is a standard concrete weir, the crest length is 67.4 m. The reservoir gives a live storage volume of about 400,000 m3, suitable for daily regulations.

A hydraulic operated sliding-gate, gives the possibility to scour out sand and other deposits just in front of the intake. A 700 m long tunnel leads the water to the power-station. Water for cooling-purpose passes through a settling tank, before it is pumped to the power station.

The power-station is located underground with the generator-floor below the normal tailwater level.

The power-station is equipped with 2 synchronous generating units; 700 kVA and 2150 kVA respectively. The power-station can also operate on an isolated network, and can therefore serve as an emergency source of power if an interruption in the power supply from ESCOM should occur.

The underground power-station furnish control-room, battery-room, store, work-shop area and 33 kV switchgear. The power-station is also equipped with a crane with 10 tonnes capacity.

The transformer-section is located in a separate underground transformer hall, connected to the power-station via a cable-ditch.

3. PROJECT DESIGN

3.1 Early studies

Review Study report, July 1983
Ref /2/

The review study concerning Rural Electrification and Development of Small-scale hydropower included four project sites earlier studied by SOGREAH from France, and one new project suggested by the Client WEMMIN. The study was based on SOGREAH's report, but all five project sites were investigated, and in many cases several alternative project sites were investigated.

The five project areas were; Mokhotlong, Sehongkong/St. Theresa, Sehlabathebe, Semonkong and Mantsonyane.

The projects at Mokhotlong, Semonkong and Mantsonyane were recommended for feasibility studies.

The construction cost per kWh produced varied between 0.5-1.0 Maloti/kWh (Exchange rate 6.0 NOK/Maloti).

Feasibility Study Report, February 1984
Ref /3/

The recommendation to proceed with the feasibility study for 3 of the projects was approved by the Client, and the work continued throughout 1983 with completion of the report in February 1984.

The Mokhotlong Project did not undergo an economic analysis, since it would not have compared favourably with the nearby located project Tlokoeng which was decided to go ahead during the feasibility project. The two remaining projects Mantsonyane and Semonkong are quite different in nature, Mantsonyane supplying to the main grid, while Semonkong supplying the Semonkong village only.

The Mantsonyane Project was compared directly with the cost of continuing supply to the 33 kV line from Maseru (ESCOM), and the internal rate of return was found to be 7 %.

The intention is to run the power-plant at full output for a few hours when the grid approaches peak demand, to reduce the monthly peak charge from ESCOM in South Africa. In emergency cases the power-plant can also supply power to crucial institutions, hospitals, etc.

The Semonkong Project was compared with the cost of building a 33 kV transmission line from Roma to Semonkong, and the internal rate of return was found to be 7½ %.

Based on the results from the feasibility study, it was recommended that both the Mantsonyane and Semonkong Projects should be designed in detail, whereas the Mokhotlong Project was shelved.

3.2 Design report
Ref /4/ and /5/

The final design for Mantsonyane hydropower project and for Semonkong hydropower project were presented in separate reports in November 1984.

The final design reports were presented together with tender documents for the electrical and mechanical equipment. Tender documents for the civil works were not presented, but bills of quantities were given.

3.3 Detail Design

The detail design was carried out throughout the whole period for implementation of the project.

The detailed design was mainly carried out at Norplan's project office in Norway, while only minor changes were taken directly in Lesotho.

4. PROJECT CONSTRUCTION - CIVIL WORKS

4.1 Construction Period

The original construction schedule and the actual implemented schedule are both shown in figure 4.1.

The start of construction works at Semonkong was deliberately delayed due to the extremely difficult access situation during the first rainy season before the new main road was constructed.

Access to the dam site and the power station area at Mantsonyane was established according to the original time schedules. The time schedules were however later revised due to delays caused by reasons explained later under this chapter. The main reasons for the delays were:

- Underestimated supervision requirement.
- Adverse weather conditions during the construction period.
- Underestimation of effect of Lesotho Highland conditions.
- Design changes.

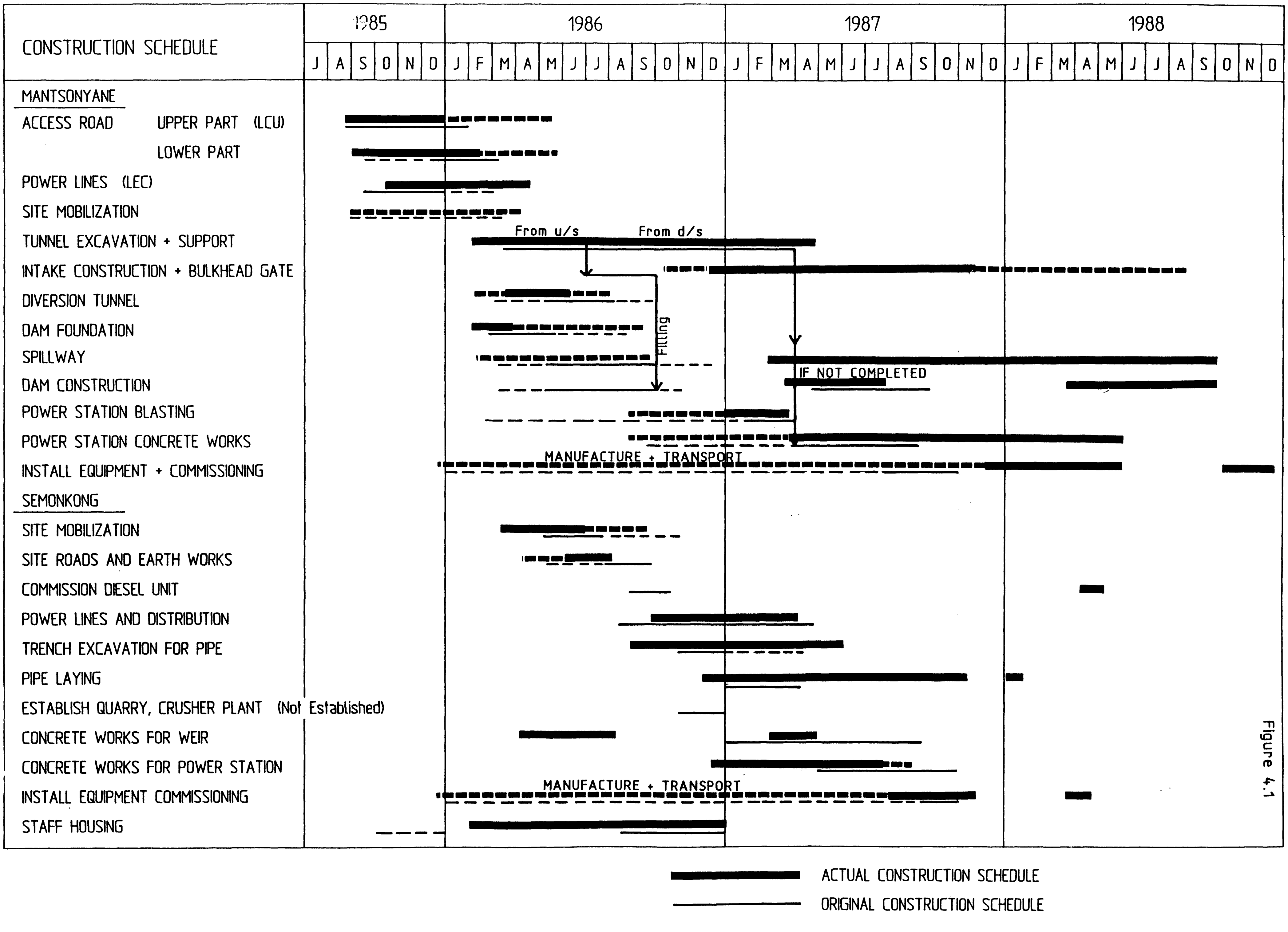
The order of listing give no indication of the quantity of each delay which will be very difficult to determine.

The work with the access roads to Mantsonyane Hydropower Projects, started in September 1985, while the site mobilization at Semonkong started in March 1986.

The electro-mechanical erection work started in September 1987 at Semonkong and continued at Mantsonyane from January 1988.

Mantsonyane was completed in October 1988, but some electrical problems delayed the commissioning and the taking over took place in February 1989, while the official inauguration took place 30th April 1989.

Semonkong hydropower plant was completed in December 1987, but due to the delay at Mantsonyane the commissioning took place in May 1988 with taking over by LEC in June 1988. The official inauguration took place 20th April 1990.


CONSTRUCTION SCHEDULE
1985
1986
1987
1988
J A S O N D
J F M A M J J A S O N D
J F M A M J J A S O N D
J F M A M J J A S O N D
MANTSONYANE
ACCESS ROAD UPPER PART (LCU)
LOWER PART
POWER LINES (LEC)
SITE MOBILIZATION
TUNNEL EXCAVATION + SUPPORT
From u/s
From d/s
INTAKE CONSTRUCTION + BULKHEAD GATE
DIVERSION TUNNEL
DAM FOUNDATION
Filling
SPILLWAY
DAM CONSTRUCTION
IF NOT COMPLETED
POWER STATION BLASTING
POWER STATION CONCRETE WORKS
MANUFACTURE + TRANSPORT
INSTALL EQUIPMENT + COMMISSIONING
SEMONKONG
SITE MOBILIZATION
SITE ROADS AND EARTH WORKS
COMMISSION DIESEL UNIT
POWER LINES AND DISTRIBUTION
TRENCH EXCAVATION FOR PIPE
PIPE LAYING
ESTABLISH QUARRY, CRUSHER PLANT (Not Established)
CONCRETE WORKS FOR WEIR
CONCRETE WORKS FOR POWER STATION
MANUFACTURE + TRANSPORT
INSTALL EQUIPMENT COMMISSIONING
STAFF HOUSING
ACTUAL CONSTRUCTION SCHEDULE
ORIGINAL CONSTRUCTION SCHEDULE
Figure 4.1

4.2 Site Mobilization

The planning for the site mobilization started immediately upon the Resident Manager and the Construction Managers arrival in Lesotho in August 1985.

The administrative office was located just outside the centre of Maseru, where parking plots for vehicles were available.

The expatriate camp for Mantsonyane was located at the St. James Hospital, only 1 km from Mantsonyane centre on the road to the hydropower site.

At Semonkong the expatriates stayed at Frazer Lodge from March -86 up to December -86. The workers stayed in 6 local standard steel huts, while the rest of the workers stayed in rented houses in the nearby villages.

All the expatriates lived in Maseru with their families, and stayed up at site from monday to friday, while the week-ends normally were spent in Maseru.

At Mantsonyane the mechanical workshop and the storage facilities together with the site office were located just downstream of the dam. Similar but smaller facilities for Semonkong were located close to the power station and the staff houses.

The workers were recruited from various districts in Lesotho. At site they stayed in the surrounding villages. Noremco paid the rental fees, and supplied beds, blankets and cooker/heaters, while the workers had to supply their own meals.

The majority of the workers were transported daily from Mantsonyane Centre and back by truck. The last thursday every month was payday, and the workers were transported by truck to Maseru, and back to sites again sunday afternoon.

At Mantsonyane the 33 kV line from Mantsonyane centre to site was constructed first to give sufficient power to the construction work.

Many power-failures for several days on the overhead line made it necessary to use a diesel-generator unit as standby to secure power for the constructions works.

At Semonkong small diesel-generator units gave the power needed for construction purpose.

Water for construction purposes was taken from the rivers.

At Mantsonyane the camp was connected to the St. James H··pitals water-system, while ground-water was used at S··onkong from the time the staff-houses were completed and the expatriates moved in.

4.3 Construction Equipment

NOREMCO CONSTRUCTION was prior to departure from Norway asked to suggest construction plant procurement based on the budget available for this purchase. The choice of equipment should satisfy the requirements for both the dam construction and the concrete structures involved. Second-hand construction plants were at the time available on very reasonable terms in Norway, and the following Key-equipments for the project were purchased in Norway and shipped to Lesotho:

1.	UNIMOG H 406 6G MOD WITH CRANE	1 PC
2.	DYNAPACK CP - 16 COMPACTOR	1 PC
3.	DYNAPACK CM - 60 COMPACTOR	1 PC
4.	WACKER BS 1004	1 PC
5.	WATER PUMPS	3 PCS
6.	BERGJET INJECTION TANK	1 PC
7.	HANY INJECTION EQUIPM.W/SPARE PUMP UNIT	1 PC
8.	CONCRETE SPRAYING MACHINE BSM 603	1 PC
9.	CONCRETE MIXER IAKO TU 175	1 PC
10.	VENTILATION FAN TUNNEL GAL 6 KORFMAN	2 PCS
11.	COMPRESSOR ATLAS COPCO PR 700	1 PC
12.	COMPRESSOR ATLAS COPCO ST 950D	1 PC
13.	DRILLING MACHINES BBC16/BBC24	1 PC
14.	DRILLING MACHINES BBD46	3 PCS
15.	PUSHING LEG BMT 51	10 PCS
16.	GRINDING MACHINE BAVER	1 PC
17.	PNEUMATIC BREAKER TAX 11	3 PCS
18.	VIBRATOR 48 MM EL.	3 PCS
19.	VIBRATOR 48 MM PNEUMATIC	1 PC
20.	STEEL BENDER	1 PC
21.	GJERDE SAWS	2 PCS
22.	BLASTING MACHINE ZEP HV 160	2 PCS
23.	CHARGING UNITS 20/amps WITH 10HEAD LAMPS	2 PCS
24.	PNEUMATIC TANK 1.3 MCB	1 PC
25.	CONCRETE MIXER FAO 375 L DIESEL POWERED	1 PC
26.	CONCRETE VIBRATORS PNEUM.	2 PCS
27.	WORKSHOP CONTAINER FULLY EQUIPPED	1 PC
28.	FAXER INJECTION EQ	2 PCS
29.	LASER FOR TUNNEL	1 PC
30.	GRINDEX ROCKMASTER SENIOR	1 PC
31.	GENERATOR DIESEL CAT 3306 205KVA	1 PC
32.	POWER SCREEN	1 PC
33.	CAT 950 WHEELLOADER 77 MOD	1 PC
34.	DYNAPAC CH45 6 T ROLLER	1 PC
35.	VOLVO 616B 78 MOD TRACTOR	1 PC
36.	CAT 215 EXCAVATOR	1 PC

In addition to the equipment shipped from Norway, the following units were supplemented by local purchase after arrival to Lesotho and as replacement for wrecked units during the run of the project;

1.	TRUCK MERCEDES BENZ TIPPER (New)	2 PCS
2.	PICK-UP TOYOTA 4X4	3 PCS
3.	PICK-UP TOYOTA DOUBLE CAB 4X4	1 PC
4.	PICK-UP TOYOTA DOUBLE CAB 4X4	1 PC
5.	TOYOTA LANDCRUISER 4X4	1 PC
6.	TOYOTA STALLION	1 PC
7.	LAND ROVER 4X4	1 PC
8.	NISSAN KING-CAB 4X4, SECOND HAND	1 PC
9.	TOYOTA LAND-CRUISER, SECOND HAND	1 PC
10.	CAT 936 WHEEL-LOADER (New)	1 PC
11.	CATERPILLAR 215 B. L.C. EXCAVATOR	1 PC
12.	CATERPILLAR 3208 GENERATOR-SET	1 PC
13.	DYNAPAC ROLLER SECOND HAND	1 PC
14.	VENTILATION FAN	2 PCS
15.	SELTORQUE 80 A PUMP	1 PC
16.	MASSEY FERGUSSON TRACTOR, SECOND-HAND	1 PC
17.	MERCEDES CRANE TRUCK, SECOND HAND	1 PC
18.	CATERPILLAR 950 SECOND HAND WHEELLOADER	1 PC

Rubber boots and raincoats were given to the workers, but these items notoriously appeared to be in short supply.

According to the Contract the construction equipment should be given to the Client, WEMMIN, upon completion of the project.

Noremco Construction A/S had, however, priority to purchase the equipment from WEMMIN, and gave after completion an offer for all the construction equipment, and the offer was accepted by the Client WEMMIN.

4.4 Construction Materials and Supplies

4.4.1 Concrete Works

Coarse aggregates

At Mantsonyane site a portable screening unit was transported to site to produce both coarse aggregate, and fine aggregates for the concrete works.
In addition the screening should also give aggregates for the bituminous core in the dam. The material was taken both from tunnel, spillway- and power-house-excavation.

The screening-unit was taken by the flood wave caused by the dam-breach, and at the end of the construction period coarse aggregates for concreting had to be transported from Maseru.

For the concrete works at Semonkong coarse aggregates were transported from Maseru from the beginning.

Fine Aggregates

At Mantsonyane the fine aggregates were initially screened from the tunnel-spoil. Due to the ceolite content of the basalt, special cement had to be used ref. /13/. During the severe flood in September 1987, the storage of fine aggregates were flushed away by the water, and new had to be supplied. Locally sand-deposits of acceptable quality, free from organic impurities were available in the reservoir, but in small quantities only. Therefore sand had to be transported from Maseru in some periods, when not available at site.

The fine aggregates at Semonkong were taken from the river upstream of the intake throughout the whole construction period. The sand was of good quality and abundant quantity.

In addition "dust" was transported to both sites from Maseru.

Cement

Standard Portland Cement was purchased in Maseru and transported to both sites, where small stores were kept.

Due to the ceolite content in the basalt-stone special fly-ash cement was purchased in Maseru and transported to Mantsonyane.

The supply of cement went smoothly, and was never a bottle-neck for the construction progress.

Reinforcing steel

The reinforcing steel was purchased in 2 rounds in Maseru and transported to both sites.
The Supply of reinforcing steel was never a problem.

4.4.2 Bitumen

The bitumen grade 200/100 was supplied by Lesotho Roadbinders Ltd in Maseru. The Supplier was also responsible for transporting to Mantsonyane site.

The bitumen was transported in 20 tonnes containers, and stored in a 25 tonnes container at site. When pouring the bitumen, a 5 tonnes trailer was used from the storage-tank to the dam.

The bitumen transport proved to be a severe problem for the progress of the dam-construction. The bad-road conditions in Lesotho made it impossible to do the transport in heavy rains and in severe snow-conditions, that often lasted more than 1 week. The road to Mantsonyane goes up to almost 2500 m.a.s.l, and the weather changes very rapidly.

4.4.3 Diesel Fuel

The diesel fuel was transported to both sites by Shell Lesotho upon 1 week notice. The diesel fuel was stored in 20,000 litres tanks. The supplier did not always manage to supply diesel in due time, and at times this caused delays in work and extra costs when emergency transports had to be arranged.

4.4.4 Explosives

Explosives were partly delivered to the site by Mines Department in the Ministry of Water, Energy and Mining upon 1 week notice.

The Contractor erected his own explosive store at Mantsonyane and got approval from Mines Department for transport by his own of explosives to the site.

Strict security measures, involving military personnel were imposed in transport of the explosives, and special storing and handling measures at site were undertaken throughout the whole construction period.

4.5 Management Staff

In accordance with the Management Contract, the following permanent expatriate staff started work in August/September 1985:

1 Resident Manager
1 Construction Manager
1 Site Engineer
1 Chief Mechanic
1 Carpenter Foreman

The electrical engineer seconded to LEC arrived in September 1986.

Noremco Construction employed all the local foremen (also all the workers) and trained them in the various fields. Due to misconduct in service some of the local foremen had to be replaced, and peace-corps members who had finished their contracts, but wanted to remain in Lesotho, were engaged.

Due to the fact that the work fell behind the schedule, additional expatriate foremen were recruited from Norway for shorter and longer periods, e.g., additional tunnel-foreman and carpenter foremen. The site engineer was also replaced by a carpenter foreman. It was also necessary to increase the management staff to cope with the geographical distance between the two projects sites.

The maximum management staff comprised:

1 Resident Manager
1 Construction Manager
1 Chief Mechanic
1 Tunnel Foreman
3 Carpenter Foremen

and 3 locally employed peace corps members, totally 10 expatriates. This number was engaged only for a short period after the dam breach in September 1987.

4.6 Labour Force

The local labour-force was recruited throughout the whole of Lesotho. The work-force varied in number from about 45 the first month to a maximum of 170 workers. Except for operators they were mostly unskilled labourers.

The distribution between Mantsonyane and Semonkong was about 130 and 40 respectively.

4.7 Semonkong Hydropower Station

4.7.1 General

After an early inspection in September 1985 it was decided to wait with the start-up of the construction works at Semonkong till after the rainy season. Ongoing road works on the main road to Semonkong would also improve the access conditions on a later stage.

4.7.2 Spillway/dam/intake

The construction work for the dam started in March 1986. The concrete spillway crest is 60.5 m long, split into 14 sections each between 4.44 and 4.2 m.

The intake and the concrete dam (or retaining wall) about 6 m high and 30 m long, are located on the north river-bank.

Very close to the intake, but a little lower, is the scour-gate located, to keep the about 30 m long intake canal free from sand and silt deposits.
The scour-gate is operated by a wheel on top of the dam, while the intake has double guides for gate and trashrack.

The first dry season (March/October 1986), 7 sections of the spillway was completed.

Construction of the wall sections on the left river-bank took place during the following rainy season and in October 1987 the walls on both riverbanks were completed and backfilled/plastered, and only one section of the spillway was remaining.The spillway could not be completed until January 1988 due to frequent floods in the Maletsunyane River.

4.7.3 Pipeline and Surge Chamber

Excavation of soil and rock in the pipeline alignment started also in March 1986. The pipeline should be buried and deep trenches had been blasted/excavated to get the necessary gradient.

The first section to the surge-chamber consists of concrete pipes, inside diameter 1.35 m and the total length 295.5 m. The surge-chamber is a concrete tank about 10 m long, 3.5 m wide and 6 m deep. If any sand or silt will settle, the surge-chamber is also equipped with a 300 mm butterfly valve and a scour-pipe in front of the intake. A trash-rack placed in guides is located in front of the intake. The last pipe-section between the surge-chamber and the power-station, is

Glassfibre Reinforced Pipes (GRP) supplied from Norway with inside diameter 1.2 m and 1.0 m, and a total length of 151.7 m.

The first section, concrete pipes were completed and backfilled in October 1987. Sand/gravel from a quarry 2 km from the pipeline was filled around the pipes, while existing soil was backfilled on top. There were no big problems with the concrete pipes, but the weight (approx. 2,5 tonnes each) made it necessary to make special lifting devices, and the excavator was also occupied with pipe-laying much of the time. Special jack-tools were used to pull the pipes together.

The work with the lower pipe section from the surge-chamber to the power-station started in November 1987 and was completed in January 1989. The laying of GRP-pipes had to be carried out much more carefully compared to concrete pipes since the GRP pipes are flexible pipes that need support from the surrounding ground. Instructions were given to the foremen and workers before start-up and carefully supervised throughout the laying period. The pipes were joined with steel-couplings with rubber seals mounted to the coupling. Very important for the result was good compaction around the pipes, especially the lower section, and correct tightening of the couplings to a preset torque with special wrench tools.

During test filling of the pipeline a leakage was disclosed, most probably caused by a section insufficiently compacted, and a coupling that was not properly tightened.
Recompaction and concrete embedding were carried out, and in addition all joints were silicon injected and some joints fibreglass bandaged. The work was completed early March 1988.

The surge-chamber was completed in January 1988. The surge-chamber will reduce water-hammers and make it easier to run the turbines on the isolated network with varying load.

4.7.4 Power Plant

The excavation and blasting for the power station started in September 1986 after the access road was completed.

The power station is about 135 m2 and contains the main machine hall, diesel-generator room, small workshop, control-room, store-room, toilet and a small entrance area. The main machine-hall is prepared for another similar 200 kW generation unit in phase 2.

The lower-section is concrete structure on rock, while the upper section is a steel super-structure filled in with concrete blocks, and plastered with a stone pitching.

The roof on top of the steel-structure is made of corrugated steel covered with thatch, to give the power-station a traditional look. The bottom-section was completed in April 1987 and the power-station was completed and painted in September 1987 before the electro-mechanical erection work started.

4.7.5 Staff houses

A local architect firm, S. McCarty, made the layout of the staff-houses, also designed in local Lesotho style, roundavels, with natural-stone walls and thatch roofing. 2 staff houses were constructed nearby the power-station, each house containing kitchen, livingroom, 2 bedrooms and a bathroom. The staff houses are fully furnished, with necessary beds, tables, chairs, and the kitchen equipped with electrical stoves and refrigerators. For heating the houses are equipped with electrical heaters and one coal or wood-burning stove.

The construction of the staff-houses started in March 1986 and the Noremco foreman moved into the house in November 1986. In February 1987 both staff-houses were completed, and moved into. The thatch roofing delayed the finishing of the houses, otherwise there were no special problems. The construction of the first house at Semonkong was carried out according to traditional procedures with walls made of concrete embedded stonework. The method proved to be expensive as it requires a lot of concrete in the walls. The next 3 houses at Semonkong and Mantsonyane were therefore constructed with walls made of blockwork lined with a 5 cm external layer of natural stone pitching.

4.7.6 Transmission and Distribution Network

Since the transmission and distribution network would have been a costly task for LEC, this was also included in the contract to secure that the local consumers should be connected to the power-station and benefit from the new hydropower project.

The contract for erection of about 3350 m 11 kV transmission lines and 2700 m 380 V distribution lines with 11 kV/380 V transformers was signed with LEC, and the work started in December 1986.

LEC did all the work including land-surveying, procurement, erection and testing. The work was completed in April 1987.

4.7.7 Re-regulating weirs

In dry periods with shortage of water the power-station can be operated after a start-stop procedure and run for 1-2 hours.

To even out the water-flow, 2 downstream weirs were constructed. The upper one is located about 300 m downstream of the power-station, while the lower one is located about 300 m downstream of Frazer's Lodge.

The weirs are constructed of stones from the river, with a concrete wall bolted to rock in the middle as a core. A small slice in the centre of the weir, will always release water and empty the small reservoir when the power-station is shut-off, while water will be stored when the turbine runs.

The construction work started in August 1988, but the last weir was only completed in August 1989 due to frequent floods in the river.

4.8 Mantsonyane Hydropower station

4.8.1 Access road

The work with the access road from Mantsonyane village to the power-station, about 13 km started in September 1985, the access road was divided into two sections, the first section from Mantsonyane to Aurey Mission was according to the main contract subcontracted to Labour Construction Unit (LCU) in the Roads Department. This section followed an existing path/track about 8 km long. The lower part of the road down to the power-station was constructed by Noremco.

Access to the dam site was established in December 1985, and to the Power-station in June 1986. The road-work was completed in June 1986, when LCU left Mantsonyane.

4.8.2 Transmission and Distribution line

The construction of the transmission and the distribution lines was subcontracted to LEC and the work started at the end of October 1985. The line is a 33 kV overhead line from Mantsonyane to the hydropower plant with branch lines to Auray Mission/Ha-Nyane and St. James hospital. Stepdown transformers were also included in the contract.

The work was completed in May 1986, and the camp-site at St. James Hospital and the working-sites got the much needed power.

In June 1988 the outgoing 33 kV cable from the power-station was connected to the 33kV overhead line, and in June 1988 the final low-voltage power-line to the intake was completed.

4.8.3 Dam and Spillway

For details see ref.(12)

The construction of the diversion tunnel, the dam and the spillway started as soon as access to the site was established.

The 108 m long diversion tunnel was completed in July 1986.

In August 1986 cleaning of the dam site including blasting for the core foundation was completed and deep holes in the centre-line of the dam was drilled so high pressure water testing and grouting could take place. Holes were drilled 10 m below the surface. Leakages through the rock were detected in about 30 m of the river bed, and grouting took place.

Screening of tunnel spoil materiel for dam-construction was carried out from the beginning of the tunnelling, while most of the rock should be carried direct from the spillway quarry into the dam. The concrete slab was completed at the end of 1986, and the contact grouting between the rock and the concrete slab was carried out just after. Preparations for the dam-construction was carried out in the wet season, waiting for May to come, when the actual dam-construction started.

A cofferdam up to elevation 2015 was built just upstream of the dam, and the water diverted through the future scour-tunnel. Since the capacity of the tunnel was limited, there was always a risk that a flood could submerge the dam site, and just after Easter in 1986, when the dam site was prepared for the start-up and pouring of bitumen, the dam site was flooded and the work delayed. The only diversion possibility up to dam-elevation 2024 m.a.s.l. was the future scour-tunnel, and there was always a calculated risk that overtopping of the dam could take place, if a flood struck in the dry season.

Special arrangements to handle reasonable floods were carried out during the construction of the dam. The downstream rockfill was always kept above the core-elevation, and the downstream toe had a gradient 1:100.

The bitumen for the impervious core was transported to Mantsonyane in 20-tonnes trucks, stored in a 25 tonnes tank at site, and transported to the dam in a 5 tonnes trailer-tank. The transport of bitumen up into the Maluti mountains during the winter-season was a critical operation for the dam construction. With snow in the mountains, the transport of bitumen had to stop, and this caused delay in the dam-construction.

The rockfill was taken directly from the spillway and carried into the dam-body, and four additional trucks were hired for this purpose. The drilling of the spillway was carried out with hand-held drilling-equipment, and to speed up the drilling capacity, drilling was carried out in two working-shifts. Later a drilling-rig was purchased, to increase the drilling capacity.

In September 1987 a severe flood struck (see ref./16/ for details) and a dam-breach occurred. At that time the dam was only about 2 weeks from completion. The dam-work came to a stop, the dam body was protected from further damages, but another, even bigger, flood in March 1988 eroded more of the body of the dam.
The reconstruction of the dam started in May 1988 after a big cleaning up job.

The old and the new bitumen core gave a good joint when the hot (190°C) bitumen melted the old bitumen. Six pipes, filled with bitumen were installed to secure high pressure in the bitumen.

The spillway crest was concreted during the dry period, but nevertheless the site was flooded several times. Water pressure testing and grouting was carried out. Extensive rip-rap works were carried out on the downstream part of the spillway, for erosion protection.

4.8.4 Intake

The intake is a concrete structure with guides for trashrack and gate. The gate is normally placed on the platform, while the trashrack is placed in front of the tunnel. A steel-structure with lifting device is located on top of the intake.

The scour-gate is located next to the intake, but about 3-4 m lower. The scour gate is a sliding gate hydraulic manouvered from the top of the intake. The construction of the combined concrete structure for the intake and the "scour-gate" proved to be very time-consuming, mostly due to the height (20 m), but also due to the flood water that always had to be diverted through the scour-gate, also during the construction and the erection of the gate.

4.8.5 Tunnel

Due to the gradient of the tunnels, wheelgoing or trackdriven equipment were required. The equipment should also be suitable for the dam construction. Load and carry with a Cat 950 wheelloader combined with drilling equipment was therefore chosen as method for the tunnelling.

This method has in Norway proved to be a cost-effective alternative for tunnels up to at least 500 m length from one face. The cross section had to be increased to min 12 m^2 due to the loading equipment, but the additional rock volume was required for the dam construction and the concrete production. The increased cross section would also reduce the headloss in the tunnel. The method should normally give a safe production advance of 20 m/weekly from one face.

Information received in forehand indicated that trained tunnel miners were available in Lesotho.

The precuttings for the diversion tunnel and the headrace tunnel from the intake were started in January/February 1986 as originally scheduled.

An intensive training programme was started in order to achieve the required drilling accuracy, and experiments were carried out to find the most favourable drilling and charging pattern. It became, however clear already from the beginning that the requirements for supervision had been underestimated. The planned minimum production was not achievable under the existing circumstances.

The Chief Mechanic, who was also an experienced tunnel miner had to share his time between the two tasks of maintaining the secondhand equipment and supervise the tunnelling. The tunnels were originally on the critical path in time schedule. The work was forced by means of 2 shift operation and excavation from a downstream face through a second access from the transformer hall. A special additional supervisor from Norway was brought down to supervise the tunnelling during the final period.

The rate of advance never reached a satisfactory level, mostly due to breakdown either on the drilling equipment or the wheel-loaders.

The delay in the tunnelling kept the wheel-loaders occupied in the tunnel work for a longer period than scheduled, and hampered other parallel work.

The 108 m long Diversion tunnel was completed in July 1986. Breakthrough in the 710 m long Headrace tunnel was carried out 19 September 1987. The 35 m long Tailrace tunnel was completed in June 1987.

The geological conditions in the Headrace tunnel was very similar to the descriptions in the geological report and the tunnel was left unlined except for grouting and shot-creating of 5 faults crossing the tunnel.

Rockbolting was also limited to the areas where the falls are crossing the tunnel. No security works except for ordinary weekly scaling was necessary during the excavation of the tunnels.

4.8.6 Power Station

The topsoil cleaning and security works on site were completed in July 1986, and the blasting of the cavern started initially in August 1986.

The original design of the Power House had a 5 m high top section and a 4.5 m high bottom section and the excavation of this cavern would be well fit for the equipment used in the tunnels. The electromechanical equipment should be moved in and mounted by means of a simple crane arrangement fixed to a steel beam running along the top centre line of the cavern.

The final discussions with the electromechanical suppliers before manufacture and shipment from Norway required, however, a major change of the design of the power house, and the excavation was delayed until this process was finalized.

The excavation and the installation works in the Power Station became decisive for the completion of the Mantsonyane project.

After redesign of the power-station in October 1986, the blasting of the power-station cavern resumed again early November 1987. The top-section above elevation 1991.5 was blasted first and completed with grouted rockbolts in a 1.5 m x 1.5 m pattern.

The excavation of the lower-section of the power station was completed in July 1987 and the concrete works and erection of steel-columns for the crane arrangement started. The concrete works were well in progress when the dam-breach occurred in September 1987, and the flood-wave filled the power station. Extensive cleaning up work had to be carried out before the concrete works could resume again.

Parallel with the work in the power-station, concrete works also took place in the transformer hall. No special problems occurred, except that due to the delay, and the erection work soon to start, there was always a very tight time-schedule to be followed. The main concrete works in the transformer hall was completed in February 1988.

In the main power-station the concrete works, embedding the draft-tubes and the intake pipes continued and followed the revised progress-schedule worked out together with the supervisors from the electro-mechanical supplier. The concrete works were completed in May 1988. Extensive water-pressure testing and grouting was carried out around the intake-pipes, and the concrete plug. Later also water-leakages through the rock between the floor and the walls were detected.

Grouting works with special grouting material imported from Norway were carried out, and the leakages were significantly reduced. Minor supplementary works were carried out up to October 1988.

Latest information from LEC is that the water-leakages now are sealed.

4.8.7 Staff-houses

The staff-houses were built according to the same drawings as for Semonkong, see item 4.7.4.

5. ELECTRO-MECHANICAL EQUIPMENT

5.1 Tendering
/4 and 5 volume III/

Comprehensive Tender-documents and specifications were originally drafted in 1984 for the purpose of international tendering. The budget prices in the contracts were based on international tendering.

Later it was decided that only Norwegian suppliers should be invited, and the documents were submitted to the shortlisted firms Sørumsand Verksted A/S and Hafslund Hydropower the 24th March 1986.

The evaluation of the proposals after the opening the 16th May 1986 showed that Hafslund Hydropower had not followed the specifications given for the tendering, and their proposal was not complete, and therefore had to be refused.

The proposal from Sørumsand Verksted A/S was given in accordance with the specifications, but the price was far above budget-prices.

After discussion with the Client and the Donor the conclusion was that negotiations should be held with Sørumsand Verksted. This was approved by the Client in a meeting 9th June 1986. The budget-, tender-, contract- and final prices are shown in table 5.1.

Table 5.1.

Electro-Mechanical Equipment-Prices:
(Price-level mid 1986)

	Mantsonyane (NOK)	Semonkong (NOK)	Total (NOK)
Budget prices	8,600,000	3,900,000	12,500,000
Sørumsand Verksted A/S Tender	15,227,300	6,923,600	22,150,900
Contract	11,578,300	5,840,200	17,418,500
Final price	-	-	19,234,225

The Contracts for both Mantsonyane and Semonkong were signed by the Client 3rd October 1986.

The Contract included also freight-costs, training-costs and spare parts.

5.2 Testing and inspection

On behalf of the Client the workshop inspection and control function relating to all electro-mechanical equipment was carried out by Norplan.

Detailed testing and control took place during manufacturing, as well as in the process of erection and commissioning at the site.

Besides systematic follow-up and approval of shop-drawings, specifications and calculations, workshop control incorporated the following activities;

- Control and approval of shop procedures, and the general program of work.
- Review and approval of material certificates and, where applicable, material tests.
- Periodical workshop visits to inspect and approve the manufactured equipment.
- Shop tests of the assembled generator, including insulation control, no-load and short-circuit testing, and measurements of generator cores.

None of the scheduled inspections and tests revealed faults or divergences seriously affecting the functioning of the equipment.

The following main equipment was produced in Germany;

Reliance Generator	200 kW	(Semonkong)
- " -	600 kW	(Mantsonyane)
Main shut-off valves	(2 pcs Mantsonyane, 1 pc Semonkong)	

Both the generators and the valves were manufactured in a fully automatic and standardized production lines in accordance with internationally accepted regulations. Test and approved certificates were submitted by the suppliers and visits to the plant were not considered necessary.

5.3 Transport and Shipment

All the electro-mechanical equipment was contracted delivered to site, and all freight-costs were included in the respective contracts.

The supplier arranged shipment from Oslo Harbour to the port of entry Durban, Republic of South Africa (RSA), where the 8 containers were cleared and railed to Maseru in Lesotho.
From Maseru the containers were lifted onto big trucks, which could be manoeuvred on the steep mountain roads. At site the containers were unloaded and returned to Durban, except for 2 containers that were kept for storing during the erection period.

The shipment left from Oslo in July 1987, 2 weeks delayed, and before the equipment reached the site another 2 weeks were added. The first truck arrived at site 4th September, and all transportation was finished 13th September.

The de-watering gate was shipped together with the rest of the electro-mechanical equipment, while the Glassfibre-Reinforced Pipes (GRP) were shipped the same route separately.

The only damage was on the transformer-body on the station-transformer at Mantsonyane that had to be replaced.

5.4 Site-Erection, Testing and Commissioning

The Suppliers of the electro-mechanical equipment held supervisors for the erection works while LEC held the necessary helpers in accordance with the contract specifications.

The helpers were skilled electrotechnical personnel that was designated to become the future operators. They took part in the work, from the very beginning and were trained in all aspects concerning the equipment.

5.4.1 Semonkong

The Consortium Sørumsand/NEBB made 1 mechanical erector and 1 electrician available for complete assembly of the generating unit, including turbine, shut-off valve, generator, diesel generator, transformers, control-panel, and all auxiliary equipment.

The erection work started in the beginning of October (7th) 1987 and was completed in the beginning of December 1987.

The civil works were completed when the erection work started and only minor supplementary work took place. The erection-work proved to be more time-consuming than included in the contract.

The testing and commissioning was postponed until mid April (11th) 1988, so the two commissioning engineers could continue with the commissioning of Mantsonyane on the same trip.

Testing and commissioning work took much longer time than anticipated, due to several small changes in the electrical system.

A severe fault on the generator-unit was detected, when the test runnnig started, and an expert from the manufacturer in Germany had to come to Semonkong to repair the generator. This incident alone delayed the commissioning about 2 weeks. A load-bank was transported to site in May, so the Commissioning engineers could complete their testing. The work was completed the 24th May 1988.

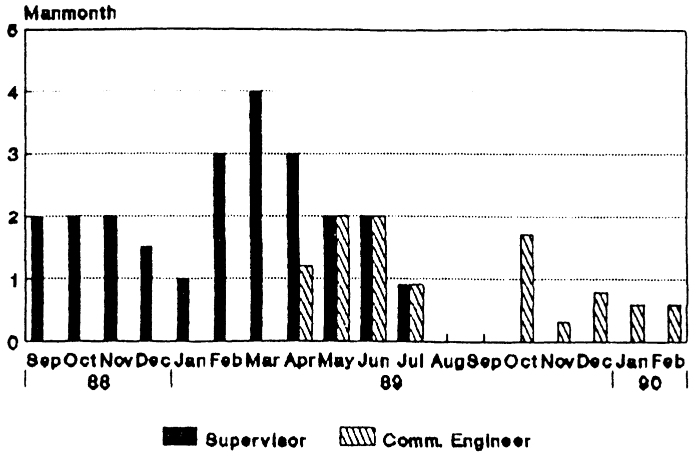
A Load-bank was again brought up to Semonkong when the final testing with experts from Norplan present took place 24th and 25th October 1988. The hydropower station was taken over by LEC on behalf of the Government of Lesotho the 4th November 1988 and put into commercial operation.
For details, ref. /9/.

5.4.2 Mantsonyane

The erection of the electro-mechanical works commenced in January 1988 with 1 mechanical erector and supervisor. In February 2 electrical erectors and supervisors were made available for complete assembly of the 2 generating units, including turbines, shut-off valves, generators, diesel-generator, transformers control-panel and all auxiliary equipment.

From late February and throughout March 1 more electrical erector and supervisor joined the team. The manmonth input of supervisors and commissioning engineers are shown in Figure 5.1.

Manmonths Input



The erection work was completed the 8th June when the last supervisor left Mantsonyane.

The testing and commissioning started the 30th of May 1988 and should have been carried out in 2 phases. The first phase was completed the 10th July, when both units had been tested and operated to be sure that there were no major faults with the equipment.
The second phase of the testing and commissioning took place in the period from 10th October 1988 to 4th November 1988.

The final test run with experts from Norplan present took place from 18th to 21st October. During this test run period noise from the main-inlet valve was observed, and the valve did not close properly. The headrace-tunnel had to be emptied again, the manufacturer dismantled the inlet valve, and took the valve back to the work-shop for repair. The valve was installed again 2nd December 1988, and has since then been operating satisfactorily.

Both commissioning engineers left Lesotho in the beginning of November, but the electrical commissioning engineer had to come back to Lesotho between the 28th November and 16th December to try to solve another serious problem. This problem was also detected during the "final" test run (18-21 October), when the small generator cut off due to alarm-signals indicating over-heating in the generator windings.

The electrical engineer made comprehensive tests and was continuously in contact with the German manufacturer, but the problem was still present.

The very last commissioning period took place from mid January to mid February 1989, and the German manufacturer had to assist the electrical engineer, and to open the generator for some adjustments inside.

New final test runs with Norplan experts present took place 16th February 1990, and Mantsonyane hydropower was taken over by LEC on behalf of the Government of Lesotho. For details see ref. (9).

5.5 Mechanical Equipment - Produced in Lesotho

The following equipment was produced by Lesotho steel:

Semonkong Hydropower Station:

- 2 pcs guides for gates and trashracks
- 1 steel gate complete with hoist
- 2 trashracks
- complete steel-structure for power-house
- 3 sliding doors
- 2 steel-doors
- radial crane
- bifurcation pipe
- all frames and covers for cable ditches
- handrails

Mantsonyane Hydropower Station

- 2 pcs guides for gates and trashrack
- 1 steel gate
- 1 trashrack
- steel-foundations for foot-bridge
- steel-frame for hoist-arrangement at dam
- steel-frame for future trashrack in front of inlet pipes
- 2 steel inlet pipes
- stairs in power-station
- steel-doors and main entrance gate at power-station
- all frames and covers for cable ditches.
- gallery for main-crane power-station (incl. columns and beams)
- all air-inlet pipes at intake

Lesotho produced steel-equipment for approximately 1.4 million NOK, and the project management had a very good cooperation with Lesotho Steel's Management. All main welding-joints were controlled in the work-shop, and main welding-joints carried out at sites, were controlled by X-ray tests.

The following services or equipment were purchased from local firms in Lesotho;

- ventilation system
- cooling water arrangement
- drainage pump arrangement
- electrical wiring Semonkong H.P.S
- electrical wiring Mantsonyane H.P.S
- concrete pipes for Semonkong

6. TRAINING

The contract describes the scope of training of local employees and counter-part staff. The Terms of Reference also stress the training objectives.

6.1 Civil Works

The civil engineer trainee was identified when the project started, but he was soon transferred to the Lesotho Highland Water Project (LHWP). A new civil-engineer counter-part with background from the Lesotho technical college joined the project in March 1987. He was trained in land surveying work, and was involved in the same work at site. Unfortunately his background was not adequate to discuss and take part in the planning of the civil engineering design. Well qualified personnel were all transferred to LHWP, and the other departments and parastatels lacked therefore qualified personnel.

The civil engineer trainee was transferred to the Department of Water Affairs where he worked as a site-supervisor and was responsible for all land-surveying. He was later granted a 3 years scholarship in England.

Construction Training

From the start-up of the construction works in September 1985 to the completion in October 1988, practical on site training has continuously been carried out on various categories of construction works;

1) Carpentry including formwork and concrete works.
2) Shotcreeting and grouting.
3) Rock blasting.
4) Plant mechanic.

A relatively high number of the local trainees have been with Noremco Construction from the beginning, and therefore received a long term site training.

We feel that on category 1) Carpentry, about 10 employees who have showed very good progress, can work as foremen and team leaders in the future.

Shotcreeting and grouting have only been carried out a short period, and therefore only two of the employees are well qualified.

Rockblasting was one of the major fields of training, with blasting of tunnels, power-house caverns and the spillway. Around ten of the employees should be well qualified for tunnel drilling and blasting, and also blasting of quarries similar to the spillway.

Plant mechanic training have been going on since the start-up, and 5 of the employees are now well qualified mechanics.

As reported in the Summary Progress report for the 5th Advisory Group meeting no special training courses leading to Exams and Training Certificates have been held.

Most of the trained and skilled employees are still with Noremco Construction in Lesotho.

6.2 Electro/Mechanical Works

Electrical Engineer B.Sc/Electrical and Mechanical Technicians.

The 5 LEC trainees were appointed before the mounting works started at Semonkong and Mantsonyane in October 1987 and they have therefore followed the installation of the equipment, the testing period and the final theoretical/ practical training leading to the Exams and Certificates in February 1989.

All 5 LEC trainees were first trained by the supervisors from the electro-mechanical supplier Sørumsand, when the mounting took place at Semonkong followed by Mantsonyane. They participated in the mounting of the turbines, generators, transformers, control-panels and auxiliary equipment, also including cabelling, and they should all be well acquainted to the equipment.

During the testing and commissioning period they have received comprehensive training, both theoretical and practical training, when running the power-stations on both the local grid and connected to the main grid.

From the 5 trainees originally appointed by LEC, 3 had to leave the project because of misconduct. In spite of general lack of trained technicians/engineers, LEC was able to replace these and step by step build up the necessary staff of 3 operators at each station (4), qualified personnell at LEC head-quarter (3), and guardsmen at the plants. However, the sacking of trainees left LEC with a problem of lost training ground.

6.3 Power Plant Operation

As already mentioned in 6.2 the operating personnel received extensive training in running the power-stations on both local grid and connected to the main grid, in the period immediately following the testing and commissioning.

The immediate purpose of this training was to provide the regular staff with sufficient knowledge and experience to competently supervise the routine operation of the plant, and to facilitate the performance of maintenance and repair functions, as required.

Following the initial period of training and testing, both Semonkong and Mantsonyane hydropower plants have been operating successfully under direction of LEC-staff. A problem has been the lack of operators, which has delayed the arrangement with rotation of personnel.

6.4 LEC - Generation Department

LEC has established an organizational unit, the Generation Department to take care of the daily operation of the power generation installations. The responsibility comprises operation and maintenance of small hydropower stations (4), and maintenance of a number of diesel power stations belonging to LEC and Government institutions.

Senior Engineer, Mr. Steinar Grongstad was assigned to Lesotho Electricity Corporation from 1st September 1986 until 13th September 1989. He has been a central person in establishing the new Generation Department in LEC. He was also responsible for training of operators and counter-part personnel in LEC.

A main problem was the shortage of operators and staff, and LEC has therefore requested NORAD to make funds available for additional training of operators. Mr. Grongstad's counter-part is now in charge of the Generation Department, but since this department is new, further training and support are necessary.

Norad has made funds available for additional training and support throughout 1991.

7. PROJECT COSTS

7.1 Total Costs

The total costs for the project reached 81.5 million NOK while the estimated budget was only 57.0 million NOK, 43 % cost-increase. Excluding 3.0 million NOK payed by Insurance company give total costs of 78.5 million NOK and 37.7 % cost increase.

Table 7.1.1 Summarizes the total costs:

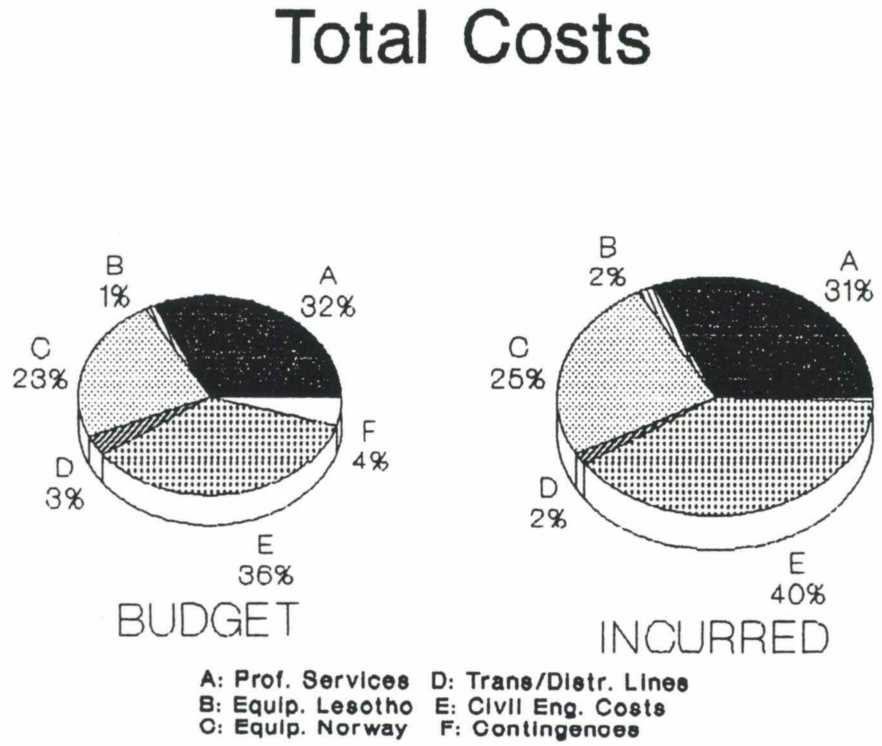
	Budget (NOK)	Incurred (NOK)	Difference (NOK)	%
1. Professional Services ***)	18,153,000	25,559,923	7,406,923	40.8
2. Equipment from Norway *)	13,300,000	20,195,879	6,895,879	51.8
3. Locally Manu-factured equipm	700,000	1,386,612	686,612	98.1
4. Transmission and Distrib. Lines	1,900,000	1,375,586	- 524,414	-27.6
5. Civil Engineer-ing-Constr. Costs	20,397,000	32,609,826	12,212,826	59.9
6. Contingencies	2,550,000	406,028	-2,143,972	-84.1
Total	57,000,000	**) 81,533,854	24,533,854	43.0

*) Equipment from Norway includes GRP-pipes at Semonkong and Scour-gate and Station Crane at Mantsonyane in addition to the main Electro-Mechanical Equipment Package.

**) Total Costs include 3.0 million NOK payed by Insurance company.

***) Professional Services include all costs for both Consultant and Contractors expatriate personell and personell in Norway. The professional services also include all cost for Senior Engineer assigned to Lesotho Electricity Corporation (3 years).

Figures 7.1.1 and 7.1.2 show a pie chart and bar chart of Table 7.1.1.



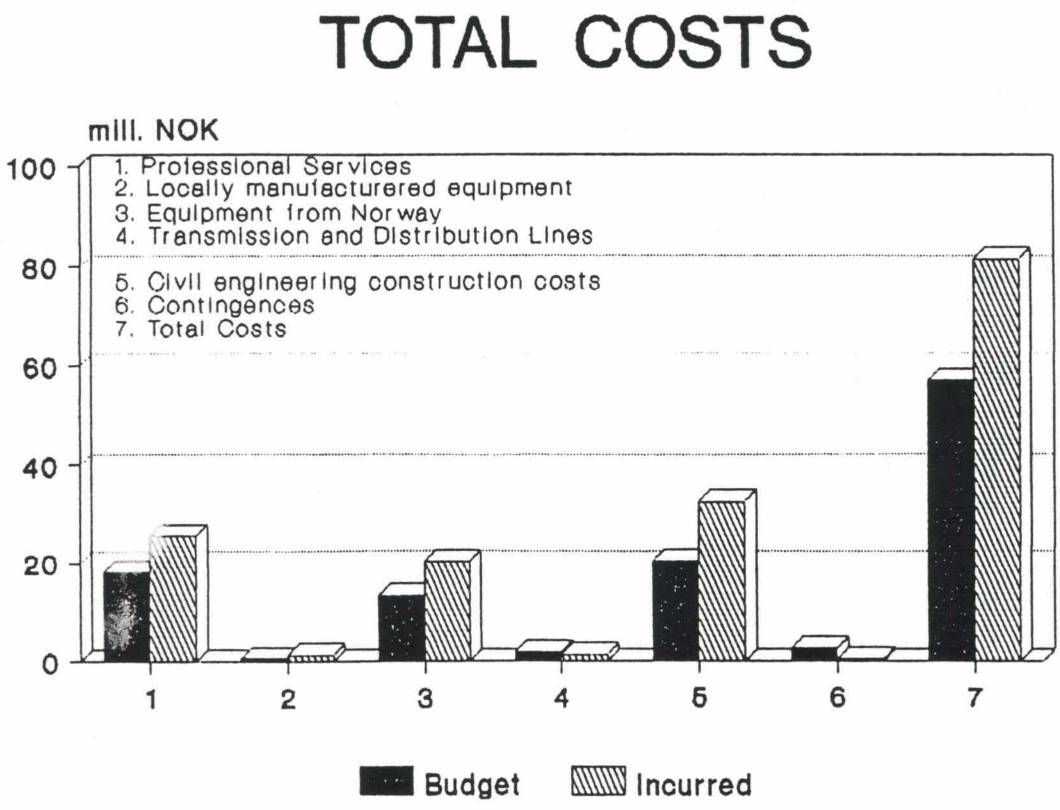


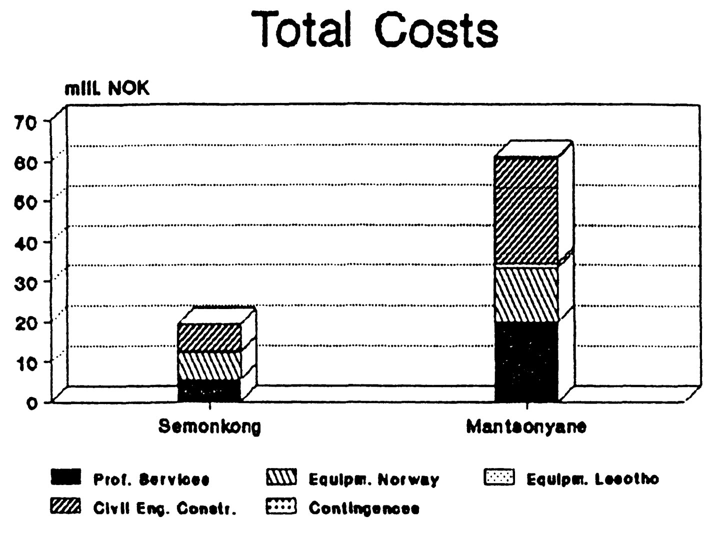
Table 7.1.2 Summarizes the total costs apportioned on Mantsonyane and Semonkong.

	Mantsonyane (NOK)	Semonkong (NOK)
1. Professional Services	19,972,762	5,587,150
2. Equipment from Norway	13,423,899	6,771,956
3. Locally manufactured Equipment	1,160,365	226,245
4. Transmission and Distribution lines	888,994	486,591
5. Civil Engineering-Construction costs.	9,823,315	2,455,829
5.1 Vehicles and Construction equipment	1,147,983	-
	14,821,467	4,009,167
5.2 LCU Road Mantsonyane		
	206,808	145,254
5.3 Labour & Material		
	316,700	89,327
5.4 Staff Houses *)		
6. Contingencies		
Total	61,762,293	19,771,519

The figures in Table 7.1.2 are estimated from the total costs since the accounting system only split the costs on various types of work and not locations.

*) Labour- and transport-costs are posted in 5.3. The real costs for the staff-houses are calculated to approx. 200,000 NOK each.

Figure 7.1.3 Shows a stacked bare comparison of Mantsonyane and Semonkong.



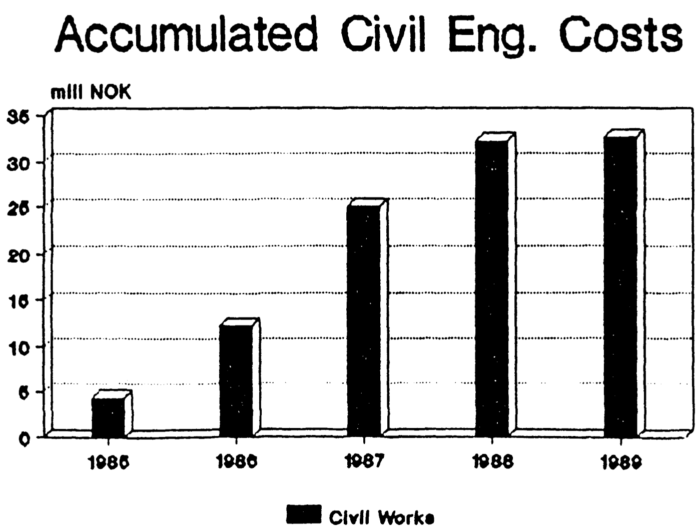
7.2 Civil Works

Table 7.2.1 gives the accumulated costs in NOK at the end of each year.

	1985	1986	1987	1988	1989
5. Civil Engineering Constr. Works.					
5.1 Vehicles and Constr. Equipment					
5.1.1 Mantsonyane	2,462,090	4,592,497	8,337,212	9,718,905	9,823,315
5.1.2 Semonkong	615,523	1,148,125	2,084,303	2,429,727	2,455,829
5.2 LCU Road Works Mantsonyane	431,470	1,147,983	1,147,983	1,147,983	1,147,983
5.3 Labour, Material					
5.3.1 Mantsonyane	749,952	4,112,457	10,263,837	14,603,873	14,821,467
5.3.2 Semonkong	-	1,119,676	2,794,479	3,976,118	4,009,167
5.4 Staff houses *)					
5.4.1 Mantsonyane	-	8,810	205,135	206,808	206,808
5.4.2 Semonkong	-	85,260	151,545	145,254	145,254

*) Cost 5.4 "Staff houses" does not give the real costs, since the labour-costs are posted in 5.3 Labour and material.

Figure 7.2.1 Shows the development of Civil Engineer Costs



7.3 Electro-Mechanical equipment

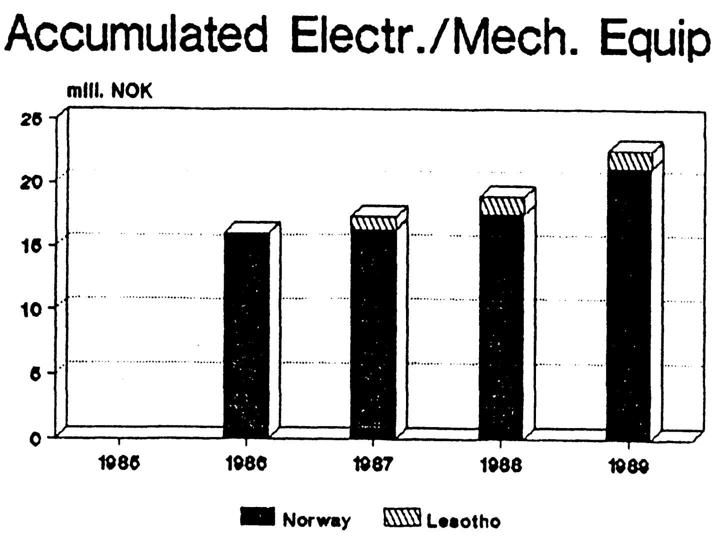
Table 7.3.1 gives the accumulated costs in NOK at the end of each year

	1985	1986	1987	1988	1989
2. Equipment from Norway *)					
2.1 Mantsonyane	-	10,646,296	10,806,624	11,548,752	13,423,899
2.2 Semonkong	-	5,370,738	5,451,619	5,926,001	6,771,956
3. Locally Manufact Equipment					
3.1 Mantsonyane	-	-	795,577	1,160,365	1,160,365
3.2 Semonkong	-	10,760	205,834	226,245	226,245

*) Equipment from Norway also includes de-watering gate delivered by HATO A/S, and Crane delivered by Munck International, both for Mantsonyane.

The total costs for electro-mechanical equipment delivered by Consortium Kværner/EB Energy is 19,234,225 NOK.

Figure 7.3.1 Shows the development of Electro-Mechanical equipment costs.



7.4 Professional Services

Table 7.4.1 gives the accumulated costs in NOK at the end of each year.

Year	1985	1986	1987	1988	1989
Professional Services	3,093,389	9,187,476	17,369,002	24,353,483	25,559,923

Figure 7.4.1 Shows the development of Professional Services Costs. Includes both Consultant and Contractor.

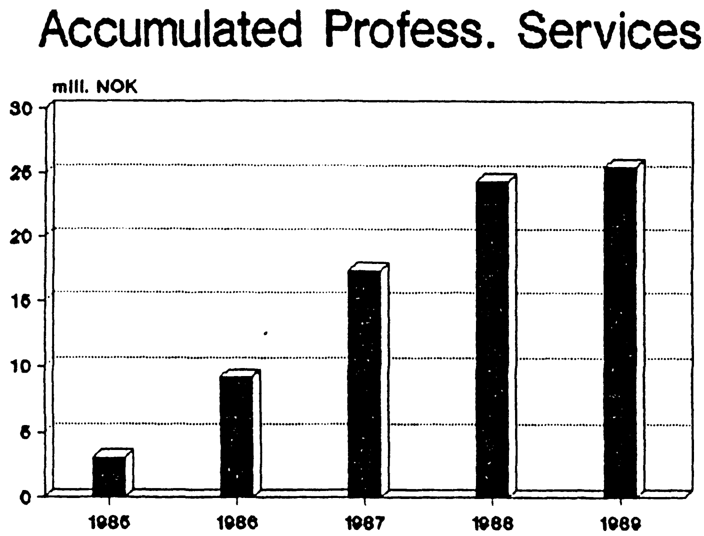
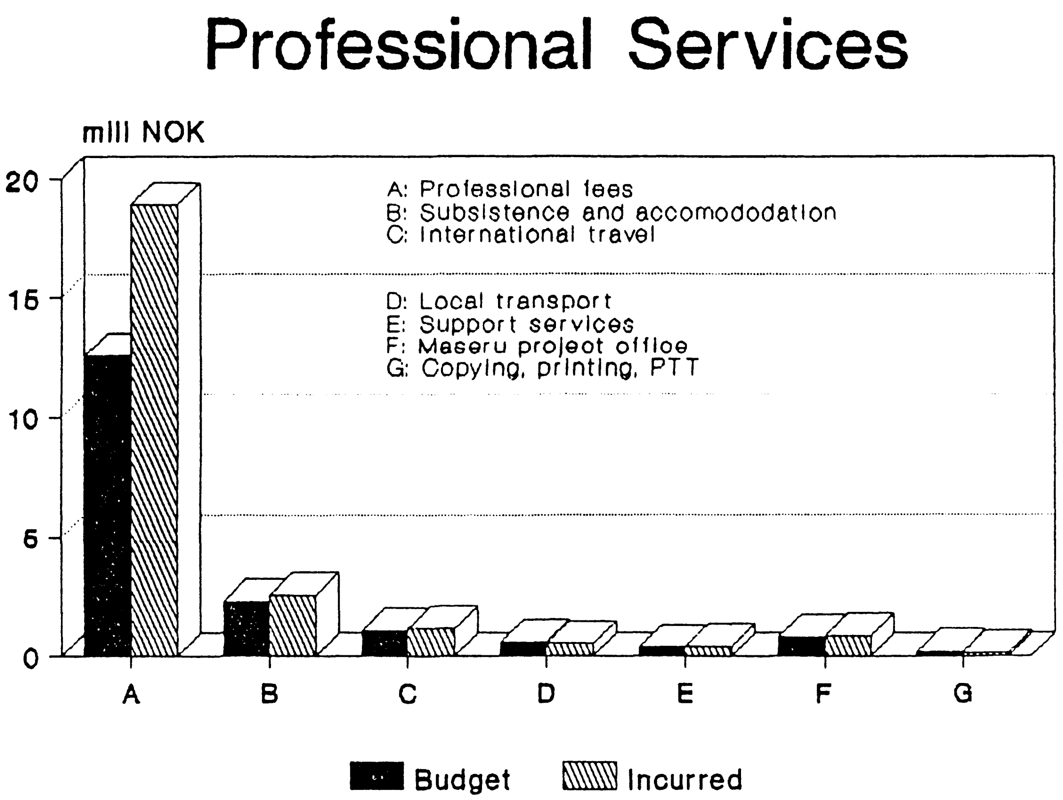


Table 7.4.2 gives the incurred costs in NOK compared with the estimated budget.

	Budget	Incurred	Difference
1.1 Professional fees	12,502,000	18,924,601	6,422,601
1.2 Subsistence and accommodation	2,300,000	2,574,303	274,303
1.3 International travel	1,100,000	1,169,920	69,920
1.4 Local Transport	600,000	521,626	78,374
1.5 Support Services	400,000	426,192	26,192
1.6 Maseru Project office	831,000	872,897	41,897
1.7 Copying, printing, PTT	200,000	170,742	29,258
TOTAL	18,153,000	25,559,923	7,406,923

Figure 7.4.2 Shows the budgeted and incurred Professional fees cost. Includes both Consultant and Contractor.



8. ENVIRONMENTAL AND SOCIAL ASPECTS.

8.1 Mantsonyane Hydropower Project.

The Mantsonyane project resulted in diversion and drying out of a 1.5 km stretch of the river between the dam and the power station. There is no habitation and no agricultural land along this stretch of the river, and water can easily be reached both upstream and downstream. During the rainy season when the reservoir is spilling, water will be available in the old river. The main reservoir will create a good habitat for fish, but migration from the river is not possible. This was not possible before the construction started either, due to a 3-4 m vertical fall just upstream of the power station.

The most negative impact of the project could have been the intermittent operation of the power-station, when the water-flow vary from 0 to 6.5 m3/s. These variations will be evened out by natural ponds and stone-weirs downstream of the power-station. Water will therefore be available for both people and animals downstream of the power station.

The reservoir inundated and swamped a very small and limited area of agricultural land in the upper end of the reservoir.

At a very early stage of the project, a new overhead line was built down to the power station site, and branch offs were built to Aurray Mission and St. James Hospital. Electricity has been available there since mid. 1986. Norplan also proposed for NORAD and LEC to supply Mantsonyane village, by step-down transformers and a small 380 Volt network (as for Aurray Mission and St. James hospital). NORAD agreed and made additional funds available, unfortunately LEC did not accept the offer, but wanted a sophisticated system with step-down transformer (33/11 kV), 11 kV network and stepdown- transformers (11/0,4 kV) for each consumer. This system was very costly and could not be accepted by NORAD. Mantsonyane village is therefore still today not connected, while the overhead line is passing through the village.

The access road has been improved from Mantsonyane village to the power-station and crossing of the river by car have been improved since almost 30 m3/s can be taken through the power-station and the scour-tunnel (mean annual flow is 4.5 m3/s). The access to the nearby villages has been improved by the project, and new projects continue road-construction to some of the villages.

Compared to other similar hydropower projects it can be concluded that the Mantsonyane project has had a very small negative impact on the environment.

The plant is a "peak-lopping" plant connected to the main network, and only St. James Hospital and Aurray Mission has been electrified from the project.

8.2 Semonkong Hydropower Project

The Semonkong hydropower project resulted in diversion and drying out of a 500 m long stretch of the river, most of which lies in a deep gorge practically inaccessible. The construction did not negatively affect the fishing, since migration of fish have never been possible due to the Semonkong Falls barrier.

The small intake reservoir inundated a very small area of agricultural land just upstream of the intake dam. An area up to 1 m above the crest-level have been fenced, and planted with willow trees which requires periodic submerged ground. Willow trees are a renewable source for firewood, which is needed by the local people.

Also at Semonkong is the power-station operated intermittent. To secure a steady flow downstream of the power-station re-regulating weirs have been built down-stream of the power-station. This have secured a reasonably steady level in the river without any manual attendance.

Semonkong hydropower project included also 11 kV network and 380 V network to 9 selected consumers, as schools, clinics, missions, etc. Most of the 9 selected consumers are connected, but many new consumers that are anxious to get electricity, find the connection fees and the tariffs to high and cannot afford electricity. The electrification at Semonkong has therefore been delayed, until tariffs and fees will be made affordable for average consumers. It is therefore to early to assess the social aspects from the project.

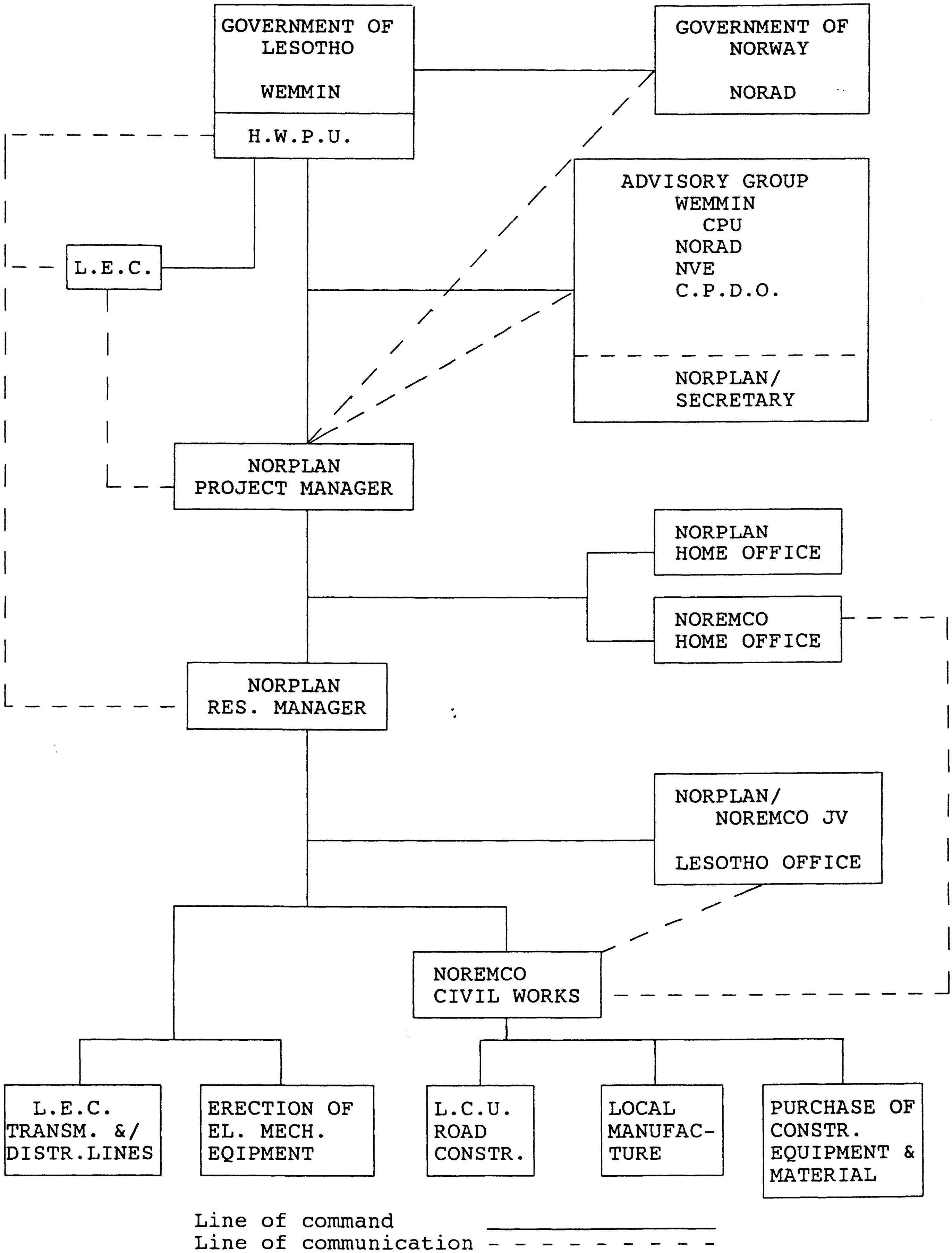
Semonkong hydropower project was also part of an integrated Development Project in the Semonkong area, where infrastructure development has been an important part. The power plant has been a stimulus to the growth of activities in Semonkong.

The Semonkong project has also very little effect on the environment, and compared to other similar projects very little negative impact.

APPENDICES

Appendix 1:	**Organization Chart**
Appendix 2:	**Main project Data**
Appendix 3:	**Layout Drawing** **3.1 Location of Projects** **3.2 Semonkong Hydropower Project** **3.3 Mantsonyane Hydropower Project**
Appendix 4:	**List of Abbreviations**
Appendix 5:	**References**
Appendix 6:	**Photos**

APPENDIX 1: ORGANIZATION CHART



Appendix 2

Main Project Data

Semonkong Hydropower Project
(Local elevation System)

Hydrology:

Catchment area	: 231 km2
Average Annual runoff	: 2.4 m3/s
Design flood (1000 years return period)	: 600 m^3/s

Intake and Dam/Spillway:

Dam/Spillway-
Concrete gravity weir

Total crest length	: 60.48 m
Scour outlet capacity	: 7 m3/s
Crest level	: 101.5 m
Retaining wall level	: 104.5 m
Live Storage	: 20.000 m3
Low water level	: 100.8 m
High water level	: 101.5 m
Design flood level	: 104.3 m
Intake gate (bxh)	: 1.5x1.7 m
Trash rack, (bxh)	: 1.5x1.7 m

Headrace Conduit:

Concrete Reinforced Pipes:

- Diameter	: 1.35m
- Length	: 296 m

Surge Chamber
Concrete tank:

- Area	: 25 m2
- Volume	: 140 m3
- Top level	: 103.0

Scour-valve:	: 300 mm.

<u>Glassfibre Reinforced Pipes:</u>

- Diameter	: 1.2 m
- Length	: 71 m
- Diameter	: 1.0 m
- Length	: 80 m

<u>Power Station:</u>

Lower section	: Reinforced concrete
Main building	: Steel-structure, filled in with concrete blocks and covered with natural stone.
Roof	: Corrugated steel covered with thatch.

<u>Installation</u>:

Turbine type	: Horizontal Francis
Turbine Discharge	: 1.2 m3/s
Rated output	: 200 kW
Synchronous speed	: 750 rpm
Average net head	: 18.5 m
Generator type	: 3-phase Horizontal Synchronous Reliance-manufacturer
Rated output	: 250 kV
Generator Voltage	: 380 V
Excitation System	: Brushless AC exciter
Step-up transformer type	: Outdoor, ONAN, A/S Møre
Power rating	: 500 kVA
Step-down transformer, staff-houses	: 50 kVA
Step-down transformer, power-station	: 25 kVA
Voltage rating	: 11.000±2x2.5%/380V

Diesel generator set		
- Rated output	:	150 kVA
- Generator voltage	:	380 Volt
Circuit breaker	:	12 kV indoor
Transmission line voltage	:	11 kV, 3350 m
Distribution line voltage	:	380 Volt, 2700 m
4 Stepdown transformers	:	11 kV/380V

Tailrace:

High water level (400 m3/s)	:	86.0 m
Low water level	:	82.0 m
Water level (1.2m3/s)	:	82.5 m

2.2.2 Mantsonyane Hydropower Project

Hydrology:

Catchment area	: 567 km2
Average Annual runoff	: 142 million m3/year
Average flow	: 4.5 m3/s
Design flood 100 years return period (Increased to 1800 m3/s, Nov. -87)	: 1300 m3/s

Dam and Spillway:

Dam-type:

Rockfill dam with bituminous core	: 50.000 m3
Downstream toe	: 15.000 m3
Crest length	: 120 m
Crest elevation	: 2030.0 m.a.s.l.
Kerb stones	: 2030.5 m.a.s.l.
Maximum height	: 18.5 m
Bituminous core, top level	: 2025.5 m.a.s.l.
Fine Filter - core	: 2029.8 m.a.s.l.

Spillway:

Ungated, concrete weir	:
Crest elevation	: 2024 m.a.s.l.
Capacity length	: 67.4 m
Capacity (2030 m.a.s.l.)	: 1800 m3/s
Bottom outlet:	
- Scour-gate	: 1.0x1.8 m
- tunnel section	: 12 m2
- tunnel length	: 110 m

Intake:

Trash rack, bxh	:	2.1x3.4 m
Service gate, bxh	:	2.1x3.4 m
Intake elevation, bottom	:	2016.3 m.a.s.l.

Reservoir:

High water level	:	2024.0 m.a.s.l.
Low water level	:	2020.0 m.a.s.l.
Live storage	:	400,000 m3
Design flood level		
1800 m3/s	:	2030.0 m.a.s.l.
1300 m3/s	:	2027.0 m.a.s.l.

Headrace tunnel:

Unlined tunnel:		
- length	:	740 m
- cross-section	:	13 m2
- slope	:	4.5 %

Power Station:

Station type	:	Unlined rock-cavern
Lower section generation floor:		
length	:	14.5 m
width	:	9.0 m
height	:	9.5 m
Mid-section:		
length	:	7.0 m
width	:	9.0 m
height	:	6.0 m
Entrance section:		
length	:	7.5 m
width	:	6.5 m
height	:	5.0 m
Transformer hall Pumps for cooling:		
length	:	15 m
width	:	4.5 m
height	:	4.0 m

Installation:

Munch Monobox E.O.T. Crane
w/trolley and hoist

Capacity : 10 tonnes

Max height of lift : 10.5 m

	Unit 1	Unit 2
Turbine type:	Horizontal Francis	Horizontal Francis
Turbine discharge:	2.0 m3/s	5.8 m3/s
Synchronous speed:	750 rpm	500 rpm
Rated output:	600 kW	1800 kW
Average net head	36 m	36 m
Generator type:	3-phases Horizont. Synchronous Reliance Manufact.	EB Energi-Manufact.
Rated output:	700 kVA	2150 kVA
Generator voltage:	660 V	660 V
Frequency:	50 Hz	50 Hz
Excitation system:	Brushless AC exciter	Brushless AC exciter

Step-up transformer type : out-door, ONAN, BBC

Voltage rating ratio : 33.000 ± 2x2,5%/660 Volt

Circuit breaker : 33 kV

Diesel generator set : 60 kVA


LESOTHO
REPUBLIC OF SOUTH AFRICA
REPUBLIC OF SOUTH AFRICA
BUTHA-BUTHE
LERIBE
BEREA
MASERU
MAFETENG
MOHALE'S HOEK
QUTHING
QACHA'S NEK
MOKHOTLONG
MOKHOTLONG
MANTSONYANE
SEMONKONG
CENTRAL
MALUTI
DRAKENSBERG
Fouriesburg
Caledonspoort
Ficksburg
Maputsoe
Ladybrand
Hobhouse
Hermon
Wepener (Qibing)
Siloe
Teyateyaneng
Roma
Mazenod
Morija
Thaba Bosiu
Thaba Tseka
Sehlabathebe National Park
Sani Pass
Maletsunyane Falls
Mphaki
Mt Moorosi
Holy Cross
Tosing
Makoae
Sekake
Ramatseliso's Gate
Qacha's Nek
Heights in feet
4000-6000
6000-8000
8000-10000
Over 10000
LEGEND
All Weather Road
Fair Weather Road
Motorable Track
Mountain Pass Sani
River Ngoajane
Hotel H
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Other Town or Village
International Boundary
District Boundary
District Name MASERU
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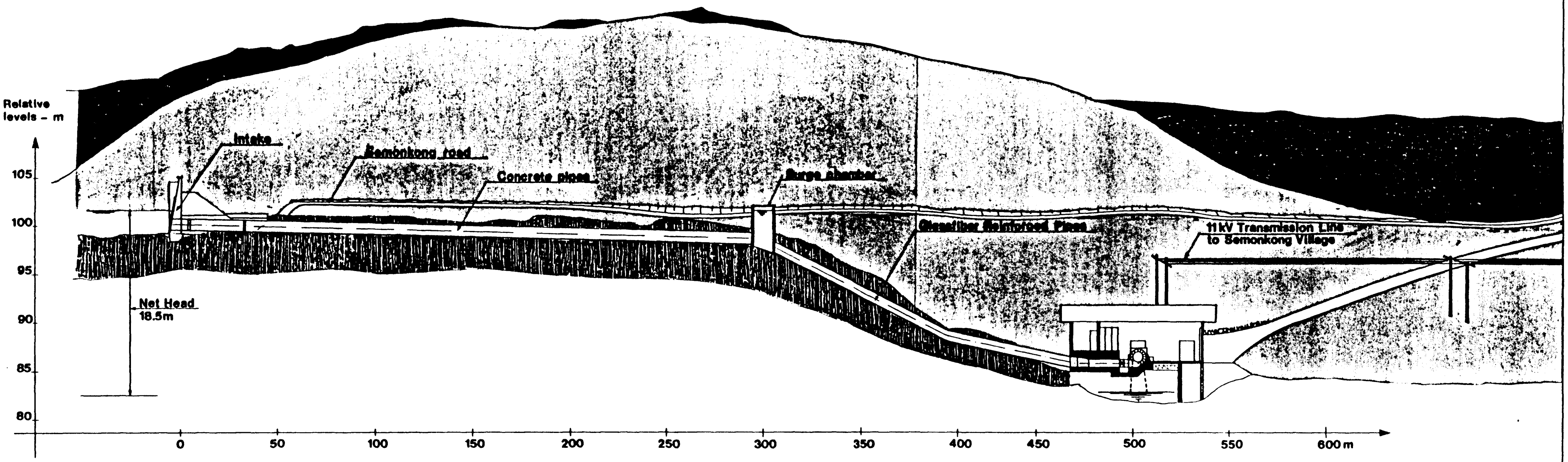
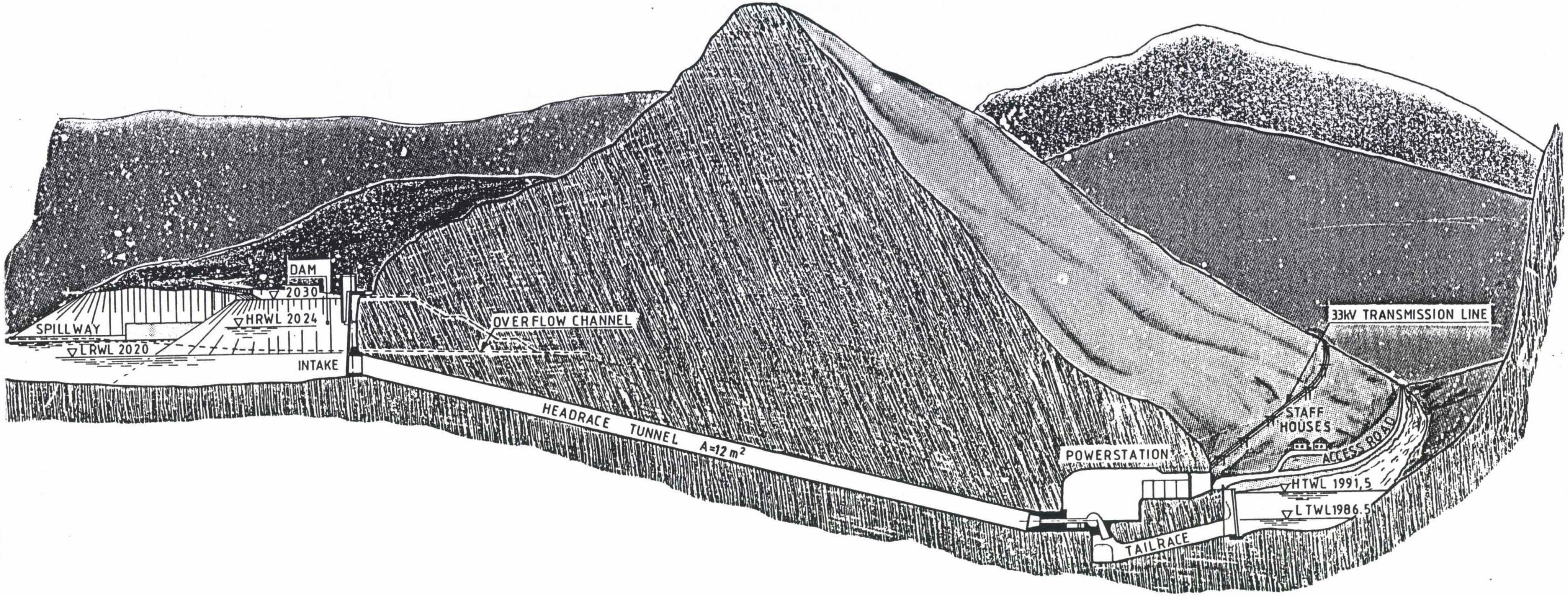


Section through Semonkong Hydroelectric Power Station

NORPLAN OF NORWAY

A3-2



SECTION THROUGH MANTSONYANE HYDROELECTRIC POWER STATION

NORPLAN
OF NORWAY

Appendix 4

LIST OF ABBREVIATIONS

NORAD	-	Norwegian Agency for International Development
WEMMIN	-	Ministry of Water, Energy and Mining
LEC	-	Lesotho Electricity Corporation
ESCOM	-	Electricity Supply Commission (South Africa)
RSA	-	Republic of South Africa
NOK	-	Norwegian Kroner
DWA	-	Department of Water Affairs
LCU	-	Labour Construction Unit
NVE	-	Norwegian Water Resources and Energy Administration
NORPLAN	-	Norwegian Consultant
NOREMCO	-	Norwegian Contractor
LHWPU	-	Lesotho Highland Water Project Unit
CPDO	-	Central Planning Development Office.
CPU	-	Central Planning Unit

Appendix 5

References

Can be obtained from Norplan A/S, Holtevn. 5, 1400 Ski

/1/ Contract between "The Ministry of Water Energy and Mining and NORPLAN A/S". September 1985.

/2/ Study of rural electrification and development of mini-hydropower in Lesotho.
Review Study Report - July 1983.

/3/ Study of rural electrification and development of mini-hydropower in Lesotho.
Feasibility Study report - Mantsonyane, Semonkong and Mokhotlong - February 1984.

/4/ Mantsonyane Hydropower Project - Final Design.
November 1984.
Vol I Project Description and Drawings
Vol III Electromechanical Package - Tender Documents

/5/ Semonkong Hydropower Project - Final Design.
November 1984.
Vol I Project Description and Drawings
Vol III Electromechanical Package - Tender Documents

/6/ Progress Report nos 1 - 39 1985 - 1989

/7/ Summary Progress Reports
Advisory Group meeting nos 1-6.

/8/ Certificates of Payment nos 1 - 15

/9/ Taking-Over-Protocol

/10/ Mantsonyane Hydropower Station: Short operation instructions Civil Works

/11/ Semonkong Hydropower Station : Short operation instructions Civil Works

/12/ Mantsonyane Hydropower Project: Report on Dam-Construction

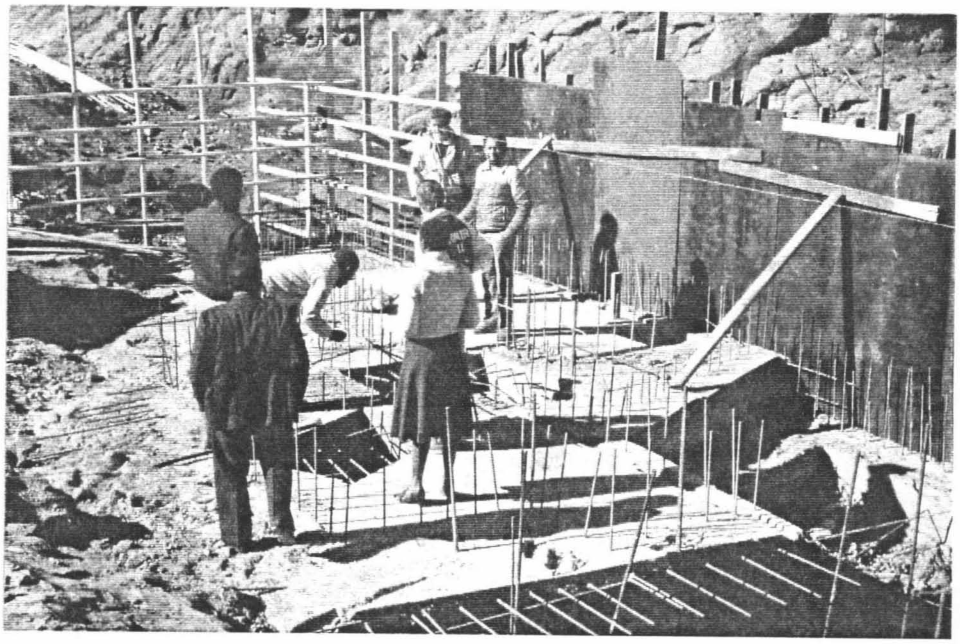
/13/ Mantsonyane and Semonkong Hydropower Projects : Report on Concrete Strength test

/14/ Mantsonyane Hydropower Project: As Built Drawings-Civil Works

/15/ Semonkong Hydropower Project : - " - - " -

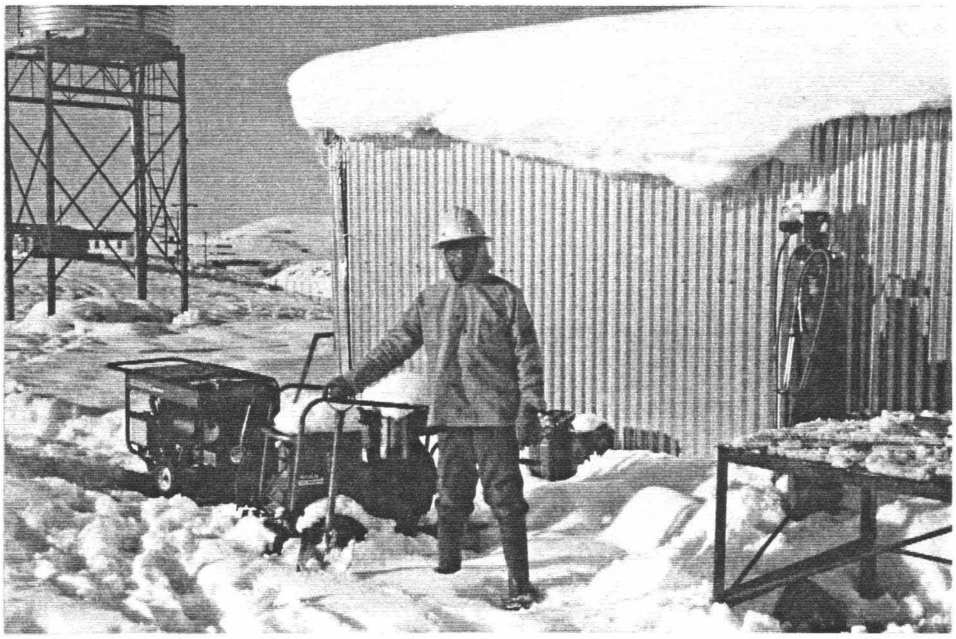
/16/ Final Dam Breach Raport. Maseru 24/11-87

Excavation for the power station, September 1986

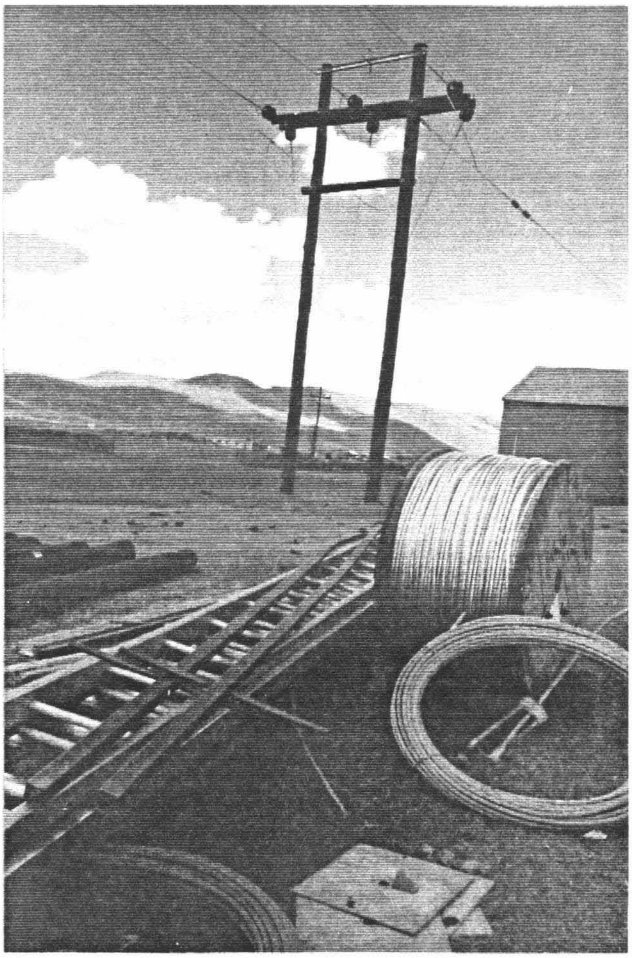


Advisory Group visiting the power station, May 1987

Local women preparing thatch for roofing of the power station, October 1987

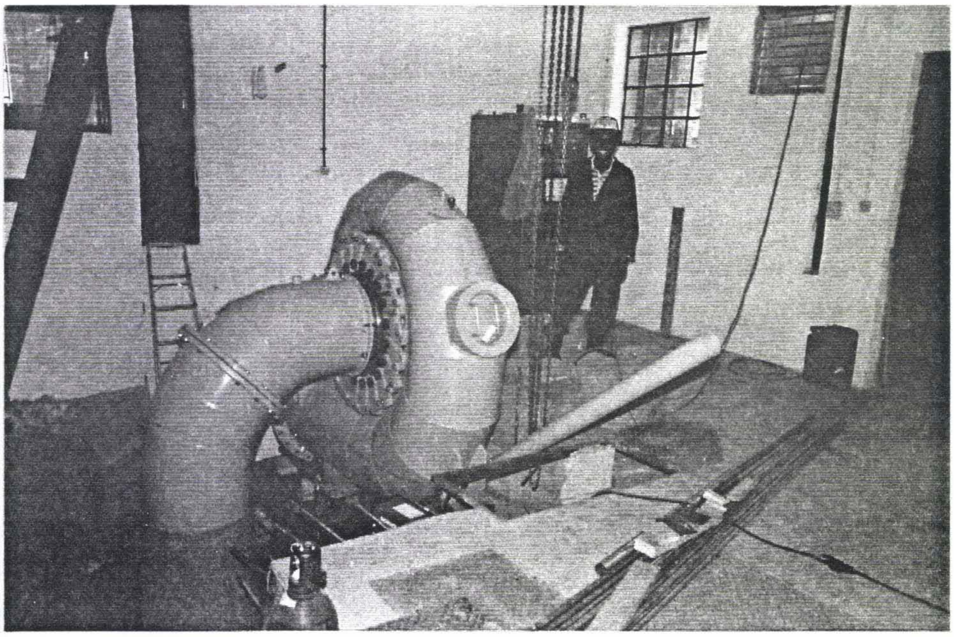


Rough winter conditions, August 1987

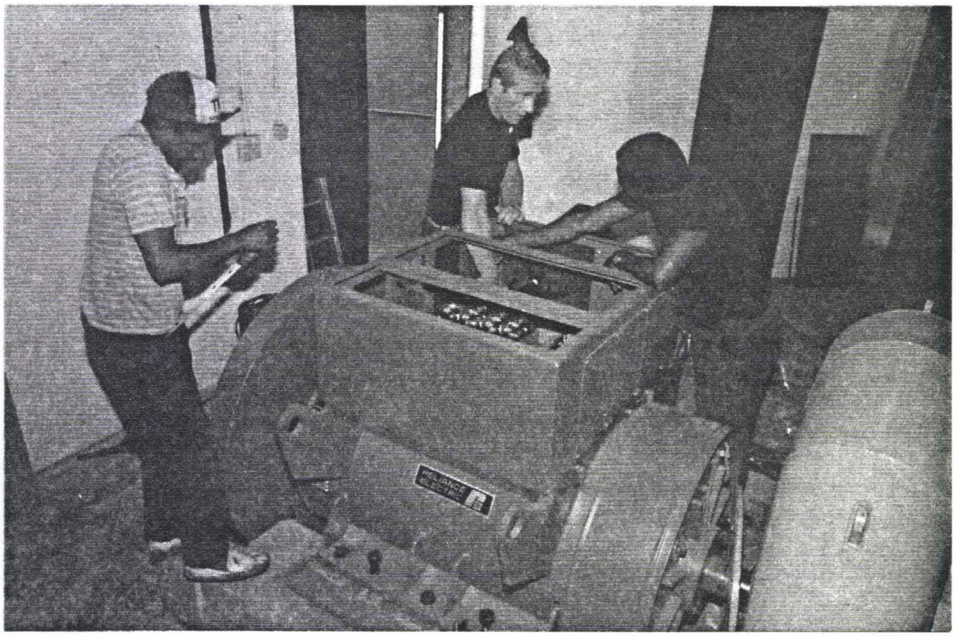


Transmission and Distribution Lines
subcontracted to LEC, February 1987

Erection of first pipe section at intake, December 1986

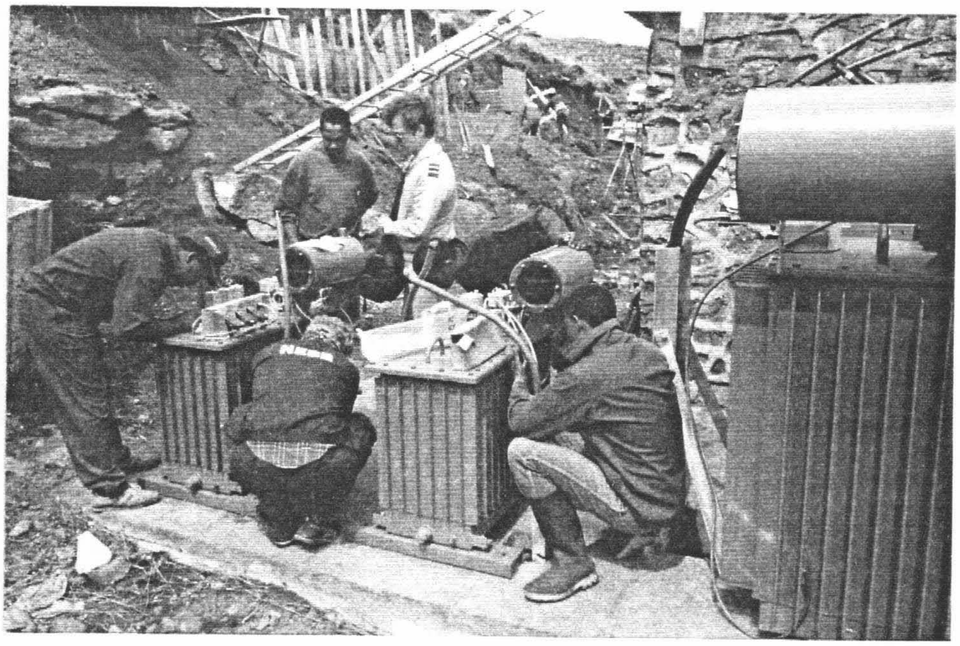


Erection of turbine, November 1987

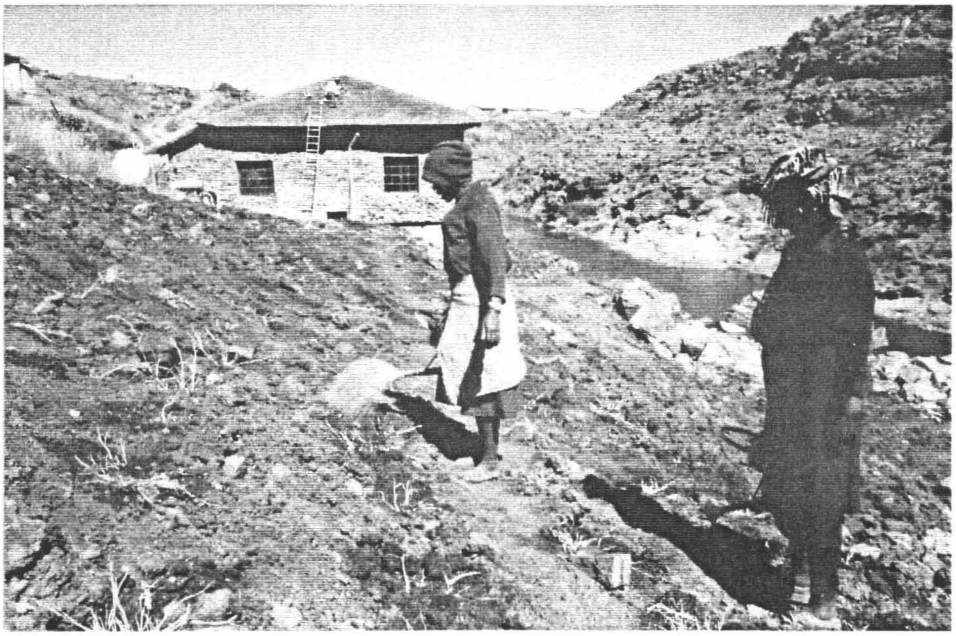


Connection of generator, November 1987

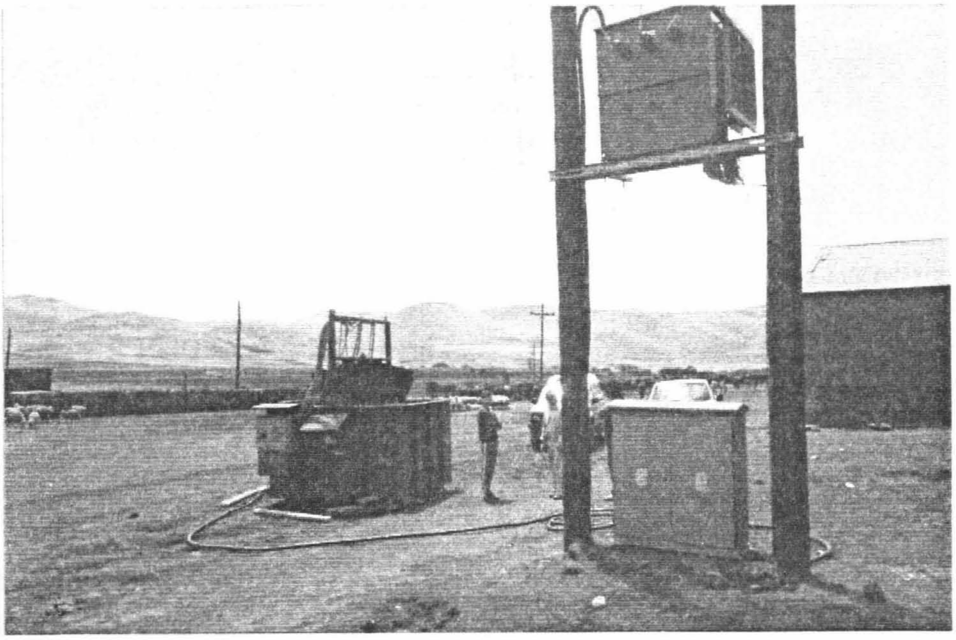
Laying of glassfibre reinforced pipes, November 1987



Connection of transformers, November 1987

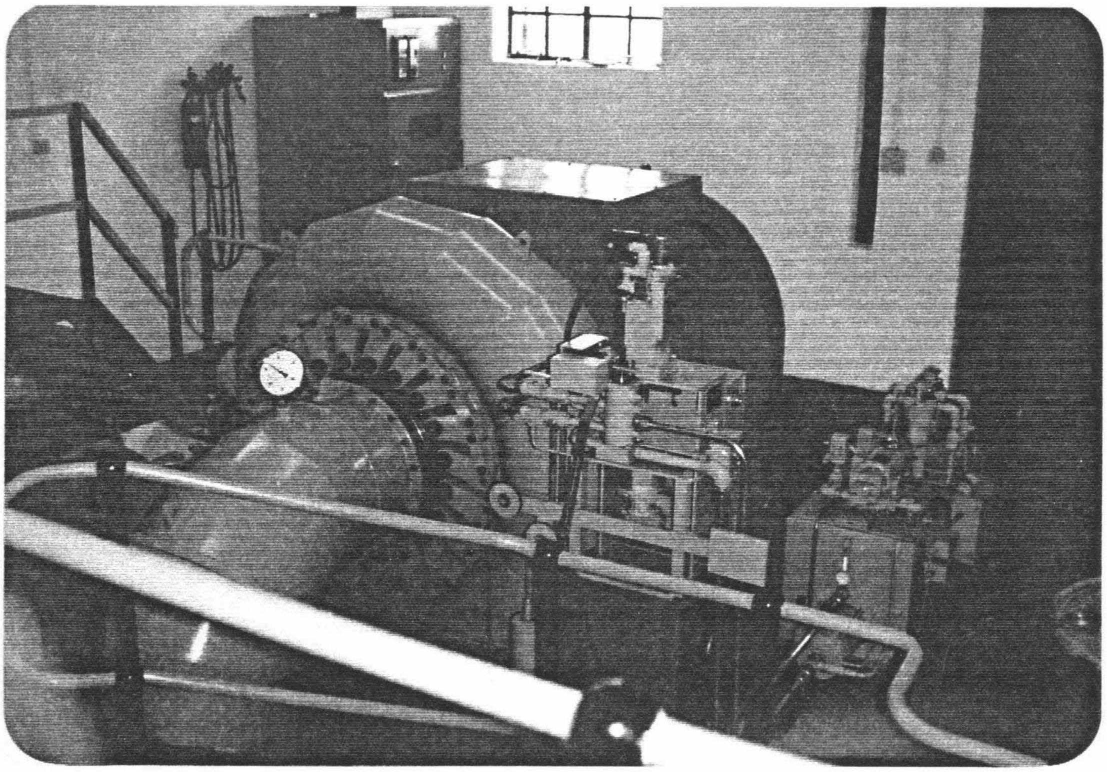


Local women watering the grass plants, January 1988

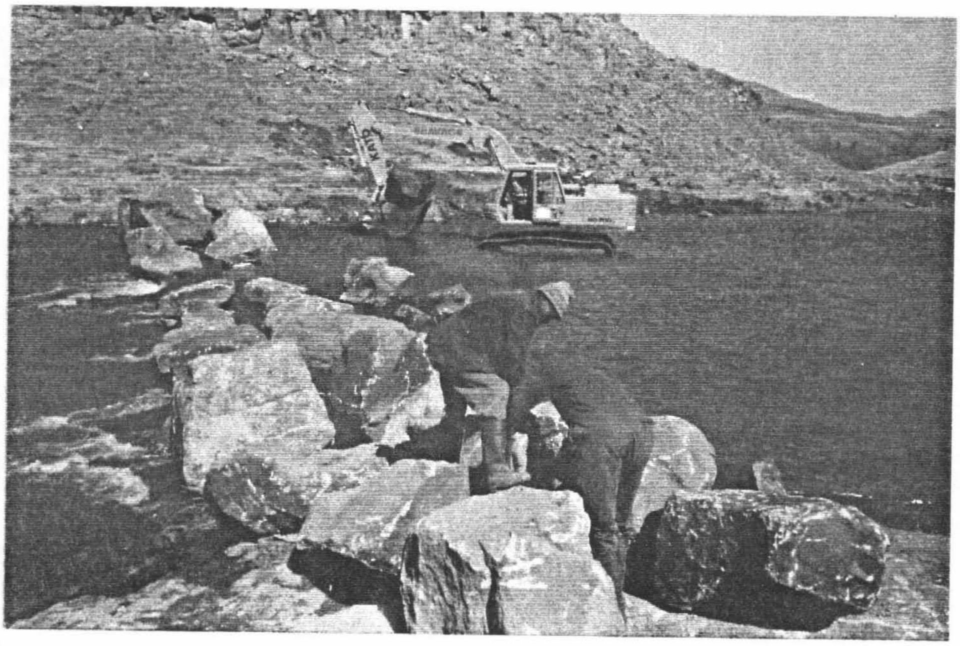


Load bank connected to the network, November 1988

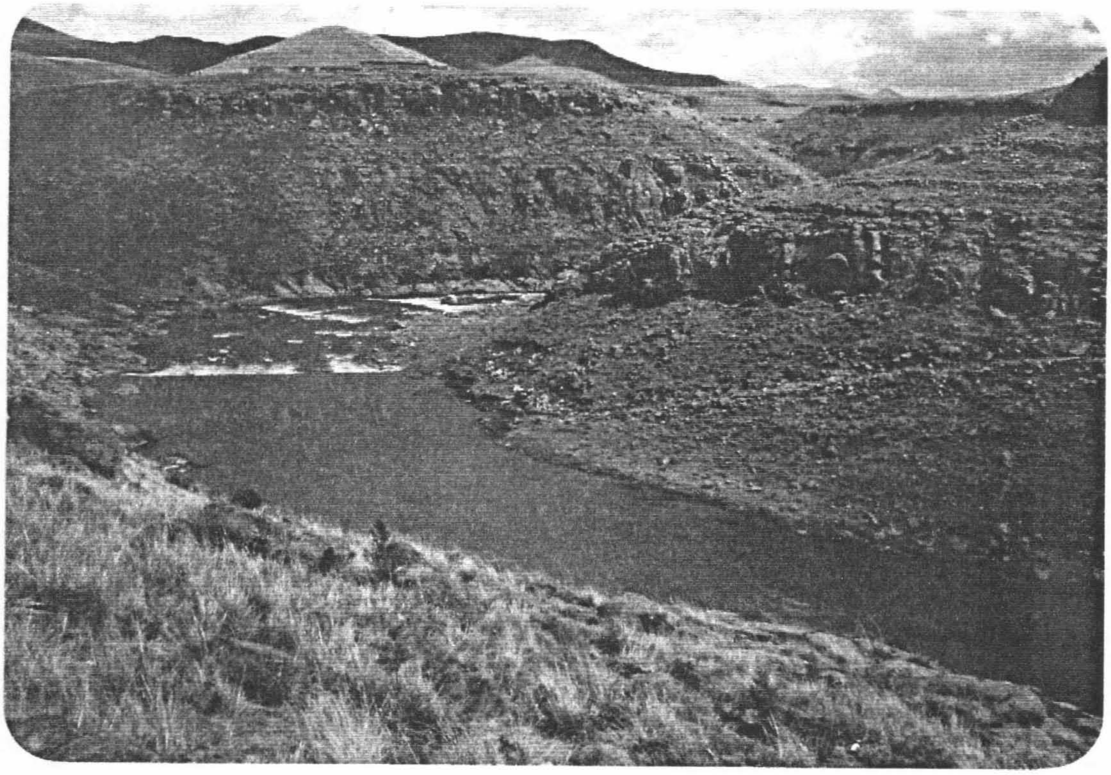
Mr. Mohale, LEC trainee, explains the Operation to the Minister of WEMMIN, May 1988



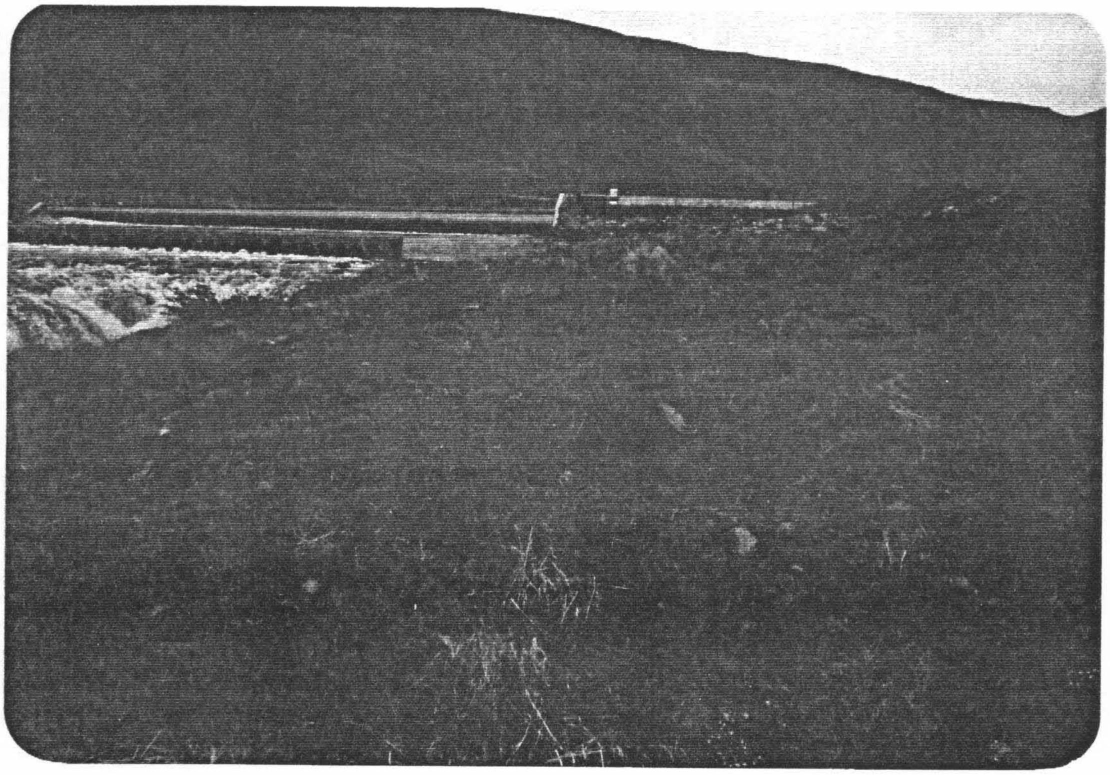
Complete turbine and generator, November 1989



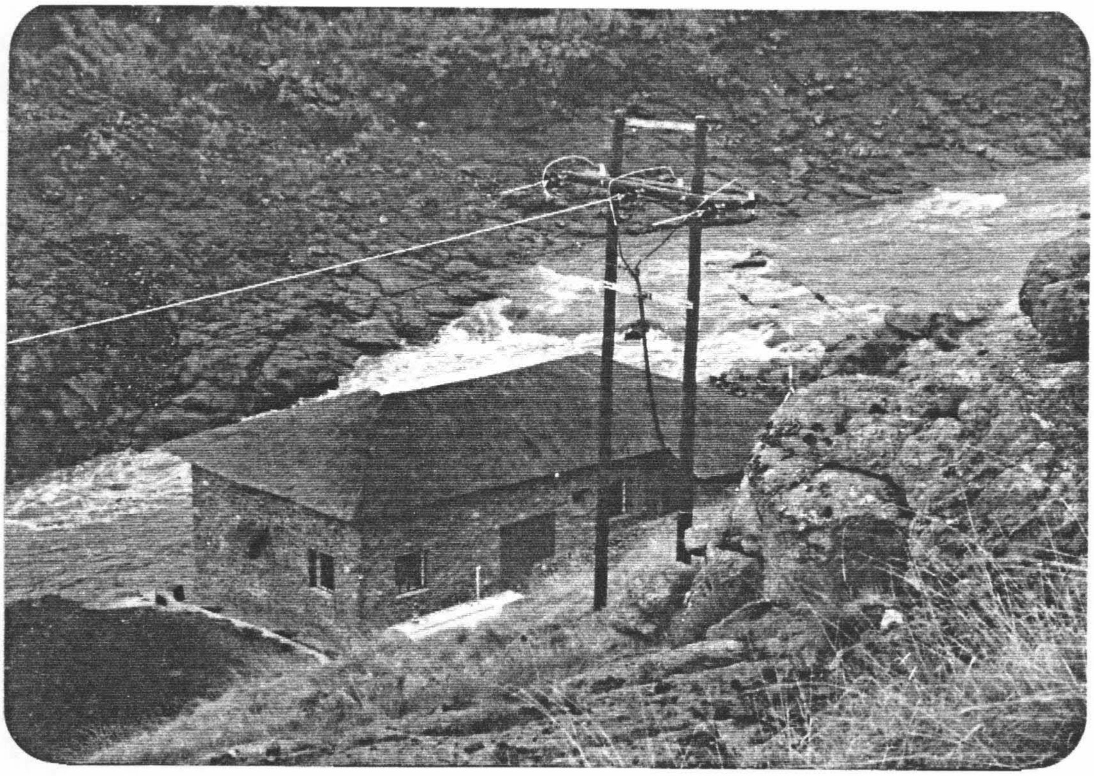
Construction of downstream re-regulating weir, October 1988



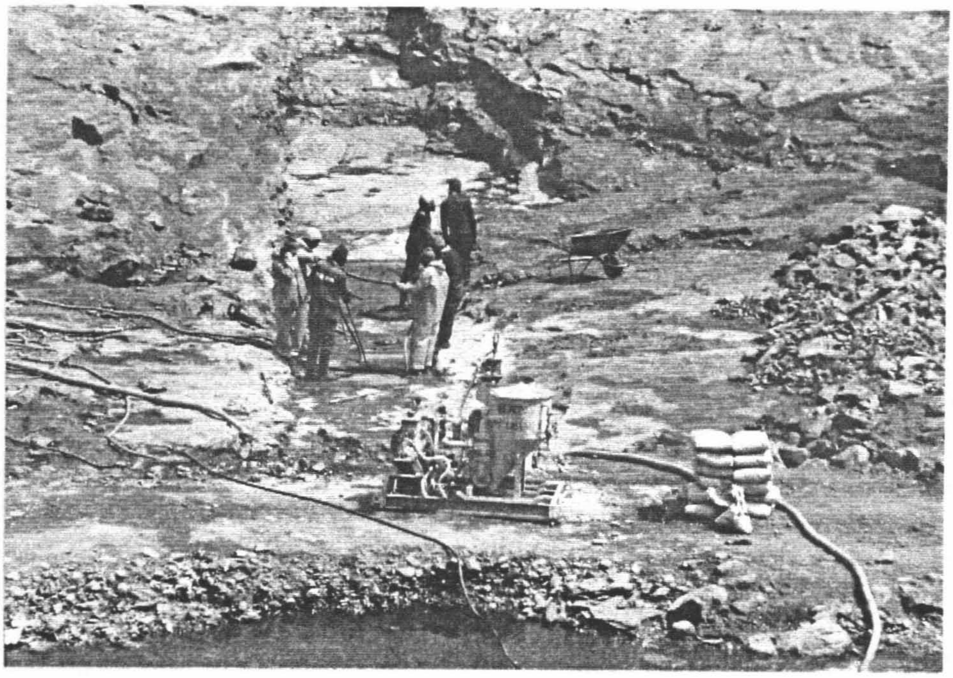
Downstream re-regulating weir in operation, November 1989



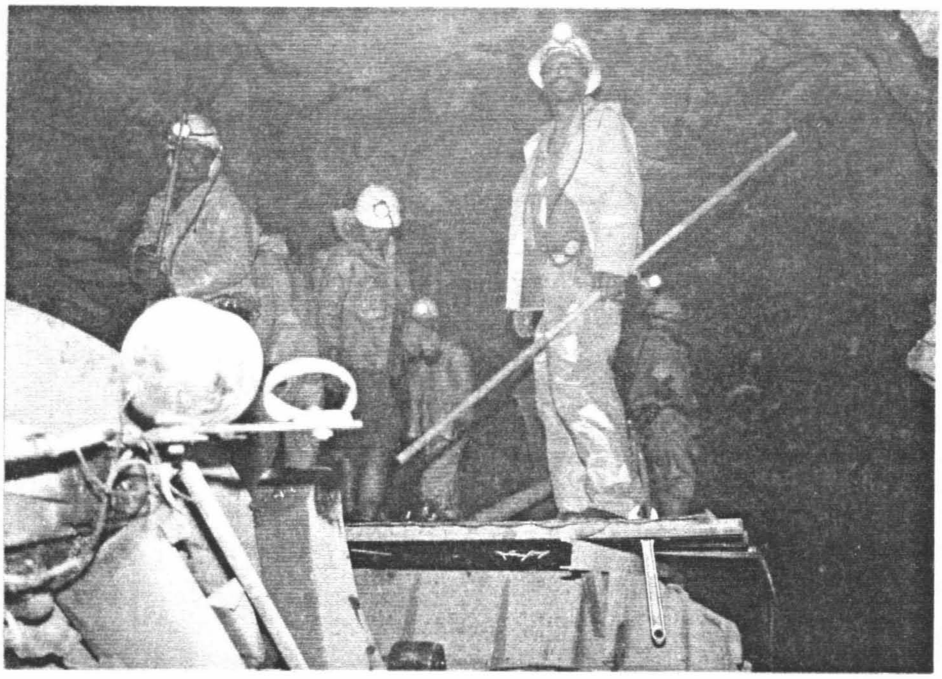
Intake pipe alignment, November 1989



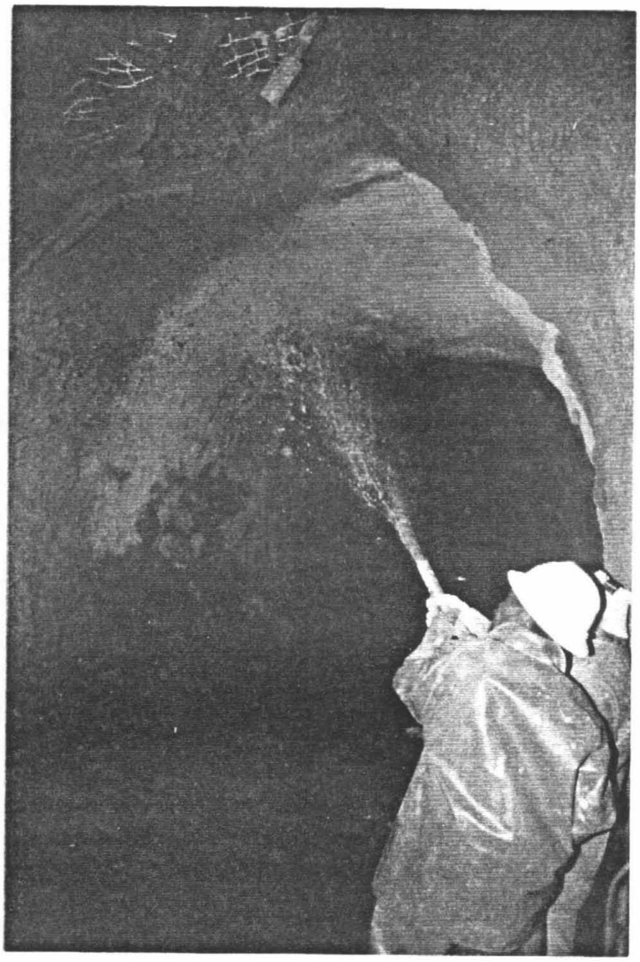
Complete hydroelectric power station, November 1989



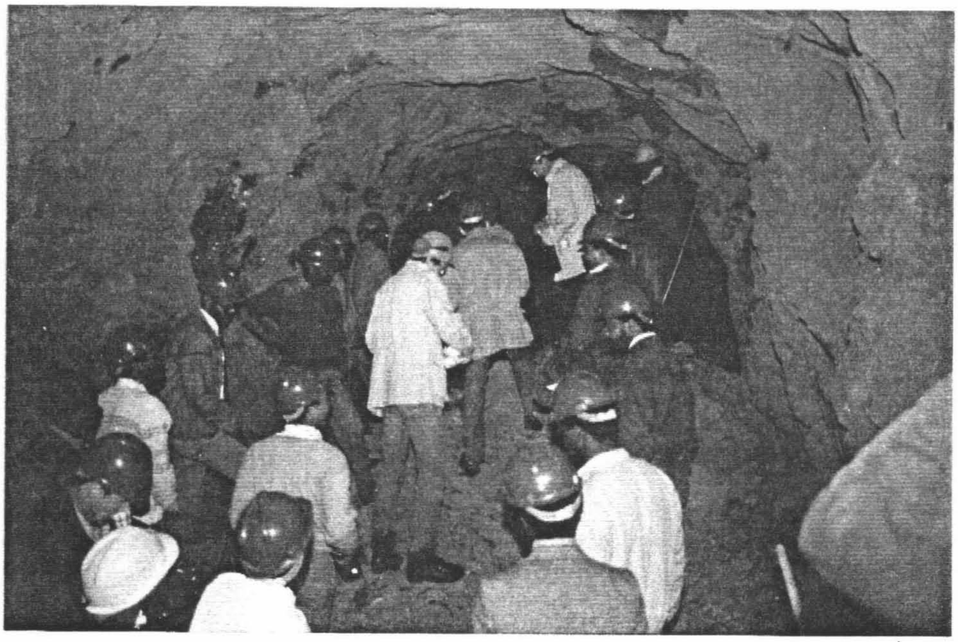
Deep-grouting at Mantsonyane Dam, August 1986



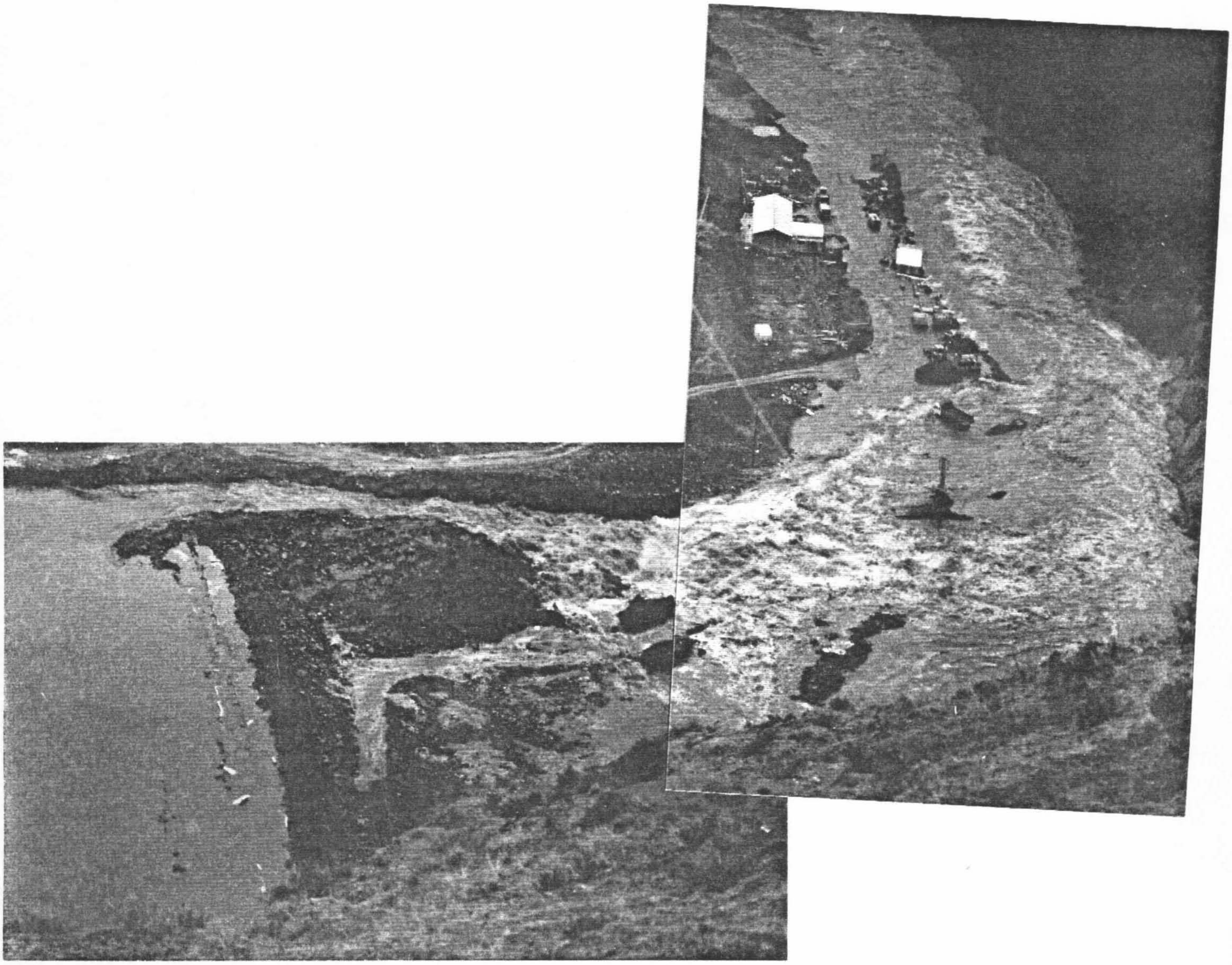
Tunnel crew preparing for blasting, September 1986



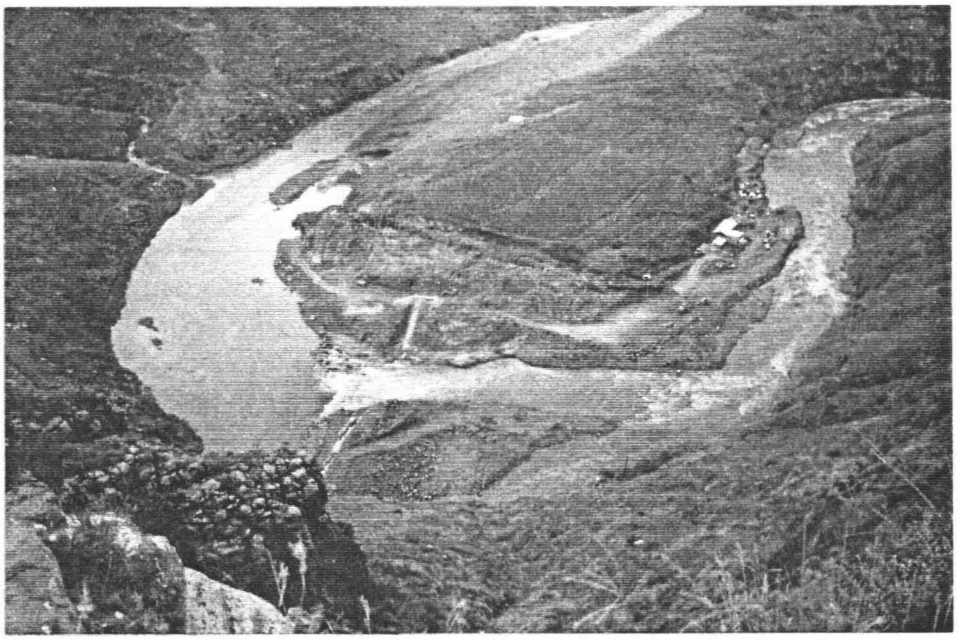
Shot-creeting of faults in tunnel, December 1987



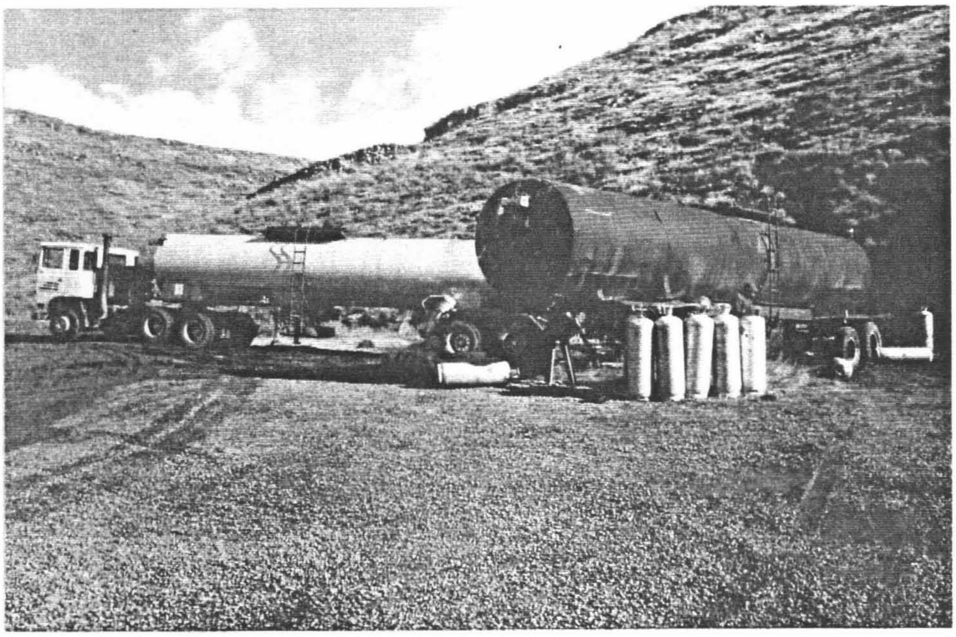
Tunnel breakthrough, September 1987



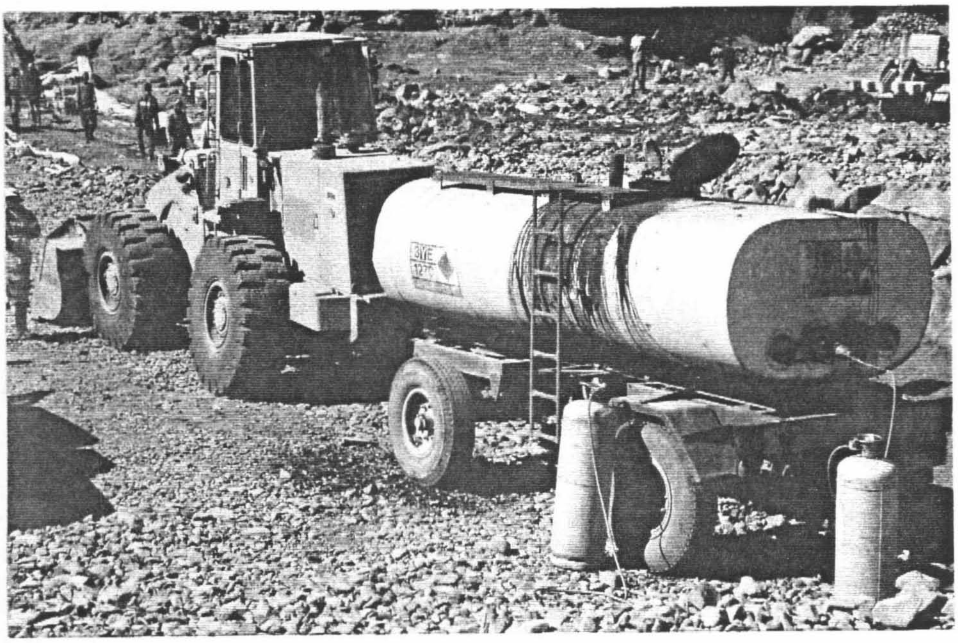
Dam breach, September 1987



Dam breach, March 1988

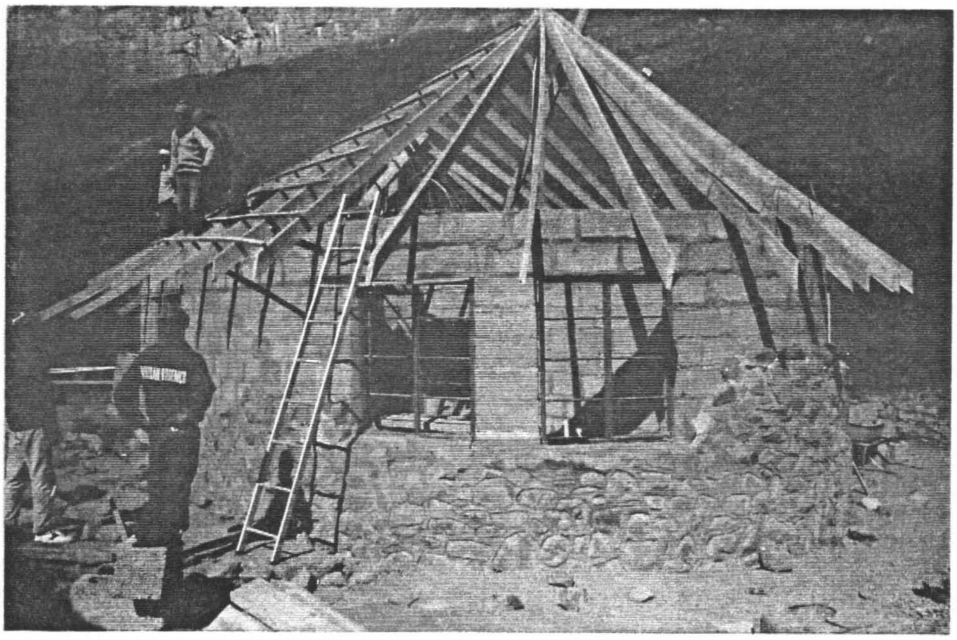


Transport of Bitumen to storage tank

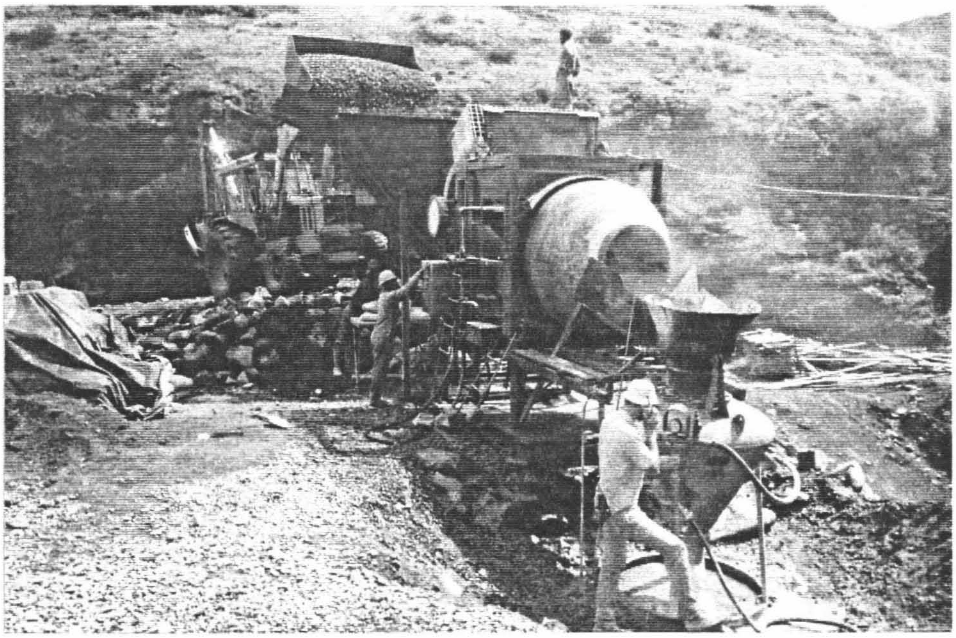


Tank for pouring at dam site

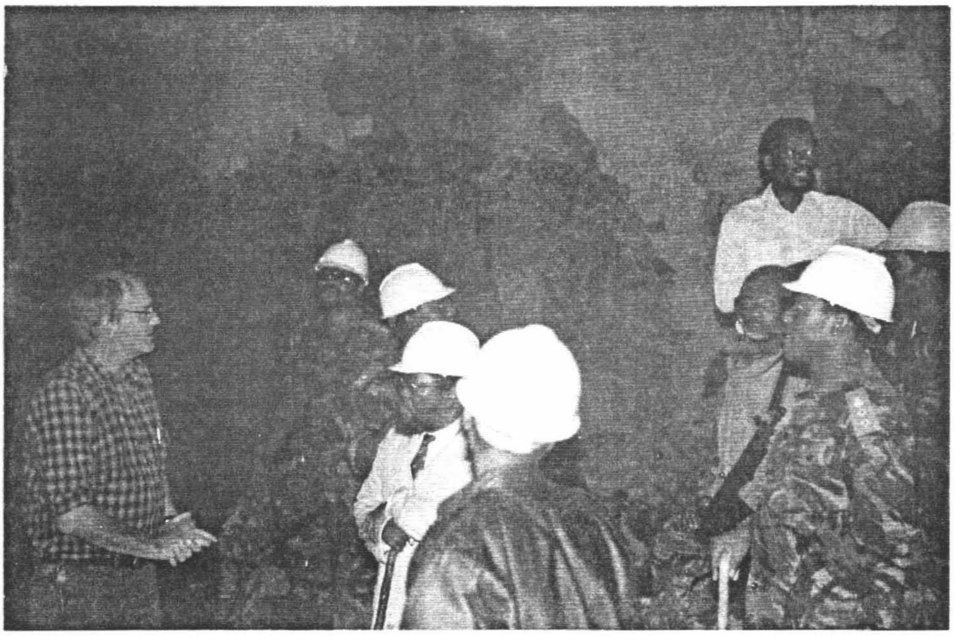
Pouring of bitumen into core



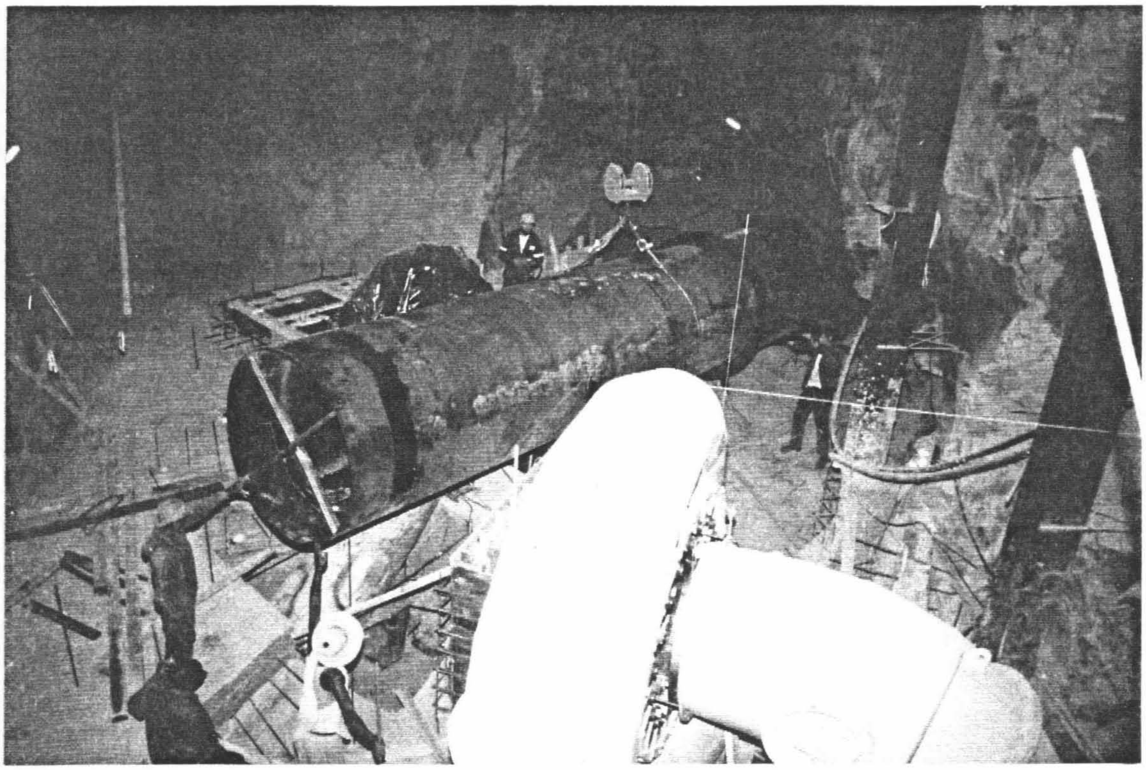
Construction of staff house, May 1987



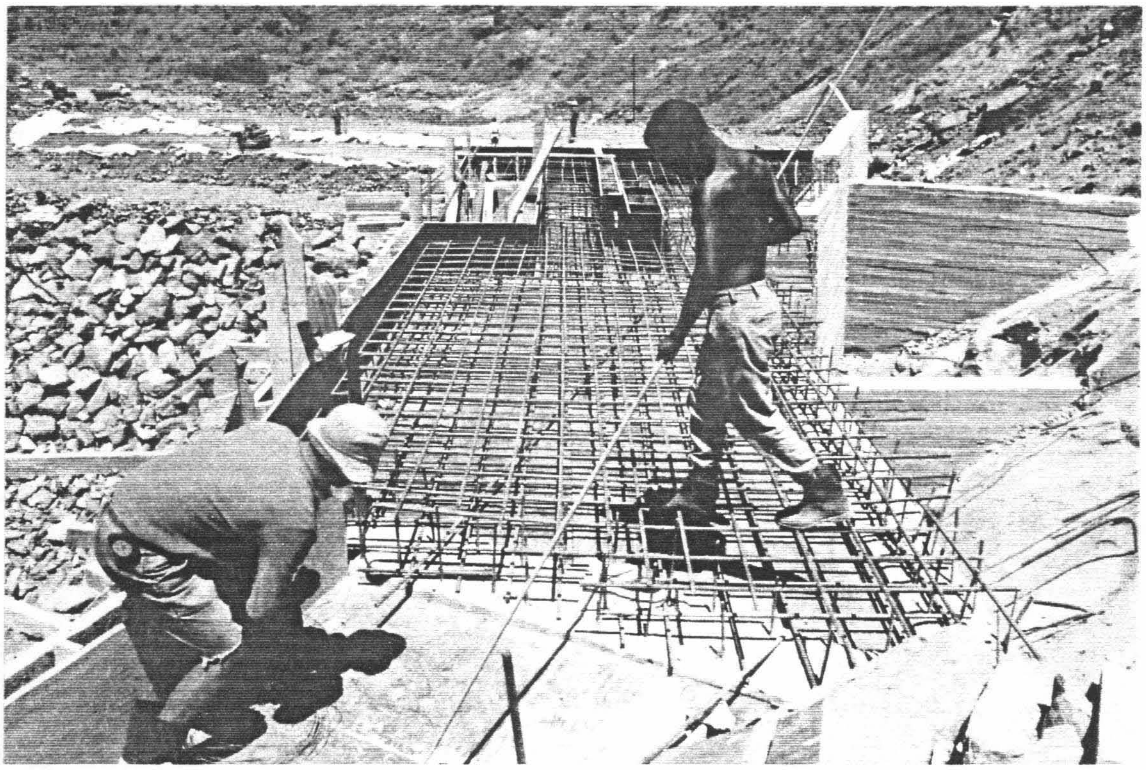
Concrete mixing set-up, June 1987



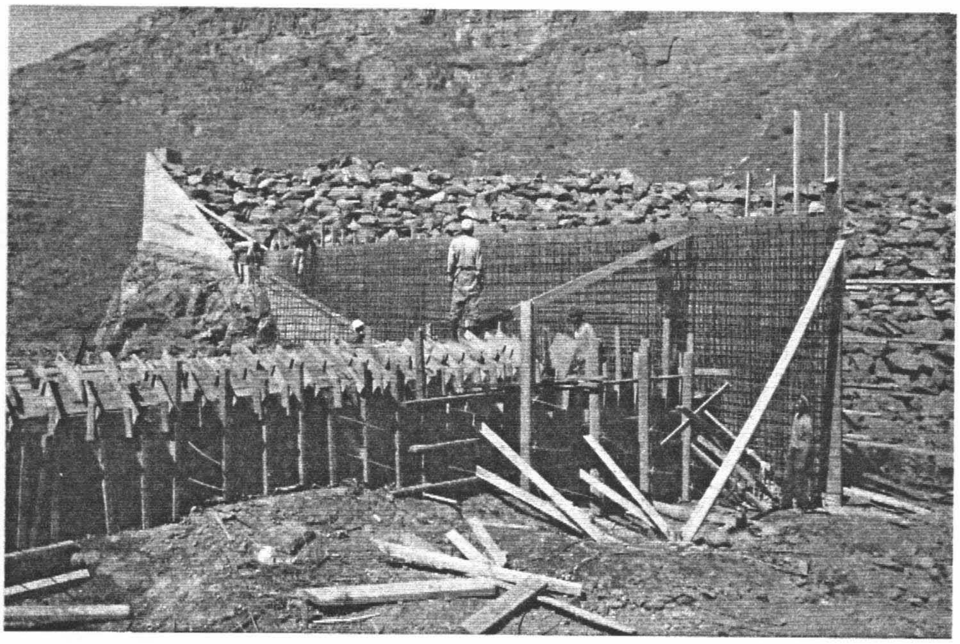
Visit to power station by
Hon. Minister Jané and staff, May 1987



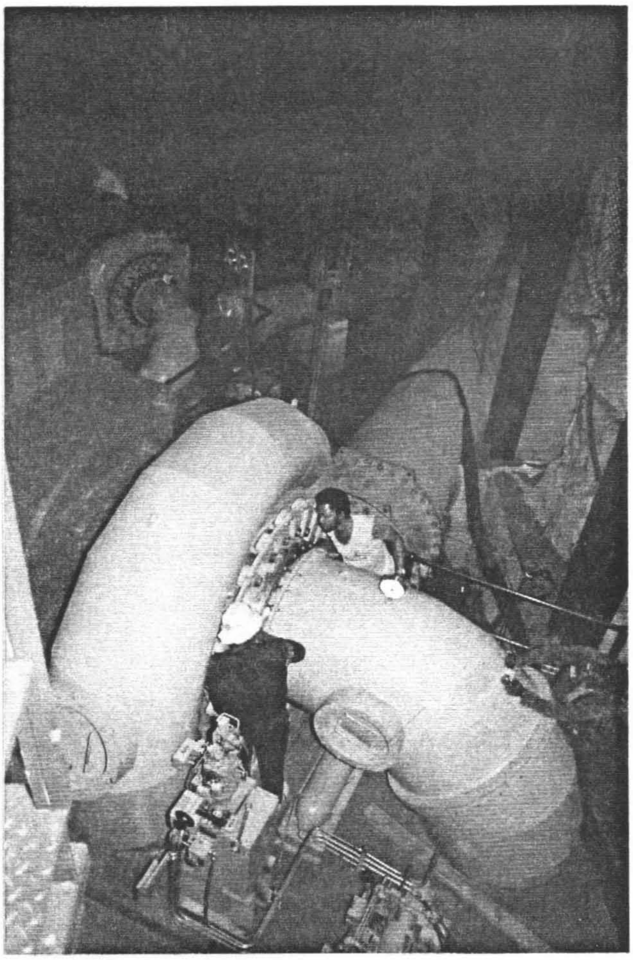
Erection of turbines and intake pipes, January 1988

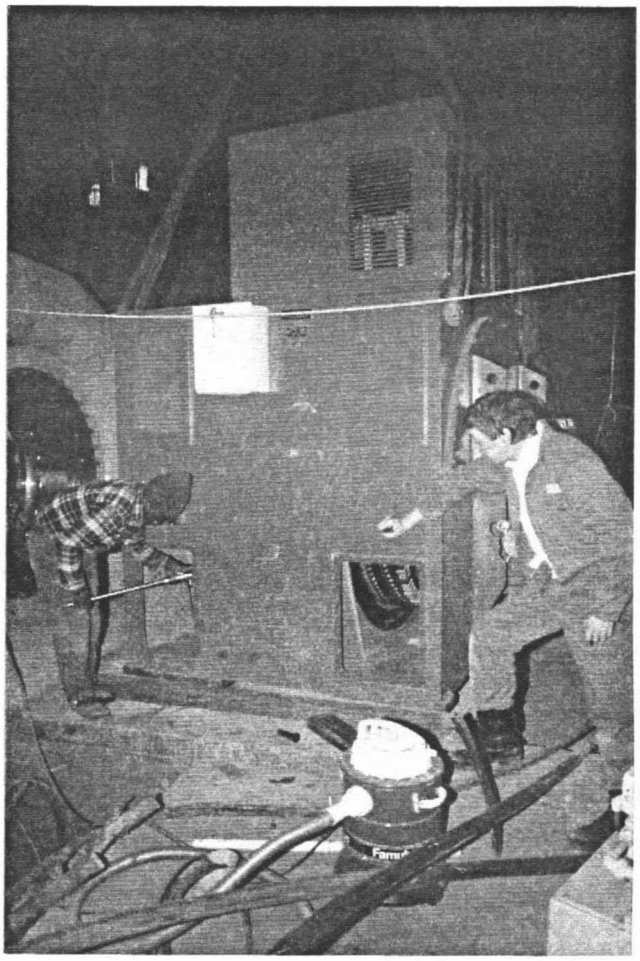


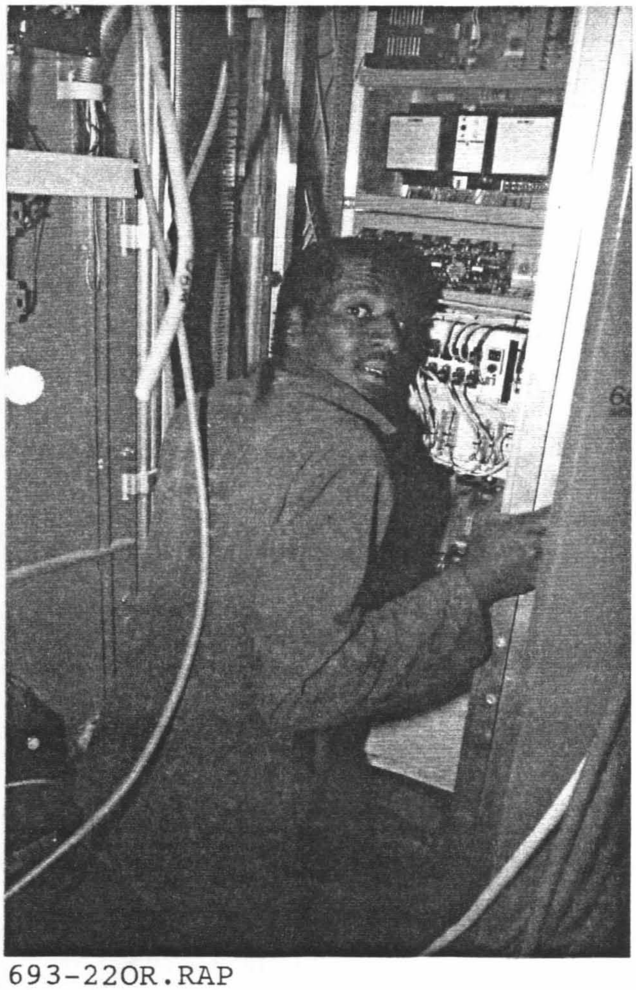
Intake platform with dam in background, February 1988



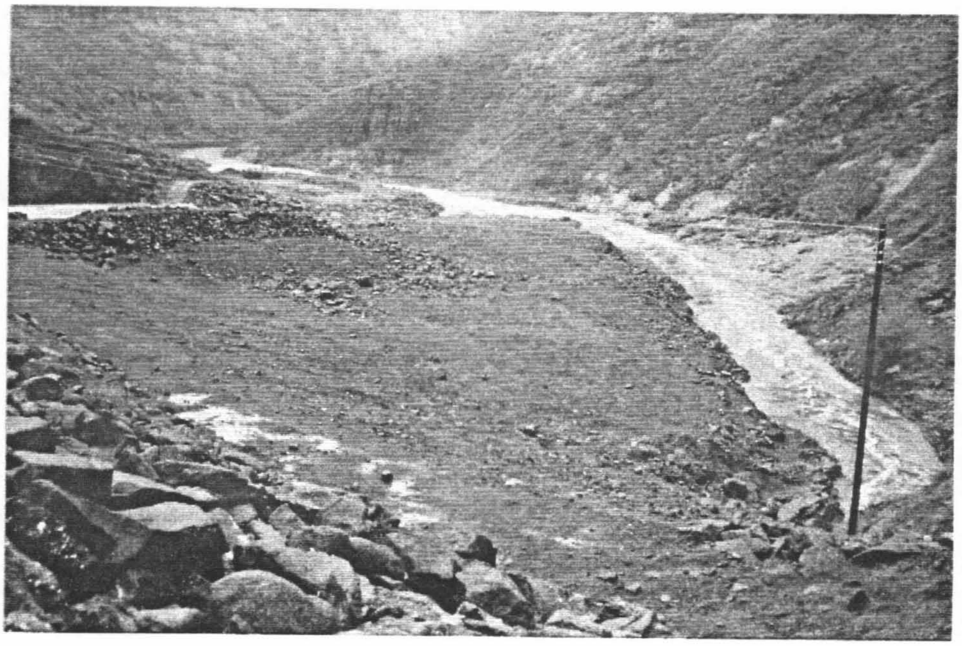
Retaining wall and spillway crest, September 1988



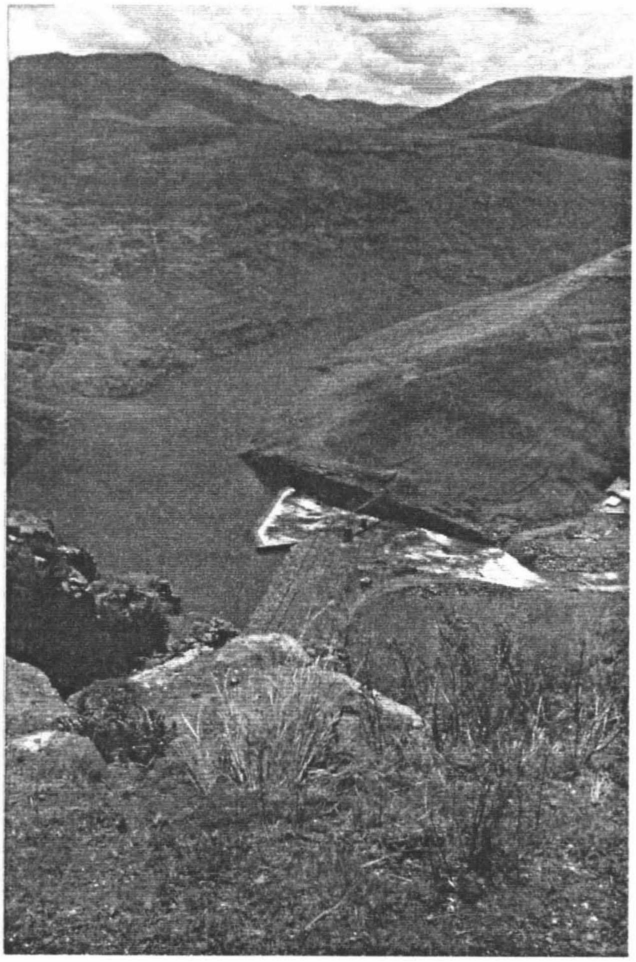




Mounting of turbines, generators and control panels in power station, 1988



Downstream of dam, April 1989



Complete dam and spillway, November 1988

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