ESTABLISHMENT OF HYDROMETRIC STATIONS WITHIN QUTHING RIVER BASIN, LESOTHO

A MISSION REPORT

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The report provides recommendations on the establishment of hydrometric stations in the Quthing river basin, based on a mission 18-22 April 1988.

Some comments are also given on the Feasibility Study carried out on the Small Hydro Power Project Quthing.

Lesotho.
Quthing River.
Hydrometric Stations
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1. INTRODUCTION

A possible cooperation agreement between Department of Water Affairs (DWA) in Lesotho and the Norwegian Water Resources and Energy Administration (NVE) within the sector of hydrology is presently being discussed. In this connection, a representative from NVE visited Lesotho on a short-term mission 18 - 22 April 1988. The present report is dealing with this mission’s findings and recommendations on the hydrometric investigations in the Quthing river basin and possible future DWA/NVE cooperation on this specific project only.

As part of the mission, a field trip to the Quthing area was made. DWA provided the transport and gave all other possible assistance to carry out the field investigations in an efficient way.

DWA-participants in the field trip were:

- Mr. Thabang Makong, Water Resources Engineer, Department of Water Affairs

- Mr. Thaele Sakoane, Principal Technical Officer, Water Affairs Office, Quthing

- Mr. Seoehla Setlae, Technical Assistant, Water Affairs Office, Quthing

With the assistance of Mr. Makong, all relevant material concerning the hydrology of Quthing was made available at DWA’s headquarters.
2. SUMMARY AND RECOMMENDATIONS

Generally, the Quthing river is considered to be an extraordinarily hard river to gauge, due to its steep gradient and excessive sediment transport. Consequently, the existing hydrometric data are far from satisfactory. As an immediate measure, it is recommended to

- rehabilitate the existing hydrometric station SG 52, at Hoko. The existing staff gauge should be changed to an automatic water level recorder (Stevens). Two alternatives are given as to the construction of the station:

  A) A stilling well dug into the river bank.

  B) A stilling pipe attached to a rock outcrop about 10 m downstream the present staff gauge.

  Mainly due to the expected silting problem, alternative B is recommended. NVE has available a Stevens Recorder which can be sent DWA on short notice.

Since the upper Quthing river is the most interesting part with respect to hydropower development, efforts should be made to establish a hydrometric station in this area. For several reasons, the Letsie Dam is considered to be the best location for such a station. If the lake is going to be used as a reservoir for hydropower production, hydrological data from this part of the catchment will be of utmost importance. The establishment of a hydrometric station at the Letsie Dam is considered to be rather expensive. Before any decision is made, it is recommended to

- carry out a detailed survey of the existing dam and to check the possibility of changing the spillway into a broad-crested weir. A total cost estimate on the work needed to repair the dam and make it suitable for gauging should be worked out.
Time did not allow to visit the meteorological stations in the area. It is highly recommended, however, that

- all historical meteorological data from the area are checked on their quality, and, if needed, the stations should be rehabilited up to an acceptable standard.

The need and possibilities to measure sediment transport is not dealt with in this report.

The DWA-office in Quthing was visited. To be able to carry out the needed hydrometric measurements in the Quthing river basin it is recommended to

- make available for the DWA-office in Quthing a new Ott current meter and portable cableway. Purchase of this equipment could be considered part of NVE's contribution, if a cooperation DWA/NVE is agreed upon. Great care should be taken that all new instruments and other equipment should be of the same kind and make previously used in the region, and recommended by DWA.

A feasibility Study on a small hydropower project in upper Quthing has been made by the Institute of Water Management, Vienna-Austria [1]. Based on request by DWA, some comments on the hydrological part of the study are given in this report.

Generally, the study suffers from the lack of hydrometric data from the project area. It is not always clear which data have
been used in the various analyses, and the quality of data is not sufficiently analyzed.

Furthermore, the study does not provide the complete design criteria needed for such a project, like estimation of design floods by acceptable methods, and generation of inflow runoff series for estimation of power production and shortage risks.
3. THE QUTHING CATCHMENT

3.1 General description

The Quthing river is a tributary to the great Orange River in the South-East Lesotho, near the border with South Africa. It is a steep mountain river with an estimated catchment area of 614 km² at Hoko, hydrometric station SG 52, about 5 kms upstream the confluence with Orange. Figure 1 gives the main drainage pattern of the Quthing river.

The steep gradient of the river and extensive soil erosional activities within the catchment have the effect of heavy sediment transport by the river. As most of the rivers in the region, it has a typical flashy character with high-peaked floods and low base-flow values in the dry period. The occurrence of frost is common during the winter (May-September).

It is the upper part of the river which has been considered for hydropower development [1], see fig. 2. The catchment characteristics in this area are given [1] as:

![Map of the Quthing river](image)

Fig. 1. The Quthing river. The hydrometric station, SG 52, is marked.
**Fig. 2. Upper Quthing catchment areas. From [1].**

<table>
<thead>
<tr>
<th>Catchment</th>
<th>Letseng La Letsie I</th>
<th>Letseng La Letsie II</th>
<th>Folestry</th>
<th>Quthing to diversion</th>
<th>Quthing to confluence with Folestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area (km²)</td>
<td>8.5</td>
<td>11.0</td>
<td>22.0</td>
<td>51.5</td>
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<tr>
<td>Maximum alt. (m)</td>
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<td>2 800</td>
<td>2 820</td>
<td></td>
<td>2 850</td>
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<tr>
<td>Minimum alt. (m)</td>
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<td>2 420</td>
<td>2 420</td>
<td></td>
<td>1 880</td>
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<td>Length</td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>10</td>
<td>26.5</td>
</tr>
</tbody>
</table>

| Catchment area A | Catchment area B |
3.2 Proposed hydrometric stations

Hydrometric station SG 52

Hydrometric data are available from one station only within the Quthing catchment. Some other stations in nearby rivers were also visited, see Section 4.

The hydrometric station SG 52, Quthing river at Hoko (fig. 3), was established in February 1979. It has not been continuously observed, however, and is now considered closed. A total of 62 discharge measurements have been made, but only by wading at low flows. The rating curve is therefore insufficiently defined at high levels. Conditions for discharge measurements by cableway are favorable, also at high stages. The catchment area is given as 614 km².

The station has a channel control for low flows with downstream changes to partly rapids control with boulders about 80 m down river (Fig. 4). Some shifting control has been experienced at low flows.

The staff gauge readings were reported to be unreliable for several periods.

As a conclusion, the existing run-off series based on present data from Station SG 52 may not be considered reliable.

According to information from the Water Affairs Office in Quthing, it has been proposed to move the station from its present location about 5 km upstream of the confluence of Quthing and Orange to a site about one km upstream from the confluence. The new site, 4-500 m upstream of the new road bridge, was inspected, but due to the very unstable river channel and high flow velocities at flood conditions, this site is not recommended.
A slightly better solution would be to establish the station at the left (looking downstream) bridge pier. However, an unstable river channel and probable occurrence of backwater effects from the Orange also exclude this location.

**Based on the inspection of the accessible parts of the Quthing river it is safely concluded that the best site for a hydrometric station is the present site of Station SG 52, at Hoko.**

Even if the control is not considered permanent at low flows, no better site has been found in the Quthing main river.

It is recommended that the existing staff gauge is changed to an automatic water level recorder (Stevens). There are two alternatives concerning the construction of the station:

A) A stilling well with communicating pipes to the river channel can be dug into the river bank 3-4 m downstream of the present gauge, and about 3 m outside the road (Fig. 4). Rock may be experienced at some depth and blasting may be necessary. A concrete wall should be constructed upstream the stilling well to protect against floods.

The advantage of this alternative is that the recorder house will be well sheltered also at high flows. The disadvantage is the possible blocking of the communicating pipes with silt. Daily inspection of the station can not be expected since the nearby village is abandoned.

B) A stilling pipe can be attached upstream to the rock outcrop about 10 m downstream from the present staff gauge (Fig. 5, also visible on Fig. 4). There is sufficient water depth to record also the low water levels.

The advantage with this location is that the silting problem can partly be avoided. The disadvantage is that the stilling pipe will be very exposed to flood flows. The construction and protection of the pipe therefore has to be very sound and sturdy to withstand major floods. To attach the upper part of
the pipe, a solid concrete support has to be constructed, and bolted to the rock.

Mainly due to the expected silting problem, alternative B with a stilling pipe is recommended.

If this recommendation is supported by Water Affairs, the construction of the station should start as soon as possible. As to the construction details, reference is made to the Manuals on Hydrometry [2] by Mr. Østen Tilrem, available at Water Affairs office in Maseru.

Possible Hydrometric Station at Letsie Dam

The Letsie Dam (Fig. 1) is probably the best location for a hydrometric station in the entire Quthing river basin. It is located in the Folestri River which is a tributary to Quthing. The catchment area is given as 42.4 km². The lake is situated in a rather remote area not accessible by car most of the rainy season. The hydrometric station must therefore be equipped with a Stevens Recorder.

For any hydropower development in the upper Quthing river, and also nearby areas, runoff data from the Letsie Dam will be very valuable.

The existence of an old dam (Fig. 6, 7 and 8) at the outlet of the lake complicates the location of a hydrometric station in the lake itself. The dam has a considerable leakage and its shape makes it ill suited as a control for a gauging station. Due to its location in the Quthing river basin, however, it could prove worthwhile to invest both funds and efforts in repairing and adjusting the dam to make it suitable as a control for gauging.

The erosional power of the water flowing over the dam during floods is clearly illustrated by the photos on Figures 6 and 9. The photo on Fig. 6 was taken in advance of the disastrous flood in September 1987 while the photo on Fig. 9 was taken
after the flood. The damage experienced on the road is considerable.

Before any decision is made, it is recommended to carry out a detailed survey of the dam, to check the possibility of preventing the leakage (for example by injection), and to check the possibility of changing the spillway into a broad-crested weir to obtain reliable gauging of low flows. In this connection, the possibility to raise the level of the road up to the level of the dam crest should be considered.

A total cost estimate on the work needed to repair the dam and to make it suitable for gauging should be worked out.

It is recommended that the office of A/S NOREMCO CONSTRUCTION in Maseru is requested to carry out the above mentioned task. The present Construction Manager has extensive experience in the establishment of hydrometric stations in Tanzania and is therefore very qualified for this kind of work.

Possible other locations

As part of the mission, all accessible parts of the Quthing river and the lower part of some tributaries were inspected to find possible locations for hydrometric stations. No other suitable sites were found however, mainly due to the steep gradient of the river and the lack of well-defined permanent controls.

Also about 1-1.5 km of Quthing upstream the upper road bridge, was inspected. Fig. 10 and Fig. 11 give typical pictures of the river channel in this area, not suitable for gauging. Fig. 12 shows a previous photo of the Quthing river, just downstream of the proposed site of the hydropower station. The river channel seems to be of the same character.

It should be emphasized, however, that due to the short time available for the field investigation, not all possible sites for gauging stations were inspected. For a complete survey, a period of about 2 weeks would be needed.
Measurements of other hydrometric parameters

Regrettably, time did not allow to visit the meteorological stations in the area. In the absence of reliable historical data on runoff, however, the availability and quality of series of climatic data from the area could be of outmost importance as a mean to generate runoff data by simple mathematical models.

Furthermore the possibilities and need to measure sediment transport is not dealt with in this report.
4. OTHER FINDINGS

As part of the mission some other hydrometric stations in the area as well as the DWA-office in Quthing town were visited.

4.1 Sebapala River, hydrometric station SG 51

The station consists of a staff gauge. The catchment area is given as 849 km². The control is probably not permanent at low stages. A great number of discharge measurements are taken at low flows, but no flood measurements are available. The upper part of the rating curve is extended by the Stevens method.

The station was established in 1979 and is not observed at the moment. It is considered moved upstream avoiding backwater effect from the confluence with the Orange River. The proposed new site pointed out is located on the other side of the river, only about a hundred meters upstream the present site.

It is recommended to check the possibilities to find a site still further upstream to be sure to avoid the backwater effect from Orange.

4.2 Qomo-Qouong river at Quthing, hydrometric station GS 40

The station was established in November 1972. It consists of an asbestos stilling pipe with a Stevens recorder. The catchment is given as 208 km². Data from this station are considered to be reliable. The control at low flows is somewhat shifting.

A great number of discharge measurements at low flows have been taken, but flood measurements are lacking.

As a cableway is now set up at this station, it is strongly recommended to make efforts taking flood measurements. This is the only possibility to check the upper part of the curve which is now extended by the Stevens method.
4.3 The Orange River, Seaka Bridge, hydrometric station SG 3

This is a modern gauging station completed in 1972 with a stilling well, a Stevens recorder, and a permanent cableway. It is the last station to gauge the Orange before the river leaves Lesotho.

4.4 The Water Affairs office in Quthing town

The Water Affairs Office in Quthing has the following hydrometric equipment available:

- One universal current meter. Ott, of older date.
- One Pygmé current meter. Seba, very new.
- Two Ott cable ways:
  i) One portable, presently set up at station GS 40, Qomo-Quoung River
  ii) One permanent, in use at station SG 3, Orange River.
- Some surveying equipment

The Water Affairs building in Quthing is very small and functions as combined office and store. Better facilities would be desirable, but this is outside the scope of the proposed cooperation between DWA and NVE.

To be able to carry out the needed hydrometric measurements in the Quthing River basin, however, a new Ott current meter and a new portable cableway will be needed. Purchase of this equipment should be considered part of NVE's contribution, if a cooperation DWA/NVE is agreed upon.
5. POSSIBLE COOPERATION DWA AND NVE

A general proposal for cooperation between DWA and NVE has been worked out, but will not be considered in this report.

NVE is, however, in a position to offer some immediate assistance connected with the hydrological investigations in Quthing river. Based on the recommendations in this report, NVE can on short notice make available a Stevens Recorder for the use at SG 52 hydrometric station.

Further, funds are probably available to assist DWA with the purchase of a new Ott current meter and new portable cableway to be used by the Water Affairs office in Quthing town.
6. COMMENTS ON SMALL HYDRO POWER PROJECT QUTHING, FEASIBILITY STUDY

During the visit in Maseru the report

*Small Hydro Power Project Quthing, Feasibility Study*
*(August 1984)*

*made by*

*Institute of Water Management, Universitaet Fuer Bodenkultur, Vienna-Austria*

was made available. Based on request by DWA, some comments on the hydrological part of the report are made in the following.

The study concentrated on the upper Quthing river as outlined on the map in Fig. 2 in this report. It concludes with a single reservoir (Letseng La Letsie Dam) and power station system combined with a diversion. The gross head utilized from the Dam to the power house in the Quthing valley is 540 m and the regulated discharge is estimated to 0.96 m³/s.

The proposed hydropower project in Quthing is also described in a previous NVE-report [3], where the possibility for a peak power project is mentioned. The report also considers the runoff data used in the feasibility study to be too optimistic.

The Austrian study strongly emphasizes that the lack of hydrological data from the area makes the hydrological analyses highly uncertain. All the hydrological information have been derived by correlations with other catchments. The study therefore urgently recommends that a system of hydrological stations be installed.

The fact that the feasibility study is based on an unsatisfactory hydrological knowledge of the area considerably reduces the value of the study. Additionally, complete design criteria should include information on
- Design flood (order of 20-100 years flood) for the coffer dam or a diversion structure during construction

- Design flood (order of 10 000 year flood) for the main dam

- Annual yield

- Inflow series (observed or synthetic) for a period of at least 30 years for estimation of power production and shortage risks. Depending on live reservoir storage this may require daily data (monthly data will underestimate flood spill losses, especially at intakes for diversion tunnels.

Since the amount of available data is low, it follows a need for thorough analyses of the data sets themselves and also that models used have to be very simple. In the report most of the above mentioned considerations (if not all) have to added or completed.

The region where the project area is situated has a sparse number of stations for meteorological or hydrological observations. A good background to a decision whether it is possible to use the design values or not would be an analysis of the quality of the given values or at least any kind of sensitivity test.

The sparse existing hydrometric network makes it necessary to utilize all kinds of information that could lead to better estimates of design values.

As precipitation estimates serve as an important basis in the report more care should be given to this variable. The precipitation mean value of the project area is set equal to the mean of the station nearest to the area. This station is located at an altitude of about 1700 m while the mean altitude for the project basin is approximately 2500 m. There has been taken no account into the difference in altitude. It is concluded that "...although there was a certain relationship between altitude and rainfall, this was not pronounced."
This conclusion is very much in conflict with the information presented in figure 5.8 in the study. The figure shows this relationship for two classes of stations. A rough test on each of these groups gave a correlation coefficient of about 0.9 for both groups which would be satisfactory enough.

The report lacks quite a lot of information that would facilitate a validation of estimates and of models. It is e.g. not always clear which data sets that have been used in the various analyses and the source of information in some cases.

A Markov-model is used for flow series simulation. Here it would be of great interest to the reader to know the autocorrelation coefficients which are not presented. One could expect low coefficient values for this region which would make the use of a Markov-type model somewhat doubtful.
REFERENCES


Fig. 4. Hydrometric station SG 52, seen downstream. Site for stilling well (Alt. A).

Fig. 5. Hydrometric station SG 52. Site for stilling pipe (Alt. B), seen upstream.
Fig. 6. Letsie Dam.

Fig. 7. Letsie Dam.
Fig. 8. Letsie Dam.

Fig. 9. Flood damage on the road below Letsie Dam.
Fig. 10. Quthing river, just upstream the upper road bridge.

Fig. 11. Quthing river, 1–1.5 kms upstream the upper road bridge.
Fig. 12. Quthing river valley, just downstream the proposed hydropower plant.