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# THE GOVERNMENT OF THE REPUBLIC OF MALAWI

## MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT

## IRRIGATION, RURAL LIVELIHOOD

## AND

## AGRICULTURE DEVELOPMENT PROJECT

# KAPICHIRA DAM AND SHIRE VALLEY IRRIGATION PROJECT

# VISIT REPORT BY PANEL OF EXPERTS

**BY**


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## 1. BACKGROUND

Since the 1940s, Malawi has been interested in the implementation of Shire Valley Irrigation Project (SVIP) to develop irrigation in the Lower Shire Valley. Since then, the proposed project has been the subject of a large number of surveys and studies but these studies did not result in the preparation of detailed project proposals and design acceptable for funding by donor agencies.

In 2008 African Development Bank ($A_fDB$) funded a study by CODA and Partners that was intended to synthesize the outputs from the previous studies and formulate a 42,000 ha irrigation project. A joint World Bank (WB) and AfDB identification mission in January 2011 reviewed the latest feasibility report and proposals of CODA and agreed with the Government of Malawi (GoM) that additional work would still be required to formulate a "bankable" project. The gaps identified by the joint mission included: (i) confirmation of water availability at Shire river taking into consideration of the irrigation water requirements of the SVIP and future plans for hydropower development downstream of the intake for the SVIP; (ii) the optimum site for the intake structure; (iii) management of the bulk water and infield irrigation infrastructure; (iv) the choice of irrigated crops and marketing; (iv) land consolidation and land allocation policies to smallholders; (iv) operation and maintenance (O&M), cost recovery and sustainability; and (v) role of private sector and possible public-private-partnerships (PPP) for financing different aspects of the project for construction as well as post-project O&M. Since then a number of studies including several studies for water availability for SVIP have been completed or are nearing completion. The technical feasibility study of the Project is nearly completed. A hydraulic modelling study has been carried out with the objective of optimising the site of the proposed intake at the Kapichira Dam.

A Panel of Experts (PoE) has been established under the Ministry of Agriculture, Irrigation and Water Development (MoAIWD) to undertake periodic, comprehensive and independent reviews with the objective of evaluating features and actions pertaining to the safety of critical water infrastructure in Malawi and providing recommendations of actions that may be needed to upgrade the existing infrastructure and/or construct new dams and appurtenances to acceptable safety standards in compliance with relevant national and international water infrastructure safety guidelines.

It is proposed to locate the intake of the SVIP upstream of Kapichira dam. Therefore, safety of Kapichira dam and its operation will be indispensable for the successful operation of the SVIP to be able to generate expected socio-economic benefits. World Bank's Operational Policy (OP) 4.37 on Dam Safety stipulates establishment and activation of a PoE as a mandatory requirement and execution of specific activities to ensure safety of the dams related with any project funded by the WB. More specifically, the OP 4.37 requires that any dam that can influence the performance of the project or affect safety and performance downstream of the project area must be identified, its safety must be assessed, and necessary dam safety measures, remedial works and actions are identified and implemented.

The SVIP is proposed to be implemented in two phases: Phase I of the Project would extend to 21, 015 ha, while Phase II of the Project will cover 21,485 ha area. Total area under SVIP would be 42,500 ha.

It is now proposed to locate the intake for SVIP in the right bank of the head-pond for Kapichira Hydropower Station. However, the head pond also acts as a sedimentation basin for the power station, the morphology of which is highly sensitive to the incoming flow, the pond geometry and the flushing regime that has been established over the years. The construction of an

intake in the right bank of the head pond would almost certainly modify the morphology and, if not carefully sited, possibly impact on the efficiency with which sediments are flushed from the pond.

Because of the importance, location, and hydraulic linkage of the proposed SVIP intake structure with the Kapichita dam, it is considered as an appurtenunt component of Kapichira Dam for safety considerations. From this perspective the scope of the Panel of Experts has been extended to include Review of safety of existing and proposed infrastructure for the proposed Shire Valley Irrigation Project and Kapichira Dam.

## 2. KAPICHIRA DAM AND HYDROELECTRIC POWER PLANT

Kapichira Hydroelectric Power Plant is located on the left bank of the Shire River at Kapichira Falls on Shire River, Chikwawa District, in the southern part of Malawi, about 70 km south of Blantyre. Location coordinates are: Latitude= -15.8955, Longitude= 34.7519. The hydropower plant has a design capacity of 128 MWe and is part of the "Malawi Power V" project.

The Project comprises an 820 m long rockfill dam with a clay core, with a maximum height of 31 m at the foundation. A ski jump concrete spillway (crest level of 134.0 m) on the left bank with five openings controlled by sluice gates (each 15.24 m wide and 13.50 m high) has discharge capacity of 8,750 m³ per second. The bridge deck level is 150 m. An internal drainage/grouting gallery runs all along the spillway at Elevation 129.6 m. Four waterways from the intake feed the 500 m long and 8.80 m in diameter, reinforced power tunnel through a vertical drop shaft. A surge tank is located about 70 m upstream of the penstock/ manifold. The invert of the intake is set at El 138 m and has a waterway width of 50 m. The dam was designed by TAMS of New York and was completed in 1999.

Adjacent to the right abutment there is a 130 m long fuse plug spillway integral with the dam and designed to trigger at $Q_{100}$. The crest at this point is about a metre or so lower than the crest of the main dam and is located across the old bed of the river.

A couple of hundred metres upstream of the dam there is a spur, stretching several hundred metres from the right bank of the river to the middle of the reservoir/river. This was put in, following model testing by TAMS, in order to direct sediment away from the spill weir.

**Upstream spur viewed from close to proposed intake site.**

## 3. VISITS OF POE MEMBERS TO KAPICHIRA DAM

### 3.1 First Visit October 2014

Two members of the POE for Shire Valley Irrigation Project and Safety of Kapichira Dam: Johnathan Hinks and M. Aslam Rasheed visited the Kapichira dam separately. Johnathan Hinks visited the Project on October 14, 2014 in company with Mr. Crosby Mphande Project Engineer of Irrigation, Rural Livelihoods and Agriculture Development Project (ILARDP) and Mr Charles G. Mwalabu Chief Irrigation Officer of Ministry of Agriculture, Irrigation and Water Development. M. Aslam Rasheed another member of the POE visited the Project on October 24, 2014 in company with Mr. Crosby Mphande of ILARDP and Mr. Charles G. Mwalabu Chief Irrigation Officer of Ministry of Agriculture, Irrigation and Water Development. Mr. Archibald Kandoje of ESCOM met the teams on site, during both the visits, and was extremely helpful. The combined POE Report on these visits mainly concentrated on review of various Reports on Water Availability for SVIP and included a recommendation to locate the SVIP intake at Kapichira dam. These Reports included the following;

1. CODA (2005-2008). Various Feasibility and Design Reports (Incomplete Copies
2. Coyne et Bellier (2010). Shire Valley Irrigation Project: High Level Canal Project Review Report.
3. BRL Ingénierie (2011). Public Private Partnership Options Study and Awareness Raising for Irrigation Investment In Malawi. Final Report.Atkins (2011).
4. Norplan (2013). Water Availability Study on the Shire River at Kapichira Dam for The Proposed Shire Valley Irrigation Project & Hydropower Production.

The POE concluded that all the studies carried out so far more or less confirmed the UNDP and CODA estimates on water availability and it is concluded that monthly flow of the Shire River at Liwonde is generally above 300 cumecs with a long-term mean flow of 394.5 cumecs. Between February and July, the mean monthly flow is generally above 400 cumecs but falls to below 400 cumecs between July and November. Atkins study estimated that the average discharge at Liwonde will increase to 420 cumecs at Kapichira because of the contribution from the catchment area between Liwonde and Kapichira.

The implementation of SVIP was found to be feasible seen from a water availability point of view and the preparation for the implementation of the project should continue.

Based on the review of the Reports POE recommended that potential site for locating the intake upstream of Kapichira Dam on the upstream of the spur should be studied further. River training works will be needed to guide the required flow towards the SVIP intake without modifying the existing spur. In any event it will be important to obtain, from ESCOM, a copy of the TAMS (now Earth Tech) model testing report as well as the latest report on Dam Safety and monitoring.

### 3.2 Second Visit October 2015

The second visit to the dam was made by Jonathan Hinks and Aslam Rasheed on Oct 6, 2015 for meeting with ESCOM, where they were briefed about the Project by Mr. W.W. Liabunya Power Station Manager Kapichira Hydropower station and Mr. Archibald Kandoje. The meeting was also attended by the Technical Feasibility Consultants and Dr. R.M.A Champiti; Project Technical Team Coordinator Shire Valley Irrigation Project. The POE and other visiting members also walked along the dam, spillways and the fuse plug. Based on these discussions and observations the POE members submitted a Visit Report on October 08, 2015. The Report

was shared by MoAIWD with ESCOM who did not agree with several observations of the POE. The POE Report under reference and ESCOM'S comments are attached as Appendix A and Appendix B respectively.

### 3.3 Third (Present) Visit

The third visit by the POE to Kapichira Dam was made on January 27. The visit started with a brief discussion at Kapichira Boardroom presided by Mr. Michael C. Gondwe Senior Projects Manager ESCOM, Projects Department was also attended by officers from EGENECO (Generation Company established after bifurcation of ESCOM), MoAIWD and SVIP (List of participants attached as Appendix C). During the meeting the POE was informed that EGENCO had provided a number of Reports and documents to MoAIWD, which were shared by Mr. Peter Kadwere with the POE Members. These include:

1. Kapichira Reservoir Scouring Report: (2nd 2005 Scouring Exercise – Monday, 17th January 2005)
2. A Presentation On Kapichira Reservoir Siltation
3. Siltation Inspection Report 13th July 2003
4. Kapichira Dam Siltation Damage Detail, Sketch
5. Kapichira Phase I Performance Inspection & Assessment Report; TAMS- March 2005
6. Report on Kapichira Reservoir Scouring Exercise on 9 February 2004 by the Station ManagerReport on Inspection and Performance of Dam and Spillway by TAMS, July 2002
7. Inspection and Performance Evaluation by Earth Tech/Tams; December 2004
8. Inspection and Performance Evaluation by Earth Tech/Tams; December 2004-March 2005
9. A folder containing miscellaneous photographs
10. A folder containing Piezometer data and plots of piezometric data 1999 to date

In addition to the Data and Reports supplied by EGENCO, SVIP provided the following Reports to the POE.

1. Hydraulic Modelling of Intake V10 by Artelia
2. Chapter 13: Preliminary Design of Technical Feasibility Study for Shire Valley Irrigation Project (SVIP)

The meeting was followed by a Site Visit to the dam and spillway and a wrap up meeting after site visit. The POE agreed to review the data and reports and submit a report about the safety of Kapichira Dam and the positioning of SVIP intake.

During the meeting following points emerged:

1. EGENCO informed that two inspections have been carried out in the past. It is noted that the last inspection was carried out in 2005. Since then no inspection has been carried out. EGENCO follows a regime of 5 yearly periodic inspection as such the inspections due in 2010 and 2015 have not been carried out. EGENCO informed that they plan to have an inspection this year.

2. EGENCO informed that piezometric data are being collected and analyzed.

3. EGENCO informed that Phase II of Kapichira was commissioned in early 2014 and there are no plans for further expansion as would conflict with the water requirements for the SVIP.

4. The concrete erosion on the Spillway chute (as reported in the POE second visit Report) has been present for quite some time and has mainly occurred due to less cover over the temperature reinforcement and has not been repaired so far. EGENCO has been monitoring the same for years for remedial action, if the wear is considered to reach levels that would affect the functional requirements of the chute.

5. The broken rope of Gate 3 as noticed during the second visit has not yet been repaired as closure was not possible due to power shortage. It is likely to be repaired this year. It was noted that Gate 3 was fully closed and there was no leakage from the gate.

6. At the time of the visit the reservoir level was 147 m (maximum operating level). Spillway Gate 1 was open 0.3 m and was discharging 44 $m^3/s$. All other gates were closed. Leakage was noticed in Bays 2, 4 and 5. EGENCO informed that leakage through closed gates is due to some stuck debris below the gates but this could not be confirmed.

7. EGENCO informed that normally the gates are operated from the control panel at the Spillway based on hydro metrological data. In floods the gates are automatically operated. It was reported that gates are designed to be overtopped.

8. In answer to a query from Mr. Nigussie, Irrigation Engineer of SVIP, if an Emergency Preparedness Plan (EPP) was available EGENCO said yes, but during discussion that they are only referring to any emergency with respect to the power generation and that an EPP does not exist.

9. EGENCO informed that settlement monitoring is being carried out but no data or its analysis was shared with the POE.

10. Through a mail on July 29 the POE informed MoAIWD and EGENCO that the documents supplied to the POE by EGENCO include the 2004 and 2005 reports by Earth Tech/TAMS but do not include monitoring reports produced since then. POE suggest that monthly monitoring reports be prepared in future and that the first of these be supplied to the independent Inspecting Engineer for the 2017 inspection..

11. In response EGENCO informed that the 5-Year's inspections for 2010 and 2015 were not carried out, since during the time ESCOM were in the process of implementing Kapichira Phase II and were planning to undertake the next major Inspection after completion of Kapichira Phase II. Kapichira Phase II was completed in 2014 and ESCOM decided to operate the Power Station

with all 4 Units for 2 years before it scheduled another major inspection. This next major inspection is now due and will be planned for later this year.

12. EGENCO further informed collection and analysis of annual monitoring and the data requirement was provided for in the Operations & Maintenance Manual of the Civil Works for Kapichira.

13. In terms of readings of Piezometers, measurement of these were being done periodically by the Station Staff, even though the same has not been consistent over the years. The readings indeed showed normal readings and no cause for alarm.

14. Pressure readings in the Spillway Drainage Gallery are also monitored and there has not been any cause for alarm over the years. Electronic data on the same was not readily available.

15. The Station Staff was reported to have no capacity to undertake monitoring of the Survey Monuments as it requires surveyors and equipment. ESCOM Surveyors have over the years been requested to undertake these surveys. As electronic copies of the results the same were not shared with the POE. EGENECO stated that there have not been any alarming settlements or lateral displacements of the Dam.

## 4. SAFETY INSPECTIONS OF KAPICHIRA DAM

As per documents supplied by EGENCO two inspections have been carried out since the completion of the dam in 1999 i.e. about 16 years ago. These include an inspection carried out by the designers TAMS in 2002 and the second inspection in 2004-05 by Earthtech/TAMS. Since then no inspection by an outside agency has been carried out. EGENCO follows a regime of 5 yearly periodic inspection as such the inspections due in 2010 and 2015 have not been carried out. EGENCO informed that they plan to have an inspection this year.

### 4.1 2002 Inspection

The first inspection was made by TAMS New York ; the designers of the dam. As per inspection report of 2002 an inspection was also made in January 2001 when seepage and piezometer monitoring were carried out. The report of January 2001 inspection has not been made available. The observations in 2002 were reported to be in line with those made in 2001. The report also mentions that movement measurements were made in August 2001 and that the results should be mailed to New York.

Visual inspection was carried out from June 1 to 5, 2002 at reservoir elevation of $\pm$ 146.6 m and discharges over the spillway were made using Gates 1 and 4 at about 3 to 5% opening for discharge of 150 to 200 $m^3/s$. Gate 5 was also tested in full open position.

During the inspection cracks were observed on dam crest. The cracks were investigated through test pits and were found to have localized effect only. The test pits were back filled with clean river sand in July 2002. Other components of the dam were found to be satisfactory. It was recommended that crack monitoring should continue.

Seepage from the main dam was estimated as 2.86 lts/sec at a reservoir level of El 146.7 m and was consistent with previous readings for the same reservoir level. The seepage flow was clear. Seepage from the right bank downstream of fuse plug was estimated at 13.6 lts/sec and

was also found consistent with previous readings. Seepage in the drainage gallery was 0.33 lts/sec and was completely clear.

During the inspection standpipe type pizometers in the dam, dam abutments and spillway were read on 6.04.2002 and were mostly lower than the observations on 22.01.2001. The piezometer on the right side of the Spillway showed a 35% reduction in head, whereas the pizometer on the left side showed a reduction of 82%. Calculated factors of safety against sliding were 1.71 on the right and 2.35 on the right neglecting any cohesion. The Spillway stability was considered satisfactory.

The 2002 inspection report concluded that the response of the dam and its foundation was within expected behaviour to the increase in upstream water level. Vertical and horizontal movements were small. The overall seepage was very small and change in downstream ground water conditions was stable. The performance of the dam, the Spillway and downstream area was found to be entirely satisfactory.

### 4.2 2004-2005 Inspection

The 2004-2005 inspection was undertaken in two stages. Initially the inspection was carried out from November 30 to December 7, 2004. The second stage inspection was carried out from 21 to 30 March 2005. The project performance with respect to the impact of reservoir sedimentation on the project and reservoir operation was evaluated. In addition the objective was to inspect the civil components of the project and the trend in the instrumentation measurements.

Initially the intention was to inspect the power tunnel in December 2004, but in order to avoid the need for prolonged load shedding, the tunnel inspection was deferred to the Easter holiday in the last week in March 2005.

The Principal Findings of the Second Inspection are reproduced below:

- **Overall Project Condition**

The Kapichira Project was found to be basically in good operating condition. The main water retaining structures, embankment dam and spillway showed a stable behavior and were considered safe. The operating staff had built up experience with the specific characteristics of the project and had instituted remedial works to overcome some of the operational problems that had been experienced in the past year. With some further small changes in operating conditions and further minor remedial works as described in the inspection report the project could be expected to operate in a reliable fashion for the foreseeable future.

- **Reservoir Sedimentation**

By mid-2003 significant amount of sediment had accumulated in the reservoir mainly because the reservoir had been operated in the first three years of its life at a somewhat higher level than the recommended level. It was concluded that a good proportion of the sediment in the reservoir was deposited as a consequence of the flood event of January 2003. However, since Kapichira reservoir is designed to be a self-flushing reservoir, ESCOM had been able in the course of 2004 to restore the preferred flow path in the reservoir and to flush large volumes of sediment from the reservoir and gain back most of the live storage.

- **Present (2005) Storage Available in Kapichira Reservoir**

The inspection team assessed the remaining storage volume of the reservoir using timed emptying and filling techniques. The computations indicated that about 47% of the total storage at Kapichira was occupied by sediments. However, most of this sediment was located in the dead and inactive storages and was not detrimental to the project. Only 26% of the active storage had been lost and the remaining 2.6 million cubic meters of active storage was more than sufficient for peaking purposes. It was considered important to preserve this active storage and it is partly for this reason the inspection team recommend adopting a low target operating level of El.145 m.

- **Sediment Flushing in Kapichira Reservoir**

Sediment flushing (scouring) is designed to remove sediment along the whole length of the reservoir and is achieved by lowering the reservoir significantly and allowing the river to rework the sediments and pass high volumes of sediment through the spillway. In this process generation has to be curtailed and as a result flushing can only be undertaken at times of low demand such as on Sundays. Unlike most projects, sediment flushing is possible at Kapichira because of the small volume of the reservoir in comparison to the inflows and because of the high discharge capacity of the spillway at low reservoir levels. The amount of flushing that had to be undertaken in 2003/2004 has caused some operational problems in the powerhouse but that should not be taken as typical. These flushing operations were in response to a problem that had been accumulating over a three-year period. Flushing operations in the future will be less in most years. Successful flushing since 2003 to end of March 2005 have regained an active storage estimated at 2.6 million cubic meters, approximately 1.5 times the storage required for peaking operations with four units.

- **De-silting or Sediment Sluicing at Kapichira**

De-silting or sediment sluicing is the removal of local sediment deposits at the normal operating level of the reservoir and can be undertaken without interrupting generation. Sediment sluicing removes sediment in the vicinity of the outlet works and in front of the tunnel intake and is adopted at Kapichira to keep the power intake clear of sediment and preclude the ingress of coarse sediments into the power tunnel (periodic flushing as mentioned above will further ensure that coarse sediment is kept away from the tunnel intake). Sediment sluicing is most effective when the reservoir is close to its minimum operating level and the policy of ESCOM to adopt a target operating level at El.l45 m was endorsed by the inspection team. Sediment sluicing has been successfully undertaken at Kapichira at this operating level.

- **Sediment Dredging**

Because more than sufficient active storage for peaking operations was available, and because ESCOM had succeeded in removing large quantities of sediment from the reservoir through sediment flushing, the inspection team observed that there was no immediate need to undertake sediment dredging as was being considered by ESCOM. However, to remove sediment from those reservoir areas that are not expected to be scoured even under the flood conditions, a modest capacity dredger would be required. Moreover, a dredger could prove to be a useful river management tool for dealing with unexpected flow conditions an as such a modified dredging contract should be considered.

**POE Observation:** Though the 2005 inspection report had recommended provision of a modest capacity dredger the same does not seem to have been done and EGENCO is now planning to acquire a dredger.

- **Sediment Monitoring Program**

It was recommended that ESCOM implement the sediment-monitoring program developed by Earth Tech/TAMS in 1999/2000. As a minimum, it is recommended that the sediment gauging station upstream of Kapichira reservoir be implemented in the next dry season or as soon thereafter as possible. This will provide valuable data on the sediment loads entering the reservoir during and after flood events and will assist greatly in establishing the most advantageous reservoir operating procedures.

- **Repairs to Dam and Training Dike**

Some erosion of the dam and training dike occurred when the main flow path in the reservoir moved to around the nose of the training dike and along the upstream face of the dam . Most of this damage probably occurred as a result of local high velocity flows when the reservoir was drawn down in July 2003 to inspect the sediment deposits. The repairs to the dam and training dike undertaken by ESCOM in November and December 2003 appear to have been well executed and were an appropriate response to the emergency situation that had to be resolved prior to the 2003/2004 flood season. It is important to ensure that theses features are not subject to high velocity flows in the future. Since December 2004 additional ccumulation of sediment in the area between the dike and dam have precluded flow around the end of the dike into the embayment between dike and dam and. therefore, made flows next to the dam near the spillway significantly less dangerous, precluding future scour of the dam's upstream shell. Future dredging, if undertaken, needs to be performed such that this flow pattern is not reversed to the pre December 2004 adverse conditions.

- **Need for New Stockpile**

All the stockpiled rockfill and large size riprap had been utilized in the repairs to the main dam and training dike. It is possible that further remedial repairs to the training dike may be necessary in the future the inspection report recommended that ESCOM should either open a new quarry at the project site or import the material from an outside source. Whatever is more economical, to replenish the stockpile. The recommended stockpile volume should be about 20,000 cubic meters.

- **Target Reservoir Operating Level**

The inspection report recommended that the target reservoir operating level be raised from El.144.5 m (as stated in the O&M Manual) to El.l45.0 m. However, this raising of the target operating level should only be implemented in conjunction with the installation of additional steel plates at the power intake. Once the steel plates at the power intake are installed down to El.l44.5 m, raising of the reservoir level to El.l45 m will help prevent most the floating trash from entering the tunnel. Raising the reservoir level without the benefit of additional steel plates will not help with the floating trash, it will only worsen the sediment situation.

**POE Observation:** It is noted that the present target water level at El 147 m, which is 2.5 m higher than the recommended design water level, and presumably is an encroachment on the free board. It is not clear that the present increase in water level has been based on any calculations or has been raised arbitrarily. Encroachment on freeboard is a safety concern specially for a dam which is designed for $Q_{100}$ and that too with fuse plug being activated at $Q_{100.}$ The dam crest at El 149 m a freeboard of 2 m is available whereas for the fuse plug only 1 ft freeboard is available.

- **Checking Reservoir Level Gauge**

Approximate measurements made during the inspection visit indicated that the reservoir level gauge in the spillway gate control building was registering levels about 0.5 m above the actual reservoir level at the power intake. ESCOM has adjusted the level gage so that it now reads within 0.lm of the actual reservoir level. Periodic comparison of the readings should be made so that the spillway gate operators are aware of the true reservoir level at all time

- **Reservoir Operations in Flood Conditions**

Because of the need to avoid high velocity flows at the training dike it will be necessary to allow the reservoir to rise during significant flood events. It is important to monitor such floods carefully (observational method) and to bring the reservoir level down to the normal target operating level as the flood recedes in order to minimize sediment deposition in the reservoir. As a guide the inspection report recommended that when the reservoir inflow exceeds about 2,000 $m^3$/s, the reservoir level should be increased gradually to El.l46 m once the inflow has reached about 3,000 $m^3$/s and to El.l47 m once the inflow has reached 4,000 $m^3$/s. It should be emphasized that the actual rule curve should be established by field observations. During the next flood events the velocities at the training dike should be observed and the trigger value of 2,000 $m^3$/s modified if need be.

- **Spillway Gate Operation**

The 2004-05 inspection report re-iterated the importance of monitoring the spillway gate operations on a 24-hour basis as was being done by ESCOM at that time. The spillway gates were operated under both automatic and manual control from the spillway gate control room. It should be recognized that it would only take a few hours of incorrect spillway gate operation to raise the reservoir level to the normal maximum pool level of El.147 m. At this level the gates should automatically go into emergency full gate opening mode to prevent any further reservoir level rise and thus avoid operation of the fuse plug spillway unless required for passing the project Probable Maximum Flood (PMF).

It is partly because of the small volume of active storage available in Kapichira reservoir that a low target operating level should be adopted, giving a storage cushion in the event of incorrect spillway gate operations. It was strongly recommended by the inspection team that responsible executive staff should be present in the spillway gate control house whenever reservoir inflows reach about 2,000 $m^3$/s. By that time reservoir level and gate positions must be monitored and adjusted continuously rather than at 30 minute intervals.

- **Spillway Chute Condition**

Spillway chute and the downstream channel show a moderate erosion of the concrete surfaces especially on the left side of the spillway. These areas should be monitored for future adverse activity.

**POE Observations:** Moderate erosion of the concrete surfaces have probably developed into the larger erosions as pointed out in the second visit of the POE. The erosions need to be properly repaired as these have potentional to enlarge during long operation of the affected bays.

- **Installation of Units 3 and 4**

The Kapichira project had been designed and built for four 32 MW units. In Kapichira Phase I, the civil works for all four units were completed but only Units 1 and 2 were installed. During

the past three years of operation, the powerhouse staff have become very familiar with the behavior of the units and associated equipment and had implemented several improvements in the powerhouse. Kapichira Phase II, under which Units 3 and 4 were installed, will assist in meeting system load growth[1]. Based on this inspection and project performance it was anticipated that the project will operate well with all four units installed.

## 5. SCOUR IN 2004

In 2004 there was significant erosion of the upstream shoulder of the dam close to the spillway. This was made good at the time and there have been no reports of further damage in the area. Nevertheless it demonstrates the need to avoid high velocity flows parallel to the dam. POE recommend that the ARTELIA model be run with a revised configuration incorporating a dyke to prevent flows parallel to the dam.

## 6. PROPOSED LOCATION OF SVIP INTAKE

### 6.1 Hydraulic Model Studies

ARTELIA have recently submitted the final draft version of their report on the hydraulic modelling of the proposed SVIP water intake. They have set up a mathematical model to investigate the hydraulics and sedimentation in the reservoir and at the Intake using the program TELEMAC 3D to solve the Navier-Stokes equations and transport-diffusion equations for suspended sediment and bed change.

Bathymetric data based on 2016 estimates of reservoir siltation was used for the reservoir which is generally quite shallow except for a deeper channel leading to the spillway and power intakes.

EGENCO flush the reservoir every two months with a flow of about 1,000 $m^3/s$ over a time period of about 8 hours. This is done when reservoir level is about 142.9 masl ( ie 4.1 m below Full Supply Level ).

A total of four configurations were considered with the intake on the right bank of the reservoir. One of these configurations upstream of the spur was discarded as it could not deliver the required 50 $m^3/s$ through the intake.

Other observations are as follows:

(1) The impact of the SVIP intake on the flow of sediment at the power intake will be very low. The preferred configuration, which includes dredging of the deposits downstream of the spur dyke, does not show any increase.
(2) The amount of sediment entering the SVIP intake will be about 162,000 tons of clay and 26,500 tons of silt per year.
(3) Most of the benefit of dredging will be lost in about four years.
(4) EGENCO operate the generators between 145.5 masl and 146.5 masl (now 147.0 masl ). This is a strict regime which should be observed in the design of the SVIP and Main Canal.
(5) Suitable wing walls will be needed on the approach to the intake.

The location of SVIP indicate as determined by hydraulic modelling is shown on Figure 6.1.

[1] The expansion was successfully achieved in 2014

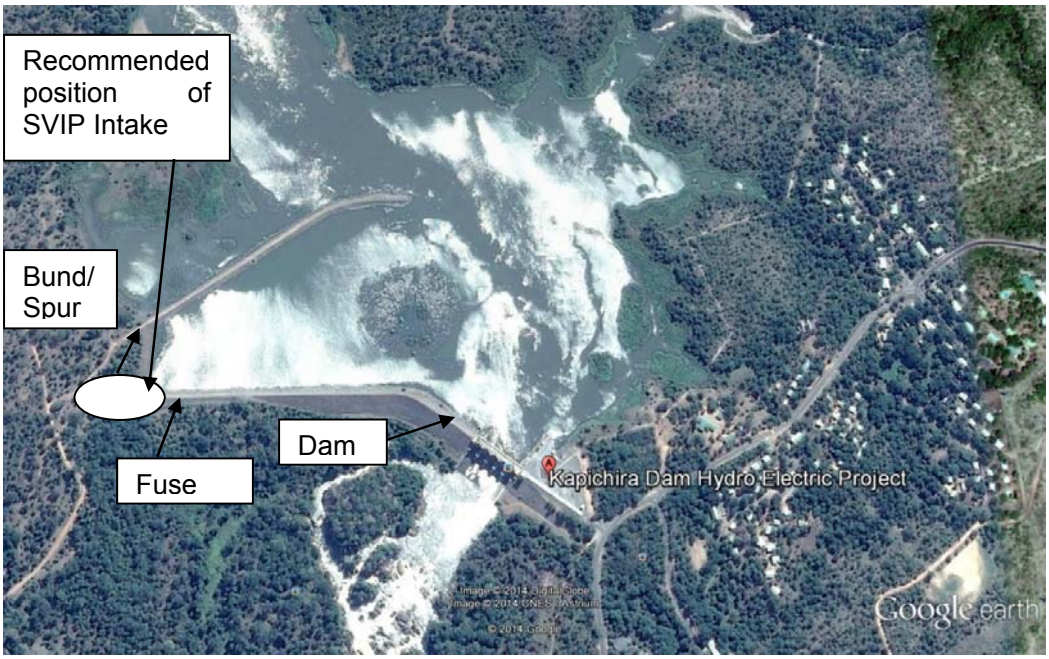


**Figure 6.1:Recommended position of SVIP Intake**

### 6.2 EGENCO's Comments on SVIP Intake Location

During the meeting of Jan 27 EGENCO expressed concern on the proposed location of SVIP intake on the downstream side of the dyke. Their concern is that it may lead to parallel flows along the dam and may result in damage to the rip rap as happened in 2004.

It is recommended that SVIP and EGENCO management discuss EGENCO's concerns and try to answer the EGENCO's concerns, which can probably be further alleviated by construction of a dyke on the left side of the approach channel of the intake of SVIP more or less parallel to the existing dyke. The location and length of this dyke could be optimised on the hydraulic model, which should clearly demonstrate that the proposed location of the SVIP intake will not result in flows parallel to the dam.

## 7. PIEZOMETERIC DATA

### 7.1 Data and Analysis

There are, at the dam, some 20 piezometers with a further 4 at the spillway ( which are fitted with manometers in the gallery at El. 129.6 masl ) and 5 installed along the left bank rim. The December 2004 report by Earth Tech – TAMS notes that the piezometric levels had all fallen between January 2001 and December 2004. The highest level recorded in any piezometer when reservoir level was 145.0 masl was 138.3 masl ( ie 6.7 m below Full Supply Level ). The December 2004 report by Earth Tech/TAMS recommends the following:

- Piezometers to be read twice per year
- Seepage flows to be read twice per year
- Movement of monuments to be measured once per year

There are two discharge points into a sump where flow can be measured. Total seepage at the dam was about 8 to 12 l/s in 2004/5. This seems to be decreasing as a result of sealing by sediment brought into the reservoir.

No indications have been given of settlement or horizontal movement along the dam.

## 8. SAFETY ISSUES OF KAPICHIRA DAM

### 8.1 Inspections

The Kapichira Dam is a large dam as per ICOLD Guidelines. In accordance with International Commission of Large Dams (ICOLD) Bulletin No. 59 on Dam Safety Guidelines, dams require periodic safety inspections. A dam safety inspection plan incorporates (1) routine dam safety inspections to be undertaken by the Dam Operation Staff of the owner, (ii) Annual and 5-yearly (comprehensive) dam safety inspections to be undertaken by experienced Dam Safety Experts together with the Dam Operation Staff of the owner, (iii) special inspections to be undertaken following major floods, earthquakes etc., (iv) Dam Safety Reviews, (v) Potential Failure Modes Analysis (PFMA) and (vi) Risk Assessments. It is recommended that a programme for dam safety inspection be implemented for the Kapichira dam.

### 8.2 Freeboard

POE understand that the crest level of the dam is 149.0 masl and that the crest length of the fuse plug is one metre lower at 148.0 masl. It is understood that the maximum level for operation of the reservoir has recently been raised from 146.5 masl to 147.0 masl. The effective freeboard at the fuse plug is, thus, only 1.0 m which appears very low bearing in mind the possibility of misoperation of the spillway gates and the need to cater for waves and settlement.

POE recommends that the requirements for freeboard should be reviewed and, if necessary, increased. It should be borne in mind that incorrect settings of the high level cutouts and inadequate freeboard were amongst the causes of the failure of the upper reservoir for the Taum Sauk pumped storage scheme in the USA.

Figure 8.1. Taum Sauk Dam after failure.

### 8.3 Design Flood

Selection of design flood for spillways is a very crucial matter, and many countries and organizations have devised standards for this purpose. Generally the design flood for spillway is selected in consideration of dam height, storage volume, vulnerability of dam structure due to over topping, threat to population and loss of economic infrastructure downstream of dam etc. In view of these crucial factors and the strong potential of the catchment area to receive large rainfall, selected design flood of 100 year return period is an under design and the dam should be able to pass higher flows. The onsequences of triggering of fuse plug at 100 year return period will include:

(1) Replacement of fuse plug
(2) Loss of generation
(3) Loss of agriculture benefits in SVIP
(3) Environmental damage

The design flood could be selected for a reasonable return period however the design should be checked for the Probable Maximum Flood (PMF). Overtopping and failure of the dam under PMF conditions should be avoided though minor damages may be acceptable.

As per classifications of International Commission on Large Dams (ICOLD) the Kapichira Dam falls in the category of large dams[2]. The criteria for spillway design, as advocated by ICOLD, are based upon two categories of floods:

1. The traditional “Design Flood” is based on probability of occurrence between 1:100 and 1:1,000 return periods depending on the Dam and reservoir size and damage potential downstream. The reservoir level is kept well under the dam crest.

2. In the modern times the Inflow Design Flood is related to height of the dam, volume of the reservoir storage and the hazard potential classification that depends upon the damage to human life and economic properties in the event of a hypothetical dam failure.

The ICOLD criterion for selection of design flood for various types of dams and adapted by American Army Corps of Engineers (US ASCE) is given in

[2] ICOLD defines large dams as 'those having a height of 49.2 ft (15 meters) from the foundation or, if the height is between 16.4 to 49.2 ft (5 to 15 meters), having a reservoir capacity of more than 106 million cuft (3 million cubic meters).

**Table** , Table 8.1 and 8.3.

**Table 8.1: Dam Size Classification (USACE)** [3]

| Category | Reservoir Capacity | Height of Dam |
|---|---|---|
| | **($Hm^3$)** | **(m)** |
| **Small** | 0.06 – 1.2 | 7.6 – 12.2 |
| **Intermediate** | 1.2 – 61.5 | 12.2 – 30.5 |
| **Large** | > = 61.5 | > = 30.5 |

**Table 8.1: Downstream Hazard Classification (USACE)**

| Hazard | Loss of Life | Economic Loss |
|---|---|---|
| **Low** | Not expected (no permanent structures for Human Habitation) | Minimal (undeveloped to occasional structures for Agriculture) |
| **Significant** | Few (no urban development no more than a small number of inhabitable structures) | Appreciable (Notable Agriculture Industry or Structures) |
| **High** | More than a few | Excessive (Excessive community, Industry or Agriculture) |

**Table 8.2: Design Flood, Recommended Safety Standards (USACE)**

| Size | Hazard | | |
|---|---|---|---|
| | **Low** | **Significant** | **High** |
| **Small** | 50 – 100 | 100 – 0.5 PMF | 0.5 PMF – PMF |
| **Intermediate** | 100 – 0.5 PMF | 0.5 PMF – PMF | PMF |
| **Large** | 0.5 PMF – PMF | PMF | PMF |

According to the various criteria given above the Kapichira Dam with reference to height (30m) falls under the category of large dams and should be safe for PMF.

[3] New Trends in Design Flood Assessment, L. Berga, ICOLD Symposium on Dams and Extreme Floods 1998

## 9. EMERGENCY PREPAREDNESS PLAN

At present there is no Emergency Preparedness Plan (EPP) for the Kapichira dam. POE recommends that an EPP may be prepared.

### 9.1 Emergency Preparedness Plan

The purpose of the Emergency Preparedness Plan (EPP) is to:

1. Provide a plan during emergencies including failure of the dam, which facilitates public safety by notifying all appropriate authorities;
2. Provide information to all stakeholders to allow for an informed evaluation to be made during emergency events;
3. Provide plans of action for foreseeable flood emergencies affecting safety of the downstream infrasture;
4. Provide for a plan of action to carry out repairs and reduce the impact of any such event where possible.

### 9.2 Outline of EPP

Outline of Emergency Preparedness Plan is given below:

**1.General**
1.1 Introduction
1.2 Purpose of the Plan
1.3 Description of Facility
1.4 Responsibilities
1.5 Dam Surveillance
1.6 Outside Agencies

**2 Emergency Identification**
2.1 Potential Serious Situation
2.2 Dam Failure

**3 Emergency Response**
3.1 Technical Information
3.2 Access to the Site
3.3 Response During Darkness and Adverse Weather
3.4 Power Sources.
3.5 Incidental Procedures During Breach
3.6 Mitigative Measures

**4 Notification**
4.1 Notification Procedures – Dam Incident
4.2 Notification Procedures – Dam Failure

**5 Inundation**
5.1 Mapping 6

**6 Maintenance and Testing**
6.1 EPP Maintenance
6.2 EPP Testing

**7 Communications and Warnings**

Appendix A – Registered EPP Holders
Appendix B – Communications Directory
Appendix C – Emergency Report Form
Appendix D – Inundation Maps
Appendix E – Letters of Acknowledgement
Appendix F – EPP Revisions and Testing

## 10. POE CONCLUSIONS AND RECOMMENDATIONS

### 10.1 General Observations

The impression gained during the 3 visits and various discussions, Kapichira Dam generally appears to be in sound condition; the principal comments of the POE are as follows:

(a) Independent inspections should be carried out every 5 years by an engineer with no connection to the Owner or to the original designers of the dam.
(b) The Owner should produce an annual inspection report on the dam and instrumentation monitoring
(c) The dam should be checked for performance during the Probable Maximum Flood ( PMF). Triggering of the fuse plug would be acceptable under these conditions.
(d) The fuse plug of Kapichira Dam is nominally set to trigger with the flood of a return period of 100 years. However this figure may be too low bearing in mind waves, possible inaccurate settings of the automatic control of the spillway gates and the decision to raise Full Supply Level to 147 m asl. POE recommend that the matter be reviewed by the next Inspecting Engineer taking account of the cost and consequencies of triggering of the fuse plug.
(e) The freeboard needs to be checked as it seems to have been significantly encroached.

### 10.2 Site of SVIP Intake

POE have studied the recent report on numerical modelling by ARTELIA and consider the work to be of high quality.

First, it appeared that with configuration 3, the intake is hydraulically not able to take 50 $m^3/s$. It was therefore discarded. Based on the model runs the most appropriate site for the SVIP intake appears to be on the right bank of the reservoir downstream of the spur dyke. However at a meeting on 28 January 2017 EGENCO expressed concerns about parallel flows under these conditions bearing in mind the erosion to the dam which occurred in 2004 from flows parallel to the dam.

In view of the above POE recommend another run of the ARTELIA model incorporating a dyke running approximately parallel to the spur dyke from the left hand side of the intake.

The model should show the desirability of a continuous programme of dredging in the reservoir to keep the approach to the intake clear of sediment. POE recommends that the costs of such a programme be investigated and that consideration be given to possible sites for the disposal of the dredged material.

# APPENDIX A: VISIT REPORT BY POE OCT 2015

**THE GOVERNMENT OF THE REPUBLIC OF MALAWI**

**MINISTRY OF AGRICULTURE, IRRIGATION AND WATER DEVELOPMENT**

# KAPICHIRA DAM AND SHIRE VALLEY IRRIGATION PROJECT

**VISIT REPORT BY PANEL OF EXPERTS**

**by**

**Muhammad Aslam Rasheed** — **Lahore Pakistan**

**Jonathan Hinks** — **Marlborough, United Kingdom**

**Oct 08, 2015**

## REPORT ON VISIT TO KAPICHIRA DAM

### *Introduction*

As per instructions of Ministry of Agriculture, Irrigation and Water Development Republic of Malawi Messrs Jonathan Hinks and Aslam Rasheed visited Kapichira Dam on Oct 6, 2015 for meeting with ESCOM, Technical Feasibility Consultants and Shire Valley Irrigation Project. The Visit was coordinated by Mr. R.M.A Champiti; Project Technical Team Coordinator Shire Valley Irrigation Project. Consultant's team leader Mr. Jo, Jin Hoon and irrigation engineer also joined the meeting. Prior to departure for Kapichira a meeting was held with Mr. Champiti at his office in Blantyre. It was informed that a Joint Venture of Korea Rural Community Cooperation, Dasan Consulting Company of Korea and GK Works Civil and Structural Engineers Malawi has been appointed consultants for technical feasibility of the Shire Valley Irrigation Project. The contract was signed on July 9, 2015 and the Consultants mobilized on July 13, 2015. The Consultants have submitted an Inception Report which has been reviewed and a revised report will be submitted by October 14, 2015. It was further informed that request for proposal for hydraulic modeling of the intake has been issued to 6 short listed firms and proposals are due in 3rd week of November 2015. Messrs Jonathan Hinks and Aslam Rasheed advised that preliminary design and tentative location of the intake should be given priority as these will be required for the Consultant for hydraulic modeling. Prior to departure from Blantyre a meeting was held with Mr. Champiti and Mr. Benson Sumani Chief Irrigation Officer where the salient points of the visits and conclusions and recommendations were discussed.

### *Summary of discussions*

At Kapichira Dam the team was briefed by Mr. W.W. Liabunya Power Station Manager Kapichira Hydropower station and Mr. Archibald Kandoje.

The Kapichira Dam comprises an 830 m long rockfill dam with a clay core, with a maximum height of 30 m at the foundation. A ski jump concrete spillway on the left bank with five openings controlled by sluice gates (each 15.24 m wide and 13.50 m high) has discharge capacity of 8,750 $m^3$ per second. From the dam there is a 8.8 m square to circular tunnel (with the downstream 76 m long section steel lined) which leads to the power station via a surge shaft/tower. The dam was designed by TAMS of New York and Knight Piesold of UK and was completed in 1999.
Adjacent to the right abutment there is a fuse plug spillway integral with the dam. The spillway and fuse plug operating together can pass the PMF. The crest at this point is about a metre or so lower than the crest of the main dam and is located across the old bed of the river.

It is concluded from discussions that no formal inspection of the dam and other works has been carried out since its completion. Piezometer readings are taken by staff of central office and are said to be stable although no readings have been taken recently. No feedback is given to the local office. No report on the analysis of piezometric data was available at site.

No seepage was observed downstream. Seepage is not measured by the Project staff. The spillway gallery is also reported to have little seepage.

There is no programme for monitoring settlement along the dam crest or at other structures.

It was reported that erosion occurred on the upstream face of the embankment in 2004 near its junction with the spillway. The damage was repaired. It was pointed out that the cofferdam for

construction of the spillway was not removed and is submerged in the water. At the time of erosion part of the old coffer dam was also washed out.

The spillway has 5 radial gates, which are power operated. The standby generator is operated three times a week to ensure availability when it is needed. One of the gates (gate 3) is presently out of operation due to breaking of rope, which is being replaced.

The operation of the gates is decided by the Station staff based on reservoir levels. The staff has no access to hydrometrological data from upstream. Sensors are installed to open the gates automatically in case of high flood. It is desirable that there should be written instructions to the operating staff with regard to the operation of the spillway gates.

50 cumecs flow is continuously released downstream as environmental flow and for flushing sediments. The flushing is done through spillway generally every month. For the last two months no flushing was done due to water shortage.

A prefeasibility study for expanding the capacity of power house has been completed. However no decision has been made to proceed with feasibility study.

The Power house has 4 units of 32 MW each, which require 67 cumecs for generating 32 MW. The total discharge required by 4 units is 268 cumecs to produce 128 MW.

*Observations*

Weeds and bushes are growing on the upstream and downstream slopes of the embankment.

Observations from the deck of the spillway indicated that:

The sloping chute of Bay 1 shows normal wear and tear.
Cracks are observed on chute of Bay 2.
Cracks are observed on Chute of Bay No 3. Some concrete near the toe has been washed away.
In Bay No. 4 reinforcement is exposed in one block.
The bottom seals of most of the gates are not effective and leakage is taking place.

The above described conditions are shown in the photographs in Figures 1 and 2

| | |
|---|---|
| Figure 1 Exposed Reinforcement bay 4 and leakage | Figure 2 Washed out concrete in bay 3 |

***Conclusions and Recommendations***

The Kapichira Dam is a large dam as per ICOLD Guidelines. In accordance with International Commission of Large Dams (ICOLD) Bulletin No. 59 on Dam Safety Guidelines, dams require periodic safety inspections. A dam safety inspection plan incorporates (1) routine dam safety inspections to be undertaken by the Dam Operation Staff of the owner, (ii) Annual and 5-yearly (comprehensive) dam safety inspections to be undertaken by experienced Dam Safety Experts together with the Dam Operation Staff of the owner, (iii) special inspections to be undertaken following major floods, earthquakes etc., (iv) Dam Safety Reviews, (v) Potential Failure Modes Analysis (PFMA) and (vi) Risk Assessments. It is recommended that a programme for dam safety inspection be implemented for the Kapichira dam.

The dam and other structures are being managed by the Power House staff. It is recommended that a qualified civil engineer be appointed by ESCOM for operation and maintenance of the dam and other structures.

The damages on the concrete chute should be repaired as per recommendation of a qualified civil engineer.

Weeds and bushes growing on the upstream and downstream slopes should be removed taking care that the fill material and riprap are not disturbed.

| | |
|---|---|
|  |  |
| Jonathan Hinks<br>Dams Specialist | Muhammad Aslam Rasheed<br>Hydraulic Engineering Specialist |

## APPENDIX B ESCOM COMMENTS ON VISIT REPORT OF POE OCTOBER 2015

On Tue, Aug 16, 2016 at 3:29 AM, Micheal C. Gondwe <mgondwe@escom.mw> wrote:

Dear Mr. Champiti,

Sorry to comment late on a Report that seems to have been finalised last year and submitted. Going through the 5-Page Report, I have noted several factual errors that, if given a chance at draft stage of the Report, ESCOM would have reacted and clarified. I note these as follows:

1. Even though the Kapichira facility belongs to and is operated by ESCOM, and thus ESCOM has full knowledge of its design and operational regime, including issues of dam monitoring (Operational & Maintenance Manuals for Kapichira Civil Works cover comprehensively issues of dam monitoring and ESCOM has been using the same since the Station was commissioned in the year 200 to monitor the same) the Panel of Experts seems to think that ESCOM operates the blindly. This is unfortunate. It might have been because the Panel of Experts only talked to the staff at Kapichira and did not find it necessary to come and talk to other expert staff at ESCOM head office, even though there might have been gaps in the information that the Panel of Experts received from the Kapichira staff. Instead, according to the Report, the Panel of Experts only held discussions with the SVIP PMU in Blantyre to present their findings and recommendations of their visit to Kapichira, before submitting their Report. A meeting with ESCOM in Blantyre after the visit to Kapichira would have been of assistance to clarify some of the factual errors as contained in the attached Report and detailed in the following points;

2. On the first Page of Section 2 in the Report, it is said that from discussions held at site it was concluded that no formal inspection of the dam and its associated works has been carried out since its completion. This is factually incorrect. Several inspections have been carried out on the dam and its associated works, both as part of the operational monitoring of the same and also as part of the preparations for the implementation of Kapichira Phase II development in more recent years, an expansion that was successfully achieved in 2014. Reports of these inspections are available and the Kapichira staff are fully aware of these inspections, since they were part and parcel of the same. Thus it is surprising that sentiments otherwise could have been drawn by the Panel of Experts from discussions with the Kapichira staff;

3. The same page also mentions that piezometer readings are taken by central staff and the readings are never shared by the local office. This statement is incorrect. The piezometer reading equipment has always been sited at Kapichira and the operational staff were trained in the use of the same to check the readings. May be the issue is that this is never done by the local operational staff, which is an operational matter that could easily be resolved by the Power Station management.

4. The second page under Section 2 mentions that no seepage measurements are done by project staff. Which project staff? The SVIP staff? Are SVIP staff mandated to measure seepage at ESCOM structures at Kapichira? If so, under what arrangement and for what purpose?

5. Page 2 under Section 2 also states that there is not programme for monitoring settlement along the dam and its structures. This is also factually incorrect. The O&M Manuals for Civil Works referred to above outline exactly how horizontal and vertical movements in the dam and its associated works are to be monitored and survey monuments were installed on the dam alignment for this purpose. The same have been measured and results analyzed in previous

inspections and the results are contained in the Reports referred to above. ESCOM's Survey Department is the section that undertakes the same when called upon to do so;

6. The fourth paragraph on page 2 under Section 2, which talks about the erosion of part of the dam in 2004 and the issue of the Cofferdam is also factually incorrect in many respects. All the erosions that occurred in 2004 were repaired and design enhancements were done to prevent any future occurrences. These enhancements were done to both the main Dam and the Training Dyke. The operational regime of the reservoir were also modified to avoid the recurrence of unfavourable flow conditions in the reservoir that had led to the erosion of the dame and part of the Cofferdam in the first place. The Station staff are fully aware of these issues. The same are also contained in the inspection reports that were produced when the erosion occurred in 2004 and after the same were repaired. In addition, the Cofferdam referred to in the Report as being "left" after construction and is underwater is in fact a design feature of the reservoir that is part of the Training Dyke and hence was supposed to be like that by design and not just "left" after construction. Only a certain portion of the Training Dyke upstream is above the water level by design and hence is normally seen at normal operational level of the reservoir.

7. On the same second Page under Section2, it is stated that there are no written instructions for the operation of the Spillway Gates. This is totally incorrect. No hydropower Station would be built and put into operation without operational instructions for the reservoir and Spillway Gates. The Operation & Maintenance Manuals for the Spillway Gates and all other civil structures at the Intake are available and detail exactly how the same should be operated in different seasonal conditions. If the same are not used by the operational staff in their operations of these structures, then that is another matter that could be handled differently. It also has to be noted that the ESCOM hydropower schemes are in a cascade on the Shire River, thus hydro data from upstream is available from both Liwonde Barrage and the other power stations to guide reservoir operations of downstream power stations. So the stamen that no hydro data is available from upstream is factually incorrect;

8. On the same Page 2 under Section 2 , there is a mention of a pre-feasibility study to expand the powerhouse. No such study has been done, as the current powerhouse, after development of Phase II of Kapichira and which was commissioned in early 2014, cannot be further expanded. The only study that was done was the proposed Kapichira Phase III, which entails the construction of a new hydropower scheme at the same site, which will only share the same reservoir, but have a separate intake, waterways and powerhouse, which will be located further downstream of the existing Powerhouse and beyond the existing access bailey bridge. However, any further studies on this scheme were put on hold last year by Government, as it was contended that it conflicted with the water requirements for the SVIP. These facts were not properly captured in the attached Report;

9. Under Sections 3 & 4, the issue of weeds and bushes growing on the upstream and downstream slopes of the dam is a normal thing and the same are removed and the Power Station has annual programmes to clear the same. This is also covered in the O&M Manual of the Civil Works. However, the Report seems to suggest the Station staff are not aware of the need to remove weeds from the dam slopes and that even if they were to remove the same, they seemed not to know the need and care they have to exercise in such an exercise in order not to disturb the riprap. This is factually incorrect, the Station staff are already aware of this and know exactly how to remove the weeds and have been doing it on a biannual basis for years.

10. Also under Sections 3 & 4, the issue of wear of the chute slab of the Spillway is mentioned and seems to suggests that ESCOM was unaware of this and hence does not monitor the same.

This is factually incorrect. ESCCOM is aware of the wear of the chute slab, which is normal and ESCOM has been monitoring the same for years for remedial action, if the wear is considered to reach levels that would affect the functional requirements of the chute. The sections of the affected chute were already assessed by both ESCOM and other independent civil engineers in the past and repairs recommended. Thus the same just remains to be undertaken by the Station as part of routine annual maintenance.

11. Under Section 4, last paragraph, it has to be noted that as outlined above, the fact that the Panel of Experts found no major defect on the dam after over 15 years of operational is because the dam is monitored and all major defects that occur are repaired immediately. Therefore the sweeping statement that the Dam is not monitored is incorrect.

I just wanted to make these clarifications and clear some of the misconceptions that the Report might have created about how ESCOM takes care of its Kapichira Hydropower Station and operatives the same. Should the SVIP want access to the documents referred to in the above analysis and reactions, the same can be requested through the office of the CEO and the same would be provided.

Regards,

Michael C. Gondwe
Senior Projects Manager
ESCOM
Projects Department

**APPENDIX C: LIST OF PARTICIPANTS OF MEETING OF JANUARY 25, 2017 AT KAPICHIRA DAM**

| Name | Organization |
|---|---|
| Mr. Michael Gondwe | Senior Projects Manager EGENCO |
| Mr. Archibald Kandoje | EGENCO |
| Mr. Bernard Njinga | EGENCO |
| Mr. Patrice Munthali | EGENCO |
| Mr. Pepani Kaluwa | MOAIWD |
| Mr. Peter Kadwere | MOAIWD |
| Mr. Oswald Mwamsamali | MOAIWD |
| Mr. Ayalew Nigussie | SVIP |
| Mr. James Chikhungu | SVIP |
| Mr. Boniface Nthakoma | SVIP |
| Mr. Aslam Rasheed | POE |
| Mr. Johnathan Hinks | POE |