**Environmental compliance- Ecological flow-Waki SHPP**

***The project***

The Waki Hydro Power Project is “Run-of-River” (ROR) type of development designed to harness the flow and topographical difference in the elevation of the River Waki. The diversion structure, a trench weir constructed across the full width of the river about 14 km downstream of the existing bridge over the Waki River on the Hoima-Biiso Road. Waki Hydro Power Project is utilizing the head between the dam site at 808.46 m asl on top of the eastern escarpment of the Albertine Graben and the power house at 644.132 m asl at the foot of the steep escarpment. The Project is composed of a water conductor system on the left bank to comprise of: open feeder channel of 2 m base width and 78.75 m long connecting the trench weir and desilting basin and feeder Pipe of 1.72 m diameter and 1098 m length. There is a open power channel of 2 m base width and 583 m long connecting feeder pipe and forebay, surface Penstock of 1.05 m diameter and 422 m long, surface power house -2 units of 2.40 MW each, a tail race channel and two horizontal-axis francis turbines, each of 2.40 MW rating, with synchronous speed of 1000 rpm along with vertical generators of 11 kV,50Hz. The project also includes construction of associated infrastructure such as access roads, temporary and permanent camps, and yards for the construction phase, waste rock disposal sites, and power evacuation line.

An Environmental and Social Impact Assessment (ESIA) was undertaken in 2013 and approved by the National Environment Management Authority (NEMA) on 24th April 2013. Following comments from Get Fit Uganda, an addendum was prepared to the ESIA in 2014. The Directorate for Water Resources Management (DWRM) approved a Surface Water Abstraction Permit in November 2013. This Permit provides for water abstraction of up to 299,808 $m^3$/s per day, equivalent to an average of 3.47 $m^3$/s. The permit does not provide for the continuous minimum flow. We should note that the surface water abstraction permit expires on the 13th November 2018 (Appendix xxx) and the renewal process has been kick started. The consultant was not able to able to see the Q inflow (from the hydrological studies and records). Different methods and standards / guidelines can be followed to arrive at the value. In this case, the developer estimated that a continuous minimum flow of 0.38 $m^3$/s (see Appendix xxx a note on note on water level monitoring and control operation of dam/weir and forebay).

***Minimum Flow***

The minimum flow requirement provided in the note is 0.38 $m^3$/s. This requirement represents only about 11 per cent of the mean annual flow. There is an attempts to mimic natural flow variation as the eco-flow pipe has been placed below the weir intake as elaborated in sections below. Hwoever, it should be noted that the flow between the weir and the tailrace will be higher during parts of the year when there is spilling from the weir due to high inflows, but the natural dynamics that aquatic fauna and flora are adapted to will become permanently altered.

The section after weir supports a number of fish mainly seeking to spawn that will probably survive during project operation but at a reduced population level. According to the latest fish study (Feb, 2018) of Waki power project, the in-stream and riparian habitat has remained relatively unchanged since the 2015 assessment except at the ongoing construction activities in the project area neighbouring the river such as at the weir and tail race. The aquatic monitoring study has

reported a reduction in the relative abundance of fish species when comparing the assessments of December 2015 and July 2017 and February 2018. The fish species established to exist include *Enteromius jacksonii; Synodontis victoriae; Hippopotamyrus graham; Raiamas senegalensis; Oreochromis niloticus; Clarias gariepinus; Schilbe mystus; Oreochromis leucosticus; Haplochromis sp; Pseudocrenilabrus multicolour; Enteromius prince; and Enteromius apleurogramma*. Reduction in available habitat for these species is not proportional to the reduction of flow. Sufficient habitat for the species survival is likely to remain in the river flow if the minimum flow is released on a permanent basis. Failure to release the minimum flow, even in short periods, will be devastating to the population and must be avoided.

In terms of the hydrological flows in Waki River major changes could occur if there is any planned use of the waters both upstream and downstream which is not in existence. Apart from water abstraction at the Army barracks downstream, no other river use was identified. The hydrologic studies determined that the Waki Hydro Power plant will not affect downstream flows in Waki village nor

The in-stream water quality as measured by turbidity and total suspended solids varied at the project sites due to construction activities. The project construction activities did have some negative impacts on water quality that will likely cease when construction is completed and the opened up areas restored. It is likely that the project operation shall directly impact this aquatic life and alter species biodiversity. This is as a result to changes in hydrological flow, increased peak flows and flood duration, erosion and degradation of ecosystems. This will increase downstream impacts to aquatic species and disrupt/changes to local species.

***Peaking***

The project may be required to release its excess water at its reservoir and forebay during periods of high peak and storing it during off peak periods. This peaking mode of operation is possible. The daily flow cycles that result from such alterations can have adverse impacts downstream such as stranding fish including spawning nests and juvenile fish, posing hazards to the river users and increasing bank erosion.

***Measurement of environmental flow***

For water level monitoring at the weir, two Numbers of ultrasonic type level transmitter are to be provided. One number Ultrasonic level transmitter (UT1) will measure the water level at intake to maintain head required for environmental flow release and corresponding design head for generation. Second number of Ultrasonic level transmittal (UT2) will be provided at downstream of environmental flow pipe to measure water level for calculating environment flow discharge. Both UT1 and UT2 will communicate data with programmable logic controller (PLC) Panel which is mounted near to the intake and further transmit to powerhouse PLC by means of Optical fibre cable (OFC) cable. A third level transmitter will be provided at Forebay to measure water level at forebay to maintain design head at that location and will function similarly.

The PLC will constantly monitor the water level and compare it to a maximum and minimum water level set point entered by operator. This will allow PLC to know if the water is rising, falling or not changing.

The water level at the weir shall be maintained at Full Supply Level (FSL). Based on water level at weir vis-a-vis inflow in the river, output of turbine shall be regulated automatically and manually by PLC

In case, the water level at intake goes down from FSL during its operation as monitored by UT1, the same will be communicated by PLC panel to SCADA system to Guide vanes and generation will be controlled accordingly. With this process from UT1 to PLC Panel to Scada System to Guide Vane will take approximately 5-10 seconds. Thus, out flow through turbine will be controlled such that outflow will be equal to inflow minus environmental flow at dam/weir and the water level at intake will start rising thereafter and will be maintained at FSL. Here also, some time will be required to attain the level at FSL depending on the variation of inflow during that time.

As a precautionary measure, it is Waki power project has installed the invert level of environmental pipe 100 mm below the calculated level against stipulated environmental flow corresponding to FSL. It is expected that the FSL at the intake will not come down by 100mm in 5 to 10 seconds in any operating condition and thus minimum release of environmental flow at all time will be ensured.

**Operation sequence of (Supervisory control and data acquisition) SCADA system**

At the outset, the water level at intake will be at FSL at 808.42M and once level in forebay also reached to FSL, one turbine shall be started for synchronization which will take a few minutes. Once turbine is synchronized, turbine will load at 30% of load immediately. Based on level of forebay and Dam/Weir, load will be increased gradually and level will be monitored at both places till first turbine reaches to full capacity.

Based on available water level at forebay and weir, second machine will be synchronized with grid and further loading on turbine will be done based on available discharge and maintaining level of Weir at 808.42m and corresponding level at forebay till second turbine reaches to full capacity.

When both the turbines will synchronise with the grid and both the machines or one machine is running at admissible load and there is any fall in water level of forebay as well as Dam/weir due to lower inflow, output of one of the turbine shall be reduced according to variation of discharge/inflow till water level is maintained at set point i.e. 808.42m at weir site.

It may be noted that the variation of inflow and consequently the reduction of water level at the weir site would be gradual and there is a enough cushion of 100 mm kept at weir which will well take care of minimum release of environmental flow during fall of water level for a very short duration.

In case the load on any turbine falls below 30%, then same unit will be tripped and second turbine will be running in same load condition. The second turbine shall be in running condition till water level i.e. 808.42m is maintained at Dam/weir. The output of turbine shall regulate as per discharge available.

Ultrasonic level transmittal (UT2) provided at downstream of environmental flow pipe will measure water level above the crest of the weir. The levels will be recorded in the data log of SCADA system which can be viewed at all times. Considering this recorded level as head over the crest, the discharge can be calculated with the help of established weir formula at any time.

The consultant observed that the project is provided with water flow control gates, which enable measurement of used water. In terms of fish protection, water intake is equipped with a screen which prevents large fish entry into the division system.

**Conclusions and recommendations**

Ecological flow values should be such that the aquatic life (flora and fauna) can survive alongside the power generation operational activities. The following are the recommendations based on the audit:

1) Lowering the invert of the Eco-flow flow pipe to 806.15m is critical. This elevation is good enough and compliance is required.
2) Calibration of the ultrasonic level transmitters(ULT) before installation is required
3) The O&M regime needs to be carefully understood especially if the OFC cable is laid on the surface
4) The time duration for SCADA regulation of the guide vanes is 5-10 seconds when the flow reduces to 0.2 cums. There is need to consider the dry season scenarios to obtain the mean scenario for 12 months.
5) Release of water during operation (peaking) should be regulated to avoid extreme cases. A gradual release mimicking the natural river is recommended
6) Routine monitoring would assist in creating species profiles and determine how species are adapting to the newly constructed hydropower site.
7) Monitoring should be undertaken to verify the level of impacts, the effectiveness of mitigation measures, and to provide a basis for informed decision-making during operation. As part of monitoring, the following is recommended in terms of aquatic ecology downstream the dam:
    - Water quality sampling prior to operation start to establish a baseline for physical, chemical, and biological water quality parameters.
    - Phytoplankton and zooplankton (microinvertebrates) sampling in the river section prior to operation start to establish a baseline.
    - Fish sampling in the Waki River using electric fishing gear to enhance validity of the results. It is advised that this be done biannual then annually as the operation commences