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1.0 INTRODUCTION

ZESCO Limited and Tata Africa Holdings (PTY) Limited intends to develop a 120MW power station at Itezhi Tezhi and have established Itezhi Tezhi Power Corporation, a joint venture company. Technical, economic and environmental feasibility studies have been conducted to determine the viability of the project.

An Environmental Impact Assessment (EIA) study was undertaken and was approved by the Environmental Council of Zambia through their decision letter referenced ECZ/ins/101/4/1 and dated 14th November, 2006. At the time the EIA was conducted, the plan was to build an underground power station. However, after undertaking further technical studies and cost reviews, it has been decided that a surface power station be built instead of an underground one.

Because of the change from underground to surface power station, it became necessary to prepare an addendum to the EIA to determine the potential impacts of the change in the scope of the project. This Addendum focuses on the environmental and social aspects associated with the proposed surface power station and does not seek to address all the environmental and social aspects of the entire project as these were covered in the full EIA report prepared for the project to which this report is an addendum.

2.0 TECHNICAL CONSIDERATION OF UNDERGROUND AND SURFACE POWER STATION OPTIONS

It should be noted that the topography in and around the project area tunnel intake and outlet has been studied and the available geotechnical data has been reviewed. Based on this review it is concluded that both types of power houses, underground and surface, are technically feasible. Further, both arrangements have been reviewed in terms of technical details and costs implications so that selection is based on technical and economic considerations. The two options are hereby discussed as follows;

2.1 Option 1: Underground Power House

2.1.1 Location

In this option, the existing south diversion tunnel will be utilized as part of the power house cavern. Based on the interpretation of the available geological data, granite is encountered in the stretch between 375m and 500m and is competent and of better quality. Hence it is advantageous to locate the whole underground system between 375m and 500m and away from the mylonite zone.

2.1.2 Water Conductor System

Butterfly valves will be installed as main inlet valves for isolation of each turbine generator unit.

Intake trash screens and their cleaning mechanism will be provided at the start of the south side diversion tunnel. The entire length of the south side diversion tunnel shall be lined with reinforced concrete. This forms part of the water conductor system for the new scheme since, as subsequent to the development of the hydropower scheme, the tunnel will be subjected to water pressure and flow conditions that will be different from the present condition.

The existing concrete plug that is about 290m downstream of the intake will be removed. Downstream of this, the existing tunnel will be converted and modified into a steel lined tunnel in order to save cost. As the penstock, a steel lined tunnel, diameter is 6m, it is necessary to encase the steel liner with concrete; therefore the space between inside of the existing tunnel, of dimension 12.5m by 15m, and 6m diameter lined penstock will be filled with concrete.

The second tunnel will be excavated about 70m downstream of the existing plug by taking a 45-degree angle with respect to the south side diversion tunnel and will also be steel lined.

Studies were made to ascertain the necessity of providing a surge shaft in the water conductor system. The maximum capacity of the Itezhi Tezhi power plant is 120 MW which is about 6% of the total capacity of the Zambian electricity grid at present.

Preliminary transient analysis was carried out considering GD^2 value of the Turbine Generator unit as 1750 Ton m^2 and with guide vane closing time of 7 seconds.

The pressure rise of the Turbine Generator unit was within the permissible limits of 40% even without provision of a surge shaft.

If the underground power house is the selected option, detailed transient analysis will be carried out during project execution stage based on actual parameters of the Turbine Generator unit and opening and closing times will be set based on the outcome of this study. These times can be adjusted based on the commissioning test results.

Two smaller tailrace tunnels (TRTs) will convey the discharges into the main TRT that is 9m in diameter. It is proposed to line the TRTs with M 25 grade concrete.

2.1.3 Power House

The power house cavern will be 75m long, 25.6m wide and 47m high from the bottom of the foundation. The two butterfly valves, each 6m in diameter will be accommodated within the power house cavern.

2.1.4 Access, Construction, Escape and Cable Tunnels

In this option, it is necessary to provide access to the power house by constructing a 7m by 7m D-shaped tunnel. This tunnel will start near the road on the east of the diversion tunnel outlet. Some length of the tunnel, below the road, may have to be cut and covered because of inadequate cover. The length of the access tunnel up to the nearer end of the power house will be 227m (170 + 12 +45) and 25.6m (170 + 12 + 45 + 25.6) up to the farther end.

It is also required to construct a 6m D-shaped construction escape tunnel. The length of the tunnel is about 135m up to the power house cavern. The tunnel will start from the existing road with its invert level matching the road level and will enter the power house cavern overt. A spiral staircase will connect the machine hall with the construction escape tunnel. This tunnel will be used as an exit in case of emergencies like fire, flooding, etc.

Cable tunnel of 6m D-shaped will carry the cables from transformer cavern to the outdoor switchyard. The invert level of the tunnel will match with the road level from where buried cable trenches will carry the cables to the switchyard. The total length of the cable tunnel will be about 145m.

2.1.5 Switchyard

The switchyard will be an outdoor type with main and transfer bus scheme. Dimensions of switchyard will be 65m by 65m. Station transformers will be located in the outdoor switchyard.

2.1.6 Project Cost

The total project cost of the underground power house option is estimated at about 173 million USD.

2.1.7 Project Execution Duration

The estimated time for completing the work is 52 months from the date of award of contract.

2.2 Option II – Surface Power House

2.2.1 Location

Available geology and topographical survey data were studied with a view to determine the feasible location for the power house. It is intended to locate the power house on the right bank of the Kafue River about 110m to the east of the south diversion tunnel outlet. In this option, the power house will be located on competent granite rather than weathered phyllites occurring to the north of the granite zone.

It is required to cut a portion of the hill to facilitate the excavation for the power house. The existing road to Namwala and Musungwa lodge will also have to be re-routed.

Figure 1: Proposed location of the Power House.

2.2.2 Water Conductor System

Works like modification to intake, lining of tunnel up to concrete plug are the same as in the option with the underground power house. In addition it will be required to line the tunnel up to the branch-off from the diversion tunnel where the new head race tunnel will start.

Butterfly valve will be installed as main inlet valves for isolation of each Turbine Generator unit.

Intake trash screens and their cleaning mechanism will be provided at the start of the south side diversion tunnel. Cost provision has been made towards installation of trash screens and trash rakes. It would be prudent to line the tunnel with reinforced concrete, as subsequent to the development of the hydropower scheme, the tunnel will be subjected to water pressure and flow conditions that will be different from the present condition.

The existing concrete plug that is located at about 290m downstream of the intake will be removed. It is required to construct a new tunnel that starts at a distance of 120m downstream from the plug portion about 410m from intake. As specific geological and geotechnical data is not available along the new tunnel alignment, interpretation is made based on the geological data of the two existing diversion tunnels. Geological features of the two tunnels are extrapolated for fixing the new tunnel alignment.

The new modified horse-shoe shaped tunnel will be concrete lined, 300mm thick, and 9m in internal diameter.

Studies have been made to ascertain the requirement of a surge shaft. It is found that, to provide stability to the generating units, a surge shaft is essential for the option of the surface power house. Various types of surge shafts like a surge shaft with restricted orifice and a surge shaft with a riser were considered and the effects were evaluated. It is concluded that a surge shaft with a riser will be the least cost solution.

The proposed arrangements consist of the surge shaft with diameters of:

- 10m in the riser portion from top of tunnel at E1.1048.00m
- 30m in the upper portion from E1.1007m to E1.1048.00m

The length of the new tunnel from the start point to the surge shaft is about 145m. The surge shaft will be concrete lined. The existing ground level at the location of the surge shaft varies between 1044m and 1055m.

It is required to have an 8.3m diameter steel lined tunnel downstream of the surge shaft as it will be subject to higher transient pressures as a result of quick closure of guide vanes of the turbine. The 50m long steel line tunnel will bifurcate into two at 50m upstream of the power house. Each of these penstocks will be 6m in diameter.

The tailrace channel, trapezoidal in section having side slope of 1 H: 1 V to facilitate excavation, 20m wide at the bottom and 150m long will convey the discharge to the Kafue River. The channel will meet the river at 100m downstream of the diversion tunnel outlet channel. As the tail race channel passes through phyllite region, at this stage excavation quantities are determined by adopting a side slope of 1 H:IV.

2.2.3 Power House

The power house will be 80m long, 25.6m wide and 49m high from the bottom of the foundation and will be a conventional steel reinforced concrete structure. The centre line elevation of the Turbine Generator units will be at an elevation of 979m. Two 6m diameter butterfly valves shall serve as main inlet valves for safe isolation of the Turbine Generator unit during trips.

2.2.4 Switchyard

The switchyard will be located outdoor near the powerhouse building. Generators will be connected by segregated phase bus ducts to generator transformers (GT) in the GT yard. From the GT yard a short transmission line will connect GTs to the switchyard. Unit Auxiliary transformers will be located in the outdoor GT yard. Station transformers will be located in the switchyard.

2.2.5 Project Cost

The total cost of the surface power house option is estimated at about 165 million USD.

2.2.6 Duration of Project Execution

The estimated time for completing the work is 42 months from the date of award of contract.

2.3 The Selected Option

Comparing the project costs of surface and underground power house option, it is found that the surface power house option is cheaper by 8 million USD as compared to the underground power house option. In addition, the project will be completed about 10 months earlier. With the underground power house option, this will result in loss of revenue due to delay in commissioning the project.

A comparison of the two options is made in the Table below. Considering all factors it is found that the option with the surface power house will be more viable vis-à-vis underground power house and is considered in further studies.

Table 1: Comparison of Underground and Surface Power House Options

No.	Underground Power House System	Surface Power House System
1	During cavern excavation should heavy ingress of ground water or other geological surprises be encountered, these could result in time and cost over runs	Under similar conditions engineering solutions are less expensive
2	Underground excavation works require higher expertise in deployment of equipment and personnel within a limited space to work simultaneously	Severity of these requirements is relatively less.
3	Underground excavations require adequate ventilation facility to safeguard health of workmen and minimize hazards due to dust and noise	Requirement is less stringent
4	Requirement of auxiliary power will be higher	Relatively lower
5	In the present case, surge shaft is not required	Surge shaft is required
6	Total project cost excluding transmission line works is about 173 million USD	Total project cost excluding transmission line works is about 165 million USD
7	Project execution time – 52 months after award of contract	Project execution time – 42 months after award of contract
8	Enhanced risks due to flooding and fire hazards	Risks are relatively less severe. Emergency evacuation could be done in a shorter time
9	Less vulnerable to seismic induced damage	Relatively more vulnerable
10	Less vulnerable to risks of war damage, terrorists attacks, vandalism, etc	Risks are there

2.4 Activities and Infrastructure

The main activities in development of the surface power house shall involve excavation of ground covering about 90m long, with a width of 30m and depth of about 50m at the location indicated on the drawings. Approximately 140,000m^3 of rock shall be removed and dumped at the old quarry to the north side of the reservoir. About 30% of the excavated rocks shall be used for concrete aggregate requirement during construction works.

The current road to Namwala shall be diverted during construction as shown on attached drawing. The road shall further be constructed to provide for a bridge crossing over the power house tailrace as a permanent arrangement. The total length of the bridge is about 40m.

Other infrastructure such as office accommodation, stores and workshop are in the same location as in the underground power house alternative.

2.5 Other Project Facilities and Equipment

As mentioned on the EIA report, the power station will have all the necessary facilities and equipment such as headrace and tailrace tunnels; hydraulic mechanical system such as turbines, governors, cooling water system, compressed air system, hydraulic monitoring and measuring system; eelectrical system including generators, transformers, power cable, generator circuit breaker and an outdoor switchyard.

The power station will also have computer control and protection system, communication equipment, hhydraulic steel structures such as trash rack, trash rack bulkhead gate and its hoisting equipment at the tailrace tunnel outlet, water supply and sewerage system and safety devices.

2.6 Project Construction Activities

The project construction activities will include among other activities; construction of access roads, camp sites, excavation for tunneling, powerhouse, surge shaft, and machine installation.

3.0 DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1 Physical Environment

3.1.1 Geology

The Itezhi-Tezhi power house is located at the foot of a hill (as shown in Figure 1) and the proposed site is generally rocky. The bedrock is granitic basement rock with some foliated metamorphic rock, underlying the mudstone sequence.

Away from the hill, the overburden is a sandy/silty residual soil (laterite) from the in-situ weathering of the granitic bedrock. Residual soils are on the order of 2-5 meters thick; alluvium ranges to a maximum thickness in the order of 10-12 meters.

Source quarries and borrow pits for soil and rock construction materials are available on site for future expansion work.

3.1.2 Seismicity

Itezhi tezhi dam site is located in the seismic region. The site actually lies on the relatively suitable plateau, about 200km West of the more active regions of the East African System. This is manifested by frequent low intensity activity with occasional larger events. Initial review of data on seismicity revealed no earthquakes larger than 5.6M within approximately 300km of Itezhi Tezhi since records were first kept in the early 1900s (1904 – 1910) to 1978.

There is limited data indicating the possible occurrence of the reservoir induced seismicity at the Itezhi Tezhi reservoir. In early May 1978 and late August 1978, the number of earthquakes recorded reached a local high (25 and 15 daily events) compared to more normal daily occurrences of <2/day. The magnitudes of "most can be expected to be lower than 2.8" (Seismic Activity During Filling of Itezhi – Tezhi Reservoir, VBB, 2/7/79,p.5)

In addition to the evaluation by VBB (above reference), microseismic earthquake data in the period March 1981 to April 1987 were also reviewed and evaluated by the Central

Water and Power Research Station, Pune, India (Memo 380-22, October 1991). In their summery of activity, the following points are made:

- The increased seismic activity in 1978 shortly after filling began could be surmised to be RIS (reservoir induced seismicity).
- After a quiet period of about three years, the seismicity in close proximity to the dam increased in August 1982, with several shocks ranging in magnitude from 3.0 to 4.0. These can be considered as reservoir induced shocks. (This is also the seismic activity that has been associated with the general decline in aquifer pressures, which began in October 1982)
- After 1982, the level of activity “steadily reduced almost to its natural level”, the exception being a “spurt of activity” in October 1984, with the main shock rated at 4.4 M; this was judged by Pune to have characteristics of a natural, rather than a reservoir induced shock.

Review of seismic data since the dam was constructed has shown that the RIS events at Itezhi-tezhi to date have been of a similar magnitude as natural seismic events (generally <3-4 M), and have been nowhere near the levels of activity that had been experienced at Kariba, in southern Zambia.

3.1.3 Topography

The Itezhi-Tezhi power house will be located at the foot of a hill with steep slopes overlooking the Kafue River downstream of the Dam. After hill, the land is generally flat with occasional rock outcrops.

3.1.4 Soils

The Itezhi-Tezhi power house is located at the foot of a hill (as shown in Figure 1) and the proposed site is generally rocky. Away from the hill, there is sandy/silty residual soil (laterite) from the in-situ weathering of the granitic bedrock. Residual soils are on the order of 2-5 meters thick; alluvium ranges to a maximum thickness in the order of 10-12 meters.

3.1.5 Climate

In general, the weather of Itezhi Tezhi is subtropical continental and can be classified in four seasons:

• April – August	Cool and dry
• September – October	Hot and dry
• November – January	Hot and wet
• February – May	Cool and wet

The rain season starts at the beginning of November and may last until the end of March. The annual precipitation ranges from 1,400mm in the upper Kafue River basin to about 800 mm in the lower basin. The average rainfall above the Itezhi-Tezhi Reservoir is about 1,100 mm. The maximum rainfall months are December and January.

The average temperature in Lusaka is about 21^0C ranging from an average low of 15^0C to an average high of 27^0C. June and July are the coolest months averaging slightly more than 16^0C while the warmest temperatures occur in October and November when the mean temperature reaches about 24^0C. The mean humidity is about 62 percent ranging from 41 percent in November to 81 percent in January and February. Winds are generally from the east in the cool and dry months and from the northeast in the other seasons. Wind velocities are usually between 5m/s and 10m/s.

3.1.6 Hydrology

The Kafue River is the only river near the proposed site for the power house. Upstream of the Power House area is Itezhi Tezhi dam which led to the creation of the Itezhi Tezhi reservoir with a storage capacity of 6005MCM at full supply level of 1030.5m above sea level. The reservoir is the main water source facility for the Kafue hydroelectric system.

3.1.7 Significant pollutant sources

There are no known sources of significant pollutants as there are no industries in the area. However, an insignificant source of pollution would be the sewerage system for Itezhi Tezhi town and other human activities related to fishing camps located in the Kafue fisheries area.

3.2 Biological Environment

3.2.1 Flora

The proposed power house site has a dry and light deciduous forest which can be classified as a Baikiaea forest. The overstory is dominated by *Baikiaea plurijuga* and *pterocarps antunesii. Lonchocarpus nelsi* occurs in moderate numbers. The common short trees include *Baphia massaiensis obovata* and *combretum celastroides.*

Other common understorey trees are *Acacia ataxacantha. Acalypha cylindrical. Alchornea occidentalis. Grewia avellana. Tarenna luteola, Citropsis daweana, popowia obovata, Waltheria indica* and *Triumfetta dekindtiana.* Forbs and smaller shrubs common are *Achyranthes aspera, plumbago zeylanica* and *Blepharis madaraspatensis.* Common climbers include *Hippocratea parviflora* and *Baissea wulfhorsti*. *Epiphytes* are few.

On the banks of the Kafue River, there is light riparian woodland which is dominated by *Syzygium guineense spp. barotsense.* Common tall trees are associated with *Syzygium guineense* and include *acacia albida*, *Albizia glaberrima, Diospyros mespiliformis, Homalium abdessammadii* and *S*yzygium *cordatum.* Small trees are represented chiefly by *Nuxia oppositifolia, Oncoba spinosa, phoenix reclinata, rhus quartiniana* and *salix subserrata.*

Common shrubs in the riparian woodland include *Acalypha ornate, Antidesma venosum, Byrsocarpus orientalis, Diospyros lycioides, Mimosa pigra, Nidorella resedifolia, phyllanthus reticulates, Sesbania sesban, and phragmites mauritianus.* Climbers are chiefly *Cissampelos mucronata, Glycine wightii, jasminum fluminense, Mikania cerdata, Mucuna pruriens, Paullinia pinnata* and especially *Tacazzea apiculata.*

Grasses are also common along the banks of the Kafue Rive. The riverine grasses are dominated by *Hyparrhenia* grasses and reeds.

This vegetation community is important for river bank stability and grazing by a variety of wildlife species. In the GMA the vegetation is used by both wildlife and cattle for grazing.

Figure 2: Baikiaea forest type of vegetation around the proposed power house site

3.2.2 Fauna

The proposed site for the power house falls within the open area that was given to ZESCO by the Government at the time of construction the Itezhi Tezhi dam. However, the site is at edge of Namwala and Nkala Game Management Areas (GMAs) and wild animals do reach the area earmarked for the power house and the associated facilities.

Dominant antelopes in the area include roan antelope (*Hipprotragus Niger),* buffalo *(Syncerus caffer)* eland (*Traurotragus oryx),*wildbeest (*Connochaetes taurinus), z*ebra

(*Equus burchelli),* impala (*Aepyceros melampus*), warthog *(phacochoerus aethiopicus),* waterbuck (*Kobus ellipsiprymnus crawshayi), bushpig (Potamochoerus porcus),* Common duiker (*Silvicapra grimmia), o*ribi (*Ourebia ourebi),* reedbuck (*Redunca arundinum),* puku (*Kobus vardoni),* hartebeest (*Alcelaphus lichtensteini),* bushbuck *(Tragelaphus scriptus),* and kudu (*Tragelaphus strepsiceros).*

Less frequent seen antelopes include Blue duiker (*Cephalophus monticola)* and yellow backed duiker (*Cephalophus sylvicultor).* These mammals are under protection due to their low numbers. Other mammals are elephant (*Loxondonta Africana) (*which is protected and hunting is not allowed and hippopotamus (*Hippopotamus amphibious).* Many schools of hippopotamus (*Hippopotamus amphibious)* occur along the Kafue River and in Lake Itezhi-Tezhi.

Vervet monkey (*Cercopithecus aethiops)* and Chacma baboons (*Papio ursinus)* are plentiful all over the park and adjacent areas. Carnivores include lion (*Panthera leo), leopard (Panthera pardus),* Hyaena (*Crocuta crocuta),* wilddog (*Lycoan pictus)* and jackal *(Canis adustus).*

The majority of wildlife species in the area move from area to another in response to changes in the availability of water and food, which depend on changes in the seasons of the year.

3.2.3 Birds

Numerous waterbirds and upland bird species are found in the area. Common waterbirds include: pelican (*Pelecanus onocrtalus),* spurwing goose *(Plectopterus gambensis),* wattled crane (*Bugeranus caruculantus),* crowned crane (*Bulearica regulorum),* openbill (*Anustomus lamelligerus),* white faced tree duck (*Dendrocygna viduata),* redbilled teal (*Anas spp.),* yellowbilled duck (*Anas undulate)* and pygmy goose (*Nettapus auritus).*

Upland birds include helmeted guinea fowl (*Numida meleagris),* crested guinea fowl (*Guttera edouardi),* scaly francolin (*Francolinus squamatus)*, African fish eagle (*Haliaeetus vocifer)* and bateleur (*Terathopius ecaudatus).*

Figure 3: Vervet monkey common in the project area

3.2.4 Reptiles

The biggest reptile in the area is the crocodile (*Crocodilus niloticus)* common both in the Kafue River and Lake Itezhi-tezhi. Lizards are represented by geckos, cameleons and skinks and monitor lizard (*Varantus niloticus).* Snakes are represented by python (*Python sebae),* boomslang (*Dispholidus typus*), cobra *(Naja mosambica)* and puffadder (*Bitis arietans).*

3.2.5 Rodents

A variety of rodents occur in the project area, including the adjacent GMAs. These include giant rat (*Cricetomys gambianus), Tetra valida, T. leucogaster, Saccostamus* *campestris, Pelomys fallax, Lemniscomys Griselda, Elephantulus brachyrhynchus* and *Petrodromus tetradactylus.* Family pedelidae is represented by spring hare (*pedetes capensis).*

KNP which partially covered by the Itezhi-Tezhi dam attracts substantial number of tourists. The nearest lodges to the project area are Musungwa and New Kalala. The Nkala and Namwala GMAs attract international safari hunting clients who come hunt big game.

3.2.6 Fish

The fishermen in the study area rely mostly on gill nets and seines. Some traditional gear, such as baited lines and traps, are used but not extensively. Common fish species found in the Itezhi Tezhi Lake and the Kafue River include Green-headed bream *(Oreochromis machrochir),* Three-spotted bream *(Oreochromis andersoni),* Red-breasted bream *(Tilapia rendalli),* Thin- faced bream *(Serrachromis angusticeps),* Purple-faced bream *(Serrachromis marcocephala),* Bulldog *(Marcusenius macrolepidotus),* Silver robber *(Alestes lateralis),* Dot tail *(Barbus poechi)and* Bottle nose *(Mormyrus lacerda)*

Figure 4: Type of fish in the Lake Itezhi-tezhi and Kafue River

3.3 Socio-Economic Environment

The proposed site for the power house falls within the Itezhi Tezhi dam area where certain activities such as farming, building houses, cutting trees and hunting are restricted. Hence, the proposed site has no houses and crops. There are no known archaeological / heritage site.

There are some social aspects pertaining to the project as a whole, but not necessarily specific to the power house, which have been discussed in the main EIA report.

4.0 IMPACT ASSESSMENT AND MITIGATION

This section of the report seeks to address the potential impacts of building a surface power house at the identified location. The main objective in assessing the potential effects of the project is to allow the planning of actions to prevent or reduce undesirable effects of the project and to identify actions to enhance the secondary benefits of the project. It should be noted that most of the potential impacts identified are mainly associated with the construction phase of the project. Once construction is completed, there are no significant impacts that can directly be associated with the project, except for the permanent distortion of aesthetic beauty of the area.

4.1 Physical Environment

4.1.1 Geology and Soils

As mentioned earlier, the power house will be located at the foot of the hill and part of the hill will be cut to accommodate the power house. Because the proposed location is rocky, construction works will involve blasting with explosives, drilling and excavation. These activities will generate large quantities of rubble in form of stone, aggregates and soil. Blasting, drilling and excavation may result in loosening of rocks on the hill leading to periodic rockfalls, which is a safety hazard.

Dams are known to cause seismic activities in the areas where they are located. There is a risk that the power house may be affected by seismic activities which be caused by the existing Itezhi Tezhi dam.

Mitigation: To stabilize the rocks on the slopes of the hill, gabions and other environmentally friendly methods should be employed. The rubble in form of rock and aggregates should be used in various construction activities and the excess should be dumped in designated areas approved by the District Council. At the beginning of construction works, the topsoil should be removed before excavation works are carried and stored so that it can be used for landscaping at the end of the project.

Source quarries and borrow pits for soil and rock construction materials are available in the project area. Hence, there will be no need to open new ones.

A review of seismic data available showed that since 1982, the level of seismic activity has steadily reduced almost to its natural level due to the general decline in aquifer pressures over time. Hence, the risk of reservoir induced seismic activities affecting the power house is low.

4.1.2 Topography

The Itezhi-Tezhi power house will be located at the foot of a hill with steep slopes overlooking the Kafue River downstream of the Dam. After the hill, the land is generally flat with occasional rock outcrops. Part of the hill will be excavated to facilitate the construction of the surge chamber and the power house itself. The topography of the area will be modified since part of the hill (towards the foot of the hill) will be excavated to accommodate the power house.

Mitigation: As the slopes are quite steep, there will be need for slope stabilisation using gabions and other environmentally friendly slope stabilization methodologies such as grassing as opposed to shot creting. Site restoration and landscaping in work areas should be made part of the construction works and should be included in the contract.

4.1.3 Hydrology and Water Quality

The Kafue River is the only river near the proposed site for the power house and is less than 1km from the proposed site for the power house. Excavations and other construction works may increase the sediment load arising from the waste water mixed with soil that may flow from the construction site into the River and this may affect the fish and other forms of aquatic life.

Mitigation: During construction, settling ponds should be constructed where waste water should collect before it is discharges in the River. This will allow the suspended load in the water (including soil particles) to settle in the ponds to minimize the volume of the sediments to be discharged in the River. Frequent cleaning of the settling ponds will be undertaken to maintain sufficient capacity to handle runoff water from large rainfall storms.

4.1.4 Landscape and Scenic beauty

The power house will be located at the foot of a hill and part of the hill excavated to facilitate the construction of the surge chamber and the power house itself. Secondly, many trees will be cut at the power house site. These will lead to the distortion of the landscape and scenic beauty of the area.

Mitigation: Vegetation removal should be kept to a minimum by ensuring that only trees on the direct area of construction are removed. Trees outside the areas to be excavated should be preserved and others should be thinned or trimmed if need arises. On the banks of the Kafue, vegetation removal should be controlled strictly to avoid erosion of the banks and disturbing the riverine ecosystem.

A re-vegetation programme shall be implemented at the end of construction to plant trees and grass to facilitate ecological restoration. Only indigenous tree species should be used for re-vegetation. This programme will have positive effects on physical, biological and human environments.

The rubble in form of rock and aggregates should be used in various construction activities and the excess should be dumped in designated areas approved by the District Council. The dumped rock and aggregates should be leveled, covered with a layer of soil and planted with trees and grass to blend with the natural environment.

After construction, landscaping around the power house shall be undertaken to restore and enhance the scenic beauty of the area.

4.1.5 Air Quality and Noise

Because the proposed location of the power house is rocky, construction works will involve blasting with explosives, drilling and excavation. These activities will generate noise which will be a nuisance to the tourists and the people living in the vicinity of the project (Itezhi Tezhi town, Musungwa and Kalala lodges, and the villages). Construction activities, particularly blasting, drilling and excavation, will generate dust emission which will affect the workers on site and other people in the vicinity.

Mitigation: Timing for blasting can be arranged so as to reduce noise impact on surrounding population. Blasting should not be done at night so that people who are sleeping are not disturbed. A watering program to reduce dust from drilling, blasting and excavation can be easily implemented during construction. Controlled blasting should be undertaken to ensure less dust emission, flying stones and debris. If necessary, gravel roads can be kept wet near populated areas to avoid clouds of dust.

4.1.6 Waste Management

Construction will produce some waste such as concrete, steel bars, bolts, nuts, cables, cable drums, waste oils, paper, plastics, metal, woody vegetation and domestic waste which have adverse impacts on the environment. Construction will produce large quantities of rubble from the blasted rock.

Mitigation: The waste should be sorted according to types. Plastics and empty cement bags will be collected from site and disposed in designated dump sites. Leftover metal pieces (steel bars, bolts, nuts, conductors and cables) should be removed from site and stored for reuse. Those which cannot be reused, should be sold as scrap metal or be donated to the local blacksmiths. Those pieces of metal which cannot be used for anything, should be dumped in designated dump sites. Waste oil should be put in drums and sold to companies that recycle used oil.

The machinery should be kept in good working condition to avoid oil leakages. Washing and servicing of all equipment shall be done in designated areas away from the construction site. Dumping of waste should be done at designated sites approved by Environmental Council of Zambia and the District Council.

The woody vegetation cut will be given to the local people to be used as firewood. Cable drums will be given to the local carpenters to use for making various wooden products. Rubbish bins shall be provided for domestic waste. These shall be collected and the rubbish shall be disposed off in designated places. 0Water borne toilets, instead of pit latrines, shall be constructed on site for use by workers during construction.

Some of the rubble can be used for various construction activities. The rubble that cannot be used in construction should be disposed in dumping sites approved by the local authority.

4.2 Biological Environment

4.2.1 Vegetation

The proposed power house site has a dry and light deciduous Baikiaea forest with few tall trees and many shrubs. On the banks of the Kafue River, there is light riparian woodland with slightly more tall trees than at the actual place where the power house will be located.

Removal of natural vegetation is inevitable during construction. Indiscriminate removal of vegetation may induce soil erosion from runoff rain water considering the fact that the power house is located at the foot of the hill and may also lead to a permanent loss of some tree species in the immediate project area. Vegetation removal on the banks of the Kafue River may lead to erosion of the banks and may increase the sediment load of the river. The riverine ecosystem can also be affected by vegetation removal.

Mitigation: Vegetation removal should be kept to a minimum by ensuring that only trees on the direct area of construction are removed. Trees outside the areas to be excavated should be preserved and other trees can just be thinned or trimmed, if need arises, instead of cutting them. On the banks of the Kafue, vegetation removal should be controlled strictly to avoid erosion of the banks and disturbing the riverine ecosystem.

A re-vegetation programme should be implemented at the end of the construction to plant trees and grass to facilitate ecological restoration. Only indigenous tree species should be used for re-vegetation. This programme will have positive effects on physical, biological and human environments.

4.2.2 Wildlife

The proposed site for the power house falls within the open area that was given to ZESCO by the Government at the time of construction the Itezhi Tezhi dam. However, the site is at edge of Namwala and Nkala Game Management Areas (GMAs) and wild animals do reach the area earmarked for the power house and the associated facilities.

There is high risk that some of the workers may engage in poaching of wildlife using guns, snares and other methods. Although there were no indications observed during the environmental screening that the proposed power station site was on the animal route to the river to drink water, it is possible that the power house will partially block the corridor to the river for some animal species.

Cutting of trees and excavation works may lead to habitat destruction for some small animals, birds and reptiles and some may even be killed.

Mitigation: A vigorous campaign for anti-poaching and environmental conservation should be instituted. Any person found poaching should be dismissed from work and reported to the Zambia Wildlife Authority or Zambia Police for prosecution . Any animal, bird or reptile that is found during construction should be rescued and released in the natural environment nearby.

4.3 Social Environment

4.3.1 Health

If proper water supply and sanitary facilities are not put in place at site, there is the risk of waterborne diseases such as diarrhea, dysentery and typhoid breaking out among the workers. Various types of accidents may also occur during construction.

Some of the workers to be employed will come from various places outside the project area and this may lead to the spreading of communicable diseases such as HIV/AIDs and sexually transmitted Infections (STIs).

Mitigation: Clean and safe drinking water should be provided to the workers on site. As part of the project, the existing water and sewerage system shall be rehabilitated and expanded to cater for both the existing residents and the project camp sites. Rubbish bins shall be provided for domestic waste. These shall be collected and the rubbish shall be disposed off in designated places. Pit latrines shall not be allowed on the construction site. Instead, water borne toilets shall be constructed on site for use by workers during construction.

Health awareness campaigns should be conducted regularly to educate the workers and the local community on the dangers and prevention of HIV/AIDS, STIs and other communicable diseases. Support shall be given to the District Hospital in HIV/AIDS management programmes. As part of the project, the existing District Hospital shall be supported in terms of the provision of medical equipment and in other ways as will be deemed necessary during project implementation.

4.3.2 Safety on Site and on the Road

The power house will be located at the foot of a hill on the road to Namwala, Ngoma ZAWA camp, Kalala and Musungwa lodges. This will obstruct the smooth flow of traffic on the road and may lead to an increase in road traffic accidents. Various types of accidents are also anticipated from the construction activities on site. During construction for a project of such magnitude, the risks for accidents resulting in injuries are high.

Mitigation: The Itezhi Tezhi – Namwala road will be re-route towards the river and appropriate road signs should be placed in appropriate places to warn motorists about the diversion and the works. A speed limit of 30km per hour shall be set for all motorists driving in and around the construction area. Work areas shall be clearly labeled and all workers will be required to wear appropriate protective clothing when they are in the work areas. Even visitors should be provided with protective clothing when they come to site to visit the project.

To minimize accidents, regular safety awareness campaigns should be conducted. First Aid training shall be provided to the construction workers and a First Aid box shall be available on site all the time.

4.3.3 Archaeological and Heritage Site

Although there are no known archaeological sites at the proposed power house site, it is possible to find some artifacts when construction works commence. Excavation works may lead to the discovery of some artifacts.

Mitigation: Workers should be sensitized on the need to watch out for archeological artifacts. If any artifact is found, National Heritage Conservation Commission (NHCC) should be contacted for advice on how to conserve them. A hotline shall be given to the supervisors and foremen to ensure immediate notification of relevant authorities when/if artifacts are discovered.

4.4 Summary of Potential Impacts and Mitigation Measures

Table 2 below gives a summary of potential impacts and the recommended mitigation measures which have to be adhered to by the developer during the construction and operational phases of the power station.

Table 2: Potential Impacts and Mitigation Measures

Topic	Type of impact	Mitigation Measures and Comments
1.0 Physical Environment		
1.1 Geology and Soils	Rock distabilisation and stone rubble generation	To stabilize the slopes of the hill, gabions and other environmentally friendly methods should be employed. The rubble (rock and aggregates) should be used in various construction activities and the excess should be dumped in designated areas. Landscaping should be done at the end of the project to prevent soil erosion.
1.2 Topography	Distortion of topography of the area	Slope stabilisation should be done using gabions and other environmentally friendly methodologies. Grassing as opposed to shot creting should be done. Site restoration and landscaping in work areas should be done.
1.3 Hydrology	Water Quality effects	Settling ponds should be constructed to allow the suspended sediments in the waste water to settle in the ponds before the waste water is discharged in the Kafue River.
1.4 Landscape	Scenic beauty distortion	Vegetation removal should be kept to a minimum by ensuring that only trees on the direct area of construction are removed. A re-vegetation programme should be implemented at the end of construction to plant trees and grass to facilitate ecological restoration around the Power House.

1.5 Air quality and noise	Air and noise pollution	Local people and workers should be informed about times for blasting. Blasting should not be done at night. Controlled blasting should be undertaken to ensure less dust emissions and flying stones and debris. A watering program should be developed to reduce dust. Gravel roads should be kept wet to avoid of dust.
1.4 Waste Products	Pollution from Cable drums and cement bags	Cable drums should be removed from site and stored for reuse. Empty cement bags should be collected from site and disposed in designated dump sites.
Waste Products cont'd	Pollution from Leftover pieces of metal and concrete	Leftover pieces of metal should be removed from site and stored for reuse. Those which cannot be reused can be sold as scrap metal.
	Pollution from Transformer oil	Transformers and auxiliary equipment to be procured for the project should be PCB-free.
	Pollution from liquid waste	Oil leakages should not be allowed. Non-reusable oils should be put in drums and transported to a suitable storage site and should be disposed of according to the governing environmental regulations. Washing and servicing of all equipment shall be done in designated areas away from the construction site.
	Pollution from domestic waste	Water borne toilets, and not pit latrines, shall be provided in designated areas for use by construction workers. Rubbish bins shall be provided for domestic waste which shall be collected and disposed in designated places.
	Pollution from concrete waste	Left over concrete should scraped and dispose of in dumping sites designated by the District Council.
	Soil, gravel and aggregates	Soil, gravel, aggregates and stone to be generated should be used in various constriction activities. The excess should be dumped in designated places and covered with top soil to facilitate ecological restoration by planting trees and grass. Quarries should be buried and trees and grass should be planted to facilitate ecological restoration.

2.0 Biological Environment		
2.1 Flora	Deforestation	Vegetation removal should be kept to a minimum by ensuring that only trees on the direct area of construction are removed. A re-vegetation programme should be implemented at the end of construction to plant trees and grass to facilitate ecological restoration.
2.2 Fauna	Disturbance to wildlife	A vigorous campaign for anti-poaching and environmental conservation should be instituted. Any animal, bird or reptile that is found during construction should be rescued and released in the natural environment nearby.
3. Socio-economic Environment		
3.1 Health	Health risks	Clean and safe drinking water should be provided on site. Water borne toilets, and not pit latrines, shall be provided in designated areas for use by construction workers. Rubbish bins shall be provided for domestic waste which shall be collected and disposed in designated places. Health awareness campaigns should be conducted regularly to educate workers and the local community on the dangers and prevention of HIV/AIDS, STIs and other communicable diseases.
3.2 Safety	Accident risks on site and on the road	Appropriate road signs should be placed on the Itezhi Tezhi – Namwala road, which will be re-routed. A speed limit of 30km/h shall be set for all motorists driving in and around the construction area. Regular safety awareness campaigns shall be conducted. Work areas shall be clearly be clearly labeled and all workers and visitors will be required to wear appropriate protective clothing. First Aid training should be provided to all the workers and a First Aid box should be available on site all the time.
3.3 Archaeological and Heritage sites	Disturbance to Archaeological and Heritage sites.	Workers should be sensitized on the need to watch out for archeological artifacts. If any artifact is found, National Heritage Conservation Commission should be contacted immediately for advice on how to conserve them. A hotline shall be provided to the supervisors and foremen to ensure immediate notification of relevant authorities on discovery of artifacts.

5.0 ENVIRONMENTAL IMPACT MANAGEMENT PLAN

The mitigation actions discussed in Section 4.0 are intended to reduce or completely eliminate adverse environmental effects of the preferred option of building a surface power station.

Environmental monitoring is important during project implementation and a monitoring programme has to be put in place. The monitoring program serves two basic purposes: (1) to ensure that the mitigation actions have been carried out in accordance with instruction given in the Environmental Impact Assessment report and the Environmental Management Plan (EMP) for the project, and (2) to identify and arrest any unforeseen effects of the project on its environment.

The Environmental Coordinator on the project is responsible for monitoring the implementation of the environmental mitigation measures to ensure compliance to mitigation measures during construction and operation of the power line. Environmental Council of Zambia is also expected to monitor the implementation of the project from time to time to ensure that mitigation measures are followed.

To implement certain programmes, such as health, safety and conservation education for workers and the community, stakeholders such as Ministry of Health, ZAWA and Non-Governmental Organisations may be involved. It is the responsibility of the developer to provide the needed funds to facilitate the implementation of the mitigation measures recommended in this report and the EMP. Funds for the implementing the mitigation measures are part of the overall project budget.

The table below gives the mitigation activities, implementing agency and the estimated cost of each activity. It is estimated that the implementation of the mitigation measures will cost US $371,000.00.

It should be noted that some of the environmental mitigation measures are already incorporated in the design and costing of various works, especially civil works. Hence not all the mitigation measures are costed in this report.

Table 3: Mitigation Monitoring Plan and Responsible Agencies

Activity	**Implementing Agency**	**Estimated Cost (US $)**
1. Health		
• Conducting health awareness campaigns to construction workers and the local community ($8,000 x 4 years)	Ministry of Health – Itezhi Tezhi in collaboration with Environmental Coordinator	32,000.00
• Support to the District Hospital (equipment and outreach programmes) ($50,000 x 4 years)	Ministry of Health – Itezhi Tezhi	200,000.00
Subtotal		***232,000.00***
2. Conservation		
• Conducting conservation awareness campaigns to construction workers and the local community ($6,000 x 4 years	Project Environmental Coordinator in conjunction with Forestry Dept and ZAWA	24,000.00
• Support to ZAWA for monitoring ($10,000 x 4 years)		40,000.00
Subtotal		**64,000.00**
3. Road		**10,000.00**
• Procurement of road signs to warn motorists about construction works and detours on the road.	Contractor	

4. Safety		
▪ Conducting safety awareness campaigns to construction workers and the local community	Project Safety Officer in collaboration with Environmental Coordinator	10,000.00
▪ Work area safety labeling	Contractor	5,000.00
▪ First Aid training	Contractor	10,000.00
Subtotal		**25,000.00**
5. Water Quality monitoring ($10,000 x 4 years)	Project Environmental Coordinator	**40,000.00**
Total		**371,000.00**

6.0 RECOMMENDATIONS AND CONCLUSION

During the Environmental Impact Assessment (EIA) for the proposed surface power station for the Itezhi Tezhi Hydroelectric project, it was noticed that the proposed location had no houses, crops or fruit trees because it is a restricted area under the existing Itezhi Tezh dam. This minimized the impacts significantly. However, several adverse impacts were identified and mitigation measures were recommended to reduce or completely eliminate the impacts and to enhancement measures for the positive impacts.

To ensure implementation of the proposed mitigation measures, a budget of US $371,000.00 has been recommended which should be included in the total project cost. Further, the actual implementation of the various environmental aspects recommended in this report will be guided by the Environmental Management Plans for the different project components and will be strictly monitored by the Project Environmental Officer who will be stationed on site.

Taking into account all the identified environmental impacts of the proposed surface power house and the recommended mitigation measures for the identified negative impacts and enhancement measures for positive impacts, the surface power house for the Itezhi Tezhi Hydropower Station is an environmentally friendly option and should be considered for implementation.

This Addendum shall be implemented within the approved Environmental Impact Statement for the whole project and all the costs associated with the implementation of the Environmental Management Plan shall be treated as part of the total project cost.

7.0 REFERENCES

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APPENDICES

APPENDIX 1: DRAWINGS SHOWING THE LOCATION OF THE POWER HOUSE