CRIDF

Kufandada Irrigation Scheme: Detailed Design Report

Project Name: Kufandada River Protection

Version: Final

March 2015

Version #: Final **Date:** 17 March 2015 **Lead Author:** Lloyd Agere **QA'd by:** Leonard Magara

Disclaimer

The British Government's Department for International Development (DFID) financed this work as part of the United Kingdom's aid programme. However, the views and recommendations contained in this report are those of the consultant, and DFID is not responsible for, or bound by the recommendations made.

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List of Acronyms

Acronym	Long-Form
ASI	Adam Smith International
AC	Asbestos Cement
BADEA	Arab Bank for Economic Development
AGRITEX	Department of Agricultural Technical and Extension Services
CBA	Cost Benefit Analysis
CBMP	Community Based Water Management Project
CRIDF	Climate Resilient Infrastructure Development Facility
DDF	District Development Fund
DFID	Department of International Development
ENPV	Economic Net Present Value
EOCC	Economic Opportunity Cost of Capital
FOCC	Financial Opportunity Cost of Capital
ERR	Economic Rate of Return
ECC	Engineering Construction Contract
EIA	Environmental Impact Assessment
EMA	Environmental Management Agency (Zimbabwe)
EMP	Environmental Management Plan
FAO	Food and Agricultural Organisation
FBCR	Financial Benefit-Cost Ratio
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value
GRP	Glass Reinforced Plastic
ICZ	Interconsult Zimbabwe (Pvt) ltd
MC	Management Contract(or)
MDPE	Medium Density Polyethylene
MFI	Micro-Finance Institution
MSMEC	medium scale enterprises and cooperatives
NGO	Non-Governmental Organisation
O & M	Operation and Maintenance
P and G	Preliminary and General
SADC	Southern Africa Development Community
SSA	Sub-Saharan Africa
TOR	Terms of Reference
USD	United States Dollar

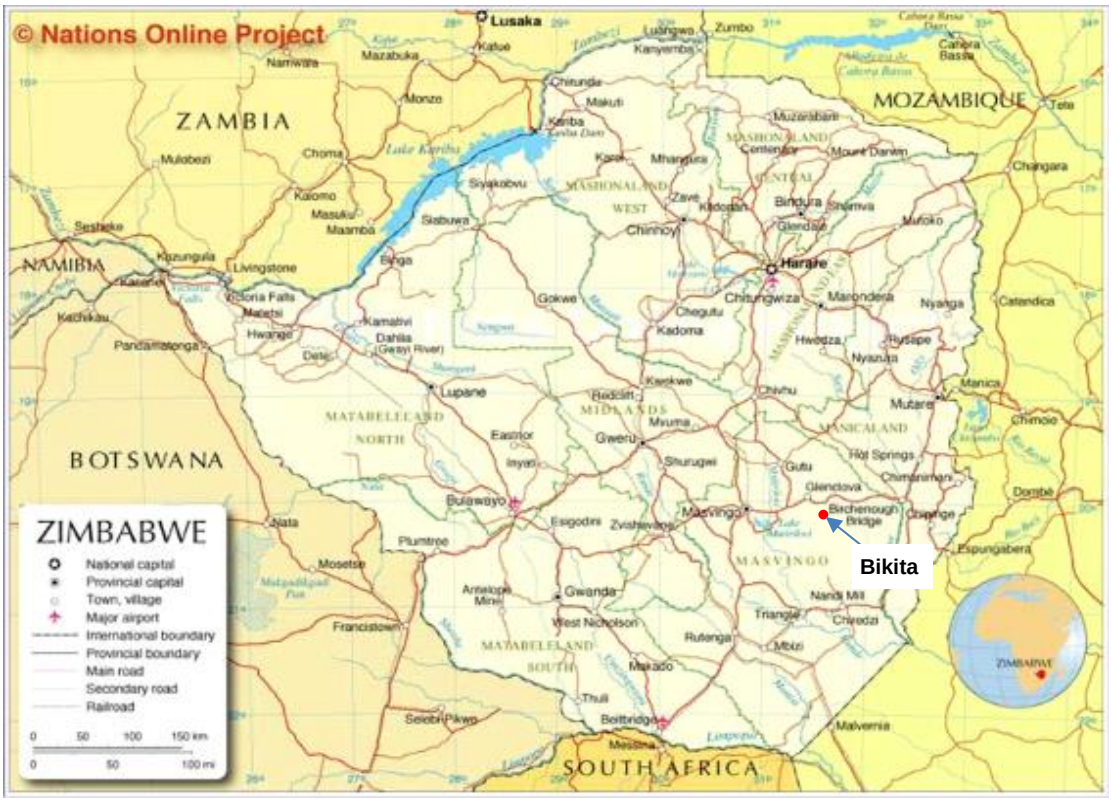
VIP Latrine	Ventilated Improved Pit Latrine
WASH	Water Supply, Sanitation and Hygiene
ZINWA	Zimbabwe National Water Authority
ZIMVAC	Zimbabwe Vulnerability Assessment

Executive Summary

Background

The proposed Kufandada Irrigation is among a number of Quick Win water projects identified for possible development in the region under CRIDF to be delivered relatively quickly in order to demonstrate immediate benefits. Following reconnaissance and feasibility studies, the project was selected for support under the Facility.

The proposed Kufandada irrigation scheme will benefit three villages of Ndimo, Nhamo, and Mandivengerei Villages in Wards 10 and 13 of Bikita District with an estimated 120 households. The location of the scheme is shown in the map below.



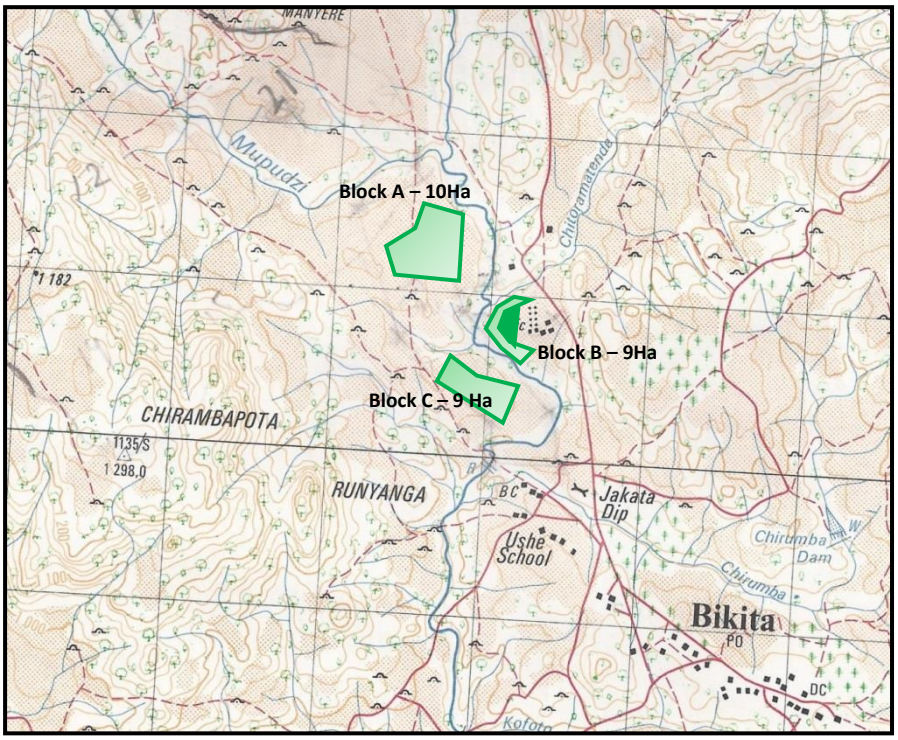
Following a reconnaissance visit to the project area, and assessment for possible support, the project was screened and found to comply with CRIDF's requirements. A decision was then made to provide support for the feasibility assessment of the project. This was undertaken and completed during the last quarter of 2014. The feasibility study developed technical aspects of the project through optioneering, and cost-benefit analysis, which established the financial and economic viability of the project. Further screening resulted in a decision to provide support for the implementation of the project. This report is an outline of the key technical components of the project, the manner in which they will be implemented, as well as Bill of Quantities and Cost Estimates.

Project Description

The project area is wholly located in communal land where the community mainly depends on rain-fed agriculture production to meet its food requirements, and rainfall patterns are no longer predictable as they were in the past. The main elements of the project are the irrigation scheme, water supply and sanitation as well as river and environmental protection.

Proposed Irrigation Scheme

Local traditional and community leaders have identified 28 ha of land distributed among three blocks to be incorporated in the irrigation scheme. The location of the irrigation blocks is shown below.



The land is currently being utilised under rain-fed farming. It is owned by individual households, who have ceded their land for common use under the proposed scheme. The scheme also includes land which has been provided by the Bikita Hospital to establish a nutrition Garden for patients as well as staff.

Analysis of rainfall data from a nearby rainfall stations shows a decreasing rainfall trend after 1999/2000 to 2013/14.

It is proposed to utilise yield from the perennial Mupudzi River as a source of water for the irrigation scheme. The supply from the river will be supplemented by releases from the upstream Rozva dam. ZINWA has given an undertaking to issue an abstraction permit and to enter into a memorandum of agreement for the supply of additional water from the dam, if required during low flows.

Hydrological analysis indicated that 28 ha could be irrigated from the average yield of the combined flow from Mupudzi River and Chitoramatende River, supplemented by releases from Rozva dam during periods of low flow. The irrigated area is apportioned between the three irrigation blocks as follows:

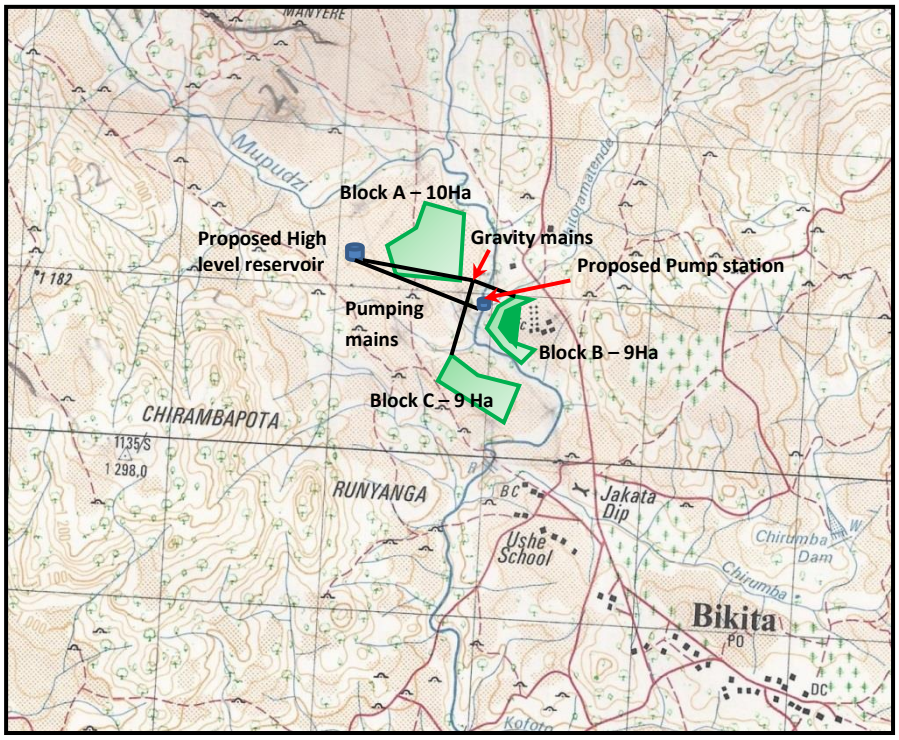
Block A - 10 ha

Block B - 9 ha

Block C - 9 ha

The adopted design criterion for the bulk water supply for irrigation is based on the delivery of water to night storage over a maximum period of 16 hours using the industry standard which assumes a water demand of 15,000 m3/ha/annum. This results in a design flow of 157.3 m^3/hr for the pumping system. With respect to in-field irrigation, the FAO approach has been adopted which gave a design flow of 204.6 m^3/hr for the delivery to the field.

It is proposed to abstract water from Rozva River at a location approximately 250m downstream of existing Kufandada Dam for the irrigation scheme. The general layout of the scheme is shown in schematic below.



Water will be pumped from the river to night storage reservoirs located at an elevated location west of the river. From the night storage reservoirs, it will gravitate to the irrigation fields.

Water supply and sanitation

Options for the water supply were investigated, including connection to the ZINWA system and the provision of groundwater supplies. It is recommended that two new boreholes be drilled, as well as the rehabilitation of

the broken down hand pump at the existing borehole. The proposed delivery mode for sanitation is for the project to supply selected building materials for 24 VIPs with the beneficiaries providing construction labour.

Environmental protection

There is widespread stream bank and in-stream cultivation along the Rozva River and its tributaries. This has resulted in extensive water habitats destruction and siltation of water bodies. It is proposed to re-establish the statutory 30m buffer protection zones and plant grass and indigenous trees for protection in select areas.

Cost Estimates and Bill of Quantities

Bill of Quantities have been developed based on abstraction of water from Rozva River and the irrigation of 28 ha, including the provision of 2 new boreholes, the rehabilitation of a one, and supply of building materials for the construction of VIP latrines. It is estimated that the project will cost USD

Introduction

Background

The Climate Resilient Infrastructure Development Facility (CRIDF), supported by DFID aims to deliver sustainable small-scale infrastructure across 11 SADC countries. The demand driven programme focuses on water services, water resources management and agriculture with the objective of creating a lasting impact on the region's water and food security. Among a number of parallel programmes, CRIDF will support projects which can be delivered relatively quickly, to demonstrate immediate benefits. To this end, the CRIDF team has carried out high level consultations to identify these "Quick Win" projects throughout the region.

The feasibility study for the proposed river protection irrigation scheme established that the environmental protection works and irrigation of approximately 28 ha of land from a new take-off weir on Rozva River at Kufandada village near Bikita, Zimbabwe, was technically feasible. It also demonstrated the financial and economic feasibility of the project, and that there were significant positive environmental impacts arising from its implementation. This report outlines the development of a technical design for the Kufandada Irrigation Scheme based on the option selected at feasibility stage. It covers salient technical issues to provide the back ground of key components of the project to enable its construction.

The proposed Kufandada irrigation scheme will benefit three villages of Ndimo, Nhamo, and Mandivengerei Villages in Wards 10 and 13 of the District with an estimated 120 households. In addition, the scheme will also benefit the Bikita Rural Hospital and its staff.

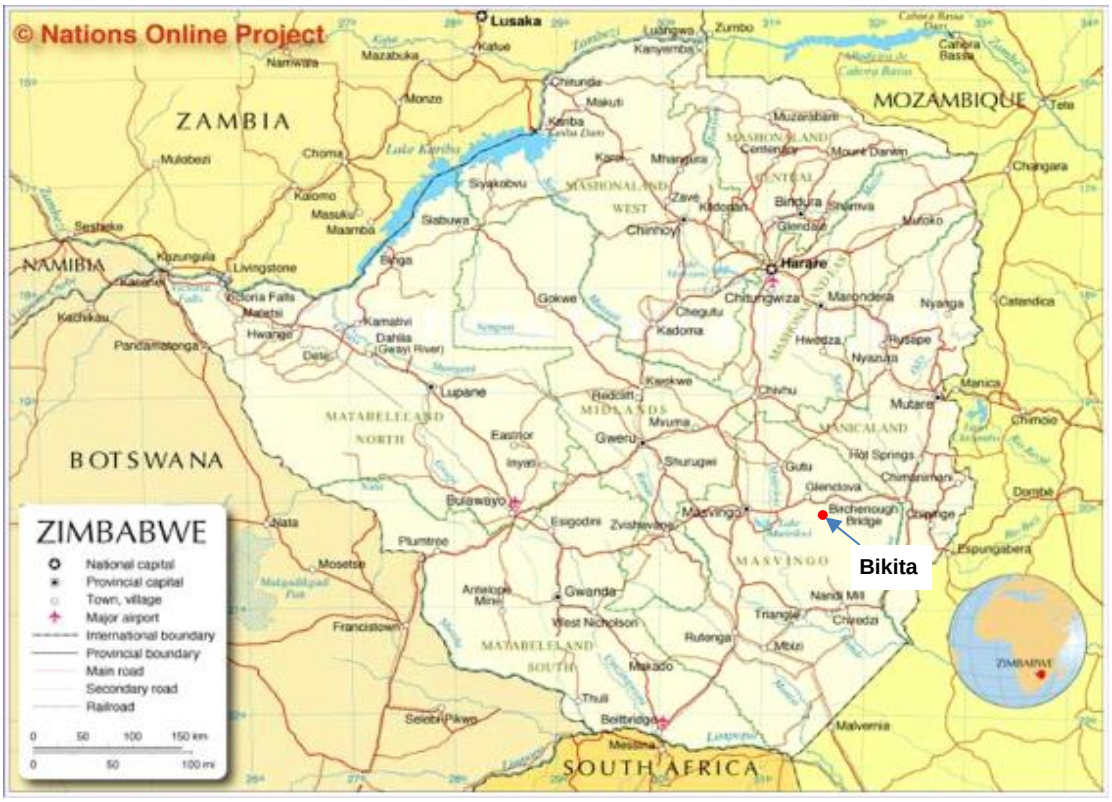
Project Location and Site Access

The proposed project area is within three villages called Ndimo, Nhamo and Mandivengerei Villages which are in wards 10 and 13 of Bikita District. All these villages are located approx. 7km from Nyika Growth Point and 3km from Bikita DA's offices which is the local government service centre for the district. Figure 1 bewlow shows the location of Bikita District Administrative Centre.

Access to the proposed scheme is via the main road from Nyika Growth Point, which branches off the Masvingo road to turn southwards to Bikita District Centre. The scheme is located across the Rozva River just south of Bikita Hospital.

The villagers are mainly peasant farmers with a few of them employed by local government agencies and other private enterprises at Bikita Service Centre and Nyika Growth point respectively. There are no major economic activities in the area except some commercial farming activities at nearby Rozva dam located near Nyika Growth Point and also other dams located further south of Bikita. Bikita Minerals, a world renowned lithium producer is some 30km away.

Figure 1 **Location Map**



The project area is located in relatively dry agro-ecological region III of Zimbabwe where yearly rainfall typically ranges from 650 to 800mm. The soils in the area are generally sandy gravelly loam soils and the peasants there are mostly involved in seasonal cultivation of the staple crop maize.

Structure of the Design Report

This report covers salient technical aspects on the design of Kufandada Scheme to provide some context to the accompanying design drawings. It covers a general description of the project area, the main components of the scheme, design assumptions and key hydraulic features, concerning the transfer of water from proposed river abstraction works to the irrigation fields.

Project Description

General Description of the Project Area

The project area is wholly located in communal land where the community mainly depends on rain-fed agriculture production to meet its food requirements. However, the rainfall pattern is no longer as predictable as it was in the past, with the now frequent short rainfall season resulting in poor agricultural yields. Most farmers have adopted conservation agriculture in an effort to increase crop yields while contour ridging is no longer common. Although there is still a dependence on livestock, the number of large livestock has dwindled significantly. Most poor households derive their livelihoods from the sale of wild fruits (mashuku and chakata), while the able bodied community members depend on casual work at the nearby business centres and the fledgling Rozva and Shereni irrigation schemes, 7 and 30km away respectively.

There is rapid urbanization affecting the two wards due to the nearby Bikita administrative centre, where parts of ward 13 have now been co-opted in the centre's development plans.

Water supply coverage is generally poor although some villagers have private connections from the ZINWA system which supplies Bikita. Generally the villagers get water for their domestic purposes in shallow and deep wells. Of three boreholes constructed and equipped with bush pumps only one is still functional. Consequently, some villagers walk more than a kilometre to the existing borehole to augment their domestic water supplies

Land-use is dominated by rain-fed agriculture, grazing and small gardens. Due to the hilly terrain, isolated patches of vegetation flourish on the slopes which used to provide a habitat for large forms of wildlife such as hyenas, baboons, kudu, buck, rock rabbits and hares. In general wild life population has declined due to habitat destruction and unrestricted hunting in the area. Grasslands occur on the edges of crop fields and provide pastures for the cattle.

The Mpudzi River as well as the Rozva River transport large volumes of silt that is washed into the river from the hinterland. This resulted in the silting of the Kufandada Dam, which was constructed some 20 years ago. Water passes over the silted weir, and is used by community members for laundry, bathing and livestock watering

Key environmental issues in the project area are land degradation, climate change, declining water availability and siltation of the streams, exacerbated by general poverty and over-dependence on natural resources for livelihoods. Unsustainable land management practices are aggravated by periodic droughts and floods. The Save River Basin has become so heavily degraded that the Environmental Management Agency has declared it a basin requiring 'restoration'.

The primary energy source for cooking in ward 10 and 13 is firewood, with very few people connected to the nearby electricity grid. The project area was selected for CRIDF support because of its vulnerability to

climate change, poor land use practices that impact negatively on transboundary water resources, the prevalence of extreme poverty, a high rate of population increase, frequent natural disasters such as droughts

and floods, and agricultural systems (both crop and livestock production) that depend heavily on rainfall. Climate variability and change have further exacerbated the scarcity of natural resources such as forests, with the consequent loss in the biodiversity of flora and fauna. Predictions for the Bikita area indicate that changes in temperature and weather patterns were affecting the frequency and severity of rainfall, droughts, floods, access to water and the use of land.

Available Irrigation land and soil suitability

Local traditional and community leaders have identified three blocks of land to be incorporated in the irrigation scheme. The location of the irrigation blocks is shown in Figure 1 below.

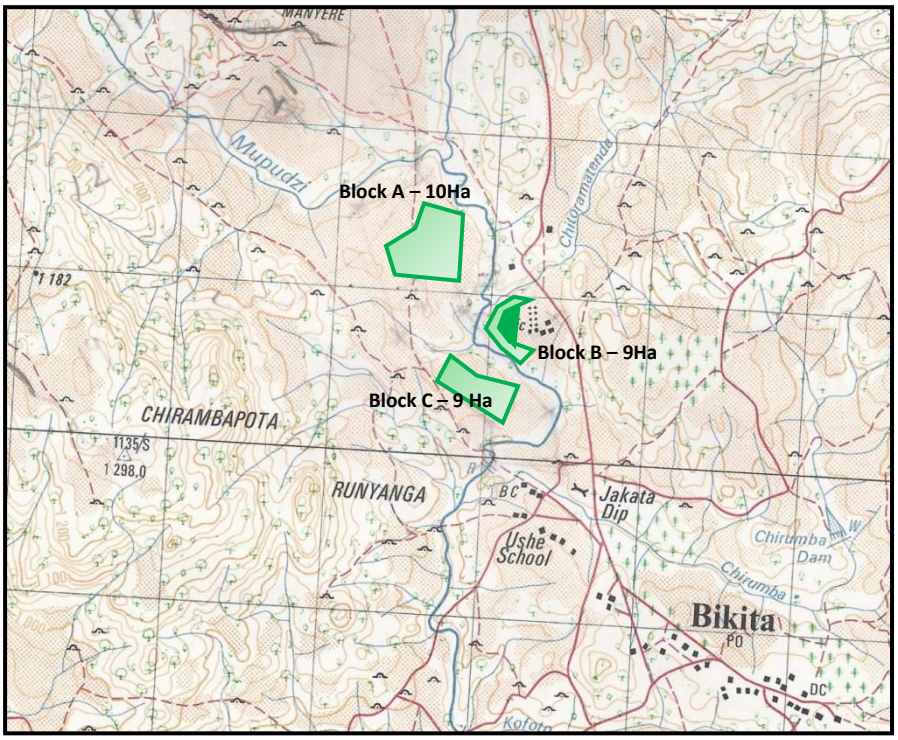


Figure 2 **Location of identified irrigation land**

The land is currently being utilised under rain-fed farming. It is owned by individual households, who have ceded their land for common use under the proposed scheme. The scheme also includes land which has been provided by the Bikita Hospital to establish a nutrition Garden for patients as well as staff.

A preliminary visual assessment that was undertaken during a recent site visit indicated similar soil types for all the tree blocks, dominated by sandy soils overlaying a soft quartzite rock. Terrain is gently undulating (3-5% slope) with visible signs of soil erosion including rills. Reworking of the soils is proposed to improve the soil for irrigation. This includes deep ploughing, accompanied initially by high rates of application of fertiliser and irrigation water.

Summary of the Hydrology

General climate

The hinterland area falls within agro-ecological region 4. However, the area around the project area has a micro- climate where rainfall is generally higher than the rest of the region. Consequently, it been classified under Region 3. Mean annual temperature is below 20^0 centigrade, while mean maximum temperatures are around are 30^0 centigrade. Long term mean annual rainfall is in excess of 1,000 mm. Analysis of rainfall data from a nearby rainfall stations shows a decreasing rainfall trend after 1999/2000 to 2013/14.

Existing Sources of Water

It is proposed to utilise yield from the perennial Mupudzi River as a source of water for the irrigation scheme. The river drains an area where rainfall is in the region of 1000 mm per annum. It enters Rozva River just above the Kufandada dam. A minor tributary, the Chitoramatende flows into Rozva River just below the dam. Yield analysis was undertaken at a location on Mupudzi River above the confluence with Rozva River, and below Kufandada dam after the confluence of Rozva River with Chitoramatende River. The results are summarised below:

Above the confluence with Rozva River

10% yield	186,400 m^3 per annum
20% yield	286,386 m^3 per an

Just below the confluence Chitoramatenda

10% yield	225,544 m^3 per annum
20% yield	346,528 m^3 per annum

The 20% yield of 346,528 m^3 per annum is adequate to meet the water demand for the 28 Ha irrigable lands. However, government policy requires the use of 10% yield for the planning of irrigation schemes.

Water rights and permits

A permit will be required from the Catchment Council to abstract water from Rozva River utilising the yield from Mupudzi River. There will also be a need to enter into a Memorandum of Agreement with ZINWA to obtain water from Rozva dam to supplement supplies in the event of low flows. ZINWA has given an undertaking that the permit will be made available, including entering into a Memorandum of Agreement to facilitate access to water from Rozva Dam for the irrigation scheme.

Water demand

Irrigation water demand

The estimation of irrigation water demand has been based on industry accepted standards for the region. The results of the analysis have been used in the design of the bulk water supply, as well as the sizing of irrigation land to be developed.

Error! Reference source not found. below gives indicative values of water requirements for common cereal and horticultural crops in Zimbabwe

Table 1 **Indicative values of crop water needs and sensitivity to water shortage**

Crop	Water need (mm/total growing period)	Sensitivity to drought
Bean	300-500	Medium-High
Cabbage	350-500	Medium-High
Maize	500-800	Medium-High
Onion	350-550	Medium-High
Groundnut	500-700	Low-Medium
Potato	500-700	High
Soya bean	450-700	Low-medium
Tomato	400-800	Medium-High

The analysis of bulk irrigation water demand was based on the following assumptions derived for the irrigation of 28 ha. It does not take into account the varying crop water requirements for different crops or efficiencies that can be realised by the various irrigation methods in common use. It has been used in the sizing of bulk water delivery components and to develop the general layout of infield irrigation systems.

Duration of irrigation cycle*	**:**	**7 days**
Irrigation days per cycle	:	5 days
Rate of application	:	45 mm per ha/ application
Total available irrigable land	:	28 ha
Total irrigation period per year (April – Nov)	:	244 days
Total no of cycles per year = 244/7	:	34.85
Therefore Irrigation water demand per ha/ year$(45 \times 10^4 \times 34.85)/10^3$ m^3	:	15,682 m^3
Effective irrigation days per year = 5 x 34.85	:	174.28 days
Total area of irrigation fields		28 ha

Total annual water demand for ha	:	439,096 m^3
Nominal area to be irrigated per cycle	:	5.6 ha
Total water demand per day	:	2,520 m^3
10% Yield of Mupudzi at the confluence with Chitoramatende River	:	1,294 m^3/day

The above indicates a shortfall of 1,226 m^3/day, at a 10% level of service. The average yield of Mupudzi River is estimated at 5,312 m^3/day. Thus on average, there will be adequate flow to cater for the planned irrigation scheme, with shortfalls being experienced during periods of low flow. As indicated earlier, these shortfalls will be supplemented by releases obtained from Rozva Dam.

Domestic water demand and sanitation coverage

Villagers get water for their domestic purposes from shallow and deep wells. During good rainfall years water is generally available for domestic purposes. However there are reports that shortages occurred in the past and some boreholes were sunk by some non-governmental organisations to assist the villagers.

Of three boreholes constructed and equipped with bush pumps only one is still functional. Some villagers walk more than a kilometre to the existing borehole to augment their domestic water supplies.

Estimated No. of households	120
Assuming a household size of	4.5
Total estimated population in the project area	540
Unit water consumption	20 l/person/day
Total water demand per day	10.8 m3

Existing water supplies consist of one functional borehole in Nhamo Village, and two which have broken down hand pumps. One site was surveyed but not drilled.

Livestock water consumption

Because of relative good availability of perennial river flows on Rozva and Mpudzi Rivers, water for domestic animal consumption is considered to be adequate.

Description of Kufandada Irrigation Scheme

Size of irrigation scheme

Hydrological analysis indicated that a total of 28 ha could be irrigated from the average yield of the combined flow from Mupudzi River and Chitoramatende River supplemented by releases from Rozva dam during periods of low flow. The irrigated area is apportioned between the three irrigation blocks as follows:

Block A - 10 ha

Block B - 9 ha

Block C - 9 ha

Two sites have been investigated for the abstraction of water to irrigate the above blocks. The locations of the sites are shown in the excerpt from the 1:50,000 map Figure 3 below.

Site 1 – Weir on Mupudzi River

Site 1 is located on Mupudzi River, approximately 300 m upstream of the confluence with Rozva River, at geographic co-ordinates 20° 3.45'S and 31° 35.93'E. There are no rock outcrops visible at the site, which would be suitable for the 5 m high, 130 m long earth dam. The purpose of the dam will be to facilitate the diversion of water to the pump station located on the left bank. It would be a run-off river arrangement with minimum storage, receiving flows only from the Mpudzi River.

The riverbed elevation is approximately 926 m above mean sea level. Assuming a total freeboard of 3 m the dam would raise the water level to a minimum of 929 m.

Site 2 – Weir on Rozva River

Site 2 is located on Rozva River, approximately 240 m downstream of the existing Kufandada Dam, at geographic reference 20° 3.958'S and 31° 36.193'E, just after the confluence with Chitoramatende River. The site has solid rock outcrops across the width of the river channel, which offers ideal foundation conditions for a masonry weir. The pump station would be located on the right bank.

The weir will act as a pick-up facility to facilitate abstraction of water from the Rozva River. It will receive flows from both Mupudzi River and Chitoramatende River, both tributaries of the Rozva River. It will also be possible to utilise releases from Rozva Dam during periods of low/no flows in the Mupudzi and Chitoramatende Rivers.

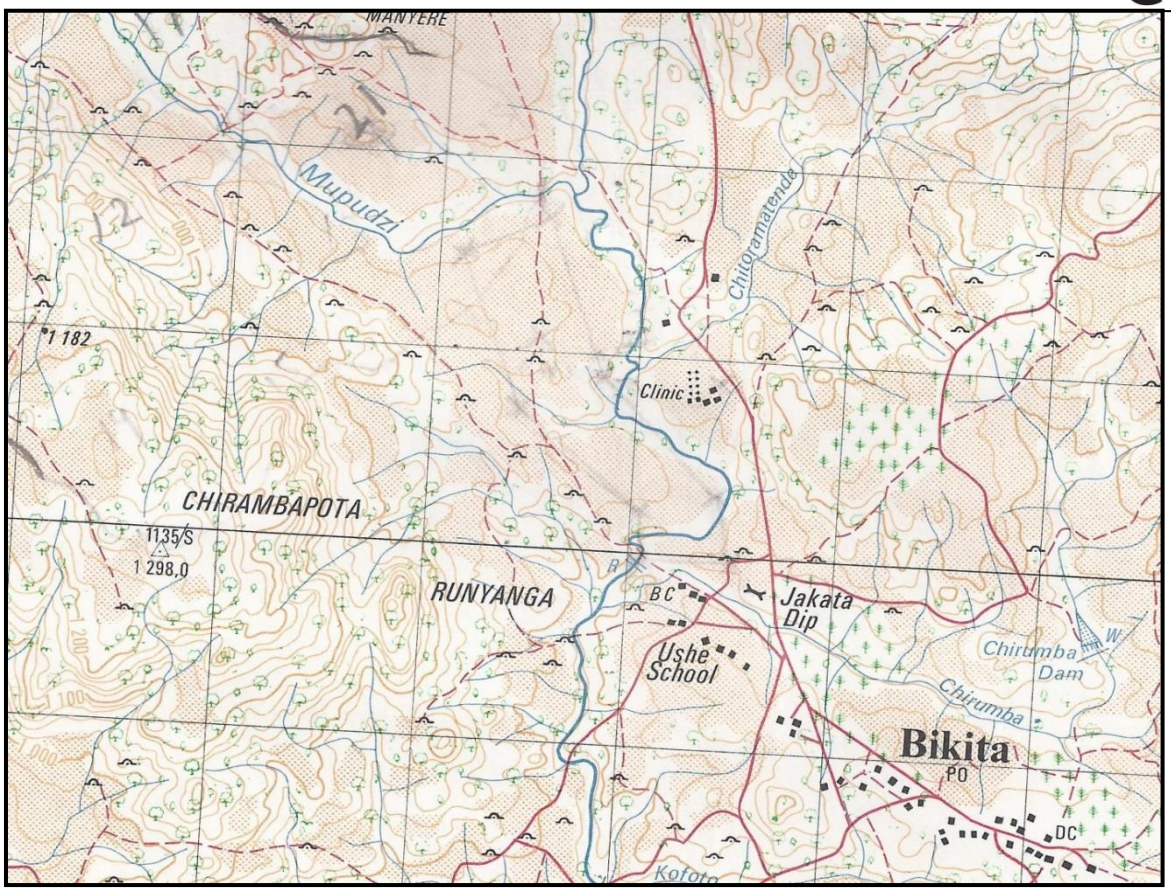


Figure 3 **Locations of potential abstraction sites**

The riverbed elevation is approximately 910 m above mean sea level. Assuming a weir height of 3 m, the weir will raise the water level to a minimum of about 913 m.

A comparative analysis of the two sites was undertaken at feasibility stage and Site 2 selected for the diversion of water to the irrigation blocks.

Design flows

Bulk water Supply to Night Storage

The adopted design criterion for the bulk water supply is based on the delivery of bulk water to night storage over a maximum period of 16 hours using the industry standard which assumes a water demand of 15,000 m^3/ha/annum.

The calculated design flows for the irrigation of 28 ha of Block A are as follows:

Delivery to night storage - 0.044 m^3/s =157.5 m^3/hr

The above flow was used to design the pumping mains for the delivery of bulk water supply.

Irrigation Water Demand at the Field

Irrigation water demand depends on the type of soils, climate, topography and the irrigation system employed. The selection of the most appropriate irrigation system was based on agro-socio-economic characteristics of the commonly used irrigation systems in Zimbabwe. The drag line sprinkler irrigation system was selected as the most suitable one for adoption at Kufandada Irrigation Scheme.

The FAO approach was adopted to determine the irrigation demand at the field based on sprinkler irrigation of a maize crop. The results are summarised in Table 2 below.

Table 2 **Irrigation design data based on a maize crop**

Area to be irrigated (ha)	**28**	
Pan evaporation rate (mm/day)	8	Bindagombe Dam Station
Crop factor (f)	0.7	
Water holding capacity (mm/m)	55	Sandy loam
Infiltration rate of the soil	12	
Effective rooting depth(m)	0.9	
% allowable water depletion	50	
System efficiency (%)	80	
Effective rainfall (mm/day)	0	
lateral spacing (m)	18	
Sprinkler spacing (m)	12	
Calculated		
Evapotranspiration(mm/day)	5.6	
Readily available water(mm)	24.8	
Net irrigation requirement (mm/day)	5.6	
Gross irrigation requirement (mm/day)	7	
Calculated Cycle Length	4.4	
Actual Cycle Length	5	
Irrigable land per day (Ha)	5.6	
Wetted area (m^2)	216	
Application rate (mm/h)	7.87	
Sprinkler discharge (m^3/h)	1.7	
Gross application rate (mm/h)	7.87037037	Sprinkler size is ok

Net application rate (mm/hr)	6.3	
standing time (hr)	3.9	
No of sets per day	2	
Working hours per day (hr)	7.9	
No of sets per cycle	10.0	
Gross application per cycle (mm)	35.0	
No of sprinklers operating simultaneously(>=)	130	
System Capacity (m^3/hr)	220.4	
	61.2	l/s

The above design flows were used to size the pumping system and gravity mains.

General layout

It is proposed to abstract water from Rozva River at a location approximately 250m downstream of existing Kufandada Dam to irrigate 28 ha of land distributed in the three blocks as described above. The general layout of the scheme is shown in schematic Figure 4 below. Water will be pumped from the river to night storage reservoirs located at an elevated location west of the river. From the night storage reservoirs, it will gravitate to the irrigation fields. A description of the key components of the scheme is outlined in the following sub-sections.

Pick-up Weir on the Rozva River

It is proposed to construct a masonry gravity pick-up weir on Rozva River just downstream of the confluence with Chituramatenda River. The selected site of the weir is rocky, with numerous boulders. A photograph of the site is shown in Figure 5 below. Foundation conditions are expected to be adequate to support the masonry structure. However, conditions in the right bank are uncertain due to the absence of a visible rock outcrop. The weir will be 40 m long and 3.5 m high, at the deepest section of the river. The crest of the weir will be 1 m wide with a downstream of 4:3, and a vertical upstream face. The stability of the weir was checked against overturning, sliding and uplifting at a maximum flood surcharge of 2.5 m above the crest using CADAM 2000 software and found to be adequate. The output from the stability computations is presented in Appendix 1.

The intake will comprise a raised bellmouth pipe in a screened chamber connected to a 40 m long, 300mm diameter suction pipe leading to the pumping station in the right bank, downstream of the weir. A gate valve on the suction main and within the pumping station is proposed for maintenance and installation of additional appurtenances.

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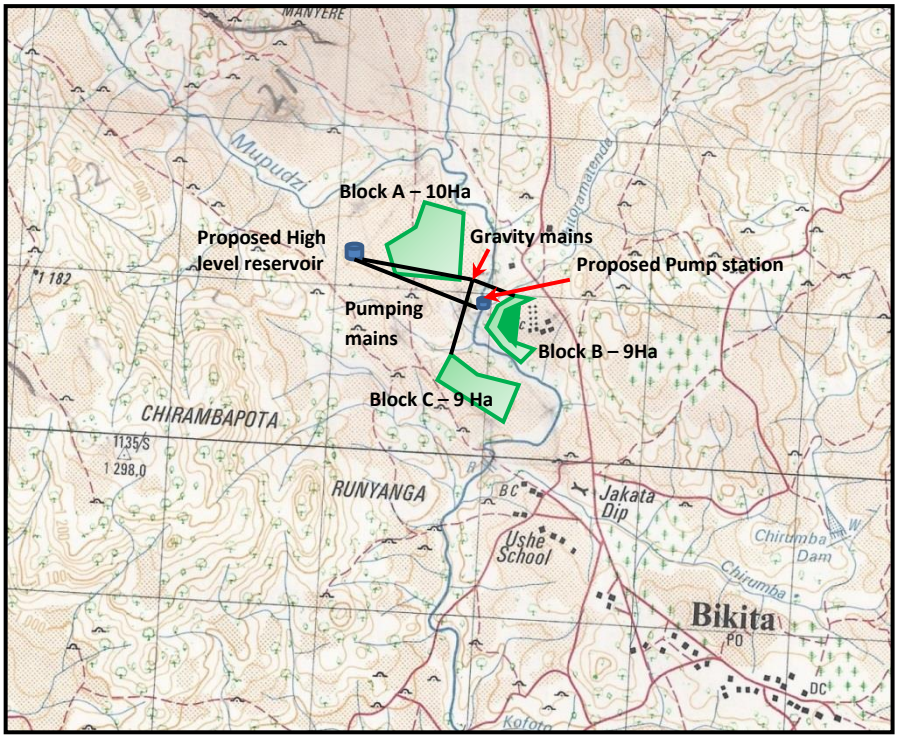


Figure 4 **General layout of proposed Kufandada irrigation scheme**

Depending on ground conditions in the right bank of the river established during the start of construction, it is proposed to protect the right weir abutment with a combination of gabions, rock and stone pitching. A barrier to deliberately block access to the top of the weir to discourage villagers and kids will be installed

The weir has been design as a run-of-river structure primarily to raise the water level, with minimal upstream storage.

Suction Main

The suction main is a 40m long 300mm diameter steel pipe which terminates in a 400mm diameter suction manifold pipe within the pumping station. An isolation gate valves to allow repairs is proposed within the pumping station. At the inlet point, the suction pipe will be fitted with a gate to isolate the pump station during maintenance.

Thrust blocks have been designed to provide support on all the bends along the pipeline. Concrete encasement has also been designed where there is little cover.

Figure 5 **Pick-up weir site**

Pump Station

The pump station will be located downstream of the weir, above flood level. It will be an excavated dry pit on the right bank. Two centrifugal pumps will be provided, one duty with one standby pumping, delivering 158 m^3/hr against a total head 60 m. The pumps are designed to switch on and off when the reservoirs are full by use of a level switch. The pumps will be driven by a 32 kW, 3-phase, 4-pole electric motors supplied from a dedicated ZETDC transformer.

The low level dry pit of the pump station will ensure a flooded suction under all operating conditions.

The 10 m long and 6 m wide pump station building will be constructed from brick under corrugated iron / fibreglass roof sheeting, supported on steel trusses. A 1.5 tonne overhead crane will be provided to facilitate installation and maintenance.

Inlet and outlet pipework has been designed with 45^o bends to limit head losses in the pump station, particularly on the suction side.

There will be provision for pump attendants quarters, designed to ZINWA standard. The installation will be fenced and gated to provide security.

Pumping Mains

From the pump station water will be delivered to 2 No 1 Ml prefabricated night storage reservoirs located on a hill through an 950m long, 200 mm diameter, mPVC Class 16/Steel pipeline. Air and scour valves will be provided as necessary along the pipeline.

Thrust blocks have been designed to provide support on all the bends along the pipeline.

Night Storage

Two prefabricated night storage reservoirs each with a capacity of 1 ML will be supported on reinforced concrete floor slabs at the top of the knoll. The reservoirs will be fabricated from high yield galvanised iron sheeting, and lined internally with 1 mm thick PVC.

A valved bifurcation will supply both reservoirs simultaneously from the pump station. There will be separate outlets from the reservoirs, which will lead to a second bifurcation to deliver water from both reservoirs simultaneously into the gravity mains.

Gravity Mains

Water will gravitate from the storage reservoir through a 773 m long 250 mm diameter Class 6 mPVC pipeline which passes through the middle of block A in the east, feeding into secondary mains that supply the block. At the end of the block, on its eastern boundary, the pipeline will turn southwards, reducing in diameter to 200 mm class 6 mPVC piping, and running for 309 m before bifurcating near the pump station to feed Block B to the east and Block C in the south. The 390 m long limb supplying block B will cross the river just below the weir, passing through a grave yard, to terminate at the western boundary of the block. The section across the river and through the graveyard will be laid over the 95 m span in steel piping. From the bifurcation, block C will be fed by a 478 m long 200 mm diameter mPVC class 6 buried pipeline except at stream crossings where steel, supported on concrete columns, will be used.

Air and scour valves will be provided as necessary along the pipeline. Thrust blocks have been designed to provide support on all the bends along the pipeline.

Infield Irrigation Systems

Analysis of the three different irrigation systems selected the drag hose sprinkler irrigation system as the most suitable for adoption for Kufandada irrigation scheme. It is adaptable to any terrain, as well as small irregular plots. In addition, nearly all crops can be irrigated by the system, although the characteristics of the crop, especially the height, have been considered in system selection.

A preliminary design of the system has been undertaken to establish the general lay out of the systems. Final design will be carried out by the equipment supplier.

Typical design data for the system based a maize crop and the size and geometry of the irrigation field is summarised in Table 2 above.

System Hydraulics

Pumping systems

Figure 6 below shows the hydraulic grade line for the suction and pumping mains. Suction conditions are flooded throughout the pipeline, with all pressures in the pumping main are above the allowable maximum working pressure. The contractor will be required to make the final pump selection which will need to be

approved by the Engineer. The final control philosophy of the pumps will also be jointly developed with the contractor to suit final selected pump.

A preliminary pump selection was carried out based on a KSB pump series. The most suitable pump was found to be the Etanorm 100-08-250. The pump performance and system curves are shown in Figure 7 below. Conditions in the pumping main will be as follows:

Manometric discharge head at normal operating level (weir crest level) = m

Suction conditions for the pump considered are as follows:

Available NPSH = 9.5 m

Required NPSH = 4 m

While the design has been made on the KSB model to test functionality, the BoQs will refer to pump duty point requirements, and not specific pump model.

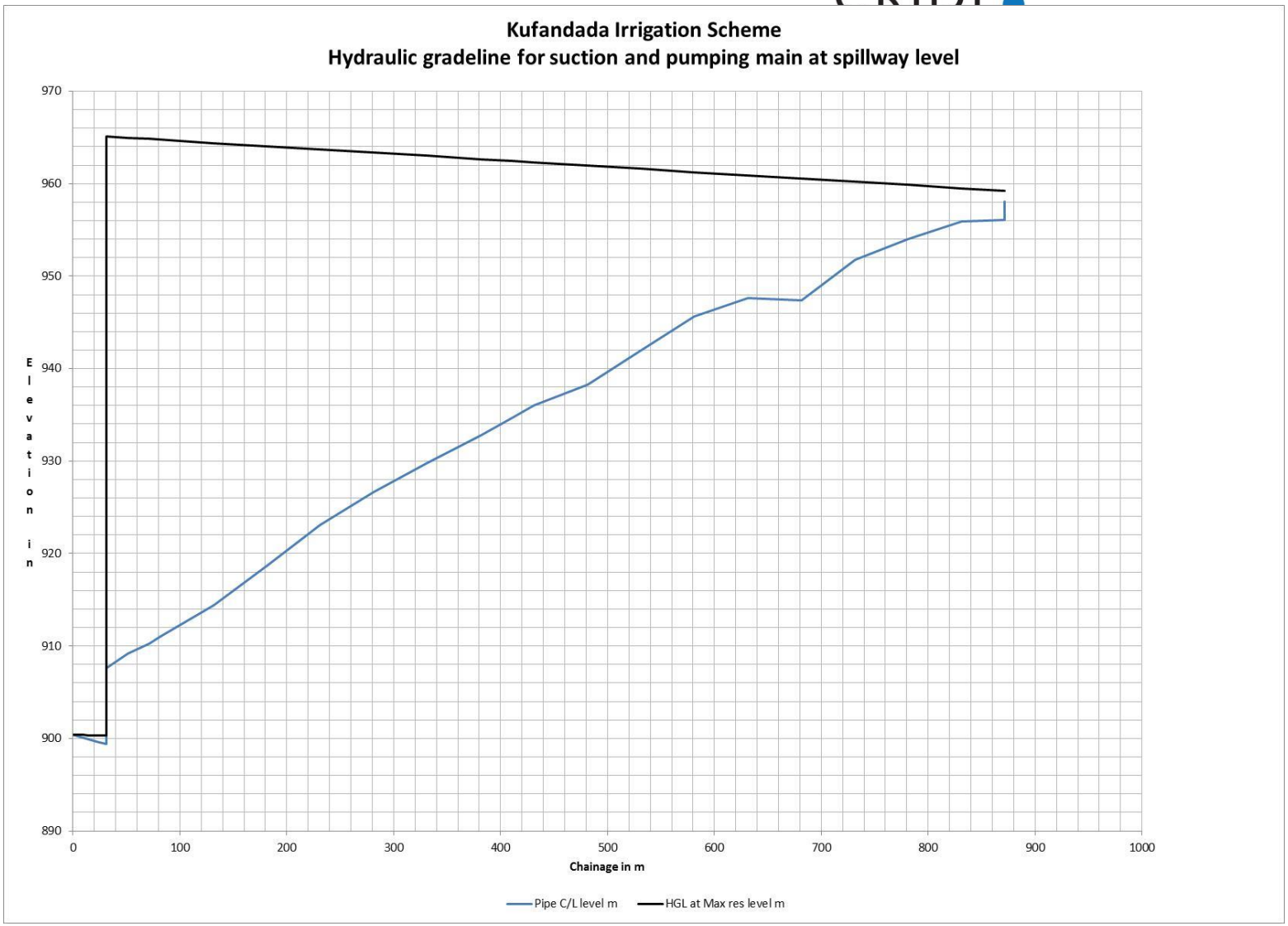


Figure 6 **Hydraulic gradeline for suction and pumping mains**

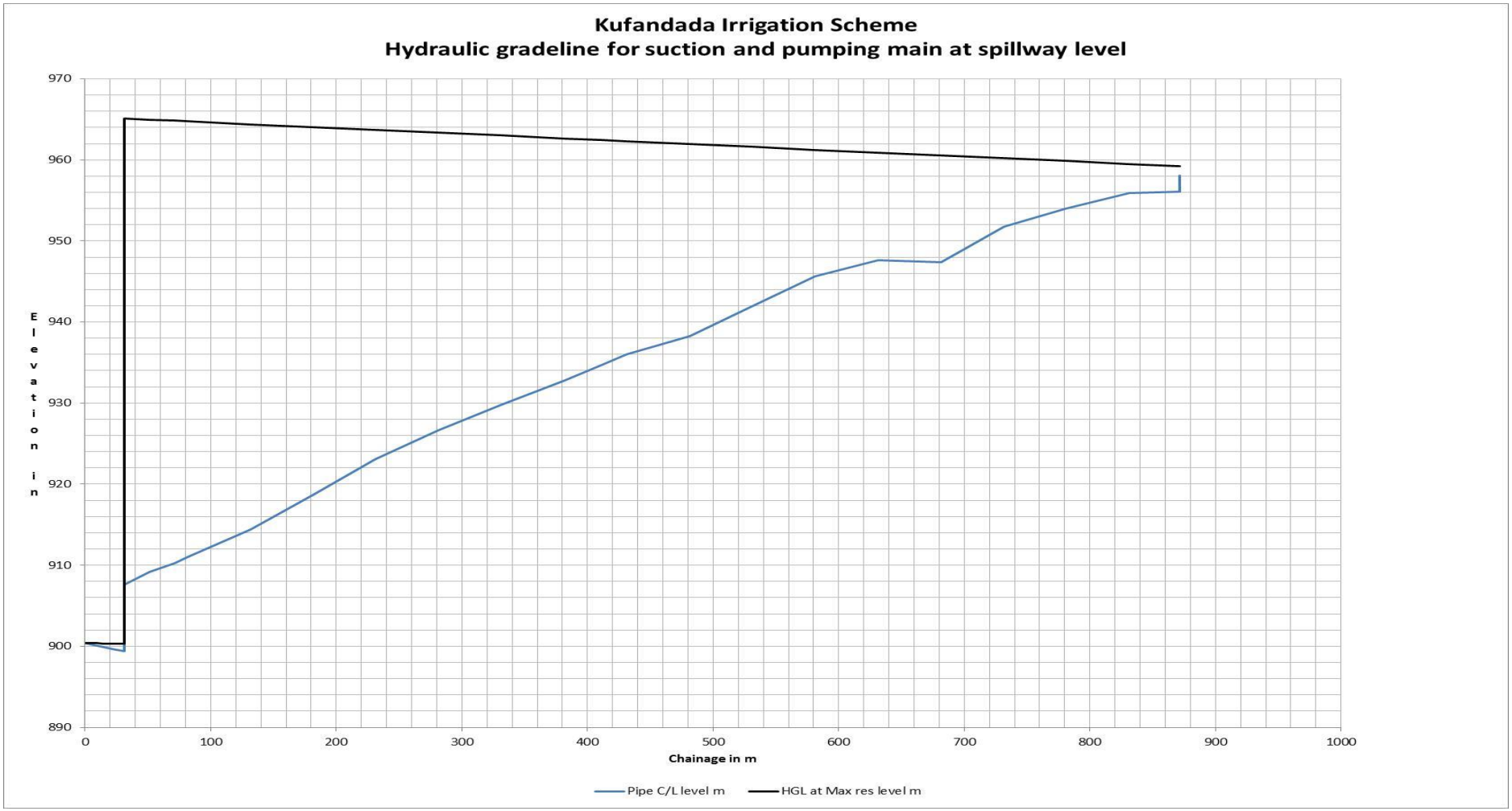


Figure 7 **Typical Pump performance and system curve**

Gravity Mains

The gravity mains has been designed to ensure adequate pressure in the in-field irrigation system, in as far as is possible, within the constraints of the existing topography. Pressures in Block A range from about 14.05 at the upstream end of the secondary main, increasing to about 39 m at the extreme end to the east of the block. The lower pressures in the western side are due to the higher elevations in the western portion of the block. *It will be necessary to use hose pipes for irrigation in the low pressure zones when demand in the system is close to maximum and pressures are low.* All areas under Block B and C are within the minimum design pressure zone of around 30 m for the use of sprinkler irrigation.

Rapid valve closure at the delivery to the irrigation field within a period of less than critical time of 2.5 seconds will result in maximum surge pressures being experienced in the system.

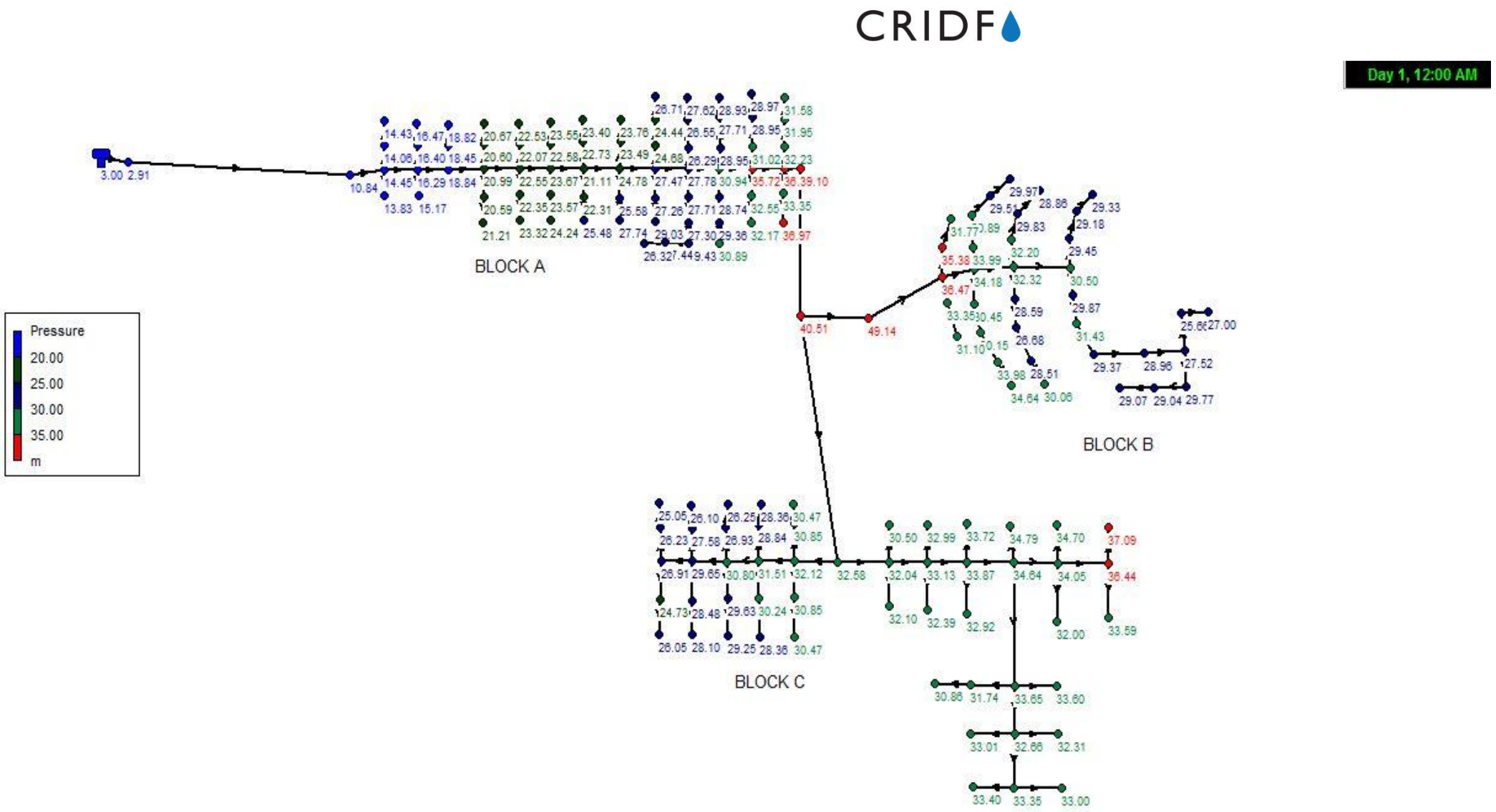
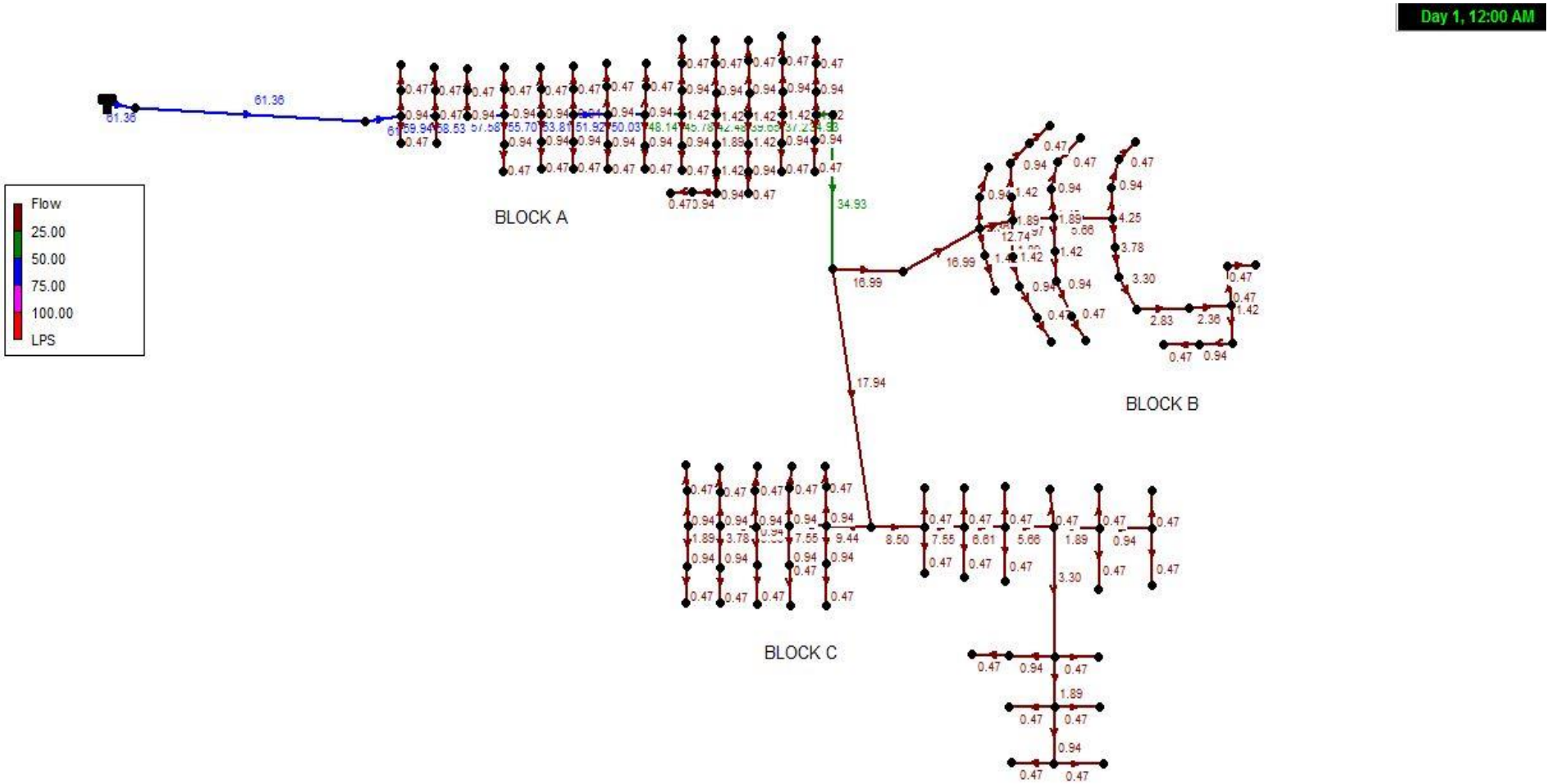


Figure 8 **Epanet model showing irrigation system pressures for Kufandada irrigation network**

Figure 9 **Epanet model showing irrigation system flows in l/s for Kufandada irrigation network**



Proposed Agronomic Model

Cropping Patterns

The selected cropping pattern for Kufandada Irrigation Scheme has been designed to increase agricultural production and the incomes of the poorest families, as well as strengthening organisation at grass-roots level. New high yielding and more profitable crops are proposed for the scheme as shown:

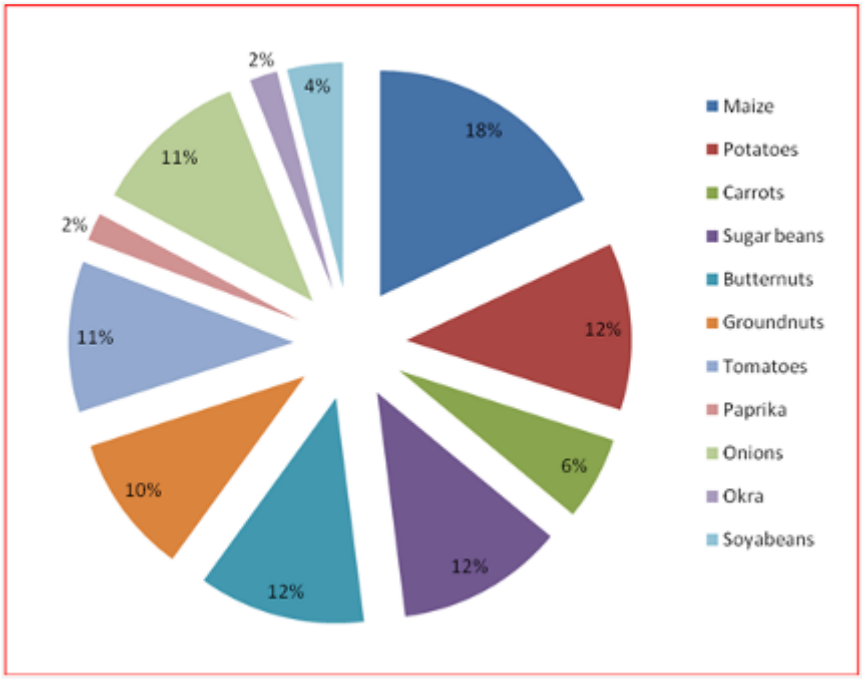


Figure 10 **Proposed cropping programme**

The selection of an intensive horticulture production of high value crops is predicated by the limited land size available as well as the need to maximise incomes among beneficiaries. Technical issues related to rotation and seasonality, diversity and the need for efficient utilization of irrigation water were also taken into consideration.

Environmental protection

Extensive erosion is occurring on the left bank of Rozva River immediately downstream of Kufandada Dam. This erosion is slowly encroaching the area between the river and the main road. It is proposed to place gabion mats against the gulley walls to arrest the erosion

There is widespread stream bank and in-stream cultivation along the Rozva River and its tributaries. This has resulted in extensive water habitats destruction and siltation of water bodies. It is proposed to re-establish the statutory 30m buffer protection zones and plant grass and indigenous trees for protection in select areas.

Water supply and sanitation

Options for the water supply were investigated, including connection to the ZINWA system and the provision of groundwater supplies. It is recommended that two new boreholes be drilled, as well as the rehabilitation of the broken down hand pump at the existing borehole; the location of the boreholes is shown below.

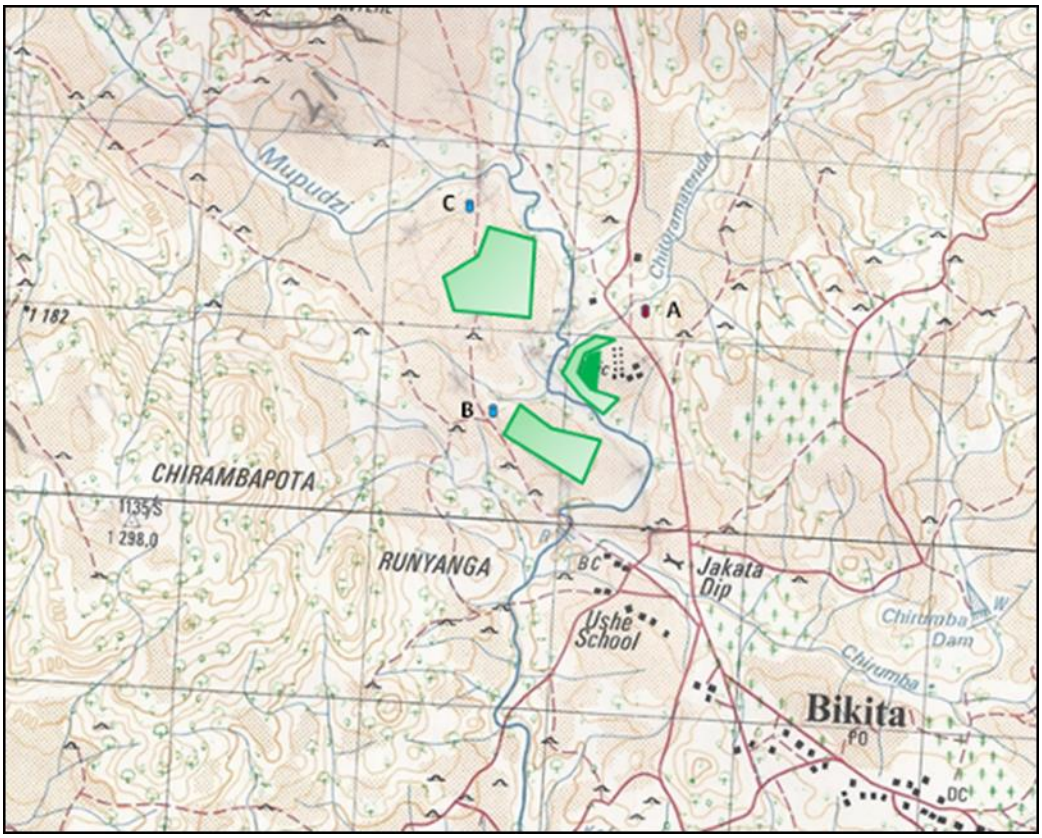


Figure 11 **Location of proposed boreholes**

Sanitation

Access to proper sanitation facilities is still a challenge for many as they still practice open defecation. The ventilated-improved pit (VIP) latrine is recommended as the long term solution for sanitation in rural communities.

The proposed delivery mode for sanitation is for the project to supply selected building materials for 24 VIPs with the beneficiaries providing construction labour.

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Drawings

The following drawings have been prepared for the design of components of the scheme.

Drawing Title	Drawing No
1. General Layout (insert – locality Map)	QW06/CE01
2. Plan and longitudinal section of pumping mains	QW06/CE02 SHT 1-5
3. Plan and longitudinal section of suction mains	QW06/CE03 SHT 1-9
4. Plan and longitudinal section of suction mains	QW06/CE04 SHT 1-5
5. Valve Chamber details	QW06/CE05
6. Pumping Station and Weir Details	QW06/CE06
7. River Crossing Details	QW06/CE07
8. Anchor and Thrust Block Details	QW06/CE08
9. 2ml Galvanised Steel Tank, Plan And Sections	QW06/SE01
10. Irrigation Field	
10.1. Layout of sprinkler system	
10.2. Erosion protection and drainage system	
10.3. Blair Toilet	

.

Cost Estimates

A Bill of Quantities has been developed based on the abstraction of water from Rozva River, and the design and drawings for the proposed scheme described in the Report. The estimated cost for the implementation of Kufandada Irrigation Scheme is summarised below.

	SUMMARY				
1	Pipeline				139,034.51
2	2.0 Ml Reservoir				145,420.00
3	Pump Station				**74,990.00**
4	Infield Works				72,856.53
5	Weir Construction				51,605.00
6	Environmental				6,937.50
	Subtotal				**490,843.54**
	Add CONTINGENCIES			0.10	**49,084.35**
	Add VAT 15%			0.15	**73,626.53**
	TOTAL				**613,554.42**
	Management contractor				90,000.00
	Technical support costs				12,000.00
	Direct labour costs			2%	**9,203.32**
	GRAND TOTAL				**724,757.74**

A breakdown of costs is given in the priced Bill of Quantities in Appendix 3.

A comparison of bankability stage budget estimates against current estimates is given below:

Kufandada Budget Review

Item	SUMMARY	Feasibility Stage	Design Stage	Difference	Comment
1	**PIPELINE**	**85,692.84**	**139,034.51**	**53,341.67**	• Pipe class for pumping main was increased to 16 • additional steel sections • Pipe fittings were underestimated at the feasibility stage
2	**2.0 ML RESERVOIR**	**145,420.00**	**145,420.00**	**0.00**	-
3	**PUMP STATION**	**56,000.00**	**74,990.00**	**18,990.00**	• The 11kV overhead line was changed to 33kV because ZESA is no longer installing 11kV lines • The transformer was upgraded from 200kVA to 500kVA • Pump attendant's quarters was omitted at the feasibility stage
4	**INFIELD WORKS**	**85,249.75**	**72,856.53**	**-12,393.22**	• Secondary infield pipes were reduced
5	**WEIR CONSTRUCTION**	**51,605.00**	**51,605.00**	**0.00**	**-**
	ENVIRONMENTAL	**6,937.50**	**6,937.50**	**0.00**	**-**

	SUBTOTAL	**430,905.09**	**490,843.54**	**59,938.45**	**-**
	Add CONTINGENCIES	**43,090.51**	**49,084.35**	**5,993.84**	**-**
	Add VAT 15%	**64,635.76**	**73,626.53**	**8,990.77**	**-**
	TOTAL	**538,631.36**	**613,554.42**	**74,923.06**	-
	MANAGEMENT CONTRACTOR	**90,000.00**	**90,000.00**	**0.00**	-
	TECHNICAL SUPPORT COSTS	**12,000.00**	**12,000.00**	**0.00**	-
	DIRECT LABOUR COSTS	**8,079.47**	**9,203.32**	**1,123.85**	-
	GRAND TOTAL	**648,710.83**	**724,757.74**	**76,046.91**	• 10.4 % increase

Appendices

Appendix 1: Proposed Weir Stability Calculations

CADAM 2000 - GEOMETRY REPORT

Project: Kufandada Irrigation Scheme	Project engineer: Interconsult Zimbabwe
Dam: Kufandada Weir	Analysis performed by:
Owner: Kufandada Irrigation Scheme	Date: 11/02/2015 9:49
Dam location: Bikita, Zimbabwe	Units: Metric

Geometry

L1=	4.000 m
L2=	0.000 m
L3=	2.500 m
L4=	1.000 m
Elev. A=	899.000 m
Elev. B=	899.000 m
Elev. C=	901.000 m
Elev. D=	900.000 m
Elev. E=	902.000 m
Elev. F=	902.000 m
Elev. G=	904.000 m
Elev. H=	900.000 m
Elev. I =	900.000 m

Concrete Volumetric Mass

ρ=	2400 kg/m³

Lift Joint Material Properties

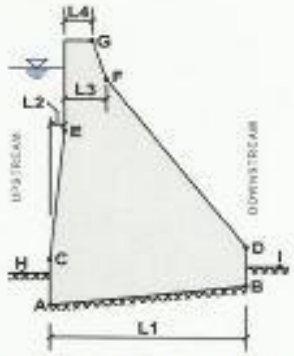
Material name	Concrete strength fc (kPa)	Concrete strength ft (kPa)	Peak friction Cohesion (kPa)	Peak friction Angle (deg)	Residual friction Cohesion (kPa)	Residual friction Angle (deg)	Minimal compressive stress for cohesion (kPa)
Base joint	30000	0	0	55	0	45	0

Lift Joint(s)

Joint id	material name	Upstream end Elevation (m)	Upstream end Position x (m)	Downstream end Elevation (m)	Downstream end Position x (m)	Length (m)	Inertia (m^4)
Base	Base joint	899.000	0.000	899.000	4.000	4.000	5.333333333

Pre-Cracked Lift Joint(s)

Joint id	material name	Upstream end Crack length (m)	Upstream end Crack length (%)	Downstream end Crack length (m)	Downstream end Crack length (%)
Base	Base joint	-	-	-	-



Water Volumetric Mass

ρ=	9.810 kg/m³

Ice cover

Load=	0 kN
Thickness=	0.000 m
Elevation=	904.000 m

Silts

Elevation=	900.000 m
γ=	7 kN/m³
ϕ=	20 deg
Assumption=	at rest

Reservoirs

	Upstream side	Downstream side
Normal operating level:	904.000 m	901.000 m
Flood level:	906.500 m	903.000 m
Crest overtopping pressure	100.00 %	50.00 %

Uplift pressures: Uplift pressures are considered as an external load (linearisation of effective stresses)

Cracking options

cracking considered for all combinations: No

Numerical options

Convergence method:	Bi-section
Accuracy=	Medium (1E-6)

Tensile strength

	Usual	Flood	Seismic	Post-seismic
Crack initiation=	ft / 3.000	ft / 3.000	ft / 3.000	ft / 3.000
Crack propagation=	ft /10.000	ft /10.000	ft /10.000	ft /10.000
Seismic magnification=			1.500	

Uplift pressures

Static analysis:	Full uplift pressures applied to the crack section
Dynamic analysis:	Uplift pressures remain unchanged
Post-seismic analysis:	Full uplift pressures applied to the crack section
D/S closed crack:	Restore uncracked uplift condition
Drain effectiveness:	No drain effectiveness under any cracking condition

CADAM 2000 - Result report

Project:	Kufandada Irrigation Scheme	Project engineer:	Interconsult Zimbabwe
Dam:	Kufandada Weir	Analysis performed by:	
Owner:	Kufandada Irrigation Scheme	Date:	11 February 15
Dam location:	Bikita, Zimbabwe	Units:	Metric

LOAD COMBINATION FACTORS

	Usual	Flood	Seismic #1	Seismic #2	Post-seismic
Self-weight	1.000				
Hydrostatic (upstream)	1.000				
Hydrostatic (downstream)	1.000				
Uplift pressures	1.000				
Silts					
Ice					
Post-tensioning					
Applied forces					
Seismic (horizontal)					
Seismic (vertical)					

USUAL COMBINATION (STRESS ANALYSIS)

Joint		Cracking				Stresses							
		Upstream		Downstream		Normal stresses		alowable stresses		Shear			
ID	Upstream elevation (m)	Crack length (%)	(m)	Crack length (%)	(m)	Upstream (kPa)	Downstream (kPa)	tension (kPa)	Compression (kPa)	Upstream (kPa)	Maximum (kPa)	Maximum at l-axis (% of joint)	Downstream (kPa)
1	Base					-13.098	-84.879	0.000	-9990.000	0.000	38.627	50.000	0.000

USUAL COMBINATION (STABILITY ANALYSIS)

Joint		Safety factors					Resultants				Uplift	Rock
		Sliding		Overturning		Uplifting	Normal	Shear	Moment	Position	Final Force	Passive wedge resistance
ID	Upstream elevation (m)	Peak	Residual	Toward U/S	Toward D/S		(kN)	(kN)	(kN-m)	(% of joint)	(kN)	(kN)
1	Base	2.717	1.902	2.962	1.571	2.427	-196.0	103.0	95.7	62.211	137.3	0.000

FLOOD COMBINATION (STRESS ANALYSIS)

Joint		Cracking				Stresses							
		Upstream		Downstream		Normal stresses		alowable stresses		Shear			
ID	Upstream elevation (m)	Crack length (%)	(m)	Crack length (%)	(m)	Upstream (kPa)	Downstream (kPa)	tension (kPa)	Compression (kPa)	Upstream (kPa)	Maximum (kPa)	Maximum at l-axis (% of joint)	Downstream (kPa)
1	Base					0.000	0.000	0.000	-15000.000				

FLOOD COMBINATION (STABILITY ANALYSIS)

Joint		Safety factors					Resultants				Uplift	Rock
		Sliding		Overturning		Uplifting	Normal	Shear	Moment	Position	Final Force	Passive wedge resistance
ID	Upstream elevation (m)	Peak	Residual	Toward U/S	Toward D/S		(kN)	(kN)	(kN-m)	(% of joint)	(kN)	(kN)
1	Base	> 100	> 100	> 100	> 100	> 100	0.0	0.0	0.0	50.000	225.6	0.000
	Required:	2.000	1.300	1.100	1.100	1.100						

Appendix 2: Letter of undertaking to enter into a memorandum of Agreement with ZINWA

WATER IS LIFE
Zimbabwe National Water Authority
ZINWA
EVERY DROP COUNTS

Save Catchment
P.O. Box 210
Mutare
Tel:020 60926
Fax: 020 62848
Email: zinwas@mweb.co.zw

Interconsult Zimbabwe
Consulting Engineers
P.O Box 4710
Harare, Zimbabwe

Thursday, 29 January 2015

Attention: Mr. V. Tapfuma

Dear Sir

RE: APPLICATION FOR A WATER PERMIT AND AGREEMENT WATER; KUFANDADA IRRIGATION SCHEME

We acknowledge receipt of your letter, dated 27 January 2015, on the above subject matter. We hereby confirm that the application process for Mupudzi River Water abstraction Permit should be done through Lower Save West SubCatchment Council for determination by Save Catchment Council. For the supplementary requirements from Rozva Dam, the Agreement Water application should be made directly through ZINWA Save for determination.

In light of the 9-months supplementary water requirements of 675ML (megalitres) from Rozva dam, we are confirming that, given the current Rozva Dam commitments, **the required volumes of water for Kufandada Irrigation Project is available and shall be made available.**

Zimbabwe National Water Authority
CATCHMENT MANAGER
29 JAN 2015
SAVE CATCHMENT
7 PARK ROAD
P.O. BOX 210, MUTARE

Yours, Truly

V. S. Mazambani (PrEng)
Catchment Manager - Save River Basin

CC; Save Catchment Council Chairperson – Mr. W. Nyatanga
LSW SubCatchment Council Chairperson – Chief Budzi (Mr.)

Head Office
8th floor Old Mutual Centre
3rd Street / Jason Moyo Avenue
P.O. Box CY 617
Causeway, Harare
Tel:04 797610-3 / 04 797 604-7
Fax: 04 708732 / 04 796980
Email: zinwa@mweb.co.zw

RuraleCatchment
P.O. Box 250
Mvurwi
Tel:029 262490/262950-2
Fax: 029 263972

Save Catchment
P.O. Box 554
Mutare
Tel:054 22251-4
Fax:054 220168

Gwayi Catchment
P.O. Box 565
Bulawayo
Tel:09 69361-3/67628
Fax: 09 77109

Mzingwane Catchment
P.O. Box 2008
Bulawayo
Tel:09 885191/2/3/8
Fax: 09 883863

Manyame Catchment
P.O. Box CY 2008
Harare
Tel:738784-6
Fax: 738785

Mazowe Catchment
3rd Floor, Old Mutual House
2nd Street/Speke Ave
P.O. Box CY 715, Causeway
Harare
Tel:738781-3 / 761465-6 / 761280
Fax: 791394

Appendix 3: Bill of Quantities

Item	Description	Qty	Unit	Rate	Cost
1	PIPELINE				
1.3	Pipe Laying				
1.3.1	**Supply MPVC pumping mains**				
	a) 200 mm dia Class 16	840	m	39.22	32,944.80
1.3.2	**Supply MPVC gravity mains**				
	a) 250 mm dia Class 6	482	m	26.98	13,004.36
	b)200mm dia Class 6	601.5	m	17.65	10,616.48
	c)160mm dia Class 6	773	m	11.52	8,904.96
1.3.3	**Supply Steel gravity mains**				
	a) 160 mm dia PN 160	105	m	80.75	8,478.75
1.3.3	**Supply and install fittings pumping mains**				
1.3.3.1	mPVC (Class 6) Bends				
	a) 200 x 45°	0	No.	71.04	0.00
	b) 200 x 22,5°	2	No.	71.04	142.08
	c) 200 x 11,25°	5	No.	71.04	355.20
1.3.3.2	GI Bends				
	a) 200 x 45°	2	No.	700.00	1,400.00
	b) 200 x 22,5°	4	No.	700.00	2,800.00
	c) 200 x 11,25°	1	No.	700.00	700.00
1.3.3.3	CI reducers				
	a) 250/200	0	No.		
1.3.3.4	PVC Tees				
	200 dia equal tee	0	No.	133.75	0.00
1.3.3.5	CI Gate valves				
	a) 250 dia	2	No.	2,500.00	5,000.00
	b) 200 dia	0	No.	2,500.00	0.00
1.3.3.6	Air Valves				

	a) 250 dia	0	No.	1,200.00	0.00
	b) 200 dia	2	No.	1,200.00	2,400.00
1.3.3.7	Scour Valves				
	a) 250 dia	0	No.	1,200.00	0.00
	b) 200 dia	2	No.	1,200.00	2,400.00
1.3.4	Allow for bulk water meter to suit 200mm MPVC pipe	1	No	4,000.00	4,000.00
2.4	**Supply and install fittings for gravity mains**				
2.4.1	mPVC (Class 6) Bends				
	b) 200 x 45°	9	No.	71.04	639.36
	c) 200 x 22,5°	7	No.	71.04	497.28
	d) 200 x 11,25°	7	No.	71.04	497.28
	e) 250 x 90°	1	No.	124.48	124.48
	f) 250 x 45°	2	No.	96.31	192.62
	g) 250 x 22,5°	10	No.	96.31	963.10
	h) 250 x 11,25°	21	No.	96.31	2,022.51
2.4.2	GI Bends				
	b) 200 x 45°	2	No.	750.00	1,500.00
	c) 200 x 22,5°	4	No.	750.00	3,000.00
	d) 200 x 11,25°	1	No.	750.00	750.00
2.4.4	CI reducers				
	a) 250/200	1	No.	850.00	850.00
2.4.5	PVC Tees				
	200 dia equal tee	1	No.	133.75	133.75
2.4.6	CI Gate valves				
	a) 250 dia	2	No.	2,500.00	5,000.00
	b) 200 dia	3	No.	2,500.00	7,500.00
2.4.7	Air Valves				
	a) 250 dia	2	No.	1,200.00	2,400.00

	b) 200 dia	3	No.	1,200.00	3,600.00
2.4.8	Scour Valves				
	a) 250 dia	2	No.	1,200.00	2,400.00
	b) 200 dia	4	No.	1,200.00	4,800.00
1.4	**Sundries**				
1.4.1	Precast Concrete Valve Boxes 700mm x 400mm C/W concrete lids	5	No	510.00	2,550.00
1.4.2	a) Valve Marker Posts	5	No	97.50	487.50
1.4.3	**Allow for concrete thrust blocks at every change on pipe direction Grade 15**	2	m^3	165.00	330.00
1.4.4	Allow for concrete encasing where directed	10	m^3	200.00	2,000.00
1.4.5	Allow for concrete anchor blocks on steep grades	10	m^3	165.00	1,650.00
1.4.6	Allow for connection to reservoir	1	P.Sum	2,000.00	2,000.00
	TOTAL FOR PIPELINE (carried to summary)				**139,034.51**
2	**2.0 ML RESERVOIR**				
ITEM	**DESCRIPTION**	QTY	UNIT	RATE	AMOUNT
2.1	**Galvanized Water Storage Tank Installation**				
2.1.1	Supply and fix 1,000L galvanised steel tank	2	No	55,000.00	110,000.00

2.1.2	Earthworks (leveling and sub base and hardcore compaction)		Sum	5,000.00	5,000.00
2.2	**Construction of floor**				
2.2.1	Concrete Class 15/20 in sub-foundation blinding.	60	m3	180.00	10,800.00
2.3	**High tensile round deformed reinforcement. Supply, bend, place and fix.**				
2.3.1	12mm dia. and smaller.	10800	kg	1.50	16,200.00
2.4	**Formwork**				
2.4.1	Apply 1:3 cement mortar screed 12mm thick to top of no fines concrete lower floor slab, steel trowel finish.	285	m2	12.00	3,420.00
	TOTAL FOR RESERVOIR (carried to summary)				**145,420.00**
3	**PUMP STATION**				
ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT
3.1	33 kV line construction	0.5	km	10,000.00	5,000.00
	-				
3.2	Supply and install 500 Kva, 33kV/400V transformer	1	Sum	35,000.00	15,000.00
3.3	Supply and install pump set	2	Sum	10,500.00	21,000.00
3.4	Construct Pump house and ancillaries	1	Sum	15,000.00	15,000.00
3.5	Construct Pump Attendant's Quarters	1	Sum	12,000.00	12,000.00
	TOTAL FOR PUMP STATION (carried to summary)				**68,000.00**

4	**INFIELD WORKS**				
ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT
4.1	Land preparation and levelling	15	Ha	600	9,000.00
4.2	Fencing the irrigation scheme	1,923	m	3.25	6,249.75
4.3	Sprinkler irrigation system				
4.3.1	Supply and Install infield Sprinkler system				
4.3.1.1	5mm brass Sprinklers 3 bars, 1.7m3/hr, 7.87mm/hr	120		28.00	3,360.00
4.3.1.2	20mm brass garden tape	120		22.60	2,712.00
4.3.1.3	1m x 20mm GI riser pipes	120		6.55	786.00
4.3.1.4	20mm elbows	240		1.25	300.00
4.3.1.5	1m tripod stand complete with 1m GI riser pipe	120		29.84	3,580.80
4.3.1.6	32m x 20mm reinforced garden hose	120		62.40	7,488.00
4.3.1.7	20mm GI sockets	240		0.85	204.00
4.3.1.8	20mm swage nipples	240		1.65	396.00
4.3.1.9	20-25 Dupli clips	240		0.75	180.00
4.3.1.10	Thread tape rolls	500		0.20	100.00
4.3.1.11	40mm Brass gate valves	20		42.00	840.00
4.3.1.12	50mm Brass gate valves	15		56.00	840.00
4.3.1.13	63mm Brass gate valves	6		60.00	360.00
4.3.1.14	75mm Brass gate valve	2		84.50	169.00
4.3.1.15	90mm Brass gate valve	2		105.00	210.00
4.3.1.16	110mm Cast iron gate valve	2		149.80	299.60
4.3.1.17	500 ml Solvent cement	4		17.82	71.28
4.3.2	Supply HDPE				
	a) 40mm Class 6	4,130	m	1.30	5,368.90
	b) 50mm Class 6	3,423	m	1.30	4,449.90
4.3.3	Supply MPVC pipework				
	a) 40mm Class 6	201	m	1.23	247.23
	b) 50mm Class 6	214	m	1.69	362.20
	c) 63mm Class 6	177	m	2.14	378.78

	d) 75mm Class 6	252	m	2.58	650.16
	f) 110mm Class 6	295	m	5.21	1,535.70
	h) 160mm Class 6	872	m	11.52	10,048.67
	i) 200mm Class 6	577	m	17.65	10,178.93
4.3.4	MPVC bends to suite MPVC pipes				
	a) 200 mm 90 deg	1	No	83.58	83.58
	b) 160 mm 45 deg	2	No	45.76	91.52
	c) 160 mm 22.5 deg	4	No	45.76	183.04
	d) 160 mm 11.25 deg	2	No	45.76	
	d) 110 mm 22.5 deg	2	No	17.70	35.40
4.3.5	Tees				
	a) 200/50 unequal Tee	10	No	128.73	1,287.30
	b) 200/40 unequal Tee	3	No	128.73	386.19
	d) 160/75 unequal Tee	1	No	72.60	72.60
	e) 110/40 unequal Tee	1	No	27.36	27.36
	f) 75/40 unequal Tee	5	No	18.91	94.55
	g) 75/63 unequal Tee	1	No	57.91	57.91
	h) 50/40 unequal Tee	5	No	18.91	94.55
	i) 40 equal Tee	4	No	18.91	75.64
	TOTAL FOR INFIELD WORKS (carried to summary)				**72,856.53**
5	**WEIR CONSTRUCTION**				
ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT
5.1	Clearing of site, excavations (including rock blasting) for weir of length 74m	700	m3	5	3,500.00
5.2	Weir construction: 74m of 1,5m high masonry including foundations	172.42	m3	250	43,105.00
5.3	Clearing area, diversion works/cofferdam construction, excavations for pump house sump	1	Sum	5000	5,000.00
	TOTAL FOR WEIR CONSTRUCTION (carried to summary)				**51,605.00**
6	**ENVIRONMENTAL**				

ITEM	DESCRIPTION	QTY	UNIT	RATE	AMOUNT
6.1	Allow for environmental protection works by use of gabions and buffles	1	Sum		6,000.00
6.2	Tree seedlings and planting	1250	plant	0.75	937.50
	TOTAL FOR ENVIRONMENTAL (carried to summary)				**6,937.50**
	SUMMARY				
1	**PIPELINE**				**139,034.51**
2	**2.0 ML RESERVOIR**				**145,420.00**
3	**PUMP STATION**				**68,000.00**
4	**INFIELD WORKS**				**72,856.53**
5	**WEIR CONSTRUCTION**				**51,605.00**
6	**ENVIRONMENTAL**				**6,937.50**
	SUBTOTAL				**483,853.54**
	Add CONTINGENCIES			0.10	**48,385.35**
	Add VAT 15%			0.15	**72,578.03**
	TOTAL				**604,816.92**
	MANAGEMENT CONTRACTOR				**90,000.00**
	TECHNICAL SUPPORT COSTS				**12,000.00**
	DIRECT LABOUR COSTS			2%	**9,072.25**
	GRAND TOTAL				**715,889.18**

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