CRIDF

Bindangombe Irrigation Scheme: Detailed Design Report

Project Name: Bindangombe Climate Resilience

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

Disclaimer

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List of Acronyms

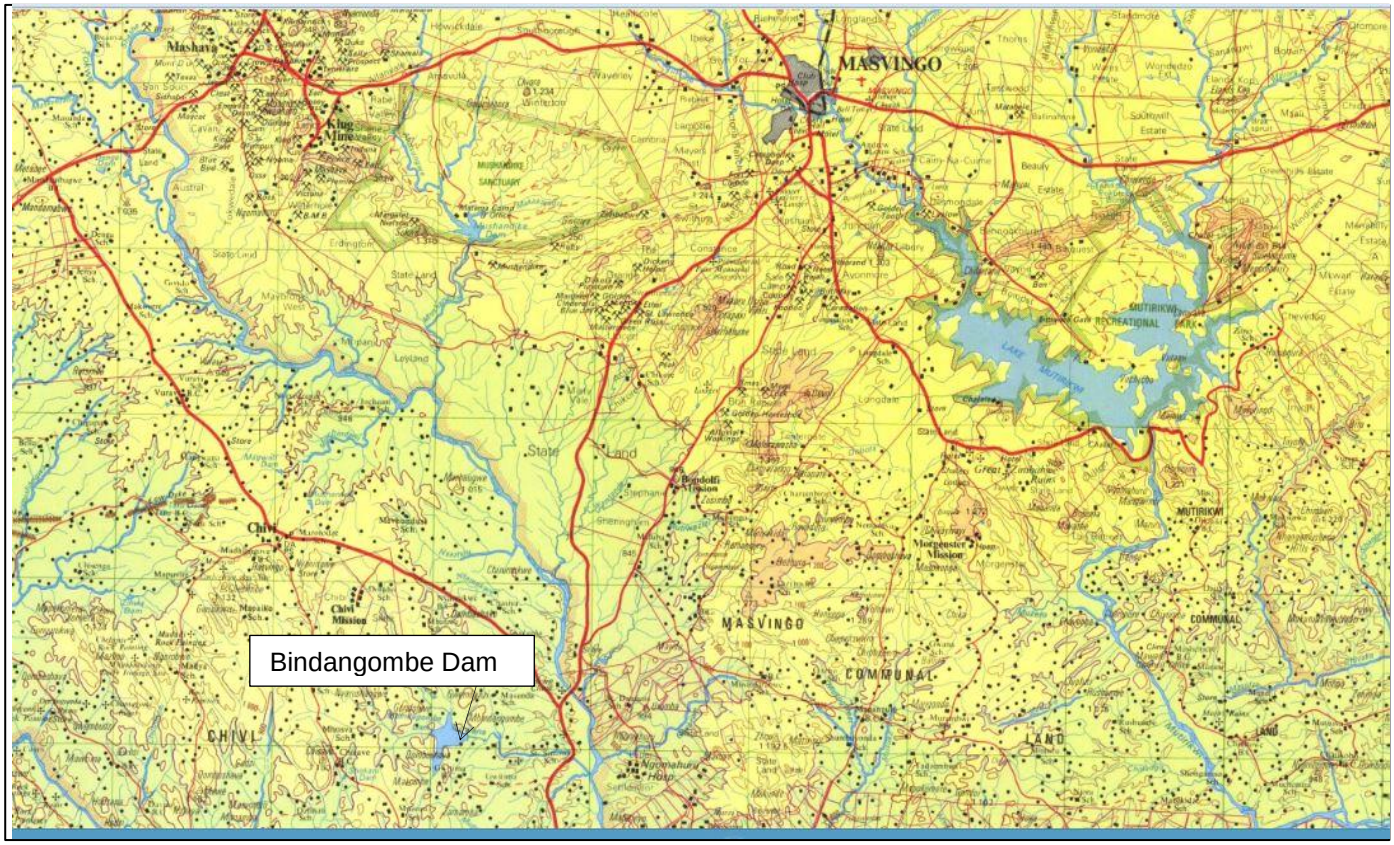
Acronym	Long-Form
AC	Asbestos Cement
AGRITEX	Department of Agricultural Technical and Extension Services
ASI	Adam Smith International
BADEA	Arab Bank for Economic Development
CBA	Cost Benefit Analysis
CBMP	Community Based Water Management Project
CRIDF	Climate Resilient Infrastructure Development Facility
DDF	District Development Fund
DFID	Department of International Development
ECC	Engineering Construction Contract
EIA	Environmental Impact Assessment
EMA	Environmental Management Authority (Zimbabwe)
EMP	Environmental Management Plan
ENPV	Economic Net Present Value
EOCC	Economic Opportunity Cost of Capital
ERR	Economic Rate of Return
FAO	Food and Agricultural Organisation
FBCR	Financial Benefit-Cost Ratio
FIRR	Financial Internal Rate of Return
FNPV	Financial Net Present Value

FOCC	Financial Opportunity Cost of Capital
GRP	Glass Reinforced Plastic
ICZ	Interconsult Zimbabwe (Pvt) ltd
MC	Management Contractor
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
ZIMVAC	Zimbabwe Vulnerability Assessment
ZINWA	Zimbabwe National Water Authority

Executive Summary

Background

The proposed Bindangombe 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 Bindangombe irrigation scheme will benefit in excess of 1000 residents of five villages in wards 18 and 20 of Chivi District, Masvingo Province in Zimbabwe. The location of the scheme is shown in the map below.



The scheme is located in agro-ecological region V, where rainfall is low and erratic. In addition, the area is increasingly under threat from falling rainfall trends coupled with frequent crop failures due to endemic drought.

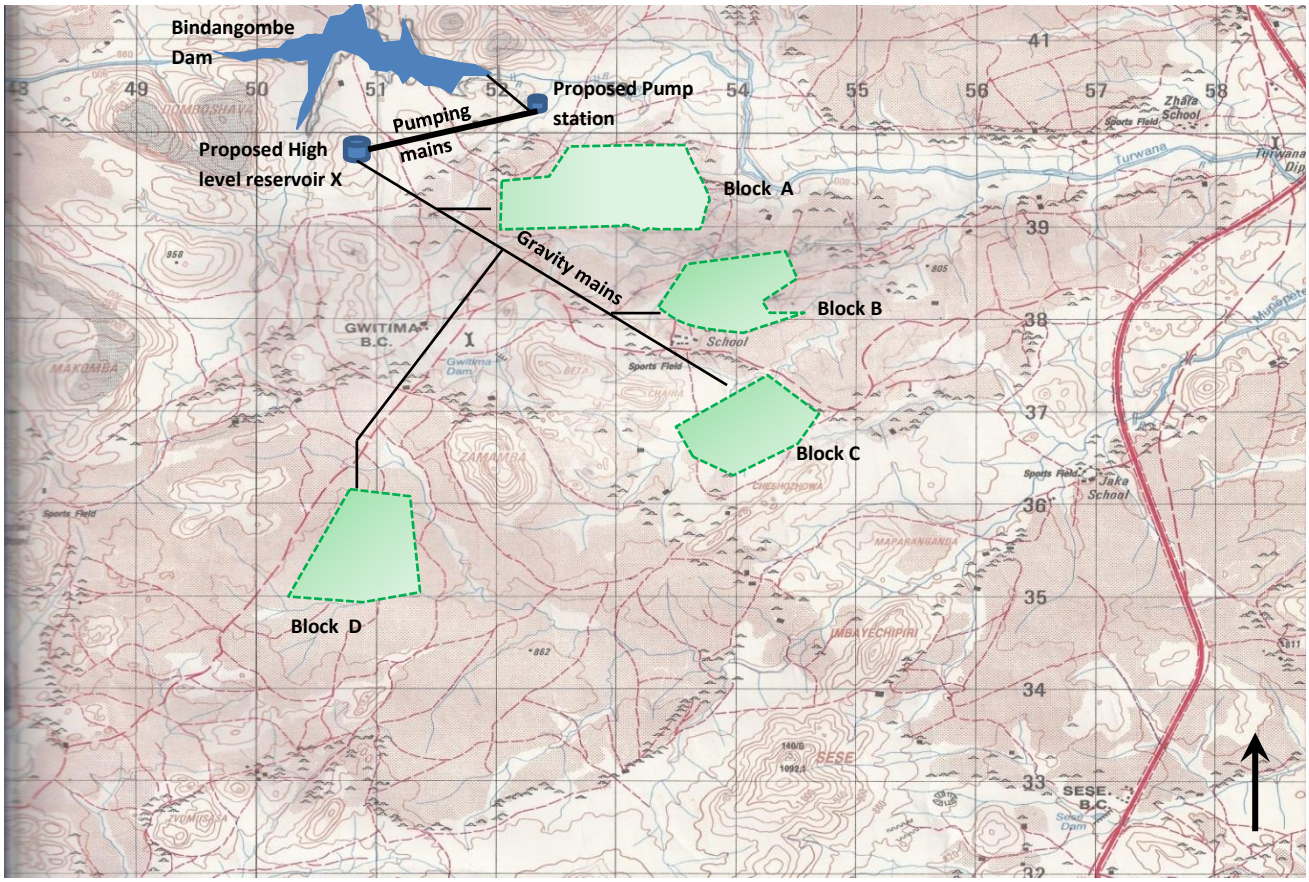
Following a reconnaissance visit to the project, and assessment for possible support, the project was screened and found to comply with CRIDF's requirements. A decision was then made to provide support for the feasibility assessment of the project. This was undertaken and completed during the last quarter 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

Irrigation

The Zimbabwe Department of Irrigation identified four blocks of land totalling 363 ha to be set aside for the Bindangombe Irrigation Scheme. The location of the irrigation lands is shown in the excerpt from the 1:50,000 map given below. An assessment of the lands for irrigation purposes and water resource availability was made at feasibility stage, which established that the yield from Bindangombe Dam could irrigate a total of 126 ha of the available land, based on a reliability of 20%. CRIDF would support the development of 34 ha of Block A for irrigation from the dam, out of a potential of 100 ha in the block.



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 m^3/ha/annum. This results in a design flow of 191.3 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 223.0 m^3/hr for delivery to the field.

At feasibility stage, only one alternative for the abstraction of water from the dam was considered, which utilised the use of an existing outlet pipe to draw water to the pump station. Following the topographic survey of the project area, it became necessary to consider a second abstraction option which consisted of the location of a pump station on a floating pontoon in the reservoir. The second option offered better suction conditions. The more favourable option between the two alternatives would be finalised and selected for implementation at value engineering stage. The irrigation options are briefly described below.

1. *Options A*

Water will be abstracted from the reservoir through a single connection to one of the 300 mm diameter valved twin outlets. It will be pumped through a 1856 m long mPVC/Steel pipeline to 1 Ml storage reservoirs located at the top of a hill, south west of the main dam wall. The diameter of the suction main will be 300 mm, reducing to 250 mm after the pump station. The later will comprise a pump station building housing two centrifugal pumps, one duty and the other standby designed for a flow of 191.3 m^3/hr against a total head of 50.6 m, at minimum operating level.

Water will gravitate from the reservoirs through a 250 mm diameter 1267 m long mPVC/Steel mains to irrigate 34 ha located to the south east of the dam by means of sprinklers.

2. *Option B*

This option proposes the location of a pump station on a pontoon in a bay, south of the main dam wall. From the pump station, water will be delivered to the two reservoirs on the hill through a 250 mm diameter, 986 m long mPVC/Steel pipeline, to gravitate to the field as described above.

Both options provide feasible suction conditions, with respect to NPSH of the pump. However, Option A has a much longer pumping main.

Water supply and sanitation

Two options were explored at feasibility stage for the provision of domestic water supply, with the supply of water from boreholes being selected as the preferred alternative. Fifteen sites for the drilling of boreholes were identified, based on the need to reduce walking distance to domestic water supplies. The feasibility stage recommended the provision of ventilated-improved pit (VIP) latrine to cater for approximately 1,000 households. The project would provide designs and materials for the construction of the sanitation facilities.

Environmental Protection

Extensive gulley formation in the north western boundary of Block A as well as in the central area of the block was observed. The project will implement measures to control the gulley formation by means of gabions. Due to the dynamic nature of the erosion, details would be determined on site at the time of implementation.

Cost Estimates and Bill of Quantities

Two separate Bills of Quantities have been developed based on the options considered for the abstraction of water from Bindangombe Dam. The estimated cost of for each option are summarised below.

Option A USD825,008.91

Option B USD789,222.69

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 irrigation scheme established that the irrigation of 34 ha of land from Bindangombe Dam was technically feasible. It also demonstrated the financial and economic feasibility of the project, and that there were would be no significant environmental impacts arising from its implementation. This report outlines the development of a technical design for the Bindangombe 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 Bindangombe irrigation scheme will benefit residents of five contiguous villages of Mawoneke, Mufara, Rukasi, Zimoni and Matondo in ward 18. In ward 20, Charumengwe, Kamera, Mudzingwa, Dambudzo, Tavagadza and Mupepete villages are proposed to be part of the scheme.

Project Location and Site Access

The proposed Bindangombe irrigation scheme is located in Chivi communal lands, wards 18 and 20 of District, Masvingo Province, approximately 50 km south of the town of Masvingo.

below gives the location of the scheme which is generally hot and dry, with below average rainfall. The main access to the site is gained from the Masvingo-Beitbridge Road, branching of the main road approximately 55 km from Masvingo to turn west along a poorly maintained but accessible gravel road to Gwitima Shopping Centre, 6.1 km from the turn-off. Bindangombe Dam is located approximately 2.3 km north of the shopping centre, and is accessed via a well-used track road.

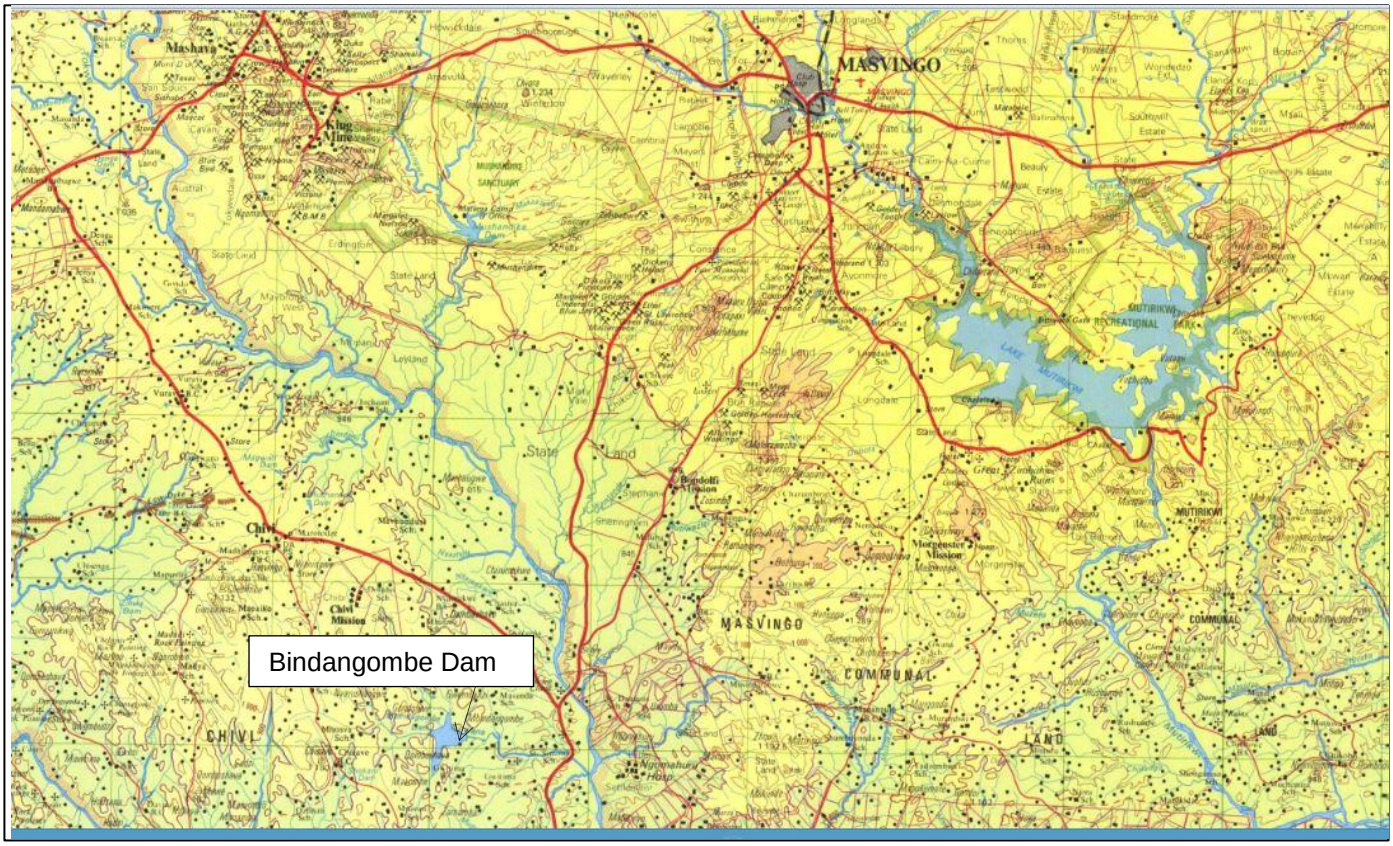


Figure 1 **Location of Bindangombe Irrigation Scheme**

Structure of the Design Report

This report covers salient technical aspects on the design of Bindangombe irrigation 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 Bindangombe dam to the irrigation fields.

Project Description

General Description of the Project Area

The project area is located in wholly communal land where rain-fed agriculture livestock rearing are the main economic activity, although some villagers practice small garden irrigation south of the Bindangombe Dam using seepage from the reservoir through the saddle dam. Approximately 1000 villagers from wards 18 and 20 of Chivi District are expected to benefit from the scheme, in an area were perennial food shortages are rampant due to frequent droughts. Access to water and sanitation is inadequate due to low ground water levels, coupled with high salinity in some zones.

Chivi District lies in Agro-ecological Region V, which is an extensive, farming region covering 27% of Zimbabwe. Rainfall is very low and erratic for the reliable production of grain crops including drought resistant ones. The soil types that are predominant in the two wards are generally sandy soils and loamy sands that are fragile and require good management. There are no environmentally sensitive sites (e.g. wetlands under the Ramsar Convention agreements, international or national sites, protected sites or nature reserves) or endangered species of flora or fauna within the terrestrial and aquatic environment.

Approximately 90% of the project area is covered with degraded open lands that comprise mostly of fields and grazing lands, with only a few isolated individual trees of the Miombo Woodlands now existing. There is no evidence of large species of fauna in the project area, except for a few bird species, aquatic fauna (anthropods, amphibians and fish) and insects (grasshoppers, locusts and butterflies) which were observed during the environmental field assessment. Land in the project area is severely degraded mainly due to unsustainable land-use practices, coupled with the occurrence of fragile soils the semi-arid region. There is virtually no vegetation cover on most of the land, which gives rise to numerous erosion gullies.

Availability, location, size and suitability for irrigation land

The Department of Irrigation identified four blocks of land totalling 363 ha to be set aside for the Bindangombe Irrigation Scheme. An assessment of the lands for irrigation purposes was made at feasibility stage, and a decision made based on the available 20% yield of Bindangombe Dam to develop 34 ha of Block A for irrigation from the dam, out of a potential of 100 ha in the block. The total irrigable land under the available yield is approximately 126Ha. The location of the block A is shown in the excerpt from the 1:50,000 map of the area given in **Error! Reference source not found.** below.

The soil type within blocks A is predominantly granitic sands of medium coarse texture. It is characterised by high infiltration of between 12-18 mm/hr, low water holding capacity, low water retention rate and high porosity. The soil will require high fertility management and the judicious use of water and cultivation of crops.

The terrain in Block A is gently rolling, with visible signs of soil erosion including small shallow rills, which can be eliminated by normal cultivation.

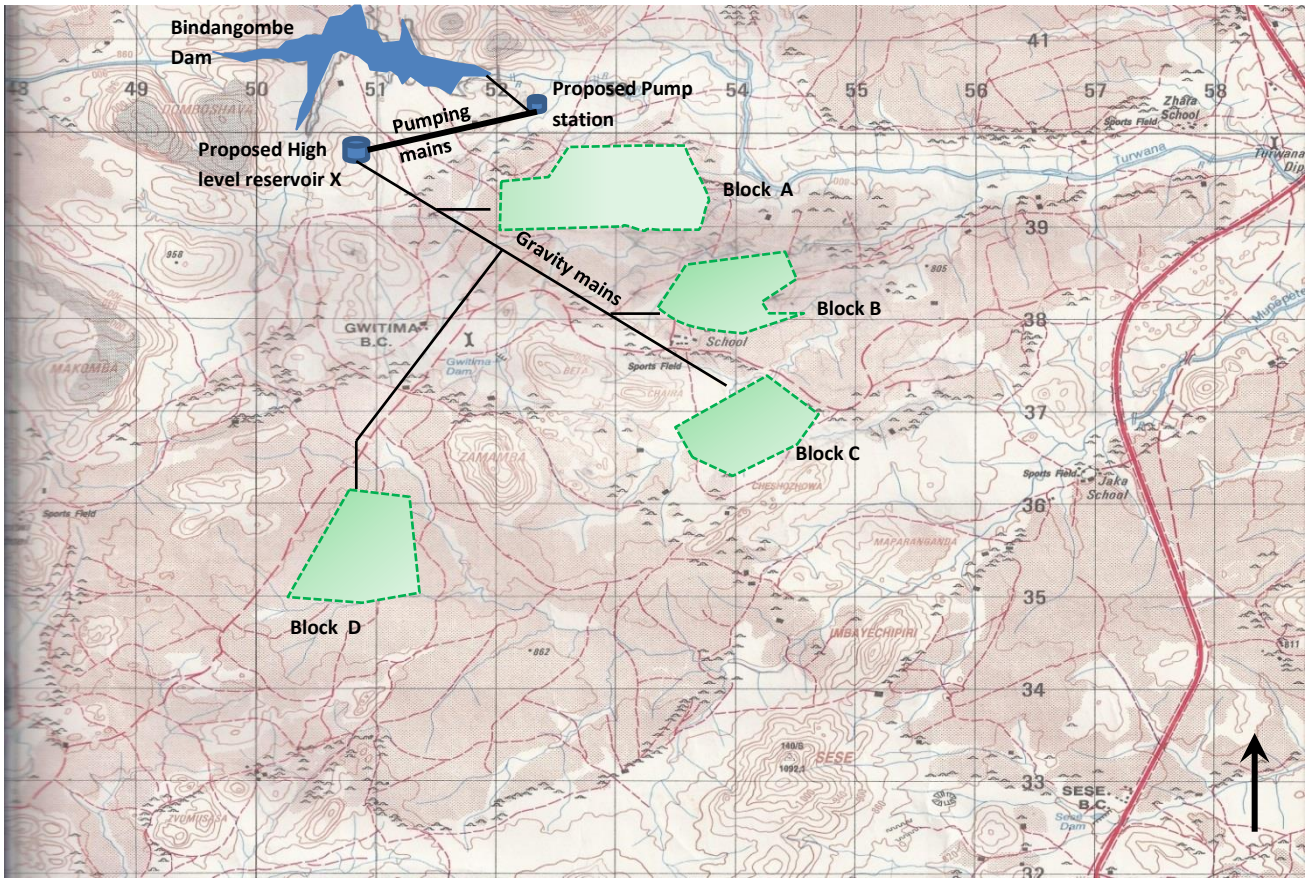


Figure 2 **Location of irrigation land at Bindangombe**

Summary of the hydrology

General climate

The proposed Bindangombe irrigation scheme is located in agro-ecological region V where rainfall is low and erratic. Annual mean temperature is around 20^0 centigrade, while maximum temperatures exceed 30^0 centigrade. Long term mean annual rainfall is below 600 mm. Analysis of rainfall for Chivi Centre which lies approximately 30 km to the east of the scheme indicates a downward trend in annual rainfall, as shown in **Error! Reference source not found.** below. The area is therefore increasingly under threat from falling rainfall trends. This scenario is consistent with reports from locals which indicate deteriorating climatic conditions coupled with frequent crop failures due to drought.

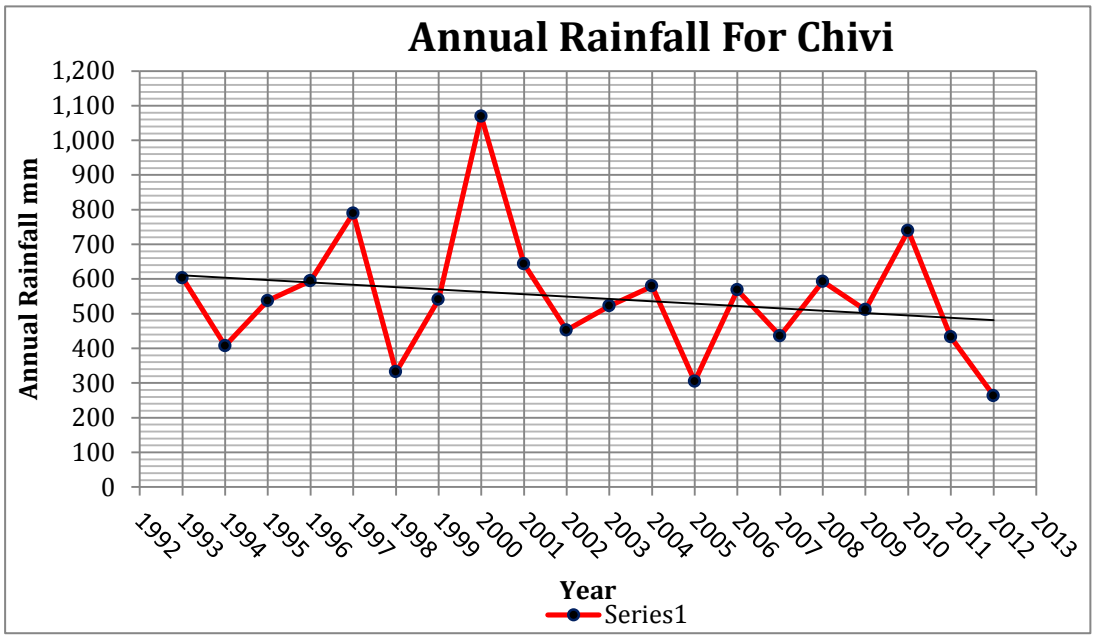


Figure 3 **Annual average rainfall at Chivi**

Existing and Source of Water for Irrigation

It is proposed to supply the proposed Bindangombe irrigation scheme from Bindangombe dam 25.14' S and 30° 37.38' E, on the Tugwana River, a tributary of the Tokwe River. The concrete gravity was constructed in 1988. It has a capacity of 22.6 x 10^6m^{3}and a reported 10% yield of 6.044 x 10^6m^3 per annum.

gives the elevation-capacity curve of the dam.

The following flow statistics of the Tugwana River at the inflow into Bindangombe dam were calculated at feasibility stage from generated inflow data.

- Mean annual inflow : 9,987 x 106 m3
- Standard deviation : 12,838
- Coefficient of Variation : 1.29
- Storage ratio : 2.26

The high storage ratio of Bindangombe dam suggests that it is a carry-over storage in which water stored in one year is carried over and used in subsequent years, with spills occurring every few years.

A behavioural analysis was undertaken based on the generated historical inflow by subjecting the reservoir to increasing target drafts or abstractions. The results indicate a lower dam yield than that previously computed, as follows.

- 10% Yield : 3.6 x $10^6 m^3$ per annum
- 20% yield : 4.2 x $10^6 m^3$ per annum

The above lower values may also reflect declining rainfall in the region since 1988 when the dam was planned and built. The 20% yield of 4.2 x 10^6 m^3 per annum is adequate to meet the water demand for the 126 Ha irrigable lands. However, government policy requires the use of 10% yield for the planning of irrigation schemes.

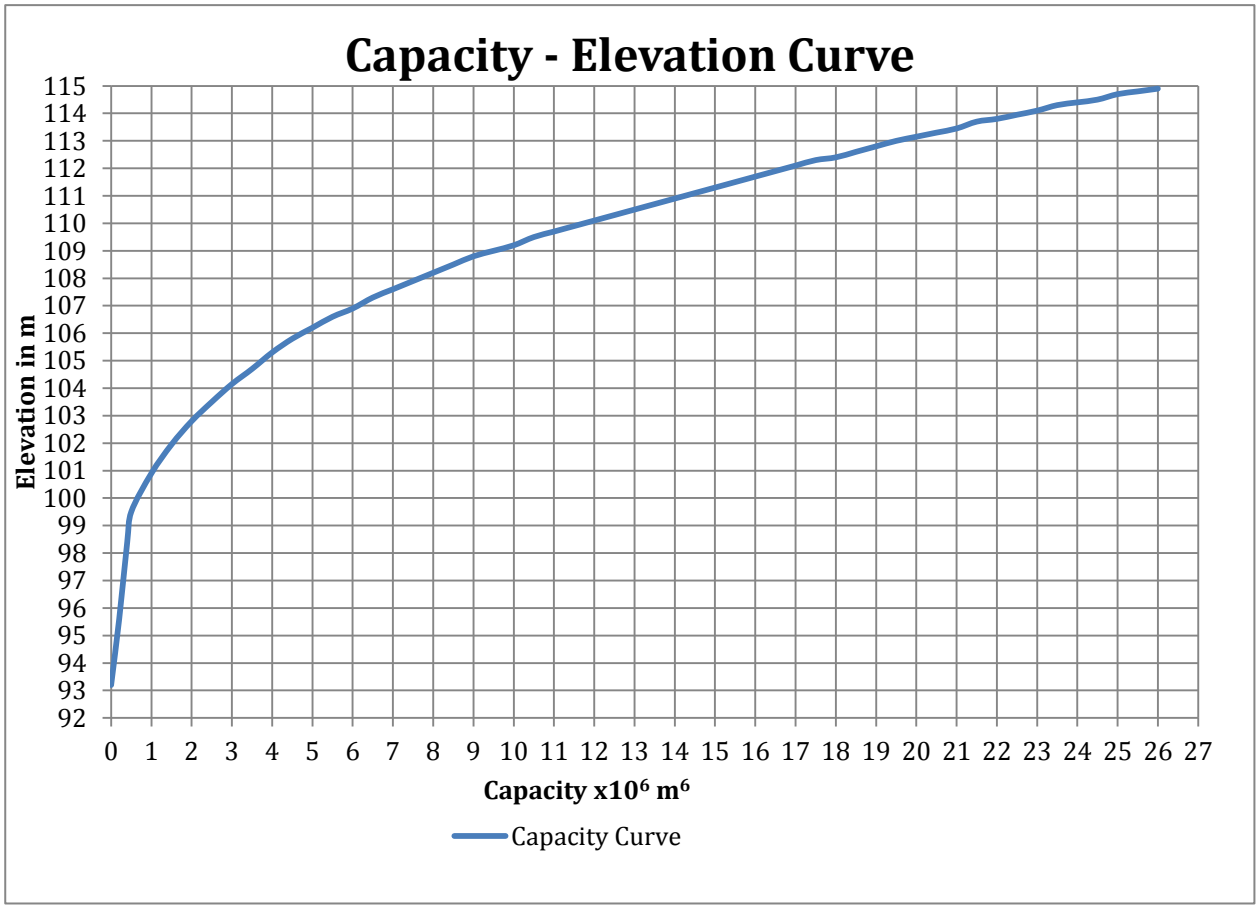


Figure 4 **Elevation-Capacity Curve of Bindangombe dam**

Water rights and/or permits

Bindangombe dam was originally built to supply Ngomahuru Hospital. The hospital is now supplied from Muzhwi dam. Information from ZINWA indicates that the yield from Bindangombe dam has now been allocated towards the supply of water to the proposed irrigation scheme. Thus the dam yield is currently not being utilised. ZINWA has given a written undertaking that water required for the irrigation of 34 ha of Bindangombe Irrigation Scheme will be made available. A copy of the written undertaking is shown in Appendix 1. The process to enter into a Memorandum of Agreement for the supply of water for the project is now in progress.

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 irrigation water demand was based on the following basic assumptions derived for the irrigation of 34 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 per application
- Total available irrigable land : 34 ha
- Total irrigation period per year (April – Nov) : 244 days
- Total no of cycles per year 244/7 : 34.85
- Effective irrigation days per year = 5 x 34.85 : 174.28 days

Therefore Irrigation water demand per ha per year = $(45 \times 10^4 \times 34.85)/10^3$ m^3

= 15,682 m^3

Total annual water demand for 34 ha = 533,314m^3

Total per day	= 3,060 m^3
20% yield of Bindangombe dam per day	= 11,377 m^3
Maximum ha irrigated per year	= 126 ha
Total Annual Demand (34 ha)	= 1,982,905 m^3

Description of Bindangombe Irrigation Scheme

Size of Irrigation Scheme

Hydrological analysis indicated that a total of 126 ha could be irrigated from the 20% yield of Bindangombe Dam. This area was then apportioned proportionally between all the four irrigation blocks as follows:

Block A - 34 ha

Block B - 23 ha

Block C - 22 ha

Block D - 47 ha

Three options for the provision of bulk water supply to all the blocks were developed and analysed, for selection of the preferred alternative. All the options proposed the use of Bindangombe dam as a source of supply, with water being pumped to elevated storage for delivery to all the irrigation blocks. The essential differences among the options were the positions of the high level storages located at three different hillocks, which in turn dictated the layout of the trunk mains. Details are outlined in the Feasibility Study Report. with the ultimate preferred option selected on the basis of least cost. CRIDF proposes to support a scaled down component of the preferred option consisting of the irrigation of 34 ha of Block A.

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 34 ha of Block A are as follows:

Delivery to night storage - 0.053 m^3/s =191.3 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

The adopted design criterion for the supply of water to the irrigation field was based on irrigation over 8 hours. Based on this assumption, the calculated design flow for the irrigation of 34 ha of block A are as follows:

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)	**34**	
Pan evaporation rate (mm/day)	8	Bindangombe Dam Station
Crop factor (f)	0.7	
Water holding capacity (mm/m)	50	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)	22.5	
Net irrigation requirement (mm/day)	5.6	
Gross irrigation requirement (mm/day)	7	
Calculated Cycle Length	4.0	
Actual Cycle Length	4	
Irrigable land per day (Ha)	8.5	
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)	3.6	
No of sets per day	3	
Working hours per day (hr)	10.7	
No of sets per cycle	12.0	
Gross application per cycle (mm)	28.0	
No of sprinklers operating simultaneously(>=)	131	
System Capacity (m^3/hr)	223.0	
	61.9	l/s

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

Project layout

The project will abstract water from Bindangombe dam to irrigate 34 ha of land located to the south-east of the dam. Water will be pumped from Bindangombe Dam to night storage reservoirs located on a small hill just south of Bindangombe Dam at geographic reference 20°25'28.36"S and 30°37'0.98"E. From the night storage reservoirs, it will gravitate to the irrigation fields. Two options have been examined for the delivery of bulk water to night storage as shown in the general layout of the scheme in **Error! Reference source not found.** below. A description of each option is outlined below.

Option A

Outlet Works

Water will be abstracted from the reservoir through a single connection to one of the 300 mm diameter valved twin outlets. A sluice gate upstream of the outlet serves to isolate the gate valves from the reservoir when required for maintenance and installation of additional appurtenances. The gate valves are located inside a concrete walled recess on the downstream side of the concrete arch dam as shown in the photograph in Figure 5 below.

Figure 5 **Bindangombe dam outlet works**

One of the gate valves will be connected to the suction main to deliver water to the pump station.

Suction Main

From the active gate valve, water will be delivered through a 300 mm diameter, 762 m long steel and mPVC suction main to the pump station. The 528 m long steel section of the suction main will be laid above ground supported on short concrete stub columns. The existing stockpile of 300 mm diameter steel will be incorporated in the suction main to save costs. The suction main traverses along the rocky slope on the right bank of the Tugwane River, following the old access road from the dam, to reach a low level concrete box culvert. The pipeline will cross the stream supported on the culvert wing walls. From the box culvert, the pipeline changes to a buried 300 mm diameter mPVC pipeline, laid along a track road, to reach the pump station at chainage 762 m. Air and sour valves will be provided as necessary along the suction main. Thrust blocks have been designed to provide support on all the bends along the pipeline.

Pump Station

The pump station for Option A will be located at geographic reference 20°25'19.97"S and 30°37'38.19"E. It will consist of two centrifugal pumps, each designed to deliver 191 m^3/hr against a total dynamic head ranging from 57 m, at the minimum reservoir level and 40.4 m at the maximum reservoir operating level. Operating arrangements will be one duty, with one standby. There will be provision for a third pump to cater for future growth of the irrigation scheme. The pumps will be driven by 3-phase, 4-pole electric motors supplied from a dedicated ZETDC transformer.

Suction conditions at the eye of the impeller will range from -1.23 m at the minimum reservoir operating level to flooded, + 17.25 m when the reservoir is full. Careful pump selection will therefore be essential at low reservoir levels.

The 14.4 m long and 9.2 m wide pump station building will be constructed from brick under asbestos roof sheeting, supported on steel trusses. A 1 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.

The existing pump attendants quarters, designed to ZINWA standard, will be renovated to habitable 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 a 1,856 m long, 250 mm diameter, mPVC/Steel pipeline. The pipeline will traverse along a track road leading from the dam to Gwitima business centre, up to the small gardens to the south of the road. The first 843 m of the pipeline will be laid in buried Class 12 MPVC piping up to the edge of the hill. Thereafter, the pipeline changes to 243 mm diameter bitumen lined steel pipe, laid above ground over a distance of 250 m. It will be supported on short concrete column stubs at 6 m centres before bifurcating to discharge into the two reservoirs. 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.

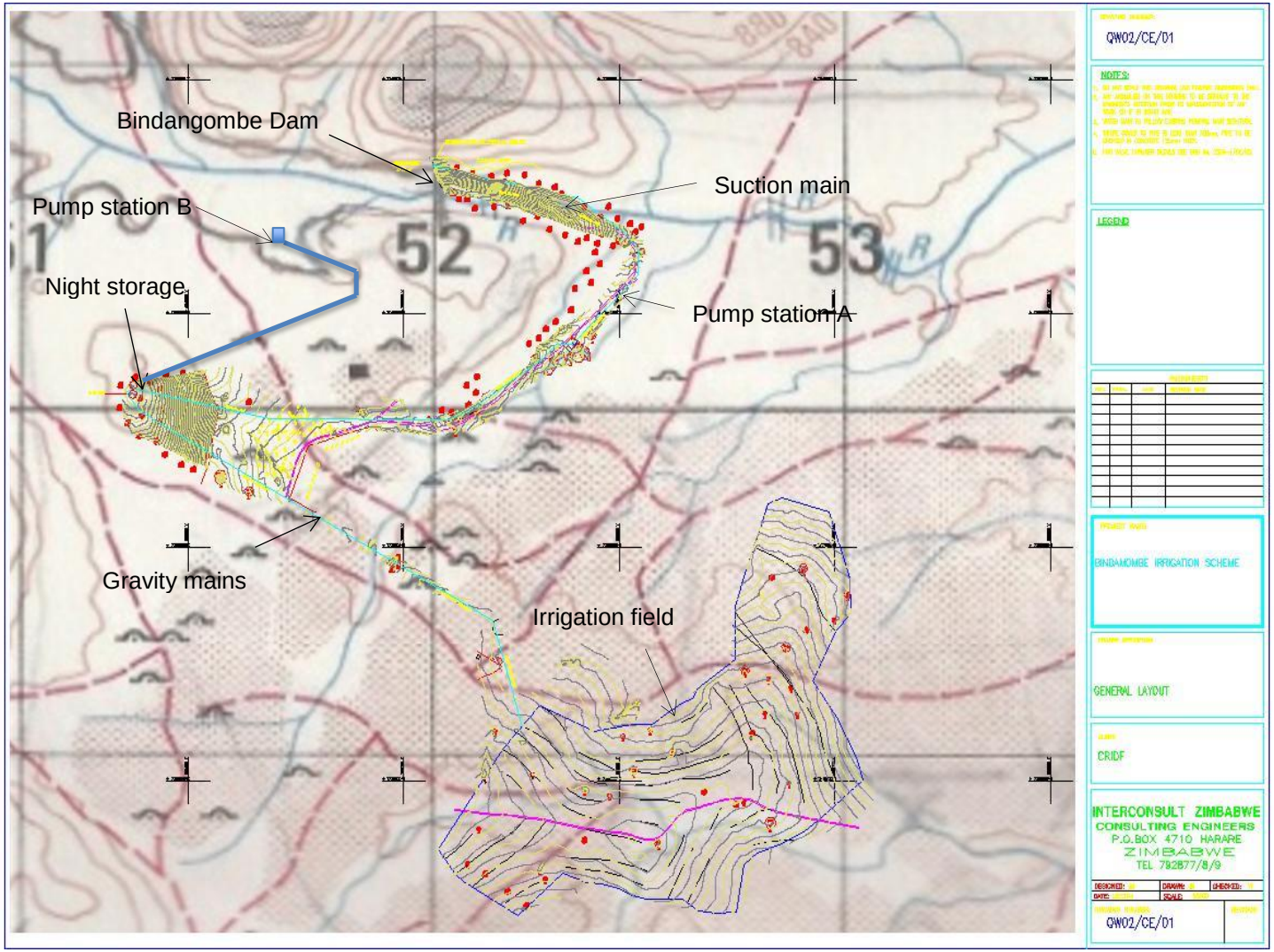


Figure 6 **General layout of Bindangombe Irrigation Scheme**

Option B

This Option, developed after the feasibility stage examines an alternative intake arrangement which will obviate the need for a long suction main associated with Option A. It also provides a much shorter pumping main route to the night storage reservoir. However, it is likely to have operational challenges for a rural small scale scheme, notwithstanding the savings in both initial investment and operational costs.

Intake and Pump Station

It is proposed to install a 4 m x 4 m floating pump station on a pontoon located in the vicinity of a bay on the south bank of the reservoir. The structure would be positioned, at the outlet level of the dam, which is the minimum reservoir operating level, as shown in the google earth image shown in Figure 7 below. A preliminary general arrangement of the pump station and access gangway is shown in the drawings.

Figure 7 **Location of proposed intake and pump station on pontoon**

The pontoon will be fabricated from bitumen lined steel buoyancy tanks with provision for ballast to provide stability. The main deck will be formed from wecrolok type grid flooring on a tubular steel lattice frame. It will be enclosed in a timber cladded building and roofed with corrugated iron sheeting. The buoyancy tanks will be bolted under the tubular steel lattice frame by means of welded brackets. A 1.2 m wide, 76 m long hinged wecralok walkaway on smaller buoyancy tanks will link the head works and switch room to the pump station.

The delivery main and electrical cabling will span the length of the walkaway, strapped on the wecrolok deck to the pump-station. There will be provision for lockable hinged steel tube railing along each side of the walk way.

The spacing of the lockable hinges along the walkaway will be 6 m long or less. As the level rises the section of walkaway above the water levels off by pivoting at the unlocked hinge at the edge of the reservoir, while all other hinges remain locked. Each section of walkaway on dry land will be fixed to a set of steel brackets on top of stub columns by means of a similar pair of steel brackets welded to the underside of the buoyancy tanks. As the reservoir level rises, the unlocked hinge moves upstream, 6m for each move. The walkaway section on dry land will follow the slope of the bank fixed to the stub columns, while that on water levels off by pivoting on the hinge closest to the lake shore. The upstream section of the walkaway nearest the head works will be anchored to a concrete block. A pair of steel cables attached to the concrete block will be strung through the hand rail tubing all the way to the pontoon and fixed onto the supporting lattice to provide lateral stability of the structure.

Electric and signal cables will run from a switch room located at the top of the hill to the pump station through a 100 mm uPVC pipe strapped on the deck of the walkaway.

Pumping Mains

From the floating pump station, water will be delivered through a 250 mm diameter 75 m long flexible black polyethelene (HDPE) pipe supported on the floating walkaway to the head works. From the head works, steel pipe will be laid above ground on stub columns over rocky ground covering a distance of 367 m. To save cost, the existing 154 m long 300 mm diameter steel piping which is currently stock piled on site, will be used for part of the section, with the rest being laid above ground with 250 mm steel pipe. The steel pipe will deliver into buried 312 m long, 250 mm diameter, Class 12 MPVC pipe to the base of the hill. It will then climb the hill, laid above ground, on stub columns for 135 m to bifurcate into two night storage reservoirs. 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.

Selection of Preferred Option

Final selection of the preferred pump station option will be made at the value engineering stage, based on separate project BoQs and cost estimates prepared for each option.

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

A 1,210 m long 250 mm diameter (u or m?) uPVC/Steel gravity mains will deliver water from the night storage dams to the irrigation field, laid to grade. The 245 m long descent from the top of the knoll will be laid in bitumen coated steel piping, supported on short column stubs. With the exception of a short stream crossing, the rest of the pipeline will be laid in buried 250 mm diameter class 12 MPVC piping. A pipe bridge will be provided at the stream crossing.

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.

In-field Irrigation Systems

Analysis of four different irrigation systems selected the drag hose sprinkler irrigation system as the most suitable for adoption for Bindangombe 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, must be considered in system selection. Variable height riser pipes will be provided. A preliminary design of the system has been undertaken to establish the general layout 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

Suction and Pumping Mains

Option A

Figure 8 below shows the hydraulic grade line for the suction and pumping mains at the minimum and maximum operating levels of the Bindangombe Dam reservoir. Hydraulic conditions at the minimum operating level will result in a negative suction head of -1.23 m at the eye of the impeller. Along the pipeline alignment of the suction main, there is a high ridge which occurs between chainages 50 and 350 m which will result in negative pressures in the suction system of up to -3.3 m. This condition will require the careful checking of the specific speed of the selected pump against Hydraulic Institute Charts to ensure stable pump operation at low reservoir levels.

Analysis, allowing a factor of safety of 20% has estimated the available Net Positive Suction Head of 5 m.

A preliminary pump selection was carried out based on a KSB pump series. The most suitable pump was found to be the Etanorm 200-150-400 GG 1A PO. The pump performance and system curves are shown in Figure 9 below. Conditions in the pumping main will be as follows:

Manometric discharge head at minimum reservoir operating level	= 50.6 m
Manometric discharge head at maximum operating level	= 45.0 m

At normal operating conditions, maximum pressure in the pumping main will vary between the above maximum and minimum manometric discharge, heads and operate at discharges ranging from 190 m^3/hr and 370m^3/hr.

Suction conditions for the pump considered are as follows:

Available NPSH = 8.7 m

Required NPSH = 1.3 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.

Option B

The hydraulic grade line for Option B is shown in Figure 10 below. It reflects the varying levels of the pump impeller eye with reservoir level. A preliminary pump selection was carried out based on a KSB pump series. The most suitable pump was found to be the KSB Eta 150-50. The pump performance and system curves are shown in Figure 11 below. Conditions in the pumping main will be as follows:

Manometric discharge head at minimum reservoir operating level	= 55 m
Manometric discharge head at maximum operating level	= 47.0 m

At normal operating conditions, maximum pressure in the pumping main will vary between the above maximum and minimum manometric discharge heads and operate at discharges ranging from 225 m^3/hr and 360 m^3hr.

Suction conditions for the pump considered are as follows:

Available NPSH = 7.0 m

Required NPSH = not provided

Frequent ZETDC power outages create a real risk of unsustainable surge pressures in the pumping mains due to pump trip, which could result to undesirable to column separation. Although the flat gradient of the pipeline profile near the pump followed by a steep slope in the vicinity of the night storage reservoir provides a natural surge alleviating mechanism, there is still a need to undertake surge analysis to establish pressure conditions after power outage. It is proposed that this should be done as a separate activity due to the additional resources required for the analysis. This normally results in addition of surge tanks at minimal costs, covered under the contingency amount provided.

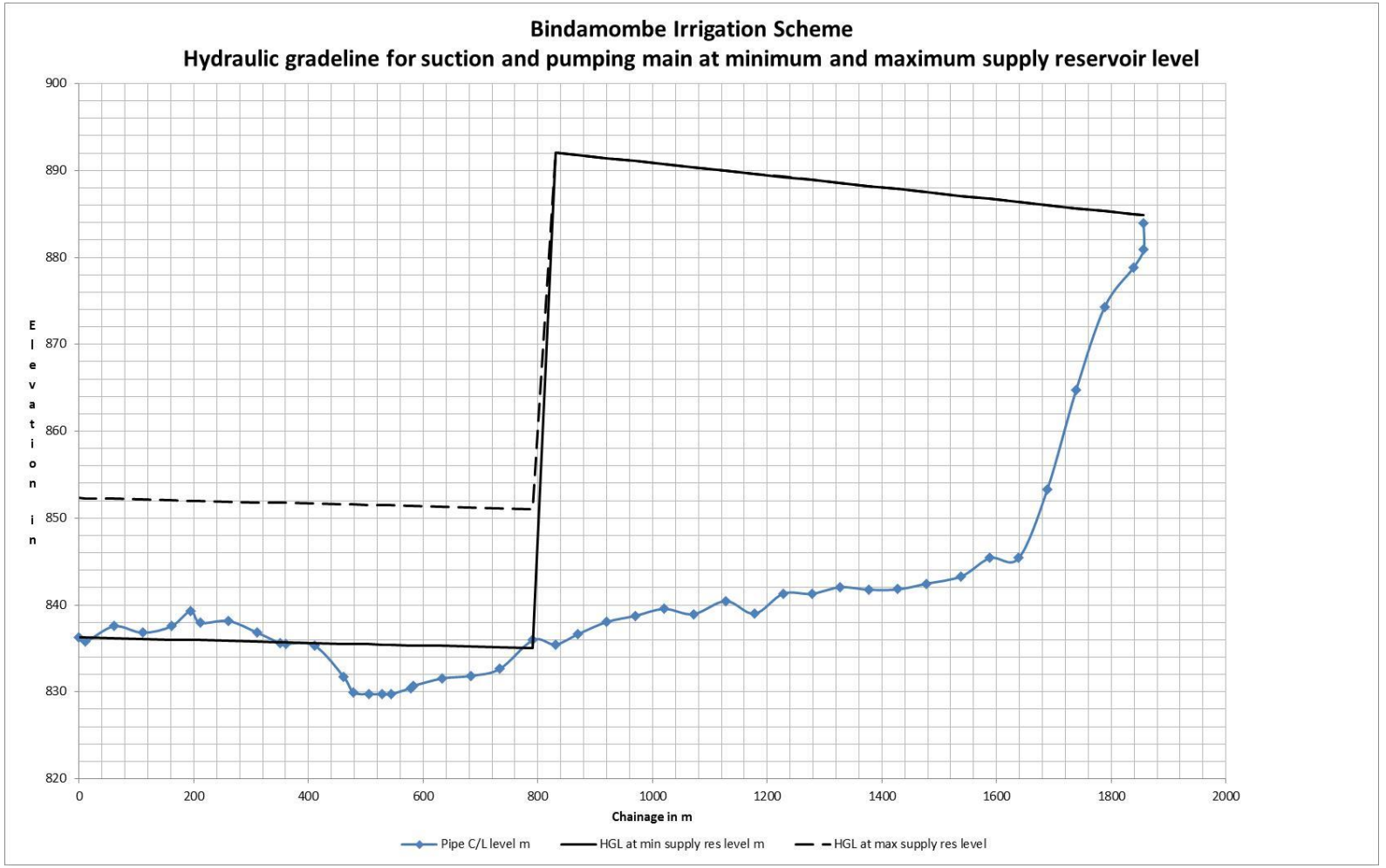


Figure 8 **Hydraulic grade line for suction and pumping mains for Option A**

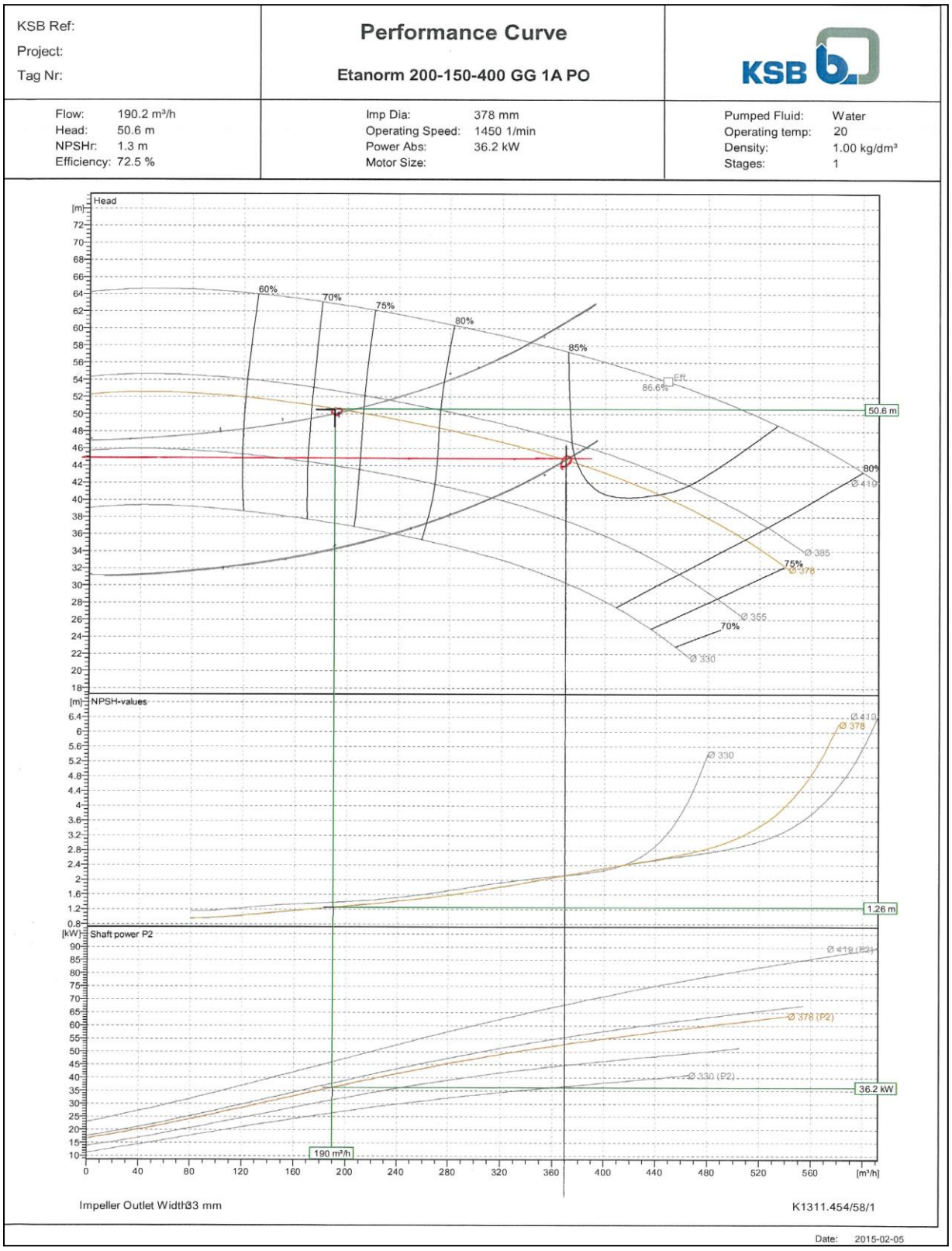


Figure 9 **Pump performance and system curve for Option A**

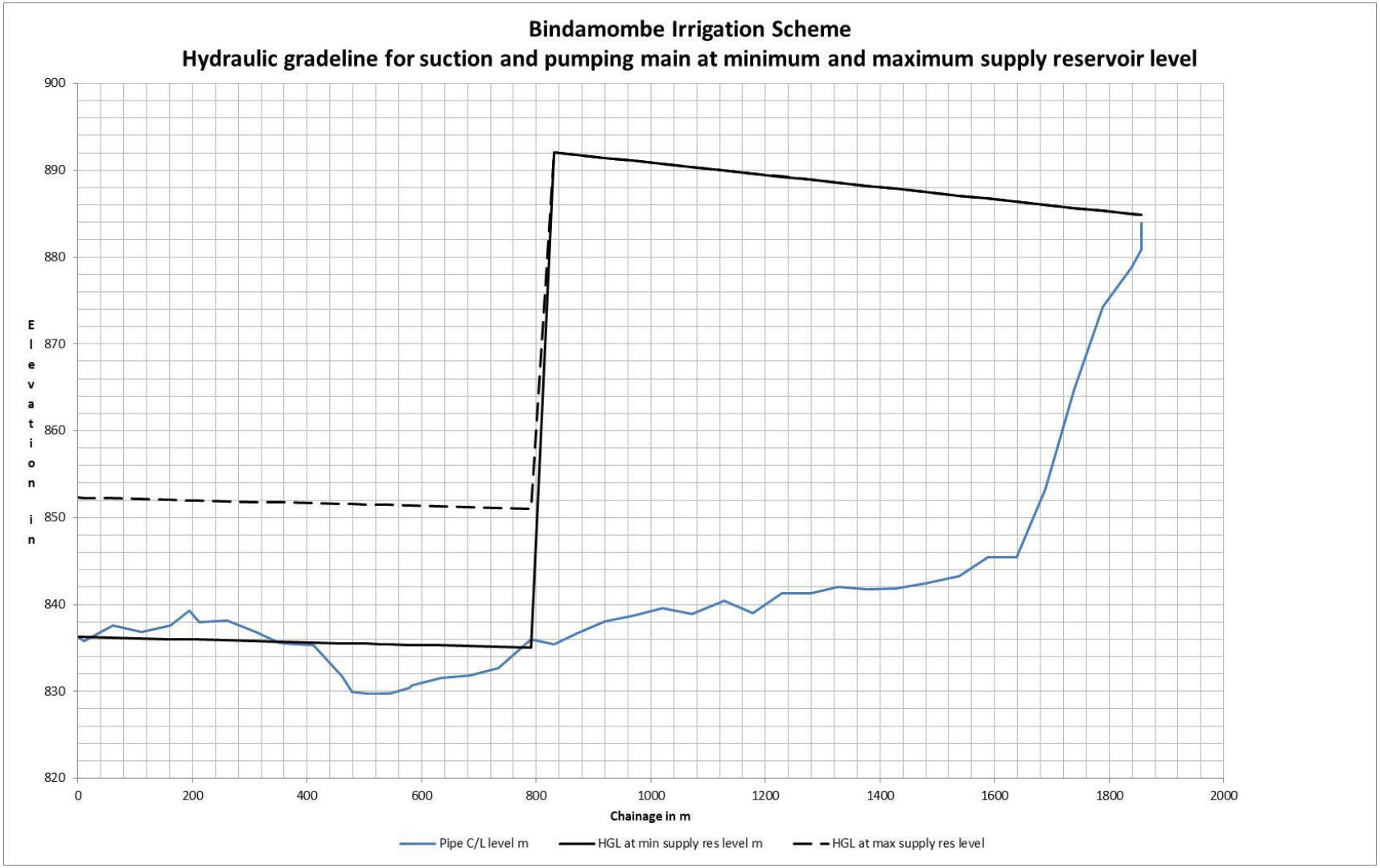


Figure 10 **Hydraulic grade lines for minimum and maximum operating levels for Option B**

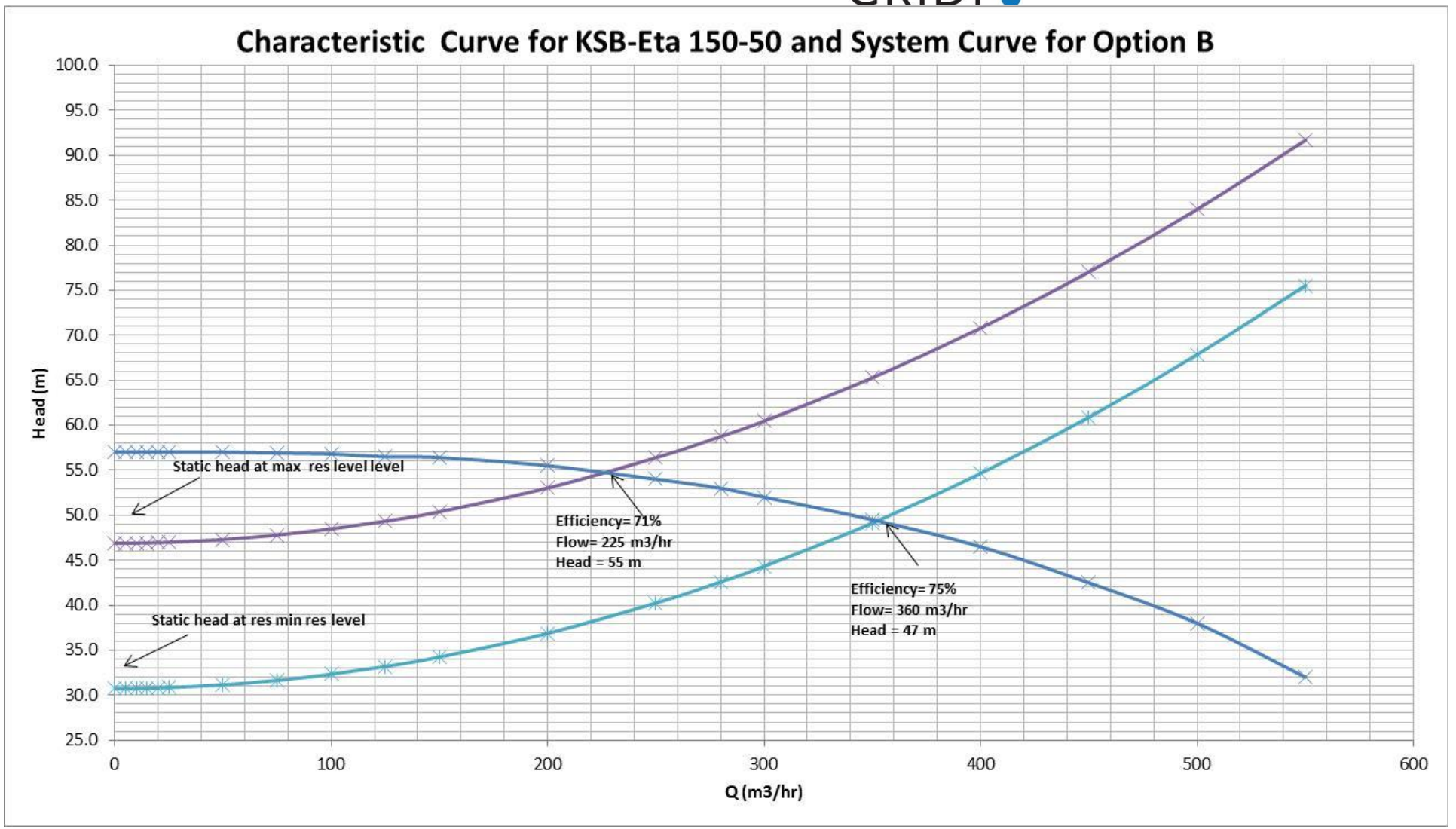


Figure 11 **Pump characteristic and system curve for Option B**

Gravity Mains and Sprinkler Irrigation System

The gravity mains has been designed to ensure adequate pressure in the in-field irrigation system, with a maximum total head of 44.4 m at the connection to the main line, and a maximum total delivery discharge of 220 m^3/hr (61.36 l/s). The system has been analysed in EPANET hydraulic software to check the level of pressures at the connections to the sprinkler, based on the design sprinkler discharge of 1.7 m^3/hr. The results of the simulation are respectively shown in Figures 12 and 13, respectively for pressures and flows in the irrigation system. The model demonstrates that the system will operate satisfactorily, with pressure falling within in the normal range of minimum pressure requirements for sprinklers available on the market. Rapid valve closure at the delivery to the irrigation field within a period of less than critical time of 2.5 second will result in maximum surge pressures being experienced in the system. It is proposed to carry our surge analysis of the gravity mains to establish potential surge pressures and the need for an appropriate hydraulic transient strategy.

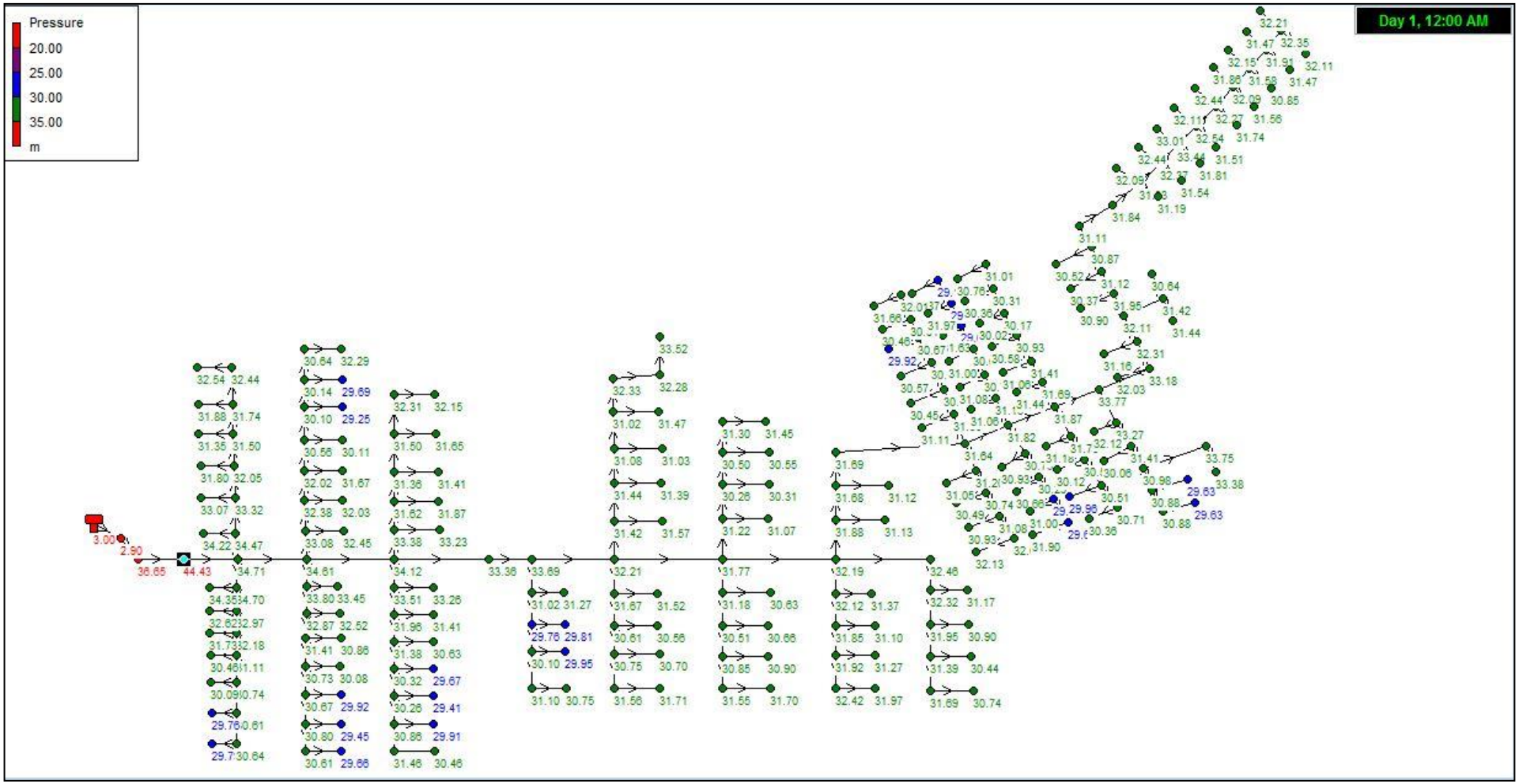


Figure 12 **Epanet model showing irrigation system pressures for the Bindangombe irrigation network**

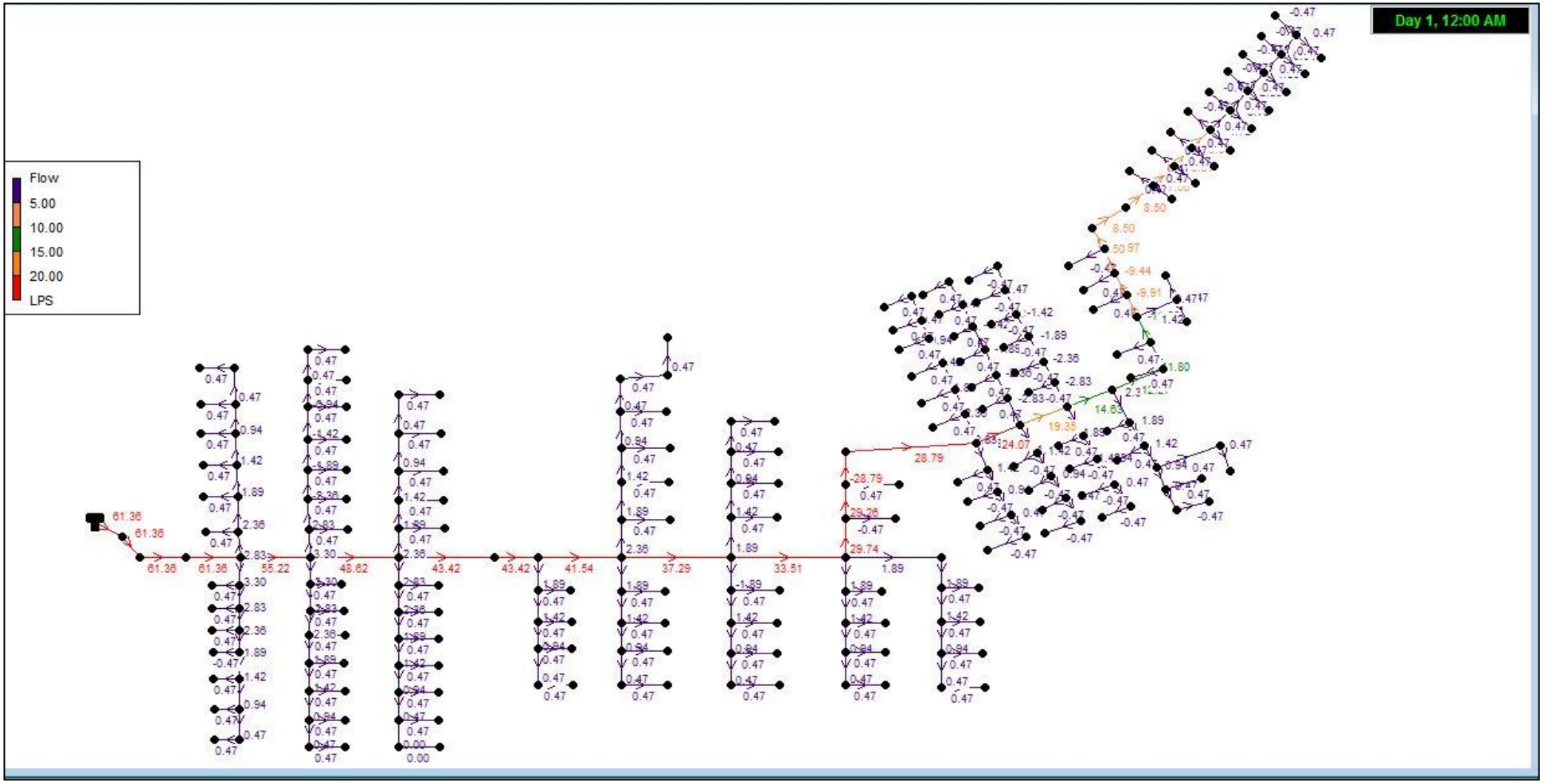


Figure 13 **Epanet model showing irrigation system flows for the Bindangombe irrigation network drawings**

Working Drawings

The following drawings have been prepared for the design of components of the scheme. A3 copies will be produced for site use, as necessary.

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Drawing Title	Original Paper Size	Remarks
1. General Layout (insert – locality Map) QW02/CE01A	A0	
2. General Layout (insert – locality Map) QW02/CE01B	A0	
3. General Arrangement Drawings - Pipeline Strip Plans	A0	
3.1. Plan and longitudinal section of suction mains QW02/CE02		
3.2. Plan and longitudinal section of pumping mains QW02/CE03A		
3.3. Plan and longitudinal section of pumping mains QW02/CE03B		
3.4. Plan and longitudinal section of gravity mains QW02/CE04		
4. Detailed Drawings of Suction Main		
4.1. Intake at Bindangombe Dam outlet QW02/CE05A	A1	
4.2. Intake at Bindangombe Dam outlet QW02/CE05A	A1	

4.3. Above Ground Steel Support Details QW02/CE06	A1	
4.4. Valves QW02/CE07	A1	
4.5. Suction main bridge crossing QW02/CE08	A1	
5. General Arrangement of Pump Station		
5.1. Pump house - Plan, Cross-sections and Elevations QW02/SE01	A1	
5.2. Pump attendant's quarters - Plan, Cross-sections and Elevations QW02/SE02	A1	
5.3. External drainage and Security Fencing QW02/CE09	A1	
5.4. Pipework arrangement QW02/CE10	A1	
6. Detailed Drawings of Pumping Main		
6.1. Below main QW02/CE11	A1	
7. Reservoir		
7.1. Floor slab plan and sections QW02/SE03	A1	
7.2. Reservoir Inlet and outlet pipework QW02/SE04	A1	
8. Detailed Drawings of Gravity Mains		

8.1. Gravity Main River Crossing QW02/CE12	A1	
9. Irrigation Field		
9.1. Irrigation layout 2.1. QW02/CE13	A0	
9.2. Typical VIP Latrine 2.2. QW02/CE14	A1	
10. Infield Erosion protection and drainage system 2.3. QW02/CE15	A2	
11. Erosion protection of degraded areas drawings 2.4. QW02/CE16	A1	
12. Electrical Reticulation Single Line Diagram 2.5. QW02/ME01	A1	
13. Pump House Electricals 2.6. QW02/ME02	A1	
14. Pump Attendant's Quarters Electricals 2.7. QW02/ME03	A1	

Water Supply and Sanitation

Water supply

Two options were explored at feasibility stage for the provision of domestic water supply, with the supply of water from boreholes being selected as the prefrred alternative. Fifteen sites for the drilling of boreholes were identified, based on the need to reduce walking distance to domestic water supplies. The location of the sites is shown in Figure 14 below.

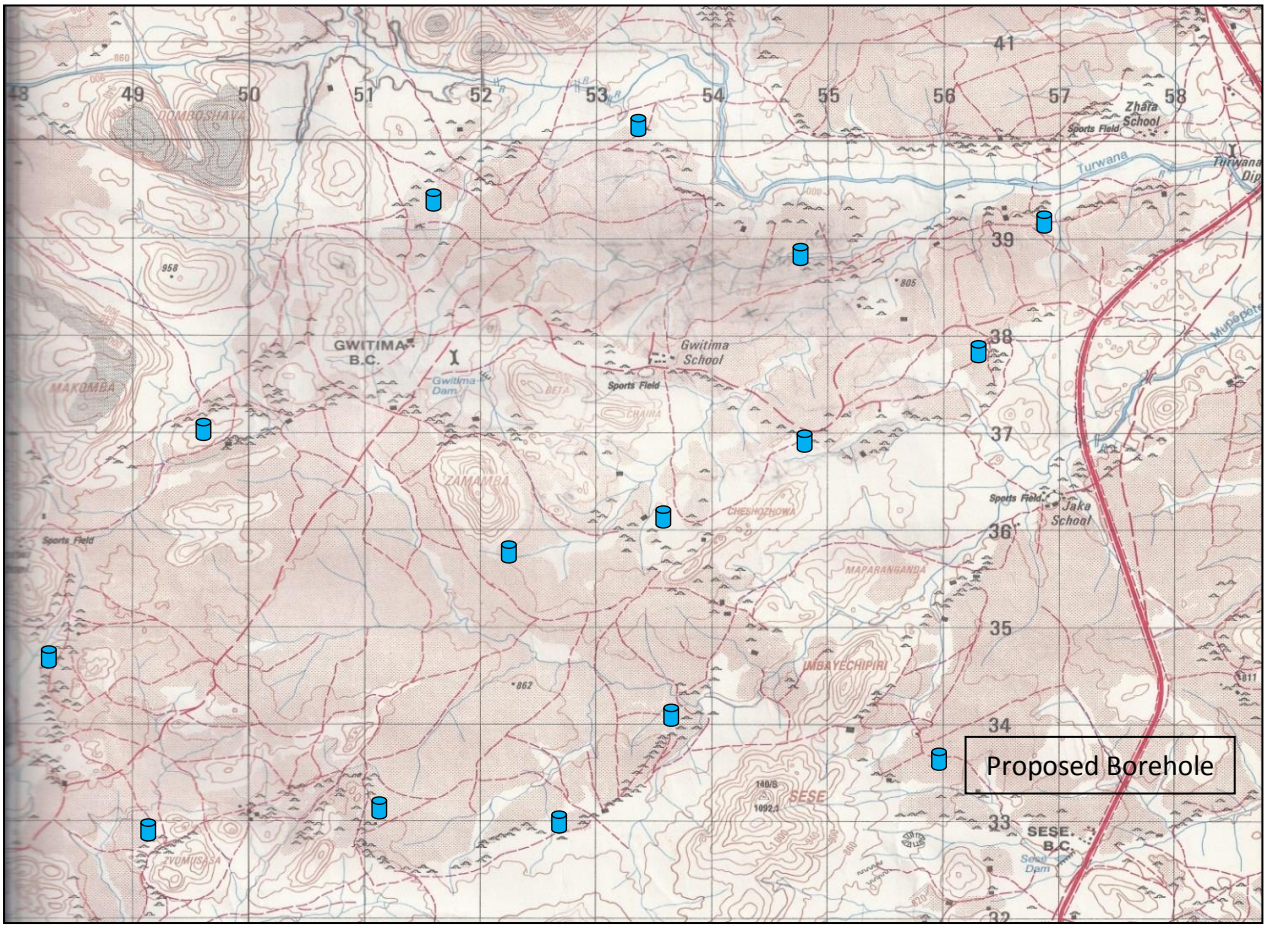


Figure 14 **Proposed sites for the installation of new boreholes and hand pumps**

Sanitation

The feasibility stage recommended the provision of ventilated-improved pit (VIP) latrine to cater for approximately 1,000 households. The project would provide designs and materials for the construction of the sanitation facilities.

The ventilated-improved pit (VIP) latrine has been recommended as the long term solution for sanitation in rural communities. The latrine is designed to reduce odour and flies which carry disease pathogens. The project will support the construction of 1008 VIP latrines through the provision of materials.

Each household will be provided with cement, brick force, reinforcement, wire, vent pipe, steel gauze and, roofing sheets and roofing nails. The beneficiaries will be responsible for the provision of bricks, stones, sand, and drought power for transport and labour for the construction of the toilet

Environmental Protection

There is extensive gulley formation in the north western boundary of Block A as well as in the central area of the block. The locations of the erosion areas are indicated in **Error! Reference source not found.** below.

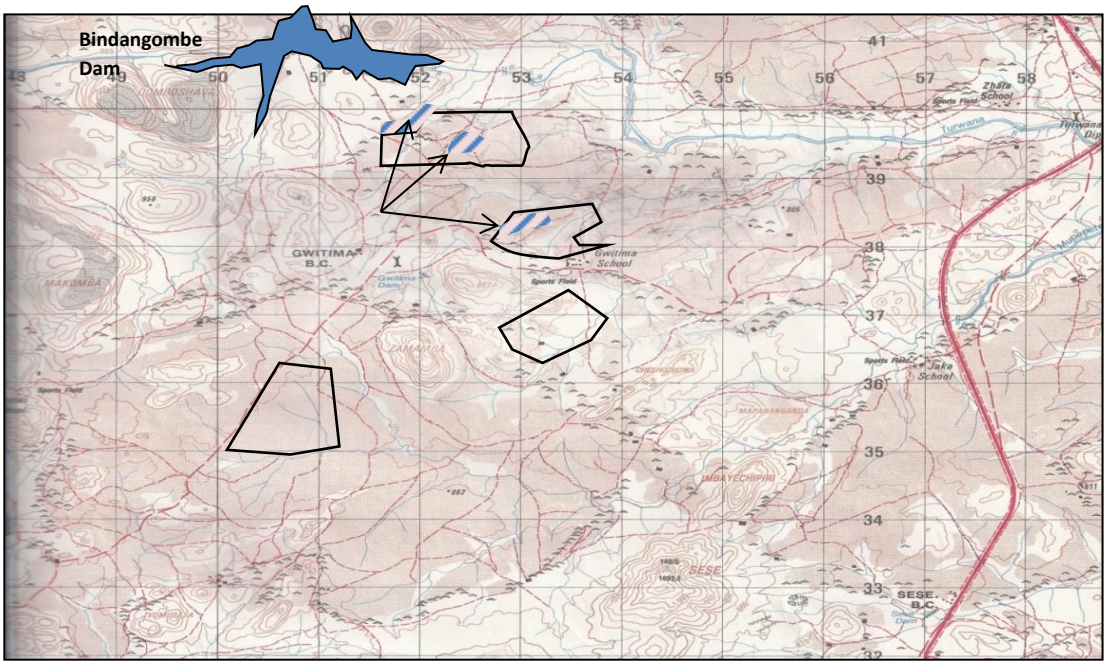


Figure 15 **Gulley formation areas**

Cost Estimates

Two separate Bill of Quantities have been developed based on the options considered for the abstraction of water from Bindangombe Dam, and the design and drawings for the proposed scheme described in the Report. The estimated cost of for each option are summarised below:

Bindangombe Irrigation Bill of Quantities Option A					
1	**BULK WATER PIPELINE**				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT**
	-				
1.1	**Pipe Laying**				
	-				
1.1.1	Supply MPVC Suction pipes				
	a) 315 mm dia Class 12	263	m	71.95	18,922.85
1.1.2	Supply Bitumen Coated Steel Suction pipes				
	a) 300 mm dia PN 350	373	m	110.00	41,030.00
1.1.3	Supply MPVC pumping pipes				
	a) 250 mm dia Class 12	823	m	49.06	40,376.38
1.1.4	Supply Bitumen Coated Steel Pumping pipes				
	a) 250 mm dia PN 350	242	m	93.48	22,622.16

1.1.5	Supply MPVC gravity pipes				
	a) 250 mm dia Class 6	937	m	26.98	25,280.26
1.1.6	Supply Bitumen Coated Steel Gravity pipes				
	a) 250 mm dia PN 350	274	m	93.48	25,613.52
1.1.7	Supply and install fittings for MPVC pipes				
1.1.7.1	MPVC bends to suite MPVC pipes				
	c) 315 mm 45 deg	2	No	160.00	320.00
	e) 250 mm 11,25 deg	2	No	113.31	226.62
	f) 250 mm 22,5 deg	2	No	113.31	226.62
	g) 250 mm 45 deg	3	No	113.31	339.93
1.1.8.2	Tees				
	a) 315x200 MPVC Tees	2	No	250.09	500.18
	b) 250x200 MPVC Tees	7	No	160.95	1,126.65
1.1.8.3	Reducers				
	a) 200/140 MPVC	2	No	49.85	99.70
	b) 140/110 MPVC	2	No	22.87	45.74

1.1.9	Supply and install fittings for Bitumen Coated Steel pipes				
1.1.9.1	Steel bends to suite Steel pipes				
	a) 300 mm 11,25 deg	2	No	700.00	1,400.00
	b) 300 mm 22,5 deg	1	No	760.00	760.00
	c) 300 mm 45 deg	1	No	820.00	820.00
	d) 300 mm 90 deg	2	No	852.00	1,704.00
	e) 250 mm 11,25 deg	0	No	650.00	0.00
	f) 250 mm 22,5 deg	2	No	650.00	1,300.00
1.1.9.2	Tees				
	a) 300x100 Steel Tees	3	No	800	2,400.00
	b) 250x100 Steel Tees	2	No	750	1,500.00
1.1.10	RSV gate valves to SABS 664:1989 - non-rising spindle, double socketed to suite pipes - Class 12				
	a) 250 mm MPVC	1	No	2,500.00	2,500.00
	b) 300 mm MPVC	1	No	2,500.00	2,500.00
	c) 250 mm Steel	1	No	2,500.00	2,500.00

1.1.11	Air Valves				
	a) 100mm dia MPVC	2	No.	1,100.00	2,200.00
	b) 100mm dia Steel	4	No.	1,100.00	4,400.00
1.1.12	Scour Valves				
	a) 100mm nb MPVC	5	No.	1,100.00	5,500.00
	b) 100mm nb Steel	2	No.	1,100.00	2,200.00
1.1.13	Water Meter				
	a) 300mm diameter on MPVC	1	No	4,000.00	4,000.00
1.2	**Sundries**				
	-				
1.2.1	Valve boxes & Markers				
	Construct valve chambers with the valve and the outlet, including for all materials, excavations, backfill and formations of outfall drain.				
	a) Gate Valves	3	No	510.00	1,530.00
	b) Air and Scour Valves	13	No	510.00	6,630.00
	c) Pressure Reading Gauges	1	No	400.00	400.00
1.2.2	Supply all materials and erect markers for				

	a) Gate Valves	3	No	97.50	292.50
	b) Air and Scour Valves	13	No	97.50	1,267.50
	c) Pressure Reducing Valves	1	No	97.50	97.50
	d) Pipeline	5	No	97.50	487.50
	-				
1.2.3	Allow for concrete thrust blocks at every change on				
	pipe direction Grade 15 and at fittings where required	4	m^3	165.00	660.00
1.2.4	Allow for concrete anchor blocks at every change on				
	pipe direction Grade 15 and at fittings where required	2	m^3	165.00	330.00
1.2.5	Allow for concrete encasing where directed	4	m^3	165.00	660.00
	(for uPVC under river and on rock)				
1.2.6	Allow for concrete anchor blocks on steep grades	10	m^3	165.00	1,650.00
1.2.7	Allow for connection to reservoir	1	Sum	2,000.00	2,000.00

	TOTAL FOR PIPELINE (carried to summary)				**228,419.61**
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	54,050.00	108,100.00
2.1.2	Earthworks (levelling and sub base and hardcore compaction)		Sum	0.00	0.00
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**				
2.4.7	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)				**138,520.00**
3	**PUMP STATION**				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT**
3.1	33 kV line construction	3	km	10,000.00	25,000.00
3.2	Supply and install 500 Kva, 33kV/400V transformer	1	Sum	35,000.00	35,000.00
				.	
3.3	Supply and install booster pumps	2	Sum	9,850.00	19,700.00
3.4	Construct Pump house and ancillaries	1	Sum	20,000.00	20,000.00
3.5	Construct Pump Attendant's Quarters	1	Sum	12,000.0	12,000.00

				0	
	TOTAL FOR PUMP STATION (carried to summary)				**111,700.00**
4	**INFIELD WORKS**				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT**
4.1	Land preparation and levelling	34	Ha	600.00	20,400.00
4.2	Fencing the irrigation scheme	2,335	m	3.25	7,588.75
4.3	Sprinkler irrigation system				
4.3.1	Supply ans Install infield Sprinkler system				
4.3.1.1	5mm brass Sprinklers 3 bars, 1.7m3/hr, 7.87mm/hr	131		28.00	3,668.00
4.3.1.2	20mm brass garden tape	131		22.60	2,960.60
4.3.1.3	1m x 20mm GI riser pipes	131		6.55	858.05
4.3.1.4	20mm elbows	262		1.25	327.50
4.3.1.5	1m tripod stand	131		29.84	3,909.04
4.3.1.6	32m x 20mm reinforced garden hose	131		62.40	8,174.40
4.3.1.7	20mm GI sockets	262		0.85	222.70
4.3.1.8	20mm swage nipples	262		1.65	432.30

4.3.1.9	20-25 Dupli clips	262		0.75	196.50
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 Class 6 pipe	8,600	m	1.30	11,180.00
4.3.3	Supply MPVC pipework				
	a) 40mm Class 6	588	m	1.23	723.24
	b) 50mm Class 6	432	m	1.69	730.08
	c) 63mm Class 6	276	m	2.14	590.64
	d) 75mm Class 6	624	m	2.58	1,609.92
	e) 90mm Class 6	252	m	3.69	929.88
	f) 110mm Class 6	72	m	5.21	375.12

	g) 125mm Class 6	150	m	7.08	1,062.00
	h) 160mm Class 6	210	m	11.52	2,419.20
	i) 200mm Class 6	360	m	17.65	6,354.00
	j) 250mm Class 6	120	m	26.98	3,237.60
4.3.4	MPVC bends to suite MPVC pipes				
	a) 200 mm 22,5 deg	1	No	83.58	83.58
	b) 160 mm 90 deg	1	No	45.76	45.76
	c) 160 mm 45 deg	1	No	45.76	45.76
	d) 90 mm 90 deg	1	No	17.70	17.70
	e) 90 mm 45 deg	1	No	17.70	17.70
	f) 75 mm 90 deg	1	No	14.11	14.11
4.3.5	Tees				
	a) 200/90 unequal Tee	1	No	128.73	128.73
	b) 200/75 unequal Tee	3	No	128.73	386.19
	c) 180/160 unequal Tee	1	No	89.29	89.29
	d) 160/90 unequal Tee	2	No	72.60	145.20
	e) 110/40 unequal Tee	1	No	27.36	27.36
	f) 75/40 unequal Tee	1	No	18.91	18.91
	g) 125 equal Tee	1	No	57.91	57.91
	TOTAL FOR INFIELD WORKS (carried to summary)				**81,917.60**

5	**ENVIRONMENTAL**				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT**
5.1	Allow for environmental protection works by use of gabions and buffles	1	Sum		6,000.00
5.2	Tree seedlings and planting	1,250	plant	0.75	937.50
	TOTAL FOR INFIELD WORKS (carried to summary)				**6,937.50**
	SUMMARY				
1	BULK WATER PIPELINE				**228,419.61**
2	2 Ml RESERVOIR				**138,520.00**
3	PUMP STATION				**111,700.00**
4	INFIELD WORKS				**81,917.60**
5	ENVIRONMENTAL				**6,937.50**
	SUBTOTAL				**567,494.71**
	Add CONTINGENCIES			10%	**56,749.47**
	Add VAT			15%	**85,124.21**

	TOTAL				**709,368.39**
	MANAGEMENT CONTRACTOR				**90,000.00**
	TECHNICAL SUPPORT COSTS				**15,000.00**
	DIRECT LABOUR COSTS			2%	**10,640.53**
	GRAND TOTAL				**$825,008.91**

Binda Irrigation Bill of Quantities Option B					
1	**BULK WATER PIPELINE**				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT**
	-				
1.1	**Pipe Laying**				
	-				
1.1.1	Supply Flexible Suction Poly pipes				
	a) 315 mm dia Class 12	75	m	49.06	3,679.50
1.1.2	Supply MPVC pumping pipes				
	a) 250 mm dia Class 12	271	m	49.06	13,295.26
1.1.3	Supply Bitumen Coated Steel Pumping pipes				

	a) 250 mm dia PN 350	484	m	93.48	45,244.32
	b) 250 mm dia Class 12	0	m	93.48	0.00
1.1.4	Supply MPVC gravity pipes				
	a) 250 mm dia Class 6	937	m	26.98	25,280.26
1.1.5	Supply Bitumen Coated Steel Gravity pipes				
	a) 250 mm dia PN 350	274	m	93.48	25,613.52
1.1.6	Supply and install fittings for MPVC pipes				
1.1.6.1	MPVC bends to suite MPVC pipes				
	a) 250 mm 11,25 deg	2	No	113.31	226.62
	b) 250 mm 22,5 deg	2	No	113.31	226.62
	c) 250 mm 45 deg	2	No	113.31	226.62
1.1.6.2	Tees				
	b) 250x100 MPVC Tees		No		0.00
1.1.7	Supply and install fittings for Bitumen Coated Steel pipes				
1.1.7.1	Steel bends to suite Steel pipes				
	a) 250 mm 11,25 deg	1	No		650.00

				650.00	
	b) 250 mm 22,5 deg	1	No	852.00	852.00
	c) 250 mm 45 deg	0	No	852.00	0.00
	d) 250 mm 90 deg	2	No	852.00	1,704.00
1.1.9	RSV gate valves to SABS 664:1989 - non-rising spindle, double socketed to suite pipes - Class 12				
	a) 250 mm MPVC	1	No	2,500.00	2,500.00
	b) 300 mm MPVC	1	No	2,500.00	2,500.00
	c) 250 mm Steel	1	No	2,500.00	2,500.00
1.1.10	Air Valves				
	a) 100mm dia MPVC	2	No.	1,200.00	2,400.00
	b) 100mm dia Steel	4	No.	1,200.00	4,800.00
1.1.11	Scour Valves				
	a) 100mm nb MPVC	5	No.	1,200.00	6,000.00
	b) 100mm nb Steel	2	No.	1,200.00	2,400.00
1.1.12	Water Meter				
	a) 300mm diameter on MPVC	1	No	4,000.00	4,000.00

1.2	**Sundries**				
	-				
1.2.1	Valve boxes & Markers				
	Construct valve chambers with the valve and the outlet, including for all materials, excavations, backfill and formations of outfall drain.				
	a) Gate Valves	3	No	510.00	1,530.00
	b) Air and Scour Valves	13	No	510.00	6,630.00
	c) Pressure Reading Gauges	1	No	510.00	510.00
1.2.2	Supply all materials and erect markers for				
	a) Gate Valves	3	No	97.50	292.50
	b) Air and Scour Valves	13	No	97.50	1,267.50
	c) Pressure Reducing Valves	1	No	97.50	97.50
	d) Pipeline	5	No	97.50	487.50
	-				
1.2.3	Allow for concrete thrust blocks at every change on				
	pipe direction Grade 15 and at fittings where required	4	m^3	165.00	660.00

1.2.4	Allow for concrete anchor blocks at every change on				
	pipe direction Grade 15 and at fittings where required	2	m^3	165.00	330.00
1.2.5	Allow for concrete encasing where directed	4	m^3	165.00	660.00
	(for uPVC under river and on rock)				
1.2.6	Allow for concrete anchor blocks on steep grades	10	m^3	165.00	1,650.00
1.2.7	Allow for connection to reservoir	1	Sum	2,000.00	2,000.00
	TOTAL FOR PIPELINE (carried to summary)				**160,213.72**
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	54,050.00	108,100.00

2.1.2	Earthworks (levelling and sub base and hardcore compaction)		Sum	0.00	0.00
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**				
2.4.7	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)				**138,520.00**
3	**PUMP STATION**				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT**

3.1	33 kV line construction	3	km	10,000.00	25,000.00
3.2	Supply and install 500 Kva, 33kV/400V transformer	1	Sum	35,000.00	35,000.00
				.	
3.3	Supply and install booster pumps	2	Sum	9,850.00	19,700.00
3.4	Construct Pump house and ancillaries	1	Sum	20,000.00	20,000.00
3.5	Construct Pump Attendant's Quarters	1	Sum	12,000.00	12,000.00
3.6	Install Pontoon and pipe bridge	1	Sum	40,000.00	40,000.00
	TOTAL FOR PUMP STATION (carried to summary)				**151,700.00**
4	**INFIELD WORKS**				
ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT**

4.1	Land preparation and levelling	34	Ha	600.00	20,400.00
4.2	Fencing the irrigation scheme	2,335	m	3.25	7,588.75
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	131		28.00	3,668.00
4.3.1.2	20mm brass garden tape	131		22.60	2,960.60
4.3.1.3	1m x 20mm GI riser pipes	131		6.55	858.05
4.3.1.4	20mm elbows	262		1.25	327.50
4.3.1.5	1m tripod stand complete with 1m GI riser pipe	131		29.84	3,909.04
4.3.1.6	32m x 20mm reinforced garden hose	131		62.40	8,174.40
4.3.1.7	20mm GI sockets	262		0.85	222.70
4.3.1.8	20mm swage nipples	262		1.65	432.30
4.3.1.9	20-25 Dupli clips	262		0.75	196.50
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 Class 6 pipe	8,600	m	1.30	11,180.00
4.3.3	Supply MPVC pipework				
	a) 40mm Class 6	588	m	1.23	723.24
	b) 50mm Class 6	432	m	1.69	730.08
	c) 63mm Class 6	276	m	2.14	590.64
	d) 75mm Class 6	624	m	2.58	1,609.92
	e) 90mm Class 6	252	m	3.69	929.88
	f) 110mm Class 6	72	m	5.21	375.12
	g) 125mm Class 6	150	m	7.08	1,062.00
	h) 160mm Class 6	210	m	11.52	2,419.20

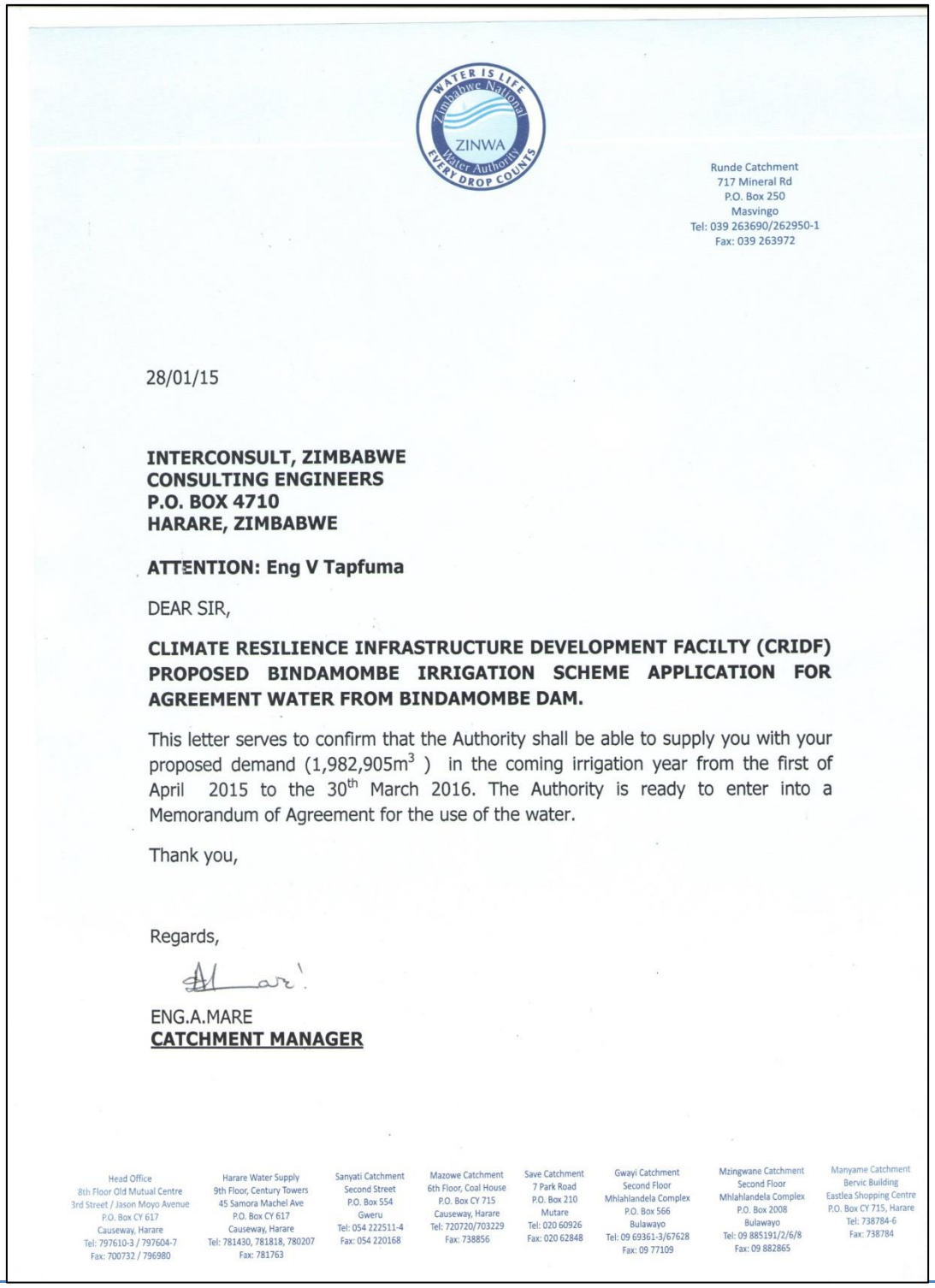
	i) 200mm Class 6	360	m	17.65	6,354.00
	j) 250mm Class 6	120	m	26.98	3,237.60
4.3.4	MPVC bends to suite MPVC pipes				
	a) 200 mm 22,5 deg	1	No	83.58	83.58
	b) 160 mm 90 deg	1	No	45.76	45.76
	c) 160 mm 45 deg	1	No	45.76	45.76
	d) 90 mm 90 deg	1	No	17.70	17.70
	e) 90 mm 45 deg	1	No	17.70	17.70
	f) 75 mm 90 deg	1	No	14.11	14.11
4.3.5	Tees				
	a) 200/90 unequal Tee	1	No	128.73	128.73
	b) 200/75 unequal Tee	3	No	128.73	386.19
	c) 180/160 unequal Tee	1	No	89.29	89.29
	d) 160/90 unequal Tee	2	No	72.60	145.20
	e) 110/40 unequal Tee	1	No	27.36	27.36
	f) 75/40 unequal Tee	1	No	18.91	18.91
	g) 125 equal Tee	1	No	57.91	57.91
	TOTAL FOR INFIELD WORKS (carried to summary)				**81,917.60**
5	**ENVIRONMENTAL**				

ITEM	**DESCRIPTION**	**QTY**	**UNIT**	**RATE**	**AMOUNT**
5.1	Allow for environmental protection works by use of gabions and buffles	1	Sum		6,000.00
5.2	Tree seedlings and planting	1,250	plant	0.75	937.50
	TOTAL FOR INFIELD WORKS (carried to summary)				**6,937.50**
	SUMMARY				
1	BULK WATER PIPELINE				**160,213.72**
2	2 Ml RESERVOIR				**138,520.00**
3	PUMP STATION				**151,700.00**
4	INFIELD WORKS				**81,917.60**
5	ENVIRONMENTAL				**6,937.50**
	SUBTOTAL				**539,288.82**
	Add CONTINGENCIES			10%	**53,928.88**
	Add VAT			15%	**80,893.32**

	TOTAL				**674,111.03**
	MANAGEMENT CONTRACTOR				**90,000.00**
	TECHNICAL SUPPORT COSTS				**15,000.00**
	DIRECT LABOUR COSTS			2%	**10,111.67**
	GRAND TOTAL				**$789,222.69**

Appendices

Appendix 1: Letters of undertaking to enter into a memorandum of Agreement with ZINWA



WATER IS LIFE
Zimbabwe National
ZINWA
Water Authority
EVERY DROP COUNTS

Runde Catchment
717 Mineral Rd
P.O. Box 250
Masvingo
Tel: 039 263690/262950-1
Fax: 039 263972

28/01/15

INTERCONSULT, ZIMBABWE
CONSULTING ENGINEERS
P.O. BOX 4710
HARARE, ZIMBABWE

ATTENTION: Eng V Tapfuma

DEAR SIR,

CLIMATE RESILIENCE INFRASTRUCTURE DEVELOPMENT FACILTY (CRIDF) PROPOSED BINDAMOMBE IRRIGATION SCHEME APPLICATION FOR AGREEMENT WATER FROM BINDAMOMBE DAM.

This letter serves to confirm that the Authority shall be able to supply you with your proposed demand (1,982,905m^3) in the coming irrigation year from the first of April 2015 to the 30th March 2016. The Authority is ready to enter into a Memorandum of Agreement for the use of the water.

Thank you,

Regards,

ENG.A.MARE
CATCHMENT MANAGER

Head Office
8th Floor Old Mutual Centre
3rd Street / Jason Moyo Avenue
P.O. Box CY 617
Causeway, Harare
Tel: 797610-3 / 797604-7
Fax: 700732 / 796980

Harare Water Supply
9th Floor, Century Towers
45 Samora Machel Ave
P.O. Box CY 617
Causeway, Harare
Tel: 781430, 781818, 780207
Fax: 781763

Sanyati Catchment
Second Street
P.O. Box 554
Gweru
Tel: 054 222511-4
Fax: 054 220168

Mazowe Catchment
6th Floor, Coal House
P.O. Box CY 715
Causeway, Harare
Tel: 720720/703229
Fax: 738856

Save Catchment
7 Park Road
P.O. Box 210
Mutare
Tel: 020 60926
Fax: 020 62848

Gwayi Catchment
Second Floor
Mhlahlandela Complex
P.O. Box 566
Bulawayo
Tel: 09 69361-3/67628
Fax: 09 77109

Mzingwane Catchment
Second Floor
Mhlahlandela Complex
P.O. Box 2008
Bulawayo
Tel: 09 885191/2/6/8
Fax: 09 882865

Manyame Catchment
Bervic Building
Eastlea Shopping Centre
P.O. Box CY 715, Harare
Tel: 738784-6
Fax: 738784

Appendix 2 Bill of Quantities for Bindangombe irrigation Scheme

Attached separately.

CRIDF