

THE NATIONAL REGIONAL STATE OF OROMIA

OROMIA IRRIGATION DEVELOPMENT AUTHORITY



***LAGA DHUMMUGA SMALL-SCALE IRRIGATION PROJECT
ENGINEERING STUDY & DESIGN DRAFT REPORT***



OROMIA WATER WORK DESIGN & SUPERVISION ENTERPRISE

TEL.: +251 11 439-21-62/24-70

FAX: 25111 439-20-08

E-mail: owwdse@telecom.net.et

April, 2019

Finfinne

TABLE OF CONTENTS

TABLE OF CONTENTS.....	I
LIST OF TABLES	II
LIST OF FIGURES.....	III
1. INTRODUCTION	1
1.1 OBJECTIVE OF THE PROJECT.....	1
1.2 LOCATION AND ACCESSIBILITY	1
2. ELECTROMECHANICAL DESIGN OF DHUMUGA BORE HOLES	1
2.1 DESIGN INPUT DATA FOR DHUMMUGA BH (DHUMMUGA BH1).....	1
2.1.1 Design and Selection of Electro-Mechanical Equipment.....	2
2.1.2 Pump selection	2
2.2 HYDRAULIC DESIGN FOR BORE HOLE NO 1 (BH-1)	2
2.2.1 Diameter & Velocity Determination	2
2.2.2 Determination of submersible pump power	7
2.2.3 Determination of submersible motor power	7
2.2.4 Summary Submersible Pump Bore hole No-1 (BH-1).....	8
2.3 HYDRAULIC DESIGN OF BOREHOLE NO 2 (BH-2)	9
2.3.1 Diameter & Velocity Determination	9
2.3.2 Determination of submersible pump power.....	13
2.4.3 Determination of submersible motor power	13
2.4.4 Summary Submersible Pump Bore hole No-1 (BH-2).....	14
2.4 HYDRAULIC DESIGN FOR BORE HOLE NO 3.....	14
2.4.1 Diameter & Velocity Determination	15
2.4.2 Determination of submersible pump power.....	19
2.4.3 Determination of submersible motor power	20
2.4.4 Summary Submersible Pump Bore hole No-3 (BH-3).....	20
2.5 HYDRAULIC DESIGN FOR BORE HOLE NO 4.....	20
2.5.1 Diameter & Velocity Determination	21
2.5.2 Determination of submersible pump power.....	25
2.5.3 Determination of submersible motor power	25
2.5.4 Summary Submersible Pump Bore hole No-1 (BH-4).....	26
2.6 HYDRAULIC DESIGN FOR BORE HOLE NO 5.....	27
2.6.1 Diameter & Velocity Determination	27
2.6.2 Determination of submersible pump power	31
2.6.3 Determination of submersible motor power	32
2.6.3 Summary Submersible Pump Bore hole No-1 (BH-5).....	32
3 LITHOLOGICAL DESCRIPTION CUTTING SAMPLES.....	33
4. FIELD WATER QUALITY MEASUREMENT.....	35
5 IRRIGATION DISTRIBUTION SYSTEM DESIGN	36
5.1 CANAL SYSTEM	36
5.1.1 Description of Water Distribution System.....	36
5.1.2 Canal Alignment (Canal Layout).....	36
5.2 DESIGN OF CANALS	36
5.2.1 Main Canal.....	38
5.2.2 Secondary Canals	40

5.2.3	Tertiary Canal	40
5.2.4	Longitudinal Section of Canals.....	40
5.3	CANAL STRUCTURES	41
5.3.1	Design of Storage Reservoirs.....	41
5.3.2	Box Culverts	49
2.1.3	Division Box.....	51
5.3.2	Turnout/Offtakes	53
5.3.3	Drops	59
5.3.4	REFERENCE	60
6.	BILLOFF QUANTITY.....	60
	ANNEX - III: LIST OF DRAWINGS	69

LIST OF TABLES

TABLE 1:	INPUT DATA BH-1.....	2
TABLE 2	TOTAL DYNAMIC HEAD LOSS OF FITTINGS FOR BH-1,.....	4
TABLE 3	INPUT DATA FOR BH-2.....	9
TABLE 4	TOTAL DYNAMIC HEAD LOSS OF FITTINGS FOR BH-2.....	11
TABLE 5:	INPUT DATA FOR BH-3	15
TABLE 6	TOTAL DYNAMIC HEAD LOSS OF FITTINGS	17
TABLE 7:	INPUT DATA FOR BH-4	21
TABLE 8	TOTAL DYNAMIC HEAD LOSS OF FITTINGS FOR BH 4	23
TABLE 9	BILL OF MATERIALS FOR BH-4	26
TABLE 10	INPUT DATA FOR BH-5.....	27
TABLE 11	TOTAL DYNAMIC HEAD LOSS OF FITTINGS AT WELL HEAD.....	29
TABLE 12	LITHOLOGICAL DESCRIPTION OF CUTTING SAMPLES.....	33
TABLE 13	WATER QUALITY	35
TABLE 14	DESIGN PARAMETERS OF MAIN CANAL	39
TABLE 15	HYDRAULIC CHARACTERISTICS OF THE CANALS AT THE PROPOSED BOX CULVERT SITES	49
TABLE 16	CANAL ELEVATION AT EACH SECTION	51
TABLE 17	HYDRAULIC DESIGN OF DIVISION BOX.....	53
TABLE 18	IRRIGATION OUTLET ON MAIN CANAL	54
TABLE 19	IRRIGATION OUTLET ON SECONDARY CANAL.....	55
TABLE 20	IRRIGATION OUTLET ON TERTIARY CANAL (TC)	56

LIST OF FIGURES

FIGURE 1 GENERAL LAYOUT OF LAGA DHUMMUGA BORE HOLE	35
FIGURE 2 GENERAL LAYOUT OF LAGA DHUMMUGA IRRIGATION PROJECT	38
FIGURE 3 SECTIONS OF CANALS	39
FIGURE 4 PLAN OF NIGHT STORAGE	43
FIGURE 5 POND OUTLET	47
FIGURE 6 ENERGY PROFILE OVER THE SPILLWAY	49
FIGURE 7 LONGITUDINAL SECTION OF BOX CULVERT	51
FIGURE 8 LONGITUDINAL SECTION OF DIVISION BOX.....	52
FIGURE 9 LAYOUT OF TURNOUT	54

1. INTRODUCTION

Laga Dhumuga small scale irrigation project is aimed at ensuring food self-sufficiency as well as alleviating poverty by making use of ground water (deep well). The project is intended to irrigate **189.5ha** of land. Sample selection of bore hole and its design is done from previous drilled borehole during ground water potential exploitation and pumps are designed & its operation is for 16hrs/day. The project Irrigation duty is 12hrs and pond (wet well) is designed to store for 4hr pumped water. Major activities during the execution of the project will be Borehole drilling, electromechanical installation, pressure line laying, Wet wells (pond construction), Generator houses construction, irrigation canals, drainage canals, and different irrigation and drainage structures.

1.1 Objective of the Project

The main objective of deep well drilling is to exploit (pump) sufficient irrigation water for the command during the period of dry time. And the work, electromechanical installation and Pipe laying is done in order to pump ground water towards the Wet wells, so as to ensure a regulated continuous supply of water in to the distribution canal.

1.2 Location and Accessibility

Dhumuga Small Scale Irrigation Project is found in Bahima-Harchumma & Unke kebele, Shanan Kolu District, Arsi Zone of Oromia Regional state, at 340km from Finfinne via Adama and Cholle in Arsi Zone. It is geographically located at zone- 37 Easting – 637467m, northing – 932141m and 1465masl. About **118KM** asphalt road from Finfinne to Dhera whereas **240KM** gravel & weathered road from Dhera via Sire ,Cholle ,Chancho to Dhumuga SSI project site is the main access to site.

2. ELECTROMECHANICAL DESIGN OF DHUMUGA BORE HOLES

2.1 Design input data for Dhumuga BH (Dhumuga BH1)

The following table shows the design input for boreholes No 1 from well completion report.

FROM WELL COMPLETION REPORT, THE FOLLOWING DATA ARE TAKEN FOR DESIGN PURPOSES.

TABLE 1: INPUT DATA BH-1

No	Description	Corresponding data Measurements
1	Wet well Top elevation	1598 meter above sea level
2	Well head elevation	1462 meter at sea level
3	Static water level	40 meter
4	draw down	110 meter
5	Dynamic water level	150meter
6	Recommended pump position	200meter
7	Recommended design discharge	30 liter/second
8	Casing diameter	305mm
9	Borehole depth	350 meter
10	Riser Pipe	150 millimeter or 6inch
11	Head work pipe	150mm diameter
12	From all BH head to junction point	Length and diameters are known

2.1.1 Design and Selection of Electro-Mechanical Equipment

Design and selection of major electro-mechanical equipment considered in this project are; submersible pumps, control panels, power cables, control cables, pipes and fittings, diesel generator and transformer are some to mention.

2.1.2 Pump selection

It is selected based on the type of water source (tube well) and hence submersible pump is selected.

2.2 Hydraulic design for bore hole no 1 (BH-1)

Hydraulic design is based on safe yield, $Q = 30\text{l/sec}$, to irrigate more than 190ha of land during peak water requirement of crops. There are totally five bore holes .Hence pump diameter, total pump head, etc. are determined as follows.

2.2.1 Diameter & Velocity Determination

The well is already drilled as production well having 305mm (12") casing diameter up to 350m well depth. In principle, the diameter of the well casing should be at least 5cm larger than the nominal diameter of the pump to accommodate the pump with proper clearance for installation and efficient operation. Therefore the nominal size of pump bowls should be 250mm (10") and diameter of riser pipe can be taken as 150mm (6").

Velocity of water in riser main can be calculated as:

$$v = \frac{4 \times Q}{3.14 \times d^2}$$

Where Q =discharge in m³/sec and d in riser pipe diameter

$$v = \frac{4 \times 0.03}{3.14 \times (0.15)^2}$$

V=1.7m/sec

Total Dynamic Head of Submersible Pump

$$H_T = H_s + H_L$$

Where: H_T = Total submersible pump head

H_s = Static head

H_L = Head Loss

Static head

It can be calculated as follows:

$$H_s = \text{Wet well elevation} - \text{Wellhead elevation} + \text{Dynamic water level}$$

$$H_s = 1598 - 1462 + 150$$

$$\therefore H_s = 286$$

Head Loss

a) Riser pipe and head work pipe loss (h_{111}) DN150 L=200m, Q = 30 l/s

By Using Hazen Williams's formula

$$h_{111} = 10.67 \times \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{D^{4.87}}$$

Where,

C = coefficient of Roughness for GS pipe (120)

D = Pipe diameter (0.15m)

$$Q = \text{Flow Rate } 0.03 \frac{m^3}{\text{sec}}$$

$h_{11} =$ pipe friction loss

$L =$ Riser pipe and head work pipe length = 200 m

Therefore by substituting the value:

$$h_{111} = 10.67 \times \left(\frac{0.03}{120}\right)^{1.85} \times \frac{200}{0.15^{4.87}}$$

$$\therefore h_{111} = 4.8$$

b) Dynamic Head Loss of Fittings (h_{112}) at well head

TABLE 2 TOTAL DYNAMIC HEAD LOSS OF FITTINGS FOR BH-1,

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
90° bends	PCs	3	GS	DN 150	1.7	0.75	$\frac{3 \times K \times v^2}{2 \times g}$	0.3
Check valve	PCs	1	GS	DN 150	1.7	1.9	$\frac{K \times v^2}{2 \times g}$	0.3
Gate valve	PCs	1	GS	DN 150	1.7	0.15	$\frac{K \times v^2}{2 \times g}$	0.1
Reducer	PCs	1	DCI	DN150/200	1.7	1.5	$\frac{k \times (v_1^2 - v_2^2)}{2 \times g}$	0
Water meter	PC's	1	GS	DN 150	1.7	6	$\frac{K \times v^2}{2 \times g}$	0.6
Total dynamic head loss of fittings (h_{112}) at well head								1.3

Where K – coefficient of friction loss

V – Velocity of water

g -Acceleration due to gravity

Total head Losses of riser pipe and head work pipe and fittings (h₁₁)

$$h_{11} = h_{111} + h_{112} = 4.8 + 1.3 = 6.1$$

Transmission main head losses (h₁₂)

Straight pipe head loss from end of borehole head to wet well (h₁₂₁)

PVC DN 200 mm, L= 1123 m, Q = 30 l/s

Using Hazen Williams’s formula

$$h_{121} = 10.67 \times \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{D^{4.87}}$$

Where:

C = coefficient of Roughness for PVC pipe (150)

D = Pipe diameter (0.20m)

Q = Flow Rate $0.03 \frac{m^3}{sec}$

h₁₂₁ = pipe friction loss

L = Straight pipe length= 1123 m

$$h_{121} = 10.67 \times \left(\frac{0.03}{150}\right)^{1.85} \times \frac{1123}{0.20^{4.87}}$$

$$h_{121} = 4.34m$$

d) Dynamic Head Loss of Fittings (90°) bends at transmission main pipe line (h₁₂₂)

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
90° bends	PCs	1	DCI	DN200	0.96	0.75	$\frac{K \times v^2}{2 \times g}$	0.5
Dynamic Head Loss of Fittings at transmission main pipe line (h₁₂₂)								0.5

<i>Description</i>	<i>Unit</i>	<i>Qty.</i>	<i>Material</i>	<i>Size (mm)</i>	<i>Velocity m/s</i>	<i>Coefficient K</i>	<i>Formula</i>	<i>Dynamic Loss (m)</i>
<i>Gate valve</i>	<i>PCs</i>	<i>1</i>	<i>DCI</i>	<i>DN200</i>	<i>0.96</i>	<i>0.15</i>	$\frac{K \times v^2}{2 \times g}$	<i>0.3</i>
Dynamic Head Loss of Fittings at transmission main pipe line (h₁₂₂)								0.3

e) Dynamic Head Loss of gate valve at transmission main pipe line (h₁₂₃)

Total head Losses of transmission main pipe and fittings (h₁₂) due to:

Transmission line + 90° bends + Gate valve

$$(h_{12}) = h_{121} + h_{122} + h_{123} = 4.34 + 0.5 + 0.3 = \mathbf{5.14}$$

Total Head Losses (h₁)

Total Dynamic head loss consists fitting losses (from head work) + pipe friction losses

$$\mathbf{H_D = h_1 = h_{11} + h_{12}}$$

$$\mathbf{H_D = 6.1m + 5.14 m = 11.24 m}$$

Total Dynamic head for submersible pump Head (H_T)

$$\mathbf{H_T = H_s + H_L}$$

$$\mathbf{H_T = 286 + 11.04 = 297.24 \text{ take } 298 \text{ m}}$$

Therefore, the pump duty point is selected to be:

∴ Duty Point: 30 l/s at 298m head for BH-1

2.2.2 Determination of submersible pump power

Taking the above calculated duty point of the pump:

Known & assumed values: -

$$Q = 30 \text{ l/s}$$

$$H_T = 298 \text{ m}$$

η = pump efficiency = 70 %

The required pump power can be calculated from:

$$\mathbf{P_p = \frac{(Q \times H_T)}{(102 * \eta_p)}}$$

$$\mathbf{P_p = 125 \text{ Kw}}$$

2.2.3 Determination of submersible motor power

By assuming 10-20 % for Electric motor overload, the pump motor will be:-

$$\mathbf{P_m = P_p \times (1 + 0.2)}$$

$$P_m = P_p \times (1 + 0.2), \text{ kW}$$

Where

P_p = pump power

P_m = motor power

$P_m = 125 \times (1 + 0.2) = 150\text{Kw}$

Hence, 150 kW motor shall be selected from the available motor rating standards.

2.2.4 Summary Submersible Pump Bore hole No-1 (BH-1)

No	Description	Qty
1	Number of pumps	1 submersible pump
2	Make and Model	From supplier
3	Capacity(Discharge rate)	108m ³ /hr.
4	Total Dynamic head	298
5	Bore hole casing Diameter	305mm (12inch)
6	Motor Power	150Kw
7	Medium to be pumped	Ground water for irrigation
8	Pump position below ground level	200m
9	Pump efficiency	0.7

2.3 Hydraulic Design of borehole No 2 (BH-2)

From well completion report, the following data are taken for design purposes.

TABLE 3 INPUT DATA FOR BH-2

No	Description	Corresponding data Measurements
1	Wet Well head Top elevation	1598 meter at sea level
2	Well head elevation	1444 meter at sea level
3	Static water level	40 meter
4	draw down	110 meter
5	Dynamic water level	150meter
6	Recommended pump position	200meter
7	Recommended design discharge	30 liter/second
8	Casing diameter	305mm
9	Borehole depth	350 meter
10	Riser Pipe	150 millimeter or 6inch
11	Head work pipe	150mm diameter
12	From all BH head to junction point	Length and diameters are known

2.3.1 Diameter & Velocity Determination

Velocity of water in riser main can be calculated as:

$$v = \frac{4 \times Q}{3.14 \times d^2}$$

Where Q =discharge in m³/sec and d in riser pipe diameter

$$v = \frac{4 \times 0.03}{3.14 * (0.15)^2}$$

$$\underline{V=1.7\text{m/sec}}$$

Total Dynamic Head of Submersible Pump

$$H_T = H_s + H_L$$

Where: H_T = Total submersible pump head

H_s = Static head

$H_L = \text{Head Loss}$

Static head

It can be calculated as follows:

$H_s = \text{Wet well elevation} - \text{Wellhead elevation} + \text{Dynamic water level}$

$$H_s = 1598 - 1444 + 150$$

$$\therefore H_s = 304$$

Head Loss

a) **Riser pipe and head work pipe loss (h_{111}) DN150 L=200m, Q = 30 l/s**

By Using Hazen Williams's formula

$$h_{111} = 10.67 \times \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{D^{4.87}}$$

Where

C = coefficient of Roughness for GS pipe (120)

D = Pipe diameter (0.15m)

Q = Flow Rate $0.03 \frac{m^3}{\text{sec}}$

h_{11} = pipe friction loss

L = Riser pipe and head work pipe length = 200 m

Therefore, by substituting the value

$$h_{111} = 10.67 \times \left(\frac{0.03}{120}\right)^{1.85} \times \frac{200}{0.15^{4.87}}$$

$$\therefore h_{111} = 4.8$$

b) Dynamic Head Loss of Fittings (h₁₁₂) at well head

Description	Unit	Qty	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss(m)
90° bends	PCs	3	GS	DN 150	1.7	0.75	$\frac{3 \times K \times v^2}{2 \times g}$	0.3
Check valve	PCs	1	GS	DN 150	1.7	1.9	$\frac{K \times v^2}{2 \times g}$	0.3
Gate valve	PCs	1	GS	DN 150	1.7	0.15	$\frac{K \times v^2}{2 \times g}$	0.1
Reducer	PCs	1	DCI	DN150/200	1.7	1.5	$\frac{k \times (v_1^2 - v_2^2)}{2 \times g}$	0
Water meter	PC's	1	GS	DN 150	1.7	6	$\frac{K \times v^2}{2 \times g}$	0.6
Total dynamic head loss of fittings (h₁₁₂) at well head								1.3

TABLE 4 TOTAL DYNAMIC HEAD LOSS OF FITTINGS FOR BH-2

Where K – coefficient of friction loss

V – Velocity of water

g - Acceleration due to gravity

c) Total head Losses of riser pipe and head work pipe and fittings (h₁₁)

$$h_{11} = h_{111} + h_{112} = 4.8 + 1.3 = 6.1$$

Transmission main head losses (h₁₂)**Straight pipe head loss from end of borehole head to wet well (h₁₂₁)**

PVC DN 200 mm, L= 1337 m, Q = 30 l/s

Using Hazen Williams's formula

$$h_{121} = 10.67 \times \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{D^{4.87}}$$

Where: C = coefficient of Roughness for PVC pipe (150)

D = Pipe diameter (0.20m)

Q = Flow Rate $0.03 \frac{m^3}{sec}$, h_{121} = pipe friction loss, L = Straight pipe length= 1123 m

$$h_{121} = 10.67 \times \left(\frac{0.03}{150}\right)^{1.85} \times \frac{1337}{0.20^{4.87}}$$

$h_{121} = 5.2m$

e) Dynamic Head Loss of Fittings (90°) bends at transmission main pipe line (h₁₂₂),

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
90° bends	PCs	1	DCI	DN200	0.96	0.75	$\frac{K \times v^2}{2 \times g}$	0.3
Dynamic Head Loss of Fittings at transmission main pipe line (h₁₂₂)								0.5

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
Gate valve	PCs	1	DCI	DN200	0.96	0.15	$\frac{K \times v^2}{2 \times g}$	0.3
Dynamic Head Loss of Fittings at transmission main pipe line (h₁₂₂)								0.3

f) Dynamic Head Loss of gate valve at transmission main pipe line (h₁₂₃)

Total head Losses of transmission main pipe and fittings (h₁₂) due to:

Transmission line + 90° bends + Gate valve

$$(h_{12}) = h_{121} + h_{122} + h_{123} = 4.34 + 0.3 + 0.3 = \mathbf{5.14m}$$

Total Head Losses (h₁)

Total Dynamic head loss consists fitting losses (from head work) + pipe friction losses

$$\mathbf{H_D = h_1 = h_{11} + h_{12}}$$

$$\mathbf{H_D = 6.1m + 4.94 m = 11.04 m}$$

Total Dynamic head for submersible pump Head (H_T)

$$\mathbf{H_T = H_s + H_L}$$

$$\mathbf{H_T = 304 + 11.04 = 315.04 \text{ take } 316 m}$$

Therefore, the pump duty point is selected to be:

∴ Duty Point: 30 l/s at 316m head for BH-2

2.3.2 Determination of submersible pump power

Taking the above calculated duty point of the pump:

Known & assumed values: -

$$Q = 30 \text{ l/s}$$

$$H_T = 316 \text{ m}$$

$$\eta = \text{pump efficiency} = 70 \%$$

The required pump power can be calculated from:

$$\mathbf{P_p = \frac{(Q \times H_T)}{(102 * \eta_p)}}$$

$$\mathbf{P_p = 133 \text{ Kw}}$$

2.4.3 Determination of submersible motor power

By assuming 10-20 % for Electric motor overload, the pump motor will be:-

$$\mathbf{P_m = P_p \times (1 + 0.2)}$$

$$P_m = P_p \times (1 + 0.2), \text{ kW}$$

Where

P_p = pump power

P_m = motor power

$$\underline{P_m = 133 \times (1 + 0.2) = 160Kw}$$

Hence, 160 kW motor shall be selected from the available motor rating standards

2.4.4 Summary Submersible Pump Bore hole No-1 (BH-2)

No	Description	Qty
1	Number of pumps	1 submersible pump
2	Make and Model	From supplier
3	Capacity(Discharge rate)	108m ³ /hr.
4	Total Dynamic head	316m
5	Bore hole casing Diameter	305mm (12inch)
6	Motor Power	160Kw
7	Medium to be pumped	Ground water for irrigation
8	Pump position below ground level	200m
9	Pump efficiency	0.7

2.4 Hydraulic design for bore hole no 3

Hydraulic design is based on safe yield, $Q = 30l/sec$, to irrigate more than 200ha of land during peak water requirement of crops.

From well completion report, the following data are taken for design purposes.

TABLE 5: INPUT DATA FOR BH-3

No	Description	Corresponding data Measurements
1	Wet Well head Top elevation	1598 meter at sea level
2	Well head elevation	1437 meter at sea level
3	Static water level	40 meter
4	draw down	110 meter
5	Dynamic water level	150meter
6	Recommended pump position	200meter
7	Recommended design discharge	30 liter/second
8	Casing diameter	305mm
9	Borehole depth	350 meter
10	Riser Pipe	150 millimeter or 6inch
11	Head work pipe	150mm diameter
12	From all BH head to junction point	Length and diameters are known

2.4.1 Diameter & Velocity Determination

The well is already drilled as production well having 305mm (12") casing diameter up to 350m well depth. In principle, the diameter of the well casing should be at least 5cm larger than the nominal diameter of the pump to accommodate the pump with proper clearance for installation and efficient operation. Therefore the nominal size of pump bowls should be 250mm (10") and diameter of rise pipe can be taken as 150mm (6").

Velocity of water in riser main can be calculated as:

$$v = \frac{4 \times Q}{3.14 \times d^2}$$

Where Q =discharge in m³/sec and d in riser pipe diameter

$$v = \frac{4 \times 0.03}{3.14 * (0.15)^2}$$

$$\underline{\underline{V=1.7m/sec}}$$

Total Dynamic Head of Submersible Pump

$$H_T = H_s + H_L$$

Where: H_T = Total submersible pump head

H_s = Static head

H_L = Head Loss

Static head

It can be calculated as follows:

$H_s = \text{Wet well elevation} - \text{Wellhead elevation} + \text{Dynamic water level}$

$$H_s = 1598 - 1437 + 150$$

$$\therefore H_s = 311$$

Head Loss

a) Riser pipe and head work pipe loss (h_{111}) DN150 L=200m, Q = 30 l/s

By Using Hazen Williams's formula

$$h_{111} = 10.67 \times \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{D^{4.87}}$$

Where

C = coefficient of Roughness for GS pipe (120)

D = Pipe diameter (0.15m)

Q = Flow Rate $0.03 \frac{m^3}{\text{sec}}$

h_{11} = pipe friction loss

L = Riser pipe and head work pipe length = 200 m

Therefore by substituting the value

$$h_{111} = 10.67 \times \left(\frac{0.03}{120}\right)^{1.85} \times \frac{200}{0.15^{4.87}}$$

$$\therefore h_{111} = 4.8$$

b) Dynamic Head Loss of Fittings (h_{112}) at well head

TABLE 6 TOTAL DYNAMIC HEAD LOSS OF FITTINGS

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
90 ⁰ bends	PCs	3	GS	DN 150	1.7	0.75	$\frac{3 \times K \times v^2}{2 \times g}$	0.3
Check valve	PCs	1	GS	DN 150	1.7	1.9	$\frac{K \times v^2}{2 \times g}$	0.3
Gate valve	PCs	1	GS	DN 150	1.7	0.15	$\frac{K \times v^2}{2 \times g}$	0.1
Reducer	PCs	1	DCI	DN150/200	1.7	1.5	$\frac{k \times (v_1^2 - v_2^2)}{2 \times g}$	0
Water meter	PC's	1	GS	DN 150	1.7	6	$\frac{K \times v^2}{2 \times g}$	0.6
<i>Total dynamic head loss of fittings (hI12) at well head</i>								1.3

Where K – coefficient of friction loss

V – Velocity of water

g - Acceleration due to gravity

(c) Total head Losses of riser pipe and head work pipe and fittings (h₁₁)

$$h_{11} = h_{111} + h_{112} = 4.8 + 1.3 = 6.1$$

Transmission main head losses (h₁₂)

Straight pipe head loss from end of borehole head to wet well (h₁₂₁)

PVC DN 200 mm, L= 1681 m, Q = 30 l/s

Using Hazen Williams’s formula

$$h_{121} = 10.67 \times \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{D^{4.87}}$$

Where: C = coefficient of Roughness for PVC pipe (150)

D = Pipe diameter (0.20m)

Q = Flow Rate $0.03 \frac{m^3}{sec}$

h₁₂₁= pipe friction loss

L = Straight pipe length= 1681 m

$$h_{121} = 10.67 \times \left(\frac{0.03}{150}\right)^{1.85} \times \frac{1681}{0.20^{4.87}}$$

$$h_{121} = 6.53$$

c) Dynamic Head Loss of Fittings (90°) bends at transmission main pipe line (h₁₂₂)

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
90° bends	PCs	1	DCI	DN200	0.96	0.75	$\frac{K \times v^2}{2 \times g}$	0.5
Dynamic Head Loss of Fittings at transmission main pipe line (h₁₂₂)								0.5

d) Dynamic Head Loss of gate valve at transmission main pipe line (h₁₂₃)

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
Gate valve	PCs	1	DCI	DN200	0.96	0.15	$\frac{K \times v^2}{2 \times g}$	0.3
Dynamic Head Loss of Fittings at transmission main pipe line (h₁₂₂)								0.3

Total head Losses of transmission main pipe and fittings (h₁₂) due to:

Transmission line + 90° bends + Gate valve

$$(h_{12}) = h_{121} + h_{122} + h_{123} = 6.53 + 0.5 + 0.3 = \mathbf{7.33}$$

Total Head Losses (h₁)

Total Dynamic head loss consist fitting losses (from head work) + pipe friction losses

$$H_D = h_1 = h_{11} + h_{12}$$

$$H_D = 6.53\text{m} + 7.33\text{ m} = \mathbf{13.86\text{ m}}$$

Total Dynamic head for submersible pump Head (H_T)

$$H_T = H_s + H_L$$

$$H_T = 311 + 13.86 = \mathbf{324.86\text{ take } 325\text{ m}}$$

Therefore, the pump duty point is selected to be:

∴ Duty Point: 30 l/s at 325m head for BH-3

2.4.2 Determination of submersible pump power

Taking the above calculated duty point of the pump:

Known & assumed values: -

$$Q = 30\text{ l/s}$$

$$H_T = 325\text{ m}$$

η = pump efficiency = 70 %

The required pump power can be calculated from:

$$P_p = \frac{(Q \times H_T)}{(102 * \eta_p)}$$

$$\underline{P_p = 137\text{ Kw}}$$

2.4.3 Determination of submersible motor power

By assuming 10-20 % for Electric motor overload, the pump motor will be:-

$$P_m = P_p \times (1 + 0.2)$$

$$P_m = P_p \times (1 + 0.2), \text{ kW}$$

Where

P_p = pump power

P_m = motor power

$$P_m = 137 \times (1 + 0.2) = 165 \text{ Kw}$$

Hence, 165 kW motor shall be selected from the available motor rating standards.

2.4.4 Summary Submersible Pump Bore hole No-3 (BH-3)

No	Description	Qty
1	Number of pumps	1 submersible pump
2	Make and Model	From supplier
3	Capacity(Discharge rate)	108m ³ /hr.
4	Total Dynamic head	325
5	Bore hole casing Diameter	305mm (12inch)
6	Motor Power	165Kw
7	Medium to be pumped	Ground water for irrigation
8	Pump position below ground level	200m
9	Pump efficiency	0.7

2.5 Hydraulic design for bore hole no 4

Hydraulic design is based on safe yield, $Q = 30\text{l/sec}$, to irrigate more than 200ha of land during peak water requirement of crops. There are totally five bore holes .Hence pump diameter, total pump head, etc. are determined as follows.

From well completion report, the following data are taken for design purposes.

TABLE 7: INPUT DATA FOR BH-4

No	Description	Corresponding data Measurements
1	Wet Well head Top elevation	1590 meter at sea level
2	Well head elevation	1425 meter at sea level
3	Static water level	40 meter
4	draw down	110 meter
5	Dynamic water level	150meter
6	Recommended pump position	200meter
7	Recommended design discharge	30 liter/second
8	Casing diameter	305mm
9	Borehole depth	350 meter
10	Riser Pipe	150 millimeter or 6inch
11	Head work pipe	150mm diameter
12	From all BH head to junction point	Length and diameters are known

2.2.5 Diameter & Velocity Determination

The well is already drilled as production well having 305mm (12") casing diameter up to 350m well depth. In principle, the diameter of the well casing should be at least 5cm larger than the nominal diameter of the pump to accommodate the pump with proper clearance for installation and efficient operation. Therefore the nominal size of pump bowls should be 250mm (10") and diameter of rise pipe can be taken as 150mm (6").

Velocity of water in riser main can be calculated as:

$$v = \frac{4 \times Q}{3.14 \times d^2}$$

Where Q =discharge in m³/sec and d in riser pipe diameter

$$v = \frac{4 \times 0.03}{3.14 * (0.15)^2}$$

V=1.7m/sec

Total Dynamic Head of Submersible Pump

$$H_T = H_s + H_L$$

Where: H_T = Total submersible pump head
 H_s = Static head

H_L = Head Loss

Static head

It can be calculated as follows:

$$H_s = \text{Wet well elevation} - \text{Wellhead elevation} + \text{Dynamic water level}$$

$$H_s = 1590 - 1425 + 150$$

$$\therefore H_s = 315$$

Head Loss

a) Riser pipe and head work pipe loss (h_{111}) DN150 L=200m, Q = 30 l/s

By Using Hazen Williams's formula

$$h_{111} = 10.67 \times \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{D^{4.87}}$$

Where,

C = coefficient of Roughness for GS pipe (120)

D = Pipe diameter (0.15m)

Q = Flow Rate $0.03 \frac{m^3}{sec}$

h_{11} = pipe friction loss

L = Riser pipe and head work pipe length = 200 m

Therefore by substituting the value

$$h_{111} = 10.67 \times \left(\frac{0.03}{120}\right)^{1.85} \times \frac{200}{0.15^{4.87}}$$

$$\therefore h_{111} = 4.8$$

B) DYNAMIC HEAD LOSS OF FITTINGS (h_{I12}), AT WELL HEAD

TABLE 8 TOTAL DYNAMIC HEAD LOSS OF FITTINGS FOR BH 4

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
90° bends	PCs	3	GS	DN 150	1.7	0.75	$\frac{3 \times K \times v^2}{2 \times g}$	0.3
Check valve	PCs	1	GS	DN 150	1.7	1.9	$\frac{K \times v^2}{2 \times g}$	0.3
Gate valve	PCs	1	GS	DN 150	1.7	0.15	$\frac{K \times v^2}{2 \times g}$	0.1
Reducer	PCs	1	DCI	DN150/200	1.7	1.5	$\frac{k \times (v_1^2 - v_2^2)}{2 \times g}$	0
Water meter	PC's	1	GS	DN 150	1.7	6	$\frac{K \times v^2}{2 \times g}$	0.6
Total dynamic head loss of fittings (h_{I12}) at well head								1.3

Where K – coefficient of friction loss

V – Velocity of water

g - Acceleration due to gravity

Total head Losses of riser pipe and head work pipe and fittings (h_{I1})

$$h_{I1} = h_{I11} + h_{I12} = 4.8 + 1.3 = 6.1$$

Transmission main head losses (h_{I2})

Straight pipe head loss from end of borehole head to wet well (h_{I21})

PVC DN 200 mm, L= 1437 m, Q = 30 l/s

Using Hazen Williams's formula

$$h_{121} = 10.67 \times \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{D^{4.87}}$$

Where:

C = coefficient of Roughness for PVC pipe (150)

D = Pipe diameter (0.20m)

Q = Flow Rate $0.03 \frac{m^3}{sec}$

h_{121} = pipe friction loss

L = Straight pipe length= 1437 m

$$h_{121} = 10.67 \times \left(\frac{0.03}{150}\right)^{1.85} \times \frac{1437}{0.20^{4.87}}$$

$h_{121} = 5.6m$

d) Dynamic Head Loss of Fittings (90°) bends at transmission main pipe line (h₁₂₂)

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
90° bends	PCs	1	DCI	DN200	0.96	0.75	$\frac{K \times v^2}{2 \times g}$	0.5
Dynamic Head Loss of Fittings at transmission main pipe line (h₁₂₂)								0.5

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
Gate valve	PCs	1	DCI	DN200	0.96	0.15	$\frac{K \times v^2}{2 \times g}$	0.3
Dynamic Head Loss of Fittings at transmission main pipe line (h₁₂₂)								0.3

e) Dynamic Head Loss of gate valve at transmission main pipe line (h₁₂₃)

Total head Losses of transmission main pipe and fittings (h₁₂) due to:

Transmission line + 90° bends + Gate valve

$$(h_{12}) = h_{121} + h_{122} + h_{123} = 5.6 + 0.5 + 0.3 = \mathbf{6.4m}$$

Total Head Losses (h₁)

Total Dynamic head loss consists fitting losses (from head work) + pipe friction losses

$$\mathbf{H_D = h_1 = h_{11} + h_{12}}$$

$$\mathbf{H_D = 6.1m + 6.4 m = 12.5 m}$$

Total Dynamic head for submersible pump Head (H_T)

$$\mathbf{H_T = H_s + H_L}$$

$$\mathbf{H_T = 315 + 12.5 = 327.5 \quad take \quad 328 m}$$

Therefore, the pump duty point is selected to be:

∴ Duty Point: 30 l/s at 328m head for BH-4

2.5.2 Determination of submersible pump power

Taking the above calculated duty point of the pump:

Known & assumed values: -

$$Q = 30 \text{ l/s}$$

$$H_T = 328 \text{ m}$$

$$\eta = \text{pump efficiency} = 70 \%$$

The required pump power can be calculated from:

$$\mathbf{P_p = \frac{(Q \times H_T)}{(102 * \eta_p)}}$$

$$\mathbf{P_p = 138 \text{ Kw}}$$

2.5.3 Determination of submersible motor power

By assuming 10-20 % for Electric motor overload, the pump motor will be:-

$$\mathbf{P_m = P_p \times (1 + 0.2)}$$

$$P_m = P_p \times (1 + 0.2), \text{ kW}$$

Where

P_p = pump power

P_m = motor power

$P_m = 138 \times (1 + 0.2) = 166\text{Kw}$

Hence, 166 kW motor shall be selected from the available motor rating standards.

Therefore, similar hydraulic calculation is performed for the remaining four bore holes and summary of the submersible pumps are obtained as follows.

2.5.4 Summary Submersible Pump Bore hole No-1 (BH-4)

TABLE 9 BILL OF MATERIALS FOR BH-4

No	Description	Qty
1	Number of pumps	1 submersible pump
2	Make and Model	From supplier
3	Capacity(Discharge rate)	108m ³ /hr.
4	Total Dynamic head	328
5	Bore hole casing Diameter	305mm (12inch)
6	Motor Power	166Kw
7	Medium to be pumped	Ground water for irrigation
8	Pump position below ground level	200m
9	Pump efficiency	0.7

2.6 Hydraulic design for bore hole no 5

Hydraulic design is based on safe yield, $Q = 30\text{l/sec}$, to irrigate more than 200ha of land during peak water requirement of crops. There are totally five bore holes. Hence pump diameter, total pump head, etc. are determined as follows.

From well completion report, the following data are taken for design purposes.

TABLE 10 INPUT DATA FOR BH-5

No	Description	Corresponding data Measurements
1	Well head Top elevation	1590 meter at sea level
2	Well head elevation	1414 meter at sea level
3	Static water level	40 meter
4	draw down	110 meter
5	Dynamic water level	150meter
6	Recommended pump position	200meter
7	Recommended design discharge	30 liter/second
8	Casing diameter	305mm
9	Borehole depth	350 meter
10	Riser Pipe	150 millimeter or 6inch
11	Head work pipe	150mm diameter
12	From all BH head to junction point	Length and diameters are known

2.6.1 Diameter & Velocity Determination

The well is already drilled as production well having 305mm (12") casing diameter up to 350m well depth. In principle, the diameter of the well casing should be at least 5cm larger than the nominal diameter of the pump to accommodate the pump with proper clearance for installation and efficient operation. Therefore the nominal size of pump bowls should be 250mm (10") and diameter of rise pipe can be taken as 150mm (6").

Velocity of water in riser main can be calculated as:

$$v = \frac{4 \times Q}{3.14 \times d^2}$$

Where Q = discharge in m³/sec and d in riser pipe diameter

$$v = \frac{4 \times 0.03}{3.14 \times (0.15)^2}$$

$$\underline{V = 1.7 \text{ m/sec}}$$

Total Dynamic Head of Submersible Pump

$$H_T = H_s + H_L$$

Where: H_T = Total submersible pump head

H_s = Static head

H_L = Head Loss

Static head

It can be calculated as follows:

$$H_s = \text{Wet well elevation} - \text{Wellhead elevation} + \text{Dynamic water level}$$

$$H_s = 1590 - 1414 + 150$$

$$\therefore H_s = 326$$

Head Loss

a) Riser pipe and head work pipe loss (h_{111}) DN150 L=200m, Q = 30 l/s

By Using Hazen Williams's formula

$$h_{111} = 10.67 \times \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{D^{4.87}}$$

Where: C = coefficient of Roughness for GS pipe (120)

D = Pipe diameter (0.15m)

$$Q = \text{Flow Rate } 0.03 \frac{m^3}{\text{sec}}$$

h_{11} = pipe friction loss

L = Riser pipe and head work pipe length = 200 m

Therefore by substituting the value

$$h_{111} = 10.67 \times \left(\frac{0.03}{120}\right)^{1.85} \times \frac{200}{0.15^{4.87}}$$

$$\therefore h_{111} = 4.8$$

B) DYNAMIC HEAD LOSS OF FITTINGS (h₁₁₂) AT WELL HEAD

TABLE 11 TOTAL DYNAMIC HEAD LOSS OF FITTINGS AT WELL HEAD

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
90 ⁰ bends	PCs	3	GS	DN 150	1.7	0.75	$\frac{3 \times K \times v^2}{2 \times g}$	0.3
Check valve	PCs	1	GS	DN 150	1.7	1.9	$\frac{K \times v^2}{2 \times g}$	0.3
Gate valve	PCs	1	GS	DN 150	1.7	0.15	$\frac{K \times v^2}{2 \times g}$	0.1
Reducer	PCs	1	DCI	DN150/200	1.7	1.5	$\frac{k \times (v_1^2 - v_2^2)}{2 \times g}$	0
Water meter	PC's	1	GS	DN 150	1.7	6	$\frac{K \times v^2}{2 \times g}$	0.6
Total dynamic head loss of fittings (h₁₁₂) at well head								1.3

Where K – coefficient of friction loss

V – Velocity of water

g - Acceleration due to gravity

Total head Losses of riser pipe and head work pipe and fittings (h₁₁)

$$h_{11} = h_{111} + h_{112} = 4.8 + 1.3 = 6.1$$

Transmission main head losses (h_{12})**Straight pipe head loss from end of borehole head to wet well (h_{121})**

PVC DN 200 mm, L= 1445 m, Q = 30 l/s

Using Hazen Williams's formula

$$h_{121} = 10.67 \times \left(\frac{Q}{C}\right)^{1.85} \times \frac{L}{D^{4.87}}$$

Where:

C = coefficient of Roughness for PVC pipe (150)

D = Pipe diameter (0.20m)

Q = Flow Rate $0.03 \frac{m^3}{sec}$ h_{121} = pipe friction loss

L = Straight pipe length= 1445 m

$$h_{121} = 10.67 \times \left(\frac{0.03}{150}\right)^{1.85} \times \frac{1445}{0.20^{4.87}}$$

 $h_{121} = 5.6$ **e) Dynamic Head Loss of Fittings (90°) bends at transmission main pipe line (h_{122}),**

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
90° bends	PCs	1	DCI	DN200	0.96	0.75	$\frac{K \times v^2}{2 \times g}$	0.5
Dynamic Head Loss of Fittings at transmission main pipe line (h_{122})								0.5

Description	Unit	Qty.	Material	Size (mm)	Velocity m/s	Coefficient K	Formula	Dynamic Loss (m)
Gate valve	PCs	1	DCI	DN200	0.96	0.15	$\frac{K \times v^2}{2 \times g}$	0.3
Dynamic Head Loss of Fittings at transmission main pipe line (h_{122})								0.3

f) Dynamic Head Loss of gate valve at transmission main pipe line (h₁₂₃)

Total head Losses of transmission main pipe and fittings (h₁₂) due to:

Transmission line + 90° bends + Gate valve

$$(h_{12}) = h_{121} + h_{122} + h_{123} = 5.6 + 0.5 + 0.3 = \mathbf{6.4m}$$

Total Head Losses (h₁)

Total Dynamic head loss consists fitting losses (from head work) + pipe friction losses

$$H_D = h_1 = h_{11} + h_{12}$$

$$H_D = 6.1m + 6.4 m = 12.5$$

Total Dynamic head for submersible pump Head (H_T)

$$H_T = H_s + H_L$$

$$H_T = 326 + 12.5 = 338.8 \text{ take } 339m$$

Therefore, the pump duty point is selected to be:

∴ Duty Point: 30 l/s at 339m head for BH-5

2.6.2 Determination of submersible pump power

Taking the above calculated duty point of the pump:

Known & assumed values: -

$$Q = 30 \text{ l/s}$$

$$H_T = 339 \text{ m}$$

$$\eta = \text{pump efficiency} = 70 \%$$

The required pump power can be calculated from:

$$P_p = \frac{(Q \times H_T)}{(102 * \eta_p)}$$

$$P_p = \mathbf{143 \text{ Kw}}$$

2.6.3 Determination of submersible motor power

By assuming 10-20 % for Electric motor overload, the pump motor will be:-

$$P_m = P_p \times (1 + 0.2)$$

$$P_m = P_p \times (1 + 0.2), \text{ kW}$$

Where

P_p = pump power

P_m = motor power

$$P_m = 143 \times (1 + 0.2) = 172 \text{ Kw}$$

Hence, 172kW motor shall be selected from the available motor rating standards.

2.6.3 Summary Submersible Pump Bore hole No-1 (BH-5)

No	Description	Qty
1	Number of pumps	1 submersible pump
2	Make and Model	From supplier
3	Capacity(Discharge rate)	108m ³ /hr.
4	Total Dynamic head	339m
5	Bore hole casing Diameter	305mm (12inch)
6	Motor Power	172Kw
7	Medium to be pumped	Ground water for irrigation
8	Pump position below ground level	200m
9	Pump efficiency	0.7

3 LITHOLOGICAL DESCRIPTION CUTTING SAMPLES

TABLE 12 LITHOLOGICAL DESCRIPTION OF CUTTING SAMPLES

Depth (m)		Thickness (m)	Description	Hardness	Remark
From	To				
0	2	2	Brownish top Soil	Soft	
2	6	4	Basaltic origin gravel deposit	soft	
6	12	6	Gray sandstone	Medium	
12	18	6	Reddish sandstone	Medium	
18	34	16	Fractured grey sandstone	Medium	
34	38	4	Gypsum	Hard	
38	54	16	Fractured grey sandstone	Medium	
54	56	2	Gypsum	Hard	
56	72	16	Slightly Fractured grey sandstone	Medium	
72	74	2	Gypsum	Hard	
74	82	8	Moderately fractured sandstone	Medium	
82	86	4	Massive sandstone	hard	
86	90	4	Highly fractured limestone	soft	Aquifer
90	94	4	Moderately fractured limestone	medium	
94	102	8	Moderately fractured sandstone	Medium	
102	104	2	Highly fractured limestone	Medium	Aquifer
104	114	10	Slightly Fractured grey limestone	Hard	
114	116	2	Moderately fractured limestone	Medium	
116	120	4	Slightly Fractured limestone	Hard	
120	124	4	Highly fractured limestone	Medium	Aquifer
124	144	20	Massive limestone	Hard	
144	146	2	Moderately fractured limestone	Medium	Aquifer
146	148	2	Highly fractured limestone	Medium	Main Aquifer
148	154	6	Moderately fractured limestone	Medium	Aquifer
154	164	10	Slightly Fractured limestone	Medium	Aquifer
164	170	6	Highly fractured limestone	Medium	Aquifer
170	174	4	Slightly Fractured grey limestone	Medium	
174	178	4	Dark gray silicified limestone	Hard	
178	182	4	Slightly Fractured grey limestone	Hard	

Depth (m)		Thickness (m)	Description	Hardness	Remark
From	To				
182	186	2	Moderately fractured grey sandstone	Medium	Aquifer
186	188	2	Highly fractured and weathered sandstone	Medium	Aquifer
188	196	8	Slightly Fractured silicified gray limestone	Hard	
196	200	4	Slightly Fractured grey limestone	Hard	
200	222	22	Weathered gray sandstone	Medium	Aquifer
222	228	6	Light gray moderately fractured limestone	Medium	Aquifer
228	262	34	Slightly fractured grey limestone	Hard	
262	274	12	Weathered and fractured limestone	Medium	Aquifer
274	280	6	Moderately fractured grey limestone	Medium	Aquifer
280	282	2	Grey sandstone	Medium	
282	284	2	Highly fractured dark limestone	Medium	Aquifer
284	288	4	Slightly fractured dark limestone	Hard	
288	298	10	Slightly fractured grey limestone	Hard	
298	316	18	Slightly fractured dark limestone	Hard	
316	320	4	Fractured and weathered sandstone	Medium	Aquifer
320	336	16	Slightly fractured dark limestone	Medium	

4. FIELD WATER QUALITY MEASUREMENT

Some water quality parameters measured at the field during drilling activities given in the table below using conductivity meter (EC-meter).

TABLE 13 WATER QUALITY

S/N	EC (μs)	TDS (mg/lit)	Temp (0°C)	Depth (m)	Turbidity	Remark
1	714	433	23	113	Less turbid	
2	656	391	22.7	130		
3	505	303	22.5	148		
4	524	315	23.1	153.5		
5	509	314	23.2	158		
6	505	301	23.2	159.5		
7	506	306	23.7	165		
8	531	319	23.4	210		

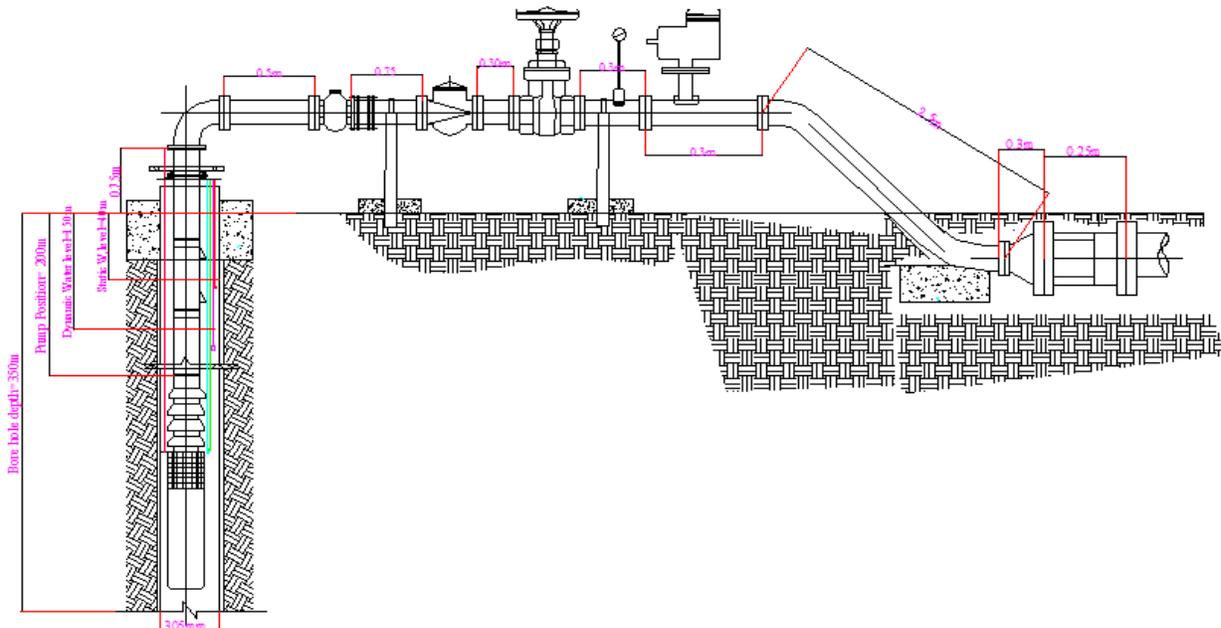


FIGURE 1 GENERAL LAYOUT OF LAGA DHUMMUGA BORE HOLE

5 IRRIGATION DISTRIBUTION SYSTEM DESIGN

5.1 CANAL SYSTEM

5.1.1 Description of Water Distribution System

The water from Laga Dhumuga Deep well is pumped to Wet Well-1 & Wet Well-2 to be distributed to the farm through a network of canals by gravity flow. The physical purpose of irrigation is to satisfy the demands of crop water requirement by increasing the moisture content of the soil in the root zone of the crop. For this canal distribution system should be planned to convey the required amount of water from the outlet as described above. In the case of the Laga Dhumuga irrigation scheme since gravity led irrigation practice is designed and furrow irrigation method is selected. Each command area with small channels (furrow) water reaches over the soil surface.

5.1.2 Canal Alignment (Canal Layout)

The Dhumuga site has sufficient and suitable irrigable area on left sides of the river (see Fig. 3 the layout of the command area). The command area of this Irrigation project is 189.5ha and stretched along the left side of the Dhumuga River. The proposed canal system of the scheme consists of one main canal for Wet Well-1 is 1,898m long, four secondary canals (three SC for WW1 and one SC for WW2) 2,848.2m long and 31 tertiary canals [WW1TC(22) ,WW2TC(9)] 12,978.83m long. As the canal system passes through villages and social infrastructures, more than 3 road and footpath crossings are required.

Canal layout is marked on the field and profile is taken for each route of all main, secondary and tertiary canals. The following points are considered while preparing the canal layout:

- The layout is done based on block areas to be irrigated by taking drains and ridges into consideration.
- Deep cutting and high banking is tried to be avoided
- The alignment of Main canal follows almost on the periphery of the command area as a contour canal.

5.2 Design of Canals

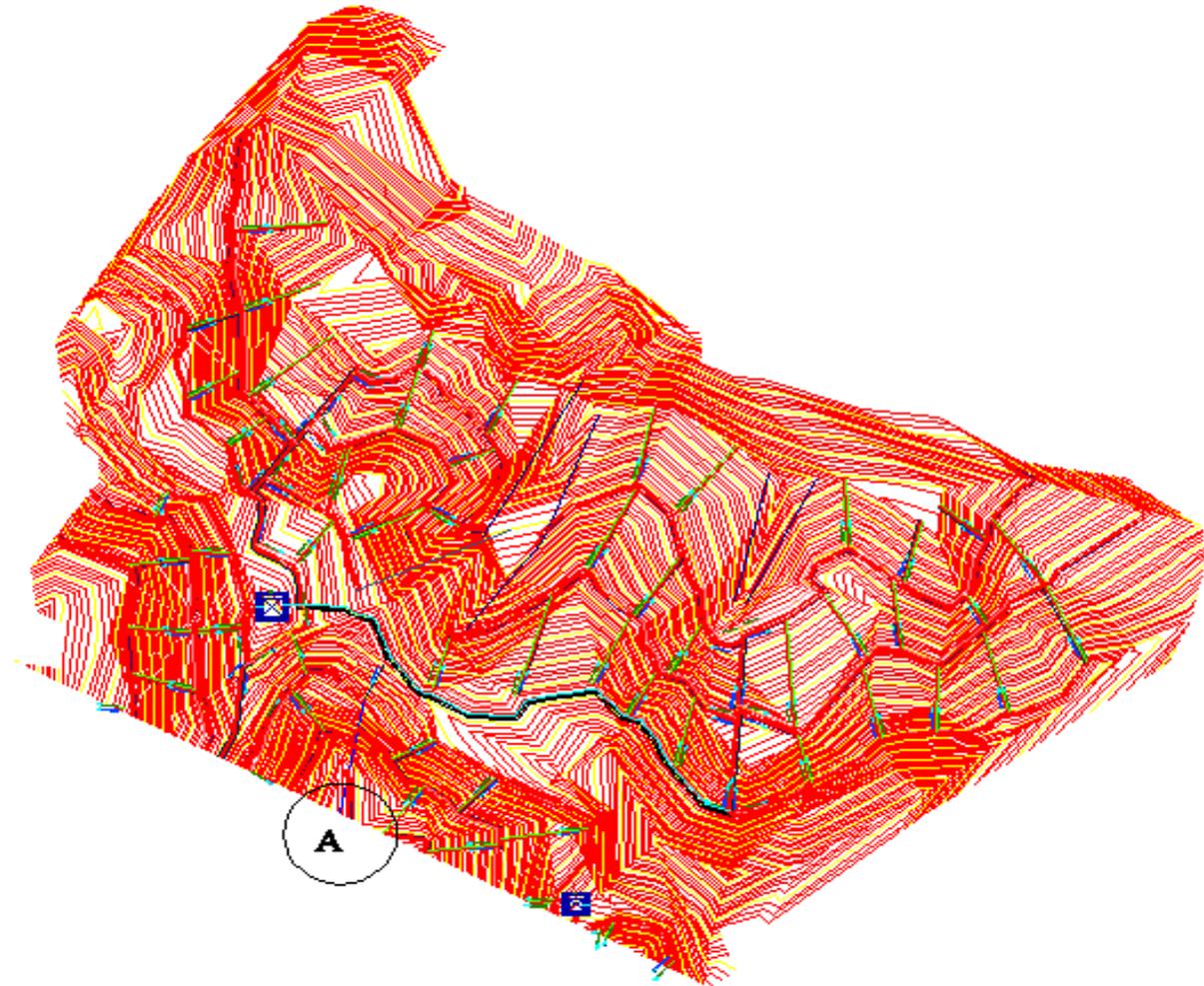
Canal design is used to decide the parameters like the depth of flow, bed width, flow velocity, etc. These depend on design discharge, bed slope, and coefficient of roughness and side slope of canals if the cross section is trapezoidal and Rectangular. Design discharge is the maximum discharge that the canal is required to carry in any year .It depends on irrigation intensity, cropping pattern, size of command area, duty and time factor.

Design Discharge Determination

Duty, $q = 2.08 \text{ lit/sec/ha}$

Command Area, $A = 189.5 \text{ ha}$

Design Discharge, $Q_d = 0.395 \text{ m}^3/\text{sec}$



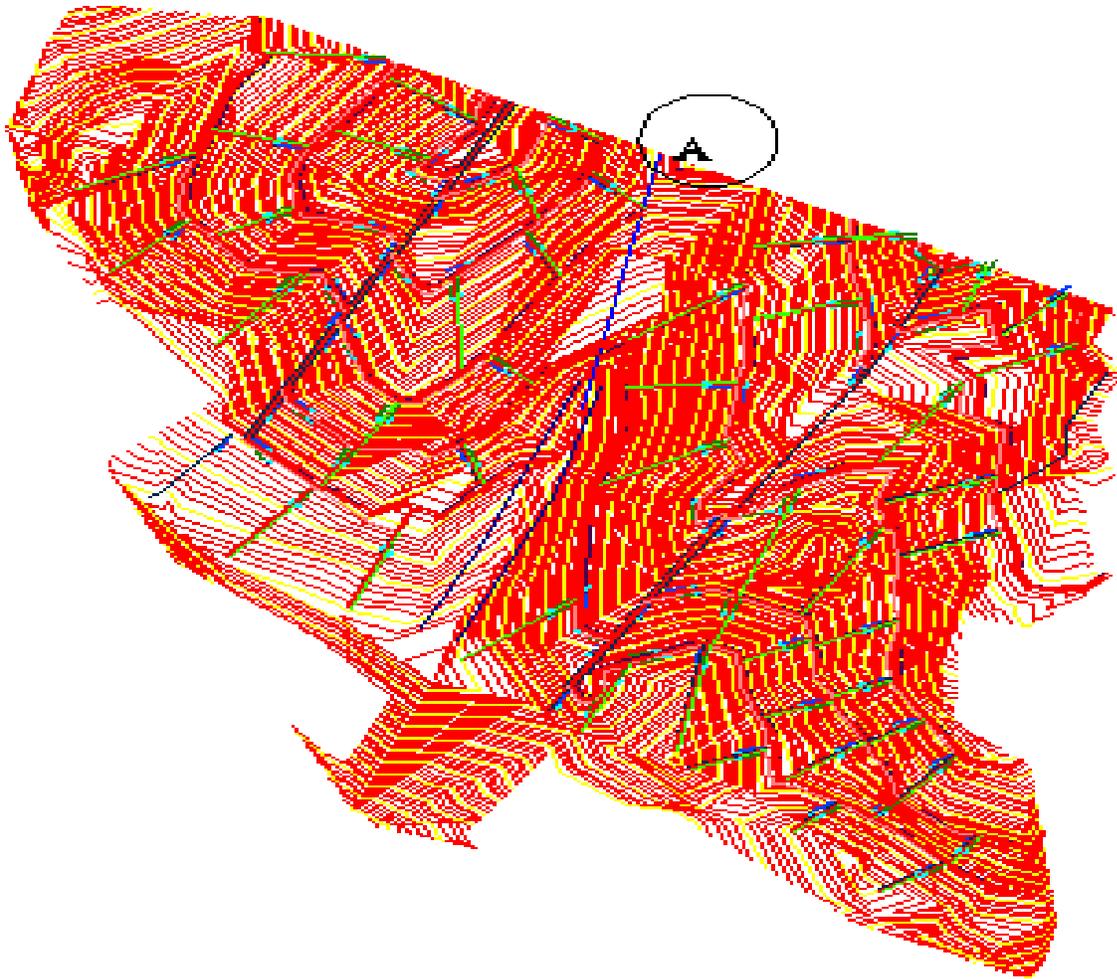


FIGURE 2 GENERAL LAYOUT OF LAGA DHUMMUGA IRRIGATION PROJECT

5.2.1 Main Canal

Design Discharge Determination

Duty, $q = 2.08$ lit/sec/ha

Command Area, $A = 124$ ha

Design Discharge, $Q_d = 0.258$ m³/sec

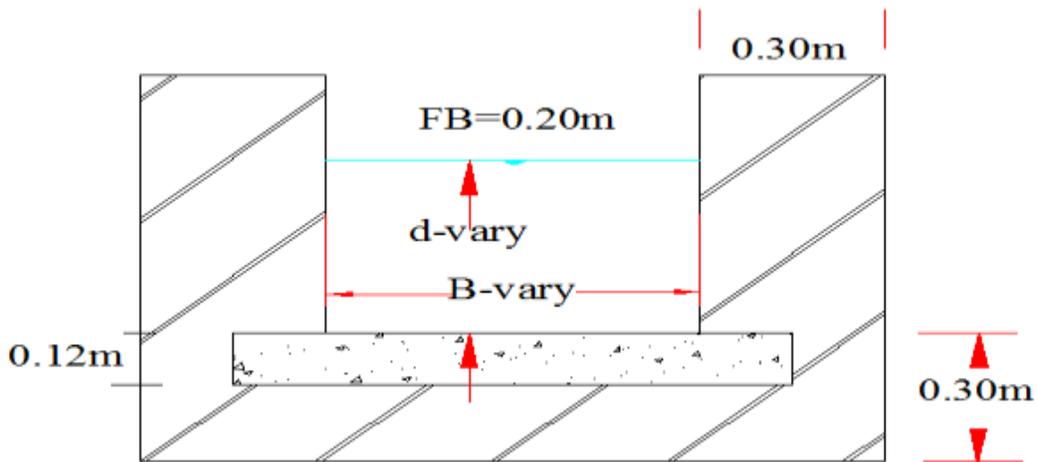


FIGURE 3 SECTIONS OF CANALS

TABLE 14 DESIGN PARAMETERS OF MAIN CANAL

Canal Design	Rectangular		Remark
Canal bed width, b	0.8	m	@initial
Water Depth, d	0.4	m	
Canal Side Slope, m	0	m/m	
Water area, A	0.32	m ²	
Wetted Perimeters, P	1.6	m	
Hydraulic Radius, R	0.2	m	
Roughness Coefficient, n	0.014		
Canal bed slope, I	0.0134	m/m	
Flow Velocity, V	2.83	m/s	
Flow Discharge, Q	0.258	m ³ /s	

5.2.2 Secondary Canals

Command Area = 190ha

Duty, $q = 2.08$ lit/sec/ha

Design Discharge, $Q_d = q \cdot CA$ is vary as area vary

Table 16 Design Parameters of Secondary Canals

Canal Design	unit	Wet well-1			Wet well-2
		SC-1	SC-2	SC-3	SC-1
Command Area	ha	60.06	23.35	40.63	65.44
Canal bed width, b	m	0.65	0.45	0.5	0.6
Water Depth, d	m	0.35	0.2	0.25	0.3
Canal Side Slope, m	m/m	0	0	0	0
Water area, A	m ²	0.23	0.09	0.13	0.18
Wetted Perimeter, P	m	1.35	0.85	1	1.2
Hydraulic Radius, R	m	0.17	0.11	0.13	0.15
Roughness Coefficient, n		0.014	0.014	0.014	0.014
Canal bed slope, I	m/m	0.0015	0.0015	0.0015	0.0015
Flow Velocity, V	m/s	0.84	0.62	0.69	0.78
Flow Discharge, Q	m ³ /s	0.125	0.0485	0.0845	0.1361

5.2.3 Tertiary Canal

Tertiary canal conveys irrigation water to field canal. There are 31 tertiary canals provided for this project.

Command Area = 190ha

Duty, $q = 2.08$ lit/sec/ha

Design Discharge, $Q_d = q \cdot CA$, is vary as area vary

5.2.4 Longitudinal Section of Canals

The longitudinal section along the canals is prepared with levels at intervals based on the natural topographic changes indicating the following details:

- ❖ Chain age
- ❖ Existing ground level (OGL)
- ❖ Canal bed level (CBL)
- ❖ Full supply level (FSL)
- ❖ Canal top level (CTL)
- ❖ Bed slope, Bed width (S, B)
- ❖ Discharge, velocity (Q, V)
- ❖ Location of turnouts and other related structures

The longitudinal profile of the main, secondary, and tertiary canals is shown in the drawings with canal section details.

5.3 CANAL STRUCTURES

There are many canal structures are on the main, secondary and tertiary canals such as:-

Two Night storage Reservoirs(WW1 & WW2)

125 Box Culverts

Five Division Boxes

159 offtakes /Turnouts

47 Drops

And there design is prepared based on the canals design parameters which they are sited and their hydraulic characteristics, the detail working drawings each structures are attached with this engineering design report.

5.3.1 Design of Storage Reservoirs

Assuming the irrigation water pumped from each bore hole to this reservoir for 16 hrs. and direct uses for irrigation for 12 hrs(duty) with the designed water application .the dimension of night storage is fixed only for four (4) hours storing time.

5.3.1.1 Basic Design Data for WW1

Inflow, Q mc = 0.193m³/s

Area to Irrigate = 124 ha

Water Duty, q = 2.08lit/sec/ha

Irrigation Time, T = 12 hr.

Storing Time Ts = 4hr

Pond Center OGL = 2364.50 m

Pond Center DBL = 1590.41m

Side slopes: inside = 1:2.5 and outside = 1:2

Top embankment width, W =3.00m

Geometrical Capacity (Gross) is determined Using Frustum Formula where h, water Depth in the Pond, B1 & B2 are top and bottom areas of the Pond.

$$GCG = \frac{h}{3} * (B_1 + B_2) + (B_1 * B_2)^{0.5}$$

Shape of the pond is frustum with square top & bottom.

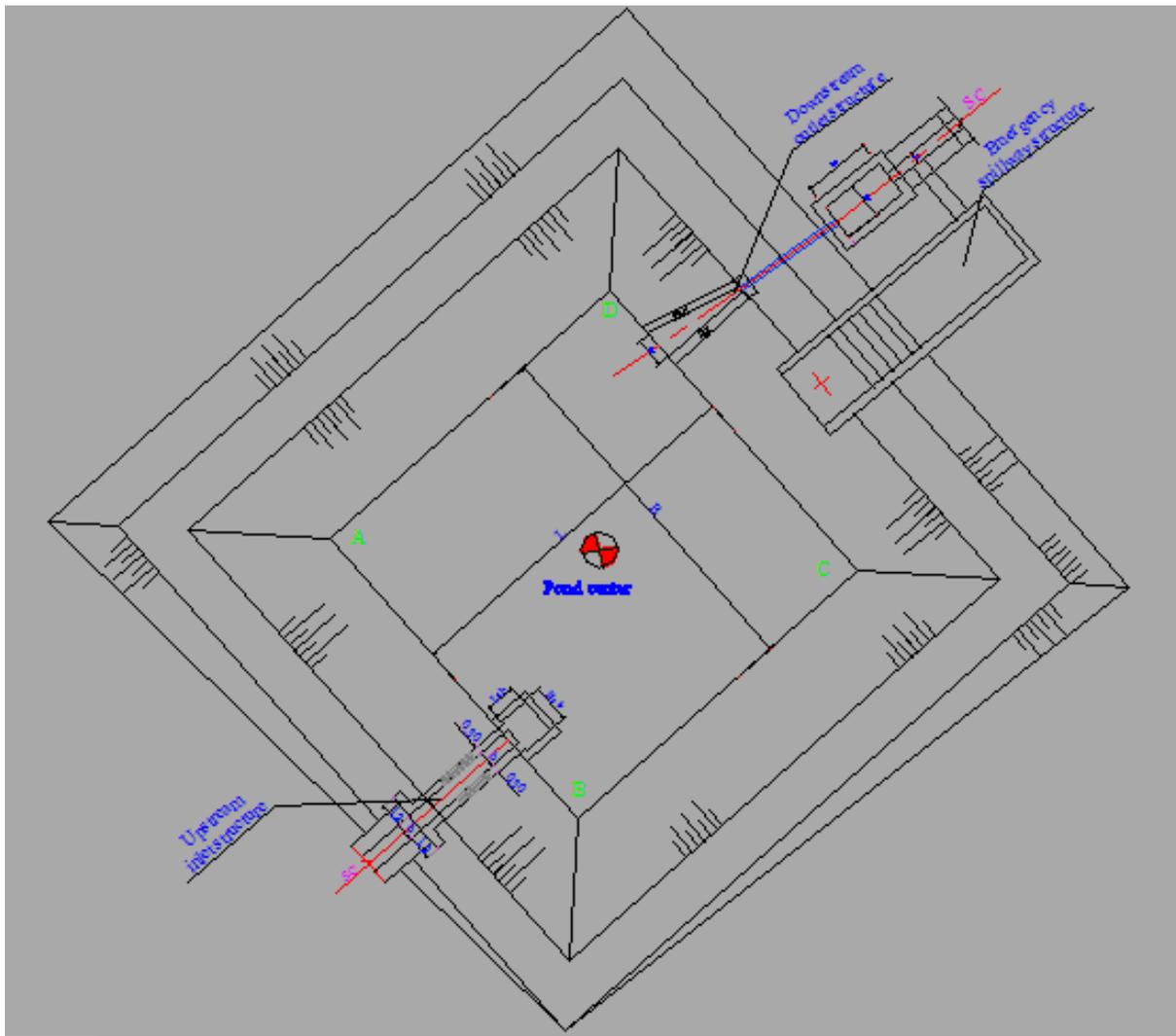


FIGURE 4 PLAN OF NIGHT STORAGE

Top Width, $T = 44.00$ m

Bottom Width, $B = 32.00$ m

Top area, $B1 = 1936.00 \text{ m}^2$

Bottom area, $B2 = 1024 \text{ m}^2$

Water depth in the Pond, $h = 2.25\text{m}$

Free Board, $F_b = 0.50$ m

Total Depth of the pond, $D = 2.75$ m

Geometrical Capacity (Gross) = 3,894.92m³ Using Frustum Formula where h, water Depth in the Pond, B1 & B2 are top and bottom areas of the Pond.

Dead Storage = 778m³ 20% of gross storage

Depth of Dead storage = 0.25 m

Live Storage = 2,748.67 m³, the net water used for irrigation

5.3.1.2 Inlet or Chute Design WW1

a) Critical flow hydraulics

Design discharge, $Q_d = 0.193$ m³/sec

Width of Notch, $b_c = 0.30$ m

Unit discharge, $q = 0.48$ m³/sec/m

Critical depth, $d_c = 0.288$ m

Critical Velocity, $V_c = 1.68$ m/sec

Velocity Head, $h_{v_c} = 0.144$ m

Water area, $A_c = 0.115$ m²

Wetted Perimeter, $P_c = 0.976$ m

Hydraulic Radius, $R = 0.118$ m

Water Surface slope, $I_c = 0.014$ m/m

b) Energy at section C

$\Delta Z = 2.25$ m

$E_c = 2.68$ m

c) Energy at section 1

Designation	Result of calculation			
	1			2
Trail No				
Assumed d_1	0.050			0.085
$b_1=bc$	0.40			0.40
$A_1=b_1 \times d_1$	0.02			0.03
$V_1=Q/A_1$	9.60			5.69
$h_{v1}=v^2/2g$	4.70			1.65
$P_1=b_1+2d_1$	0.50			0.57
$R_1=A_1/P_1$	0.04			0.06
$l_1=(nv_1/R^{2/3})^2$	1.93			0.40
$l_m=(l_c+l_1)/2$	0.97			0.21
$h_{fl}=l_m.L$	4.89			1.05
$E_1=d_1+h_{v1}+h_{fl}$	9.64			2.78
$E_1=E_c=2.78$	too large			accept

d) Conjugate depth after jump

Fraud number, $Fr = 6.23$

Conjugate depth, $d_2 = 0.71m$

e) Stilling basin

1. Length, $L = 1.9m$

2. Width, $B = 0.6m$

3. Bottom elevation, EL. C

$$V_2 = q/d_2 = 0.68m/s$$

$$h_{v2} = V_2^2/2g = 0.02m$$

$$E_2 = d_2 + h_{v2} = 0.73m$$

$$d_3 = 0.1m$$

$$h_{v3} = 0.051m$$

$$E_3 = d_3 + h_{v3} = 0.15 \quad m$$

$$a = E_2 - E_3 = 0.58m \text{ use } 0.3 \quad m$$

$$El. C = El.3 - a = 1590.11m$$

5.3.1.3 Outlet works Intake facilities

Circular Intake for WW1

Intake capacity, $Q(\text{m}^3/\text{s}) = 0.193\text{m}^3/\text{sec}$

Length of RCC pipe, $L (\text{m}) = 9.30\text{m}$

Pipe Diameter, $d_1, \text{Ø} (\text{m}) = 0.35\text{m}$

Roughness Coefficient, $n = 0.014$

Intake lose, $h = (v^2/2g) (\text{FT})$

Where $\text{FT} = \text{Entry} + \text{Exit} + \text{Friction loses} = 0.5 + 1.0 + \text{Fl}$

And $\text{Fl} = (f \cdot L) / \text{Ø}_p$, Where $f = 124.6n^2 / \text{Ø}_p^{1/3}$

Hence, using a 100% full pipe of diameter, the intake loss, h is calculated.

The size of the pipe is increased for ease of access during cleaning.

$$f = 124.6(0.014)^2 / (\text{Ø}_p)^{1/3} = 0.035\text{m}$$

$$\text{Fl} = f \cdot L / \text{Ø}_p = 0.92\text{m}$$

$$\text{FT} = 0.5 + 1.0 + \text{Fl} = 2.42\text{m}$$

$$A = 3.14 \cdot \text{Ø}_p^2 / 4 = 0.10\text{m}^2$$

$$V = Q/A = 2.01\text{m/s}$$

$$\text{Therefore, Total Head Loss, } H = (V^2/2g) \cdot (\text{fT}) = 0.50\text{m}$$

If 10% extra head is included, the toatal head becomes,

$$H_t = 1.1 \cdot H = 0.55\text{m}$$

Therefore, The elevation of downstream water level is

$$\text{D/S W.L} = \text{u/s W.L} - H_t = 1589.91 - 0.55 = 1589.36$$

$$D/S \text{ G.L} = d/s \text{ W.L} - d1 = 1589.87 - 0.35 = 1589.52$$

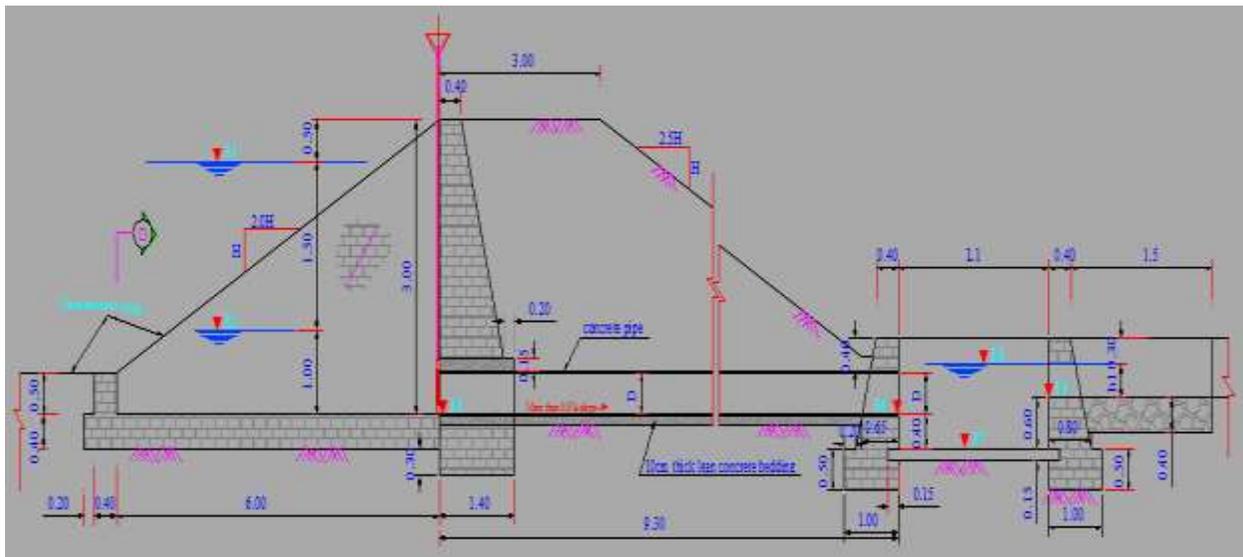


FIGURE 5 POND OUTLET

5.3.1.4 Design of spillway

Providing inclined drop spillway to be built at the abutment of the embankment. And assuming the design discharge, bed width and water depth is the same as the entrance for control section. After the pond is filled up to the maximum pond level the peak discharge that out flow from the pond is the same discharge that inflow in to the pond is $0.193 \text{ m}^3/\text{sec}$ (WWI). So the flow depth in the approach canal is 0.7 m . the peak discharge routing will also be neglected. Therefore the capacity of the spillway should be designed to pass the peak flow discharge of $0.193 \text{ m}^3/\text{sec}$.

- a) Determination of the width of inlet section

$$L = Q / 1.7 * H^{3/2} = 0.1938 \text{ m too small take } L = 0.30 \text{ m}$$

Then the critical depth d_c for flow at the control section is:-

$$U/S \text{ Spillway Crest Level} = 1592.66 \text{ m}$$

$$q = Q/B = 0.64 \text{ m}^3/\text{s/m}$$

$$d_c = [q^2/g]^{1/3} = 0.348\text{m}$$

$$F = 1.000\text{m}$$

$$F/d_c = 2.9 \text{ say } 3.00$$

$$V_c = q/d_c = 1.846\text{m/sec}$$

$$h_{vc} = V_c^2/2g = 0.174\text{m}$$

The value of d_2/d_1 and d_1/d_c corresponding to the values of F/d_c can be read in Appendix B-1 of Design manual(IDD)

$$d_1/d_c = 0.311 \quad \text{and}$$

$$d_2/d_1 = 0.760$$

$$d_1 = 0.165 * d_c = 0.108 \quad \text{m}$$

$$d_2 = 2.053 * d_1 = 0.082 \quad \text{m}$$

$$V_1 = q/d_1 = 5.9\text{m/sec}$$

$$h_{v1} = V_1^2/2g = 1.7956\text{m}$$

$$V_2 = q/d_2 = 7.810\text{m/sec}$$

$$h_{v2} = V_2^2/2g = 3.11\text{m}$$

$$\text{El.A} = \text{U/S crest level} + (d_c + h_{vc}) = 1593.18\text{m}$$

$$\text{El.C} = \text{El.A} - (d_1 + h_{v1}) = 1591.28\text{m}$$

$$\text{El.C} = \text{El.A} - (d_2 + h_{v2} + F) = 1588.99\text{m}$$

By comparing the above two values of El.C the lower bottom elevation of 1588.99m will be selected.

Stilling basin

Length, $L = 0.41\text{m}$ take $L = 0.5\text{m}$

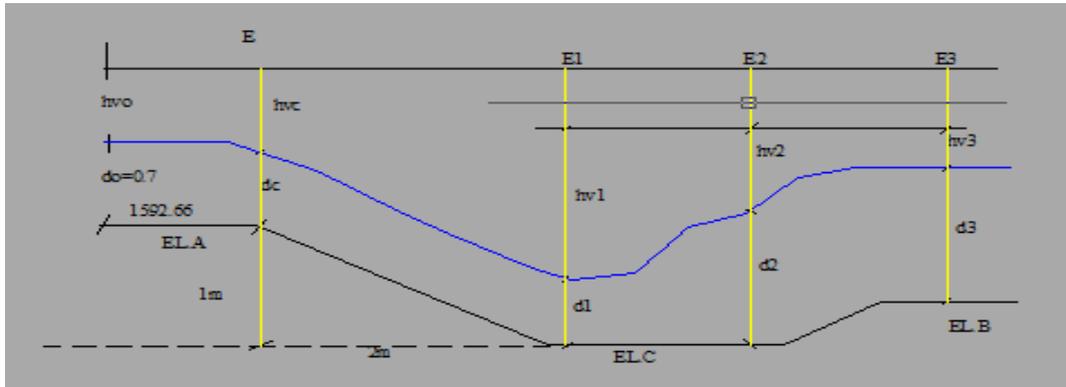


FIGURE 6 ENERGY PROFILE OVER THE SPILLWAY

5.3.2 Box Culverts

Road (Foot Path) Crossing

There are 110 and 15 box culvert field road crossings at the Tertiary and Secondary canal system of the Laga Dhumuga irrigation scheme respectively. It is used to cross cattle from one area to another, the average width of crossing is 3.00m.

Hydraulic calculation

A- Given Data

TABLE 15 HYDRAULIC CHARACTERISTICS OF THE CANALS AT THE PROPOSED BOX CULVERT SITES

chainage	type of canal	Discharge (m ³ /s)	Width(m)	Depth(m)	Velocity(m/s)	Bed slope	roughness
0+139.168	SC	0.125	0.75	0.35	0.89	0.0015	0.014
0+467.291	SC	0.111	0.40	0.20	2.12	0.019	0.014
0+062.7	TC	0.004	0.30	0.15	0.49	0.0015	0.014

B- Flow Hydraulics of culverts

Assuming $b_2 = 0.70\text{m}$ $d_2 = 0.35\text{m}$ $A = b_2 * d_2$
 0.245m^2

Roughness Coefficient, $n = 0.014$ $V_2 = Q/A = 0.12/0.245 = 0.51\text{m/s}$

$$h_v = V^2 / (2g) = 0.51^2 / (2 * 9.81) = \mathbf{0.013m} \quad L = 6m$$

$$P = b + 2 * d = 0.7 + 2 * 0.35 = \mathbf{1.4m}$$

$$R = A / P = 0.245 / 1.4 = \mathbf{0.175m}$$

$$R^{2/3} = 0.175^{2/3} = 0.313$$

$$I = (nv / R^{2/3})^2 = (0.014 * 0.51 / (0.313))^2 = 0.00052$$

Differences in elevation b/n B and C is

$$L = 6m$$

$$hf = I * L = 0.00052 * 6 = 0.00312$$

C- Water surface changes at the U/S and D/S of the culvert

i. Drop of water surface at the Inlet of culvert

$$\Delta h_1 = 1.5 * (V^2 - V_1^2) / (2g) = 1.5 * (0.51^2 - 0.89^2) / (2 * 9.81) = -0.040m$$

ii. Rise of water surface at the D/S of canal section

$$\Delta h_2 = 0.3 * (V^2 - V_1^2) / (2g) = 0.3 * (0.51^2 - 0.89^2) / (2 * 9.81) = -0.0080m$$

D-Elevation

Invert elevation at U/S canal = **1588.41**

Water surface elevation at U/S canal = 1588.41 + 0.35 = **1588.76**

Water surface at the culvert inlet = 1588.76 - Δh_1 = **1588.80**

Invert elevation at the culvert inlet = 1588.8 - d₂ = **1588.45**

Invert elevation at the culvert outlet = 1588.45 - hf = **1588.45**

Water surface elevation at culvert outlet = 1588.45 + d₂ = **1588.80**

Invert surface elevation at the D/S canal = 1588.8 + Δh_2 = **1588.79**

Inverted elevation at the D/S canal = 1588.79 - d₁ = **1588.44**

E- Total head loss

$$HT=0.5\Delta hv+hf+0.7\Delta hv=1.2\Delta hv+hf \quad \Delta hv=(V2^2-V1^2)/2g)^2$$

$$Ht=0.0040m$$

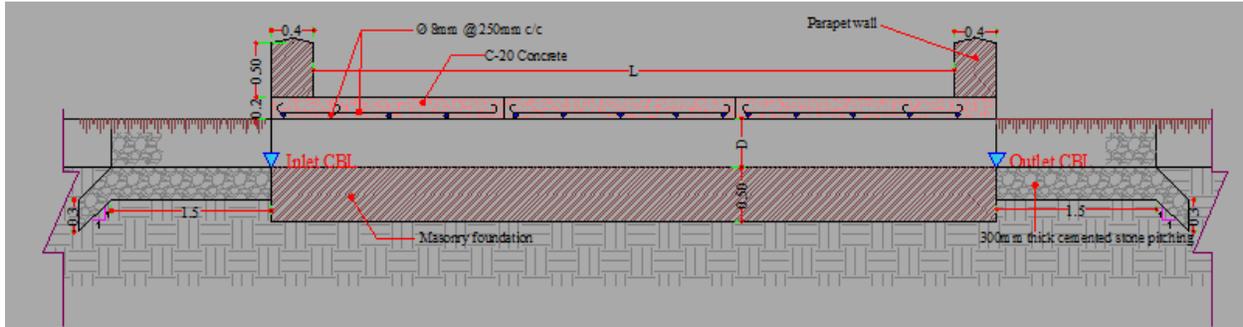


FIGURE 7 LONGITUDINAL SECTION OF BOX CULVERT

f. Canal Elevation at each section

TABLE 16 CANAL ELEVATION AT EACH SECTION

Section	Location	Water Depth (m)	Change in Water Level		Elevation of	
					Canal Bed	Water Surface
A	U/S Canal	0.51	-	-	2368.62	2369.13
B	Barred	0.48	Drop	0.20	2368.46	2368.94
C	“	0.48	Drop	0.06	2368.40	2368.88
D	D/S canal	0.51	Rise	0.04	2368.41	2368.92

2.1.3 Division Box

Division structures are provided at the canal system, which are used to divide the flow from the main canal between two secondary canals and from these secondary canals to other traditional tertiary canals. The division boxes are designed to divert flow to each canal on proportional bases during the maximum flow and on rotational bases during the low flow (when the flow is less than the design flow of the canal). There are five Division boxes which are provided to divert flow to each canal on proportional bases during the maximum flow and on rotational bases during the low flow (when the flow is less than the design flow of the canal). The width of each outlet is generally proportional to the diversion of water to be made. In lined canal, a full gate opening at the intake to the box is made covering approximately the same area as the canal section, since the canal design to carry water at relatively high velocity.

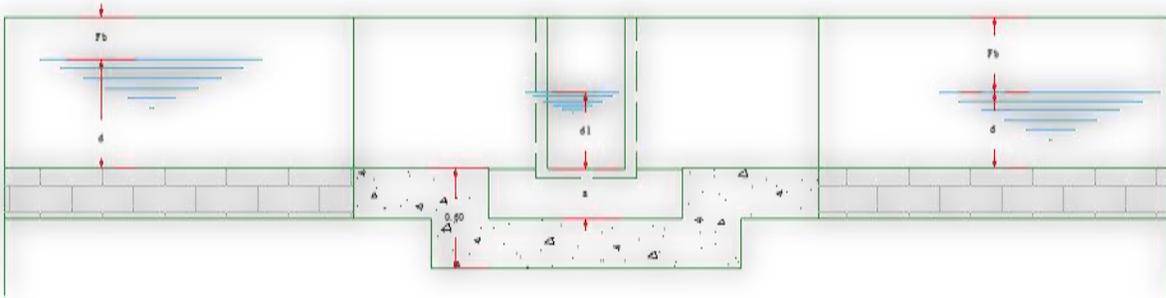


FIGURE 8 LONGITUDINAL SECTION OF DIVISION BOX

The general weir equation is used to design the division boxes:

$$Q = CLH^{3/2} \quad , \text{ Where, } Q - \text{ Discharge (m}^3\text{/sec)}$$

C - Discharge coefficient = 1.70

L- Crest length (m)

H - Water depth on the crest (m)

From the broad crested weir formula, the head over crest can be fixed as follows:

$$h_2 = (Q/C*B^2)^{2/3}$$

Sill height (above bed), $h_s = U/S \text{ FSL} - \text{Driving head}$

Sill height (above bed), $h_s = 0.33\text{m say } 0.30\text{m}$

Thickness of sill, $t = 2/3 * \text{height of sill}$

Throat length, $L_d = 3 * \text{water depth } d/s (d_2)$

TABLE 17 HYDRAULIC DESIGN OF DIVISION BOX

		Hydraulic Design of Division box																
Division Box	Parent Canal	Originating Canals	Chainage	Q ₁	Q ₂	Q ₃	Q ₄	h	h ^{3/2}	L ₁	L ₂	L ₃	L ₄	d	fb	D	b	B
			(m)	m ³ /s	m ³ /s	m ³ /s	m ³ /s	(m)		(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)	(m)
RDB -01	RSC-1-1-1-3 to	RTC-1-1-1-3-1 and RTC-1-1-1-3-3	0+0050	0.127	0.065	0.019	0.043	0.25	0.125	0.60	0.30	0.09	0.20	0.25	0.30	0.55	0.60	1.70
RDB -02	RSC-1-3-2 to	RTC-1-3-2-1 and RTC-1-3-2-2	0+020	0.229	0.113	0.044	0.072	0.35	0.207	0.65	0.32	0.12	0.20	0.35	0.30	0.65	1.00	2.30
RDB -03	RSC-1-3-1 to	RTC-1-3-1-1 and RTC-1-3-1-9	0+051	1.316	1.190	0.047	0.079	0.60	0.465	1.67	1.51	0.06	0.10	0.60	0.30	0.90	2.40	4.20
RDB -04		RTC-1-3-1-3 and RTC-1-3-1-11	1+873	1.034	0.890	0.063	0.081	0.60	0.465	1.31	1.13	0.08	0.10	0.60	0.30	0.90	1.85	3.65
RDB -05		RTC-1-3-1-4 and RTC-1-3-1-12	1+874	0.957	0.770	0.094	0.094	0.60	0.465	1.21	0.97	0.12	0.12	0.60	0.30	0.90	1.70	3.50

5.3.2 Turnout/Offtakes

The turnouts are designed to divert flow to each field canal on proportional bases during the maximum flow and on rotational bases during the low flow (when the flow is less than the design flow of the canal). As it has already mentioned before, since field canals are not provided, simple turnouts at the main, secondary and tertiary canals, which directly take flow to the fields are provided. These turnouts are provided on the main, secondary canals based on the available command area and topography. At every 50 -100m distance between two field canals, one turn out is provided. The water surface level in tertiary canals at off take points of canals is maintained 10 to 15cm higher than the existing ground levels in the irrigable area for siphoning. The flow at each turn out (to each field canal) is controlled by gate operation. There are 76 numbers of turnouts and they are designed proportionally according to discharges in both parent and off take canals as follows.

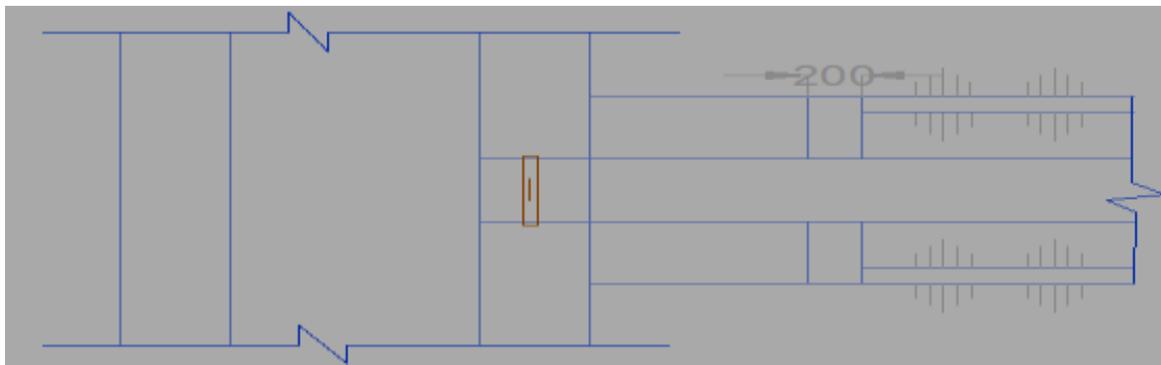


FIGURE 9 LAYOUT OF TURNOUT

Plan of Turnout

Available data:-

Using orifice formula $Q = C_d \cdot A \cdot \sqrt{2gHL}$

Where, Q - Full Supply Discharge (m³/sec)

Discharge Coefficient, $C_d = 0.73$ for submerged flow

HL – working head or loss of head between u/s and d/s = 0.05 m

A - Area of pipe = $\pi d^2/4$

g = 9.81

TABLE 18 IRRIGATION OUTLET ON MAIN CANAL

Name of canal	Station	Area,ha	Q,m ³ /s	b(width),m	d(depth),m	Driving head,m
WW1LSC1-1-1	0+31.805	60.10	0.125	0.2580	0.15	0.15
WW1LSC1-1-2	0+31.842	23.32	0.0485	0.1331	0.15	0.15
WW1LSC1-1-3	0+898.0	40.63	0.0845	0.0845	0.15	0.15

Table 19 Irrigation outlet on Secondary Canal

Name of canal	Station	Area,ha	Q,m3/s	b(width),m	d(depth),m	Driving head,m
WW1LTC1-1-1	0+143.245	56.51	0.118	0.75	0.15	0.15
WW1LTC1-1-2	0+148.491	53.28	0.111	0.75	0.15	0.15
WW1LTC1-1-3	0+474.38	45.36	0.094	0.7	0.15	0.15
WW1LTC1-1-4	0+522.51	40.61	0.084	0.6	0.15	0.15
WW1LTC1-1-5	0+620.361	25.04	0.052	0.6	0.15	0.15
WW1LTC1-1-6	0+643.812	25.04	0.052	0.6	0.15	0.15
WW1LTC1-1-7	0+768.339	10.63	0.022	0.5	0.15	0.15
WW1LTC1-1-8	0+787.722	6.50	0.014	0.5	0.15	0.15
WW1LTC1-1-9	0+937.193	3.72	0.008	0.4	0.15	0.15
WW1LTC1-1-10	1+044.123	7.87	0.016	0.3	0.15	0
WW1RTC1-2-1	0+147.811	21.81	0.045	0.5	0.15	0.15
WW1RTC1-2-2	0+237.227	16.12	0.034	0.4	0.15	0.15
WW1RTC1-2-3	0+280.265	12.40	0.026	0.3	0.15	0
WW1RTC1-2-4	0+354.925	6.56	0.014	0.3	0.15	0
WW1RTC1-2-5	0+412.436	6.56	0.014	0.3	0.15	0
WW1RTC1-2-6	0+512.072	6.56	0.014	0.3	0.15	0
WW1RTC1-3-3	0+162.987	20.15	0.042	0.4	0.15	0.15
WW1RTC1-3-4	0+185.508	20.15	0.042	0.5	0.15	0.15
WW2RTCB1-1-3	0+177.323	46.77	0.097	0.8	0.15	0.15
WW2RTCB1-1-4	0+261.835	38.29	0.080	0.65	0.15	0.15
WW2RTCB1-1-5	0+595.104	27.11	0.056	0.6	0.15	0.15
WW2RTCB1-1-6	0+603.986	17.84	0.037	0.5	0.15	0.15
WW2RTCB1-1-7	0+795.85	13.25	0.028	0.5	0.15	0.15
WW2RTCB1-1-8	0+878.772	6.99	0.015	0.5	0.15	0.15
WW2RTCB1-1-9	0+978.082	6.99	0.015	0.4	0.15	0.15

TABLE 20 IRRIGATION OUTLET ON TERTIARY CANAL (TC)

Name of canal	Station	Area,ha	Q,m3/s	b(width),m	d(depth),m	Driving head,m
WW1LFC1-1-1-1	0+60.197	3.55	0.0074	0.3	0.15	0
WW1LFC1-1-1-2	0+65.2	2.15	0.0045	0.3	0.15	0
WW1LFC1-1-1-3	0+200.552	1.29	0.0027	0.3	0.15	0
WW1LFC1-1-1-4	0+355.915	0.74	0.0015	0.3	0.15	0
WW1LFC1-1-2-1	0+90.635	3.23	0.0067	0.3	0.15	0
WW1LFC1-1-3-1	0+84.724	7.92	0.0165	0.3	0.15	0
WW1LFC1-1-3-2	0+89.796	5.62	0.0117	0.3	0.15	0
WW1LFC1-1-3-3	0+186.529	4.32	0.0090	0.3	0.15	0
WW1LFC1-1-3-4	0+341.303	3.02	0.0063	0.3	0.15	0
WW1LFC1-1-3-5	0+444.631	2.17	0.0045	0.3	0.15	0
WW1LFC1-1-3-6	0+571.816	1.21	0.0025	0.3	0.15	0
WW1LFC1-1-4-1	0+111.324	4.75	0.0099	0.3	0.15	0
WW1LFC1-1-4-2	0+116.795	2.79	0.0058	0.3	0.15	0
WW1LFC1-1-4-3	0+224.544	1.77	0.0037	0.3	0.15	0
WW1LFC1-1-4-4	0+382.509	0.72	0.0015	0.3	0.15	0
WW1LFC1-1-5-1	0+151.085	8.89	0.0185	0.3	0.15	0
WW1LFC1-1-5-2	0+156.524	6.94	0.0144	0.3	0.15	0
WW1LFC1-1-5-3	0+280.406	4.93	0.0103	0.3	0.15	0
WW1LFC1-1-5-4	0+486.065	2.50	0.0052	0.3	0.15	0
WW1LFC1-1-6-1	0+135.611	6.68	0.0139	0.3	0.15	0
WW1LFC1-1-6-2	0+142.603	4.18	0.0087	0.3	0.15	0
WW1LFC1-1-6-3	0+264.926	2.50	0.0052	0.3	0.15	0
WW1LFC1-1-6-4	0+406.109	1.34	0.0028	0.3	0.15	0
WW1LFC1-1-7-1	0+95.506	9.10	0.0189	0.3	0.15	0
WW1LFC1-1-7-2	0+101.233	6.85	0.0142	0.3	0.15	0
WW1LFC1-1-7-3	0+288.864	4.32	0.0090	0.3	0.15	0
WW1LFC1-1-7-4	0+424.809	2.60	0.0054	0.3	0.15	0
WW1LFC1-1-8-1	0+179.34	5.31	0.0110	0.3	0.15	0
WW1LFC1-1-8-2	0+184.749	3.93	0.0082	0.3	0.15	0
WW1LFC1-1-8-3	0+335.064	2.26	0.0047	0.3	0.15	0
WW1LFC1-1-9-1	0+146.139	4.13	0.0086	0.3	0.15	0
WW1LFC1-1-9-2	0+151.88	3.12	0.0065	0.3	0.15	0
WW1LFC1-1-9-3	0+300.086	1.32	0.0027	0.3	0.15	0
WW1LFC1-1-10-1	0+126.735	6.50	0.0135	0.3	0.15	0
WW1LFC1-1-10-2	0+131.777	4.18	0.0087	0.3	0.15	0
WW1LFC1-1-10-3	0+267.473	1.74	0.0036	0.3	0.15	0

WW1RFC1-2-1-1	0+71.052	1.54	0.0032	0.3	0.15	0
WW1RFC1-2-1-2	0+76.136	0.64	0.0013	0.3	0.15	0
WW1RFC1-2-2-1	0+106.097	5.69	0.0118	0.3	0.15	0
WW1RFC1-2-2-2	0+111.201	5.08	0.0106	0.3	0.15	0
WW1RFC1-2-2-3	0+221.779	4.32	0.0090	0.3	0.15	0
WW1RFC1-2-2-4	0+347.803	3.40	0.0071	0.3	0.15	0
WW1RFC1-2-3-1	0+113.848	3.72	0.0077	0.3	0.15	0
WW1RFC1-2-3-2	0+124.636	2.92	0.0061	0.3	0.15	0
WW1RFC1-2-3-3	0+196.553	0.83	0.0017	0.3	0.15	0
WW1RFC1-2-4-1	0+106.657	5.84	0.0121	0.3	0.15	0
WW1RFC1-2-4-2	0+111.957	4.59	0.0095	0.3	0.15	0
WW1RFC1-2-4-3	0+267.039	3.03	0.0063	0.3	0.15	0
WW1RFC1-2-4-4	0+408.543	1.54	0.0032	0.3	0.15	0
WW1RFC1-2-5-1	0+148.731	3.34	0.0069	0.3	0.15	0
WW1RFC1-2-5-2	0+151.237	2.29	0.0048	0.3	0.15	0
WW1RFC1-2-5-3	0+260.655	1.26	0.0026	0.3	0.15	0
WW1RFC1-2-5-4	0+361.631	0.57	0.0012	0.3	0.15	0
WW1RFC1-2-6-1	0+108.973	3.22	0.0067	0.3	0.15	0
WW1RFC1-2-6-2	0+114.475	2.49	0.0052	0.3	0.15	0
WW1RFC1-2-6-3	0+270.921	1.39	0.0029	0.3	0.15	0
WW1RFC1-3-1-1	0+108.273	7.51	0.0156	0.3	0.15	0
WW1RFC1-3-1-2	0+114.746	6.43	0.0134	0.3	0.15	0
WW1RFC1-3-1-3	0+239.278	5.64	0.0117	0.3	0.15	0
WW1RFC1-3-1-4	0+320.273	4.82	0.0100	0.3	0.15	0
WW1RFC1-3-1-5	0+441.434	2.86	0.0059	0.3	0.15	0
WW1RFC1-3-1-6	0+584.822	1.15	0.0024	0.3	0.15	0
WW1RFC1-3-2-1	0+141.465	10.08	0.0210	0.3	0.15	0
WW1RFC1-3-2-2	0+146.657	8.70	0.0181	0.3	0.15	0
WW1RFC1-3-2-3	0+281.402	7.45	0.0155	0.3	0.15	0
WW1RFC1-3-2-4	0+367.588	6.16	0.0128	0.3	0.15	0
WW1RFC1-3-2-5	0+491.061	4.93	0.0103	0.3	0.15	0
WW1RFC1-3-2-6	0+648.889	2.88	0.0060	0.3	0.15	0
WW1RFC1-3-3-1	0+130.366	5.46	0.0114	0.3	0.15	0
WW1RFC1-3-3-2	0+135.536	4.56	0.0095	0.3	0.15	0
WW1RFC1-3-3-3	0+252.886	3.52	0.0073	0.3	0.15	0
WW1RFC1-3-3-4	0+369.615	1.85	0.0038	0.3	0.15	0
WW1RFC1-3-4-1	0+95.41	7.87	0.0164	0.3	0.15	0
WW1RFC1-3-4-2	0+100.744	6.83	0.0142	0.3	0.15	0
WW1RFC1-3-4-3	0+268.257	5.25	0.0109	0.3	0.15	0
WW1RFC1-3-4-4	0+329.993	3.90	0.0081	0.3	0.15	0

WW1RFC1-3-4-5	0+491.073	2.85	0.0059	0.3	0.15	0
WW1RFC1-3-4-6	0+610.577	1.92	0.0040	0.3	0.15	0
WW1RFC1-3-5-1	0+273.431	4.76	0.0099	0.3	0.15	0
WW1RFC1-3-5-2	0+278.896	2.41	0.0050	0.3	0.15	0
WW1RFC1-3-5-3	0+366.096	1.04	0.0022	0.3	0.15	0
WW1RFC1-3-6-1	0+251.486	4.95	0.0103	0.3	0.15	0
WW1RFC1-3-6-2	0+257.064	3.24	0.0067	0.3	0.15	0
WW1RFC1-3-6-3	0+364.821	2.14	0.0045	0.3	0.15	0
WW1RFC1-3-6-4	0+578.322	0.89	0.0019	0.3	0.15	0
WW2RFCB1-1-1-1	0+64.126	5.44	0.0113	0.3	0.15	0
WW2RFCB1-1-1-2	0+69.269	4.16	0.0087	0.3	0.15	0
WW2RFCB1-1-1-3	0+212.84	2.85	0.0059	0.3	0.15	0
WW2RFCB1-1-1-4	0+386.093	1.80	0.0037	0.3	0.15	0
WW2RFCB1-1-1-5	0+499.161	0.92	0.0019	0.3	0.15	0
WW2RFCB1-1-2-1	0+78.513	4.87	0.0101	0.3	0.15	0
WW2RFCB1-1-2-2	0+85.378	4.26	0.0089	0.3	0.15	0
WW2RFCB1-1-2-3	0+222.098	3.18	0.0066	0.3	0.15	0
WW2RFCB1-1-2-4	0+330.166	2.31	0.0048	0.3	0.15	0
WW2RFCB1-1-3-1	0+132.031	8.36	0.0174	0.3	0.15	0
WW2RFCB1-1-3-2	0+137.032	4.73	0.0098	0.3	0.15	0
WW2RFCB1-1-3-3	0+257.366	3.19	0.0066	0.3	0.15	0
WW2RFCB1-1-3-4	0+362.95	2.05	0.0043	0.3	0.15	0
WW2RFCB1-1-3-5	0+528.238	1.11	0.0023	0.3	0.15	0
WW2RFCB1-1-4-1	0+374.174	8.48	0.0176	0.3	0.15	0
WW2RFCB1-1-4-2	0+381.246	5.21	0.0108	0.3	0.15	0
WW2RFCB1-1-4-3	0+591.923	3.50	0.0073	0.3	0.15	0
WW2RFCB1-1-4-4	0+699.71	2.24	0.0047	0.3	0.15	0
WW2RFCB1-1-5-1	0+215.072	11.18	0.0233	0.3	0.15	0
WW2RFCB1-1-5-2	0+220.09	7.48	0.0156	0.3	0.15	0
WW2RFCB1-1-5-3	0+334.506	5.55	0.0115	0.3	0.15	0
WW2RFCB1-1-5-4	0+524.008	3.68	0.0077	0.3	0.15	0
WW2RFCB1-1-6-1	0+107.05	9.27	0.0193	0.3	0.15	0
WW2RFCB1-1-6-2	0+114.703	8.02	0.0167	0.3	0.15	0
WW2RFCB1-1-6-3	0+359.385	5.35	0.0111	0.3	0.15	0
WW2RFCB1-1-6-4	0+554.032	3.93	0.0082	0.3	0.15	0
WW2RFCB1-1-6-5	0+669.513	3.05	0.0063	0.3	0.15	0
WW2RFCB1-1-6-6	0+756.716	2.36	0.0049	0.3	0.15	0
WW2RFCB1-1-6-7	0+837.071	1.57	0.0033	0.3	0.15	0
WW2RFCB1-1-7-1	0+96.664	4.59	0.0095	0.3	0.15	0
WW2RFCB1-1-7-2	0+103.222	3.01	0.0063	0.3	0.15	0
WW2RFCB1-1-8-1	0+124.015	6.26	0.0130	0.3	0.15	0

WW2RFCB1-1-8-2	0+129.04	4.88	0.0102	0.3	0.15	0
WW2RFCB1-1-8-3	0+260.618	4.09	0.0085	0.3	0.15	0
WW2RFCB1-1-8-4	0+387.197	3.11	0.0065	0.3	0.15	0
WW2RFCB1-1-8-5	0+477.427	2.14	0.0045	0.3	0.15	0
WW2RFCB1-1-8-6	0+595.277	1.29	0.0027	0.3	0.15	0
WW2RFCB1-1-8-7	0+720.777	0.75	0.0016	0.3	0.15	0
WW2RFCB1-1-9-1	0+81.803	6.99	0.0145	0.3	0.15	0
WW2RFCB1-1-9-2	0+151.61	6.77	0.0141	0.3	0.15	0
WW2RFCB1-1-9-3	0+259.225	5.04	0.0105	0.3	0.15	0
WW2RFCB1-1-9-4	0+488.555	3.50	0.0073	0.3	0.15	0
WW2RFCB1-1-9-5	0+646.557	2.45	0.0051	0.3	0.15	0
WW2RFCB1-1-9-6	0+823.011	1.07	0.0022	0.3	0.15	0

5.3.3 Drops

Canals and drains are provided with vertical type drops, chute type drops and outfalls. These structures are used whenever the available natural ground slope is steeper than design slope. Some of these structures can be located along the canals are fitted with simple sliding gates so that they could be used as a check structure i.e., to regulate the water level of the canal upstream of the structures. Vertical drop structure designed with different heights for this particular project. 47 (1 on MC, 25 on SC and 21 on TC) drops are provided in this project.

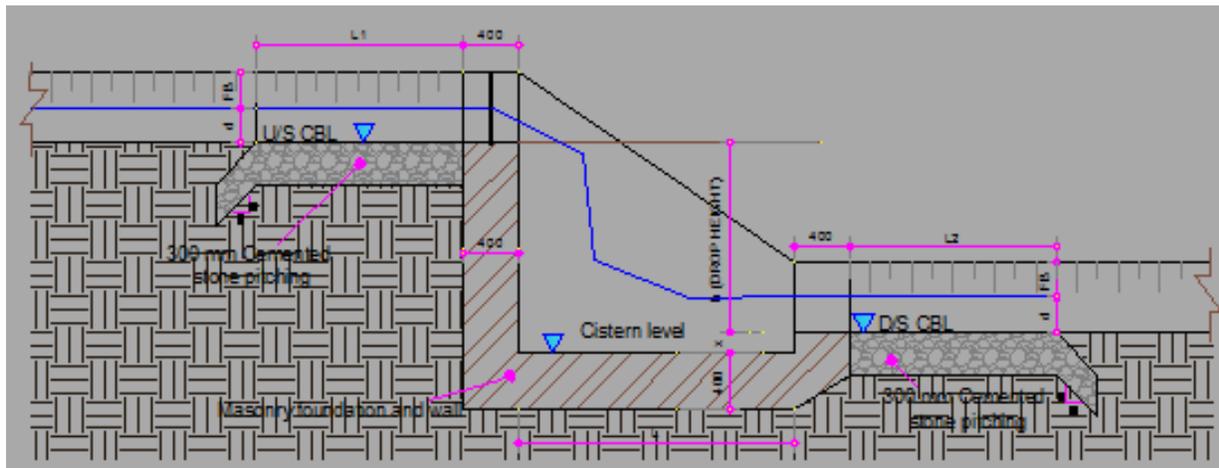


Figure 10: LAYOUT OF DROP

5.3.4 REFERENCE

1. Farmers and Administrative Institutions in the nearby of the site.
2. Irrigation Engineering and Hydraulic structures by S.K.Garg
3. Irrigation Engineering and Hydraulics structure by S.R. Saharabuthe, 1994
4. Guide lines to design irrigation infrastructure by P.N.RAO (Indian Expert)

6. BILLOFF QUANTITY

Bill of Quantities for Laga Dhumuga Small Scale Irrigation Project.					
Item No.	Description of work	Unit	Qty	Unit cost	Total cost
1	General works				
1.1	Mobilization (Manpower, machinery, material, work commencement to be paid on his work schedule submission)	Ls	1	100000	100000
1.2	Demobilization is to be paid after taking over of the project	LS	1	120000	120000
1.3	Furniture and office equipment for the site supervisor (these are considered as the property of the client and formally to be handed over)				
1.4	Supply standard single drawer table with chair;	Set	1	35000	35000
1.5	Supply standard 90cm width and 16cm thick single sponge mattress, a pair of pillow, a pair of bed sheet (250cm), and Blanket;	Set	1	25000	25000
1.6	Supply 90cm wide folding iron bed	No	1	7500	7500
1.7	Supply a Motorcycle or Equivalent; Engine 2-Stroke, Single-Cylinder, air cooled; Fuel capacity: 13 liters; 200cc; Seat Height: 835mm; Height: 1150mm with all accessories.	No	1	200000	200000
Total Carried Summary Birr					487,500.00
2	Access Road Construction				
2.1	Access Road Maintenance cutting to an average depth of 0.2m, with 6m width	km	2	7000	14,000.00
2.1	Field Road construction cutting to an average depth of 0.15m with 3m width	km	6.6	3500	23,100.00
Total Carried Summary Birr					524,600.00
3	Camping (3m x 13.85m office & bed room, 4m x 6m kitchen & Cafeteria, 5m x 5m store, 4mx2m Toilet & Shower, 2m x 2m guard house				
3.10	Site clearance to a depth of 20cm	m2	175	11.89	2,080.75

3.20	Excavation	m3	63.336	57.2	3622.8192			
3.30	Cart away all excess excavated material for safe place with a radius of more than 500m	m3	88.52	31.2	2761.824			
3.40	25cm thick hard core	m3	89.7	36.4	3265.08			
3.50	Masonry work with 1:3 mortar mix	m3	38.404	858.54	32971.37016			
3.60	5cm thick mass concrete (1:2:4 mix ratio)	m3	12.71	2002.72	25454.5712			
3.70	2cm cement screed	m2	91	90.64	8248.24			
3.80	CIS walling G-32	m2	337	142.91	48160.67			
3.90	CIS roofing G-32	m2	194.5	211.94	41222.33			
3.10	Chip wood wall ceiling	m2	256	129.33	33108.48			
3.11	Supply, assemble and fix in position eucalyptus wall post of length 3 m with span length of 1.2m	No	161	225	36225			
3.12	Supply and fix purlin in Eucalyptus wood size 50 x 70 mm nailed into eucalyptus truss	m	586	69.375	40653.75			
3.13	Supply, assemble and fix in position eucalyptus roof truss	No	36	225	8100			
3.14	Supply and fix purlin in zigba wood size 50 x 70 mm nailed into eucalyptus truss including three coats of anti - termite external treatment	m	190	69.375	13181.25			
3.15	Supply and fix CIS doors size 1.0x2.10m with accessories	No	14	3139.25	43949.5			
3.16	Supply and fix CIS windows size 1x1.2m	No	9	2150.25	19352.25			
3.17	Fence 2.0m height & 15cm φ eucalyptus poles placed every 2m with barbed wire at 20cm vertical interval & erected in 0.6m depth embedded with concrete	LS	1	84943.2	84943.2			
Total Carried Summary Birr					971,901.08			
No	Description of work	Unit	Quantity	Unit cost	Total cost	cost		Total Sum in Birr
						Installation	Test and Commissioning	
4	Electro Mechanical Installation	5 bore hole						

4.1	Multistage submersible pump of Discharge rate Q=30l/sec, (Head)=298m,Electric Motor=150KW, speed= 1500RPM, Frequency= 50Hz, Maximum Motor diameter 10", Casing diameter 12" Equipped with its switch board (control panel)	Set	1	1,800,000.	1,800,000.00	300,400.00	10,000.0	2,110,400
4.2	Multistage submersible pump of Discharge rate Q=30l/sec, (Head)=316m,Electric Motor=160KW, speed= 1500RPM, Frequency= 50Hz, Maximum Motor diameter 10", Casing diameter 12" Equipped with its switch board (control panel)	Set	1	1,950,000.	1,950,000.00	300,000.00	10,000.0	2,260,000
4.3	Multistage submersible pump of Discharge rate Q=30l/sec, (Head)=325m,Electric Motor=165KW, speed= 1500RPM, Frequency= 50Hz, Maximum Motor diameter 10", Casing diameter 12" Equipped with its switch board (control panel)	Set	1	2,100,000.	2,100,000.00	250,000.00	10,000.0	2,360,000
4.4	Multistage submersible pump of Discharge rate Q=30l/sec, (Head)=298m,Electric Motor=166KW, speed= 1500RPM, Frequency= 50Hz, Maximum Motor diameter 10", Casing diameter 12" Equipped with its switch board (control panel)	Set	1	2100000	2,100,000.00	250,000.00	10,000.0	2,360,000
4.5	Multistage submersible pump of Discharge rate Q=30l/sec, (Head)=339m,Electric Motor=172KW, speed= 1500RPM, Frequency= 50Hz, Maximum Motor diameter 10", Casing diameter 12" Equipped with its switch board (control panel)	Set	1	2,100,000.	2,100,000.00	250,000.00	10,000.0	2,360,000
4.6	Heavy Duty GS Double Flanged Riser Pipe, with cable way (L=6m) DN150 , PN40	pcs	170	22000	3,740,000.00			3,740,000
4.7	GS Double Flanged pipe of length L=0.5m, DN150 , PN40	pcs	5	12,000	60,000.00			60,000
4.8	GS Single Flanged pipe of length L=0.75m , DN150, PN40	pcs	5	14,000	70,000.00			70,000
4.9	GS Double Flanged pipe of length L=0.3m, DN150, PN40	pcs	15	12,000.00	180,000.00			180,000
4.10	GS Double Flanged pipe 45° degree bended at both ends of length, L=2.5m, DN150 , PN40	pcs	5	14,000.00	70,000.00			70,000
4.11	GS Double flanged 90° bended elbow, DN150, PN40	pcs	5	9000	45,000.00			45,000
4.12	GS Double flanged Check valve , DN150, PN40	pcs	5	12,000	60,000.00			60,000

4.13	GS Double flanged short pattern Gate valve DN150 ,PN40	pcs	5	8000	40,000.00			40,000
4.14	Single Air Release valve DN150, PN40	pcs	5	17,500	87,500.00			87,500
4.15	DCI dismantling Joint DN150, PN40	pcs	5	16,250	81,250.00			81,250
4.16	All flanged tee DN150x100x50 ,PN40	pcs	5	19,200	96,000.00			96,000
4.17	Pressure Gauge with Switch valve reading (0-40Bar)	pcs	5	7,500	37,500.00			37,500
4.18	Double Flanged Flow Meter DN 150, PN40	pcs	5	25,000	125,000.00			125,000
4.19	Double Flanged Concentric reducer dn150/DN200, PN40	pcs	5	10,500	52,500.00			52,500
4.20	GS/ upvc double flanged adaptor outside diameter 210, DN200, PN40	Pcs	5	16250	81,250.00			81,250
4.21	Power Cable 3x95mm ² +1x50mm	meter	1100	2800	3,080,000.00			3,080,000
4.22	Static Water level Sensor electrode (c/s=2.5mm ²), L=70m	m	350	40	14,000.00			14,000
4.23	Dynamic Water level Sensor(C/s=2.5mm ²), L=175m	m	865	40	34,600.00			34,600
4.24	High temperature Sensor electrode (c/s=2.5mm ²), L=225m	m	1125	40	45,000.00			45,000
4.25	Motor Protection Sensor electrode(c/s=2.5mm ²), L=225m	m	925	40	37,000.00			37,000
4.26	Two Steel support of 2 meter, RHS	Pcs	10	1500	15,000.00			15,000
4.27	Collar to tighten the steel	pcs	10	500	5,000.00			5,000
4.28	Steel Camps	set	10	2500	25,000.00			25,000
4.29	GS Flange 12" to be welded to the casing (casing cup)	pcs	5	3500	17,500.00			17,500
4.30	Double flanged female socket ½" for the connection of pressure gauge L=0.1m	pcs	5	7000	35,000.00			35,000
4.31	Transformer 315KVA	pcs	5	800,000	4,000,000.00			4,000,000
4.32	Manual Change Over switch (I=340A)	pcs	5	70,000	350,000.00			350,000
4.33	Lamps	pcs	10	100	1,000.00			1,000
4.34	Socket out let	pcs	15	100	1,500.00			1,500
4.35	Industrial plug socket	pcs	20	200	4,000.00			4,000
4.36	Diesel Generator 565KVA	Set	1	3,000,000.	3,000,000.00	20,000.00	20,000.0	3,040,000
4.37	Diesel Generator 600KVA	Set	1	3,000,000.	3,000,000.00	20,000.00	20,000.0	3,040,000
4.38	Diesel Generator 625KVA	Set	1	3,200,000.	3,200,000.00	20,000.00	20,000.0	3,240,000
4.39	Diesel Generator 625KVA	Set	1	3,200,000.	3,200,000.00	20,000.00	20,000.0	3,240,000
4.40	Diesel Generator 650KVA	Set	1	3,200,000.	3,200,000.00	20,000.00	20,000.0	3,240,000
Total Carried Summary Birr								40,712,901.08
5	Pipe lines to Wet well	no	5					
5.1	Heavy Duty Steel Pipe with coupling, L=6m, DN200, PN40	Pcs	1173	30,000	35,190,000.00	5,000,000	250,000	40,440,000

5.2	Double Orifice Air release valve DN50, PN40	Pcs	10	20,000	200,000.00			200,000
5.3	Gate Valve DN200, PN40	Pcs	5	22,000	110,000.00			110,000
5.4	Mechanical Sealing DN200, PN40	Pcs	5	2,500	12,500.00			12,500
Total Carried Summary Birr								81,475,401.08
6	Generator House having external dimension of 7m*6m	no	5					
6.1	Site Clearing 20cm depth	m ²	360	11.89	4,280			
6.2	Normal soil excavation	m ³	220	57.2	12,584			
6.3	Hard Core 25cm thick	m ³	90	327	29,435			
6.4	Wet stone masonry	m ³	45	2,565	114,903			
6.5	Lean concrete grade C10	m ³	10	2002.72	20,378			
6.6	Cement screeding (1:3 ratio)	m ²	210	241	50,547			
6.7	Mesh Wire	m ²	38	298	11,166			
6.8	Formwork supply and fixing	m ²	249	248	61,814			
6.9	HCB Walling	m ²	450	416	187,182			
6.10	Plastering	m ²	900	123	110,700			
6.11	External face masonry pointing	m ³	22	102	2,292			
6.12	150mm thick Reinforced Concrete Class C20 for Floor Slab and 100mm thick mass concrete for Pavement around Building	m ³	45	3,389	153,964			
6.13	Reinforced Concrete Class C25 for Beam, Column and Generator Seat Block	m ³	22	3,513	77,994			
6.14	300mm Diameter half ditch concrete open drainage ditch around the building pavement	ml	155	941	145,815			
6.15	Supply and provide 15mm thick stayrophom at the expansion joint between generator seat block periphery and Floor slab.	ml	75	280	21,000			
6.16	Reinforcement bar cut, bend, tie and fixing in position				0			
	8mm dia.	kg	810	48	39,066			
	12mm dia.	kg	506	48	24,404			
	14mm dia.	kg	684	48	32,989			
	16mm dia.	kg	795	48	38,333			
6.17	250x25mm Fascia Board	ml	37	183	6,771			
6.18	600mm development length G-28 Sheet metal Roof Rain Water Collector Gutter	ml	37	370	13,690			
6.19	Supply and fix in position 110mm diameter PVC down pipe to discharge roof rain water to the side ditch including all accessories such as coupling, bends and fixing material.	ml	60	300	17,995			

6.20	Supply, built up and fix in position of Roof Truss with embedded tie 6mm dia. tie bars in the top tie beam Constructed out of 100mm and 80mm eucalyptus tree well-seasoned and painted anti termite protection oil paint.	No.	30	1,535	46,055
6.21	Corrugated iron sheet roofing with gauge 28"	m ²	226	499	112,606
6.22	Development length of 900mm , Gauge 28 Cupping for HCB Wall Top	ml	100	325	32,545
6.23	Doors:				0
6.24	Double Leaf 3.0mx2.75m constructed out of 2mm thick sheet metal including framing, hinge, lock and two cats of antirust	No	5	18,833	94,164
6.25	Windows:		0		0
6.26	600mm wide Wire mesh window framed with 50x50x3mm angle iron frame	lm	125	656	82,018
6.27	Manufacture and fix in position 3.25mx2.5m Louver Window for ventilation purpose, constructed out of 2mm thick sheet metal and 50x50x3mm angle iron frame including two coats of antirust paint.	Pcs	5	4,979	24,897
Total Carried Summary Birr					83,044,989.05
7	Main Canal & Related Structures	no	1		
7.1	Main Canal	Km	1.90		
7.1.1	Lined	km	1.90		
7.1.1.1	Site clearance to a depth of 20cm	m2	3292.33	12	39,145.81
7.1.1.2	Soil excavation 70%	m3	218.84	57.2	12,517.92
7.1.1.3	Soft Rock Excavation 20%	m3	27.36	108.2	2,959.88
7.1.1.4	Hard Rock excavation 10%	m3	27.36	277	7,577.50
7.1.1.5	Fill & compaction	m3	1,065.00	143.44	152,763.60
7.1.1.6	25cm Hardcoring	m3	334.89	36.4	12,190.17
7.1.1.7	Masonry Work	m3	356.09	1456	518,472.63
7.1.1.8	5cm thick mass concrete (1:2:4 mix ratio)	m3	30.63	2002.72	61,343.02
5.1.1.9	Plastering work	m2	1,617.22	123.23	199,289.65
Total Carried Summary Birr					84,051,249.24
7.1.5	Drops 1.5m	no	1		
7.1.5.1	soil Excavation	m3	76.0836	57.2	4,351.98
7.1.5.2	Masonry	m3	14.0026	1456	20,387.79
7.1.5.3	plastering	m2	13.0378 1	123.23	1,606.65
7.1.5.4	Back Fill	m3	39.01	143.44	5,595.59
Total Carried Summary Birr					84,083,191.25

7.1.5	Offtake/turnout	no	3		
7.1.5.1	soil Excavation	m3	0.55	57.2	31.46
7.1.5.2	Masonry	m3	0.51	1456	742.56
7.1.5.3	plastering	m2	3.3	123.23	406.66
7.1.5.4	Back Fill	m3	0.51	143.44	73.15
Total Carried Summary Birr					84,084,445.08
7.1.5	Pond/ Wet Well storage	no	2		
7.1.5.1	Soil excavation	m3	6830	57.2	390676
7.1.5.2	Fill & compaction	m3	21724	143.44	3116090.56
7.1.5.3	Geomembrane	m2	4879.21 4		0
7.1.5.4	Masonry	m3	63.25	1456	92092
7.1.5.5	Stone Pitching	m2	7	201.8	1412.6
7.1.5.6	Lean concrete C-10	m3	1.02	1573	1604.46
7.1.5.7	Concrete C-15	m3	1	2002.72	2002.72
Total Carried Summary Birr					87,688,323.42
8	Secondary Canals, & Related Structures	no	4		
8.1	Secondary Canals,	Km	2.85		
8.1.1	Lined	Km	2.85		
8.1.1.1	Site clearance to a depth of 20cm	m2	6493.53	12	77,208.07
8.1.1.2	Soil excavation 90%	m3	4497.96	57.2	257,283.48
8.1.1.3	Soft Rock Excavation 10%	m3	499.77	108.2	54,075.51
8.1.1.4	Fill & compaction	m3	3011.42	143.44	431,957.95
8.1.1.5	25cm Hardcoring	m3	2003.37	36.4	72,922.57
8.1.1.6	Masonry Work	m3	2373.11	1456	3,455,242.37
8.1.1.7	5cm thick mass concrete (1:2:4 mix ratio)	m3	37.93	2002.72	75,972.17
8.1.1.8	Plastering work	m2	3229.89	123.23	398,019.79
Total Carried Summary Birr					92,511,005.34
8.1.2	Drops	no	25		
8.1.2.1	soil Excavation	m3	791.51	57.2	45,274.25
8.1.2.2	Masonry	m3	163.18	1456	237,588.45
8.1.2.3	plastering	m2	176.84	123.23	21,792.52
8.1.2.4	Back Fill	m3	433.99	143.44	62,251.81
Total Carried Summary Birr					92,877,912.37
8.1.3	Box Culvert	no	15		
8.1.3.1	soil Excavation	m3	15.97	57.2	913.48
8.1.3.2	Masonry	m3	69.98	1456	101,890.88

8.1.3.3	C-20 concrete	m3	7.32	2118.3	15,505.96
8.1.3.4	Reinforcement Iron Bars	kg	133.59	85.5	11,421.95
8.1.3.5	plastering	m2	38.66	123.23	4,764.07
8.1.3.6	Back Fill	m3	21.54	143.44	3,089.70
Total Carried Summary Birr					93,015,498.40
8.1.4	Offtake/turnout	no	27.00		
8.1.4.1	soil Excavation	m3	3.48	57.2	199.06
8.1.4.2	Masonry	m3	3.57	1456	5,197.92
8.1.4.3	plastering	m2	22.97	123.23	2,830.59
8.1.4.4	Back Fill	m3	3.57	143.44	512.08
Total Carried Summary Birr					93,024,238.05
9	Tertiary Canal & Related Structures	no.	31		
9.1	Tertiary Canal (TC)	Km	12.98		
9.1.1	Lined	Km	12.98		
9.1.1.1	Site clearance to a depth of 20cm	m2	33763.0 7	12	401,442.92
9.1.1.2	Soil excavation	m3	7834.03	57.2	448,106.31
9.1.1.3	Fill & compaction	m3	6,779.24	143.44	972,414.40
9.1.1.4	25cm Hardcoring	m3	3,891.12	36.4	141,636.71
9.1.1.5	Masonry Work	m3	5,167.55	1456	7,523,954.84
9.1.1.6	5cm thick mass concrete (1:2:4 mix ratio)	m3	179.56	2002.72	359,616.50
9.1.1.7	Plastering	m2	20258.6 3	123.23	2,496,470.91
Total Carried Summary Birr					105,367,880.6
9.1.3	Drops	no	21		
9.1.3.1	soil Excavation	m3	231.03	57.2	13,214.92
9.1.3.2	Masonry	m3	52.84	1456	76,939.41
9.1.3.3	plastering	m2	73.79	123.23	9,092.76
9.1.3.4	Back Fill	m3	128.52	143.44	18,434.19
Total Carried Summary Birr					105,485,561.9
9.1.4	Box Culvert	no	110		
9.1.4.1	soil Excavation	m3	53.38	57.2	3,053.34
9.1.4.2	Masonry	m3	657.99	1456	958,033.44
9.1.4.3	C-20 concrete	m3	51.94	2118.3	110,024.50
9.1.4.4	Reinforcement Iron Bars	kg	989.71	85.5	84,620.21
9.1.4.5	Plastering	m2	458.68	123.23	56,523.14
9.1.4.6	Back Fill	m3	146.71	143.44	21,044.08

	Total Carried Summary Birr				106,718,860.6
9.1.4	Offtake/turnout	no	129.00		
9.1.4.1	soil Excavation	m3	23.54	57.2	1,346.49
9.1.4.2	Masonry	m3	14.45	1456	21,039.20
9.1.4.3	plastering	m2	92.53	123.23	11,402.47
9.1.4.4	Back Fill	m3	14.45	143.44	2,072.71
	Total Carried Summary Birr				106,754,721.5
10	Total Project Cost	Birr	106,754,721.48		
11	Overhead cost =5% of Total Project Cost	Birr	5,337,736.07		
12	Total Carried Summary Birr	Birr	112,092,457.56		
13	For Supervision Cost = 5% of final Total Summary Birr	Birr	5,604,622.88		
14	Final Total Carried Summary Birr	Birr	117,697,080.43		
15	Vat 15%	Birr	17,654,562.07		
16	Grand Total	Birr	135,351,642.50		

ANNEX - III: *LIST OF DRAWINGS*