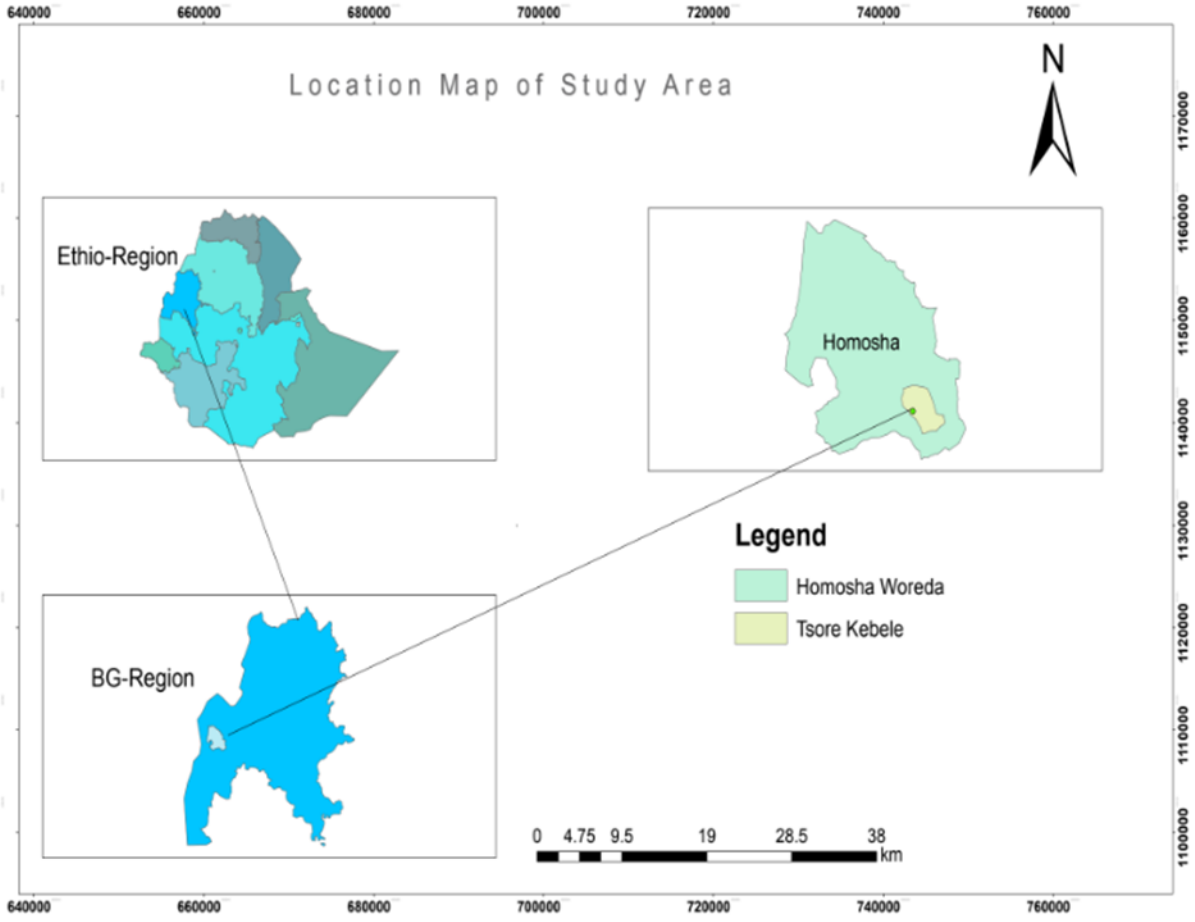
WATER SOURCE IDENTIFICATION, FEASIBILITY STUDY, DETAIL ENGINEERING DESIGN FOR FIKADU NEMERA WAQO FARMING FARM DEVELEPMENT



(Final Report)

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EXECUTIVE SUMMARY

Irrigation development has been identified as one of the priority investment sectors in Ethiopia and the government has been implementing a number of efforts that enhance the planning and implementation of small-scale irrigation projects in the country. The aim was to identify the potential, feasibility and profitability of irrigation development for spices production mainly pepper in Homosha woreda, Tsore keble of Assosa Zone, Benishangul Gumuz region. This woreda is mostly characterized by Black clay soil type which is highly productive type of soil in Ethiopia. In most of the fields, the slope gradient ranges from 0% to 5%. The project was studied to irrigate the command area through gravity close pipe conveyance system of drip irrigation and surface irrigation with diverting of water to the pond and using submersible pump by using the power of solar system and also to use standby generator. It was studied that it is suitable for irrigable land for surface irrigation. An agronomic cropping pattern and production calendar of the farming system had identified for the sustainable supply of raw material for the agro-processing plant. Therefore, in the dry season using full irrigation 225ha from which, 50ha Banana, 40ha Avocado, 40ha orange ((Both Red & Valencia), 15ha papaya, 30ha mango, 40ha, and 10ha lemons. The implementation of the proposed irrigation project would require diversion of tsore River to the pond by gravity system from the river to the pond, and from the pond to command area by using surface pump to pump water to the command irrigated area and the total number of the pond is 12 with the capacity of 30m width, 20m length and 4.5m depth and with the total 32,400m3 water capacity of the pond constructed and also the sources of irrigation system is bore hole with the discharge of 12 l/sec of water was pumped from the ground water to the constructed 360m3 of reservoir and distributed to the project command area. Therefore, Fikadu Nemera Waqo Farming Investment, aimed to drill one borehole for for irrigation purposes to meet the present and future demand. To satisfy this requirement of water demands drilling of boreholes is choosing due to its quality, quantity and less cost than others. The required capacity of water is pumped by a submersible pump from the Borehole to the proposed reservoir and the material type is HDPE pipe with a diameter of 90mm (3") and 80mm (3") GI pipe for inlet into the reservoir and 3" DCI pipe outlet, overflow and drain into the reservoir. The elevation of the proposed borehole and Ground reservoir is 1485m and 1570 meters (amsl) respectively and the length from the borehole to the ground reservoir is 1000m. Water is conveyed from the proposed Under Ground reservoir to consumers by gravity system through 90, 75mm and, 63mm HDPE pipe material is used. For the design of water schemes the national and regional standards are thoroughly considered. Based on the program implementation the study and design document includes the engineering design of the water supply system.

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1 INTRODUCTION

1.1 Background and Justification

Irrigation is a mechanization tool that comes into play as one of the means of improving total volume or reliability of agricultural production by managing water for the crop (Barton, 1977). The world trend in irrigation is such that the total irrigated area was 311 million hectares from (FAO, 2009). As of 2010, the countries with the largest irrigated areas were India (39million hectares), China (19 million hectares) and United States. Globally agriculture makes use of available water accounting for about 70% of all use. In countries where agriculture is the main activity as in India and Africa, 90% of water is used for agriculture entailing use of irrigation. It has been found that because of temporal and spatial variations potential in usable water supply is small (Megh, 2014). In Ethiopia agricultural sector accounts for nearly 35.79% of the GDP, yet agricultural productivity is on the decline as the population increases. Olden surface irrigation methods are however still in use including use of bucket systems that result into water wastage resulting into decline in yield. River, Ground water and Runoff water harvesting is the main water source for the area from which abstraction can be made to be utilized for irrigation to improve crop production.

1.2 Objectives

The objective of this project is to design irrigation project for substantial share in the effort to reduce the risk of production decrease due to rainfall variability, minimize water wastage, increase the productivity of the resource, and make sustainable crop production in the dry season possible over 225ha of land through irrigation.

1.3 **Location and Accessability**

The project area under consideration is found in the North-east part of the Assosa Town bordering with Kurmuk in the west and Ura woreda in the south. Moreover, specifically the target project area is within Tsore Almetama kebele and located around the southwestern margin of the Homosha Woreda as it is depicted on the figure 1 below. The selected Kebele can be accessed through the asphalt road from Asossa the capital city of the region up to Homosha woreda for about 36 km and then there is all-weather gravel road extending from Tsore refuge cap to the project farm land.

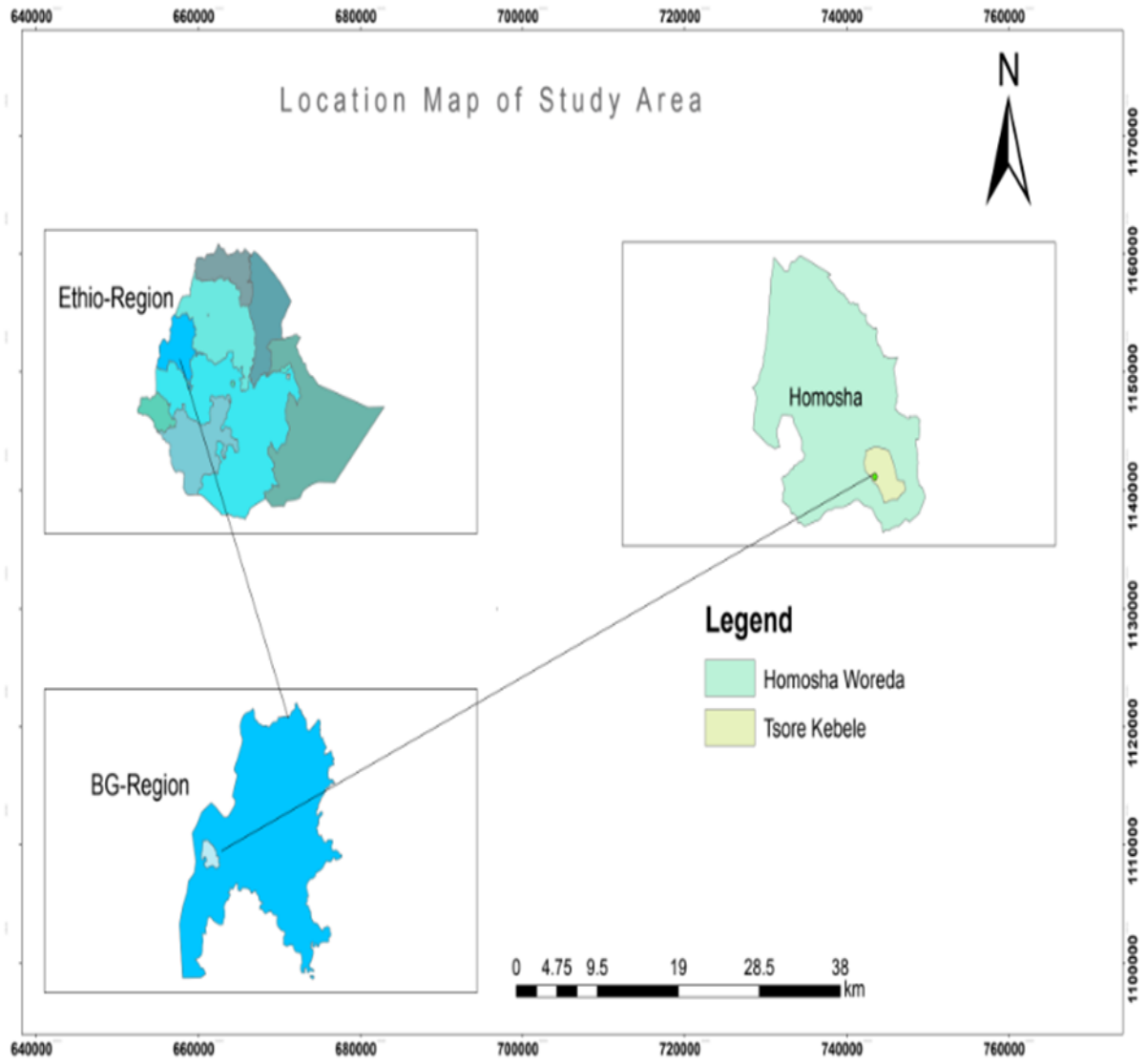


Figure- 1 Location Map of the study area

2 Drainage and Climate

2.1 Drainage characteristics of the area

The drainage system of the Benishangul Gumuz Region attributed to the geological and tectonic phenomena that resulted in the prevailing physiographic features such as the Western plateau and associated lowlands trends to Western plain lands, which cover most part of the Benshangul Gumuz Region. The most prominent drainage system of the region is Abay and Daubs rivers. The drainage is dendritic with different streams. Selege and Hoha River is the Perennial Rivers flowing through the study area and some of them are the tributaries of the Debus sub basin. The river flow direction and the drainage types are shaped by both tectonic impacts like faults and erosional processes. Perennial River carry deposits sediments from weathered parts of volcanic and basement rock in addition to fracturing from geological faults and it has high contributions to groundwater recharge through primary and secondary porosity. The geomorphology of the area is generally an out came of repeated tectonism with associated intrusion and erosion.

The drainage density and pattern are also partly or wholly controlled by tectonic activity and geological variation in the area. The drainage density is higher in the relatively elevated areas especially when the weathered section is thick or when the pattern of structures crossing the rocks is higher. In general, narrow deep to shallow gorges are found in the highland.

The physiographical setup of the project area is controlled by geological and tectonic setting. Step faults and erosional process shapes the landform of the study area. Based on Elevation the physiographic setup of the study area is classified in to five distinct zones.

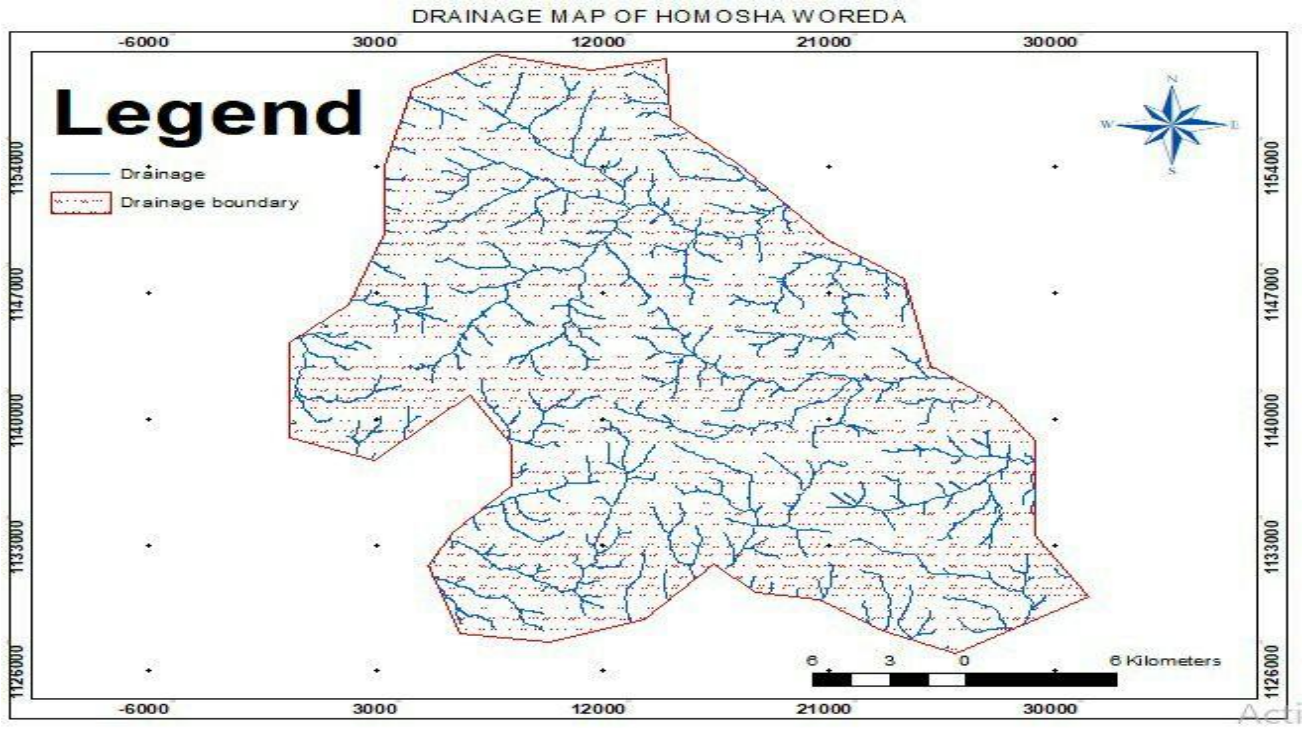


Figure 2 Drainage map of the area

2.2 Climate of the Study area

Based on annual and monthly mean temperature, rainfall & seasonal changes of rainfall, type of associated natural vegetation, and altitude, the climate of the study area varies from "Kur" to Kolla" climatic conditions (National Atlas of Ethiopia, 1988). In general, the main rainy season in most of the study areas is "Kiremit" which lasts from June to September while the dry season is from October to May. The climatic conditions for the study area are explained in each subheading. Table 1 shows the Climate classification based on altitude and means annual temperature (National Atlas of Ethiopia, 1988).

2.3 Temperature of the area

The climate in the study areas is influenced mainly by altitude. The influence of the altitude, the pressure, and the airflow pattern determine the tremendous difference in the climate of the Benshangul Gumuz region. The study is located in the **Abbay basin** of the Daubs sub-basin with an intermediate altitude relative to the rest of the basin.

The temperature influences the potentiality of the groundwater since the rainfall /precipitation is affected by temperature. As in all parts of the country, the altitude of the sun is somewhat high in the study area which makes the solar radiation strong.

Table 1.Climate classifications and its description

Altitude (m.a.s.l)	Mean annual temperature (	Description	Traditional description
>3300	< 10	Cool	Kurk
2300 – 3300	10-15	Cool temperate	Dega
1500-2300	15-20	Temperate	Woinadega
500-1500	20-25	Warm temperate	Kolla
<500	>25	Hot	Berha

The study area is found between warm and temperate climatic zone. Mean maximum temperature and mean minimum temperatures of the project area from Assosa station are 31.8, 17 and 31.5 and 17.2 in the year 2022/23 in March and April respectively. Based on the temperature the study area is exposed to a high rate of evaporation and transpiration from surface water bodies and vegetation but dense vegetation enhances the rate of evaporation and facilitates infiltration.

Table .Maximum and Minimum temperature of the study area

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sept	oct	Nov	Dec
Minimum temperature (°C)												
Avg.	14.5	16	17	17.2	16.7	15.5	15.1	14.9	14.8	15	14.4	14.6
Maximum temperature (°C)												
Avg.	29.9	32	31.8	31.5	28	25.5	23.9	23.9	25.6	26	27.4	29.3

2.3.1 **Rainfall of the study area**

The rainfall distribution of Assosa town is from May to October with 6-month rainfall periods. The maximum monthly rainfall recorded in the Assosa station is 208Mm in the month of August and the mean monthly rainfall is 1.0mm and 0.0mm in the month of December. The rainfall distribution of Assosa and its surrounding area is sufficient for groundwater circulation, infiltration through fractured and weathered rocks, thick soil deposits, and regolith zones. The river which is flowing through the study area is perennial since there is high rainfall intensity and dense vegetation cover.

Table 2.Rainfall of the area

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Humidity (%)	48	47	48	50	74	82	83	84	78	73	66	56
Wind speed(m/s)	1.7	1.7	1.4	1.7	1.7	1.4	1.4	1.4	1.4	1.4	1.4	1.7
Sunshine(hours)	8.7	8.1	6	8.3	6	4.9	4.5	3	6.1	7	7.4	7.9
Precipitation (mm)	0	0	31	32	118	189	207	208	207	103	21	0

3 METHODOLOGY

This report is prepared mainly based on the field assessment. During the preparation of detail engineering design report, the following points were followed and modified to suit into the actual condition;

- Studying the current population information of Fikadu Nemera Integrated Farming Investment staff.
- Conducting detailed surveying work
- Assessing the water demand based on the current and projected population
- Reviewing surveying reports of the distribution and transmission lines, reservoirs sites.
- Studying distribution of the water users by category, and setting the nodal demand.
- Designing of each scheme components based on the basic related design criteria.
- Preparation of working drawings for each scheme components.
- Preparation of the cost estimates of the project by using the current market prices

4 POTENTIAL WATER SOURCE INVESTIGATION

4.1 Introduction

Water is an essence food and basic component of life. The need for water is strongly ascending and has a diversified function, which is not only important for drinking purposes but is also vital for any developmental activities. Nowadays, the use and sustainability of water is getting more complex due to population growth, urbanization and industrialization. Any development is related either directly or indirectly with water utilization. For any developmental activity, both surface and groundwater sources are the main components depending on their quality and availability. In an area where surface water is not feasible for the desired activity, groundwater is the second alternative, if it has the anticipated amount and quality.

For this project purpose as observed from the site the surface water and constructed pond were the source of water for irrigation project. Besides these two sources groundwater investigation is the other option for water source to add additional yield for irrigation water source. Therefore, groundwater can be explored using different methods. There are four major groundwater exploration methods are the areal method, surface method, subsurface method and esoteric methods. Among these methods, esoteric method is not based on science, mostly based on traditional indicators. Each of the above listed groundwater exploration methods have different sub-methods under them. Geophysical survey is therefore one of the sub-methods under the surface method of groundwater exploration. This method is very important for both groundwater resource mapping and water quality evaluations. Its application for groundwater exploration purposes has increased over the last few years due to the rapid advances in computer packages and associated numerical modeling solutions.

The farming industry, also known as the agriculture industry, involves the production, processing, and distribution of agricultural products. It encompasses crop and livestock production, aquaculture, fisheries, and forestry for food and non-food products. Agriculture was the key development in the rise of sedentary human civilization, whereby farming of domesticated species created food surpluses that enabled people to live cities. Agriculture in Ethiopia is the foundation of the country's economy, accounting for half of gross domestic product (GDP), 83.9% of exports, and 80% of total employment. Fikadu Nemera Inetgrated farming is one of the newly established integrated farming in Homosha Woreda, Benishangul Gumuz Regional State and the water demand for different purposes like drinking water and Irrigation became increased and it seeks to investigate its own groundwater source using the aid of advanced geophysical instruments that may detect the subsurface material properties. Therefore, a hydrogeological and geophysical investigation of groundwater and location of potential borehole sites was conducted to respond to the demand of the hotel. Data were acquired from the site using PWQT instrument along north-southeast and east-west direction with a maximum of 2 and 3m electrode spacing, in the farming site and data points

were collected along a small stream that start draining from high land to east direction. Qualitative analysis of PWQT data was accomplished by using its own software and the processed image were exported and downloaded.

4.2 Approaches and Methodology

The following approaches and methodologies were used during the investigation

- The utilization of past experiences in the area of interest
- Previous studies and secondary Data at regional, zonal and district levels
- The checklist development and Inventory to selective collection of water source data
- Discussion with existing water supply users, water committees and local elders.
- Direct observation and visits of existing water sources and supply in the study area.
- Detail geological, Hydrogeological and Geophysical investigation.
- Take the location of prioritized and optional potential water source sites by GPS.
- Finally, triangulation of the collected data and reporting

The work was carried out in two phases:

A. Data collection and analysis in the office (Desk Study) and B. Field investigations

A. Desk study

The hydrogeological analysis was made using different methods.

1. The assessment of the existing published and unpublished reports and maps.
2. Evaluation of regional and sub-regional hydrogeological maps.

B. Field investigation

The field activities include:

1. Conducting field assessment for water source identification (surface, ground and other water source)
2. Detailed assessment of the structural and geological setup of the specific localities and their relation with regional geological structures having hydrogeological importance.
3. Evaluation of recharge and discharge conditions by accounting catchment area and hydrometeorology.
4. Conduct existing water point inventory and evaluation detailed hydrogeological features
5. Geophysical Surveying using PWQT.

C. Materials and equipment used

During desk and field study the following materials and equipment are used;

- Topographic map with scale 1:250,000
- Geological map with scale 1:250,000
- Hydro Geological map with scale 1:250,000
- Google Earth mapping

- GPS/Garmin
- Soft ware's;GIS, Global Mapper

D. Interpretation of Maps

Due to its rugged topography, poor accessibility and unavailability of detailed hydrogeological maps of the region at higher resolution/scales it was hardly possible to fully describe and investigate the details of the hydrogeology of the target villages distributed in the different watersheds with variable geomorphological set up. To overcome some of these problems and unravel groundwater localization, the importance of integrating multiple data sources such as previous exposure to recent hydrogeological field investigations is very essential.

Accordingly, aside from the collection and analysis of hydrogeological published and unpublished reports, an exhaustive analysis of the hydrogeology of the area was made using indirect geophysical surveyed data.

A converging evidence approach is followed. The existing hydrogeological data (yield, hydraulic conductivity, hydro chemical data, lithological logs, pumping test data, etc.), the field observed hydrogeological information and collected data were integrated into a GIS environment for spatial data analysis to prepare the hydrogeological map and delineate major water-bearing zones and locating them on the map for easily observing them. The enhanced studies were used for the identification of important hydrogeological features such as faults, hydro stratigraphic units, recharge and discharge zones, different land use types, etc. From the image it was possible to identify the Trap Series volcanic rocks forming the plateau, the basement complex rocks covering wide areas in the flat plains and undulating transitional areas, clay-rich soils on flat areas, eroded traps on the slope and alluvial deposits. Faults trending S-N and EW-SSW were observed in the study area. Descriptions of the hydro stratigraphic units in the area are mainly based on qualitative interpretation such as degree of weathering and fracturing, existence or absence of springs, vegetation and soil cover.

D. Discussions with relevant offices and professionals

During the fieldwork, there were visited existing water supply sources. The working team discussed relevant issues with concerned administrators, and women and community leaders were interviewed.

1. Phases and sources of data for this study

This study will have two components desk and field study. There are two phases in the field. These are pre-field assessments and detailed field studies. Primary data are collected through checklists, focus group discussion, direct observation and detailed geotechnical work. The secondary data will be collected from well-source site study reports, study documents and well-completion reports. Before, during and after the study; desk study will be carried out to improve the study result. These are described in steps as follows;

- ✓ Desk review of documents on previous works
- ✓ Detail field data collection and study
- ✓ Data entry and analysis

- ✓ Draft report preparation and presentation
- ✓ Final report preparation and submission.

4.3 Previous Study Review

The northwestern part of the country is characterized by metamorphic terrain. Stratigraphic ally situated as weathered sediment deposit at the top; tertiary volcanic /intrusive rocks below and the metamorphic rock/basement at the bottom. The success and failure of the well site located depend very much on the proper utilization of the complex structure of Precambrian metamorphic and intrusive rocks and the existence of thick permeable weathered zones.

An integrated system of exploration such as geological, physical, hydrogeological and geophysical methods are very important in the kind of terrain. The metamorphic rocks exposed in the western parts like in the Benishangul Gumuz region are located within favorable rainfall conditions. However, their water-holding properties are poor as witnessed by the springs, which emerge from contact between overburdened soil and massive bedrock. The probability of obtaining highly yielded aquifer in the crystalline rock will be maximized if they are located and drilled in places with highly fractured and weathered are localized under good recharge conditions and catchment area.

Generally, the aquifer of Meta volcanic crystalline rocks occurs in the weathered overburdened regolith and fractured bedrocks. These rocks have very low fracture permeability and are confined in shallow groundwater depth (Tamiru, 2006).

Around the study area, there is the exposure of volcanic and metamorphic rock complex of metamorphic terrain which is covered in most places by a shallow layer of weathered sediments; volcanic/basalt and Meta volcanic and in some places by extrusive crystalline and underlying by metamorphic rocks like granite, Meta quartzite and other metamorphic rocks. Weathered and fractured basalt, granite and thick sediment deposits are the main water-bearing zone in the two districts. The existence of Gravity springs emerging at the base of the hills/mountains and contacts between volcanic and massive Meta volcanic and in the weak/fracture zones are an indicator of potential groundwater sources.

Therefore, proper physical assessment and tracing of fracture lines using a Geophysics instrument and further professional interpretation of the output data are critical to locate the high-yielding site in the area.

4.4 Local Geology of the area

The local geology of the area comprises three main rock types;

The recent sediment: - This is the upper thin layer that resulted from weathering of the underlying rock and was transported from the nearby highland. It is fine clay type and lateritic soil with depth that varies from place to place; relatively thick flat area and thin in the gentle and sloppy areas.

The basalt/meta volcanic: - This is the dominant rock type exposed in rivers and on the surface and weathered, fractured and massive basalt region. The texture is fine to gain and black at the upper weathered and next fractured or massive. The thickness is up to 30-50m but varies from place to place.

The basement: - this is the bed rock composed of granite/granodiorie or other basement complexes.

Intrusive basement complex rocks: - These are granites and granodiorites. The intrusive rocks form regional stocks and batholiths. Hence no rock can be found below these rocks as they are very large intrusive bodies. They display a different degree of weathering. Mostly they show slight weathering and are very hard rocks. In a few places, they show schistose structures indicating low-grade metamorphism.

The intrusive rocks are introduced by different quartz veins and in places small pegmatite. These quartz veins are likely to be the source of gold. Secondary gold mining is widespread.

Tertiary volcanic- it covers a wide area of Assosa-Homosha Woreda. It has very good weathering and fracturing, and source for a good aquifer.

Quaternary sediments - The quaternary deposit are alluvial sediments along streams/river courses and residual soils. Along the course of the small streams, thick clay/silt/ sand is common. The thickness varies widely depending on the morphology of the streams/river bed.

4.5 Hydrology, Geology & Hydrogeology Hydrology & morphology

The study area has an elevation that ranges from 1400m to 2100m with rug topography. The lowland area is located at eastern, western and northwestern boundaries and the highest area is in the south eastern and northeast central parts of the area and found within the Abay river basin.

The Abay drainage is the result of river incision of the Cenozoic basaltic uplifted land. The Daubs River captures much of its runoff from the highlands in the southern and central parts of the basin. The Blue Nile River is characterized by very high discharge during the wet season and very low discharge during the dry season. This reflects that the river discharge is dominated by inputs from rainfall and surface runoff rather than groundwater. Most of the main tributary streams of the Abay River begin at the plateau in the east, Northeast and southeast of the region.

They flow generally toward north-west to relatively low land area. Streams are well developed at relatively high land area and undeveloped in low land area. Many of the streams are ephemeral. Drainage density is moderate to high.

4.5.1 Hydrogeological set-up

There is a fragmented hydrogeological study conducted in the area. The only studies obtained in this study for reference are the following:

- Hydro-geological and geophysical investigation and Water Resources of the area.
- Hydrogeological map of Ethiopia (1:2,000,000) by Tesfaye Cherent.

Based on field investigations and the limited hydrogeological information obtained from the above studies attempt is made to present the hydrogeology and groundwater potential.

Tertiary Volcanic Rocks: Alkaline basalts: The major outcrops in the woreda are Alkali basalts and intrusive volcanic rocks. It is much localized with highly weathered and fractured outcrop covered with red clay soil in places. Springs and Hand-dug wells are common in front of houses. This is probably because of the presence of fractured basalts.

Intrusive Rocks: Meta-granodiorite, meta-granite and granite intrusions are observed during the field survey and observed on large area of the woreda. Intrusions and plugs with high resistance to erosion remain outstanding and develop dissected and rolling topography.

4.5.2 Hydrogeology and its Aquifer

As mentioned in the previous section, water point inventory has been carried out in most of the target areas. Springs are mostly unprotected and dug wells and boreholes with shallow depths are inventoried. The water point site description is mainly used to look at outcrops nearby and yield estimation. The springs mostly emerge at the contact of basalt and metamorphic rocks and along fractured basalt. In Some areas, low-yield springs were emerged along the fractures of basalt and following structures. The rocks and groundwater relationships and aquifer systems are defined based on the hydrogeological characteristics of hydro stratigraphic units. General descriptions of the geological and hydrogeological features of the major rocks of the area are given below.

i. Porous media aquifers (alluvial, residual, colluviums) - The groundwater is stored and transported in the pore spaces of these unconsolidated materials. Water-laid sediments along river courses, feet of mountains and hills, pockets between hills and in situ highly weathered and fractured rocks on flat topography generate this type of aquifer. This aquifer is mostly characterized by shallow groundwater and is easily dug with human power. The dug wells proposed for the implementation of the project are located in this area.

ii. Fissured Aquifers (Volcanic rock) - The volcanic aquifer in the area is only Alkali Olivin basalt overlaying the basement rocks directly.

iii) Fissured aquifers with low potential (metamorphic and intrusive rocks) - some of the target Keble's are constituted by metamorphic formations and intrusions. These hard rocks inherently have no porosity and permeability to transport and store surface water to recharge the groundwater. Hence, secondary porosity generated from fractures and

Weathering may only allow infiltrating rainwater and stored as groundwater. On the other hand, the depth of these fracturing and weathering are limited. The more depth the opening developed by the fractures will be closed up with secondary mineral fillings. Therefore, groundwater is shallow in this aquifer system and limited quantity and also quality.

iv) Aquitards (Metamorphic and intrusive rocks): where secondary porosity and permeability are not developed in these rocks, groundwater movement and storage are limited or non-existent. These rocks are mostly high-grade metamorphic rocks such as Meta - ultramafic rocks.

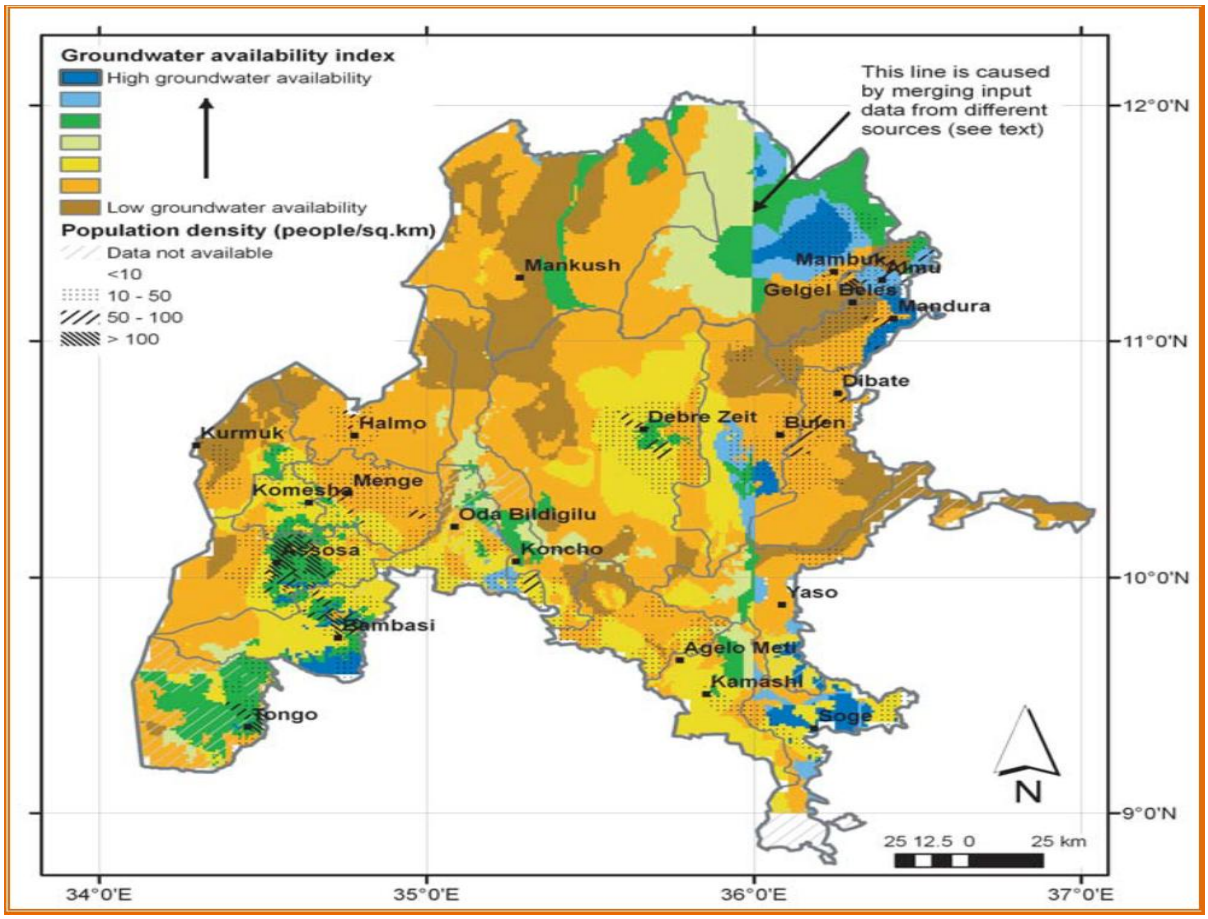


Figure 3.Ground water availability of BenishanguGumuz regional state (By Ripple Ethiopia)

There are three important geological patterns that control the nature & distribution of hydrogeological units in the geologic system. These are lithology, strati-graphy & structures of the geologic formation.

Litho-logy is the physical makeup of the sediments (rock) that make up the geologic system, for example, mineral composition, grain size & grain packing.

Stratigraphy describes the geometrical and age relationships between various formations in the geologic system. Structural features, such as fractures and faults are the geometrical properties of the geologic system produced by tectonic or during crystallization. Metamorphic rocks are aquifers due to their primary and/or secondary porosity (fractures, etc.), from where springs & some streams in this lithology are starting & flow following the fracture line. Groundwater is present in almost all landscapes. The interaction of Groundwater with surface water depends on the physiographic & climatic setting of the landscape. For some rocks, found in mountain terrain, underlying soil may be highly weathered and fractured and may transmit a significant additional amount of water flow through the subsurface. In some settings this rapid flow of water results in hillside springs. Springs are the manifestation of Groundwater which mostly appear where the local Groundwater table exposed to the surface or fracture line leads water to the surface. These springs are common in highland areas, mainly on mountain feet.

In the various formations the variation in groundwater storage, transmission and yield are the basis for the classification of aquifers. Lithology, topography, area coverage, fracture, weathering etc are considered for

the qualitative classification of the aquifers. The occurrence of groundwater depends not only on the nature of the rock but also on its geologic history. The direct groundwater recharge of the area ranges from 50 to 150mm/year Aquifers in the area of investigation are classified based on two factors: - qualitative and quantitative classifications (Bayissa Asfaw, 2003).

a) Qualitative classification

In areas where hydrogeological data are not available field observations such as distribution and magnitude of discharge of spring, degree of fracturing of rocks, grain size, rounding and sorting type and degree of cementation, depth and extent of weathering are taken into consideration.

Quantitative classification

Data of pumping test such as yield and drawdown are used for classification by calculating transmissivity and hydraulic conductivity of the area. Based on these data together with topographic setting, and recharge conditions are used to classify aquifers according to productivity. According to Bayissa. A, 2003 reports lithological units can be classified in to aquifer types based on their productivity. These are:-

- Aquifers with high productivity
- Aquifers with moderate to high productivity
- Aquifers with moderate productivity
- Aquifers with low productivity
- Aquifers with very low productivity

❖ According to Tesfaye Chernet, 1985 Lithological units found in Ethiopia are categorized under five hydrogeological types. These are:-

❖ Sediments with dominant inter-granular permeability

❖ Volcanic rocks and some sandstones-variable fracture and fissure permeability

❖ Limestone and associated rocks- variable fracture, fissure and karstic permeability

❖ Crystalline non-carbonate metamorphic and intrusive rocks-:- localized high permeability where fractured or deeply weathered

❖ Metamorphic and intrusive rocks- localized low or moderate permeability where fractured or deeply weathered Aquifers found in our study areas are categorized under two hydrogeological types. These are:-

a) Aquifers with fracture permeability productivity

According to Tesfaye chernet, 1985 volcanic rocks are categorized under extensive aquifers with fracture permeability, aquifers of low to high productivity. These units are identified as moderate productive with fracture permeability in the mapped area. They comprises of both basic and acidic volcanic rocks. (Ethiopian Hydrogeological map).Springs and existing shallow wells confirm that the area is suitable for shallow groundwater abstraction and the area can be categorized as moderate productivity aquifer.

b) Aquifers with localized permeability productivity:

- Late Proterozoic rocks
- Proterozoic and Phanerozoic rocks

According to Tesfaye chernet, 1985 this unit is categorized under localized aquifers where deeply weathered and fractured. According to Bayissa Asfaw this unit is categorized as very low productive aquifers. In the mapped area, the unit is categorized as aquifers of very low productivity. Regionally the unit is mapped as aquiclid.

4.5.3 Local Hydrogeology

The occurrence and movement of groundwater in a given area depend on geomorphology, presence of vegetation & soil cover, drainage density, geological & structural formation of the area, rainfall intensity & duration and sunshine hour & strength etc. The study area is characterized by a variable land escape, narrower flat plain following streamline at some places surrounded by relatively high lands & moderate to hilly slopes.

The study area is found in the Abay basin (from 700m-2400m a.s.l) area of the Temperate warm temperate (W/dega Kolla) climatic zone. Steep topography leads to rapid runoff and fast-flowing streams, and most of the recharge occurs in valleys in alluvium or other permeable rocks. This is the case where much runoff from the highlands contributes recharge from flood to the foot of the mountain, where the water either evaporates or infiltrates the alluvial and/or fractured and permeable rocks. Most of the area is covered by basement rocks. The hydrogeology of the study area is categorized into low-productive and moderately productive aquifers.

Most of the area of hydrogeology is characterized by a dual-permeability aquifer that the complete porous media system can be represented by two different interacting subsystems: the matrix and the fracture pore domain. For some soils like fractured clays, the fracture domain may be empty, which makes its physical behavior differ significantly from the capillary flow.

4.5.4 Ground water Recharge and Discharge

The most important recharge of the Study area is elevated areas along the water divides in the north-eastern part. Direct recharge from rainfall is the most important process in these areas. Rainfall in the lowlands is less. Recharge is likely to be from rivers/streams and preferentially through fractures during the high rainfall season. The discharge of groundwater is local. It is manifested as spring discharges. The discharge from groundwater is high. The groundwater withdrawal from shallow wells and dug wells is medium. Discharge of groundwater may locally be possible as base flows of main rivers.

Aquifer characteristics - Previous works have made comparative aquifer classification. The hydrodynamic characteristics of various geological series are classified for the whole country. Similarly, the hydrogeological study of the Assosa-Kurmuk area classified the target geological formations into four on the basis of field observation and quantitative pumping test data analysis. Transmissivity, specific capacity

and yield of aquifer parameters are used for the classification. Since the study area is very narrow, the term recharge and discharge area is here a relative term. A recharge area is a portion of the drainage basin in which the net saturated flow of groundwater is directed away from the water table and there is a component to the direction of groundwater flow near the surface that is downward, where as a discharge area is a portion of the drainage basin in which the net saturated flow of groundwater is directed toward water table and there is a component to the direction of groundwater flow near the surface that is upward.

In the recharge area, the water table usually lies at some depth whereas, in the discharge area, it is usually at or very near the surface (Freez and Cherry, 1979). Topography and geology govern groundwater flow system. Moreover, their feature on a given area significantly determines the amount of recharge to groundwater and discharge to surface water. The recharge area is usually found in topographically higher places where as discharge areas are located in a relatively lower topography.The main recharge for the study area is the elevated parts that found at the north-western part of the study area. Different streams start from recharge areas and flow down to join the main River Blue Nile by cutting the tertiary volcanic rocks. Springs are manifestations of ground water in this area.

4.5.5 Groundwater flow in the study area

The aquifer in the study area has developed nearly parallel to the main streams from west and southeast to south-east and west direction. The direction of groundwater flow is also nearly parallel to the main Baro River in west direction. A better potential area for groundwater extraction is the relatively flat part of the study area, closer to streams in highly weathered and fractured rocks. The important parameter for the consideration of the groundwater flow is spring flow direction, topography, water quality, the static water level of existing water points and the top of the aquifer boundary (top screen position). Since there is no top-of-screen data or static water level, we use the rest indicator (topography and Regional spring flow & water quality) to show groundwater flow in the area. Therefore, the topography of the area shows high elevation from the east & and decreases towards the west. Most springs is gravity springs, emerging at the foot of high lands. Detailed groundwater potential evaluation requires an integrated approach involving both conventional and up-to-date techniques. Quantification of the amount of groundwater present in a given aquifer/basin demands a detailed water balance study and defining the boundary conditions, the establishment of the lateral and vertical extent of aquifers and confining beds and the interaction of surface water and groundwater interactions. In the absence of detailed hydro meteorological and hydrogeological data on groundwater, this task is very difficult. In data scares areas the assessment tends to be more qualitative or semi-quantitative than quantitative.

The groundwater investigation of this project for the most part is depending on the systematic and previous exposures/experiences of short-term field hydrogeological investigations and surface geophysical surveying results. Both approaches provide information on the availability of groundwater semi-quantitatively. Geophysics provides some information on the accurate amount of groundwater available in

the subsurface. The amount can only be guessed from the local hydrogeological features such as recharge potential, availability of permeable rocks, catchment areas, the existence of conductive geological structures etc.

4.5.6 **Geophysical Survey and Analysis**

Exploration Geophysics is the application of the principles of physics in the study of the earth. Electrical Resistivity/conductivity traces fresh versus weathered rocks, the presence of conductive materials, and clays versus sands and gravel. Its purpose is to provide geophysical input to the solution of geological problems (specifically groundwater exploration).

The study of groundwater potential could be aided by the geophysical method that studies the resistivity (conductivity) of the subsurface formation since groundwater highly affects these physical properties of the subsurface formation. Fikadu Integrated Farming has planned to study, design and construct deep wells for water bottling purpose. Hence, based on that the water and energy resource development bureau experts have done the groundwater potential assessment and potential drilling sites with the aid of geophysical instruments for host and school communities. Groundwater, through the various dissolved salts it contains, is ironically conductive and enables electric currents to flow into the ground. Measuring the ground and subsurface resistivity, therefore, gives the possibility to identify conditions necessary for the presence or otherwise of water. The resistivity of rocks generally depends on the water content (porosity), the resistivity of the water, the clay content and the content of metallic minerals (Bernard, 2003). The following considerations help in the determination of the resistivity of rocks.

- A hard rock without pores or fractures is very resistive to the flow of electric current. This is generally observed in hard fresh Precambrian rocks.
- Dry sand without water is very resistive.
- Porous or fractured rock bearing free water has resistivity, which depends on the resistivity of the water and on the porosity of the rock. Impermeable clay layer, which is wet, has low resistivity but may not contain enough yields for successful groundwater exploitation.
- Mineral ore bodies (iron, sulphides) have very low resistivity due to their electronic conduction; usually lower or much lower than 1ohm-m (Bernard, 2003).

To identify the conditions necessary for the presence of groundwater from resistivity measurements, the absolute value of the ground resistivity must be considered. The usual target for aquifer resistivity can be between 50 ohm-m to 2000 ohm-m. (Bernard, 2003).

- In hard rock environment, which is considered very resistant to the flow of electric current, a low resistivity anomaly will be the target for groundwater.
- In a clayey or salty environment that is normally considered conductive, a comparatively high resistivity anomaly will most probably correspond to fresh water and thus will be the target in the case for groundwater exploration for domestic use.

Resistivity values of earth materials cover a wide range. The variety of resistivity has been the essential reason why the technique can be used for different applications (Loke, 2001).

In resistivity measurements, the highest resistivity is associated with igneous rocks. Sedimentary rocks tend to be most conducive due to their high fluid content. Metamorphic rocks have intermediate resistivity. Granites and quartzite have high resistivity ranges; sandstone and shale have intermediate resistivity ranges (Bernard, 2003). The resistivity therefore in a particular geological environment has an influence on the aquifer resistivity. Numerical values for various types of water are outlined.

Table 3.Resistivity rang of some rocks and sediments

NO	Rock or Sediments	Resistivity Range(ohmmeter)
	Clay	1-100
	Sand	1-1000
	Granite	$3x10^2$-10^6
	Diorite	10^4-10^5
	Quartz diorite	$2x10^4$-$1.8x10^6$
	Marble	10^2-$2.5x10^5$
	Gabbro	103-106
	Gneiss	$6.8x10^4$-$3x10^6$
	Quartzite	10-$2x10^8$

Table 4.Numerical values for various types of water (modified from Bernard, 2003)

Types of water	Resistivity(ohm-m)	Conductivity(micros/c	Salinity(mg/l)
Very fresh	200	50	35
Fresh	20	500	150
Salted	20	500	150
Sea water	0.3	30000	35000

4.5.7 **PQWT geophysical instrument**

It is based on the field source of earth's electromagnetic field and differences in conductivity of different and underground geological structures, to study the variation law of electric field components at different. PQWT Survey investigation is better to understand the subsurface hydrogeological condition in general and to determine water bearing zones so as to estimate depth to ground water potential and thickness of the aquifer. The PQWT Survey investigation was determine the variation of resistivity value with depth, the nature and thickness of the underlying formation both in horizontal and vertical direction. The figure below shows the ways of result interpretation.

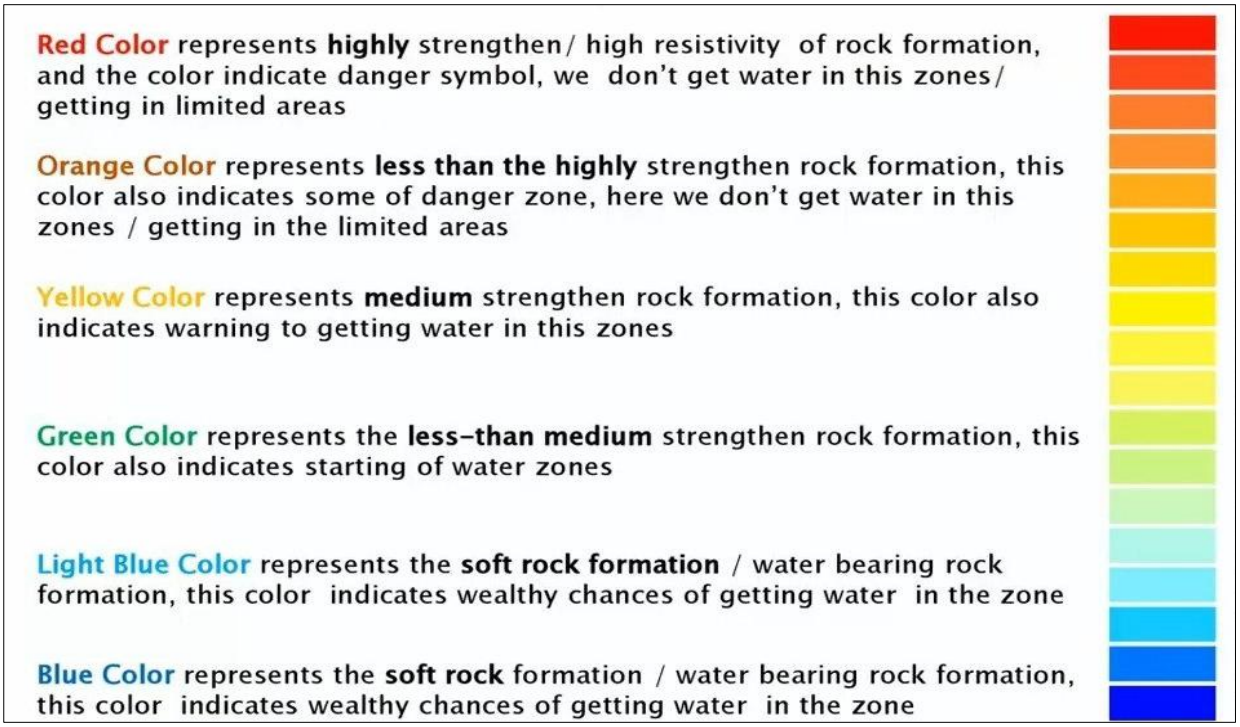


Figure 4.Standard Color descriptions for PQWT instrument results

4.5.8 **Profile image survey line**

The electrical resistivity profile conducted along Line-2 in the direction from East to West at the base point faces towards the west at 1 and the last electrode position is towards west at 19 marks. From 1m to 57m horizontal distance from the beginning is shows the potential drop value between 0.0 to 0.22 which is considered to be alluvial deposit, 0.22 to 0.44 Scoria basalt, 0.44 to 0.51 is Aphanitic basalt and finally 0.51 to 1.26 is granitic rock and from geophysical surveying result one borehole were proposed on this area at distance from the starting point 42m as shown the bellow and recommended for drilling at point 14.

Table 5 Resistivity of the material

Resistivity(ohm's)	**Description /interpretation**	**Remarks**
0.0-0.22	Alluvial deposit	
0.22-0.44	Scoria basalt	Major Aquifer zone
0.44-0.51	Apphanitic basalt	Minor aquifer zone
0.51-1.26	Granitic rock	

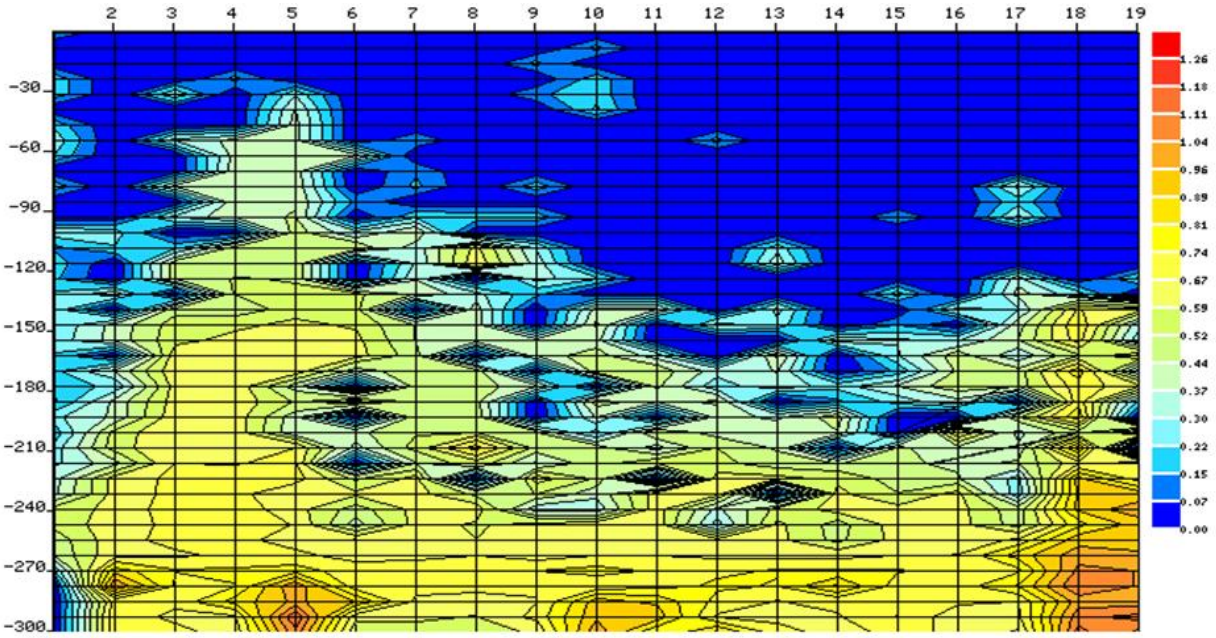


Figure 5. PQWT result of line one

4.5.9 **Profile image survey line two**

The electrical resistivity profile conducted along Line-2 in the direction from East to West at the base point faces towards the west at 1 and the last electrode position is towards west at 14 marks. The line has a length of about 42m and data points were read at 3m.

From 1m to 42m down distance from the beginning are shows the resistivity value between 0.00 to 0.31 which is considered to be alluvial deposit that are a mixture so, many lithological units and from 0.31 to 0.79 moderately fractured basalt and it could be act as aquifer position of such site and finally from 0.79 to 1.88 massive basement rocks and finally from1.88 to2.66 is very massive basement rocks. From geophysical surveying result one borehole were proposed on this area at distance from the starting point 21m as shown the figure bellow.

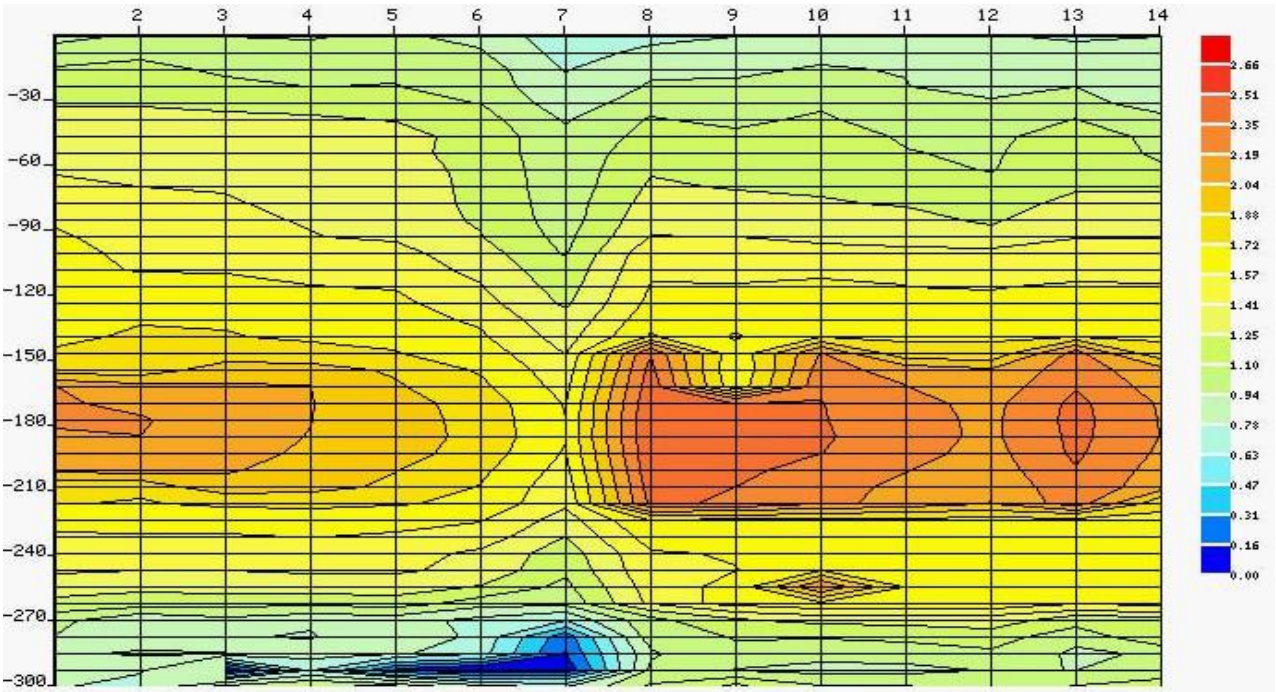


Figure 6.PQWT result of line two

4.5.10 **Proposed site for drilling**

The rationale for selecting priority areas for drilling is the promising geology and the structural condition of the area. The proposed drilling site for Fikadu Integrated Farming one site for a maximum depth of 50-60m. The proposed site from profile image survey line one at the 21m from the starting point and located within farming site in between two stream junction that emit from the mountain

Table 6.Recommended borehole drilling site

2D ID NO	X	Y	Z	Recommended Depth	Alignment	Locality
2d 1	0679436	1132298	1488	50-60	E-W	Farming sit

5 Proposed Design for Irrigation System

5.1 General

In Fikadu Nemera Integrated Farming the sources of the irrigation waters are bore hole, pond water and Natural River.

5.2 Proposed Alternative Water irrigation System Layouts

As described in, above, and it is clear that the available water sources is not sufficient for water supply and irrigation farming. However, the use of each source for the future supply of the project area has its own peculiar comparative advantage in utilizing the existing infrastructures while achieving the required hydraulically efficient scheme.

The following major activities should considered

- Supply and installation of Transmission line
- Supply and installation of Gravity and Distribution system
- Construction of 360m3 underground reservoir
- construction of Guard house @sources and proposed SR
- Supply and installation of electromechanical system
- Excavations of Ponds
- Laying of 20mm HDPE pipe

Table 7.Transmission Main Pipe

S/no	Diameter(mm)	Pipe Type PN-16	Length (m)	Remark
1	90	HDPE Pipe	1000	
	Total Length		**1,000**	

Table 8.Hydraulics analysis Transmission Main

Junction	Easting	Northing	Elevation	Pipe length L(m)	cum. Length (m)	Pipe mat.	C	Dia. (m)	A(m2)	Q (m3/s)	Major loss hL(m)	Minor Loss Hl(m)	Total head loss HL(m)	Cumm. HL(m)	V (m/s)	Velocity head(m) V^2/(2*g)
BH	1194879	3599224	1485	BP	0	0	0	0	0	0	0	0	0	0	0	0
BM2	1194879	3599224	1485	0.00	0.000	HDPE	130	0.09	0.006	0.00700	0.00	0.000	0.00	0.00	1.100	0.062
RESERVOIR	1194215	3599244	1574	670.24	670.237	HDPE	130	0.09	0.006	0.00700	11.46	1.146	12.60	12.60	1.100	0.062

5.3 Water Source

The adequacy of water source to meet the water requirement for farming land were generated from three sources. As mentioned below the total

5.3.1 **Ground Water**

The Ground Water is located 1km far from the drilled borehole that yields 12l/s.

Table 9. Location of Borehole

	East	North	Elevation	Discharge(Q)
Ground Water(BH)	679436	1132298	1488	12l/s

5.3.2 **Surface water**

The available surface water source in the area is drained or flow from the north-west to south-east direction and this surface water is estimated to 30l/s and used as water source for irrigation water using water pumping generator.

5.3.3 **Ponds**

Pond is one mechanism of water harvesting system to add additional water to feed the farming. This water harvesting is either from surface run-off or from diverting the normal flow of river to the constructed pond. Total the constructed pond were 12 in number with 20m length, 30m width and 4.5m depth with the capacity to store 2700m3 water per pond and the total volume of water stored from 12 ponds is 32,400m3 in addition to the surface water and 12l/s from groundwater. A farm pond is constructed at different site within the field and each irrigation block, water pumps lift water from the ponds into the main and secondary pipeline which conveys water to the fields.

5.4 **Transmission Main**

The transmission system's function is to transport water from source to the reservoir, if any, and to the distribution point. Water conduits for the transmission system may be canals, aqueducts or tunnels, free-flow pipelines, or pressure pipelines. The transmission of water will either be under gravity or pumping.

Normally, the sizing of the transmission main is dependent on the total storage capacity and the way the supply is transmitted to the distribution system. The main should have at least the carrying capacity to supply water at a rate equivalent to the maximum day demand of the system for a given design year.

For systems with a storage reservoir with an intermediate storage capacity (20 – 25%) of average day demand), the transmission main to the reservoir is designed at a carrying capacity rate 1.3 times the average day demand. However, for our design the safe yield of deep well-2 is (which are 12 lit /sec). As a result it is mandatory to design the transmission and rising main by considering safe yield of the well.

The Transmission main is designed to convey economically the required maximum day demand by considering a certain pumping hour. The Transmission main pipe is HDPE OD 90mm PN 16 from bore hole to proposed 360m3 service reservoirs with a total length of about 1000m.To determine the economic diameter for pressure line between bore hole and service reservoir, the following equation is adopted. To determine economic diameter of raising main D,' Lea' formula is used.

D= 0.97 to 1.22√Q (Lea formula)

Q-Pump discharge =12l/s =0.012m3/s

Taking 0.97√Q to 1.22*√Q=1.22√0.012=0.09134m=90.3mm to take 0.0116=110mm HDPE pipe

Checking the permissible velocity

V= (0.012)/ (3.14*0.09^2/4)

V=1.5 m/s OK

Table 10.Transmission line

Transmission line	**Pipe material**	**Diameter Mm**	**Length M**	**Velocity(m/s)**	**Head loss 10.66c^-1.85*D^-4.87*Q^1.85 *L**
Bore Hole to 360 m3 Reservoir	HDPE PN-16	90mm	1000	1.1	5.09

5.5 Gravity and Distribution Network

The designing of Gravity main and Distribution systems of small water supply system vary depending on the method of delivery to the consumers. For purposes of designing the pipelines, the distribution systems are considered also in terms of the topology or layout that is used.

There are two types of water distribution system to consumers these are:

A. Branched System

B. Looped System

1. Branched System

Also referred to as a Dead-end System, the size of the main line in this distribution system decreases as its distance from the source increases, in consideration that the further pipes have to carry less water. The design of a branched system is generally straight forward, where the direction of water flow in all pipes and the flow rate can be readily determined.

One of the advantages of a branched system is generally lower costs.

The disadvantages of branched system type water distribution are:-

- ✓ A main break will cause all downstream consumers to be out of service.
- ✓ It results in poor chlorine residuals and aging of water in low demand areas.
- ✓ During high demands, the velocities are faster, hence head losses are higher.

2. Looped System

A distribution network is looped when there are only few or no pipe dead-ends, such that water can move through the system freely.

The advantages of a looped system type water distribution are:-

- ✓ The lower water velocities in the main reduce head losses, resulting in greater capacity.
- ✓ Main breaks can be isolated, minimizing service interruptions to consumers.
- ✓ Usually better chlorine residual content is achieved.

The disadvantage is generally more costs because of the need for more pipes to create the loops.

Based on the above comparison of water distribution system to consumers branched system is selected due to the suitability of topology or layout of the pipe line for branched system and also due to lower costs

The distribution network is designed in such a way that it safely and economically accommodates the Peak hour demand. The layout of the distribution network has been prepared based on the existing road network. As per the design criteria, the following guidelines are maintained in the analysis of the distribution network.

♦ During Peak hour flow velocity shall be between 0.3 and 2.2 m/s.

♦ During minimum consumption water shall not be stagnant in the distribution network

Table 11 .Summaries of Pipe Diameter and Length

S/no	Diameter OD (mm)	Pipe Type PN-16	Length (m)	Remark
1	90	HDPE Pipe	1136	Gravity main
2	75	HDPE Pipe	1823	Distribution
3	63	HDPE Pipe	1804	Distribution
4	20	HDPE pipe	30,083	Drip irrigation
	Total Length		**34,846**	

The irrigation water for each block is planned to be conveyed by the main pipeline, and the following types of distribution systems. A reticulated pipeline system is adopted to satisfy the route of water conveyance in this case.This reticulated pipeline system reduces the suspension of water conveyance.

5.5.1 **Route Alignment:**

Pipe line route selection is the primary activity undertaken before conducting instrumental survey and many factors were considered among them are

- The route selected also proposed to reach all the beneficiaries expected during the design period
- Line with less probability of crossing drainages and gully also preferred
- close to road for good access during maintenance

5.5.2 **Selected Pipe Material:**

HDPE pipes with pressure resisting capacity of minimum PN16 have been selected at different segments based on topographic and geologic configuration. The fittings for joining shall be ductile cast iron, or any approved material fulfilling the pressure requirement.

Table 12.Hazen-Williams roughness coefficients adopted for this detail design work

Pipe Characteristics	C Value for new pipe
GS	120
HDPE	150
DCI	130

5.5.2.1 **Pipe Material**

The selection of pipe material will depend upon the nature of the ground in which pipes are to be laid, over burden soil pressure, surge, type of traffic load and the cost of the pipe. When a pipe is found technically suitable for particular case the economical pipe materials available for choice are:

- HDPE pipes
- DCI pipes
- GS pipes

The physical characteristics of the pipes must suit the actual service conditions in the water supply system such as pressure, external load, soil condition and the topography.

5.5.2.2 **Trench Depth**

Where the pipe is subjected to vehicular traffic the minimum cover provided shall be 1.0 m. In other areas the minimum depth of cover will be 0.8m or 0.9m depending on the selected material. If the above depths cannot be obtained, due to the natural ground profiles, the pipes will be encased in concrete.

5.5.2.3 **Pipe Backfilling and Bedding**

A typical trenching, backfilling and bedding design encompassing backfilling material type and bedding thickness is included in the tender documents.

5.6 **Pipe Fittings**

5.6.1 **Air Valves**

On the transmission mains air valves were located at all high points and wherever the rising grade reduces or the falling grade increases. The maximum spacing between air valves was 800m.

The size and rating of air valves was not compatible in this system.

5.6.2 **Washout Valves**

Washout valves were provided at all low points on both transmission and distribution mains to enable mains to be drained for maintenance and repair. On mains of diameter above 250mm the

washout valves shall be DN 100 or DN80 and for smaller diameter pipes DN 50 valves will be installed.

5.6.3 **Isolating Valves**

Isolating valves on transmission mains will be provided to allow a portion of the system to be isolated for repairs. The locations of the valves were dictated by the profile of the pipeline and were usually located adjacent to a washout. The maximum spacing between valves shall be 500m.

On distribution mains the number of isolating valves to be installed at a junction will be n-1, where n is the number of branches at the junction. Valve locations could be at interconnecting pipes, bypass pipe connections, hydrant connections, washouts and air vents. Gate valves compatible in size, type and pressure ratings to the system were used as isolating valves.

5.7 **Ancillary Fittings**

(i) Pipeline Fittings (bends, tees, etc...)

Pipeline fittings (bends, tees, etc.) were appropriate for the pipeline material and were similar in size and class to the pipeline. Dead ends were provided with a valve that can be used to flush the main.

5.7.1 **Thrust Blocks**

If the pipeline was unrestrained (i.e. spigot and socket joints are used) then concrete thrust blocks were provided to resist thrust forces at all bends, tapers, junctions or valves.

5.7.2 **Pipe Supports**

Concrete supports for pipes were provided whenever the pipe was to be laid above the ground surface and also in situations where the ground conditions are poor. Lateral transverse anchors were provided when the pipe is to be laid on a steep slope.

5.7.3 **Valve Chambers**

Concrete / Masonry valve chambers shall be provided for each valve location for protection and to provide easy access.

5.7.4 Road and River/Ditch Crossings

Whenever a pipeline crosses gravel or river/ditch crossing, ferrous pipes or structures which will protect the pipe shall be provided. For heavy traffic road crossings, concrete encasements shall be considered.

5.7.5 **Disinfection**

The raw water from the boreholes will be disinfected using calcium hypochlorite compound and a gravity system for dosing.

6 Irrigation water Requirements

6.1 Crop Water Requirement (CWR)

The calculation of crop water requirement is a very important aspect for planning of any irrigation project. Several methods and procedures are available for this. The Food and Agriculture Organization (FAO) of the United Nations has also made available several publications on this subject and other issues related with this. The computer program available in FAO Irrigation and Drainage Paper No. 56 "CROPWAT" has been used for the calculation of Crop Water requirement. This program is based on Penman-Monteith approach and procedures for calculation of crop water requirements and irrigation requirements are mainly based on methodologies presented in FAO Irrigation and Drainage Paper No. 24 "Crop Water Requirements" and No. 33 "Yield Response to Water". The corresponding values of the crop water requirements of the proposed crops of the project are presented in the Agronomy Study of the same project.

The input data required for calculation of CWR, IWR, and irrigation scheduling three types of data is required to use the CROPWAT software, namely climate data, soil data, and crop data. Climate data include maximum temperature, minimum temperature, relative humidity, wind speed, and sunshine hours. Table 1 shows the minimum and maximum temperatures in the study area.

Table 13Minimum and maximum temperatures in the study area

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Minimum temperature (°C)												
Avg.	14.5	15.7	17.0	17.2	16.7	15.5	15.1	14.9	14.8	14.9	14.4	14.6
Maximum temperature (°C)												
Avg.	29.9	31.5	31.8	31.5	28.0	25.5	23.9	23.9	25.6	25.8	27.4	29.3

6.1.1 Air humidity, sunshine hours, wind speed, and precipitation

As table 14 describes the air humidity, sunshine hours, wind speed, and precipitation in the study area. The study area is generally not characterized by high humidity. The maximum average humidity is 82% and the minimum average humidity is 47%. The precipitation pattern over the study area shows maximum precipitation during the summer period, June to September, with low average precipitation of 21–32 mm.

Table 14. Air humidity and sunshine

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Humidity (%)	48	47	48	50	74	82	83	84	78	73	66	56
Wind speed(m/s)	1.7	1.7	1.4	1.7	1.7	1.4	1.4	1.4	1.4	1.4	1.4	1.7
Sunshine(hours)	8.7	8.1	6.0	8.3	6.0	4.9	4.5	3.0	6.1	7.0	7.4	7.9

Precipitation (mm)												
Precipitation (mm)	0.0	0.0	31.0	32.0	118.0	189.0	207.0	208.0	207.0	103.0	21.0	0.0

6.1.2 **Fruit, Vegetable and soil data**

The main fruits and vegetables grown in the study area are Avocado, Lemon, Valencia and red orange, Papaya, bananas, tomato and onion, etc. However, the soil characteristics used in this study are the black clay soil characteristics.

6.1.3 **Reference evapotranspiration and effective rainfall**

The reference evapotranspiration is the rate of evapotranspiration (*ET*) from a hypothetical crop with a height, albedo, and fixed canopy resistance, respectively. Whereas the fraction of rainfall that is stored in the soil profile and helps in the growth of crops is effective rainfall (P_{eff}).

6.1.4 **The CWR, effective rainfall, and IWR**

The total CWR, effective rainfall, and IWR for different crops in various agro-ecological zones, obtained after the application of respective data of the study area in the CROPWAT model, the CWR are described in Tables 15–23. The CWR, effective rainfall, and IWR for studied crops such as wheat, cotton, and banana, for the entire crop season are summarized in Table 23.

The total CWR for the entire growing season for Lemon, papaya, Red orange, and Valencia orange, Avocado, Banana, Tomato, and onion were found to be 966.8, 446.5, 787.80, 692.2,1,027, 981.90,608.3 and 433.50 mm/dec, respectively. However, the IWR for Lemon, papaya, Red orange, and Valencia orange, Avocado, Banana, Tomato, and onion for the entire growing season was found to be 615.50,388.20,449.30,390.40,521.30,510.0,447.70,407.20, mm/dec.

The amount of water needed by each crop as the depth to meet the water loss through evapotranspiration can be referred as CWR. The Crop water requirement (ETc) is calculated by multiplying reference crop evapotranspiration (ETo) values with the Crop coefficients (Kc). The Kc values for wheat, maize, and barley at the different growth stages (initial, development, mid, and late stage) are obtained from the FAO-56 crop manual. The crop water requirement (CWR) was determined using the CROPWAT program based on the FAO Penman-Monteith method.

$$ETc=ETo\times Kc \quad (4)$$

Where ETc is crop evapotranspiration in mm, Kc is crop factor in fraction and ETo is reference crop evapotranspiration in mm per month.

The amount of water corresponding to the loss of water from a cultivated field due to evapotranspiration is called the CWR. It is expressed by the rate of ETC in mm/day. The IWR is the

depth of water required to meet crop water needs in excess of effective rainfall when a disease-free crop is grown in large fields under nonrestrictive soil and soil water conditions with adequate fertility (Allen et al. 2006). The IWR (Irr.Req) is higher than CWR when agriculture is completely dependent on irrigation. However, when agriculture is completely dependent on irrigation and rainfall, the IWR is slightly lower than the CWR because the excess water is provided by rainfall. It can be calculated by Equation (1).

$$\text{IWR} = \text{CWR} — P_{\text{eff}} + \text{Contribution of Groundwater} \quad (1)$$

Therefore, the crop water requirement was calculated using the computer application CROPWAT to calculate crop water requirement. CROPWAT 8.0 for Windows is a computer program for calculating crop water requirements, and irrigation requirements based on soil, climate, and crop data. In addition, the program allows the development of irrigation for different farming conditions and the calculation of water demand for different cropping patterns. CROPWAT can also be used to evaluate farmers' irrigation practices and estimate crop performance under both rain fed and irrigated conditions and CWR were calculated for each crop as stated below.

Table 15. Crop water Requirement for Lemon

Month	Decade	Stage	Kc coeff	CWR mm/day	CWR mm/dec	Eff rain mm/dec	IWR. mm/dec
Jan	3	Init	0.69	3.3	6.6	0	29.7
Feb	1	Init	0.7	3.41	34.1	0	34.1
Feb	2	Init	0.7	3.5	35	0	35
Feb	3	Init	0.7	3.42	27.4	0.1	27.3
Mar	1	Init	0.7	3.3	33	2.1	30.8
Mar	2	Init	0.7	3.2	32	3.2	28.8
Mar	3	Deve	0.7	3.41	37.5	3.2	34.3
Apr	1	Deve	0.69	3.69	36.9	1.1	35.8
Apr	2	Deve	0.68	3.84	38.4	0.2	38.2
Apr	3	Deve	0.67	3.43	34.3	8	26.3
May	1	Deve	0.65	2.99	29.9	16.8	13.1
May	2	Deve	0.64	2.65	26.5	23.6	2.9
May	3	Deve	0.63	2.43	26.8	29.9	0
Jun	1	Deve	0.61	2.22	22.2	37.4	0
Jun	2	Deve	0.6	2.03	20.3	44.4	0
Jun	3	Mid	0.59	1.94	19.4	45.3	0
Jul	1	Mid	0.58	1.89	18.9	46	0
Jul	2	Mid	0.58	1.84	18.4	47.8	0
Jul	3	Mid	0.58	1.78	19.6	47.7	0
Aug	1	Mid	0.58	1.68	16.8	47.4	0
Aug	2	Mid	0.58	1.6	16	47.5	0
Aug	3	Mid	0.58	1.78	19.6	47.4	0
Sep	1	Mid	0.58	1.98	19.8	49.9	0
Sep	2	Mid	0.58	2.14	21.4	51.1	0
Sep	3	Mid	0.58	2.17	21.7	40.6	0

Oct	1	Mid	0.58	2.19	21.9	27.9	0
Oct	2	Mid	0.58	2.21	22.1	18.2	3.9
Oct	3	Late	0.63	2.41	26.5	12.4	14.1
Nov	1	Late	0.69	2.64	26.4	2.7	23.7
Nov	2	Late	0.69	2.64	26.4	0	26.4
Nov	3	Late	0.69	2.74	27.4	0	27.4
Dec	1	Late	0.69	2.83	28.3	0.1	28.2
Dec	2	Late	0.69	2.92	29.2	0	29.2
Dec	3	Late	0.69	3.02	33.2	0	33.2
Jan	1	Late	0.69	3.12	31.2	0	31.2
Jan	2	Late	0.69	3.22	32.2	0	32.2
Jan	3	Late	0.69	3.3	29.7	0	29.7
		Total			966.8	702.1	615.5

Table 16.Crop water Requirement for Papaya

Month	Decade	Stage	Kc coeff	CWR mm/day	CWR mm/dec	Eff rain mm/dec	IWR mm/dec
Jan	3	Init	0.4	1.9	3.8	0	3.8
Feb	1	Init	0.4	1.95	19.5	0	19.5
Feb	2	Deve	0.41	2.04	20.4	0	20.4
Feb	3	Deve	0.56	2.75	22	0.1	21.9
Mar	1	Deve	0.79	3.7	37	2.1	34.9
Mar	2	Deve	1.04	4.73	47.3	3.2	44.1
Mar	3	Mid	1.15	5.58	61.4	3.2	58.2
Apr	1	Mid	1.15	6.11	61.1	1.1	60
Apr	2	Late	1.11	6.3	63	0.2	62.8
Apr	3	Late	0.96	4.97	49.7	8	41.7
May	1	Late	0.8	3.69	36.9	16.8	20.1
May	2	Late	0.65	2.71	24.4	21.3	0.8
		Total			**446.5**	**55.9**	**388.2**

Table 17. Crop water Requirement for Red orange

Month	Decade	Stage	Kc coeff	CWR mm/day	CWR mm/dec	Eff rain mm/dec	IWR mm/dec
Jan	3	Init	0.49	2.35	4.7	0	21.1
Feb	1	Init	0.3	1.46	14.6	0	14.6
Feb	2	Init	0.3	1.5	15	0	15
Feb	3	Init	0.3	1.47	11.7	0.1	11.6
Mar	1	Init	0.3	1.41	14.1	2.1	12
Mar	2	Init	0.3	1.37	13.7	3.2	10.5
Mar	3	Init	0.3	1.46	16.1	3.2	12.9
Apr	1	Init	0.3	1.6	16	1.1	14.9
Apr	2	Init	0.3	1.7	17	0.2	16.8
Apr	3	Init	0.3	1.55	15.5	8	7.5
May	1	Init	0.3	1.37	13.7	16.8	0
May	2	Init	0.3	1.24	12.4	23.6	0
May	3	Init	0.3	1.17	12.8	29.9	0
Jun	1	Init	0.3	1.09	10.9	37.4	0
Jun	2	Init	0.3	1.01	10.1	44.4	0
Jun	3	Deve	0.3	1	10	45.3	0
Jul	1	Deve	0.38	1.22	12.2	46	0
Jul	2	Deve	0.48	1.53	15.3	47.8	0
Jul	3	Deve	0.59	1.81	19.9	47.7	0
Aug	1	Deve	0.7	2.02	20.2	47.4	0
Aug	2	Mid	0.8	2.19	21.9	47.5	0
Aug	3	Mid	0.82	2.51	27.6	47.4	0
Sep	1	Mid	0.82	2.79	27.9	49.9	0
Sep	2	Mid	0.82	3.02	30.2	51.1	0
Sep	3	Mid	0.82	3.05	30.5	40.6	0
Oct	1	Mid	0.82	3.08	30.8	27.9	2.9
Oct	2	Mid	0.82	3.12	31.2	18.2	12.9
Oct	3	Mid	0.82	3.12	34.3	12.4	21.9
Nov	1	Mid	0.82	3.12	31.2	2.7	28.5
Nov	2	Mid	0.82	3.12	31.2	0	31.2
Nov	3	Mid	0.82	3.23	32.3	0	32.3
Dec	1	Mid	0.82	3.34	33.4	0.1	33.3
Dec	2	Mid	0.82	3.45	34.5	0	34.5
Dec	3	Late	0.77	3.33	36.7	0	36.7
Jan	1	Late	0.67	3.01	30.1	0	30.1
Jan	2	Late	0.58	2.69	26.9	0	26.9
Jan	3	Late	0.49	2.35	21.1	0	21.1
		Total			**787.8**	**702.1**	**449.3**

Table 18. Crop water Requirement for Valencia orange

Month	Decade	Stage	Kc coeff	CWR mm/day	CWR mm/dec	Eff rain mm/dec	IWR mm/dec
Jan	3	Init	0.48	2.28	4.6	0	20.5
Feb	1	Init	0.3	1.46	14.6	0	14.6
Feb	2	Init	0.3	1.5	15	0	15
Feb	3	Init	0.3	1.47	11.7	0.1	11.6
Mar	1	Init	0.3	1.41	14.1	2.1	12
Mar	2	Init	0.3	1.37	13.7	3.2	10.5
Mar	3	Init	0.3	1.46	16.1	3.2	12.9
Apr	1	Init	0.3	1.6	16	1.1	14.9
Apr	2	Init	0.3	1.7	17	0.2	16.8
Apr	3	Init	0.3	1.55	15.5	8	7.5
May	1	Init	0.3	1.37	13.7	16.8	0
May	2	Init	0.3	1.24	12.4	23.6	0
May	3	Init	0.3	1.17	12.8	29.9	0
Jun	1	Init	0.3	1.09	10.9	37.4	0
Jun	2	Init	0.3	1.01	10.1	44.4	0
Jun	3	Deve	0.3	1	10	45.3	0
Jul	1	Deve	0.36	1.15	11.5	46	0
Jul	2	Deve	0.43	1.36	13.6	47.8	0
Jul	3	Deve	0.51	1.55	17	47.7	0
Aug	1	Deve	0.58	1.68	16.8	47.4	0
Aug	2	Mid	0.65	1.79	17.9	47.5	0
Aug	3	Mid	0.67	2.04	22.5	47.4	0
Sep	1	Mid	0.67	2.27	22.7	49.9	0
Sep	2	Mid	0.67	2.46	24.6	51.1	0
Sep	3	Mid	0.67	2.49	24.9	40.6	0
Oct	1	Mid	0.67	2.51	25.1	27.9	0
Oct	2	Mid	0.67	2.54	25.4	18.2	7.2
Oct	3	Mid	0.67	2.54	28	12.4	15.5
Nov	1	Mid	0.67	2.54	25.4	2.7	22.7
Nov	2	Mid	0.67	2.54	25.4	0	25.4
Nov	3	Mid	0.67	2.63	26.3	0	26.3
Dec	1	Mid	0.67	2.72	27.2	0.1	27.1
Dec	2	Mid	0.67	2.81	28.1	0	28.1
Dec	3	Late	0.64	2.77	30.5	0	30.5
Jan	1	Late	0.58	2.61	26.1	0	26.1
Jan	2	Late	0.53	2.45	24.5	0	24.5
Jan	3	Late	0.48	2.28	20.5	0	20.5
		Total			**692.5**	**702.1**	**390.4**

Table 19. Crop water Requirement for avocado

Month	Decade	Stage	Kc coeff	CWR mm/day	CWR mm/dec	Eff rain mm/dec	IWR mm/dec
Jan	3	Init	1	4.76	9.5	0	9.5
Feb	1	Init	1	4.88	48.8	0	48.8
Feb	2	Init	1	4.99	49.9	0	49.9
Feb	3	Init	1	4.89	39.1	0.1	39
Mar	1	Init	1	4.71	47.1	2.1	45
Mar	2	Init	1	4.57	45.7	3.2	42.5
Mar	3	Deve	1	4.87	53.5	3.2	50.4
Apr	1	Deve	1.01	5.4	54	1.1	52.9
Apr	2	Deve	1.03	5.85	58.5	0.2	58.3
Apr	3	Deve	1.06	5.44	54.4	8	46.4
May	1	Deve	1.08	4.93	49.3	16.8	32.5
May	2	Deve	1.1	4.54	45.4	23.6	21.8
May	3	Mid	1.12	4.35	47.8	29.9	18
Jun	1	Mid	1.12	4.09	40.9	37.4	3.5
Jun	2	Mid	1.12	3.8	38	44.4	0
Jun	3	Mid	1.12	3.72	37.2	45.3	0
Jul	1	Mid	1.12	3.64	36.4	46	0
Jul	2	Mid	1.12	3.56	35.6	47.8	0
Jul	3	Mid	1.12	3.44	37.8	47.7	0
Aug	1	Mid	1.12	3.24	32.4	47.4	0
Aug	2	Late	1.12	3.06	30.6	47.5	0
Aug	3	Late	1.1	3.35	36.9	47.4	0
Sep	1	Late	1.08	3.66	36.6	49.9	0
Sep	2	Late	1.06	3.89	38.9	51.1	0
Sep	3	Late	1.04	3.87	23.2	24.3	2.9
		Total			**1027.6**	**624.5**	**521.3**

Table 20. Crop water Requirement for banana

Month	Decade	Stage	Kc coeff	CWR mm/day	CWR mm/dec	Eff rain mm/dec	IWR mm/dec
Jan	3	Init	0.5	2.38	4.8	0	4.8
Feb	1	Init	0.5	2.44	24.4	0	24.4
Feb	2	Init	0.5	2.5	25	0	25
Feb	3	Init	0.5	2.44	19.5	0.1	19.4
Mar	1	Init	0.5	2.36	23.6	2.1	21.4
Mar	2	Init	0.5	2.28	22.8	3.2	19.6
Mar	3	Init	0.5	2.43	26.8	3.2	23.6
Apr	1	Init	0.5	2.66	26.6	1.1	25.5
Apr	2	Init	0.5	2.83	28.3	0.2	28.1
Apr	3	Deve	0.5	2.58	25.8	8	17.8
May	1	Deve	0.52	2.39	23.9	16.8	7.2
May	2	Deve	0.56	2.31	23.1	23.6	0

May	3	Deve	0.59	2.3	25.4	29.9	0
Jun	1	Deve	0.63	2.29	22.9	37.4	0
Jun	2	Deve	0.66	2.24	22.4	44.4	0
Jun	3	Deve	0.7	2.31	23.1	45.3	0
Jul	1	Deve	0.73	2.37	23.7	46	0
Jul	2	Deve	0.77	2.42	24.2	47.8	0
Jul	3	Deve	0.8	2.45	27	47.7	0
Aug	1	Deve	0.84	2.41	24.1	47.4	0
Aug	2	Deve	0.87	2.39	23.9	47.5	0
Aug	3	Deve	0.91	2.77	30.5	47.4	0
Sep	1	Deve	0.94	3.21	32.1	49.9	0
Sep	2	Deve	0.98	3.6	36	51.1	0
Sep	3	Deve	1.01	3.76	37.6	40.6	0
Oct	1	Deve	1.05	3.93	39.3	27.9	11.5
Oct	2	Mid	1.07	4.05	40.5	18.2	22.3
Oct	3	Mid	1.07	4.05	44.6	12.4	32.1
Nov	1	Mid	1.07	4.05	40.5	2.7	37.8
Nov	2	Mid	1.07	4.05	40.5	0	40.5
Nov	3	Late	1.06	4.18	41.8	0	41.8
Dec	1	Late	1.04	4.25	42.5	0.1	42.3
Dec	2	Late	1.02	4.3	43	0	43
Dec	3	Late	1	4.37	21.9	0	21.9
		Total			**981.9**	**702.1**	**510**

Table 21. Crop water Requirement for tomato

Month	Decade	Stage	Kc coeff	CWR mm/day	CWR mm/dec	Eff rain mm/dec	IWR mm/dec
Jan	3	Init	0.6	2.85	5.7	0	5.7
Feb	1	Init	0.6	2.93	29.3	0	29.3
Feb	2	Init	0.6	3	30	0	30
Feb	3	Init	0.6	2.93	23.5	0.1	23.3
Mar	1	Deve	0.67	3.17	31.7	2.1	29.6
Mar	2	Deve	0.81	3.69	36.9	3.2	33.7
Mar	3	Deve	0.95	4.62	50.8	3.2	47.7
Apr	1	Mid	1.09	5.81	58.1	1.1	57
Apr	2	Mid	1.14	6.44	64.4	0.2	64.2
Apr	3	Mid	1.14	5.87	58.7	8	50.7
May	1	Mid	1.14	5.22	52.2	16.8	35.4
May	2	Mid	1.14	4.72	47.2	23.6	23.6
May	3	Late	1.11	4.31	47.4	29.9	17.5
Jun	1	Late	0.98	3.57	35.7	37.4	0
Jun	2	Late	0.86	2.9	29	44.4	0
Jun	3	Late	0.78	2.57	7.7	13.6	0
		Total			**608.3**	**183.6**	**447.7**

Table 22. Crop water Requirement for onion

Month	Decade	Stage	Kc coeff	CWR mm/day	CWR mm/dec	Eff rain mm/dec	IWR mm/dec
Jan	3	Init	0.7	3.33	6.7	0	6.7
Feb	1	Init	0.7	3.41	34.1	0	34.1
Feb	2	Deve	0.7	3.51	35.1	0	35.1
Feb	3	Deve	0.78	3.79	30.3	0.1	30.2
Mar	1	Deve	0.88	4.14	41.4	2.1	39.3
Mar	2	Deve	1	4.55	45.5	3.2	42.3
Mar	3	Mid	1.05	5.1	56.1	3.2	52.9
Apr	1	Mid	1.05	5.58	55.8	1.1	54.7
Apr	2	Late	1.05	5.93	59.3	0.2	59
Apr	3	Late	1	5.17	51.7	8	43.7
May	1	Late	0.96	4.38	17.5	6.7	9.1
		Total			**433.5**	**24.6**	**407.2**

Table 23. Summary of CWR, contribution of rainfall, and IWR for all crops

S. No.	Crop	CWR (mm/dec)	Eff rain(mm/dec)	IWR (mm/dec)
1	Lemon	966.8	702.1	615.5
2	papaya	446.50	55.9	388.20
3	Red orange	787.80	708.1	449.30
4	Valencia orange	692.20	702.1	390.40
5	Avocado	1,027.00	624.5	521.30
6	Banana	981.90	702.1	510.00
7	Tomato	608.30	183.6	447.70
8	Onion	433.50	24.6	407.20

6.1.5 **Irrigation efficiency (Ep)**

To complete the evaluation of the demand, the efficiency of the water distribution system and of application must be known. The gross requirement of water for irrigation system is very much dependent on the overall efficiency of the irrigation system, which in turn is dependent on several factors: Method of irrigation, type of conveyance (Lined and/or Unlined piping line), method of operations (Continuous or Rotational water supply), and availability of structures (for controlling and distribution and measuring and monitoring).

On the basis of these factors, it is planned to impose surface irrigation method (using furrows) and Drip irrigation system. The irrigation system is considering of operation, maintenance and management consideration. Hence, the conveyance efficiency has been estimated to be 95%, distribution efficiency 80%, and field application efficiency 60%. As a result of these the overall irrigation efficiency has been estimated to be 45%. According to the soil lab result, soils of the command area are predominantly characterized as black clayey soils.

6.1.6 Land use norms and standards

According to the norms and stands of the various aspects related to land development, including irrigation, building construction sites, and land utilization for farming. Here are some of the common norms and standards the farm under study will follow;

Regulatory Compliance

- **Local, National, and International Laws**: the promoter will adherence to zoning regulations, environmental laws, and building codes.
- **Land Use Policies**: the promoter will follow the government guidelines for land access and utilization at the region

- **Environmental Standards**

  - **Impact Assessments**: the promoter has conducted Environmental Impact Assessments (EIA) to evaluate potential negative effects on the ecosystem in which this will be submitted
  - **Sustainability Practices**: the promoter will implement practices that promote sustainable land use, such as water conservation, soil management, and crop rotation techniques.
  - **Biodiversity Protection**: as the farm type is fruit and vegetables it ensures that development activities do not affect local wildlife and plant species

- **Social Standards**

  - **Community Engagement**: the promoter plans to involve local communities in the planning and development process to use local knowledge in addition of hiring both as temporary and permanent employees

- **Resettlement Guidelines**: there is no communities that are affected by land development projects and there is no compensating and relocating individuals or communities
- **Technical Standards**

  - **Construction Standards**: the promoter with the hired contractors will define the specifications for building materials, structural integrity, and safety measures during construction
  - **Irrigation Systems**: the promoter will establish protocols for the design and implementation of irrigation systems, including drip irrigation for 135 hectares of the land (54%) will be used as well as furrow irrigation for 90 hectares of land (36%)

- **Soil and Water Conservation**: the promoter will prepare guidelines for maintaining soil fertility and preventing erosion as well as use the government guidelines

➢ **Operational Guidelines**

- **Project Management Principles**: the promoter will prepare an outline and methods for project planning, monitoring, and evaluation throughout the development process in addition that it prepares the implementation schedules as attached as annex
- **Financial Management**: put standards for budgeting, funding allocations, and financial reporting to ensure accountability and transparency hence the permanent staff from finance will undertake it

➢ **Health and Safety Standards**

- **Occupational Health and Safety**: the promoter will ensure compliance with safety standards for workers involved in construction and agricultural operations
- **Emergency Preparedness**: will plans for managing emergencies (e.g., floods, landslides) that may arise during development operations.

➢ **Quality Assurance**

- **Quality Control Measures**: ll prepares specifications for conducting routine inspections and assessments of construction work and agricultural practice to ensure compliance with set standards.
- **Performance Indicators**: will establishing measurable indicators to assess the success and sustainability of land development initiatives with its productivity

➢ **Training and Capacity Building**

- **Skill Development Programs**: the project will provide training for workers and stakeholders about best practices in land development and management.
- **Knowledge Sharing**: after creating platforms for sharing experience for nearby farmers and regional level research centers, innovations, and experiences related to land utilization.

➢ **Technological Integration**

- **Adoption of Smart Agriculture Practices**: the project will encourage the use of technology in agriculture, such as precision farming techniques, for enhanced productivity.

These standards and norms will help in promoting efficient land use and minimizing negative impacts on the environment and it is also understandable as it ensure economically viable and socially inclusive hence it is an irrigation farm.

6.2 Irrigation methods

The methods of irrigation Fikadu Nemera waqo farming is proposed both furrow and drip irrigation systems. Total command area is 225ha from this 135ha of the land is used by drip irrigation and the remaining of the 90ha of the land is by using surface irrigation (furrow irrigation) is used.

However, each method has its own advantages and disadvantages. Care should be taken when choosing the method which is best suited to the local circumstances, i.e., depending on slopes, soil types, selected crop types, amount of water available, etc. of the command area.

The method allows applying light irrigation and can be laid out in sloping fields along the contour. Furrow irrigation method is best suited for most of the proposed and row planted crops. In general, furrow irrigation method is simple, manageable and widely practiced irrigation method. This method is suitable for row crops that cannot stand in water for long periods. The only thing required to use this method is row planting of crops. Therefore, the Fikadu Namera Waqo farming exercise two irrigation methodology on 225ha and among this total farming land 90 ha developed by surface irrigation and 135 ha of farm land were plan to exercise drip irrigation system.

6.2.1 **Surface irrigation**

This is the oldest method of irrigation that has been in existence since irrigation was discovered. It was first used in Mesopotamia and involves application of water by gravity across the soil surface by flooding or small channels such as basins, boarders, paddies, furrows, rills and corrugation. The scheme layout up to field level, such as canals and drains, can be similar for each system According to FAO (1989), 95% of the irrigated area in the world is under surface irrigation. Some of the major advantages of surface irrigation systems over other systems are that they are easy to operate and maintain with skilled labor, they are not affected by windy conditions and, with the exception of furrow irrigation, they are good for the leaching of the salts from the root zone. Generally, they are associated with low energy costs and the total area irrigated by surface is 90 ha which is 40% of the total of 225ha farming land and currently from 90ha of land exercise surface irrigation the existing irrigated land were 11.59% and the new area that will be irrigated are 28.4%.

6.2.2 **Drip irrigation system**

In the last two centuries (1800-2000), irrigated area in the world has increased from 8 million to about 260 million hectares for producing required food for the ever growing population (Megh, 2014). Water scarcity seems to be a threat to global food production thus necessitating use of water efficiently while at the same time aiming to improve productivity of land. This necessitates

introduction of drip system. Drip irrigation is also being used in the green houses especially for high valued crops. The total area irrigated by Drip irrigation system is 135ha which covers 60% of the total of 225ha farming land and the existing farm land irrigated by drip irrigation system were 5% from 135ha of the farm land and the new area that expected to irrigated by drip irrigation system will be 55% of 135 ha irrigated by drip system and the cost of pipe and fitting of new area (55%) developed by drip system will be covered by Fikadu Nemera Waqo.

6.2.3 Irrigation and drainage system layout

The irrigation system layout for the project is prepared taking the following points into consideration besides other factors.

- A primary concern in the layout of the system is that it serves the purpose of conveying and distributing water to the command area.
- The excavation and earth fill volumes not be excessive, otherwise the construction costs can be tremendous.
- To facilitate operation services within the irrigated command area.

The proposed irrigation system layout comprises One Main gravity pipe line, Distribution system, conveyed to dispose excess run of within the command area as shown on the layout system drawings. The main gravity pipe runs for most of its length parallel to the contours and several changes of direction are necessary to follow the topography.

6.2.4 Conveyance System

The irrigation water will be obtained from Groundwater, stored water to the Pond from river by laying the pipeline and conveying the water through fields and finally irrigation takes place mostly in furrows and drip. The conveyance system consists of Main gravity line to irrigate total net command area of 225 ha.

7 Electromechanical System Design

The electro- mechanical equipment (pumps, mechanical and electrical control fittings, generating sets and electrical motors) shall be selected according to pipeline profile designed, proposed flow quantity, site condition, borehole diameter, reservoir elevation, suction height, static head, maximum temperature , pipe length diameter and pipe material.

The pump control will be partially automated

The following parameter are generally used in electro mechanical system design

1. Planed Data	**BH**	
Actual Head (H_a)		
Elevation of well head	1485	m.a.s.l.
Service Reservoir OGL Elevation	1575	m.a.s.l.

Reservoir inlet level above the OGL	3	M
Design discharge water level	1578	m.a.s.l.
SWL, mtrs water level	0	M
Draw dawn, mtrs	25	M
dynamic water level	1460	m.a.s.l.
Geodetic head	118	M
Flow rate of pump	7	l/s
Pump Position	40	M
Transmission main pipe length	100	M
RAIZERT pipe length	55	M

7.1 Riser Pipe Selection

For the design of borehole riser and wellhead piping as well as Transmission main piping, flow velocity limits Assuming the flow velocity inside the riser pipe to be limited to maximum of 2.0 m/s, the Transmission main piping side pipe to be limited to B/N of 0.6-1.9 m/s size is determined applying the following equation: in the design criteria section were adopted. The following formula is used for calculating pipe sizes.

$$V = 1.274*Q / D^2$$

Where, V = velocity of water in pipe in m/sec

Q = station design discharge in m^3/Sec

D = diameter of selected pipe in meter

By substituting the known values in the above equation, the Rizer pipe diameter is selected to be

Pipe Segments	**Discharge**		**Design Velocity [m/s]**	**Calculated Diameter D[mm]**	**Standard Diameter D[mm] ID**	**Pipe Segment Velocity[m/s]**	**Standard Diameter D[mm] OD**
	[l/s]	**[m^3/s]**					
BH							
GS Pipe Rizer	7	0.007	2	56.43	65	1.51	
Transmission main	7	0.007	1	79.81	65	1.51	110.00

Data of feed pipeline

	HDPE			
Transmission main	OD=		110.00	Mm
Raizer pipe	GS	DN=	65	Mm

1. *Head Losses*

A. *Transmission main*pipe work head losses (h_{l1})

Transmission main pipe length 700 m (hl11)

$h_{l11} = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$(Hazen-Williams formula)

$h_{l11} = 10.666 \times 150^{-1.85} \times 0.010^{-4.87} \times D^{1.85} \times L$(Hazen-Williams formula)

23.53m

B. *RIZER PIPE* head losses (h_{l1})

Data of feed pipeline

Raizer pipe		ss	DN=	65 Mm
Raizer pipe		GI	DN=	0.065 M
	V:			
Velocity for DN				1.51 MM

1. *Head Losses*

$h_{l11} = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$(Hazen-Williams formula)

$h_{l11} = 10.666 \times 120^{-1.85} \times 0.010^{-4.87} \times D^{1.85} \times L$(Hazen-Williams formula)

2.79m

Description	*Unit*	*Qty*	*Type*	*Discharge [m^3/s]*	*Diameter [m]*	*Velocity [m/s]*	*Roughness*	*Friction Coefficient*	*Formula*	*Dynamic Loss [m]*
90^0 bends	*PCs*	*3*	*GS*	*0.005*	*0.065*	*1.51*		*0.35*	*$K*v^2/2g$*	*0.12*
Check valve	*PCs*	*1*	*GS*	*0.005*	*0.065*	*1.51*		*1.9*	*$K*v^2/2g$*	*0.22*
Flow meter	*PCs*	*1*	*GS*	*0.005*	*0.065*	*1.51*		*0.016 bar*		*0.16*
Gate valve	*PCs*	*1*	*GS*	*0.005*	*0.065*	*1.51*		*0.4*	*$K*v^2/2g$*	*0.05*
Riser pipe	*mts*	*55*	*GS*	*0.005*	*0.065*	*1.51*	*120*	*H. William*		*2.79*
Collector pipe	*mts*	*700*	*HDPE*	*0.008*	*65*	*1.51*	*150*	*H. William*		*23.53*
90^0 bends	*PCs*	*10*	*GS*	*0.008*	*0.1*	*2.5*		*1.5*	*$K*v^2/2g$*	*4.78*
Total Dynamic Loss										**31.65**

A) Duty Point Calculation for Submersible Pump

The total pumping head is calculated from: HT = HS + HD

Where H_T : total head

H_S : static head

H_D : dynamic head loss

Substituting the known values in the above equation:

The total pump head, H_T =	118	+	31.65	=	149.65

HT **149.65** m

Therefore, the pump duty point is selected to be 145m considering allowance of 3.29m for losses not considered (Transmission main fittings loss)

HT **150.00** m 18

Duty Point: 23.58 m3/h at 145 m

B) Pumping Unit Summary			
No of Pump :	1	Submersible Pump	
Capacity	5	LIT/SEC	
Head	150.0	m	
Medium to be pumped	Ground water;		
Pump speed	2900	rpm	
pump efficiency %	70%		
A) ***Determination of pump Power***			
Required Minimum Pump Power			
Taking the above calculated duty point of pump where: -			
➢ Q in L/s			5
➢ H in Mts and			150.0
➢ η_P = in %, pump efficiency			70%
➢ η_m = in %, motor efficiency			85%
The minimum required pump power could be calculated from: -			

The minimum required pump power could be calculated from: -				
P_p =	**(Q * H) /(102* ηP)**			
Where :	Q :	pump discharge [l/s]		
	H :	total pumping head [Mts]		
Pp =	**10.50**	**KW**		
Pump Motor				
The capacity of the motor to drive the pump is determined by the following formula.				
P_m =	**(Q * H) /(102* ηp x ηm)**			
Pm	**12.36**	**KW**	**13**	**KW**

Borehole site power calculation

Borehole site power calculation			
1. Steady Condition with max. consumers in operation			
1.1	Motor Rated power, kw	13	
1.2	Taking motor efficiency required power (KW)	85%	
1.3	Running KW= motor shaft KW / Motor η	15.29	
1.4	power factor 0.8	0.8	
1.5	Running KVA= motor shaft KW / cos ϕ	19.12	
1.6	All station Auxilary consumers KVA	2.00	
1.7	Resulting Max. Steady load	21.12	
2. Pump start Condition			

Borehole site power calculation			
2.1	Pump start Condition	Y / Δ	
2.2	Nominal Voltage of motor in V	400.00	
2.3	Nominal Current of motor (P=1.73*In*V	28	
2.4	Starting Current of motor Is=(2-3)*In (taking 3 times of the nominal current)	83	
2.5	Max. Starting KVA =1.73 X U(nom.) X I st + auxilary consumers	59	

3. SELECTION OF THE GENERATOR SET	
	The selection of the generator set takes place in 3 steps:
3.1	Checking the start current of the load.It is very important to check whether the
3.2	Determining the required power .Attention should be paid that the engine can
3.3	Checking the generator set,• on single load step acceptance, and • on

POWER CALCULATION FOR GENERATOR SET					
Since the Characteristics of generators permit an overload of 200 - 300% during the first 20 seconds,					
Borehole site					
	Running KVA of the Generator = Max. Starting KVA demand at pump Start/(200%- 300%) take for granted 200%	30			
	So the diesel generator should be capable of supplying (KVA) apparent power during starting. Prime power at site in KVA after derating	30			
	NOTE :- THE ABOVE POWER IS AFTER DE-RATING				
When derated by (it depends on the manufacturer engine de-rating chart)					
	Temperature:----------			X KVA	
	Altitude ----------			Y KVA	
	Sub Total derated Power----------			(X+ Y) KVA	
To accommodate the above load with tolerance a generator with (Prime power at site in KVA befor					
capacity (STANDBY POWER) Shall be Proposed					
Checking the generator set					
1	Max. Steady load KVA ≤ Running KVA of the Generator at site (after derating)				
2	Max. Starting KVA demand at pump Start ≤ Starting KVA of the Generator (SKVA)				
3	Single load step acceptance				
	The single load step acceptance is the maximum increase in load,				
	in one single step, that the generator set is able to handle				
4	Frequency and voltage drops				
	Pay attentention that frequency and voltage drops can be maintained				
	within acceptable limits when the various loads are introduced.				
	If the voltage drop is too high, the load will not be able to start.				

SPECIFICATION FOR MAIN COMPONENTS OF THE PUMPS:

S NO	COMPONENTS	SPECIFICATIONS
1	Casing/Diffuser	The Casing/Diffuser should be in fabricated stainless steel AISI 304.
2	Impellers	stainless steel AISI 304
3	Driving Shaft	Stainless steel 304/420
4	Sleeves	Stainless steel AISI 329/ 304

5	Gaskets	Rubber Gaskets
6	Bearings	AISI 329 stainless steel
7	Coupling & Screen + Cable Guard	Stainless steel AISI 316/319/304/420
8	Non-Return Valve	As per British standard specifications (BSS), Minimum 16 bar pressure sustaining design
9	Pressure Gauge	As per British standard specifications (BSS), having PSI or Bar scale
10	Clamps	Steel – Pressed
11	Pump Efficiency	The minimum efficiency of the pump should be 60% at the duty point

7.2 **Power Cable**

The cables from the array to the control cabinet and from the control cabinet to the pump shall meet the following specifications: "IEC 60811-common test methods for insulating and sheathing materials of electric cables".

- The cable should be flexible and used to supply electrical motors.
- The power cable should be insulated with PVC sheath having; flexible, annealed, and tinned copper conductors of high conductivity.
- 4 core power cable (in one shield) flat or round type to minimize the pump diameter and flange size.
- The selected cable from the panel to the controller and controller to the motor should indicate the number of cores, cross-section, and material.
- Cable diameter to be such that the voltage drop at the maximum depth setting is not more than 3% at an ambient temperature of 30°C.
- The cable connected to the motor should be with a waterproof joint to the motor cables.
- The cable length for each pump should be according to the requirement.
- The cable diameter, number of cores, and manufacturer name should available on the cable.
- Cables must be color coded under the existing electric coding norms in PV applications. (I.e. blue being the negative pole).
- Securing of cables and safety rope on riser pipe done every 3m apart.
- The cable from the array to the control cabinet shall be armored in an HDPE pipe, with a minimum wall thickness of 3mm, for protection (depending on the distance between the controller and combiner box).

- ❖ The HDPE pipe shall be underground (at least 40cm deep) for the distance between the array and the control cabinet.

The minimum size of the cable shall be as follows:

01. Module to module: 2.5 mm²
02. Array to control box: should be higher than that of the size of cable given for the pump
03. Pump cable: minimum as per given on the system sizing provided by the bidder.
04. Other relevant information.

7.3 Solar Control System

The appropriate solar pump control system must be based on the identified power requirement. The work includes identification, supply, and installation of the control system, and inverter for pumping by considering the below main functions within the control system:

- Tracking of the Point of Maximum Power (PMP) for the PV solar generator. This exploits the maximum power available at the solar generator at all times;
- "Passing Cloud" management. The system responds to sudden changes in radiation, avoiding shutdowns and start-ups of the pump that would not be acceptable in high-power systems;
- Pressure Control. This can limit the pressure of the pumping system to a maximum value using an external sensor;
  - Auxiliary AC Input. The board assembly allows for an auxiliary AC input from a generator set for the grid to function in parallel with the solar panels without the need for any additional switches;
  - Source/Borehole dry" detection function. This function prevents the pump from running on empty without the need for senses.
  - Level detection. Equipped with inputs for configurable level sensors to shut down operation once the established level is reached;
  - Configurable for asynchronous and synchronous permanent magnet motors. Given their greater efficiency, permanent magnet motors are an efficient option for solar pumping;
  - "Wake" and "Sleep" functions. This includes the programming required to operate only with the solar generator, avoiding unnecessary start-ups and shutdowns when the sun rises set;
    - Aluminum housing for interior or exterior installation, alternating current switch, LCD graphics screen, RS-485, and Ethernet ports, digital sinusoidal current regulator, prepared for track installation. Includes accessories required for proper installation. Fully assembled, connected tested.

7.4 AC SYSTEM CONTROLLER

Control equipment is any equipment that is used between the solar generator and the pump motor. Control equipment includes monitoring, power conversion, MPPT (Maximum Power point Tracking) sensors, and other equipment related to the solar pumping system.

- The control equipment must meet EN 61800-1, EN 61800-3, EN 60204-1, or internationally recognized equivalent standards
- The control box should be mounted separately under the higher part of the array of the PV array and a minimum of 50cm from the ground.
- Protection against reverse polarity.

- Efficiency ≥ 60%,
- Integrated MPPT (maximum power tracking), Enclosure class IP 54
- Control inputs for dry running protection, remote control, data display, and signal indicator shall be inbuilt into the controller, etc.
- Protected against overload and over temperature, over and under voltage, and short circuits.
- Have the ability to add on an optional power pack if required in the future.
- Provide diagnostic indicators to show status.
- Have provision for continuous performance measurement.
- Have an on /off switch at ground level to allow for speed control adjustment at ground level.
- Not allow users to adjust speed controls without the use of tools to avoid tampering.
- Not be integrated into pumps as this presents service access problems.
- Have simple system health indicators that are user-visible for troubleshooting purposes – typically of pump status, pump speed, well dry, and the tank full information.
- Be easy to service and unit replaceable by a trained person with modest skills.

7.5 Dc System Controller

Electronic equipment for controlling and/or optimizing the pump operation such as inverters with built-in switch gear shall be installed in a control cabinet meeting the following requirements:

- The cabinet shall be solidly mounted with a height of 50cm
- The cabinet shall be placed under the higher part of the array to be protected from direct sunlight and rain any time of year.
- Weather and water resistance of enclosures shall be according to IP 54 standard or equivalent.
- The cabinet shall be made of glass-reinforced polyester that avoids condensation.
- Equipped with a vertically hinged door that can be locked
- Adequate cooling shall be provided to remove any heat generated by the electronic device(s)
- The size of the cabinet should be such that the space occupied by the equipment (including the switchgear and protection devices) shall not exceed 50% of the total inside space. The cables inside the cabinet shall be arranged in a clear and orderly manner, using tiers or other methods to bundle cables together.
- The cable shall be of the flexible type for outdoor applications, all connections should be made with cable sleeves to ensure a neat and durable electrical connection.

8.6 Junction Box

The protective index for the junction box shall comply with IP54.

7.6 Dry Run Protection

The system must have dry run protection to protect the system in the event of low water levels. The dry run protection must:

1. Be of modular design, exchangeable, and preferably a float mechanism. Wet electrodes will not be accepted due to unpredictable and unreliable performance.
2. Not be an integral part of the submersible pump or due to issues with serviceability and cost of replacement. Control equipment matched to pump an array. Control equipment is Any equipment that is used between the solar generator and the pump motor. Control equipment includes monitoring, power conversion, and other equipment related to the solar pumping system.

7.7 Mandatory Accessories

Accessories like pressure switch, surge protector, liquid pressure sensor, water meter, sun switch, surge protector, cable splice kit, PV disconnects, PV combiner, two pairs of pipe clamps, etc. to be fitted with the system according to the system design.

7.8 Distant Monitoring Of Solar Pumping Systems

Data regarding system performance and real-time status must be available for viewing and analysis from a distant point. The requirement is that all pump systems included in this specification can be monitored from one central office.

7.9 Remote Control of Solar Water Pumping Systems

The system must be capable of being controlled (speed, pump on, pump off) from a remote point. This is to provide central management of water delivery. The system must have safeguards to prevent a local override of any remotely set parameters.

7.10 Pv Mounting Structure

The PV array is mounted on a pedestal which is made from concrete with a height of not less than 40 cm from the ground. Mounting structures/panel support structure mentioned above will be made of steel with a minimum ground clearance of 1,5m fabricated from,

- 2" Medium class Galvanized steel (GS pipe) stand/ vertical support structure,
- 1"medium class GI pipe top and intermediate Beam, and
- 40x40 X4mm angle iron L-section positioned horizontally north to south painted mild steel beam, with all required bolts, nuts, and washers. This structure must withstand wind speeds of a minimum of 120km/h. In addition to this, all these structures must paint with mild steel to minimize rusting
- The lower part of the array shall be between 1m from the ground level to ensure easy cleaning.

No tracking systems are permitted. Fixed Mount structures are less expensive and tolerate higher wind loading.

PV modules are generally tested, labeled, and listed with four mounting holes used for bolting the modules to the mounting surface. Module manufacturers shall provide instruction manuals that specify where top clamps may be used on the module frame where required.

Drawing for the support structure which includes some modules on lines and system wiring should be submitted with the offer during the material supply.

Excavation of the foundation for the structure

- All trees, bushes, and hedges are to be removed within a distance of 20 meters from the area of the foundation foundations. Roots are to be killed or removed within this width to minimize the shed for the PV module.

  NB: - And these trees, bushes, and hedges at the site shall not be cut down, damaged, or destroyed without the approval of the Engineer/or the community to minimize complaints.
- Excavation for structures shall be to the width and depth necessary to provide adequate space for structural foundation and supporting formwork, and if required over the excavation of unsuitable material, over-excavation required because of unsatisfactory soil conditions resulting from lack of drainage or dewatering equipment will be the responsibility of the contractor.
- The depth of excavation for black cotton soil shall be up to a depth of 1.5m or until the soil texture changes. For other stabilized soils the minimum depth of excavation for the foundation should be up to a depth of 1m.
- Any excavation backfills or mass concrete foundations over that specified on the drawings or ordered by the site engineer will be at the Contractor's expense.
- The bulk excavated shall be filled with selected material and compacted in layers not exceeding 150mm
- If excess foundation excavation is executed by the contractor, the overlaying structure should be placed there without backfilling. Thus, the excess volume of work of the structure put is due to the expense of the contractor.

7.11 Concrete Work for the Structure

- The minimum Cement Content of the concrete of class C-15 shall be 200 kg/m3.
- The minimum Cement Content of the concrete of class C-25 shall be 300 kg/m3.
- The water/cement ratio shall be the minimum consistent with adequate workability but in any case not greater than the Maximum free water/cement ratio of 0.55. The Contractor shall take into account that this requirement may need the inclusion of a workability agent in the mix as per the engineer's approval.
- Concrete shall not be placed during rain which is sufficiently heavy or prolonged to wash mortar from coarse aggregate on the exposed faces of fresh concrete.

- Concrete shall be protected during the first stage of hardening from loss of moisture and the development of temperature differentials within the concrete sufficient to cause cracking.
- The methods used for curing shall not cause damage of any kind to the concrete. Curing shall be continued for as long as may be necessary to achieve the above objectives but in any case for at least seven days or until the concrete is covered by later construction whichever is the shorter period.
- The concrete block of C-25 grade should be reinforced with a reinforced bar of 10mm diameter and with 1:2:3 ratios.
- The minimum size of the support structure shall be 70cmx70cm and the depth should be as per the actual soil formation of the area. That is for stabilized soils 70cm and black cotton soil up to 1.5m.

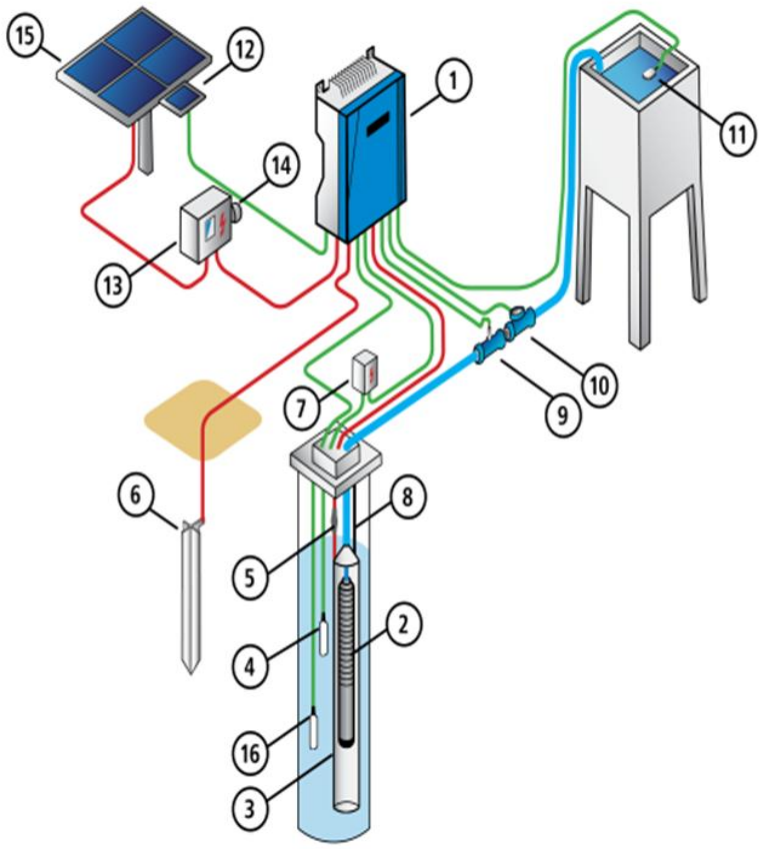
7.12 **Lightning Arrestor and Grounding**

Grounding issues shall be free from failing inspection at PV installations as a result of hardware and product installation inconsistencies. Typically, a module has four labeled grounding holes that have been tested to meet UL 1703 requirements for safe connection to the earth through the equipment-grounding system. Module instruction manuals and tech notes shall be provided with detail on how these labeled grounding holes are intended to be used to ground the PV modules.

A lightning conductor should extend at least 1.5m above the highest point of the array in the northern direction. The lightning arrestor system shall consist of the following:

- All metallic parts to be electrically connected (modules, supporting structure, metallic cabinet if any, etc.)
- All DC distant cables, in and out, are fitted with arrestors (MOV - metal oxide variance) between + and – poles.
- One of the poles is connected to the earth via an arrestor (possibly Positive if compatible with the rest of the system).

The system shall be grounded to a single point using the shortest practical route to an adequate earth contact using an uninterrupted copper conductor of at least 16mm in diameter and 1500mm in length to be properly installed in the ground.



1: PS2 Controller
2: Submersible Pump
3: Stilling Tube
4: Well Probe
5: Cable Splice Kit
6: Grounding Rod
7: Surge Protector*
8: Safety Rope
9: Water Meter
10: Pressure Sensor
11: Float Switch
12: Sun Switch
13: PV Disconnect
14: Lightning Surge Protector
15: PV Generator

*It is recommended to install a Surge Protector at each controller sensor input.

8 Quality of Water

Quality of water is defined as the physical, chemical, and biological characteristics of water. It is most frequently used by reference to a set of standards against which compliance can be assessed. The most common standards, almost universally used to assess water quality related to drinking water, based on safety of human contact and wealth of ecosystem is the World Health Organization (WHO) maximum allowable concentration (mg/l).

8.1 Impurities of Water

Absolute pure water is never found in nature. The natural water contains a number of impurities in varying amount. As water vapor condenses in the air and falls in to the ground, it absorbs dust and dissolves oxygen (O2), carbon dioxide (CO2), and other gases. At ground surface it takes up silts and other inorganic materials, a few bacteria will have entered from air, but at the ground surface many more will be picked up. Small amount of the products of the decomposition of organic matter, nitrites, ammonia and CO2 will go in to the solution. These entirely called Impurities of Water.

8.2 Water quality requirement and standards

The domestic water supply is required to be;

- Colorless and sparkling, which may be accepted by the public at large;
- Free from bacteria which may cause diseases;

- Tasteless, odorless and cool;
- Free from objectionable matter;
- It should not corrode pips;
- It should have dissolved oxygen and carbonic acid so that it may remain fresh.

Benishangul Gumez Regional State Water,Irrigation and Energy Resource Development Buearu

Detailed water Quality Laboratory Test and Monitoring

August2024

WATER QUALITY LABORATORY MONITORING FORM

2.physico-chemical report result of water sample analysis

1.sample serial number.....A-1 3. Time of collection 11 :00 AM..

2.Date of collection..29/07/2024 4. Time of analysis 14:48 PM

5.Region.....B/G/R/S..... 6.Zone.....Assosa

7.Woreda..**Homosha**. 8.Kebele **Tsore**

9.Source of sample. **Deep Well** 10.Nature of sample Not chlorinate

11.Year of construction..**2024 G.C**

No	Physico-chemical parameters	Result	WHO standards	Remark
1	Color	2	15TCU	
2	Turbidity	0	5NTU	
3	Hydrogen power(PH)	7.90	6.5-8.5	
4	Iron	0.01	0.3 mg/l	
5	Calcium hardness	35	500 mg/l	
6	Fluoride	0.80	1.5 mg/l	
7	Conductivity	283@26.1°c	400 µs/cm	
8	TDS	169.80	1000 mg/l	
9	Nitrite	0.12474	3mg/l	
10	Manganese	0.006	0.05 mg/l	
11	Total hardness	75	500 mg/l	
12	Total Alkalinity	180	250 mg/l	
13	Nitrate	0.8316	50 mg/l	
14	Magnesium	10	100 mg/l	
15	Calcium	14	70 mg/l	
16	Sodium	18	200 mg/l	

General Recommendation ;- AS we have seen above from the table the laboratory result of analyzed sample source shows that every analyzed parameters are below WHO standards ,So that the water source is safe to drink.

Reported By: Jebessa Kepitano . Sign.....Date..29/08/2024

WATER QUALITY LABORATORY MONITORING FORM

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9	Nitrite	0.12474	3mg/l	
10	Manganese	0.006	0.05 mg/l	
11	Total hardness	75	500 mg/l	
12	Total Alkalinity	180	250 mg/l	
13	Nitrate	0.8316	50 mg/l	
14	Magnesium	10	100 mg/l	
15	Calcium	14	70 mg/l	
16	Sodium	18	200 mg/l	

General Recommendation ;- AS we have seen above from the table the laboratory result of analyzed sample source shows that every analyzed parameters are below WHO standards ,So that the water source is safe to drink.

Reported By: Jebessa Kepitano . Sign.....Date..08/08/2024.....

Water bureau water quality monitering form

1.Bactteriological Result of sample Analysis

A. Back Ground data

Sample serial no: A- 3 **Time of collection.11:00 AM**

Date of collection:29/07/2024 **Time of incubator started 3:30 PM**

Region...B/G...Woreda...Homosha Kebele...Tsore

Source of Sample... DeepWell

B.Test Result	**WHO standards**
a. fecal coli form{ 0/100 ml }	**{ 0/100 ml }**
b.Total coli form { 0/100 ml }	**{0/100 ml}**

C.Coments

- **{ yes } Bacteriological potable**
- **{ no } Bacteriological not potable**
- **{ Yes } Chlorination Recommended**
- **{ } Disinfection Recommended**

D. sanitary condition of the scheme ?/presence of potential contaminates in the area:

is the water point fenced?(new constructed)

Reported by;-Jebessa Kepitano sign..... date..29/07/2024

Irrigation systems Infrastructure

- Command area size: 225ha
- Total number of pond:12
- Irrigation systems
  - ✓ Drip irrigation:135ha
  - ✓ Surface irrigation (furrow irrigation):90ha
- underground reservoir capacity:360m3
- solar power capacity: 22440 watt
- submersible pump capacity : 13kw
- Generator capacity for standbys :100kv

9 Conclusion and Recommendation

The implementation such integrated irrigation development project will bring a number of economic and social benefits. These include improved economic and nutritional status through increased agricultural production and productivity of crop, and to improve income and market access for local producer, creation of employment opportunities and farming skill development. Fikadu Nemera Integrated Farming Investment is found to be technically feasible based on the field data analysis and studied documents. Fikadu Nemera Integrated Farming Investment irrigation scheme with 225 ha with good suitability of soil and enough availability of surface water. Projects that can take advantage of pre-existing infrastructure and services may appear economically preferable, but the economic criteria are not the only ones, and in the development of a country like Ethiopia.The demand of water for irrigation increases with the increase of sunshine, which can be coincided by using solar water pump. The proper design of the solar water pump can result in long term cost benefits and less environmental pollution as compared to conventional water pumps. The integration of solar energy in irrigation and agriculture sector is found to be environmentally friendly and economically feasible alternative.

	Summary of Project Costs			
Table	**DESCRIPTION**	**Unit**	**Quantity**	**Total amount**
1	General items	LS	1	1,230,000
2	Supply and Installation of distribution system	LS	1	12,579,124
3	Supply and Installation of Transmission Main	LS	1	2,558,710
4	Construction of 360m³ under ground Reservoir	LS	1	5,671,053
5	construction of guard house @Reservoir Area and around the sources	No	1	845,742
6	electromechanical supply and installation	LS	1	3,283,761
7	Deep well drilling	LS	1	2,612,868
8	**Excavation pond**	LS	1	14,580,000.00
	Total	LS		**43,361,257**

Table 1: General items

ITEM	**DESCRIPTION**	**UNIT**	**QTY**	**RATE (BIRR)**	**TOTAL (BIRR)**
1.1	Mobilization of plant, equipment and personnel to the site	LS	1	500,000	500,000
1.2	Demobilization of plant, equipment and personnel from the site after finalization of the work	LS	1	250,000	250,000
1.3	Provide survey control points and setting out of the work for construction	LS	1	80,000	80,000
1.4	Prepare and provide as built drawings of all works constructed as per the specification	LS	1	90,000	90,000
1.5	Establishment of storage area , & also for pipe & fittings shade with 4 mx 10 m & remove after completion of the project	LS	1	120000	120,000.0
1.6	Matrial testing for work construction project	LS	1	100,000	100,000
1.7	Water quality testing	LS	1	30,000	30,000
1.8	Fabricate and erect metallic sign board for identification of the site area	LS	1	60000	60000
1	**Sub-Total**				
					1,230,000

Table-2 supply and installation of distribution system

Item No	**DESCRIPTION**	**Unit**	**Qty**	**Unit Rate**	**Total Amount**
2.1	**Site clearing and earth work**				
2.1.1	site clearing along the route in 2m width	m2	9,526	68	647,768

2.1.2	Excavation of common soil for trench commencing at ground level not exceeding 0.7width with 0.9m deep for installation of distribution main pipe, including disposal of surplus excavated material	m^3	2370.69	458	1,085,776
2.1.4	Extra over for trench excavation in hard rock formation to a 0.7 width with a depth of 0.9.m and disposal of surplus excavated material.	m^3	630.00	750	472,500
2.1.6	Backfill pipe trenches with suitable material	m^3	3,000.69	250	750,173
2.2	**Laying of pipes,**				-
	Supply and Installation of HDPE Pipe PN-16				-
2.2.1	**PN-16 HDPE Pipe**				-
a	OD 63mm HDPE Pipe	m	1804	783	1,413,254
b	OD 75mm HDPE Pipe	m	1823	885	1,612,990
c	OD 90mm HDPE Pipe	m	1136	1,200	1,363,200
	OD 20mm HDPE Pipe	M	30083	135	4,061,205
2.3	**Supply and Installation of HDPE Butt. Welding and Compression Fittings**				-
I	**Butt Welding TEE (OD)**				-
a	DN90/75/90mm	No	5	9,000	45,000
b	DN 75x63X 75mm	No	5	8,306	41,532
c	DN 75x75x75mm	No	5	8,710	43,549
d	DN 63x63x63 mm	No	6	989	5,933
II	**Butt Welding REDUCER (OD)**				-
a	90mmx75mm	No	3	6,458	19,373
b	90x63mm	No	1	6,097	6,097
d	75x63mm	No	4	6,500	26,000

III	**Flanged Gate valve**				-
a	DN 80mm PN-16	No	8	10,894	87,154
b	DN 65mm PN-16	No	12	9,951	119,415
V	**Supply and Installation of HDPE end cap.**				-
a	OD 63mm	No	5	2,082	10,410
VI	**Union GS PN-16**				-
a	2"x2"	No	10	290	2,900
b	3"x3"	No	4	350	1,400
VII	**GS Nipple**				-
a	2"x2"	No	5	793	3,965
b	3"x3"	No	10	500	5,000
VIII	**Adapter**				-
a	Compression female adapter 90mmx3"	No	10	2,900	29,000
b	Compression female adapter 75mmx21/2"	No	10	2,700	27,000
c	Compression female adapter 63mmx2"	No	8	2,500	20,000
2.4	**Trust and anchor blocks**				-
2.4.1	Construction of grade C15 concrete thrust blocks for 90,30,45, degree bends and 80mm dia ; price includes reinforcement and formwork	No	1	2,500	2,500
2.4.2	Construction of grade C15 concrete anchor blocks for pipes laid over steepy ground ; price includes reinforcement and formwork	No	1	2,000	2,000
2.5	**Construction of Crossings**				-
2.5.1	Supply grade C20 concrete and construct type II crossing as shown in the standard drawings.	No	1	2,500	2,500

2.6	**Construction of valve chambers , installation of valves and devices plus accessories; price includes reinforcement and formwork**				-
2.6.1	construction of valve chambers on installed gate valves	No	8	10,000	80,000
2.7	**PRESSURE TESTING AND DISINFECTION**				-
2.7.1	Pipeline testing and commissioning for the whole work, including all necessary works such as thrust blocks, anchor blocks, transportation and use of water, pipe fittings, disposing of used water.	m	4,763	50	238,150
2.7.2	Disinfection of Pipe lines: flushing with clear water, filling with water containing 0.15 g/l calcium hypochlorite, left for 24 hours. This includes supply of all necessary equipment, chemical and water.	m	4,763	50	238,150
	Grand Total				**12,579,124**

3 Supply and Installation of Transmission main

Item No.	Description	Unit	Qty.	Unit Rate	Amount (birr)
3.1	**EARTHWORK**				
3.1.1	**SITE CLEARANCE**				
3.1.1.1	General clearance of site, along proposed distribution mains route to a width of max 2m of all bushes and trees including grapping of roots of stumps and removing from site (provisional) (1000m length)	m^2	2,000	250	500,000
3.1.2.1	Excavation of common soil for trench commencing at ground level not exceeding 1m deep*0.7m for installation of distribution main pipe, including disposal of surplus excavated material for 600m	m^3	420	600	252,000
3.1.2.2	Extra over for trench excavation in soft rock formation to a max. depth 1m*0.7m width and disposal of surplus excavated material for 150m	m^3	140	600	84,000
3.1.2.3	Extra over for trench excavation in hard rock formation to a depth 1m*0.7m and disposal of surplus excavated material for 150m.	m^3	280	750	210,000
3.1.2.4	Backfilling the trench excavation	m^3	840		

				250	210,210
	Sub-total				**1,256,210**
3.2	**Supply and installation of Transmission main pipe**				
3.2.1	HDPE pipe OD 90mm PN 16	m	1000	1,200	1,200,000
	Sub-total				**1,200,000**
3.3	**TRUST AND ANCHOR BLOCKS**				
3.3.1	Construct concrete thrust blocks (C-25), as shown in the standard drawing including, but not limited to, all required materials, labor, formwork, reinforcement, excavation, etc.	No.	1	2,500	2,500
Sub-total	**Sub-total**				**2,500**
3.4	**PRESSURE TESTING AND DISINFECTION**				
3.4.1	Pressure testing and commissioning of new pipeline for the whole work according to the specification, including all necessary works including checking of thrust blocks, anchor blocks, transportation and use of water, pipe fittings, and disposing of used water	m	1000	50	50,000
3.4.2	Disinfection of pipelines: flushing with clean water, filling with water containing 0.15 g/l calcium hypochlorite, left for 24 hours. This includes supply of all necessary equipment required for the work, chemical and water, as approved by the Engineer	m	1000	50	50,000
	Sub-total				**100,000**
	Total sum				**2,558,710**
Table-4 Construction of 360m³ concrete ground reservoir					
It. No	**DESCRIPTION OF WORK**	**Unit**	**Quantity**	**Rate**	**Amount**
4.1	**EARTH WORK**				
4.1.1	site clerance	m2	160	45	7,200
4.1.2	Bulk excavation in normal soil to a depth of 500mm	m^3	80	481	38,488
4.1.3	Ditto but in soft rock formation	m^3	325.62	450	146,529

4.1.4	Ditto but in hard rock formation	m^3	108.54	775	84,119
4.1.5	Cart away all excavated material, deposit to appropriate distance not exceeding 1 km	m^3	514.16	294	151,194
4.1.6	Place and compact back fill with selected material	m^3	27.135	206	5,597
4.1.7	Provide and fill hard core with hard basaltic or equivalent stone, well compacted and blinded with crushed stone to a finished thickness of 25 cm under the reservoir and valve chamber	m^2	26.38	850	22,423
4.2	**Concrete work**				-
4.2.1	70mm thick lean concrete(C10) under the reservoir base slab and valve chamber	m^2	108.54	1,500	162,810
4.2.2	Reinforced concrete type C-30 filled into form work and vibrated around reinforced bar for the reservoir				-
4.2.3	base slab	m^3	10.854	19,751	214,372
4.2.4	Wall	m^3	68.8	19,751	1,358,834
4.2.5	roof slab	m^3	10.854	19,751	214,372
4.2.6	10cm thick C-25 reinforced concrete for roof and floor slab of valve chamber	m^3	0.18	19,751	3,555
4.3	**Provide and fix Form work**				-
4.3.1	For base slab	m^2	25	1,338	33,438
4.3.2	For wall	m^2	50	1,338	66,875
4.3.3	For roof slab	m^2	37.39	1,338	50,009
4.3.4	for valve chamber	m^2	2.88	1,338	3,852
4.4	**Provide, cut, bend and fix in position reinforced steel bar. All according to structural drawing. Price should include tying wires**				-
4.4.1	diameter 8mm	kg	81.33	250	20,333
4.4.2	diameter 10mm	kg	297.15	250	74,287
4.4.3	diameter 12mm	kg	2721.54		

				250	680,386
4.4.4	diameter 14mm	kg	143.03	250	35,757
4.5	**Masonry work**				
4.5.1	40cm thick Masonry wall constructed for valve chamber with cement & sand mortar (1:3)	m3	68.80	5,516	379,466
4.5.2	10cm thick 1m width stone pitching pavement C-20 around reservoir floor	m2	21.50	515	11,073
4.6	**FINISHING WORKS**				-
4.6.1	3cm thick plastering floor slab finish with (1:2) mix	m2	91.98	1,463	134,576
4.6.2	Apply 3cm thick plastering of internal walls up to fine finish with (1:2) mix	m2	159.20	1,463	232,926
4.6.3	Apply 12mm thick render plastering of external walls of the reservoir	m2	64.50	1,463	94,370
4.6.4	3cm thick cement screed mix (1:3) roof slab finish	m2	91.98	1,463	134,576
4.6.5	Plastering of the internal wall of valve chamber, floor and roof slab	m2	32.00	1,463	46,819
4.6.6	Pointing of the external wall of valve chamber	m2	6	1,463	8,779
4.6.7	Provide and install water stop made up of natural and synthetic rubber or electromagnetic plastic compound with basic polyvinyl chloride (PVC) width 30cm	m	64	1,250	80,000
4.6.8	Provided and install access internal and external ladder constructed out of 1 1/2" dia GS pipe and hooked to the wall as per the drawing; including safety cages	LS	1	55,000	55,000
4.7	**PIPES, VALVES AND FITTINGS**				-
4.7.1	Install DCI Inlet pipes and fittings and valves of with all required accessories, rubber sealing flat gaskets, bolts, nuts with washers				-
4.7.1.1	DN 80 flanged bell mouth	No	1	15,250	15,250
4.7.1.2	DN 80, L=4.7 m double flanged pipe	No	1	15,600	15,600
4.7.1.3	DN 80, 90^0 Duck foot bend	No	1	15,676	15,676
4.7.1.4	DN 80, Central puddled double flanged pipe L=1m	No	1	13,500	13,500
4.7.1.5	DN 80 dismantling piece	No	1		

				14,625	14,625
4.7.1.6	DN 80 double flanged pipe L=1.25 m	No	1	13,500	13,500
4.7.1.7	DN 80, 90^0 double flanged bend	No	2	15,676	31,353
4.7.2	**Install Outlet pipes and fittings and valves of with all required accessories, rubber sealing flat gaskets, bolts, nuts with washers**				-
4.7.2.1	DN 100 suction strainer	No	1	13,500	13,500
4.7.2.2	DN 100 Central puddled double flanged pipe L=1m	No	1	13,500	13,500
4.7.2.3	DN 100 dismantling piece	No	1	14,625	14,625
4.7.2.4	DN 100 flanged gate valve	No	1	16,335	16,335
4.7.2.5	DN 100, 90^0 double flanged bend	No	2	15,676	31,353
4.7.2.6	DN 100 double flanged pipe L=4.7m	No	1	15,650	15,650
4.7.2.7	DN100 Flanged water meter	No	1	12,500	12,500
4.7.3	**Install Over flow and drainage pipes and fittings and valves of with all required accessories, rubber sealing flat gaskets, bolts, nuts with washers**				
4.7.3.1	DN 80 Flanged bell mouth	No	1	15,250	15,250
4.7.3.2	DN 80 double flanged pipe L=240cm	No	2	16,500	33,000
4.7.3.3	DN 80, 90^0 double flanged bend	No	3	15,676	47,029
4.7.3.4	DN 80 Central puddle Double flanged pipe L=1m	No	1	14,500	14,500
4.7.3.5	DN 80x80x80 flanged Tee	No	1	16,500	16,500
4.7.3.6	DN 80 Central puddled flanged spigot pipe L=1m	No	1	12,565	12,565
4.7.3.7	DN 80 flanged gate valve	No	1	16,000	16,000
4.7.3.8	DN 80 double flanged pipe L=3m	No	2	13,560	27,120
4.7.3.9	DN 80 Central puddled flanged spigot pipe L=1m	No	1	13,560	13,560

4.7.3.10	DN 3" GI ventilation pipe with dome, L =1.0m and DN21/2" roof drain pipe, L=0.5m	pcs	1	13,500	13,500
4.8	**COMPOUND WORK**				-
4.8.1	Filling and compacting of selected material excavated from site in layers not exceeding 20 cm thickness	m^3	314.7	1,250	393,375
4.8.2	Provide broken or other approved granular material forming bearing courses of road and parking areas of 25cm compacted thickness, including spreading in layers, watering and compacting	m^2	157.5	1,250	196,875
4.8.3	Supply and erect Zinc coated (galvanized) steel chain link fence fabric with mesh size (1"-2") and nominal coated diameter (3.05mm) and RHS gate (80*80mm) as detailed, include for all intermediate straining and 50mm GI Pipe posts @ 2000mm spacing, 2600mm high (2100mm above OGL) and struts are to be embedded in concrete C-25 to a depth of 500mm as detailed on the drawings including earth work and all associated works. The dimension of the compound will be directed by the site engineer	m	120	750	90,000
	Sub-Total				**5,671,053**
	Table -5 Construction of Gourd House @ Reservoir Site				
Item No.	**Description**	**Unit**	**Qty.**	**Unit Rate**	**Amount**
5.1	**EARTH WORK**				
5.1.1	Clearing of site to remove top soil to a depth of 200mm	m^2	30.25	450	13,613
5.1.2	Excavation for stone masonry foundation; 0.5m wide and 0.5m depth	m^3	6.94	575	3,993
5.1.3	Excavation for floor slab 0.3m depth	m^3	2.61	575	1,501
5.1.4	Cart away and deposit excavated surplus material to a distance not exceeding 1km	m^3	6.06	294	1,782
5.1.5	Provide and fill hard core with hard basaltic or equivalent stone, well compacted and blinded with crushed stone to a finished thickness of 25cm	m^2	8.7	1,450	12,615
5.1.6	Provide fill and compact selected material layer by layer in 200mm layer	m^3	3	406	1,218

5.2	**CONCRETE WORK**				-
5.2.1	R.C. floor tie beam	m^3	2.24	19,500	43,680
5.2.2	R.C. column	m^3	0.4	19,500	7,800
5.2.3	Lintel	m^3	0.16	19,500	3,120
5.2.4	R.C. roof tie beams	m^3	0.49	19,500	9,555
5.2.5	Mass concrete fill on floor slab (100mm)	m^3	0.87	19,500	16,965
5.26	**Provide, cut, bend and fix inposition reiforced steel bar. All according to the structural drawing. Price should include tying wires.**				-
5.2.6	Mild steel reinforcement with diameter 6mm deformed bar	kg	9.8	250	2,450
6.26	Mild steel reinforcement with diameter 12mm deformed bar	kg	230.8	250	57,700
5.3	**BLOCK WORK**				-
5.3.1	Supply and raise 500mm thick 0.9m high hard trachyte or equivalent stone masonry foundation wall beded in cement mortar mix 1:3	m^3	12.12	15,515	188,042
5.3.2	Rendering external wall, price includes one coat of plastering before rendering	m^2	26.42	1,515	40,026
5.3.3	Class C, 200m thick HCB wall with the designed compressive strength, bedded in cement mortar (1:3)	m^2	44.16	1,888	83,352
5.4	**CARPENTRY AND ROOFING**				-
5.4.1	Supply, assemble and fix in position eucalyptus roof truss of length 4.6m price shall include the application of three coats and external anti-termite treatment as per the drawing including eualyptus vertical and diagonal members	No.	3	231	693
5.4.2	Supply and fix roof purlin in zigba wood size 50 x 70 mm nailed in to eucalyptus truss including three coats of anti-termite external treatment	m	35	255	8,925

5.4.3	Supply and fix roof cover in G-28mm corrugated galvanized iron sheet fixed in to zigba wood purlin with dome headed galvanized nails (Purlin and ridge cover measured separatly	m^2	25	2,108	52,700
5.4.4	Supply and fix metal doors size 2.06 x 0.9m with figured glass in upper half	No.	1	16,500	16,500
5.4.5	Supply and fix metal windows size 1.1 x 1.12m price includes 4mm thick glass	No.	1	15,000	15,000
5.5	**FINISHING: finishing work shall include all surface pre-cleaning, polishing and cleaning at the end of finishing**				-
5.5.1	Apply floor screed of 20mm thick with cement mortar screed	m^2	8.7	1,463	12,728
5.5.2	Apply three coats of plaster in cement mortar to internal cement concrete block wall	m^2	26.42	1,463	38,652
5.5.3	Apply cement mortar to all external concrete block where there is no rendering	m^2	26.42	1,250	33,025
5.5.4	Apply three coats of plastic paint to internal walls and synthetic paint to metal doors and windows	m^2	26.42	1,463	38,652
5.5.5	Supply and fix 4 x 5cm ceiling buttons	m	26.42	1,250	33,025
5.5.6	Supply and fix chip wood ceiling	m^2	10	1,500	15,000
5.5.7	Supply and fix external roof ceiling gribbed sheet	m^2	9	1,670	15,030
5.5.8	Supply and fix 25 x 250 mm fascia board to the truss around the roof	m	20	1,450	29,000
5.6	**ELECTRICAL INSTALLATION**				-
5.6.1	Supply and install all the required electrical works including light and socket points, flush mounted switches, electrical cables, junction boxes, uPVC conduts for cable installations, etc	L.S	1	20,000	20,000
5.6.2	Supply and install distribution box	L.S	1	15,000	15,000
5.7	**MISCELLANEOUS**				-
5.7.1	Stone pavement around the building	m^2	9	1,600	14,400
	Total for Two Guard House				**845,742**

6.SUPPLY AND INSTALLATION OF ELECTRO-MECHANICAL EQUIPMENT					
Bill. No	**Description**	**Unit**	**Qty**	**Unit price**	**Total Price**
	Supply and Installation of Solar water pump system at the (source site)				
	Supply, Installation and commissioning of Solar water pumping system at the source (Bore hole site)				
6.1	supply of 6"S6cR24M17/19 13kwsubmersible pump	pc	1	180,966	180,966
6.1.1	supply of 6" 145MC /17 13kw submersible Motor	pc	1	182,521	182,521
6.2	suuply 15kw solar power inverter with control module can oprate hybrid with 400v genertor quality equvialent or above tha specified in document	Pc	1		-
6.2.1	Hober HSPH22KH,22KW	Pc	1	434,798	434,798
6.3	Surge protector	Pc	1	7,500	7,500
6.3.1	Dc breaker /circuit breaker set or pair of 10A fuse with its holder at - and +	Pc	5		-
6.3.2	Dc breaker/circuit breaker	Pc	3	15,000	45,000
6.4	water level sensor	Pc	1	3,000	3,000
5	*solar moudule >=500w or above at related voltage of up to ssvoc(the module total watt should be >=20000watt)the suppliers should fill the question under*	watt	22440		
5.1	*solar module 440wp*	Pc	51	21,426	1,092,726
6	*3x10mm2cores pvc power 99% cooper cable from head to pump*	M	100	885	88,500
7	*2x1.5mm2 single core control cables*	M	100	146	14,600
8	*6mm2flexible cooperwirefor Dcline*	M	80	146	11,680
9	*16mm2single core cooper wire earthing*	M	20	525	10,500
10	cable splacing kits	Ls	1	7,000	7,000
11	earthing road with conectting clamp	Pc	1	2,100	2,100

12	Lightning arrestor: Lightning arrestor made up of copper and high 1.5m above the highest PV module.	Pc	1	10,500	10,500
13	manual changeovers swich =/>100Awith conection cable 100	Pc	1	28,000	28,000
14	pannel support steel structure (minmum side hagight above ground 0.6m with gelvanized pipe 2" horizontally support 1 1/2" and angle 3mmtick u chanel steel road (detail on drawing) or as in drawing	Set	1	404,410	404,410
15	metalic enclosure and supply for DC breaker changeovers swich and controller	Set	1	20,300	20,300
16	installation and commssion	Ls	1	350,000	350,000
17	transportation of materials	Ls	1	150,000	150,000
18	21/2"Gsclass B GS pipe with ringed havey duty socket for rising pipe		10	16,250	162,500
19	21/2" flanged GS pipe with welded on diameter 12x100mmwell heded cover havey		1	21,000	21,000
20	Treaded Reducer21/2"x3"	Pc	1	2,860	2,860
21	Treaded 21/2' elbow	Pc	4	1,300	5,200
22	Treaded 21/2"water meter	Pc	1	18,200	18,200
23	Barometer with isolating ball valve and connecters	Pc	1	6,500	6,500
24	treaded 21/2"pn16 chak valve	Pc	1	9,100	9,100
25	treaded 21/2"pn16 union	Pc	2	3900	7,800
26	treaded 21/2"x3" reducer	Pc	1	1,300	1,300
27	male treaded 3" adapter	Pc	1	2,600	2,600
28	female treaded 3" adapter	Pc	1	2,600	2,600
	Sub-Total				**3,283,761**
7.COST ESTIMATION FOR DEEP WELL					
Item No.	**Description**	**Unit**	**Qty.**	**Rate in Birr**	**Amount (Birr)**
1	Mobilization of the drilling machine, well	LS	1		400,000.00

	construction materials to the sites				
2	Inter-site Mobilization	**No**	**1**		
3	Demobilization of the drilling machine, well construction materials.	**LS**	**1**		**580,000.00**
1	**Drilling**				
1.1	Site clearing	M^2	60		
1.2	drilling in all formation				
1.3	well Diameter 14" up to 6 (for surface casing)	M	6	18,000	108,000
1.4	well Diameter 12" from 6-50m	M	46	16,500	759,000
2	**logging**				
2.1	litho logic logging	LS	1	1	
2.2	El ectrical Logging	LS	1		
3	**Supply and installation of casings**				
3.1	Temporary Surface casing installation and removal	M	10	-	
3.2	Permanent Surface casing installation	M	6	16,000	96,000
3.3	PV C screen casing 8"	M	34	9,000	306,000
3.4	PVC Blind casing 8"	M	16	9,200	147,200
3.5	Supply and installation of 3/4 steel observation pipe	M	40		0
4	**River side, well sorted gravel packing(6-9mmΦ)**	M3	5	15000	75,000
5	Well development	hrs.	6	15,500	93,000
5.1	**Well Head Work Construction**				0
5.2	Construct C-20, Trapezium type, well head including grout	LS	1	21,500	21,500
5.3	Step draw down and Constant discharge test	Hrs.	6	28	168
5.4	Recovery test(up to 95% recovery to static water level)	Hrs.	4	1,500	6,000
5.5	Water Sampling and water quality analysis	LS	1	13,000	13,000
5.6	Well completion Report production	LS	1	8,000	8,000
Sub Total for one Deep well drilling					2,612,868
8	**Earth Work For Pond**				
Bill. No	**Description**	**Unit**	**Qty**	**Unit price**	**Total Price**
8.1	excavation of pond	m3	32,400.00	450	14,580,000
	Total				**14,580,000**

TAKE-OFF SHEET for Transmission main					
NO.	**L/W/D**	PRODUCT		**DESCRIPTION**	
				3.1	**Earth Work**
	1000 2			3.1.1.1	General clearance of site, along proposed distribution mains route to a width of max 2m of all bushes and trees including grapping of roots of stumps and removing from site
		2,000	**m2**		
	600 0.7 1	**420**	**m3**	3.1.2.1	Excavation of common soil for trench commencing at ground level not exceeding 1m deep*0.7m for installation of distribution main pipe, including disposal of surplus excavated material for 600m
	200 0.7 1	140	m3		
	400 0.7 1			3.1.2.3	Extra over for trench excavation in hard rock formation to a depth 1m*0.7m and disposal of surplus excavated material for 150m.
		280	m3		
	840	840	m3		
		-		**3.2**	**Supply and installation of Transmission main pipe**
		1000	m	3.2.1	HDPE pipe OD 90mm PN 16
		-		**3.3**	**TRUST AND ANCHOR BLOCKS**
		1	No.	3.3.1	Construct concrete thrust blocks (C-25), as shown in the standard drawing including, but not limited to, all required materials, labor, formwork, reinforcement, excavation, etc.
		-		**3.4**	**PRESSURE TESTING AND DISINFECTION**
		1000	No.	3.4.1	Pressure testing and commissioning of new pipeline for the whole work according to the specification, including all necessary works including checking of thrust blocks, anchor blocks, transportation and use of water, pipe fittings, and disposing of used water
		1000	No.	3.4.2	Disinfection of pipelines: flushing with clean water, filling with water containing 0.15 g/l calcium hypochlorite, left for 24 hours. This includes supply of all necessary equipment required for the work, chemical and water, as approved by the Engineer

TAKE-OFF SHEET for Construction of 250m³ concrete ground reservoir					
NO.	**L/W/D**	PRODUCT		**DESCRIPTION**	
				4.1	**EARTH WORK**
	16 10			4.1.1	site clearance
		160	m2		
	16 10 0.5			4.1.2	Bulk excavation in normal soil to a depth of 500mm
		80	m3		
	13.4			4.1.3	Ditto but in soft rock formation

	8.1 3				
		325.62	m3		
	13.4 8.1 1			4.1.4	Ditto but in hard rock formation
		108.54	m3		
	514.16			4.1.5	Cart away all excavated material, deposit to appropriate distance not exceeding 1 km
		514.16	m3		
	13.4	-		4.1.6	Place and compact back fill with selected material
	8.1	-			
	0.25	-			
		27.135	m3		
	13.4	-		4.1.7	Provide and fill hard core with hard basaltic or equivalent stone, well compacted and blinded with crushed stone to a finished thickness of 25 cm under the reservoir and valve chamber
	8.1	-			
		108.54	m2		
				4.2	**Concrete work**
	13.4			4.2.1	70mm thick lean concrete(C10) under the reservoir base slab and valve chamber
	8.1	108.54	m2		
	13.4			4.2.3	base slab
	8.1				
	0.1				
		10.85400	m3		
	43			4.2.4	Wall
	4				
	0.4				
		68.8	m3		
	13.4			4.2.5	roof slab
	8.1				
	0.1				
		10.85400	m3		
				4.2.6	10cm thick C-25 reinforced concrete for roof and floor slab of valve chamber
				4.3	**Provide and fix Form work**
				4.3.1	For base slab
	5				
	5				
		25	m2		
				4.3.2	For wall
	10				
	5				
		50	m2	4.3.3	For roof slab
	5				

	6				
		30	m2		
2	1.2			4.3.4	for valve chamber
	1.2				
		2.88	m2		
				4.4	**Provide, cut, bend and fix in position reinforced steel bar. All according to structural drawing. Price should include tying wires**
		81.33	kg	4.4.1	diameter 8mm
		297.15	kg	4.4.2	diameter 10mm
		2721.54	kg	4.4.3	diameter 12mm
		143.03	kg	4.4.4	diameter 14mm
				4.5	**Masonry work**
	43			4.5.1	40cm thick Masonry wall constructed for valve chamber with cement & sand mortar (1:3)
	4				
	0.4				
		68.80	m3		
				4.5.2	10cm thick 1m width stone pitching pavement C-20 around reservoir floor
	21.5				
	1				
		21.50	m2		
				4.6	**FINISHING WORKS**
	12.6			4.6.1	3cm thick plastering floor slab finish with (1:2) mix
	7.3				
		91.98	m2		
				4.6.2	Apply 3cm thick plastering of internal walls up to fine finish with (1:2) mix
	39.8				
	4				
		159.20	m2		
				4.6.3	Apply 12mm thick render plastering of external walls of the reservoir
	43				
	1.5				
		64.50	m2		
				4.6.4	3cm thick cement screed mix (1:3) roof slab finish
	12.6				
	7.3				
		91.98	m2		
				4.6.5	Plastering of the internal wall of valve chamber, floor and roof slab
8	1				
	4				
		32.00	m2		
		6	m2	4.6.6	Pointing of the external wall of valve chamber
		64	m	4.6.7	Provide and install water stop made up of natural and synthetic rubber or electromagnetic plastic compound with basic polyvinyl chloride (PVC) width 30cm
		1.00	LS	4.6.8	Provided and install access internal and external ladder constructed out of 1 1/2" dia GS pipe and hooked to the wall as

					per the drawing; including safety cages
				4.7	**PIPES, VALVES AND FITTINGS**
				4.7.1	Install DCI Inlet pipes and fittings and valves of with all required accessories, rubber sealing flat gaskets, bolts, nuts with washers
		1	No	4.7.1.1	DN 80 flanged bell mouth
		1	No	4.7.1.2	DN 80, L=4.7 m double flanged pipe
		1	No	4.7.1.3	DN 80, 90^0 Duck foot bend
		1	No	4.7.1.4	DN 80, Central puddled double flanged pipe L=1m
		1	No	4.7.1.5	DN 80 dismantling piece
		1	No	4.7.1.6	DN 80 double flanged pipe L=1.25 m
		2	No	4.7.1.7	DN 80, 90^0 double flanged bend
				4.7.2	**Install Outlet pipes and fittings and valves of with all required accessories, rubber sealing flat gaskets, bolts, nuts with washers**
		1	No	4.7.2.1	DN 100 suction strainer
		1	No	4.7.2.2	DN 100 Central puddled double flanged pipe L=1m
		1	No	4.7.2.3	DN 100 dismantling piece
		1	No	4.7.2.4	DN 100 flanged gate valve
		2	No	4.7.2.5	DN 100, 90^0 double flanged bend
		1	No	4.7.2.6	DN 100 double flanged pipe L=4.7m
		1	No	4.7.2.7	DN100 Flanged water meter
				4.7.3	**Install Over flow and drainage pipes and fittings and valves of with all required accessories, rubber sealing flat gaskets, bolts, nuts with washers**
1		1	No	4.7.3.1	DN 80 Flanged bell mouth
		2	No	4.7.3.2	DN 80 double flanged pipe L=240cm
		3	No	4.7.3.3	DN 80, 90^0 double flanged bend
		1	No	4.7.3.4	DN 80 Central puddle Double flanged pipe L=1m
		1	No	4.7.3.5	DN 80x80x80 flanged Tee
		1	No	4.7.3.6	DN 80 Central puddled flanged spigot pipe L=1m
		1	No	4.7.3.7	DN 80 flanged gate valve
		2	No	4.7.3.8	DN 80 double flanged pipe L=3m
		1	No	4.7.3.9	DN 80 Central puddled flanged spigot pipe L=1m
		1	pcs	4.7.3.10	DN 3" GI ventilation pipe with dome, L =1.0m and DN21/2" roof drain pipe, L=0.5m
				4.8	**COMPOUND WORK**
		314.7	m^3	4.8.1	Filling and compacting of selected material excavated from site in layers not exceeding 20 cm thickness
		157.5	m^2	6.8.2	Provide broken or other approved granular material forming bearing courses of road and parking areas of 25cm compacted thickness, including spreading in layers, watering and compacting
		120	M	4.8.2	Supply and erect Zinc coated (galvanized) steel chain link fence fabric with mesh size (1"-2") and nominal coated diameter (3.05mm) and RHS gate (80*80mm) as detailed, include for all intermediate straining and 50mm GI Pipe posts @ 2000mm spacing, 2600mm high (2100mm above OGL) and struts are to be embedded in concrete C-25 to a depth of 500mm as detailed on the drawings including earth work and all associated works. The dimension of the compound will be directed by the site engineer

	TAKE-OFF SHEET for distribution system				
NO.	**L/W/D**	PRODUCT		**I.NO**	**discription**
				I	**supply and installation of distribution system**
				2.1	Site Clearance
	4763			2.1.1	Site Clearance for distribution system
	2.00				(2m Width)
		9526.00	m2		
	3763.00			2.1.2	Excavation of common soil for trench commencing at ground level not exceeding 0.7width with 0.9m deep.
	0.90			-	
	0.70				
		2370.69	m3		
	1000.00			2.1.4	Extra over for trench excavation in hard rock formation to a 0.7 width with a depth of 0.9.m.
	0.90				
	0.70				
		630.00	m3		
		3000.69	m3	2.1.6	Backfill pipe trenches with suitable material
				2.2.1	**PN-16 HDPE Pipe**
		1804	M	a	OD 63mm HDPE Pipe
		1823	M	b	OD 75mm HDPE Pipe
		1136	M	c	OD 90mm HDPE Pipe
		30083	M	D	OD 20mm HDPE Pipe
				2.3	**Supply and Installation of HDPE Butt. Welding and Compression Fittings**
				I	**Butt Welding TEE (OD)**
		5	No	a	DN90/75/90mm
		5	No	b	DN 75x63X 75mm
		5	No	c	DN 75x75x75mm
		6	No	d	DN 63x63x63 mm
				II	**Butt Welding REDUCER (OD)**
		3	No	a	90mmx75mm
		1	No	b	90x63mm
		4	No	d	75x63mm
				III	**Flanged Gate valve**
		8	No	a	DN 80mm PN-16
		12	No	b	DN 65mm PN-16
		8	No	c	DN 50mm PN-16
				V	**Supply and Installation of HDPE end cap.**
		5	No	a	OD 63mm
TAKE-OFF SHEET foTAKE-OFF SHEET for Gaurd House @ Reservoir Site					
				5.1	**EARTH WORK**
	5.5			5.1.1	Clearing of site to remove top soil to a depth of 200mm
	5.5				
		30.25	m2		
2	2.30			5.1.2	Excavation for stone masonry foundation; 0.5m wide and 0.5m depth working space (external) = 0.20

	0.80				working space (internal) = 0.10
	0.70				
		2.576	**m3**		**total of 5.1.1**
2	3.90				
	0.80				
	0.7				
		4.37	m3		
		6.94			**total of 5.1.2**
				5.1.4	Cart away and deposit excavated surplus material to a distance not exceeding 1km
				5.1.5	Provide and fill hard core with hard basaltic or equivalent stone, well compacted and blinded with crushed stone to a finished thickness of 25cm
2	3.9			5.1.3	Excavation for floor slab 0.3m depth
	0.2				
	0.7				
		1.092	m3		
2	2.3				
	0.2				
	0.7				
		0.64	m3		
4	2.1				
	0.1				
	0.7				
		0.588	m3		
	3.1				
	3.1				
	0.3				
		2.883	m3		
		5.21	**m3**		
				5.1.6	Provide fill and compact selected material layer by layer in 200mm layer
	3.1				
	3.1				
		9.61	**m2**		
				5.2	**Masonry and Concrete Work**
				5.2.1	R.C. floor tie beam
	13.2				
	0.2				

	0.2				
		0.528	m3		
				5.2.2	R.C. column
4	3				
	0.2				
	0.2				
		0.48	m3		
				5.2.3	Lintel
	3.10	-			
	0.20	-			
	0.20	-			
		0.12	**m3**		
				5.2.4	R.C. roof tie beams
	13.2				
	0.2				
	0.2	-			
		0.53	m3		
				5.2.5	Mass concrete fill on floor slab (100mm)
	3.1				
	3.1	-			
	0.1	-			
		0.961	m3		
		32.3232	Kg	i	Diameter 8 mm deformed bar
		271.0176	Kg	ii	Diameter 12 mm deformed bar
				5.3	**Block work**
				5.3.1	Supply, assemble and fix in position eucalyptus roof truss of length 4.6m price shall include the application of three coats and external anti-termite treatment as per the drawing including eualyptus vertical and diagonal members
	2	3.50			
		0.50			
		0.70			
			2.45	m3	
	2	2.5			
		0.5			
		0.7			
			1.8	m3	
	2	6.60			
		0.50			

		1.20			
			7.92	m3	
			12.12	m3	
				5.3.1	Supply and raise 200mm thick concrete block wall laid in cement mortar mix 1:3
4	3.1				
	3	-			
		37.20	m2		
2	1.1				above top tie beam
0.5	3.5				
		3.85	m2		
	3.5				Paraphet wall
	1.1				
		3.85	m2		
	14				above roof
	0.2				
		2.8	m2		
	2.1				deduction for door
	0.9	-			
		-1.89	m2		
	1.5				deduction for windows
	1.1	-			
		-1.65	m2		
		44.16	**m2**		**total of HCB**
				5.4	**Carpentry and Roofing**
		12.6	**M**	5.4.1	roof truss price shall include the application of three coats and external anti-termite treatment
		21.00	**M**	5.4.2	Supply and fix purlin in zigba wood size 50 x 70 mm nailed into eucalyptus truss
				5.4.3	Supply and fix roof cover in G-28 mm corrugated galvanized iron sheet
	4.36				
	3.50				
		15.26	**m2**		
		4.90	**M**	5.4.6	Supply and fix 25x 250 mm fascia board to purlin
				10.5	**Finishing work**
		-		5.5.2	Apply three coats of plaster in cement mortar to internal cement concrete block wall

4	3.1	-			
	3.2				
		39.68			
	2.1				deduction for door
	0.9	-			
		-1.89	m2		
	1.5				deduction for windows
	1.1	-			
		-1.65	m2		
		36.14	**m2**		**Total of item 5.5.2**
				5.5.3	Apply cement mortar pointing to all external cement concrete block wall
4	3.1	-			
	3.2				
		39.68	m2		
0.5	3.5	-			above top tie beam
2	1.1	-			
		3.85	m2		
	3.5				
	1.1				
		3.85	m2		
	2.1				deduction for door
	0.9	-			
		-1.89	m2		
	1.5				deduction for windows
	1.1	-			
		-1.65	m2		
		43.84	**m2**		**Total of item 5.5.3**
12	30 20 4.5	**32,400**	**M3**		**8.Pond** Excavation

10 Annexes-1

a. Drilling method, Drawings/Design, and other related works

A. General

The areas within the Sites of the Works on which the Contractor shall be permitted to do his work, to assemble his equipment and tolls, to erect his stores as well as the rights-of-way for access to the said areas mentioned herein will be provided by the Employer.

B. Royalties

Any royalties payable by the Contractor in respect of soils or rocks excavated, or land outside that made available free under the Contract, for the construction of permanent works, shall be reimbursed.

C. Access to Well Sites

The Contractor shall perform all work necessary for access to the sites.

D. Clearing up of Site

During the progress and upon completion of the works, the Contractor shall clear up and remove from the surface of the ground all temporary buildings as per the Engineer's instructions. The Contractor clears from the site plant, material, and debris resulting from demolitions, litter, rubbish, and surplus soil which may be left on the ground or in and about the works or land temporarily occupied by the Contractor. After completion of the Works, the Contractor shall clean up the entire site and shall leave it in a neat and clean condition to the satisfaction of the Engineer.

b. Construction of Deep Wells

E. General

All materials and workmanship shall be of the best quality throughout and shall comply with the relevant latest edition of the American Petroleum Institute (API) or with equivalent ISO or British Standards. All materials to be permanently built-in shall be new and shall be accompanied by Manufacturer's Certificates, stating their compliance with this Specification and the standards mentioned therein and the name of the inspection authority.

F. Drilling Equipment

The Drilling rigs shall be capable of drilling to the specified depths and diameters and carrying out all subsequent operations required in this specification to tender the wells complete.

The Contractor shall permit the Engineer inspection of the Rigs and the equipment at his disposal at the time of tendering.

G. Methods of Drilling

Unless specified differently the Contractor shall be at liberty to drill the Deep wells in the said locations by any of the following drilling methods

i) Down the hole (DTH) drilling

ii) Air Rotary/Mud rotary

iii) Combination of any of the above

Unless the geological formation forces to apply Air rotary due to hard formation encounters and approval of the Engineer, **the Contractor shall apply only Mud rotary drilling methods for the construction of production and observation wells**.

H. Drilling Procedure

After the Contractor has acquainted himself with the specific conditions of the sites to be drilled, and before the beginning of work, he shall submit his detailed program of work. The following is only a general description of the work to be carried out and specific details will be determined while drilling is in progress and more information is at hand about the geological formations.

Whenever the nature of the geological formation is such that it is necessary to ensure the stability of the Deep well and/or that deposits are likely to fall in and/or be washed into the Deep well then the Contractor shall line the shallow well to the satisfaction of the engineer with suitable temporary casing.

The Contractor shall notify the Engineer in advance of each and every decrease in diameter of drilling.

The following shall apply to drilling with conventional drilling rigs:

The equipment shall be of the proper type and shall be in good condition so that the work can be done without any interruption. Drill collars of sufficient size and length shall be installed to maintain verticality.

Foaming additives and Bentonites can be used in DTH/Mud Rotary drilling method.

The selection, supply and use of drilling additives shall be the sole responsibility of the Contractor. Toxic or dangerous substances that may adversely affect the quality of the water shall not be added to the drilling fluid.

The Contractor shall be responsible for maintaining the quality of the drilling fluid to assure:

- Protection of water bearing and potential auriferous formations exposed in the well,
- Good representative samples of the formation material.

The Contractor shall collect samples at each 2 meters drilling depth intervals and shall measure electrical conductivity (EC) and temperature for the interval specified on the discharged water during drilling.

I. **Casing for Permanent use and Centralizes**

Casing to be used for the conductor pipe shall be of the specified diameter. The casing pipe may be of the longitudinal screw type. However, different types of casing may be used subject to the Engineer's approval. Casing to be used for the permanent inner casing and as permanent part of the shallow well shall have the specified diameter. The type and grade of tube shall be in accordance with API Standards.

J. **Temporary Casings**

Temporary casings under this specification are defined as temporary units or outer casings, which may be withdrawn when the permanent casing and screen are placed. The temporary outer casings intended for construction purpose only, shall be of such weight and design as necessary to prevent entrance of fine material, to be reasonably watertight, and to permit its installation without distortion or rupture to the specified depth and dimension.

K. **Well Screens**

Well screens of **8 inch nominal diameter** shall be provided for the production wells as directed by the Engineer. The length of active screen shall be determined in relation to the thickness of water-bearing strata and according to the driller's log and electrical log. The screen shall be designed to produce a

minimum loss of head or draw down between the water bearing strata, and the well and shall be of a standard manufactured type.

The type of screen to be used shall be slotted type. Screen opening as approved by the Engineer shall preferably be V shaped, widening inward to permit fine particles to pass through without clogging during development of the borehole. **The total open area of the screens shall be at least 30% of the total pipe area.**

Geologist's Approval for the Construction and Completion of the Well

The Contractor shall present for the geologist's approval his proposed material and construction methods for the completion of the Deep wells with regard to the following subjects:

a. Completion of the Deep wells by natural development

b. Details of the screen including type and technical specification

The Contractor shall construct the well as aforesaid on data and analysis of samples taken from the drilled well and other information obtained during drilling operations and to the Engineer's satisfaction. In no case should the Contractor undertake the completion of a shallow well prior to obtaining the Engineer's approval.

L. Grouting

The annular space between the surface casing and the wall of the drilled hole shall be filled with cement grout.

M. **Withdrawal of Temporary Outer Casing**

Temporary casings shall be gradually and carefully extracted to expose the screen completely in the water bearing formation.

The Contractor may leave the temporary casing in the shallow well above the screen but no payment will be made for such temporary casing left in the drilled well.

N. Testing for Verticality and Alignment

Verticality and alignment shall be tested by lowering into the housing line below ground surface a section of pipe 13m long or a cylindrical dummy of the same length.

The outer diameter of the pipe used for this test (the plumb) shall be 12mm smaller than the diameter of that part of the casing or hole being tested, If a dummy is used, it shall consist of a 10 or 13m long galvanized rolled sheet metal.

If the Contractor fails to correct such faulty alignment or verticality the Engineer may refuse to accept the payment of the drilled well. The engineer may waive the requirements of this paragraph for verticality if, in his judgment:

a. The Contractor has exercised all possible care in constructing the Deep well and the defect is due to circumstances beyond his control.

b. The usefulness of the completed Deep well will not be materially affected.

c. The cost of necessary remedial measures will be excessive. In no event will the provisions of this paragraph with respect to alignment be waived.

The Contractor shall, after completion of the test, prepare and submit to the Engineer a graph showing the verticality and alignment, or deviations there from, for every 3m from ground level up to the bottom of the housing line.

The average Well depth investigated to range shown on the bill of quantities depending upon the geological findings however the Well depth can be 120% of the bill of quantity drilling depth without any price adjustment. On the contrary, the Contractor might be ordered to stop the drilling operation at any shallower depth based on the Engineers recommendation drawn from investigation/analysis on the actual ground formations during the drilling. The drilling contractor is therefore required to be equipped, accordingly. The contractor shall be instructed by the Hydro geologist/Engineer on site about the final depth of the borehole.

c. **Development of Wells**

The Contractor shall furnish all necessary pumps, compressors, and other needed equipment as well as equipment of approved size and type for measuring the water discharge and shall develop the well by such approved methods as shall be necessary to give the maximum yield of water per meter of drawdown and extract from the water-bearing formation the maximum practical yield.

After conducting provisional pumping test, developing process shall start immediately and will be considered as completed when the deep well produces entirely clear water to the satisfaction of the Engineer. The water shall be considered sand free when no samples taken during the pumping test contain more than 5 parts per million of sand size particles by weight. The Engineer may require additional development work aimed to further improve the specific capacity of the well. Testing should not commence until complete development is achieved.

Development process shall be carried out in the presence of the Engineer who will issue detailed instructions as the work proceeds. The Contractor shall advise the engineer in sufficient time before staring the development of the borehole.

i. Airlift Development

Development by air compressor shall start immediately after well construction is completed and no elapsed time period is permitted. The airlift is to proceed systematically, from top to bottom until the discharge will be composed of load free clear water. Changing to further development methods such as the usage of surge plunger, jetty tool and pump development is subject to the Engineers approval.

d. Testing for Yield and Drawdown

General

After the well has been constructed and developed the Contractor shall notify the Engineer to that effect and shall make the necessary arrangements for conducting the final pumping tests. Pumping tests shall follow immediately after the completion of the Development Works.

Besides these final tests the Engineer may order the Contractor to carry out such additional tests during and after construction as he may deem necessary. All tests shall be run with similar equipment and in a manner like that hereinafter described.

The Contractor shall furnish all labor, materials, equipment and supplies required and shall operate the pumping unit at such rates of discharge and for such periods of time as required for the execution of the tests.

Step Draw down Tests

The following requirements shall apply to step drawdown and step recovery tests:

i. General

Before the test commences, a deep-meter, a stopwatch, and graph paper pad and pencil shall be on hand. The deep-meter shall be checked by lowering into the casing and a trial measurement shall be performed.

Once the equipment has been checked, at least three readings of the water level shall be taken during the half hour immediately preceding the test at ten-minute intervals to obtain the trend of the water level. If two of these are identical, it is possible to proceed with the test. If variations occur, the readings must continue for some time until a definite pattern is obtained.

ii. Procedures

The test shall cover at least four or five steps.

During successive steps, the discharge shall be increased when the draw down starts to stabilize. Discharges shall preferably, but not necessarily, be increased in steps of 0.2x Q-max. The Q-max will be known approximately from the pumping development stage and preliminary pumping test. The test shall commence with the lowest envisaged discharge rate.

Water levels shall be recorded during this time at intervals as follows for each of the steps:

Every	1	Minute	from	1-10	Minutes of Pumping
"	2	"	"		10 to 20 " " "
"	5	"	"		20 to 50 " " "
"	10	"	"		50-100 " " "
"	20	"	"		100 - 180 " " "
"	30	"	"		180 - 360 " " "
"	60	"			After more than 6 hours.

During this time the discharge rate shall be kept constant and recorded periodically.

The duration of each step shall be in no case less than 90 minutes, and if necessary longer, until a stable dynamic water level has been achieved.

At successive steps, the procedure for recording water levels and rates of discharge shall be repeated. The discharge rates of each subsequent step shall be increased by at least 50% of the preceding step until the maximum discharge is attained. A similar procedure shall be followed when a reverse step test is carried out. At the start of a reverse step test pumping from the borehole shall be at the maximum discharge and the dynamic water level shall be stable. Discharge and water levels shall be recorded. In the first step, the discharge shall be decreased. The following steps will be in the same pattern as the conventional step drawdown test. The consistency of the arrayed discharge/drawdown readings, i.e. the anticipated rectilinear regression line, is to be checked in the field. Should further development of the well be decided upon, another step-drawdown test shall be carried out at the well after the additional development.

Drawdown and Recovery Test

The following shall apply to drawdown and recovery tests: Drawdown and recovery tests shall be carried out in wells after development and the step drawdown tests have been completed. Tests shall commence after a stable water level trend has been ascertained by the means as specified under sub-clause 4.14.2 a) above.

Procedures

During the drawdown test, the discharge to be determined by the Engineer (most probably Q-max) will be constant at all times. The time of its start will be noted by use of a stop watch. Water levels will be recorded immediately preceding the start, and then at the following intervals of time in minutes in accordance with clause 4.14.2. (b) After pumping has started.

The test shall be continued for 120 hours or shall be terminated earlier in case the dynamic water level has stabilized for more than 8 hours.

At the end of a drawdown test, a recovery test will be carried out. This test is a mirror image of a drawdown test. The time at which recovery commences, is when pumping stops. This time is recorded, and water levels are recorded at the same time interval arrangement as previously noted.

Pumping Equipment for Development and Testing

The Contractor shall furnish and install the necessary pumping equipment consisting of a sufficient numbers, capable of **pumping 0.5-8 l/s at a head of 200m**. In case the production well is less than 0.5 l/s the Contractor should have on site a 1 l/s at a head of 200 meters Satisfactory throttling devices or other approved devices shall be provided so that the discharge may be controlled as required.

The pump shall be a vertical turbine pump, oil or water lubricated or any other submersible pump type of pump approved by the engineer and shall be in good running condition. The pumping unit shall be complete with prime mover of ample power, controls and appurtenances and shall be capable of being operated for long periods without interruption.

The pump base shall have a suitable opening for inserting a water level measuring device. The Contractor shall make available at the site during pumping test programme, at least two such pumps.

The Contractor shall also furnish, install and maintain equipment of approved size and type for measuring the flow of water, such as a weir tank, orifice or water meter. A regulation valve shall be inserted into the discharge pipe just outside the pump head.

Pump Test Pump Capacity for Deep wells

Submersible pump with all its accessories which can give 2- 8 Lit/second at 200m head, but also equipped with stand by pump

a. For Medium Discharge Borehole 5-10 Lit/second with 200m Head.

b. For Small Discharge Borehole 0.5-3 Lit/second with 200m Head.

Submersible pump with all its accessories which can give 4-8Lit/second with 130 m head, but also equipped with stand by pump

a. For Medium Discharge Borehole 8-12 Lit/second with 170m Head.
b. For Small Discharge Borehole 1-4Lit/second with 170m Head.

H. Recording and Reports of Development and Testing

The results of all tests described in Clause 5.3.13 and 5.3.14 shall be recorded in the form prescribed by the Engineer and full test reports shall be transmitted to the Engineer's office within ten days after the completion of the tests. General Requirements for analysis of Water Quality

Field and laboratory analyses of water quality shall be carried out by the Contractor with equipment and by methods approved by the Engineer. The number of samples to be taken and to be analyzed shall be at least two per borehole or as directed by the Engineer. Each sample shall be properly recorded, stating date and time, number of borehole and depth from which the sample was taken. Reports of the results of the analysis shall be submitted to the Engineer in triplicate within 15 days.

I. Field and Laboratory Analysis of Water Quality

The following water analysis shall be carried out:-

i. Field Tests

1) Temperature
2) PH
3) Electrical Conductivity (EC)

ii. Laboratory Tests

eneral Parameter	**Iajor Cat ions**	**Iajor Anions**
Electrical conductivity (EC) PH Total dissolved solids Alkalinity Hardness	alcium (Ca) Iagnesium (Mf) odium (Na) otassium (k) on (Fe) Ianganese (Ma)	hloride (Cl) luoride (F) arbonate (Co3) icarbonate (Hco3) ulphate (So4) itrate (No3) hosphate (Po4) oron (B)

I. **Daily Reports**

The Contractor shall submit a daily report describing the nature of material encountered, the work done during each day, including such items of work accomplished as depth drilled, casing set, the water level in the well at the beginning and end of each shift and such other pertinent data as he is requested to record by the Engineer.

J. Working Records and Samples

The Contractor shall furnish to the Engineer, in a form to be approved, the following records and samples:

Identification and Lithology of Formations

The Contractor shall keep an accurate record of the materials encountered during the drilling of the well and shall make every endeavor to describe accurately the formation layers. The Contractor shall also ensure that the description of the formation samples given by him is sufficiently accurate to permit the identification of both litho logy of the formation penetrated by the borehole and the strati graphical succession.

Representative samples shall be taken at fixed intervals of not more than 2m and at each change in formation. Samples and cores shall be stored temporarily until completely dry, in wooden or aluminum alloy boxes with compartments on which the depth interval represented by each sample shall be clearly marked.

Records of Water Levels

The Contractor shall keep an accurate record of the depth at which the water level stabilizes as each auriferous unit is encountered and of the depth of the top and bottom of each stratum penetrated.

Records of Casing and Screen Pipes

The Contractor shall keep and exact record of the order in which each length of pipe is installed in the well, identifying each one by number, size and length.

Records of Verticality and Alignment

As per clause 5.3.12

Records of Pumping Tests

The Contractor shall keep an exact record of all data pertinent to pumping tests specified under clause 5.3.13 and 5.3.14.

Records of Water Analyze

The Contractor shall keep a complete record of all water analyses as set out in clauses 5.3.17 and 5.3.18. All samples and records shall be submitted to the Engineer during the progress of work as and when required by him.

Capping of the well

On completion of the well, concrete slab shall be cast around the upper part of the surface casing to a depth of 20cm dimensions as directed by the Engineer and so as to fill the space between the surface casing and the wall of the well. The top of the permanent casing shall reach 20cm above normal ground level. The conductor pipe (surface casing) around the inner casing shall be raised at least 30 cm above the inner casing and then capped properly by welding 6mm thick steel plate to secure the well. An appropriate socket and plug is to be installed in the steel cap to enable static water level observations.

Completion of well

Upon the completion to the Engineer's satisfaction of all work and tests and submittal of all records and reports as set out under this specification, or required by the Engineer during the execution of the drilled well, the Engineer will issue a Certificate of completion for each well as and when completed.

Well Completion Report

A full borehole completion report shall be prepared by the Contractor and submitted to the Engineer within ten days of the completion of the pumping tests. The borehole completion report shall be prepared in the form prescribed by the engineer and shall include the following:

a. A borehole long, showing: borehole location, ground surface elevation, measuring point elevation, soil strata, static water level and dimensions of casing, screen, grouting and cap.

b. Pumping tests reports

c. Results of analysis of water

d. All other records as specified under Clause 5.3.20

Items (a), (b) and (c), shall be submitted to the Employer.

K. Clean Up

After the borehole has been completely constructed, its environs shall be thoroughly cleaned of all foreign substances, including tools, timbers, and ropes, debris of any kind, cement, oil grease, joint dope and scum.

L. **Protection of well**

At all times during the progress of the work, the Contractor shall protect the borehole in such a manner as is effective to prevent either tampering with the well or the entry of foreign matter into it.

M. Precautions against Contamination

The Contractor shall take such precautions as are necessary at any time or as may be required permanently to prevent contaminated water having undesirable physical or chemical characteristics form entering the stratum from which the well is to draw its supply, through the opening made by the Contractor is drilling the well He shall also take all necessary precautions during the construction period to prevent contaminated water, gasoline, or any other contaminant from entering the drilled well either through the opening or by seepage through the ground surface.

In the event that the borehole becomes contaminated or that water, having undesirable physical or chemical characteristics, enters the well because of negligence by the Contractor, he shall, at his own expense, perform such work or supply such casing, seals, sterilizing agents or other material as may be necessary to eliminate the contamination or shut off the undesirable water.

N. Freedom from Load and Turbidity

The Contractor shall exercise extreme care in the performance of his work in order to prevent the breakdown or caving-in of strata overlying that from which the water is to be drawn. He shall develop, pump, or bail the borehole by such methods as may be approved by the engineer, until the water pumped from the borehole shall be substantially free from load and until the turbidity is less than 5 mg/1.

O. Stoppage of Drilling

The Engineer reserves the right to stop drilling operations at any well:

I. When the Engineer considers that a sufficient supply of water has been obtained,

II. When the engineer considers that further drilling is unlikely to be advantageous,

III. If the engineer considers that the work is not being carried out in a satisfactory

P. Abortive well

Any borehole/well, which on completion yields less water than in the opinion of the Engineer is necessary to render it of use, shall be considered as an abortive well. In this case the Contractor will be paid for drilling of the borehole at the appropriate rates in the Bill of Quantities. The abandoned well shall be sealed as described in clause 5.3.28

Q. **Failure to complete a well**

Should the Contractor fail to comply with the requirements of this specification or should the Contractor fail to complete the borehole due to loss of tools or any other cause, and the borehole as a result thereof, has to be abandoned, then the Engineer shall have the right to instruct the Contractor to commence a new well as near as practicable to the abandoned one and no payment will be made for drilling the abandoned well or any other work carried out in it, or for the casing or other materials used therein.

The Contractor shall seal the borehole at his own expense, within one month after he has been instructed to seal. Salvaged material furnished by the Contractor shall remain his property.

R. Sealing of Abandoned or Abortive well

Abandoned or abortive well/ boreholes shall be sealed by filling with concrete, grout, neat cement, clay or clay and sand. In the event that the water bearing formation consists of coarse gravel and producing wells are nearby, care must be taken to select sealing materials that will not affect the producing wells. Concrete may be used if the producing wells can be shut down for a sufficient time to allow the concrete to set. Clean, disinfected sand or gravel may also be used as fill material opposite the water-bearing formation. The remainder of the well, especially the upper portion, shall be filled with clay, concrete, grout, or neat cement to exclude surface water. The latter method, using clay as the upper sealing, materiel, is especially applicable.

S. Electric Logging

Electric logging shall be conducted in successful well the obtained electric logs shall verify and supplement the descriptive logging of the borehole recorded by the Contractor as drilling proceeds, as to the following:

- Details of the litho logical profile
- Depth of aquifers

Instrumentation for electric logging shall be of the two electrodes “normal device” type. One electrode shall be for the measurement of self-potential (SP), and the other electrode for the measurement of the apparent resistivity (R). All equipment and instruments used for electric logging shall be to the approval of the engineer.

The Contractor shall carry out the required operations by personnel skilled both in conducting the measurements and the interpretation of the results. The operation shall be as follows:

a. Electric logging shall be conducted in uncased boreholes upon completion of the drilling of the pilot holes (before reaming).

b. The drilled hole shall be cleaned by circulation of drilling fluid and its depth measured.

c. The electrode cables shall be lowered into the borehole while at the same time measuring the depth.

d. The logs shall be taken from the bottom of the borehole upwards while the cable is taut over its entire length. Upon completion of all operations the Contractor shall provide the Engineer with the electric logs comprised of SP curve and R curve, together with their interpretation. Contractors equipped with Gamma or neutron logs on top of Sp and resistivity logs are preferred. Should the engineer refuse to accept the results of the logging because of technical faults, then the Contractor shall repeat the measurement until satisfactory results are obtained

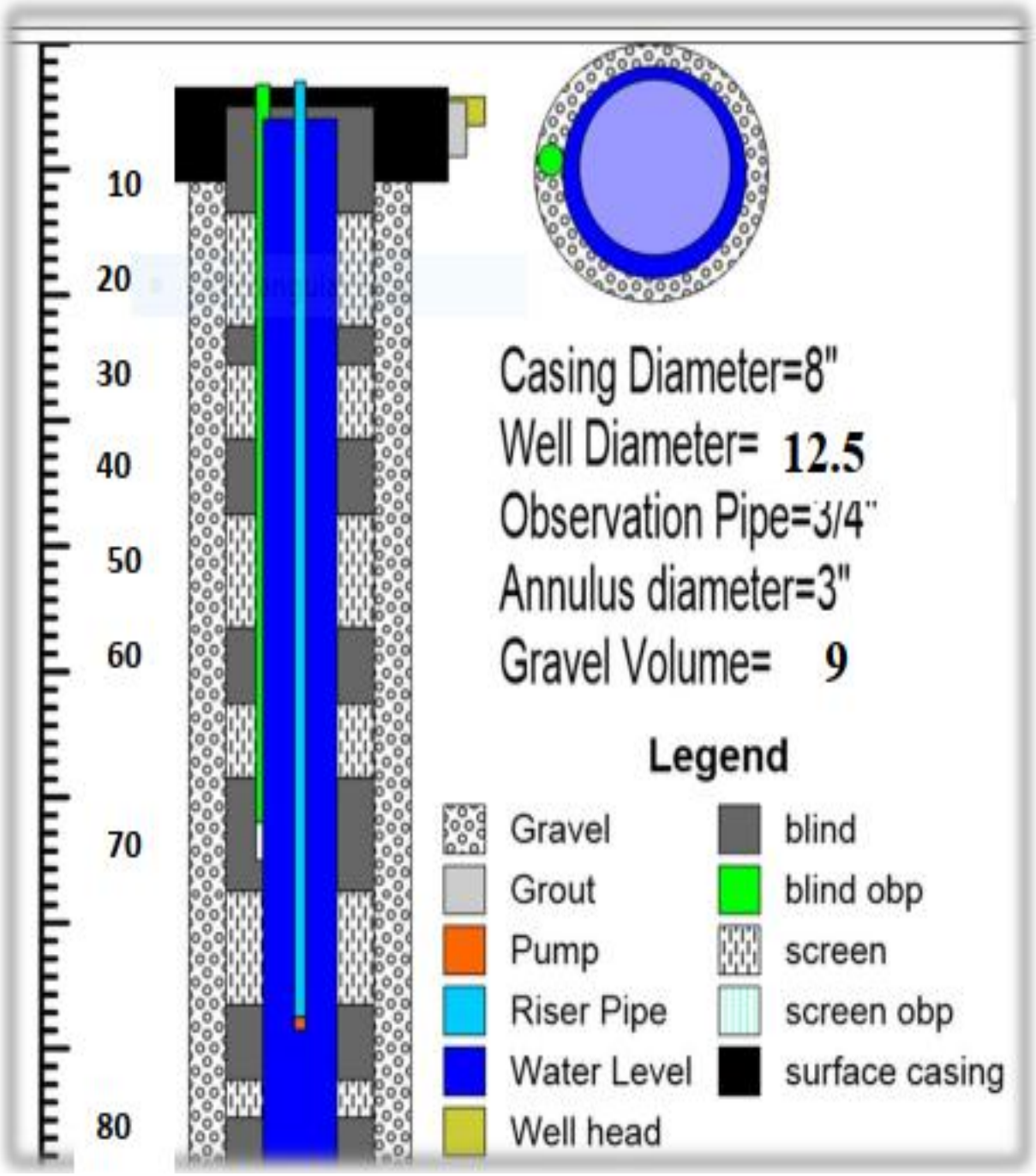
e. Classification of formations

Deep well drilling shall be classified as soft medium and hard formations defined as below:

- Soft:- shall mean unconsolidated materials. /grain size range between clay - cobble/and highly weathered rock.
- Medium:- shall mean un consolidated materials / grain size greater than cobble size/and moderately weathered rocks
- Hard: - shall mean all rocks/degree of weathering from fresh to slightly weathered/.

Preliminary Well Design

The proposed wells or Water wells are located based on the findings of geological, hydrogeological, structural, Geomorphological and hydrological investigation result of the area. The overall objective of the design is to create a structurally stable, long-lasting, efficient well that has enough space to house pumps or other extraction devices, allows groundwater to move effortlessly and sediment-free from the aquifer into the well at the desired volume and quality and prevents bacterial growth and material decay in the well, and Well design depends on the types of aquifer, aquifer formation, the expected discharge and local geology of the study area.



Appendix-2

<u>Checklists for Water well Drilling Supervision and Construction but not Limited</u>

1. Location

Lat/long_____N, _____E or UTM in_____meters using WSG/Adinand Specific Kebele/Got_____

2. Site clearing (Yes/No)

3. Drilling Commencement and Compilation Date from _____to_____
4. Drilling rig type /DTH/Air/rotary/_____
5. Well logging / Litho logical logging;

epth(m) From--to--	thology	ormation/water strike/Aquifer

5. Casing Arrangement

epth(m)	ype of casing(blind/Screen)	emark

6. Total depth____m, 7. Estimated yield _____l/s,
8. Drilling diameter_____in inch, 9. Blind casing used ____m in _____inch and Screen casing used_____m in _____inch
10. Surface casing used_____m 11. River Gravel packed_____m3
13. Well Development_____hr 14. Static water level_____m, Dynamic water level_____m
15. Well head construction (as per agreement/not), 16. Well Disinfection (Yes/No)
17. Hand pump supply and installed (Yes/No)