AMHARA NATIONAL REGIONAL STATE
WATER ,IRRIGATION AND ENERGY BUREAU
(BWIE))

# FEASIBILITY STUDY & DETAIL DESIGN OF CHELEKA DIVERSION/WEIR SMALL SCALE IRRGATION PROJECT

## VOLUME II: ENGINEERING GEOLOGY

## FINAL REPORT

CONSULTANT:
AMHARA DESIGN & SUPERVISION WORKS ENTERPRISE

**Amhara National Regional State**

**Bureau of Water Irrigation and Energy (BoWIE)**

**Feasibility Study and Detail Design**

**Of**

**Cheleka Diversion Weir Small Scale Irrigation Project**

**Engineering Geology**

**Final Report**

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**Ethiopia DESSIE**

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## Table of Contents

## Plates and List of Figures

# 1. Introduction

## 1.1 General

Since agriculture is one of the principal means of bringing sustainable development in the country, it is vital to plan and modify the farming system by adopting modern agricultural practice and utilizing naturally available water resources for irrigation purpose. In this line, the regional government has planned to implement irrigation projects, with the help of various funding agencies and by its own budget in order to solve food security problems. The Amhara Water Bureau of water irrigation and energy is the sole agent or client to implement the engineering identification, study and design, and later construction supervision of small scale irrigation schemes following various approaches; on force and/or contractual modalities the Amhara Design and Supervision Works Enterprise (ADSWE) have received several such schemes to provide consultancy services; study and design. One of those projects that have been given attention is the Cheleka weir diversion small scale irrigation project.

For the design of various stable and cost effective engineering structures in different parts of the project, the areas were investigated to gather engineering geological and geotechnical input data. This engineering geological feasibility study was carried out from June 12 to 19, 2008EC.

Geotechnical investigations are performed to evaluate those geologic, and soil conditions that affect the safety, cost effectiveness, design and excavation of the proposed project. The fact that insufficient, faulty interpretation of results, or failure to portray results in a clearly understandable manner may contribute to inappropriate designs, delay in construction schedules, costly construction modifications, use of sub-standard borrow material, environmental damage to the site, post construction remedial work and even failure of structure and subsequent litigation. Hence, geotechnical investigation is usually thought of as the backbone of engineering structure design.

Investigations performed to determine the geologic setting of the project include the geology (nature and behavior of rock materials), soil and rock behaviors, and seismic conditions. This parameters influence the construction site selection through the control of the characteristics of the foundation soil and rocks, geotechnical conditions, project safety, design, and construction, critical geomorphic processes and source of natural construction materials.

Based on the above facts, the site selection criteria and factors that should be taken in to account in studying the diversion site are as listed below:

- Nature of subsurface material at the diversion axis and potential canal route with the fact that they should be sound and resistant to bear the load imposed by the weight of the overlying materials, including the structures to be built.
- Suitability (shape and depth) and stability of the valley slopes at the abutment and capability to bear the lateral pressure imposed by the nearby soil material.
- Nature of the abutment ground material in reaction with water (solution resistant rock, soil, or nature of clay material).
- Uniformity of geological formations, geological structures and their continuity.
- Topographic conditions of the river both upstream and downstream of the anticipated weir axis.
- Relation of the anticipated diversion axis with the potential canal route and the available command area.
- Availability and quality of naturally occurring construction materials within an economically justified distance from the project site.

### 1.2 Objectives

The study is focused to give sufficient pertinent information on the geologic formations and their suitability for proposed construction. Consequently, the specific objectives to be addressed within this study are:

- Developing overall approach on the geological parameters through investigation of surface and subsurface geological conditions of the site to provide geotechnical inputs needed for the design of the diversion structure and main canal, so that the project becomes cost effective, durable and socially acceptable.
- Explaining the local geology and developing findings to the rock units and structural patterns on the context of the local area of interest.

- Locating the specific sites for the construction of the headwork and potential canal routes, which are resolute on the basis of:
  - ✓ Determining the geotechnical conditions of the headwork axis and potential canal routes.
  - ✓ Defining the distribution of formations in space.
  - ✓ Suitability of the land and stability of the foundation material for the construction and establishment of stable water tight zone.
  - ✓ Strength, workability and permeability of the existing formations.
  - ✓ Providing pertinent and reasonable information for post survey data analysis in the design and construction of the proposed structures.
- Determining the qualities and identifying the sources of naturally available construction materials within an economically feasible distance from the construction site.
- Defining ground water condition and its influence on the structures.

### 1.3 Locations and Accessibilities of the Project

The project site is located in the Amhara National Regional State, South Wollo Zone, Kalu Woreda, Abecho Kebele. The Weir site is located at 599088 E, 1229872 N and 1428m river bed elevation GPS reading. The project can be accessed from Kombelcha town which is the Woreda town, located at about 25km far from project site. The first 20km is along Kombelcha– Bati main Road. It is about 3.5 km gravel road from the kebele and the remaining about 1.5km is along the river which needs cross road.

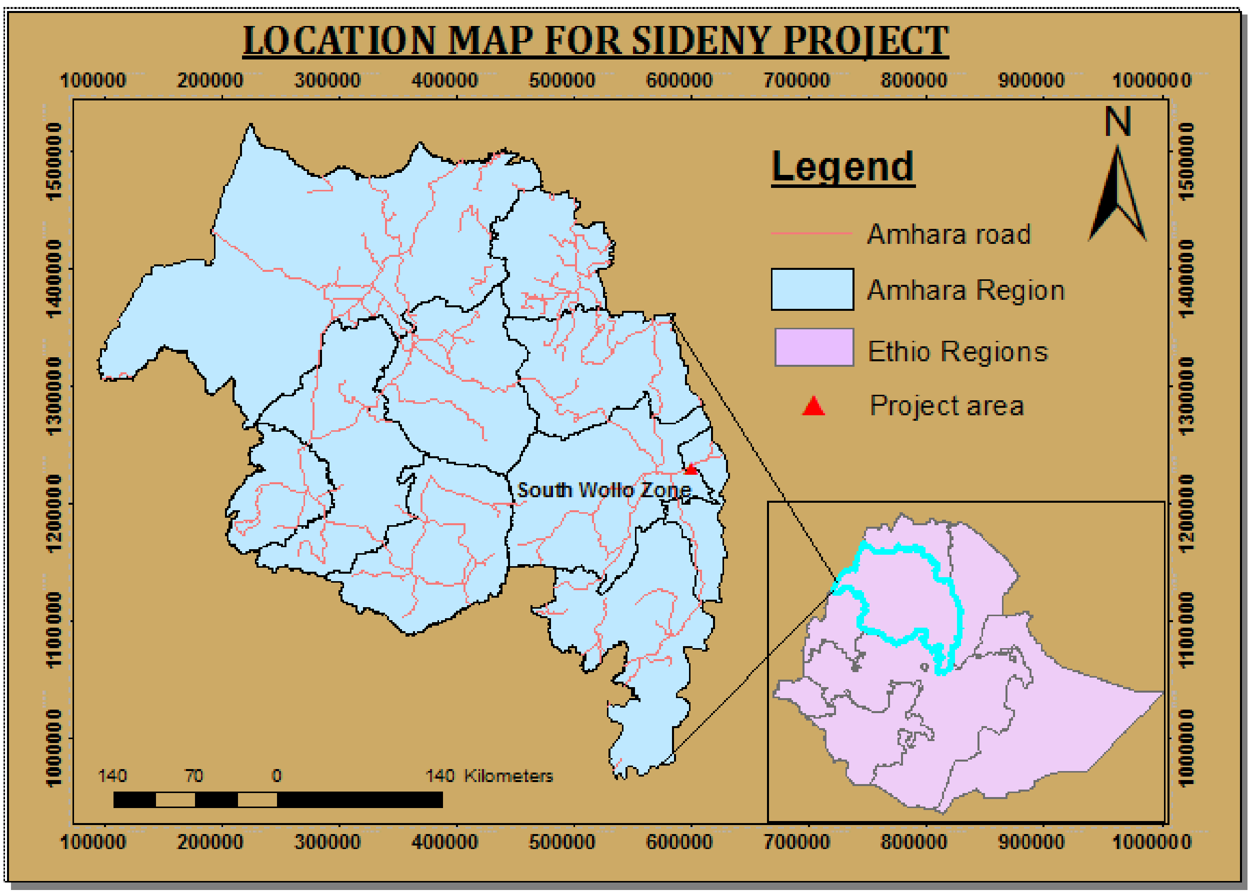


**Figure 1: Location Map for Project Area**

## 1.4 Methodology

- ✓ Different traverse were taken to have clear geological visualization of the study area, following river line, gully sections main canal route, exposures etc.
- ✓ Hand dug test pits taken for sub-surface geology and workability descriptions.
- ✓ Review previous works concerning the regional geology and hydro geological setting of the study area.

## 1.5 Materials and Instruments used

During geological feasibility studying the following materials were used to take data from weir axis, canal route, abutments, flood plain etc.

- Global position system (GPS)
- Computer
- Photo Camera
- Hand digging tool,
- Tape meter

# 2. Geology of the Study Area

## 2.1 Regional Geology

The Ethiopian volcanic province is characterized by two volcanic series: the Tertiary Trap Series of the high plateau and the recent (Pliocene-Quaternary) Aden volcanic series. Contemporaneous with the major uplift of the Horn of Africa, extrusion occurred from fissures and centres of immense quantities of flood lavas (Traps). These lavas covered the greater part of the Mesozoic rocks in Ethiopia.

The Trap Series consists of a very thick succession of lava flows, chiefly flood basalts (Traps), but with Trachytes and Rhyolites occurring especially near the top of the Series. The Trap Series essentially pre-dates the Rift faulting and therefore forms the great heights of the Ethiopian plateau. The Aden Volcanic Series post-dated the Rift faulting and is largely confined to the floor of the Rift System where it lies on the Trap Series (Mohr, 1962).

According to Blandford (1869), three volcanic units are distinguishable: the Trap Series of the plateau subdivided into the Ashangi and the Magdala groups; and the Aden Series. The Ashangi group includes predominantly basaltic rocks while the overlying Magdala group is essentially Silicic. Young (Quaternary) volcanic rocks were designated as the Aden Series (Kazmin, 1962).

There are three volcanic cycles for the north eastern part of the western plateau, Zanettin and Justin-Visentin (1975):

- First cycle: pre-Oligocene volcanic activity giving rise to the outpouring of the Ashangi basalts that cover the upper sandstone unit.
- Second cycle: after a long quiescence, the second volcanic cycle began to erupt in the lower middle Oligocene and cover the Ashangi penplain. This cycle started first with flood basalts (Aiba basalts) and later with large quantities of ignimbrites (alkaline rhyolites and trachytes) with variable quantities of interbedded basalts, collectively known as the Alaji rhyolites. This cycle culminated in the emission of large quantities of basalt, termed Tarmaber basalts that cover most of the Alaji rhiolites.

- The third cycle is confined more to the rift and its periphery and also to the Lake Tana Area of Plio-Pleiostocene age.

The Trap Series, consisting of Asahngi, Aiba, Alaji and Tarmaber formations, make up the regional rock units from bottom to top in the north eastern part of the western plateau.

The Ashangi formation is tholeiitic and/or basalts (Zenettin et al., 1978). The Aiba basalts, which overlie the lower Ashangi basalts unconformably, are transitional between tholeiitic and alkaline basalts. The Alagi rhyolites and basalts, which are a product of fissural volcanism, are dominantly Silicic and are made up of alkaline rhyolites and Sodic ignimbrites intercalated with variable quantities of transitional basalts. Tarmaber basalts are products of central eruption and are alkaline in composition.

The Tarmaber Series consists of lenticular basalts with a large amount of tuffs, scoriaceous lava flows and typical red paleosoils (Merla et al., 1973). The Tarmaber basalt is a thick sequence that reaches 1,000 m and when thicker, characterizes volcanic centres such as Guna Terara. The Tarmaber basalts directly overlie the Ashangi basalts (in northwestern Ethiopia), mark the Tertiary volcanic cycle in the region. Based on a few sections from escarpment part of the plateau, the above was assumed to be valid until recent times for the entire western plateau. Therefore from field observation the study area is belongs to **Aiba basalt**.

## 2.2 Local Geology

The solid geology of the study area is characterized by Aiba formations. These formations which are belong to Tertiary periods; and superficial soil that covered the Study area is Alluvium deposits/ Quaternary sediments. Brief description of these geological units is presented in the following subtitles.

### 2.2.1 Basalt

The basalt unit is observed at the river bank exposures near headwork axis, which is characterized by weathered to slightly jointed basalt unit.

### 2.2.2 Quaternary Sediments

Most part of the study area is covered with unconsolidated deposit. The deposit has been classified as residual and alluvial on the basis of its origin. Brief description of each group has been presented in the following section.

Following the Tertiary volcanic basaltic rock formation, the area has been affected by different surface processes of weathering, and sediment transportation that superficial soil are developed and cover some areas of the site. These superficial soil materials observed at the site are classified into five major units for the sake of this project. These are:-

a. Silt, with some fine sand, Floodplain Deposit,
b. Sand with Gravels and boulders, recent loose alluvium,
c. Cobbles and boulders with some gravel and sand, of dense old alluvium,
d. Gravely clay, of residual soil at sloppy part.
e. Silt clay, alluvial soil at command area.

The distributions and geotechnical characteristics of the various superficial materials found in the project area with their influence in the engineering design of various structures are described in section 6 chapters.

## 3. Seismicity Condition of the Study Area

Earth quake is the vibration of the earth due to the sudden release of energy in the earth's surface that creates seismic waves. The seismicity of the area refers to the frequency, type, magnitude and size of the earth quakes experienced over a long period of time in a specific area.

To construct durable, cost effective and long lasting engineering structures in general and hydraulic structures in particular, assessments on the susceptibility to seismic hazards are the fundamental issue. Therefore, the degree of seismicity of the area should be taken in to account with great emphasizes as an important design parameters by evaluating the seismic nature of the area from history and records of previous earthquakes and knowledge of local geological formation.

However the seismic susceptibility is usually made with the application of secondary data from the national geography and geo observatory data sources. The most famous edition in Ethiopian context is the seismic susceptibility map of the country by Laike Mariam Asfaw, 1986. According to the seismic hazard map of Ethiopia, the country has been subdivided in to five seismic zones as: zone (0) no hazard ,zone(1)low hazard, zone(2)moderate, zone(3)higher and zone(4)highest. The project site is located within the seismic zone of zone (4) that is highest seismic zone. The engineering structures constructed on this zone is must be consider the horizontal acceleration of $0.07*9.8m/s^2=0.686m/s^2$.

For general understanding of the countries seismic zones with respect to the project area could be analyze with the following figure which prepared.

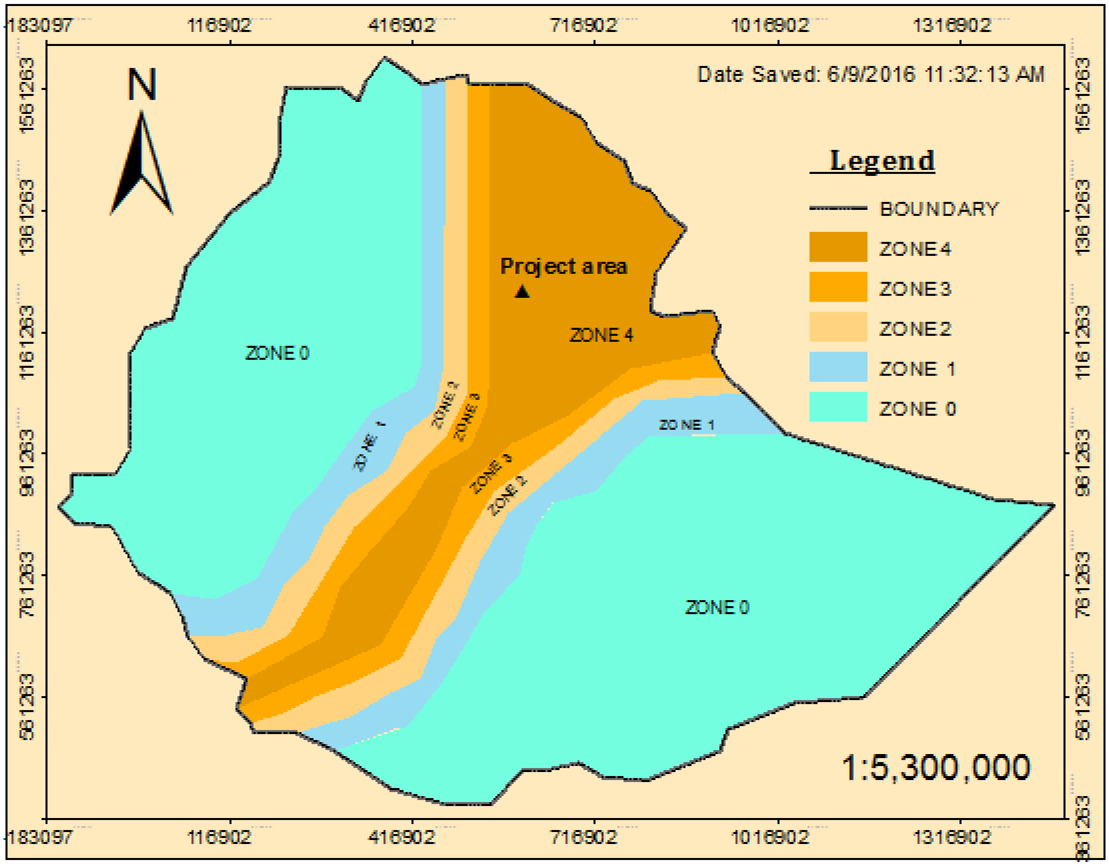


**Figure 2: Seismic Risk Map of Ethiopia 99 Years Return Period**

# 4. Geomorphology and Drainage Patterns

## 4.1 Geomorphology of the Area

The surface geological assessment and detail topographic survey of the study area are the main relevant components of the project during site investigation.

The project site is characterized by lowland command area with very steep high morphology of surrounding ridges in all direction. The command area is located in the East direction of the proposed diversion head site.

## 4.2 Geomorphology of the River and Drainage Patterns

The river almost has gentle to medium slope which is depositional river. And erosion is minimal due to its stable Rock River banks. However, the river is mature, defined and has stable abutment so that the course may not be changed through time.

**Plate 4.1: River Morphology**

# 5. Hydrogeology

The ground water storage, transmission and yield of the aquifer at different formation are different due to the cementation and consolidation of soils and the weathering, and fracturing condition of rock formations.

In the study area the aquifer characteristics of the formation were studied on the basis of field observations such as the distribution of springs, the degree, extent and orientation of fracturing rocks, the grain size distribution, the degree of cementation of soils as well as the depth and extent of rock weathering.

The mountains and hills of the study area are highly weathered that have different orientation of fractured rocks that allow increasing the infiltration rate of surface water to the subsurface. Due to this condition springs are outflow at the foot of the mountains and the ridges and flow towards the main river and join it.

# 6. Engineering Geological and Geo-technical Investigation

This part emphasizes on the details of engineering geology and geo-technical aspects of the project focusing on strength and permeability characteristics of the underlying formations over which proposed structures lies, mainly at headwork and along main canal route. In addition to this, required natural construction materials' source areas and their suitability conditions are discussed.

## 6.1 Headwork Site

The weir site of Cheleka irrigation project is locates at GPS reading 599088 E, 1229872 N and 1428m above river bed elevation.

For this project a weir structure has been proposed for diverting the water to the main canal. The headwork site geological surface and subsurface conditions have been investigated based on the nature of the proposed structure. At the site and immediate vicinity, the stream flows along nearly gentle slope course and its bed mainly covered with recently deposited alluvial sediments. These sediments are dominated with gravel sand sediment deposit. At some portions of the stream bed, especially at the left ends, there is deposit of cobbles and boulders. On the other hand, both banks of the stream at the headwork site are made up of bed rock (basalt bed rock). The detail geologic nature of the banks, and bed of the stream along the headwork axis and immediate vicinity are described and their potential geotechnical influence on the proposed structures also discerned/detected below, with remedial measures.

### Left Bank

At the headwork site/axis, the left bank is characterized by relatively moderate slope. This river bank portion has 2.5m rock exposure which is made up of top weathered and slightly jointed to fresh bed rock to the depth. This rock unit is basalt rock which has good strength that can help to construct any structure. This rock unit continues its thickness upstream and decreases downstream.

**Plate 6.1: Left Bank and Stream Bed ends Geologic Formations**

**Stream Bed**

At the proposed headwork site the stream bed or course is well defined, nearly straight, and shows rough surface due to recent sediment accumulations and undulating appearance of bedrock outcrops. Along the weir axis, the bed is made up of two basically different geologic materials, as seen from surface observation. These are **recently deposited alluvial coarse grained sediments**, and **underling bedrock**.

The central areas of the bed (lower elevation portions) are totally covered with the alluvial deposits, whereas at both stream bed ends there is fresh basalt rock. The bedrock is totally covered with the sediments at the central areas of the stream bed. To know the thickness of the sediments or depth to bedrock, a test pit (AbFOTP-1) has been taken at 599084 E, 1229879 N and 1427m elevation GPS reading within stream bed. Due to excessive subsurface water inflow to the pit, the excavation has been interrupted before encountering the required bedrock. The bed is totally covered with the sediments at the central areas of the stream bed. To know the thickness of the sediments or depth to bedrock, surface geological understanding of the area (careful observation of up and downstream of the river geology) would be used to estimate the thickness of sediment covered the area of the stream bed. And the thickness of the sediment at the center of the stream bed estimated about 3 to 4m depth from the surface. Totally the stream bed deposits mainly composed of gravel and sand with some cobble and boulders. To determine the average grain size of these deposits, it has been taken to laboratory and the result will be attached finally as Annexture.

**Plate 6.2: Headwork site**

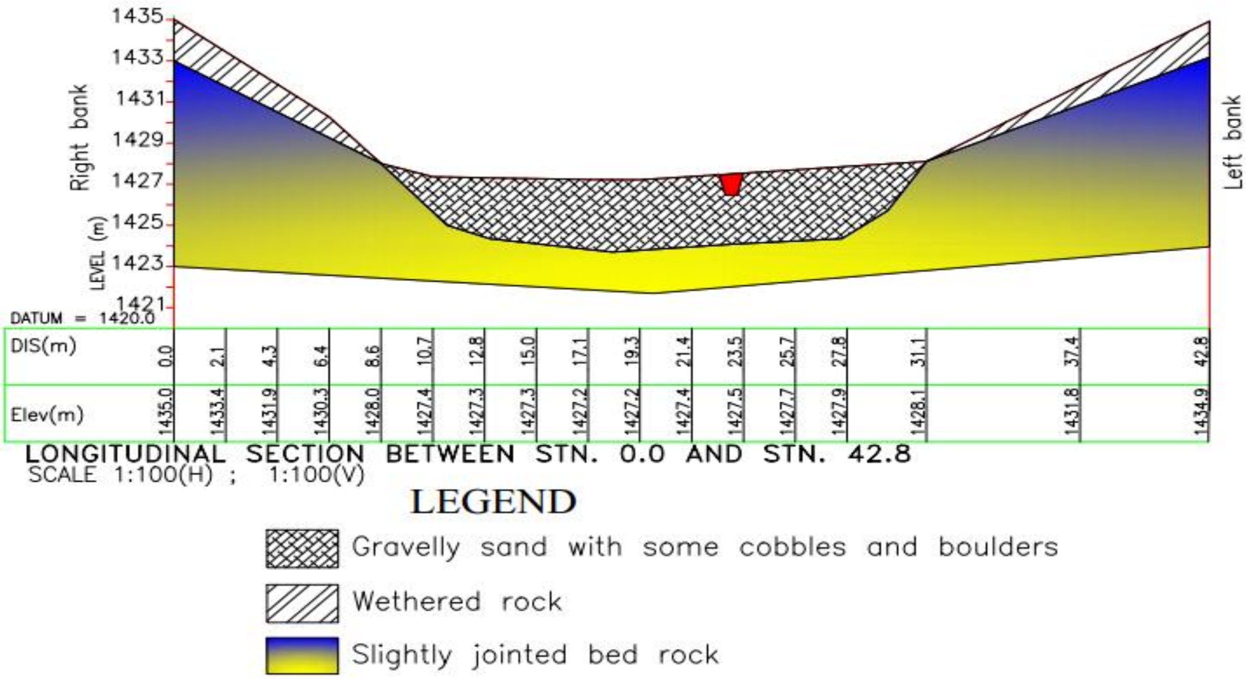


**Figure 3: Engineering Geological X- Section along Headwork Axis**

As described above, the foundation area of the headwork site is characterized by non-uniform geologic materials of the stream bed; the sediments and bedrock. The former is loose and pervious, while the bedrock is strong and impervious. It is therefore better to incorporate a positive cut-off masonry wall at the central portion of the bed that anchored to the bedrock after intercepting the about 3 to 4m thickness sediment layer. This will help for both seepage barrier and also stability conditions.

**Table 6.1: Properties of Stream Bed Materials**

| No | Parameters | | Sample Code |
|---|---|---|---|
| | | | AbFOTP- 1 |
| 1 | Grain size distribution | Gravel % | 24.5 |
| | | Sand % | 67.3 |
| | | Silt & clay | 8.17 |
| 2 | Soil Classification | D10 | 0.16mm |
| | | D15 | 0.29mm |
| | | D30 | 0.65mm |
| | | D50 | 1.2mm |
| | | D60 | 2.2 |
| 3 | Soil class | USCS name | GP |
| 5 | SP | 2.79 | |

**Right Bank**

At the proposed headwork axis and immediate vicinities, the right bank forms relatively steep slope topography. From surface observation, the bank is made up of one basic geological unit. The rock unit is slightly jointed basalt bedrock which has very hard strength the same as at the left bank. This rock unit continues downstream and decreases upstream. Its thickness at the headwork axis is 3m vertical exposure.

**Plate 6.3: Right Bank and Stream Bed Ends**

### 6.2 Main Canal Route

For this particular project, the main canal is left sided canal and the proposed canal has about 4.7km length. Within this length, the canal passes different geologic materials. To bring water from river to the proposed command area and well-designed main canal route, which is based on the ground nature, is very important. The distribution of the geologic materials with respect to the canal route, and their characteristics, especially permeability, stability and workability have been investigated during the field work using visual inspection of different exposures along the expected canal route.

Based on the findings of the surface and subsurface geological investigations and with reference to design chainages and also natural existing features, the canal route ground conditions have been described in the succeeding sections.

- **From 0+000m to about 0+900m** (within the Left bank slope), the proposed canal route passes silty clay soil of gentle slope topography, see plate below. During construction, rock excavation may include along the first 30 to 50m of this interval, workability problems are an avoidable due to rock excavation.

**Plate 6.4: The First 0 + 900m Main Canal Route**

- ✓ Within this interval along main canal route a 1m test pit has been taken at 599159 E, 1230310 N GPS reading and from the test pit log it is made up of loam clay.

**Plate 6.5: Test Pit one along Canal Route**

- **From 0+900m to about 1+400m Main Canal Route,** the canal route passes across moderate to steep slope unstable ground which is composed of silty sandy clay to loam clay soil.

**Plate 6.6: Between the First 0+600m to about 1+400m of Main Canal**

- **From 1+400m to about 1+700m**, the main canal route passes along moderate to gentle slope topography, there is some seepage problem observed during field investigation. It is stiff and stable flat ground.

**Plate 6.7: Between 1+400m to about 1+700m of Main Canal Route**

Within this interval the canal passes one main gully (flume) which needs to clarify.

- Flume one is found at this interval which has 16m width and 5m in depth. From the gully exposure; the gully banks formed from silt clay whereas the gully bed covered with gravel and sand soil.

**Plate 6.8: Flume at 1+400m to about 1+700m Canal Route Interval**

- **From 1+700m to 2+500,** the main canal passes through gentle slope consist of top gravely clay and black cotton clay soil.
  - ✓ Within this interval along main canal route a 1m test pit has been taken at 599981 E, 1230599 N GPS reading and from the test pit log it is made up of black cotton.

**Plate 6.9: Test Pit Two along Canal Route**

Within this interval the canal passes one main gully (flume) which needs to clarify.

- ❖ Flume two is found at this interval which has 35m width and 8m depth. From the gully exposure; the gully banks formed from gravely clay whereas the gully bed covered with gravely sand with some cobbles size rock fragments.

- **From 2+500m to about 3+250m,** the main canal route passes through gentle slope ground which is composed of silt clay to gravely sandy clay soil.

Within this interval the canal passes one main gully (flume) which needs to clarify.

- ❖ Flume two is found at this interval which has 45m width and 4m depth. From the gully exposure; the gully banks formed from gravely sandy clay whereas the gully bed covered with gravely sand silt soil.

## 6.3 Natural Construction Materials

During the site investigation, natural construction materials required for the construction of the various proposed engineering structures at the headwork and within the farmland have been assessed, and possible quarry sites and borrow areas have been identified within the vicinity of the area as much as possible. In addition to the identification, the quality, quantity, accessibility condition and ownership of each proposed production sites have also been studied and described in this report; on separate sub-sections below. The natural materials required for the construction of the proposed hydraulic structures include rock for masonry stones, aggregates (both coarse and fine), impervious soil for fill and/or lining, backfill soil, and water.

### 6.3.1 Quarry Site for Masonry Rocks

Quarry site that can be used for production of rock for masonry stone has been assessed during the field work session within the vicinity of the project area at economic distance for hauling. One possible quarry site has been identified at about 22km of total distance till the headwork site to the West direction which locally known as **Muti Kolo**. From the total distance about 18km is along Bati - Kombolcha main road; and the remaining 4km is gravel road. At this quarry site, the available rock type is Rhyolite which is fine grained volcanic rock. This quarry site has good quality rock. At the quarry site, fresh rocks are found in large quantity that suffices the requirement of the project. From this site, rock of different sizes can be produced; ranging from cobble size to large boulders.

### 6.3.2 Coarse Aggregate Sources

Sufficient amount of basalt rocks which includes gravel and cobble size fragments are available all along the river channel both at the upstream and downstream of the weir axis. These basaltic rocks can be used as coarse aggregates after crushing and broken them in desirable sizes and shapes.

### 6.3.3 Fine Aggregates

Borrow areas of fine aggregate or natural sand have been assessed starting from the project stream itself. A natural deposit of such materials is found when assessed within the beds of the stream in the project area; source of these materials are available within the project stream. In the stream good quantity, which suffices the need of this project, is available. The deposit dominated by sand sized transported alluvial sediments, though some amount of fines and over sizes are also observed. The individual grains of sand are mainly originated from basalt rock and reveals high crushing resistant that the sand has good quality in this respect. The sand has good strength as it mainly develops from basalt rock and experiences long stream transportation, which normally removes any weak zones of the grains, See the Plate below. The river sand is taken to Amhara Design & supervision laboratory section (fine aggregate lab results for concrete works) and the result will be as the following figure-4.

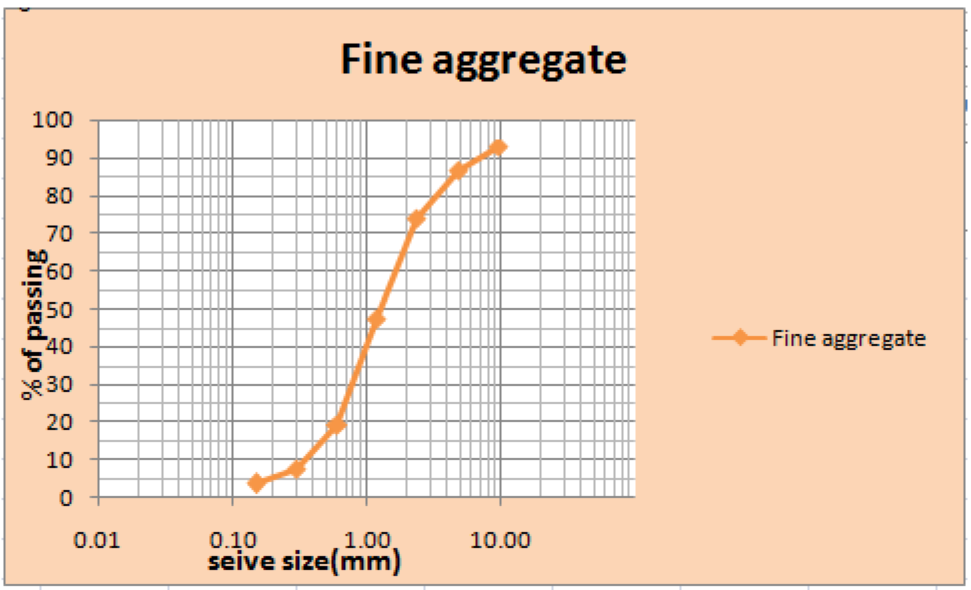


**Figure 4: Fine aggregate**

### 6.3.4 Canal Fill Material

Along the main canal route, there are no more places that exceed 1m that needs where the original ground level is lower than the designed canal bed level (CBL). However; for fill of different structures that constructed at the head work site and along the main canals will be proposed from the excavations along the canals. For such fill, natural fine grained soil material having low to medium plasticity, non-expansive and impervious is required. For this project such soil material source can be get from command area. But it is enough for fill of the structures cited above that is found through the canal route.

From visual examination of the material source, the soil has black to brown color, and composed of silt and sand. It is residual soil having low plasticity and low liquid limit. It is non expansive soil. According to the Unified Soil Classification System, the soil group lies in Low plastic SILT (MH). Such soil type possess a maximum dry density (MDD) lies within 1.25 to 1.37gm/cc; on average 1.31gm/cc, and the associated optimum moisture content (OMC) of 33.1% to 39.5%; on average 36.3%. The construction of the fill can be then done using these parameters.

### 6.3.5 Water

Water for construction purposes can be getting from the project stream **Cheleka** River itself. Water for construction purposes can be getting from the project perennial river that flows throughout the year used for local irrigation purpose.

# 7. Conclusion and Recommendation

## 7.1 Conclusion

- The project site is characterized by lowland command area with very steep high morphology of surrounding ridges.

- The river almost has gentle to medium slope that is depositional type of river. The river is mature, defined and have stable abutment so that the river course may not change through time.

- The command area is mainly covered by quaternary sediment of silty clay soil. The formation of this soil is due to weathering transportation and deposition of the pre existed Aiba formations of the upper ridges and escarpments.

- The mountains and hills of the study area are highly weathered that have different orientation of fractured rocks that allow increasing the infiltration rate of surface water to the subsurface. Even if it is the case there is no spring outflow at the foot of the mountains and the ridges and flow towards the main river and join it or to the command area.

- It is intended to design and construct a diversion irrigation project using weir structure, at **Cheleka** stream found in South Wollo Zone, Kalu woreda of the region. For these works, a suitable diversion headwork site has been selected and required technical data have been collected to design safe and economic structure. One of the data are the geological and geotechnical conditions of the foundation area at the headwork site, along proposed main canal route and associated drainage crossing sites. In addition to this, nearby source areas for suitable required natural construction materials have been also assessed. In these regard.

- During site investigation different natural construction material assessment is done. Only clay source used to lining material for earthen cannel is found on the command area by back filing. Possible quarry site for Masonry has been identified at about 22km of total distance till the headwork site to the West direction which locally known as **Muti Kolo**. From the total distance about 18km is along Bati - Kombolcha main road; and the remaining 4km is gravel road. At this quarry site, the available rock type is Rhyolite which is fine grained volcanic rock. At the quarry site, there is fresh rock that is found in large quantity that suffices the requirement of the project.

- Water source for construction can be getting from the project Stream of **Cheleka** River itself.

## 7.2 Recommendation

- Rain water and flood water storing ditch's must be constructed throughout the command area to store water during the flood time, this water that is store on the constructed ditch's is used to stop flood and also it is used to control the moisture content of the command soil.

- Since the headwork foundation area is made up of non-uniform geologic materials; rock and alluvial sediments, it is better to design a masonry or concrete cut-off wall at the central portion of the stream that is anchored with the bedrock found at sides. The wall should penetrate the sediment and anchored to the underlying bedrock, expected at the depth of 3 to 4m from surface at center area of the stream bed. This wall has two benefits; it for stability, and also as seepage barrier that subsurface water flow be blocked and will be utilized for the irrigation.

- Since the proposed canal route is made up of impervious geological material which is silty clay soil all the canal routes will not necessary to lining.

- Since the fine aggregate source of the River sand has some coarse grained content it is necessary to sieve once the sand before using it.

-