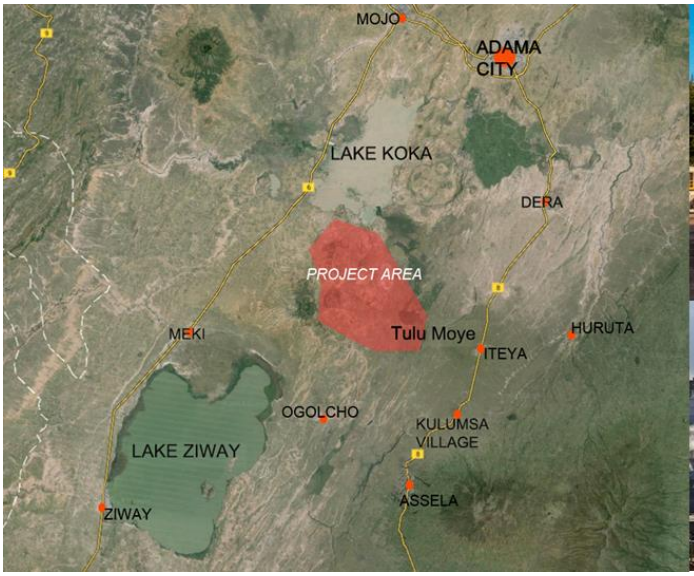


Tulu Moye Geothermal Development Project - Phase I:
Environmental and Social Impact Assessement

ESIA Report: Part II of III

Version 02 – Nov. 2017

Report no. 17005-01

www.vso.is

Borgartún 20
105 Reykjavík

585 9000
vso@vso.is

Page left intentionally blank.

CONTENT

List of Figures

List of Tables

Acronyms and glossary

AD	Anno Domini
AFI	Acute Febrile Illness
AfDB	African Development Bank
ADLI	Agricultural Development Led Industrialization
AoI	Area of Influence
Asl	Above Sea Level
ARCCH	Authority for Research and Conservation of Cultural Heritage
ARDO	Agriculture and Rural Development Office
BSG	Bushed Scrubbed Grass Land
CEDAW	Convention on the Elminiation of All forms of Discrimination Against Women
CH_4	Methane
CIA	Cumulative Impact Assessment
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CLO	Community Liaison Officer
CMS	Conservation of Migratory Species of wild animals
CO_2	Carbon dioxide
CRC	Convention on the Rights of the Child
CSE	Consservation Strategy of Ethiopia
dB	Decibel
dBA	Decibels Acoustic
DEM	Digital Elevation Model
DHO	District Health Office
EA	Environmental Assessment
EAR	East African Rift
EBI	Ethiopian Biodiversity Institute
EC	Electrical Conductivity
EEA	Ethiopian Energy Authority
EEP	Ethiopian Electric Power
EEPCo	Ethiopian Electric Power Corporation
EHS	Environment, Health and Safety
EIA	Environmental Impact Assessment
EPA	Environmental Protection Authority
EPC	Environmental Protecton Council
EPLAUA	Environmental Protection, Land Administration and Use Authority
EPSE	Environmental Policy and Strategy of Ethiopia
ERA	Ethiopian Roads Authority
ERP	Emergency Response Plan

E&S	Environmental and Social
ESAP	Environmental and Social Action Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
EWCA	Ethiopian Wildlife Development and Conservation Authority
F	Fluoride
FAO	Food and Agricultural Organization
FDRE	Federal Democratic Republic of Ethiopia
FGD	Focus Group Discussions
g	Gram
GDP	Gross Domestic Production
GIS	Geographical Information System
GTP	Growth and Transformation Plan
H_2S	Hydrogen Sulphide
H&S	Health and Safety
IBA	Important Bird Areas
ICS	Interconnected System
IFC	International Finance Corporation
ILO	International Labour Organisation
IUCN	International Union for Conservation of Nature
KPI	Key Performance Indicator
LA	A-weighted sound level
LA_{eq}	Equivalent sound level
M a.s.l.	Meter Above Sea Level
mcm	Million Cub. Meter
MDGs	Millenium Development Goals
MER	Main Ethiopian Rift
mg/l	Milligram Per Liter
MoEF	Ministry of Environment and Forestry
MoWIE	Ministry of Water, Irrigation and Energy
MoM	Ministry of Mines
MWe	Megawatt Electrical
MW	Megawatt
NCG	Non-Condensable Gases
NGO	Non-Governmental Organization
NMSA	National Meteorological Services Agency
NMT	Non-Motorised Transport
OFWE	Oromia Forest and Wildlife Enterprise
OG	Open Grass Land

OMC	Optimum Moisture Content
ONRS	Oromia National Regional State
ORA	Oromia Roads Authority
OW	Open Wood Land
PAP	Project Affected People
PLC	Private Limited Company
POPs	Persistent Organic Pollutants
PPB	Parts Per Billion
PPM	Parts Per Million
RAP	Resettlement Action Plan
RPF	Resettlement Policy Framework
RFP	Request for Proposal
SEP	Stakeholder Engagement Plan
SNNPR	Southern Nations, Nationalities & Peoples' Region
TBD	To be decided
TDS	Total Dissolved Solid
t/hh	tonnes per household
UNFCCC	United Nations Framework Convention on Climate Change
URTIs	Upper Respiratory Tract Infections
VECs	Valued Environmental and Social Components
VES	Vertical Electrical Sounding
VIP	Ventilated Improved Pit
WBG	World Bank Group
WFB	Wonji Fault Belt
WHO	World Health Organization
WRMP	Water Resource Management Policy
UEPA	Universal Electricity Access Program
UNU	United Nations University
USC	Unified Soil Classification

Terminology

It should be noted that spelling may vary between sources.

Zone:

Arsi - Arsii

East Shewa /East Showa

Woreda – Wereda:

Bora

Dodota

Hitosa – Hitossa – Hetosa - Etosa

Ziway Dugda – Zeway /Zuway Dugda

Kebele:

Amude - Amuddee

Anole - Anole Salen

Arba Chafa – Arba Chefa

Bite - Betti

Bite Daba – Bite Dabaa

Boka

Bora

Burka Lemafo – Burka Lamafo

Denisa - Danisa

Ula Arba - Hula Arba

Hurtu Dembi – Hurtuba Dembi /Bedenbi

Meja Shenen – Meja Shenan

Tero Desta – Terro Desta – Tera /Terra Desita – Tero Dastaa

Tero Moye– Terro Moye – Tulu Moye – Teru Moye

Wal Argi – Wul Argi - Walaargi

Town:

Adama City – Nazret

Alem Tena

Asela - Assela

Dera

Hawassa – Awassa

Iteya

7 Social impact assessment

7.1 Introduction

The following chapter describes the socio-economic baseline of the Project area with regards to Zones, Woredas and Kebeles. The baseline information was gathered by GIBB International (GIBB International, 2015) by both qualitative and quantitative methods. Attempts were made to ensure that focused group discussions were disaggregated by gender to ensure that gender issues were well captured. The study was carried out in four main phases:

- Inception phase - desk study and review of relevant documents and preparation for fieldwork
- Fieldwork
- Data processing, analysis
- Reporting

The impact assessment was made by VSO Consulting and RG. The chapter addresses the demographic characteristics of the area, economic activities, health and health care, education, religion, culture and ethnicity, service, finance, poverty and tourism.

7.2 Impact area

The Project can have direct impact on society within Drilling area, which is within the defined Project area, but in terms of employment opportunities the impact area can reach further out from the Drilling area. In the absence of certainty of where indirect impacts end the definition of the Project area is used.

7.3 Legislative and policy framework

7.3.1 National

- The National Energy Policy (FDRE 2013)
- Public Ownership of Rural Lands Proclamation No. 31 /1975
- Expropriation of Landholdings for Public Purposes and Payment of Compensation Proclamation No. 455/2005
- Payment of Compensation for Property Situated on Landholdings Expropriated for Public Purposes Council of Ministers Regulations No. 135 /2007
- Oromia Rural Land Use and Administration Proclamation No. 130 /2007
- Oromia Bureau of Land and Environmental Protection Establishment Proclamation No. 147/2009
- Energy Proclamation No. 810/2013
- Growth and Transformation Plan
- Public Health Proclamation No. 810/2013
- The 1960 Civil Code of Ethiopia

7.3.2 International

- Millennium Development Goals
- Convention on the Rights of the Child
- Convention on the Elimination of all forms of Discrimination against Women
- International Labour Organisation
- World Bank Operational Policy OP 4.11 Physical Cultural Resources
- World Bank Operational Policy OP 4.12 Involuntary Resettlement

- World Bank Operational Policy OP 17.50: Public Disclosure
- IFC Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts.
- IFC Performance Standard 2: Labour and Working Conditions.
- IFC Performance Standard 4: Community Health, Safety, and Security.
- IFC Performance Standard 5: Land Acquisition and Involuntary Resettlement.
- IFC Performance Standard 8: Cultural Heritage.

7.4 Baseline description

7.4.1 Administrative division and governance

The Federal Democratic Republic of Ethiopia (FDRE) constitutionally comprises the Federal State and nine Regional States. Each region is divided into Zones and Woredas. The basic administration unit is the Woreda (district) and each Woreda is further sub-divided into Kebeles (Sub districts) and Peasant/Farmers Associations. Each administrative unit has its own local government elected by the people. The power and duties of the Federal, Regional and Local governments are defined by Proclamations 33/ 1992, 41/1993, and 4/1995. Under these Proclamations, duties and responsibilities of Regional States include: planning, directing and developing social and economic development programs, as well as the protection of natural resources of their respective regions.

Administratively, the proposed larger Project /Study area includes parts of two Zones, three Woredas, 13 Kebeles, 39 sub Kebeles (Got) and 279 villages. A village consists of groups of 25 to 30 households.

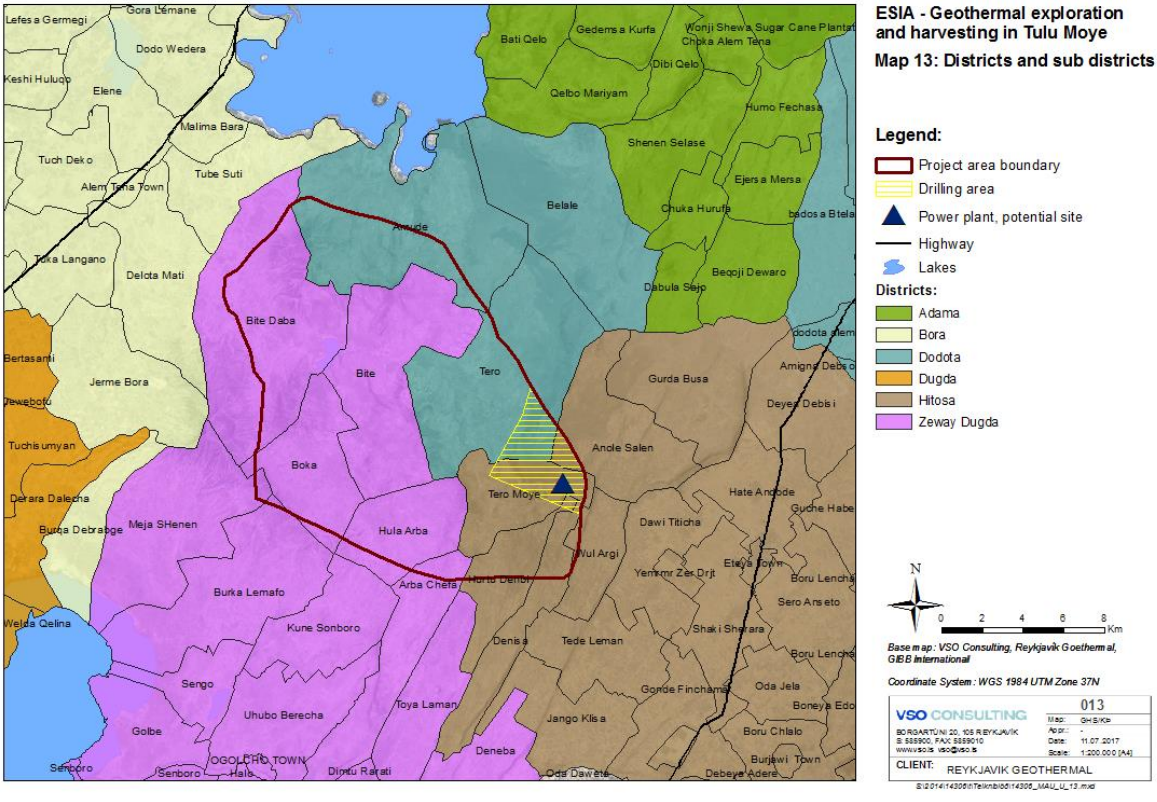


Figure 7.1 **Districts (Woredas) and sub districts (Kebeles) in the Project and Drilling area.**

Table 7.1 Administrative divisons of the Project area

Zone	Woreda	Kebele administration	Sub Kebeles	Geri/Villages
Arsi	Dodota	Tero Desta*	3	9
		Amude	3	44
	Hitosa	Anole Salen*	3	9
		Tero Moye*	3	9
		Wal Aargi*	3	10
		Denisa*	3	9
		Hurtu Dembi*	3	9
	Ziway Dugda	Bite	3	45
		Boka	3	13
		Ula Arba	3	20
		Meja Shenen	3	45
		Arba Chafa	3	23
		Burka Lemafo	3	34
		Total	39	279

*Kebeles or parts of Kebeles within Drilling area

7.5 Demographics

Impact assessment questions and objectives of study according to scoping document regarding demographics

Describe population distribution in the region, Zone and Project area.

- Define age and gender distribution

- Describe ethnic groups

Is the Project /study area inhabited or close to any settlement?

- How large is the population and density of the settlements?

- What is role of the settlement? (e.g. does it provide service for rural area etc.).

7.5.1 Project area population characteristics

According to the estimates from the Census data and projections from the Woreda Finance and Economic Development offices, the three potentially affected Woredas had a total population of 453,729 by 2014. Total rural dwellers represent 85% of the total population, while the urban dwellers are about 15%. Female population in the four Woredas accounted for about 50% as shown in Table 7.2.

Table 7.2 Distribution of population by gender and areas

Area	Gender	Dodota*	Hitosa*	Z Dugda
Rural	Male	51%	50%	50%
	Female	49%	50%	50%
	Total	69%	85%	96%
Urban	Male	49%	49%	51%
	Female	51%	51%	49%
	Total	31%	15%	4%
Total	Male	50%	50%	50%
	Female	50%	50%	50%
	Total	100%	100%	100%

Source: Projected based on 2007 CSA report, Projected based on 1994 CSA report of Oromia (GIBB International, 2015). *Kebeles within potential drilling site

According to data obtained from the respective Kebele administration, it is estimated that Kebeles within the Project area have a population of about 59,917 of which 55 % are females. The average family size per household is about 6.8. Table 7.3 shows population by administrative locations of Kebeles affected by the Project.

Table 7.3 Population of Kebeles within Project area

Zone	Woreda	Kebele	Male	Female	Population
Arsi	Dodota	Tero Desta*	46%	54%	6,313
		Amude	53%	47%	7,352
	Hitossa	Anole Salen*	47%	53%	4,780
		Tero Moye*	47%	53%	3,150
		Wal Argi*	51%	49%	2,000
		Denisa*	51%	49%	2,830
		Hurtu Dembi*	48%	52%	1,541
	Ziway Dugda	Bite	46%	54%	7,000
		Boka	47%	53%	3,469
		Ula Arba	38%	62%	4,200
		Meja Shenen	38%	62%	4,200
		Arba Chafa	36%	64%	6,975
		Burka Lemafo	48%	52%	6,107
		Total	45%	55%	59,917

Source: Woreda SES 2007 (GIBB International, 2015). *Kebeles within potential drilling site.

According to the projected population for the year 2014 the young age population (0-14) ranges from 45% for Dodota to 51% in Ziway Dugda. The old age population (65+) is about 5% ranging from a low of 3% in Ziway Dugda to a high of 9% in Dodota and productive age population is 48% (Table 7.4). The dependency ratio considers the number of children (0-14 years old) and older persons (65 years and over) to the working-age population (15-64). This can be represented mathematically as:

Dependency ratio = Children (0-14) + Older persons (65+) * 100
Productive age (15-64)

Table 7.4 Age distribution in Woredas within the Project area

Age	Dodota*	Hitosa*	Z Dugda	Overall
0-14	45%	49%	51%	48%
15-64	46%	47%	46%	46%
65 and above	9%	4%	3%	5%
Dependency ratio	54%	53%	54%	52%

Source: Projected based on 2007 CSA report, Projected based on 1994 CSA report of Oromia (GIBB International, 2015). *Woredas within potential Drilling area.

Table 7.5 shows the general household composition obtained from the field study. The Woreda data relates well with the baseline data. The young age group population (0 to 14) of the overall Project area is about 47% (males are 46% and females are 47%) and the old age group (60 and above) are 2.5% (males are 4% and females are1%). On the other hand, the economically active age group population (15 to 59) is 51% (males are 50% and females are 51%). The dependency ratio of the Project area stands at 49%. This implies that every 100 persons in the economically productive age group are responsible to take care of themselves and additional 49 persons. The dependency ratio of the Project area is slightly lower than that of the overall rural areas of the four Woredas.

Table 7.5 Age and gender distribution according to field study

			Age Group			Total	Dependency Ratio
Woreda	Gender		0-14	15-59	60+		
Dodota*	Male		44%	51%	5%	100%	49%
	Female		45%	53%	2%	100%	48%
	Total		45%	52%	3%	100%	48%
Hitosa*	Male		43%	53%	4%	100%	47%
	Female		48%	50%	1%	100%	50%
	Total		46%	52%	3%	100%	48%
Ziway Dugda	Male		48%	49%	3%	100%	51%
	Female		47%	51%	1%	100%	49%
	Total		48%	50%	2%	100%	50%
Overall	Male		46%	50%	4%	100%	50%
	Female		47%	51%	1%	100%	49%
	Total		47%	51%	3%	100%	49%

*Woredas affected by the Drilling area.

In Dodota, the young age group (0 to 14) are about 45% (males are 44% and females are 45%). The old age group (60 and above) is about 3% (males are 5% and females are 2%). About 52% are within the economically active population group, with 51% male and 53% female. The dependency ratio in Dodota is about 48%.

In Hitosa, the young population (0 to 14) is about 46% (43% males and 48% females). The old age group (60 and above) is about 3% (males are 4% and females are 1%). The

economically active age group population (15 to 59) is about 52% (males are 53% and females are 50%). The dependency ratio of is about 48%.

In Ziway Dugda, the young age group population (0 to 14) is about 47% (males are 46% and females are 47%). The old age group (60 and above) is about 2% (males are 3% and females are 1%). On the other hand the economically active population (15 to 59) is about 50%. The dependency ratio of is about 50%.

From this information, it can be concluded that the dependency ratio is generally high. There are more elderly men than women. It is also important to mention that the Project area is considered to have a growing population since 47 % of the overall population is young and have potential for greater impact in the future in terms of employment and the need for social amenities.

Household characteristics

The fourteen Kebeles have a total of 10,209 households of which 2,562 (25%) are households headed by female and 7,833 (75%) headed by males. As such female headed households are a minority. Kebeles such as Tero Moye, Hurtu Dembi, Bite, Anole have a higher proportion of female headed households compared to the other Kebeles. Depending on the nature of gender vulnerabilities faced, these villages should be given special considerations to facilitate inclusion in project sharing.

The average household size of the Project area is about 7. The overall average age of a household head is about 42 years with a low of 39 in Ziway Dugda and high of 45 years in Hitosa. On the other hand, the average age of a spouse is 33 years. In general, about 13% of households interviewed in the Project area are headed by a female. This shows that in case of resettlement and livelihood restoration measures, additional support should be provided to the female headed households in terms of participation, capacity building, relocation assistance and livelihood restoration support strategies.

Table 7.6 Number of households in the Project affected Kebeles

Kebele	Total households	Female headed%
Tero Desta*	1,081	15%
Amude	1,040	25%
Anole Salen*	503	32%
Tero Moye*	800	44%
Wal Argi*	293	15%
Denisa*	322	20%
Hurtu Dembi*	302	34%
Bite	950	41%
Boka	554	20%
Ula Arba	667	12%
Meja Shenen	1,013	22%
Arba Chafa	827	19%
Burka Lemafo	1119	27%
Bite Daba	738	21%
Total	10,209	25%

*Kebeles affected by the Drilling area

The Project area is dominated by extended family life. The household survey confirms that though it varies from one Woreda to another, a household head may have more than one house in one compound under his control. In an ideal situation, a household would have an additional external kitchen, a granary and a house for visitors. This indicates that there are situations where a household head would possibly let go more than one housing unit during the Project construction.

Marital status and composition of study population

Marital status of the Project area is described in Table 7.7. Although the Ethiopian constitution explicitly states that "marriage shall be entered into only with the free and full consent of the intending spouses" and the minimum legal age for marriage is 18 for both boys and girls, the laws are not always enforced. Early marriage remains a deeply rooted tradition as local customs and religious courts have the power to allow marriages below 12 years of age. From this study, it has been established that about 4% of those below the age of 18 years are married. This shows evidence of early marriages among the population. Divorce and separation rates among the population are notably low. The data also shows that single parent families arising from divorce, death of spouse or separation are a minority among the population.

Table 7.7 Marital status of all Woreda household heads

		Woreda			
Age Group	Marital Status	Dodota*	Hitosa*	Z Dugda	Overall
17 years and below	Single	93%	98%	96%	96%
	Married	7%	2%	3%	4%
	Divorced	0%	0%	0%	0%
	Widowed	0%	0%	0%	0%
	Total	100%	100%	100%	100%
18 years and above	Single	24%	38%	31%	31%
	Married	72%	61%	66%	65%
	Divorced	0%	0%	1%	0%
	Widowed	4%	0%	2%	2%
	Separeted	0%	0%	0%	0%
	Total	100%	100%	100%	100%
Overall	Single	59%	70%	66%	65%
	Married	39%	30%	33%	34%
	Divorced	0%	0%	0%	0%
	Widowed	2%	0%	1%	1%
	Separted	0%	0%	0%	0%
	Total	100%	100%	100%	100%

*Woredas affected by the Drilling area.

Demography of the proposed Drilling area

Concluding from the information above the demographic characteristics of the Kebeles affected by the Drilling area is as follows.

The Drilling area has direct effect on parts of 3 Kebeles; Tero Moye, Anole and Tero Desta. Possibly at some stage, also on Wal Argi, Denisa and Hurtu Dembi. Those 6 Kebeles have a total of 55 villages. Total inhabitants of the Kebeles are 20,614. On average the population within the Kebeles consists of 45% males and 55% females. Numbers for age distribution within Kebeles are not available but within the Dodota and Hitosa Woredas where the Drilling area is located the age distribution is 46% 0-14 years old, 52% 15-59 years old and 3% 60 years old and older. The dependency ratio is 48% within the Woredas. The high dependency ratio and high proportion of children indicates that the population is growing. The proportion of males being the heads of households is 75% and therefore 25% of household heads being female except in Tero Moye, Hurtu Dembi and Anole where proportion of female household heads area is higher than in other Kebeles (32-44%). Those households can be defined as more vulnerable than those headed by males. Other vulnerable groups are elderly, women, youth, children, widowed, unemployed, disabled and chronically ill. The average household size is 7 and one household head can have more than one house in his care. In Dodota the proportion of marriages under 17 years old is 7% but in Hitosa it is 2%.

7.6 Economic activities

7.6.1 Livelihood activities

Ethiopia's economy is chiefly agricultural, with more than 80% of the country's population employed in this sector. Although majority of the population is engaged in farming, productivity still remains low due to reasons such as severe land degradation, low technological inputs, and poor soil fertility among other factors.

About 96% of the cultivated land in Ethiopia is under smallholder farming, while the remaining is used for commercial farming (both state and privately owned). Per capita cultivated land holding averages only around 0.5 hectare. The main livelihood stream of the people in the proposed Project area is mixed farming, consisting of crop and animal husbandry for subsistence purposes. The area is food insufficient due to recurrence shortage of rainfall and low level of crop productivity. It has been observed from the discussions with Kebele administration officials that the average size of farm and grazing land is reducing due to fragmentation to meet the needs of the growing population. Sale of firewood, charcoal production and sand harvesting are supplementary. Other complementary sources of income include trading and salaried employment.

Half (50%) of the Project area population, falls within the working age population (15-59 years). Within this group, 21% is unemployed. In terms of labour participation, self-employment stands at 64% per cent. Only 7% per cent are in paid employment.

Nearly two thirds (68%) of those between the ages of 20-39 years are self-employed. Overall, 23% of the 20 years and above in the Project area are unemployed.

Annual household on farm income in the Project area ranges from as low as 550 Birr to a high of about 980,000 Birr, the mean being 36,364. Off farm income also ranges from a low of 200 Birr to a high of 56,000 Birr with the mean being 5,674.

Figure 7.2 **Agriculture is the main economic activity in the Project area.**

7.6.2 Agriculture

The major annual crops grown in the district are cereal, pulses and oil seeds. From cereal crops barley, teff, wheat and maize are the most widely grown crops. Some cash crops like tomato, onion, and oil seeds are also produced in the Woredas. Due to extreme shortage of rain in autumn – December to March (*Belg*), production activities are minimized. Summer - March to December (*Meher*) is the main season for crop production.

The time for performing agricultural activities such as land preparation, planting, weeding and harvesting vary depending on the season of cultivation (Meher/Summer and Belg/Autumn) and types of crops cultivated at that time. Agricultural calendar is shown in Table 7.8 below.

Table 7.8 Farming calendar

Activity	Meher season (summer)
Land preparation	March-June
Planting (sowing)	June- August
Weeding	August-September
Harvesting	October-December

The main crop grown in the Project area is teff with an overall percentage of 85% of households growing it. Wheat was the second major crop grown in the area. Maize farming is practised more in Ziway Dugda (88%) and less in Hitosa (48%). Other significant crops grown in the area include barley, green beans and sorghum.

Crop yield is one of the farm productivity indicators and a measure of farm performance. The four main crops that are mainly grown in the area are maize, wheat, teff and barley. Households produce crops mainly for home consumption and to fulfil some of the household needs, such as clothing, payment of tax as well as other external expenses.

However, the quantity produced is never adequate to cover these needs, mainly because of low farm productivity. Maize is produced at at average of 13 tonnes per household, out of which an average of about 9 t/hh being consumed and wheat production is estimated at 14 t/hh with an average consumption of 9 t/hh and the rest taken to markets. Teff production in the area averages at 6 t/hh with the quantitiy consumed almost equal to the one for markets.

Crop pests and diseases cause reduction in crop production. They have a great contribution in decreasing volume of production both at pre-harvesting and post-harvest period. The major crops pests in the districts are Cut worm, Stalk borer, Aphids, American ball worm, Quell birds and Potato tuber moth while the major crop disease are Potato tuber moth, Paper blotch, Downey mildew, Leaf spot, rust and smut. Weed and rain fall variation are also major constraint in crop production in the Woredas.

Ethiopia is the world's tenth largest livestock producer and the biggest exporter of livestock in Africa. According to the Central Statistics Authority of Ethiopia, between 2010 and 2011 the country had 53 million cattle, 25 million sheep 22 million goats and one million camels. Livestock production is among the main livelihood streams in the proposed Project area. Cattle, sheep, goat, and horses are the four major livestock population found in the Woredas surrounding the proposed Project. According to the livestock population report, cattle, sheep and goats accounted for more than 87% of the total livestock population in the year 2014. Household survey results indicate that most of the households keep donkeys (85%), oxen (84%), poultry (81%), cattle (76%), and shoats (50%).

People are keeping livestock for various reasons which include for draught power (81%), milk production (81%), transport (76%), meat production (61%) and savings. Besides, the status of the household head increases in the society as his number of livestock increases.

Irrigation is marginally practised in the proposed Project area for the sole reason that there is scarcity of water. Therefore, out of the interviewed households only 8% practise irrigation, with proportions in Dodota (15%) and Zeway Dugda (10%). Irrigation is practised along the shores of Lake Zeway and Lake Koka.

Households in the Project area produce crops primarily for home consumption. Asked about how soon they sell their produce after harvesting, 18% of households surveyed mentioned that they always sell immediately after harvesting, while 83% indicated that they sell later.

The household survey has identified that only 28% of the households produce enough food for home consumption. This clearly shows that they do not meet household food requirement. The remaining 72% have to get food from other sources to meet their needs. And as such, they end up buying (95%) or get as food aid (22%) or assistance from relative (4%). The household survey identified the problems contributing to low farm production. Some of these challenges include shortage of rain (96%), increase in fertilizer cost (96%), shortage of land (85%), shortage of improved inputs (80%), problems of soil fertility (75%), pest problems (64%), flood problem (57%) and other causes (8%).

Some of the problems encountered when marketing their produce include; changes in market prices (99%) in accessibility to market due to poor roads (53%) and transportation problems to market (21%).

7.6.3 *Land tenure and land use*

Impact assessment questions and objectives of study according to scoping document

Land Ownership & Rights

- Who are the owners /land leases of the Project area?

- Who has the rights to use the land?

In general, land tenure refers to the legal regime in which land is owned by an individual who is said to 'hold' the land. Land is the principal form of wealth in rural areas and a source of social status. The regime under which the land is held has implications on its security and consequently on its utilization.

The Constitution of Ethiopia (1995), vests land ownership exclusively in the State and in the people of Ethiopia. The Constitution provision asserts state ownership of land and prohibits private ownership of land. Individuals can only be granted usufruct/ holding rights, and not private ownership. The Land Administration and Use Proclamation (FDRE, Proc. No.456/2005) states that, every citizen from 18 years whose main residence is in the rural area and who wants to make a living from agriculture should be accorded free access to rural land and permitted to exercise usufruct/holding rights for an indefinite period.

For the purpose of this study, ownership types were categorised as:

- Those with holding certificate
- Those who do not own land (tenants)
- Those with land but do not have holding certificates (as a result of inheritance).

This survey identified that about 84% of the community members have land holding with certificate, 4% own land but do not have land holding certificate, while about 12% of the households do not own land. The last two categories of ownership can be considered as vulnerable groups in case of resettlement.

The average land size owned in the Project area is estimated to be 2.3 hectares, with a minimum of 0.1 and a maximum of 17.8 ha. This distribution is similar across the Woredas. Rental land sizes stand at an average of 1.3 ha with a maximum rental land of 10.5 ha. Average land under cultivation is 2.1 ha while that under grazing in about 1 ha. Dodota Woreda has the highest land size for grazing. On the other hand, the average size under grazing is about 1 ha with a minimum of 0.2 ha and a maximum of 25 ha. This explains why subsistence farming is practiced in this area.

Land use and land cover distribution in the region depends on variation in altitude, climatic conditions, population density, land use practice and agricultural activities. Human interference to the physical environment is great in the Project area and surroundings. The high growth rate of population in the area resulted in search of additional farmlands by clearing the existing small patches of vegetation covers. Farming is also practiced on slopes which is aggravating the erosion rate. Different types of soil erosions like sheet and gully types are largely observed.

Moderately cultivated lands include livestock grazing. Few natural trees in the area are found. The high demand of wood for fire and charcoal has highly intensified the deforestation. There are also patches of barren lands which need special treatment. The land use within the Project area consist mainly of pastoral and sylvo-pastoral practices (Figure 7.3). Sylvopasture is a combination of forestry and grazing of domestic animals (Wikipedia, 2016).

The major types of land covers include Bushed Scrubbed Grass Land (BSG), Open Wood Land (OW) and Open Grass Land (OG). Bushed Scrubbed Grass Land (BSG) covers most part of the area and grass land is very often mixed with trees, bushes and shrubs. Wood land is interspersed with moderately cultivated land in such areas the main activity is livestock grazing. The mapped land uses compare well with reports from the Woreda Agricultural and Rural Development Offices. These reports acknowledge that land use changes from time to time has taken place due to socio economic changes, such as population growth and economic development, and also estimate that the current land use pattern is in favour of agricultural activities. Figures also show that agricultural land takes about 45-50% of the land mainly for crop production, with about 12% forest/bush cover. Grassland cover is estimated at about 14% of the land total cover (Figure 7.4). About 24% of the total land cover is dedicated for residential houses and homesteads.

Spatial distributions of main land use of the Project area is shown in the map below (Figure 7.3).

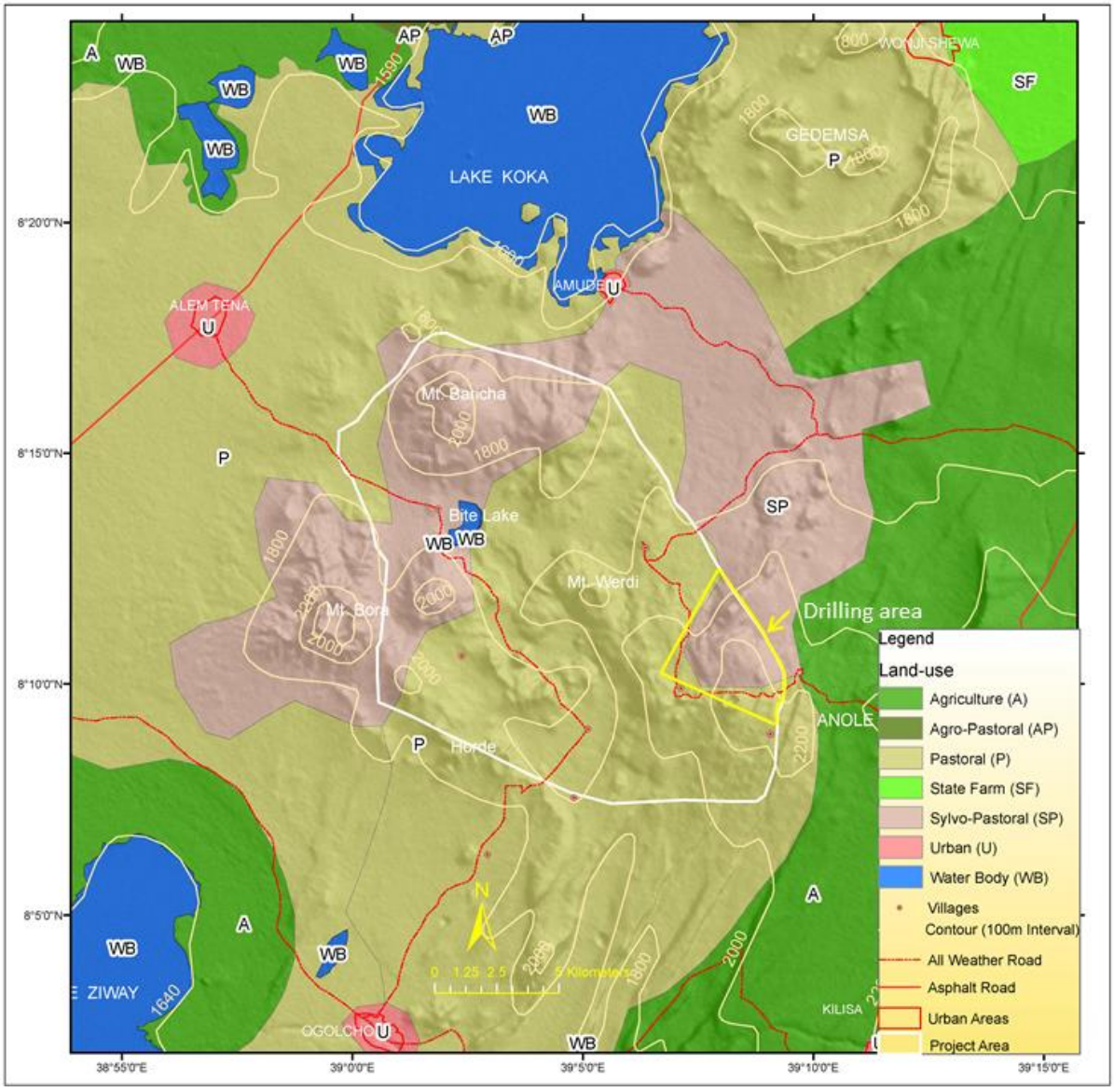


Figure 7.3 **Land use of Project area** (GIBB International, 2015) **and Drilling area.**

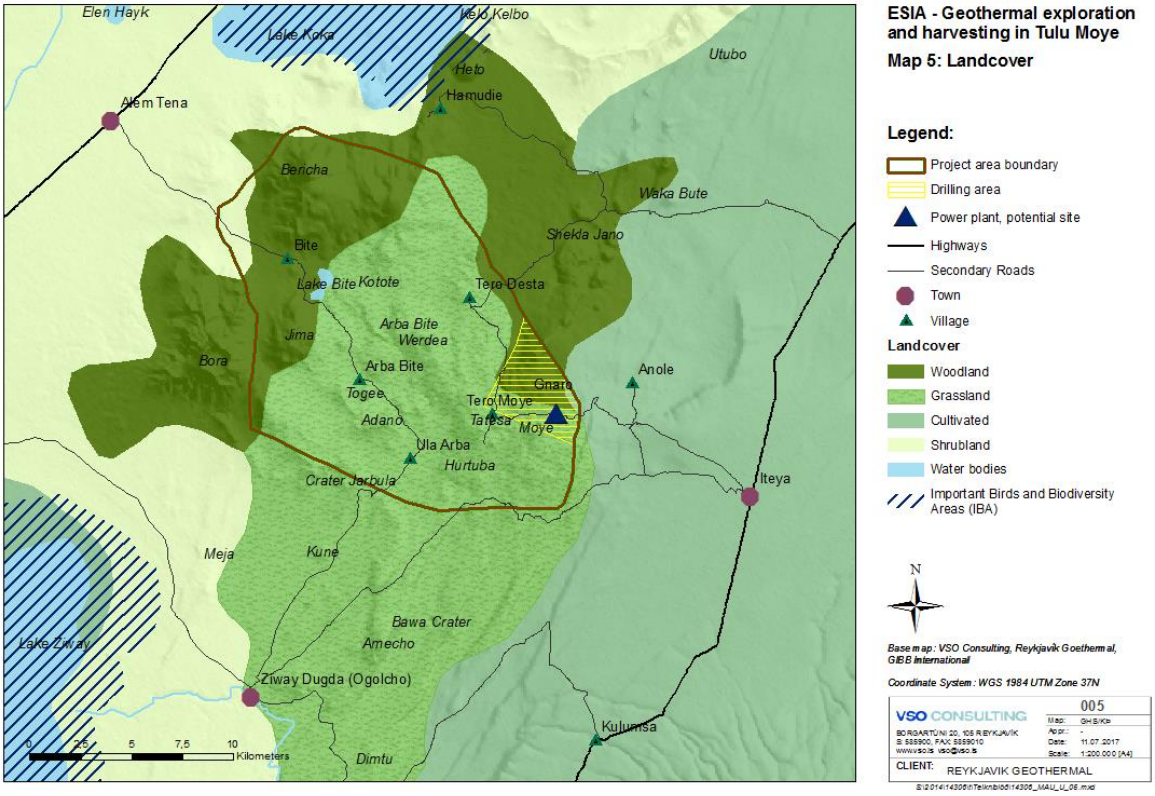


Figure 7.4 **Land cover of the Project area and surroundings.**

Baseline of economic activities within the Drilling area

The area doesn't produce enough food for the population's consumption. This is due to shortage of rainfall and fragmentation of land due to population increase. Proportion of households in Dodota that do not produce enough food for home consumption is 71% while 65% of Hitosa households do not produce enough for home consumption. They meet the food requirements by food aid (Dodota 32% and Hitosa 44%) and by buying (Dodota 94% and Hitosa 99%). The main income in Dodota (88%) and Hitosa (86%) is farming. Other sources of income are trading and salary. In Dodata 75% is self-employed while 35% is self-employed in Hitosa. Unemployment rate is 28% in Hitosa and 19% in Dodota. Regarding land ownership 82% of Dodota community members have land holding certificates and 11% do not own land while in Hitosa 89% have land holding certificates and 9% do not own land.

7.7 Health and health care

Impact assessment questions and objectives of study according to scoping document

Public health

- Description of the major health problems of the Project areas and the main reasons for them (diseases, safe drinking water, sanitation, living standards and nutrition).
- Is health care depending on the development area?
- Is the development site of importance regarding public health? Does it have a sanitary role for the local community? Is hot water and minerals a health factor?
- Is the food provision/availability of the area or Zone somehow dependent on the Project area?

Morbidity patterns

Morbidity basically refers to the incidence of illness or simply put, 'disease load'. A condition of low morbidity logically follows that the health status is better. However, it is difficult to measure illness incident using one source of data. For this reason, two data sources were used, that is the household level data on lay reporting of illness and the second data source was from the public health officers. From the field study, illness characteristics or symptoms were established. Table 7.9 shows the responses to a question regarding illnesses during the four-month period prior to the survey. These symptoms were then matched with records of diseases from the health facilities. Headache was the most frequently made complaint accounting for about 80% of all cases. This was followed by incidences of common cold (69%), cough (66%), fever (37%), abdominal pains (29%) and Diarrhoea (24%). These illnesses have characteristics that are associated with diseases such as Upper Respiratory Tract Infections (URTIs), pneumonia, cholera, typhoid and malaria.

Complaints of headache, joint pains and fever taken together are symptoms of malaria, although other sicknesses including viruses and bacterial infections can present such symptoms. Complaint of chest pains, cough and common cold taken together are symptoms of respiratory infections. Diarrhoea and abdominal pains are complaints that originate from gastro-intestinal system and are closely linked to food hygiene, sanitation and bacteriological water quality. The question of worms in the stool elicited about 28% of responses. This response confirms presence of intestinal worms which are prevalent in the area.

Secondary data indicate that top five prevalent diseases are T.B., typhoid, diarrhoea, malaria and gastritis. Socio economic reports from the Woredas indicate that URTI, diarrhoea, Acute Febrile Illness (AFI), typhoid, malaria, pneumonia, are some of the top five diseases in the four Woredas.

Table 7.9 Morbidity distribution in the Woredas

	Woreda			
Illness	Dodota*	Hitosa*	Z Dugda	Overall
Headache	79%	84%	79%	80%
Common Cold	62%	77%	67%	69%
Cough	72%	58%	67%	66%
Fever	24%	46%	40%	37%
Abdominal pains	34%	32%	28%	29%
Worms in stool	38%	32%	24%	28%
Eye ailments	26%	31%	25%	26%
Diarrhea	27%	16%	23%	24%
Backache	24%	26%	18%	21%
Chest pains	7%	11%	13%	10%
Joint pains	10%	4%	12%	9%
Convulsions	2%	8%	5%	5%
Fainting	3%	7%	4%	4%
Other	2%	1%	4%	3%

*Woredas within proposed Drilling area

HIV/AIDs challenges at the Woredas level are still active although improvements are noticeable. Data from Dodota District Health Office indicate that by 2014, there were 51 HIV carriers and 50 AIDs patients in the entire district. Harmful traditional practices such as early marriages, wife inheritance, female genital mutilation and polygamy are believed to increase transmission of infection.

Health institutions

Even though efforts have been made to overcome health problems in the area, health status of the population within the four Woredas has not reached the desired stage. According to the WHO standards, one health centre is adequate to serve about 25,000 people. According to the data obtained from the District Health Office (DHO), there are a total of 12 health centres, 26 clinics and 66 health posts in the three Woredas surrounding the Project area (Table 7.10). The Kebeles within the Project area have elementary post and only two and three of them have health centres and veterinary clinics, respectively. The existing health posts are focused on pre-natal and post-natal service. They do not have capacity to provide clinical services for the local people since they do not have professional health workers, laboratory equipment, patient rooms with beds and other required facilities. Therefore, the local people have to walk for about 3 to 5 hours to get better health service at nearby urban areas.

Table 7.10 Health facilities in the Project area

	Woreda			
Health Institution	Dodota*	Hitosa*	Z Dugda	Overall
Health centre	2	4	6	12
Clinic	11	14	1	26
Health post	12	24	30	66
Total	25	42	37	104

*Woredas within proposed Drilling area

Accessibility to health services is sometimes very difficult for most of the population in the Project area. For instance, some Kebeles do not have health centres and this would mean the sick have to go or be taken to the neighbouring facility for medical services. In Bora and Dodota, for instance, respondents would on average have to travel between 10 to 12 kilometres to access health centre. On average, patients would cover about 7.4 kilometres to access a health centre. Health posts, although they are found in every Kebele, only provide child care services and programs such as immunization and vaccination services.

Sanitation

Sanitation literally means measures put in place for improving and protecting health and wellbeing of the people. Sanitation is any system that promotes proper disposal of liquid and solid wastes. It is estimated that about 19% of the rural population in Ethiopia have access to improved sanitation facilities. Improved sanitation facilities include flush/pour latrine (to piped sewer system, septic tanks, and pit latrine), Ventilated Improved Pit (VIP) latrine, pit latrine with slab and composting toilets (WHO).

Around 52% per cent of households surveyed do use bush/garden for personal sanitation. This indeed confirms the national figures that use of sanitation facilities still low in the Project area. Using any available open land for defecation would aggravate the health conditions of the people via spread of diseases such as diarrhoea and typhoid.

The study shows that majority of the households dispose solid wastes and is used as fertilizer (65%) while the liquid waste is often poured away (90%). Due to continuous health education and awareness creation sessions, toilet utilization and personal hygiene and sanitation conditions have improved in schools and health institutions. However, hygiene and sanitation conditions at homes are still low hence increase in reported cases of illness associated with poor sanitation and hygiene conditions.

Baseline of health and health care within the Drilling area

The most common illness symptoms experienced four months prior to survey are headache (Dodota 79%, Hitosa 84%), common cold (Dodota 62%, Hitosa 77%), cough (Dodota 72%, Hitosa 58%), fever (Dodota 24%, Hitosa 46%), abdominal pains (Dodota 34%, Hitosa 32%), worms in stool (Dodota 38%, Hitosa 32%), eye ailment (Dodota 26%, Hitosa 31%), diarrhoea (Dodota 27%, Hitosa 16%) and back ache (Dodota 24%, Hitosa 26%).

HIV carriers are 50 in Dodota and 51 HIV patients. Data for Hitosa on HIV is not available.

WHO recommends 1 health centre for every 25,000 persons. In Dodota there are two health centres for 13,665 persons and in Hitosa there are four health centres for 14,301 persons. Accessibility is however not good as the mean distance to health centre in Dodota is 12 km and 6 km in Hitosa, especially if it is kept in mind that inhabitants travel mainly by foot.

Sanitation is poor in the area, where 47% of household in Dodota has pit latrines, 52% use bush and 1% has flush toilets. In Hitosa 61% of households use pit latrines and 35% relieve themselves in the bushes. High proportion of household dispose of solid waste as fertilizers (Dodota 55%, Hitosa 66%) and majority of liquid waste is poured down after use (Dodota 97%, Hitosa 86%).

7.8 Education

Impact assessment questions and objectives of study according to scoping document

- Education. What is the general educational level in the Project area /zone?
- Is the Project likely to improve education in the region?

Considerable proportion (43%) of household heads does not have any formal education. Of the household heads that are educated, majority (39%) have only attained primary level of education. Only about 13% of household heads have attained secondary level of education. None of the household heads or their spouses has university level of education. The Kebeles within the Project area have elementary schools with two of them having secondary schools in Amude and Ula Arba and a farmers' training centre in Tero Moye. Upon completion of primary education, students travel far to Woreda centres or Zonal towns to continue with further education.

There is a correlation between poverty and education attainment by household head. Those households whose household head have low level of education tend to be poorer compared to the ones with relatively higher level of education. Women are seriously disadvantaged when it comes to education in the area as the proportions of those with education compared to men are relatively lower.

Assessing level of education among school going children is an important variable, as this projects future education level of the community. Similarly, higher enrolment level is a positive indicator for the future development of the area. According to the latest Demographic and Health Survey, 41% of children ages 7-12 attend primary school nationally, with no disparities between boys and girls. However, many children attending primary school are outside of the official age range. This is reflected in the difference between net and gross attendance rates. Only about 11% of the primary school students are in the appropriate grade for their age. Repetition and late entry into school are cited as the main reason for this.

Table 7.11 Available schools in Kebeles within the Project area.

	School			
Kebele	grade 1-6	grade 1-8	grade 9-10	Farmers' training centre
Tero Moye*	0	1	0	1
Tero Desta*	0	2	0	0
Anole Salen*	0	1	0	0
Amude	0	3	1	0
Bite	0	2	0	0
Boka	0	1	0	0
Ula Arba	0	1	1	0
Arba Chafa	0	2	0	0
Hurtu Dembi*	1	0	0	0
Denisa*	1	1	0	0
Wal Argi*	0	1	0	1
Burka Lamafo	1	1	0	0
Meja Shene	1	1	0	0
Bite Daba	0	1	0	0

*Kebeles within Drilling area.

In Oromia region, primary school net attendance rate stands at 42% for male and 39% for female. Data obtained from Dodota and Hitossa Education offices indicate that both Woredas had a total of about 29,793 primary school children in 2014.

Table 7.12 shows percentage of children between ages 7 and 12 years who are currently attending school in the proposed Project area. Slightly above half (56%) of the children are actually in schools. Hitossa recorded proportion is 70% among the school going children who are actually attending schools. In Dodota, only 46% of these children go to school. From this analysis, it is evident that most children are not in school, contrary to the MDGs Goal no 2, which set a target of enrolment of 91% for primary school going children by 2015.

Table 7.12 Percentage of 7-12 year old population in school

Woreda	In school	Not in school
Dodota*	46%	54%
Hitosa*	70%	30%
Ziway Dugda	52%	48%
Overall	56%	44%

*Woredas within proposed Drilling area

Baseline of education within the Drilling area

Most household heads in Hitosa do not have any formal education (58%) and the same goes for their spouses (62%). In Dodota fewer household heads have no education (34%) while their spouses are less educated (55% with no education). In Dodota 50% of household heads have primary education while in Hitosa the proportion is 30%. The proportion of spouses having primary education is 40% in Dodota and 32% in Hitosa. Education beyond primary level is 13% in Dodota for household heads and 7% in Hitosa. Women are in general less educated. Available schools for children in the Kebeles that are affected by the Drilling area are not many. Tero Moye, Anole Salen, Hurtu Dembi and Wal Argi have one each. Tero Desta and Denisa have two each. In Dodota 54% of children 7-12 years old are not in school and 30% of the same age in Hitosa. Distance to school and school age population versus number of available schools is not available.

7.9 Religion, culture, ethnicity

Impact assessment questions and objectives of study according to scoping document

Socio Cultural Aspects

Ethnic diversity and structure of Project area. Which ethnic groups inhabit or use the Project area?

- Is the Project area of importance to any specific group of people (inhabitants or users)?

Socio-cultural significance of Project area.

- Does the geothermal area or sites close by have a cultural or historic significance which might be impacted by the Project?
- Are any settlements or groups of people dependent in some way on the potential Project area?

Religion. Baseline information defines the different religious groups in the Project area.

- Is the Project likely to impact on or is it contradictory to religious live and activities in some way?

The predominant religion in the Project area is Islam followed by Christianity, categorised as Orthodox and Protestants. About 97% of the population in the Project area is Muslims followed by Christians at 3%. The Project area is predominantly occupied by the Oromo ethnic group. The Oromo ethnic group is the largest society at national level in terms of its population and administrative area.

Table 7.13 Inventory of religious institutions within Kebeles

Kebele	Mosque	Church
Tero Moye*	3	0
Tero Desta*	12	0
Anole Salen*	3	0
Amude	9	2
Bite	8	0
Bite Daba	7	0
Boka	3	0
Ula Arba	1	0
Arba Chafa	6	0
Hurtu Dembi*	2	0
Denisa*	4	0
Wal Argi*	1	0
Burka Lemafo	6	0
Meja Shenen	4	0
Total	69	2

Figure 7.5 A mosque in the Project area.

7.9.1 *IFC Performance Standard 7*

IFC Performance Standard 7 applies to communities or groups of Indigenous Peoples who maintain a collective attachment, i.e., whose identity as a group or community is linked, to distinct habitats or ancestral territories and the natural resources herein. It may also apply to communities or groups that have lost collective attachment to distinct habitats or ancestral territories in the project area, occurring within the concerned group members' lifetime, because of forced severance, conflict, government resettlement programs, dispossession of their lands, natural disasters, or incorporation of such territories into an urban area.

The PS 7 puts a disclaimer that the proponent needs to ascertain whether a particular group can be considered as Indigenous, by using competent professionals. It specifies and requires that the proponent ensures the Free, Prior, and Informed Consent (FPIC) of the Affected Communities of Indigenous Peoples. It also works towards promotion and preservation of culture, knowledge and practices of Indigenous Peoples.

7.9.2 *Indigenous Peoples*

Unlike some other states in Ethiopia, such as the SNNPR that is an extremely ethnically diverse region of Ethiopia inhabited by more than 80 ethnic groups of which 45-56 percent are indigenous to the region - Oromia is inhabited chiefly by two main ethnic groups. These are Oromo (about 88%) and Amhara (about 7-8%) and they make up the 27 million people population of Oromia; with Muslims (48%), Orthodox Christians (30%) and Protestant Christians (18%). Oromo (Oromiffa) is the most commonly spoken language, spoken by about 85% of the population.

There are Camel-herding nomads in the highlands of southern Ethiopia. None were encountered or reported in the Project or the Drilling area in the Baseline study. The main religion of the population of the Project area is Islam (97%), and the area is predominantly occupied by the Oromo ethnic group. The Oromo ethnic group is the biggest society at national level in terms of its population and administrative area.

Consulting a local E&S expert, Oromo people are divided into two major branches: the Borana Oromo and Barentu Oromo. Borana is further divided into Mech and Tulama. Barentu is further divided into Hanbana, Borana, Arsi, Ittu and Karayu. The Oromo people in the Project area are mostly Barentu. The Oromo are the dominant group in the Project area, they are not considered, nor do they consider themselves, as indigenous.

Therefore, the conclusion is that no indigenous people occupy the Project or Drilling area and that the IFC Performance Standard 7 does not apply.

Baseline of religion and ethnicity within the Drilling area

Islam is the predominant religion with Christianity as minority. The largest ethnic group is Oromo. There are no indigenious people living in the Project area and no Camel-herding nomads have been reported to travel through the area.

7.10 Service

Impact assessment questions and objectives of study according to scoping document

Infrastructure

Transportation

- Describe the type of transportation system in the Project area.
- Will the transportation system possibly be affected by the development?

Accessibility

- Does the Project call for new transport infrastructure?
- Does the Project have an effect on accessibility in the Project area?

Energy

- What is the main energy source in the Project area and Zone?
- What impacts will the Project have on energy accessibility?
- How is water supply managed? What is the access to drinking water?

7.10.1 Roads and site accessibility

The Project area is about 150 km south of Addis Ababa and can be accessed from Addis Ababa through two main routes (Table 7.6). One is using the Addis Ababa - Mojo – Adama (Nazret) – Iteya – Tero Moye road. The road from Addis Ababa all the way to Iteya is asphalted while the remaining road from Iteya to the Project area is all weather gravel road. The other alternative is through Addis Ababa - Mojo – Alem Tena – Bite Daba or Mojo – Alem Tena – Meki – Ogolcho (Abura). The road from Addis Ababa all the way to Meki is asphalted and the remaining route from Alem Tena to Bite Daba is a dry weather road usually difficult to access the Project area through it. On the route from Alem Tena there is a sharp turn at the end of one of the bridges that further eliminates large cars.

The road from Meki to Ogolcho is all weather gravel road. Only two roads pass the area Tero Moye – Tero Desta and Ogolcho – Bite Daba to access the eastern and southern part of the Project area whereas the rest of the Project area is inaccessible by a field car. The field assessment of these parts of the Project area was carried out by following the available few foot trails. Further analysis of the roads can be found in chapter 8.2 of the baseline study report (GIBB International, 2015).

The proposed Drilling area can be accessed from Tero Desta from the north or Iteya from the south. Secondary roads and paths will be upgraded if needed to improve access (Figure 7.8).

All the above roads have various signage warning about approaches to sharp bends, settlements, steep slopes, valley crossings etc. However, some sign posts are damaged and require replacement and additional signage will be required depending on additional traffic envisaged from the Project implementation.

In all the roads within the Project area, Non-Motorised Transport (NMT) by use of horses, donkeys and horse/donkey- drawn carts is common-place with elevated traffic notable during market days in the various trading centres, notably Ogolchoo, Iteya, Alem Tena and Asela.

All access roads are graded earth and constitute one of the major sources of dust which mainly affect adjoining settlements. There is no single road that can be used to access the entire Project area. There is no road that connects the east and west sides of the project area.

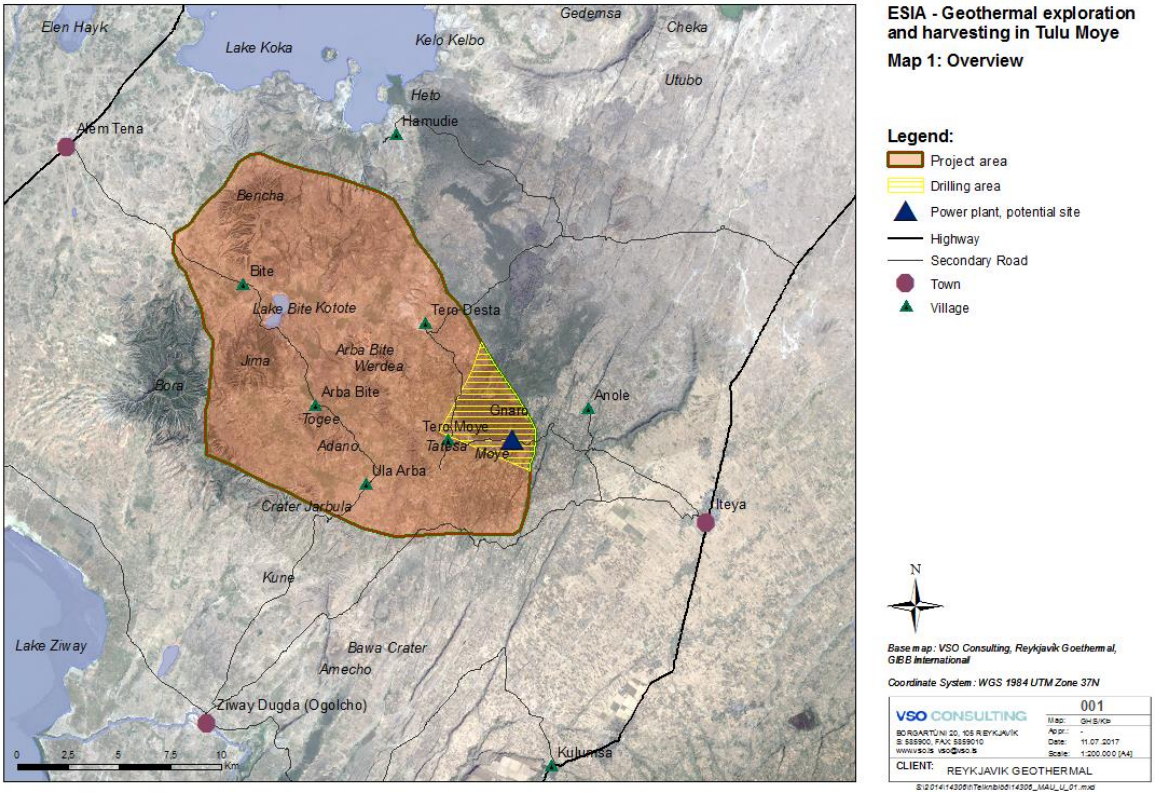


Figure 7.6 **Overview of Project and drilling area and accessibility from Alem Tena and Iteya.**

Figure 7.7 **Roads and bridges in the Project area are of varied conditions.**

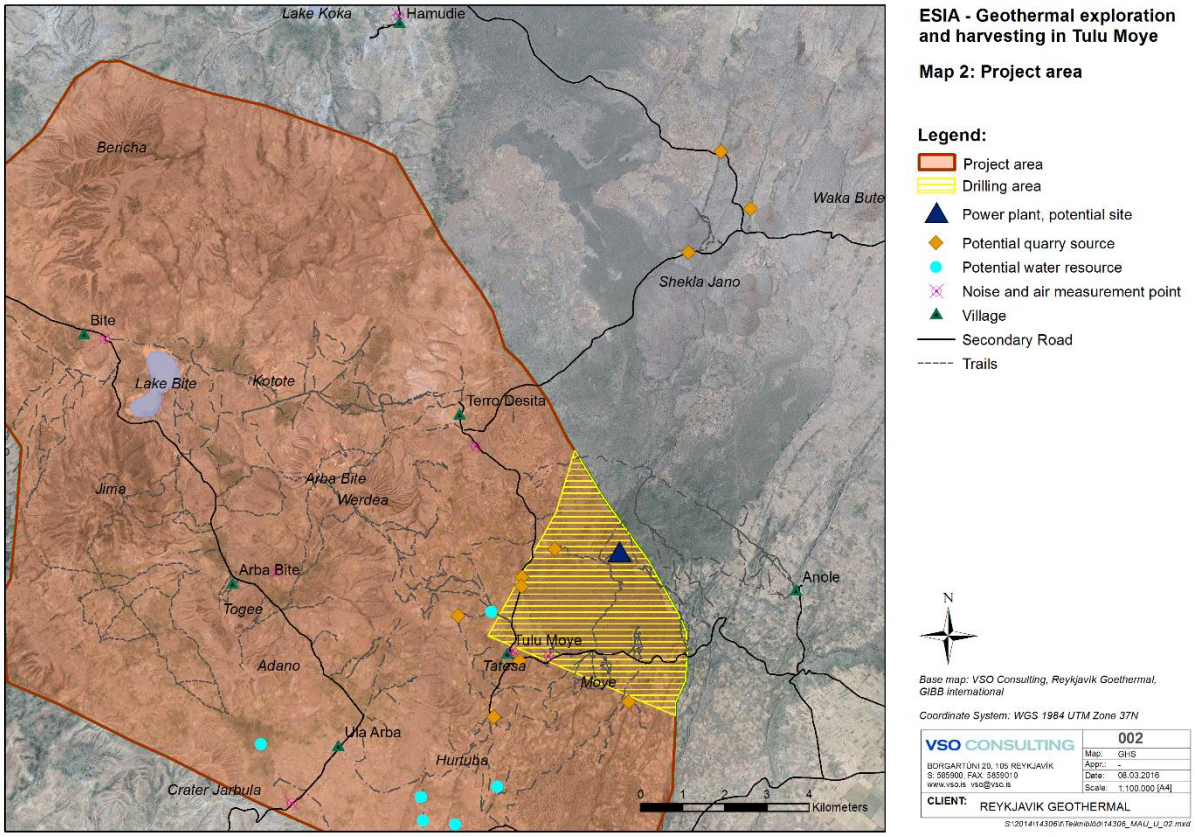


Figure 7.8 **Roads and trails (gray dotted line) within Project and Drilling area.**

7.10.2 Distance to the nearest social services

From the focus group discussions (FGD) carried out with the communities during the field studies and the consultants site visits, it was obvious that people do not have well-equipped and furnished social services (schools, health facilities, grinding mills, water supply services, etc). The extent of the challenges became more serious with increased distance to these social services. Health posts are found in each Kebele, but these health posts provide very basic services such as immunization and basic child support programs. On average, the health posts are about 4 km from the homesteads. Similarly, primary schools are about the same distance to homesteads. Secondary schools and trading centres are on about 13 km from the homesteads while financial institutions are nearly 20 km away from the nearest homestead (see chapter 7.7 for health and chapter 7.8 for education).

7.10.3 Access to water

Ethiopia reached its Millennium Development Goal target of 57% access to safe drinking water in 2015. Access to improved sanitation has also improved but is at 28% nationwide (USAID Ethiopia, 2016). Shortage of water supply is one of the problems affecting people living in the proposed Project area. Lack of clean water is associated with health problems as this is related to sanitation problems.

The available sources of drinking water in the proposed Project area for dry season would vary from the wet season. During wet season, there is higher reliance on rain collection and pond, whereas during dry season, reliance is on piped water, ground water, and pond.

Piped drinking water in the Project area is provided by Gonde Water Supply scheme. Water is distributed through pipes to the community water points in the villages and costs about 0.25 Birr per jerry can. It has been understood from discussions that the water is not adequate to meet the needs of the people for domestic use. The problem becomes worse during dry seasons. Bite and Meja Shenen use ponds and traditional wells, respectively.

One in two (56%) of the respondents travel for between 0 to 30 minutes to a water point, while 12% of households say that they take between 30 minutes to 1 hour; and about 32% households respond that they have to travel more than one hour to collect water from the source. This shows that access to water points is a challenge to most households.

Figure 7.9 Community water post in the Project area.

WHO estimates average water use for drinking, cooking and personal hygiene in any household at least 15 litres per person per day. The study identified that about 41% of households use 41 to 100 litres per day, 34% about less than 30 litres, 9% about 81 to 100 litres. Nearly one in ten (10%) households use between 101 to 160 litres of water per day while 7% use more than 160 litres for domestic use. This shows that with an average household size of 7, the quantity consumed is not adequate, as per the standards.

Respondents were asked to provide a list of strategies that they use for purifying their water before drinking. About eight in ten (85%) use the water without any purification method. This is an indication that water and sanitation public health related diseases such as diarrhoea and typhoid are high. Some use methods such as straining water through cloth (12%), boiling (7%), adding bleach or chlorine (6%), while other let it stand and settle (5%) and water filter (4%).

7.10.4 *Finance*

The availability of various financial institutions like banks and insurance, rural credit and saving association play a significant role in transforming any economy. Financial institutions operating in the area include Oromo Cooperative Bank, Oromo International Bank, Commercial Bank of Ethiopia and Oromo Saving and Credit institution. From the study, about 16% of the respondents have bank accounts. This corroborates what has been established in the rural areas where there are no financial institutions to provide such services. This also shows that the culture of saving and borrowing among people in the Project area is still low. Among those who have bank accounts, this study further established that account opening started increasing in 2003 (2011 according to the European calendar).

7.10.5 *Source of energy*

Reports indicate that in urban areas, over half the households in Ethiopia rely on biomass (wood, dung and agricultural residues) for cooking, and in rural areas, virtually all do (except for 0.2% who use kerosene, and 1.2% charcoal). Our baseline study shows similar narrative. In terms of lighting, kerosene lamps were the most prevalent at 93% but a significant proportion of households use battery lamp. Uses of firewood and kerosene have a diverse effect on global warming effects as well as serious impacts on individual health.

Baseline of service within the Drilling area

Roads are scarce in the Drilling area although the area can be accessed from Tero Desta from the north or Iteya from the south, both by gravel roads. Trails cross the Drilling area.

The affected Kebeles rely on Gonde Water Supply Scheme where drinking water is piped to community water points in villages. In Dodata 54% of the population is in a less than hour's distance from water source as opposed to 79% of Hitosa population.

According to WHO estimation a household person uses 15 litres of drinking water per day for drinking, cooking and personal hygiene. The average household size is 7 persons which means that every household in Dodota and Hitosa should be using approximately 105 litres per day. According to the survey 84% of households use less than 100 litres per day. This indicates that drinking water is not easily accessible.

Households in Dodota and Hitosa rely mostly on firewood for cooking but also charcoal and kerosene. Source of energy for lightning is mainly kerosene and then battery lamps. Electricity is virtually non-existent.

7.11 Poverty, deprivation and vulnerable groups

Vulnerable groups

This study identified a number of vulnerable groups for the Project, including the elderly, youth, women, widowed, unemployed, children and the disabled as well as chronically ill persons. These groups will need to receive special consideration at all times so as to uplift their standards. The consultant carried out consultation meetings with these vulnerable groups particularly with women and various issues were raised during the discussion. The following issues resulted from the discussions:

Culture and the role of women

From consultation with women in the project area, women face certain unique vulnerabilities which arise from the way society is structured, their roles and responsibilities. Nonetheless, it is important to note that these same roles give them a sense of place and belonging within the community, therefore a balance between cultural

sensitivity and gender mainstreaming is necessary for all interactions with this community.

The participants also stated that since the community has practiced Islamic religion for generations, there is no clear demarcation of expectations from culture and religion. This therefore suggests that Christan minorities among the RG workforce will have to be sensitized on cultural/religious expectations to avoid conflict and misunderstanding in interactions with the community in general and with women in particular.

Development priorities

From the discussions, it was clear that women within the community are very aware of their sense of place as determined by their culture. The main role of women in the community is child rearing and taking care of the home. As such, all the perceptions on expected project benefits are geared toward improving their socio-economic environment. For example, all the women consulted during the FGDs prioritized access to health services, potable water and mills for grinding crops. The environmental concerns were also based on the lack of adequate fuel resources due to deforestation in the area. They complained that the current strained sources are not well processed hence there are problems with in-door air pollution due to the smoke content in the fuel wood.

Employment and paid labour

Paid labour and employment are considered as secondary activities that can only be conducted by single women or women with older children who are not at home during working hours. Even in the latter scenario, women who work are expected to “organize themselves” such that they are able to pick up with home related duties before leaving for work and after coming back from work. For those who are lucky to live with adult female relatives, it was reported that certain duties can be delegated to them. However, the main responsibility remains with the wife and mother in the home.

Some individuals felt that women with young children should focus on child rearing until the children are old enough to go to school. Even then, there may be need for additional support to women in the form of flexible working hours such as leaving work early to continue with duties in the home. For example, it was reported that the children in early childhood education can be released from school between 12 noon and 3 pm.

Differences across the female age groups arose in the form of expectations on paid labour. The older women expect women in the labour force to earn a lower income as compared to their male counterparts. They felt that women should be paid less since they are not equal mentally and physically in the case of manual labour.

This sentiment was however not shared by the younger generation who felt that men and women should receive equal pay. They proposed an option of work opportunities being divided into three shifts to allow for women with younger children to work between 9 am and 3 pm, while those with no other responsibilities working as any other member of the labour force.

It is therefore clear for women to benefit from employment opportunities by RG, there is need to profile available opportunities and support them with gender mainstreaming interventions to provide equal opportunitiesto men and women in the project area. It is also recommended that employment opportunities offered to women should be given special attention during disclosure to ensure that the platforms used to communicate such opportunities are easily accessible to local women.

Land take and resettlement

The sample group consulted during the FGDs felt that in the event of cash compensation, families would be vulnerable to poverty and homelessness. The FGD participants therefore promoted in-kind compensation and adequate livelihood restoration strategies at the resettlement site. The participant re-iterated that there is (relatively) adequate land, the poor productivity in terms of fodder and water sources is a hindrance to small scale or confined grazing patterns. As such, there was also a fear of diminished grazing grounds after land take by the project. Other issues that were expected to arise include positive and negative social change and relocation of graves which they felt should be avoided at all costs.

Resource mobilisation by local women

From the discussions, it was clear that the local women have some experience in resource mobilisation through table banking. The women reported that they save money and pool it together to purchase sheep and fatten them prior to selling them in the markets. Money raised is either used to increase their capital base, loaned to members or paid out as a profit.

Internventions for children

From the discussions, it can be deduced that since the primary care giver of children is the mother. As such, interventions aimed at improving the quality of life of children in the project area would require additional consultation with women.

7.12 Gender roles

In the Project area, the frequency of participations of household members in various activities depends on their gender and age. According to the household survey data, men (83%) have a great share of involving themselves in agricultural activities followed by boys (62%). Cooking is the preserve of the women (81%), and girls (66%). Collection of water, women (73%) and girls (59%) still perform such chores as well as in collecting firewood, women (76%) and girls (63%). Taking care of children is still the reserve of women (68%) and girls (59%), just as undertaking market activities, (women (64%) and girls (44%). Livestock keeping, is performed by men (69%) and boys (59%) as well as building houses, men (81%) and boys (62%).

According to the discussions held with the respective Woreda women, Children and Youth Affairs, the Constitution has given equal rights for both males and females and they have equal opportunities and say in all aspects. However, the long lasting traditional practices and cultures which favour the males are not totally improved as they require continuous awareness creation. Due to this reasons though there is some improvement, in most cases the participation on overall decision making and resource utilization is dominated by men.

7.13 Households ownership and assets

Since the Project area population are mostly farmers and pastorals, it is evident that the majority own ox plough (84%), donkey (84%), oxen (81%) and hand hoes (79%). This is a clear indication that they solely depend on agriculture for their livelihood. Other items owned include mobile phone (59%), radios (47%), which are important tools for communication. Bicycle is owned by about one in every ten households (9%). Television is owned by about 7% of households, but it is predominantly owned in Hitossa compared to the other Woredas.

Table 7.14 Household ownership and assets

	Woreda			
Household assets	Dodota*	Hitosa*	Z Dugda	Overall
Ox plough	87%	87%	80%	84%
Donkey	90%	88%	78%	84%
Oxen	82%	89%	77%	81%
Hand hoes	70%	85%	80%	79%
Mobile phone	56%	72%	55%	59%
Radio	53%	54%	44%	47%
Bicycle	3%	10%	13%	9%
Television	4%	11%	6%	7%
Oxen cart	2%	2%	11%	7%
Water pump	1%	2%	2%	2%
Horse cart	1%	1%	2%	1%
Motor vehicle	1%	1%	2%	1%
Tractor	0%	1%	0%	0%

*Woredas within potential drilling site.

7.13.1 *Housing quality*

Shelter is one of the basic human needs and good quality of life includes having comfortable housing. There is generally a strong relationship between household economic conditions and quality of housing and as such information on housing characteristics is critical to explaining associations between households' social and economic conditions. In this survey, the quality of respondent's houses was assessed in terms of roofing, walls and floor.

Majority of houses in the Project area are grass thatched with a few having iron sheet roofing. Walls are mainly made of mud with earthen floors. Houses with iron sheet roofing suggest relatively better income level than those that are grass thatched.

Figure 7.10 A typical house in the Project area.

Figure 7.11 **Houses in the Project area, both with iron roofs and typical grass thatched roofs.**

Baseline of vulnerable groups, poverty and deprivation within the Drilling area

Females are a vulnerable group in the Drilling area with typical gender roles where females take care of the family and home while the males make decisions and take care of agricultural activities, build houses etc.

Housing is basic in the area, with grass, mud and earth being building materials for roof, walls and floor and sometimes iron sheets for roofing. Household material assets consist mainly of agriculture related items.

7.14 Tourism

Overall, there is low tourism activity in the area, where visitors come to Tulu Moye mainly to experience the geothermal steam baths. However, the area has high potential for birdwatching and avi-tourism. Sites of cultural significance, means any site that have aesthetic, historic, scientific, social or spiritual value for past, present or future generations. Dodota and Hitosa have some attraction sites which have already been identified by the Culture and Tourism Bureau (Table 7.15) however only few of these sites area within the project area; Tero Geothermal Steam, Natural steam baths in Tero Moye and then Anole Martyrs Monument which is near the Project area.

Table 7.15 Sites of cultural attraction within the Woredas listed by the Culture and Tourism Bureau.

Name of attraction	Location
Dilfakar regional park	Dera
Dilfakar shrine	Dera
Tero Geothermal Steam	Tero Desta
Shabalo Hot Water	Mire shire
Belale's forest	Belale
Lake Koka	Amude
Mount Dabaso	Dabaso
Amude Haro Rophi Lake	Amude
Anole Martyrs Monument	Anole
Natural steam baths	Tero Moye

7.15 Impact assessment

7.15.1 Impacts during construction and operation phases

Building of well pads, access roads and power plant can result in loss of agricultural and/or grazing land. This may affect local households in the area and may call for expropriation of land used for settlement or agriculture.

When locating the sites for the Power Station, well pads GA and B and access roads - it has been the aim to minimize potential negative impacts on current housing and agrigulture. Figure 7.13 shows how the location of these project components have a direct impact on agricultural land and current housing. Apparently, 3-4 huts are located within the site for the Power stations. There is one located in the marked area (Figure 7.12 and Figure 7.13). There is another about 100 m from the area. The next is about 400 -500 m away. The number in housholds in these residence is not known. There are no settlements in the Gnaro lava field, where the well pads are located.

Based on the current state of settlement and agricultural land it seem likely that the proposed location of well pads, power station and access road will have minor to moderate impacts.

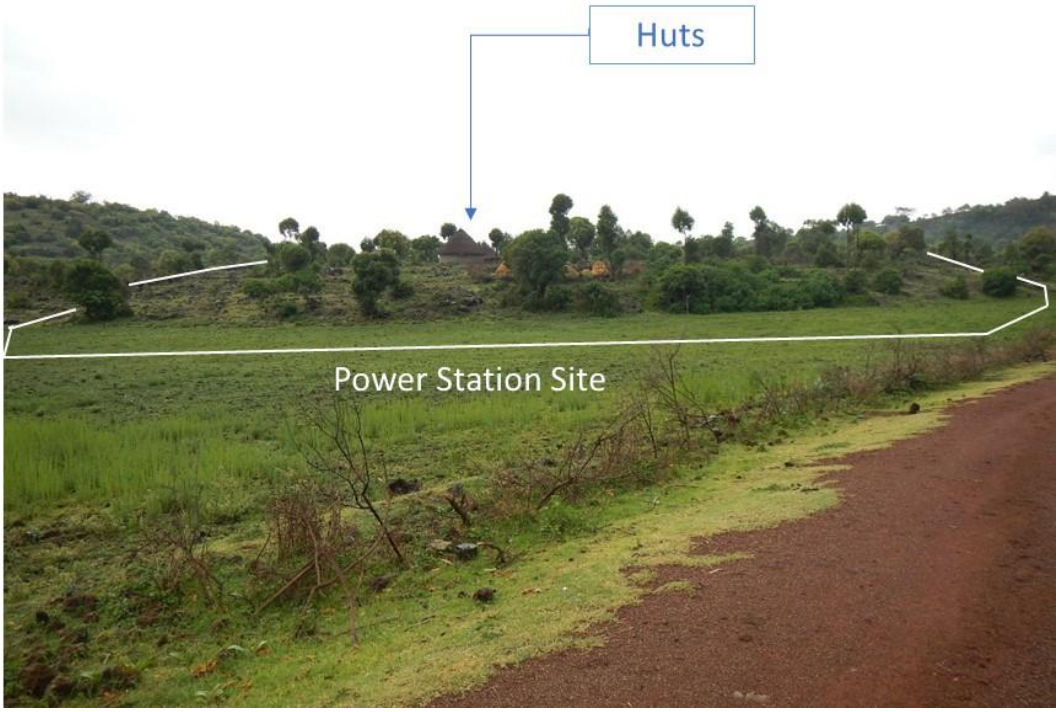


Figure 7.12 **Current status of the Power Station site in June 2017**

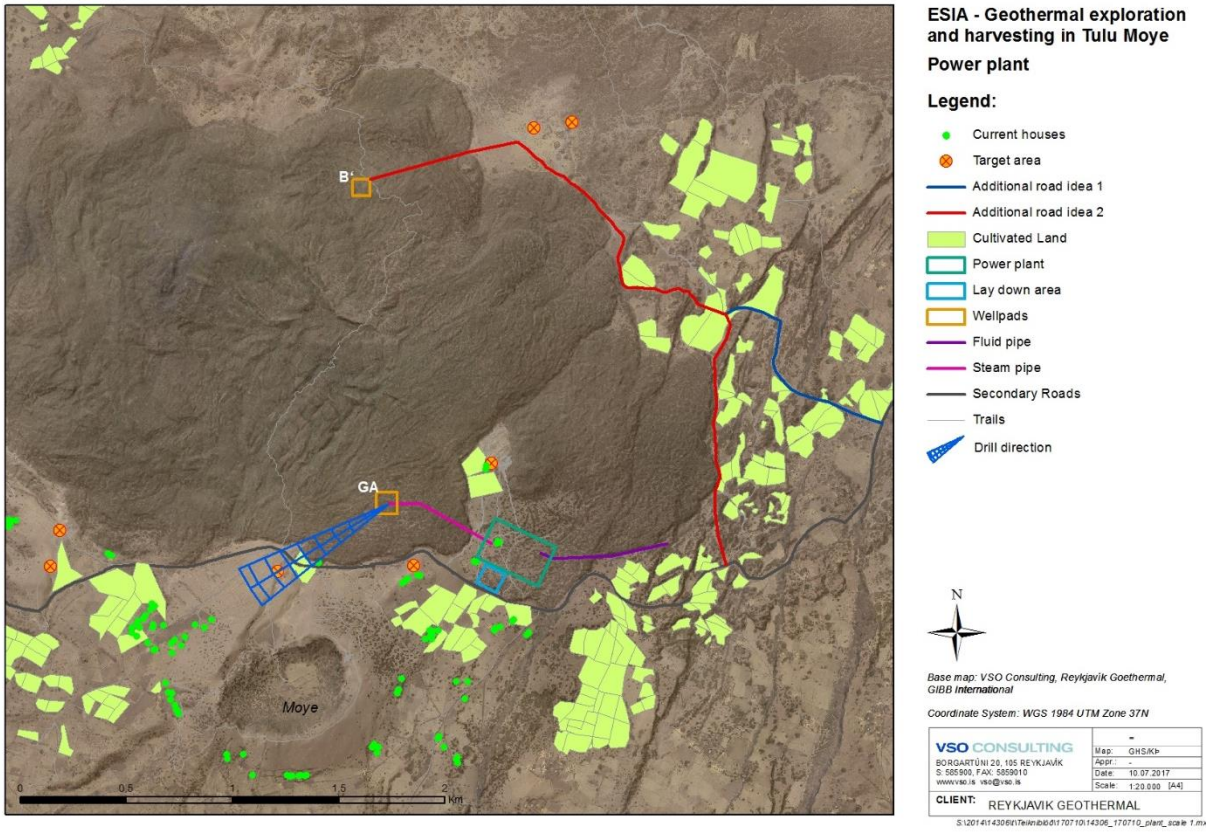


Figure 7.13 **Power station, well pads, access roads, current houses around the projects and cultivated land**

The population of the six Kebeles affected by the Drilling area is 20,614. It is expected that temporary jobs will be created in connection with the Project. Local workers will be hired in order to reduce risk of socio-cultural conflict due to influx of people to the Project area. Increased activity in the area will however generate temporary influx of people. This might affect the way of life, cause cultural conflicts and strain on local resources

It depends on the site selection for the Project how many households will be directly affected by the Project. Choosing drilling sites or locating a power station close to villages will affect more households directly than if the drilling takes place in more rural areas. RG's proposal for the location of the first two well pads and Power Station seem to minimize the number of households that may be directly affected by the Project.

In general, the Project will improve quality of life in the local community. It will create jobs and opportunites for new income sources.

Conventionally, projects of this nature create typical men's jobs on site although jobs needed to support the work force may be a mixture of both genders. Disclosure and consultation with elders will be important in all preparation, planning and organization prior to and during construction and operation.

Technical training will be provided to local staff and expertise passed on to local entities. This transition will include training and education of local experts and cooperation with regional institutions and local contractors and consultants. UNU geothermal programs will be introduced and utilized to increase the competence of employees and partners. This will increase the overall skills and have positive impact in the area.

The impact significance on cultural sites depends on site selection. Site selection will take into consideration the location of cemeteries and mosques in the Project area. Defining buffer Zones for potential impact during construction and operation helps identifying desirable and undesirable sites for drilling and operating a power station and simultaneously minimizing the impact on sites having cultural significance. The locations of well pads GA and B, power station and the access roads seem to be clear of cultural sites, cementaries and mosques.

During construction, the risk of accidents for workers may increase. This also applies to the operation of a power station. The transfer of high heat steam and water increases risk of burning. This calls for limited or controlled access to Project sites.

The geothermal Project is not likely increase health problems, given that the noise and air quality will be acceptable to standards. A possible significant positive impact, is if the Project leads to easier access to drinkable water and access to electricity.

If drilling for water proves successful and the water is potable this could have significant positive impact on the water supply for the local communities in the area. This would also have positive impact on the public health in the area. There is insignificant risk of adverse impacts on water supply of local households as the proposed drinking water extraction sites for the Prjoct are not close to any known local drinking water sources.

7.15.2 Impacts during decommissioning phase

Land restoration that follows the demolition of buildings and structures can temporarily increase employment opportunities. It also causes risk of accidents to workers and locals which can be minimized with information campaign, health and safety plan, fencing and signage.

Closing of the power plant will cause employment loss along with decreased income for households. It also causes lowered standards in terms of access to drinking water and electricity.

7.16 Summary of impacts and mitigation measures

7.16.1 Impacts during construction phase

Table 7.16 Construction phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measures	Residual significance
Land expropriated	Household loses its main source of income and food	Major	Livelihood Restoration Plan. Resettlement Action Plan.	Moderate
	Vulnerable groups lose their main source of income and food	Major	Policy for compensation and site selection	Moderate
Site clearance	Crops lost	Moderate	Compensation for lost crops. Location of project.	Minor
Water extraction	Households get less water	Major	Water supply from other sources than in local use	Insignificant
Hiring of local workers	Lower unemployment rate	Moderate		
	Increased income for households	Moderate		
	May enhance situation of vulnerable groups	Moderate		
Influx of non-local workers	Socio-cultural conflict	Minor	Disclosure of Recruitment Policy. Inform workers of the local religion.	Insignificant
	Sexually transmitted diseases	Moderate	HIV /AIDS Policy and Engagement Plan	Minor
	Non-local workers will be hired at the cost of individuals in vulnerable groups, i.e. women will not be employed	Moderate	Disclosure of Recruitment Policy. Avoid gender bias if possible.	Minor
Training for employees	Improves overall skills and knowledge in the area	Moderate		
Construction work	Risk of accidents for workers and residents	Major	Training program for staff and preventative safety measures in place for residents and visitors such as fencing and signage	Minor
			Health and Safety Program	Minor
	May disturb peace cemeteries and mosques	Moderate	Take into consideration during site selection	Minor
Building new roads	Infrastructure improves and enhances access to places and services	Moderate		

Action	Impact	Significance	Mitigation measures	Residual significance
	Access for tourists may improve	Moderate		
	Increased access may adversely affect tourist sites	Minor	Take tourist potential into consideration during site selection and design	Insignificant
Well testing	Disturbance for locals (noise, air)	Moderate	See chapter 8 on air and 12 on noise	
	Risk of burning from steam	Major	Signage, informing locals, fencing	Minor

7.16.2 *Impacts during operation phase*

Table 7.17 Operation phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Employment regarding operation	Increased income for households	Minor		
	Risk of accidents or work related health issues	Moderate	Staff training and occupational health and safety plan	Minor
Drilling of additional wells and testing of wells	See table Table 7.16		Health & Safety Program including training	
Operation of a geothermal plant	Attracts tourists, which can benefit the economy	Minor		

7.16.3 *Impacts during decommissioning phase*

Table 7.18 Decommissioning phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Land restoration	Increased employment	Minor		
	Risk of accidents for workers and locals	Moderate	Information campaign, health and safety plan, fencing, signage	Minor
Closing of operation	Employment loss, decreased income for households	Minor		

7.17 Conclusion

The Project is likely to have minor to moderate positive impacts on the social aspects of the environment. Employment will increase and thus enhance the economy and livelihood of households and lower unemployment rate at least temporarily. Infrastructure will be improved and thus enhance access for tourists which are likely to be interested in the geothermal plant. Increased tourist attraction can have positive impact on the local economy. Having taken mitigation mesures into account the residual adverse impacts on social aspects is insignificant to moderate.

The most critical impact is the land exproptiation which will be met with Livelihood Restoration Plan and Resettlement Action Plan. Impact on vulnerable groups losing their income and livelyhood will be met with compensation policy and site selection. The location of the Power Station, well pads GA and B, as well as access roads seems to minimize the potential impact on agricultural land and households.

In order to minimize risk on health and safety of workers and locals a training program and preventative safety measures will be put in place. Cultural conflicts due to influx of workers of other culture and religion will be met with information and training. Disturbance of cemetaries and other culturally significant sites will be avoided by/when selecting site for the operation.

8 Biodiversity and ecology

8.1 Introduction

This chapter aims to describe the biodiversity and ecology of the Project area and predict the potential impacts the proposed Project will have there on. A definition is given of the affected area and an overview of the appropriate legislation, guidelines and standards. The baseline information was gathered by GIBB International for the purpose of this EISA (GIBB International, 2015). The information was collected through desk top study and field sampling. The impact assessment was done by VSO Consulting and RG.

To verify earlier baseline findings during the wet season, RG is currently preparing a Rapid Biodiversity Study for the likely Project area of the first phase of the Project, i.e. the well pads within drilling area, site of the Power Station and access roads. When the study is available, it will be published as a report to accompany this ESIA. At later date, ESIA V.03 will have this chapter will be updated with the latest information on the current state.

8.2 Affected area

The affected area is defined by distances from potential drilling site:

- Protected sites within 10 km from Drilling area
- Ecosystems within 500 m from Drilling area
- Migratory birds, mammals and herpetofauna within 2 km from Drilling area

8.3 Legislative framework

8.3.1 National

- The Environmental Policy of Ethiopia
- Conservation Strategy of Ethiopia (CSE)

8.3.2 International

- Convention on Biological Diversity
- African Convention on the Conservation of Nature and Natural Resources (The Algiers Convention)
- Convention on International Trade in Endangered Species (CITES). CITES list of protected species.
- Convention on the Conservation of Migratory Species of Wild Animals
- United Nations Convention to Combat Desertification (UNCCD)
- The Ramsar Convention on Wetlands of International Importance. Ethiopia is yet to adopt this convention.
- International Union for Conservation of Nature (IUCN). The IUCN Red List of Threatened Species.
- Birdlife Important Bird and Biodiversity Areas (IBAs).
- IFC PS 6 - Biodiversity Conservation and Sustainable Management of Living Natural Resources

Impact assessment questions and objectives of study according to scoping document

Vegetation

- Determine vegetation composition and identify community types of each area.
- Determine if there are endangered plant species or communities that would be affected by the development in the area.
- Compare the study with the vegetation mapping.

Wildlife and Habitats

- What is the wildlife within the Project area?
- Are there important bird areas close to the Project area?
- Are there endemic, endangered or vulnerable species within the Project area? Critically endangered, endangered and vulnerable within Oramia are: Black rhinoceros and Ethiopian wolf are considered to be critically endangered, Grevy's zebra, mountain nyala and wild dog are endangered and African elephant, cheetah and lion are considered vulnerable.
- Are there woodlands, bio-diversity, soil and important factors for food security within the Project area?
- Are there species important for local communities within the Project area?
- Are there migration routes of animals within the Project area?
- Are there IBAs (Important Bird Areas) within or close by the Project area?
- Can noise and vibration affect animals?

8.4 Baseline description

The following chapter describes the baseline condition of the biodiversity and ecology of the Project area. Emphasis is put upon describing protected species or species of conservation value as well as the characteristic vegetation type, plants, birds, mammals and herpetofauna.

8.4.1 Protected areas and species

Within 10 km from Project area

There are no protected areas i.e. national parks, reserves or wildlife sanctuaries within the Project area. However, Lake Koka and Lake Zeway found close to the Project area (more than 10 km distance from Drilling area) are listed as Important Bird Areas (IBAs). The two lakes are listed as IBA sites on the basis of holding globally threatened bird species such as shoebill (*Balaeniceps rex)* and black-winged pratincole (*Glareola nordmanni) at* Lake Zeway and lesser flamingo (*Phoeniconaias minor)* and basra reed warbler (*Acrocephalus griseldis)* at Lake Koka. Although these lakes are outside the Project area boundary, their location with regard to the Project area means that birds may move between the two wetlands as well as Bite Lake are likely to fly over the Project area. The larger Project area represents a migration corridor for birds as it is located within the Great Rift Valley flyway, which is one of the world's most important bird migration corridors linking Europe, Asia, and Africa for birds migrating between breeding and wintering grounds in Eurasia and Africa.

Within Project area

Furthermore, nine bird species are listed in the IUCN red list, of which three are Endangered, three Vulnerable and three Near Threatened species. Additionally, some 29 bird species are listed in Class A of the Algiers Convention. Another 22 species are listed in Class B of the same convention and one species, i.e. Lesser Kestrel, is recognized by

Ethiopian Wildlife Development, Conservation and Utilization Council of Ministers Regulations as a Protected Species.

One plant species within the Project area i.e. *Osyris lanceolata* is listed in CITES Appendix 2 which means not necessarily threatened with extinction now but may become so unless trade is closely controlled. Other plants of conservation concern include invasive species like *Senna didymobotrya, Nicotiana glauca, Lantana camara* and *Argemone Mexicana.*

Four mammal species occurring in the area are listed in Class B of the African Convention on the Conservation of Nature and Natural Resources (The Algiers Convention). They include hippopotamus, klipspringer, oribi, grivet monkey and aardvark (Figure 8.1). The hippopotamus is also listed in Class B as well as being classified as threatened by IUCN. Although not found within the Project area, it is however found at Lake Koka and Lake Ziway.

Protected sites and species within Project area and within 10 km from the area

IUCN, red list: 9 bird species.

IBA sites: Lake Koka and Lake Ziway, habitat of globally threatened bird species.

CITES lists (Convention on International Trade in Endangered Species of Wild Fauna and Flora): One plant species

Algiers Convention: Five mammals, including one at Lake Koka and Lake Ziway. Total of 51 bird species.

Protected by Ethiopian regulations: One bird species

8.4.2 Plants and vegetation

Two major vegetation types are characteristic for the Project area vegetation: i) dry evergreen montane forest and grassland complex; and ii) *acacia- commiphora*. Other vegetation types are the human dominated agro-forestry and seasonal wetlands. Vegetation survey within the Project area recorded a total of 83 vascular plants within 45 families.

8.4.2.1 Dry evergreen montane forest and grassland complex

This vegetation type occurs mainly in the south-eastern side of the Project area covering Tulu Moye, Wal Argi, Denisa and Hurtu Dembi Kabeles and therefore the proposed Drilling area. This vegetation type is characterized mainly by *Juniperus procera* and *Olea europaea* and occurs at an altitude range of 2.200 – 2.330 m a.s.l. Other occasional species found in this area include *Ficussycomorus*, *Ficus vasta, Cussonia arborea* and *Croton macrostachyus*. The *Juniperus* and *Olea* trees in this area do not form continuous canopy, instead they occur as scattered isolated stands or in clusters owing to previous human disturbance. The open areas between the trees are either covered by shrubby-grassland or used as farmland where the terrain and soils are suitable. Besides being a habitat for arboreal fauna such as birds, bats and monkeys, this vegetation type is mainly utilized for timber, construction material, fuel wood and charcoal. *Olea europaea* is specially used by the local people as a milk flavoring agent. Major parts of Tulu Moye and Tulu Tatesa hills, which rise up to 2.330 m are largely covered by montane grassland such as *Festuca sp. and Aristida sp*. Grassland in all the areas especially on the hill sides is used for cattle grazing besides being a habitat for grassland biodiversity.

Adjacent to the *Juniper-Olea-grassland complex,* and within the drilling site, is a continuum of mixed evergreen scrub thicket on volcanic rocks at 2.231 m a.s.l. This unique vegetation type covers only a small area in Tulu Moye extending into Tero Desta Kebele as a plateau. It is dominated by the evergreen trees like *Rhus lancea, Olea*

europaea, Cussonia arborea, Juniperus procera while evergreen shrubs here include *Maytenus senegalenis, Rhus natalenis, Dodonea angustifolia, Buddleja polystachya, Carissa spinarum* and *Osyris lanceolata*. Among the shrubs found within the Project area is heather (*Erica arborea)* which is typical of Afroalpine and Subafroalpine ecosystem in higher altitudes above 3.200 m. This particular vegetation type is very important refugia for secretive species such as hyenas, rock hyrax, klipspringer and others. The white-cheeked Turaco was only recorded in this habitat type during the survey period.

Local people obtain vital livelihood resources such as fuel wood, construction material, medicinal herbs and farm tools handles from this thicket.

8.4.2.2 *Acacia-commiphora woodland*

This vegetation type dominates most of the Project area, and is found within the drilling site. It covers most of the drier parts including Tero Desta, Amude, Bite, Bite Daba, Boka, Meja Shenen, Burka Lemafo, Ula Arba and Arba Chafa Kebeles. This vegetation type is characterized by drought resistant trees and shrubs which are either deciduous or have small evergreen leaves. The dominant trees include *Acacia tortilis, A. sengal, A. seyal, Commiphora africana*, *C. schimperi, Balanites aegyptiaca, Lannea riva* among others. The ground is rich in subshrubs in the genera *Acalypha, Bareria* and *Aerva*. Grasses growing here belong mainly to the genera *Hyparrhenia, Heteropogon, Setaria, Sporolobus and Panicum*. Within the *Acacia-Commiphora* woodland there are occasional natural occurrences of succulents that are typical of dry ecosystem such as *Euphorbia, Cactus, Aloe* and *Agave*. This vegetation type acts as habitat for wildlife such as klipspringer, porcupine, oribi, dikdik, scrub hare as well as providing fuel wood, charcoal and bee hive locations for local communities.

8.4.2.3 *Other ecosystem types*

There are no major wetland ecosystems within the Project area apart from Lake Bite which is seasonal. Furthermore, the rivers occurring within the Project area are small and seasonal only flowing during rains. For this reason, there is not much aquatic biodiversity within the Project area.

In all Kabeles there is substantial land cover under human settlements and agro-forestry where subsistence farming and livestock keeping are the major activities. Dominant farmland trees include *Ficus* species, *Croton macrostachyus* and other species that are common in respective Kabeles such as *Acacia* and *Balanites*. Typical farmland fauna includes warthogs, aardvark, baboons, oribi, abyssinian ground hornbill, vultures and other numerous birds. Overall, acacias are the most dominant plants especially in the dry hilly landscape while *Ficus* trees (indicative of low water table) and *Croton macrostachyus* are widely spread over the entire area, being less abundant in drier areas.

8.4.3 Birds

Within 10 km from Project area

A total of 259 bird species within 63 families were recorded. Nine of these species are listed in the IUCN red list, of which three are Endangered, three Vulnerable and three Near Threatened species. Additionally, some 29 bird species are listed in Class A of the Algiers Convention. Another 22 species are listed in Class B of the same convention. Furthermore, one species, i.e. Lesser Kestrel, is recognized by Ethiopian Wildlife Development, Conservation and Utilization Council of Ministers Regulations as a Protected Species. According to these regulations female and juvenile of all species are protected species. Of the birds recorded, 61 species are migratory, comprising of 46 parlaearctic migrants (from Europe and Asia) and 27 intra-African migrants. Part of the populations of 13 parlaearctic migrants is known to also remain and breed in Africa.

Although some of the species listed under different threat and protection status occur outside the Project area i.e. Lake Zeway and Lake Koka, these and many other birds (water birds or otherwise) are expected to fly over the Project area. Steep cliffs and average high temperatures within the Rift Valley produce ideal conditions for thermals i.e. the moving hot air currents that raptors and large soaring birds, such as storks, need for their long journeys.

Overall, the presence of large numbers of vultures in this area (most of them endangered) is remarkable considering that the populations of this group of birds is alarmingly declining in the entire African region and even globally. Appendix I provides detailed species list of bird species, their conservation status and occurrence patterns.

8.4.4 Mammals

Within Project area

Despite the area being subject to diverse human activities mainly farming and grazing, 40 species of mammals within 28 families were recorded most of which are small mammals. Out of these, only one mammal species recorded during this study is listed by IUCN as threatened. This is the hippopotamus which is listed as vulnerable. This species can be found in Lake Koka and Lake Zeway both of which are outside the Project area. Five species occurring within the Project area are listed in Class B of the African Convention on the Conservation of Nature and Natural Resources (The Algiers Convention). This means that they are totally protected, but may be hunted, killed, captured or collected under special authorization granted by the competent Authority in contracting states. They include hippopotamus, klipspringer, oribi, grivet monkey and aardvark.

The aardvark, is recognized by Ethiopian Wildlife Development, Conservation and Utilization Council of Ministers Regulations as a Protected Species. Indeed, according to these regulations females and juveniles of all species are protected species. Appendix I provides detailed species list of mammal species, their conservation status and occurrence patterns within the Project area.

The term *wildlife corridor* is often used to refer to an area of habitat connecting wildlife populations separated by human activities or structures such as roads or other developments. Although considerable number of wildlife species does occur within the Project area, the area does not represent a migratory corridor since there are no major wildlife conservation areas such as national parks, reserves or wildlife sanctuaries nearby. In any case the mammal species found here occur only in very small resident populations that tend to be sedentary. Although certain mammals such as baboons can be highly mobile, traversing different habitat types within the Project area in search of food, they have high ecological adaptability which may enable them to remain in the general area all year round. They may especially do well in this area since they live alongside humans, where they feed from remains of human food sometimes as pests.

	
Hippopotamus (Hippopotamus amphibius)	Aardvark (Orycteropus afer)
	
Klipspringer (Oreotragus oreotragus)	Oribi (*Ourebia ourebi)*
	
Grivet monkey (Chlorocebus aethiops)	Shoebill (Balaeniceps rex)

Figure 8.1 Examples of wildlife in and near the Project /Study area.

8.4.5 Herpetofauna (reptiles and amphibians)

Within Project area

A total of 30 species in the herpetofauna groups were recorded including 12 species of snakes, 11 lizards, 2 chameleons, 1 tortoise, 3 frogs and 1 toad. Though none of the recorded species is listed in the IUCN red list, they are highly prone to disturbances from geothermal operations such as vibration especially since they are burrowing animals - most of which lack swift movement.

It is noteworthy that reptiles do exhibit seasonal variation in abundance, many being able to hibernate during the unfavourable dry seasons. This may be the reason for registering low encounter rates of reptiles and amphibians during this survey. Further field survey during wet season may yield more species.

8.4.6 Aquatic biodiversity

Due to lack of permanent water reservoir such lakes, dams or rivers, the Project area does not hold significant aquatic biodiversity. In particular, there are no fisheries

resources within the Project area. However, various frog species are known to exist in this area.

8.4.7 *Ecosystem and biodiversity values to local communities*

The local communities make diverse uses of the biodiversity and ecosystem resources found within this area. Most importantly, the flat lowland areas with deep soils are suitable for agriculture where different crops and livestock are cultivated for food security. Additionally, the seasonal water collection points within the area such Lake Bite and other man-made ponds also form crucial source of water for domestic use and for livestock as well as for wildlife in the area. Further, the diverse plant species in this area are put to different uses by the local community such as a source of house construction material, medicine, food, cosmetics, making of farm implement tools and tool handles while other plants are important animal fodder. Bee keeping and honey production is also an important economic activity practiced in this area – where bees can obtain nectar from various plants especially Acacia.

Certain trees particularly *Ficus* species has both cultural and livelihood importance to local communities. For instance, in case of prolonged droughts, elders gather and give offering under the big ficus trees. Cutting down of the big ficus tree stands is therefore not allowed. These trees provide excellent shade for meeting places and also act as resting places for livestock besides supporting diverse species of biodiversity such as birds, bats, monkeys and invertebrates. Other plants having cultural value to the communities are those species that are either planted or naturally grow within cemeteries. These include *Croton macrostachyus, Juniperus procera, Olea europea, Ficus and Acacia* species among others.

One peculiar ecological phenomenon observed at various locations within the Project area is the fact that *Ficus* trees act as centers of regeneration for other plants whose seeds grow near them when seeds have been dropped by birds and other seed dispersers. This happens when the Ficus attract frugivorous fauna especially birds which disperse seeds under or near the tree crown where they germinate better that in open areas.

Other indirect ecosystem benefits from biodiversity, including the observation provided of the fairly large numbers of vultures in the area. The vultures likely have access to sufficient carcasses of dead animals to sustain their numbers.

There are several myths and beliefs associated with different wildlife species occurring among the local communities in this area i.e. the abyssinian hornbill and ground hornbill. It is due to strong cultural believes that many animals have persisted in the midst of farmers since they are not hunted or killed.

Overall, there is low tourism activity in the area, where visitors come to Tulu Moye mainly to experience the geothermal steam bath. However, the area has high potential for birdwatching and avi-tourism.

8.4.8 *Threats to biodiversity within the Project area*

Key threats to biodiversity identified in Project area include: a) unsustainable anthropogenic activities; and b) natural phenomena such as i) drought and climate change, ii) soil erosion and iii) spread of invasive species and c) the interaction between these processes.

Some of the anthropogenic activities observed in the area that have negative effects on wildlife and ecosystems include charcoal burning and cutting trees for fuel- wood especially for sale. There is also evidence of game meat where hunting game birds such as guienafowls and francolins seem to be the main target.

Prolonged drought may be a serious problem for the resident human and wildlife populations who may be forced to travel long distances in search of water. In some areas such as Bite and Bite Daba Kebeles, soil erosion is a severe problem leading to formation of deep gullies.

Several invasive plant species have been identified in many parts of the study area such as *Lantana camera* and *Nicotian glauca*.

Finally, there are several forms of human-wildlife conflicts in the Project area. These include crop raids by baboons and other wildlife such as warthogs and antelopes as well as wounding and killing of livestock by hyenas. There are also cases of farmers losing honey to honey badgers forcing them to innovate ways of preventing the animals form climbing the trees with bee hives.

Baseline summary - proposed Drilling area

Flora: Bushed shrubbed grassland and open woodland. Acacias are the most dominant plants especially in the dry hilly landscape while *Ficus* trees and *Croton macrostachyus* are widely spread over the entire area, being less abundant in drier areas.

Fauna: Arboreal fauna such as birds, bats and monkeys. Flyway for birds through the Great Rift Valley thus extending outside the Drilling area and Project area. Secretive species i.e. hyenas, rock hyrax, klipspringer. Klipspringer, oribi, grivet monkey and aardvark are protected species.

A total of 30 species in the herpetofauna groups were recorded at the Project area. It is not clear if those species are found within the Drilling area. To minimize potential adverse impacts, a biodiversity survey should be carried out prior to any interruption of land.

8.5 Impact assessment on biodiversity and ecology

8.5.1 Impact during construction and operation phase

Figure 8.2 Typical vegation in the Gnaro obsidian lava field

Site clearance in preparation for construction causes disruption of vegetation cover, as well as disruption of habitat (fauna) and possible disruption of pathways/corridors. This can result in adverse impacts on protected species. Biodiversity survey will be carried out prior to site selection in order to minimize adverse impacts and avoid disturbing sensitive areas and species. Clearance of certain vegetation can have adverse impacts on secretive species and burrowing fauna and thus consideration will be given to that regard during site selection. If applicable, sensitive areas will be cordoned off as to not being disturbed by accident.

Clearance of natural vegetation can also give invasive species opportunity to spread. In order to prevent the spreading of invasive plants a Wildlife Protection Plan will be put in place. Soil or other material with invasive plant residues such as seeds and roots will be treated properly and when re-vegetating land only native species will be used.

Clearing of culturally important vegetation such as acacia, ficus and olea will be avoided as possible. Consultation with locals will be undertaken as necessary.

Following issues are recommended for timely management of ecosystems:

- Adhere to the findings of the Biodiversity Study
- Involving experts identification and mapping of species and priority ecosystems
- Special attention should be paid to endemic and endangered spieces.
- Flush out species prior to any interruption of land
- Remove and relocate important flora and sessile fauna to other/protected area(s)
- Stakeholder consultations in 2017 referred to indigenous tree species:
  - Plan for possibly planting trees instead of ones that need to be cut down
  - All trees that will be cut down should be counted and registered
  - If possible and legal, the residents of the area could be asked to cut down the trees and use for charcoal making

Steam and geothermal fluid can cause damage to vegetation during drilling and well testing. Hot steam can scald vegetation and therefore have impact on fauna. This is however temporary impact during drilling and testing of wells and should be reversible. Damage to vegetation due to geothermal steam will be mitigated by controlled well testing time.

Although geothermal structures are generally not very high, steam from cooling towers or high rise temporary buildings structures can impede on bird flyways. The project is located in an area that is a part of an important flyway and thus advice should be sought from specialists regarding potential risk of birds flying into cranes and structures. Possibly equipment to defer birds from colliding with structures should be considered as part of the Wildlife Protection Plan.

Conflicts between humans and animals may be exacerbated by the project activities especially if the animals' semi-natural habitats are reduced in size or the animals' dens are opened up during construction work.

Accidental deaths of wildlife will be minimized by undertaking biodiversity survey before the commencement of the project with focus on protected, endemic and endangered species, breeding birds and burrowing animals. This survey will be repeated on a regular basis as the project expands and appropriate actions taken to lower the risk of accidents.

Hunting, cultivation or deforestation by personnel will be prohibited.

In order to minimize impact on fauna efforts will be made, within reasonable limits, to plan construction outside breeding season.

Impacts on air quality and noise is discussed in consequent chapters (chapter 9 and 12).

8.5.2 Ecosystem services

Unless it is mitigated, Project direct impacts on priority ecosystem services may result in adverse health and safety risks and impacts to affected communities, resulting in significant changes to the physical environment, such as natural vegetation cover, existing topography, and hydrologic regimes.

In the geothermal case, special precautions should be followed to prevent reduction in the availability of surface water and groundwater for human and agricultural use, and prevent degradation in the quality of these resources. These requirements also apply to soil resources used by the community for agricultural or other purposes.

The quality of soil and water as well as other natural resources such as fauna and flora, woodlands, forest products and marine resources, should be protected to prevent risk to human health, safety, and the environment due to the presence of pollutants.

The ESIA needs to be updated once the water supply options are known, and once the biodiversity study has been revisited and reported.

8.5.3 Impacts during decommissioning phase

Noise from machineries and demolition can affect animals, disturb them or scare them which could have impact on results from nesting season. One way to mitigate impacts is to plan demolition outside breeding season.

Demolition can cause trapping or accidents for animals. Accidental deaths of wildlife will be minimized by undertaking detailed surveys before the commencement of the demolition. Demolition will be planned so it will be continuous and surface finish will not leave hazards of abandoned structures for wildlife.

8.6 Data limitation and uncertainty

Few herpeto fauna species were recorded in the survey. This can be because the survey was done in dry season. More species can emerge during wet season.

Although the baseline study did not report any endemic species, it identified some plant, mammal and bird species with conservation and protection status and IUCN red listed. The presence of these species in the Drilling area should be confirmed through biodiversity survey prior to any operation.

8.7 Summary of impacts and mitigation measures

8.7.1 Impacts during construction and operation phase

Table 8.1 Construction and operation phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Removal of vegetation cover	Habitat loss for fauna, fauna species lost.	Moderate	Biodiversity Man. Plan carried out prior to civil works and all through operations.	Minor
	Flora species lost.	Major	Biodiversity Man. Plan carried out prior to civil works and all through operations.	Minor

	Protected species lost	Major	Biodiversity Man. Plan carried out prior to civil works and all through operations. Sensitive areas cordoned off	Minor
	Disruption of pathways/corridors	Minor	Survey carried out prior to site selection. Biodiversity Man. Plan	Insignificant
	Spreading of invasive plants	Moderate	Soil and material with invasive plant residues will be treated.	Minor
			Only native species used when re-vegetating.	Minor
	Conflicts between humans and animals due to reduction of habitats or opening up of dens	Moderate	Biodiversity Man. Plan carried out prior to civil works and all through operations.	Minor
Steam and geothermal fluid from wells	Scalding of vegetation with impact on fauna	Minor	Controlled well testing time. Fluids directed to infiltration ponds.	Insignificant
High rising buildings and steam from cooling towers	Disruption of bird flyways	Moderate	Cooperate with bird experts, relevant authorities and locals when doing survey.	Minor
			Collision deferring equipment placed on high rise structures	Minor
Construction activity	Accidental deaths of wildlife, especially endangered species, breeding birds and burrowing animals.	Moderate	Biodiversity Man. Plan carried out prior to civil works and all through operations.	Minor
			Plan construction outside breeding season.	Insignificant

8.7.2 *Impacts during decommissioning phase*

Table 8.2 Decommissioning phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Noise from machineries	Disturbance of wildlife, impact on results from nesting season	Moderate	Plan demolition outside breeding season. Decommission Plan	Minor
Demolition	Trapping or accidents of wildlife	Moderate	Carry out surveys before starting demolition.	Minor

			Biodiveristy Man. Plan Decommission Plan	
			Demolition planned so it will be continuous and surface finish complete	Minor

8.8 Conclusion

After having taken mitigation measures into account the Project is likely to have insignificant to minor impacts on biodiversity. This evaluation will be revisited following a detailed biodiversity survery prior to site selection and following through by implementing a Biodiversity Management Plan described in ESMP with this ESIA report.

It has been established that within the Project area there are some species that have protection status and are IUCN red listed. The presence of these species in the Drilling area should be confirmed through a biodiversity survey prior to any operation conducted during wet-season to cover species not found in the original Baseline study on biological environment.

9 Air quality

9.1 Introduction

This chapter aims to describe the baseline air quality of the Project area and predict the potential impacts the proposed Project will have there on. A definition is given of the affected area and an overview of the appropriate legislation, guidelines and standards. The baseline information was gathered by GIBB International for the purpose of this ESIA (GIBB International, 2015). The information was collected through desk top study and field sampling. Data on wind for the period January 2014 to December 2014 was acquired by GIBB International from the Pennsylvania State University /National Centre for Atmospheric Research PSU/NCAR Mesoscale Model known as MM5.

The impact assessment was done by VSO Consulting and RG.

9.2 Affected area

Radius around residential area of 500 m which would represent the limit to sense foul smell of H_2S (0.3 ppm, 30 sec average) (RWDI, 2009), see Figure 9.6. Hydrogen sulphide concentration of 7 µgr/m_3 (0.005 ppm) with a 30-minute averaging period is recommended as a limit for odour (WHO, 2005).

9.3 Legislative framework

9.3.1 National

- Environmental Pollution Control Proclamation No. 300/2002
- Prevention of Industrial Pollution Council of Ministries Regulation No. 159/2008
- EPA draft guidelines for EIA for Mineral and petroleum operation projects, 2003

9.3.2 International

- IFC Environmental Health and Safety General Guidelines: 1.1. Ambient Emissions and Ambient Air Quality
- IFC Environmental, Health and Safety Guidelines for Geothermal Power Generation
- IFC PS 3: Resource Efficiency and Pollution Prevention
- Vienna Convention for the Protection of the Ozone Layer
- The 1992 UNFCCC (Rio Convention)
- Kyoto Protocol to the UNFCCC
- WHO air quality guidelines (2005)
- The Paris Agreement to the UNFCCC

9.4 Baseline description

Impact assessment questions and objectives of study according to scoping document

The assessment for climate issues will focus on:

- Comparison of CO_2 emissions with alternative power generation schemes.

The Project will include emission of different gas components. The assessment for air quality will be based on the current standard of air quality and a detailed study will be carried out to give data on:

- The emissions from the drilling and operation of the power plant (H_2S, NO_x, CO_2, SO_2, VOC).
- How the emissions comply with national and WHO standards.

9.4.1 *Baseline air quality*

Sampling for baseline air quality measurements was undertaken at seven strategic points distributed over the study area and identified as key potential receptors based on observation of the existing settlements (**Figure 9.1**). Sensitive receptors considered generally include private residences/villages, community buildings such as schools, hospitals and any publicly accessible areas.

Level of dust (PM_{10}) was determined by use of static sampling where a battery powered sampling pump connected by tubing to a filter holder, was clamped and positioned in selected areas of concern. Sampling of H_2S was done using passive diffusion tubes.

The key natural factors likely to influence ambient air quality in the study area are the manifestations of fumaroles, topography, vegetation cover/barrier and atmospheric conditions. The existing artificial factors are limited to intermittent traffic on the earth roads, mechanised tillage of farmlands especially in dry windy weather conditions associated with whirlwinds and charcoal burning.

Both PM_{10} and H_2S values measured at all the selected sample points are below the respective World Health Organization guideline values. The natural H_2S levels at existing fumaroles manifestation was slightly elevated as would be expected, about 20% higher than in other sampled areas without such manifestations.

It is notable that no industrial activities exist within or in close proximity of the Project area. The nearest major industry, Wonjii sugar factory is about 20 km to the North East of the Project site. The detailed description of sample locations for baseline air quality measurements is presented in Table 9.1.

Table 9.1 Air quality measurements results

ID	Sampling location	PM_{10}	H_2S
AQ1	Ula Arba: Village near Hula Arba centre and dispensary	2.4 µg/m³	<3.6 µg/m³
AQ2	Bite: Rumsa Tullu Togee School	5.1 µg/m³	<3.6 µg/m³
AQ3	Bite Daba: Next to Mosque at Turbu Werke (TW), school and settlements	2.0 µg/m³	<3.6 µg/m³
AQ4	Tero Moye: Administration Centre – School, mosque and residents	1.0 µg/m³	<3.6 µg/m³
AQ5**	Tero Moye: At fumaroles manifestation	-	4.3 µg/m³
AQ6**	Tero Desta: Village settlements	0.7 µg/m³	<3.6 µg/m³
AQ7	Amude: Manabamoota School and Amude trading/commercial centre	0.6 µg/m³	<3.6 µg/m³
BLK	Field Blank	2.4 µg/m³	<3.6 µg/m³
WHO guideline value for community health (24 hr mean)*		50 µg/m³	150 µg/m³

* (WHO, 2005) ** within Drilling area

According to the WHO air quality guidelines the 24-hour health limit for H_2S concentration in air is 150 µgr/m³ (107 ppb) (WHO, 2005). Hydrogen sulphide concentration of 7 µgr/m³ (0.005 ppm) with a 30-minute averaging period is recommended as a limit for odour to avoid „substantial complaints about odour annoyance among the exposed population“ (WHO, 2005).

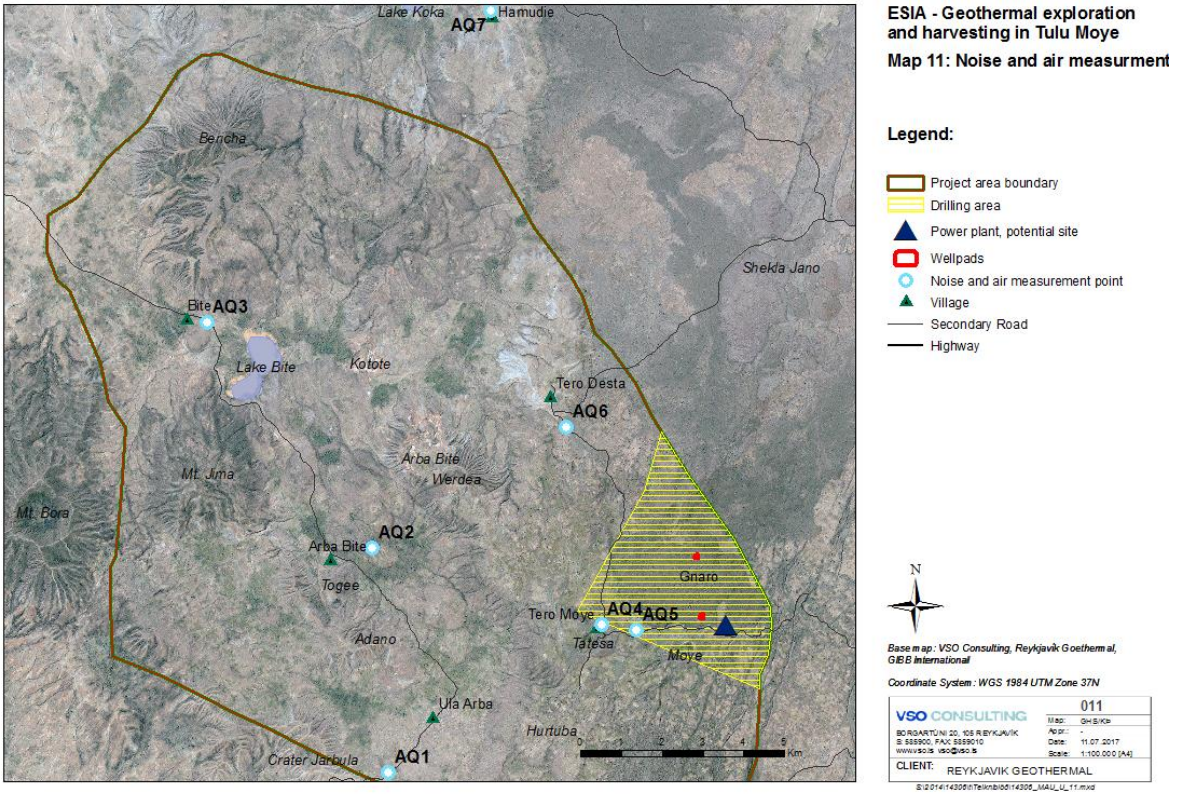


Figure 9.1 **Air quality measurement points.**

Table 9.2 WHO air quality standards and guidelines (WHO, 2005).

Pollutant	Averaging period	Guideline Value (µg/m³)
SO_2	24-hour maximum	20
	10-minute maximum	500
NO_2	1-year mean	40
	1-hour maximum	200
TSP	1-year mean	No guideline
	24-hour maximum	No guideline
PM_{10}	1-year mean	20
	24-hour assessed as the third highest 24 hour period (99th percentile)	10
$PM_{2.5}$	1-year mean	10 (guideline)
	24-hour maximum	25

Table 9.3 EPA Air Quality Standards: Discharges to air (Adopted from Ministry of Environment, British Columbia, Canada 1989).

Parameter	Maximum discharge (ppb)
Sulphur Dioxide	
Annual arithmetic mean	75.00
24 hour concentration	260.00
3 hour concentration	665.00
1 hour concentration	900.00
Antimony (Sb)	0.50
Arsenic (As)	1.00
Beryllium (Be)	0.1
Cadmium (Cd)	0.30
Chromium (Cr)	0.10
Copper (Cu)	2.50
Fluorine (F)	2.00
Lead (Pb)	2.50
Mercury (Hg)	1.00
Molybdenum (Mo)	2.50
Nickel (Ni)	0.10
Selenium (Se)	0.50
Uranium (U)	6.00
Vanadium (V)	1.00
Zinc (Zn)	2.50

Table 9.4 **Established dose-effect relationships and guidelines for H_2S concentration in atmosphere** (WHO, 2005)

Description	ppm	µgr/m³
Odour limit, 30 min average period	0.005	7
WHO, 24 hrs health limits	0.107	150
Threshold for eye irritation	10-20	15,000-30,000
Loss of olfactory sense	150-250	210,000-350,000
Risk of death	>300	>420,000

The IFC Environmental, Health and Safety Guidelines for geothermal power generation, emissions monitoring guidelines say that H_2S emissions or other types of emissions should not result in ambient concentrations above rationally established air quality standards or, in their absence, internationally recognized guidelines.

9.4.2 Wind

Wind speed determines both the distance of downward transport and the rate of dilution of pollutants. The generation of mechanical turbulence is similarly a function of the wind speed, in combination with the surface roughness. Annual wind rose for the Project area

indicates that the prevailing direction of winds is NE. Most of the time in the Project area, winds blew from NE direction at 8.8-11.10 m/s. However, minimal seasonal variations exist.

December to May and September to November is a dry season with the general wind motion trend from North-East to South-West. The predominant wind speeds are in 8.8-11.10 m/s range.

June to August is a wet season with the general motion trend from South-West and predominant wind speed from 5.7 to 8.80 m/s range.

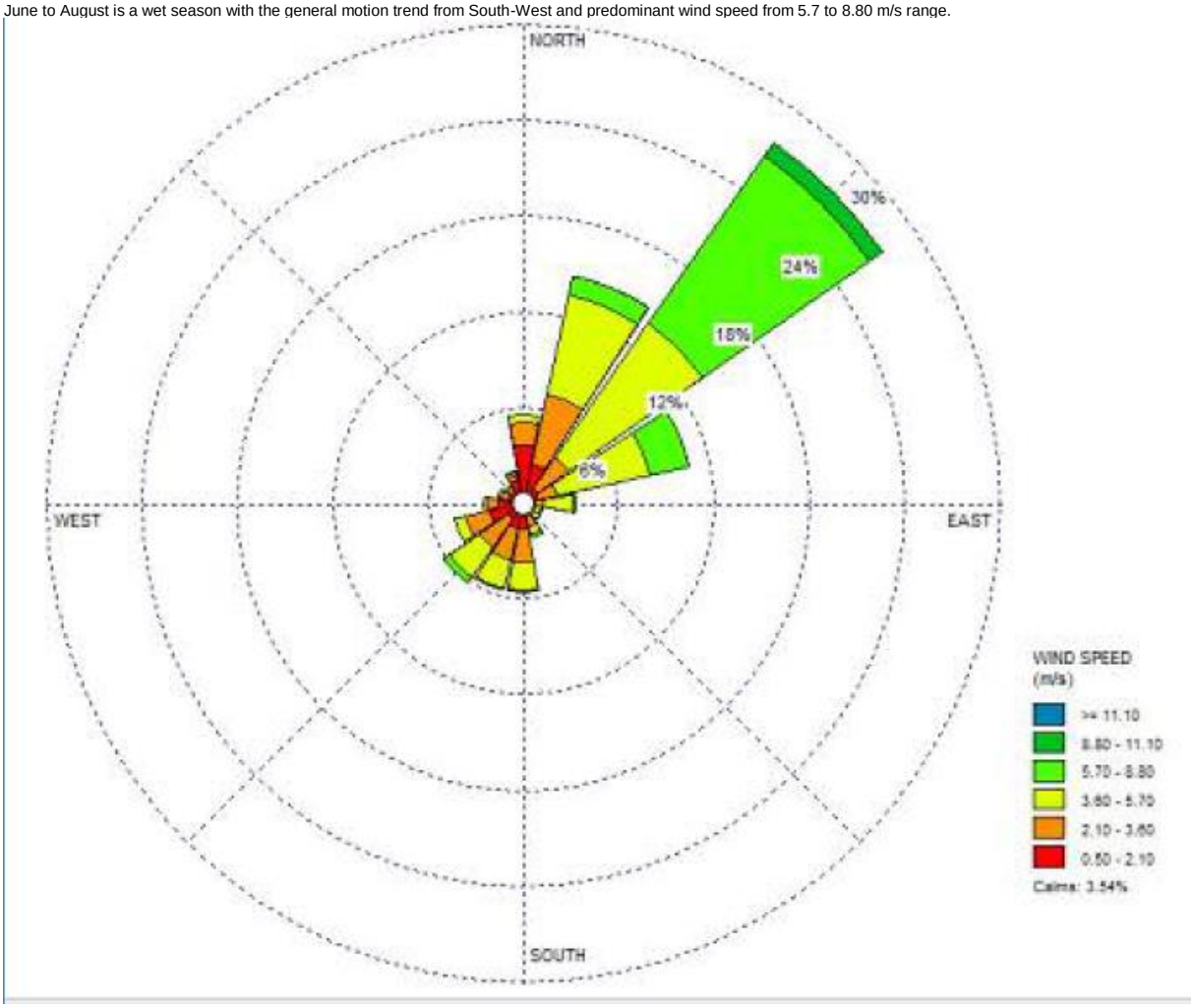


Figure 9.2 **Annual wind rose for the Project area.**

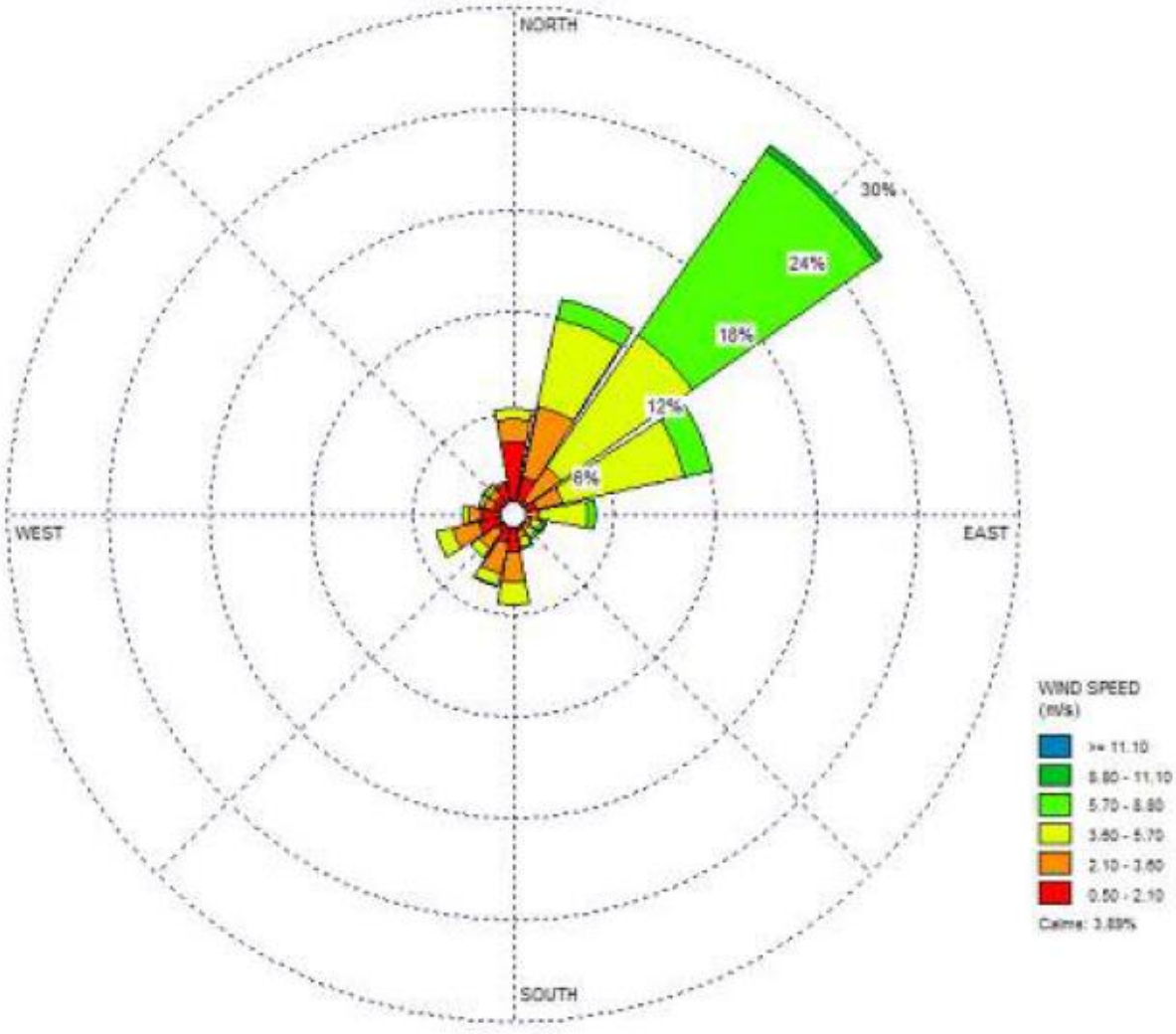


Figure 9.3 **Wind rose for the Project area from March to May**

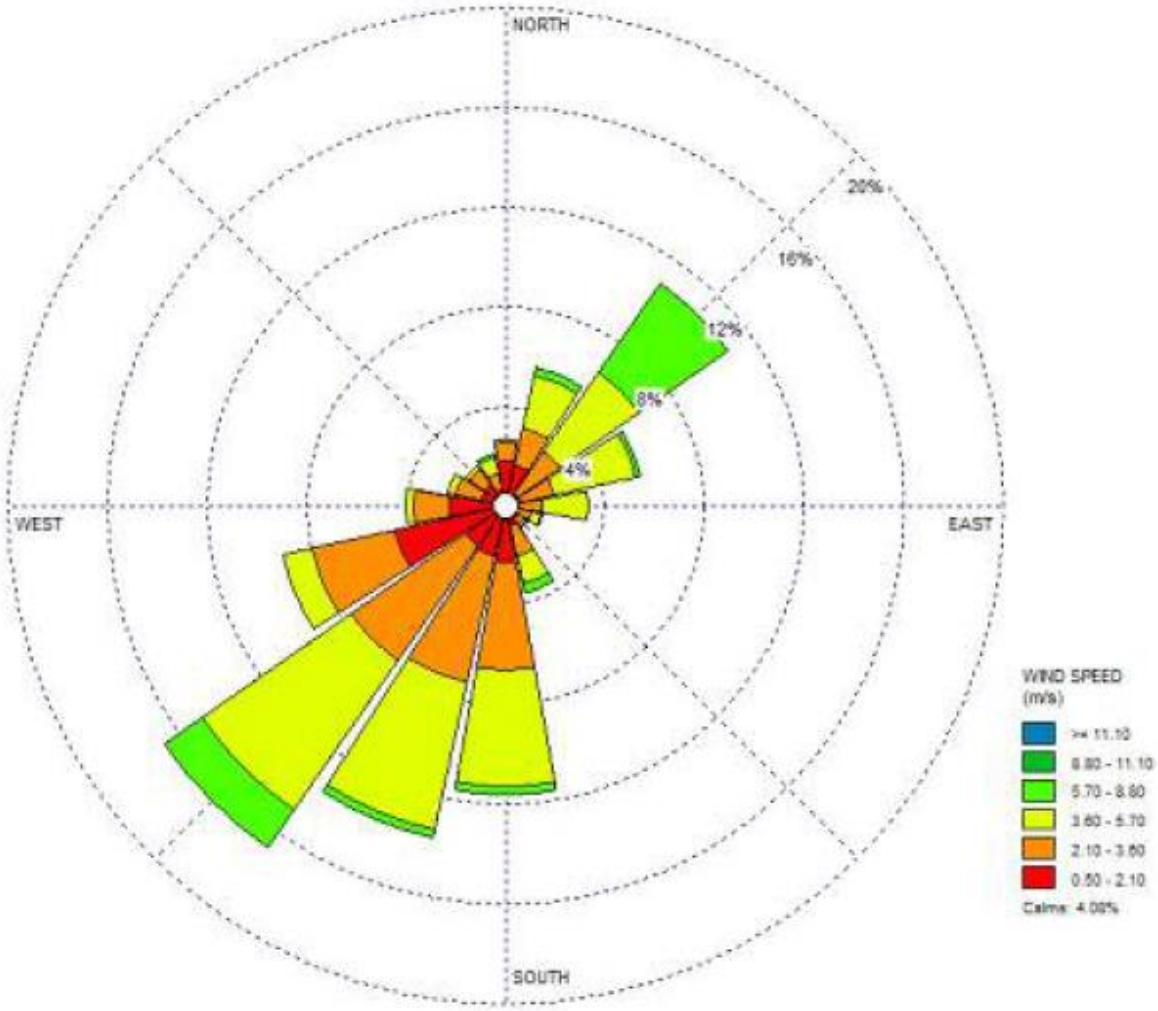


Figure 9.4 **Wind rose for the Project area from June to August.**

9.4.3 Summary of baseline of air quality at Drilling area

Baseline of Drilling area

Measurements at two points in the south part of the Drilling area indicate that air quality is within limits of WHO standards. Prevailing wind direction is NE in the dry season and from SW in the wet season. Wind speed is less in wet season.

9.5 Impact assessment on air quality

9.5.1 Impact during construction and operation phase

Geothermal gases will be released during the testing period and the operation of the power station. This includes carbon dioxide (CO_2), hydrogen sulphide (H_2S), nitrogen (N_2), hydrogen (H_2), and methane (CH_4). The gas concentration in geothermal power plant emissions can vary over time.

Compared to fossil fuel power plants in terms of carbon dioxide (CO_2) and sulphur dioxide (SO_2), geothermal power plant emission is very low. In terms of greenhouse gasses, geothermal power plants release carbon dioxide and methane (Table 9.5). Gas emission during drilling is expected to be insignificant except if the drilling hits a gaschamber but that is difficult to predict. In the case of H_2S relase during drilling the drilling company's contingency plan will become effective.

Table 9.5 Average Green House Gas emission from different sources of different electricity generation.

Technology	gCO_2 equivalent /kWh
Coal	1,000
Oil	790
Natural Gas	560
Hydroelectric	7
Geothermal	188

Source: (VSO Consulting and Reykjavik Energy, 2008), (Austurbrú, 2016)

It is likely that 1-2% of the uptake (see chapter **Error! Reference source not found.**) will b e gas of which 25-30% is H_2S and 65 - 70 % is CO_2 and 5% other gases, mainly methane and the rest hydrogen and argon.

Hydrogen sulphide (H_2S) is a gas with an offensive “rotten eggs” odour that is detectable at very low concentrations, below 8 µg/m_3 in air (WHO, 2005). It is formed when sulphides are hydrolysed in water, like in geothermal conditions. However, the level of hydrogen sulphide found in drinking-water will usually be low, because sulphides are readily oxidized in well aerated water.

The concentration in geothermal power station emission varies greatly between sites and even between wells within the same geothermal area. In Reykjanes power plant in Iceland the concentration of H_2S in different wells has been measured in the range of 26-86 mg/kg (Fridriksson & Giroud, 2007).

The compound can accumulate in certain areas, tunnels and depressions, which can increase danger to workers at the Project site. The emission of H_2S is expected to cause odours in the neighbouring areas during well testing and during operation of the power station, although trees and landscape will probably provide some barrier. And, in open areas wind will disperse the gases, preventing accumulation around the power plant.

However according to preliminary data it can be assumed that H_2S odour can be detected at some settlements, given that radius around residential area of 500 m which would represent the limit to sense smell of H_2S (0.3 ppm, 30 sec average) (RWDI, 2009). Hydrogen sulphide concentration of 7 µgr/m_3 (0.005 ppm) with a 30-minute averaging period is recommended as a limit for odour (WHO, 2005). It can also be expected that the H2S concentration is higher closer to the source. Figure 9.6 shows 500 radius from settlement known within and close by the Drilling area. RG has located the first two well pads, GA and B, and the site for the Power Station. With this location RG has minimized the number of affected households due to potential H_2S odour.

Dust: Vehicles transporting equipment and materials during construction will cause dust clouds but the affected area will be limited. Impact will be more in dry season with more winds and dryer surface. Individual households may though be affected.

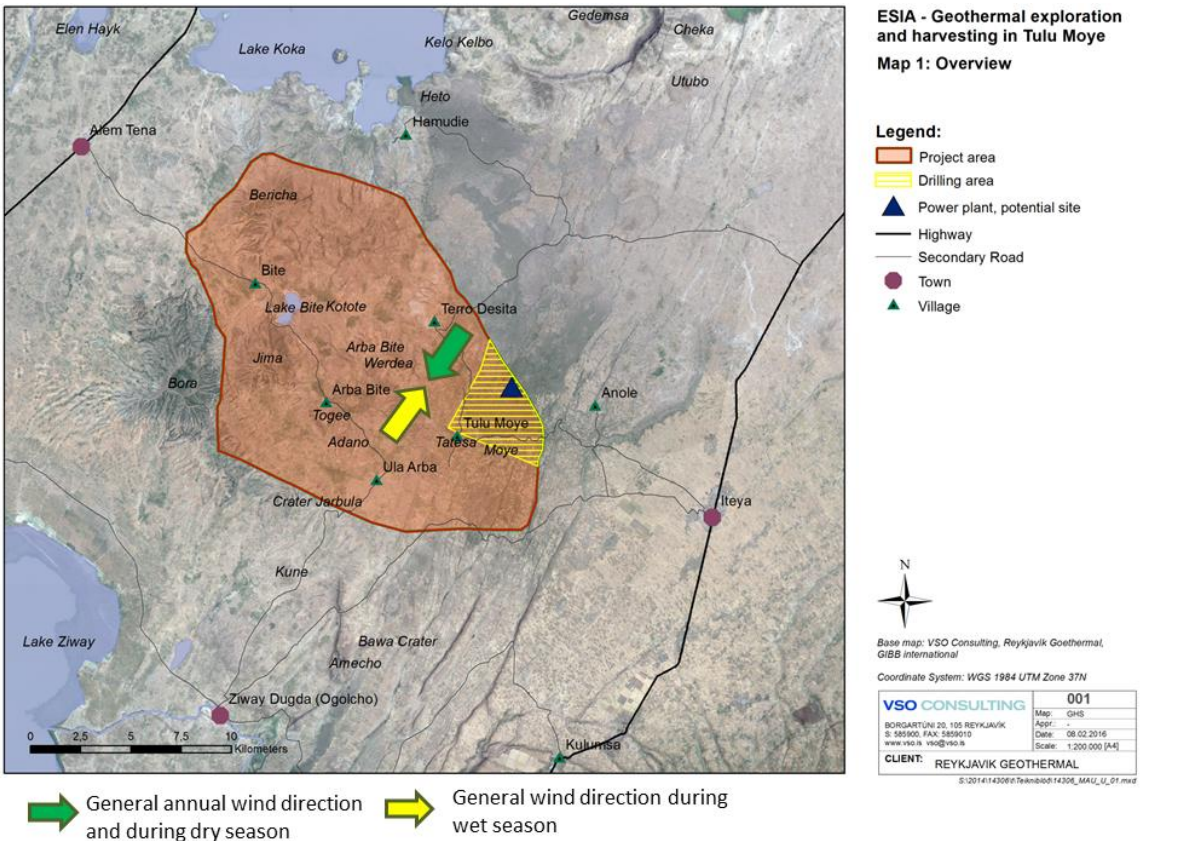


Figure 9.5 Wind direction in the project area (based on windroses from baseline report (GIBB International, 2015)**).**

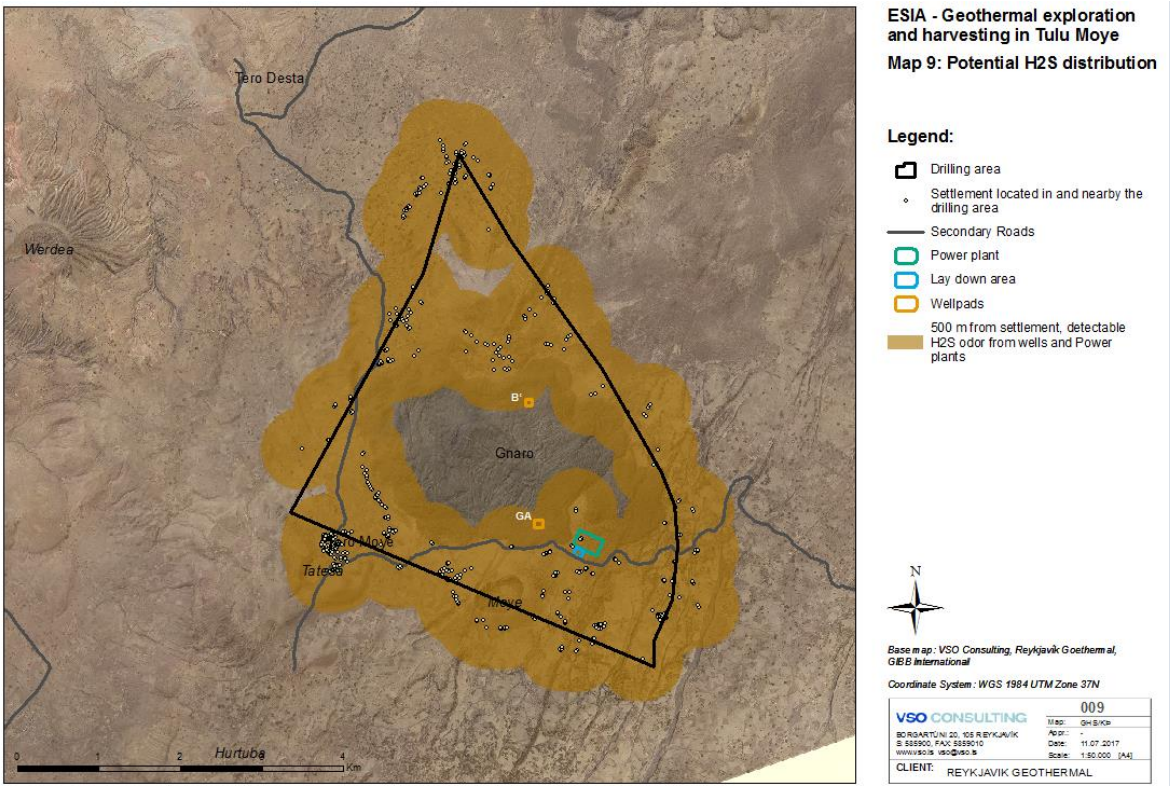


Figure 9.6 Radius, 500 m, from settlement indicates limits of potential H_2S odor.

9.5.2 Impacts during decommissioning phase

Vehicles transporting materials from demolition site will cause dust clouds but the affected area will be limited. Dust can also be generated with the demolition of buildings

and structures. A plan will be put into place to manage dust from building material that may pose hazard to workers and locals. Impact will be more in dry season with more winds and dryer surface. Individual households may though be affected.

9.6 Data limitation and uncertainty

Composition of gas from drilling and operation will not be clear until exploration drilling is finished. There is however ample data on gas concentration from other geothermal power plants and this data is used as a basis for the impact prediction.

9.7 Summary

9.7.1 Impacts during construction and operational phases

Table 9.6 Construction and Operational phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measures	Residual significance
Earthworks	Dust from vehicles causing deterioration of air quality for locals and workers.	Moderate	Work procedures plan for minimizing dust creation. Provide workers with personal protective equipment.	Minor
	Dust from vehicles causing deterioration of air quality for fauna	Minor		
Site clearance	Dust from disturbed, de-vegetated surfaces affects air quality for locals and workers.	Moderate	Work procedures plan for minimizing dust creation. Provide workers with personal protective equipment.	Minor
	Dust from disturbed, de-vegetated surfaces affects air quality for fauna.	Minor		
Transport of materials	Dust rising from truck beds and road affects air quality for humans and fauna.	Moderate	Work procedures plan for minimizing dust creation. Provide workers with personal protective equipment.	Minor
Well drilling and testing	Release of geothermal gases can cause risk to locals, workers and fauna. Especially H_2S.	Moderate	Concentration of H_2S and other relevant gases will be monitored around the power plant. A contingency plan regarding high levels of H_2S will be implemented.	Minor

Action	Impact	Significance	Mitigation measures	Residual significance
Geothermal gases exhaust from operation	Release of geothermal gases can cause risk to locals and fauna. Especially H_2S.	Moderate	Concentration of H_2S and other relevant gases will be monitored around the power plant. A contingency plan regarding high levels of H_2S will be implemented.	Minor
Release of green house gases	Green house gases contribute to climate changes	Minor		
Exhausts from drill rig and vehicles	Emission of combustion related pollutants can have effect on air quality for locals and workers	Minor		
	Emission of combustion related pollutants can have effect on air quality for fauna.	Minor	Site selection with regard to vulnerable species.	

9.7.2 Impacts during decommissioning phase

Table 9.7 Decommissioning phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Demolition of buildings	Dust creation from building material being demolished affects air quality.	Moderate	Plan for preventing dust arising from harmful building material.	Minor
			Personal protective equipment for workers.	Minor
Earthworks	See table Table 9.6			

9.8 Conclusion

Impacts on air quality are minor, after having taken mitigation measures into consideration. Emphasis will be placed on minimizing dust creation and geothermal gas will be monitored during construction and operation. The location of the Power Station and the first two well pads is such that the impact on households has been minimized.

A preliminary study shows that settlement in the Drilling area is distributed over large part of the area. Creating a buffer of 500 m around settlements where H2S odour is possible to be detected shows that little area is left where no odour is predicted to be detected. This means that wells and Power plant will likely be located within impact zone and thus settlements may be affected. Gas emission will be monitored and a contingency plan regarding high levels of H_2S will be implemented.

10 Archaeology and cultural heritage

10.1 Introduction

This chapter aims to describe the archaeology and cultural heritage of the Project area and predict the potential impacts the proposed Project will have there on. A definition is given of the affected area and an overview of the appropriate legislation, guidelines and standards. The baseline information was gathered by GIBB International for the purpose of this EISA (GIBB International, 2015). Various anthropological methods were applied to obtain baseline information on the cultural heritage of the Project area. These included but not limited to desk top review, cartographic and aerial imagery reviews, site visits, transect walks, interviews and consultation.

The assessment of environmental impacts was done by VSO Consulting and RG.

10.2 Affected area

- Project area for indirect impacts
- Drilling area for direct impacts

10.3 Legislative framework

10.3.1 National

- Research and Conservation of Cultural Heritage Proclamation No. 209/2000

10.3.2 International

- IFC PS 8: Cultural Heritage
- World Bank Operational Policy OP 4.11 Physical Cultural Resources

10.4 Baseline description

Impact assessment questions and objectives of study according to scoping document

The objective of the study is to:

- Determine if any archaeological, cultural and historical sites are within the area and to assess their value.
- Determine the risk of adverse impacts due to the Project's construction and operation.

10.4.1 Sites of Cultural Significance

Sites of cultural significance, means any site that has aesthetic, historic, scientific, social or spiritual value for the past, present or future generations. Dodota and Hitosa have some attraction sites which have already been identified by the Culture and Tourism Bureau. The baseline study listed sites of cultural attraction as seen in table Table 10.1.

Table 10.1 Sites of cultural attraction within the four Woredas listed by the Culture and Tourism Bureau.

Name of attraction	Site location
Dilfakar regional park	Dera
Dilfakar shrine	Dera
Tero Geothermal Steam	Tero Desta
Shabalo Hot Water	Mire shire
Belale's forest	Belale
Koka manmade lake	Amude

Mount Dabaso	Dabaso
Amude Haro Rophi Lake	Amude
Anole Martyrs Monument	Anole
Natural steam baths	Tero Moye

Geothermal/steam in Tero Desta and natural steam bath in Tero Moye are within the larger Project /Study area while Anole Martyrs monument is close to the delineated Project area's eastern boundary. Other sites are outside the Project area. The Anole Martyrs monument was erected as a tribute to the Arsi Oromos who were victims of the Emperor Menelik's imperial expansion, in the 19th century. Inaugurated in 2014, the monument was erected to commemorate those Oromo heroes and heroines who were cruelly massacred for strongly resisting the then oppressive regime. It serves as Oromo cultural heritage hall that consists of the Oromo Martyr's memorial monument, an ethnographic museum, a mural as well as research and study centres. It is managed by the Oromia culture and tourism bureau, who also market it as a tourist attraction center.

About 6% of the households surveyed mentioned presence of cultural sites around their localities. The study established a number of sites of cultural significance in the area. The following were established:

- Grave/ burial sites
- Various religious institutions (mosques and churches)

There are about 69 mosques, two churches and 118 cemeteries which serve the local communities. Muslims and Christians have separate cemeteries.

Figure 10.1 A graveyard in the Project area.

Figure 10.2 **A graveyard on the left and a herd of cattle.**

Table 10.2 Graveyards within the Kebeles within the Project area

Kebele	Graveyards
Tero Moye*	7
Tero Desta*	10
Anole Salen*	7
Amude	10
Bite	22
Bite Daba	10
Boka	6
Ula Arba	7
Arba Chafa	10
Hurtu Dembi*	8
Denisa*	9
Wal Argi*	4
Burka Lemafo	6
Meja Shenen	2
Total	118

*Kebeles within proposed Drilling area

Location of exactly what sites can be impacted by Phase I of the Project is getting clearer now that RG has carried out a survey in order to prevent the disturbance of these culturally important sites.

10.5 Sites of Social Significance

The study into socially significant places complements already collected baseline data. The purpose is to map information on location of:

- Cemeteries
- Steam baths
- Mosques /churches
- Water kiosks
- Health posts

In the vicinity of the proposed Project area (Figure 10.6).

10.5.1 Cemeteries

RG has located 26 cemeteries or burial grounds in the Drilling area but likely there are more within the license area. The location of cemeteries in the nearest vicinity of the Gnaro lava field can be seen on maps in Figures below. The cemeteries are usually small and modest without walls and signs of any kind. The size of the cemeteries found ranges from about 13 x 13 m to 50 x 80 m.

The larger cemeteries are located close to the communal centers, i.e. Tero Moye, Tero Desta and Anole, while smaller cemeteries are found close to smaller settlements. It is difficult to tell if some of the cemeteries are still being used. One indication is the construction of the graves as it seems that it is only in recent times that the graves have been sealed with concrete top.

Closest Cemetery

The closest cemetery to a planned drilling site is by the road to Tero Moye south of Gnaro obsidian, some 350 meters from the location of the planned drill pad GA.

There is a small cemetery some 350 m to the east of proposed power plant location. This cemetery is located on top of an escarpment, 20 – 30 above the power plant location, making highly unlikely that this cemetery will be affected.

Figure 10.3 Cemetery near Tero Desta

10.5.2 Steam Baths

Within the Tulu Moye geothermal prospect area, people have used heat rising from the ground by constructing thermal baths on the most prominent steam vents. These steam huts are constructed by stones and soil to create a small room, usually no more than 1.5 m to the ceiling and similar in dimensions. These huts are usually rather robust and have survived excessive rains during the rainy season, but some have collapsed.

Due to the behavior of the steam at surface, vents close and open because of small earthquakes and rain, some steam baths lose the inflow steam vent or temperature decreases. Often the locals build new steam baths at a “new” better location.

The people use the steam baths to bathe, some locations have separate baths for men and women, but in others the huts are used by both sexes at different times.

Closest Steam Bath

Five steam baths are located near the first drilling pad (Figure 10.6). Those steam bath are located near and above the targets area for the first drilling target. They will possibly be affected when harvesting of the wells will start. The situation is similar at the northern side of the Gnaro obsidian where there are about 6-7 steam baths close to the second drill pad. All those stem baths can possibly be affected when and if harvesting of the area start after drilling.

10.5.3 Mosques

The people of the Project area are mainly of the Oromo ethnic group and the predominant religion is Islam. There are about 16 mosques in and around the Kebeles of Tero Moye, Tero Desta and Anole Salen. No Orthodox Ethiopian church has been located.

Closest Mosque

In the vicinity of Gnaro obsidian there are three mosques. The nearest mosque is between 2 -3 km away from expected drill pads (Figure 10.6).

10.5.4 Water Points

There is one water pipeline from Gonde that brings spring water to water kiosks located in Tero Moye, Anole and Tero Desta. There is insufficient water in these Kebeles, particularly in Tero Desta, for the increasing population. The spring in Gonde has gradually been drying up resulting in loss of pressure in the pipeline and the water kiosks do not work most of the time. There are mapped 4 water points /posts near the road between anole to Tero Desta. The nearest water point is about 600 m from the expected powerhouse area.

Figure 10.4 Water point in Anole

10.5.5 Health Posts

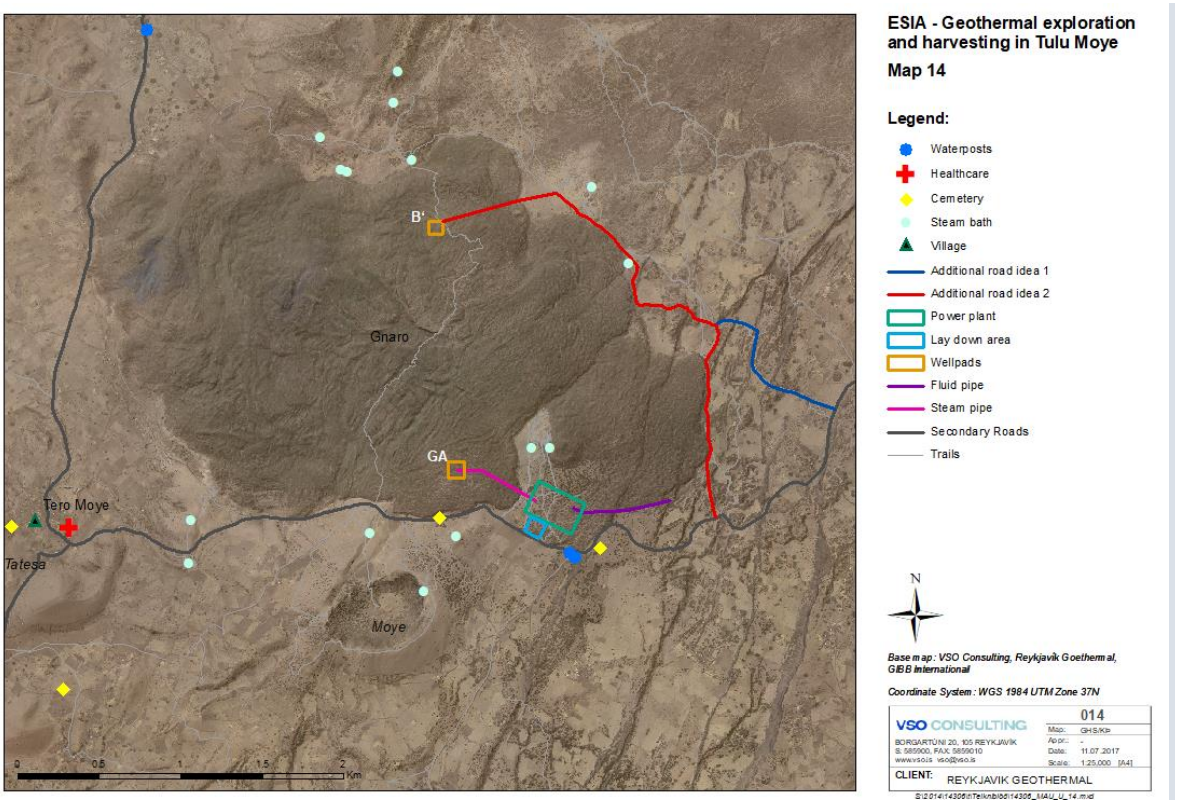
Mapping of Kebele health posts /centers has been carried out through RG staff visits. Health posts are few and far between and some of the people must travel long distances to get service. There are three healthcare centers in the vicinity of the Gnaro obsidian. The healthcare centers are located in the villages, Tero Moye, Tero Desta and Anole. The nearest in Tero Moye, about 2,5 – 3 km away from the suggested powerhouse area.

Figure 10.5 Health care centre in Tero Desta

10.6 Impact assessment on archaeology and cultural heritage

10.6.1 Impacts during construction and operation phase

Site clearing and earth works can disturb archaeological remains or sites of historic and cultural value. These places will be avoided based on findings of a survey on socially significant places by RG and located with GPS. In the case of unearthing previously undiscovered remains Chance Find Procedure will be followed (see Part III of this report).



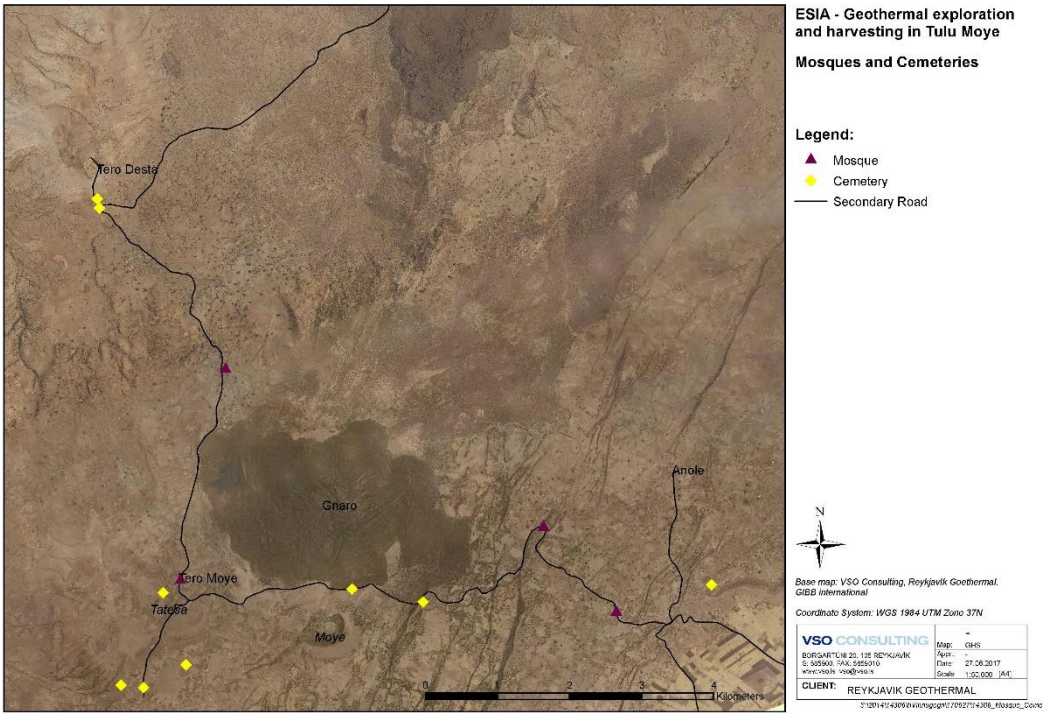


Figure 10.6 Socially significant places in the Drilling area (cementeries, mosques etc.)

RG has put forth a proposal for the well pads, Power Station and the access road. These project components are not likely to have a direct impact on cementariees and mosques as seen in Figure 10.6.

Noise from testing of wells and from the operation of the power plant can have adverse effects on those visiting historical sites and cemeteries. The noise will causes risk of disturbance of peace for those visiting the sites. This has been avoided as much as possible by site selection. Further mitigation measures can involve raising sound barriers.

Odor in low concentrations can causes nuisance for people visiting historical or cultural sites. Closer to source in higher concentration can cause health risk. This can mainly be avoided by site selection and monitoring of gas emission.

10.7 Data limitation and uncertainty

There is always an uncertainty regarding archaeological remains. First of all the remains may not be recorded and second of all they may be difficult to see if the ground is densely vegetated.

If archaeological remains will be uncovered in the process of the Project relevant authorities will be notified as per Chance Find Procedure. There are several cemetaries, churches and mosques in the area. A survey has been carried out to help with location of these project comoponents.

10.8 Summary

10.8.1 Impacts during construction and operational phases

Table 10.3 Construction and Operational phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measures	Residual significance
Site clearing	Disruption of archaeological remains or site of historical value	Major	Site selection, signage and cordoning archeological remains off	Minor
			Chance Find Procedure	
Noise and vibration from wells	Disturbance of peace at historical sites and graveyards	Major	Site selection and sound barriers	Minor
Emission of gases from wells	Odor in low concentrations causes nuisance for people visiting historical or cultural sites. Closer to source in higher concentration can cause health risk.	Moderate	Site selection. Gas emission monitoring.	Minor

10.8.2 Impacts during decommissioning phase

No significant impacts.

10.9 Conclusion

Impacts on archaeological remains and cultural heritage are minor, due to the fact that the first phase of the Project is unlikely to have a direct impact. If previously unknown

archaeological remains are discovered a Chance Find Procedure will be followed. Disburbance of peace at graveyards and historical sites will be limited by site selection, sound barriers and gas emission monitoring.

RG staff will continue to map places of social significance and update the Project GIS database accordingly.

11 Landscape and visual impacts

11.1 Introduction

The following chapter aims to describe the landscape character of the project and Drilling area and describe how the project is likely to impact on the landscape and visual ameneties. The baseline description of the Project area was made by GIBB International (GIBB International, 2015) and the description of the landscape within proposed Drilling area was made by VSO Consulting. Various maps, aerial photographs and other resources were consulted during the impact assessment i.e. RG report on Remote Sensing in Tulu Moye (Sigurbjorn Jonsson, 2015).

11.2 Affected areas

Affected areas are the Project area on one hand and Drilling area with 5 km visibility buffer on the other hand.

11.3 Legislative framework

- IFC PS 8: Cultural Heritage
- World Bank Operational Policy 4.01 Environmental Assessment

11.4 Baseline description

Impact assessment questions and objectives of study according to scoping document

- Does the landscape at and near the Project area have special characteristics?
- Project area will be presented on photographs, showing the Project sites before and after development.

11.4.1 Landscape character

The landscape character of the Project area is rural with landscape elements being predominantly natural topographic features with limited artificial elements. These include numerous hills/volcanic cones and valleys, lakes (Bite and Koka), rural settlements and administrative/rural centres, farmlands and natural vegetation cover (bush land thicket). The composition of these elements exhibit very minimal variation from one part of the Project area to the other. Cemeteries form an important cultural landscape element within the study area. These are mainly sited along the roads and are conspicuous to any travellers using the existing road network. Anole Martyrs Monument sited just outside the eastern border of the Project area also constitutes an important historical landscape feature. Even though the study area is expansive, the landscape character can be generally described as enclosed, within a greater caldera. The extent of visibility of the various features within it is limited by the numerous hills/volcanic cones. These hills offer screening effects within short distances from any point within the study area. Potential receptors of landscape/visual impact within the study area will mainly be the residents of rural settlements and persons using the public roads within the area. Outside the study area, potential receptors will be residents of the Amude Trading Centre at the northern edge of the Project area as well as users of the Dera turn off – Amude road. Amude trading centre is a small rural centre located at the northen edge of the project area at the shores of Lake Koka. This landscape character can be described as having medium sensitivity.

The rural settlements are mainly located near valley bottoms and on the slopes of the hills. Though scattered in most areas, the settlements near administration centres exhibit clustered trait. Vegetation cover constitutes a major landscape element within the study area. Visual influence due to vegetation within the area is expected to alternate seasonally between green and brown hues depending on available ground moisture

content and the farming seasons (depending on whether crops are still in the farms or have been harvested).

Figure 11.1 Landscape at the Project area. Grassland, lavafield with settlement and a mountain in the background.

Figure 11.2 Settlement at a hillside in the Project area.

Road infrastructure constitutes a small component of the landscape character in the study area as their construction results in the introduction of alien elements into the existing landscape. Distribution of road network within the area is limited and all the roads are of graded gravel. Given the hilly nature of the terrain, the roads offer an opportunity to view the other landscape elements apart from creating own landscape feature.

Looking outwards from the study area, the extent of visibility of landscape features is limited by the screening effects of the outer rim/edge of the greater caldera. Similarly, looking towards the study area from the surrounding areas in all directions, with exception of the Amude trading centre/lake Koka area near Amude, the extent of visibility of the Project area is limited by the same caldera rim. However, from Amude trading centre and along section of the Dera turning off Amude road, it is possible to see small section of the study area, mainly the low-lying areas from Tero Desta towards Lake Koka.

Consequently, any project related landscape impacts (e.g. new roads, well pads and associated drilling rigs) are expected to be minimal, only concentrated within small portions of the study area with exception of plumes from escaping geothermal steam which may be projected vertically to heights higher than existing hills and be noticeable from long distances depending on the prevailing atmospheric conditions.

Baseline of landscape within Drilling area

The landscape character of the proposed Drilling area can be divded into five main categories:

1. Extensive and promintent densely vegetaded lava hill which has been little altered by man. The landcover is shrubland (Figure 11.3).
2. A ridge, partly vegetated and which surface has been altered by man in agriculture purposes (figure Figure 11.4)
3. Fault impacted landscape characterised by ledges and surface altered by man in settlement and agriculture purposes (Figure 11.5).
4. Plains with agriculture and settlement characteristics (Figure 11.6).
5. A prominent crater, partly vegetated. Its floor has been altered for agriculture purposes (Figure 11.5).

Figure 11.3 Landscape character type 1 in the potential Drilling area. Densely vegetated lava hill which has been little altered by man. Photo taken from Google earth, March 2016.

Figure 11.4 Landscape character type 2 in the proposed Drilling area. A ridge, partly vegetated and which surface has been altered by man in agriculture purposes.

Figure 11.5 **Landscape character type 3 in the proposed Drilling area. Fault impacted landscape characterised by ledges and surface altered by man in settlement and agriculture purposes. Character type no. 5 can be seen in the upper left hand corner. Photo taken from Google earth, March 2016.**

Figure 11.6 **Landscape character type 4 in the proposed Drilling area. Plains with agriculture and settlement characteristics.**

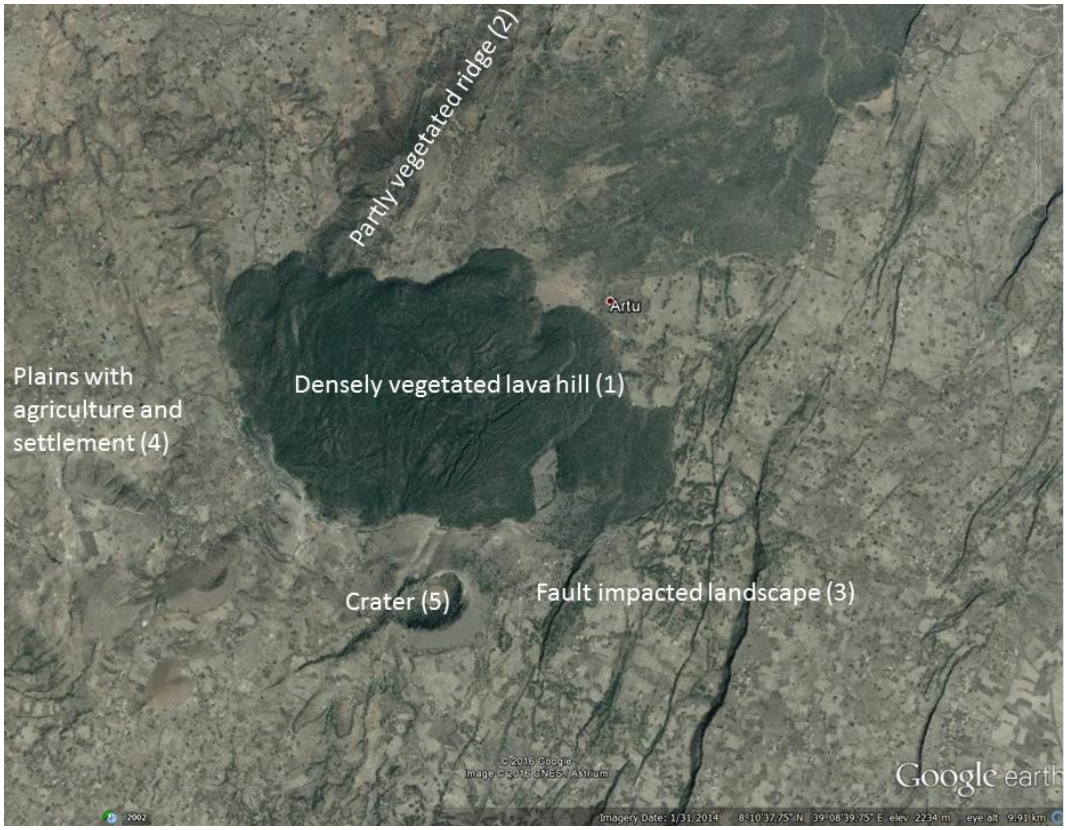


Figure 11.7 Overview of proposed Drilling area with landscape character type (numbers refer to type described in figures 12.3 to 12.6).

11.5 Impact assessment

11.5.1 Impacts during construction and operation phase

The landscape is a combination of large untouched areas of lava and then low technology agriculture landscape with dispersed settlement. Bringing a geothermal power plant into the landscape will unavoidably change the visual aspects of the landscape although landscape forms will not be altered.

RG has made the selection for the first two well pads, located the access road and the site for the Power Station. The well pads are within the Gnabo lava hills (1), while the site for the Power Station and access road is located within the area of fault impacted landscape (3). These project components will have an impact on the visual aspects, but the location is such that the number of those that will be affected will be limited based on the location of current households and cultivated land.

The building of access roads, well pads, pipelines and power station can affect the landscape by changing its character and change visual aesthetics. Steam coming from temporary testing of wells, steam stacks and cooling tower can rise high and can be expected to be seen as far as 5 km distance or more, depending on weather conditions. Proposed site for power plant is more than 5 km away from Anole, but it can be expected that steam plumes can be seen from there.

Temporary drilling rigs can rise a few meters and be visible and be contrasting in the landscape.

Geothermal power plants are known to be of interest to tourists, for example in Iceland and one can expect that the plant itselft will be of attraction in an area with few tourist sites. This could lead to indirect job creation in the area.

In general, the structures and steam related to the power plant can be seen from nearby settlements. Well pads and their borehole structures can be designed as to be low key in the landscape.

11.5.2 Impacts during decommissioning phase

Demolition will be planned so it will be continuous and surface finish will not leave signs of abandoned power plant. Surface will be levelled and revegated as applicable.

11.6 Data limitation and uncertainty

The location and the design of some components (such as water works system) is not yet available, but will be available as the geothermal development progresses. Visual impacts should be considered to and mitigate with site selection and design of structures.

11.7 Summary

11.7.1 Impacts during construction and operation phase

Table 11.1 Construction and operation phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Building of structures	Change landscape character and visual aesthetics	Moderate	Site selection and design of structures that aim to blend in with the landscape.	Minor
Steam plumes from wells	Steam plumes will be visible from afar.	Minor		
Steam plumes power plant	Steam plumes will be visible from afar.	Moderate		
Raising of drilling rigs	Contrast in the landscape	Minor		
Power plant attracts tourists	Indirect job creation	Minor		

11.7.2 Impacts during decommissioning phase

Table 11.2 Decommissioning phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Demolition of building and structures	An abandoned and derelict plant has adverse impacts on visual amenities	Moderate	Demolition will be planned so it will be continuous. Lava field surface will be affected. Otherwise finish will not leave signs of abandoned power plant. Surface will be levelled and revegetated as applicable.	Moderate

11.8 Conclusion

Impact on landscape and visual aspects is likely to be minor to moderate, having taken mitigation measures into account. It is evident that the structures and steam plumes that will be placed in the landscape will be visible and some of them from afar. The location of the Power Station, well pads and access roads is such that the number of people that may be affected are limited compared to other possible locations.

Mitigating the effects can be done by site selection and design of structures. The Project is also likely to have minor beneficial effects as it may attract tourists.

12 Noise

12.1 Introduction

This chapter aims to describe the baseline noise levels of the Project area and predict the potential impacts the proposed project will have there on. A definition is given of the affected area and an overview of the appropriate legislation, guidelines and standards. The baseline information was gathered by GIBB International for the purpose of this ESIA (GIBB International, 2015). The environmental noise level measurements were carried out with respect to the ISO 1996, Acoustics – Description and Measurement of Environmental Noise. The impact assessment was carried out by VSO Consulting and RG. The impact assessment is based on the following references (Mannvit, 2010), (Efla, 2009), (Kötter Consulting Engineers, 2008), (VSO Consulting and Reykjavik Energy, 2008), (Efla, 2014).

12.2 Affected areas

Construction phase without mitigation: About 1,200 m (1-1,500 m) radius around settlement where noise level of 45 dB(A) is reached. With mitigation: 5-600 m radius.

Operation phase: About 500 m radius around settlement where noise level of 45 dB(A) is reached.

Decommissioning phase: Affected area not specified as additional noise from machineries will be within 5 dB(A).

12.3 Legislative framework

12.3.1 National

- The Constitution of the Federal Democratic Republic of Ethiopia
- Environmental Standards for Industrial Pollution Control - Noise
- Public Health Proclamation No. 810/2013

12.3.2 International

- IFC Environmental Health and Safety Guidelines: 1.7 Noise
- IFC Environmental Health and Safety Guidelines: 4.2 Occupational Health and safety and 4.3 Community Health and Safety.
- IFC PS 4: Community Health, Safety and Security.
- IFC Environmental, Health and Safety Guidelines for Geothermal Power Generation
- British Standard 5228 – Code of Practice for Noise and Vibration Control

12.4 Baseline description

Impact assessment questions and objectives of study according to scoping document

- Information for the ambient noise and vibration at the mentioned sites.
- Noise map for the Project, around the drilling pads and power station. Showing the decibel levels of noise.
- Data on the vibration from the drilling.
- Data on possible vibration and noise during construction.
- Can noise and vibration have negative impacts on residents in and near the Project area and employees of the Project?
- Can noise and vibration disturb wildlife and grazing animals?

12.4.1 *Baseline noise survey*

The main activities identified in the local area that attribute to ambient noise levels are intermittent road traffic and commercial activities within the rural trading centres. From the noise measurement results, three locations (Tero Moye, Bite and Bite Daba rural centres) recorded noise levels which are above the Ethiopia Country Noise thresholds for residential areas.

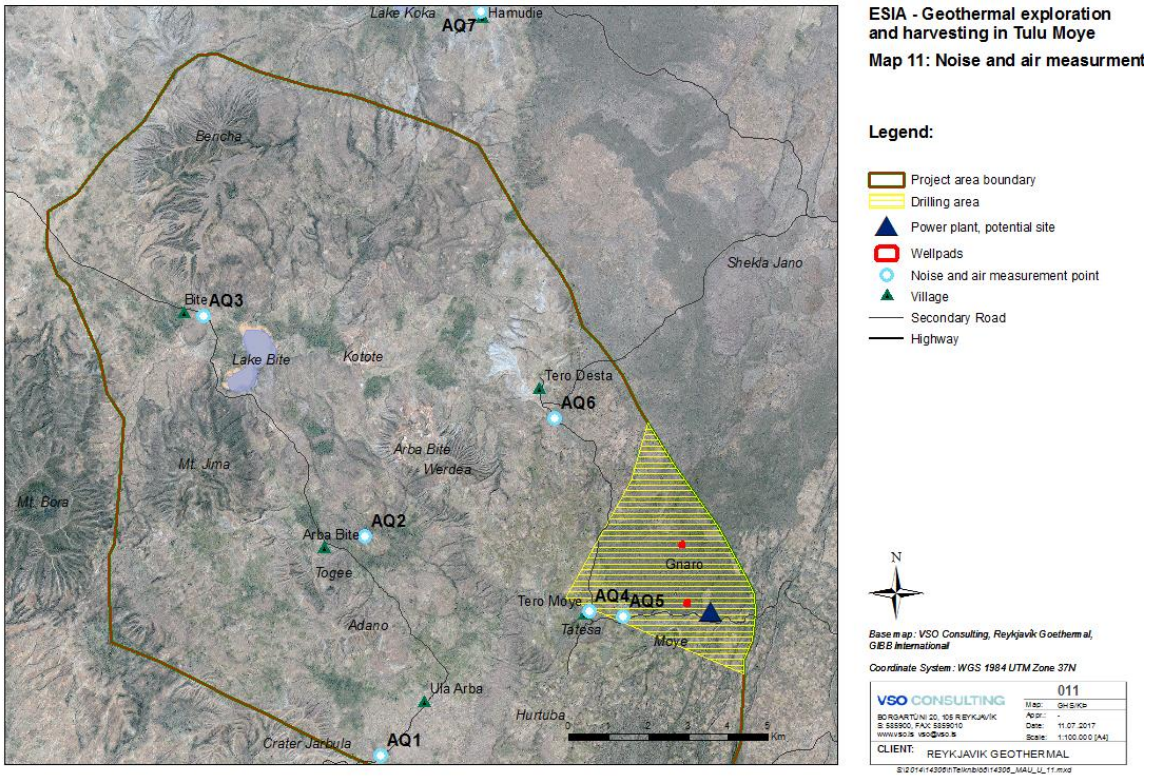


Figure 12.1 Noise and air quality measurement points

The Environmental Standards in Ethiopia gives general guidance on noise levels for daytime and night time for three broad categories receptors: industrial, commercial and residential.

Table 12.1 EPA noise emissions limits

	Noise Limits in dB(A) LAeq, 15 min	
Category	Daytime (06:00-21:00)	Night time (21:00-06:00)
Industrial area	75	70
Commercial area	65*	55*
Residential area	55	45

*This will be used instead of IFC guidelines since it is more stringent.

Table 12.2 IFC/World Bank noise level guidelines.

	One hour LAeq, dB(A)	
Category	Daytime (07:00-22:00)*	Night time (22:00-07:00)
Residential, institutional, educational	55	45
Industrial, commercial area	70*	70

*More stringent and therefore used as a guidance level for Tulu Moye. *Daytime for Tulu Moye will be defined as 07:00-21:00 since it is more stringent.

Sampling for baseline noise measurements was undertaken at seven strategic points distributed over the study area and identified as key potential receptors based on observation of the existing settlements. Sensitive receptors considered generally include private residences/villages, community buildings such as schools, hospitals and any publicly accessible areas. The measurements were done on 7 and 8 June, 2015 for a period of 15 minutes at each of the selected monitoring locations and sessions.

The main activities identified in the local area that attribute to ambient noise levels are road traffic and commercial activities within the trading centres. The noise sampling points and prevailing conditions on site at the time of measurements are presented in Table 12.3 below.

Table 12.3 Noise measurements of Tulu Moye baseline noise levels in dB(A).

Date	Start time	Location	LA min	LA max	LA eq	LA_{10}	LA_{90}
7/6/15	15:00	Ula Arba, AQ1	40.2	72.4	49.3	45.1	41.0
7/6/15	15:55	Bite, AQ2	31.3	85.3	58.0*	57.4	39.5
7/6/15	17:00	Bite Daba, AQ3	35.0	83.9	56.1*	56.5	39.6
6/6/15	15:20	Tero Moye, AQ4	32.8	81.3	55.7*	56.0	41.5
6/6/15	17:17	Tero Desta, AQ6	39.7	84.9	59.6*	61.5	46.3
7/6/15	10:15	Amude, AQ7	33.0	71.9	49.0	52.2	38.6

*Exceeds limits for residential area. LA in the table means A-weighted sound level, eq means equivalent sound level, LA_{10} means the noise level just exceeded for 10% of the mesurement period and LA_{90} is the noise level exceeded for 90% of the measurement period.

From the results, four locations (Tero Moye, Tero Desta, Bite and Bite Daba centres) recorded noise above the Ethiopia Country Noise thresholds for residential areas. Although these locations also show lower background noise levels (LA_{90}), and as such the proposed Project could have a noise impact of medium significance (medium probability to have an impact) on the noise climate in the surrounding area due to the distance between the proposed development and the closest noise-sensitive receptors and the nature and zoning.

Baseline summary - proposed Drilling area

One measurement point for noise is within the Drilling area (AQ4).

The baseline for noise is 55.7 dB(A) Leq for that point which is located at Tero Moye Centre next to Tero Moye School and a mosque. While measuring, there was a volley ball match, kids at playground and informal meeting going on. The background noise LA_{90} was 41.5 dB(A). It can be expected that noise is less in rural areas.

12.5 Impact assessment on noise

12.5.1 Impact during construction phase

The Tulu Moye area is rural and background noise level can be considered very low in general (Table 12.3). Therefore, all development will cause an impact. Residents, livestock and wildlife are potential receptors of noise and vibration due to development during construction.

It is anticipated that construction will take place between 06:00 and 18:00 (natural available light) and include the following activities; Site establishment (site office, stores/material depot, workshops), excavation operations (foundations infrastructure, compaction of sub soil and surface levels, trenches for cabling and piping etc.), general construction activities (concrete mixing, building, steel work, concrete vibration) and

general vehicle movement (on-site movement, delivery of materials and construction equipment). The equipment likely to be required to complete the above tasks will typically include: grader/bulldozer, a vibratory roller, concrete truck(s), mobile crane and various 4WD and service vehicles. The impact from these construction noises will depend on the type of activities taking place, the number of activities taking place at the same time, type of equipment used. Traffic relating to this construction project is not considered to be an additional noise source of any significance given the already existing traffic in the area.

These activities are not expected to give an increase of 5 dB(A) and as such will not exceed the existing guideline values. However, monitoring is encouraged during the construction phase during which the greatest noise increase is expected.

Noise levels will be raised temporarily during the preparation, drilling, and testing. The most impact will be noise from drilling and from testing geothermal wells. Noise distribution is very dependent on surface and landscape. Therefore, the selection of drilling site can have considerable impact on noise levels. There will be vibration during drilling and construction but this is temporary impact. Operation of the power plant also causes some vibration near the plant.

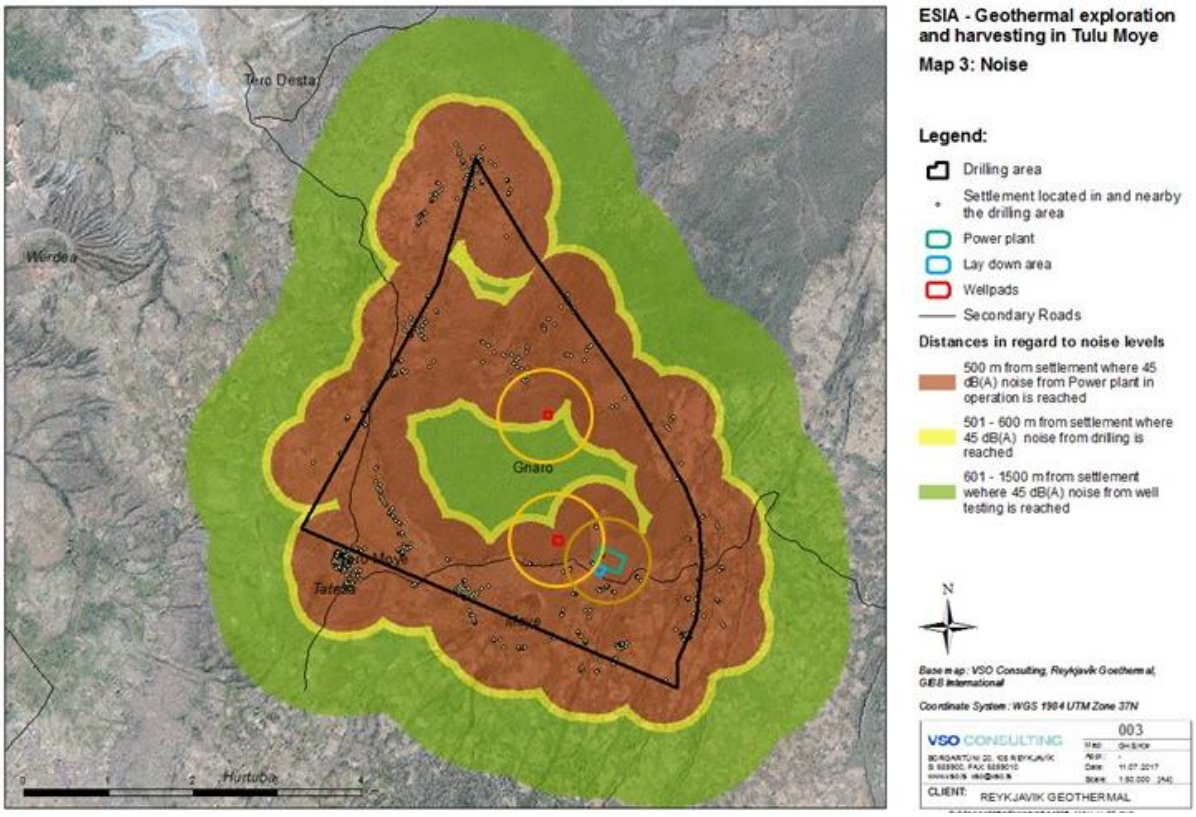


Figure 12.2 **Distances to closest settlement and the Drilling area (orange circles around well pads shows 600 m radius where noise can temporarily exceed 45 dB(A) during testing, and brown circle around the Power Station shows the 500 m radius were noise from the Station's operation can exceed 45 dB(A)**

Noise from drilling is generally in the range of 70-100 dB(A) in 10 m distance from the source, depending on the equipment used. In this case all drilling equipment will fulfill strictest standards regarding noise levels and highest noise levels can be expected to be 92 dB(A) at a 2 m distance. At 80 m distance the noise has dropped to below 70 dB(A). At 600 m distance the sound level is below 45 dB(A).

Noise from discharging wells or wells being **tested** ranges from 70-110 dB(A). This noise level varies e.g. due to different ratio of steam and water. Icelandic measurements show that the noise drops to 60 dB(A) level at 200 m from the well. At a distance

approximately 1,500 m over bare land the sound level has reached the 40 dB(A) level (Figure 12.2). The rise in background noise level is temporary and limited to the drilling and testing period that can range from 2 weeks to 6 months. Figure 12.2 shows a 1,500 m buffer from settlement to where the noise from drilling has reached 45 dB(A) without mitigation measures. The figure shows that impact from discharging wells is wide and is likely to affect settlements within the Drilling area. The impact is however temporary.

Figure 12.2 shows a 500 m buffer from settlement to where the noise *from drilling* has reached 45 dB(A) and a 1,500 buffer from settlement to where the noise *from well testing* has reached 45 dB(A) without mitigation. Emphasis will be placed on blow-test design /setup, site selection for wells, landscape barriers and other viable mitigation measures.

Figure 12.2 also displays the location of the first two well pads and the Power Station. The location is such that few settlements/households will be directly affected by the noise when drilling and the operation of the Power Station. These impacts are minor to moderate, but can change when more drill pads will be located.

12.5.2 Impacts during operational phase

The Tulu Moye area is rural and background noise level can be considered very low in general (Table 12.3). Therefore, all development will cause an impact. Residents, livestock and wildlife are potential receptors of noise and vibration due to development during operation.

An increase in noise in relation to the baseline conditions is expected during operations. The additional noise sources for geothermal power plant typically include:

- The steam turbine
- The generator
- The droplet separator
- The steam strainer
- Valves (main and stop valves)
- Pumps (incl. oil pumps, vacuum pumps, hot well pumps and cooling water pumps)
- Ejectors
- The main condenser
- The cooling towers
- Transformers

Noise ratings of the plant equipment will have to be considered in assessing likely project impacts.

Noise during operation is mainly from cooling towers, power plant and separators. It can be concluded that the noise level from coolers is around 80 dB(A). According to experience from Icelandic geothermal projects, both measurements and noise distribution models, the residential noise limits 45 dB(A) are met within 500 m distance from cooling towers and wells during operational phase. Noise from power plant and seperators can be expected to be around 55 dB(A) and the residential noise limits are met at approx. 160 m. As mentioned above this is quite dependent on terrain and surface.

Figure 12.2 shows a 500 m max. buffer from settlement to where the noise from power plant, cooling towers and wells has reached 45 dB(A). The location of the Power Station is such that few households/settlements are within the buffer. An emphasis will be placed on site selection for wells with regard to sensitivity and viable mitigation measures.

12.5.3 Impacts during decommissioning phase

Impacts during decommissioning phase are similar to the ones in the construction phase, without the drilling and testing of wells. Those impacts are temporary.

12.6 Data limitation and uncertainty

Due to accessibility challenges with the heavy rainfall episodes during the site work, no night measurements were done. However, given that there are no major sources of high noise levels within the Project area, variation between the day and night time levels are expected to be very minimal if any.

Distance from noise sources to settlements has been considered in selection of first drill pads and should continue to be considered during planning and design. ~~is not known.~~

12.7 Summary

12.7.1 Impacts during construction phase

Table 12.4 Construction phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Drilling	Increased noise level for residents	Moderate	Site selection	Minor
			Raise sound barrier between noise source and residential area	Minor
	Risk of hearing loss for workers	Major	Personal protection equipment and health and safety plan	Minor
	Disturbance for fauna	Moderate	Site selection and/or sound barriers	Minor
Well testing	Increased noise level for residents	Moderate	Silencers put on top of wells during testing periods	Minor
			Site selection	Minor
			Raise a sound barrier between noise source and residential area	Minor
			Rocks in sound muffler, insulation and dock around	Minor
			Shorten well testing down to 2 weeks	Minor
	Risk of hearing loss for workers	Major	Personal protection equipment and health and safety plan	Minor
	Noise disturbance for wildlife	Moderate	Consider design /setup. Shorten well testing period. Site selection and/or sound barriers.	Minor
	Vibration causes disturbance for wildlife	Moderate		

Action	Impact	Significance	Mitigation measure	Residual significance
Earth works and construction	Increased noise level for residents	Moderate	Implement policy with regard to condition of machineries.	Minor
			Sound barriers.	Minor
	Risk of hearing loss for workers	Moderate	Implement policy with regard to condition of machineries.	Minor
			Personal protection equipment and health and safety plan	Minor
	Disturbance for fauna	Moderate	Site selection	Minor
			Sound barriers	Minor

12.7.2 *Impacts during operation phase*

Table 12.5 Operation phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Cooling towers	Increased noise level for residents	Major	Sound barriers between source of noise and settlement	Moderate
			Site selection	Minor
	Risk of hearing loss for workers	Major	Personal protection equipment and health and safety plan	Minor
	Disturbance for wildlife	Major	Sound barriers between source of noise and settlement	Moderate
			Site Selection	Minor
	Vibration causes disturbance for wildlife	Moderate		
	Vibration causes disturbance for locals	Minor		

12.7.3 *Impacts during decommissioning phase*

Table 12.6 Decommissioning phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Earth works and demolition	Increased noise level for residents	Moderate	Implement policy with regard to condition of machineries.	Minor
			Sound barriers.	Minor
	Risk of hearing loss for workers	Moderate	Implement policy with regard to condition of machineries.	Minor

			Personal protection equipment and health and safety plan	Minor
	Disturbance for wildlife	Moderate	Sound barriers	Minor
			Timing of demolition with regard to i.e. breeding season	Minor

12.8 Conclusion

The Project is likely to have minor to moderate impacts on noise having taken mitigation measures into account. The main source of noise is from drilling, well testing and cooling towers. Drilling and well testing is temporary but noise from cooling towers remains through the operation of the power plant. Both people and wildlife can be affected by noise and vibration but mitigation measures in the form of silencers on top of wells, sound barriers and site selection will minimize the impact. Eleveted noise levels can cause hearing loss for personnel during construction and operation. Emphasis will be placed on personal protection equipment and health and safety plan for personnel.

13 Geology and soils

13.1 Introduction

This chapter aims to describe the baseline geology and soils of the Project area and predict the potential impacts the proposed project will have there on. A definition is given of the affected area and an overview of the appropriate legislation, guidelines and standards. The baseline information was gathered by GIBB International for the purpose of this EISA (GIBB International, 2015). The impact assessment was done by VSO Consulting and RG.

13.2 Affected areas

Potential impacts to surface and sub-surface geology and soils are most likely to occur at the Drilling area but a baseline survey for the Project area is needed to understand and map geological formations and processes that extend beyond the Drilling area. Thus the baseline of the Project area is also discussed.

13.3 Legislative framework

13.3.1 National

- Mining Operations Proclamation No.678/2010
- Mining Operations Council Of Ministers Regulations No. 182/1994
- Oromia Bureau of Land and Environmental Protection Establishment Proclamation No. 147/2009
- EPA draft guidelines for EIA for Mineral and petroleum operation projects, 2003. Soil quality criteria.

13.3.2 International

- African Convention on the Conservation of Nature and Natural Resources
- United Nations Convention to Combat Desertification (UNCDD)
- IFC PS 8: Cultural Heritage
- World Bank Operational Policy 4.01
- IFC EHS Guidelines: Construction and Decommissioning
- IFC EHS Guidelines: Emergency Preparedness and Response

13.4 Baseline description

Impact assessment questions and objectives of study according to scoping document

The study on geology focuses on:

- The appearance of geysers, hot springs and other important geological formation in the Project area.
- The possible long term impacts on geothermal activity on the surface.
- The direct surface disturbance to important geological formations.

13.4.1 Geology

Tulu Moye area is named after the mountain Moye, a volcano in the eastern part of the concession, the word “tulu” in the local language meaning a mountain (Eysteinsson, Jonsson, & Tekka, 2015).

The East African Rift System (EARS) is one of the largest continental rift systems. The EARS is a Miocene – Quaternary intercontinental extensional system. The Main Ethiopian Rift (MER) constitutes the northernmost part of the East African Rift System

(EARS), connecting the EARS with the Afar Triple Junction. MER is geographically divided in to three sub-sectors: Northern, Central and Southern Sectors. The Tulu Moye geothermal Project area is situated in the Central Sector of MER, South West of Adama, close to the eastern margin of the rift as shown in Figure 13.1. It is a wide Zone where tectonic and volcanic activities are concentrated. Extensional structures (normal faults and tensional fissures) are associated with volcanic edifices (Volcano – Tectonic Correlation). Compilation of all available geological, structural and thermal field data shows a close relationship between dense Quaternary faulting and associated eruptions. Volcanic activity is more recent and young at the Project area (west of the eastern escarpment), junction of three set of faulting.

The Project area is generally characterrized by intense Quaternary faulting and fracturing. Three set of faults are mapped in the area namely; NE – SW striking marginal normal faults, NW – SE to E – W trending trans-rift faults (extension) and the youngest and active NNE – SSW to N – S striking faults of the Wonji Fault Belt (WFB). Thermal sites (vents) and tectonics in the area follow the general NNE – SSW trend of the intensively and densely populated faults of the WFB.

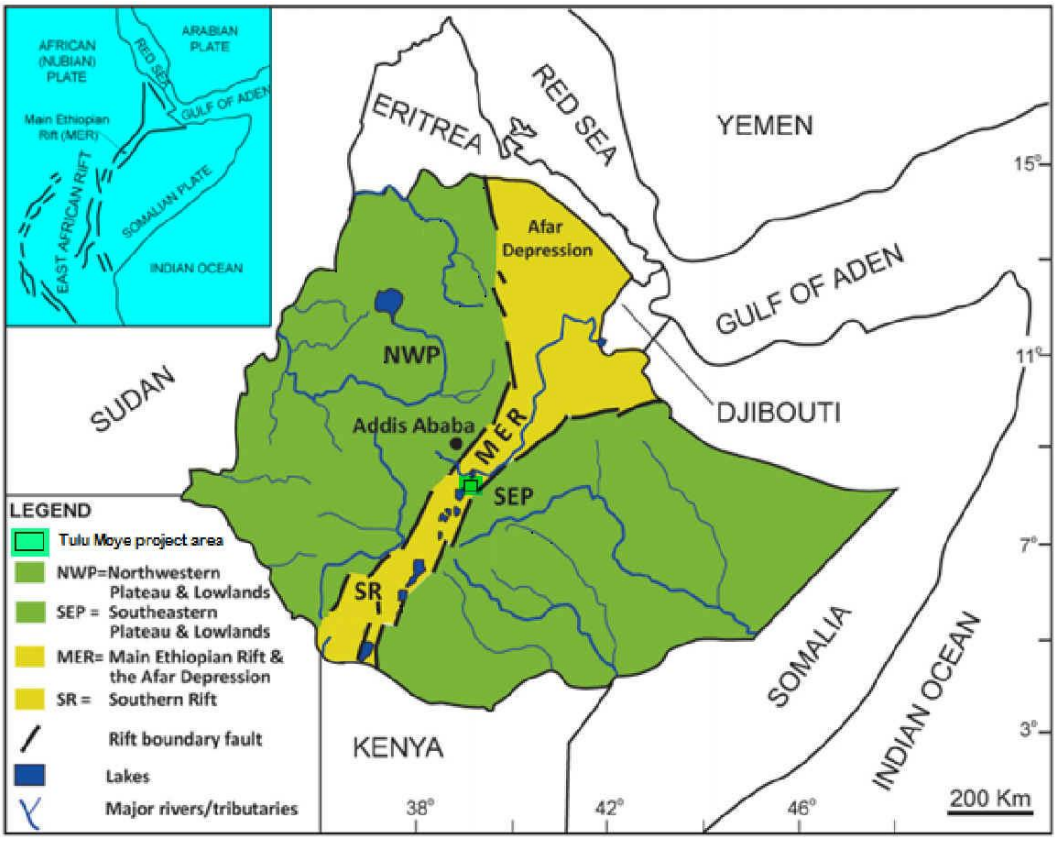


Figure 13.1 Tulu Moye Project area is located at the central part of the Main Ethiopean Rift (MER). (GIBB International, 2015)

Recent Quaternary sediments, Holocene central volcanic complexes, rift floor basaltic flows, Dino formations and Tertiary Chilalo volcanic and Nazeret group constitute the stratigraphy of the area from the youngest to the oldest.

Tulu Moye is a pyroclastic cone with last known Eruption in 1900 AD. The summit is 2,349 m a.s.l. Mt. Gniaro erupted a large silicic lava flow about two centuries ago from a regional fissure. Flank fissures have produced silicic lava flows as recently as about 1900 AD. The same fissures have also erupted prehistorical basaltic lava flows (Smithsonian Institution, 2016). The small crater at the bottom centre of the cone is blanketed by a youthful obsidian lava flow. Two other obsidian flows are prominent 5 km to the north.

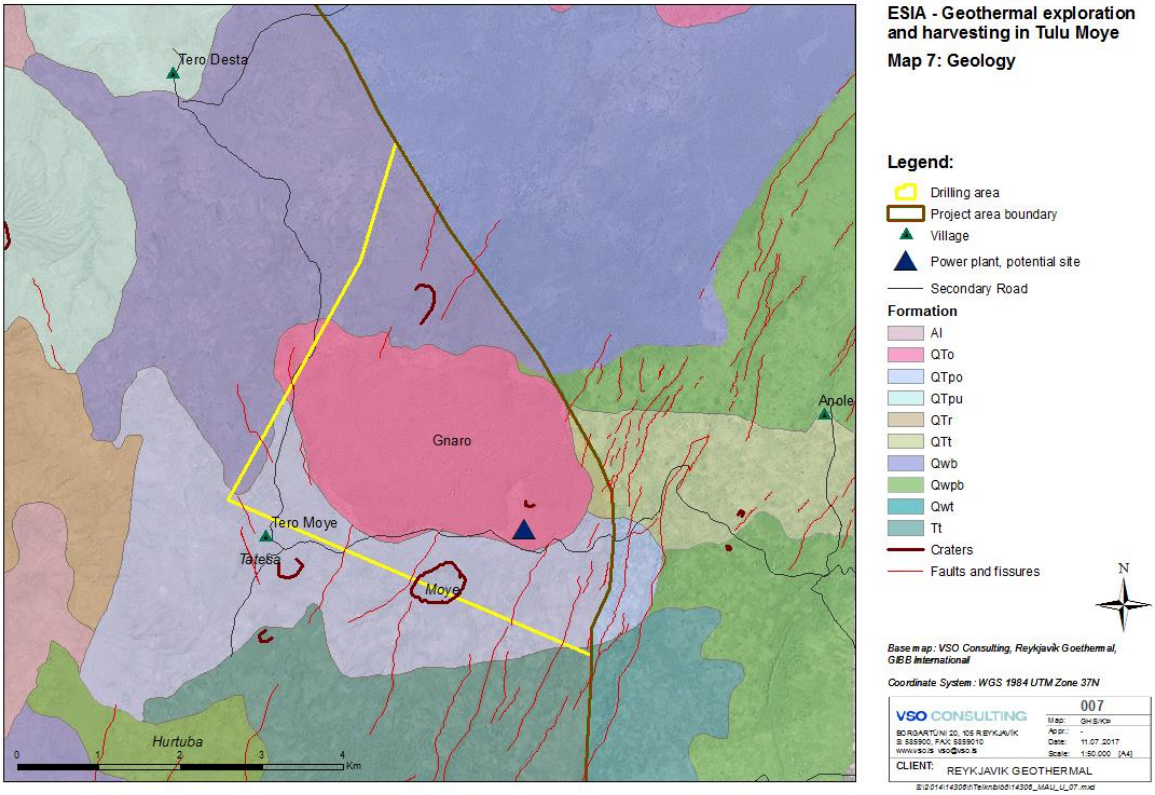


Figure 13.2 **Geology of the proposed Drilling area.**

Mount Bericho is a pyroclastic cone with summit at 2,285 m a.s.l, Mount Bora Sapo is a pyroclastic cone and then there are rhyolitic pumice cones along the Wonji Fault Belt, as a part of the Bora-Bericho volcanic complex. The silicic Bora and Bericho pumice cones, among the most youthful volcanoes of the Rift valley, rise 350-500 m above the floor of the rift. Produced by the accumulation of rhyolitic pumice around its vent, Bericho is capped by a small summit crater. Erosion of the unconsolidated pumice has produced parasol- like ribbing on the flanks of the cone. Its twin volcano, Bora has a 1.5- km-wide summit crater, and the more conical Bericho is capped by a small summit crater and has a 1-km-wide crater on its south flank. Small silicic pyroclastic cones are found on the east flanks of both Bora and Bericho. All volcanic products in this area are considered to be Holocene in age. Vigorous fumarolic activity continues at Bora-Bericho.

Gedemsa Caldera, summit 1984 m is located along the Main Ethiopian Rift east of Lake Koka and SW of the Wonjii Sugar Estate Farm. The 7 x 9 km wide caldera is cut by many NNE-SSW-trending regional faults of the MER, particularly on the east side of the caldera. The caldera is steep-sided, with 100-200 m high walls whose upper part consists primarily of Rhyolitic lava flows, and formed as a result of the eruption of a series of Trachytic Ignimbrites. Late-Pleistocene to Holocene volcanoes form a chain of rhyolitic lava flows and pumice deposits, known as Ittisa, that rises about 200-250 m above the floor of the caldera. A chain of Rhyolitic lava flows and a large 1-km-wide crater occupies the caldera floor. A young lava dome and flow is found on the SW flank of the volcano (lower left) and small basaltic spatter cones have formed inside the caldera rim. Weak fumarolic activity was observed at Gedemsa. Of the previous mentioned mountains Mt. Baricha, Mt. Bora and Mt. Moye are within the Project area (Figure 13.2).

The present topographic configuration and geomorphological development of the Project area is highly related to the geological, paleo-geographical development and mainly a series of tectonic activities that took place over the region. The Western part of the

Project area lies at the rift floor and the eastern part of the Project area is at the eastern margin of the rift valley that is affected by series of normal faults, part of the WFB. Generally, the whole Project area lies in the MER bounded by Eastern rift escarpment. Regionally three prominent topographic features are observed. These are: (i) The extensive Rift Margin, including Arsi highland plateau (Mt. Galema and Mt. Chillalo) at the Eastern shoulder of the MER and Gurage highland plateau at the Western margin of the MER: (i i) The deeply faulted rift escarpment; and (iii) The Rift Floor (Figure 13.4 and Figure 13.5).

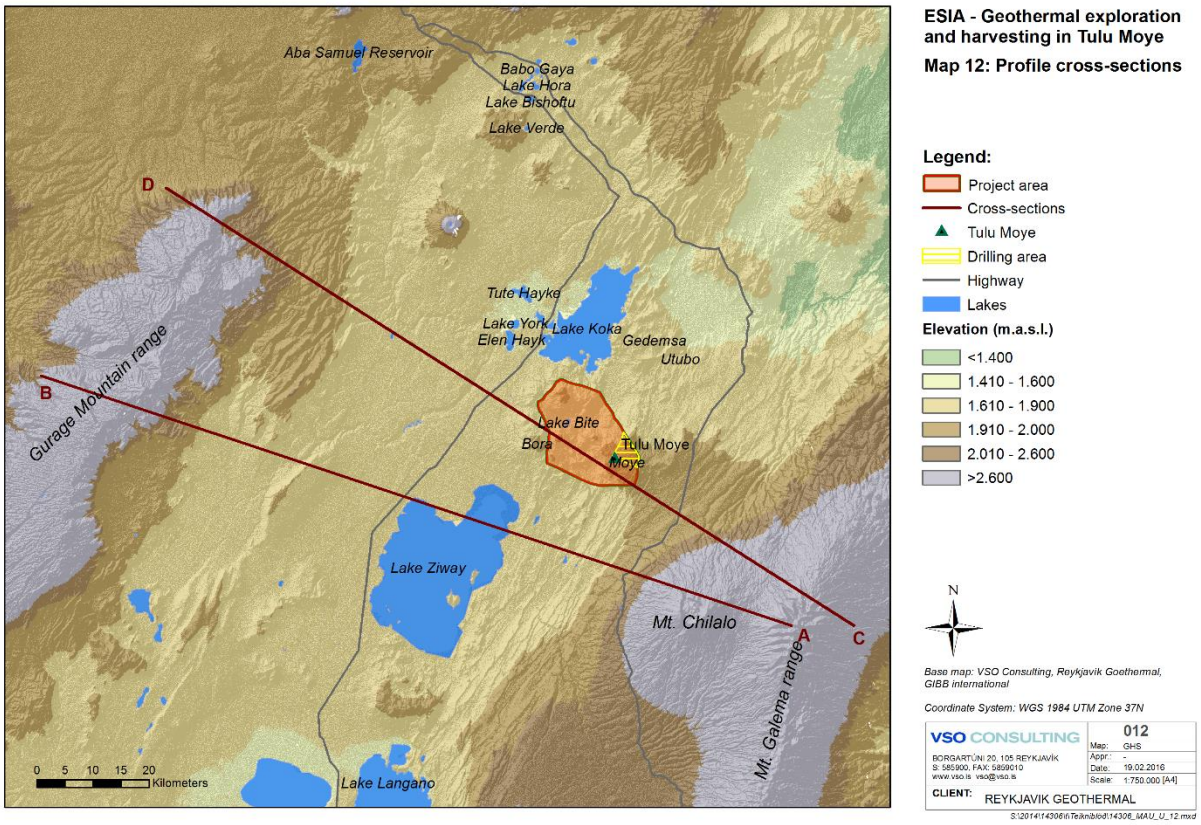


Figure 13.3 Profile cross-sections for figures 14.4 and 14.5

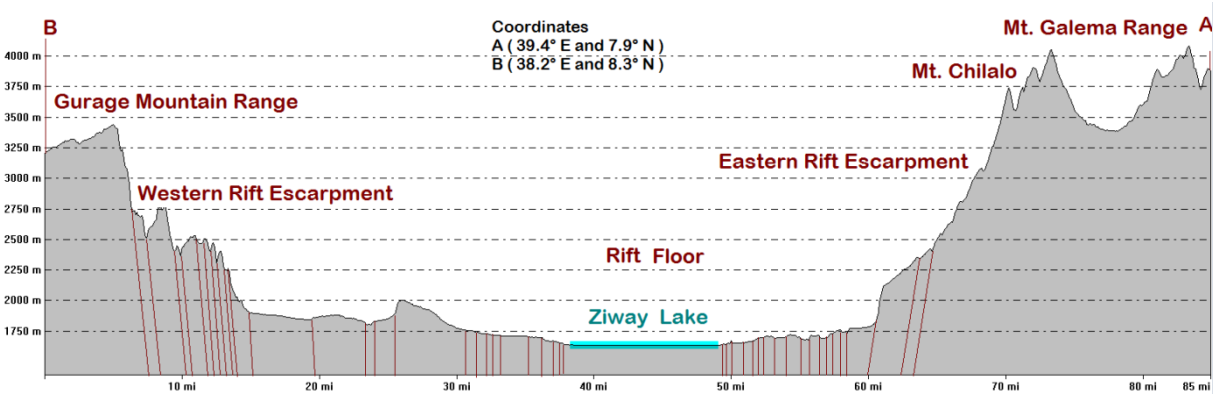


Figure 13.4 Profile section at southern part of Tulu Moye Project area along AB line. (GIBB International, 2015)

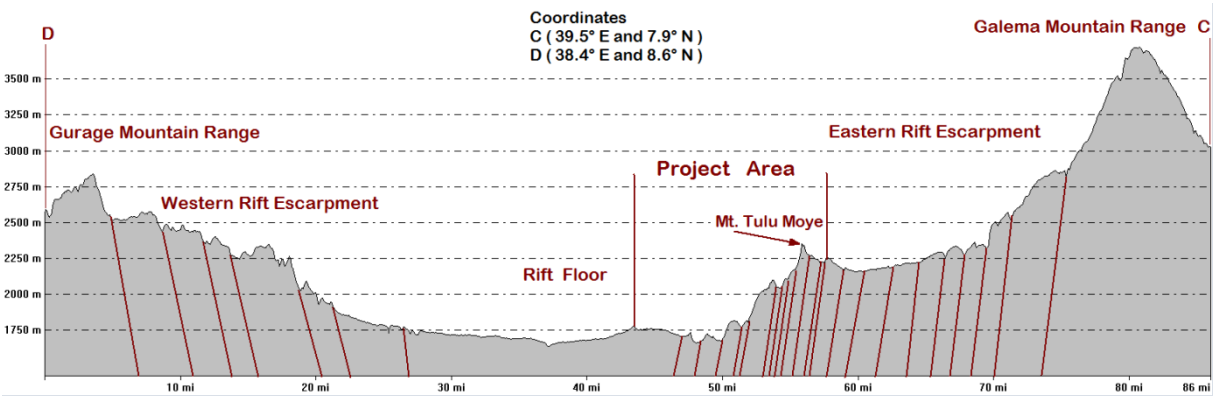


Figure 13.5 **Profile section crossing the Project area along CD line.** (GIBB International, 2015)

13.4.2 Hydrothermal activity

Hydrothermal manifestations are widespread in the Tulu Moye area. The most common manifestations are weak fumaroles, active steaming grounds and altered grounds (Figure 13.6). Hydrothermal manifestations can be categorized as environmentally sensitive areas according to Ethiopia EIA Guidelines.

Table 13.1 The main hydrothermal activities within the Project area (Mamo, Gudbrandsson, & Gislason, 2015).

Location	Description	Temperature
Bekere	An altered area at the edge of a rhyolitic dome south of Lake Koka. Characterized by white, red and yellowish alteration soft material deposits. Several weak fumaroles.	Up to 45°C
Kechkechi	Extensive area of hydrothermally altered Zone south of Bite village. Active warm ground at the base of Kechkechi hill and further up the hill. Chalcedony deposits following the NNW striking fault direction mainly covering the top of the recent pumice falls and flows	
Elada	Located east of Bite village. Very extensive reddish – whitish clay area of fossil hydrothermal alteration Zone, following a NNW trending structure.	
Werdi	The north-eastern side of the Mt. Werdi has large altered Zones, both on the top and along the slopes and at the foot of the mountain. There are several steam vents in the altered Zone. Most of the surrounding area is covered with fragments of chalcedony.	
Dima	The alteration on the top of the Mt. Dima is characterized by warm ground and weak fumaroles aligned in NNW. On the eastern part of Mt. Dima there is a hydrothermally altered Zone with white and red soft clay material.	Up to 50°C
Mt. Moye*	Two volcanoes in the area, Tulu Moye Danise and Tulu Moye Terro. The area has been highly affected by hydrothermal activity and there is an extensive area of thermal manifestation. There are hissing and powerful fumaroles and warm ground in the area. Surface alterations mainly include reddish clay and sometimes-yellowish material.	Up to 90°C

*Within Drilling area

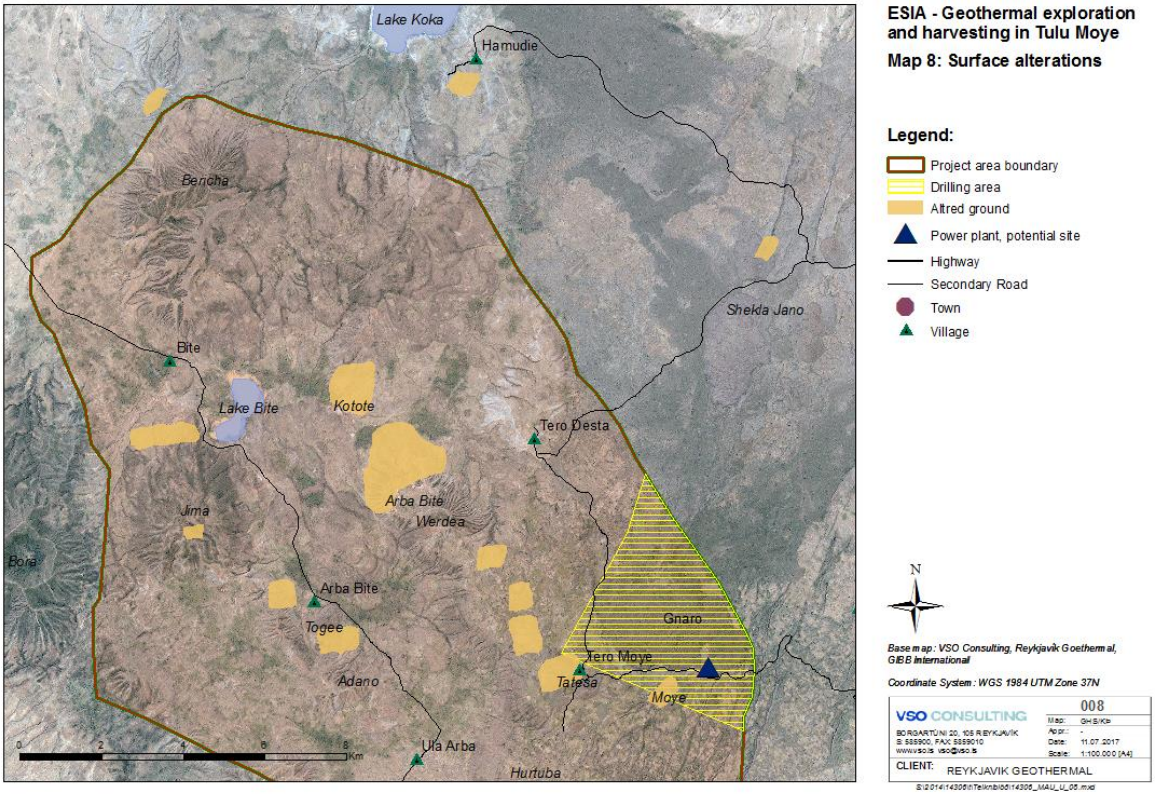


Figure 13.6 **Surface alterations and hydrothermal manifestations in the Project area.**

13.4.3 Soils

According to soil map of Ethiopia prepared by Ministry of Agriculture, there are 12 major types of soils in the Project area. The soil classification is based on FAO soil classification scheme. The Major soil type in the Project area and the surrounding area are Chromic Luvisols (LVx), Chromic Vertisols (VRx), Dystric Nitisols (NTd), Eutric Cambisols (CMe), Eutric Fluvisols (FLe), Eutric Regosols (RGe), Leptosols (LP), Lithosols (LI), Luvic Phaeozems (PH), Molic Andosols (ANm), Vertic Cambisols (CMv) and Vitric Andosols (ANv) (Figure 13.7).

The defined Drilling area in the eruptive plateau of Gnaro is partially vegetated rhyolitic obsidian lava field, without any agriculture practise. Potential for erosion seems limited. The petrology in the Tulu Moye geothermal concession is characterized by rocks ranging from basalt to rhyolite in composition.

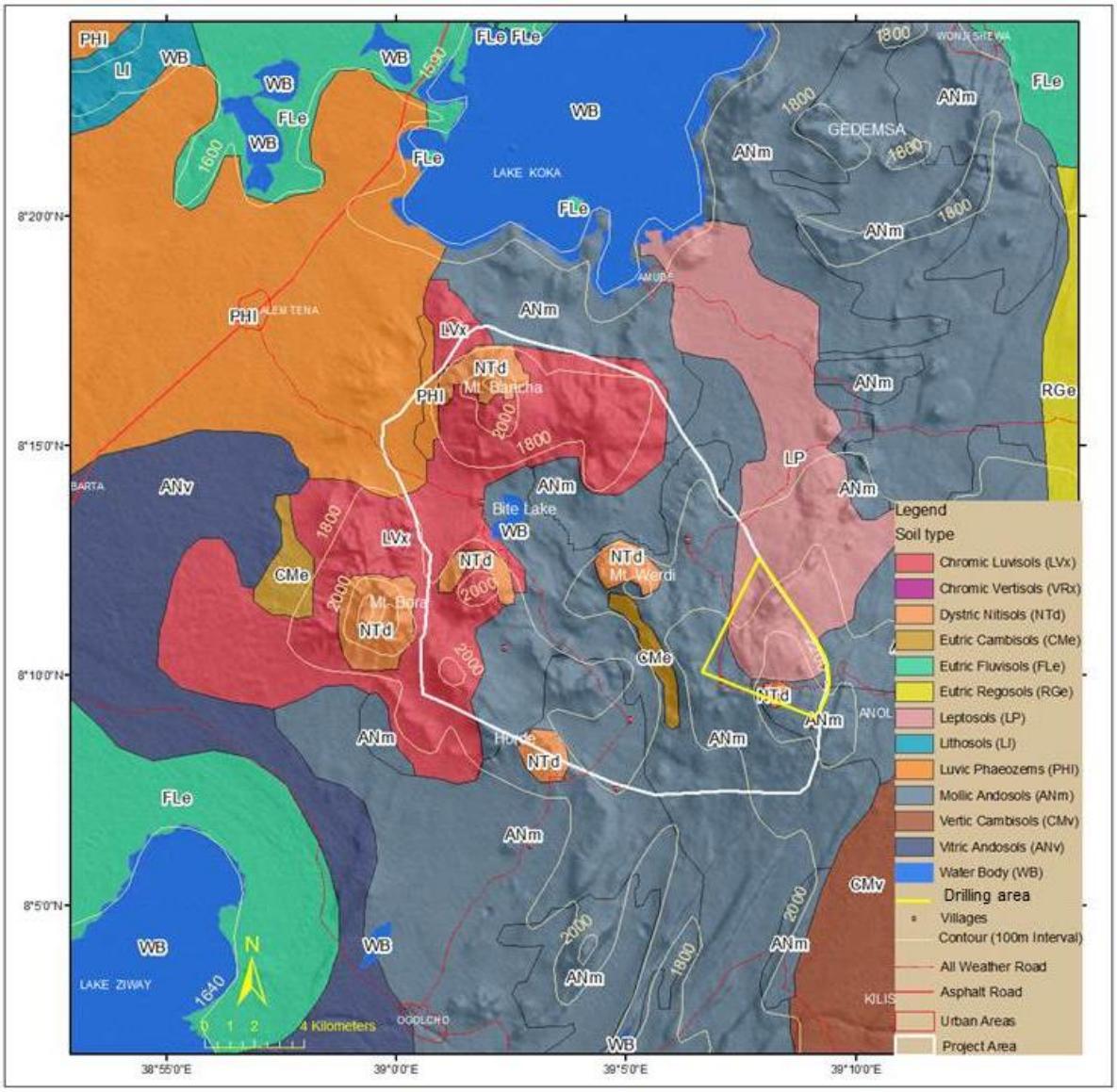


Figure 13.7 **Soil map of the Project area** (GIBB International, 2015) **and Drilling area.**

Baseline summary - proposed Drilling area

Soils within the Drilling area are mainly leptosols (LP), mollic andosols (ANm) and dystric nitisols (NTd).

Mt. Tulu Moye is a pyroclastic cone with last known Eruption in 1900 AD. The summit is 2,349 m above sea level, Elevation 2349 m.

The Drilling area is located at the eastern margin of the rift valley that is affected by series of normal faults, part of Wonji Fault Belt (WFB).

The area has been highly affected by hydrothermal activity and there is an extensive area of thermal manifestation. There are hissing and powerful fumaroles and warm ground in the area. Hot springs are defined as sensitive areas according to Ethiopia EIA Guidelines.

13.5 Impact assessment on geology and soils

13.5.1 Impact in construction phase

There is a risk of soil erosion with surface water runoff or wind erosion following surface clearance prior to construction. The soil is very fine grained and susceptible to erosion. In order to mitigate these impacts designs of drains and channels will be made with restistance to flood erosions. Surface that is sensitive to wind erosion will be covered and areas revegetated as soon as possible. In the case of decreased slope stability cuts and slopes will be stabilized with walls and structures as well as minimizing the steepness of slope.

The project may possibly cause the direct disruption of geological phenomenon or formations with conservation value. The Project area is characterized by geological formations which may be rare in surrounding areas even on national basis. Emphasis will be put on avoiding formations of consveration value in the site selection process.

By using directional drilling it gives the possibility to select drilling site which causes minimum disruption of geological or other natural phenomenon.

13.5.2 Impacts in operational phase

Extraction from the geothermal reservoir can affect fumaroles and hot springs on the surface. If groundwater levels lowers these phenomenons may decrease in activity. Also, the development of a steam cap as a result of extraction can increase the activity in fumaroles and hot springs. This would be considered as an adverse impact.

13.5.3 Impacts in decommissioning phase

No significant impacts on geology during decommissioning.

13.6 Data limitation and uncertainty

Location of first wellpads (in terms of geological formations) is within and bordering a lava field. Conservation value of a lava fields is different between countries. ~~is not known.~~

13.7 Summary

13.7.1 Impacts during construction phase

Table 13.2 Construction phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Surface clearance	Risk of soil erosion with surface water runoff or wind erosion	Moderate	Design of drains and channels made with regard to resistance of flood erosions. Design drainage system that takes possible floods into account.	Minor
			Surface sensitive to wind erosion will be covered.	Minor
			Revegetate areas as soon as possible.	Minor

	Decreased slope stability	Minor	Cuts and slopes stabilized with walls and structures.	Insignificant
			Minimize steepness of slope.	Insignificant
Earthworks and construction	Disturbance of sensitive or valuable geological formations such as surface manifestations/hot springs	Major	Site selection to avoid disturbance.	Minor

13.7.2 *Impacts during operation phase*

Table 13.3 Operation phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Resource extraction	Increased or decreased surface manifestation.	Major	Monitor sustainability of resource extraction.	Moderate

13.7.3 *Impacts during decommissioning phase*

Table 13.4 Decommissioning phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
	No significant impact on geology			

13.8 Conclusion

The Project is likely to have insignificant to moderate effects on geology and soils, having taken mitigation measures into account. The main impact would be the removal of or disturbance of sensitive or valuable geological formations such as surface manifestations/hot springs. Surface clearance can also have adverse impacts on soils and soil erosion. Mitigation methods involve limiting areas of disturbance, to design drains and channels to resist floods. Also to stabilze cuts and slopes with walls and structures and re-vegetate areas to stabilize slopes.

14 Water and hydrology

14.1 Introduction

This chapter aims to describe the hydrology of the Project area and predict the Project impact on water in the area. Baseline data was collected by GIBB International (GIBB International, 2015) and Reykjavik Geothermal. The information gathering entailed both desk study where previous research was reviewed and field work to verify information and fill identified gaps. Impact assessment was done by VSO Consulting and RG.

14.2 Affected areas

Defnition of affected areas is based on predicted impacts and mitigation measures.

Construction and Operation Phase

- The affected area can be defined as the Drilling area itself with the extension to the south where potential water sources are located (Figure 14.4).

Decommissioning Phase

- Impacts during decommissioning phase are limited to the drilling site.

14.3 Legislative framework

14.3.1 National

- Ethiopian Water Resources Management Proclamation No. 197/2000
- Ethiopian Water Resources Management Council of Ministers Regulations No. 115/2005
- Ethiopian Water Resources Management Policy.
- Ground and surface water quality criteria, adopted from tentative Netherlands criteria and from UK Environment Agency.
- ES 261:2001 Standard for Drinking Water - Specifications

14.3.2 International

- WHO Guidelines for drinking-water quality set requirements for drinking-water safety.
- IFC Environmental, Health and Safety General Guidelines.
- IFC PS 4: Community Health, Safety and Security

Impact assessment questions and study objectives according to Scoping document

- Description of the hydrogeology of the Project area.
- Identifying the baseline condition of the chemical composition of groundwater and surface water in the Project area.
- Potential water sources and to determine the sustainability of the supply.
- The quality of the water source in terms of operation standards and that of the drinking water itself.
- The amount and chemical compounds of the discharge water.
- The water source biology and possible impacts on water supply for the Project.
- Are there seasonal lakes that form within the Project area?
- Identify other users of the lakes and groundwater close to new wells.

14.4 Baseline description

14.4.1 Rainfalls and temperature

The Project area climate is tropical with annual mean temperature of 30 degree Celsius. The geomorphology of the study area, together with the vegetation, influences the relationship between precipitation over the area and water drained from it. Seasonal classification over the area is mainly based on the average rainfall distribution pattern over the year, and the seasonal variation of the study area range from dry season (Bega) to heavy rainfall in rainy season (Keremt) (Figure 14.1). Though the duration, amount and spatial distribution of rainfall vary in the highlands and in the rift floor, mono-modal type of rainfall regime is generally observed. The Project area has two distinct seasons, wet from June to September and dry from November to February, with the rainfall peak occurring from July to August.

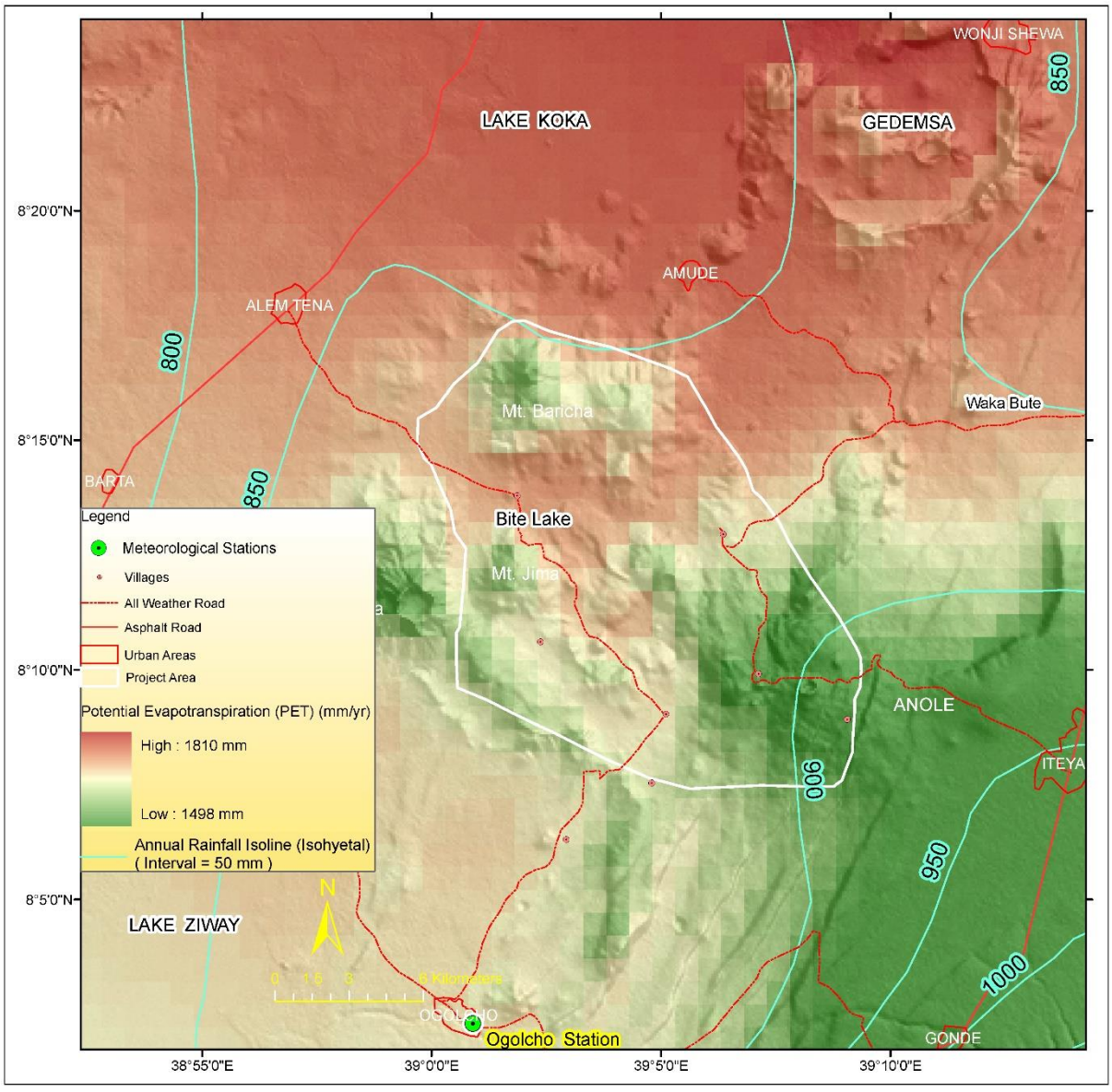


Figure 14.1 **Annual rainfall depth (mm) at the Project area** (GIBB International, 2015)**.**

14.4.2 *Drainage patterns in the Project area*

The Project area is located on the rim where the Central Rift Valley and the Eastern rift escarpment adjoin. In the area there are also localized volcanic ridges and depressions due to trans-rift strike-slip faults, which form localized alluvial fans and alluvial deposits of intermittent streams. This makes it possible to find small hydrogeological basins of shallow ground water. Floods and overland flow recharge them, and many of these aquifiers are only temporary and dry out. The water quality varies according to the underlying geological formation and period of the year.

The Project area is located in the Awash and Lakes Region major basins. The area has low drainage density and the drainage pattern is highly dissected by intensive faulting. Drainage density is relatively higher at the Eastern rift escarpment and margin. The rivers (Keter and Meki) mostly follow the rift faulting alignments and the topographic gradient in the landscape.

Most of the Project area lies in upper Awash basin that includes Lake Koka. Upper Awash basin starts from the Gurage Mountains to Lake Koka and drains from West to East. The Main River Awash includes many perennial and intermittent tributary streams (Figure 14.3). Awash River and all tributaries form sub-parallel drainage pattern.

The most southern part of the Project area is a part of the drainage basin of the Keter and Meki rivers, which run into Lake Ziway. Several runoff rivers gather into the Keter River, (Figure 14.3). The river has a high gradient and is highly affected by the topographical profile which spreads as the faulting in the area. Lake Ziway is one of the Rift Valley Lakes, which are mainly distributed in the centre of low profile valley and flat lands created by the rift. No perennial rivers are within the Project area but several intermittend ones run through the northern part of the area.

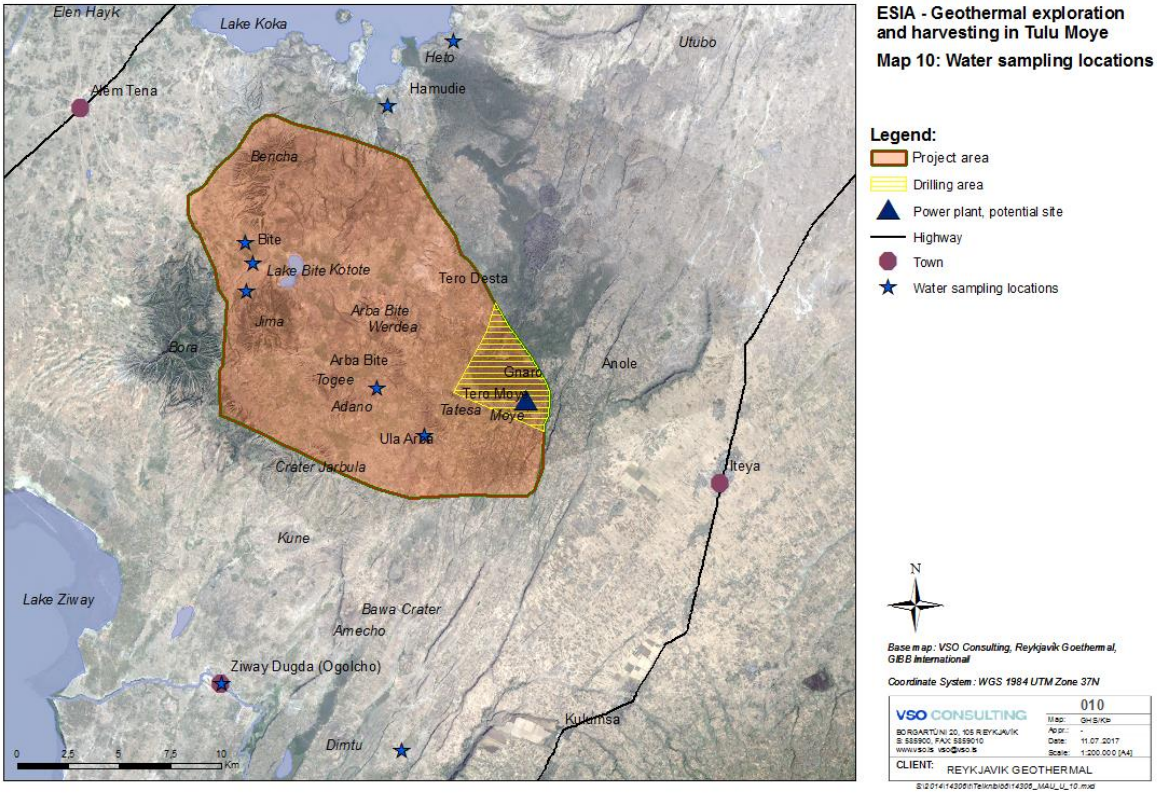


Figure 14.2 **Water samples location**

14.4.3 *Water resources and water quality*

Several productive boreholes for water supply are in and near the Project area. The groundwater level is at 100-180 m depth (GIBB International, 2015). High discharge springs are located at the foot of Mt. Chillalo.

Water quality is influenced by the underlying geological formation, land use and varies by the time of year. This is because the participation is high six months a year and low the other six months. Fertilizers added on farm lands causes of pollution in this regard.

In the Project area and surrounding region, there is great spatial hydrochemical variation due to active volcano-tectonic activities. Spatial variation in the ionic concentration of groundwater and surface water systems in the region are due to rock-water interaction (dissolution, adsorption, precipitation, etc), groundwater residence time, geomorphological setting and climate.

The total dissolved solids (TDS) increase from the highland to the rift valley following the regional groundwater directions towards areas of low rainfall and high evaporation and groundwater residence time. In contrast with the rift valley waters, the highland waters are more homogeneous in their chemical composition and are characterized by low TDS (varying often from 50 to 1200 mg/l). Highland waters are dominantly Ca-Mg bicarbonate type except few waters with high SO_4 content in some localities. The rift valley waters are mainly Na-bicarbonate type with very high TDS (varying in a wide range between 200 and 73,015 mg/l) and F. The escarpment waters are mixed type with moderate TDS. The high F in the rift is related to the dominance of acid volcanics, high temperature in geothermal fields associated with high CO_2 out gassing incorporating F.

In view of the general similarity of rock types drained by streams and rivers in highland volcanic province the major ion chemistry of surface waters is not significantly different from the shallow groundwater system of the same region. The groundwater tends to change from HCO_3 to SO_4 and then Cl type all the way from the MER to the Afar in the direction of regional surface water and groundwater flow directions and decrease in altitude. This is peculiar hydrochemical evolution of natural water in big river basins.

Unlike the highland lakes and rivers, the rift lakes have exceptional high ionic concentration with extreme variability both in the TDS and type of major ions. The closed basin and terminal lakes attain the highest salinity, alkalinity and F concentrations as a result of subsequent evaporation. The dominant cation in almost all rift lakes is Na. Few waters in major urban centres have high NO_3 indicating anthropogenic pollutions (A., 2005).

Chemical analysis from several water sampling sites in the Project area indicate that the ground water has signs of geothermal influence. Based on the SiO_2 and F concentration it can be surmised that the water can be used as cooling agent for the drilling and operation of the geothermal power plant. Drinking water that complies with quality standards will have to be obtained from other sources.

Table 14.1 Temperature and chemical concentration of well water samples south of Drilling area (see Figure 14.2). Units are in mg/l unless otherwise specified.

Sample site	°C	SiO_2	B	NH_4	Ca	Mg	Na	SO_4	Cl	F	NO_3
Well 31	34	108.1	0.37	0.83	74.1	15.8	275.9	26.9	13.8	4.75	8.68
Well 33	23	49.3	0.21	0.01	24.0	8.39	20.0	3.12	7.80	0.25	5.70
Limit*	-	-	0.3	1.5	75	50	200	250	250	1.5	50

*Maximum passable level according to ES 261:2001 Ethiopian drinking water standard.

Table 14.2 Content of toxic and/or disease causing substances of drinking water (adapted from ES 261:2001, Ethiopian drinking water standard). The maximum passable levels are the similar as in WHO guidlines for drinking water quality.

Toxic or disease causing substance or characteristic	Maximum passable level mg/l
Barium (Ba)	0.7
Mercury (Hg)	0.001
Cadmium (Cd)	0.003
Arsenic (As)	0.01
Nitrate (NO_3)	50
Lead (Pb)	0.01
Boron (B)	0.3
Fluoride (F)	1.5
Chromium (Cr)	0.05
Characteristics that affect palatability	**Maximum passable level mg/l**
Total dissolved solids (TDS)	1,000
Iron (Fe)	0.3
Ammonia (NH_3+NH_4)	1.5
Chloride (Cl)	250
Magnesium (Mg)	50
Calcium (Ca)	75
Copper (Cu)	2
Sulfate (SO_4)	250
Sodium (Na)	200

14.4.4 Ground water flow

(a) Groundwater flow

Groundwater flow direction in the area is mainly controlled by structures and partly by geomorphology. Most of the springs emerge along the trend of NE-SW at the foot of Mt. Chilalo (topographic break) and also at the lithological contacts. Generally, groundwater flows from high gradient Arsi highland to low gradient rift floor, but this flow direction is highly controlled by rift marginal normal faults and then younger NNE-SSW and NW-SE faults. Groundwater flow in the Project area is mainly structurally controlled. Thus the proposed well field and sites are based on hydro-structural reasoning.

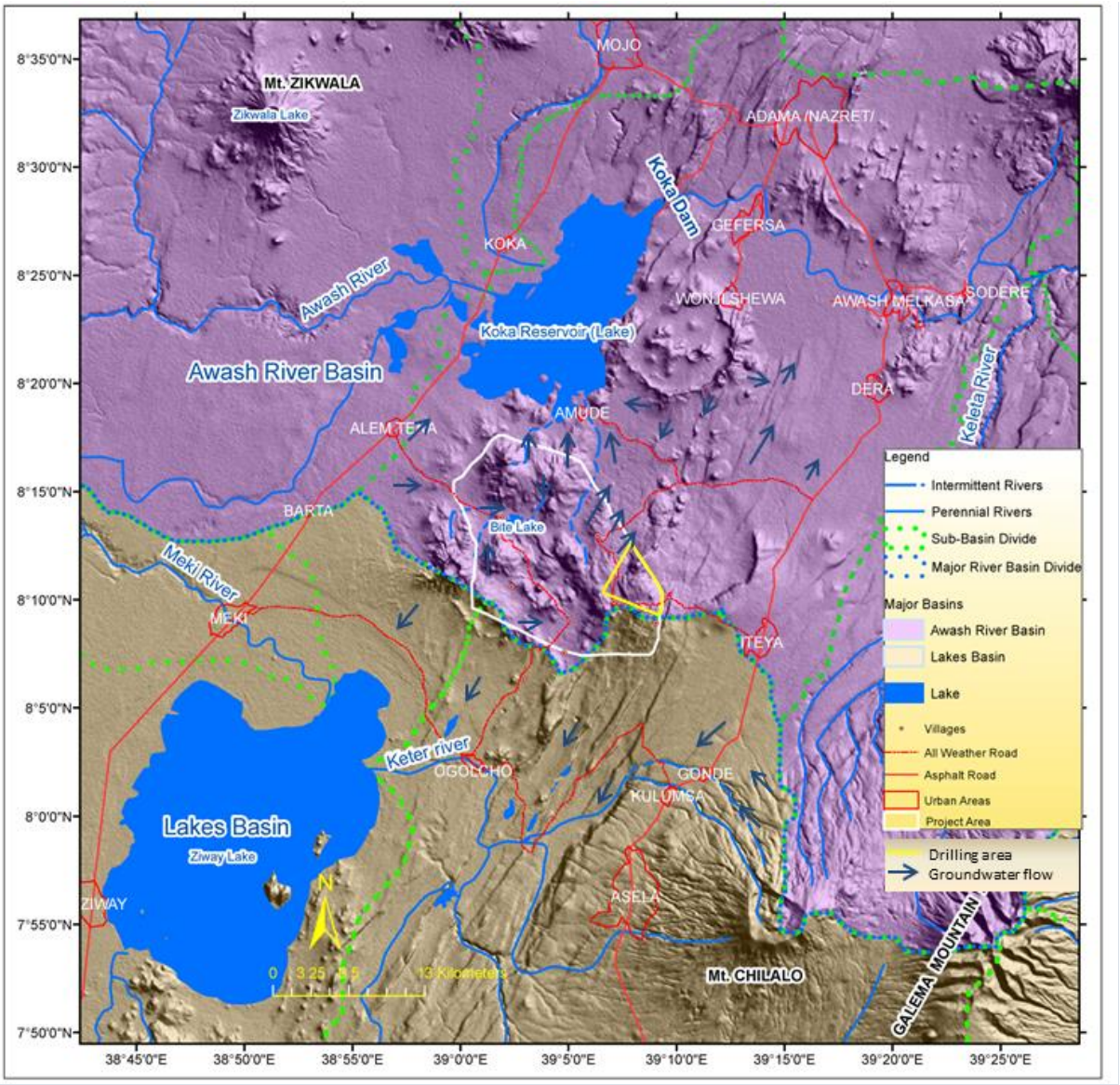


Figure 14.3 **Hydrology of the Project area** (GIBB International, 2015) **and Drilling area.**

(b) Groundwater recharge

The main source of recharge to groundwater in the area is rainfall in Arsi highlands. There is also base flow recharge from Ziway Lake, Lake Koka and perennial Awash, Keter and Meki rivers. Most of the stream courses and wetlands in the region are highly controlled by intensive faulting that also favours recharge. The base flow recharge the shallow and deep aquifer systems of the area through minor fissures and intensive faulting of the area respectively. Most of recharge in the area and in the region goes to the deep circulation that indicates the potentiality of geothermal aquifer in the area.

(c) Groundwater discharge

Structures, topography and lithologies of the region control groundwater discharge. Groundwater discharge occurs as springs at the foot of highlands and mainly as seepages on the rift valley. All lakes in the MER (Main Ethiopian Rift) are seepages (discharges) of the highlands recharge. But greater volume of groundwater from the region joins the deeper circulation. The Project area and the surrounding have great deeper aquifer due to huge amount of recharge all along the structures starting from the highlands to the rift floor.

14.4.5 *Climate change impacts on the Project*

Climate has significant effects on the groundwater distribution. Mt. Chilalo and Mt. Galema receive high amount of rainfall (1100-1200 mm/yr) and lower evapotranspiration (Figure 14.1). These Arsi highland plateaus are dissected by perennial rivers and faulted by MER down to the rift floor and they are the main recharge place for the area while the rift floor dominated by pyroclastics and sediments acquire little amount of rainfall, low drainage density, and then low groundwater recharge. Generally, the rainfall decreases from the Arsi highland to the rift floor as the elevation and vegetation cover decline.

14.4.6 *Access to drinking water in the Drilling area*

In and around the Drilling area, there is limited access to drinking water and basic sanitation. Contaminated water leads to death and disease, and harvests may fail that are entirely dependent on rainfall. Due to lack of water, there is no irrigation systems deployed in the area. Women and girls must travel large distances to fetch water, and for that reason they are unable to go to school or participate in community life.

Due to lack of drinking water and basic sanitation hundreds of people fall ill and die daily because of drinking contaminated water. Also, because little food is produced since the harvests are entirely dependent on rainfall and livestock die from diseases related to poor water quality. This situation is also the cause of a serious social problem, particularly in rural areas.

There is 34 km water pipeline from Gonde that brings spring water to water kiosks located in Tero Moye, Anole and Tero Desta (Figure 14.2). There is insufficient water in these kebeles, particularly in Tero Moye /Tulu Moye, for the increasing population. One of the two springs in Gonde has dried up and the other is gradually drying up resulting in loss of pressure in the pipeline. The water kiosks do not work most of the time. Particularly the water kiosk in the Tulu Moye area that remains mostly closed (dry). When the communities have no access to water for more than a month, it is considered “red alert” by the Iteya municipality, and water trucks provide essential life-line amidst the drought.

14.4.7 *Summary of Drilling area baseline*

Hydrology baseline of Drilling area

Annual rainfall is around 900 mm. Wet season is June to September with peaking rainfall in July and August. No rivers or lakes are within the Drilling area but the area is located mostly within the Awash river basin. The groundwater flows to NE. Water samples from within the Drilling area are not available but samples from wells to the south of the Drilling area indicate that the groundwater is influenced from geothermal activities. Drinking water may have to be transported to the Project area from elsewhere.

14.5 Impact assessment on water and hydrology

14.5.1 *Impact during construction phase*

The main potential impacts on water during construction phase are:

- Disruption of seasonal waterways/run offs due to structures that come with the Project or compaction of soils and vegetable clearance.
- Surface water pollution due to accidental spillage or poor water management and discharge of waste water/sewage on site.
- Water consumption of workers and construction competes with that of locals.
- Discharge of drilling fluids and/or geothermal fluid from testing of wells pollutes surface and/or ground water.

Care will be taken to adjust design and landscaping as to minimize the disruption of seasonal waterflow.

Cooling water for drilling will be obtained from boreholes south of the Drilling area (Figure 14.2) and will not compete with drinking water of locals as there are no drinking water sources in that area. Drinking water for the Project will be obtained from sources that comply with drinking water standars. RG recognizes that water is scarce in the area and care will be taken as to use water in a sustainable and responsible way and in accordance with standards and guidelines. The IFC EHS guidelines 1.4 Water Conservation include water monitoring and management and setting of targets for water use. They also address process water reuse and recycling and possible interventions for building facility operations, cooling and heating systems.

Drilling of geothermal holes and testing of wells entails the discharge of geothermal effluent. It contains dissolved minerals of which concentration can be considerably higher than in water at lower temperatures. To minimize the risk of water pollution, the Project owner will adhere to the Environmental, Health, and Safety Guidelines for Thermal Power Plants developed by the World Bank are shown in Table 15.2. Geothermal effluent from well testing and drilling will be directed to infiltration ponds and/or shallow wells that will be installed close to the drill sites. The fluid is led through a basin where most of the drill cuttings and other sediment will settle.

The waste fluid can be disposed of in shallow wells, through open fissures or disposed of in /through some other authorized way or designated sites. Groundwater levels in the Project area are approximately 100-180 m below the surface. Although drilling and well testing are temporary measures, these operations yield fluid with substances. Unless groundwater level is close to the surface, disposing of geothermal fluid through the ground is usually harmless, as the fluid will filtrate trough numerous earth/lava layers before possibly reaching groundwater. This method of disposing of geothermal fluind in moderation is practised in geothermal operations. Once there are several wells, then injection or reinjection is implemented. The IFC Environmental, Health and Safety Guidelines for geothermal power generation, effluent monitoring guidelines recognize that effluents should meet site-specific discharge levels for surface water as discussed in the General EHS Guidelines (Table 15.2 and Table 15.3).

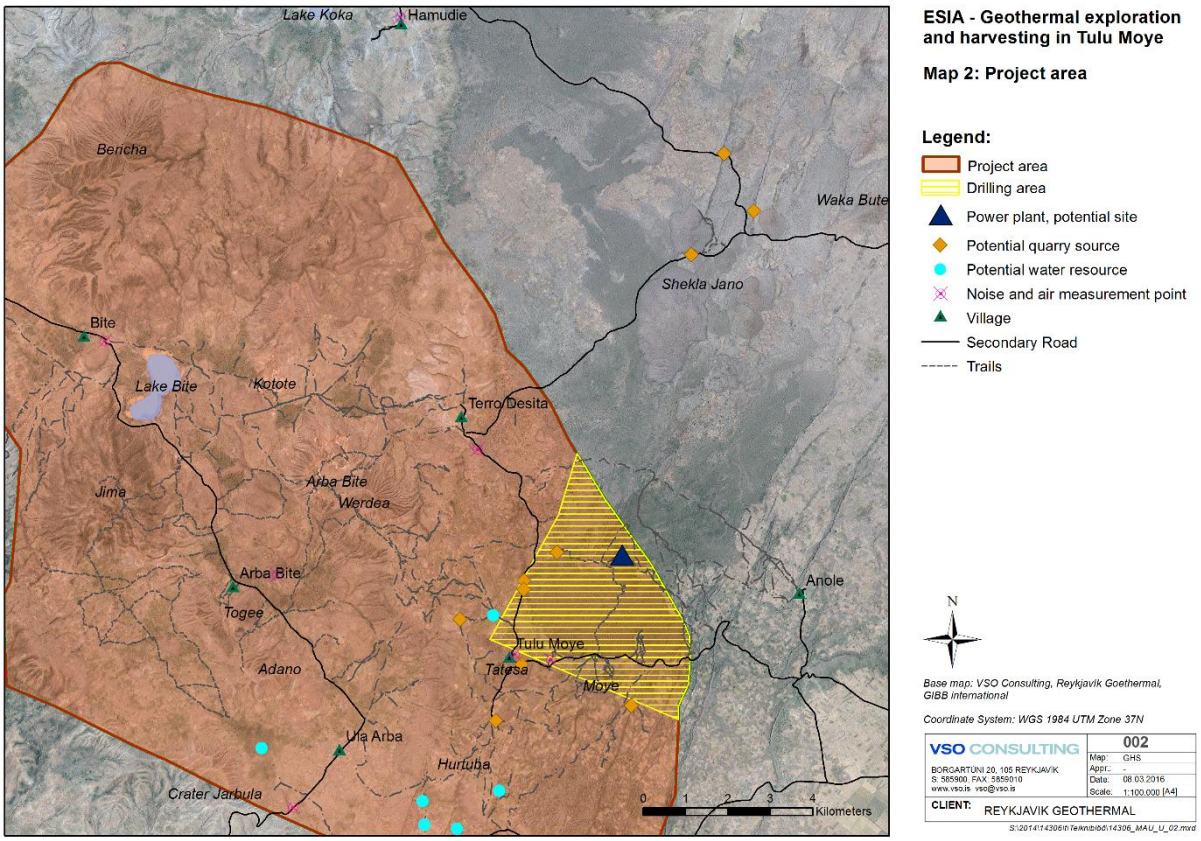


Figure 14.4 **Potential water resources in the Project area.**

14.5.2 *Impacts during operational phase*

The main potential impact on water during construction phase is similar to those during construction phase:

- Disruption of seasonal waterways/run offs due to structures that come with the project or compaction of soils and vegetable clearance.
- Surface water pollution due to accidental spillage or poor water management and discharge of waste water/sewage on site.
- Water consumption competes with that of locals.
- Discharge of geothermal fluid from power plant pollutes surface and/or ground water.

For discussion of impacts see chapter 14.5.1.

During operation geothermal fluid will be injected into the ground, below ground water as to avoid ground water pollution.

Environmental and Social Management System will be implemented. Emphasis will be put upon good household standards in order to avoid accidental spillages. Wastewater and sewage will be treated according to law and regulation and not disposed of untreated to waterbodies or groundwater.

14.5.3 *Impacts in decommissioning phase*

The main potential impacts on water during decommissioning phase are:

- Surface water pollution due to accidental spillage from machineries.
- Water pollution due to remaining chemicals after closing of power plant.

Good site management can prevent pollution from machineries. In order to minimize pollution risk from abandonded power plant it is possible to require that all chemicals be

removed before abandonment or that the decommissioning party is carefully informed of the location of possible chemicals and their hazards before starting of decommissioning. Carefully prepared dismantling of the power plant and proper handling of waste is vital in preventing water pollution.

14.6 Data limitation and uncertainty

Data on the quality of ground water in the Project area and especially in the Drilling area is sparse. Existing data however indicates that ground water in the area is affected by gothermal activity.

Data on microbiological characteristics of surface- and groundwater is not available.

14.7 Summary

14.7.1 Impacts during construction phase

Table 14.3 Construction phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Building of well pads and roads	Compacting of ground and clearing of site leads to flooding of farmland or surface water becomes polluted after flooding.	Major	Adjust design and landscaping to minimize the disruption of seasonal waterflow.	Minor
Well testing	Geothermal effluent causes surface water pollution.	Major	Effluent is directed to infiltration ponds and not released untreated into the environment.	Insignificant
	Geothermal effluent causes groundwater pollution.	Major	Bedrock layers filtrate substances from effluent before reaching groundwater.	Insignificant
	Spillages or overflow cause water pollution.	Moderate	Infiltration ponds and basins will be monitoried for effluent level.	Insignificant
Cooling water and drinking water harvesting	Obtainable water for locals will diminish due to the water use of the project.	Major	Different water sources will be used than that of the locals.	Insignificant
			Water monitoring and management, setting of targets for water use according to IFC EHS guidelines 1.4	Insignificant
Disposal of sewage	Surface water polluted due to sewage disposal from work camps.	Major	Adhere to IFC and local standards.	

14.7.2 *Impacts during operation phase*

Table 14.4 Operation phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Geothermal effluent discharge	Pollution of surface or ground water.	Major	Effluent is injected into bedrock, below groundwater.	Insignificant
Spillage of oil or other chemicals	Pollution of surface or ground water.	Moderate	Establish good householding practices.	Insignificant
		Moderate	Establish Environmental and Social Management System.	Insignificant

14.7.3 *Impacts during decommissioning phase*

Table 14.5 Decommissioning phase: Summary of potential impacts and residual significance after taking mitigation measures into account

Action	Impact	Significance	Mitigation measure	Residual significance
Earth works and construction	Disposal of waste water or chemical spillage to surface pollutes surface water	Moderate	Good site management plan.	Insignificant

14.8 Conclusion

Impact on water and hydrology is likely to be insignificant to minor. Care will be taken to adjust design and landscaping as to minimize the disruption of seasonal waterflow. Geothermal fluid will be directed to infiltration ponds during construction and then injected to the bedrock below groundwater during operation phase. Ground water is already geothermal influenced but it is not likely that the Project will add to that influence. Different water sources will be used than that of the locals and thus the Project will not have impact on drinking water availability of the local community.

15 Waste

15.1 Introduction

This chapter aims to describe the main types of waste generated by the Project during construction, operation and decommissioning. Likely impacts of waste on the environment is predicted and legal requirements and those of international standards identified. Impact assessment was done by VSO Consulting and RG.

15.2 Affected areas

The impact of waste on the environment is on one local if disposed of within the Drilling area and on the other hand within Project area and vicinity depending on where the waste will be transported to.

15.3 Legislative framework

15.3.1 National

- Solid waste management proclamation no. 513/2007
- Standards for industrial effluents (EPA)
- Environmental pollution control proclamation no. 300/2002
- Ethiopian water resources management Council of Ministers regulations no. 115/2005
- Public health proclamation no. 810/2013
- Ethiopian water resources managment policy

15.3.2 International

- World Bank Environmental, Health and Safety guidelines, on limits for wastewater
- IFC Environmental, Health and Safety general guidelines,
  - 1.3 Wastewater and ambient water quality
  - 1.6 Waste management
- IFC Environmental, Health and Safety Guidelines for geothermal power generation
- IFC PS 3: Resource Efficiency and Pollution Prevention

15.4 Baseline description

Information on waste handling in the Project area was not gathered as part of the baseline studies. As the Drilling area is placed in rural environment it is surmised that waste generation in the area is rather low. Information below is based on similar projects.

15.5 Impact assessment

15.5.1 Impacts during construction phase

Main waste generation during construction phase will be excavation materials, concrete mix and concrete washings, iron and steel scrap, drilling mud, timber, paper and cardboard and household waste. Some hazardous wastes will be generated from the construction. Geothermal fluid from well testing can be considered as waste.

The waste which will be generated from the construction of the Project will be handled according to national and international laws, regulations and standards. A waste management plan will be put in place as to minimize the adverse impacts the waste can have on the environment. Emphasis will be placed on reducing waste, reuse and recycle, in that order. Environmental impacts can entail groundwater and soil pollution and other contamination. Discarded waste can be blown around the vicinity and cause harm to wildlife and have adverse visual impacts.

Table 15.1 Overview of likely main waste stream during construction phase

Waste	Potential Impact	Management
Excavation material	Dust generation	Reuse on site if possible e.g. as sound barrier or disposal at landfills.
Drilling mud and cuttings	Visual impact	Directed to infiltration ponds. Sediment is disposed of in a approved landfill.
Concrete mix and washings	Dust generation, visual impact	Wash water directed to infiltration ponds, concrete solids disposed of in landfills.
Scrap metal	Visual impact, hazard for locals and wildlife.	Segregate for recycling.
Timber and wood based waste	Visual impact.	Segretated for recycling. Reused if possible.
Paper and cardboard	Visual impact, waste is easily blown away.	Reuse and recycle.
Household waste	Visual impact, odour, pest.	Collected in closed containers and transported to appropriate disposal site.
Waste from hygiene facilities	Ground and soil pollution, desease distribution.	Sewage treated according to standards as not to create risk of pollution.
Hazardous waste (oils, lubricants, batteries, chemicals, tyres)	Contamination of receiving environment.	Segretated as appropriate and stored in closed containers. Collected by licenced party to dispose of in a safe manner.
Geothermal fluid from well testing	Groundwater and soil contamination. Visual impact from silica deposits.	Directed to infiltration ponds which will be covered with earth after use.

Table 15.2 International limit values for liquid effluents from thermal power plants

Parameter	Limit Values World Bank [mg/l][1]
pH	6-9 pH-units
Total suspended Solids	50
Oil & Grease	10
Copper (Cu)	0.5
Chromium (Cr)	0.5
Iron (Fe)	1.0
Zinc (Zn)	1.0
Temperature increase[2]	Less than or equal to 30 °C

[1]Maximum value for effluents from thermal power plants (Pollution Prevention and Abatement Handbook, July 1998) [2]The effluent should result in a temperature of no more than 30° C at the edge of the Zone where initial mixing and dilution takes place. Use 10 m as the minimum limit from the point of discharge to the nearby water point.

Table 15.3 IFC indicative values for treated sanitary sewage discharges

Pollutant	Units	Guideline value
PH	pH	6-9
BOD	Mg/l	30
COD	Mg/l	125
Total nitrogen	Mg/l	10
Total phosphorus	Mg/l	2
Oil and grease	Mg/l	10
Total suspended solids	Mg/l	50
Total coli form bacteria	MPN/100 ml	400

15.5.2 *Impacts during operational phase*

Waste generated during operational phase is considerably less than of the construction phase. Waste is mainly generated form maintenance, personnel and from the spent geothermal fluid which will be injected into the bedrock.

Table 15.4 Overview of likely main waste stream during operation phase

Waste	Potential Impact	Management
Scrap metal from maintenance	Visual impact, hazard for locals and wildlife.	Segregate for recycling.
Timber and wood based waste	Visual impact.	Segretated for recycling. Reused if possible.
Paper and cardboard	Visual impact, waste is easily blown away.	Reuse and recycle.
Household waste	Visual impact, odour, pest.	Collected in closed containers and transported to appropriate disposal site.
Waste from hygiene facilities	Ground and soil pollution, desease distribution.	Sewage treated according to standards as not to create risk of pollution.
Hazardous waste (oils, lubricants, batteries, chemicals, tyres)	Contamination of receiving environment.	Segretated as appropriate and stored in closed containers. Collected by licenced party to dispose of in a safe manner.
Geothermal effluent	Groundwater and soil contamination. Visual impact from silica deposits.	Effluent injected into the bedrock below groundwater level.

15.5.3 *Impacts during decommissioning phase*

Decommissioning of the Project entails removal of all structures and facilities and closing of wells. This would generate a considerable amount and variety of waste. A specific waste mangement plan for decommissioning would have to be put in place, ensuring that among other, hazardous waste is identified and disposed of in a proper manner. Emphases should be placed on recovering, reusing and recycling of waste.

15.6 Data limitations and uncertainty

Information on waste handling in the Project area was not gathered as part of the baseline studies and present discussion is based on experience from similar projects.

Depending on the hazardous waste the disposal places vary. Reykjavik Geothermal has ascertained that recyclable waste like used batteries, used oil, ink cartridges, scrap iron and steel, etc. can be transferred to recycling facilities in the nearby town, which in present case is Nazareth (Adama City) or Assela.

The best way to do deal with hazardous chemicals is through outside contractor, for example TS Environment who is a company that work in the management of environment and waste. In this case RG will require the contractor to provide proof that the disposal of hazardous wastes has been delivered to an accredited facility.

For other like medical waste, obsolete electronics etc. incinerator can be used which TS Environmental can provide. Sewage waste can be handled by Nazareth /Adama municipality. Assela that is closer might also have such facility.

15.7 Conclusion

If not handled properly, waste can have adverse impact on the environment, causing contamination, visual impact and causing hazard to locals and wildlife. A waste management plan will be put in place where emphasis will be placed on reducing, reusing and recycling therefore impact of waste on the environment is likely to be minor.

16 Environment, Health and Safety (EHS)

16.1 Introduction

This chapter discusses the main apsects of health and safety with regard to construction and operation of the Project. The chapter is based on IFC Environmental, Health and Safety guidelines, chapter 2.0 (International Finance Corporation, 2007), IFC Environmental, Health and Safety Guidelines for Geothermal Power Generation (International Finance Corporation, 2007) and with the following impact assessment questions in mind.

Impact assessment questions according to scoping document

Hazards and risk

- Are there any environmental hazards that threaten the development?

- Can local hazard management or shelter structures be impacted by the development? Sandstorms, desertification?

16.2 Affected areas

The Project can have adverse impacts on EHS on workers, locals and guests at the Drilling site. The affected area is defined by the drilling area.

16.3 Legislative framework

16.3.1 National

- Environmental Pollution Control Proclamation No. 300/2002
- Public Health Proclamation No. 200/2000
- Prevention of Industrial Pollution Council of Ministries Regulation No.159/2008
- Labour Proclamation No. 377/2003
- Environmental Standards for Industrial Pollution Control

16.3.2 International

- Standards of the International Labour Organisation
- IFC Performance Standard 2: Labour and Working Conditions.
- IFC Performance Standard 4: Community Health, Safety, and Security.
- IFC Environmental, Health and Safety General Guidelines
- IFC Environmental, Health, and Safety Guidelines for Geothermal Power
- Generation

The IFC Environmental, Health and Safety Guidelines for geothermal power generation, occupational health and safety guidelines require occupational health and safety performance of geothermal project to be evaluated against internationally published exposure guidelines. Examples of these include: the Threshold Limit Value (TLV) occupational exposure guidelines and Biological Exposure Indices (BEIs) published by American Conference of Governmental Industrial Hygienists (ACGIH), the Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational safety and health (NIOSH), Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA), Indicative Occupational Exposure Limit Values, published by European Union member states, or other similar sources.

The emission of H_2S gas from the Project can cause hazard to workers. A review of the various international guidelines for hydrogen sulphide (H_2S), for both general community

health and occupational exposure relevant to the project is summarized in table below. The WHO limits are recommended for the Tulu Moye project's community health and odour assessment while ACGIH guidelines are recommended for occupational exposure

Table 16.1).

Table 16.1 Summary of recommended limits of H2S by various international organizations.

Effect	Concentration (µg/m3)	Concentration (ppm)	Averaging period
Occupational	1500 (ACGIH)	1	8 hour
Community health	150 (WHO)	0.1	24 hour
	50 (Iceland)	0.03	24 hour
	10 (OEHHA*)	0.007	annual
Community odour	7 (WHO)	0.005	30 min
	70 (New Zealand)	0.05	1 hour

*Office of Environmental Health Hazard Assessment Agency, under California Environmental Protection Agency

16.4 Potential EHS hazards of the project

The EHS hazards related to the project can be divided into few components:

- General hazard related to construction work
- Occupational hazard related to the operation of the Project
- Hazard that is specific to geothermal projects, both during construction and operation.

The hazards of construction work and operation are much the same although at a different scale since a construction site is busier than a powerplant in operation.

RG and its contractors are obliged to implement all reasonable precautions to protect the health and safety of workers. Risk assessment will be carried out prior to the commencement of the project as to analyse potential risk. Based on the analyse Preventative and protective measures will be introduced according to the following order of priority (see further IFC guidelines) (International Finance Corporation, 2007):

- Eliminate the hazard
- Control the hazard
- Minimize the hazard
- Provide appropriate personal protective equipment

An EHS management plan will be put in place, and a part of that will be monitoring of occupational accidents and diseases, dangerous occurrences and incidents.

There are no known environmental hazards that threaten the Project and the Project does not have impact on existent hazard management or shelter structures.

16.4.1 General hazard related to construction work, power plant operation and decommissioning

Construction work is of the nature that it can pose hazard for the personnel and others on site. The main hazards of the work are identified in Table 16.2, the table is not exhaustive and does not take the place of a thourough risk assessment. The hazards of construction work, operation and decommissioning are much the same. In order to minimize risk an EHS management plan and Emergency Response Plan will be put in place.

Table 16.2 Overview of hazards related to construction work, power plant operation and decommissioning. The table does not replace a thorough risk assessment.

Hazards	Consequences	Measures
Rotating and moving equipment	Injury or death from being trapped, entangled or struck by machinery	Eliminate hazard by design. Installation of EHS regulation on site.
Noise	Hearing loss	Adhere to noise limits, provide PPE.
Vibration	Nuisance and possible health effects	Adhere to exposure limits
Electricity	Injury or death from electrocution	Signage, information, inspection of electrical devices
Eye hazard	Solid particles or liquid chemical strike worker in eye, causing injury or blindness	Use machine guards, splash shields, safety goggles. Installation of EHS regulation on site.
Welding/hot work	Bright and intense light that can injur workers eyesight	Provide proper eye protection. Standard operating procedures.
Site Traffic	Risk of accidents due to poor skills or vehicular and pedestrian traffic	Training and licencing. Define traffic routes, rights of way and other rules at site.
Working environment temperature	Exposure to hot or cold conditions can result in temperature stress related injury	Monitor conditions and put in place a contingency plan
Working at heights	Injury or death due to fall from heights or a falling object from heights	Fall prevention equipment and measures for work over 2 m
Chemical hazards	Potential illness or injury due to exposure	Replace hazardous substances with less hazardous ones. Provide material safety data sheets and PPE, information and training.
Air quality	Respiratory irriation, discomfort, illness	Implement work practices to minimize air pollution. Provide ventilation and PPE
Fire and explosions	Loss of property, injury or fatalities of project workers	EHS regulation, proper storage of flammables. Work procedures.
Confined spaces	Loss of consciousness, fatality	Identify confined spaces, measure oxygen level, work procedures, contingency plan.

16.4.2 Hazards specific to geothermal projects

Hazards related to work in geothermal projects are mostly related to the fluid and steam of extreme temperatures and the emission of geothermal gases, especially H_2S.

Table 16.3 Overview of hazards specific to geothermal projects. The table does not replace a thorough risk assessment.

Hazards	Consequences	Measures
Geothermal gases	Impact on health or fatality due to H_2S release.	Gas monitoring and warning system, contingency plan, ventilation. EHS Management Plan & Emergency Response Plan /Procedure
Heat	Potential blowout accidents, burn injuries or fatalaties when maintaining hot pipes, wells. Heat related stress.	Reduce time required for work in hot environments, shield surfaces, PPE, safety procedures. Provide plenty drinking water.

16.4.3 Public health and safety issues to consider

Health and safety issues related to the public that will have to be considered are suggested in following table.

Table 16.4 Overview of public health and safety issues.

Hazards	Consequences	Measures
Accidents, injuries	Risk of public accidents and injuries if they get into the working zone	Preventative safety measures in place for residents and visitors such as fencing and signs. Possibly security personnel
Increased noise	Risk of increased noise due to earth work, construction, drilling and testing	Implement sound barriers between source of noise and settlement. These can be purchased as tailored shields put on fences in place
Increased traffic	Risk of accidents due to poor skills or vehicular and pedestrian traffic	Training and licencing. Define traffic routes, rights of way and other rules at site. Put up signs and limit speed
Influx of workers	Influx of woarkers may result in conflicts and increase of diseases	Implement Recruitment Policy. Avoid gender and religion bias. HIV /AIDS Policy and Engagement Plan.

16.5 Conclusion

The construction, operation and decommissioning of the project poses some hazards. The hazards will be met with preventative or mitigative measures as to minimize the risk of accidents. A thorough risk assessment will be conducted for the work and from that a set of EHS rules and management plan for the site will be established. RG recognizes the importance for workers' health and safety and will comply with national and international legislation and standards to ensure the safekeeping of the workers.

17 Figure reference

Hippopotamus (Hippopotamus amphibius) [Photograph]. (2016). Retrieved from http://www.nationalparks-worldwide.info/eaf/ethiopia/national-parks/south-west/hippopotamus-guinea-bissau_small.jpg

Klipspringer (*Oreotragus oreotragus*) [Photograph]. (2016). Retrived from http://www.biodiversityexplorer.org/mammals/ruminantia/images/4474684028_658w.jpg

Oribi (*Ourebia ourebi*) [Photograph]. (2016). http://www.yourafricansafari.com/Articles/shrinking-savanna-grasslands-threatens-life-for-the-oribi-gazelle

Grivet monkey (*Chlorocebus aethiops*) [Photograph]. (2016). http://mammalwatching.com/Afrotropical/Images/Ethiopia/Grivet%20Monkey.jpg

Aardvark (Orycteropus afer) [Photograph]. (2016). http://yourshot.nationalgeographic.com/u/ss/fQYSUbVfts-T7pS2VP2wnKyN8wxywmXtY0-FwsgxoQzSg8SoIDcXZfpIzPmDl_b8GGugcnxq4s3o7JIsr95h/

Shoebill (Balaeniceps rex) [Photograph]. (2016). https://ethiobirds.smugmug.com/1BirdsofEthiopiaVgelthiopiens/Shoebill-Schuhschnabel-1/i-ZBFJ7WC/0/M/DSC_1770as-M.jpg

18 Bibliography

A., T. (2005). *Major ions composition of the groundwater and surface water systems and their geological and geochemical controls in the Ethiopian volcanic terrain.*

Austurbrú. (2016, March 13). *Losun gróðuhúsalofttegunda með því minnsta sem þekkist*. Retrieved from Sjálfbærniverkefnið á Austurlandi: http://www.sjalfbaerni.is/austurlandsverkefnid/ahugaverdar-nidurstodur/nr/424

EEPCO, G. &. (2005). Geothermal Exploration and Development in Ethiopia. *Proceedings World Geothermal Congress* , 1-9.

Efla. (2009). *IDC HH220 Noise Mapping.* Reykjavik: Efla.

Efla. (2014). *Havadadreifing fra borholu, minnisblad, unnið fyrir HS Orku.* Reykjanesbaer: HS Orka.

EPA. (2003). Environmental Impact Assessment Procedural Guidelines Series 1. EPA.

Eysteinsson, H., Jonsson, S. B., & Tekka, A. H. (2015). *Resisitivity study of the Tulu Moye Geothermal Prospect, Ethiopia. Resisitivity exploration.* Reykjavik: RG.

FDRE. (1994). Mining Operations Council of Ministers Regulation No. 182/1994. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2000). Ethiopian Water Resources Management Proclamation No. 197/2000. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2000). Public Health Proclamation No. 200/2000. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2000). Research and Conservation of Cultural Heritage Proclamation No. 209/2000. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2002). Environmental Pollution Control Proclamation No. 300/2002. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2002). Environmental Protection Organs Establishment Proclamation No. 295/2002. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2002). Investment Proclamation No. 280/2002. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2003). Labour Proclamation No. 377/2003. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2005). Ethiopian Water Resources Management Council of Ministers Regulation No. 115/2005. *Federal Negarit Gazeta* . Addis Ababa.

FDRE. (2007). Payment of Compensation for Property Situated on Landholdings Expropriated for Public Purposes Council of Ministers Regulation No. 135/2007. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2007). Solid Waste Management Proclamation No. 513/2007. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2009). Prevention of Industrial Pollution Council of Ministries Regulation No. 159/2008. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2010). Mining Operations Proclamation No. 678/2010. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2011). Ethiopia's Climate Resilient Green Economy Strategy.

FDRE. (2013). Ethiopian Electric Power Establishment Council of Ministers Regulation No. 313/2013. *Federal Negarit Gazeta*. Addis Ababa.

FDRE. (2013, February). Ethiopian National Energy Policy (Draft) . Addis Ababa: Ministry of Water and Energy.

FDRE. (n.d.). Public Ownership of Rural Lands Proclamation No. 31/1975. *Federal Negarit Gazeta*. Addis Ababa: FDRE.

Fridriksson, T., & Giroud, N. (2007). *The Reykjanes geothermal gas: cencentrations and emissions.* Reykjavik: ISOR.

GIBB International. (2015). *Environmental and Social Baseline Studies, Stakholders (community) Engagement Plan and Resettlement Policy Framework.* Reykjavik: Reykjavik Geothermal.

International Finance Corporation. (2007, April 30). Environmental, Health and Safety (EHS) Guidelines. IFC World Bank Group.

International Finance Corporation. (2007, April 30). Environmental, Health and Safety Guidelines for Geothermal Power Generation. International Finance Corporation and World Bank Group.

Jackson, A. R., & Jackson, J. M. (2000). *Environmental Science. The Natural Environment and Human Impact.* Essex: Prentice Hall.

Kötter Consulting Engineers. (2008). *Schalltechnischer bericht nr. 208170-01.01 über die prognostizierte Geräuschsituation eines Standard „Euro-Rig“ während des Bohrbetriebes.*

Mamo, T., Gudbrandsson, S., & Gislason, G. (2015). *Tulu Moye Geothermal Prospect. Surface Exploration: Geology report.* Reykjavik: RG.

Mannvit. (2010). *Þeistareykjavirkjun Allt að 200 MWe jarðhitavirkjun í Þingeyjarsveit og Norðurþingi.* Reykjavik: Landsvirkjun.

Ministry for the Environment and Natural Resources. (2015, December 12). *Parísarsamkomulagið í höfn*. Retrieved February 20, 2016, from Umhverfis- og auðlindaráðuneytið: https://www.umhverfisraduneyti.is/frettir/parisarsamkomulagid-i-hofn

Ministry of Finance and Economic Development. (2010). Growth and Transformation Plan 2010/2011-2014/2015.

Mott MacDonald & Green and Clean solutions. (2013). *Karisimbi Geothermal Exploration Drilling Project. Volume II - ESIA.*

ONRS. (2007). Proclamation No. 130/2007 to amend the proclamation No. 56/2002, 70/2003, 103/2005 of Oromia Land Use and Administration.

RWDI. (2009). *H2S Dispersion Modeling for an Un-ignited Uncontrolled Release. Masdar City Geothermal Project. Project number #0940338.* Abu Dhabi.

Scientists, U. o. (2016, April 27). Retrieved from www.ucsusa.org: http://www.ucsusa.org/clean_energy/our-energy-choices/renewable-energy/how-geothermal-energy-works.html#.VyOXRvmLT0M

Sigurbjorn Jonsson. (2015). *Remote Sensins in Tulu Moye.* Reykjavik: RG.

Smithsonian Institution. (2016, April 12). *Global Volcanism Program*. Retrieved from Smithsonian Institution National Museum of Natural History: http://volcano.si.edu/volcano.cfm?vn=221250

United Nations. (1979). The Convention on the Elimination of All Forms of Discrimination agians Women. United Nations.

United Nations. (1989, November 20). *Convention on the Rights of the Child*. Retrieved from Untied Nations Human Rights Office of the High Commissioner: http://www.ohchr.org/en/professionalinterest/pages/crc.aspx

United Nations. (2016, April 15). *United Nations Millenium Goals*. Retrieved from United Nations: http://www.un.org/millenniumgoals/bkgd.shtml

USAID Ethiopia. (2016, March). Water. *Fact sheet*. USAID Ethiopia.

VSO Consulting and Reykjavik Energy. (2008). *Hverahlidarvirkjun. Allt ad 90 MWe jardvarmavirkjun. Matsskyrsla.* Reykjavik: Reykjavik Energy.

Walta Information Center. (2011). *Electrification in Ethiopia is boosting development*. Retrieved from http://www.waltainfo.com/index.php?option=com_content&task=view&id=25858&Itemid=47 .

WHO. (2005). *Air Quality Guidelines. Global update 2005.* Copenhagen: WHO Regional Office for Europe.

Wikipedia. (2016, March 14). *Silvopasture*. Retrieved from Wikipedia The Free Encyclopedia: ttps://en.wikipedia.org/wiki/Silvopasture

World Nuclear. (2011). *WNA Report Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources.* London: World Nuclear Assocation.

19 Maps