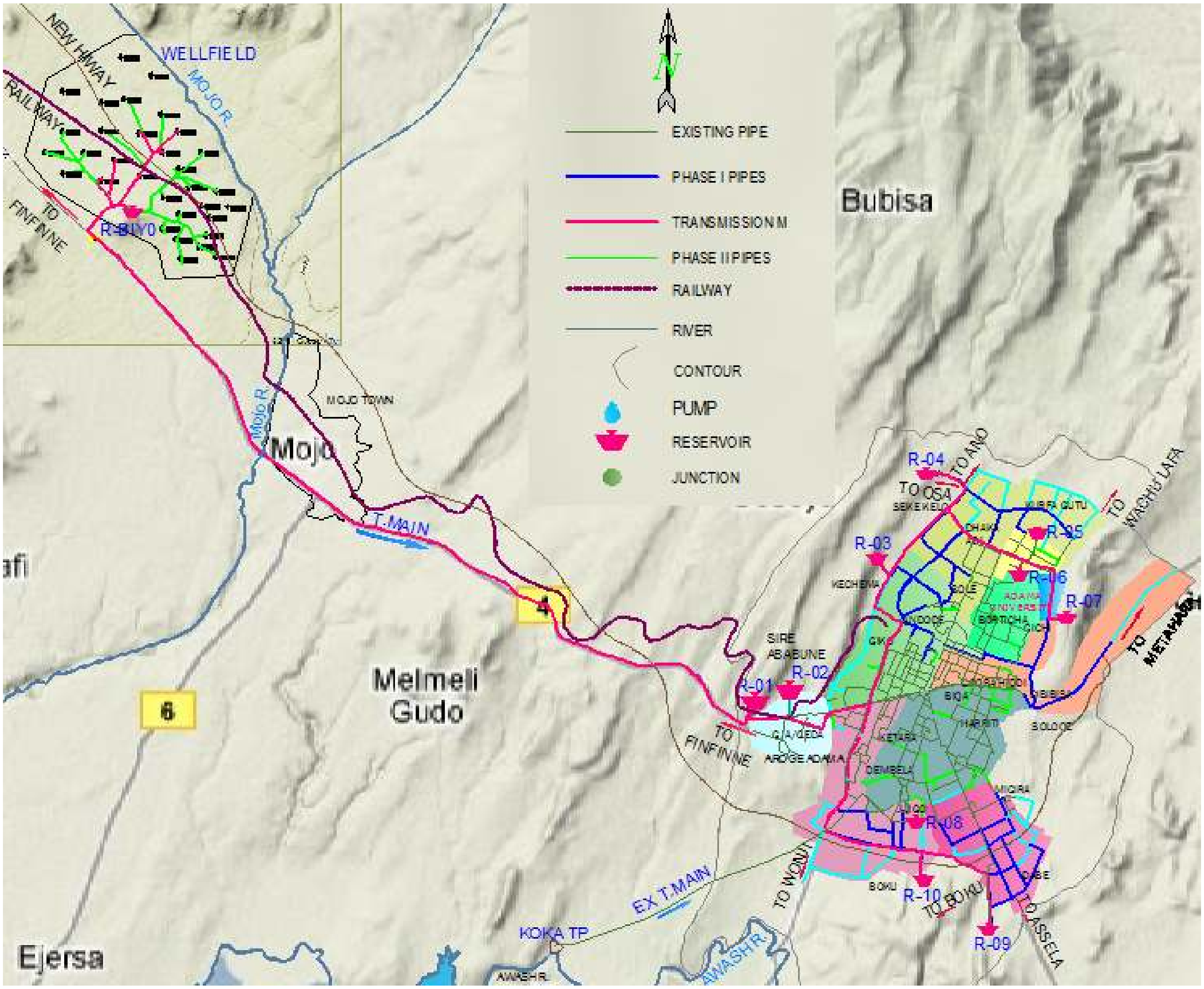
ADAMA TOWN WSSS ENTERPRISE



VOLUME V

DRAFT DETAIL DESIGN REPORT

JULY 2012

OROMIA WATER WORKS DESIGN & SUPERVISION ENTERPRISE

Oromia Water Works Design & Supervision Enterprise

IN ASSOCIATION WITH

GG WATER WORKS CONSULTANT

FINFINNE, ETHIOPIA

FEASIBILITY STUDY AND DETAIL DESIGN OF ADAMA TOWN WATER SUPPLY PROJECT

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CHAPTER 1 INTRODUCTION

1.1 GENERAL

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- CHAPTER 2 SOCIAL AND ECONOMIC CONDITIONS
- CHAPTER 3 DESIGN CRITERIA AND PROCEDURES
- CHAPTER 4 POPULATION AND WATER DEMAND

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VOLUME – V DETAIL DESIGN AND TENDER DOCUMENTS (THIS REPORT)

This **Detail Design Report of Adama Town Water Supply Project** has been prepared in response to the contract to carryout Feasibility Study and Detail design of Adama Town Water Supply Project. It has been prepared following the data collection and analysis listed below:

1. Studying of Socio-Economic conditions
2. Studying and setting of the design criteria

3. Studying the present and future Population growth and water demand requirements
4. Studying and Evaluation of the Existing water supply System
5. Hydrological and Hydrogeological Study
6. Environmental impact Assessment
7. Feasibility Study and Preliminary Design
8. Surveying Work of the New Transmission Main
9. Geotechnical Investigation

This report encompasses the preliminary design of water supply system components that could assist the client for decision making on implementation of the project. It has been divided into 6 chapters as listed below.

- CHAPTER 1 INTRODUCTION
- CHAPTER 2 WATER SOURCE DEVELOPMENT AND PROTECTION
- CHAPTER 3 WATER COLLECTION AND TRANSMISSION SYSTEM
- CHAPTER 4 WATER STORAGE AND DISTRIBUTION SYSTEM
- CHAPTER 5 AUXILIARY BUILDINGS AND MISCELLANEOUS WORKS
- CHAPTER 6 ENGINEERING COST ESTIMATE
- ANNEX-A HYDRAULIC ANALYSIS RESULTS

1.2 OBJECTIVE

The objective of the assignment has two major Components:

- To evaluate the existing water supply system and propose improvement measures
- To conduct the Feasibility Study and Detail Design of Adama Town Water Supply Project and produce conceptual planning and detailed design report that could assist the Client to determine the most suitable and practicable methods of sustainable water supply development.

The development objective of the project is to provide safe, adequate and sustainable water supply service to the population of the town up to the end of design period.

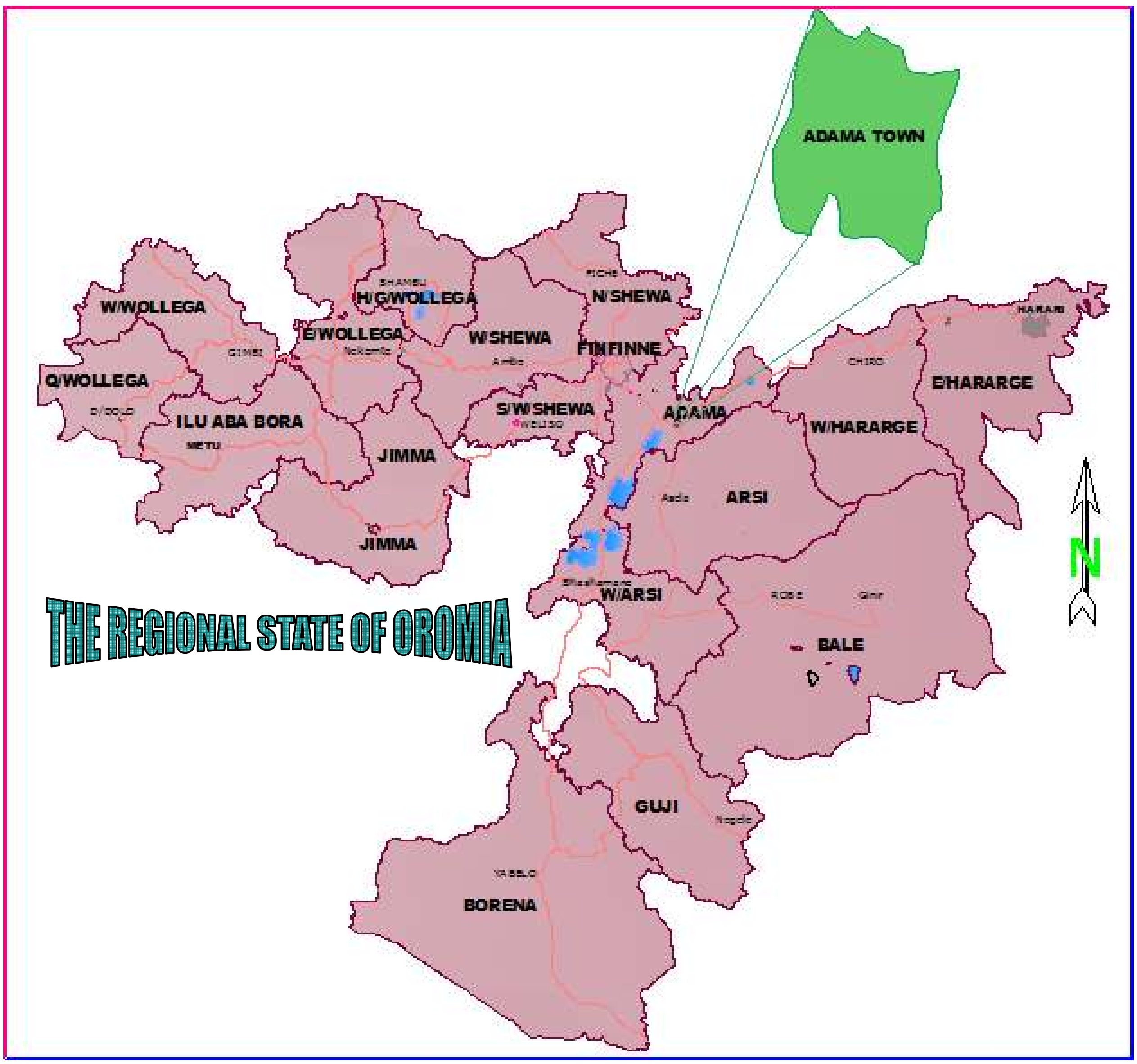
1.3 BACKGROUND OF THE PROJECT

1.3.1 LOCATION AND ACCESSIBILITY

Adama town is located about 100 km South-East of Finfinne. It is situated in the Great Rift Valley on relatively flat lowland between two mountain ridges. The Geographical location of the town ranges from 8⁰27.5'N-8⁰35.7'N and 39⁰13.5'E-39⁰19'E (Figures 1.1).

The town is accessible by a good asphalt road from Finfinne. It is also accessible by asphalt and better gravel roads from West, East, North and South directions of the country because of its strategic setting at a junction of roads leading to those areas (Figure 1.1).

FIGURE 1.1 LOCATION MAP OF ADAMA TOWN

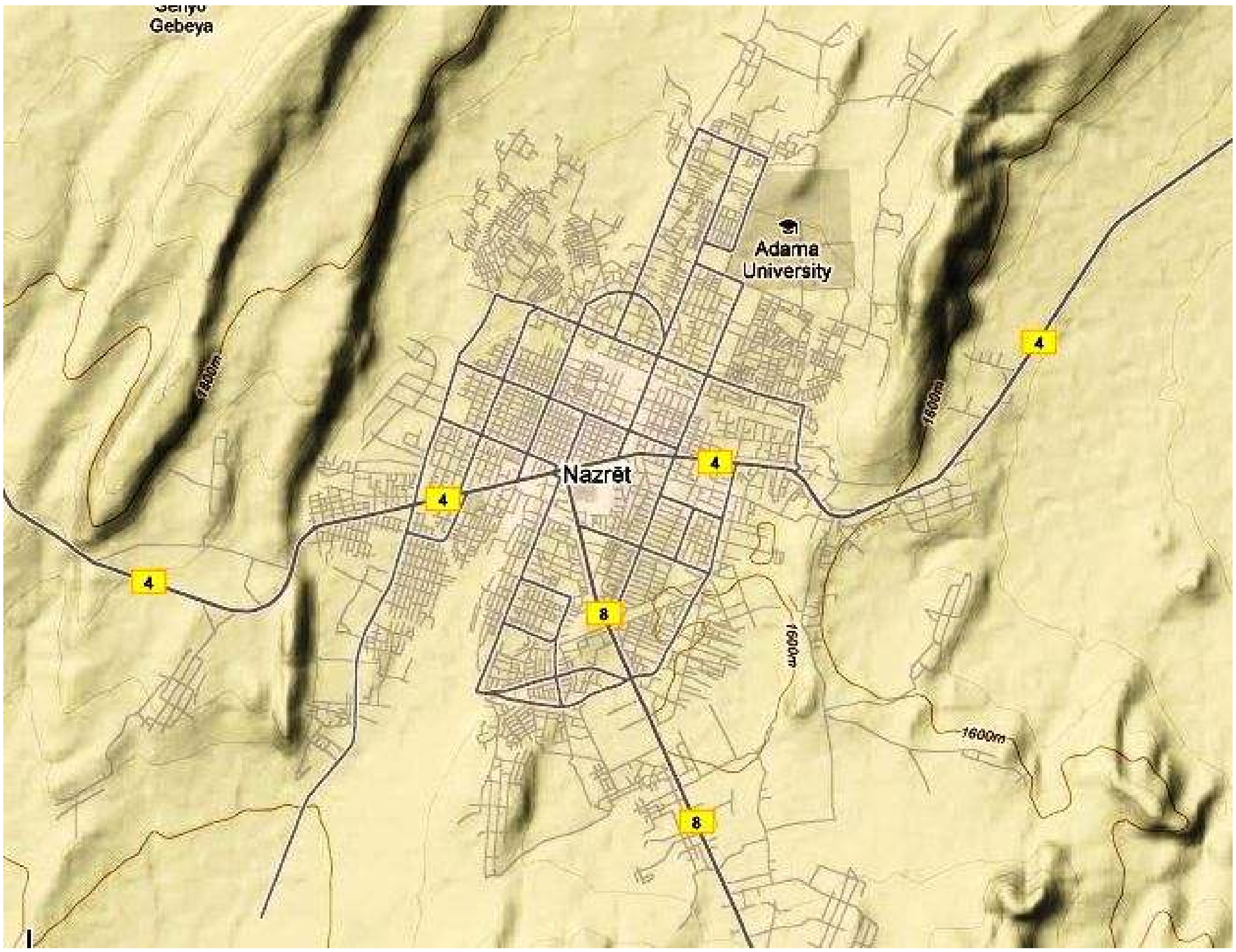


1.3.2 TOPOGRAPHY

Topography of Adama town varies from ground elevations of 1,595masl to 1,740masl. The southern central part of the town constitutes the lowest areas with ground elevation ranges from 1595masl to 1630masl.

Areas with higher altitudes are found from the central to the northern and on the southern verges of the town. The altitude of theses areas vary from 1630masl to 1740masl (Figure 1.2).

FIGURE 1.2 TOPOGRAPHY OF THE TOWN



1.3.3 CLIMATE

Adama town is located in the Grit Rift Valley of tropical climatic zone. There are four climatic seasons, Gena/Kremt, (rainy period) Bona/Bega, (dry period) Belg (small rains) and Meher (a spell between the long and small rains).

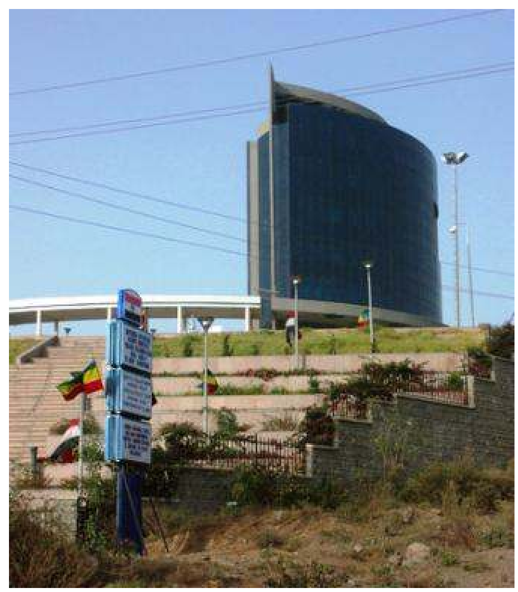
The daily temperature varies between 5.5^{0}C during November/December and 35^{0}C during March to May. The mean annual ambient temperature is between 19 ^{0}C and 22 ^{0}C. Maximum temperatures usually occur in March to May. The mean monthly maximum exceed 30 ^{0}C. Minimum temperatures are at their lowest in November.

The mean annual rainfall for the years 1995-1998 is 822.5 mm. The wettest months are July and August. The average amount of rainfall in July is 230 mm and in August 200 mm. The proportion of the precipitation in these two months is about 55% of the annual total.

1.3.4 DEVELOPMENT PROSPECTS

Adama town has been continuously growing in both social and economic aspects due to the following major factors.

1. The restructuring of the town by Regional Government to the higher level of special zonal administration.
2. Improved lifestyle of its population
3. Availability of improved town infrastructures and its close proximity to Finfinne.
4. Strategic location of the town on the highways connecting the eastern and southern part of the country; and the port of Djibouti with Finfinne has greatly contributed to its development.
5. The Finfinne-Djibuti railway passing through the town also enhances the growth.
6. The Wonji and Metehara sugar state farms and factories,



7. The Sodere resort area,
8. Favorable Environmental Conditions for living and investment

1.3.5 SOCIO-ECONOMY

9. Adama Town Population growth has been progressively increasing from time to time. The total population estimate of the towns at present is around **310,600** and expected to reach **730,000** by year 2035
10. Moreover, peri-urban dwellers around the four corners of the town have been merged to Adama town since it has been already restructured and established by the Regional Government to higher level of special zonal administration.

11. University, colleges, TVET and other lower educational institutes have been flourished There are around **189** Educational Institutions. The first and secondary level schools have over **70,000** students while colleges have more than **12,000** regular and evening students. Adama University alone among accommodates about **14,000** students

12. The number of health service institutions has been increasing over the past years. A total **105** Public and Private Health Institutions have been established so far.

13. There are **56** religious institutions of which 22 mosques 21 Orthodox churches and 13 evangelical churches are found in Adama. There are also about 13 categories of sporting entities organized under 47 different clubs are in the city. Four stadiums are found in Adama to entertain various sporting events.

14. Quite a lot of residential building put in place. There were **59,431** housing units in the city, according to population census of year 2007 (CSA, 2007).

15. Trade plays a significant role in the economy of Adama. There are **11,160** legal traders though the existences of considerable illegal traders are inevitable.

16. Industrial activities have been increased. Around **542** industrial establishments are found in the town. Around **685** ha of land or **15%** of the Master Plan have been reserved for industries.

17. Urban farms have started to be expanded in a large scale. Cattle fattening is a major practice in Adama town. Around **100,000** cattle are kept daily for fattening and milk production purposes.

18. The recently built historical buildings, specifically, Gelma Aba Geda and Memorial Monument are prospects for contributed a lot in attracting tourists and also a master plan which is fundamental for the present and future socio-economic development the same.

19. In general the town has all infrastructures such as modern communication network, Road Network, Electric power supply, Fuel supply and Water supply systems. It has also the latest and unique television broadcasting station, “TV-Oromia”, which is the second in the country.

1.3.6 EXISTING WATER SUPPLY

Adama town has a modern water supply system which is managed by Enterprise and Board of administration. The system was commissioned and inaugurated in November 2002.

The system was designed and implemented to cover the water demand of the town in two phases. As the 1st phase design of the system has almost being completed by the end of this year; implementation of the second phase of the project should be required.

The phase I design capacity of the system was around 300 l/s and designed to serve the population of Adama town only. However, now it is serving both Adama and Wonji towns with a population of **389,300** which is by far more than its capacity.

FIGURE 1.3 INAUGURATION OF WATER SUPPLY PROJECT, NOVEMBER 2002

As mentioned earlier the rapid economic development and radical population growth of the town coupled with the expansion of the system to Wonji which was not included in the initial design of the project have rapidly aggravated the water supply shortage in the town.

Currently, the quantity of raw water source being used from Awash River is around **285 l/s (24,624m^3/d**) where as the required will be **415 l/s (35,856m^3/d).** This amount covers only around **70%** of the water demand requirements and will be decline to **60%** by end of 2014.

Moreover, there is no alternative water source for emergency case; if supply fails from Awash River; water supply situation is becoming worst in the town due to lack emergency water supply source. This situation was happened in the system due to power interruptions. The design life of existing system has been phased out by year 2012 and needs to be rehabilitated before water shortage crises ad disaster will take place.

The existing distribution system covers around 50% or 2575 ha of the Master Plan area of the Town. It has also limited to the central lowlands of Adama town, it should be expanded to the highland areas to solve the current water shortage of the residents

The improvement of the water supply service for the town is vital so far the Adama Town Water Supply Service and Sewerage Enterprise (AWSSSE) with its Board of administration has already aware of the problem, and committed to enhance the social welfares of the population through provision of adequate water supply services. The provision of this precious service could also boost in turn socio-economic development of the town.

Consequently, this project is designed to solve the water problems of the Adama and Wonji towns.

1.4 DESIGN CAPACITY OF SYSTEM COMPONENTS

The water supply system has been designed for design flows presented in THE Table below.

TABLE 1.1 SUMMARIES OF POPULATION AND WATER DEMANDS

No	Description	Unit	2011	2012	2015	2020	Phase I (2025)	2030	Phase II (2035)
1.1	**Adama Population**								
	Residing in Adama	No	264,173	275,585	312,147	381,237	461,163	552,496	655,558
	Rural and Floating	No	19,813	20,669	23,411	28,593	34,587	41,437	49,167
	Adama University	No	14,000	14,350	15,453	17,484	19,782	22,381	25,322
	Sub total	**No**	**298,000**	**310,600**	**351,000**	**427,300**	**515,500**	**616,300**	**730,000**
1.2	**Wonji Population**	No	75,432	**78,691**	89,131	108,859	131,681	157,761	187,189
	Total Population	**No**	**373,400**	**389,300**	**440,100**	**536,200**	**647,200**	**774,100**	**917,200**
1.3	Livestock Population	No	100,000	100,000	100,000	100,000	100,000	100,000	100,000

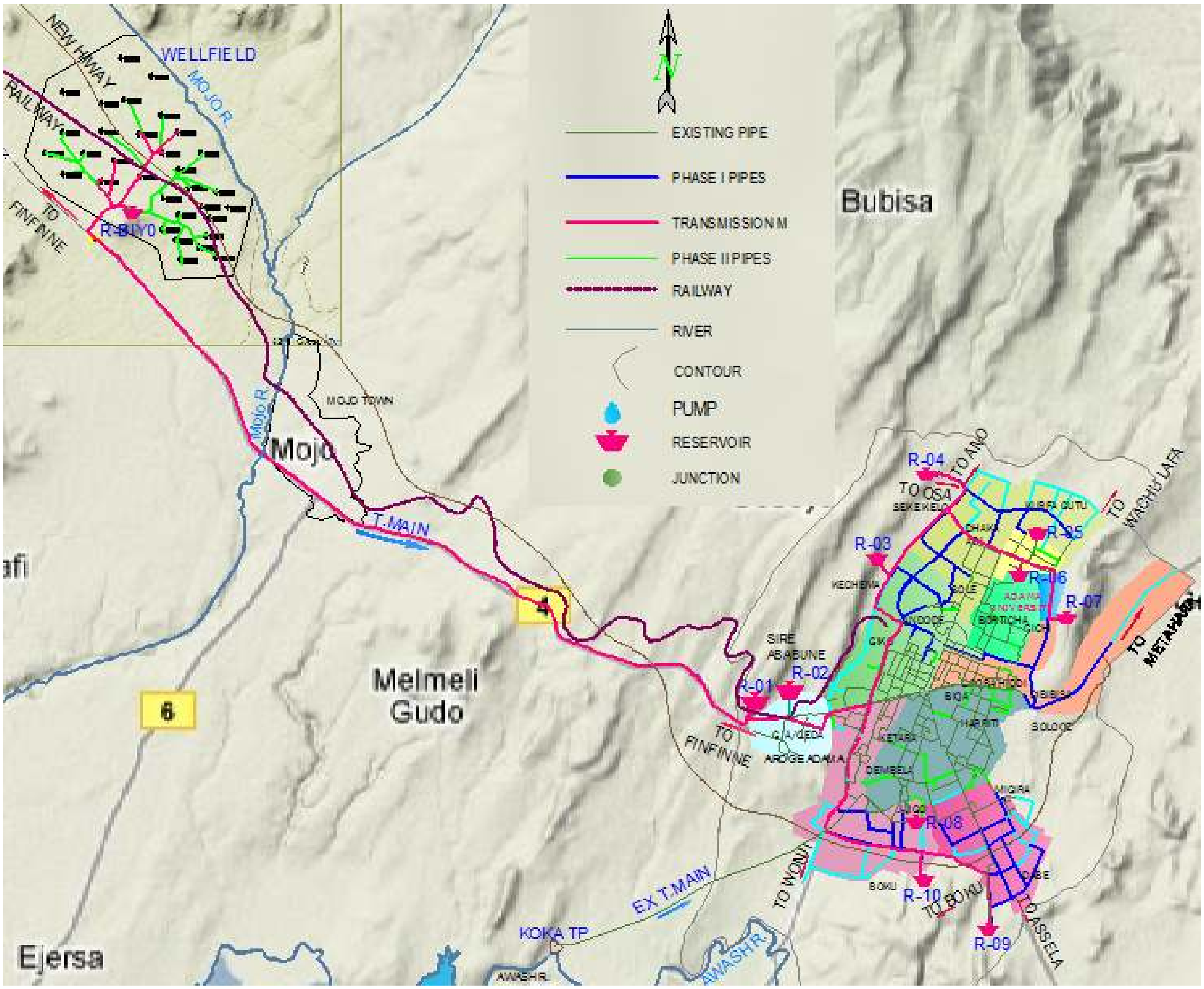
No	Description	Unit	2011	2012	2015	2020	Phase I (2025)	2030	Phase II (2035)
2.1	**Adama Water Consumption (Excluding Un-Accounted For Water (UFW))**								
	Domestic Demand	m^3/d	10,520	10,974	12,430	18,907	26,051	35,173	46,617
	Public and Commercial	m^3/d	3,156	3,292	3,729	5,672	7,815	10,552	13,985
	Livestock	m^3/d	2,500	2,500	2,500	2,500	2,500	2,500	2,500
	Industrial Demand	m^3/d	1,052	1,097	1,243	1,891	2,605	3,517	4,662
	Adama University	m^3/d	840	861	927	1,049	1,187	1,343	1,519
	Total	m^3/d	**18,068**	**18,725**	**20,830**	**30,019**	**40,158**	**53,085**	**69,284**
2.2	**Adama Avg Day Demand (ADD)**								
	Un-Accounted For Water	%	34%	34%	15%	20%	25%	30%	35%
	Domestic Demand	m^3/d	3,577	3,731	1,865	3,781	6,513	10,552	16,316
	Public and Commercial	m^3/d	1,073	1,119	559	1,134	1,954	3,166	4,895
	Livestock	m^3/d	850	850	375	500	625	750	875
	Industrial Demand	m^3/d	358	373	186	378	651	1,055	1,632
	Adama University	m^3/d	286	293	139	210	297	403	532
	Total	m^3/d	**24,211**	**25,092**	**23,954**	**36,022**	**50,197**	**69,010**	**93,533**

No	Description	Unit	2011	2012	2015	2020	Phase I (2025)	2030	Phase II (2035)
2.3	**Adama Maximum Day Demand (MDD)**								
	Maximum Day Factor		1.2	1.2	1.2	1.2	1.2	1.2	1.2
	Domestic Demand	m^3/d	14,097	14,706	14,295	22,688	32,563	45,725	62,934
	Public and Commercial	m^3/d	4,229	4,412	4,288	6,806	9,769	13,717	18,880
	Livestock	m^3/d	3,350	3,350	2,875	3,000	3,125	3,250	3,375
	Industrial Demand	m^3/d	1,410	1,471	1,429	2,269	3,256	4,572	6,293
	Adama University	m^3/d	1,126	1,154	1,066	1,259	1,484	1,746	2,051
	Total MDD	**m^3/d**	**29,050**	**30,110**	**28,750**	**43,230**	**60,240**	**82,810**	**112,240**
		l/s	**336**	**348**	**333**	**500**	**697**	**958**	**1299**
2.4	**Adama Peak Hour Demand (PHD)**								
	Peak hour Factor		1.6	1.6	1.6	1.6	1.6	1.6	1.6
	Peak hour demand (PHD)	**l/s**	**538**	**558**	**532**	**800**	**1,115**	**1,534**	**2,079**
3	**Adama and Wonji Towns**								
3.1	MDD Adama	m^3/d	29,053	30,110	28,744	43,227	60,237	82,813	112,238
		l/s	**336**	**348**	**333**	**500**	**697**	**958**	**1,299**
3.2	MDD Wonji	m3/d	4104	4320	4268	6891	9977	14100	19503
		l/s	**48**	**50**	**49**	**80**	**115**	**163**	**226**
	Total	**m^3/d**	**33,157**	**34,430**	**33,012**	**50,118**	**70,214**	**96,913**	**131,741**
		l/s	**384**	**398**	**382**	**580**	**813**	**1,122**	**1,525**
4	**Existing Average Production and distribution from Awash River**								
4.1	**Production**	**l/s**	**285**	**285**					
4.2	**Adama**								
	Distribution	%	88%	87%					
	Quantity of Water	**l/s**	250	249					
	Water Supply Coverage	**%**	**74%**	**72%**					
	Womji								
4.3	Distribution	%	12%	13%					
	Quantity of Water	**l/s**	35	36					
	Water Supply Coverage	**%**	**74%**	**72%**					

1.5 GENERAL DESCRIPTION OF THE PROJECT

The principal alternative sources for meeting the demand requirements of both Adama and Wonji towns (up to year 2035) have been from the existing Awash River and the newly identified groundwater potential in the wellfield located Northwest of Mojo town (see Figure below).

FIGURE 1.4 GENERAL LAYOUT OF THE WATER SUPPLY SYSTEM



The feasibility of the well field has been justified for the following reasons:

- Hydrogeological investigation on ground water potential of Mojo wellfield indicates that sufficient & reliable water sources can be abstracted within reasonable depths.
- The groundwater quality of the well field can also meet the required standards set by both WHO and Ethiopian Drinking Water Guidelines, hence no need of treatment.
- Once the water is pumped on the ground surface, it is transported and distributed to the town by flow of gravity, no need of booster pumps.
- As a result of gravity distribution, the existing expenditure on booster pumps will be eliminated.

The total water demand required for phase II (year 2035) is around 1,570 l/s. Awash River will be rehabilitated to cover 330 l/s of the total demand. The deficit amount of demand i.e. 1,240 l/s will be met by developing ground water in Mojo wellfield.

A total of around 25 boreholes shall be drilled to meet the demands required up to end of phase II. The design of each borehole is a ***Telescope*** type having a total depth of 350m depth of which 180m and 170m are intended for pump and riser champers respectively. Each borehole is estimated to yield 50 l/s at average dynamic depth of 60 mbgl.

The water from this wellfield of average elevation 1844 masl will be pumped through collector pipes to two Reservoirs located on Biyo hill of ground level 1900 masl (see Figure below).

The water from Biyo hill of RBI-1900 will be conveyed by a Gravity Main of length 24.36km to a Transfer Reservoir located on Sire Ababune Mountain, at ground level of 1800masl. The gravity pipe has a nominal diameter of 1000mm and designed to transport 1,250 l/s of the deficit maximum day demand of Phase II.

The Sire Ababune Reservoir will transfer the water received from wellfield to the 10 (ten) pressure zone service reservoirs located on the West, North, East and Southern sides of Adama town via the two transfer mains designated as North-East and South-East Transfer Mains.

The 10 service reservoirs are designed to distribute about 2,080 l/s of the total Peak Hour Demand of Phase II to Adama Town, through respective 10 distribution Zones by flow of gravity. No need of booster pumping stations from the commissioning of this project (see Figure 1.1).

CHAPTER 2 WATER SOURCE DEVELOPMENT AND PROTECTION

2.1 BRIEF DESCRIPTION OF THE COMPONENTS

The principal alternative sources for meeting the demand requirements of both Adama and Wonji towns have been from the existing Awash River and the newly identified groundwater potential in the wellfield located Northwest of Mojo town.

The total water demand required for phase II (year 2035) is around 1,570 l/s. Awash River will be rehabilitated to cover 330 l/s of the total demand. The deficit amount of demand i.e. 1,240 l/s will be met by developing ground water in Mojo wellfield.

Accordingly, a total of around 25 boreholes shall be drilled to meet the demands required up to end of phase II. The design of each borehole is a ***Telescope*** type having a total depth of 350m depth of which 180m and 170m are intended for pump and riser champers respectively. Each borehole is estimated to yield 50 l/s at average dynamic depth of 60 mbgl.

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The detail design of water source development and Protection encompasses two main components of the Mojo Wellfield.

1. Borehole Water Development
   - Identification of the design capacity of boreholes
   - Preparation of borehole development plan
   - Selection and alignment of boreholes sites to be drilled in the well field
2. Borehole Construction and Protection Works
   - Design of Borehole sections
   - Design of drainage system around the well
   - Design of Fence with Gate
   - Design of Guard and Switch Board Houses
   - Design of Access Road for operation and maintenance of the well

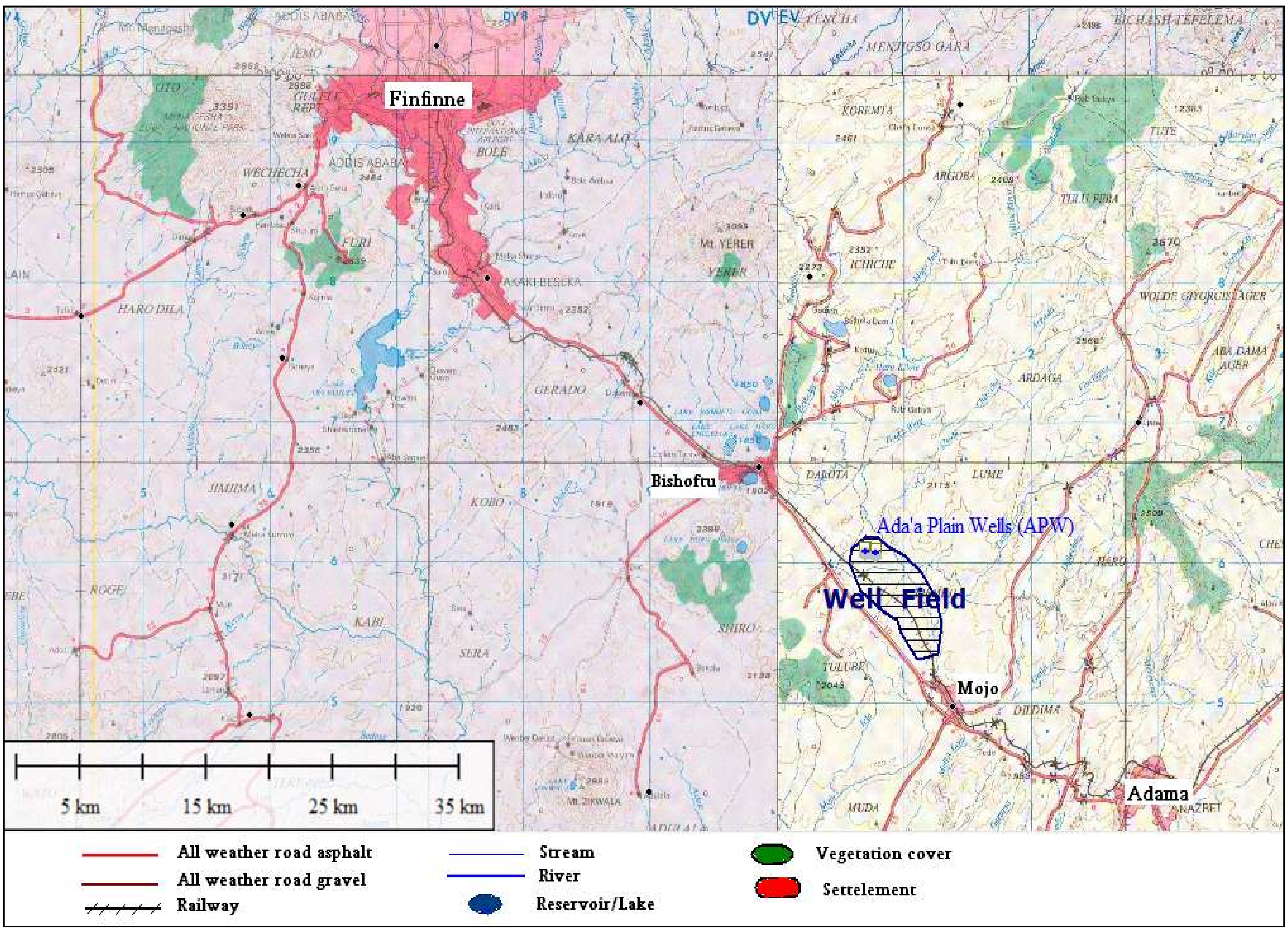
2.2 GROUND WATER DEVELOPMENT

2.2.1 LOCATION OF THE WELLFIELD

The wellfield is found close to Mojo Town, in the Eastern part of Oromia National Regional State in Aana Lume (Lume District) of East Shewa Zone. It is located at about 56 km on the New highway stretched from Finfinne/Addis Ababa/-through Akaki-Dukem-Bishoftu-Mojo to the main rift in the Eastern Oromia, Ethiopia.

The demand area, Adama town, is astronomically located at 529649m easting and 943494m northing (UTM, 37N, Adindan). The location of the town and well field is presented in Figure 2.1 below.

FIGURE 2.1 LOCATION OF THE WELLFIELD



2.2.2 PHYSIOGRAPHY OF THE WELLFIELD

From physiographical point of view, Ethiopia is broadly divided into three major regions:

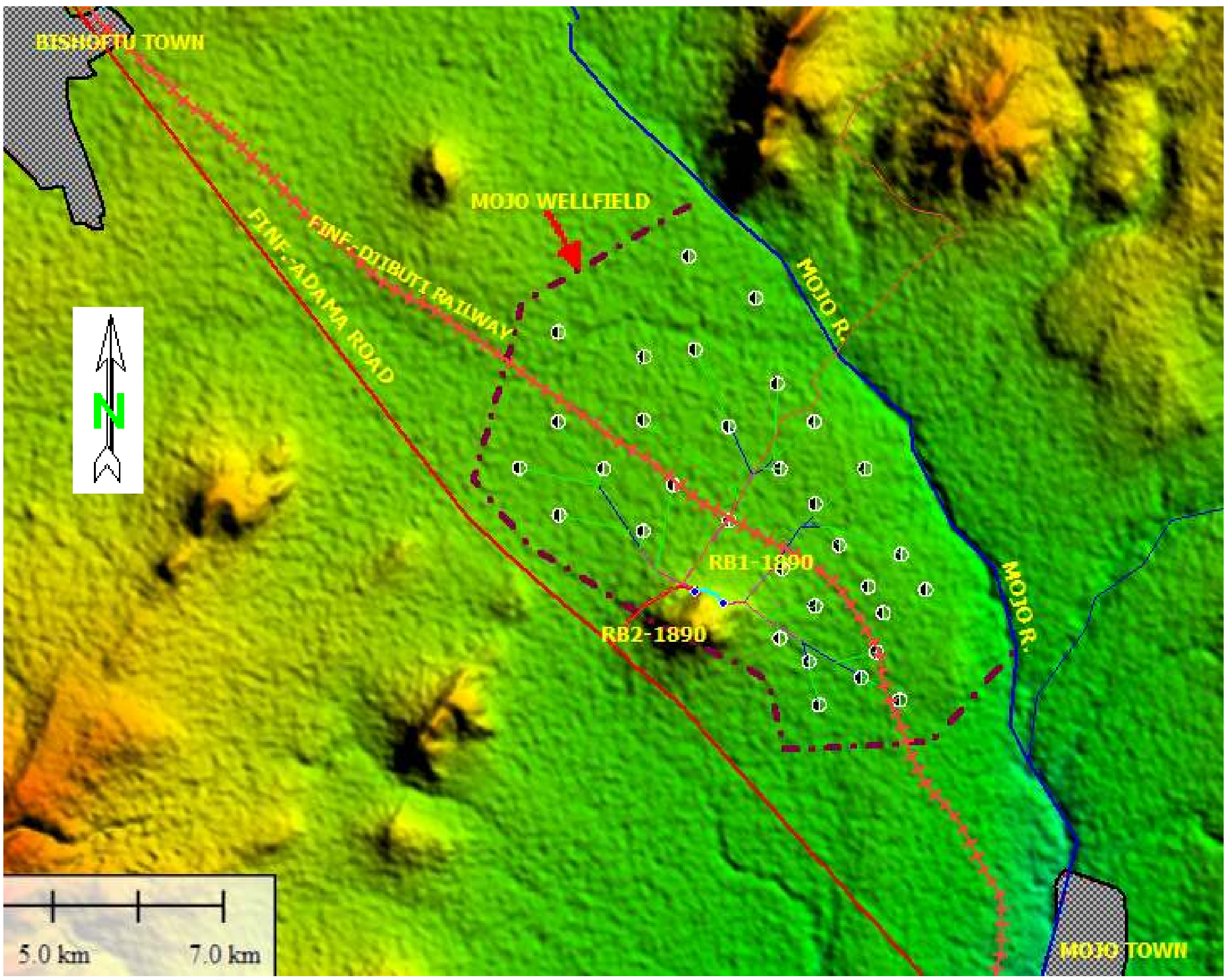
a. The western highland, including the Ethiopian plateau and associated lowlands (WHAL),

b. The Eastern Highland and associated lowlands (EHAL) and,

c. The Rift Valley (RV), running North-South approximately, in the middle of the country and dividing the western from the eastern highlands.

The area lies at the upper shoulder (western margin) of the Main Ethiopian Rift (MER) system, within Upper Awash River Basin. Quaternary tectonics, volcanism and sedimentation, played a significant role in shaping the present morphology of the Rift valley, and hence the project area.

FIGURE 2.2 PHYSIOGRAPHY OF THE WELLFIELD



It is deforested and only scattered Acacia and Eucalyptus trees are observed. Thus, indigenous tree cutting and not planting of the same shall be discouraged in order to create conducive situation for the environment and hence animal population. Soil formation in the area is more or less is uniform black cotton soil, which is developed over lacustrine sediment and volcanic rocks on a flat topography of Ada'a plain. Where this soil is significantly thick, it retards local recharge to groundwater.

FIGURE 2.3 PARTIAL VIEW AND PANORAMA OF MOJO WELLFIELD

Partial View and Panorama of Mojo Wellfield

2.2.3 WATER QUALITY OF THE WELLFIELD

Table 2.1 is the comparison of borehole water quality test result with that of WHO and Ethiopian (MoWR*) Drinking Water Standards for samples collected in the vicinity of the study area.

TABLE 2.1 WATER QUALITY OF THE WELLFIELD

Parameter	Analysis result	Acceptable limit		MPL**	
		WHO (1963)	MoWR (2002)	WHO (1963)	MoWR (2002)
Calcium(Ca), mg/l	2.08 – 5.25	75	75	200	200
Sodium (Na), mg/l	34.5 - 117				
Magnesium(Mg) , mg/l	0.116 - 2.26	50	50	150	150
Iron(Fe) , mg/l	0.006 - 0.442	0.3	0.1	1	1
Manganese(Mn) , mg/l	0.018 - 2.98	0.1	0.05	0.5	0.5
Lead (Pb), µg/l	2.91 – 41.44				
Lithium (Li), µg/l	0.421 - 41.22				
Copper (Cu) , µg/l	0.04 - 11.41	1	0.05	1.5	1.5
Chloride (Cl) , mg/l	0.0 - 14.46	200	200	600	600
Sulphate(SO4) , mg/l	0.21 - 6.56		200	250	400
Fluoride (F)* , mg/l	0.82 - 5.96	1		1.7	
Boron (B) , mg/l	0.04 - 149				
Nitrate (asN) , mg/l		10	10	-	Not specified
Nitrate (as No3) , mg/l	0.0 - 0.54	45 +			
Total hardness, mg/l (as CaCo3)	0.0 - 22.41		100		500
PH	7.06 - 7.47	7- 8	7 - 8.5	min. 6.5 max.9.2	6.5 - 9.2
Total Dissolved Solids(TDS), mg/l	246 - 384	500	500	1500	1500
Total solids at 105 0C, mg/l	450 - 850				
Turbidity, units	0.48 - 9.32	5	5	25	25
Colour, units		5	5	50	50
Odour and taste			un objectionable		un objectionable

*MoWR** =Ministry of Water Resources; *MPL**= Maximum permissible limit*

As shown in the above table, the groundwater quality of the study area can satisfy the required standards set by both WHO and Ethiopian Drinking Water Standard with the exception of very few parameters that exceed the maximum permissible limit. The amount of fluoride (F-) in one of the boreholes, sampled from Mojo town has showed high value (5.96 mg/l) which is attributed to change in lithology southwards as it is also evidenced from previous borehole data.

2.2.4 DESIGN PARAMETERS OF BOREHOLES

The design parameters of boreholes and collection system are based on the information and data described below.

- Geological and Geomorphological studies of the wellfield
- Hydrogeological and Geophysical investigation reports
- Inventory and evaluation of existing wells
- Previous water resources study and evaluation of the Ada'a and Becho Plains Ground Water Basin for Irrigation Development Project (MOWR) which is summarized below.

For the planning purpose and to set the boreholes location, recharge estimated for the sub-catchment (up Stream of Mojo River) and discharge expected from the proposed 32 boreholes were computed (Table 2.2).

The discharge of the proposed boreholes will be estimated 50 l/s each. It was estimated based on the test well data (AdTW3) which was drilled within the current proposed well field area (Table 2.3).

TABLE 2.2 SUMMARY OF ADTW3 BOREHOLE PARAMETERS (WWDSE, 2008 WELL DRILLING REPORT)

Well Name	AdTW3
Depth	324 m
Well Diameter	0 – 170 = 12'' & 170 – 324 = 6''
Static Water Level	6.91m
Pump Position	60m
Pumping rate	60 l/s
Pumping test length	69 hours
Dynamic Water Level at the end of the test	14.58 m
Drawdown	7.4 m
Specific Capacity	8.1 l/s/m
Transmisivity from time drawdown plot	40800 m^2/day
T. Dissolved Solid 105^{0}C(mg/l)	438
Fluoride (mg/l F)	0.69

TABLE 2.3 GROUNDWATER RESOURCE EVALUATION IN THE WELL FIELD AREA

Description	Unit	Quantity	Remark
Total Q per sec	Lit	1,600	32 BHs x 50 l/s each
Total Q per day	Lit	138,240,000	
Total Q per day	M3	138,240	
Total Q per year	MM^3	50.46	32 BHs x 50 l/s each
Total Recharge	MM^3	153	for the sub-catchment
% Planed to be used	%	32.98	for this project
Difference	MM^3	102.54	Might be used for other purposes, non-exploitable, etc

(Lit = Litter, MM^3 = Million Cubic meter, l/s = litter per second, Q = Discharge)

Based on the above simple mathematical computation (Table 6.13), about 50.46 MM3 of groundwater source will be planned to utilize annually for this project. It accounts about 33% of the total recharge to sub-catchment (up Stream of Mojo River) where the proposed well field is located. This analysis shows that the planned amount of groundwater which can be withdrawn annually will be totally replenished and even it is by far less than the estimated annual recharge.

Although, the above simple computation led to a conclusion that the recharge and discharge parameters are balanced (recharged is greater than discharge), it is impractical to accept at this stage of analysis and study. This is because of limitation on the estimated recharge amount, lack of detail study, geo-lithologic setting of the area, distribution of discharge area, etc.

By considering the above limitation, the discharge of the planned boreholes (50 l/s each) is estimated below the recommended discharge (70 l/s) of the area.

Consequently, the total water demand required for phase II (year 2035) is around 1,570 l/s. Awash River will be rehabilitated to cover 330 l/s of the total demand. The deficit amount of demand i.e. 1,240 l/s will be met by developing ground water in Mojo wellfield.

Accordingly, a total of around 25 boreholes shall be drilled to meet the demands required up to end of phase II. The design of each borehole is a ***Telescope*** type having a total depth of 350m depth of which 180m and 170m are intended for pump and riser champers respectively. Each borehole is estimated to yield 50 l/s at average dynamic depth of 60 mbgl.

2.2.5 DEVELOPMENT PLAN OF BOREHOLES

The proposed development plan of boreholes shall be in phases of 5 year as this approach allows gradual accumulation of the funds for investment, as well as the intermediate evaluation and adaptation of the design where actual development deviates from the original planning (Table 2.4).

TABLE 2.4 DEVELOPMENT PLAN OF BOREHOLES

No	Description	Unit	2011	2014	2015	2020	Phase I 2025	2030	Phase II 2035
3.3	**MDD-Adama Town**	**m³/d**	**29,050**	**32,330**	**28,750**	**43,230**	**60,240**	**82,810**	**112,240**
		l/s	**336**	**374**	**333**	**500**	**697**	**958**	**1299**
3.5	**MDD Wonji Town**								
	MDD Wonji	l/s	48	54	49	80	115	163	226
	Total of Both Towns	**l/s**	**384**	**428**	**382**	**580**	**813**	**1,122**	**1,525**
4.1	**Water Source Capacity**								
	Surface Water (Treatment Loss 6%)	l/s	405	455	405	615	860	1190	1615
	Ground Water (Treatment Loss 3%)	l/s	400	445	395	600	840	1160	1570
4.2	**Available Source (Awash River)**	**l/s**	**285**	**285**	**330**	**330**	**330**	**330**	**330**
	Cumm Water Required From Mojo WF	l/s	115	160	65	270	510	830	1240
	Net Water Required From Mojo WF	l/s			300	200	350	400	
4.3	**BH Development Plan in Phase of 5 years for 50l/s/BH**	No			**6**	**4**	**7**	**8**	

2.2.6 LOCATIONS OF THE PROPOSED BOREHOLES

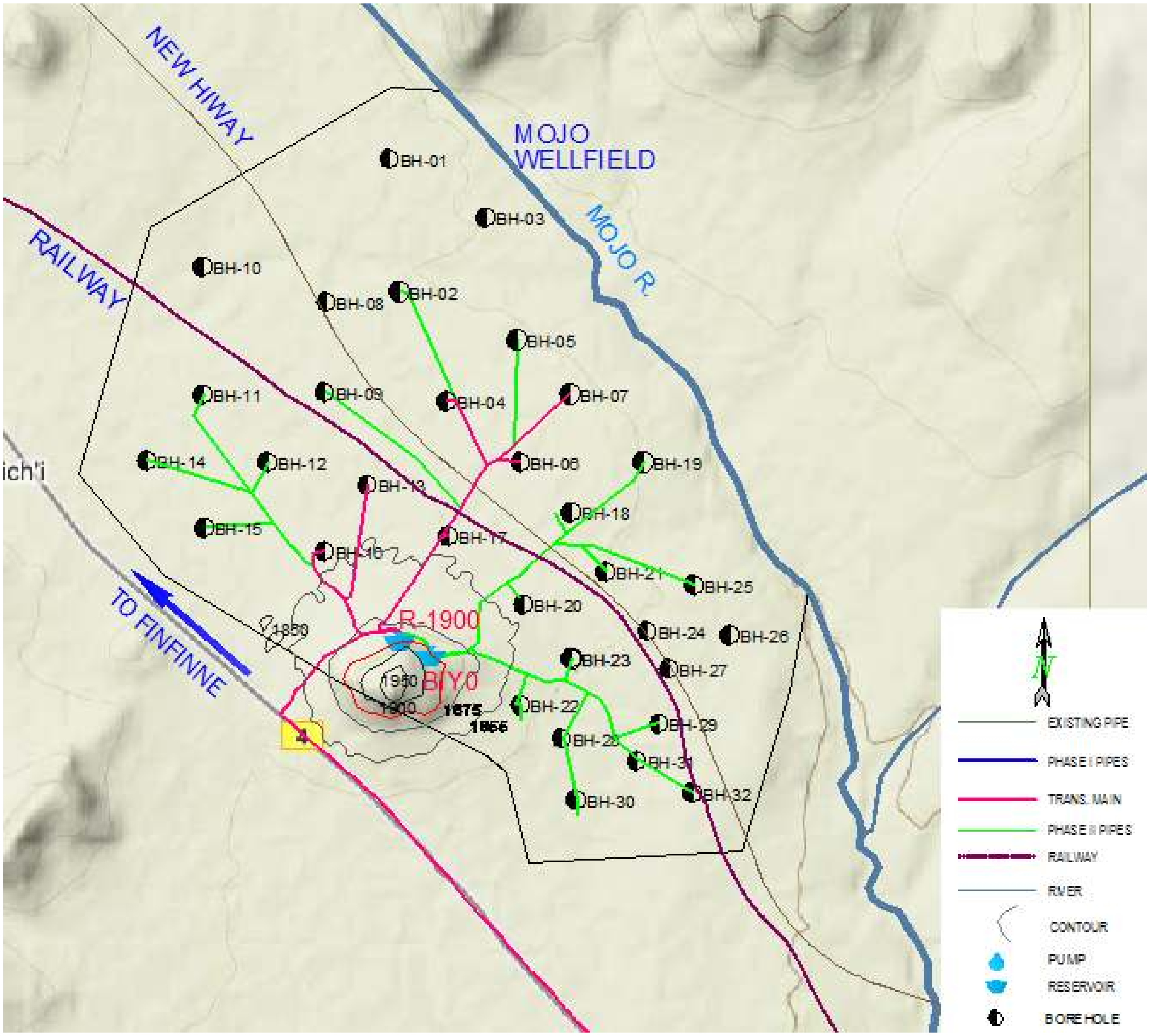
The locations of proposed boreholes are presented in the following Table and Figure.

TABLE 2.5 PROPOSED LOCATIONS OF BOREHOLES

Label	X (m)	Y (m)	Elevation (m)	Depth (m)	Remarks
BH01	508502	960497	1846.74	350	
BH02	508576	959405	1846.61	350	
BH03	509287	960009	1840.71	350	
BH04	508968	958503	1847.46	350	Phase I
BH05	509541	959002	1841.75	350	
BH06	509574	958005	1848.00	350	Phase I
BH07	509977	958557	1841.92	350	Phase I
BH08	507983	959320	1849.27	350	
BH09	507972	958578	1854.54	350	
BH10	506975	959607	1852.27	350	
BH11	506975	958557	1855.46	350	
BH12	507505	958005	1851.88	350	
BH13	508322	957814	1851.78	350	Phase I
BH14	506519	958016	1853.36	350	
BH15	506985	957464	1852.56	350	
BH16	507972	957273	1853.10	350	Phase I
BH17	508980	957400	1851.32	350	Phase I
BH18	509987	957591	1846.38	350	
BH19	510571	958005	1840.05	350	
BH20	509563	956891	1852.04	350	
BH21	510264	957107	1843.96	300	
BH22	509572	956016	1845.10	300	
BH23	509985	956396	1843.47	300	
BH24	510607	956623	1839.87	350	
BH25	510988	956999	1835.00	350	
BH26	511280	956587	1829.49	350	
BH27	510785	956314	1836.29	350	
BH28	509909	955743	1836.68	260	
BH29	510702	955857	1829.98	350	
BH30	510029	955235	1828.47	350	
BH31	510524	955552	1825.59	350	
BH32	510975	955292	1825.30	350	

The wellfield is bounded by Mojo River on the Eastern side and by existing Finfinne –Adama road on the Western side. The new Finfinne – Adama highway and the Finfinne -Djibouti Railway bisect the wellfield as shown in the Figure.

FIGURE 2.4 PROPOSED LOCATIONS OF BOREHOLES



2.3 WELL DESIGN AND PROTECTION

2.3.1 WELL DESIGN

The proposed borehole design is also based on the information and data described in the aforementioned section.

The design of each borehole is a ***Telescope*** type having a total depth of 350m of which 180m and 170m are intended for pump chamber and riser pipe respectively. Each borehole is estimated to yield 50 l/s at average dynamic depth of 60 mbgl.

Detailed specifications will be provided in the tender document; however, the proposed construction design is summarized below. The typical section of well design is shown in Figure below.

a. The boreholes will be proposed to be drilled to an average depth of 350mbgl. However; the exact depth will be decided on actual site conduction during the implementation of the project.

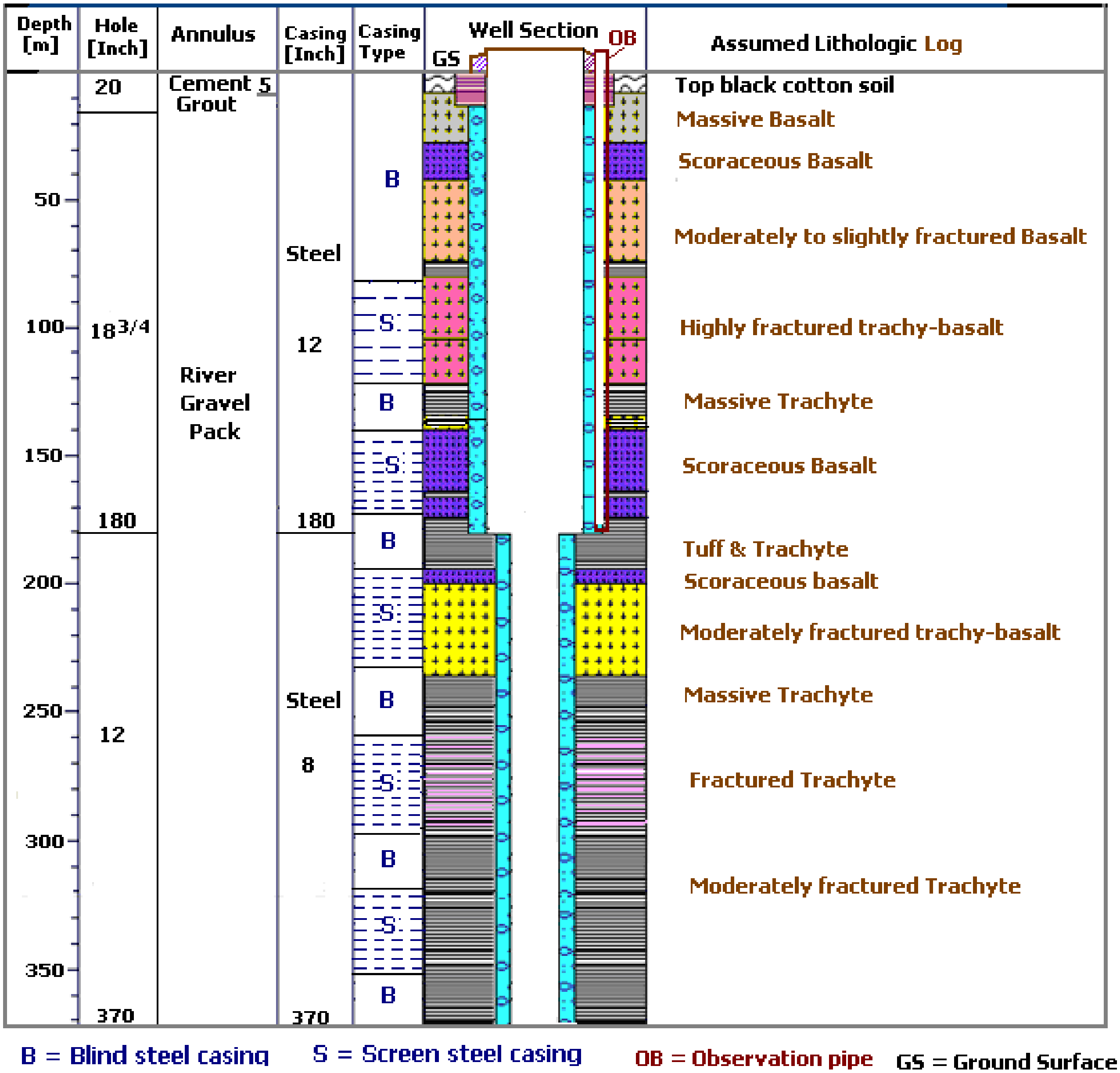
b. The drilling diameter below surface casing installation depth shall be 183/4" and 12"as specified in the BOQ and shown in the well design. If the borehole is to be housed with casing and screens their positioning shall be instructed in written by the Hydrogeologist/Engineer based on the result of lithologic and electrical log conducted.

c. If written instruction is given by the Hydrogeologist /engineer gravel pack will be installed in the annular space of the borehole wall and the outer portion of the casings to a minimum of 5m above the static water level.

d. Cement grout shall be applied above the gravel pack in unconsolidated section. Before applying cement grout a minimum of 15-20cm thick sand bridge shall be placed above the gravel to protect cement infiltration.

e. On completion of testing, the borehole shall be secured with 6mm thick steel plate welded to the top of well or surface casing, as the case may be, and well head shall be constructed as per the specification.

FIGURE 2.5 TYPICAL DESIGN OF BOREHOLE



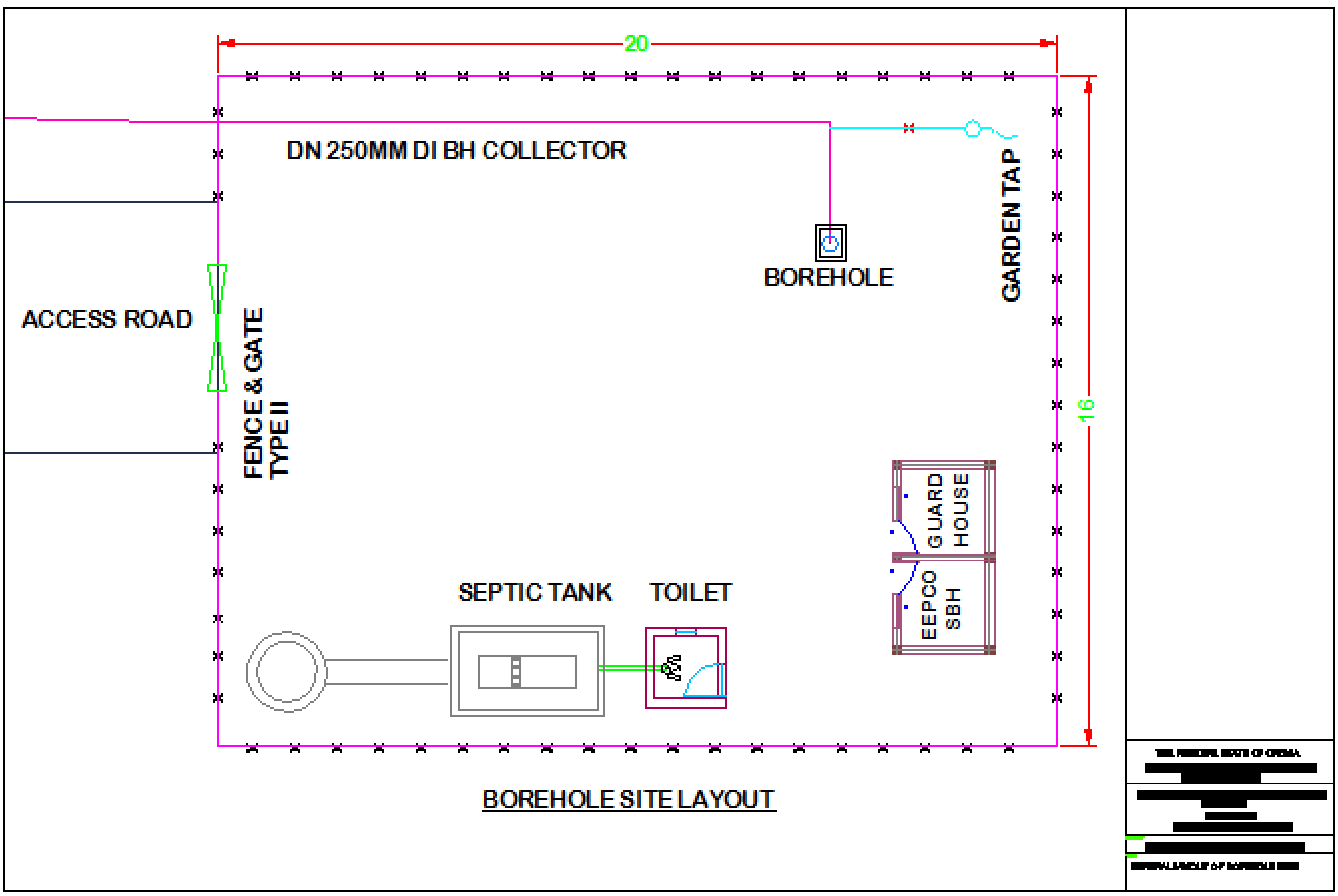
2.3.2 BOREHOLE SITE PROTECTION

Each borehole has been designed to have the following components.

- A Fence with Gate Size of 20x16m for well protection
- A building with two rooms for Guard House, EEPCO Switch Board and submersible pump control Panel
- A drainage System around the borehole site
- Access Road for operation and maintenance of the well
- A water tap for sampling, supply service and watering the garden of compound.

The typical plan and layout of borehole site is shown in Figure below.

FIGURE 2.6 TYPICAL PLAN AND LAYOUT OF BOREHOLE SITE



CHAPTER 3 WATER COLLECTION AND TRANSMISSION SYSTEM

3.1 OUTLINES OF SYSTEM COMPONENTS

The total water demand required for phase II (year 2035) is around 1,570 l/s. Awash River will be rehabilitated to cover 330 l/s of the total demand. The deficit amount of demand i.e. 1,240 l/s will be met by developing ground water in Mojo wellfield.

A total of around 25 boreholes shall be drilled to meet the demands required up to end of phase II. The design of each borehole is a ***Telescope*** type having a total depth of 350m depth of which 180m and 170m are intended for pump and riser champers respectively. Each borehole is estimated to yield 50 l/s at average dynamic depth of 60 mbgl and pump position of 100mbgl.

The water from the wellfield of average elevation 1844 masl will be pumped through collector pipes to two Reservoirs located on Biyo hill of ground level 1900 masl as shown in Figure Below.

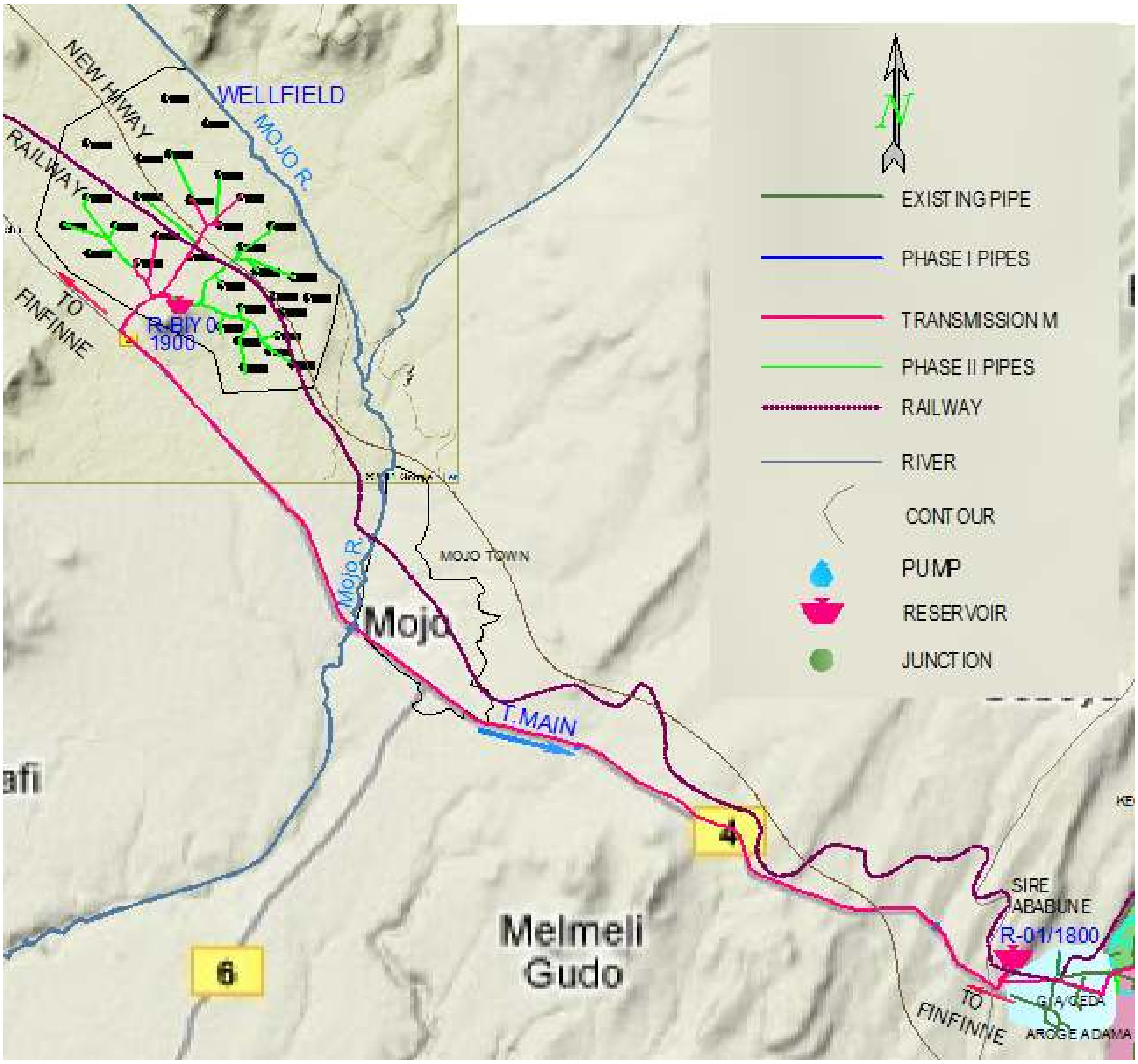
The water from Biyo hill of two collector reservoirs will be conveyed by a Gravity Main of length 24.36km to a Transfer Reservoir located on Sire Ababune Mountain, at ground level of 1800masl. The gravity pipe has a nominal diameter of 1,000mm and designed to transport 1,250 l/s of the deficit maximum day demand of Phase II.

The detail design of water collection and transmission system thus includes the water system components of the project from the Wellfield to Adama Sire Ababune Transfer Reservoir, SAR1-1800.

Figure 3.1 shows the general layout of the system. The components described under this section are summarized below.

1. Riser Pipes, for Conveying Water from Submersible Pumps To subsidiary collectors
2. Collectors Pipes, for Conveying Water from Riser Pipes to Collector Reservoirs.
3. Transmission Main for Conveying Water from Collector Reservoirs to Transfer Reservoir.
4. Borehole Submersible Pumps for Lifting from Boreholes Dynamic Water Levels to Collector Reservoirs.

FIGURE 3.1 GENERAL LAYOUT OF WATER COLLECTION AND TRANSMISSION SYSTEM



3.2 RISER PIPES

Riser pipe are smaller in diameters, designed to convey water from boreholes pump positions to collector pipes. They are sized to safely transport the optimum design yields of boreholes. In this case, the pump position is set 110 mbgl and the safe yield of each borehole is 50 l/s. Based on these data hydraulic analyses have been performed for different sizes of pipes available on market.

TABLE 3.1 DETAIL DESIGN REPORTS OF RISER PIPES

Label	DN (mm)	L (m)	Q (l/s)	V (m/s)	Pipe HL (m)	HL Grdnt (m/km)	U/S P (mH2O)	D/S P (mH2O)	Material	Desc.
BH-30	200	100	48	1.5	1.2	11.6	150	88	GI	PN 16
BH-32	200	100	48	1.5	1.2	11.8	149	87	GI	PN 16
BH-31	200	100	50	1.6	1.3	12.5	146	85	GI	PN 16
BH-29	200	100	50	1.6	1.3	12.7	145	84	GI	PN 16
BH-25	200	100	52	1.6	1.4	13.6	142	80	GI	PN 16
BH-07	200	100	53	1.7	1.4	14	140	79	GI	PN 16
BH-19	200	100	47	1.5	1.1	11.3	135	74	GI	PN 16
BH-28	200	100	48	1.5	1.1	11.5	134	73	GI	PN 16
BH-05	200	100	48	1.5	1.2	11.7	133	73	GI	PN 16
BH-21	200	100	49	1.6	1.2	12.1	132	71	GI	PN 16
BH-02	200	100	49	1.6	1.2	12.2	132	71	GI	PN 16
BH-04	200	100	51	1.6	1.3	13.1	128	67	GI	PN 16
BH-18	200	100	51	1.6	1.3	13.2	128	66	GI	PN 16
BH-23	200	100	51	1.6	1.3	13.2	128	66	GI	PN 16
BH-13	200	100	52	1.6	1.4	13.5	127	66	GI	PN 16
BH-22	200	100	52	1.6	1.4	13.6	127	65	GI	PN 16
BH-06	200	100	52	1.7	1.4	13.9	126	64	GI	PN 16
BH-15	200	100	48	1.5	1.2	11.7	122	62	GI	PN 16
BH-12	200	100	49	1.6	1.2	12.1	121	60	GI	PN 16
BH-09	200	100	49	1.6	1.2	12.3	120	60	GI	PN 16
BH-14	200	100	50	1.6	1.2	12.5	120	59	GI	PN 16
BH-11	200	100	50	1.6	1.3	12.9	119	57	GI	PN 16
BH-17	200	100	51	1.6	1.3	13.1	118	56	GI	PN 16
BH-20	200	100	51	1.6	1.3	13.1	118	57	GI	PN 16
BH-16	200	100	52	1.7	1.4	13.8	116	54	GI	PN 16
		2500	**1251**	**1.6**	**1.3**	**13**				

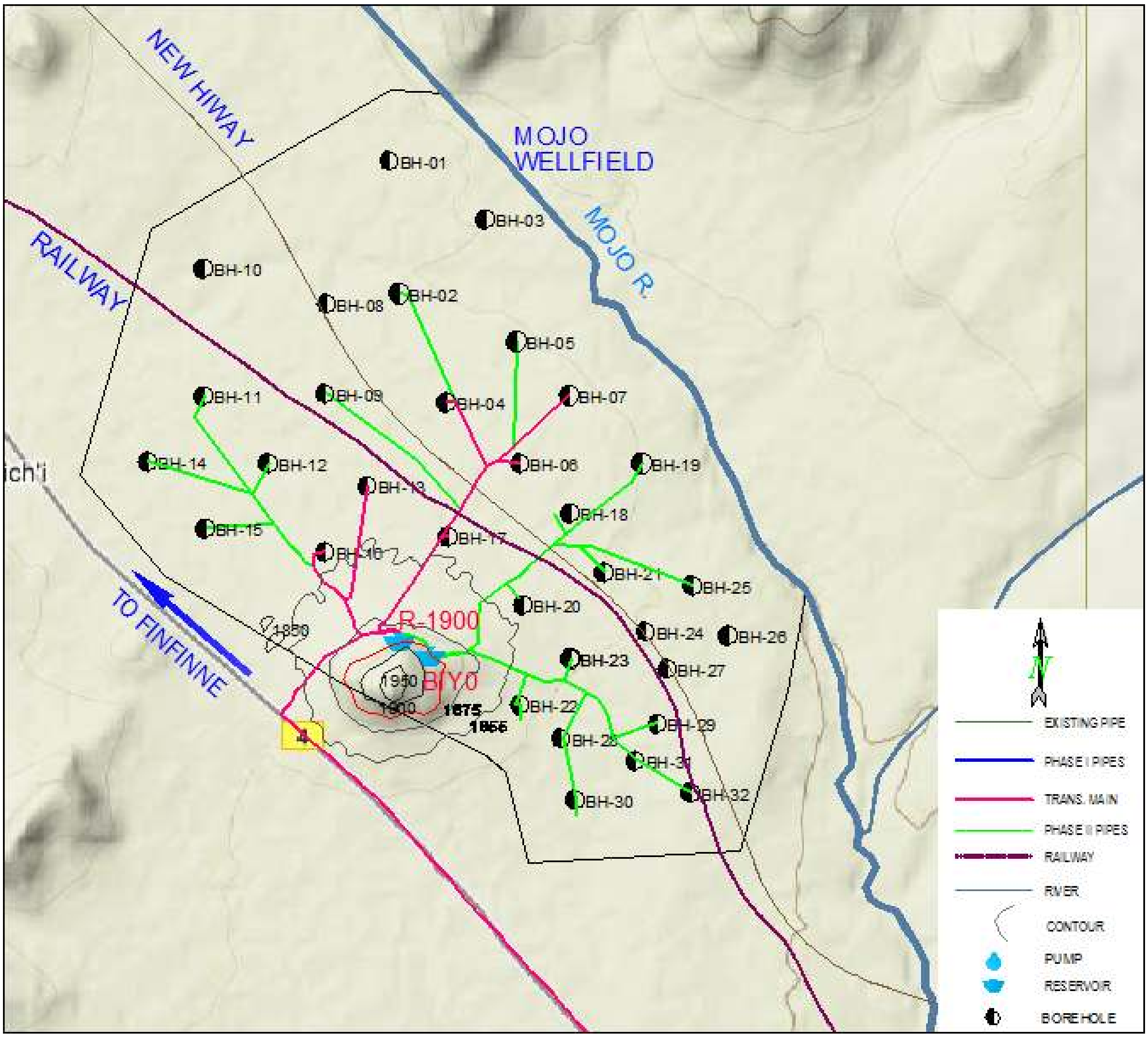
According to the analysis result, DN 200 mm Riser pipes are selected with an average velocity of 1.6m/s and head loss of 1.3m which is acceptable for borehole pumps. The strength of the pipes is governed by pump pressures which are varying from 54mH_2O to 150 mH_20 as shown in the above Table.

Therefore, a pressure pipe of PN16 bar is sufficient to safely convey the required flow from the pumps to collector pipes. The to quantity of riser pipes required for this purpose is around 2500m for the assumed average dynamic water level of 60mbgl and pump position of 100mbgl.

3.3 COLLECTOR PIPES

For the purpose of clarification, collector pipes are divided into two components, subsidiary collectors and main collectors. The subsidiary collectors transport water from each borehole to the main collectors while the mains are linking the water received from subsidiaries to the transmission mains (Figure 3.2).

FIGURE 3.2 BOREHOLE WATER COLLECTORS LAYOUT



Collector pipes are designed to meet the maximum day demands and their respective quantities are determined by the spatial distribution of the boreholes.

The maximum design pressure in the junctions of collector pipes are around 76mH_2O which are occurred at the out let of the riser pipes. Pipe materials and respective strengths are selected based on theses hydraulic pressures as shown in Table 3.2. The quantity of pipes required for both phases is summarized in Table 3.3.

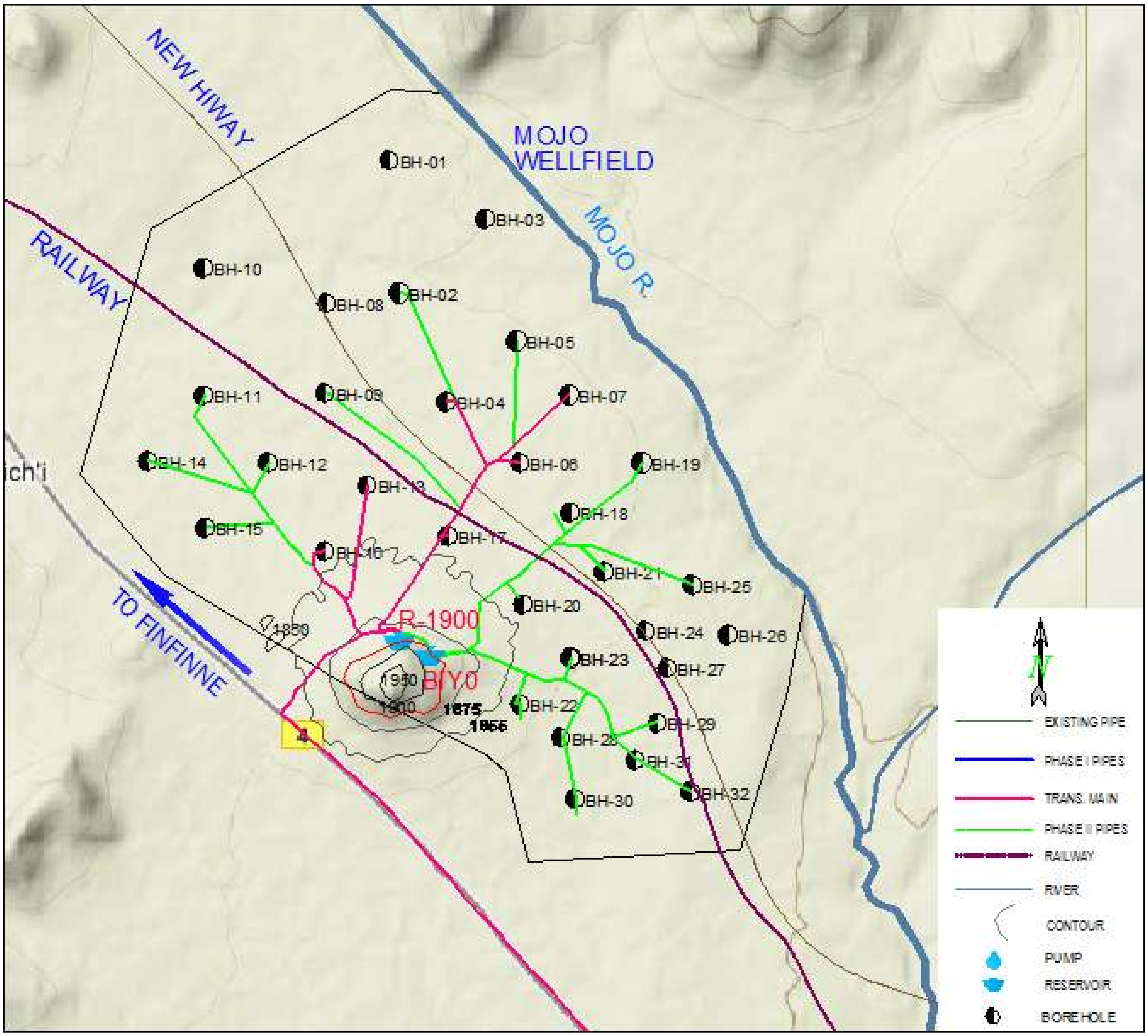
TABLE 3.2 QUANTITY OF PIPES REQUIRED FOR COLLECTOR PIPES

S/N	DN (mm)	L (m)	Material	Pressure Class
1	700	403	DI	K9
2	600	141	DI	K9
3	500	4313	DI	K9
4	450	2915	DI	K9
5	300	1760	DI	K9
6	250	7654	DI	K9
7	200	5074	DI	K9
Total		**22,260**		

3.4 COLLECTOR RESERVOIRS

Two collector reservoirs have been design for the two groups of boreholes. These reservoirs transfer water from boreholes to Sire Ababune reservoir. The 1st and 2nd collector reservoirs will transfer 600 l/ and 650 l/s respectively. They are situated at ground elevations of 1900 masl as shown in Figure and Table below.

FIGURE 3.3 ARRANGEMENT OF BOREHOLES AND COLLECTORS



According to the design criteria, transfer reservoirs those are used for pumping station will be sized based on one hour and half detention time of the transferred maximum day demand. The size of these collector and transfer reservoirs are thus summarized in table below.

TABLE 3.3 DESIGN CAPACITIES OF COLLECTOR RESERVOIRS

Reservoir ID	No of BH	Yeild (l/s)	1Hr Storage (m^3)	Phase I 2025 (m^3)	Phase II 2035 (m^3)
Eastern Biyo Reservoir, RBIE-1900	12	600	2160	2500	
Western Biyo Reservoir, RBIW-1900	13	650	2340		2500
Total	**25**	**1250**	**4500**	**2500**	**2500**

While discussions on the selection of suitable sites for collector reservoirs

3.5 DISINFECTION UNIT

One (1) building shall be constructed to facilitate the dosing of chlorine in the new 1200m^3 Service Reservoir. Mixing is made at the ground level in a shade of approx. 10 m^2. The layout of the disinfection building and mixing shade is shown on drawing album of Tender Document.

3.6 ELECRO-MECHANICHAL COMPONENTS

3.6.1 BOREHOLE SUBMERSIBLE PUMPS

The submersible pumps are designed to lift water from the boreholes average dynamic depth of 60 mbgl and pump position of 100 mbgl to the wellfield collector reservoirs located on Biyo hill at average ground elevation **1900** masl through collector pipes described in the aforementioned sections.

As mentioned in the forgoing sections, in designing borehole submersible pumps, the characteristics and logical potential yields of boreholes have been estimated based on the study reports as shown below.

TABLE 3.4 DESIGN PARAMETERS OF SUBMERSIBLE PUMPS

Description	Depth mbgl	Static Water level mbgl	Drawdown mbgl	Optimum yield l/s	Design Yield l/s
Boreholes Development	350	10	60	60-80	50

The total yield required for the project is 1,250 l/s of which 500 l/s is for phase I and 750 l/s will be augmented for Phase II.

Accordingly, the design of pumps has been conducted in grouping into three categories in accordance with their spatial locations against the collector reservoirs.

The following tables will show design categories and details of the whole 25 borehole submersible pumps respectively.

TABLE 3.5 DESIGN CATEGORIES OF SUBMERSIBLE PUMPS

Pump Category	Quantity	Discharge (l/s)	Head (m)
SP CAT-01	8	50	120
SP CAT-02	11	50	130
SP CAT-03	6	50	145
Total	**25**		

Phase I

Pump Category	Quantity	Discharge (l/s)	Head (m)
SP CAT-01	2	50	120
SP CAT-02	3	50	130
SP CAT-03	1	50	145
Total	**6**		

TABLE 3.6 DESIGN DETAILS OF SUBMERSIBLE BOREHOLE PUMPS

S/N	Identification and Location					Pump Characteristics					
	BH Label	Pump Label	X (m)	Y (m)	Elev. (masl)	Q (l/s)	Head (m)	DWL (masl)	Discharge Level (masl)	Category	Remark
1	BH-16	SP-16	507,972	957,144	1,793	50	120	1,793	1,909	SP CAT-01	Phase I
2	BH-20	SP-20	509,563	956,761	1,792	50	120	1,792	1,910	SP CAT-01	
3	BH-17	SP-17	508,980	957,266	1,791	50	120	1,791	1,909	SP CAT-01	Phase I
4	BH-11	SP-11	506,975	958,426	1,795	50	120	1,795	1,914	SP CAT-01	
5	BH-14	SP-14	506,519	957,890	1,793	50	120	1,793	1,913	SP CAT-01	
6	BH-09	SP-09	507,972	958,463	1,795	50	120	1,795	1,916	SP CAT-01	
7	BH-12	SP-12	507,505	957,873	1,792	50	120	1,792	1,913	SP CAT-01	
8	BH-15	SP-15	506,985	957,342	1,793	50	120	1,793	1,916	SP CAT-01	
9	BH-06	SP-06	509,574	957,876	1,788	50	130	1,788	1,914	SP CAT-02	Phase I
10	BH-22	SP-22	509,572	955,887	1,785	50	130	1,785	1,912	SP CAT-02	
11	BH-13	SP-13	508,322	957,681	1,792	50	130	1,792	1,919	SP CAT-02	Phase I
12	BH-23	SP-23	509,985	956,266	1,783	50	130	1,783	1,911	SP CAT-02	
13	BH-18	SP-18	509,847	957,467	1,786	50	130	1,786	1,914	SP CAT-02	
14	BH-04	SP-04	508,968	958,376	1,787	50	130	1,787	1,916	SP CAT-02	Phase I
15	BH-02	SP-02	508,576	959,280	1,787	50	130	1,787	1,919	SP CAT-02	
16	BH-21	SP-21	510,264	956,982	1,784	50	130	1,784	1,916	SP CAT-02	
17	BH-05	SP-05	509,541	958,868	1,782	50	130	1,782	1,916	SP CAT-02	
18	BH-28	SP-28	509,909	955,618	1,777	50	130	1,777	1,911	SP CAT-02	
19	BH-19	SP-19	510,571	957,877	1,780	50	130	1,780	1,915	SP CAT-02	
20	BH-07	SP-07	509,977	958,429	1,782	50	145	1,782	1,922	SP CAT-03	Phase I
21	BH-25	SP-25	510,988	956,884	1,775	50	145	1,775	1,917	SP CAT-03	
22	BH-29	SP-29	510,702	955,728	1,770	50	145	1,770	1,916	SP CAT-03	
23	BH-31	SP-31	510,524	955,418	1,766	50	145	1,766	1,912	SP CAT-03	
24	BH-32	SP-32	510,975	955,156	1,765	50	145	1,765	1,914	SP CAT-03	
25	BH-30	SP-30	510,029	955,110	1,768	50	145	1,768	1,918	SP CAT-03	

Finally, the proposed performance curve of each pump category is presented in consecutive Figures below.

FIGURE 3.4 PERFORMANCE CURVES OF SUBMERSIBLE PUMPS OF CATEGORY-01

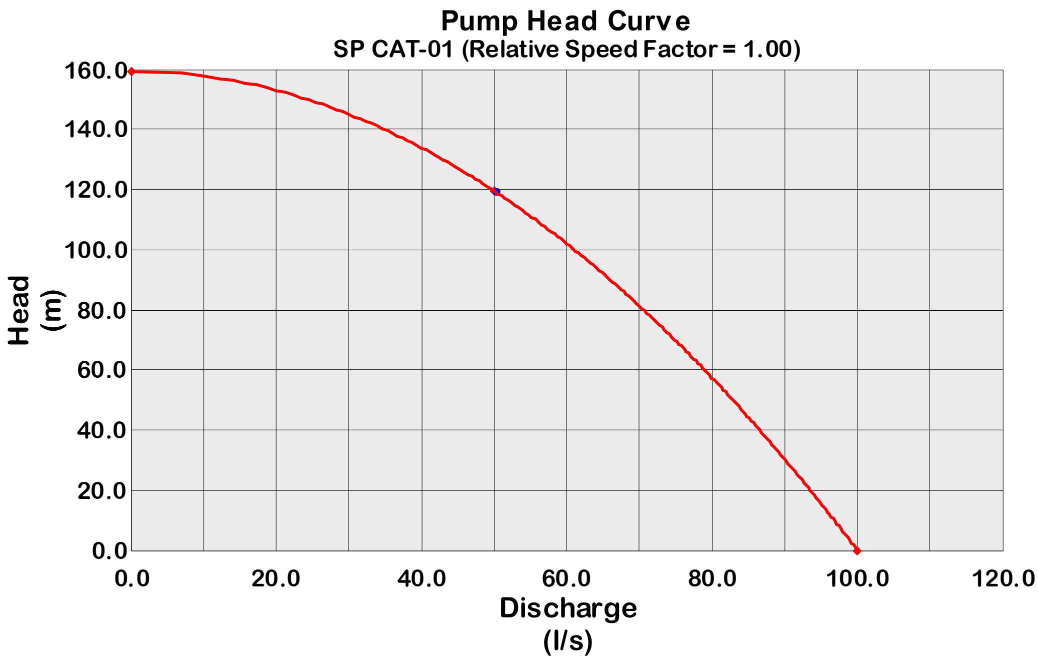


FIGURE 3.5 PERFORMANCE CURVES OF SUBMERSIBLE PUMPS OF CATEGORY-02

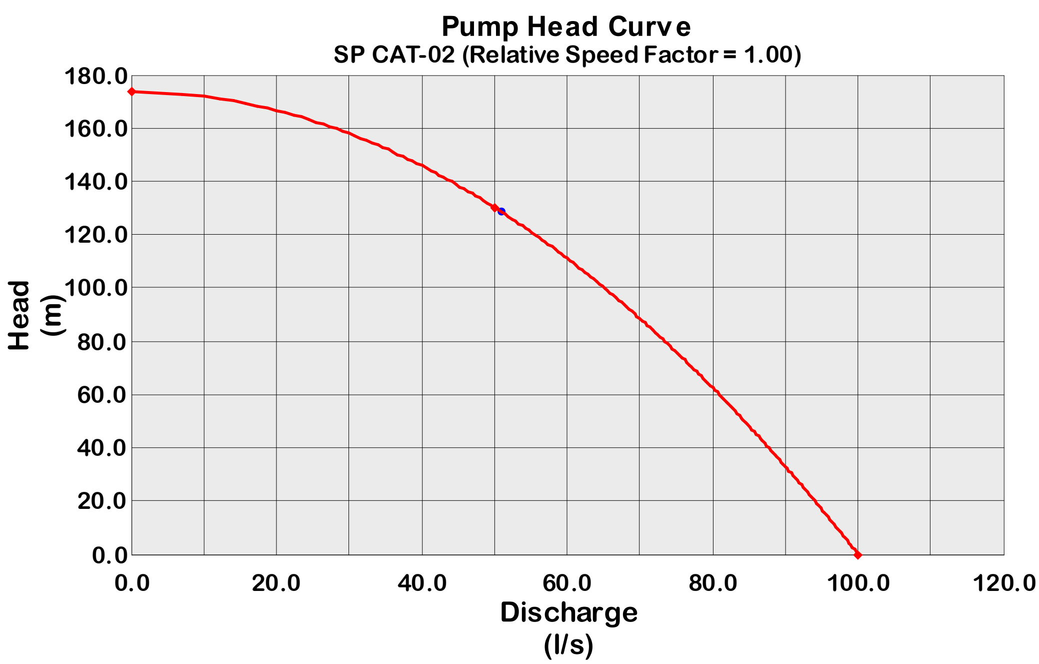
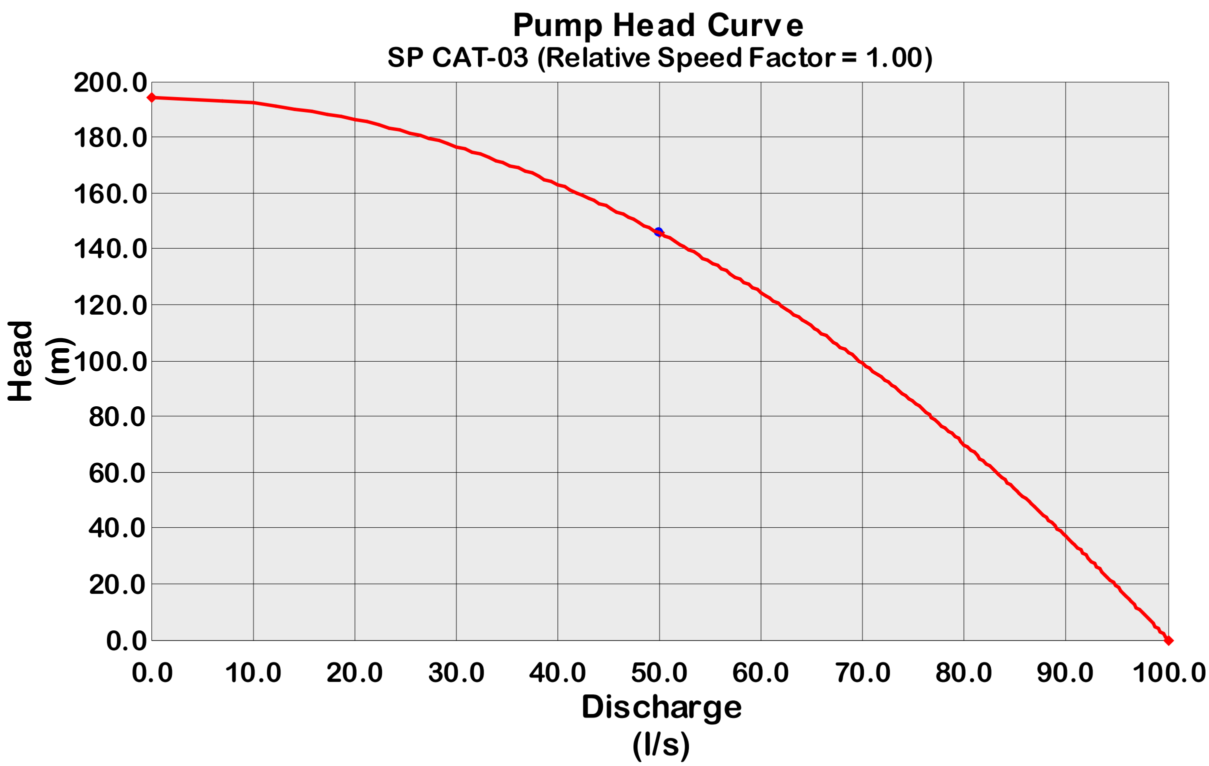


FIGURE 3.6 PERFORMANCE CURVES OF SUBMERSIBLE PUMPS OF CATEGORY-03



3.6.2 POWER SUPPLY

The general power supply scheme will be that of EEPCO providing 15 kV or 33 kV high voltage at each borehole site via overhead lines. The power will be stepped down to 380 V at each location.

The length of electric transmission lines will be assumed either from the new Finfinne-Adama highway or from the existing asphalt road. However it is proposed to be supplied from the new highway for its close proximity to the wellfield.

In some location when the distance between loads are less than 300 m a low voltage overhead line is used. Back-up power supply is provided at each site.

The scheme provides good flexibility during power failure and also provides good flexibility if a borehole will be reallocated as a result of low yield or for other reasons. A high voltage overhead line may easily accommodate new borehole arrangements.

3.6.3 RATING OF ELECTRICAL EQUIPMENT

A) TRANSFORMERS

The rating is assessed by calculating and summarizing the probable single loads in the supply system. From the list of standard transformer ratings, the one anticipated standard size above the calculated value is assessed as the supply transformer for the actual site. A transformer has a lifetime of at least 40 years. The transformer is rated to cover the combined load of both Stages I and II.

B) HIGH VOLTAGE (HV) LINES

The HV distribution lines from the national distribution grid to each site shall be rated to cover the combined load of Stages I and II.

The indicative power required for each borehole submersible pump and those of phase-1 is summarized in tables below. The detail design will be presented in the EM component.

TABLE 3.7 POWER REQUIRED FOR BOREHOLES

Power Required For Submersible Pumps	Design Data			
	T=	20^0C	η_{pump}	75%
	g=	9.81	η_{motor}	90%
	ρ=	998.20	cosϕ	0.8

S/N	Label	SP Q (l/s)	SP H (m)	N (kW)	N_{pump} (kW)	N_{motor} (kW)	Recom. N_{motor} (kW)	Category	Remark
BH-16	SP-16	50	120	59	78	87	90	SP CAT-01	Phase I
BH-20	SP-20	50	120	59	78	87	90	SP CAT-01	
BH-17	SP-17	50	120	59	78	87	90	SP CAT-01	Phase I
BH-11	SP-11	50	120	59	78	87	90	SP CAT-01	
BH-14	SP-14	50	120	59	78	87	90	SP CAT-01	
BH-09	SP-09	50	120	59	78	87	90	SP CAT-01	
BH-12	SP-12	50	120	59	78	87	90	SP CAT-01	
BH-15	SP-15	50	120	59	78	87	90	SP CAT-01	
BH-06	SP-06	50	130	64	85	94	95	SP CAT-02	Phase I
BH-22	SP-22	50	130	64	85	94	95	SP CAT-02	
BH-13	SP-13	50	130	64	85	94	95	SP CAT-02	Phase I
BH-23	SP-23	50	130	64	85	94	95	SP CAT-02	

BH-18	SP-18	50	130	64	85	94	95	SP CAT-02	
BH-04	SP-04	50	130	64	85	94	95	SP CAT-02	Phase I
BH-02	SP-02	50	130	64	85	94	95	SP CAT-02	
BH-21	SP-21	50	130	64	85	94	95	SP CAT-02	
BH-05	SP-05	50	130	64	85	94	95	SP CAT-02	
BH-28	SP-28	50	130	64	85	94	95	SP CAT-02	
BH-19	SP-19	50	130	64	85	94	95	SP CAT-02	
BH-07	SP-07	50	145	71	95	105	105	SP CAT-03	Phase I
BH-25	SP-25	50	145	71	95	105	105	SP CAT-03	
BH-29	SP-29	50	145	71	95	105	105	SP CAT-03	
BH-31	SP-31	50	145	71	95	105	105	SP CAT-03	
BH-32	SP-32	50	145	71	95	105	105	SP CAT-03	
BH-30	SP-30	50	145	71	95	105	105	SP CAT-03	
	Total	**1,250**		**1,596**	**2,128**	**2,360**	**2,395**		

TABLE 3.8 POWER REQUIRED FOR BOREHOLES

S/N	Label	SP Q (l/s)	SP H (m)	N (kW)	N_{pump} (kW)	N_{motor} (kW)	Recom. N_{motor} (kW)	Category	Remark
Group-I									
BH-13	SP-13	50	130	64	85	94	95	SP CAT-02	Phase I
BH-16	SP-16	50	120	59	78	87	90	SP CAT-01	Phase I
BH-17	SP-17	50	120	59	78	87	90	SP CAT-01	Phase I
Total		**150**		**181**	**242**	**268**	**275**		
Group-II									
BH-04	SP-04	50	130	64	85	94	95	SP CAT-02	Phase I
BH-06	SP-06	50	130	64	85	94	95	SP CAT-02	Phase I
BH-07	SP-07	50	145	71	95	105	105	SP CAT-03	Phase I
Total		**150**		**198**	**264**	**293**	**295**		

3.6.4 STANDBY DIESEL GENERATORS FOR PHASE-I PROJECT

The main requirement for the standby power supply is to cover 67% of the water supply when the main power supply is interrupted. For this purpose, the operation of pumps has been conducted in categorizing into two groups in accordance with their spatial locations against the collector reservoirs. Thus one generating set has been designed for three pumps as shown in the above table. The rating will be assed by calculating and summarizing the probable single loads in the supply system. The starting current of the larger pump is added to the combined load instead of just the nominal current of this particular pump.

In the specifications, the minimum necessary rating of the diesel generating is stated. Different diesel suppliers have different standard units. The electrical Contractor shall quote for a diesel-generating unit rated equal or above the specified rating. A maximum voltage drop of 5% is used for the low voltage system design.

The diesel generating units shall be used when the main power supply from the national distribution grid fails. The diesel shall be manually initiated by activating the start push button. When the main power supply returns, a manual procedure shall be carried out for the switch back to normal operation. The circuit breaker for the diesel generating unit and the circuit breaker for the EEPCO incoming feeder shall be interlocked. The indicative power required for each Generating set for phase-1 is summarized in tables below. The detail design will be presented in the EM component.

TABLE 3.9 STANDBY GENERATORS FOR PHASE-I PROJECT

Standby DG required for Phase I Submersible Pumps

Design Data

T=	20^0C	η_{pump}	75%
g=	9.81	η_{motor}	90%
ρ=	998.20	η_{diesel}	85%
		cosϕ	0.8

BH No	Label	SP Q (l/s)	SP H (m)	N (kW)	N_{pump} (kW)	N_{motor} (kW)	Recom. N_{motor} (kW)	N_{diesel} (KVA)	Category
Group-I									
BH-13	SP-13	50	130	64	85	94	95		SP CAT-02
BH-16	SP-16	50	120	59	78	87	90		SP CAT-01
BH-17	SP-17	50	120	59	78	87	90		SP CAT-01
		150		**181**	**242**	**268**	**275**	**550**	100%
							185	**410**	**67%**
Group-II									
BH-04	SP-04	50	130	64	85	94	95		SP CAT-02
BH-06	SP-06	50	130	64	85	94	95		SP CAT-02
BH-07	SP-07	50	145	71	95	105	105		SP CAT-03
Total		**150**		**198**	**264**	**293**	**295**	**600**	100%
							200	**435**	**68%**

General layout of the well field with locations of standby Generator houses and plan of one of the generators house in conjunction with operators dwelling are shown in the figures below.

FIGURE 3.7 GENERAL LAYOUT OF THE WELL FIELD WITH LOCATIONS OF STANDBY GERATOR HOUSES

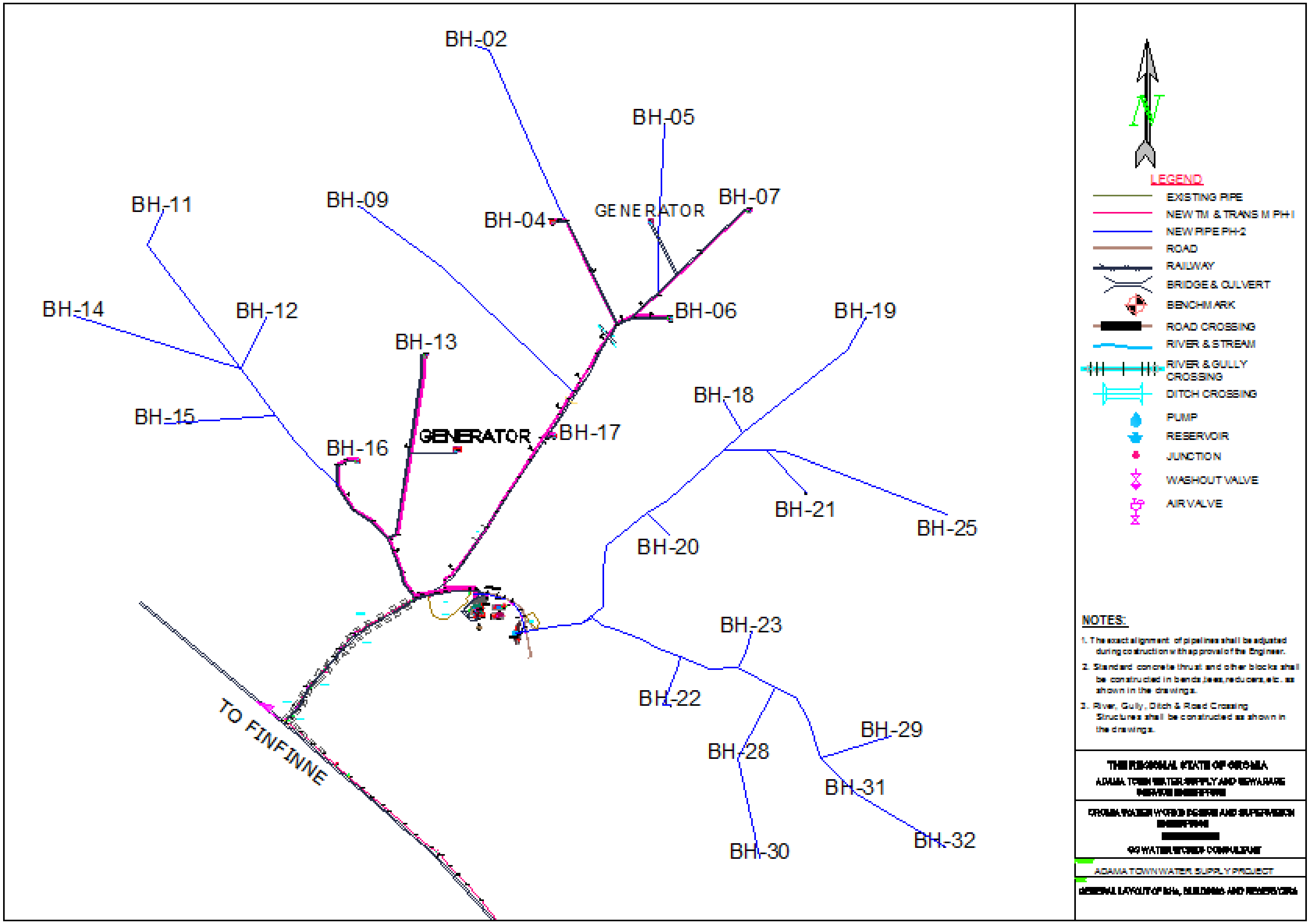
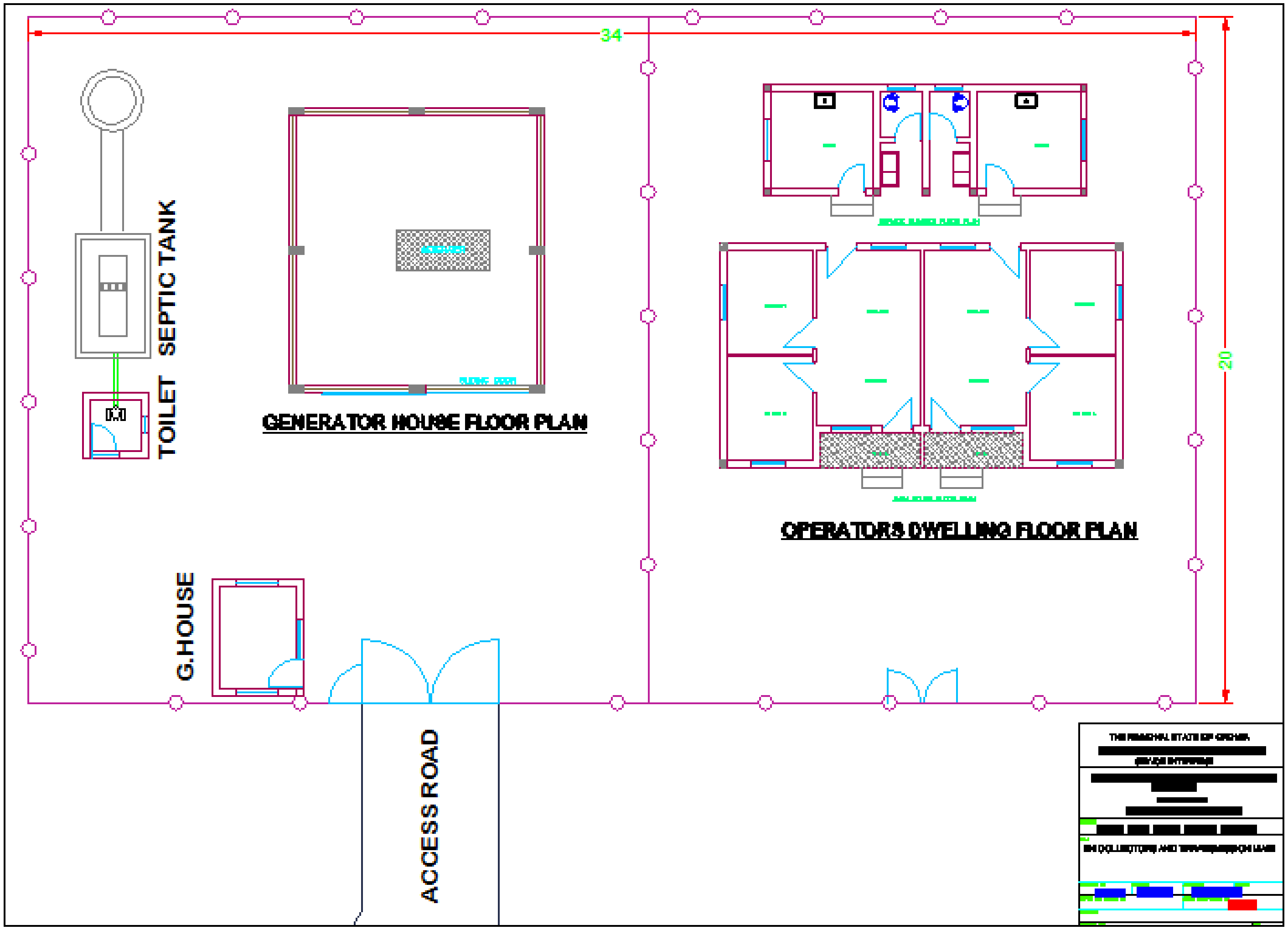


FIGURE 3.8 GENERAL LAYOUT OF STANDBY GERATOR WITH OPERATORS' DWELLING



3.6.5 PUMPING STATION PIPES AND FITTINGS

A) PUMP STATION PIPING

The internal pipe work of pump stations will be made of steel. The following design criteria will be followed in terms of velocities through the pipes:

1. Suction manifold: 1-2.0 m/s
2. Suction branch of pump: 1.2-2 m/s
3. Discharge branch of pump: 2-3 m/s
4. Discharge manifold: 2-3 m/s

B) PUMP STATION FITTINGS

The following types of fittings will be installed:

1. Valves: Full bore type, gate type (for diameters of up to 300 mm) or butterfly type (for diameters above 350 mm).
2. The valves will be manually actuated. Gate valves will be of flanged type, wedge type (without sealing), no rising stem. Butterfly valves will be flanged or wafer type, and they will include a worm gear type actuator.
3. Non-return valves: Full bore type, flanged type, swing or tilting type including externally protruded shaft.
4. Air valves: Flanged, double orifice type. Air valves will be of cast iron or bronze made, they shall be isolated using the same diameter (as the air valve) isolating gate valve.
5. Pressure gages: Mechanical, Bourdon type elastic element. They will be installed by means of three way cocks, enabling the drainage of the pressure gauge.
6. Flow meters: Mechanical turbine type, allowing the dismantling of the meter without the dismantling of the body for diameters up to DN 400 mm, and ultrasonic type for diameters above 400 mm.
7. Mechanical joints: Flanged type, of the following sub-types:
   - Suction pipes: not withstanding axial thrust (flange adaptors type or equivalent).
   - Discharge pipes: withstanding axial thrust (self restrained dismantling joint or equivalent).

All the accessories installed outside the pump station structure will be located in concrete open chambers provided with suitable access and drainage.

3.6.6 PROTECTION, CONTROL, AUTOMATION

The following protections will be provided:

1 Low level in the suction tank (level indicator/ transmitter).

2 Low pressure in the suction main (pressure switch on suction main), to protect the pumps against running dry.

3 High pressure in the rising main (pressure switch on discharge manifold), to stop the pumps when the float valve of the discharge tank has closed.

4 Low pressure in the rising main (pressure switch on discharge manifold), to stop the pumps when the rising main is broken.

5 Electric protections (including phase sequence, over/under voltage, over load, over heating, etc.).

3.6.7 AUXILIARY INSTALLATIONS

A) MONORAIL

A monorail will be installed in each pump stations' pump halls in order to enable easy installation /dismantling of the pump sets. The monorail will be installed over the centre of gravity of the pump + motor assembly. It will be designed at about 1.5 times the weight of the pump + motor assembly.

The monorail will have the following characteristics:

1 Trolley: Manual, actuated by chain, operated from the pump station floor, traveling on I beam profile.

2 Hoist (chain block): Manual, actuated by chain, operated from the pump station floor.

B) BULK DIESEL FUEL TANK

The bulk fuel tank will be required if standby by generators are proposed by the client. It will include:

1 Bulk diesel fuel tank.

2 Piping and ancillaries.

C) SURGE ARRESTORS

Surge arrestors will be designed for each high lift pumping station to control the pressure waves to be created in the pipeline during shutoff of pumps and valves.

3.7 TRANSMISSION MAIN

The Transmission main transports water from the collector reservoirs located at Biyo hill of ground elevation of 1900masl to the Transfer Reservoir located west of Adama town at ground elevation of 1800masl by flow of gravity.

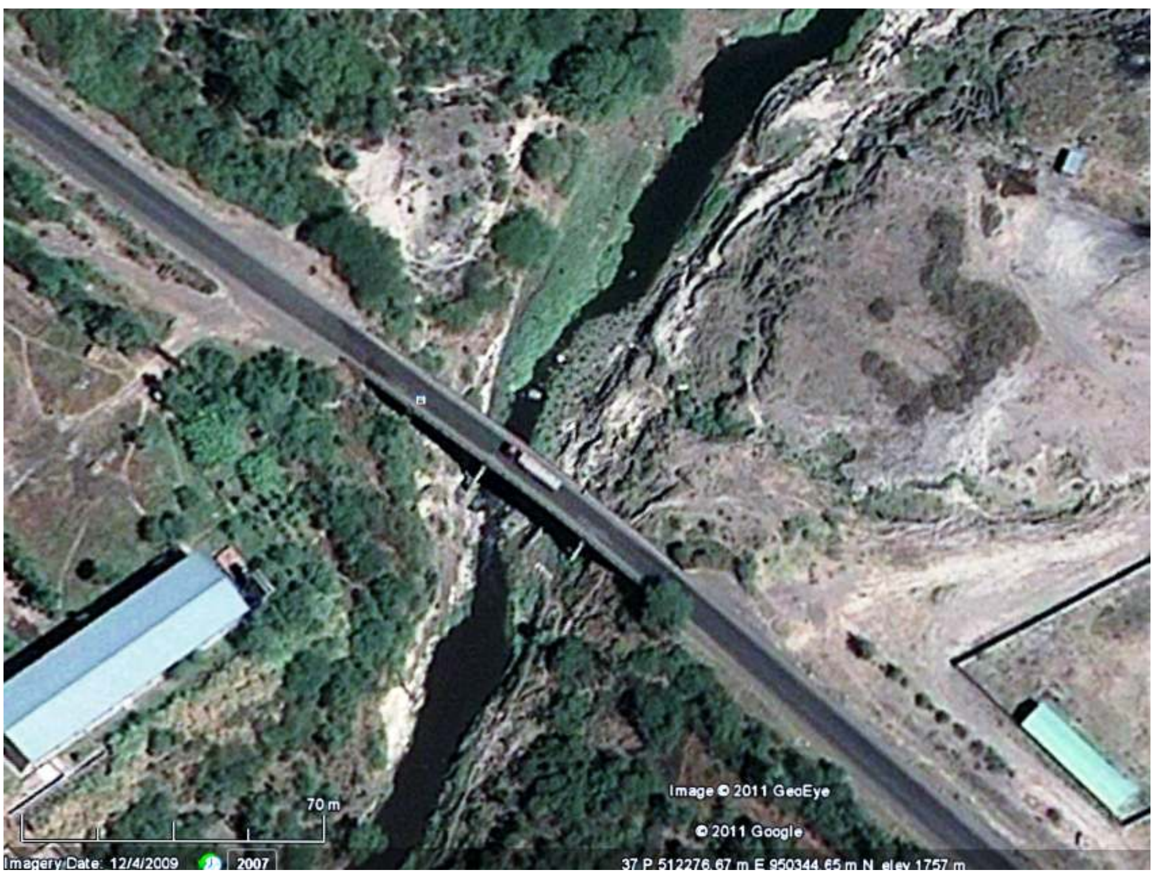
While conducting the surveying work of transmission main

The transmission main is proposed to be implemented during Phase I in order to reduce the costs required for laying parallel lines during phase II. It has a total length of 24.5km and aligned along the main asphalt road as shown in Figure 3.1.

The Transmission Main has been designed for flow capacities of second phase demand (Year 2035) which is estimated to be 1,250 l/s.

A big structure is required for crossing of Mojo River as shown in Figure below. Details of the crossings will be presented in the final design of the project.

FIGURE 3.9 LINE OF CROSSING STRUCTURE ALONG MOJO RIVER BRIDGE



Traffic jamming on the main asphalt road has been accounted in the design of TM

Selection of alternative routes while conducting the surveying work

So many crossing alternatives have been assessed for selecting the best route exclusively on Mojo River.

Analysis of hydraulic conditions of the transmission main has been conducted for sizing of pipes for the second phase water demands. A pressure along the pipe main is governed by hydraulic grade of Biyo collector Reservoirs which is 1900masl.

The detail hydraulic analysis results are annexed to this report while summaries are presented below in a table, brief paragraphs and Bullets.

TABLE 3.10 DESIGN SUMMARY OF TRANSMISSION MAIN FROM MOJO WF TO ADAMA

Description	L (m)	DN (mm)	Q (l/s)	V (m/s)	HL (m)	HL Grdnt (m/km)	Matrl	PN (Bar)
Transmission Main from Mojo Wellfield to Adama Sire Ababune Reservoir	75	800	650	1.3	0.1	1.7	DI	K9
	24435	1000	1250	1.3	29.2	1.2	DI	K9
	24510				**29.3**			

Accordingly the following results are noted.

- The maximum design capacity of the transmission main is 1,250 l/s and a little bit greater than the water demand of Phase II (1,225 l/s).
- The minimum and maximum pressures are occurred where the pipe crosses the highest and lowest ground levels.
- Minimum values
  - 10mH_2O at chain age T-0+383, ground level 1885masl
  - 11.7mH_2O at chain age T-0+500, ground level 1880masl
  - 12.2mH_2O at chain age T-17+540, ground level 1860masl
- Maximum values
  - 151.8mH_2O at chain age T-24+668, ground level 1711.7masl
  - 151.2mH_2O at chain age T-24+763, ground level 1712.2masl
- The Velocity of the transmission main is 1.3m/s. The total head loss is 29.2m with hydraulic gradient of 1.2m/km.

It can be concluded from the above results that all hydraulic parameters of the transmission main are within the acceptable limit of the design criteria. Taking into account these hydraulic conditions, pipes of the mains are sized to DN 1,000mm to safely transport the required Phase II design flows. The total pipe required for the transmission main is around **24.5**km.

3.8 PHASE I PIPES REQUIRED FOR BH COLLECTORS AND TRANSMISSION MAIN

The selected pipe materials, sizes (diameters), quantity and pressure classes required for borehole collectors and transmission main for the phase I is summarized in Table below.

TABLE 3.11 PHASE I PIPES REQUIRED FOR BH COLLECTORS AND TRANSMISSION MAIN

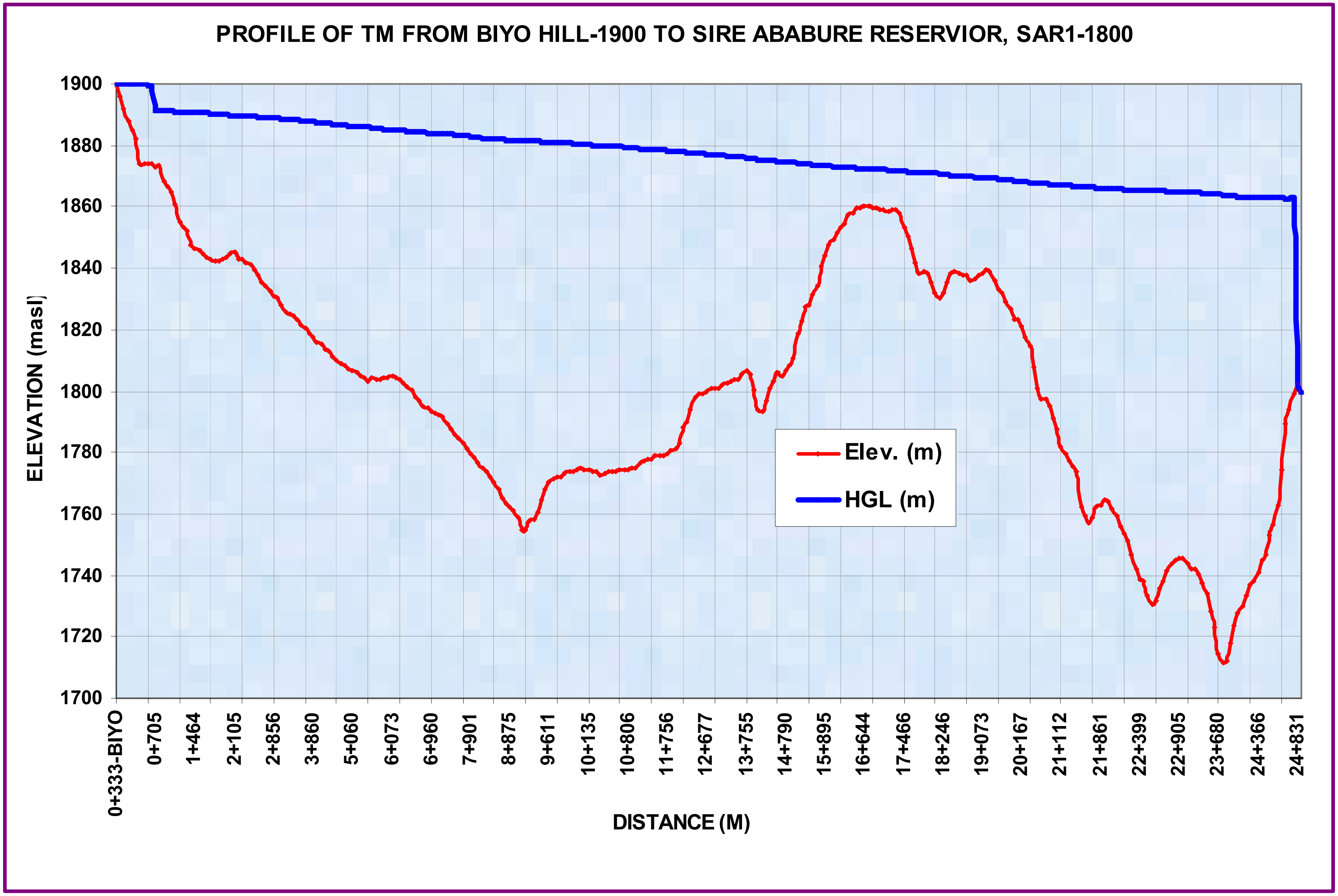
ITEM	DESCRIPTION	UNIT	QTY
TM-1.1	DUCTILE IRON PIPES		
TM1.1.1	DI Standard Socketed Pressure Pipes DN 1000 mm, Class K9, 6m Length with all laying accessories	m	25,670
TM1.1.2	Ditto, but DN 800 mm	m	60
TM1.1.3	Ditto, but DN 500 mm	m	3,180
TM1.1.4	Ditto, but DN 400 mm	m	110
TM1.1.5	Ditto, but DN 300 mm	m	790
TM1.1.6	Ditto, but DN 200 mm	m	2,250
	Total of DI Pipes		**32,060**

3.8.1 PROFILE OF THE TRANSMISSION MAIN

The transmission main has been profiled at an average trench depth of 1.2 m, with a maximum grade of approx. 30 %. Washouts and air valves have been provided where required along the pipeline's length.

Profile of the Main has been shown in Figure 3.4 below. More detailed drawings will be presented in the detail design stage of the project.

FIGURE 3.10 PROFILE OF THE TRANSMISSION MAIN

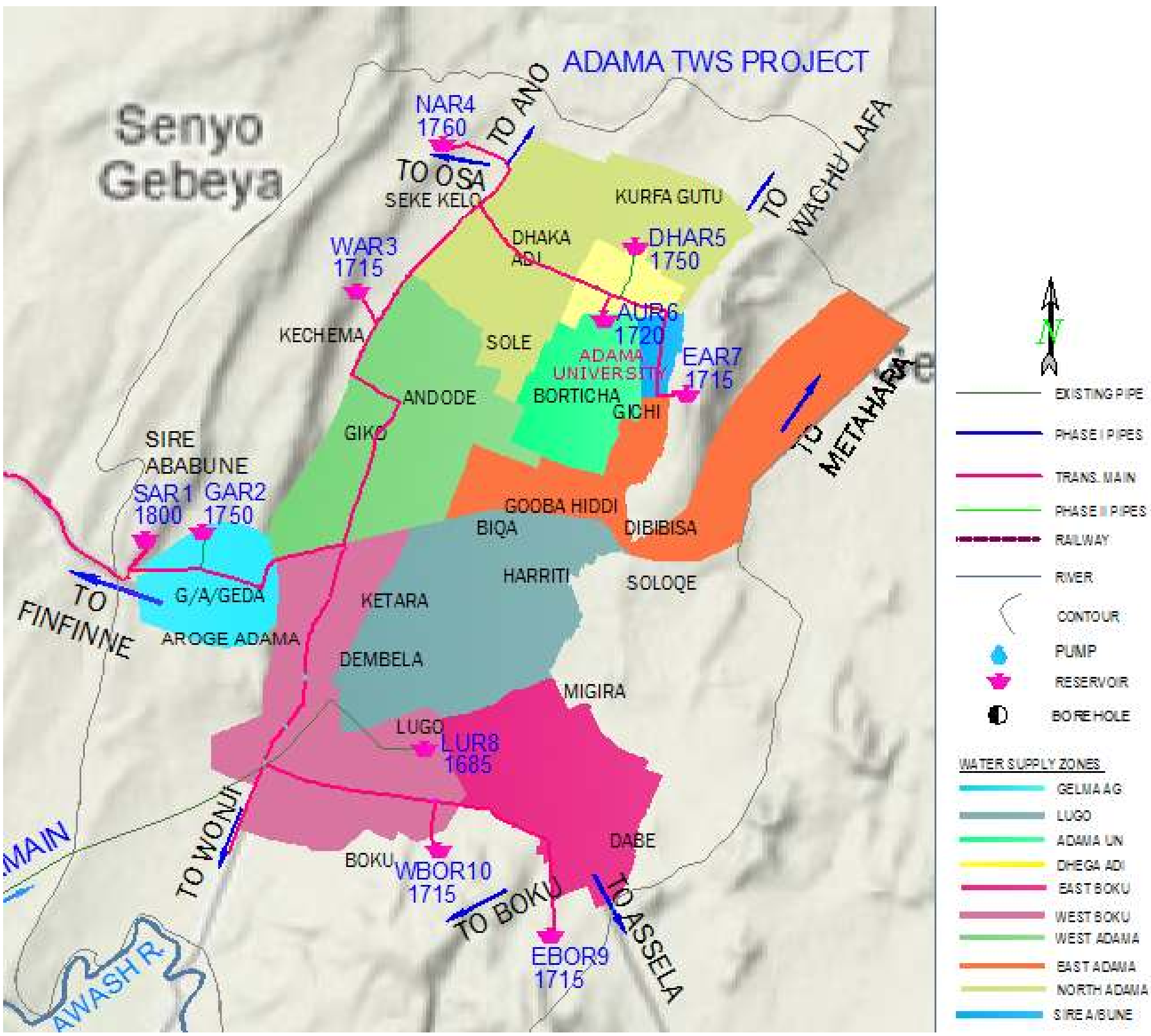


3.9 TRANSFER MAIN

3.9.1 ALIGNMENT OF TRANSFER MAIN

The transfer main, although it may have a small or no number of service connections on it, it is used to transfer/distribute the majority of flow among storage reservoirs. Hence the transfer mains are designed to transfer maximum day demand of water from Sire Ababune Reservoir to the 10 (ten) service reservoirs located on the West, North, East and Southern sides of Adama town via the two transfer mains. In accordance with their alignment and functions, the two mains are designated as Adama North-East and South-East Transfer Mains respectively as shown in Figure below.

FIGURE 3.11 GENERAL LAYOUT OF THE TRANSFER SYSTEM



The transfer mains are proposed to be implemented during Phase I in order to reduce the costs required for laying parallel lines during phase II. Their total length is about 30km and aligned along the main asphalt roads of Adama town. They have been designed for flow capacities of second phase demand (Year 2035) which is estimated to be 1,250 l/s.

A lot of crossing structures are required for crossing gullies formed in and around the periphery of Adama town. These details of the crossings will be presented in the drawing album of the Tender Document.

3.9.2 HYDRAULIC ANALYSIS OF TRANSFER MAINS

Hydraulic analysis is carried out to evaluate the hydraulic behaviors of the system. This task requires iterative processes of resizing of water supply components and reanalysis of the outputs until the results of hydraulic parameters such as discharge, velocity and pressure values will meet the required criteria.

The detail hydraulic analysis results are annexed to this report while summaries are presented below in brief paragraphs and Bullets. Only the critical hydraulic results have been presented. These are the results of minimum and maximum pressures along the mains.

Accordingly the following results are noted.

- The maximum design capacity of the transfer main is 1,250 l/s of which
  - 700 l/s of Phase II demand will be transferred to the North-East of Adama Town
  - 550 l/s of Phase II demand will be transferred to the South-East of Adama Town
- The minimum node pressures of 1-10 mH2O are occurred around the out let of Sire Ababure Reservoir. These lower pressures are occurred due to the close proximity of nodes to the reservoir. Nevertheless, the rest node pressures will meet the requirements.
- The maximum node pressures of 160- 197 mH2O are occurred where the pipline crosses the lowest areas of the town.
- The breaking/reducing of these higher pressures require installation of booster pumping station
- Velocities are ranging from 1.1 m/s to 1.6 m/s. which is within the acceptable limits.

Taking into account these hydraulic conditions, pipes of the transfer main are sized from 300 mm to 1,000 mm to safely transport the required design flows

3.9.3 PIPES REQUIRED FOR TRANSFER MAINS

The selected pipe materials, sizes (diameters), quantity and pressure classes required for the transfer main is summarized in Table below.

TABLE 3.12 SUMMARY OF PIPES REQUIRED FOR TRANSFER MAINS

ITEM	DESCRIPTION	UNIT	QTY
TR-2.1	**DUCTILE IRON PIPES**		
TR2.1.1	DI Standard Socketed Pressure Pipes DN 1000 mm, Class K9, 6m Length with all laying accessories	m	4,200
TR2.1.2	Ditto, but DN 800 mm	m	4,230
TR2.1.3	Ditto, but DN 700 mm	m	6,270
TR2.1.4	Ditto, but DN 600 mm	m	2,760
TR2.1.5	Ditto, but DN 500 mm	m	5,790
TR2.1.6	Ditto, but DN 400 mm	m	3,470
TR2.1.7	Ditto, but DN 350 mm	m	2,620
TR2.1.8	Ditto, but DN 300 mm	m	490
TR2.1.8	Ditto, but DN 200 mm	m	590
	Total of DI Pipes		**30,420**

3.9.4 PROFILE OF THE TRANSFER MAINS

The transmission main has been profiled at average trench depths from 1.2m to 1.5m, with a maximum grade of approx. 30 %. Washouts and air valves have been provided where required along the pipeline's length.

Profile of the Main has been shown in Figure below. More detailed drawings will be presented in the drawing album of the Tender Document.

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FIGURE 3.12 ADAMA NORTH-EAST TRANSFER MAIN PROFILE

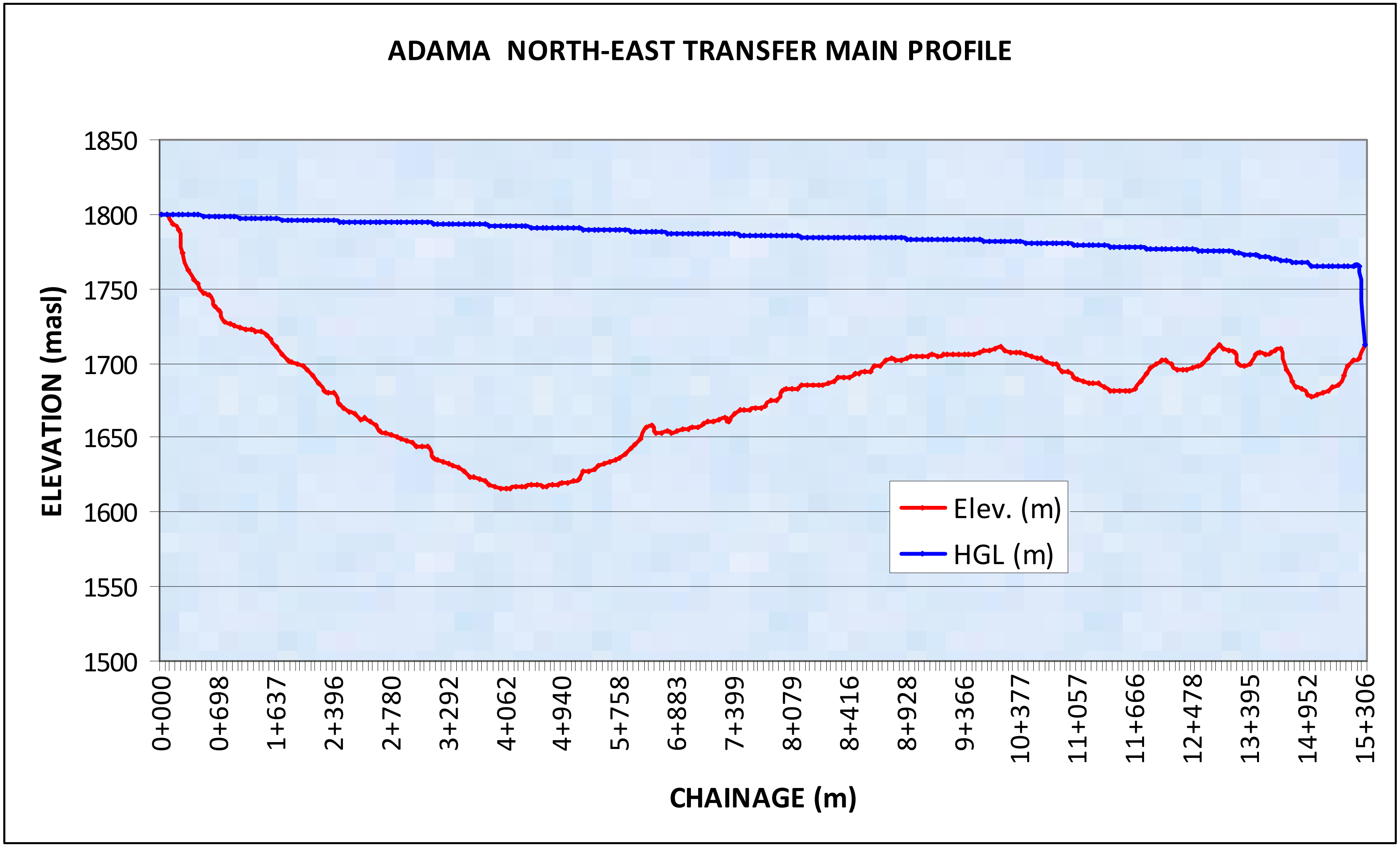
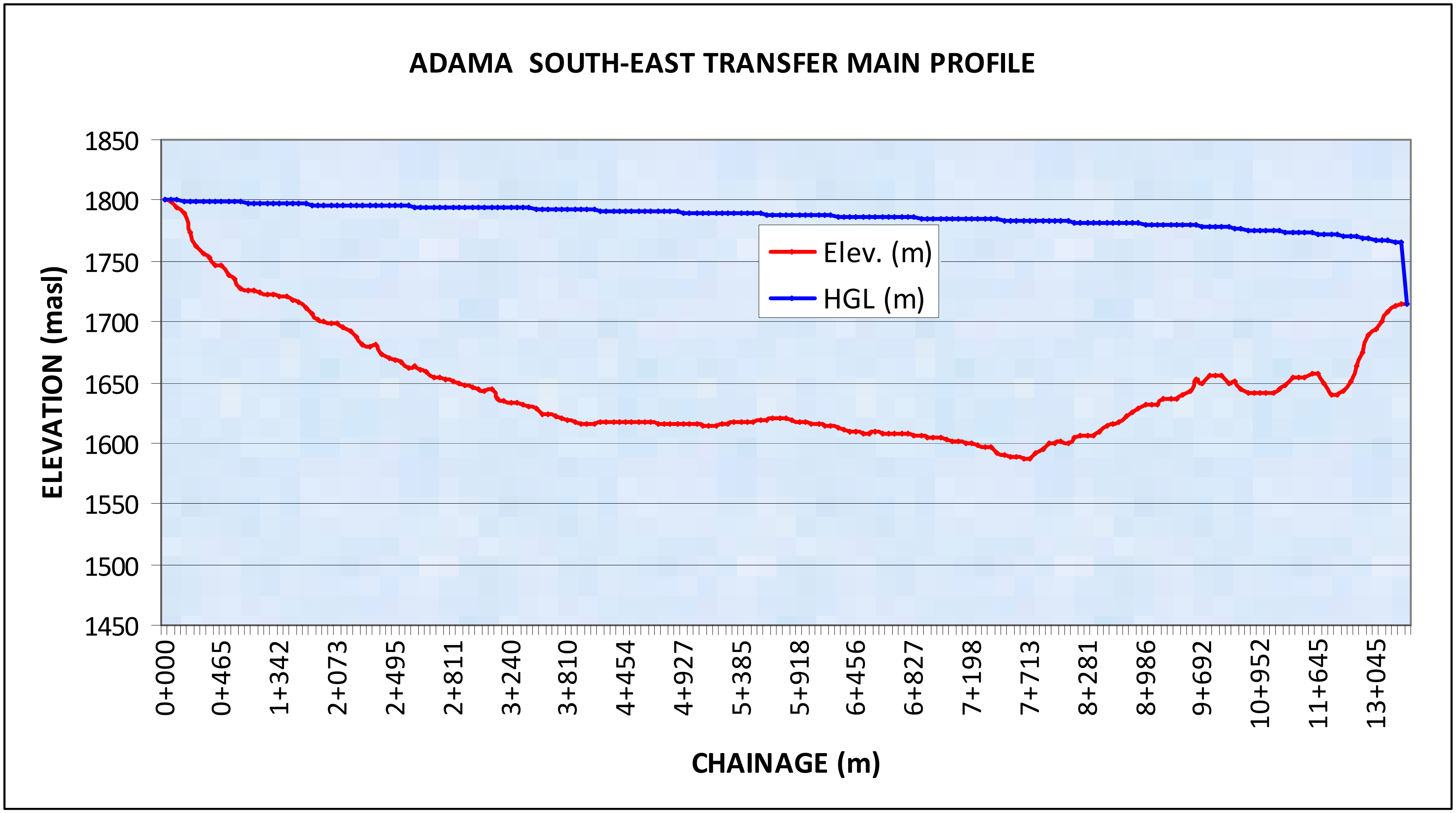


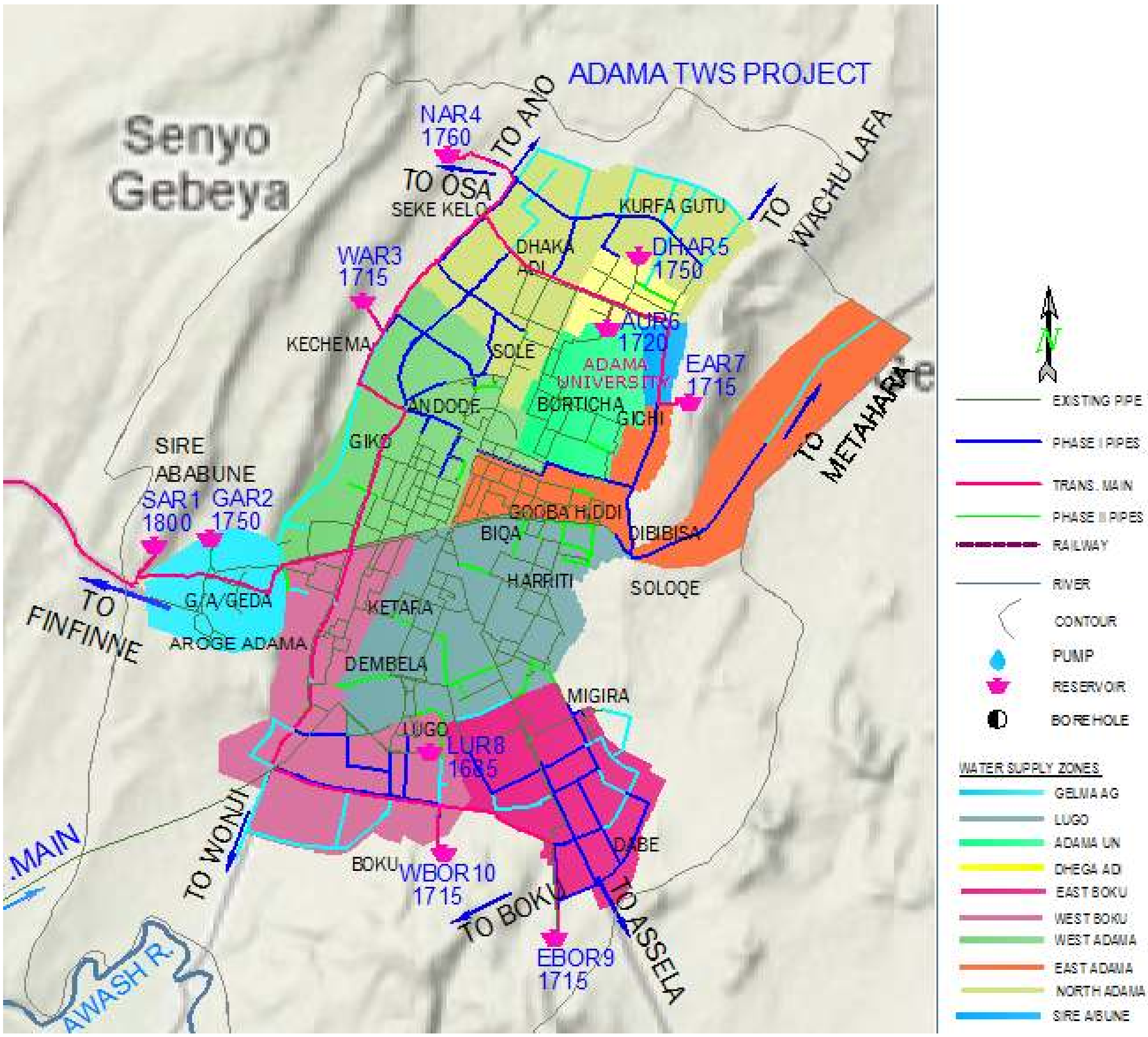
FIGURE 3.13 ADAMA SOUTH-EAST TRANSFER MAIN PROFILE



CHAPTER 4 WATER STORAGE AND DSTRIBUTION

4.1 GENERAL DESCRIPTION

The water from Biyo hill of RBI-1900 will be conveyed by a Gravity Main of length 24.36km to a Transfer Reservoir located on Sire Ababune Mountain, at ground level of 1800masl. The gravity pipe has a nominal diameter of 1,000mm and designed to transport 1,250 l/s of the deficit maximum day demand of Phase II.



The two transfer mains will transfer water from Sire Ababune Reservoir to the 10 (ten) service reservoirs located on the West, North, East and Southern sides of Adama town via the two transfer mains.

The 10 service reservoirs are designed to distribute about 2,080 l/s of the total Peak Hour Demand of Phase II to Adama Town, through respective 10 distribution networks by flow of gravity.

Consequently, the water Storage and distribution system includes the following two significant components.

1. Service reservoirs which are used for balancing the variable demands of the town.
2. The distribution network which distributes water to costumers through its primary, secondary and tertiary components with a flow of gravity.

4.2 IMPROVEMENTS MADE IN THE WATER SUPPLY SERVICE

It is envisaged that the recommendations made to improve the existing system together with the design of expansion project will significantly boost the water supply service of Adama town. The conceptual planning and design, and the construction document to be prepared as Volume 5 will assist the client and all stakeholders to decide on most suitable and practical methods sustainable water supply development.

In general, the improvements have been made in the design of existing and new water supply projects will be outlines as follows.

A) THE EXISTING SYSTEM

20. Improved data base has been established to be used for

- Planning, designing, rehabilitation and expansion
- Operation and maintenance
- Leakage controlling and management
- Geographical Information System (GIS)

21. Basic problems of the existing system have been identified, recommendations and guidelines have been prepared for immediate improvement and rehabilitation project (IIRP) to sustain the existing town water supply service for the coming ten years through maintenance, rehabilitation and improvement works of the existing water supply components. These IIRP includes

- Rehabilitation of Electro Mechanical Equipment
- Rehabilitation of Civil Works Component

- Water Loss Reduction Program
- Institutional Development
- Water Resources Protection Program

B) THE DESIGN OF NEW SYSTEM

22. It covers the fast growing water demands of **917,200** populations up to year 2035 which includes the following.

- Population Residing in Adama
- The recently merged Rural and Floating Population
- Population of Adama University and all other educational services
- Population Residing in Wonji

23. It covers the water demands of the existing and growing Public and Commercial Sectors
24. Encompasses around 542 existing small, medium and large Industries and those industries future planed industries for which 685 ha of land or 15% of the Master Plan have been reserved.
25. Included, urban farms which are being expanded in a large scale.
26. Accounted the recently built infrastructures, particularly, Gelma Aba Geda and Memorial Monument as well as surroundings other organizations.
27. Substantial reduction of operations costs by avoiding all booster pumping stations.
28. Customers complaining of unbalanced water distribution have been reduced through careful and decentralized designs of service reservoirs. This complains have been arisen from topographic configuration of the town since natural topography of Adama varies from ground elevations of 1,595 to 1,740 masl.
29. Coverage of the existing distribution system has been increased from 50% (2575 ha) to 100% (5018 ha) i.e. the master plan area of Adama town.

4.3 SYSTEM CONFIGURATIONS

4.3.1 COMPUTER MODELING

The arrangement of basic project data and corresponding modeling elements have been outlined as follows

WaterCAD is an extremely efficient tool for laying out a water distribution network. It is easy to prepare a schematic or scaled model and let WaterCAD take care of the link node connectivity.

The **WaterCAD FOR AutoCAD 2005 VERSION 6.5** has been employed for accuracy and efficiency of design works. This standard computer program has been established taking into account its significant future use by AWSSSE.

WATERCAD

AutoCAD DESIGN SOFTWARE

AutoCAD Design Software Version 2006 has been used for preparation of data for WaterCAD model and production of design drawings.

Satellite images have also been downloaded by Google earth for verification of the oldest roads where discrepancies are encountered between the existing and the oldest ones of the master plans.

TOPOGRAPHIC MAP

Soft copies of Topographical Map of the project area that shows the natural and manmade physical features such as lakes, rivers, plain lands, mountains, roads, telecommunication and power line networks has been utilized for assisting the modeling of WaterCAD Software.

ArcView GIS

Arcview GIS will be employed for extracting geographical data such as location map, master plan of the town that shows Road Plans, Residential Quarters, Industrial Areas, Commercial and Public Institution Areas, Green areas, boundaries of, Anas and Gendas with respective land sizes.

All locations of water system elements are exported from Excel to Global Mapper software for extracting contours and respective ground elevations of elements. Importing ground elevations the water system elements from global Mapper to Excel is followed for data base creation.

4.3.2 LAYOUTS OF WATER SYSTEM COMPONENTS

The procedure for computer modelling and water distribution schematization has already been presented in Volume III, Existing Water Supply System Evaluation Report. However, brief summary of the approach has been presented below to include the new expansion of system components.

1. Locations and Layouts of existing water system elements such as pipes, reservoirs, pumping stations and demand nodes are approximately drawn on the Master Plan Roads of the town using the latest version of AutoCAD Design Software.
2. The new network pipes are laid following the roads of the master plan where simply accessible for operation and maintenance.
3. Satellite images have also been downloaded by Google earth for verification of the oldest roads where discrepancies are encountered between the existing and the oldest ones of the master plans.
4. Following the locations of demand nodes, the water demand requirements have been estimated using the density of population and the average area which encloses that node.
5. Those created exisitng water supply elements have been changed to blocks and attributes for easy transfer of them to Microsoft Excel which is a base for data storage of the design software, WaterCAD. Next, attribute extraction and exporting to Excel are conducted.
6. For new water sytem objects created by AutoCAD, no need of making blocks, instead they are drictly changed to WaterCAD elements.
7. All locations of water system elements are exported from Excel to Global Mapper software for extracting contours and respective ground elevations of elements.
8. Importing ground elevations of the water system elements from global Mapper to Excel is the last step of data base creation.

Furthermore, as mentioned earlier, customers complaining of unbalanced water distribution have been reduced through careful and decentralized designs of service reservoirs. In order to meet this objective of design, the distribution system has been divided into 10 (ten) pressure zones.

The network configuration is a combination of both branched and looped type. However a looped system is dominating due to the convenient plan of the town.

Each distribution zone is commanded by respective reservoirs, as presented below in Figure 4.2 and Table 4.1.

FIGURE 4.1 LAYOUTS OF WATER DISTRIBUTION ZONES

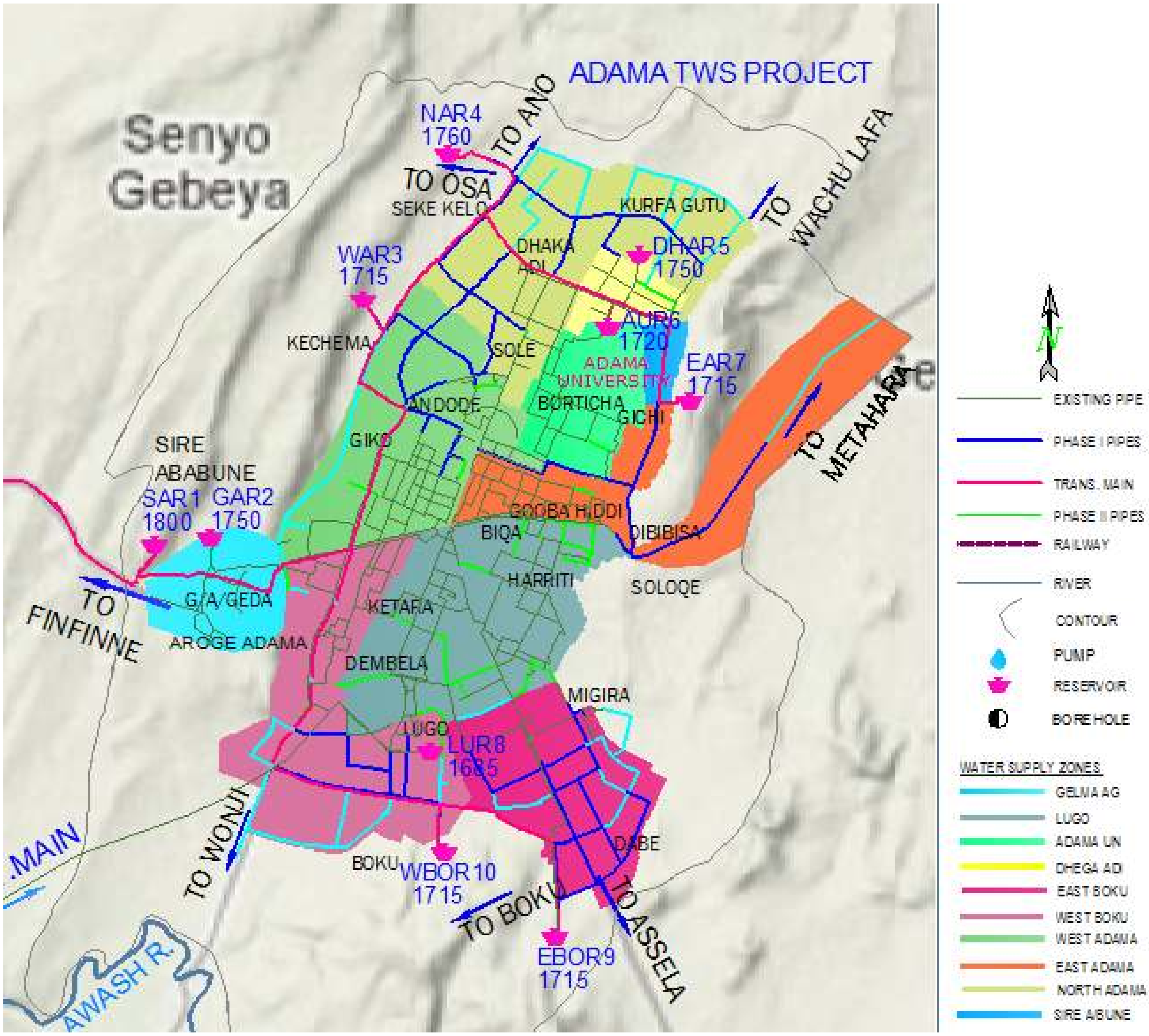


TABLE 4.1 THE TEN (10) WATER DISTRIBUTION ZONES

ID	SUPPLY ZONE	ELEVATION (MASL)	REMARKS
SAR1-1800	Sire Ababune	1800	New
GAR2-1750	Gelma Aba Geda	1750	Existing
WAR3-1715	Western Adama	1715	New
NAR4-1760	Northern Adama	1760	New
DHAR5-1750	Dhega Adi	1750	Under Construction
AUR6-1720	Adama University	1720	Existing
EAR7-1715	Eastern Adama	1715	New
LUR8-1685	Lugo	1685	Existing
EBOR9-1715	Eastern Boku	1715	Under Construction
WBOR10-1715	Western Boku	1715	New
Total	**10**		

4.3.3 SPATIAL DISTRIBUTION OF POPULATION AND WATER DEMANDS

As mentioned in the foregoing procedures, the water demand data which has been estimated in Volume-I, Chapter 4 has been spatially distributed in accordance with the master plan of the town and density of population. Either the average or maximum day demand of those areas could be used when modeling demand points. In this case the maximum day demands have been used.

The population and water demand distribution has been done for existing and newly expanded areas. The results are summarized and presented by each zone as shown in table below.

TABLE 4.2 SPATIAL DISTRIBUTION OF POPULATION AND WATER DEMANDS

Supply Zone	Adjusted Area (ha)	Population		Water Demand (l/s)	
		Phase I (2025)	Phase II (2035)	Phase I (2025)	Phase II (2035)
SAR1-1800	41	5,000	7,100	6	11
GAR2-1750	110	13,300	18,800	16	30
WAR3-1715	665	79,900	113,200	109	206
NAR4-1760	783	94,100	133,300	120	225
DHAR5-1750	136	16,400	23,200	20	38
AUR6-1720	197	23,600	33,500	50	84
EAR7-1715	381	45,800	64,900	56	105
LUR8-1685	872	104,800	148,500	129	242
EBOR9-1715	524	63,000	89,200	83	156
WBOR10-1715	578	69,500	98,400	107	203
Total	**4,288**	**515,400**	**730,100**	**697**	**1,299**

4.4 RESERVOIRS

4.4.1 SIZING OF RESERVOIRS

Reservoirs are categorized into transfer and service reservoirs. Accordingly each kind of reservoir is designed in accordance with the design criteria as follows:

A) TRANSFER RESERVOIRS

- Transfer reservoirs that are used for pumping station will be sized based on 1 hour detention time of maximum day demand.
- Reservoirs that provide transfer via gravity (break pressure tanks), if necessary, will be sized for 1 hour detention time of the maximum day demand.

B) SERVICE RESERVOIRS (TANKS)

- Service reservoirs are located at higher ground elevations where water will be distributed to target communities with flow of gravity. By doing so, the need of booster pump stations will have been avoided from the commissioning of this project.
- The storage volume required for service reservoirs have to be large enough to accommodate the cumulative differences between water supply and demands plus provision for emergency cases such as fire fighting, power interruptions and repair works.
- Capacities are thus determined by calculating one third of maximum day demand plus 10% reserve.

C) MULTIPURPOSE RESERVOIRS

Those reservoirs which have dual purposes i.e. transferred and service functions shall be sized by adding the requirements of both transfer and service capacities.

D) STANDARDIZATION

Standardization principle has been established in sizing of reservoirs without affecting the storage requirements. This principle is significant for the following major purposes.

- Planning and expansions/duplications of similar reservoirs which will reduce efforts required for preparation of design, drawing, specification and bill of quantities for various sizes.
- Procurement and utilization of equipment
- Operation and maintenance s

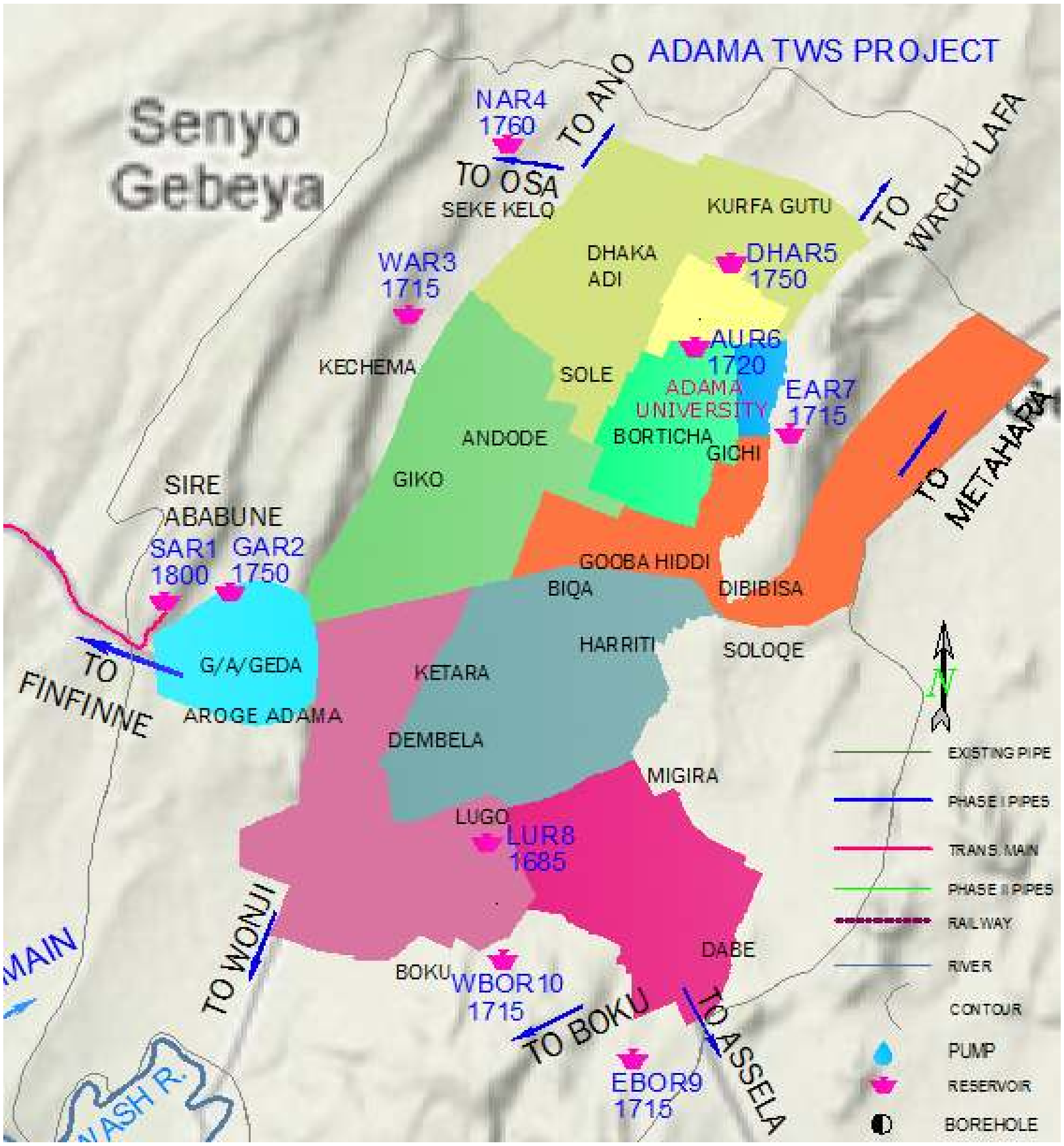
Taking into account these requirements, capacities of reservoirs are calculated and summarized in Table Below. Furthermore, the locations of reservoirs are shown below in Figure 4.2, next to the summary Table.

TABLE 4.3 SUMMARY OF DESIGN CAPACITIES OF RESERVOIRS

Transfer Reservoir	Transfer Rate (l/s)		1 Hour Transfer Storage (m^3)	
	Phase I (2025)	Phase II (2035)	Phase I (2025)	Phase II (2035)
SAR1-1800	600	1250	2160	4500

Supply Zone	1/3*MDD (m^3/d)		1/3*MDD *1.1 (m^3)		Total Required (m^3)	(m^3)	Implementation Proposal (m^3)	
	Phase I (2025)	Phase II (2035)	Phase I (2025)	Phase II (2035)	Phase II (2035)	Existing	Phase I (2025)	Phase II (2035)
SAR1-1800	176	329	2353	4862	5,000	0	2,500	2,500
GAR2-1750	468	878	515	965	1,000	200	1000	0
WAR3-1715	3149	5921	3464	6513	6,500	0	3,500	3,500
NAR4-1760	3447	6468	3792	7115	7,000	0	3,500	3,500
DHAR5-1750	578	1084	636	1192	1,500	1,000	0	500
AUR6-1720	1441	2410	1585	2651	2,500	1,000	500	1,000
EAR7-1715	1617	3030	1779	3333	3,500	0	2,000	2,000
LUR8-1685	3715	6963	4086	7659	7,500	6,000	0	1,500
EBOR9-1715	2393	4494	2632	4943	5,000	500	2,000	2,000
WBOR10-1715	3094	5837	3404	6420	6,500	0	3,500	3,500
Total	**20,079**	**37,413**	**24,247**	**45,655**	**46,000**	**8,700**	**18,500**	**20,000**

FIGURE 4.2 LOCATIONS OF RESERVOIRS



4.4.2 PROPOSED RESERVOIRS FOR PHASE I

To reduce high investment costs required for the 1st phase, implementation priorities have given for those newly proposed sites and for existing sites which have the lowest capacities to maintain the diurnal fluctuation of demands (Table 4.4). The other reservoirs are proposed to be constructed in stage of 5 years in accordance with the demand.

TABLE 4.4 PROPOSED RESERVOIRS TO BE IMPLEMNTED DURING PHASE I

S/N	DESCRIPTION	CAPACITY (m^3)
1	BIYO WF COLLECTER RESERVOIR	2500
2	SA R-01 SIRE ABABUNE TRANSFER RESERVOIR	2500
3	WA R-03 WEST ADAMA RESERVOIR	3500
4	NA R-04 NORTH ADAMA RESERVOIR	3500
5	EA R-07 EAST ADAMA RESERVOIR	2000
6	WB R-10 WEST BOKU RESERVOIR	3500
7	GA R-02 GELMA A/GEDA RESERVOIR	1000

4.5 DISTRIBUTION NETWORK

4.5.1 BRIEF SUMMARY OF THE DESIGN

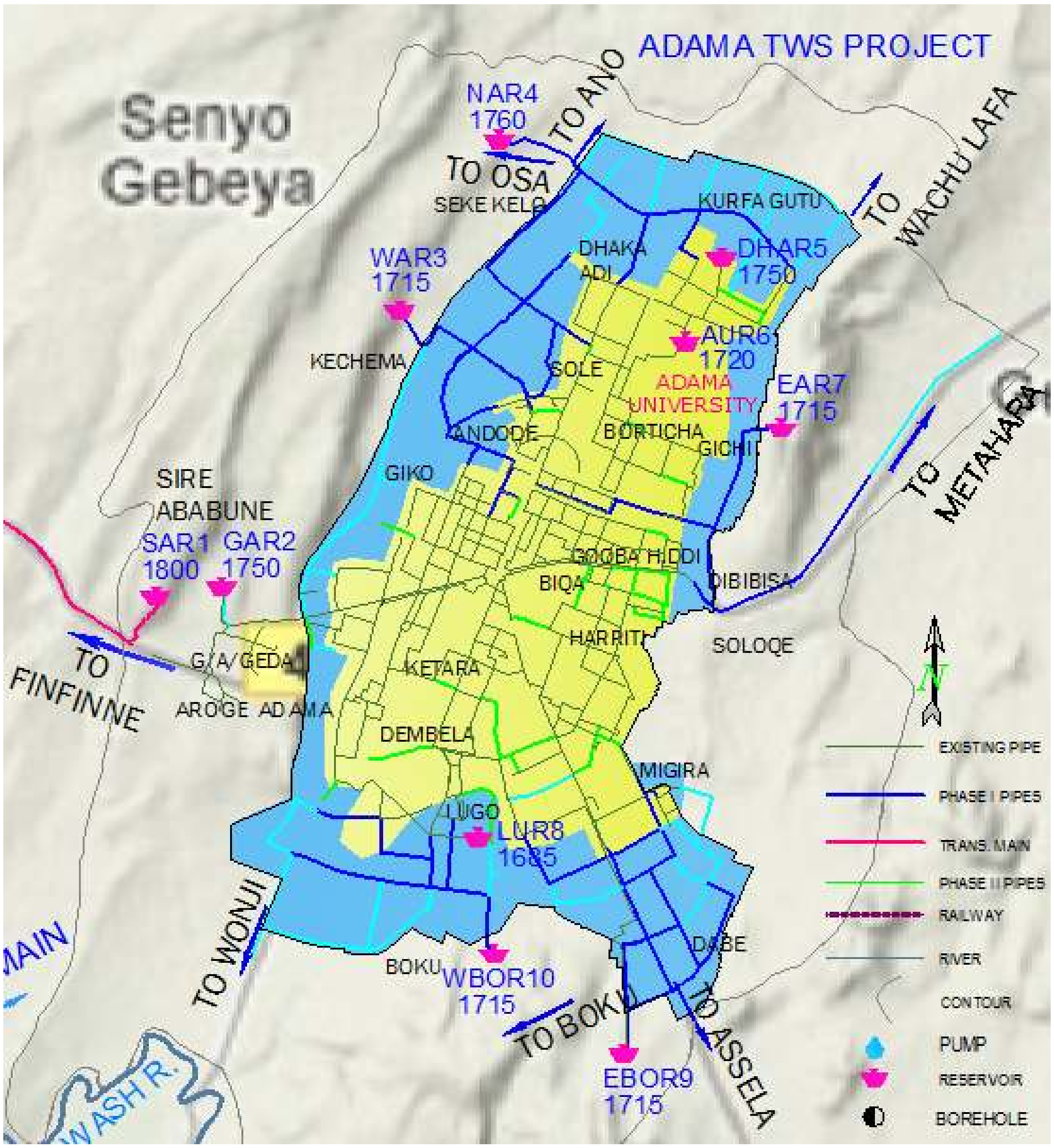
The design of distribution network has been based on the following criteria.

- The distribution network should have a capacity to distribute the peak hour water demands of customers with maintaining a minimum pressure of 10 to 15m. However, in exceptional cases, depending on the topography of the area, lower pressure levels may be permitted, but not less than 7.5 m.
- The distribution network should reliably withstand the hydraulic grade of service reservoir, particularly during minimum flow conditions and when the static pressure would be dominant.
- Pipe pressure classes are chosen for the maximum pressure head that may occur under no or minimum consumption condition which is set at nil or 10 percent of the average day demand and the service reservoir at maximum water level.
- Pipelines in the distribution system shall withstand a maximum operating pressure of 160m manometeric head and hence locally manufactured uPVC pipes of pressure class of PN 10 and PN 16 have been used as much as possible However, in exceptional cases, DI/Steel pipes are used where the breaking/reducing of such highest pressures require installation of booster pumping stations and where the pipe lines require crossing of specific low lying valleys s.
- The choice for uPVC PN10 and PN16 are justified for the following reasons;
  - The pipes have higher mechanical strength and are less sensitive to improper soil compaction.
  - Also, the advantage of a standardized pressure class for valves and fittings will eliminate the confusion of flange joints with different bore diameters for different pressure classes.

4.5.2 COVERAGE OF THE NEW DISTRIBUTION NETWORK

Coverage of the existing distribution system has been increased from 50% (2575 ha) to 100% (5018 ha) i.e. the master plan area of Adama town as shown in Figure below. The yellow painted central part of the town represents the existing system whereas the light blue one shows the coverage of the new system.

FIGURE 4.3 EXISTING AND EXPANDED AREAS OF DISTRIBUTION NETWORK



4.5.3 DESIGN CAPACITY OF DISTRIBUTION NETWORK

Each network of distribution zone has been designed for the peak hour demands of phase II which is shown in the last column of Table below. The peak hour demand is 1.6 times the maximum day demand.

TABLE 4.5 DESIGN CAPACITIES OF DISTRIBUTION NETWORK

Supply Zone	MDD (l/s)		PHD=1.6*MDD (l/s)	
	Phase I (2025)	Phase II (2035)	Phase I (2025)	
SAR1-1800	6	11	10	18
GAR2-1750	16	30	26	49
WAR3-1715	109	206	175	329
NAR4-1760	120	225	192	359
DHAR5-1750	20	38	32	60
AUR6-1720	50	84	80	134
EAR7-1715	56	105	90	168
LUR8-1685	129	242	206	387
EBOR9-1715	83	156	133	250
WBOR10-1715	107	203	172	324
Total	**697**	**1,299**	**1,115**	**2,079**

4.5.4 HYDRAULIC ANALYSIS AND PRESENTATION OF RESULTS

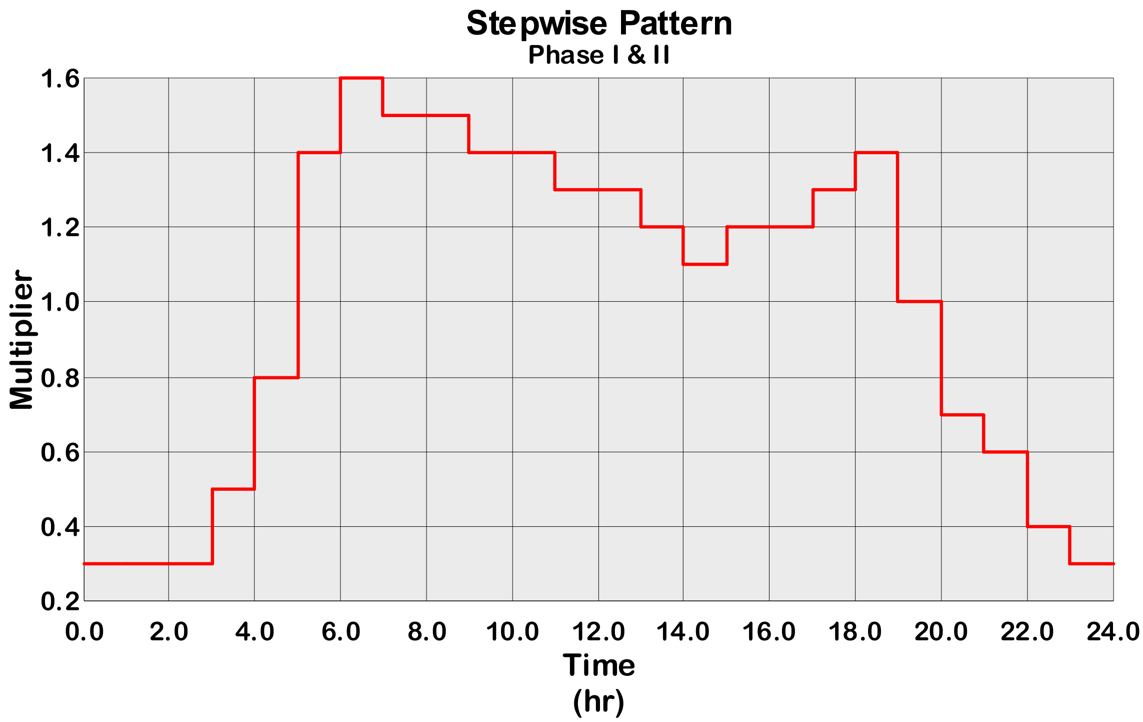
Hydraulic analysis is carried out to evaluate the hydraulic behaviors of the system. This task requires iterative processes of resizing of water supply components and reanalysis of the outputs until the results of hydraulic parameters such as discharge, velocity and pressure values will meet the required criteria.

Analysis of the distribution network has been conducted for two scenarios, i.e. the peak and minimum demands of 160% and 10% respectively, as described in the forgoing sections.

The peak hour demand is analyzed to verify that the sizes of network pipes are sufficiently to provide the minimum required pressure at all demand points. The minimum hour demand is analyzed for evaluation of pipe material and strength of the network

Consequently, the peak hour demand of each distribution zone is occurred from 6-7 O'clock in the morning when most people get up for daily business, whereas the minimum consumption is occurred from 23 to 2 hours in the night (see Figure below).

FIGURE 4.4 PEAK AND MINIMUM HOURS CONSUMPTION PATTERN



The detail hydraulic analysis results are annexed to this report while summaries are presented below in brief paragraphs and Bullets. Only the critical hydraulic results have been presented. These are the results of peak hour demands of phase II and the minimum hour demand analyses of phase I. The results of other conditions will fall between the two critical condition and satisfy all design requirements.

Consequently, hydraulic analysis results of the network during ***Peak and Minimum Hour Demands*** of the system are summarized as follows.

1 Hydraulic Conditions of New network During Peak Hour Demands of Phase II (Annex A-3 and A-4)

- The maximum design capacity of the network is 1,270.5 l/s for which the primary mains are sized.
- The minimum node pressures of 3-9 mH2O are occurred during peak hour demands around Sire Ababure Reservoir. These lower pressures are occurred due to the close proximity of nodes to the reservoir. Nevertheless, the rest node pressures will meet the requirements.
- Velocities are ranging from 0.33 m/s to 1.76 m/s. They are almost within the acceptable limits, except the occurrence of lower velocities in a very few short pipes.

Taking into account these hydraulic conditions, pipes of the network are sized from 50 mm to 1,000 mm to safely transport the required design flows

2 Hydraulic Conditions of New network During Minimum Hour Demands of Phase I (Annex A-5 and A-6)

- The maximum node pressures of 160-221 mH2O are occurred during minimum hour demands in the supply zone of Sire Ababure Reservoir. These higher pressures are occurred due to the highest strategic location of reservoir which enables distribution of water by flow of gravity.
- The breaking/reducing of these higher pressures require installation of booster pumping station

Consequently, pipe materials and pressure classes of the network are summarized as follows:

- uPVC pipes of PN10 for pressures Less than or equal to 100mH2O
- uPVC pipes of PN16 for pressures from 101 to 160mH2O
- DI pipes of K9/PN25 for pressures greater than 160mH2O

4.5.5 PIPES REQUIRED FOR BUILDING THE NETWORK

The selected pipe materials, sizes (diameters), quantity and pressure classes required for the distribution network is summarized in Table below.

TABLE 4.6 SUMMARY OF PIPES REQUIRED TO BUILD THE NEW NETWORK

NO	DN (mm)	LENGTH (m)	MATERIAL	PN (bar)
1	1,000	2873	DI	K9
2	800	3140	DI	K9
3	700	6621	DI	K9
4	600	7642	DI	K9
5	500	3280	DI	K9
6	400	20371	DI	K9
7	80	1,733	DI	K9
8	300	10,055	uPVC	PN10
9	250	2,083	uPVC	PN10
10	200	10,763	uPVC	PN10
11	200	121	uPVC	PN16
12	150	21,108	uPVC	PN10
13	150	5,050	uPVC	PN16
14	100	12,925	uPVC	PN10
15	100	3,781	uPVC	PN16
16	80	7,678	uPVC	PN10
17	80	1,312	uPVC	PN16
18	50	682	uPVC	PN10
19	50	513	uPVC	PN16
Total		**121,731**		

TABLE 4.7 SUMMARY OF PIPES REQUIRED TO BUILD PHASE I PROJECT

ITEM	DESCRIPTION	UNIT	QTY
NW1.1	**DUCTILE IRON PIPE Phase I- FOR DNW NEW SYSTEM**		
NW1.1.1	DI Standard Socketed Pressure Pipes DN 600mm, Class K9, 6m Length with all laying accessories	m	2,100
NW1.1.2	Ditto, but DN 500 mm	m	3,160
NW1.1.3	Ditto, but DN 400 mm	m	8,530
NW1.1.4	Ditto, but DN 150 mm	m	3,030
	Sub total of DI Pipes		**16,820**
NW2.1	**SUPPLY OF uPVC PIPE PHASE I- FOR DNW NEW SYSTEM**		
NW2.1.1	Supply of uPVC pipes for New and Existing Improvement of DNW OD 315mm PN10 with all pipeline materials such as rubber gaskets, bends of various angles, reducers, couplings, end caps, blank flanges, etc.	m	10,680
NW2.1.2	Ditto, but OD 280 mm PN10	m	1,850
NW2.1.3	Ditto, but OD 225 mm PN10	m	3,660
NW2.1.4	Ditto, but OD 225 mm PN16	m	740
NW2.1.5	Ditto, but OD 160 mm PN10	m	7,140
NW2.1.6	Ditto, but OD 160 mm PN16	m	2,230
NW2.1.7	Ditto, but OD 110 mm PN10	m	3,620
NW2.1.8	Ditto, but OD 110 mm PN16	m	200
NW2.1.9	Ditto, but OD 90 mm PN10	m	3,210
	Sub total of uPVC Pipes (for New)	**m**	**33,330**
NW2.2	**SUPPLY OF uPVC PIPE PHASE I- FOR DNW EXISTING SYSTEM IMPROVEMENT**		
NW2.2.1	Supply of uPVC pipes for DNW OD 315mm PN10 with all pipeline materials such as rubber gaskets, bends of various angles, reducers, couplings, end caps, blank flanges, etc.	m	360
NW2.2.2	Ditto, but OD 280 mm PN10	m	750
NW2.2.3	Ditto, but OD 225 mm PN10	m	4140
NW2.2.4	Ditto, but OD 160 mm PN10	m	3850
NW2.2.5	Ditto, but OD 110 mm PN10	m	2270
NW2.2.6	Ditto, but OD 90 mm PN10	m	3900
NW2.2.7	Ditto, but OD 63 mm PN10	m	720
	Sub total of uPVC Pipes (for Improvement)	m	**15,990**
	Total of uPVC Pipes	m	**49,320**
	Total	**m**	**66,140**

4.5.6 PUBLIC FOUNTAINS

The required number and location of public fountains shall be decided in discussions with the client. The typical public fountain drawing is as shown in the drawing album of the project.

CHAPTER 5 AUXILIARY BUILDINGS AND MISCELLANEOUS WORKS

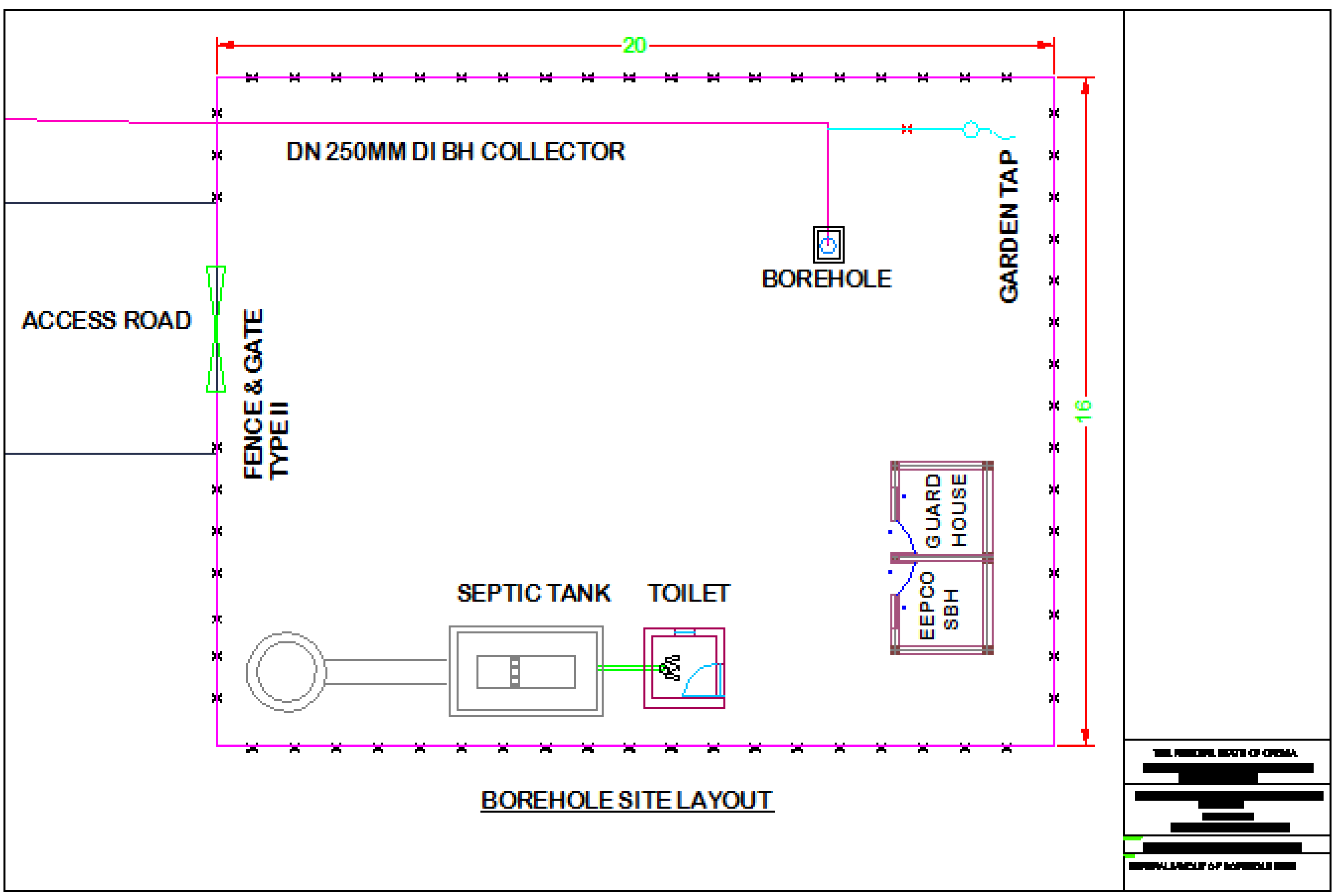
5.1 GUARD AND EEPCO SWITCH BOARD HOUSES AT BOREHOLES

Each borehole has been designed to have the following components.

- A Fence with Gate Size of 20x16m for well protection
- A building with two rooms for Guard House, EEPCO Switch Board and submersible pump control Panel
- A drainage System around the borehole site
- Access Road for operation and maintenance of the well
- A water tap for sampling, supply service and watering the garden of compound.

The typical plan and layout of borehole site is shown in Figure below.

FIGURE 5.1 TYPICAL PLAN AND LAYOUT OF BOREHOLE SITE

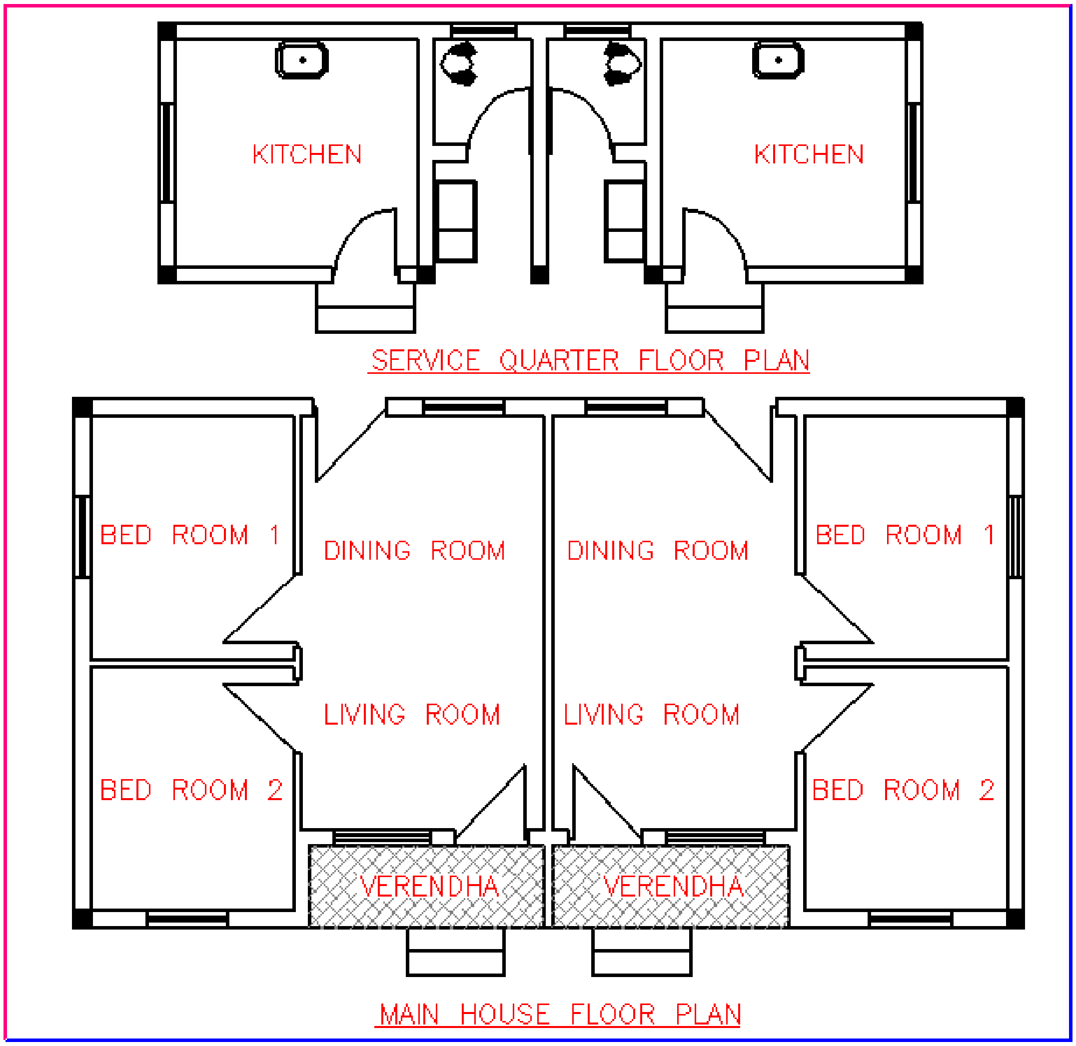


5.2 OPERATORS' DWELLING AT BOREHOLE SITES

Four (4) Operators' dwelling, with service quarters has been designed and shall be constructed at each borehole sites. Each dwelling house will be provided with Toilet equipped with Turkish type WC and a septic tank with soak-away pit

Figure 5.1 shows the plan of operators dwelling. Detailed plan, section and elevation of the building are shown on Drawing Album of Tender Documents.

FIGURE 5.2 PLAN OF OPERATORS DWELLING



5.3 WATER SUPPLY SERVICE ADMINISTRATION OFFICE

One (1) 200 m^2 office building is designed for the Water Supply Service. The layout, plan, and sections of the building are shown on the Drawing album of tender document.

5.4 WAREHOUSE

One (1) 132 m^2 store building, comprising of store, parking and pipe shade have been designed. The layout, plan and section of the Store are shown on the Drawing album of tender document.

5.5 WORKSHOP

A workshop space of 65m^2, comprising office, small store, workshop and instrument calibrating room has been designed. Workshop tools, equipment and spare parts required for at least 3 years operation period will be proposed as part of investment cost for sustainability of the project.

5.6 GUARD HOUSES

Six (6) guard houses of each 8 m^2 shall be constructed at Reservoirs Site. Detailed plan, section and elevation of the buildings are shown on Drawing Album of Tender Documents.

5.7 TOILET AND SEPTIC TANK

Six (6) guard houses shall be constructed at Reservoirs and Operators Dwelling. Detailed plan, section and elevation of the buildings are shown on Drawing Album of Tender Documents.

5.8 ACCESS ROAD

Around 23 km RR 50 access road will be constructed at the completion of the construction work within the wellfield along the collector pipes for operation and maintenance purposes

CHAPTER 6 ENGINEERING COST ESTIMATE

6.1 INTRODUCTION

The estimated costs required to implement the water supply project which takes into account a number of factors such as implementation time, availability of infrastructures, availability and costs of labour and materials, all the necessary contingencies and Government Taxes. In addition, factors like topographic conditions distances from where and how the water is abstracted, collected, pumped, transported, stored and distributed have been considered.

6.2 SUMMARIES OF COSTS TO IMPLEMENT PHASE I PROJECT

The total estimated cost required to implement **Phase I project** is Birr **641.65 Million**. Tables 6.2 and 6.3 indicate the executive summary of costs and detailed cost estimate by project components respectively.

TABLE 6.1 EXECUTIVE SUMMARIES OF COSTS

S/N	SYSTEM COMPONENTS	AMOUNT (ETB)
1	WATER SUPPLY SOURCE DEVELOPMENT	27,307,395
2	SUPPLY OF PIPES AND FITTINGS	352,643,013
3	CIVIL ENGINEERING WORKS	108,483,536
4	ELECTRO-MECHANICAL WORKS	4,266,000
5	POWER SUPPLY	1,065,000
6	CONTRACT MANAGEMENT AND SUPERVISION (3%)	14,812,948
7	CONTINGENCY (10%)	49,376,494
	Total	**557,954,387**
	Add VAT (15%)	83,693,158
	Grand Total Investment Cost	**641,647,545**

6.3 PROPOSED FINANCING PLAN

The proposed Financing Plan shall be as following

TABLE 6.2 PROPOSED FINANCING PLAN

EXPECTED FINANCERS	Percent (%)	Component
The Regional State of Oromia	15	Local
The Local Government (Adama Special Zone)	5	Local
International Development Agencies (Aid and Soft Loan)	50	Foreign
Local Development Agencies (Aid and Soft Loan)	20	Local
Wonji Sugar Factory	10	Local
Total	**100**	

Adama town WSSSE will be expected to generate sufficient revenues:

- To cover all operating and maintenance expenditures,
- A reasonable proportion of its future capital requirements plus
- Local loan repayment funds.

Its policies and procedures for charging for water supply should reflect the long run marginal costs of providing these services.

TABLE 6.3 DETAILED COST ESTIMATE BY PROJECT COMPONENTS FOR PHASE I

No	Description	Unit	Qty	Rate	Amount (ETB)
1	**SUPPLY OF PIPES AND FITTINGS**				
1.1	DI Standard Socketed Pressure Pipes DN 1000 mm, Class K9, 6m Length with all laying accessories for BH collectors and Transmission Main	m	25670	6,622	169,993,799
1.2	Ditto, but DN 800 mm	m	60	5,291	317,490
1.3	Ditto, but DN 500 mm	m	3180	3,295	10,479,134
1.4	Ditto, but DN 400 mm	m	110	1,174	129,131
1.5	Ditto, but DN 300 mm	m	790	607	479,688
1.6	Ditto, but DN 200 mm	m	2250	410	922,185
1.7	DI Standard Socketed Pressure Pipes DN 1000 mm, Class K9, 6m Length with all laying accessories for Adama NE and SE Transfer Mains	m	4200	6,622	27,813,555
1.8	Ditto, but DN 800 mm	m	4230	5,291	22,383,024
1.9	Ditto, but DN 700 mm	m	6270	4,626	29,005,678
1.10	Ditto, but DN 600 mm	m	2760	3,961	10,931,573
1.11	Ditto, but DN 500 mm	m	5790	3,295	19,079,932
1.12	Ditto, but DN 400 mm	m	3470	1,174	4,073,502
1.13	Ditto, but DN 350 mm	m	2620	1,026	2,687,897
1.14	Ditto, but DN 300 mm	m	490	607	297,528
1.15	DI Standard Socketed Pressure Pipes DN 600 mm, Class K9, 6m Length with all laying accessories for Adama DNW	m	2100	3,961	8,317,502
1.16	Ditto, but DN 500 mm	m	3160	3,295	10,413,227
1.17	Ditto, but DN 400 mm	m	8530	1,174	10,013,538
1.18	Ditto, but DN 150 mm	m	3030	314	950,572

No	Description	Unit	Qty	Rate	Amount (ETB)
1.19	Supply of uPVC pipes for New and Existing Improvement of DNW OD 315mm PN10 with all pipeline materials such as rubber gaskets, bends of various angles, reducers, couplings, end caps, blank flanges, etc.	m	11,040	732	8,086,082
1.20	Ditto, but OD 280 mm PN10	m	2,050	574	1,177,336
1.21	Ditto, but OD 225 mm PN10	m	7,800	372	2,900,898
1.22	Ditto, but OD 225 mm PN16	m	740	560	414,692
1.23	Ditto, but OD 160 mm PN10	m	10,990	194	2,127,060
1.24	Ditto, but OD 160 mm PN16	m	2,230	285	634,714
1.25	Ditto, but OD 110 mm PN10	m	5,890	101	596,068
1.26	Ditto, but OD 110 mm PN16	m	200	138	27,577
1.27	Ditto, but OD 90 mm PN10	m	7,110	80	566,631
1.28	Ditto, but OD 63 mm PN10		720	40	29,146
1.36	Supply of Plain End Steel Pipe DN 1000mm (Grade 52 to 70) for bot TM and TRM Crossing Structures	m	430	7,285	3,132,336
1.38	Ditto, but 300mm	m	44	668	29,388
1.39	Ditto, but 350mm	m	55	1,129	62,068
1.40	Ditto, but 400mm	m	68	1,291	87,809
1.41	Ditto, but 500mm	m	196	3,625	710,472
1.42	Ditto, but 600mm	m	86	4,357	374,684
1.43	Ditto, but 700mm	m	329	5,089	1,674,187
1.44	Ditto, but 800mm	m	296	5,821	1,722,911
	Sub Total of Pipes		**128,984**		**352,643,013**

No	Description	Unit	Qty	Rate	Amount (ETB)
2	**Earthwork**				
2.1	General clearance of all kind of debris, shrubs, trees and bush having girth of less than 150 mm, removal of temporary objects, etc. along the pipeline alignment within working strip boundaries of average 4m width as shown in the Drawings and as directed by the Engineer	m^2	541700	6	3,385,625
2.2	Trench excavation in all kinds of soil including temporary side stocking, for pipeline in width as shown in the Drwg along the alignment as shown in the Drawing in all kinds of soil to depth not exceeding 1.5m	m^3	112100	20	2,242,000
2.3	Ditto but in depth exceeding 1.5m but less than 2.5m	m^3	87200	25	2,180,000
2.4	Ditto but in depth exceeding 2.5m but less than 3.5m	m^3	37400	31	1,168,750
2.5	Ditto but in depth exceeding 3.5m but less than 4.5m	m^3	10000	39	390,625
2.6	Ditto but in depth exceeding 4.5m	m^3	2500	49	122,070
2.7	Extra over items of all the above for excavation in rock	m^3	49800	100	4,980,000
2.8	Supply from distance not exceeding 2.5 km and spreading, including tamping of bedding material as directed by the Engineer	m^3	14500	40	580,000
2.9	Backfilling of trench after pipe laying with selected material as shown in the Drwg and as directed by the Engineer	m^3	83900	30	2,517,000
2.10	Ditto but with random material	m^3	1400	20	28,000
	Sub total for Earthwork				**17,594,070**

No	Description	Unit	Qty	Rate	Amount (ETB)
3	**Laying of Pipes with Accessories, Testing and Commissioning**				
3.1	Laying and jointing of Ductile Iron Pipe for TM and WF DN 1000 mm K9 including all pipeline materials such as bends of various angles, reducers, couplings, end caps, blank flanges, etc, all as shown in the Drwg. And as directed by the Engineer, in trenches of various depths, and testing of pipeline in sections, repair leaking or displaced joints and repeat testing till acceptance and, where applicable, jointing of test sections into united and entire pipeline, all as described in the Specifications and directed by the Engineer	m	25670	993	25,499,070
3.2	Ditto, but DN 800 mm	m	60	794	47,623
3.3	Ditto, but DN 500 mm	m	3180	494	1,571,870
3.4	Ditto, but DN 400 mm	m	110	176	19,370
3.5	Ditto, but DN 300 mm	m	790	91	71,953
3.6	Ditto, but DN 200 mm	m	2250	61	138,328
3.7	Laying and jointing of Ductile Iron Pipe for Transfer Mains DN 1000 mm K9 including all pipeline materials such as bends of various angles, reducers, couplings, end caps, blank flanges, etc, all as shown in the Drwg. And as directed by the Engineer, in trenches of various depths, and testing of pipeline in sections, repair leaking or displaced joints and repeat testing till acceptance and, where applicable, jointing of test sections into united and entire pipeline, all as described in the Specifications and directed by the Engineer	m	4200	993	4,172,033
3.8	Ditto, but DN 800 mm	m	4230	794	3,357,454
3.9	Ditto, but DN 700 mm	m	6270	694	4,350,852
3.10	Ditto, but DN 600 mm	m	2760	594	1,639,736
3.11	Ditto, but DN 500 mm	m	5790	494	2,861,990
3.12	Ditto, but DN 400 mm	m	3470	176	611,025
3.13	Ditto, but DN 350 mm	m	2620	154	403,185
3.14	Ditto, but DN 300 mm	m	490	91	44,629

No	Description	Unit	Qty	Rate	Amount (ETB)
3.15	Laying and jointing of Ductile Iron Pipe for DNW DN 600 mm K9 including all pipeline materials such as bends of various angles, reducers, couplings, end caps, blank flanges, etc, all as shown in the Drwg. and as directed by the Engineer, in trenches of various depths, and testing of pipeline in sections, repair leaking or displaced joints and repeat testing till acceptance and, where applicable, jointing of test sections into united and entire pipeline, all as described in the Specifications and directed by the Engineer	m	2100	594	
3.16	Ditto, but DN 500 mm	m	3160	494	1,561,984
3.17	Ditto, but DN 400 mm	m	8530	176	1,502,031
3.18	Ditto, but DN 150 mm	m	3030	47	142,586
3.19	Laying and jointing of uPVC pipes for DNW OD 315mm PN10 including all pipeline materials such as rubber gaskets, bends of various angles, reducers, couplings, end caps, blank flanges, etc, all as shown in the Drwg. and as directed by the Engineer, in trenches of various depths, and testing of pipeline in sections, repair leaking or displaced joints and repeat testing till acceptance and, where applicable, jointing of test sections into united and entire pipeline, all as described in the Specifications and directed by the Engineer	m	11,040	110	1,212,912
3.2	Ditto, but OD 280 mm PN10	m	2,050	86	176,600
3.21	Ditto, but OD 225 mm PN10	m	7,800	56	435,135
3.22	Ditto, but OD 225 mm PN16	m	740	84	62,204
3.23	Ditto, but OD 160 mm PN10	m	10,990	29	319,059
3.24	Ditto, but OD 160 mm PN16	m	2,230	43	95,207
3.25	Ditto, but OD 110 mm PN10	m	5,890	15	89,410
3.26	Ditto, but OD 110 mm PN16	m	200	21	4,137
3.27	Ditto, but OD 90 mm PN10	m	7,110	12	84,995
3.28	Ditto, but OD 63 mm PN10		720	6	4,372

No	Description	Unit	Qty	Rate	Amount (ETB)
3.29	Laying and jointing of Steel Pipes for Crossing Structures DN 1000 mm (Grade 52 to 70) including all pipeline materials such as bends of various angles, reducers, couplings, end caps, blank flanges, etc, all as shown in the Drwg. and as directed by the Engineer, in trenches of various depths, and testing of pipeline in sections, repair leaking or displaced joints and repeat testing till acceptance and, where applicable, jointing of test sections into united and entire pipeline, all as described in the Specifications and directed by the Engineer	m	430	1,093	469,850
3.3	Ditto, but 300mm	m	44	100	4,408
3.31	Ditto, but 350mm	m	55	169	9,310
3.32	Ditto, but 400mm	m	68	194	13,171
3.33	Ditto, but 500mm	m	196	544	106,571
3.34	Ditto, but 600mm	m	86	654	56,203
3.35	Ditto, but 700mm	m	329	763	251,128
3.36	Ditto, but 800mm	m	296	873	258,437
3.37	Flushing and disinfecting of pipeline as described in the Specifications and directed by the Engineer	km	128.984	1,000	128,984
	Sub-total for Laying of Pipes and Installation of Accessories				**51,777,811**
4	**CONSTRUCTION OF STORAGE RESERVOIRS**				
4.1	Construction, Testing and Commissioning of Stanard Reinforced Concrete Service Reservoir for Biyo wellfield at ground level of 1900masl	m3	2500	1,275	3,187,500
4.2	Ditto, but for Sire Ababune Supply Zone, SAR1-1800	m3	2500	1,275	3,187,500
4.3	Ditto, but for Gelma Abba Geda Supply Zone, GAR2-1750	m3	500	1,275	637,500
4.4	Ditto, but for West Adama Supply Zone, WAR3-1715	m3	3500	1,275	4,462,500

No	Description	Unit	Qty	Rate	Amount (ETB)
4.5	Ditto, but for North Adama Supply Zone, NAR4-1760	m3	4000	1,275	5,100,000
4.6	Ditto, but for Adama University Supply Zone, AUR6-1720	m3	500	1,275	637,500
4.7	Ditto, but for East Adama Supply Zone, EAR7-1715	m3	2000	1,275	2,550,000
4.8	Ditto, but for East Boku Supply Zone, EBOR9-1715	m3	2000	1,275	2,550,000
4.9	Ditto, but for West Boku Supply Zone, WBOR10-1715	m3	3500	1,275	4,462,500
	Sub Total				26,775,000
5	**WATER SUPPLY SOURCE DEVELOPMENT**				
5.1	Drilling up to 370 m, Supply of all required Materials, Casings with 12" to 14" Developing, Testing and Commissioning of Boreholes	No	6	4,500,000	27,000,000
5.2	GI Pipe for Delivery line of Submersible Pumps DN 200 mm	m	600	512	307,395
	Sub Total				**27,307,395**
6	**ELECTROMECHANICAL AND POWER SUPPLY**				
6.1	Supply and Installation of Electric motor driven submersible pumps Head=130 m, Discharge=50 l/s, to be installed in 12" (300 mm) Bore hole casing with all accessories and complete protection system (Control panel and starter, power cable, level control electrodes, cable tie, jointing kit etc.) for borehole depth of 350 m	Set	6	711,000	4,266,000
6.2	Supply and installation of 15 kV power lines and Transformers up to the well fields and Reservoirs	km	15	71,000	1,065,000
	Sub Total				**5,331,000**

No	Description	Unit	Qty	Rate	Amount (ETB)
7	**AUXILIARY BUILDINGS AND MISCELLANEOUS CIVIL WORKS**				
7.1	Construction of Guard and EEPCO Switch Board Houses at Boreholes	No	6	80,640	483,840
7.2	Construction of Operators Dwelling at Boreholes	No	1	157,139	157,139
7.3	Construction of Water Supply Service Administration Office	No	1	870,530	870,530
7.4	Construction of Water Supply Service Warehouse	No	1	306,899	306,899
7.5	Construction of Water Supply Service Workshop	No	1	197,996	197,996
7.6	Construction of Guard Houses at Service Reservoirs	No	6	28,003	168,020
7.7	Construction of Toilet and Septic Tank at Reservoirs and Operators Dwelling	No	7	60,814	425,698
7.8	Construction of Access Road (3.5m wide)	km	15	648,435	9,726,532
	Sub Total				**12,336,655**
	Total				**493,764,944**
	Contract Management and Supervision (3%)				**14,812,948**
	Contingency (10%)				49,376,494
	Total				**557,954,387**
	Add VAT (15%)				83,693,158
	Grand Total Investment Cost				**641,647,545**
	Total Population to be benefited from this project for the next 5 years				917,200
	Per Capita Investment Cost	ETB			700
	Per Capita Investment Cost USD)	USD			42
	It is Cheap and acceptable				