FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF WATER AND ENERGY

Consultancy Service For Feasibility Study And Detail Design, Supervision And Contract Administration For Borehole Drilling of Climate Resilient Water Supply Sanitation and Hygiene Facilities of Adadle Town Water Supply Project (WSP) Of Somali Region

FEASIBILTY FIRST DRAFT REPORT

SocioEconomy and Engineering

CLIENT

Ministry of Water and Energy
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ACRONYMS

AET	Actual Evapo Transpiration
AMSL	Above Mean Sea Level
BGS	Below Ground Surface
BH	Borehole
BOQ	Bill Of Quantities
CSA	Central Statistics Authority
DN	Nominal Diameter
DP	Demand Point
DWL	Dynamic Water Level
E	East
EC	Ethiopian Calendar
EEU	Ethiopian Electric Utility
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization
GC	Gregorian Calendar
GL	Ground Level
GLR	Ground Level Reservoir
GPS	Global Positioning System
GS	Galvanized Steel
HC	House Connection
HW	Hazen-Williams
MoWE	Ministry of Water and Energy
NMSA	National Meteorology Service Agency
N	North
NE	North East
NW	North West
O&M	Operation & Maintenance
P	Precipitation
PET	Potential Evapo Transpiration
PF	Public Fountain
PN	Pressure Nominal class
PVC	Plasticized Poly-Vinyl Chloride

S	South
SE	South East
SPSS	Statistical Soft Ware for Social Scientists
SW	South West
SWL	Static Water Level
uPVC	Un plasticized Poly-Vinyl Chloride
UTM	Universal Transverse Mercator
UFW	Unaccounted For Water
VES	Vertical Electrical Sounding
W	West
WASH	Water Supply Sanitation and Hygiene
WHO	World Health Organization
WMB	Water Management Board
WP	Water Point
WSS	Water Supply Service
WSSA	Water Supply and Sewerage Authority
WSSO	Water Supply Service Organization
YC	Yard Connection

Dimensions

°C	degrees centigrade
A	ampere
cm	centimeter
kg	kilogram
km	kilometer
km^2	square kilometers
kv	kilo Volt
KVA	kilo Volt Ampere
kwh	kilowatt hour
l, lit	liters
l/c/d	liters per capita per day
l/s	liters per second
masl	meters above sea level
mbgl	meters below ground level
m	meter
m/s	meter per second
m^3/d	cubic meters per day
m^3/hr	cubic meters per hour
mm	millimeter
Mpa	mega Pascal

PN	nominal pressure category, in bar
M^2	square meter
V	Volts

EXECUTIVE SUMMARY

The study area Danot Woreda in Dolo Zone of Somali national Regional State .Adadle Town is the capital of Adadle Woreda in Gode Zone. It is located at a distance of 18km from zonal capital Gode and 570 km southeast of the regional capital, Jigjiga through Degehabur – Kebri Dehar - Gode. Geographically Adadle town is located at 337225m east and 640853m north in UTM with an average altitude of 310m above mean sea level and WGS84 Zone 38.

The general objective of the Consultant service is to assist the client and to carry out water source investigation (surface and groundwater) and conduct water supply study and design for the community and institution's water supply, sanitation, and hygiene of the Woreda based on TOR.

The prefeasibility include existing water source, population, demand, kebeles prone to water supply, sanitation and hygiene problem is identified.

According to population and housing census (CSA, 2007), the projected population of the woreda for the base year 2022 is 9,131and the rural population is 107,740. As per the woreda administration the current population of the Adadile Town and rural kebeles is 21,040 and 102,097 respectively. Population data collected from woreda administration and CSA on rural population almost similar. But population number for the town note match. The consultant decided to relay on the CSA data for the study. Hence, base population fixed to 116,871 at 2022 and projected population in design period 2033 for urban and rural of woreda population is 133,749. If the project will be implemented, system could have been functional starting from 2024 GC.

The residents of the town have heterogeneous religions followers as 89.6% are reported to be Muslim followed by Orthodox constituting 8.1%. The remaining 2.3% is protestant religion believers.

The main sources of income for the study area residents shows farming, private business (retail trade), government or public employee and daily labor.

Data sourced from Adadle District Education Office shows that educational service in Adadle town is provided by a total of 16 schools of which 5 primary schools (1-4), 8 juniors secondary (1-8) schools and 3 secondary schools (9-12). All the schools available are run by the Government. The total number of students and teachers in these schools are 7,864 and 153 respectively. It has also a state-run two health center, 23 health post. Overall, the town and the woreda are highly vulnerable to water borne disease or illness as a result of water shortage and consumption of unsafe sources.

Regarding infrastructures, the town has 24hrs hydropower electric and telecommunication services; and all weather gravel road currently in moderate condition.

Adadile and surrounding village existing water supply consists of non functional surface water treated water and the treatment plant constructed in 2003 E.C. The older water supply system include 15km pressure line, 200m3 survice reservoir and 9 public fountains.

The construction and design study with implimantation will held coming consicuative two (2) years. The project will be start its operation at 2024 and the design period completed after twenty (10) years at the end 2033.

The water demand of the project is estimated by using the projected populations under various modes of services and their respective per capita water consumptions. Hence it is found that, the projected maximum day water demand for human consumption is 277.23m^3/d (77.01l/s) and 364.34m^3/day (101.21l/s) respectively for the design period of 2022 - 2033. Similarly, to satisfay the life stoke consumption the average water demand for design period of 2022 and 2033 is 374.66 m^3/day (104.07l/s) and 433.72m^3/day (120.48l/s) respectively.

Water Supply Development

Proposed Water Supply Scheme for the design period

The proposed water supply scheme will cater for demands up to the year 2033. To supply the town and nearby kebeles with adequate water of good quality treatment plant at wabi Shebele river are proposed to maximum day demand (101.21l/) at the end year of 2033.If the the system is design for this demand it is not economical and 12.59l/s is proposed.

The following activities are the major undertakings recommended for the project:

- ✓ Treatment plant (roughing filter, Slow sand filter, sedimentation tank and clear water tank) with an estimated discharge of 12.59 l/s for short term cluster of targated study area.
- ✓ Pond for life stoke consumption.
- ✓ Supply and installation of 2, 3, and 1 surface pumps for short term, medium and long term respectively with associated electro-mechanical equipment.
- ✓ Collector pipe and transmission pipe Supply and Install OD110 length of 10275m and OD160 length of 7527m PN12.5 is proposed.
- ✓ Construction of a service reservoir in short term ground level of volume 200 m^3, and 200m^3 elevated reservoir for third alternative ib financial classification of feasible senario.
- ✓ Distribution pipe provision of primary and secondary distribution system which will cover the anticipated settlement areas, diameter ranging from OD50 mm to OD250 mm of PN 10 with a total length of 12466m.
- ✓ Construction of 6 new public water points with six faucets and maintenance of 10 existing water points.
- ✓ Ancillary buildings which includes office building, one generator house and Guard house, Toilets and septic tanks , etc

To satisfy human water supply of the woreda require 1,133,187,015.28 birr, but budget for the woreda is about 4. 2mill.dollar. To reduce gab the consultant plan budge into different term of cluster. Proposed cluster include short-term (Cluster I and II), medium term (cluster I and II) and long-term (Cluster I and II). The life stoke demand will be not included in system design and find alternative source. Therefore, rehabilitation existing and new construction of pond proposed for life stoke consumption.The project is feasible to proposed separated source of water for short term cluater costs **191,815,997.30** birr including 15% VAT and contingency.

1 INTRODUCTION

1.1.BACKGROUND

Water is one of the most basic necessities for the existence of living things in general and human beings in particular, especially potable water in modern world. For any country, one of the basic and essential services by all standards is efficient service in water supply. Unless and otherwise this demand of the community is efficiently met, the health of the community and developmental activities will be highly affected.Ethiopia in general; and Somali region in particular has vast groundwater potentials. Yet, millions of people in the region have no access to potable water supply. Even where people had once access to potable water supply, the constructed projects are currently observed to be non functional resulting from water source falled, incompatibility of demand and system.

Provision of clean water supply is one of the major factors that greatly contribute to the socio-economic development of the country by improving the health of a nation thereby increasing the productivity of the society. However, most developing countries, like Ethiopia, have still low coverage of potable water supply and sanitation that has resulted citizens suffering from water born and water related diseases.

Somali Regional State has low coverage of potable water supply and sanitation. To increase the water supply coverage of the region, Ministry of water and Energy Bureau and partners working in the region are making continuous efforts.

In line with this, Somali regional state and different NGO has been conducting feasibility study & engineering design of Water Supply Projects in the region. As part of this effort, for the provision of safe and adequate water supplies to the rural and urban population of the region the Ministry has prepared Terms of Reference (TOR) to employ competent consultants in order to undertake the study and design, supervision, and contract administration for borehole drilling of climate resilient water supply sanitation and hygiene facilities for adadle town water supply project and surrounding villages.

Adadle is one of the woredas in the Somali Region of Ethiopia. Part of the Shebelle Zone, Adadle is bordered on the west by the Afder Zone, on the north by the Shebelle River which separates it from Gode, on the east by Kelafo Woreda, and on the south by Somalia.

This feasibility following inception report presents detail description of objectives of the consultancy, methodology employed for the study, brief discussion of existing water supply, socio-economic condition and water potential of the area, and; all with literature review, data gaps and deficiencies and revised methodology for review and detail design phase and supervision and contract administration of drilling borehole in project implementation. Finally, revised work plan and Organizational structure of the project are presented.

1.1 OBJECTIVE

The main objectives of the Consultancy service are to undertake potential water source assessment and identification of sustainable water source, design of the water supply system and sanitation and preparation of tender document for Adadile and surrounding villages of woreda.

1.2 SCOPE OF WORK

As clearly outlined by the client, detail scopes of the consultancy service are discussed as follows:

a) Water Source Assessments

The scope of consultancy service requires a multi-disciplinary approach which includes the major activities of the surface and groundwater sources selection and water quality studies:

- Collect and review relevant existing literatures and documents on groundwater and surface Water sources
- Conduct field meteorological, hydrological and hydrogeological investigation, observation and verification
- Map the selected surface and groundwater potential areas in various scales depending on the areal coverage of the potentials.
- Carry out geological, hydro-geological, hydrological, water quality, geotechnical investigation and geophysical investigation of the potential and quality water sources (groundwater, surface water, spring, potential for water harvesting (e.g. Haffirs, Birkas, sub-surface storage (sand-dam) etc.) of the area and determine the location of intake sites, boreholes drilling site, surface water intake site, spring, site for harvesting or managed recharge etc., the expected safe yield of the source and respective costs.
- Conduct detail hydro meteorological, geophysical, geological, hydro geochemical and hydrogeological study in order to identify groundwater potential areas as well as locating production wells sites after defining the prospective well fields which includes:
  - Existing water supply system inventory, borehole logging and mapping
  - Identify water-bearing lithological units and their basic characteristics,
  - Specifying details spring types like depression springs, artesian springs, contact springs, hot springs and their specific location taken by GPS, discharge seasonal flow variability, In-situ Spring Discharge Measurement, and its accessibility and water quality included.
  - Identify recharge and discharge areas as well as groundwater flow direction,
  - Select appropriate geophysical exploration method based on the site geological situations and conduct sufficient number of surveys,
  - Characterize aquifer geometry and hydraulic parameters (hydraulic conductivity, transmissivity and storage) from secondary pumping test data and re-computing the hydraulic parameters for the representative wells for confirmation and checking the reliability of the previous analyzed data
  - Delineate spatial distribution of aquifers, hydraulic parameters and water quality of the aquifers and anticipated impacts of future exploitation.
  - Categorize water quality within water bearing formations & indicate its suitability depending recently published water quality guidelines and determine its suitability for domestic drinking purpose

- Study and evaluate the potential of the available groundwater sources for the envisaged purpose quantitatively and qualitatively
- Locate prospective groundwater potential well fields and select representative water well sites with GPS coordinates and setting benchmark
- Specify type of well design based on the expected aquifer type and well depths, well drilling methodology and machines, well construction material selection, gravel pack material selection, well head works, well discharge capacity testing methods and pump capacity design. The possible yield will be estimated based on existing data.

- Proposing solutions/options to tackle the present water supply problems of the Towns and surrounding villages. Based on the proposed solutions/or options, the following activities shall be undertaken:

a. Examining the potential prospects of water sources for water supply of the towns and sarounding villages, whether groundwater or surface water. The source options could be springs, Boreholes and Surface water/River. The river must be the last option after exhausting ground water investigation.
b. Detail Geological, hydro-geological, geophysical and hydro-meteorological data collection, review and analysis have to be made based on the source conditions.
c. Identify all possible potential sites(catchments) for geophysical survey/investigation
d. Geophysical survey/investigation includes: -
   i. Vertical electrical sounding (VES), Minimum 4 VES at each catchment or until the best data is obtained and attach the raw data and provide the soft copy and hard copy of the raw data.
   ii. 2D resistivity Imaging (Multi-Electrode Resistivity Survey). This will be conducted in basement and volcanic/basalt/ formations area that have complex geological structures to identify underground buried structures and resistivity variation with depth, and finally conduct VES to investigate the depth of the structure. The electrode separation could be 10m and attach the raw data of 2D in the report and provide in the soft copy.
   iii. Based on geological situation observed during fieldwork, therefore, the well depth drilled along the line should be more than 250m to exploit the required yields. However, final decision will made by the site hydro geologist based on actual observation while drilling.

- Conduct Water Quality analysis to determine water potability based on available and recently published water quality guidelines

b) Data collection and Analysis:

The Consultant is expected to collect the following data:

- Conduct socio Economic; demographic and environmental data that are required for the design works for the water supply system studies and design works;
- Topographic survey for the layout of the water collector pipes, pump houses, access road transmission mains, reservoirs, distribution pipes and other relevant structures;

- Undertake profile survey along the pipe routes and prepare profile drawing;
- Collection of relevant information about the water sources including: location of wells, yield estimates, static and dynamic water levels, and quality of water;
- Local community population data collection and on-site verifications;
- House hold survey
- Mapping of the project area;

c)Design of a complete water supply system

Using the data collected under item (b) above the Consultant is expected to undertake detailed design components of the entire system that consists the following:

- Estimation/Projection of design population and design/projected demand with respect to various modes of services;
- Estimate of leakage and unaccounted for water as well as programs for leakage detection and reduction.
- Prepare conceptual model of entire Water supply system
- Detail design of the well field collector pipes; well heads, control room, generator shelter, collector pipe, valve chambers, thrust/anchor blocks, access roads, river/streams & road crossing structures and collection chamber;
- Detail design of transmission mains and distribution systems;
- Detail design of pumps and pumping stations & pump houses;
- Hydraulic and structural design of all the distribution pipe network system with their routes; stream, river and gulley crossings;
- Design of service reservoirs, ancillary buildings and associated civil structures;
- Detail Electro-mechanical design for pumping stations, chlorination system, surge protection (if applicable), borehole submersible pumps & control system and others.

d) Preparation of Engineering Drawing, Reports and Cost Estimates

Following the engineering design of items (c), the Consultant shall prepare drawings and cost estimates of the entire project:

- Preparation of working drawings.
- Preparations of bill of quantities and cost estimates.
- Preparation of implementation schedule.
- Preparation of design reports
- Preparation of specifications and contract documents for civil works, electro-mechanical works and supply of pipes and fittings.

e) Preparation of Socio-Economic and Environmental Impact Assessment Reports:

During the design stage, the Consultant is expected to prepare a detailed Socio-economic report to ensure the economic feasibility and environmental viability of the project. The documents should be prepared for the design with possible recommendations during the construction period**.**

f) Procurement/ Tender Document preparation

After completion of the design, the Consultant should prepare contract packages and tendering documents for drilling and all civil works, equipment and associated services according to the Public Procurement and

Property Administration (PPA) guidelines. However, during this stage of service, the Consultant is expected to work in close consultation with the client. The Consultant will prepare confidential work package documents and provide (indicative but not limited to) the following services:

- Contract packaging and Draft Procurement Plan
- Bidding documents for works and goods (including prequalification documents and notices)
- Engineering cost estimates for all design components and associated civil structures including pipes; fittings, pumps, access roads, power, communication, housing, offices and other facilities.
- Engineering cost estimates for the pumps and pumping station, transmission mains and associated structures including power, other facilities.
- Preparation of construction plan

2 PHYSICAL DESCRIPTION OF THE STUDY AREA

2.1. Location and Accessibility

Adadle Town is the capital of Adadle Woreda in Shebelle Zone of Somali National Regional State. It is located at a distance of 18km from Zone capital Gode to South-West and 570km South-East west of theregional capital of Somali, Jigjiga. Geographically Adadle town is located at 337225m east and 640853m north in UTM with an average altitude of 310m above mean sea level and WGS84 Zone 38.

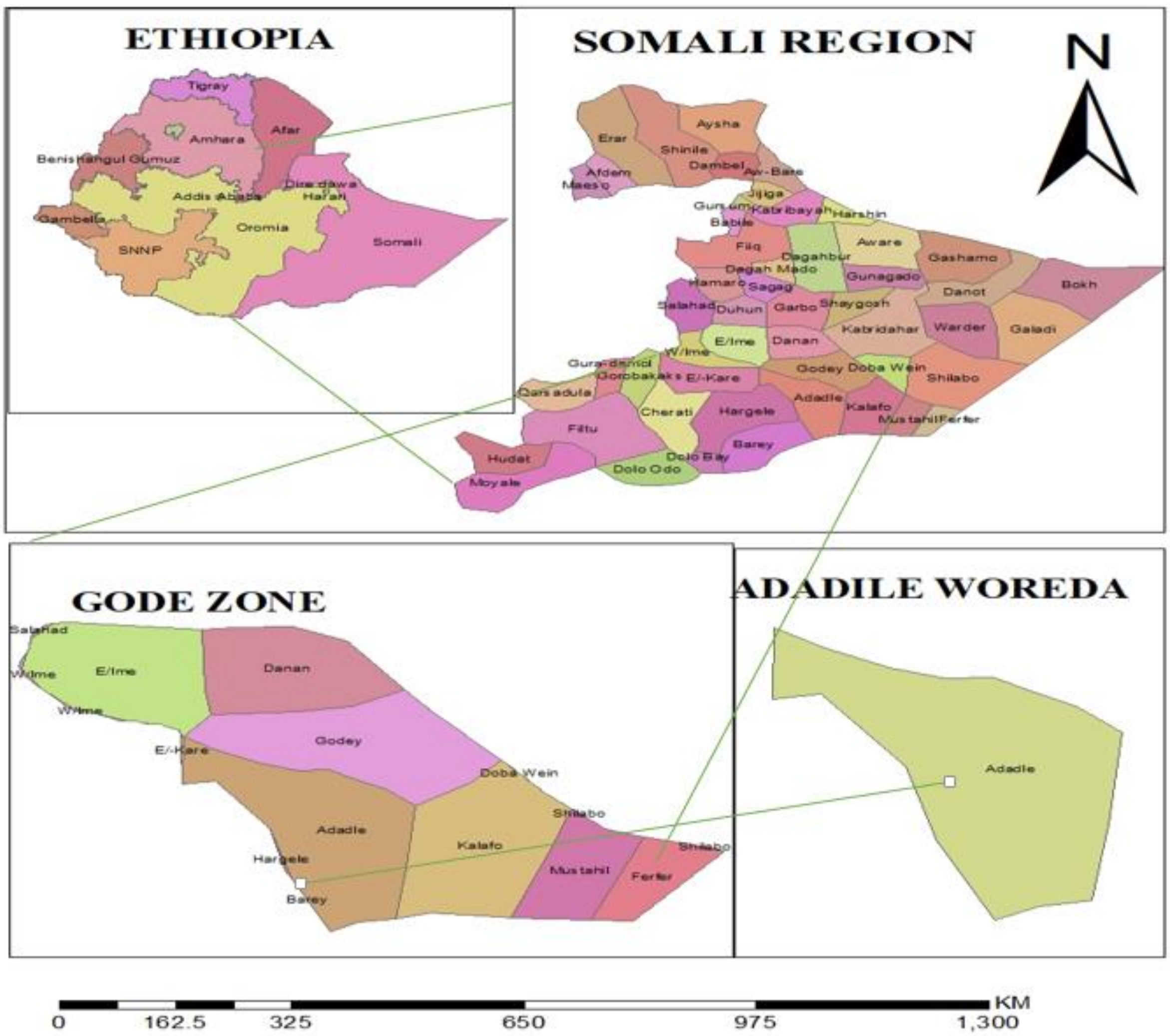


Figure 2-1 Location Map of Adadle Town

2.2. Topography and Drainage

Adadile topographic feature of Adadle town and surrounding kebele is mostly flat area and the maximum elevation difference with in project target area is not more than 15m through 20-30km length from source.

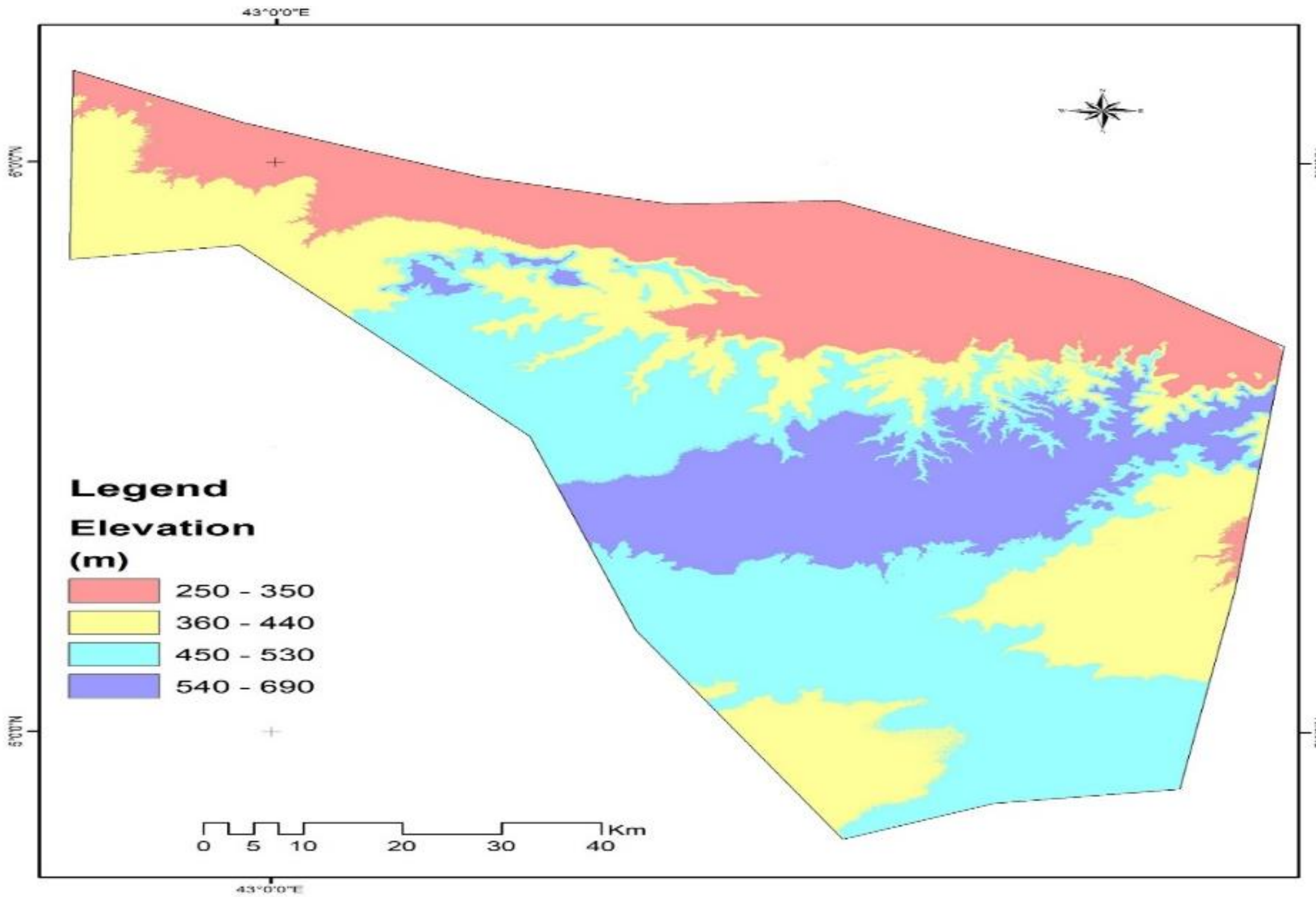


Figure 2-2 Elevation map of Adadle Woreda

2.3. CLIMATE

The town and its surrounding experiences with hot climatic condition and have low annual rainfall condition. The area is almost dry throughout the year and frequently suffered by drought. In this year there was a drought which eradicated different livestock and affects the livelihood of the community. The warmest month in this year (with the highest average

high temperature) is March (34.6°C) and the month with the lowest average high temperature is July (30°C). The rainfall type of the area with low precipitation is bimodal rainfall type. March to May and September to November is the main rainfall season of the area. The average annual rainfall is about 245mm. Objective of the assignment

a. Rainfall

The project area receives an average annual rainfall range between 40.2 mm to 535.3 mm with the average annual rainfall value of 228.4 mm. 33 years data is recorded at the Gode Met meteorological station. The average monthly rainfall data from the recorded data set varies between the minimum values of 0. 2 mm to the maximum value of 65.6 mm. The area receives a bi-modal type rainfall with a main rainfall season from October to November where March to May is the second rainfall season for the area. Usually, the rainfall of the station has a high magnitude in the month of October with the maximum value 238.5 mm.

b. Temperature

In Adadile district there is one meteorological station. The highest mean temperature is about 35.4°C and it occurs in the month of February and September while the mean minimum of 20.90C temperature occurs in the month of January.

2.4.PARTIAL VIEW OF ADADILE TOWN

Adadile woredahas covered the total area of 714.6 hectares. The major land use categories identified in the town expressed below in hectares.

Figure 2-3 Partial View of Adadile Town

3 SOCIAL AND ECONOMIC CONDITION

3.1. BACKGROUND

Study, design as well as implementation of public project such as water supply schemes and sanitation facility, usually depend on sufficient socio-economic assessment of the project sites. Proper assessment of the existing social and economic aspects of the site dwellers can provide useful information on the shortcomings of the existing systems on water consumption patterns and sanitation facility, number of households, household size, social values, economic situations etc. that can have either direct or indirect implications on the proposed water supply and sanitation project. Besides, it is an important tool to evaluate the benefits obtained from the implementation of the project.

Accordingly, this section offers some theoretical and practical insights on social and economic conditions of Adadle multi-villages which are part of the feasibility study and detail design of Water Supply and Sanitation Project. This contains the condition of the existing socio-economic profile of the town, estimation of the extent of excess demand/drinking water supply shortage and analysis of affordability and willingness to pay for the services to be conveyed for the town residents from the proposed project, potential development of the town, solid and liquid waste management practices are considered. In consequence, socio-economic study was undertaken to generate reliable and valid data and information on the various socio-economic and sanitation aspects to predict about the current and future situations of potable drinking water and then sanitation for targeted project sites. It is also essential to provide a framework within which the detailed study and design of a water supply, sanitation and hygiene system aimed at alleviating the water shortage and sanitation problem of the project has to be undertaken.

Generally, socio-economic study which is a way to learn about the social, cultural, sanitation, economic and political conditions of stakeholders including individuals, commercial enterprise, industries and public institutions in the project area that have direct or indirect effect on the proposed project.

This report presents the socio-economic situation of the target project woreda and prioritized Kebele that have been confirmed through household survey, institutional survey, focus group discussions, key informant interviews and review of secondary data. It presents the findings starting with study objectives and methodology followed by description of project area context that attempts first to discuss existing condition with regard to geographic location of the project area, population size and social service availability. Finally, the outcomes of the household and the institutional surveys are presented.

3.2. THE OBJECTIVE OF THE STUDY

The general socio-economic study was concentrated on the identification of existing water supply and sanitation aspects, overview of their existing water supply and sanitation systems and alternative prospects, brief descriptions of their socio-economic conditions, the need for the project in improving the water supply and sanitation conditions, order of magnitude of socio-economic impacts and costs, existing financial management systems, tabulation of costs and benefits and ranking and selection of candidate places which deserve to be served by the designed capacity of the water supply system.

The specific objectives of the socio-economic study are to assess demographic situation of the town, the study is to assess socio economic situation of existing conditions, economic activities, income and livelihood source, sanitation situation, the socio-economic aspect of private and public institutions those have impact on the water demand of the town, willingness of the beneficiary to participate and contribute to the realization of the water supply project, to assess the existing tariff, water consumption, identifying socio economic constraints and priority problems and asses expected positive and adverse impacts as well as stakeholder attitude and social feasibility of the project.

3.3. STUDY APPROACH AND METHODOLOGY

The general objective of the socioeconomic survey is to assess the social, cultural and economic condition of the project area communities, collect quantitative and qualitative data with particular emphasis on water supply and sanitation.

The specific objectives include:

•Compile demographic indicators such as size and structure of the beneficiary population;

•Establish WaSH baseline conditions of beneficiary households for future monitoring and evaluation of project impacts;

•Conduct household survey to assess the waste management condition at household level.

•Gather operational statistics, customer profile, institutional arrangement, financial management, etc of the water utility;

•To assess community support to the intended project and evaluate willingness to pay for improved water supply service.

•Assess availability of basic social services and infrastructure provision.

3.4.STUDY APPROACH AND METHODOLOGY

The socioeconomic survey has employed data collection methods to collate quantitative and qualitative data. Quantitative data helps us to obtain figurative information that we require to draw quantitative indicators and measurements. Household survey instrument is employed to gather quantitative data that can measure the water supply and sanitation status at household level. Besides, secondary information has been gathered to have the general socio-economic picture of the project area.

On the other hand, the qualitative data was obtained using Focus Group Discussion with selected beneficiary community members. The discussion generates information on beneficiary perception, need and feelings about the intended project. The qualitative data obtained in this tool helps to crosscheck, supplement and substantiate the quantitative information.

3.4.1. Household Survey

To investigate the socioeconomic baseline status of the study communities, a sample household survey has been conducted covering 384 randomly selected households. The household survey covers Adadle town and Higlo Kebele. The objective of the household survey was to collect data about household demographic conditions, housing characteristics, occupation and household income, solid and liquid waste management, and more importantly access to water supply.

The sample size of the project was determined using the following Cochran's Formula:

$$n_o = \frac{Z^2 * p * q}{e^2} \quad \dots\dots \quad equation\ 2$$

Cochran's sample size will be calculate using the Formula with p value of 0.5, Confidence Interval (Z) 95% and margin of error (e) 5%. Accordingly, the total number of sample households is computed to be 384. Out of the total sample size, 247 households were from Adadle town and 137 were from Higlo rural Kebele.

3.4.2. Stakeholder Consultation

During the preparation stage of the questionnaire for assessment of the topic, a decision was taken with major officials to design distinct questions to capture the households' (respondents') perception and attitude about the existing water availability, sustainability, utilization and its quality as well as the sanitation facility of the town.

3.4.3. Focal Group Discussions (FGD)

Focal Group Discussions were held with representatives of the beneficiary communities in which 15 people participated with the objective of gathering qualitative data that would be used to triangulate information obtained through the household and institutional surveys. Members of the study team worked as a mediator to facilitate the discussions and solicit the intended information from the participants by using predesigned discussion guide.

3.4.4. Personal Observation

The team has used observation as an additional means to the data collection which helped to have a general understanding of the area and how the community perceives the environment, to what extent the community is aware of the right to water, and how poor access to potable water and inadequate sanitation affects the livelihood of the community.

Additionally, the team has observed the activities of the community which may reduce their vulnerability to water borne disease and negative impacts of poor sanitation and unsafe drinking water. Since observation comprises subjective judgment the team did not completely depend on the results of the observation in the analysis part of the study unless supported by the other data collected by other means. To perform this observation, the team spent time during data collection in the institutions which did not have water and toilets and other services. This helped the consultant to understand how it feels to spend without access to these basic infrastructures.

3.4.5. Key Informants Interview

This technique helps to obtain deep understanding about water access and sanitation in the project and generate qualitative information regarding current constraints of WaSH services as well as long term solution options. Data obtained in this way also used for triangulation to validate information obtained by the other methods.

The consultant undertook key informant interviews with various stakeholders from different sectors, including the Woreda Administration, Education office, Health office, Trade office, Agriculture office, the town Health center and the WASHCO members.

3.4.6. Institutional Survey

To get institutional perspective on the WaSH status, a schools and a health center have been surveyed. This instrument will be used to collect institutional level data which consists but not limited to:

- Water supply: availability and source, adequacy, etc,
- Sanitation: availability and status of latrines,

Waste management: solid waste management practice in the institutions.

3.4.7. Secondary Data Collection

Secondary data has been an important source of information in this study. Accordingly, pertinent data has been collected from the Federal Ministry of Water & Energy, Regional Water & Energy Bureau, Woreda Administration, Education office, Health office, Trade office, Agriculture office, the town Health center in parallel to the primary data collection activities. CSA publications were also reviewed for population data.

3.4.8. Desk Study & Document Review

3.4.8.1. Review of the Ethiopian Water Resource Management Policy

The Federal Democratic Republic of Ethiopia through its water management policy has committed to enhance sustainable and reliable development and proper use of water resource that alleviates the problems of water users and on agricultural outputs. Among the fundamental principles of the Ethiopian Water Resources management policy, the relevant policies to this study are stated as follows.

3.4.8.2. Finance Policy

- Provide subsidies to communities who cannot afford to pay for basic services on capital cost only, based on established criteria and phase out subsidy gradually;
- Ensure that all water supply undertakings will adequately address costs associated with operation and maintenance and be based on “cost recovery” principles;
- Ensure responsibilities & financial accountability in the management of water supply service;
- Ensure transparency and fairness in the management of water supply services so as to enhance readiness to pay and participation by the users and communities in the financial management of systems;

3.4.8.3. Tariff Setting

- Ensure that tariff structures are site-specific & determined according to local circumstances;
- Ensure that pricing of urban water supplies shall aim at full cost recovery and develop cross-subsidization strategies and promote credit services;
- Establish a "Social Tariff" that enables poor communities to cover operation and maintenance costs;

- Ensure that tariff structures in water supply systems are based on equitable and practical guidelines and criteria;
- As willingness to pay by users of water system is a powerful impetus for financial sustainability of water resources systems, willingness to pay shall be promoted by, inter alia stating the main objectives, instituting fairness in water systems, promoting transparency and communications;

3.4.8.4. Technical and engineering aspect

- Identify and promote the development of appropriate, efficient, effective, reliable and affordable Water Supply and Sanitation technologies, which are demand driven and have great acceptability among local communities;
- Facilitate local level decision making in choice of technology by presenting a comprehensive analysis and evaluation of available options to the local population;
- Adopt economically affordable and appropriate-waste-water treatment and management systems;

3.4.8.5. Financial and Economic Aspects

- Ensure self-reliance, through the promotion of self-financing of programs and projects, based on the overall socio-economic development condition of local communities. To this end, engaged the participation of banks, private operators, micro-financing institutions, national water fund, and rural credit services etc;
- Promote the "users pay" principle in accordance with the user's willingness and ability to pay for the service, based on costs of services visa-versa given socioeconomic condition of the beneficiaries /users;
- Ensure transparency, fairness, responsibility and accountability in the utilization and management of the Water Supply and Sanitation funds;
- Promote the development of site specific water tariff based on financial, economic and social equality considerations. Involve local communities in price setting to ensure that tariff structure are compatible with customers' ability to pay with a view of providing sustainable services at affordable prices, and based on equitable and practical guidelines and cost sharing criteria;
- Set tariff in urban areas aiming at total cost recovery through time (which covers Operation and Maintenance costs, depreciation and debt servicing). Implement progressive tariff rates in the urban areas that are tied to consumption levels;

3.4.8.6. Institutional Aspect

- Recognize and strengthen the role of public sector institutions in the provision of Water Supply and sanitation service. On the other hand, assign more responsibilities to the local level institutions concerning implementation, management, monitoring and supervision of Water Supply System schemes, as well as to ensure local level-inter-sector coordination;
- Develop and enforce appropriate management actions for water supply and sanitation services to achieve autonomy and commercial viability which recognize;

- The regulatory role of the government;
- The role of communities in decentralized management;
- The use of local skills and resources; and
- The involvement of private/ informal sector entrepreneurs.

3.4.8.7. Social Aspect

Social protection is an increasingly important approach to reduce vulnerability and chronic poverty, especially in contexts of crisis such as income and consumption shocks and stresses. So, giving due attention to gender issues while establishing community based structures for the management of localized Water Supply and Sanitation systems is necessary. Particularly, empowering women economically, socially and politically by establishing equity in education contribute to the holistic wellbeing of the community in water-environment-health issues.

3.4.8.8. The One WASH National Program Documents

The One Wash National Program (OWNP) is the Government of Ethiopia‘s (GoE) main instrument for achieving the goals set out for WaSH in the Growth and Transformation Plan (GTP). The Development objective of the Program is to improve the health and well-being of communities in rural and urban areas in an equitable and sustainable manner by increasing access to water supply and sanitation and adoption of good hygiene practices. The intermediate objectives of the program are directed towards attaining:

- GTP targets of 98% and 100% access to safe water supply for rural and urban areas respectively;
- Access to basic sanitation to all Ethiopians secured;
- 77% of the population practicing hand washing at critical times, safe water
- handling and water treatment at home;
- 80% of communities in the country achieving open defecation free status.

The program has core guiding principles that govern the implementation of the OWNP. These are:

- **Integration:** integrating safe water use with good sanitation and hygiene practices at the household level, in schools and health facilities (Institutional WaSH);
- **Alignment:** ensuring alignment of the program with policies, priorities, strategies and plans with the pertinent sectoral development plans, administrative systems, standards, and procedures of the Federal and Regional Government;
- **Harmonization:** streaming into One WaSH Plan, One WaSH Budget, One WaSH Report;
- **Partnership:** recognizing Civic Society Organizations and the Private Sector as significant partners playing an essential part in attaining OWNP target.

The OWNP has mainly 4 components: 1) Rural WaSH, 2) Urban WaSH, 3) Institutional WaSH and 4) Program Management and Capacity Building.

In view of the implementation modality, the Rural WASH Program component has two major steps. These are:

- Step 1: Preparatory and planning (within the timeframe of 3 to 6 months)
- Step 2: Implementation (within the timeframe of 18 to 30 months period)

The primary responsibility of planning, managing and implementation of the Rural WaSH program rests with Woredas and communities. Woredas receive financial support from the Consolidated WASH Account to contract Woreda WASH Consultants (WWC), Community Facilitation Teams (CFTs), contractors and artisans who would in turn assist them in planning, management and implementation of their WaSH program.

Like the Rural WASH, the implementation modality of the Urban WASH component has also two major steps. These are:

- Planning and preparatory
- Implementation

With regard to the Institutional WASH Program component, it is divided into school WASH and WASH for health facilities. In the school WASH component, school facilities are provided with safe water and sanitation facilities combined with hygiene education thus improving school enrolment and attendance, potentially lowering the drop-out rate and repetition rates, especially of girls. In a similar manner the WASH program in the health facilities will support construction or rehabilitation of water supply facilities and latrines at health centers and health posts.

3.4.8.9. The Proclamation to Establish Urban Water Supply and Sewerage Enterprises

The Oromia Region has issued the legal framework for the sustainable management of the region's water supply and sanitation services by proclamation that provided for the establishment of Urban WSSE as an independent/autonomous public entities administered by generating their own income. Accordingly;

The Proclamation for the expansion of organizational system which obtains independence workings of effective existence and sustainable urban drinking water services in the region. This proclamation was issued for the determination of organization and management to facilitate to urban drinking water service enterprises so that to enable to cover the operational and maintenance costs in sufficient manner and to be established in the principles of cost recovery as per the requirements of Ethiopian water resources management policy.

The mandates, duties, responsibilities, and accountabilities of the WSSE as well as TWBs, the legal personality and autonomous rights have been defined.

3.4.8.10. Organization and Accountability

As it was stated in the regional proclamation, institutional set up of the town water supply service Enterprise is to have the following organizational units:

- A Water Board Management,
- A General Manager,

The staff required for the performance of its duties With regards to the accountability, the TWB reports to the town administration Council and the Enterprise is directly accountable to the management board. The day to day operation and administration of the Enterprise is carried out by the Utility whereas the board oversights the activities of the same. The Manager of the Enterprise is the higher executive officer and represented in the board as a non-voting member.

3.4.8.11. Membership and Composition of the water Board

As stated by the regional proclamation, members of the board are selected by the town administration and consist of the following composition;

1. The Town Administration Mayor..Chairperson
2. Water and Irrigation Development sector...............................V/Chairperson
3. Representative of Health sector...Member
4. Representative of EPPCO...…...Member
5. Representative of Women and Children.................................Member
6. Representative of Environmental Protection..........................Member
7. Representative of Customers ……………................................Member
8. Representative of Chamber of Commerce..............................Member
9. Representative of Finance & Economy Development………Member
10. General Manager of the Enterprise……...............................Non-voting Participant
11. Representatives of Enterprise Workers (two) ……….........Member
12. A staff of the Enterprise assigned by Manager…………….Non-voting Secretary

3.4.8.12. Roles and Responsibilities

i) Town Water Board

The following duties and responsibilities are assigned to the town water board:

- The Board shall direct, follow up & monitor the overall works of the Enterprise as a supreme body,
- Examine and approve the annual work program and budget of the Enterprise,
- Appraise and approve the service tariff for the Utility and monitor for proper implementation,
- Discuss on policy issues related to the works of the Enterprise,
- Determine the structure and salary of the staff of the Enterprise,
- Select, assign and dismiss the General Manager, fix his/her wage and allowance,
- Fix the amount of monthly allowance to be paid to its members,
- Perform such other activities that assist the fulfillment of the objectives of the Enterprise,

ii) Town Water Supply Service Enterprise

The regional proclamation states the following points to illustrate the powers and duties of the enterprise.

- Provide adequate potable water supply & sewerage service to dwellers in & around a specific town,
- Administers itself on the basis of cost coverage principles and decision and guidelines of a board that could be established to lead and regulate the utility,
- Partially contract out some of its works to maximize efficiency. It shall use service charges it collected only for development of water works,
- Enter an agreement; procure or sell fixed and consumable assets; possess properties,
- It can sue or be sued, acquire and own any moveable or fixed assets.

3.4.8.13. The Relationship of Enterprise with RWEB

Regarding the relationship with the Bureau, Proclamation40/2002 Art, 12 states, that the Bureau:

- Shall follow up that the service provided by the enterprise is in accordance with the water resource Management Policy and Water Law of the country,
- Issues directives and create favorable conditions that enable the enterprises get the necessary support from government and non-government organizations in the form of loans, grants and gifts,
- Gives any technical and consultancy support.

Social protection is an increasingly important approach to reduce vulnerability and chronic poverty, especially in contexts of crisis such as income and consumption shocks and stresses. So, giving due attention to gender issues while establishing community based structures for the management of localized Water Supply and Sanitation systems is necessary. Particularly, empowering women economically, socially and politically by establishing equity in education contribute to the holistic wellbeing of the community in water-environment-health issues.

3.5. METHOD OF DATA ANALYSES

The above diverse data generated through quantitative and qualitative methods demand different analyses techniques. The primary data collected through the household survey were edited, coded, labeled and entered into the Statistical Package for Social Scientists (SPSS) software for overall database management and analysis. Descriptive statistics like averages, crosstabs, proportions, percentages, ranges and the like were used in the analysis. The qualitative information drawn from FGDs and the KIIs were used to triangulate the results of the household survey.

3.6. EXISTING SOCIOECONOMIC SITUATION OF THE PROJECT AREA

3.6.1. Location

Adadle Woreda is found in Shabele Zone of Somali Regional State. It is situated South-East of Jigjiga town, the regional capital, at a distance of 570Km and 18Km South West of Gode, the Zone capital. Its distance from Addis Ababa is about 1,090 Km.

3.6.2. Population

The population data of Adadle woreda has been obtained from two sources- Woreda administration and CSA based projection. As shown in the table below the difference between the two sets of data is not that much significant. However, considering its official status and expertise in the field of population data management, the CSA based data (117,464) is considered more acceptable, and will be used as a baseline population for the water demand calculation and designing of the water supply scheme. The population figures from both sources are given in the Table below.

Table 3-1: Population data of Adadle Woreda by Kebele

No	Kebele	Population (Woreda) 2022		CSA Projected 2022		Distance from District Town (km)
		Total	**HH**	**Total**	**HH**	
1	Bohlagere	21,040	2,754	9,131	1,195	-
2	Higlo	4,795	628	5,060	662	9
3	Hiogududo	5,100	668	5,382	704	17
4	Biyolo	5,749	752	6,067	794	19
5	Sigole	4,523	592	4,773	625	22
6	Bursareedo	11,510	1,507	12,146	1,590	50
7	Gebal	9,557	1,251	10,085	1,320	29
8	Dhafdhafe	5,849	766	6,172	808	31
9	Dabafayid	5,889	771	6,214	813	13
10	Wardiid	3,632	475	3,833	502	20
11	Jerey	9,148	1,197	9,654	1,264	28
12	Malkasala	12,048	1,577	12,714	1,664	37
13	Harsog	3,543	464	3,739	489	46
14	Todop	7,288	954	7,691	1,007	90
15	Marodillee	13,466	1,763	14,210	1,860	120
Total		**123,137**	**16,117**	**116,871**	**15,297**	

Source: Adadle Woreda Administration and CSA Projection

As per the CSA Population projection values, the targeted population size reached 16,191 in 2022. In addition to demographic factors such as birth, death and migration, expansion of the town boundary also contributed significantly to the nearly double increase of the population.

As can be observed from the above table, Health office and CSA projection give almost the same result while town master plan study report. In comparing the two, though CSA is the official authority for population data in Ethiopia the consultant favors the adoption of CSA projection to use for water demand projection for this project.

Table 3-2: Annual growth rate for urban population of Oromia Regional State

Year	2010-15	2015-20	2020-2025	2025-2030
Urban	4.3	4.1	3.8	3.6
Rural	2	1.7	1.4	1.1

In general, since population growth in the project area will continue to be influenced by the economic factors projection of future population size for Adadle town might not provide precise demographic information, making it imperative to take in-migration in to consideration in addition to the normal population growth trend. The consultant intends to raise this issue with the stakeholders for in depth discussion so that a shared understanding on the socioeconomic factors that will affect population projection for the project kebele is established. The current population is estimated be **14,191**.

3.6.3. Economic Activities

3.6.3.1. Trading Activities

Business activity in the woreda is concentrated in Adadle town, as Adadle is the economic and administrative center to the surrounding rural Kebeles. Most of the commercial units are retail shops and informally operating tea houses. Besides, there are 3 hotels with around 50 bed rooms in the town. The potential for private sector development is significant once the water supply issue is solved.

3.6.3.2. Livestock in Adadle Woreda

In line with the predominantly semi-pastoral nature of the woreda population, there is a large livestock population in the Adadle Woreda. It has been observed that shortage of water induce by the prevailing draught had caused significant loss of livestock in recent months. The following table presents the livestock data in each Kebele of the woreda as reported by the Woreda Agricultural office. Accordingly, shoats (Sheep & goat) constitute over two-third (68.4%) of the total livestock population of the woreda. While cattle accounted for 18.6%, camels represent 10.8% of the total. The share of, donkey and chicken is 1.9% and 0.2% respectively.

Table 3-3: Livestock Population in Adadle woreda by Kebele

No	Kebele	Type of Livestock				
		Camel	Shoats	Cattle	Donkey	Poultry
1	BoholAgare	3,800	22,655	7,982	2,464	320
2	Maroodile	16,900	37,089	5,419	890	160
3	Todob	19,600	97,259	10,891	3,672	71
4	Haarsoog	11,000	59,277	4,600	1,200	-
5	Malakasala	12,060	72,414	6,122	1,414	32
6	Jeerey	6,700	31,566	16,386	1,342	200
7	Wardiid	250	12,400	6,195	54	27

8	Dabafayd	320	19,177	20,964	700	150
9	Hilagududo	125	18,689	8,625	132	-
10	Higlo	350	17,200	9,736	210	144
11	Biyolow	700	24,180	15,297	440	38
12	Sigoole	1,200	28,909	11,742	576	81
13	Buursareedo	3,095	35,300	18,400	1,842	190
14	Gabal	10,500	77,822	14,751	1,499	110
15	Dafdhafeey	9,400	51,463	7,890	765	64
Total		**96,000**	**605,400**	**165,000**	**17,200**	**1,587**

Source: Woreda Agricultural office

3.7. Socio Cultural Issues

3.7.1. Informal social organization

Implementation of development projects through Community participation is believed to be more sustainable and effective. In this regard the experiences of the residents in various development activities including water supply and sanitation have been reviewed through each kebeles' managers. Residents have experience of participation of organized by Kebele. The participation according to respondent households are by large through labor and cash contribution.

3.7.2. Community participation

Considering the above mentioned potable water supply and sanitation facility challenges in the town, increased participation of community seems to the direction for improved water supply and waste management in Adadle town. The communities should be involved because as consumers of the service they have an obligation to pay for it or to make some other contribution that will ensure that the service is provided for them.

In light of this, the willingness of the community to participate in every aspect of the project has been observed during the study period. In the course of survey, special emphasis was given for the collection of the attitude of the beneficiaries of water supply and sanitation project. It is identified that the beneficiaries have very positive attitude towards the implementation of the water supply and sanitation project.

All respondents reported that they are willing to participate in the construction of the project in different forms. Of the total respondents asked their attitude towards the project implementation, 12% (45 respondents) and 17% (65 respondents) reported that they are willing to participate in providing cash and labor contribution respectively while the remaining 71% (274 respondents) by contribute their both labor & cash and participating in the management system respectively.

Table 3-4: Community participation during project construction

Forms of participation	Frequency	Percent
Cash	45	12
Labor	65	17

Both cash and Labor	274	71
Management	0	-
Total	**384**	**100**

Source: Sample survey, 2022

In addition, town residents are well aware of the existing water supply shortage and poor basic sanitation facility that is unable to meet the need for domestic water demand and need especially in last three to five years.

3.7.3. Gender Issues

Here, the term gender does not refer to simple population percentages rather it is concerned with social aspects of culture, religion and class which determines the roles and status of males and females in society.

One of the guidelines of the National Water Supply and Sanitation Programme is to maximize health benefits of the community by integrating water, sanitation and hygiene through education interventions. In this regard Gender-sensitivity and mainstreaming is vital in water and sanitation programmes as far as women (and girls) and Men (and boys) use water in different ways and share the burden of collecting water disproportionately. Hence, the success of water and sanitation projects requires the active involvement of women particularly, because it is they who fetch and store water, dispose of domestic waste and children's excreta, and teach hygiene habits to children. The decision-making role of women under the Community Ownership and Management concept is therefore crucial and needs to be practiced.

With this fact in mind, a base line survey and focus group discussion made for expected beneficiaries and women and children affairs indicated that gender discrimination is highly deep rooted against females in rearing of children and fetching water for in home water consumption from the existing water supply sources. Result from sampled respondents response shows that women (mothers and girls) are assigned in transporting water for in home water consumption as their own duty by 95%. For a question raised to the respondents about who is responsible for fetching drinking water for home consumption, they responded as indicated in the following table.

Table 3-5: Gender in the context of water fetching

Question	**Family members**	**Frequency**	**Percent**
Who is responsible for fetching water?	Male HH head	5	1
	Female HH Head	295	77
	Daughter	69	18
	Boy	15	4
Total		**384**	**100**

Source: Sample survey, 2022

Gender is the socially constructed roles and responsibilities assigned to women and men but not a biological factor in a given culture or location. The sex based division of labor prevails in the town from time immemorial. Women are mostly deals with caring the children and seek member of family. It is the duty of women to prepare the food, cleaning and managing the house, purchasing food items, fetching the water from source and collecting firewood.

As far as the problem highly lies on women, the current office of women and children affairs of Adadle town is working on it to break these accustomed traditions. As the manager of the office mentioned us, currently there are no organized women.

Besides, the costs of insufficient quantity and quality of water for domestic purposes are borne disproportionately by women and children due to their predominance in the domestic sphere. These costs include:

- Long time for water collection. Because women and children are the primary water collectors, longer collection times mean that women have less time for agricultural production, less control over income, and less time for child care or rest. Children have less time to attend school.
- Less water for drinking, bathing, washing and sanitation resulted in a poor hygiene and health situation.
- Opportunity cost of water-intensive activities undertaken by women. Domestic water supplies are used in brewing local beer or other small-scale food processing activities as well as craft activities or gardening, which are important sources of income, especially for poorer households.
- Poor water quality for domestic use. Water is contaminated due to in appropriate transport vessels or containers as well as contaminated areas around public taps and water sources.
- Increased incidence of water-borne diseases. Diarrhea diseases due to contamination or other health effects of bad water management affect women disproportionately because they have to shoulder health expenses and time burdens for caring for ill household members.

Thus, construction of the project will have a far reaching effect in reducing the burden on females who are currently shouldering almost all households' homestead activities in the town thereby enable women to allocate their time and labor for other essential activities like participating in different development activities, trainings and other social & political affairs which in turn will enable them get access and control to/over different resources equally with men.

3.7.4. Development Potential of the Town

According to information obtained from the woreda's administration office and trade and industry office as well as physical observation made by the consultant, the economy of the town will improve and it is expected that small scale agro-industries will grow and the town has a potential for investors.

In the town there no heavy industry classifications. Other light industries found in the town are grain mills, wood and metal works. These are characterized by low employment, lack of infrastructural facilities; operate in low capital and technology and lack of skilled labor forces. These are the major hindrances affecting investments on manufacturing establishments.

The development of industry and commerce within Adadle town will depend almost exclusively on private investment. To attract private enterprises to invest in industrial development especially manufacturers and service providers within the town, the government needs to provide a suitable enabling environment such as reliable and sustainable potable water and sanitation facilities. The required measures include a significant improvement in the economic and social infrastructure (e.g. roads, water supply, electricity, telecommunications, education, health services etc.), favorable administrative regulations and a sound financial/legal framework. Hence, the implementation of this project will address either measures directly or indirectly contributing good condition for future betterment of the town hopefully.

3.8. Basic Social Services

3.8.1. Educational Facilities

Data sourced from Adadle District Education Office shows that educational service in Adadle town is provided by a total of **16** schools of which **5** primary schools (1-4), **8** juniors secondary (1-8) schools and **3** secondary schools (9-12). All the schools available are run by the Government. The total number of students and teachers in these schools are **7,864** and **153** respectively.

The following table presents the educational services with existing water supply & toilet facilities that found in Adadle town. Almost all the schools haven't access to water supply due to water shortage.

Toilet facilities among other things, is considered a basic requirement in every school environment to cater for both emotional and physical needs of the students. The consultant aimed to assess toilet facilities in schools within Adadle woreda. However, the design and sanitary conditions of the facilities inspected the consultant does not conform to the standard requirements.

Table 3-6: Number of Schools, Students and Teachers in Adadle woreda

No	School name	Grade	Kebele	Student by sex			Teachers by sex			Sanitation facilities	
				M	F	T	M	F	T	WS	Toilet
1	Boholhagre	1_8	Bohlagere	368	327	695	13	9	22	No	No
2	Iftin	1_8	Bohlagere	311	225	536	15	6	21	No	Yes
3	Farburo	1_7	Bohlagere	328	253	581	13	10	23	No	No
4	u/ Ibrham Cabdi	9_12	Bohlagere	268	180	448	15	1	16	No	Yes
5	Todob	1_8	Todop	329	394	723	8	1	9	No	Yes
6	Birlays	1_5	Biyolo	348	157	505	5	1	6	No	No
7	Malkasalax	1_8	Malkasala	302	268	570	8	2	10	No	Yes
8	Harsog	1_8	Harsog	326	256	582	5	2	7	No	No
9	Hodan	1_5	Hiogududo	319	251	570	5		5	No	No
10	Dhaf -Dhafay	1_8	Dhafdhafe	222	200	422	2		2	No	No
11	Gabal	1_8	Gebal	313	187	500	3	1	4	No	No
12	Biyo-Cade	1_5	Biyolo	204	150	354	1		1	No	No
13	Digno	1_5	Higlo	285	160	445	7		7	No	No
14	Biyolow	1_5	Biyolo	325	200	525	8	1	9	No	No
15	Sare'ee Karkar	9_11	Bursareedo	77	38	115	6		6	No	Yes
16	S/Maroodile	9_12	Marodillee	187	106	293	5		5	No	Yes
Total				**4,51**	**3,352**	**7,864**	**11**	**34**	**153**		

Source: Adadle woreda Education Office, report, 2022

3.8.2. Health Service

As per data from Adadle Woreda Health Office shows that 2 health centers and 23 health posts are operating in the woreda.

Overall, the town and the woreda are highly vulnerable to water borne disease or illness as a result of water shortage and consumption of unsafe sources. The information regarding the top –ten-disease is depicted in the table below.

Table 3-7: Top Ten Diseases of Adadle Town, 2021

No	Name of disease	Number of cases	Percentage (%)
1	Pneumonia	743	35.5
2	Typhoid fever	778	37.17
3	Malaria	94	4.49
4	UTI	85	4.06
5	URTI	80	3.82
6	Diarrhea	74	3.54
7	Gastritis	71	3.39
8	Otitismedis	68	3.25
9	Intestinal parasites	54	2.58
10	Others	46	2.2
Total		**2,093**	**100**

Source: Adadle Woreda Health Office, 2021

3.9. OUTCOMES OF THE SAMPLE HOUSEHOLD SURVEY

3.9.1. Demographic Conditions of Sample Households

3.9.1.1. Profile of the Sampled Households

A total of 384 sample households were drawn from 2 prioritized kebeles namely, Adadle town and Higlo rural kebeles in the study woreda. Out of the total sampled household heads, 62(16.1%) were males and 322 (83.9%) were females. Married respondents account for 63.4% of the total.

3.9.1.2. Sex and Age Composition of People Living in Respondent Families

The total number of people living in the 384 respondent families was 2,933. Accordingly, the average family size was calculated to be 7.64 persons. The Table below presents the distribution of the population in the respondent families according to broad age groups. The data shows that the proportion of children under the age of 15 is significant accounting for 40.4% of the total population. On the other hand, people aged 64 years and above represent 8.5%. Both these age groups represent the economically dependent section of the community. The economically active segment that lies between the ages of 15 and 64 constitute about 51.4%. Based on the above information, the total dependency ratio is estimated 95.8%, which is much higher than the national figure of 77.2%, as per the UNFPA report for 2022.

Table 3-8: Age Structure of People living in the Sample Households

No	Age category	Number of people	%	Cumulative%
A	<15	1,186	40.4	40.4
B	15_64	1,498	51.1	91.5
C	>64	249	8.5	100
Total		**2,933**	**100**	

Source: Sample Survey, 2022

3.9.1.3. Marital Status of Respondents

Around two-third of the respondents (63.5%) were married people. Out of the total, widowed household heads accounted for 14.3% while 13.3% were single and 8.9% were divorced.

Table 3-9: Marital Status of Respondents

No	Description	Frequency	%	Cumulative%
A	Single	51	13.3	13.3
B	Married	244	63.5	66.8
C	Widow	55	14.3	81.1
D	Divorced	34	8.9	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.1.4. Religious Affiliation

Religious affiliation of the project area communities is overwhelmingly Muslim as close to 89.6% of the total respondents identify themselves as followers of this religion. Orthodox Christianity followers constitute distant second accounting for 8.1% of the total while Protestants account for 2.3% of the total. The following Table presents religious distribution of the project area population.

Table 3-10: Distribution of Sample HH Heads by Religion

No	Description	Frequency	%
A	Muslim	344	89.6
B	Orthodox	31	8.1
C	Protestant	9	2.3
Total		**384**	**100**

Source: Socioeconomic Survey, 2022

3.9.1.5. Ethnicity

Out of the total 92.9% of the respondents are ethnic Somalis. 3.1% of the population is from Oromo ethnic group while Amhara and Tigray constitute 2.7% and 1.3% respectively.

Table 3-11: Distribution of Sample HH Heads by Ethnic Group

No	**Description**	**Frequency**	**%**
A	Somali	357	92.9
B	Oromo	12	3.1
C	Amhara	10	2.7
D	Tigray	5	1.3
Total		**384**	**100.0**

Source: Sample Survey, 2022

1.4.1 Livestock Holding

As predominantly pastoral community, people in the project area practice rearing of various types of livestock, such as camels, cattle, sheep, goats, horse and donkey. Results of the survey show that there were a total of 5,271livestock in the 384 respondent households, making the average holding of 14 animals. The livestock population was comprised of 7.3% camels, 14.6% cattle, 76.6% shoats and 1.5% donkey. The livestock data is summarized in the Table below.

Table 3-12: Livestock in Respondent Households

No	**Description**	**Frequency**	**%**
A	Cattle	771	14.6
B	Shoats	4,037	76.6
C	Equines	77	1.5
D	Camel	386	7.3
Total		**5,271**	**100.0**

Source: Socioeconomic Survey, 2022

3.9.2. Education Level of the Respondents

The household survey showed that the overall educational status of the household heads is not that much impressive as around 9.2% of the respondents didn't receive formal education and 18.5% were able only to read and write. The Table below presents the educational status of the respondents. Out of the total respondents those who attended college level education are less than 10% while primary and secondary education accounted for 36.2% and 26.9% respectively.

During the survey, there were a total of 1,711 students currently attending schools in the respondent families of which 56% were males and 44% were females.

Table 3-13: Education Level of the Respondents

No	**Education level**	**Frequency**	**%**	**Cumulative%**

A	No education	35	9.2	9.2
B	Reading & writing	71	18.5	27.7
C	1-4 grade	104	27.1	54.8
D	5-8 grade	35	9.1	63.9
E	9-10 grade	72	18.7	82.6
F	11-12 grade	31	8.2	90.8
G	Diploma	29	7.5	98.3
H	Degree	7	1.7	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.3. Housing Condition in the Project Area

The majority of the residential houses in the study area are made from Hollow Concrete Block walls and CIS roofs. Such models represent around 48.2% of all houses. The prevalence of wooden walled-CIS roofed houses is around 19.5% and CIS walled-CIS roofed is 1.6 percent. Traditional house models constitute around 30.7 percent.

Table 3-14: House Construction Material

No	Type of living house	Frequency	%	Cumulative%
A	Thatched roof with wood & mud wall	118	30.7	30.7
B	CIS roof with wood and mud wall	75	19.5	50.2
C	CIS roof with HCB wall	185	48.2	98.4
D	CIS roof and CIS wall	6	1.6	100
Total		**384**	**100**	

Source: Sample Survey, 2022

Regarding status of house ownership, the survey showed that more than half of the respondents (55.8%) are living in their own houses. Nearly 18.8% live in houses rented from individual house owners and 18.8% dwell in houses owned by Kebele Administrations. The following Table presents the status of house ownership in the study community. It is also noted that out of those having their own houses, 38% claimed to have house ownership certificates while 18% do not. The remainder 44% didn’t respond to this question.

Table 3-15: Mode of House Ownership of the Responders

No	Description	Frequency	%	Cumulative%
A	Private	214	55.8	55.8
B	Kebele	98	25.4	81.2
C	Rent	72	18.8	100
Total		**384**	**100.0**	

Source: Sample Survey, 2022

Table 3-16: If the house is private has ownership certificate

No	Description	Frequency	%	Cumulative%
A	Yes	85	38	38
B	No	40	18	56
c	No response	99	44	100
Total		**224**	**100**	

Source: Sample Survey, 2022

3.9.4. Livelihood, Income and Expenditure

3.9.4.1. Livelihood Sources of the Respondents

According to the sample survey, running own business activity is the most common source of livelihood as 46% of the respondents are engaged in this sector. The second largest source of income for households is employment in the private sector encompassing around 18% of the household heads; followed by the government sector that provided jobs for 16.5% of the households. The contribution of agriculture is limited to 9.4% of the total. Pensioners account for 3.6% while the remaining 6.3% of the households run their life working as daily laborers. The Table below presents livelihood source of the survey respondents.

Table 3-17: Distribution of HH Heads by Type of Occupation

No	Description	Frequency	%	Cumulative%
A	Government employees	63	16.5	16.5
B	Private sector employees	69	17.9	34.4
C	Own business	178	46.4	80.8
D	Agriculture	36	9.4	90.2
E	Laborer	24	6.3	96.5
F	Pension	14	3.5	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.4.2. Households Income

Income level of households is an important indicator as to the socioeconomic status of a given community. With respect to a water supply project, income levels strongly affect ability and willingness to pay for improved service. The sample survey has attempted to estimate household incomes for the project area communities. The Table below presents the income data. According to the outcome of the survey, the average monthly income of the respondent households is in the region of Birr 2,386, the smallest and the largest reported earnings being Birr 1,000 and Birr 10,000 respectively. Out of the total respondents, 46.6% are earning an income less than the sample average. The following table summarizes the incomes of the respondents.

Table 3-18: Monthly Income of Respondent Households (Birr/month)

No	Description	Frequency	%	Cumulative%
A	1000-1499	57	14.7	14.7
B	1500-1999	96	25.0	39.7
C	2000-2499	53	13.8	53.5
D	2500-2999	74	19.2	72.7
E	3000-3499	82	21.4	94.1
F	3500-4000	15	4.1	98.2
G	>4000	7	1.8	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.4.3. Household's Expenditure

The sample survey shows that the respondent households spend Birr 1,960 per month on the average. This amounts to 82.2% of the reported income. The following table summarizes the expenditure levels of the respondents.

Table 3-19: Household Expenditure (Birr/Month)

No	Description	Frequency	%	Cumulative%
A	500_999	26	6.7	6.7
B	1000-1499	99	25.9	32.6
C	1500-1999	84	21.9	54.5
D	2000-2499	115	29.9	84.4
E	2500-2999	17	4.5	88.9
F	3000-3499	19	4.9	93.8
G	3500-4000	14	3.6	97.4
H	>4000	10	2.6	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.5. Water Supply

3.9.5.1. Source of Domestic Water Supply

The communities of the project area get their domestic water from three major sources, namely, water tucking, water vendors and Birka. Of the three sources, water trucking covers 55.8% of the total domestic water supply, vendors 33.5% and Birka 10.7%. There is no piped system and reliable traditional water source in the study area. Out of the total, 99% of the respondents said they were not getting adequate water claiming that water is obtained only for three or four days in a week. The available water is also shared with the livestock. It has been confirmed during the FGD that water shortage is at a critical level in the study area. The following table summarizes the existing water sources.

Table 3-20: Distribution of Sample HHs by Primary Water Sources

No	Description	Frequency	%	Cumulative%
A	Piped system		-	
B	Water trucking	214	55.8	55.8
C	Vender	129	33.5	89.3
D	Birka	41	10.7	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.5.2. Domestic Water Consumption

The survey showed that the average amount of water collected by the project area households was 3.86 cubic meters per month. This is equivalent to 128.7 liters per day. Considering the average family size of 7.64, this translates in to 16.9 liter per person per day, which is about 67.4% of the national standard of 25 liters per capita as per the GTP2 plan.

Table 3-21: Monthly Water Consumption of Sample Households (m^3)

No	Consumption (m^3/month)	Frequency	%	Cumulative%
A	1-5 m^3	336	87.5	87.5
B	6-10m^3	35	9.1	96.6
C	11-20m^3	13	3.4	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.5.3. Cost of Domestic Water

According to the sample survey, the average expenditure of households on water supply is estimated to be 109.82 birr per month, including transportation cost. This represents 4.6% of the average monthly household income and 5.6% of the average monthly expenditure. The Table below presents the monthly payments for water supply.

Table 3-22: Monthly Water Cost of Sample Households

No	Description	Frequency	%	Cumulative%
A	Up to 45 birr	40	10.4	10.4
B	46-90	85	22.1	32.5
C	91-135	134	34.9	67.4
D	Above 135	125	32.6	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.5.4. Responsibility for Water Fetching

As to whose responsibility is it to fetch water for the family, the survey shows that it is exclusively shouldered by the females in around 80.4% of respondent households. Males, particularly boys aged less than 15 years assume responsibility of water fetching only in about 20% of the families. In general, gender bias is clearly manifested in this important but extremely laborious task of water collection.

Table 3-23: Gender of Family Members Responsible for Water Fetching

No	Description	Frequency	%	Cumulative%
A	Wife	225	58.5	58.5
B	Girls less than 15	84	21.9	80.4
C	Boys less than 15	75	19.6	100
Total		**384**	**100.0**	

Source: Sample Survey, 2022

3.9.5.5. Distance Traveled and Time Taken to Fetch Water

Distance between household and water point is one of the parameters used to measure water coverage. According to the National GTP2 plan, the rural community should have access to safe water supply within a distance of 1,000 meter (m). Analysis of the survey data shows that households in the project area travel an average distance of 834.3m to reach the water point, which is less than the national standard. However it is important to note that, for nearly 43% of the households the distance between home and water point is above the specified standard. On the other hand, the average time spent on water collection is calculated to be around 50 minutes. The data on distance traveled is presented in the table below.

Table 3-24: Average one-way Distance traveled to fetch water

No	Distance (in meters)	Frequency	%	Cumulative%
A	Up to 100m	26	6.8	6.8
B	100-500m	71	18.5	25.3
C	500-1000m	122	31.7	57
D	1000-1500m	165	43.0	100
Total		**384**	**100.0**	

Source: Sample survey, 2022

3.9.5.6. Quality of Water Collected from Current Sources

Based on the survey analysis, 66.1% of the respondents have various complaints about the quality of the water they get from the existing sources while only 33.9% have not. Regarding the types of quality defects ‘worm infestation’ has been indicated by 47.8% of those who have problems with water quality. Around 34.2% mentioned bad odor and 18.1% bad test. The table below presents quality issues as perceived by the respondents.

The survey also showed that 53.6% of the respondents treat the water at home by boiling and 46.4% by using various chemicals.

Table 3-25: Perceived Water Quality Defects

No	Is the water has quality problem?	Frequency	%	Type of quality defects		
				Bad test	Bad odor	Various worms
A	No	130	33.9	-	-	-
B	Yes	254	66.1	18.1%	34.2%	47.8%
Total		**384**	**100.0**	**66.1%**	**27.8%**	**1.1%**

Source: Sample Survey, 2022

3.9.5.7. Willingness to Pay for Improved Water Supply & Preferred mode of connection

As shown in the Table below, around 23.2% of the total respondents opted for house connections. Private yard connection is preferred by about 45% while around 32.1% of the respondents expressed that they would be satisfied by a public water points close to their locality.

Table 3-26: Preference for Mode of Service

No	Description	Frequency	%	Cumulative%
A	House connection	89	23.2	23.2
B	Yard connection	172	44.8	68
C	Water point	123	32	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.5.8. Support for the Project

With respect to this project, all of the household heads involved in this study have expressed they will support the project construction in various forms, i.e. free labour 18%, cash contribution 13.4% and both labour and cash 68.8 percent. The expressed modes of support are presented in the table below. During the FGD session the representatives of the community has expressed strong support to the project and pledged to do anything required of them for the successful completion of the project.

Table 3-27: Mode of community support to the project

No	Description	Frequency	%	Cumulative%
A	In cash	51	13.4	13.4
B	In labour	69	17.8	31.2
C	Both cash & labour	264	68.8	100
Total		**384**	**100**	

Source: Sample survey, 2022

3.9.5.9. Willingness to Pay More (WTP)

Conceptually, consumers' willingness to pay for improved water supplies can be influenced by several factors. Perceived benefits of improved water supply, water tariff, household income, mode of service, existence of acceptable alternative source, shortage of water and hardship related to fetching, etc. are some of the factors that influence the level of willingness to pay more. In this project area all the above factors are in play.

Accordingly, the respondents were asked to specify the amount of money they would be willing to spend on water supply, based on their mode of connection preference. Based on the responses, the average WTP for the entire sample has been calculated to be Birr 99.23. This amount constitutes 4.2% of the monthly average household income and 5.1% of the corresponding expenditure. Moreover, 83% of those respondents who preferred to get private pipe connections were willing to cover the required connection costs. The following Table presents the estimated willingness to pay by preferred mode of connection.

Table 3-28: Summary of Household Willingness to Pay

No	Description	Frequency (Preferred Mode)			Total	%	Cumulative%
		HC	YC	WP			
A	20-30 br	-	5	11	16	4.2	4.2
B	30-50	1	7	10	18	4.7	8.9
C	50_70	5	8	6	19	4.9	13.8
D	70_80	6	15	7	28	7.3	21.1
E	80_100	6	20	18	44	11.5	32.6
F	>100	55	25	179	259	67.4	1000
Average WTP		**104.86**	**83.56**	**325.55**	**99.23**	**100**	

Source: Sample survey, 2022

3.9.6. Liquid and Solid Waste Disposal Methods

3.9.6.1. Types of Latrines used by the Households

Based on the household survey, 96% of the households in the project area have access to toilet facilities, while 4% practice open defecation. Majority of the existing toilets, 67.9%, are traditional pit latrines and 16.5% are VIP toilets. Out of all respondents, 11.6% claimed to have flash toilets. The data also confirmed that out of the total 59.8% of the toilets are shared toilets. The households with no access to latrine blamed unaffordable construction cost and lack of construction space in the compound for their situation. The toilet data is presented in the following table.

Table 3-29: Availability of Household Toilets

No	Description	Frequency	%	Cumulative%
A	Flash toilet	45	11.6	11.6
B	VIP	63	16.5	28.1
C	Traditional	261	67.9	96

D	No toilets	15	4.0	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.6.2. Toilet Desludging

When toilets are full, the common practice in the project area is to dig a new pit which has been reported by 88% of the respondents. On the other hand 8% of the respondents said that their toilets have not been full yet. See the table below.

Table 3-30: Toilet Desludging Practice

No	Description	Frequency	%	Cumulative%
A	Dig another	338	88.0	88
B	Empty using vacuum truck	-	0	88
C	Not full yet	31	8.0	96
D	Not applicable	15	4	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.6.3. Disposal of Gray Water

Gray water is generated at household level through various domestic activities like food preparation, cloth washing, house cleaning, bathing, etc. According to the survey data, large majority of the households in the project area, 40.2%, practice splashing gray water into the outside of the compound while 35.4% have prepared a liquid waste disposal pit dedicated to gray water. The remaining 24.6% use toilet pits or septic tanks for this purpose. See the table below for the summarized gray water disposal mechanism.

Table 3-31: Household Gray Water Disposal Mechanism

No	Description	Frequency	%	Cumulative%
A	In prepared pit	136	35.4	35.4
B	In septic tank	94	24.6	60
C	Outside the compound	154	40	100
Total		**384**	**100**	

Source: Sample Survey, 2022

3.9.6.4. Solid Waste Disposal

As reveled by the survey data, solid waste management system in the project area seemed to be at the poorest level. Close to 50% of the respondents admitted littering away household garbage in any place outside of the house compound. The traditional but safe methods of disposal like burning and burring are practiced by 40.4%. The role of organized association with respect to garbage collection is about 10.2% of all households. The Table below presents the waste disposal mechanisms of the project area households.

Table 3-32: Solid waste Disposal Method of Households

No	Description	Frequency	%	Cumulative%
A	By organized association	39	10.2	10.2
B	Burning	64	16.7	26.9
C	In pit	91	23.6	50.5
D	Dispose into outside	190	49.5	100
Total		**384**	**100**	

Source: Sample survey, 2022

3.10. SUMMARY OF INSTITUTIONAL SURVEY, FGD AND KII

3.10.1. Summary of institutional Survey

The institutional survey had focussed on Adadle health centre and a school in Adadle town. The outcomes are summarized in the following bullet points:

- The school does not have running water; they are using water tracking currently.
- There are separate latrines for male and female students, as well as teaching staff. But, the sanitation status of the latrines is poor due to lack of water supply.
- Solid wastes are collected and burned inside the school compound.
- The school management expressed strong support to the intended project. The school authorities are hoping to get piped connection when the project is completed.
- The health centre has no access to piped water supply; they depend on water trucking.
- Malaria, Pneumonia and Typhoid are the most common types of diseases in the project area.
- There are separate latrines for males and females, but the number is not adequate. Lack of water is a major problem when it comes to the sanitation of the latrines.
- Hand washing facilities are available, but not fully functional due to water shortage.
- Incineration and placenta disposal system are available in the health centre.
- The management members of the health centre are very supportive of the intended water supply project. They expect to get piped connection when the project is completed.

3.10.2. Summary of the FGD and KIIs

The Key Informant Interviews conducted with representatives of the Woreda Administration and various sector offices as well as the Focal Group Discussions held with representatives of the local communities have revealed that water shortage is the top priority problem in the woreda in general, and in Adadle town in particular. The following bullets summarize the major outcomes of the FGD and the KIIs:

- Business and investment development is hampered(There are only a very few of hotels, restaurants, pensions, etc.).
- Health impact on the population as a result of using unsafe sources and insufficient per capita water consumption.
- Low status of institutional sanitation and personal hygiene.
- Massive death of livestock has been caused by the prolonged drought.
- The participants of the discussion and representatives of the sector offices have expressed strong support to the project. However they have stressed that the source of the water must be Shebelle rives and they will not accept the project if ground water is being considered as source.

Also, the participants pledged willingness to pay more if the existing worst condition of water supply is improved.

3.10.3. Recommendation

- To make the newly constructed water supply system sustainably operational the water supply service enterprise organizational structure should be revised by government.
- The existing system should be maintained and managed well at least to feed the community at optimum level in the short run by water supply enterprise of the town.
- To develop new adequate water supply systems all stakeholders, religions leaders and elders should mean of the remedy the prevailing acute problems of water supply systemof the town.

4. ANALYSIS OF EXISTING WATER SUPPLY SERVICES

4.1. GENERAL

The study and design work of this project relies upon the data gathered during the inception and baseline survey stage. Woreda administrator, Institutional office (school and health), mayor office, kebele administration and elder community representatives were consulted during the same stage of assessment. Moreover, the study and detail design at inception phase thoroughly examined the existing water supply system gaps and challenges.

This paper exclusively covers the existing systems of Adadile woreda Water Supply and Sanitation systems, including the sources, conveyance and distribution system, hydraulic facilities/infrastructures, existing treatment plant and existing power sources. The detail of the existing system is presented in subsequent sub-chapters. To identify the existing different tools are used like Google earth to visualize the study area, Civil3d to digitize existing distribution line, Hand GPS, global mapper and camera equipment.

4.1. ADADILE WOREDA EXISTING WATER SUPPLY AND SANITATION

4.1.1. Water Sources

In general, as information from the woreda water administrator, the piped system of Adadle Town existing water supply was totally non function and destroyed from the source to the distribution system which was constructed before 10 years in 2003 E.C for Adadle and surrounding Kebeles. However, the source of this nonfunctional water supply system was surface source, from Shebelle River, around 15.9km far from Adadle town to the North direction. Therefore, the existing system assessment shall be focuses on the problem of each of the system from source to the Service reservoir.

4.1.2. River Diversion

There was a constructed river intake on the right bank of the Shebelle River downstream of Shebelle bridge. This intake structure is completely nonfunctional and destroyed by flood. The main problem of this intake structure is that the river flow shifts from the side of the intake due to sedimentation and the structure is left without water. The major problem of this intake structure the position of the intake, which was not properly selected, the morphology of the river should be identified based on the scouring and silting condition. Through time the river changes its direction from the existing position and shifts from the existing intake structure to the other direction.

This river intake was also structurally damaged, since the structure stay for long period of time without function, there was a cracked section with the hot climatic condition of the area.

Figure 4-1 River intake structure

4.2.3. Treatment plant

There was a treatment plant near to Shebelle River at geographical location of 339613 East and 654787 North and 277 elevations. This treatment plant was not functional and completely out of service since 2009. But the treatment processes and combinations of existing Adadle water supply system are sedimentation, (Sedimentation Tank) coagulation (Horizontal Roughing Filter), filtration and Clear Water storage (CWR). This removes particles, including microorganisms (bacteria, viruses and protozoa), color, odor, turbidity.

The preliminary investigation is to inspect the structural elements in affected area for physical appearance and it was observed that the components of the Adadle treatment plants were shown that imperfection of civil structures like cracking, fading and etc.

Figure 4-2 Sedimentation Tank with horizontal clarification

4.2.4. Transmission Pressure line

Raw water was directly pumped to the 50m3 raw water collector stationed not more than 100m distance from the head of the intake. The collection pipe is GS pipe with DN 100mm and the length of the pipe was 95m.

Figure 4-3 SatelliteImage of existing structure at intake head and treatment plants

The raw water was transported to treatment plant near to the collection tank by gravity and after treatment of the row water by conventional treatment (sedimentation, and slow sand filter) it is pumped to the 200m3 service reservoir located at the Adadle town. The estimated total length of the pressure line is 15.9 km with UPVC PN 10 OD 110mm.

Figure 4-4 Rectangular raw water Collector Tank

4.2.5. Service Reservoirs

There is 200m3ground concrete service reservoir which is situated within the center of the town at relatively high elevated, the topographic feature the entire town is almost flat type. With this condition the ground type of the service reservoir couldn't feed the dweller with enough head. Fitting on inlet, outlet and overflow also in good condition, but the service reservoir was not fenced and the structural condition also needs further checkup.

The detail feature of existing service reservoir shown below:

Figure 4-5 Existing 200m^{3}service reservoir

Figure 4-6 50m3 service reservoirs

Table 4-1: Silent Features of Existing Services Reservoirs

No	**Description**	**Location UTM 38**		**Elevation**	**Type**	**Year of Con.**	**Remark**
		Easting	Northing	Z			
1	200m3 Service Reservoir	337221	640564	285	Concrete	2003	Not functional

Source: from physical collection by consultant

4.2.6. Distribution system Network

Existing distribution network of Adadle Town Water Supply System was from service reservoir to the water points. Even though, there is distribution line within the town to the water points, the team unable to assess the exact length of the existing distribution line due to the shortage of information from the woreda water administration. However, the geo-referenced location of water point was connected to the service reservoir based on current satellite image of the town plan. The existing distribution line was a branched distribution line with a total of 3.5km of all Upvc pipe DN50mm-DN90m which is connected to nine (9) water points. The system only works for a short period of time due to different problem specified with the problem of the existing water supply system.

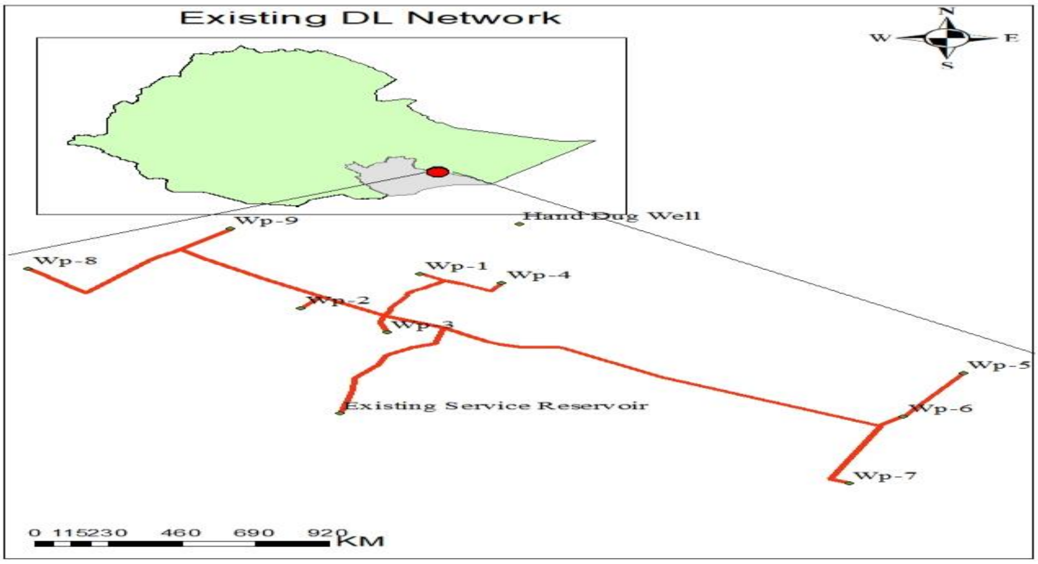


Figure 4-7 Existing Water supply system distribution line

4.2.7. Existing Water Point

Detail of water point coordinates; year of construction, functionality status and defects of water points is collected and tabulated as shown in the table below. There are existing nine public water points which isnone of them was not functional. The public water points are categorized in fully functional, partially functional and abandoned.

Table 4-2AdadleTownwater supply system Public water points detail

No.	**Description**	**X-Coordinate**	**Y-Coordinate**	**Elevation**	**Elevation**	**Condition**
1	Wp-1	337350	641130	278	278	Not Functional
2	Wp-2	337158	640991	283	283	Not Functional
3	Wp-3	337296	640892	277	277	Not Functional
4	Wp-4	337481	641093	278	278	Not Functional
5	Wp-5	338224	640728	276	276	Not Functional

6	Wp-6	338128	640552	279	279	Not Functional
7	Wp-7	338040	640280	281	281	Not Functional
8	Wp-8	336719	641151	282	282	Not Functional
9	Wp-9	337044	641314	287	287	Not Functional

The feasibility and Baseline survey have revealed that lack of maintenance, poor drainage, leakage, lack of fencing are the major challenges observed at public water point. All the public water points were 6 faucets.

Figure 4-8 Public water point in Adadle

4.2.8. Power Sources and pump house

The power sources of 30KVA diesel generators used at pumping station to collect raw water at treatment plant. At the time of inception, the generator was not functional. Raw water boosted to treatment plant by two surface pumps with a pump.

Figure 4-9 Pump station at river diversion and generator

4.2.9. The existing functional water supply system

The existing water supply system for Adadle Town and the rural area of the Adadle woreda is mainly based on water transporting by shower truck from Gode town and Shebelle River, and filled to 'birka' which is constructed underground with block wall and EGA sheet roofing. There is also a hand dug well within the Adadle/Boholagere town which they used mainly for livestock consumption and domestic water use since the water is salty. The only water the community use for drinking purpose is from Gode town which is transported by water truck. Generally, there is no functional piped system for Adadle town and Surrounding kebele which ensure the access to potable water.

Figure 4-10 Hand Dug well within the Adadle/Boholagere town (Water hunting)

Figure 4-11 underground 'Birka'

4.2. Sanitation Facilities

Inadequate sanitation and hygiene are one of the factors that cause 80 percent of all sickness and disease in the world (WHO, 1997). In Ethiopia, it has been reported that 60% of overall diseases is related to poor sanitation and lack of hygiene (Gebreselassie, 2007). It is generally believed that proper latrine construction, use and hygienic practices can reduce communicable diseases, such as diarrhea and trachoma arising from the environment, especially water and sanitation.

The sanitation condition has direct relationship with the access to adequate water supply system. In case of the Adadle woreda the sanitation condition was very poor related with water supply coverage. Public sanitation facilities refer to the sanitation facilities at market places, public gatherings like meeting hall were not totally missed out. There is no provision of toilets at market places. No public shower provision was made by the town administration or by private owners. The sanitation coverage reported from Woreda Health office was 35% the spatial

Without water personal hygiene is ridiculous, specially, in hot area the people need more water to take a shower. In Adadle town there is a poor personal hygiene due to shortage of water supply. In most of the kebeles in the Adadle Woreda, latrines are virtually non-existent in rural communities with defecation taking place in fields, bushes or along drainage ditches. Finally as report from woreda health office the sanitation coverage of the woreda in general was 38%.

Table 4-3 Water supply and sanitation availability in health facility of Adadle Woreda

S/N	Name of the health facility	Availability of Water	Type of safe water supply	Functionality status of the water scheme	Reason for non-functionality of water supply	Type of latrine constructed	Does it have hand wash
1	Bohol hagare	Yes	Birka	Functional		Pit latrine	No
2	Malkasalah	Yes	Birka	Non	Not enough	Pit latrine	NO
3	Bursaredo	Yes	Birka	Nonfictional	Not enough	Pit latrine	NO
4	Marodile	Yes	Roto	Nonfictional	Broken	Pit latrine	NO
5	Higlo	N0	N0			N0	NO
6	Hillogududo	N0	N0			N0	NO
7	Digino	N0	N0			N0	NO
8	Biyolow	N0	N0			N0	NO
9	Sigole	N0	N0			N0	NO
10	Caney	N0	N0			Pit latrine	NO

S/N	Name of the health facility	Availability of Water	Type of safe water supply	Functionality status of the water scheme	Reason for non-functionality of water supply	Type of latrine constructed	Does it have hand wash
11	Bulshowayn	N0	N0			N0	NO
12	Dirri	N0	N0			Pit latrine	NO
13	Kurtun	Yes	Roto	Nonfictional	Not enough	N0	NO
14	Gabal	Yes	Roto	Nonfictional	Not enough	Pit latrine	NO
15	Dhaf,dhafey	Yes	Roto	Nonfictional	Not enough	Pit latrine	NO
16	Dhanagab	N0	N0			N0	NO
17	Dabafayd	Yes	Roto	Functional		Pit latrine	NO
18	Wardid	N0	N0			N0	NO
19	Liban	N0	NO			N0	NO
20	Jerey	Yes	Roto	Nonfictional	Not enough	Pit latrine	NO
21	Har,us	Yes	Roto	Nonfictional	Broken	N0	NO
22	Biralays	Yes	Roto	Functional		Pit latrine	NO
23	Hadan	N0	NO			N0	NO
24	Cudhi	N0	NO			Pit latrine	NO
25	Harsog	Yes	Roto	Functional		N0	NO
26	Todob	Yes	Roto	Functional		Pit latrine	NO
27	Kulmis	N0	NO			N0	NO

Source: Woreda health office

5. POPULATION PROJECTION AND WATER DEMAND ANALYSIS

5.1. Planning Horizon

The Planning Horizon or Implementation Stage of a project is the length of time for which the system is expected to provide a community with good quality and sufficient quantity of water supply service. The consultant assumes 2022 as base year and 2023 to 20224 as year for construction. The design horizon planned to extend from 2024 to 2033. This criterion is used to forecast feature population and water demand as well as to design water supply system components on the basis of Rural Water Supply Design Criteria, 2022 set by MOWR and interest of client: technical, financial and economic feasibility.

5.2. Population

5.2.1. General

Most water supply schemes include huge and costly structures, which cannot be replaced or increased in their capacities easily and conveniently. Hence, all scenarios affecting the water supply system should have to be thoroughly accessed before the system is designed. One of the scenarios that have great impact on estimating the water demand of a particular project is the projection of the population sizes. Hence, the planning of any water supply system has to be based on the forecast of population size, population growth rate and distribution.

There are a number of factors that should be taken in to consideration in projecting the future population size of a project, some of which are fertility, mortality, economic activity in and around the project area, availability of natural resources, and status of the project area in the region both politically and economically, climate and topography of the area, relative location of the town with respect to main highways, availability of reliable urban infrastructures and facilities and etc.

5.2.2. Base Population

The use of a reliable base population figure is very important for optimizing the project costs and sustaining the project's service year. Over and under estimation of the populations could result in a higher investment cost and a lower service run period respectively. Hence, it is very important to initially get a realistic base population figures not to come with the above-mentioned problems.

As much as possible an optimum base (2022) population is estimated based on record of Adadile woreda Administration and projection of CSA 2007 estimation to 2022. Accordingly consultant decide CSA data for base population of the Adadile town and woreda population in 2022 estimated to be 9,131 and **107,740** respectively.

5.2.3. Population Projection

Following estimation of current population (base year) the consultant has projected population size over the planning hoeizon. In here, growth rate is adopted from CSA, and design guide line MoWE. Table 5.2. shows population projection of Adadile Woreda.

Table 5-1 Population Projection using Growth Rate MoWE, 2022 urban water supply deign manual

Year	2022	2024	2028	2033
Urban Growth Rate	3.80	1.10	1.10	1.10
RuralGrowth Rate	1.40	1.40	1.10	1.10
Urban Populatio based on CSA	9,131	9838	10553	11146
Urban Populatio based on Administration	21,040	22,669	24,316	11,146
Rural pop. Based on CSA	107,740	110,778	116,076	122,603
Rural pop. Based on Administration	102,097	104,976	109,997	116,181
Total Population Urban+Rural Based On CSA	116,871	120,616	126,629	133,749
Total Population Urban+Rural Based On Woreda Administration	123,137	127,645	134,313	127,327
Proposed Projected Population Urban + Rural	**116,871**	**120,616**	**126,629**	**133,749**

**NB: Arithmetic population projection method is applied for this project.

5.3. Water Demand Analysis

In the design of any water supply project, it is necessary to estimate the amount of water that is required to be supplied. This involves determining the number of people to be served and their per capita water consumption along with analysis of the factors that may operate to affect consumption.

5.2.4. Domestic Water Demand

The domestic water demand is the daily water requirement for use by human being for different domestic purposes like drinking, cooking, bathing, cleaning, gardening and etc. The domestic water demand required by human being could be supplied or obtained through different modes of services depending on the economic level and facilities owned by the individual.

5.3.1.1. Modes and Levels of Services

In this design, the conventional water supply systems in which an individual could be served depending on his economy are three. These are: House Tap Users (HTU), Yard Tap Users (YTU) and Public Tap Users (PTU).

The challenge in water supply design is to obtain right estimate of what the mode of services look like over the design period for a particular town. In fact, the previous experience is to adopt the mode of services recommended by Urban and rural Water Supply Modelling Water Demands as shown Table 5-2 below,

Mode of Services recommended by Modelling for Adadile town and surrounding villag based on design criteria the Consultants estimate the mode of services over the design period by increasing yard connection (50-60) % for each mode of services at every five years and (5-6) % decreases accordingly for public taps. The Unserved mode of service assumed to gets water from public taps in the design period.

Table 5-2 Number of Population by Mode of Services

Mode of Service	2022	2024	2028	2033
HC	0.0%	0.0%	0.0%	0.0%
YC	5.0%	7.9%	12.6%	19.9%
PT	95.0%	92.1%	87.4%	80.1%
Total	100.0%	100.0%	100.0%	100.0%

5.3.1.2. Per-Capita Water Demand

The per-capita domestic water demand for various mode of services varies depending on the various climatic, social and economic factors explained in previous section. According to design guideline (MoW, 2006, p. 14), design criteria the initial and final stage of demand for mode of service summarized as shown below.

Table 5-3 Percapita demand by mode of service

Mode of Services	Stage 1	Stage 2
House Connection (HC)	50	55
Yard Connection owned (YCO)	35	40
Public Tap (PT)	25	30

Source:- MWE, 2022, Rural water supply design criteria

The perCapita demand for GTP-II is revised based on population size. The following table shows the average Per Capita demand of towns by Category.

Table 5-4 : Town Population size and average per-capita demand

Town Category	Population size	Per-capita demand
1	>1000000	100
2	100000 - 1000000	80
3	50000 -100000	60
4	20000 – 50000	50
5	<20000	40

Source: GTP-II water Sector document

Since, GTP-II standard did not show per-capita demand breakdown by mode of service based on the table above the following steps followed to modify per-capita demand for this design of Adadile town and surrounding village.

Base and end design year population of the town determined and projected, Using the base and end year population projection, then the average per-capita demand is determined, for example Adadile woreda base and end year population is 116,871 and 133,749 respectively. From the table 5.3 above the average per-capita demand is then 36.7 & 41.67 l/c/d.

Table 5-5 and average per-capita demand of based on MWE, 2022, rural water supply design criteria is used to project mode of service for the design period and summarized in the table below:-Therefore the water supply system should carry the capacity of 39.2 l/c/d of adjusted total day demand.

Table 5-5: Per-capita demand modified based on design criteria

Mode of service	Design Period					
	2022	2024	2028	2033	2038	2043
HC	50.0	50.5	51.4	52.6	53.8	55
YC	35.0	35.5	36.4	37.6	38.8	40
PF	25.0	25.5	26.4	27.6	28.8	30

5.3.1.3. Climatic adjustment Factor

Water Consumption directly related to climatic conditions of the area. The amount of water consumed in hot areas is quite greater than the amount of water consumed in cold areas and it is also related to the amount of annual rainfall available. Hence considering these climatic conditions, depending on the altitude range of project area which lies between 200 to 500m m.a.s.l., climatic adjusting factor of 1.5 (for hot area) is adopted for this project as can be referred from the following table of previous regional and national design guide line.

Table 5-6 :Climatic Grouping Factor

Mean Annual Temp. (0C)	**Description**	**Altitude (m a.m.s.l)**	**Factor**	**Examples**
<10	Cool	>3,300	0.8	
15-Oct	Cool temperate	2,300-3,300	0.9	Goba
15-20	Temperate	1,500-2,300	1	Finfinnee
20-25	Warm temperate	500-1500	1.3	Metahara
25 and above	Hot	<500	1.5	Kebridehar

Source: MoWR, Urban Water Supply Design Criteria, 20061

5.3.1.4. Socio-Economic Factor

The Socio-economic condition of a town also plays a role in determining the water consumption of an individual town. The design criteria provided for this in the form of categories for the various degrees of development. It is however difficult to quantify many aspects of development and consequently the classification of particular town is made relatively to the others. Considering Adadile town and surrounding village one of the towns of the region under rura, a socio-economic factor of 0.9 is adopted from the following table.

Table 5-7 :Socio-Economic Grouping Factor

Group	Description	Factor
A	Towns enjoying high living standard and with very high potential for development	1.1
B	Towns having a very high potential for development but lower living standard at present	1.05
C	Towns under normal Ethiopian Condition	1
D	Advanced Rural town	0.9

Source : MoWR, Urban Water Supply Design Criteria, 2006

Applying the climatic and socio-economic adjustment factors to the average domestic water demand calculated from number of population and projected per-capita demand of respective modes of services, the adjusted average daily domestic water demand of the Adadile town and surrounding village shown below.

Table 5-8: Summary of Adjusted Daily Domestic Water Demand of Adadilr Woreda

Description	Unit	Design Period			
		2022	2024	2028	2033
Popolation					
Population growth rate	%	1.4	1.4	1.1	1.1
Population projection	No.	**116871**	**120616**	**126629**	**133749**
Socio economic factor	a	0.9	0.9	0.9	0.9
Climate factor	b	1.5	1.5	1.5	1.5
axb		1.35	1.35	1.35	1.35
Total Domestic Demand (adjusted)	**M3/d**	**4023**	**4277**	**4733**	**5390**
	l/s	46.6	49.5	54.8	62.4

5.2.5. Non - Domestic Water Demand

5.3.1.5. Public and Commercial Water Demands

Water required for schools, hospitals, hotels, public facilities, parks, offices, commercial establishments, military camps, small-scale industries and etc. are included in this demand category. Public demand is usually expressed as a percentage of the average day domestic demand.

The studies in rural having metered water supply system shows that the public water demand ranges Public/Institutional 2-6 % of domestic consumption and 5% for commertial demand, type and extents of commercial, economic and industrial activities. For Adadile town and surrounding village WSP, public and commercial Water demand is assumed to be 9 % of domestic demand.

5.3.1.6. Industrial Water Demand

Water in industries can be used for various purposes: as part of final product, for the maintenance of the manufacturing process (cleaning, flushing, sterilization, conveying, cooling, etc.) And for personal needs of the labor. Amounts needed depend on the type of industry and technological process. For planning purposes industrial demand can be estimated as a percent of the domestic water demand or the demand per square unit of land if there is a definite area allocated for industry by the town development plan.

Municipal water services are not obliged to provide water supply for the production processes of large industries; however, whenever there is no source limitation and there is no problem in securing higher initial investment costs, the option can be advantageous as it can have significant impact in reducing water tariffs for the domestic users.

According to MoWR, 2003, the project design: technical, financial and economic feasibility Issues paper when there is no land use plan for the project area, 5 to 10% of the domestic water demand can be taken as industrial demand depending on the size of the project. Therefore for this study 0% industrial demand is considered due to no master plan in the study area.

Table 5-9: Non-Domestic Water Demand

Description	Unit	Design Period			
		2022	2024	2028	2033
Popolation					
Population growth rate	%	1.4	1.4	1.1	1.1
Population projection	No.	**116871**	**120616**	**126629**	**133749**
Socio economic factor	a	0.9	0.9	0.9	0.9
Climate factor	b	1.5	1.5	1.5	1.5
axb		1.35	1.35	1.35	1.35
Total Domestic Demand (adjusted)	**M3/d**	**4023**	**4277**	**4733**	**5390**
	l/s	46.6	49.5	54.8	62.4
Public demand 9%	**m3/d**	**362.1**	**385.0**	**425.9**	**481.2**
	l/s	4.2	4.5	4.9	5.6
Industrial demand (0%)	m3/d	**0.0**	**0.0**	**0.0**	**0.0**
	l/s	0.0	0.0	0.0	0.0
Total non-domestic	**m3/d**	**362.1**	**385.0**	**425.9**	**481.2**
	l/s	4.2	4.5	4.9	5.6

5.3.1.7. Livestock Water Demand

To estimate animal (livestock) water demand, the universally accepted Global Livestock Units or Tropical Livestock Unit(LTU) conversion developed by FAO (FAO, 2003) adapted for sub-Saharan Africa can be used as reference, where 1 TLU in sub-Saharan Africa is equivalent to 1 mature cow of 250Kg with daily water consumption of 50 lpcd.

S/no	**List of kebele**	**Intervention period in cluster**	Life stoke Consumption Demand (l/s) In design			
			2022	2024	2028	2033
1	Adadle town	**Short term cluster**	5.03	5.28	5.55	5.83
2	Higlo		2.90	3.05	3.20	3.36
3	Biyolo		4.48	4.70	4.94	5.18
4	Wardid		1.90	2.00	2.10	2.20
5	Hilogududo		2.68	2.81	2.95	3.10
	Sub -Total		**16.99**	**17.84**	**18.73**	**19.67**
6	Sigole	**Medium Term Cluster**	4.37	4.58	4.81	5.05
7	Dabafayid		5.15	5.41	5.68	5.96
8	Jerrey		7.55	7.93	8.33	8.74
9	Geebal		11.32	11.89	12.48	13.11
10	Dhafdhafey		7.93	8.32	8.74	9.17
	Sub -Total		**36.32**	**38.14**	**40.04**	**42.05**
11	Bursaredo	**Long term Cluster**	7.07	7.42	7.79	8.18
12	Marodile		9.33	9.79	10.28	10.79
13	Todop		15.82	16.61	17.44	18.31
14	Harsog		8.53	8.96	9.41	9.88
15	Malkasala		10.02	10.52	11.04	11.59
	Sub -Total		**50.76**	**53.30**	**55.96**	**58.76**
	Total		**104.07**	**109.28**	**114.74**	**120.48**

5.3.1.8. Average Day Water Demand

Average day water demand is computed by summing up the nondomestic and domestic water demand and summarized here under for human consumption.

Table 5-10: Total Average Daily Water Demand for Human Consumption

Description	Unit	Design Period			
		2022	2024	2028	2033
Total Domestic Demand (adjusted)	**M3/d**	**4023**	**4277**	**4733**	**5390**
	l/s	46.6	49.5	54.8	62.4
Total non-domestic water	**m3/d**	**362.1**	**385.0**	**425.9**	**481.2**
	l/s	4.2	4.5	4.9	5.6
Non-Revenue water	%	20%	20%	19%	17%
	m3/d	**804.62**	**835.08**	**878.93**	**936.78**
	l/s	9.3	9.7	10.2	10.8
Average day demand Including Loss	m3/d	5190	5497	6038	6808
	l/s	59.24	62.84	68.99	77.85

5.3.1.9. Fire Fighting Demand

Firefighting demand is the amount of water required to fight the possible breakouts of fire in the town during the design period through installed fire hydrants installed at appropriate locations. Fire hydrants shall be installed at public and municipality interest such as schools, commercial areas, hospitals, fuel stations and at salient points of distribution network where there is minimum required pressure exists. This demand for this design is accommodated by increasing the volume of the storage tanks by 10% or in accordance with procedure to determine the storage reservoir using mass curve analysis.

5.3.1.10. Unaccounted for Water

All the water that goes in the distribution pipe does not reach the consumer. Some portion of this is wasted in the pipelines due to defective pipe joints, cracked and broken pipes, faulty valve and fittings. Some consumer keep open their taps or public taps even when they are not using the water and allow continuous wastage of water which also includes illegal connection, un metered usages such as flushing, firefighting, cleaning the system and overflow from components of the water supply system and etc.

Based on rural Water Supply Design Criteria, 2022 set by MOWE, estimation of unaccounted for water is presented as follows 20% in the first year and 15% at the end of the project.. Hence, water loss of the project for the design period is presented below.

Table 5-11: Unaccounted for Water

Non-Revenue water	%	20%	20%	19%	17%
	m3/d	**804.62**	**835.08**	**878.93**	**936.78**
	l/s	9.3	9.7	10.2	10.8

5.3.1.11. Average Day Water Demand

The average day water demand is the sum of adjusted domestic water demand, non-domestic water demand and system water loss. The above demand categories are summarized and added to estimate the total average day water demand of the project as shown in the table below for short, medium and long term cluster.

Table 5-12: Summary of Average Day Water Demand

List of kebele	**Intervention period in cluster**	Average Day demand for Human Consumption (l/s) In Design Period			
		2022	**2024**	**2028**	**2033**
Bohlagere	**Short term cluster**	4.69	5.19	5.82	6.57
Higlo		2.60	2.74	3.01	3.39
Sub -Total		**7.29**	**7.93**	**8.83**	**9.96**
Malkasala	**Medium Term Cluster**	6.53	6.90	7.56	8.52
Todop		3.95	4.17	4.57	5.16
Marodile		7.30	7.71	8.45	9.53
Dhafdhafey		3.17	3.35	3.67	4.14
Harsog		1.92	2.03	2.22	2.51
Dabafayid		3.19	3.37	3.69	4.17
Bursaredo		6.24	6.59	7.22	8.14
Sub -Total		**32.32**	**34.11**	**37.39**	**42.16**
Geebal	**Long term Cluster**	5.18	5.47	6.00	6.76
Jerrey		4.96	5.24	5.74	6.47
Hilogududo		2.77	2.92	3.20	3.61
Biyolo		3.12	3.29	3.61	4.07
Sigole		2.45	2.59	2.84	3.20
Wardid		1.14	1.29	1.38	1.62
Sub -Total		**19.62**	**20.79**	**22.76**	**25.73**
Total		**59.24**	**62.84**	**68.99**	**77.85**

5.3.1.12. Variations of Water Use

The rate of water demand keeps changing from season to season, from day to day and from hour to hour. In hot season, more water is consumed for drinking, bathing and washing clothes than in wet season. The consumption of water is high at weekends and holidays than on normal days, and also more water is required in morning and evening than early in the afternoon and late at night. Therefore, to account these fluctuating water demands, it is necessary to step up the average day demand by certain factor to get the maximum day demand and the peak hour demand. These scaled up water demand figures are used to design the capacities of source, transmission mains, storage facilities, pumping stations and distribution networks.

5.3.1.13. Maximum Day Water Demand

The maximum day water demand is the highest demand of any one 24-hour period over any specified year. If there is sufficient water and enough daily consumption record, it is possible to assume a realistic maximizing factor, however, since there is no recorded data in the past, the maximizing coefficient is taken from the Cost Effective Design Guideline for this project is 1.3.

5.3.1.14. Peak Hour Water Demand

The peak hour demand is the highest demand in any one hour over the year. It represents the diurnal variation in water demand resulting from behavioral patterns of the local population. The size, mode of service and social activities of the town significantly influence the peak hour demand. Further, studies show that the peak hour factor is greater for smaller population than bigger population. A peaking factor suiting the town is selected from the design criteria correlating peaking factor with number of population as stated in the table below.

Table 5-13: Peak Hour Factor

Demand parameter	Demand Factors
Minimum day Demand	0 to 0.3 of the average day demand
Average day Demand(ADD)	1
Maximum Day Demand(MDD)	1.1 to 1.5 of ADD
Peak hours demand(PHD)	1.5 to 2.0 of MDD(>15,000population)
	2.0 to 2.5 of MDD(<15,000 population)

Source : MoWE, Rural Water Supply Design Criteria, 2022

Hence, since the population size of the woreda under design is in the range of greater than 15000 end of the design period, a peaking factor of 2 for years of population estimate the peak hour demand of the project.

5.3.1.15. Summary of Water Demand

Overall demand summary for the project after applying all adjustment factors is described in the table hereunder.

Table 5-14: Water Demand Summary

Average water Demand (l/s)				
	2022	2024	2028	2033
Short term cluster	7.29	7.93	8.83	9.96
Medium Term Cluster	32.32	34.11	37.39	42.16
Long term Cluster	19.62	20.79	22.76	25.73
Sub -total	**59.24**	**62.84**	**68.99**	**77.85**
Maximum Day demand for Human Consumption (l/s) In Design Period				
Short term cluster	9.48	10.31	11.48	12.95
Medium Term Cluster	42.02	44.34	48.61	54.81
Long term Cluster	25.51	27.03	29.59	33.45
Sub -total	**77.01**	**81.69**	**89.68**	**101.21**
Peak Hourly Day Demand (L/s)				
Short term cluster	18.96	20.63	22.97	25.89
Medium Term Cluster	84.04	88.69	97.22	109.63
Long term Cluster	51.01	54.06	59.18	66.89
Sub -total	**154.02**	**163.38**	**179.37**	**202.41**

6. WATER SUPPLY SOURCE INVESTIGATION

6.1. Introduction

Water supply source is the critical part of any water works project. The sustainability of any water work project is entirely relied on the dependability of the water source selected. Hence, the source works that serves the system has to have sufficient capacity in quantity and quality to cover the water demand of the system for the intended design period.

Accordingly, the water supply source capacity has been investigated and selected based on the water requirement for the coming 10 years or end of design period.

The existing available and potential groundwater and surface water resources in the project area have been studied to formulate and analyze alternative sources and selection of the best option.

During the study water sample of the project area has been collected, got laboratory testing and analyzed; and compared with WHO water quality standard.

6.2. Objective of the study

The general objective of the study is to investigate water resource potential of Adadile town and surrounding village; and indicate feasible water supply sources at reasonable distance and cost for the dwellers of the town.

Water Resource Potential

6.2.1. Surface Water Resource

Shebelle river is the only perennial river drains in the east part of the woreda. It the potential surface water that supplement both domestic and irrigation purposes, but its water treatment investment might be costly.

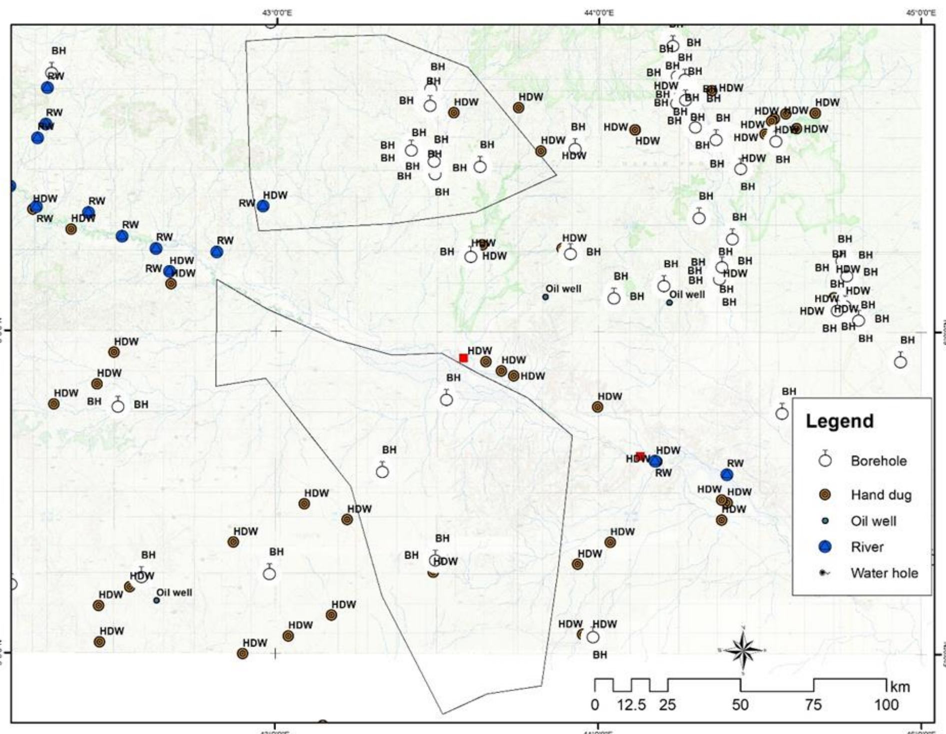


Figure 6-1:Water sources distribution in the study areas

Figure 6-2 Wabishebele Perinnial River

6.2.2. Groundwater Resource

Based on the combination of geospatial and AHP approaches, three groundwater potential zones were deduced and categorized as very poor, low, and low to moderate zones. Korahe Formation is categorized in very poor and low groundwater potential zone. Mustahil limestone is classified as low groundwater potential zones. Even the escarpment and dissected area of Mustahil limestone is categorized as very poor zone. The low potential zone is due to higher influence of rainfall on the top flat area of Mustahil limestone. In this investigation tertiary basal and quaternary sediments are also classified as low groundwater potential zones due to the influence of rainfall distribution in the area. However, based on the geophysical survey, the area may be considered as locally moderately productive aquifer. The geographic position to the recharge body may favor the recharge to the tertiary basalt and the overlying sediment at depth. Since geology plays a vital role, thickness, the relative position, and geometry of the aquifer are prudently evaluated and characterized for complete groundwater evaluation, therefore, understanding these gaps, groundwater potential delineation is mainly based on the basis of qualitative parameters rather than quantitative parameterization.

6.5.1. Water Quality

Water resource investigation is supplemented by water quality analysis during the course of the study. Accordingly, Groundwater is the important source of water used for human utilization and for both industrial and agricultural activities in regions where surface water is scarce. It plays an important role for society, economy, and ecology developments. In arid zones, water is a rare and precious resource. In recent decades, with increasing population growth and rising living standards, demand for groundwater resources for drinking purposes has increased significantly, resulting in a reduction in water quality and quantity. Long-term droughts have also had a profound influence on the quantity and quality of groundwater like in arid/semi-arid regions of the study area.

Table 6-1 :Water quality status of water points

S/N	**Water samples ID**	WQI	Water quality status (WQS)

1	EDW-3	103.14	Unsuitable
2	EDW-4	53.43	Poor
3	EDW-5	65.70	Poor
4	EDW-7	66.45	Poor
5	EDW-8	92.52	Very poor
6	EDW-9	57.06	Poor
7	EWH-13	30.34	Good
8	EWH-15	67.35	Poor
9	EWH-16	56.96	Poor
10	GDW-2	96.11	Very poor
11	GDW-3	74.64	Poor
12	GDW-4	75.35	Poor
13	GDW-10	89.50	Very poor
14	GDW-11	77.86	Very poor
15	GDW-12	54.56	Poor
16	GDW-13	69.58	Poor
17	GDW-14	61.23	Poor
18	GDW-15	61.65	Poor
19	I-river-13	68.35	Poor
20	HDW-1	46.31	Good

Groundwater quality was analysed for physical and chemical analysis. In this study, the hydrochemical analysis and water quality index methods (WQI) were used to assess groundwater quality for drinking purposes. Twenty groundwater samples were selected and analysed into fourteen parameters which were considered as important indicators for assessing groundwater quality. A comparative study of these parameters with that of the Ethiopian guideline was conducted..

6.3. Conclusion and Recommendation

6.3.1. Conclusion

Adadile Town water supply project is located Wabi shebele River basin the proposed intake site is not gauged. In the absence of data, where hydraulic structures are intended to be built using a rainfall-runoff model or transferring data from hydrologically homogeneous area is one of the methods used to generate data at point of interest. Wabi Shebele River which is gauged at Gode bridge, is used to estimate flow at the project site.

Shebele River at Gode Bridge has a catchment area of 127,300 km^2 and a mean monthly average flow of 103.325 m^3/sec. The Adadle sub-catchment being located within Shebele sub-basin, is assumed hydrologically homogeneous with Shebele sub-basin and the data obtained from this hydrological station is used for water resource availability determination. Further, there is no additional flow contribution to the system since it is located in the flood plain.

Average annual rainfall of the catchment area of this project estimated to be 228.4mm. The maximum and minimum temperature of the catchment is 35.4^{o}c and 20.9^{o}c respectively. The Annual evapotranspiration at the catchment is estimated 2248.4mm as calculated using Penman montheth Method. The average relative humidity estimated to be 52.7%. The average sunshine hours estimated to be 8.6hrs. The annual wind speed is estimated to be 2.36m/s.

The design peak flood is estimated by using Shebelle River at Gode hydrological gauged station. for peak design estimation we use three methods such as Gumbel (EVI) distribution, Log Pearson – III distribution and flood estimation based on area from three different ways of estimation peak floods water structure, it is recommended to use the flood magnitude estimated by flood estimation based on area Wabi Shebele river basin study relation for 25 years return period which is 3628.169 m^3/sec.

Considering the low hazard effect of selected 8 dams due 100 year's return period design flood was estimated for each dam and reservoir area capacity and flood routing is done for different spillway length is done.

6.3.2. Recommendations

The following recommendation are drawn from the study result for smooth implementation of Adadile Water supply Project.

- The selected 8 for Adadile micro dams catchment area are less than 300$km^{2.}$
- Vertical electrical sounding was conducted on tertiary basalt to determine the depth and water bearing thickness. According to the VES result the basalt unit is highly weathered and fractured, hence it is recommended to conduct test well to evaluate aquifer parameters and hydraulic connectivity of Shebelle River and adjacent lithology.
- As most part of Adadle woreda covered with aquiclude Korahe formation with poor groundwater quality that unsuitable for drinking, it is recommended to consider Shebelle River as a potential source for the woreda.
- It is better if the catchment area is greater than 600km^2 we can get enouph inflow which is use for demotic demand.
- The catchment area experienced to low annual rainfall, high evaporation and large livestock's consumption.
- The potential of Water resource in the basin is low since low annual rainfall is low.
- Therefore, the wabishebele at Gode Hydrological surface water source data has been found the only alternative source to use for the supply for Adadile and surrounding village.
- The projected Maximum day demand domestic water demand in Adadile woreda population is 101.21l/s.
- Finally, wabishebele river is enouph to supply Water for Adadile and surrounding village water supply system

7. PROPOSED WATER SUPPLY DESIGN CRITERIA

7.1. Water Supply Source Capacity and Quality

7.1.1. Water Supply Source Capacity and Quality

7.1.1.1. Source Capacity

A water source capacity needs to be sized for the total water demand including unaccounted-for water and fire-fighting demands. The source capacity will be sized for peak seasonal demand, including the peak day factor.

7.1.1.2. Potable Water Quality

The MoWE has prepared guidelines on drinking water quality. In the meantime, the recommendations of the World Health Organization (WHO) for drinking water will be adopted. These recommendations state that potable water shall contain no concentration of any substance or organism high enough to impair portability.

Harmful and uneconomically treatable substances will render a source as unsuitable and unusable (for potable water purposes).

7.2. Criteria for Hydraulic Design

7.2.1.1. Transmission Mains

Rising and gravity transmission mains from source to distribution will be designed for the maximum day demand, based on the design hours of water source operation. Storage facilities at the termination of the transmission main(s) will cater for the peak hourly flow in the distribution system.

Where transmission or gravity mains involve working or static pressures that are higher than advisable in relation to pump capacities or pipe pressure ratings, then break pressure tanks and/or booster stations will be considered.

No house connections will be made to transmission or rising mains.

7.2.1.2. Distribution Network

The distribution network will be designed for the peak hourly demand. The minimum pipe size to be considered for primary and secondary networks should be DN2”. Tertiary pipes may be below DN2”, but not below DN1”.Large scale networks may conceivably have a larger minimum diameter for primary and secondary pipes.

Water meters shall be provided at the source, Water points and Reservoir outlets.

7.2.1.3. Hazen-Williams Roughness Coefficients (C Value)

The Hazen-Williams equation and associated C factor is the most widely accepted flow equation for water distribution system analyses of water supply project. Determining appropriate roughness coefficients is critical in developing transmission and distribution system models. This study adopted the following roughness value which depends on the manufacturer, workmanship, age, and other factors.

Table 77-1 Hazen-Williams Roughness Coefficients adopted for this detail design work

Pipe Characteristics	C Value Adopted
UPVC/HDPE	**150**
DCI/GI	**130**
Steel	**110**

Source: MoWR, Urban Water Supply Design Criteria, 2006

7.2.1.4. Pressure Requirements in the distribution network

Pressure in the distribution network to be as follows:

As a rule, a minimum of 10-15 m manometric head is considered adequate during Peak Hour Demands.

A maximum of 60-80m monomeric head, to avoid risking leaks and bursts in the distribution system, particularly during minimum flow conditions and when the static pressure would be dominant. If necessary, the distribution system is divided into separate pressure zones so that the maximum possible pressure does not exceeded.

7.2.1.5. Flow Velocities

Flow velocities will be maintained between 0.6 and 2.5 m/sec, except in short section. Velocities in small diameter pipes (<DN100) may even be lower and for looped systems there will be pipelines with sections of zero velocity. Head loss is related to velocity and pipe roughness. The maximum head loss with therefore be governed by the maximum velocity criterion.

7.2.1.6. Pipe Material and Type

The cost of pipes in one of the principal components of a water supply investment and hence it is very import to make a careful selection. The commonly used pipes for water supply projects are Ductile Iron (DCI), uPVC, Galvanized Steel and Polyethylene pipes (HDPE). The choice of pipe material is dependent on the following factors:

- ✓ Chemical nature of soil
- ✓ Chemical nature of water
- ✓ Comparative cost of alternatives pipes
- ✓ Weather conditions of the area
- ✓ Geologic formation of the pipe route
- ✓ Expected pressure in the pipeline and

- ✓ Availability pipes in the local markets.

7.2.1.7. Storage Reservoir

Storage reservoirs will be provided for a minimum of 30% -50% of the average daily water demand or 1/3 or 1/2 of maximum day demand has to considered to fix the reservoir volume and it will be verified against the result obtain with mass curve analysis method.

7.2.1.8. Public Fountains

Public fountains are provided at a maximum walking distance of 250 m in any direction for urban and 1km for rural. Final location and spacing will be determined in collaboration with the community.

7.2.1.9. Fittings

Pipeline fittings (bends, tees, couplings, flanges, branches, elbows, etc.) should be appropriate for the pipeline configuration; normally they will be of ductile cast iron or HDPE or of uPVC or GI to match the pipeline material installed, the same diameter and the same or higher pressure class of the pipeline in which they are installed.

7.2.1.10. Alignment and laying of pipelines

The following considerations will govern the alignment of pipelines within the supply area:

- Transmission mains will follow the shortest route between the headwork and the supply area, allowing for deviations where necessitated by topographical conditions.
- Wherever possible, pipelines will be laid at road sides and verges of footpaths, pavements or green strips. Pipes to be laid along roads will be located at a minimum distance of 1m outside from the edge of the road or the roadside drain.
- Distribution system pipelines forming part of the main grid will follow the existing or planned roads, while observing the necessary requirements for hydraulic efficiency and economy.
- Marker posts shall be erected to identify gravity or rising mains alignments.

7.2.1.11. Depth of mains

Laying depth of pipelines will be subject to the following criteria:

- ✓ Depth of mains below ground will take into consideration ease of maintenance, avoidance of excessive earth pressure and protection from live load due to traffic.
- ✓ Mains unavoidably laid under carriageways or road verges will have a minimum cover of 1.00 m.
- ✓ The depth of cover will be increased as may be required where the ground level is to be changed in future for the construction of a road, where an increased depth is needed to maintain a minimum slope in the pipelines, where this will eliminate the need for an air valve, or where other special requirements call for greater depth.
- ✓ Mains laid in rocky conditions may have a minimum cover of 60cm,or could be surface

laid security and anchorage concerns are properly addressed.

Table 7-2: Normal cover for mains laid in the ground

Pipe Material	Depth of cover cm
Ductile iron(DCI)	80
Galvanized mild steel(GS)	80
HDPE	100 for D>40

Source : MoWE, Rural Water Supply Design Criteria, 2022

7.2.1.12. Pipeline appurtenant structures

i. Valve Chamber

Concrete manholes or chambers will be provided for each valve location for protection and to provide easy access for different purposes.

ii. Thrust Blocks

Whenever the pipeline changes direction horizontally or vertically or changes in size; concrete thrust blocks will be provided to resist the thrust force in the piping system.

iii. ***Pipe Support***

Concrete supports for pipes will also be provided whenever the pipe is laid above ground surface and also in situations where the foundation formations are not good. Lateral transverse anchors are designed for conditions where pipe is laid in steep slopes.

7.2.1.13. Provision of Washouts and Air Valves

i. Washouts

Washouts will be located at the lowest points of the pipeline in transmission/transfer and distribution mains, or near drains, streams, etc., wherever is suitable. Washouts will be provided taking in to account an emptying of the respective pipe linesectionin3to4hour.

When a drain pipe is connected to the drainage or sewerage system, a flap check valve must be installed on its end. The sizes of washouts if required will be provided on the respective drawings and bill of quantities. On mains of DN250 and above, washouts willnormally be of DN100 or DN80; on smaller mains and pipe lines, a washout of DN50 should be installed.

ii. ***Air Valves***

Air valves will generally be provided at the highest point on the transmission/transfer mains. They are seldom provided in distribution system as water taps at consumption points are used to evacuate air in the system.

Air vents of the double orifice kinetic type DN80 should be installed on mains of diameter DN250and larger. DN50 single orifice air vents will be installed on pipe lines of smaller diameter and for larger pipes where only accumulated air has to be expelled. They shall be assembled with isolating valves of same size. The sizes of air valves to be installed on mains will be provided on the respective drawings and bill of quantities. The flanged end of air valves and of isolating valves will be as per ISO standards as stated in the specification.

iii. Valves

The provision of valves will be based on the following considerations:

- Spacing: Isolating valves on mains will be installed at intervals as required, their spacing being dictated by factors such as washout requirements, connections to consumers and connections to other mains. In any event, the maximum spacing should be 500 m.
- Mandatory locations: Isolating valves should be provided at interconnecting pipes, by-pass pipe connections, hydrant connections, washouts and air vents.
- Diameter: Isolating valves on mains DN 400 and smaller and those installed on branches for air vents, hydrants, washouts and bypasses should be of the same size as the main or respective branch pipe. Pipelines larger than DN 400 may have valves smaller than the pipe diameter.

7.3. Distribution Reservoir

Distribution reservoirs are storage reservoirs, which store the clear water for supplying during emergencies and also to help in absorbing the hourly fluctuations in the normal water demand. Hence distribution reservoirs are provided:

- ✓ To absorb the hourly variations in demand
- ✓ To maintain constant pressure in the distribution main,
- ✓ To store water can be supplied during emergencies.

The reservoir will be situated at a higher elevation than the distribution system in order to secure gravity flow with due care not to exceed allowable pressure during **minimum** demand conditions at the lowest points in the supply areas.

8. DETAIL DESIGN OF PROPOSED WATER SUPPLY SYSTEMS

8.1. Introduction

This chapter covers the preliminary design of selected water supply option. The water resources assessment as presented in water resources development report have concluded that the ground water source potential for the town and rural kebeles capable of supplying for short term, medium, long term cluster is 12.95/s, 54.81l/s and 33.45l/s respectively of maximum day demand at the end of the design stage.

8.2. Alternative-1

8.2.1. Proposed water supply sources

The potential river source have been proposed northwest Adadile town and surrounding village of the woreda. Shebele viver is selected for the source of water demand for study area. Treatment plant is propsed for water treatmet and location shown in the following table.Existing treatment plant not considered in the system design.

Table 8-1: Detail of proposed river intake

No	Label	Easting	Northing	Elevation	Proposed well	Abstraction Yiels (l/s)
	Treatment plant Intake	38N 804,600.36	38N 656,773.69	273.60	No due to quality problem	101.21

8.2.2. Pressure Zoning

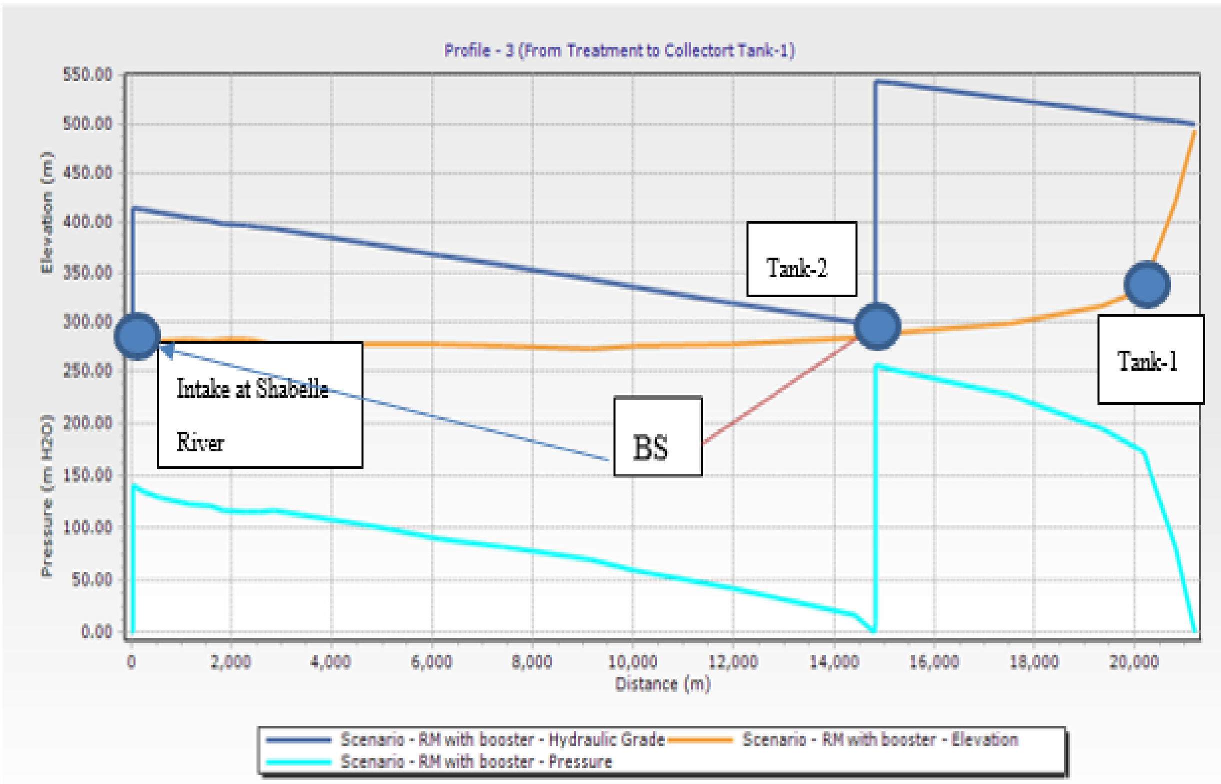
The topography of Adadile town and surrounding village undulating with maximum elevation of from 556.96 m.a.s.l. at reservoir site and with minimum elevation of 272.28 m.a.s.l at south western and north east location of the town. The total elevation difference will be 284.68m. Hence, the elevation difference greater than 100 meters this can be categorized under ten (10) pressure zone.The zone include from sigole booster station to Malka sala booster, Malka sala to Harsog, Harsog to Todop, Todop to Moradille, Wardid to Jerey booster are proposed.

8.2.3. Pressure line Pipes

Pressures line is designed using WaterGems Connection update 10.2.01 water supply modeling software. Two intake site from shabele river to 2000m^3 ground reservoir and shabele river to 400m^3 survice reservoir at Bursaredo.

The pressure line is designed to be HDPE pipes considering the nature of the soil along the route, topography, cost and high pressure within the system. However, raiser pipes proposed to be GS pipes of appropriate diameter and pressure ratings. The detail shown in Electro-mechanical design report chapter.

Each conveyance pipe line will be provided with a water meter, check valve, air release valve, pressure gauge and washout valve at start near the borehole. The transmission main will also be provided with a civil structures like valve chambers, thrust blocks etc.



Note:BS is location of booster station

Figure 8-1:Hydraulic profile of pressure from treatment plant to Tank-1

8.2.4. Collector and Transmission Pipes

Collector pipes are proposed to convey water and joining the treatment plant with main pressure lines. Tables below shows the details of collector and Transmission line pipes.

Table 8-2: Collector and Transmission Pipe Lines

Description	Unit	Length (m)	Length with 5% Contingency (m)
	Short Term Cluster		
Collector Pipe			
HDPE Pipes			
HDPE Pipe OD 315 PN16	m	13,652	14335
HDPE Pipe OD 315 PN16	m	696	731
Sub_Total			15066

Transmission Pipe			
Steel Pipes			
DN 300 Steel Pipes OD/ID 323.9/273.1	m	5,352	5620
HDPE Pipes			
HDPE Pipe OD 315 PN16	m	1,496	1571
Sub_Total			7191
Total			**22257**
	Medium Term Cluster		
Collector Pipe			
HDPE Pipes			
HDPE Pipe OD 140 PN10	m	1529	1605
Sub_Total			1605
Total			**1605**
	Long Term Cluster		
Collector Pipe/ Transmission			
HDPE Pipes			
HDPE Pipe OD PN	m	0	
Sub_Total			0
Total			0
Summary			***23,862.00***

8.2.5. Service Reservoirs Requirement

The difference in elevation within the town boundary is only 284.68 meters. Hence, during the design it assumed that four pressure zone should be considered. The service reservoir proposed to be located at 38 N, UTM 326,164.70 meter east and 638,243.73 North WGS at altitude of 493.72m.a.s.l. ground 2000m^3 water tank is proposed. To satisfay all the Adadile woreda Nine (9) Operational reservoir should be provided to command a distribution system, located at elevation(s) providing the required pressure for water flow within the system.Cocidering the topography of the study area 10 elevated tank is designed.The design considers sufficient storage to cover the difference between hourly peak demand and actual supply from the source, firefighting demands if to be allowed for, and for a limited emergency volume in case of power breakdown, repairs or O&M activities.

Possible future extension of the storage capacity is also taken into consideration when selecting the site. The reservoir is assumed to be provided with inlet, outlet, drainpipe, overflow pipe, water level indicator, manholes, internal and external ladder and ventilation pipe.

There are various methods to be used sizing the storage reservoirs. In this detail design, an urban water supply design criterion is used to determine the size of the reservoir. Accordingly, the size of the storage reservoir is computed in two ways:

According to the MOWR, Urban Water Supply Design Criteria, the storage reservoir can be computed as 30-50% of the average day demand for the town. Existing storage facilities were also considered as part of this design. The computed service reservoir example for tank-1 6807.7m^3/day*30%= 2042m^3 and 6807.7x50%= 3404m^3. The preferred reservoir size should within this range.

Similarly, the service storage reservoir can be computed using mass curve analysis based on IRC International Water & Sanitation Center (2002), and the detail analysis is shown in the figure below..

The reservoir size determine with mass curve analysis computed by considering the maximum day demand and Hourly factor. Then the cumulative demand and the cumulative supply is computed stating from midnight. The difference of the supply and demand cumulative shows the surplus and deficit water volume to be stored.

In the analysis additional water storage needed for dead storage and firefighting storages are considered in the computation process. Please see Table see for details. According to this method the servicer reservoir requirement is 2278.6m^3 in addition to exiting 200m^3 storage facility. Hence the new reservoir is recommended to be 2300m^3 by rounding to the standard size of reservoirs. Hence the proposed standard of 2000 m^3 ground and 300 m^{3}reservoir proposed.

Similarly the mass curve analysis can piloted as shown on next figure to show the storage volume requirement for the system by plotting Cumulative storage vs Hours of the day.

Table 8-3 : Mass Curve Analysis analytical Method to determine storage size

	Maximum Day Demand	368.8	m^3/hr			
Hr	**HF**	**Demand**	**Cumm. Demand**	**Supply**	**Cumm. Supply**	**Delta**
1	0.30	110.6	110.6	368.8	368.8	258.1
2	0.30	110.6	221.3	368.8	737.5	516.3
3	0.40	147.5	368.8	368.8	1106.3	737.5
4	0.50	184.4	553.1	368.8	1475.0	921.9
5	0.60	221.3	774.4	368.8	1843.8	1069.4
6	1.60	590.0	1364.4	368.8	2212.5	848.1
7	2.19	805.7	2170.1	368.8	2581.3	411.2
8	1.60	590.0	2760.1	368.8	2950.0	189.9
9	1.30	479.4	3239.5	368.8	3318.8	79.3
10	1.10	405.6	3645.1	368.8	3687.5	42.4
11	1.10	405.6	4050.7	368.8	4056.3	5.5
12	1.20	442.5	4493.2	368.8	4425.0	-68.2
13	1.10	405.6	4898.8	368.8	4793.8	-105.1
14	1.10	405.6	5304.5	368.8	5162.5	-142.0
15	1.10	405.6	5710.1	368.8	5531.3	-178.8
16	1.10	405.6	6115.7	368.8	5900.0	-215.7
17	1.10	405.6	6521.3	368.8	6268.8	-252.6

18	1.65	608.4	7129.8	368.8	6637.5	-492.3
19	2.00	737.5	7867.3	368.8	7006.3	-861.0
20	1.65	608.4	8475.7	368.8	7375.0	-1100.7
21	0.60	221.3	8697.0	368.8	7743.8	-953.2
22	0.50	184.4	8881.3	368.8	8112.5	-768.8
23	0.30	110.6	8992.0	368.8	8481.3	-510.7
24	0.30	110.6	9102.6	368.8	8850.0	-252.6
					Max(positive)	**1069.4**
					Min(negative)	**-1100.7**

Supply area	Adadile Woreda WSP	
Design Period	2024-2033	Remark
Pumping stations Operation hour	12	
Max day demand (m3/day)	13,467.5	
Hourly Supply (m3/hr)	1122.3	
Balancing volume in (m³)	2170.09	
Service Storage (m³)	2170.09	
Fire Storage(m3)	0.00	0l/s for duration of 3hr for fire fighting
Dead Storage(m3)	108.5	5% of service storage
Total storage for service (m³)	2279	Existing Reservoir 200
Existing reservoirs(m3)		
Required reservoirs(m3)	2278.6	
Recommended size (m3)	**2,280**	

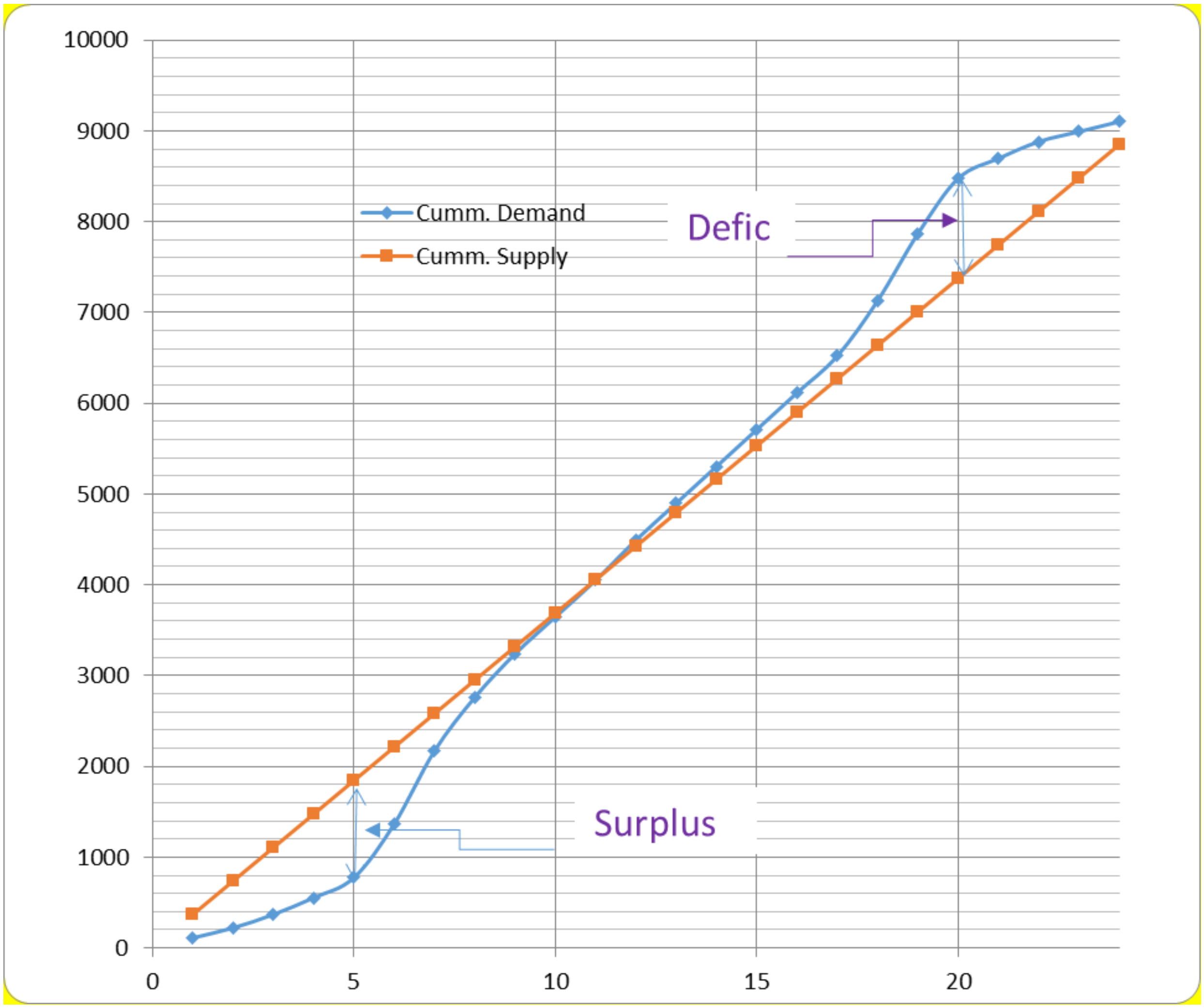


Figure 8-2: Graphic Method of Mass curve analysis to determine reservoir size

The detail is shown in the following table:

Table 8-4 : Colletor and survice reservoir of Adadile woreda

Kebeles	Label	Elevation (Base) (m)	Diameter (m)	X (m)	Y (m)	OGL Elevation (m)	Volume (m³)	Cluster	Remark
	Tank-1	493.72	22.09	326,164.70	638,243.73	493.72	2300	Short Term	Ground Collector Reservoir
Adadile Town	Tank-12	287.55	6.5	337,118.55	640,665.32	287.55	200	Medium Term	Existing Ground Service Reservoir

Kebeles	Label	Elevation (Base) (m)	Diameter (m)	X (m)	Y (m)	OGL Elevation (m)	Volume (m^3)	Cluster	Remark
Sigole	Tank-3	375.27	10.3	322,394.84	624,795.51	371.25	500		Elevated Survice and Booster Tank
Todop	Tank-7	450.1	6.8	322,489.70	567,237.18	445.1	200		Elevated Survice and Booster Tank
Moradille	Tank-8	423.82	9.7	332,840.41	539,126.93	418.82	450		Elevated Survice Tank
Bursareedo	Tank-11	301.61	9.2	305,019.30	655,589.40	296.61	400		Elevated Survice Tank
Biyolo	Tank-4	510.77	7.2	320,915.13	620,132.86	505.77	250	Long Term	Elevated Survice Tank
Harsog	Tank-6	508.5	9.2	312,957.03	609,220.18	503.5	400	Medium Term	Elevated Survice and Booster Tank
Malka Sala	Tank-5	504.35	9.8	316,075.44	616,555.44	499.35	450		Elevated Survice and Booster Tank
Wardid	Tank-9	280.28	7.3	344,287.37	650,235.26	275.28	250	Long Term	Elevated Survice and Booster Tank
Jerey	Tank-10	279.1	6.5	350,785.13	647,867.82	274.1	200		Elevated Survice Tank

8.2.6. Distribution Pipe Network System

Various scenarios have been analysed in order to come up with the best feasible system layout and network schematization of distribution pipe network. The topography of the erea major guiding tool to conduct the new system layout. The minimum size in the distribution system except for the pipes connected to public water points is OD 63 mm and maximum OD 450mm.

As from field investigation conducted during the baseline survey the age and diameter no existing pipe system in the woreda. Hence, a new distribution network pipe system for primary and secondary level was proposed for the woreda as whole. The distribution system is designed for peak hour demand. The guidelines about types of pipes, nominal sizes, maximum and minimum pressure head limits as well as maximum and minimum flow velocities stipulated in the design criteria has been used in order to optimize the network.

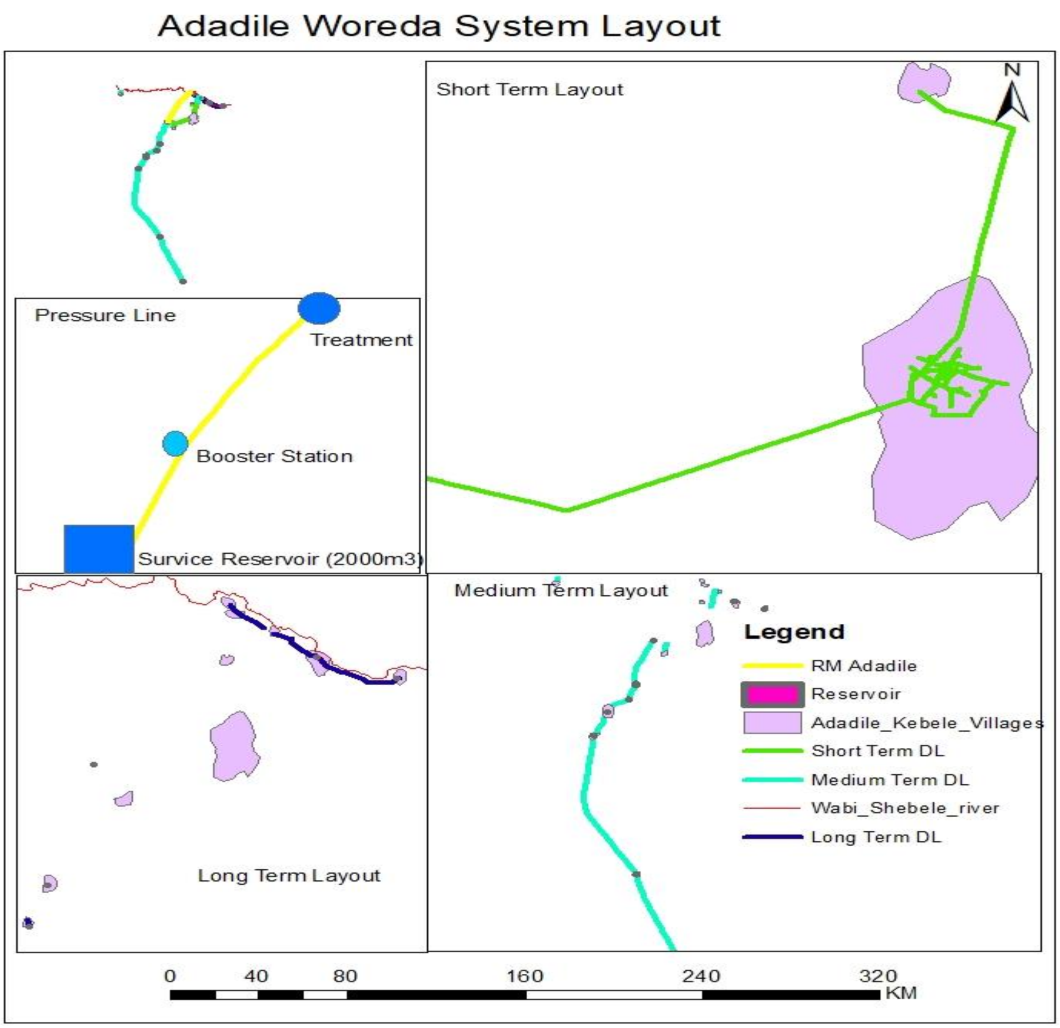


Figure 8-3: Proposed Distribution layout

8.2.7. Nodal Demand Computation

The demand analysis of the town computed based on the domestic, institutional, and any other water demand computed under the demand analysis section.

The nodal demand has been assigned to each node in accordance with appropriate estimate for domestic, public, and industrial zone served by each node as per the existing community distribution coupled with our detailed field investigation as per the following procedures:

- From the settlement plan supplemented with field survey work the spatial distribution of the existing infrastructures were identified;
- Using a digitized map the area of each node was delineated, measured and tabulated for each category user;
- The demand area ratio for each category was computed;
- Nodal demands were computed by multiplying the area at each node with the demand area ratio for the specific consumer group.
- In a branching distribution line a demand block delineated and number of nodal point assigned.
- Demand for each node allocated based on the area proportion of each category user (domestic, industrial and Public)

8.2.8. Network Simulation and Presentation of Model Result

Distribution pipe network is analysed using WATERGEMS Connection Update 10.02.1 modelling software. The adequacy of the system has been performed under several scenarios in order to optimize the system for extended period of 24 hourly time step simulations by considering the peak hourly water consumption pattern shown on Figure 8-3. Peak hourly pattern stemated based on the guide line rural water supply 2022.

The peak hour demands are used for sizing of the distribution pipelines that can deliver the required maximum flow at minimum established pressure at all consumers tap while the minimum water demand is used to analyse the maximum pressure in the system so as to select the pipe material and also to manage excessive pressure in the system.

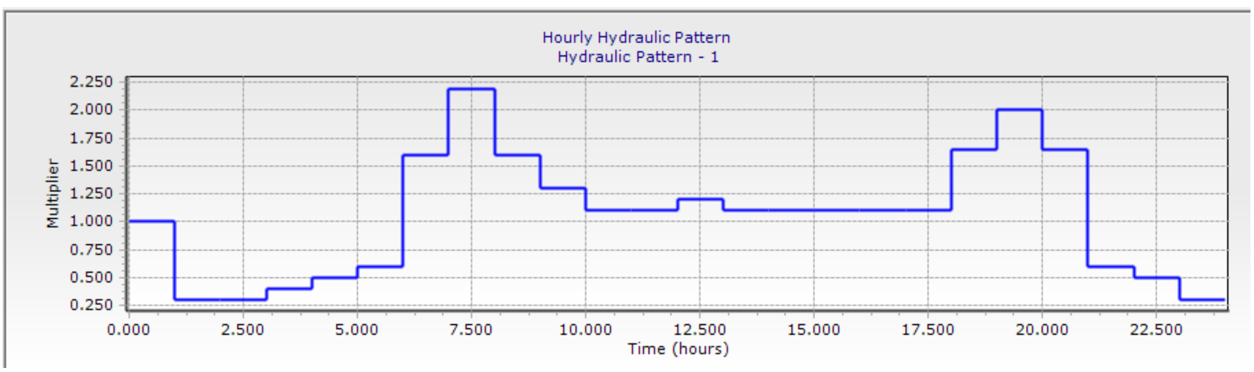


Figure 8-4:: Proposed water usage demand pattern

Critical scenarios have been identified during low and high water consumption time period. During low consumption, velocity in a pipe will be lower and nodal pressure is high while during peak hour consumption velocity is relatively high and nodal pressure is becoming lower. Therefore, a great care has been taken into consideration in order to bring the model output result within acceptable range as per the design criteria.

In only one node at sigole kebele pressure is less than 10m during minimum water demand and the maximum pressure is 194.4m at junction J-50. Although this is out of the operating range and did not propese any pressure arresting facilities due to the distribution system extended to surrounding kebele of Adadile town without booster station.Similarly, pressure at node of Adadile town distribution network pressure ranges 165m upto 171m and the figure is out of range. Pressure arresting PRV initial pressure of 80m is need between junction 268 and 285.

It obvious that the highest pressure appears during minimum demand period within the system. From these analysis the highest node of Adadile town pressure ranges from 73.34 to 90.53 and the minimum pressure for node is greater than 5.41 m of water column.

Similarly the low pressure occurs during high demand period, for this analysis the nodes with the low pressure at maximum demand are J-76, at sigole kebele, J-86, J-87 and J-88. All the nodes pressure ranges from 5.28 to 9.26 m. At those nodes the pressure is less than 10 metres and hydraulic design condition not meet as it was noted in the design criteria. Adadile woreda and surrounding kebele catagorised under advanced Ethiopian rural kebeles and for this case the pressure out of range is accepted.

Various types of pipes selected for the system including, HDPE. These pipe types are applied at various parts of pipe network system.

The distribution network of all distribution pipe system proposed to be HDPE pipe because :

- Filed observation has shown that the soil of Mekotown is thick and easily excavated with hand tools within the town vicinity except where withered rock may encountered near reservoir area.
- HDPE pipe with this diameter are simple to transport, lay and competitive in price with other pipes
- mostly the HDPE pipe may not require bedding in trench and has an advantage over uPVC pipe
- The term pressure rating (PR) refers to the static pressure rating of the pipe, calculated from the hydrostatic design basis (HDB) with an appropriate design factor (DF) and is for a pipeline with no flow. However, all municipal water systems involve flowing water. For example, HDPE (PE4710) DR 17 pipe has a static pressure rating for water of 0.86 Mpa. The working pressure rating (WPR) is based on actual system requirements and is a dynamic pressure rating, that is, a pressure rating for pipe with flowing water. The WPR includes an allowance for water hammer surge pressures. At a daily recurring average flow surge velocity of 1.5m/s and at 80o F, the working pressure rating of HDPE (PE4710) DR 17 pipe is also0.86 Mpa; similarly, the working pressure rating for PVC DR 18 is 0.83 Mpa per AWWA C900-07, PE 4710 has a higher working pressure rating than PVC at these common conditions.
- Everyday more utilities realize the advantages of trenchless technologies. More trenchless projects are being installed than in the past because of cost savings. Savings can result from quicker installations, faster permitting and design time, fewer disruptions to business and residents, less damage to parks and tress, and less disturbance to road beds (and subsequent road repair.)
- A fusion joined pipeline may be thought of as a continuous pipeline without joints. On the other hand, gasket joints are a potential source of leakage and lost water in many water systems. Leaks

may occur if the gasket is improperly installed, if dirt or grit sticks to the gasket, if the gasket is not properly lubricated, if negative pressure (vacuum) occurs in the pipeline, if ground movement or sub-trench consolidation occurs, if significant thermal change occurs and if gaskets are blown out due to surge pressures. Fused joints are far superior to gasket joints for leak prevention.

- HDPE pipe provides the lowest life cycle cost when compared to other systems due to significantly reduced or no leakage, increased billable dollars, water conservation, fewer new water-treatment plants, reduced maintenance crews, reduced seasonal water-main breaks, and no loss in flow capacity over the long term.
- Unlike the upVc pipes HDPE pipes doesn't decay and may affect human health as a result. Currently, it is highly controversial that uPVC pipe may decay by use of chlorine solution used for treatment.

Distribution main and pressure line planned to be HDPE pipe because of:

- These pipes are laid on deep soil easily to excavate and bury the transmission main to a required depth
- The HDPE Pipes are locally produced and procurement and supply will be much simpler than DCI pipes.
- To complete the project with short schedule time locally produced material are at most the preference, where at current situation it is hard to get currencies for imported materials like DCI. Hence,diameter, pipe material and lengths of the distribution system is summarized as follows:

Table 8-5: Pipes required for Distribution Network

Description	Unit	Length with 5% Contingency (m)
	Short Term Cluster	
HDPE Pipes		
HDPE Pipe OD 50 PN10	m	3398
HDPE Pipe OD 63 PN10	m	4844
HDPE Pipe OD 75 PN10	m	1508
HDPE Pipe OD 90 PN10	m	3278
HDPE Pipe OD 125 PN10	m	1214
HDPE Pipe OD 200 PN10	m	676
HDPE Pipe OD 315 PN16	m	8871
HDPE Pipe OD 355 PN16	m	11444

Description	Unit	Length with 5% Contingency (m)
	Short Term Cluster	
HDPE Pipe OD 450 PN10	m	401
Sub -Total		**35,634.00**
	Medium Term Cluster	
HDPE Pipe OD 110 PN20	m	2843
HDPE Pipe OD 110 PN10	m	264
HDPE Pipe OD 125 PN20	m	510
HDPE Pipe OD 125 PN10	m	65
HDPE Pipe OD 140 PN10	m	49361
HDPE Pipe OD 160 PN16	m	33
HDPE Pipe OD 160 PN10	m	31548
HDPE Pipe OD 180 PN10	m	1001
HDPE Pipe OD 225 PN10	m	11646
HDPE Pipe OD 280 PN10	m	8407
HDPE Pipe OD 315 PN10	m	20304
Sub -Total		**125,982.00**
	Long Term Cluster	
HDPE Pipe OD 50 PN10	m	128
HDPE Pipe OD 63 PN10	m	70
HDPE Pipe OD 75 PN10	m	8106
HDPE Pipe OD 90 PN10	m	158
HDPE Pipe OD 110 PN10	m	210
HDPE Pipe OD 125 PN10	m	1601
HDPE Pipe OD 140 PN10	m	2403
HDPE Pipe OD 180 PN10	m	4865

Description	Unit	Length with 5% Contingency (m)
	Short Term Cluster	
HDPE Pipe OD 250 PN10	m	1194
Sub -Total		**18735**
Total		**180,351.00**

NB: This Quantity includes additional 5% excess supply for O&M purpose

8.2.9. Hydraulic modelling Calculation summary

Three analysis modeled based on Peak hour Demand Alternatives. These variation in demand applied over the 24hours and the flow demanded, stored and supplied were analyzed.As it indicated in figure 8.4 Considering hydraulic calculation without booster station and selecting strategic location of collect reservoir clear water tank conveyed at Wardid booster station travelling about 30km.To verify that the model analysis satisfy the hydraulic conditions the summary is analyzed and presented below:

Network Inventory

Pipes	209	-Standard Extended	0
Laterals	0	<None>	2
Junctions	188	-Constant Speed - Four-Quadrant Characteristics	6
Hydrants	0	-Constant Speed - Pump Definition	0
Tanks	12	-Shut Down After Time Delay	0
-Circular	12	-Variable Speed/Torque	0
-Non-Circular	0	-Pump Start - Variable Speed/Torque	0
-Variable Area	0	Pump Stations	0
Reservoirs	1	Variable Speed Pump Batteries	0
Customer Meters	0	PRV's	1
Taps	0	PSV's	0
SCADA Elements	0	PBV's	0
Pumps	6	FCV's	1
-Constant Power	0	TCV's	0
-Custom Extended	0	GPV's	0
-Design Point (1 Point)	8	Isolation Valves	30
-Multiple Point	0	Spot Elevations	0
-Standard (3 Point)	0		

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Figure 8-5: Distribution Hydraulic Network Inventory of Adadile woreda

Hydraulic Model Inventory: Adadile WSP.wtg

Network Inventory

Transient Network Inventory

Turbines	0	Rupture Disks	0
Periodic Head-Flows	0	Discharges to Atmosphere	0
Air Valves	0	Orifices Between Pipes	0
Hydropneumatic Tanks	0	Valves With Linear Area Change	0
Surge Valves	0	Surge Tanks	0
Check Valves	0		

Pressure Pipes Inventory

44.0 (mm)	3,239 m	158.6 (mm)	5,587 m
55.4 (mm)	4,679 m	176.2 (mm)	645 m
66.0 (mm)	9,270 m	198.2 (mm)	11,091 m
79.2 (mm)	2,493 m	220.4 (mm)	1,137 m
80.0 (mm)	23 m	246.8 (mm)	8,007 m
85.4 (mm)	2,708 m	257.8 (mm)	8,448 m
96.8 (mm)	451 m	277.6 (mm)	19,337 m
97.0 (mm)	486 m	290.6 (mm)	10,899 m
110.2 (mm)	2,744 m	312.8 (mm)	382 m
123.4 (mm)	49,299 m	396.6 (mm)	127 m
130.8 (mm)	31 m	All Diameters	171,129 m
141.0 (mm)	30,046 m		

Figure 8-6Distribution network inventory of Adadile woreda

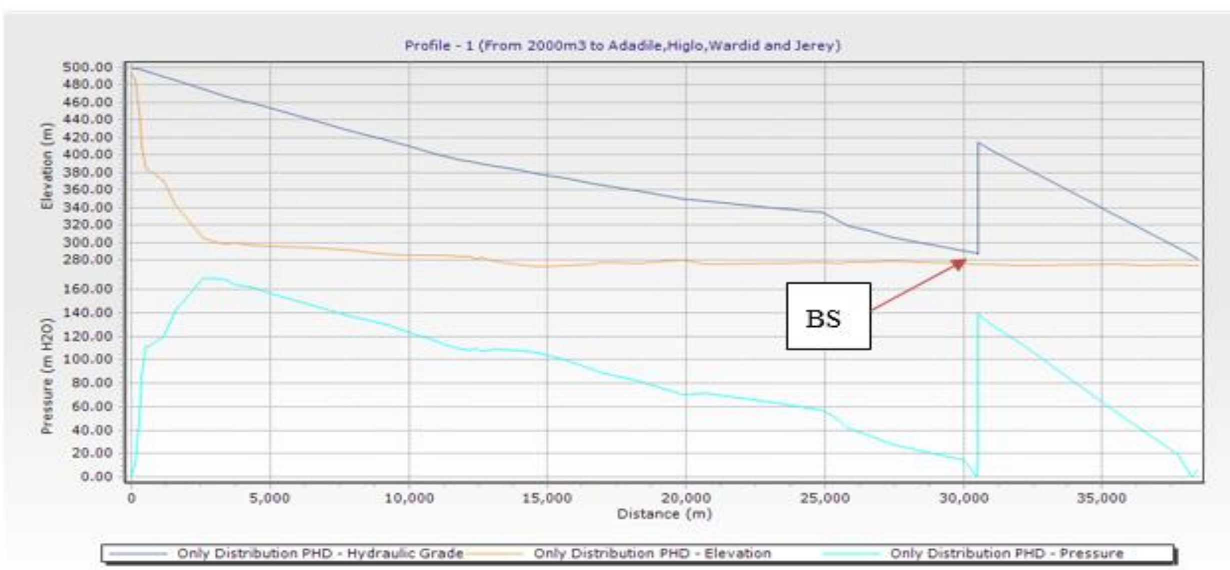
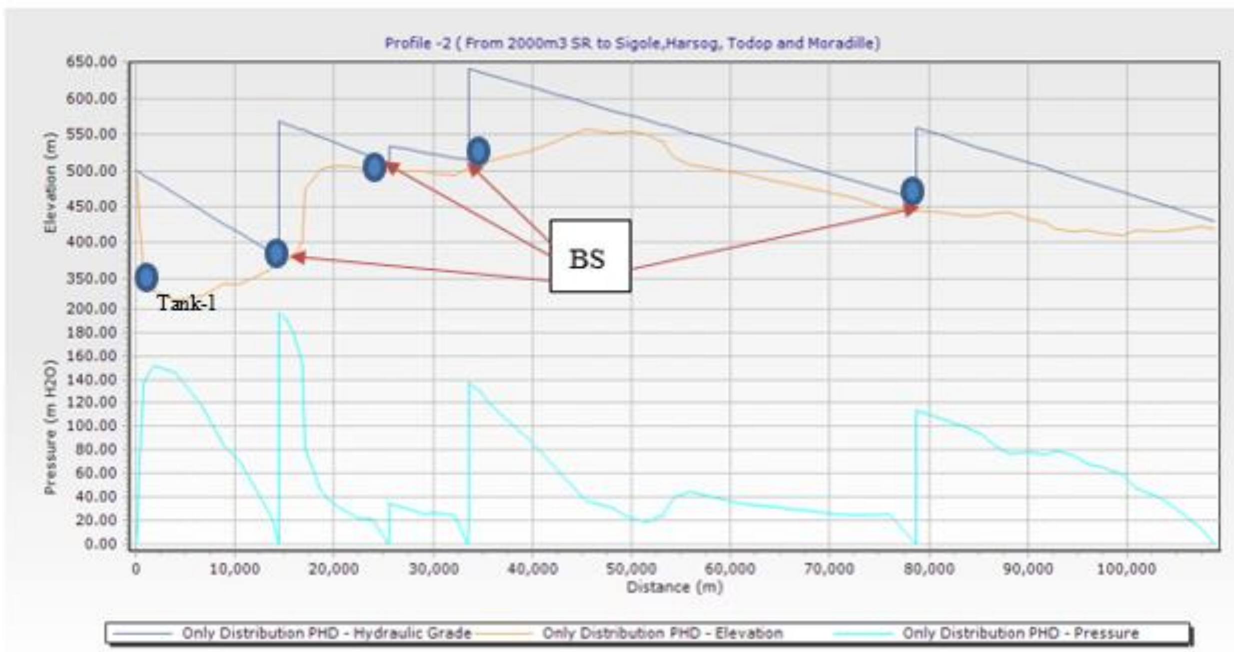


Figure 8-7: Hydraulic Profile from collector reservoir to Jerrey kebele



Note:BS is Lacation of booster station

Figure 8-8:Hydraulic Profile from collector reservoir to Moradille kebele

8.2.10. Public Fountains

As per the water demand computation model, the total number of public fountains required for Adadile woreda water supply project at the end of the stage period is 24. Presently there are16 public fountains where only 9 considered to be rehabilitated. Therefore, 15 public water points will be constructed in design period and finanal number is estimated during detail design phase.

The location of the additional public fountains shall be finalized during the construction phase after consultation with the community. However, the public water points are currently included in the layout of the distribution system assuming that user access distance should approximately fit to 250m for town and 1km for surrounding villages.

8.3. Alternative-2

8.3.1. Proposed water supply sources

The potential river source have been proposed northwest Adadile town and surrounding village Higlo kebele only. Shebele viver is selected for the source of water demand for short term cluster without considering medium and long term cluster. Treatment plant is propsed for water treatmet and location shown in the following table.

Table 8-6: Detail of proposed river intake

No	Label	Easting	Northing	Elevation	Proposed well	Abstraction

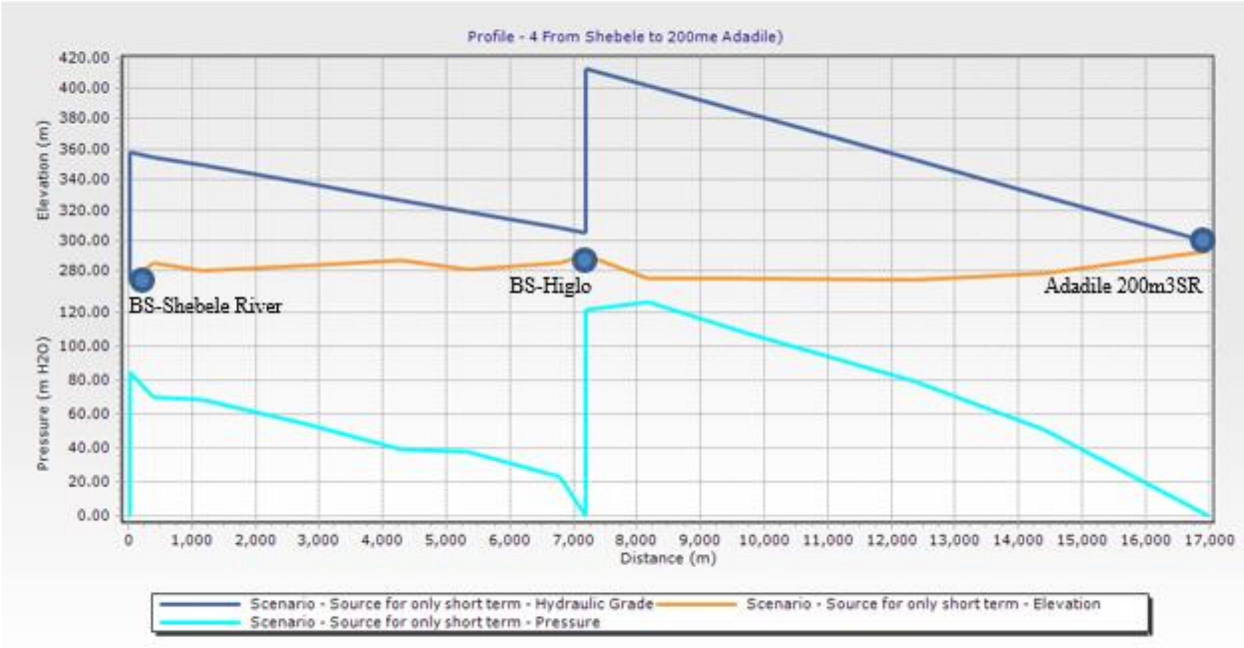
						Yiels (l/s)
	Treatment plant Intake	38N 804,600.36	38N 656,773.69	273.60	No due to quality problem	12.95

8.3.2. *Pressure Zoning*

The topography of Adadile town and Higlo village flat plan with maximum elevation of from 293 m.a.s.l. at reservoir site and with minimum elevation of 274.25m.a.s.l at south western and north east location of the town. The total elevation difference will be 18.75 m. Hence, the elevation difference less than 100 meters this can be categorized under one pressure zone and no need of pressure arresting structure.The zone include from Higlo booster station for Higlo kebele and Adadile service reservoir tto Adadile town distribution sytem are proposed.

8.3.3. *Pressure line Pipes*

Three intake site from shabele river to 2000m^3 ground reservoir, shabele river to 400m^3 survice reservoir at Bursaredo and raw water is boosted to Higlo 200m3 elavated tank.Similary to convey clear water to Adadile town additional booster proposed to lift to Adadile 200m3 service reservoir.



Note:BS is location of booster station

Figure 8-9:Hydraulic profile of pressure from treatment plant to Adadile town

8.3.4. Collector and Transmission Pipes

Collector pipes are proposed to convey water and joining the treatment plant with main pressure lines. Tables below shows the details of collector and Transmission line pipes to satisfay the demand of short term alternative only.

Table 8-7: Collector and Transmission Pipe Lines

Description	Unit	Length (m)	Length with 5% Contingency (m)
	Only Adadile and Higlo		
Pressure Main			
HDPE Pipe OD 160 PN12.5	m	7,169	7527
Transmission Nain			
HDPE Pipe OD 110 PN12.5	m	9,786	10275
Sub -Total			**17802**

8.3.5. Service Reservoirs Requirement

The difference in elevation within the town boundary is only 18.75 meters. Hence, during the design it assumed that two pressure zone should be considered. Two survice reservoir is proposed for this alternative, 200m3 elevated reservoir (x=336,800.76,Y=649,635.24,Z=290.98)at Higlo kebele used dual purposed of collector and survice. The second service reservoir proposed to be located at 38 N, UTM 337,187.32meter east and 640,024.51North WGS at altitude of 293.00m.a.s.l. ground 200m3 water tank is proposed.Cocidering the topography of the study area one elevated 200m3 and 200m3 ground tank is designed.The design considers sufficient storage to cover the difference between hourly peak demand and actual supply from the source, fire fighting demands is to be allowed for, and for a limited emergency volume in case of power breakdown, repairs or O&M activities.

Possible future extension of the storage capacity is also taken into consideration when selecting the site. The reservoir is assumed to be provided with inlet, outlet, drainpipe, overflow pipe, water level indicator, manholes, internal and external ladder and ventilation pipe.

There are various methods to be used sizing the storage reservoirs. In this detail design, an urban water supply design criterion is used to determine the size of the reservoir. Accordingly, the size of the storage reservoir is computed in two ways:

According to the MOWR, Urban Water Supply Design Criteria, the storage reservoir can be computed as 30-50% of the average day demand for the town. Existing storage facilities were also considered as part of this design. The computed service reservoir example for Adadile ground 200m^3 tank, 567.4 m^3/day*30%= 170m^3 and 189.1x50%= 284m^3. The preferred reservoir size should within this range.

Similarly, the service storage reservoir can be computed using mass curve analysis based on IRC International Water & Sanitation Center (2002), and the detail analysis is shown in the figure below..

The reservoir size determine with mass curve analysis computed by considering the maximum day demand and Hourly factor. Then the cumulative demand and the cumulative supply is computed stating from midnight. The difference of the supply and demand cumulative shows the surplus and deficit water volume to be stored.

In the analysis additional water storage needed for dead storage considered but fire fighting storages are not considered in the computation process. Please see Table see for details. According to this method the servicer reservoir requirement is 199m^3 in addition to exiting 200m^3 storage facility. Hence the new reservoir is recommended to be 200m^3 by rounding to the standard size of reservoirs. Hence the proposed standard of 200 m^3 ground at Adadile town and 200 m^3 elevated reservoir at Higlo kebele proposed.

Similarly the mass curve analysis can piloted as shown on next figure to show the storage volume requirement for the system by plotting Cumulative storage vs Hours of the day.

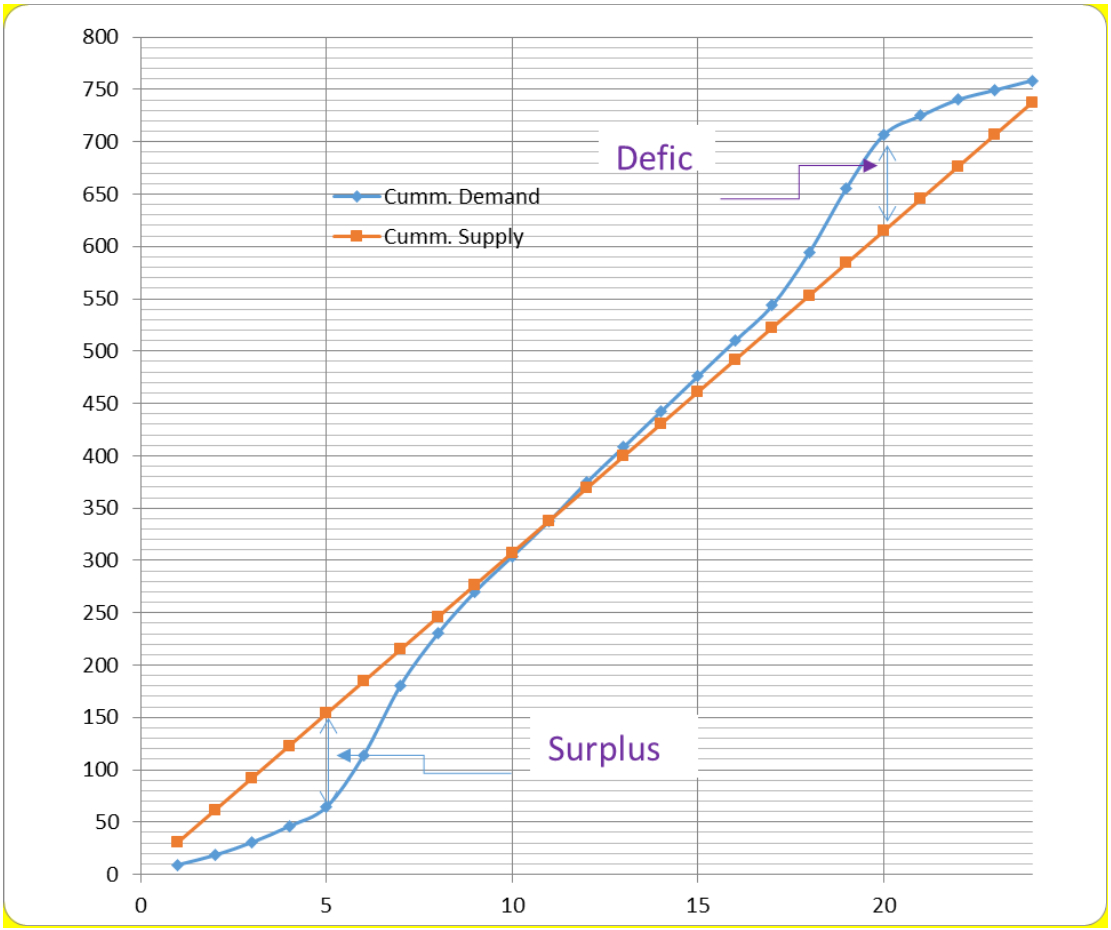
Table 8-8 : Mass Curve Analysis analytical Method to determine storage size

	Maximum Day Demand	30.7	m^3/hr			
Hr	**HF**	**Demand**	**Cumm. Demand**	**Supply**	**Cumm. Supply**	**Delta**
1	0.30	9.2	9.2	30.7	30.7	21.5
2	0.30	9.2	18.4	30.7	61.5	43.0
3	0.40	12.3	30.7	30.7	92.2	61.5
4	0.50	15.4	46.1	30.7	122.9	76.8
5	0.60	18.4	64.5	30.7	153.7	89.1
6	1.60	49.2	113.7	30.7	184.4	70.7
7	2.19	67.2	180.9	30.7	215.1	34.3
8	1.60	49.2	230.0	30.7	245.9	15.8
9	1.30	40.0	270.0	30.7	276.6	6.6
10	1.10	33.8	303.8	30.7	307.3	3.5
11	1.10	33.8	337.6	30.7	338.1	0.5
12	1.20	36.9	374.5	30.7	368.8	-5.7
13	1.10	33.8	408.3	30.7	399.5	-8.8
14	1.10	33.8	442.1	30.7	430.3	-11.8
15	1.10	33.8	475.9	30.7	461.0	-14.9
16	1.10	33.8	509.7	30.7	491.7	-18.0
17	1.10	33.8	543.5	30.7	522.5	-21.1
18	1.65	50.7	594.2	30.7	553.2	-41.0
19	2.00	61.5	655.7	30.7	583.9	-71.8
20	1.65	50.7	706.4	30.7	614.7	-91.7
21	0.60	18.4	724.8	30.7	645.4	-79.4

22	0.50	15.4	740.2	30.7	676.1	-64.1
23	0.30	9.2	749.4	30.7	706.9	-42.6
24	0.30	9.2	758.7	30.7	737.6	-21.1
					Max(positive)	**89.1**
					Min(negative)	**-91.7**

Supply area	Adadile Town WSP	
Design Period	2024-2033	Remark
Pumping stations Operation hour	12	
Max day demand (m3/day)	1,123.2	
Hourly Supply (m3/hr)	93.6	
Balancing volume in (m^3)	180.87	
Service Storage (m^3)	180.87	
Fire Storage(m3)	0.00	
Dead Storage(m3)	18.1	10% of service storage
Total storage for service (m^3)	199	Existing Reservoir 200 and it complete its design period
Existing reservoirs(m3)		
Required reservoirs(m3)	199.0	
Recommended size (m3)	**200**	**200 New Reservoir proposed.200m3 Elevated Reservor and 200m3 Ground Reservoir**

Figure 8-10: Graphic Method of Mass curve analysis to determine reservoir size



The detail is shown in the following table:

Table 8-9 : Colletor and survice reservoir of Adadile and Higlo kebeles

Kebeles	Label	Elevation (Base) (m)	Diameter (m)	X (m)	Y (m)	OGL Elevation (m)	Volume (m³)	Cluster	Remark
Adadile Town New	Tank-1	293	22.09	337,187.32	640,024.51	293	200	Short Term	Ground Collector Reservoir
Adadile Town	Tank-12	287.55	6.5	337,118.55	640,665.32	287.55	200	Short Term	Existing Ground Service Reservoir
Higlo	Tank-2	298.98	6.5	336,800.76	649,635.24	290.98	200		Elevated Service and Booster Tank

8.3.6. Distribution Pipe Network System

Various scenarios have been analysed in order to come up with the best feasible system layout and network schematization of distribution pipe network. The topography of the erea major guiding tool to conduct the new system layout. The minimum size in the distribution system except for the pipes connected to public water points is OD 63 mm and maximum OD 250mm.

As from field investigation conducted during the baseline survey the age and diameter no existing pipe system in the town. Hence, a new distribution network pipe system for primary and secondary level was proposed for the woreda as whole. The distribution system is designed for peak hour demand. The guidelines about types of pipes, nominal sizes, maximum and minimum pressure head limits as well as maximum and minimum flow velocities stipulated in the design criteria has been used in order to optimize the network.

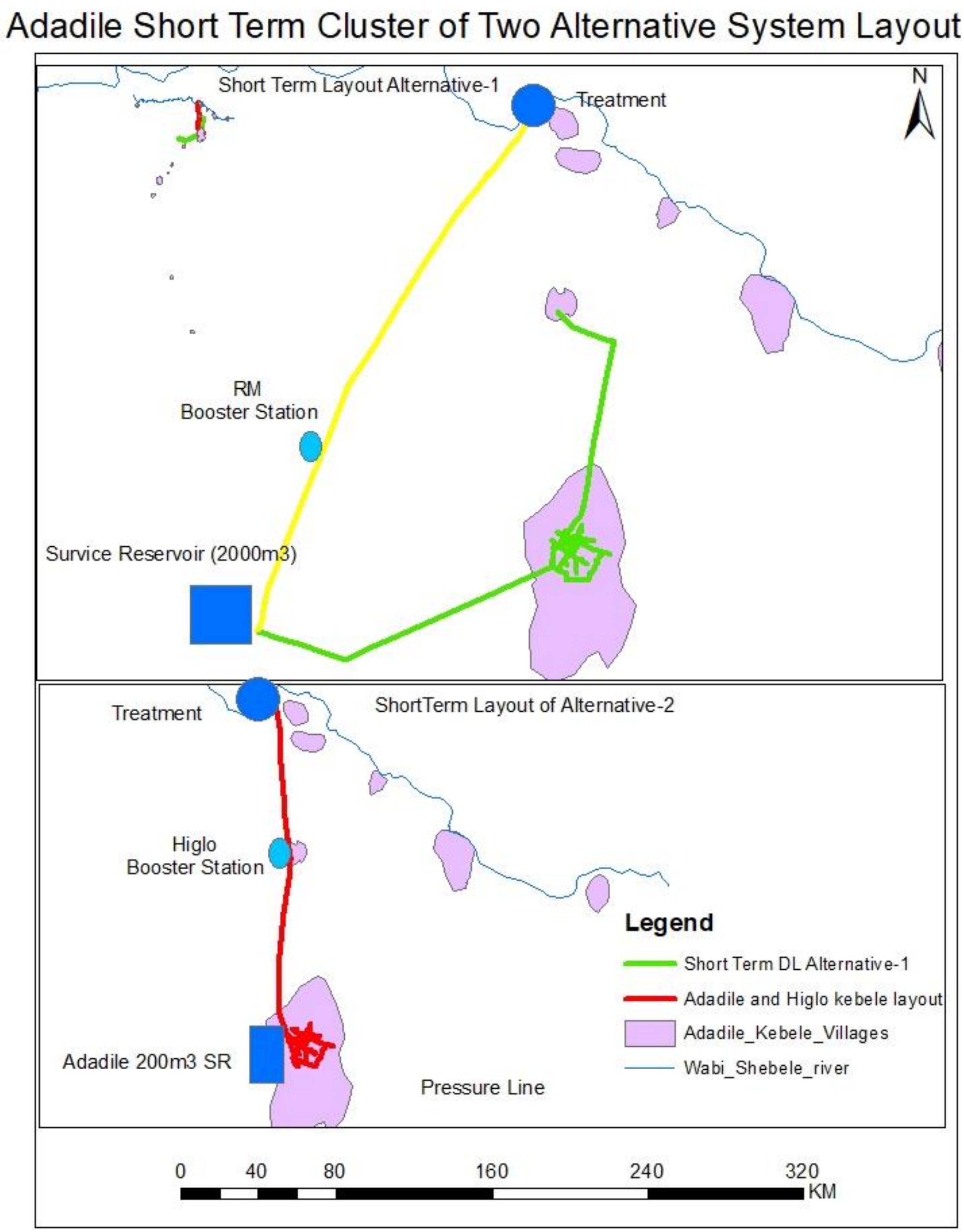


Figure 8-11: Proposed Distribution layout of two alternative

8.3.7. Nodal Demand Computation

The demand analysis of the town computed based on the domestic, institutional, and any other water demand computed under the demand analysis section.

The nodal demand has been assigned to each node in accordance with appropriate estimate for domestic, public, and industrial zone served by each node as per the existing community distribution coupled with our detailed field investigation as per the following procedures:

- From the settlement plan supplemented with field survey work the spatial distribution of the existing infrastructures were identified;
- Using a digitized map the area of each node was delineated, measured and tabulated for each category user;
- The demand area ratio for each category was computed;
- Nodal demands were computed by multiplying the area at each node with the demand area ratio for the specific consumer group.
- In a branching distribution line a demand block delineated and number of nodal point assigned.
- Demand for each node allocated based on the area proportion of each category user (domestic, industrial and Public)

8.3.8. Network Simulation and Presentation of Model Result

The adequacy of the system has been performed under several scenarios in order to optimize the system for extended period of 24 hourly time step simulations by considering the peak hourly water consumption pattern shown on Figure 8-3. Peak hourly pattern stemated based on the guide line rural water supply 2022.

The peak hour demands are used for sizing of the distribution pipelines that can deliver the required maximum flow at minimum established pressure at all consumers tap while the minimum water demand is used to analyse the maximum pressure in the system so as to select the pipe material and also to manage excessive pressure in the system.

Critical scenarios have been identified during low and high water consumption time period. During low consumption, velocity in a pipe will be lower and nodal pressure is high while during peak hour consumption velocity is relatively high and nodal pressure is becoming lower. Therefore, a great care has been taken into consideration in order to bring the model output result within acceptable range as per the design criteria.

In only one node at sigole kebele pressure is less than 10m during minimum water demand and the maximum pressure is 194.4m at junction J-50. Although this is out of the operating range and did not propese any pressure arresting facilities due to the distribution system extended to surrounding kebele of Adadile town without booster station.Similarly, pressure at node of Adadile town distribution network pressure ranges 165m upto 171m and the figure is out of range. Pressure arresting PRV initial pressure of 80m is need between junction 268 and 285.

It obvious that the highest pressure appears during minimum demand period within the system. From these analysis the highest node of Adadile town pressure ranges from 3.36 to 16.58 and the minimum pressure for node is greater than 3.36 m of water column.

Similarly the low pressure occurs during high demand period, for this analysis the nodes with the low pressure at maximum demand are existing water points. All lower pressure at the nodes ranges from 3.36 to 9.8 m. At those nodes the pressure is less than 10 metres and hydraulic design condition not meet as it was noted in the design criteria. Adadile woreda and surrounding kebele catagorised under advanced Ethiopian rural kebeles and for this case the pressure out of range is accepted.

Various types of pipes selected for the system including, HDPE. These pipe types are applied at various parts of pipe network system. Hence,diameter, pipe material and lengths of the distribution system is summarized as follows:

Table 8-10: Pipes required for Distribution Network

Description	Unit	Length (m)	Length with 5% Contingency (m)
	Only Adadile and Higlo		
HDPE Pipe OD 50 PN10	m	5,740	6027
HDPE Pipe OD 63 PN10	m	1,578	1657
HDPE Pipe OD 75 PN10	m	209	219
HDPE Pipe OD 90 PN10	m	1,437	1509
HDPE Pipe OD 125 PN10	m	1,828	1919
HDPE Pipe OD 225 PN10	m	649	681
HDPE Pipe OD 250 PN10	m	432	454
Sub -Total			**12466**

NB: This Quantity includes additional 5% excess supply for O&M purpose

8.3.9. Hydraulic modelling Calculation summary

Three analysis modeled based on Peak hour Demand Alternatives. These variation in demand applied over the 24hours and the flow demanded, stored and supplied were analyzed.As it indicated in figure 8.4 Considering hydraulic calculation without booster station and selecting strategic location of collect reservoir clear water tank conveyed at Wardid booster station travelling about 30km.To verify that the model analysis satisfy the hydraulic conditions the summary is analyzed and presented below:

Network Inventory

Pipes	63	-Standard Extended	0
Laterals	0	<None>	8
Junctions	56	-Constant Speed - Four-Quadrant Characteristics	2
Hydrants	0	-Constant Speed - Pump Definition	0
Tanks	2	-Shut Down After Time Delay	0
-Circular	2	-Variable Speed/Torque	0
-Non-Circular	0	-Pump Start - Variable Speed/Torque	0
-Variable Area	0	Pump Stations	0
Reservoirs	1	Variable Speed Pump Batteries	0
Customer Meters	0	PRV's	0
Taps	0	PSV's	0
SCADA Elements	0	PBV's	0
Pumps	2	FCV's	0
-Constant Power	0	TCV's	0
-Custom Extended	0	GPV's	0
-Design Point (1 Point)	2	Isolation Valves	8
-Multiple Point	0	Spot Elevations	0
-Standard (3 Point)	0		

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Figure 8-12: Network inventory for short term cluster (Adadile-Higlo)

Hydraulic Model Inventory: Adadile WSP.wtg

Network Inventory

Transient Network Inventory

Turbines	0	Rupture Disks	0
Periodic Head-Flows	0	Discharges to Atmosphere	0
Air Valves	0	Orifices Between Pipes	0
Hydropneumatic Tanks	0	Valves With Linear Area Change	0
Surge Valves	0	Surge Tanks	0
Check Valves	0		

Pressure Pipes Inventory

44.0 (mm)	5,740 m	100.0 (mm)	22 m
55.4 (mm)	1,578 m	110.2 (mm)	1,828 m
66.0 (mm)	209 m	136.4 (mm)	7,169 m
79.2 (mm)	1,437 m	198.2 (mm)	649 m
80.0 (mm)	12 m	220.4 (mm)	432 m
93.8 (mm)	9,786 m	All Diameters	28,863 m

Figure 8-13:Network inventory of short term cluster

8.3.10. Public Fountains

As per the water demand computation model, the total number of public fountains required for Adadile Short term cluster water supply project at the end of the stage period is 11. Presently there are 9 public fountains where 9 considered to be rehabilitated. Therefore, 11 public water points will be constructed in design period and finanal number is estimated during detail design phase.

8.4. Water Quality and Treatment

8.4.1. Water Quality

The water quality of any water supply related to the sources. The bacteriological treatment is an avoidable for any sources of water entering the system. Bacteriological treatment facilities is provided at storage - reservoirs. On top of each reservoir disinfection cubicle consisting of calcium hypochlorite preparation and disinfection tank of 300liters, calcium hypochlorite stirrer motor of 0.37kw, hypochlorite gravity dosers of 5-40l/hr capacity and all accessories used for the process. The detail illustration of this system hydrogeology report. Adadle woreda reveal that only two water samples are in good category and the other groundwater samples are found between unsuitable and poor category of water and inappropriate for drinking purposes.

Based on the assessment of existing water supply the project area is ground water quality is characterized by poor water quality.As most part of Adadle woreda covered with aquiclude Korahe formation with poor groundwater quality that unsuitable for drinking, it is recommended to consider Shebelle River as a potential source for the woreda.

8.4.2. Water Treatment

Water treatment removes contaminants and undesirable components, or reduces their concentration so that the water becomes fit for its desired end-use. This treatment is crucial to human health and allows humans to benefit from both drinking and irrigation use.

To Satisfay the maximum daya demand of Adadile town and surrounding village of woreda row water 90.62l/s diverted from Shebele river through divertion structure and 8.59l/s diverted with additional new water treatment plant for Bursareedo kebeles. Component of treatment include horizontal roughing filter, sedimentation tank, slow sand filter and 2000m3 collection chanmber is proposed. Collection chamber collect water from treatment plant.Profile of the treatment plant shown in fig.8.7 and 8.8.

8.4.2.1. Roughing filtration

The water quality of contaminated surface water can be improved significantly when filtered through gravel and sand layers. Therefore, favorable hydro geological conditions allow polluted and turbid pond water to be drawn as clear and safe groundwater from a shallow well located next to a river. However, local soils are quite often impervious for lack of gravel and sand layers. The solids removal efficiency of such a tank will drastically increase due to the greatly reduced settling distance in the gravel material.

The fine solids crossing a rectangular sedimentation tank have to overcome a vertical settling distance of 1-3 m before coming into contact with the tank bottom.

Due to small settling velocities, a large portion of the fine solids might not reach the tank bottom and will therefore not be separated. The same sedimentation tank can be filled with rough filter material of approx. 20-40mm.Roughing filters are operated at small hydraulic loads - filtration velocity is usually in the order of 0.3-1.5 m/h. The different size of roughing filter media is shown in Table5.1 and its design application of roughing filters vary considerably as shown in the figure 5.1.

Table 8-11:Different sizes of roughing filter media.

Roughing filter description	First compartment (mm)	Second compartment (mm)	Third compartment (mm)
Coarse	24	18	12
normal	18	12	8
Fine	12	8	4

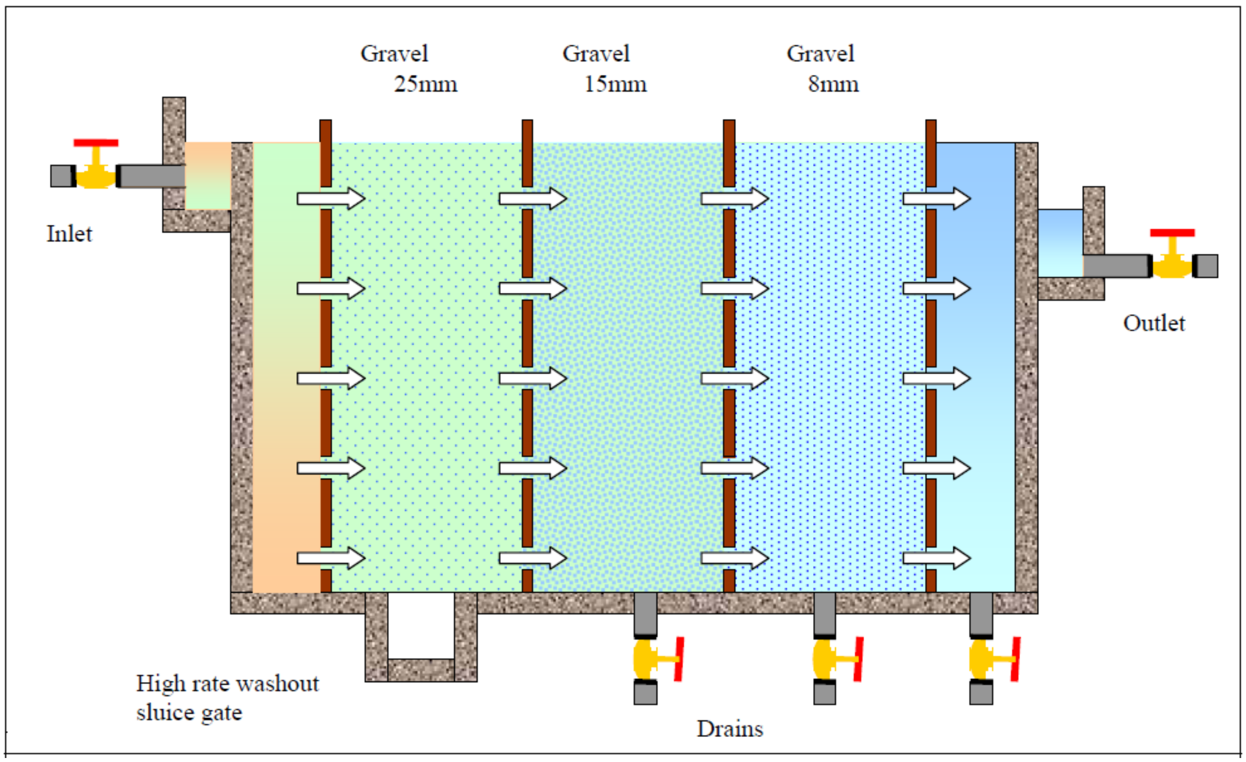

Figure 8-14 Horizontal roughing gravel pre-filter

The following parameters have been selected for this design:

Average suspended solid in raw water: Medium

Horizontal flow: 1.0m/h

Depth: 1.0m

Width: 2.0m

Length: First compartment 3.0m, Second compartment 2.5m and third Compartment 2.0m

8.4.2.2. Slow sand Filters

If you use surface water sources for household use, slow sand filtration or more accurately biologically active filtration may be an effective choice for water treatment. Slow sand filters can remove more percent of turbidity, bacteria, viruses, and, Guardia cysts without the need for chemical flocculent or the use of electrical power. Slow sand filtration is a preferred technology for customers who:

- Wish to use surface water (ponds, streams, springs)
- Use daily volumes that make cartridge use impractical
- Have no access to electrical power
- cannot or do not wish to use chemical treatment

The Technology of slow sand filter comprises.

- Effective
- Appropriate
- Affordable
- Desirable and
- Sustainable;

And significantly advance the cause for provision of safe water to the disadvantaged communities of the society. So the layout of slow sand filter for Adadile and surrounding kebeles is shown in figure5.2.

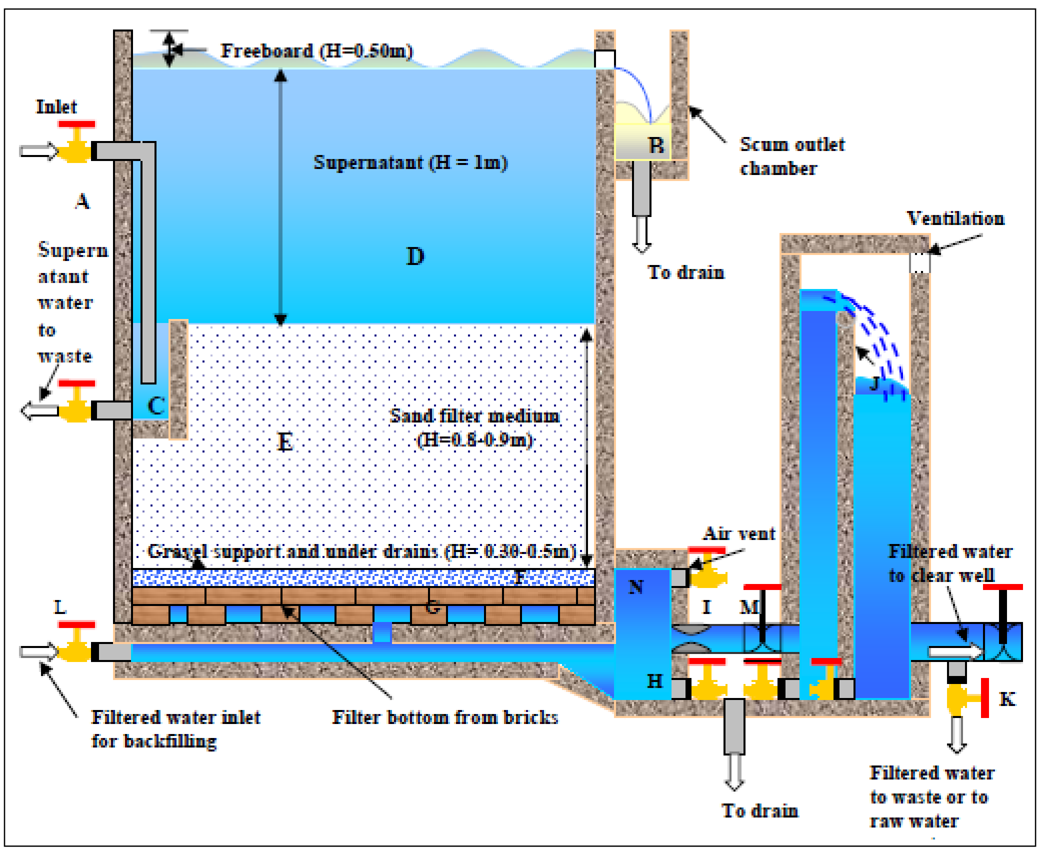

Figure 8-15 ***Typical section of slow sand filter***

A slow sand filter unit consists of the following parts

1 .Enclosure tank
2 .Filter media
3 .Base material
4. under drainage system

8.4.2.3. Enclosure tank

The traditional slow sand filter is open basin, usually rectangular in size, built below finished ground level. The water tight basin or tank is constructed either in stone or brick masonry, with a coating of water proof material. The floor has abed slope of 1 in 100 to 1 in 200 towards the central drains. The surface area of the tank varies between 50m to 1000m, and is found on the basis of filtration rate which varies between 100 to 200 liters of water per square meter. The depth of the tank varies from 2m-5m.

8.4.2.4. Filter media

The filter media consists of sand layer, 90 to 110cm thick. The effective size of sand varies from 0.20 to 0.35, with a common value of 0.3the coefficient of uniformity varies from 2 to 3, the common value being 2.5the finer the sand, better will be bacterial efficiency, but slower will be the filtration rate.

8.4.2.5. Base material

The filter media is supported on base material consisting of 30 to75cm thick gravel bed. The gravel base is graded, and laid in layers of 15cm with topmost layer of finer size and bottom most layer of coarse size, as indicated in Table 8.7:

Table 8-12 Filter media

Type of layer	**Depth**	**Size(soil)**
Topmost layer	15cm	3mm to 6mm
Intermediate layer	15cm	6mm to 20mm
Intermediate layer	15cm	20mm to 40mm
Bottom layer	15cm	40mm to 65mm

8.4.2.6. Under drainage system

The filter media and the base material are supported over the under drainage system which eventually collects the filtered water and delivers it to the clean water reservoir.
The summery of the design criteria for slow sand filter are shown in table 5.3 and 5.4.

Table 8-13 design criteria for slow sand filters

Recommend Level	Adadile SSF
Filtration rates in the filters: 0.1 to 0.2 m/h.	0.20
Filtration rates in the filters: m3/day	4.80
Reqired demand by 2033(l/sec)	53.26
Reqired demand by 2033 (m3/day)	8,850.00
Area of Filter bed Required (m2)	1844
Number of filter bed units (No.)	5.00
Area of one Filter bed Required (m2)	369
Width of one filter unit (m)	5.00
Length of one filter unit (m)	12
Height of filter bed:	1
Initial: 0.9 m	
Minimum: 0.5 to 0.6 m	
Specification of sand:	
Effective size: 0.15 to 0.30 mm	
Uniformity coefficient: <5, preferably below 3.	
Height of under-drains including gravel layer: 0.3 to 0.5 m	
Height of supernatant water: 1.0m	

Table 8-14 Summary of design of slow sand filter

Filtration rates in the filters: 0.1 to 0.2 m/h.	0.20
Filtration rates in the filters: m3/day	4.80
Reqired demand by 2033(l/sec)	53.26
Reqired demand by 2033 (m3/day)	8,850.00
Area of Filter bed Required (m2)	1844
Number of filter bed units (No.)	5.00
Area of one Filter bed Required (m2)	369
Width of one filter unit (m)	5.00
Length of one filter unit (m)	12

Height of filter bed:	1

In general the schematic treatment process of the Adadile and surrounding village water supply project is shown in figure 8.9.

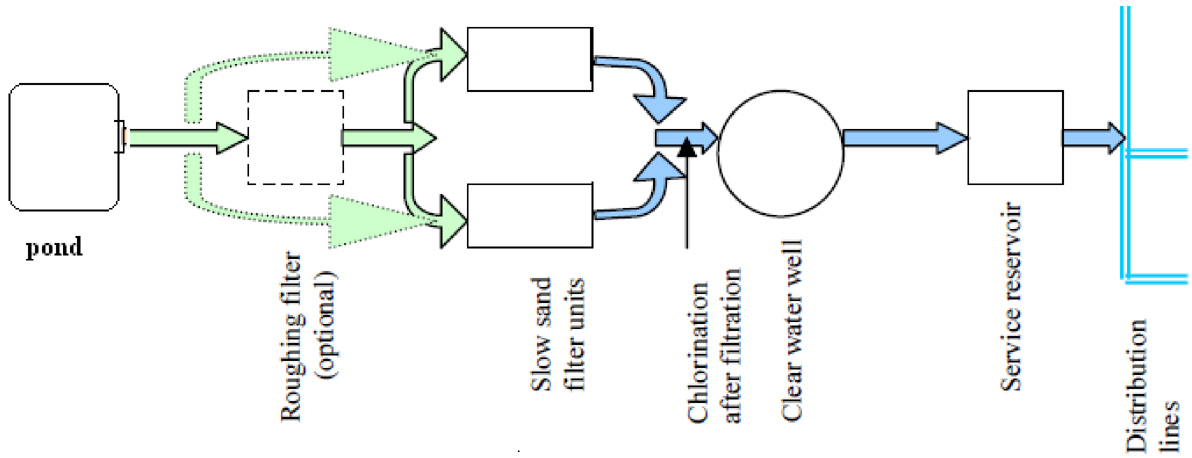

Figure 8-16:Layout of treatment plant

8.5. Proposed Elechtromechanical

8.5.1. Introduction

Detail Design of the Electro mechanical equipment's will be presented under the entitled Electro mechanical Design. Somali Multi-village Water Supply Project consists of Raw Water Pump station and two booster pump station including complete electro-mechanical Pump Stations with different pump position and dynamic water level locations below ground level in this final design report.

The boreholes are named as RWPS-01, BPS-01(PM-3 with discharge of 34.87Lit/sec in 1 +1 standby mode), BPS-02(PM-4 with discharge of 22.35 lit/sec) and BPS-03(PM-5 with discharge of 19.1 lit/sec,BPS-04 (PM-6 with discharge of 12.39lit/sec).Here, WaterGems modeling analysis conduct to preliminary analysis and presented in the flowing Figure.8-17

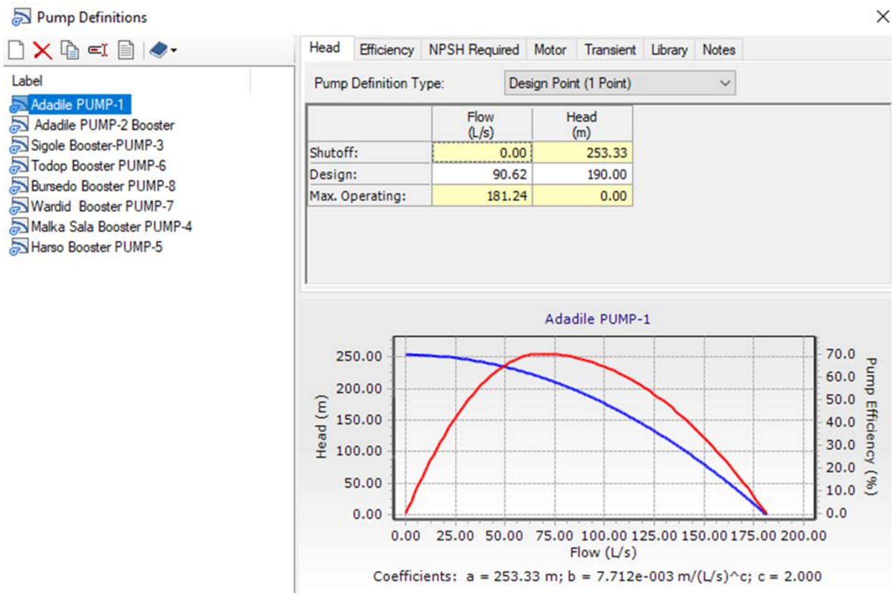

Figure 8-17 : Pump Head and Dischrge -Based on WaterCAD Simulation Model

The above naming is used for pressure line length, diameter, frictional losses and related calculation inputs for the whole system.

The design of Pumping stations was performed in three phases (Design methodology):

- Data Collection from well completion report or Hydrogeologist well design, collecting data from surveying result.
- Evaluation of alternative options to deliver directly to the collector/service reservoir
- Detail Design of the pumping stations using final selected option

The Raw water pumps are submersible sludge pumping stations designed for star delta connection electrical design. Similarly, the surface pumps are **horizontal multistage pumps in 1+1 standby** running mode the design calculations are done by pipe sizing, pump head determination, power calculations, power cable sizing. The basic drawings include pump arrangement, elevation, and discharge, list of accessories, size, and materials.

Finally, preparation of Priced Bill of Quantity, Selected pump curve, power cables sizing, standby diesel generator sizing or solar panel sizing , transformer sizing is accomplished.

8.5.2. Design Criteria

1. Design life time of 15-25years for EM Equipment
2. Pumping(running) cost optimization by reducing frictional losses using larger diameter pipes, design pump units with high efficiency, accurately calculating the system operation point;

3. Simplicity of operation &maintenance, standardization
4. Hydraulic analysis using Hazen-William's equation

H =10.675*L*(Q^1.852)/(C^1.852) *(D^4.87)

Where:

Q = the flow rate in meter cube per second

C = a coefficient depending on the smoothness of the interior of the pipe its value as indicated in calculations

D = the diameter of the pipe in meters

L = the length of the pipe

h = the frictional head loss in the pipe

On the other hand, frictional head losses associated with pipe bends, elbows, tees, valves are classified as Minor losses.

The following formula is employed to calculate the head loss.

Hf = Fc*V^2/2g Where

Hf = friction loss in fittings & valves in meters

V = velocity of water in m/sec

Fc = friction coefficient for fittings & valves

g = acceleration due to gravity in m/sec^2

In the pumping station, flow velocities should not exceed 1.5 m/s in suction pipe-lines and 3 m/s in discharge lines. In actual case, the calculated values of riser pipes velocity are shown in detail excel attached in the annex.

8.5.2.1. Net Positive Suction Head Available Calculation

$NPSH_A$ or NET Positive Suction Head Available is generally provided by the system designer or process engineer of the particular system. The value of $NPSH_A$ varies from system to system. It is dependent on the fluid temperature, the pressure exerted by the atmosphere on the fluid, losses in the pump suction side, pump static lift, or static height of fluid (generally taken from Low Water level to the top surface of fluid).

What is NPSHR?

$NPSH_R$ or NET Positive Suction Head Required is the minimum suction head required at the pump suction flange. It is provided by a pump supplier or pump manufacturer. The value of $NPSH_R$ is calculated by pump suppliers by testing the pump in his workshops. The value of $NPSH_R$ varies from pump supplier to supplier. This value also varies from the pump model to the model.

Relation between NPSHA & NPSHR

As already mentioned, the NPSH(R) is the minimum required head at the pump suction flange to avoid cavitation of the pump. So, in order to avoid cavitation NPSH(A) should always be greater than NPSH(R).

If the value of $NPSH_A$ falls below the value of $NPSH_R$ a low vapor pressure will be formed at the pump suction. Due to low vapor pressure, the water will start boiling even without attaining the boiling point. Due to which bubbles of water will start forming, these bubbles will reach the pump impeller eye and due to low pressure at the pump impeller eye, they will explode there. This explosion of bubbles will lead to deterioration of the pump impeller with many more problems.

Calculation of NPSH**A**

As mentioned above NPSHA is calculated by the process designer for a particular system. The formulae to calculate NPSHA is given as below:

$$NPSHA = HA \pm HZ - HF + HV - HVP$$

Table 8-15:NPSHa calculation parameters

Term	Detail of Term	Considerations
HA (mWc)	The absolute pressure on the surface of the liquid in the supply tank	Typically, atmospheric pressure (vented supply tank), but can be different for closed tanks.
HZ (mWc)	The vertical distance between the surface of the liquid in the supply tank and the centerline of the pump	Can be positive when the liquid level is above the centerline of the pump (called the static head) Can be negative when the liquid level is below the centerline of the pump (called suction lift) Always be sure to use the lowest liquid level allowed in the tank.

HF (mWc)	Friction losses in the suction piping.	Piping and fittings act as an obstruction (restriction), working against liquid as it flows towards the pump inlet.
HV (mWc)	Velocity head at the pump suction port	Often not included as it’s normally quite small.
HVP (mWc)	Absolute vapor pressure of the liquid at the pumping temperature	Must be subtracted in the end to make sure that the inlet pressure stays above the vapor pressure. Remember, with an increase in temperature, vapor pressure also goes up.

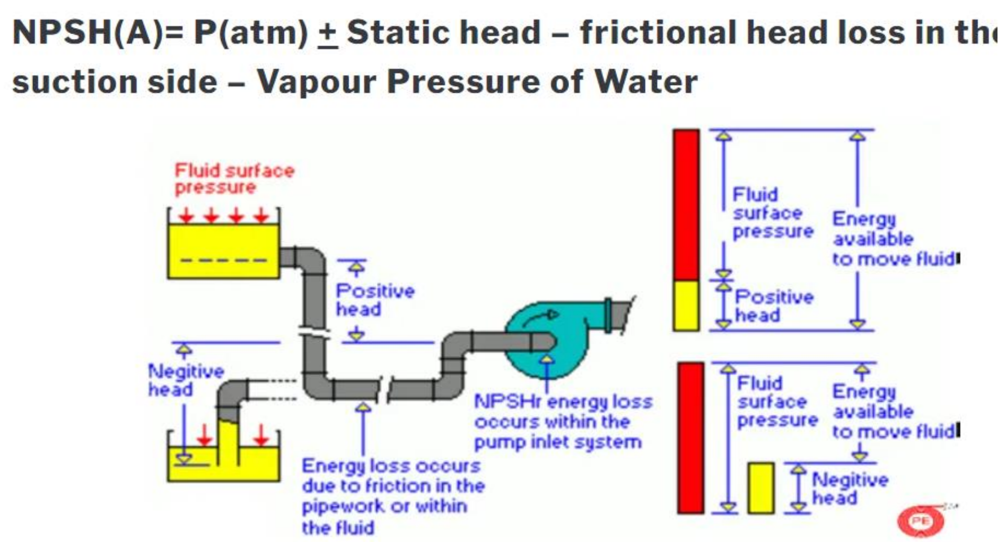

Fig 9.1.1 NPSH available calculation parameters

Negative Impacts of NPSH on Pumping System

- Impeller Erosion
- Pump Vibration
- Sound
- Bearing Damage
- High Power Consumption
- Low Pump Efficiency

Hence, the available NPSH is very important while designing and selecting a pump for a process.

The booster pump station is located near the transfer reservoir with inlet from reservoir and inlet to the surface pumps at the bottom of the reservoir as shown in the following drawing.
This number is compared to the NPSH required, and if it is larger than the NPSHR, the pump will not cavitate. In order to assure a good installation, the NPSHA should be 15 to 30 percent more than the NPSHR. This rule of thumb will allow for some process variations and keep the pump from cavitating.

$$NPSHA = (1.15 \text{ to } 1.30) \times NPSHR$$

.

Therefore, $NPSH_a = h_a - h_{vpa} + h_{st} - h_f$

ha= The absolute pressure on the surface of the liquid in the supply tank. Typically, atmospheric pressure (vented supply tank), but can be different for closed tanks.

In this case the altitude of the site is 1948masl and the absolute pressure at this altitude is 8.27m. Assuming vented tank.

Table 8-16: NPSHA-NPSHreq

S.No	Design Parameters	Symbol	Value in number	unit
1	Patm/absolute	**ha**	**8.18**	**m**
2	Vapor pressure	**hvpa**	**0.43**	**m**
3	suction elevation	**hst**	**3.35**	**m**
4	friction loss in suction	**hf**	**1.12**	**m**
5	Available positive suction head	**NPSHA**	**9.98**	**m**
		NPSHREQ	**3.87**	**m**
		NPSHA-NPSHreq in meter		**6.11**

8.5.3. ELECTRICAL DESIGN

8.5.3.1. Design of Diesel Generators, Transformers and Power cables

Diesel generators are the power source of submersible pumps at all sites depending on the client capacity to invest in the initial cost and operate the running costs. Generators are designed as a standby power option as to Ethiopian Electric Power Utility Transformer electric power which is used a main power source.

Thus, generators are designed as a standby power system to provide an alternate source of electrical power for the submersible pump and some lighting system for buildings in the event of normal electrical power source failure.

Systems include power sources, transfer equipment, controls, supervisory equipment, and accessory equipment needed to supply electrical power to the selected circuits.

Sizing of generators are important as getting a generator that can handle all our power source generation needs is one of the most critical aspects of purchasing decision.

It should be noted here that optimization is very important to size the right size or kilowatt of the equipment to run the product safely without overload and not to use unnecessary fuel amount without the need of that excess power.

In our case generator for three-phase power is sized by taking the rated motor power of the submersible pump and dividing by a power factor of 0.8 at our specific altitude and environmental temperature of our site.

Therefore, the sizing will be included in the following table for respective sites. It is important to note here that the lightning power is very small and can be included in the calculated KVA by assuming starting torque of the pump as three (3) by assuming star-delta connection.

Electrical design of power cables

Voltage Drop of power cable.

Power and control cables for outdoor use shall be XLPE insulated copper conductor with voltage rating of 0.6/1kV and maximum conductor operating temperature of 90 ^{0}C.
Identifying the nominal current, by considering V-400v & P.F-0.8

$$I_n = \frac{P_M \times 1000}{1.73 \times P.f \times V}$$

As an Example, the rated power of the first borehole pump is 20kw and rated current by considering 0.8 power factor is 33.7A. Therefore, considering the pump position of 65m below ground level and considering some tolerance of 20meters from borehole head to pump control the total power cable length is 65m.
Therefore, the power cable cross-section of the pump considering the above parameters is 4 x 16 mm^2 with a maximum voltage drop of 3% for a total length of 65meters.Similarly, all the power cables are selected in the same fashion for all the remaining borehole and booster pump station.

Power Supply

Main power

Power requirements at the Pump station shall be calculated as follows:
Motor load

Pump drive motor power = P; p.f. = 0.8
Number of pumps running simultaneously = N
Type of motor starter: Star- Delta (Y/Δ) starter type reduced voltage starter
Starting KW = 3 x P; Power is directly proportional to Current.
Total motors load = 3 x P kW
Or = [3 x P] / 0.8 kVA
The generator capacity of the pump for 15KW can be calculated as :
Genset KVA = 37*3/0.8= 139KVA

= 150KVA,

When we round up to the nearest standard generator set capacity is around 150KVA.

We have made annex

8.6. Ancillary Buildings and Access Roads

8.6.1. Ancillary Buildings

Offices, operation and maintenance buildings will have to be provided for the proper operation of the system. The proposed auxiliary buildings are as shown in the following Table 8-15.

*Table 8-17:-*No. of Auxiliary Building , Water Supply & Sanitation Facilities

Description	Unit	Quantity
PART-I: CIVIL WORK		
General Items	Ls	1
Construction of Transmission line	Ls	1
Construction of Distribution system	Ls	1
Construction of Elevated 200m3 Water Reservoir	No.	1
Construction of Ground 200m3 Concrete Water Reservoir	No.	1
Construction of 100m3 Concrete Clear Water Tank	No	1
Construction of Sixteen (9) Existing Water Points 2 new WP and 9 WP need maintenance.	No.	2
Maintenance of 9 Water point	No	9
Construction of WSS Pump House Building	No,	2
Construction of Operator Dwelling	No,	2
Construction of Generator house and controol room	No.	2
Construction of Guard house	No.	2
Construction of VIP Latrines	No.	1
Construction of Toilets and Septic Tank	No.	2
Construction of Chlorination	No.	2
Aeration facility	No.	0
Compound Work of office, Reservoir and Bore hole	No.	2

Gravel Access Road construction	No.	1
Sedimentation Tank	No.	1
Roughfing Filter	No.	1
Slow Sand Filter	No.	1
Construction of Divertion Weir and protection	No,	1
Sub-total		
PART-II: SUPPLY OF PIPES, FITTINGS		
Supply of Transmission Main	LS	1
Supply of Pipes & Fittings for Distrbution	LS	1
PART-III: SUPPLY & INSTALLATION OF EM EQUIPMENTS & PLANTS		
Supply and Installation of Electro Mechanical	Ls	2

8.6.2. Access Roads

Access road to the boreholes site important for regular follow-up, Operation and maintains of the sources structural,survice reservoir and Electro-mechanical facilities. A length of 0.5km from new proposed intake and reservoir to a road connecting to the town, the road is the minimum standard categorized under rural road with GS-5 standard with a design.

9. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

9.1. Background

Economic development can have major impacts on the environment by degrading soils, polluting bodies of water, altering landscapes and threatening biodiversity, and in some cases driving species into extinction. In addition, environmental impacts can impose significant economic and social costs on society, especially with regard to human health. ESIA, however, can predict development's negative effects and reveal strategies to avoid and mitigate them, and can also point out possibilities to enhance the positive effects of developmental activities.

Environmental and Social Impact Assessment is therefore conducted to ensure that the environmental effects of proposed activities are adequately and appropriately considered before decisions are taken. This should serve as a key aid in the decision making process for relevant authorities by providing comprehensive information on the environmental consequences of development.

Accordingly, the consultant sought the need for undertaking ESIA for the proposed Adadile woredaWater Supply Project; and this chapter provides the study process that includes major environmental impact due to the proposed project and proposed environmental mitigation.

9.2. Objective

Water Supply schemes, including the proposed Adadile woreda Water Supply Project, are meant for improving the water supply and associated health problems. With this respect, the ESIA is conducted with the following main objectives: -

- Identify environmental impact due to the project construction and operation; and propose mitigation measures for potential negative impacts
- Recommend relevant environmental enhancement measures towards sustainability of the project

9.3. Methodology

The following methodologies were used to accomplish the ESIA within the available resource and timeframe work:

- Review of relevant national and international environmental study guidelines
- Review of relevant study documents and maps to support establishing baseline environmental condition of the project area.
- Projects layout on topographic map, satellite imageries (esp. Landsat and SRTM); and other study documents provide idea on physical and socio-economic environment of the project area.
- An extensive discussion made with different professionals that take part in the project study and design. The various project characteristics and secondary information of the direct impact zone generated from the discussion.

9.4. Policy Legal and Institutional Framework

9.4.1. Environmental Policy of Ethiopia (EPE)

The Environmental Policy of the Federal Democratic Republic of Ethiopia (EPE) was approved by the Council of Ministers in April 1997 (EPA/MEDAC 1997). The overall policy goal is related with improvement and enhancement of the health and quality of the life of all Ethiopians, and the promotion of sustainable social and economic development through the adoption of sound environmental management principles. Key elements of the policy includes: -

- Recognition of the need for EIA to address social, socio-economic, political and cultural impacts, in addition to physical and biological impacts, and for public consultation to be integrated within EIA procedures;
- Incorporation of impact containment measures within the design process for both public and private sector development projects, and for mitigation measures and accident contingency plans to be incorporated within environmental impact statements (EISs);
- Creation of a legal framework for the EIA process, together with a suitable and coordinated institutional framework for the execution and approval of EIAs and environmental audits;
- Development of detailed technical sectoral guidelines for EIA and environmental auditing and
- Development of EIA and environmental auditing capacity and capabilities within the Environmental Protection Authority, sectoral ministries and agencies, as well as in the regions.

9.4.2. Proclamation on Institutional Arrangement for Environmental Protection

The Proclamation for the Establishment of Environmental Protection Organs, No. 295/2002, was issued to establish a system that fosters coordinated but differentiated responsibilities among environmental protection agencies at Federal and Regional Levels. The proclamation recognizes assigning responsibilities to separate organizations for environmental development and management activities on the one hand, and environmental protection, regulations and monitoring on the other is instrumental for the sustainable use of environmental resources, thereby avoiding possible conflicts of interests and duplication of efforts.

9.4.3. Proclamation on Environmental Impact Assessment (EIA)

The primary aim of the Proclamation on Environmental Impact Assessment No. 299/2002 is to make EIA mandatory for specified categories of activities undertaken either by the public or private sectors. For the purpose, EPA produced guideline, Environmental Study Procedural guideline EPA 2000, for determining EIA study procedure. The guideline requires all projects to be submitted to an Initial Environmental Examination (IEE) to enable a decision to be taken as to whether the project is to be submitted to full EIA, in the case of projects which may have significant impacts, and are defined as falling under Schedule 1, or are of projects such a type or scale which does not justify full EIA, and therefore fall into Schedule 2. Schedule 3 projects are the ones which have no impact on the environment and do not require EIA.

Therefore, the proposed Adadile woreda WS development project should be screened and scoped for the possible environmental impacts and the necessary mitigation and environmental management plan prepared to secure sustainability of the project. Methods used in determining the project schedule category includes referring to the environmental procedural guideline, collection and analysis of data on the project and site characteristics and preparing, previous professional experience and judgment from similar WS to consider relevant environmental parameters in relation to the project activities that fall in different development phases.

The proposed Adadile woredaWSIP uses three new borehole sources and the existing surface water treatmentand the maximum daily abstraction is in the order of 3070m^3 per day that considers the human daily requirement.

The major impacts of the project are related with the source development, storage, impacts related to pipeline construction, conflict to use of the resource, soil erosion; and subsequent contamination of water due to leakage from pipeline. These negative impacts need to be identified evaluated; and appropriate mitigation measures need to be implemented during the various development phase of the project.

With respect to implementation of ESIA, the regional environment protection and land administration office ensure that development projects have conducted ESIA prior to their implementation and the proponent of the project is expected to undertake the study to identify the likely adverse impacts of his project, and incorporate the means of their prevention. Depending on the scale and nature of the impacts, the project may be suspended or canceled from environmental authorization for its implementation.

9.4.4. Proclamation on Environmental Pollution Control

The Proclamation on Environmental Pollution Control (Proclamation No. 300/2002) is mainly based on the right of each citizen to a healthy environment, as well as on the obligation to protect the environment of the country. The primary objective of the Proclamation on Environmental Pollution Control is to provide the basis from which the relevant ambient environmental standards applicable to Ethiopia can be developed, and to make the violation of these standards a punishable act. The Proclamation states that the “polluter pays” principle will be applied to all persons.

For this purpose, country standard needs to be prepared and Environmental Inspectors be assigned by EPA or regional environment offices. Guideline ambient standards for Ethiopia have been prepared based on some countries experience, EPA 2003. Standard threshold limit has been set for industrial, agricultural and domestic wastes. Pollution of the ground water could not be a problem for some time to come since the socio-economic development and prevailing agricultural and industrial activities are very much limited and have no potential pollution source at present.

9.5. Baseline Environmental Feature of the Project Area

9.5.1. Topographic Features

Adadile woredahas rolling flat to slightly undulating landform ranging in altitude from 277 to 510m a.m.s.l. It is generally drained by shebelle Perennial rivers.

9.5.2. Climate

The town and its surrounding experiences light rainfall during September to November and classified to Bereha.

9.5.3. *Adadile woredaLand Use*

Adadile woreda has no master plan.

9.5.4. Water Resources Potential and Quality

The study area has only surface water potential of shebele river and the ground water potentioal not safe fordrinking water due to water quality and salinity.

9.6. Identified Environmental Impacts and Proposed Mitigation Measures

9.6.1. Positive Environmental Impacts

Increase Access to water supply

Implementation of Adadile woredaWater supply Project would mean increase from the current small to 8744.26m^3 in 2033GC.

Beneficial Impacts on public Health and Sanitation

Implementation of the proposed water supply project is expected to enable the population of the area to obtain safe and adequate water for drinking and other domestic uses. This in turn will reduce the prevalence of water-borne and water related diseases that are usually contracted by drinking water from unsafe sources and/or body contact with contaminated water points. With increased availability of good quality water, the health of the public will be further improved since it will enable them to keep clean the kitchen materials and eating utensils and individual personal hygiene. Better personal hygiene coupled with the elimination of the highly congested waiting lines around the water points will further reduce the spread of contagious diseases that are usually transmitted by bodily contacts.

Impacts on Women and Children

In addition to the backbreaking in-house undertakings, fetching water is one of the burdens vested up on many women and their children, particularly of girls. One of the expected benefits of providing piped water supply around homes or public fountains will be the significant reduction of time and energy spent in fetching water, usually from long distance. After implementation of the proposed water supply scheme, it is expected that there will be smaller maximum distances between the consumer's houses and public taps and no long waiting lines either, because it is tried to provide enough water points with six faucets at reasonable distances as much as possible.

This condition will allow women to spend more time for other important activities and school age children, especially girls, will have time to attend school.

Socioeconomic beneficial Impact

Employment and income generation will be one of the main channels through which project benefit will flow to the surrounding communities. It is estimated that the project will offer employment to about 100 persons during the construction phase and about 40 employees during operations.

9.6.2. Negative Environmental Impacts and mitigation Measures

General

Apart from the direct and indirect the above mentioned positive impacts, the environmental assessment analysis indicated some negative impacts that need to be considered in the project planning. These impacts generally occur during the project construction and operation period. The following section discusses on the impacts of the project during construction and operation.

9.6.2.1. Erosion

During the construction period, erosion may occur temporarily as a result of runoff in areas of excavation for collector pipe and distribution pipeline installation. Based on information from the engineering design, the pipeline will have a total length of alternative-1 about 204,213.00m and alternative-2 is 30,268m entirely laid in the ground through excavation that facilitate erosion in the area.

To avoid erosion, formation and expansion of gullies, good site construction practice should be followed by construction contractor. These include restoring working area, compaction of soils to resist erosion and enhance vegetation growth, limiting excavation to the required limit as much as possible. As much as possible, all erosion prone working area should be stabilized. On site environmental monitoring and supervision required to secure implementation of mitigation measures.

9.6.2.2. Pollution of Water Sources

Improper utilization and storage of oils and chemicals close to water collectors may pollute the water if not used and stored with care. Proper designing and construction are required to get the envisaged system safe. Proper well head construction is one of the mitigations.

To avoid impacts from petroleum products and maintenance activities, it is recommended that petroleum products should be handled in such a way that these products should not enter surface and ground water sources.Existing intake structure location topographically located below Gode town drained seware, unmanaged solid waste contaminate the river and for mitigation new intake site selected upstream of the town.

9.6.2.3. Disturbance of Farmlands

The project surface water (about 1844m2), rising main (about 42,118.00 km), and reservoir (about 901.0m2) will affect the greezing land. Therefore, community consultation and provision of replacement by the woreda and town administration are required.

9.6.2.4. *Impact on Vegetation*

The project construction activities are associated with land clearing and excavation that may affect vegetation cover close to pressure line. Some bushes could be removed from drilling site, during construction and pipe trench excavation.

The following is proposed as part of mitigation:

- Confine clearing of vegetation during excavation for collector and distribution pipeline to what is necessary and avoid excessive destruction of vegetation.
- Compensate by replanting and restoration of lost vegetation along transmission line and the reservoir.
- As much as possible avoid clearing of big trees
- Make community consultation

9.6.2.5. *Diseases Vectors*

One of the major effects of the project during operation phase will be the increasing quantity of excess wastewater in the area. The open wastewater in the area will be an ideal site for breading of disease vectors such as houseflies and mosquitoes. This in turn exposes the population of the area to malaria and other diseases. Excess wastewater may also attract rodents and other vermin which spread the feces and hence the potential for disease. In addition to these, it usually creates intolerable odor and sight nuisances including malaria epidemic since all other climatic factors are ideal for mosquito breeding.

Therefore, mechanisms have to be designed to eliminate the stagnant water around water points. One of these mechanisms is the provision of proper drainage system which is one of the fundamental solutions to avoid or minimize the potential problems and to help improve the general environmental sanitation. In addition to this, educating the communities on personal hygiene and environmental sanitation, water and sanitation, conservation of water during abstraction, control and prevention mechanisms of disease, etc will further substantiate the wellbeing of the beneficiaries and sustainability of the proposed scheme.

9.6.2.6. Conflict on the Use of Resource

The Water supply project is planned to be developed from river intake field situated north west and west of the town. The pressure line crosses about 42.12 km no such effect because no cultivated land in the study are. In addition, generator house, power control room, operator’s dwelling and guard houses will be constructed on community property which could cause conflict of interest

The following are some of mitigation measures to handle potential conflicts:

- Make consultation and discussion with communities having interest on the property
- Provide water supply system

Table 99-1. Major identified impacts and proposed mitigation measures

No.	Type of impacts	Mitigation measures	Measures should be effected during	Responsible body to carry out the measures
1	Loss of vegetation	Confine clearing of vegetation during excavation for pipeline and reservoir to what is necessary and avoid excessive destruction of vegetation especially shrubs plant	Construction	Contractor of the WSP construction
		compensate by replanting and restoration of lost vegetation	Before and during Construction	Woreda Administration and concerned sector offices
2	Soil erosion gully formation	Limit install appropriate drainage structures and lining as necessary	design and construction	Consultant and Contractor of the WSP construction
		establishment of vegetative cover on erosion surfaces as soon as possible	Construction and operation	Contractor, community and concerned sector office (Agriculture Development)
		Apply slope stabilizing mechanism on risk slope area	Construction	Contractor of the WSP
3	Impact on water resource	Install sediment traps and other screening structures to control runoff and sedimentation from construction activities	Construction	Contractor of the WSP

No.	Type of impacts	Mitigation measures	Measures should be effected during	Responsible body to carry out the measures
		Minimize use of fill dirt	Construction	Contractor of the WSP
		avoid disposal of solid and liquid wastes in drainage courses	Construction	Contractor of the WSP
4	Disease vector	Avoid conducive environment for diseases vectors (stagnant and vegetated)	Construction/operation	Contractor of the WSP Local people
		Public education and awareness	Operation	Contractor of the WSP and local Agri. B
		Strengthen health facilities	Operation	Health Office
5	Temporary impact from location of camp site	Select camping in consultation with local people and MoWE (avoid camping in community property)	Construction	MoWE, local people and Contractor of the WSP
		Aware workers about environmental sanitation and health	Construction	MoWE, local people and Contractor of the WSP
		Disposal of all wastes on established disposal sites	Construction	MoWE, local people and Contractor of the WSP

No.	Type of impacts	Mitigation measures	Measures should be effected during	Responsible body to carry out the measures
	Conflict on the use of Water	• Provide water supply service for villages along transmission line • Provide substitute or compensation for those who miss their land • Consult all concerned stakeholders • Devise proper management system	• Design • Construction • Operation	• Consultant • Contractor • MoWE • Local Administration

9.7. Environmental Management and Monitoring Plan

9.7.1. Environmental Management

Environmental management and monitoring is concerned with implementation of measures necessary to minimize or offset adverse impacts and enhance beneficial aspects. Unless the mitigation and benefit enhancement measures identified in the study implemented, the prime function of ESIA and objective of the project may not be achieved. Therefore, the environmental management and monitoring must be integrated with the overall project implementation and management and could generally fall in the construction and operation period.

9.7.1.1. Construction Phase

Most of the project environmental management activities will be carried out during the construction phase since this is when most impact can be expected to arise. The overall, responsibility for construction and also for environmental management during construction lies with the contractor. Hence the following environmental management aspect should be implemented by the contractor working on the water supply project construction:

- Construction facilities and storage areas should be located away from drainage areas.
- A waste management plan should be produced how waste oils, lubricant, other chemicals (if any), scarp metals, HDPE and PVC would be removed safely.
- Non-hazardous waste should be compacted and entrenched at an approved land fill site located far away from drainage courses.
- Disturbed top soil should be preserved and restored.
- Adequate precaution should be taken to prevent erosion.
- Earth surface, especially on unstable slopes should not be exposed immediately before the onset of the rains: loss surface should be cut only dry weather and replanted as soon as possible.
- The contractor should provide adequate sanitary provision for the workforce.

9.7.1.2. Operation Phase

For sustainable provision of water from the project, the operation level management is peculiar and requires training of concerned staff and integration work. These include:

- Careful storage filling adequate and safe disposal of oil from generators
- Control land use around catchments of source of water.
- Avoid dumps or landfill sites within a certain distance from water sources.
- Cattle holding should be prohibited near water supply facilities and monitor well functioning of cattle watering points
- Future industrial development planning should be downstream of water abstraction points and their waste water discharge should be controlled

9.7.2. Environmental Monitoring Aspect

Monitoring program is required to soften the impact of the project on the environment and as well as the impact of the environment on the project. It includes monitoring aspects related to the ground water potential, quality and utilization. Major area of monitoring includes: -

- Soil erosion and gully formation and expansion, especially around pipeline and other structures
- Leakage from pipelines and other structures
- Suspected source of pollution of ground and surface water

- Burden on health facilities from water borne and related diseases
- Decline or depletion of ground water source
- Abstracted water quantity and quality
- Land use and catchments vegetation cover condition

9.7.3. Institutional and Technical Requirements

Coordinated effort between various regional organizations together with the Oromia Water Mineral and Energy Bureau is necessary to implement the environmental management & monitoring and the overall project management. Some of the organizations that need to participate in the monitoring and management program include administration, environmental protection, agriculture and rural development, capacity building and health offices that are found at regional and districts levels.

It's recommended that the MOWE should take the lead responsibility and be equipped with the necessary technical capacity for implementing the environmental management and monitoring plan along with the overall project implementation and management. Appropriate operation of the project depend on organizational set up at the local level hence training should be provided on major environmental issues related to operation of the project.

9.7.4. Outstanding Environmental Issues

Apart from rainfall, topographic, soil, vegetation cover characteristics, water source quality and quantity are directly and indirectly related to the socio-economic activities in the watershed/recharge zone. At present and in the near future, no risk of water pollution anticipated from industrial or urban development in the project catchments area. However, yield from ground/surface water sources is directly affected with vegetation cover and the respective infiltration rate of precipitated water. Hence the need of monitoring land use and cover of the recharge area through integrated micro watershed management approach is important.

9.8. Conclusion and Recommendation

One of the very basic infrastructures of settlement centers is the provision of safe water supply. With this respect, the proposed Adadile woreda water supply project provides potable water for existing and newly established settlements in the project area. With the drinking and availability of safe water supply system, a number of other direct and project induced indirect benefits will be resulted. Improved water supply will positively improve the health condition of the communities through better individual and household hygiene and will enhance the living standard of the population. The overall environmental analysis of the project indicated significant positive impacts and hence implementing the proposed project is no time task.

However, the proposed water supply project also result in some unwanted impacts as described in the previous section and the following are recommended with this respect: -

- Ensure public consultation and participation in all phases
- Implementation of mitigation timely and adequately
- Establish appropriate organization and provide training on major environmental issues related to construction and operation of the water supply project.
- Ensure integrated work among relevant institutions
- Location of intake structure should have to the upstream Gode town

Given these points, the potential positive impacts of the project outplay or outbalance its negative counterparts and hence it sounds feasible that this project is environmentally friendly. Furthermore, the negative impacts are bearable and can be mitigated as plainly shown above.

10.PRELIMINART ENGINEERING COST ESTIMATE

10.1. Unit Rates

Unit rate analysis from up to date material, labour and equipment costs is the basis to arrive at a reasonable estimate of investment costs of a water supply project components. In order to develop a cost estimate for a project, factors that affect the costs such as implementation time, existing infrastructure facilities, cost of labour and the location of the project area have to be considered.

The unit costs are developed based on recent contracts of similar nature and ongoing projects carried out by MoWE and others, supplemented by quotations from various local and overseas manufacturers and suppliers. These unit costs are developed mainly for the purpose of estimating the investment costs of the proposed water supply scheme.

10.2. Investment Cost

10.2.1. Alternative-1

By considering collecting 90.62l/s maximum day demand for Adadile town and surrounding village diverted using intake structure to treatment plant.Clear water collected in to 2000m^3 and distributed through pipe for each kebeles. Based on this assumption the overall cost of the project including VAT and contingency is found to be **BIRR 1,133,187,015.28** which is economically impossible to implement the project in one phase. Therefore, the consultant proposes the implementation of the project in a different cluster in short, medium and long term.

Table 10-1: Over all project cost of Adadile woreda

S/no	**List of kebele**	**Intervention period in cluster**	Amount	
			Cost Summary Each Cluster (Birr) Including VAT	Total Amount (Birr) Including VAT
1	Bohlagere	**Short term cluster**	327,838,514.09	390453099.37
2	Higlo		62,614,585.29	
	Sub -Total		**390,453,099.37**	**390,453,099.37**
3	Malkasala	**Medium Term Cluster**	108,559,436.00	
4	Todop		234,878,186.47	
5	Marodile		156,149,291.73	
6	Dhafdhafey		12,369,321.33	
7	Harsog		2,861,905.86	
8	Dabafayid		35,555,395.82	
9	Bursaredo		67,188,145.20	
	Sub -Total		**617,561,682.41**	**617561682.41**
10	Geebal	**Long term Cluster**	17,372,362.76	
11	Jerrey		82,890,937.04	
12	Hilogududo		6,414,411.92	
13	Biyolo		9432237.76	

14	Sigole		3268277.91	
15	Wardid		5794006.11	
	Sub -Total		**125,172,233.50**	**125,172,233.50**
	Total		**1,133,187,015.28**	**1,133,187,015.28**

The estimated construction costs are increased to allow maintenance of the existing system, contingencies; and consultancy and capacity building service.

10.2.2. Alternative-2

Considering to satisfay the clustered kebele in medium and long term, but the construction of treatmet plant, intake, booster and collector reservoir 2000m^3 in short term cluster the cost is about 390,453,099.37 birr.This alternative also not feasible based on client budget of 4.2 million dolar.

10.2.3. Alternative-3

By considering collecting 12.95/s maximum day demand for Adadile town and surrounding village Higlo kebele diverted using intake structure to treatment plant.Clear water collected in to elvated 200m^3 at Higlo booster station and boosted to Adadile town 200m^3 ground service reservoir and distributed through pipe for each water points. Based on this assumption to satisfay short term cluster the overall cost of the project including VAT and contingency is found to be **BIRR 191,815,997.30** which is economically possible to implement the project in one phase. Therefore, the consultant proposes the implementation of the project in a single phase for short term cluster by considering abstruction raw water 12.95l/s.

Table 10-2: Estimated Cost summary for Proposed source for only short term

DESCRIPTION	CONTRACT Total (Birr)
PART-I: CIVIL WORK	62,672,928.02
PART-II: SUPPLY & INSTALLATION OF PIPES & FITTINGS	38,216,045.58
PART-III: SUPPLY & INSTALLATION OF ELECTROMECHANICAL	57,964,854.40
TOTAL	158,853,828.00
ESIA 1%	1,588,538.28
Consultancy 2%	3,177,076.56
Contengency 2%	3,177,076.56
Summary	166,796,519.40
VAT 15 %	25,019,477.91
Grand Total Civil Work Cost (Birr)	191,815,997.30

11.CONCLUSION AND RECOMMENDATION

Feasibility phase study is started by data collection from all possible sources followed by review of the documents (deskwork) and reconnaissance field surveys. The office works included collection and review of different reports, policy documents, maps and imageries of the area. Short field visit was the activity undertaken after review of previous works to get general overview and condition of the study area through observations, discussions and interview with key stakeholders.

According to population and housing census (CSA, 2007), the projected population of the woreda for the base year 2022 is 9,131and the rural population is 107,740. As per the woreda administration the current population of the Adadile Town and rural kebeles is 21,040 and 102,097 respectively. Population data collected from woreda administration and CSA on rural population almost similar. But population number for the town note match. The consultant decided to relay on the CSA data for the study. Hence, base population fixed to 116,871 at 2022 and projected population in design period 2033 for urban and rural of woreda population is 133,749. If the project will be implemented, system could have been functional starting from 2024 GC.

Adadile Town existing water supply source which is currently not functional. But the town current supply using water truck from Gode town water supply system. Only Wabi shebele river is the source of water for the study area.

The Danot and its surrounding kebeles have experiences of long time drought. The area experience high temperatures during the months of April to March and lower temperatures during the months of July to October. Accordingly, it has a maximum daily temperature of 34.6^{0}C and the average minimum temperature of 30^{o}C.

The system design in this phase by assuming the surface water from shabele river location pressure pipe line HDPE OD 110 up to 160mm, length 17802m and distribution pipe line HDPE OD 55 up to 250mm, length of 12466m estimated.

As far as the economic activities carried out and around Adadile town concerned, most of the households are pastoralist and agro-pastoralist experienced with Animal breeding, trade and mixed farming as their main livelihood strategy and income generating means which is the base for determining the economic condition of the residents.

Finally, the following recommendations are forwarded:

(a) Timely approval of this feasibility reports up on which the two parties will agree on next assignment is required
(b) Necessary facilitations during the assignment are needed.
(c) The project area is much undeveloped district. The supply of water for domestic use and livestock consumption very high and not economical if it included. Construction and rehabilitation pond the shall be accessed for life stoke.
(d) From feasibility preliminary site visit and collected data analysis we have learnt that there is no sustainable and reliable surface water source in the woreda. The area is very drought prone and characterized by very low precipitation. Hence the consultant recommends the best and climate resilient water source option for the district is highly like the groundwater source but due to the quality problem ground water source is not recommended. As result, the consultant propose shabele river as source.
(e) The project shall be prioritized for short term cluster, similar for medium and long term accordingly.
(f) The consultant recommend the formulation of project for only Adadile town and nearby Higlo kebele.

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ANNEXES:

nnex 3 Hydraulic Pipe Inventary Report proposed Alternative-3

Hydraulic Model Inventory: Adadile WSP.wtg

Title	
Engineer	
Company	
Date	10/31/2022
Notes	

Scenario Summary

ID	1837
Label	Scenario - Source for only short term
Notes	
Active Topology	Active Topology Source is for only short term
Physical	Physical Alternative-Source for only short Term
Demand	Demand Alternative- source only for short term
Initial Settings	Base Initial Settings
Operational	Base Operational
Age	Base Age
Constituent	Base Constituent
Trace	Base Trace
Fire Flow	Base Fire Flow
Energy Cost	Base Energy Cost
Transient	Base Transient
Pressure Dependent Demand	Base Pressure Dependent Demand
Failure History	Base Failure History
SCADA	Base SCADA
User Data Extensions	Base User Data Extensions
Steady State/EPS Solver Calculation Options	Base Calculation Options
Transient Solver Calculation Options	Base Calculation Options

Network Inventory

Pipes	63	-Standard Extended	0
Laterals	0	<None>	8
Junctions	56	-Constant Speed - Four-Quadrant Characteristics	2
Hydrants	0	-Constant Speed - Pump Definition	0
Tanks	2	-Shut Down After Time Delay	0
-Circular	2	-Variable Speed/Torque	0
-Non-Circular	0	-Pump Start - Variable Speed/Torque	0
-Variable Area	0	Pump Stations	0
Reservoirs	1	Variable Speed Pump Batteries	0
Customer Meters	0	PRV's	0
Taps	0	PSV's	0
SCADA Elements	0	PBV's	0
Pumps	2	FCV's	0
-Constant Power	0	TCV's	0
-Custom Extended	0	GPV's	0
-Design Point (1 Point)	2	Isolation Valves	8
-Multiple Point	0	Spot Elevations	0
-Standard (3 Point)	0		

Transient Network Inventory

Turbines	0	Rupture Disks	0
Periodic Head-Flows	0	Discharges to Atmosphere	0
Air Valves	0	Orifices Between Pipes	0
Hydropneumatic Tanks	0	Valves With Linear Area Change	0
Surge Valves	0	Surge Tanks	0
Check Valves	0		

Pressure Pipes Inventory

44.0 (mm)	5,740 m	100.0 (mm)	22 m
55.4 (mm)	1,578 m	110.2 (mm)	1,828 m
66.0 (mm)	209 m	136.4 (mm)	7,169 m
79.2 (mm)	1,437 m	198.2 (mm)	649 m
80.0 (mm)	12 m	220.4 (mm)	432 m
93.8 (mm)	9,786 m	All Diameters	28,863 m

Adadile WSP.wtg
12/15/2022

Bentley Systems, Inc. Haestad Methods Solution Center
27 Siemon Company Drive Suite 200 W
Watertown, CT 06795 USA +1-203-755-1666

WaterGEMS
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Annex 4: Collector, Pressure And Transmission Main Junction

Label	X (m)	Y (m)	Elevation (m)	Hydraulic Grade (m)	Pressure (m H2O)
J-385	336,723.87	650,041.28	285.5	308.31	22.76
J-384	336,567.56	651,470.63	281.51	318.83	37.25
J-383	336,511.06	652,534.70	287.39	326.64	39.16
J-392	336,309.44	642,453.84	278.86	329.26	50.3
J-382	336,375.60	653,973.60	283.74	337.22	53.37
J-381	336,292.94	655,631.62	280.77	349.37	68.46
J-380	336,197.49	656,398.16	285.19	355.03	69.7
J-391	336,250.11	644,490.27	274.12	352.89	78.61
J-390	336,492.67	647,115.28	275.5	383.47	107.75
J-389	336,737.88	648,646.61	275.36	401.45	125.84

Annex 5: Distribution Network Junction Report

A-Maximum Demand

Label	X (m)	Y (m)	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
J-285	336,686.31	640,496.55	285.67			
EWP_7	338,222.76	640,726.83	283.73	2.08	287.09	3.36
J-236	338,769.44	640,941.31	278.87	1	282.96	4.09
J-241	338,315.27	640,709.53	283.71	0	288.43	4.7
NWP-2	337,142.72	641,740.45	281.64	1.38	288.1	6.45
J-242	338,289.57	640,614.45	284.43	0	290.95	6.51
EWP_2	336,718.05	641,153.80	284.02	1.08	290.81	6.78
J-254	337,554.09	640,260.57	284.55	0.5	291.35	6.79
EWP_3	337,351.83	641,129.83	282.25	1.08	289.27	7

J-240	338,424.96	640,897.98	279.88	0	287.04	7.15
J-247	337,070.92	641,616.85	283.69	0	291.01	7.31
J-265	338,166.80	641,409.68	279.04	1.3	286.57	7.51
EWP_1	337,295.64	640,891.76	287.65	2.08	295.52	7.85
EWP_4	337,045.66	641,314.43	282.33	1.08	290.33	7.99
J-227	337,230.45	640,997.09	288.23	0	296.27	8.03
J-235	338,486.75	641,012.14	278.16	0.3	286.23	8.06
J-259	337,405.22	641,099.31	281.87	0	290.06	8.17
J-244	338,070.17	640,267.35	283.76	0	292.73	8.95
J-264	337,923.16	641,445.13	279.1	0	288.09	8.97
EWP_6	338,037.40	640,281.01	283.21	2.08	292.23	9
J-226	337,244.70	640,914.36	288.68	0	297.95	9.25
J-234	337,836.39	641,258.21	279.64	0	289.02	9.37
EWP_5	337,221.78	640,564.47	286.4	1.08	295.93	9.51
J-261	337,660.23	641,788.65	276.89	0	286.56	9.66
J-346	336,845.16	641,299.38	283.62	2.08	293.31	9.67
J-252	337,406.53	640,883.87	285.65	0	295.35	9.68
J-268	336,915.33	640,357.00	288.98	0	298.75	9.76
J-256	337,958.00	640,590.29	281.54	0.52	291.45	9.89
J-253	337,570.65	640,769.31	282.52	0	292.94	10.39
J-263	337,736.31	641,758.55	276.12	0.02	286.56	10.42
J-225	337,097.86	640,684.16	287.45	0	298.26	10.79
J-257	337,451.80	641,205.59	280.75	0	291.58	10.81
J-262	337,755.59	641,974.10	274.25	1.3	285.32	11.05
NWP_1	337,694.92	641,432.49	278.77	2.08	290.84	12.05
J-260	337,581.21	641,609.19	278.16	0	290.24	12.05
Higlo	336,888.84	649,595.84	289.22	8.8	301.81	12.57

J-255	337,729.57	640,719.63	279.4	0	292.33	12.9
J-248	336,866.26	641,717.88	277.97	0.02	291.01	13.01
J-267	337,762.05	640,802.21	279.13	0.02	292.33	13.17
J-233	337,650.83	641,347.60	278.93	0	292.2	13.24
J-232	337,576.35	641,379.66	278.81	0	292.49	13.65
J-228	337,341.96	641,316.86	280.43	0	294.17	13.71
J-245	337,966.20	640,011.15	282.2	0	296.08	13.85
J-231	337,502.33	641,411.56	278.71	0	293.06	14.32
J-229	337,390.48	641,459.92	278.69	0	293.44	14.72
J-230	337,434.46	641,548.39	278.28	0.02	293.44	15.12
J-251	336,708.83	641,435.27	276.59	0.2	293.2	16.58

B-Minimum Demand

Label	X (m)	Y (m)	Elevation (m)	Demand (L/s)	Hydraulic Grade (m)	Pressure (m H2O)
J-285	336,686.31	640,496.55	285.67			
J-268	336,915.33	640,357.00	288.98	0	299.3	10.3
J-226	337,244.70	640,914.36	288.68	0	299.3	10.6
J-227	337,230.45	640,997.09	288.23	0	299.3	11.05
EWP_1	337,295.64	640,891.76	287.65	0	299.3	11.62
J-225	337,097.86	640,684.16	287.45	0	299.3	11.83
EWP_5	337,221.78	640,564.47	286.4	0	299.3	12.87
J-252	337,406.53	640,883.87	285.65	0	299.3	13.63
J-254	337,554.09	640,260.57	284.55	0	299.3	14.72
J-242	338,289.57	640,614.45	284.43	0	299.3	14.84
EWP_2	336,718.05	641,153.80	284.02	0	299.3	15.25
J-244	338,070.17	640,267.35	283.76	0	299.3	15.51

EWP_7	338,222.76	640,726.83	283.73	0	299.3	15.54
J-241	338,315.27	640,709.53	283.71	0	299.3	15.55
J-247	337,070.92	641,616.85	283.69	0	299.3	15.58
J-346	336,845.16	641,299.38	283.62	0	299.3	15.65
EWP_6	338,037.40	640,281.01	283.21	0	299.3	16.05
J-253	337,570.65	640,769.31	282.52	0	299.3	16.74
EWP_4	337,045.66	641,314.43	282.33	0	299.3	16.94
EWP_3	337,351.83	641,129.83	282.25	0	299.3	17.01
J-245	337,966.20	640,011.15	282.2	0	299.3	17.06
J-259	337,405.22	641,099.31	281.87	0	299.3	17.39
NWP-2	337,142.72	641,740.45	281.64	0	299.3	17.63
J-256	337,958.00	640,590.29	281.54	0	299.3	17.72
J-257	337,451.80	641,205.59	280.75	0	299.3	18.51
J-228	337,341.96	641,316.86	280.43	0	299.3	18.83
J-240	338,424.96	640,897.98	279.88	0	299.3	19.38
J-234	337,836.39	641,258.21	279.64	0	299.3	19.62
J-255	337,729.57	640,719.63	279.4	0	299.3	19.86
J-267	337,762.05	640,802.21	279.13	0	299.3	20.13
J-264	337,923.16	641,445.13	279.1	0	299.3	20.16
J-265	338,166.80	641,409.68	279.04	0	299.3	20.22
J-233	337,650.83	641,347.60	278.93	0	299.3	20.33
J-236	338,769.44	640,941.31	278.87	0	299.3	20.39
J-232	337,576.35	641,379.66	278.81	0	299.3	20.45
NWP_1	337,694.92	641,432.49	278.77	0	299.3	20.49
J-231	337,502.33	641,411.56	278.71	0	299.3	20.55
J-229	337,390.48	641,459.92	278.69	0	299.3	20.57
J-230	337,434.46	641,548.39	278.28	0	299.3	20.97

J-260	337,581.21	641,609.19	278.16	0	299.3	21.1
J-235	338,486.75	641,012.14	278.16	0	299.3	21.1
J-248	336,866.26	641,717.88	277.97	0	299.3	21.28
J-261	337,660.23	641,788.65	276.89	0	299.3	22.37
J-251	336,708.83	641,435.27	276.59	0	299.3	22.66
J-263	337,736.31	641,758.55	276.12	0	299.3	23.14
J-262	337,755.59	641,974.10	274.25	0	299.3	25

Annex 6 Collector, Pressure and Transmission Main Pipe Report

Stop Node	Diameter (mm) Internal	Material	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss Gradient (m/km)	Pipe_Field_1
PMP-12	80	GS	130	7.46	1.48	32.821	
J-390	93.8	HDPE	150	7.46	1.08	11.599	ATL
J-391	93.8	HDPE	150	7.46	1.08	11.599	ATL
J-392	93.8	HDPE	150	7.46	1.08	11.599	ATL
Adadile 200m3 Tank	93.8	HDPE	150	7.46	1.08	11.599	ATL
J-389	93.8	HDPE	150	7.46	1.08	11.599	ATL
PMP-11	100	GS	130	15.58	1.98	43.293	
J-380	136.4	HDPE	150	15.58	1.07	7.322	ARM
J-381	136.4	HDPE	150	15.58	1.07	7.322	ARM
J-382	136.4	HDPE	150	15.58	1.07	7.322	ARM
J-383	136.4	HDPE	150	15.58	1.07	7.322	ARM
J-384	136.4	HDPE	150	15.58	1.07	7.322	ARM
J-385	136.4	HDPE	150	15.58	1.07	7.322	ARM
T-26	136.4	HDPE	150	15.58	1.07	7.322	ARM

Annex 7.Distribution Network Pipe Report

Label	Length (Scaled) (m)	Start Node	Stop Node	Diameter (mm)	Material	Hazen-Williams C	Flow (L/s)	Velocity (m/s)	Headloss (Friction) (m)	Pipe_Field_1
P-21	99	J-229	J-230	44	HDPE	150	0.02	0.01	0	Short Ter. DL
P-29	206	J-233	J-234	44	HDPE	150	1.19	0.78	3.18	Short Ter. DL
P-31	697	J-234	J-235	44	HDPE	150	0.57	0.38	2.79	Short Ter. DL
P-33	292	J-235	J-236	44	HDPE	150	1	0.66	3.27	Short Ter. DL
P-36	130	J-235	J-240	44	HDPE	150	-0.73	0.48	0.81	Short Ter. DL
P-37	223	J-240	J-241	44	HDPE	150	-0.73	0.48	1.38	Short Ter. DL
P-42	228	J-247	J-248	44	HDPE	150	0.02	0.01	0	Short Ter. DL
P-43	143	J-247	NWP-2	44	HDPE	150	1.38	0.91	2.91	Short Ter. DL
P-49	200	J-252	J-253	44	HDPE	150	1.04	0.68	2.41	Short Ter. DL
P-51	509	J-253	J-254	44	HDPE	150	0.5	0.33	1.58	Short Ter. DL
P-53	169	J-253	J-255	44	HDPE	150	0.54	0.36	0.61	Short Ter. DL
P-55	263	J-255	J-256	44	HDPE	150	0.52	0.34	0.88	Short Ter. DL
P-57	524	J-252	J-233	44	HDPE	150	0.71	0.47	3.15	Short Ter. DL
P-62	118	J-257	J-259	44	HDPE	150	1.08	0.71	1.52	Short Ter. DL
P-68	196	J-260	J-261	44	HDPE	150	1.32	0.87	3.68	Short Ter. DL
P-72	82	J-261	J-263	44	HDPE	150	0.02	0.01	0	Short Ter. DL
P-75	386	J-260	J-264	44	HDPE	150	0.69	0.45	2.15	Short Ter. DL
P-77	206	J-264	J-234	44	HDPE	150	-0.61	0.4	0.94	Short Ter. DL
P-83	89	J-255	J-267	44	HDPE	150	0.02	0.01	0	Short Ter. DL
P-123	56	J-226	EWP_1	44	HDPE	150	2.08	1.37	2.43	Short Ter. DL
P-126	61	J-259	EWP_3	44	HDPE	150	1.08	0.71	0.8	Short Ter. DL
P-130	180	J-225	EWP_5	44	HDPE	150	1.08	0.71	2.33	Short Ter. DL

P-136	296	EWP_4	J-228	44	HDPE	150	-1.08	0.71	3.83	Short Ter. DL
P-112	192	J-346	J-251	44	HDPE	150	0.2	0.13	0.11	Short Ter. DL
P-141	193	J-346	EWP_2	44	HDPE	150	1.08	0.71	2.5	Short Ter. DL
P-38	102	J-241	J-242	55.4	HDPE	150	-2.81	1.16	2.52	Short Ter. DL
P-59	216	J-232	J-257	55.4	HDPE	150	1.08	0.45	0.91	Short Ter. DL
P-66	213	J-231	J-260	55.4	HDPE	150	2.01	0.83	2.82	Short Ter. DL
P-70	209	J-261	J-262	55.4	HDPE	150	1.3	0.54	1.24	Short Ter. DL
P-79	256	J-264	J-265	55.4	HDPE	150	1.3	0.54	1.52	Short Ter. DL
P-81	96	J-233	NWP_1	55.4	HDPE	150	2.08	0.86	1.36	Short Ter. DL
P-114	356	J-229	J-247	55.4	HDPE	150	1.4	0.58	2.43	Short Ter. DL
P-128	94	J-241	EWP_7	55.4	HDPE	150	2.08	0.86	1.33	Short Ter. DL
P-131	36	J-244	EWP_6	55.4	HDPE	150	2.08	0.86	0.5	Short Ter. DL
P-47	209	J-227	J-252	66	HDPE	150	1.75	0.51	0.92	Short Ter. DL
P-25	81	J-231	J-232	79.2	HDPE	150	3.63	0.74	0.56	Short Ter. DL
P-27	81	J-232	J-233	79.2	HDPE	150	2.55	0.52	0.29	Short Ter. DL
P-39	411	J-242	J-244	79.2	HDPE	150	-2.81	0.57	1.78	Short Ter. DL
P-40	277	J-244	J-245	79.2	HDPE	150	-4.89	0.99	3.35	Short Ter. DL
P-111	490	J-227	J-346	79.2	HDPE	150	3.36	0.68	2.96	Short Ter. DL
P-191	96	T-26	Higlo	79.2	HDPE	150	8.8	1.79	3.47	
P-15	109	J-226	J-227	110.2	HDPE	150	13.25	1.39	1.68	Short Ter. DL
P-17	339	J-227	J-228	110.2	HDPE	150	8.14	0.85	2.11	Short Ter. DL
P-19	152	J-228	J-229	110.2	HDPE	150	7.06	0.74	0.73	Short Ter. DL
P-23	122	J-229	J-231	110.2	HDPE	150	5.64	0.59	0.38	Short Ter. DL
P-201	1,106	J-268	J-245	110.2	HDPE	150	4.89	0.51	2.68	
P-143	39	PRV-2	J-268	198.2	HDPE	150				Short Ter. DL
P-13	273	J-225	J-226	198.2	HDPE	150	15.33	0.5	0.31	Short Ter. DL
P-85	376	J-225	J-268	198.2	HDPE	150	-16.41	0.53	0.49	Short Ter. DL

P-87	432	J-268	Adadile 200m3 Tank	220.4	HDPE	150	-21.3	0.56	0.55	Short Ter. DL
P-142	230	J-285	PRV-2	220.4	HDPE	150				Short Ter. DL
P-187	28	Tank-12 (Adadile Existing 200m3)	J-225	277.6	HDPE	150				Short Ter. DL

Annex 8:Stakeholders contract

Stakeholders Contact Address

No	Staff Name	Sector/Bureau	Title	Tele	Date
1	Mohamud Abdullahi	Somali Water Bureau	WaSH Program Coordinator	929294174	30/03/2022
2	Tariku Tefera	Somali Water Bureau	Engineer	910001068	30/03/2023
3	Kedir Badi	Somali Water Bureau	Surveyor	915051568	30/03/2024
4	Ahmadi Ali	Somali Water Bureau	Procurement Engineer	939458741	30/03/2025
1	Ali Abdi Abdille	Shebelle Zone Adminstration	Vice Administrator	909315631	31/03/2022
2	Kamil Husein	Shebelle Zone	Water focal Person	915060842	31/03/2023
3	Suleiman Yusuf	Shebelle Zone	Interpreter	913453802	31/03/2024
1	Hussein Abdi Digole	Adadle District Administration	Chief Administrator	926743429	1/4/2022
2	Ahmed Maahin Ismael	Adadle District Livestock Office	Acting Office head	915114761	1/4/2022
3	Ahmed Ibrahim Hasen	Adadle District Water Office	Acting Office head	915650374	1/4/2022
4	Farah Mohamed Muhumed	Adadle District Women Affair Office	Acting Office head	915233361	1/4/2022
5	Alan Ali Lohane	Adadle Disttrict Crop and Natural Resource Dev't office	Acting Office head	906912136	1/4/2022
6	Halane Wali Ali	Adadle DistrictHealth Office	Acting Head	921240456	1/4/2022

Annex 9.Stake Holders Discussion Minutes

MoM (Discussion with Regional WaSh Coordination Staff) ①
March 30, 2022

Wash staff (Regional)

1. [illegible] (WaSh Coordinator)
2. [illegible]
3. [illegible]
4. [illegible]

Consultant Staff

5. [illegible]
6. [illegible]
7. [illegible]

*- [illegible]

-> Secondary data [illegible]

-> [illegible] stakeholder [illegible]

-> [illegible] Existing Water Supply, population, etc data [illegible]

-> [illegible]

1-

②

* - [illegible]
- · Hydrological data
- · Regional Water coverage data
- · Potential water source

- [illegible]

* [illegible]
- A previous project / River intake for Adadle has failed. the reason is not clear.
- Denan is a difficult area. (Tariku know better)

* [illegible]

Adadle - Water source 2 existing water supply is Shebele river intake 17 km from town. Treatment plant not functional as ~~problem~~ destroyed by the river. Not functional for about 5 yrs. The treatment system was unconvisional.
- We propose to go in there and visit
- there are also problem related to intake structure & rising main.. There are major problem areas.

Regarding Denan
- source is underground water, 20+ km from town. Not functional at present.
- This time they are using water trucking -2-

* 4f hwros / Wash Head
- The problem with ground water is it is salty around Adadle
- For Adadle the best solution is river water
- For Delan, there are around 5 BHs but we don't have detail information

* 2f hwros
- Currently Adadle is not working due to intake structure problem
- Relocation of intake site is needed
- Treatment plant system is Slow Sand Filter. Not appropriate & suitable. It also needs change.
- The best source we propose is river
- Regarding Delan
  - → there are 2 BHs. Quality R quantity not good. But currently it is working, but not adequate. Human & Livestock ~~cattle~~ population is very high.
  - → Construction of a Multi Village WS Project was stalled some 7 yrs ago due to budget. You should visit it.

(4)

- the data can be found from Somali Design & Supervision.

⇒ They agreed to write support letter to the woredas.

→ The local officials & the population in project areas are eagerly waiting for the study team & they will make all the support you need.

→ They suggest one person from the client/ministry to accompany us during field visits (next time)

[signatures]

-4-