MINISTRY OF WATER & ENERGY (MoWE)
THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
SOMALI REGIONAL WATER RESOURCES DEVELOPMENT BUREAU

THE STUDY ON JARAR VALLEY AND SHEBELE SUB-BASIN WATER SUPPLY DEVELOPMENT PLAN, AND EMERGENCY WATER SUPPLY IN THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

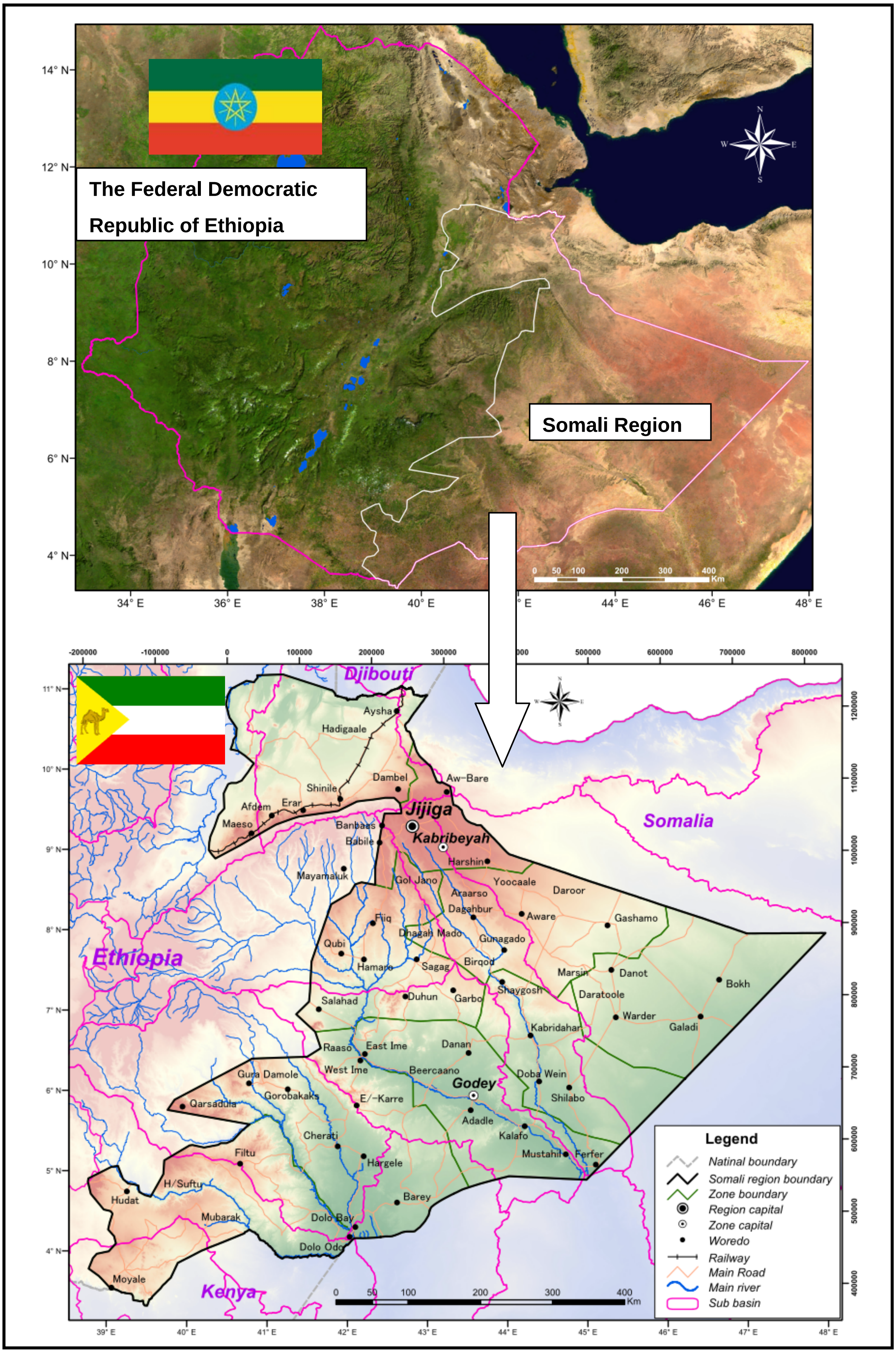
FINAL REPORT (3/7)

VOLUME 2

WATER SUPPLY PLAN

August 2013

Japan International Cooperation Agency (JICA)
Kokusai Kogyo Co., Ltd.



Location Map of Study Area

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Abbreviations

ABE	Alternative Basic Education
ARRA	Administration for Refugee and Returnee Affairs
BoFED	Bureau of Finance and Economic Development
BPR	Business Process Reengineering
CGIAR	Consultative Group on International Agricultural Research
CSA	Central Statistical Agency
CSE	The Conservation Strategy of Ethiopia
COD	Chemical Oxygen Demand
C/P	Counterpart (organization or personnel)
DFID	Department for International Development
DF/R	Draft Final Report
DTH	Down the Hole Hammer
DPPB	Disaster Prevention and Preparedness Bureau
EC	Electric Conductivity
EIA	Environmental Impact Assessment
EPA	The Environmental Protection Authority
EPC	The Environmental Protection Council
ESA	European Space Agency
ESIA	Environmental and Social Impact Assessment Unit
EU	European Union
EU-WATCH	Water and Global Change (WATCH) program funded by the European Union
EWTEC	Ethiopia Water Technology Center
FAO	Food and Agriculture Organization of the United Nations
F/R	Final Report
F/S	Feasibility Study
GEM	Global Environment Monitoring
GIS	Geographical Information System
GLCF	Global Land Cover Facility
GLG	Grass Land GIS
GMT	Greenwich Mean Time
GSE	Geological Survey of Ethiopia
GPS	Global Positioning System
GUPE map	Groundwater Utilization Potential Evaluation map
IC/R	Inception Report
IEE	Initial Environmental Examination
IRC	International Rescue Committee
ISCGM	International Steering Committee for Global Mapping
IT/R	Interim Report
JICA	Japan International Cooperation Agency
JSS	JAXA Supercomputer System
JWSO	Jijiga Water Supply Office
MODIS	MODIS Land Cover Product by using Moderate resolution Imaging Spector radiometer of Earth-Observing-System EOS
MoFED	Ministry of Finance and Economic Development
MoWR	Ministry of Water Resources
MoWE	Ministry of Water and Energy
MrSID	Multi-resolution Seamless Image Database
NFE	Non Formal Education
NGO	Non-Governmental Organization
NMA	(Addis Ababa) National Meteorology Agency
NOAA	National Oceanic and Atmospheric Administration

NRCS	Natural Resources Conservation Service, United States Department of Agriculture
O&M	Operation and Maintenance
OJT	On the Job Training
P/R	Progress Report
PA	Preliminary environmental assessment study
PALSAR	Phased Arrayed L-type Synthetic Aperture Radar
R/D	Record of Discussion
REA	Regional Environmental Agencies
RGSR	Regional Government of Somali Region
RWBs	Regional Water Bureaus
SAGE	Center for Sustainability And the Global Environment at the University of Wisconsin Madison
SEDAC	Socioeconomic Data and Applications Center
SEPMEDA	Somali Regional State Environmental Protection, Mine and Energy Development Agency
SHAAC	Shaac Consulting Engineers
SRTM	Shuttle Radar Topography Mission
SRWDB	Somali Regional Water Resources Development Bureau
SWWCE	Somali Water Works and Construction Enterprise
TDM	Time Domain Method
TEM	Transient（or Time-domain）Electromagnetic Method
TOT	Training of Trainers
TVETC	Technical and Vocational Education and Training College
UAP	Universal Access Program
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNHCR	United Nations High Commissioner for Refugees
UNICEF	United Nations Children’s Fund
USDA	United States Department of Agriculture
USAID	United States Agency for International Development
USGS	United States Geological Survey
UTM	Universal Transversal Mercator
VES	Vertical Electrical Sounding
WASH	Water Supply, Sanitation and Hygiene Programme
WASHCO	Water Supply and Health Committee
WATSANCO	Water, Sanitation & Hygiene Committee
WFP	World Food Programme
WLR	Water Level Recorder
WMO	World Meteorological Organization
WRI	World Resources Institute
WRIM	Water Resources Information Map
WSDP	Water Sector Development Program
WTP	Willingness to Pay

Chapter 1

Introduction

1 Introduction

1.1 The project

This report was prepared to present the results as of the end of July 2013 of the Study of "Jarar Valley and Shebele Sub-basin Water Supply Development Plan, and Emergency Water Supply in the Federal Democratic Republic of Ethiopia (hereafter, the Study)" based on the results of the record of discussions (R/D) agreed and signed by the Federal Democratic Republic of Ethiopia and Japan International Cooperation Agency (JICA) on 23 December 2011. JICA organized a team of consultants (the Study Team) made up of 14 members (one member was added later) to conduct the Study. The Study started in March 2012 and is confirmed to end in August 2013. The work schedule is shown in Figure 1.1 below.

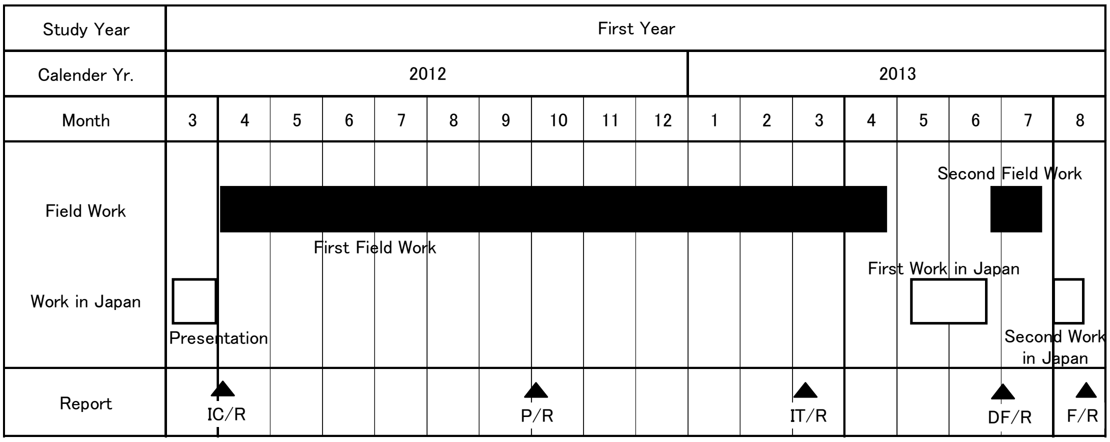


Figure 1.1: Outline of the Study Schedule

The first field work was carried out from April 2012 to April 2013, before starting the field work, the Study Team submitted the inception report (IC/R) and discussed its contents with Ethiopian side. After that, Minutes of Meeting (M/M) was exchanged between JICA and MoWE in consideration of the request of modification from the Ethiopian side (April 2012). The results of the Study were reported in the Progress Report (P/R) after seven months and the reporting in the stage of interim results was executed in the Interim Report (IT/R) five months after submitting the P/R. The contents of both reports were discussed with Ethiopian side at the steering committee, and M/M of P/R and IT/R was exchanged among JICA, Somali Regional State Water Resources Development Bureau (SRWDB) and Ministry of Water and Energy (MoWE) taking in the correction from the Ethiopian side (M/M of P/R: November 2012, M/N of IT/R: April 2013). After the first work in Japan, Draft Final Report (DF/R) was submitted to Ethiopian side at the end of June 2013 during the second field work, and M/M was exchanged between JICA and Ethiopian side after discussion of contents at the steering committee. After that, Ethiopian side carried out the final modifications, and finally JICA will submit the Final Report (F/R) to Ethiopian side by the middle of September 2013.

The study objectives are mainly to prepare a water supply plan based on the collection and analysis of the existing data, and the information of natural conditions and socio-economic situation data in the Jarar valley and Shebele sub-basin. Other important tasks are: the arrangement of a hydrogeological information system, construction works for emergency water supply focused on Kabribeyah and Godey towns and the rest of Somali region, and training to strengthen the ability of SRWDB and other relevant organizations.

The expected output and the activities of the Study are as follows;

(1) Expected outcome of the implementation of the Study

1) The potential of utilization of water resources in Jarar Valley and Shebele River watersheds will be evaluated.
2) The water supply plan for the Jarar Valley and Shebele River watersheds will be prepared.
3) The technical and organizational capacity of C/P personnel in water supply planning will be improved.
4) Water supply situation in Kabribeyah town will be improved
5) Feasibility study for the planned water supply facilities (system) will be conducted.
6) Situation of emergency water supply in Somali Region will be improved through the use of the water supply equipment and materials donated.

(2) Activities in the Study

In order to realize the outcomes stated above, the following activities will be conducted in this Study.

1) Confirmation of potential of water resources development through "water resources utilization potential survey,"
2) Proposition of concrete improvement plans for water supply systems by water supply planning, and
3) Improvement of current water supply condition by implementing emergency water supply projects
4) Capacity development of relevant staff through short-term technical training.

To sum up the above, the following Figure 1.2 illustrates the outline of this Study: the activities under (2) above were first conducted to realize the outcomes under (1) above by the end of the Study. The Ethiopian C/P organizations, then, were expected to realize the formulated water supply plan making the best of what they have learnt through short- to long-term training in order to achieve the future long-term goals in the Study that are stated under the outcomes.

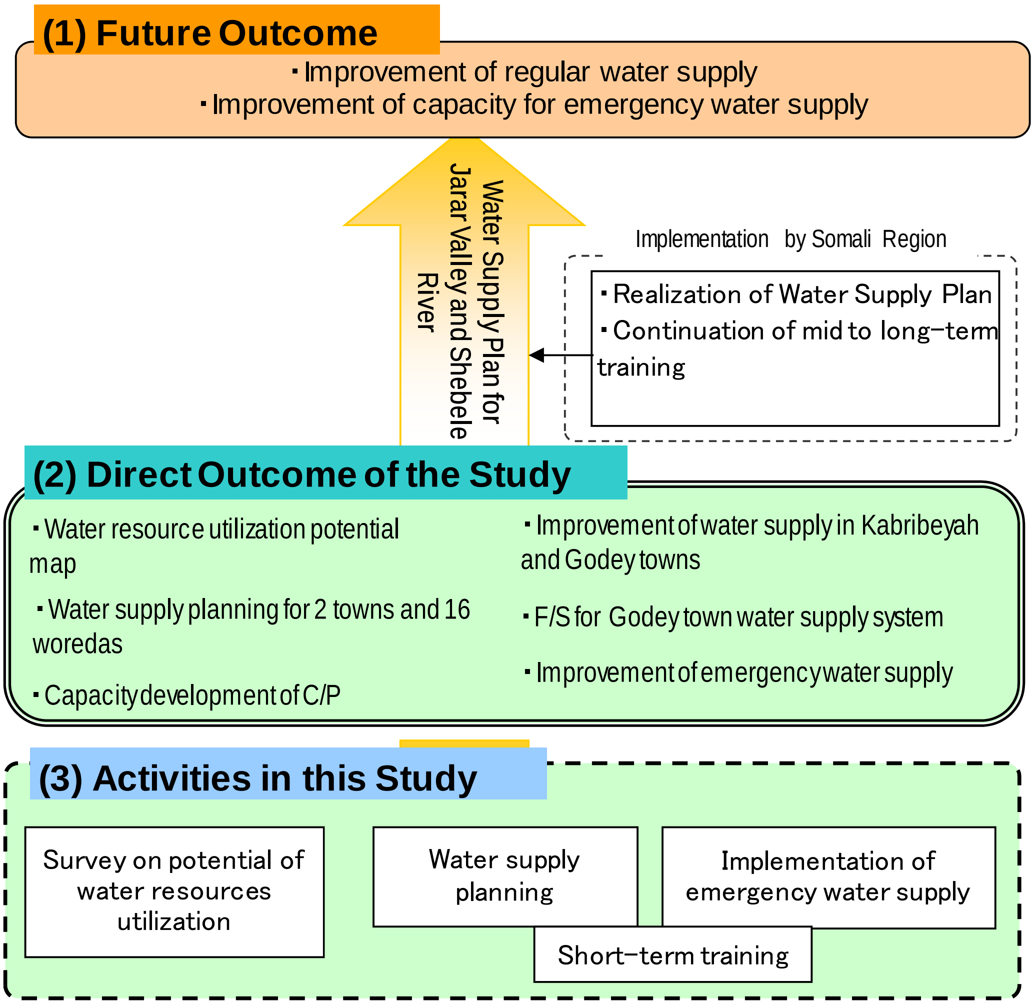


Figure 1.2: Flow of the Study (Project)

The target area differs depending on the work components of the Study: Emergency water supply works covers the whole region, water supply plan and water resources potential study target the sub-basins of Jarar Valley and Shebele River. Also pilot projects were conducted in Kabribeyah and Godey towns. These areas of project components and locations of the towns are indicated in Figure 1.3 below. The sixteen woredas and two main towns (Kabribeyah and Godey towns) were selected as the final target.

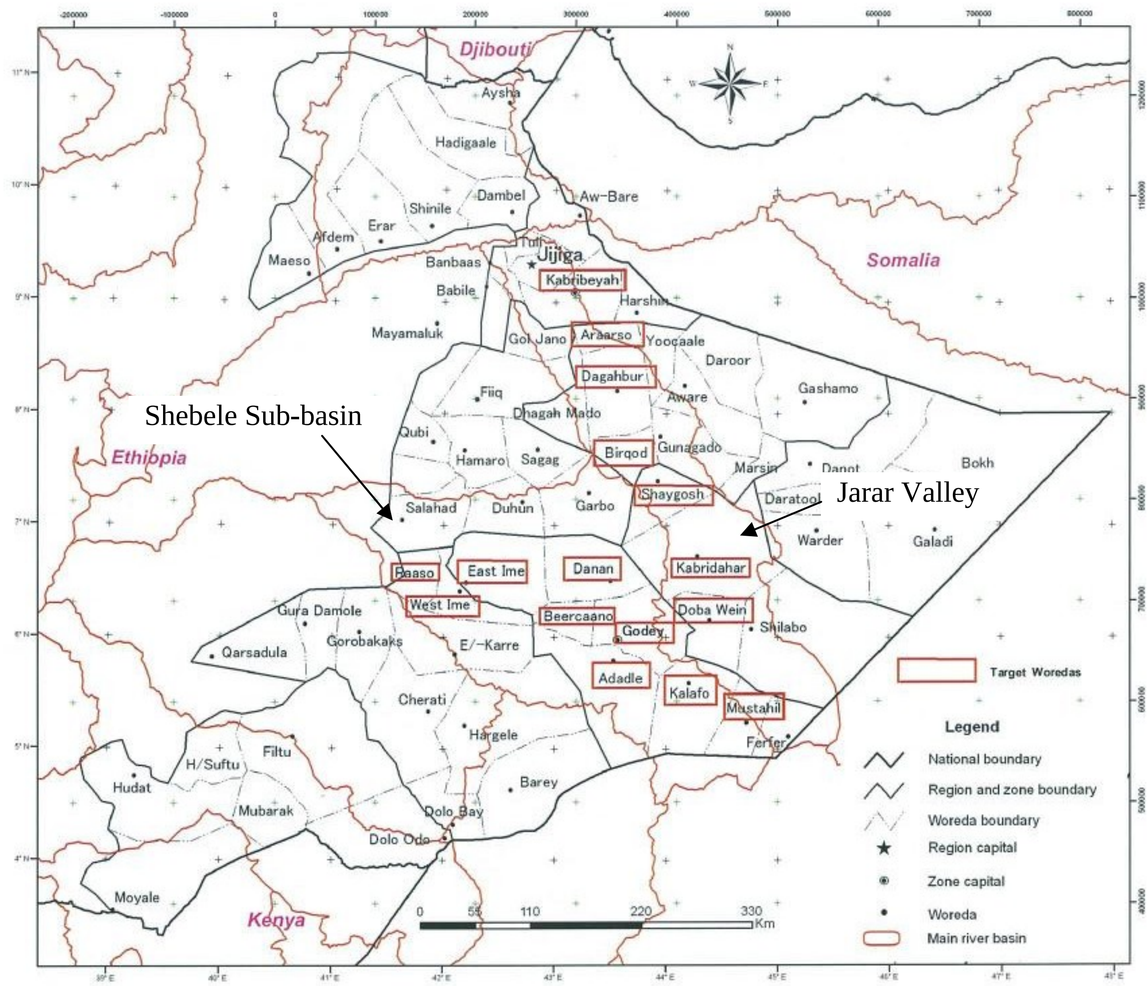


Figure 1.3: Study Area Map

The JICA Study Team was composed of fifteen (15) experts and each C/P was assigned to work exclusively with one of the Study Team members in this Study. The Study was executed through close collaboration between the Study Team and counterpart personnel (C/P) and others of Ethiopia. The R/D stipulated that a steering committee was to be established for the Study. There are many organizations concerned with this Study. Therefore, as a measure to assure good communication and information sharing with these organizations, a steering committee needed to be organized. The Study Team interacted with the Steering Committee when there were any important issues to discuss; making important decisions, sharing the progress of the Study, acceptance of various reports to be prepared in the course of the Study etc. in order to realize smooth implementation of the Study. The Steering Committee members were as follows;

<Chairman>

Director of Water Sector and Capacity Building Directorate, MoWE

<Members>

1) Representative of Ministry of Finance and Economic Development (MoFED)
2) Staff of Water Supply and Capacity Building Directorate, MoWE
3) Representative of ARRA
4) Head of SRWDB

5) Deputy Head of SRWDB in charge of Water Supply Core Process
6) Deputy Head of SRWDB in charge of Water Supply Management Core Process
7) Representative of Kabribeyah town water supply utility office
8) Representative of Godey town water supply utility office
9) Representative of DPPB
10) Representative of Jijiga sub office of UNHCR
11) Representative of Somali Regional State Environmental Protection, Mine and Energy Development Agency (SEPMEDA)
12) Representative of Bureau of Finance and Economic Development (BoFED)
13) Study Team
14) JICA Ethiopia Office

1.2 Report structure

The report structure in this time has been composed by the four activities in principal. However the results of the feasibility study in Godey town have been reported for one volume. The main items are as follows;

<Main Report>

Chapter 1 Study Summary

Chapter 2 In Relation to the Emergency and Long-Term Water Demand in Somali Region

Chapter 3 Operation and Maintenance of Water Supply Facilities

Chapter 4 Feasibility Study on Water Supply Plan

Chapter 5 Conclusions and Recommendations

<Volume 1 Survey on the Potential of Water Resources (Groundwater) Utilization>

Chapter 1 Introduction

Chapter 2 Meteorology and Hydrology

Chapter 3 Geology

Chapter 4 Hydrogeology

Chapter 5 Water Quality Analysis

Chapter 6 Groundwater Utilization Potential Evaluation Map

Chapter 7 Water Resources Information Map for Somali Region

Chapter 8 Conclusions

<Volume 2 Water Supply Plan>

Chapter 1 Introduction

Chapter 2 Basic date of Water Supply Plan

Chapter 3 Water Resources and Existing Water Supply Facilities

Chapter 4 Water Supply Plan, Cost Estimation and Implementation Plan of Each Woreda

Chapter 5 Water Supply Plan and General Design, Cost Estimation and Implementation Plan of Kabribeyah Town

Chapter 6 Water Supply Plan and General Design, Cost Estimation and Implementation Plan of Godey Town

Chapter 7 Conclusions

<Volume 3 Emergency Water Supply, Operation and Maintenance of Water Supply Facilities>

Chapter 1 Introduction

Chapter 2 Emergency Water Supply

Chapter 3 Operation and Maintenance of Water Supply Facilities

Chapter 4 Conclusions

<Feasibility Study on Water Supply Plan in Godey Town>

Chapter 1 Summary of Feasibility Study

Chapter 2 The Project Area

Chapter 3 Socio-Economic Survey

Chapter 4 Water Resources Study

Chapter 5 Population and Water Demand

Chapter 6 Existing Water Supply

Chapter 7 Water Supply Plan

Chapter 8 Cost Estimates

Chapter 9 Operation and Maintenance

Chapter 10 Environmental and Social Consideration

Chapter 11 Financial and Economical Evaluation

Chapter 12 Conclusions

1.3 Summary of Volume 2

This volume describes the proposed water supply plan for each woreda. Although, the water supply master plans were prepared for all urban and rural areas of the 16 woredas in Jarar Valley and Shebele River sub-basins, the pilot project of the water supply construction was implemented in Kabribeyah and Godey towns and the feasibility study was carried out for Godey town. Therefore, the water supply plans for the two towns are reported in more detail.

The basic data for water the supply plan was analyzed in Chapter 2. Taking into consideration the progress of the water supply access ratio in Somali Region and the design criteria in the revised UAP strategy, the target year of the water supply plan was set as the basic data. The population growth rate employed was estimated from the results of socio-economic survey, for both urban and rural areas. The water demand was determined by using the per capita water demand basically, and other water demands were also discussed in regard to the institutional and commercial water use, industrial water use, water for livestock, water for fire fighting, and water loss. The design water supply volume was determined to be the total water demand in 2020 minus 80% of the water demand to be attained in 2015 based on the projection of UAP access ratio of water supply. However, for the areas where river water is used, the water demand value for 2020 was adopted. The results of the pilot projects of Kabribeyah and Godey towns were regarded as one of the basic data in reference to the future implementation plan.

The discussion of water resources and the condition of existing facilities were described as the base of water supply plan in Chapter 3. The data from the socio-economic survey was used to grasp the condition of existing water supply systems. In the plan, it is recommended to develop deep borehole wells (deeper than 60m) in Jarar Valley area and to use river water as the priority source in Shebele River basin area. As for the size of birka and hafir dams, their standard design and sizes were employed and required numbers were determined based on the population of the users at one site.

Chapter 4 indicated the water supply plan for each woreda. The plan includes layout plans, and general designing of required facilities in rural and urban area of sixteen woredas; moreover, the implementation planning along with its cost estimation was carried out in accordance with the water supply plan. The entire period of the projects was planned to be seven years from 2014 to 2020. The main project cost is as follows;

Godey town 8,805,000USD (project term: 4 years), and Kabribeyah town 1,870,000USD (project term: 2 years). Rural area of woredas, minimum is 1,685,000USD in Birqod woreda, and the maximum is 14,664,000USD in Kabribeyah woreda (except urban area).

Chapter 5 and Chapter 6 present the water supply plans, project costs, the implementation plan, O&M plan of water supply facilities, and the results of economic-financial evaluation for Kabribeyah and Godey towns. However, the economic and financial evaluation of the project for Godey town is discussed in the volume of "feasibility study". The implementation plans indicated the distribution of work and cost required for each year to implement the projects. Also, the strategy of realization of the plans, especially securing budget was discussed under "planning of project budget".

Chapter 2

Basic Data of Water Supply Plan

2 Basic Data of Water Supply Plan

2.1 Target year and estimated population

2.1.1 National policy (water sector)

Water supply plans in Ethiopia are formulated based on the Universal Access Program (UAP) and the Water Sector Development Program (WSDP). The UAP is a country level water sector development strategy paper. Under the UAP strategy, each region formulates the WSDP as the implementation plan and then proceeds to implement individual development projects.

a. Universal Access Program (2005-2012)

Water Supply, Sanitation and Hygiene (WASH) Program had been commenced by three Ministries in order to implement water supply projects that included hygiene and sanitation aspects as a national level program. The UAP was prepared in 2005 to implement the WASH program. UAP has also the objective to accelerate WASH progress; to do so it sets a target water access ratio for each year, and its final target was a ratio of 98.3% by 2012. The UAP was revised in 2009 through the assessment of the three years program progress. In the revised UAP, the target year and access ratio were updated as below. The revised UAP defines the access ratio for rural and urban areas additionally (Table 2.1).

1) Target year : 2015

2) Water access rate : 100 %

3) Definition of access ratio

Table 2.1: Water Supply Access Ratio Definition

Area	Water volume (lit/capita/day)	Distance
Rural area	15	Within 1.5 km
Urban area	20	Within 0.5 km

Source: Revised UAP

Water supply access as of 2010 and planned access up to 2015 are tabulated in Table 2.2 below:

Table 2.2: Annual Water Supply Access Plan in the Revised UAP

Area	2010	2011	2012	2013	2014	2015
Rural	37.0%	49.6%	62.2%	74.8%	87.4%	100.0%
Urban	76.5%	81.0%	86.0%	90.0%	95.0%	100.0%
Total	42.5%	54.0%	66.0%	77.0%	89.0%	100.0%

Source: Revised UAP

b. Water sector development program phase IV

The Somali Regional Water Development Bureau (SRWDB) prepared the five-year strategic plan (2010-2014) in 2010. It describes achievements over the past 5 years, analysis of environmental, institutional and strategic issues, formulation of the action plan by 2014 including budget requirements, and monitoring and evaluation method proposal. It also sets the target water supply access ratio for urban and rural areas respectively.

SRWDB also prepares the implementation action plan each year to follow up the WSDP. It consists of the program progress in urban and rural areas, implementation plan of each project with the budget, and the financial summary. At the end of 2011, overall water supply access ratio had reached to 59.7% and was planned to increase to 69.7% in 2012 (refer to Table 2.3). The water sector development program has progressed smoothly up to now as they planned in 2010.

Table 2.3: Annual Water Supply Access Plan in Water Sector Development Program

Area	2010	2011	2012	2013	2014	2015
1. Five Year Strategic Plan						
Rural	38.4%	55.0%	70.6%	80.0%	90.0%	100.0%
Urban	47.0%	55.0%	70.6%	83.0%	95.0%	100.0%
Total	39.7%	55.0%	70.6%	80.4%	90.7%	100.0%
2. Implementation Action Plan						
Rural		49.0%	60.0%	-	-	-
Urban		64.0%	74.0%	-	-	-
Total		59.7%	69.7%	-	-	-

c. On-going projects by the SRWDB in 2012

In previous years, SRWDB mainly formulated woreda capitals' water supply projects using WASH program and governmental capital budget. In the Ethiopian fiscal year 2005 starting from September 2012, they formulated the 2005 implementation strategy and set the Jijiga water supply project as the first priority because improvement of water supply sector in Jijiga carried the greatest importance in view of Somali regional capital and population scale. Secondly, they prioritized 700 birka constructions to be implemented by the Somali regional water conservation project and woreda budget. Thirdly, borehole and haffir dam construction were taken up. For example, they planned to construct 40 boreholes each in Shinile and Birqod.

Former on-going projects such as Godey, Dagahbur, Kabridahar town water supply projects, implemented in the course of WASH program, have been suspended due to lack of project fund source.

2.1.2 Target year

As mentioned in the section 2.1.1 and Table 2.2, the revised UAP maintains the original target year 2015 and water access ratio was revised to 100% for 2015. In the case that the Study keeps the current target year, 2015, the implementation period will be only 2 years and it seems to be too short as a master plan implementation period. Besides, the implementation action plan mentions that the actual water access ratio progress follows the five year strategic plan since 2010. The five year strategic plan is already half way through its schedule and SRWDB can probably reach the target water supply access ratio, 100%, in 2015, if they follow their plan. In the case that the target year is kept at 2015, the water supply plan by this Study may duplicate their implementation action plan.

The Ministry of Water Resources formulated “Rural Water Supply and Sanitation Design Criteria” in 2005 and “Urban Water Supply Design Criteria” in 2006 respectively. In the Rural Water Supply Design Criteria, it is instructed that the target year of projects should be chosen from 5 to 30 years span from the point of planning depending on planning conditions.

In the Urban Water Supply Design Criteria, the target year is proposed to be considered 10 years for stage 1 and 20 years for stage 2 from the point of planning. The water supply plan in this Study mainly consists of rural water supply projects and most of them are small-scale spot water supply schemes. The most appropriate target year for rural water supply projects shall be 2018 and that for urban water supply projects shall be 2023. Taking into consideration these conditions, the target year of the water supply plan was set as 2020. The water supply access ratio proposed in the revised UAP strategy was followed and it was set as 100% as of 2020.

1) Target year : 2020
2) Water access ratio : 100%

2.1.3 Estimated population

Population data of each woreda was collected by the socio-economic survey and it is the base population in 2012. Each woreda administration can grasp the urban population, woreda capital population accurately. However, they can not update the rural population of each kebele. Therefore, urban population used the socio-economic survey result as 2012 population. Total rural population adopted that of the 2007 census data multiplied by annual population growth rate. The population of each kebele was allocated from the result based on the socio-economic survey results and other existing data of woredas. The population growth rate employed is 2.91% per year that was estimated from the results of socio-economic survey, for both urban and rural areas. Population projection for each woreda from 2012 to 2020 is shown in Table 2.4.

Table 2.4: Estimated Population in Each Year

Zone	Wareda	Type	2012	2013	2014	2015	2016	2017	2018	2019	2020
Fafan	Kabribeyah	Urban	40,045	41,210	42,409	43,643	44,913	46,220	47,565	48,949	50,373
		Rural	161,282	165,978	170,806	175,775	180,888	186,154	191,571	197,145	202,882
		Total	201,327	207,188	213,215	219,418	225,801	232,374	239,136	246,094	253,255
Jarar	Araarso	Urban	21,000	21,611	22,240	22,887	23,553	24,238	24,943	25,669	26,416
		Rural	20,600	21,201	21,819	22,454	23,105	23,780	24,472	25,181	25,914
		Total	41,600	42,812	44,059	45,341	46,658	48,018	49,415	50,850	52,330
	Dagahbur	Urban	69,500	71,522	73,603	75,745	77,949	80,217	82,551	84,953	87,425
		Rural	68,290	70,276	72,321	74,426	76,592	78,822	81,115	83,476	85,904
		Total	137,790	141,798	145,924	150,171	154,541	159,039	163,666	168,429	173,329
	Birqod	Urban	10,000	10,291	10,590	10,898	11,215	11,541	11,877	12,223	12,579
		Rural	9,807	10,094	10,388	10,689	11,002	11,322	11,649	11,989	12,336
		Total	19,807	20,385	20,978	21,587	22,217	22,863	23,526	24,212	24,915
Korahe	Shaygosh	Urban	12,500	12,864	13,238	13,623	14,019	14,427	14,847	15,279	15,724
		Rural	50,940	52,422	53,948	55,518	57,132	58,794	60,506	62,266	64,078
		Total	63,440	65,286	67,186	69,141	71,151	73,221	75,353	77,545	79,802
	Kabridahar	Urban	51,000	52,484	54,011	55,583	57,200	58,865	60,578	62,341	64,155
		Rural	123,300	126,890	130,580	134,378	138,286	142,311	146,454	150,716	155,104
		Total	174,300	179,374	184,591	189,961	195,486	201,176	207,032	213,057	219,259
	Doba wein	Urban	33,750	34,732	35,743	36,783	37,853	38,955	40,089	41,256	42,457
		Rural	41,250	42,451	43,687	44,957	46,265	47,612	48,997	50,423	51,891
		Total	75,000	77,183	79,430	81,740	84,118	86,567	89,086	91,679	94,348
Shebele	East Ime	Urban	9,315	9,586	9,865	10,152	10,447	10,751	11,064	11,386	11,717
		Rural	81,150	83,513	85,943	88,446	91,019	93,667	96,392	99,199	102,087
		Total	90,465	93,099	95,808	98,598	101,466	104,418	107,456	110,585	113,804
	Danan	Urban	9,800	10,085	10,378	10,680	10,991	11,311	11,640	11,979	12,328
		Rural	20,337	20,928	21,537	22,164	22,809	23,473	24,156	24,859	25,583
		Total	30,137	31,013	31,915	32,844	33,800	34,784	35,796	36,838	37,911
	Beercaano	Urban	6,300	6,483	6,672	6,866	7,066	7,272	7,484	7,702	7,926
		Rural	20,900	21,509	22,136	22,781	23,444	24,126	24,828	25,550	26,294
		Total	27,200	27,992	28,808	29,647	30,510	31,398	32,312	33,252	34,220
	Godey	Urban	29,379	30,234	31,114	32,019	32,951	33,910	34,897	35,913	36,958
		Rural	55,798	57,422	59,093	60,811	62,581	64,402	66,275	68,203	70,185
		Total	85,177	87,656	90,207	92,830	95,532	98,312	101,172	104,116	107,143
	Adadle	Urban	15,000	15,437	15,886	16,348	16,824	17,314	17,818	18,337	18,871
		Rural	89,627	92,234	94,918	97,679	100,521	103,445	106,455	109,553	112,741
		Total	104,627	107,671	110,804	114,027	117,345	120,759	124,273	127,890	131,612
	Kalafo	Urban	26,908	27,691	28,497	29,326	30,179	31,057	31,961	32,891	33,848
		Rural	76,178	78,395	80,674	83,021	85,436	87,920	90,479	93,110	95,817
		Total	103,086	106,086	109,171	112,347	115,615	118,977	122,440	126,001	129,665
	Mustahil	Urban	23,480	24,163	24,866	25,590	26,335	27,101	27,890	28,702	29,537
		Rural	49,750	51,198	52,685	54,219	55,798	57,421	59,090	60,811	62,581
		Total	73,230	75,361	77,551	79,809	82,133	84,522	86,980	89,513	92,118
Afder	Rasso	Urban	6,900	7,101	7,308	7,521	7,740	7,965	8,197	8,436	8,681
		Rural	24,450	25,162	25,896	26,647	27,425	28,225	29,047	29,895	30,766
		Total	31,350	32,263	33,204	34,168	35,165	36,190	37,244	38,331	39,447
	West Ime	Urban	7,900	8,130	8,367	8,610	8,861	9,119	9,384	9,657	9,938
		Rural	22,000	22,640	23,300	23,980	24,676	25,396	26,136	26,896	27,680
		Total	29,900	30,770	31,667	32,590	33,537	34,515	35,520	36,553	37,618

2.2 Water demand

2.2.1 Planning criteria

a. Applied standard

The following documents are referred to as the planning criteria;

- Revised UAP, December 2010
- Rural Water Supply and Sanitation Design Criteria, April 2005
- Urban Water Supply Design Criteria, January 2006

b. Daily water demand per capita

The daily water demands per capita of the revised UAP figures are as follows.

- Urban water supply 20 lit/capita/day
- Rural water supply 15 lit/capita/day

c. Institutional and commercial water demand

In urban water supply, the following institutional and commercial water demands were estimated. Urban Water Supply Design Criteria was adopted for the unit water demand and the socio-economic survey results were used to estimate the quantities.

- Government offices, and schools : 5 lit/capita/day
- Hospital : 50 lit/bed/day
- Hotel : 25 lit/bed/day

d. Industrial water demand

Industrial water demands were estimated only for urban water supply. The following items were taken up from the Urban Water Supply Design Criteria and the socio-economic survey results were used to estimate the water demand projection.

- Restaurant : 10 lit/seat/day
- Factory : 5 lit/employee/day
- Fuel station : 5 lit/user/day

e. Livestock water demand

In principle, rural water supply scheme in Ethiopia considers only human water demand for groundwater resources. Though the Somali region has a peculiar condition that many pastoral people live with their livestock and it is necessary to estimate livestock water demand in water supply. The number of livestock animals is much larger than population of an area and it is difficult to estimate all livestock water demand fully in the drinking water supply plan. Thus, livestock water demand was estimated as supplemental water demand.

Livestock water demand analysis was done in this study. Table 2.5 and Table 2.6 show the numbers of livestock animals in the Somali region estimated by the Livestock Crop & Rural Development Bureau and those for the urban area compiled from the socio-economic survey in this Study.

Table 2.5: Number of Livestock in Each Woreda

Woreda	Cattle	Sheep	Goat	Camel	Horse	Total
Kebribeyah	66,665	179,385	74,709	3,967	5,739	330,465
Degahabur	83,230	156,020	166,460	16,530	3,190	425,430
Kebridehar	50,400	345,000	215,700	82,500	1,800	695,400
Shekosh	33,600	230,000	143,800	55,000	1,200	463,600
Doboweyin	25,200	172,500	107,850	41,250	900	347,700
Adadile	40,200	100,400	63,600	1,400	800	206,400
Denan	48,240	120,480	76,320	1,680	960	247,680
East Emi	72,360	180,720	114,480	2,520	1,440	371,520
Gode	80,400	200,800	127,200	2,800	1,600	412,800
Kelafo	64,320	160,640	101,760	2,240	1,280	330,240
Mustahil	44,220	110,440	69,960	1,540	880	227,040
West Emi	118,200	147,720	94,560	9,240	1,680	371,400

Source: Livestock Crop & Rural Development Bureau

Table 2.6: Number of Livestock in Each Woreda Urban Area

Woreda	Cattle	Sheep	Goat	Camel	Horse	Total
Kabribeyah	195	320	450	165	480	1,610
Araarso	1,244	1,825	2,418	658	4,424	10,569
Birqod	5,687	4,900	6,800	2,120	280	19,587
Dagahbur	800	5,000	8,500	2,500	1,250	18,050
Kabridahar	2,610	5,078	4,816	1,435	283	14,222
Shaygosh	850	8,000	21,000	14,000	800	44,650
Adadle	17,200	182,350	110,000	11,500	520	321,570
Beercaano	4,500	9,000	7,000	2,200	450	23,150
Danan	620	5,100	3,900	1,229	134	10,983
East Ime	98,000	130,000	95,000	230,000	970,000	1,523,000
Godey	15,000	15,060	9,500	9,000	700	49,260
Kalafo	245,000	43,600	236,000	8,000	500	533,100
Mustahil	125,460	20,342	20,760	22,970	7,500	197,032
Rasso	4,550	9,974	11,543	8,116	390	34,573
West Ime	5,430	1,150	13,099	8,690	690	29,059

Based on the above figures, livestock water demands are calculated as follows. Table 2.7 shows comparison of livestock water demand and other water demands. It is evident that whole livestock water demand is far larger than whole water demands. The Study cannot include all livestock water demand taking into consideration of the objective. Water demands for humans must be the first priority in order to formulate the water supply plan. Thus, livestock water demand shall adopt the socio-economic survey results.

Table 2.7: Comparison of Livestock Water Demands and Whole Water Demands

Unit: m^3/day

Woreda	Livestock bureau data			Socio-economic survey result		
	Livestock water demand	Woreda water demands		Livestock water demand	Urban water demands	
		2015	2020		2015	2020
Kebribeyah	6,181	3,533	4,074	43	896	1,031
Ararso	1,587	803	925	328	466	537
Birkod	794	399	457	426	239	272
Degahabur	5,249	2,650	3,052	251	1,534	1,763
Kebridehar	8,630	3,148	3,630	251	1,132	1,304
Shekosh	5,753	1,158	1,329	443	325	367
Doboweyin	4,315	-	-	-		
Adadile	3,697	1,802	2,078	3,868	337	387
Beerano	828	480	554	419	138	159
Denan	4,436	557	642	134	225	258
East Emi	6,655	1,535	1,771	-	209	240
Gode	6,566	3,661	4,215	1,076	2,749	3,163
Kelafo	5,915	1,875	2,158	-	630	721
Mustahil	4,067	1,332	1,536	-	518	597
Rasso	4,155	536	618	504	176	203
West Emi	4,308	559	644	493	159	182

The following Table 2.8 shows the ratio of livestock water demand in the whole water demand. The average livestock water demand is almost double of whole water demand. It is still a large amount, particularly in Adadle woreda. The Study aims to provide domestic water primarily, while livestock water shall be the secondary water supply. Then, the ratios, which are below 50%, are calculated in the bottom column. These are 20.6% in 2015 and 17.9% in 2020 respectively, the Study adopts 20% of the whole water demand as the livestock water demand.

Table 2.8: Ratio of Livestock Water Demand

Woreda	2015	2020
Kabribeyah	4.8%	4.2%
Araarso	70.4%	61.1%
Birqod	178.2%	156.6%
Dagahbur	16.4%	14.2%
Kabridahar	22.2%	19.2%
Shaygosh	136.3%	120.7%
Doba wein	-	-
Adadle	1147.8%	999.5%
Beercaano	303.6%	263.5%
Danan	59.6%	51.9%
East Ime	-	-
Godey	39.1%	34.0%
Kalafo	-	-
Mustahil	-	-
Rasso	286.4%	248.3%
West Ime	310.1%	270.9%
Average	214.6%	187.0%
Average below 50%	20.6%	17.9%

f. Water loss

Rural water supply scheme estimates 10-20% water loss according to the Rural Water Supply and Sanitation Design Criteria. As for urban water supply scheme, the Urban Water Supply Design Criteria does not regulate any water loss percentage. It shows water loss percentage during operation period. Water loss starts from 40% at the commencement of operation and it will decrease afterward. It reaches 30% after 10 years and 25% after 20 years. However, actual water loss depends on the circumstances and condition of water supply system in each town. For example, large water loss occurs in piped water supply system rather than spot water supply. In case of spot water supply, water loss percentage is assumed to be the same as rural water supply. Taking into consideration these criteria, water loss of rural and urban water supply is set as follows:

- Rural water supply : 20%
- Urban water supply (spot supply) : 20%
- Urban water supply (piped supply) : 30%

g. Firefighting water demand

Rural water supply system is planned as spot water supply system. It is not practical to include firefighting water in the rural water supply system. Thus, firefighting water demand shall be estimated for urban water supply project and piped water supply system only. Urban Water Supply Design Criteria regulates that 10% of storage tank volume of reservoir is increased as firefighting water demand. It is applied to design reservoir for urban water supply projects.

2.2.2 Water demand projection

a. Water demand

a.1 Urban water supply

Water demand in 2020 is estimated by multiplying the population projection in 2020 by the unit water demand and other water usages. There are four urban water supply systems, which are supplied through piped water. They are Kabribeyah, Kabridahar, Dagahbur, and Godey towns. Other woreda capitals are also classified into urban population in the socio-economic survey. Thus, water demand of those towns is estimated as urban water supply as shown in Table 2.9.

Table 2.9: Urban Water Supply Demand Components

No.	Item	Equation
1	Domestic water	Population×20lit/day
2	Livestock water	Domestic water×20%
3	Institutional water	Number×Each unit water demand (lit/day)
4	Commercial water	Number×Unit water demand (lit/day)
5	Industrial water	Number×Unit water demand (lit/day)
	Sub-total	No.1~5
6	Water loss	Sub-total×30%
	Grand total	Sub-total +Water loss

a.2 Rural water supply

Kebele, which is not included in woreda capital, is estimated to be rural water supply system. Water demand of rural water supply is composed of the items in the following Table 2.10:

Table 2.10: Rural Water Supply Demand Components

No.	Item	Equation
1	Domestic water	Population×15lit/day
2	Livestock water	Domestic water×20%
	Sub-total	No.1~2
3	Water loss	Sub-total×20%
	Grand total	Sub-total +Water loss

The water demand of the target year is calculated in Table 2.11 as follows:

Table 2.11: Water Demand of Each Woredas in 2020

Unit: m^3/day

Zone	Wareda	Type	2015	2020
Fafan	Kabribeyah	Urban	2,010	2,249
		Rural	3,797	4,382
		Total	5,807	6,632
Jarar	Araarso	Urban	727	837
		Rural	485	560
		Total	1,212	1,397
	Dagahbur	Urban	2,433	2,798
		Rural	1,608	1,856
		Total	4,041	4,653
	Birqod	Urban	372	425
		Rural	231	266
		Total	603	691
Korahe	Shaygosh	Urban	508	573
		Rural	1,199	1,384
		Total	1,707	1,957
	Kabridahar	Urban	1,766	2,034
		Rural	2,903	3,350
		Total	4,669	5,384
	Doba wein	Urban	1,269	1,446
		Rural	971	1,121
		Total	2,240	2,567
Shebele	East Ime	Urban	325	374
		Rural	1,910	2,205
		Total	2,236	2,579
	Danan	Urban	351	402
		Rural	479	553
		Total	830	955
	Beercaano	Urban	215	248
		Rural	492	568
		Total	707	816
	Godey	Urban	1,243	1,418
		Rural	1,314	1,516
		Total	2,556	2,934
	Adadle	Urban	525	604
		Rural	2,110	2,435
		Total	2,635	3,039
	Kalafo	Urban	983	1,124
		Rural	1,793	2,070
		Total	2,776	3,194
	Mustahil	Urban	809	932
		Rural	1,171	1,352
		Total	1,980	2,284
Afder	Rasso	Urban	275	316
		Rural	518	598
		Total	793	914
	West Ime	Urban	248	284
		Rural	576	665
		Total	824	949

b. Design water supply volume

Water supply access ratio reached 70% for urban water supply and 52% for rural water supply as of September 2012. These amounts have already been supplied through the existing water supply facilities. Water supply volume, which is difficult to be supplied by SRWDB, shall be planned in the Study. The Study is finalized in August 2013 and each project will be practically implemented in 2014. Current 5 year strategic plan sets that water supply access rate in 2013 and 2014 are 80.4% and 90.7% of 2015 water supply volume. Taking into consideration these conditions, design water supply shall be water demand in 2020 minus 80% of water demand in 2015 (Figure 2.1).

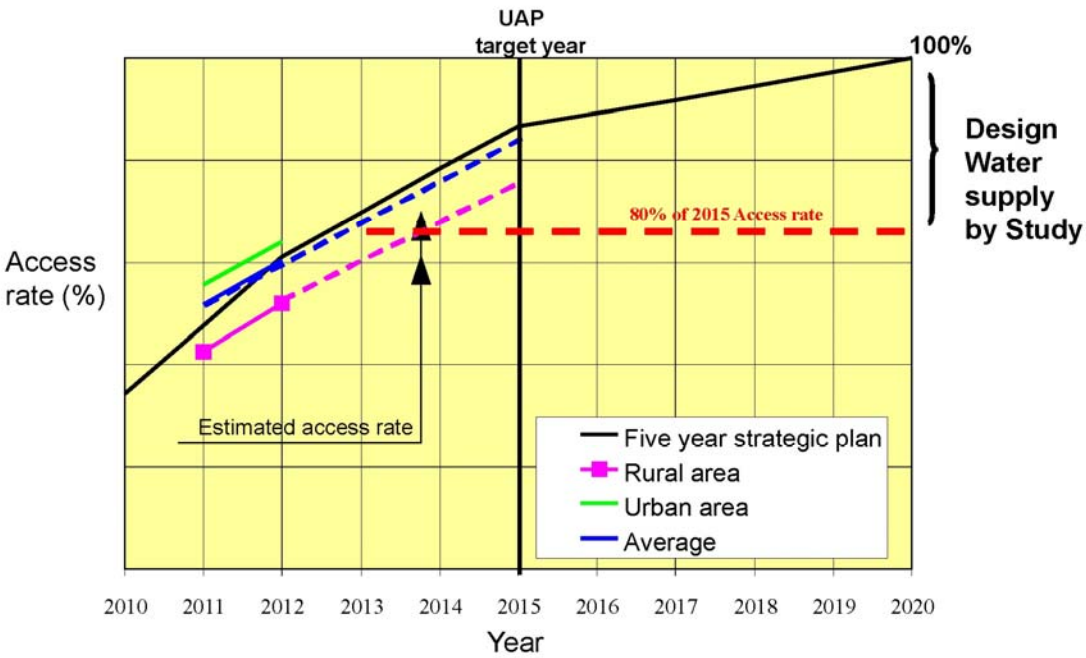


Figure 2.1: Design Water Supply by the Study

2.3 Results of the pilot projects and the application of feedback to water supply plan

2.3.1 Results of water supply construction

a. Outline of water supply facilities construction

The water supply facilities construction (hereafter referred to as "the construction") as a pilot project comprises the following two construction projects: "Improvement of Jarar valley water supply system in Kabribeyah town and Jarar valley" and "Construction of water point in Godey town". The outline of these construction projects is shown in the following Table 2.12.

Table 2.12: The Outline of the Water Supply Construction

Project (target area)	Items of the works
a.1 Improvement of Jarar valley water supply system (Kabribeyah town and Jarar Valley)	a.1.1 Drilling of new water supply wells (Two wells) and installation of submersible pumps
	a.1.2 Conveyance pipe (New water supply wells to existing pipe)
	a.1.3 Replacement of Surface and Booster pumps
	a.1.4 Water supply points construction
a.2 Water supply points construction (Godey town)	Water supply points construction

a.1 Kabribeyah Town and Jarar Valley

a.1.1 Drilling of new water supply wells and installation of submersible pumps

Two new water supply wells were drilled in Jarar Valley and two submersible pumps were installed in the wells. Also, a generator house with a generator inside was constructed beside each well (refer to Figure 2.2).

The specifications of the submersible pumps for the new water supply wells were selected, as per the following Table 2.13, based on the results of pumping test and hydraulic calculation in consideration of the length of pipeline connecting the new wells and existing conveyance pipeline. Specifications of both pumps are the same. Generator is used as power source for the pumps for the time being. In the future, commercial power lines will be connected to both of the submersible pumps. The type of the riser pipe used for the wells is galvanized Iron pipe, type B (GI pipe).

Table 2.13: Outline of the Installed Submersible Pumps

Items	Specifications
Total head (H)	H = 130 m-135m
Discharge capacity (Q)	Q = 18 m^3 / hour (Q = 5 L /sec)
Incidental facilities	Water level sensor, Pressure gauge Air valve, Check valve, Water meter

Figure 2.2: Installation of Riser Pipe (left) and Generator House Completed (right).

a.1.2 Conveyance pipe (from new water supply wells to existing pipes)

There are already several wells in the Jarar Valley water supply system, and there are existing conveyance pipelines connecting the borehole wells and the existing water treatment plant to convey water to the plant. Water conveyance pipeline from the new water supply wells, which were drilled in this project, was connected to the existing conveyance pipeline. The type of the conveyance pipe is polyvinyl chloride pipe (uPVC pipe). UNHCR also constructed two new wells in the area. These new wells are planned to be connected to the new pipeline which was constructed by JICA study team in this project. The outline of the new conveyance pipeline to be connected to the existing water system is shown in Figure 2.3.

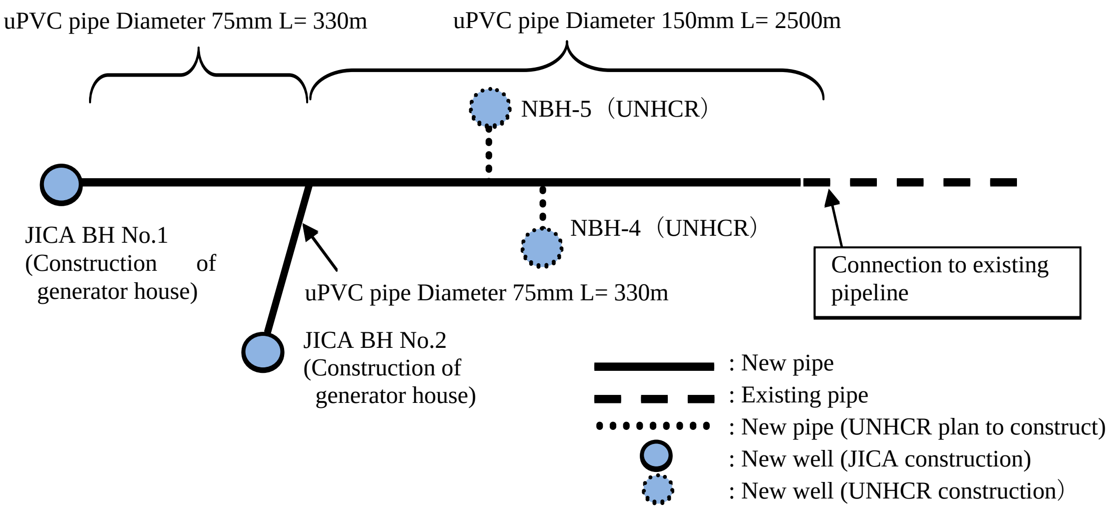


Figure 2.3: Schematic of Planned New Conveyance Pipeline

a.1.3 Replacement of surface and booster pump

In the existing surface and booster pump stations, the system was designed to operate with parallel operation of three (3) pumps, of which one (1) was in regular operation and the two (2) others as stand-by. The current operation of the pump was confirmed at the sites as shown in following Table 2.14. Two (2) pumps (No.1 and No.2), which were found in poor performance, stopped operating from time to time due to minor breakdowns. Although pump No.1 is being deteriorated, both pumps can somehow be operated and be pumped water. According to an electrician of JWSO, pump No.2 can be operated if one of the parts of the pump is replaced. In this project, three (3) new pumps were procured initially for the purpose of replacing the existing three (3) broken pumps. However, through discussion with Kabribeyah town water supply utility office, the plan was changed to replace only two pumps: pump No.3 at the surface pump station and pump No.1 at the booster pump station. These pumps were confirmed to be completely broken and had already been detached from the pipe. As for the remaining one pump, it was planned to be installed by Kabribeyah town water supply utility office in future when either of the current malfunctioning pumps at the surface pump station breaks down completely. The photos of pump installation and the pump station are presented in Figure 2.4.

Table 2.14: Current Condition of the Pumps and Target Pumps for Replacement

Surface pump station	Pump status (year pump manufactured*)	Target replacement pump in the construction
No.1 Pump	Malfunction, possible to send water (2011)	To be installed by Kabribeyah town water supply office when either pumps is broken completely
No.2 Pump	Malfunction, possible to send water with condition (2011)	
No.3 Pump	Broken and removal (2009)	Replacement
Booster pump station	Pump status (year pump manufactured *)	Target pump in the construction
No.1 Pump	Broken and removal (2009)	Replacement
No.2 Pump	Functioning (2012)	-
No.3 Pump	Functioning (2011)	-

* Year pump manufactured was estimated based on existing pumps, survey reports and inquiry survey.
* Pump number is that No.1 is the farthest pump from the entrance of the pump station. The nearest pump located from the entrance is called No.3.

Specifications of the pumps are shown in the following Table 2.15. All of three pumps have the same specifications.

Table 2.15: Specifications of Pumps

Specifications	Surface pump station	Booster pump station
Pump model	ME100K80-90 /4A-TB (Rovatti)	
Total head (H)	H=220m	
Discharge capacity（Q）	Q = 75 m^3 per hour (H=214m)	
Number of replacement	2 pumps	1 pump

Figure 2.4: Installation of the surface pump (left) and General View of Conveyance Pump Station

Immediately after replacement of pump No. 3 at the surface pump station, some leakage from the pump was confirmed because of malfunction of the non-return valve connected to the pump. In this condition, backflow of water will occur when the pump is turned off. This will then cause reverse rotation of the pump motor and will have a negative effect on the motor and even on the control panel. For this reason, the pump could not be operated at the time of installation. In response to this problem, technical staff of Kabribeyah town water supply utility office dismantled and cleaned the valve (removed scale inside the valve) immediately. The non-return valve was restored and started functioning. After this cleaning, the pump (No.3) was operated normally.

The existing two pumps (No.1 and No.2) at the surface pump station had been operating with poor capacity due to deterioration. During this pilot project, both pumps suddenly broke down and stopped operation at the end of January 2013. As a result, pumping of water to Kabribeyah town was temporarily suspended for approximately one week. Meanwhile, installation of a new pump in the station was completed in the project, and then pumping was started again. The installation of this new surface pump in the project contributed to avoiding long-term suspension in water supply in the town.

a.1.4 Water supply points construction

Selection of construction sites with C/P (through discussion) was conducted in May 2012. All five (5) water points were constructed in Kabribeyah town (see Figure 2.5). Except for one (1) water point, all water points had a water trough for livestock beside the public tap. Water points in Kabribeyah town will be connected to the existing pipelines of the water supply system. However, taking into consideration the unstable water flow and pressure in the existing water supply system, a water tank (capacity $10m^3$) was installed at each water point except for the same one site above. This will make it possible to supply water to the tanks using water trucks or to fill the tanks at night (when water pressure is expected to be higher). The water points can be used as a backup water source in the case of water supply interruption.

Figure 2.5: Water Supply Point (Construction completed at Kabribeyah Town)

a.2 Water supply points construction (Godey town)

Selection of five (5) construction sites was conducted with Godey town administration office and Godey town water supply utility office (through discussion) in May 2012. All the water supply points were constructed in the outskirts of urban area of Godey town. The water supply points constructed in Godey town are of the same design as those in Kabribeyah town (see Figure 2.6). However, water troughs for livestock were not constructed because there are no existing cattle troughs close to public taps in Godey town.

These water supply points will not be connected to the existing distribution pipelines. For the time being, water supply points will be supplied by water trucking using water tanks. And also, these water supply points were designed to be connected to the existing pipelines at the time of future expansion of the system.

Figure 2.6: Site Confirmation (left) and Public Tap (right) Completed in Godey Town

b. Result of water supply facilities construction

The construction works project was conducted by a local construction company. The construction started on 17 September, 2012. The construction works were completed in March 2013 with a record of progress shown in the following Figure 2.7. Although progress of the construction work was slow as compared to the initial schedule until November mainly due to change of construction sites for water supply points, and also to change in technical specifications of distribution pipes. The progress of the construction work had been nearly as planned since November 2012. At first, the completion date for the construction work was planned to be the end of January 2013. However, it was changed to be the beginning of March 2013 because of some design changes.

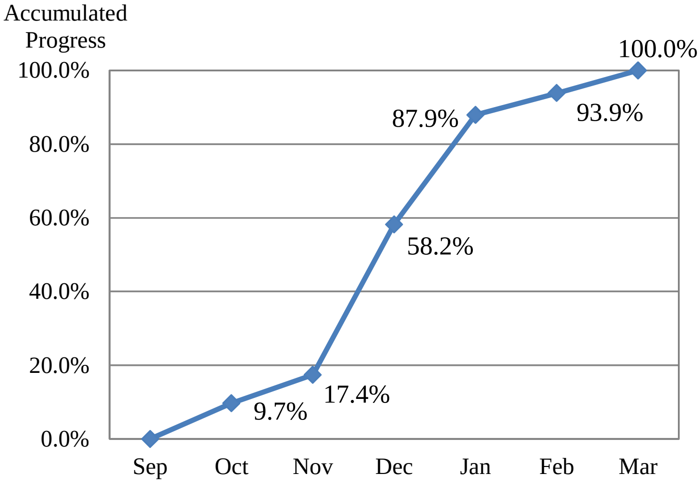


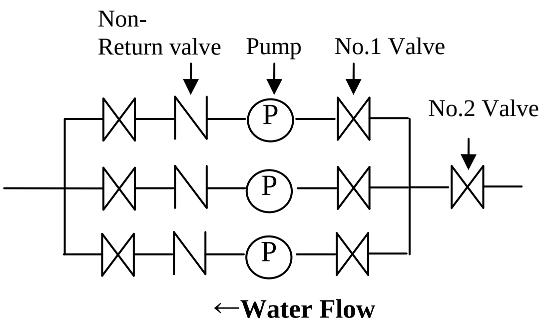
Figure 2.7: Actual Accumulated Progress of the Construction

2.3.2 Issues of water supply facilities and construction work observed during the pilot project

One of the purposes of implementing this pilot project within this study is to extract feedback (lessons) from the actual performance of the construction work and related activities. The feedback will be useful information to take into consideration at the time of actual implementation of water supply expansion and rehabilitation projects that will be proposed as a result of this study. From this point of view, the following sections present the technical issues related to the existing water supply facilities and construction works that were recognized during the pilot project.

a. Current condition of pipe fittings of conveyance and booster pump stations and perception of water loss

In the project, two (2) surface pumps were replaced. During the time of replacement, it was confirmed that the pipe fittings adjacent to the pumps were malfunctioning and that the staff of Kabribeyah town water supply utility office had low awareness of water loss due to leakage. Surface pumps and pipe fittings were connected as shown in the following Figure 2.8. Leakage would not normally occur during pump replacement if the non-return valve that worked to cut off backflow into the pipe was functioning properly and at the same time, No.1 and No.2 valves were closed.



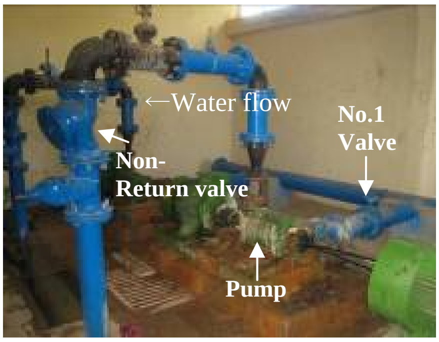
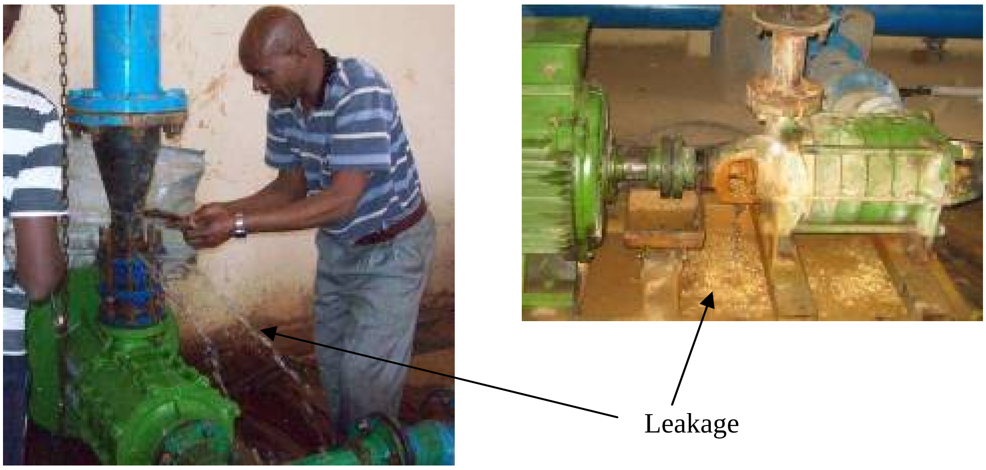


Figure 2.8: Arrangement of Surface Pump and Associated Pipe Fittings

However, as shown in the following photos (left) of Figure 2.8, leakage was confirmed at the position of the pump, despite the fact that a non-return valve existed in the outflow pipe and valve of No.1 was closed. It was also confirmed from the explanation by a staff member of Kabribeyah town water supply utility office that the valve No.2 was also not functioning well.

Furthermore, as shown in the following photo (right) in Figure 2.9, although the valve in the inflow pipe was closed, water was leaking continually from some pumps of a specific structure. In specific, water was flowing from a point of some pumps where the motor and the impeller were joined. It is assumed that a non-return valve inside this leaking pump was not functioning properly. Therefore water in outflow pipe flows back to the pump. In the project, current situation of malfunctioning of some pipe fittings was confirmed through replacement of the pumps. The situation indicates that many existing pipe fittings such as valves in Jarar Valley water supply system are also malfunctioning. This was later also confirmed by the fact that many of the valves in valve chamber boxed in the town could not be closed at the time of pipe connection work.



Leakage at the time of replacement (left) and during regular operation (right)

Figure 2.9: Leakage at Pump Stations

Although leakage was occurring continually due to malfunction of valves and non–return valves, the operators and technical staff of the water supply utility office could not take any measures to prevent the leakage. Water loss due to leakage constitutes a major portion of non-revenue water and thus the situation will lead to heavy financial loss in the management of water supply system. At present, water meters to check the amount of water flow are not being installed at appropriate points in the system. Thus, the amount of water flowing in the system as a whole cannot be confirmed. As a result, the water loss is being left unattended because any measures against malfunctioning of valves can not be taken in the above mentioned case at the surface pump station. For these reasons, it is assumed that staff of Kabribeyah water supply utility office does not have proper understanding and awareness of financial loss caused by leakage, including necessity of rehabilitating malfunctioning pipe fittings such as valves under proper plans.

b. Contract of construction and installation of equipment

In this project, two (2) submersible pumps and three (3) surface pumps were procured and installed. The procurement of these sets of equipment was performed by the procurement supplier, and the installation of the equipment was conducted by the contractor of the construction works. It was observed that responsibility of safekeeping of the equipment became obscure because procurement and installation of equipment had to be carried out separately by two different companies. In this sense, in construction projects involving procurement and installation of equipment, it is desirable that the entire work of procurement and installation of equipment should be performed by the procurement supplier or by the contractor of construction work in order to prevent the responsibility of procurement and implementation from being divided.

c. Management of equipment such as pumps and process of procurement

Pumps such as submersible pumps and surface pumps for Jarar valley water supply system, and intake pumps for Godey town water supply system are not manufactured in Ethiopia. Therefore these pumps are basically procured abroad. This procurement process takes time, and furthermore, pump procurement itself is expensive. As mentioned before, if all surface pumps were broken, there would be no choice but to stop water supply. Thus pumps in the system are, therefore, fundamental facilities. Currently, when a pump is broken, spot measures, where broken parts are replaced by the parts from another pump, are taken at the site. If all pumps were broken under such circumstances where there is no regular operation and management plan, water supply would be suspended for a long time until new pumps are procured. Moreover, pumps are expensive and the office will need to request for assistance from external organizations such as donors and NGOs. For example, the intake facilities of Godey water supply system are being operated by only one pump at the moment. If this pump breaks down completely, there will be a critical situation in water supply in Godey town.

It is crucial to keep the pumps in good operational condition including backup pumps, in order to avoid prolonged water supply suspension at the time of pump problem. It is also needed to secure budget for the purchase of pumps and materials in advance to prepare for pump problems. Although purchase budget should be covered entirely by the income from water sale, it is also needed to regularly save up purchase budget in a long run because pumps are expensive. It is currently very difficult to implement procurement and installation of pumps by only town water supply utility office which operates each of the water supply systems. Thus that the offices should seek for assistance from external organizations for procurement and installation of pumps, including measures to save budget for pump purchase.

d. Geographical condition of the Jarar valley water supply system

Relative position of the major facilities in Jarar Valley water supply system is shown in Figure 2.10. It takes about 30 minutes by a 4WD vehicle to go to the existing water resource areas, water purification plant and surface pump station from Kabribeyah town (Route1). It takes time to access by vehicle to JICA boreholes (BHs), which were constructed in this project, from the area of existing boreholes, thus it is necessary to take Route 2, which is shown in the figure. It takes about 45 minutes by vehicle to go to JICA boreholes from Kabribeyah town along this route. The distance from water purification plant and surface station to Kabribeyah town is about 20 km and the difference in elevation is about 330 m (Kabribeyah town is higher).

Locations of the JICA BHs were selected mainly taking into consideration of existing borehole locations, hydrogeological conditions, and security situation during construction. For these reasons, the wells had to be located in an area a little far from the existing facilities. Therefore the access to the wells such as JICA BHs is not easy.

During the supervising of the construction work, transportation to JICA BHs and pump stations was done using a 4WD vehicle. It took a lot of time to move to the sites because of the location of each facility and bad condition of access road. It was confirmed that a vehicle was required as a measure of transportation to carry out daily O&M of the entire facilities. Road improvement is also necessary to secure access to the water source areas in rainy season.

Considerable effort will be required to do O&M, and the cost of O&M will be high, due to the location of each set of facilities (water resource, water purification plant, pump station, water supply coverage area) and pump operation to overcome large elevation difference between the water resource and Kabribeyah town. The situation will cause the water supply cost to increase (water supply cost is indirectly affected by the geographical condition in this case). It is, thus, anticipated that O&M cost of the water supply system will inevitably be high.

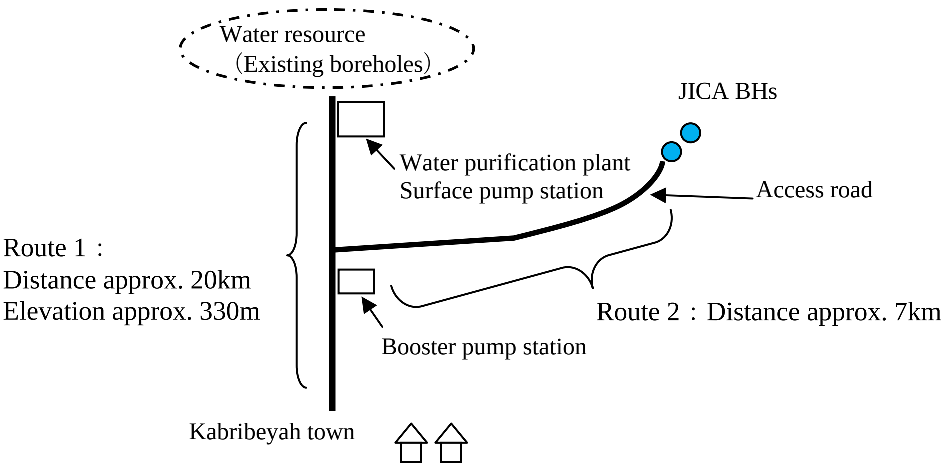


Figure 2.10: Relative Location of Facilities in the Jarar Valley Water Supply System

e. Necessity of standard drawing of cattle trough and public taps

Cattle troughs constructed in the project were designed with reference to the drawing provided from SRWDB. However, at the time of the construction, it turned out that the design of the cattle trough was for camels because the sidewall of trough was found very high. The design was immediately changed to lower the side walls so that cattle, goat and sheep could drink water from the trough.

It is necessary to standardize drawings of animal water troughs for different types of animals because the design of some animal troughs such as the one for camel and cattle was made based on the size of livestock. Public taps also have the same issue of necessity to standardize the drawings. Standardization of drawings will help decrease effort of preparation of drawings, construction and design changes during construction stage.

f. Sorting out of the information of existing water facilities

In the existing water supply systems, especially the drawings of existing transmission pipeline and distribution pipeline and the information of existing pipes such as the pipe type, installation year of the pipes could not be obtained either for the Jarar valley water supply system and Godey town water supply system. Therefore, in the drawing and construction stage, the information of existing pipelines only relied on inquiring survey and field confirmation such as installation condition of existing valves. Use of vague information from the inquiry survey will lead to high possibility of frequent changes in drawings during the construction stage. This would further result in delay of the construction work and increased construction cost. In order to implement proper O & M of water supply facilities, it is required to sort out information of existing water supply facilities and maintain them as drawings and documents.

2.3.3 Non-technical issues through the pilot project

The technical issues that were extracted from the implementation of the pilot project in this study were discussed in Section 2.3.2. This section sums up the non-technical issues concerning the O&M of the water supply facilities that surfaced during the implementation of the pilot project.

a. Issues on the collaboration among the organizations concerned (site selection)

The location of the public water points in the pilot project was determined through discussion with the water supply utility office and through actual site confirmation in the field. However, in Kabribeyah town, three of the five sites had to be relocated after the start of the construction work. This is because the mayor of the town came to claim that the selected sites were on planned roads in the town's master plan and thus construction of water points should not be allowed.

The study team was anticipating this kind of problem from the very beginning and thus, asked the woreda administration to inform all those who were concerned and to get consent from them. The study team also thought that if the selection of the sites was made by the office in charge of water supply, there would be little risk of land issues. However, as exemplified in this case, there were many parties concerned with the administration of the town. It was found that all these parties were not necessarily well coordinated and they did not share important information. In order to avoid the same problem in future, it is necessary for the project implementation side to obtain confirmation separately from each of the parties concerned.

In the same way, other minor problems and misunderstandings occurred due to the fact that the jurisdictions of the organizations concerned were not clear and they did not keep good contact with each other to share information.

b. Interruption of transportation due to truck confiscation

During the construction work, there were two cases of truck confiscation where a contractor's truck carrying construction materials was unlawfully taken away by military people who claimed an emergency. Although the truck was returned a few days later, these incidents caused delay in transportation of materials to site by a few days to a week. It would have caused serious impact on the progress of the work if the timing and items were more important ones. Thus, it is necessary to prepare for such unexpected incidents at the time of implementation of the proposed master plan projects.

c. Controlling power of town and woreda authorities and mentality of residents

After the construction of the two water source wells (including generator houses) in Jarar Valley, WASHCO training was attempted by SRWDB. However they found that there were no large communities in the vicinity of the wells and that the wells had no water supply facilities where people could directly take water. For this reason, the bureau found it difficult to create a WASHCO for the wells and the training was cancelled. After this incident, some people from the communities relatively close to the wells and some from relevant authorities expressed opinion that there should be a public water supply point near the wells. The reason they mentioned was that if there were no water points that communities could directly use, there would be a risk of not only mismanagement of the source well facilities but also destruction of the facilities. This statement was confirmed to have been based on their past experiences in the same area. As compared to the urban area of Kabribeyah town, it is more difficult to control communities in areas such as Jarar Valley where administrative influence tends to be weakened. Therefore, it is necessary to be well prepared for these problems through thorough field investigation at the time of master plan project implementation.

2.3.4 Application of the feedback to water supply plan

Kabribeyah town water supply utility office faces water leakage and equipment trouble in many cases. Due to budgetary limitations, it is quite difficult to have enough spare parts for operation and maintenance purposes at each site. Current operation and maintenance situation seems to be similar to other woredas. SRWDB shall coordinate availability of functional equipment or spare parts, bring them from other sites to troubled site, and will support sustainable operation. In order to realize such sustainable water supply facility’s operation, standardized water supply plan shall be applied to similar scaled projects and then adaptable operation and maintenance system, which can support materials and equipment, shall be built up. In addition, water supply plan shall consider easiness of water resource access and height from water resource to supply area in view of minimization of operation and maintenance cost.

As shown in Figure 2.7, the construction work takes 6 months with 5km pipeline installation works even though they have to conduct other work items. The contractor is selected by nominated contractors’ bidding competition based on the SRWDB recommendation. It assumes that their performance level is appropriate in the region. However, the pilot project meets safekeeping issue of equipment and 2 months of construction period extension. Through the pilot project experience, the water supply plan shall be small scaled one and including all components into one project.

- Standardization of water supply plan (pump equipment, public tap, cattle trough, etc.)
- Minimum O&M cost plan (low pump head, easiness of site access)
- Formulation of small scaled project
- Formulation of project component consisting of procurement and construction works into one package

Chapter 3

Water Resources and Existing Water Supply Facilities

3 Water Resources and Existing Water Supply Facilities

3.1 Types of water resources

a. Groundwater

Four types of water supply systems are included in groundwater. Differences of each system are summarized in Table 3.1 below:

Table 3.1: Classification of Groundwater Supply System

No	Water supply system type	Definition
1	Borehole with motor pump	- Depth is more than 60m - Served population is less than 900. - Public tap is provided.
2	Borehole or shallow well with hand pump	- Depth is less than 60m - Served population is less than 500.
3	Hand dug well	- Served population is 300~350. - Hand pump is provided. - Water table is below 20m.
4	Spring	- Perennial water flows throughout the year - Served population is about 140 persons for 0.1/lit/sec flow.

Source: Rural water supply and sanitation design criteria

Borehole with motor pump is the most stable water resource among the four systems, but it is also expensive. Conversely, hand dug well is the most economical and easily constructed by community level. However, it is affected by seasonal groundwater level fluctuations.

b. River water

Main stream of the Shebele River has permanent flow, it is used as water resource for drinking purposes. However, the river water contains high turbidity throughout a year and it cannot be used directly. Raw river water is stored at sedimentation tank provided next to the river to precipitate soil particles. Upper part of the river water is used as drinking water. River water infiltrates into the ground at branches of the Shebele River. They are wadi river and have seasonal flow. They cannot be used as a water resource.

c. Rainwater

Rainwater is widely used as a water resource for the project area. There are two types of facilities, birka and haffir dam, to develop rainwater in the area. Birka is smaller water supply facility and is easy to construct. It is for this reason that birka is the first priority to develop rainwater. SRWDB regulates that beneficiaries of one haffir dam is 2,500 persons. In case that served population is more than 2,500 persons, haffir dam is effective as water resource development (Refer to Table 3.2).

Hydrological study presents that annual evaporation in Godey, 4,565mm, is approximately 1.8 times larger than the one in Dagahbur, 2,596mm. These towns have almost equal annual rainfall volume, this large amount of evaporation difference seriously affects storing water in haffir dam. In order to avoid drying up water in haffir dam, it shall be designed for the Jarar valley area only and only birka shall be applied to the Shebele sub-basin to store rainwater.

Table 3.2: Birka and Haffir Dam Planning Parameters by the Study

Facility	Planning criteria	Target Area
Birka	< 2,500 served population	Jarar valley, Shebele sub-basin
Haffir dam	>= 2,500 served population	Jarar valley

3.2 Water resources of Jarar valley sub-basin

a. Existing water resources

Existing water resources in the area are illustrated in Figure 3.1 and are compiled Table 3.3. Borehole is equally used for all woredas because the Jarar River passes through in the middle of all woredas from north to south direction. Kebeles, where groundwater level is rather shallow, have constructed shallow wells or hand pump wells instead of borehole. All existing rivers are wadi, there is no surface water in the study area.

Birka is also commonly used for all woredas except Kabribeyah and Birqod. Residents have to rely on rainwater, if areas do not have boreholes or wells. As such, project implementing bodies construct birka. Kabribeyah answered no information for 19 kebeles water resource. In another question, they answered that they have 5 haffir dams and 65 birkas in the woreda. Kebeles for which there is no information are located on the eastern side of Kabribeyah town and there are no existing boreholes for the area. It is supposed that these 19 kebeles use birka or haffir dam as their water resource. In case of Birqod, the existing 5 kebeles are located close to the Jarar River and they use borehole and shallow well. As a result, it is supposed that they do not have a birka currently.

Table 3.3: Existing Water Supply System of Each Kebele in Jarar Valley Area

Zone	Woreda	Borehole	Shallow Well	Hand pump well	Hand dug well	River intake	Birka	No info
Fafan	Kabribeyah	10	1	0	0	0	0	19
Jarar	Araarso	2	1	0	0	0	2	4
	Birqod	4	1	1	0	0	0	1
	Dagahbur	4	2	0	0	0	5	6
Korahe	Kabridahar	4	2	2	0	0	2	0
	Shaygosh	3	0	0	0	0	2	0
	Doba wein	0	0	0	4	0	0	1

b. Water resources for water supply plan

Boreholes have been developed along the Jarar River only in the Jarar valley area and are used currently. Borehole is the most stable water resource in the area in view of water quantity if safe yield can be secured by new water resource development. Therefore, borehole development will be considered as the first priority in the area.

Most kebeles in the Jarar valley area are located along the highway passing through north-south direction. The highway is approximately 20km away from the Jarar River in

Kabribeyah, Araarso, and Dagahbur woredas. The kebeles along the highway are difficult to take water from the river due to its distance. Birka and haffir dam are possible water resources for those kebeles. The highway crosses the Jarar River at Dagahbur and Birqod towns, and it runs along the river after Birqod. In Shaygosh and Kabridahar woredas, kebeles that are close to the river will be developed by borehole and those that are distant from it, will be developed by haffir dam. It is because each kebele has a population of more than 5,000 people, too many birka must be required to satisfy water demand in 2020.

Kebeles in Kabribeyah woreda expand eastern side of the highway. There are no existing boreholes in principle, birka is the most practical water resource in such areas.

3.3 Water resources of Shebele River sub-basin area

a. Existing water resources

Woredas that are located along the main stream of the Shebele River, take the Shebele River water for water supply. Danan is not adjacent to the Shebele River, therefore it has to use other water resources such as borehole and shallow well. Kebeles in Godey woreda, which also exist away from the Shebele River, use groundwater as water resource. Kebeles, where they are apart from the Shebele River, cannot use river water and have to find other water resources. This is the reason why Godey has also relatively large number of kebeles that use shallow wells as their water resource. The existing water supply sources are listed in Table 3.4.

Table 3.4: Existing Water Supply System of Each Kebele in Shebele Sub-basin

Zone	Woreda	Borehole	Shallow Well	Hand pump well	Hand dug well	River intake	Birka	No info
Shebele	Adadle	1	0	0	0	2	1	7
	Beercaano	1	1	0	0	3	0	0
	Danan	1	4	0	0	0	0	0
	East Ime	0	1	0	2	7	0	2
	Godey	0	5	0	0	5	0	0
	Kalafo	0	0	0	0	5	0	5
	Mustahil	0	0	0	2	6	1	0
Afder	West Ime	0	1	0	2	7	0	3
	Rasso	0	0	0	0	3	0	2

b. Water resources for water supply plan

Most woredas rely on the Shebele River water as the water resource and the river water has vital role in the area. It must be the first priority as the water resource except Danan and Rasso woredas. Kebeles which are located around 1km from the Shebele River, will take water from it because it is the most sustainable way, taking into consideration of operation cost.

In Danan groundwater is used for all kebeles as hand dug well and/or hand pump well. Though Danan does not face to the Shebele River, it has several wadi rivers and current wells are developed on them. Therefore, groundwater development is the first priority in Danan. Served population of one hand dug well and hand pump well are 100 and 400 persons respectively. Required served population of each kebele of Danan in 2020 ranges between 2,000 and 3,000. Too many hand dug wells must be necessary if all water demand shall be covered by hand dug well and hand pump well. They also dry up easily in dry season. In order to secure stable water supply for those woredas, borehole development is appropriate rather than hand pump well and hand dug well. It is for this reason that borehole development shall be adopted for Danan.

In Rasso there is no existing borehole development at this moment. Besides, the branch of the Shebele River is wadi, population cannot expect river water in dry season and they develop hand dug wells. However, water supply by hand dug well is for limited beneficiaries. Rainwater is the only one water source in Rasso woreda. In the Shebele Sub-basin, evaporation volume is much larger than the Jarar valley area. Thus, birka shall be selected as the water source for Rasso.

Kebele, which has difficulty to access to the Shebele River and groundwater, shall also rely on rainwater. Birka shall be selected as water resource.

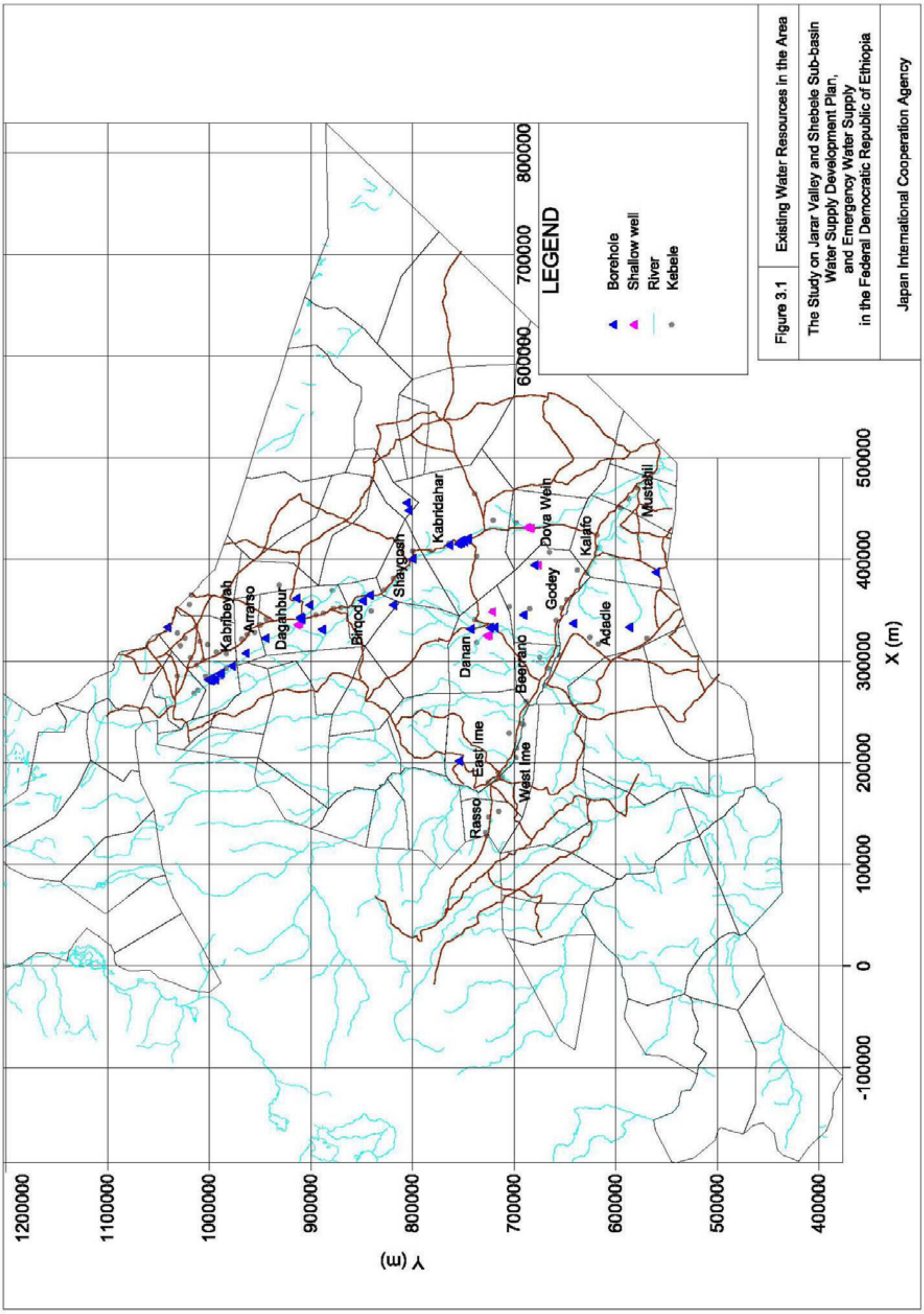


Figure 3.1: Existing Water Resources in the Target Area

3.4 Present condition of existing water supply facilities

3.4.1 Jarar Valley sub-basin

As of the year 2008, there were 45 operational water supply facilities, however Araarso and Birqod woredas did not exist. The number of the operational water supply facilities had decreased to 26 in 2012 (refer to Table 3.5). Reducing numbers are remarkable for Kabribeyah, Dagahbur, and Kabridahar, where their water demands are large in the area and they have a town water supply system. Kabribeyah and Kabridahar only answered that they owned the unused water supply facilities. These unused water supply facilities are one component of the Kabribeyah and Kabridahar town water supply system, and they can still supply water to beneficiaries using the remaining facilities.

Table 3.5: Existing Water Supply Facilities in Jarar Valley Area

Zone	Woreda	2008 Used	2012 JICA Study			
			Used	Not used	Unknown	Total
Jijiga	Kabribeyah	10	6	5	3	14
Dagahbur	Araarso	-	3	0	1	4
	Birqod	-	3	0	0	3
	Dagahbur	13	6	0	8	14
Korahe	Kabridahar	14	5	3	9	17
	Shaygosh	2	3	0	1	4
Total		45	26	8	22	56

Source: JICA Study in 2012 and SRWDB Study in 2008

Around half of the used water supply facilities in 2008 are currently of unknown condition. Dagahbur and Kabridahar have several unused water supply facilities. In the 2008 report, those water supply facilities do not have information on supplying area, construction year, and fund source; it is assumed that these projects might not formulate the definite objectives and consensus. As a result, woreda water offices cannot grasp the current situation.

Other unknown facilities were constructed before 2005. All of them take water by motorized pump, and these facilities are due for replacement of equipment. It is assumed that a) the facilities have been abandoned until equipment is replaced, and b) the residents have changed to another water resource.

All the 56 water resources in the above are groundwater and all the facilities are equipped with pumps. Though the woredas, which have the urban water supply system in Kabribeyah, Dagahbur, and Kabridahar, own more than ten water supply facilities, they do not confirm all the projects. This reflects that they cannot manage the existing water supply facilities efficiently. They have to replace motorized pumps within a certain period. According to the judging of existing data, it is less than 10 years. It is rather short in comparison with standard usage. Water supply facilities need to be used more efficiently to extend the life of the equipment.

3.4.2 Shebele River sub-basin

The existing water supply projects in the Shebele sub-basin are extremely scarce compared with Jarar valley. Most woredas have at least one water supply facility operated by the woreda water office. Four water supply facilities, two in Godey, and one each in Kalafo and Mustahil, take water from the Shebele River. West Ime and Rasso use groundwater or rainwater.

Seven water supply facilities including those not used take water from the Shebele River. Three water supply facilities are not in use currently. They are in Adadle, East Ime, and West Ime. Adadle uses boreholes because it is located more than 10km away from the Shebele River. East Ime uses river water directly since it is less than 1km from the river (refer to Table 3.6).

Table 3.6: Existing Water Supply Facilities in the Shebele Sub-basin

Zone	Woreda	2008 Used	2012 JICA Study			
			Used	Not used	Unknown	Total
Godey	Adadle	0	0	1	0	1
	Beercaano	-	0	0	0	0
	Danan	1	0	0	0	0
	East Ime	0	0	1	0	1
	Godey	2	2	0	0	2
	Kalafo	0	1	0	0	1
	Mustahil	1	1	0	0	1
Afder	West Ime	-	1	1	0	2
	Rasso	-	1	0	0	1
Total		4	6	3	0	9

Source: JICA Study in 2012 and Water Bureau Study in 2008

The Shebele River water is mainly used in the downstream area, groundwater development potential at the downstream area seems to be limited judging from the existing conditions. Among the water supply facilities taking water from the Shebele River, some are operational and some are not functional. Faulty design may cause suspension of operation. Water supply plan shall be prepared to deal with and reflect the issues interrupting the operation. Further, while the existing water supply facilities are mainly developed along the riverine area, the areas, which are away from the river, are likely to have had less water supply projects conducted.

3.5 Types of water supply facilities and scale

3.5.1 Borehole/shallow well

In urban water supply, several wells shall be required to satisfy water demand in 2020, water supply facilities' component is different in each town. Project component is described in each woreda urban water supply system plan. As for rural water supply, one well can supply water demand for one kebele, all rural water supply facilities have the same component like submergible pump with generator, 100 m pipeline to reservoir, elevated reservoir with 10m^3, distribution pipes, public taps, and cattle trough (refer to Figure 3.2).

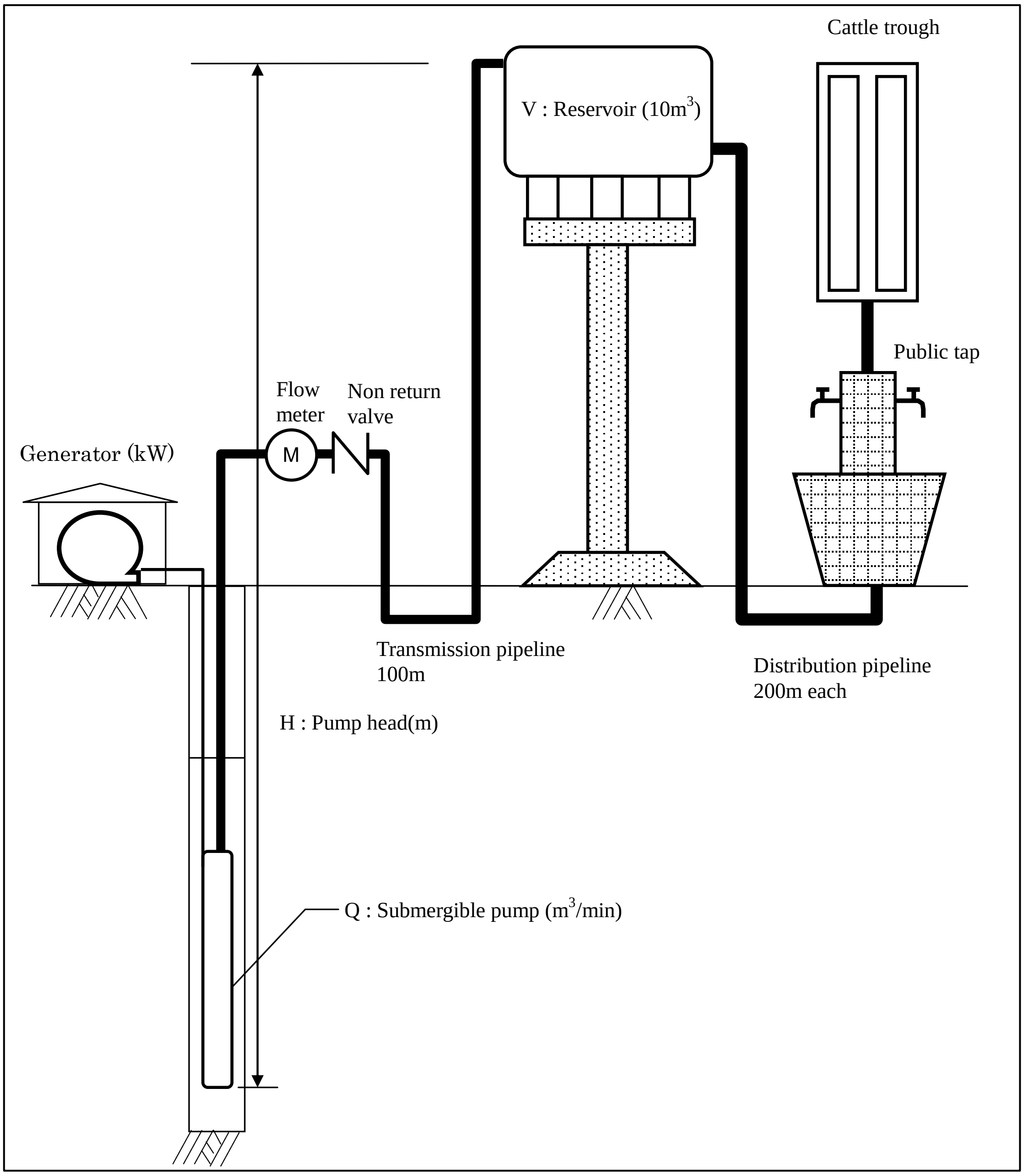


Figure 3.2: Rural Water Supply System by Well Construction

a. Well development

a.1 Groundwater in the study area

Average figures of the capacity of existing wells in each woreda are summarized in Table 3.7. Many yield data are missing in 5 woredas. Design yield is estimated based on these data and hydrogeological study results conducted by the Study.

Table 3.7: Characteristics of Wells in Each Woreda

Woreda	Average well depth	Actual yield	Design yield
Kabribeyah	220m	Unknown	5.0 lit/sec
Araarso	250m	1 lit/sec	1.7 lit/sec
Dagahbur	70m	5 lit/sec	5.0 lit/sec
Birqod	60m	3 lit/sec	3.3 lit/sec
Shaygosh	140m	Unknown	4.0 lit/sec
Kabridahar	130m	4 lit/sec	4.0 lit/sec
Doba wein	25m	Unknown	1.0 lit/sec
Danan	30m	Unknown	1.0 lit/sec
Godey	30m	Unknown	1.0 lit/sec

a.2 Intake pump design

(1) Height

Pump will be installed 10m and 5m above the well bottom for borehole and shallow well respectively.

(2) Pump capacity

Design pump capacity, Q_p (m^3/min), is calculated by applying the following formula. Design maximum daily water supply factor changes depending on population scale. Peak factor of large population is smaller than the one of small population because design average daily water supply volume absorbs little water volume fluctuation. Thus, 2 peak factors are applied in accordance with population.

Q_p = Daily peak factor × Design water supply volume (m^3/day) ÷ Daily pump operation (hrs)

Where;

Maximum daily peak factor : Population <50,000 : 1.5

: Population>= 50,000 : 1.2

Daily pump operation : 10 hours

(3) Pump diameter

Pump and riser pipe diameter is calculated with the following formula:

$$D = 146\sqrt{Q/V}$$

Where;

Q : Pump capacity (m^3/min)

V : Velocity 1.5 m/sec

a.3 Generator output

The following equation is applied to estimate generator output as power source.

$$R = \frac{0.163 Q_p H}{\eta}(1+\alpha)\times 3$$

kVA = 1.2×R

Where;

R : Generator output (kW)

Q_p : Pump yield (m^3/min)

H : Total pump head (m)

η : Pump efficiency

α : Safety factor (0.1)

b. Pipeline

Transmission and distribution pipe diameter is designed to apply a velocity in the pipe ranging from 0.6 m/sec to 3.0 m/sec.

In urban water supply system, transmission pipeline system is different from each project. It is mentioned in woreda water supply plan. 500m distribution pipeline is installed from the existing distribution pipeline to each public tap.

As for rural water supply system, 100m transmission pipeline is designed from well top to elevated reservoir. 200m distribution pipeline is installed from elevated reservoir to each public tap.

c. Reservoir volume

c.1 Urban water supply

According to urban water supply design criteria, reservoir volume is regulated to 0.3~0.5 (30 to 50%) of design average daily water supply volume. 0.5 shall be applied in case that average daily water supply volume is less than 2,000m^3/day. If it exceeds 2,000m^3/day, coefficient shall decrease gradually as below to avoid excessive water storage volume in comparison with present situation.

Q_d <2,000m^3/day : V = 0.5× Q_d×(1+10%)

2,000m^3/day <= Q_d < 2,500m^3/day : V = 0.4× Q_d×(1+10%)

2,500m^3/day <= Q_d : V = 0.3× Q_d×(1+10%)

Where;

V : Reservoir volume (m^3)

Q_d : Design average daily supply in 2020 (m^3/day)

c.2 Rural water supply

Rural water supply design criteria mentions that reservoir storage volume shall cover maximum hourly water supply volume. The following equation shall be applied to design the reservoir volume. Calculation result shows that rural water supply system by groundwater development shall be $10m^3$, they have the same reservoir capacity.

$V = a1 \times (3.6 \times Q_p)$

V : Reservoir volume (m^3)

a1 : Coefficient of hourly maximum : 1.5

Q_p : Design pump capacity (lit/sec)

d. Public tap

Rural water supply design criteria regulates that one public tap shall supply water for 900 persons. The design follows this criteria and one public tap with 6 faucets shall supply water for 900 persons.

e. Cattle trough

One cattle trough shall be provided for every 5 public taps because livestock water demand is estimated as 20% of whole water demand.

f. Chlorination

It shall be conducted for drinking water only. It shall exclude for washing water and livestock water. It is not practical to provide chlorination for each water supply facility because gross water supply volume includes above water usages and chlorine water volume will be huge. Thus, chlorine agent will be provided to users and they shall pour it into drinking water. Chlorine expense is estimated in the operation and maintenance cost. Water supply facilities plan does not estimate any chlorination cost.

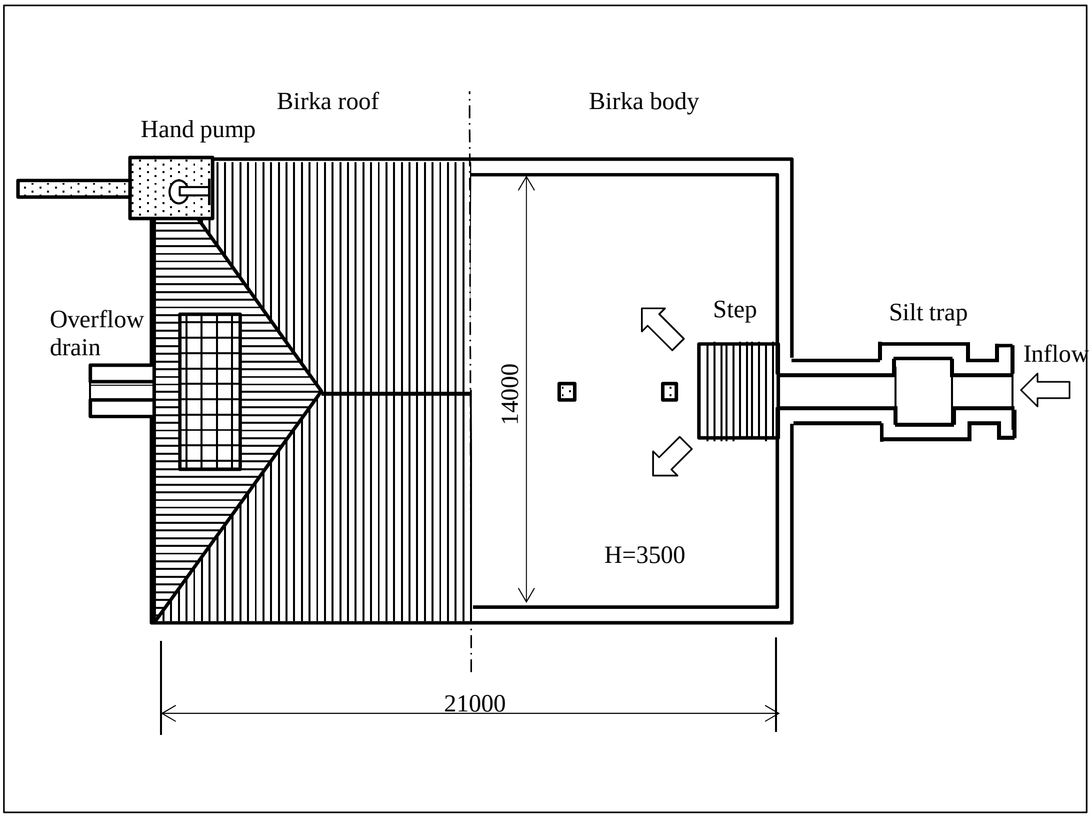
3.5.2 Birka

Ministry of Water and Energy dictates in the guideline that one birka shall provide water for 300 ~ 350 persons. The Study shall conform to this guideline and one birka shall be provided for every 300 beneficiaries.

It is the underground reservoir made by concrete. Roof is provided to protect from wastes. The roof is a checkered pattern; rainwater can drop directly into the birka body. The storage capacity is around $1,000m^3$. Hand pump is provided to pump water out. Runoff water flows into the inlet, and sand and soil particles are stored at the silt trap. Supernatant water flows into the birka (refer to Table 3.8 and Figure 3.3).

Table 3.8: Major Features of Birka

No	Description	Specifications
1	Shape	Rectangular type
2	Dimension	21 m x 14 m
3	Maximum Depth	3.5 m
4	Storage Capacity	1,029 m^3



Source: SRWDB

Figure 3.3: Birka Plan

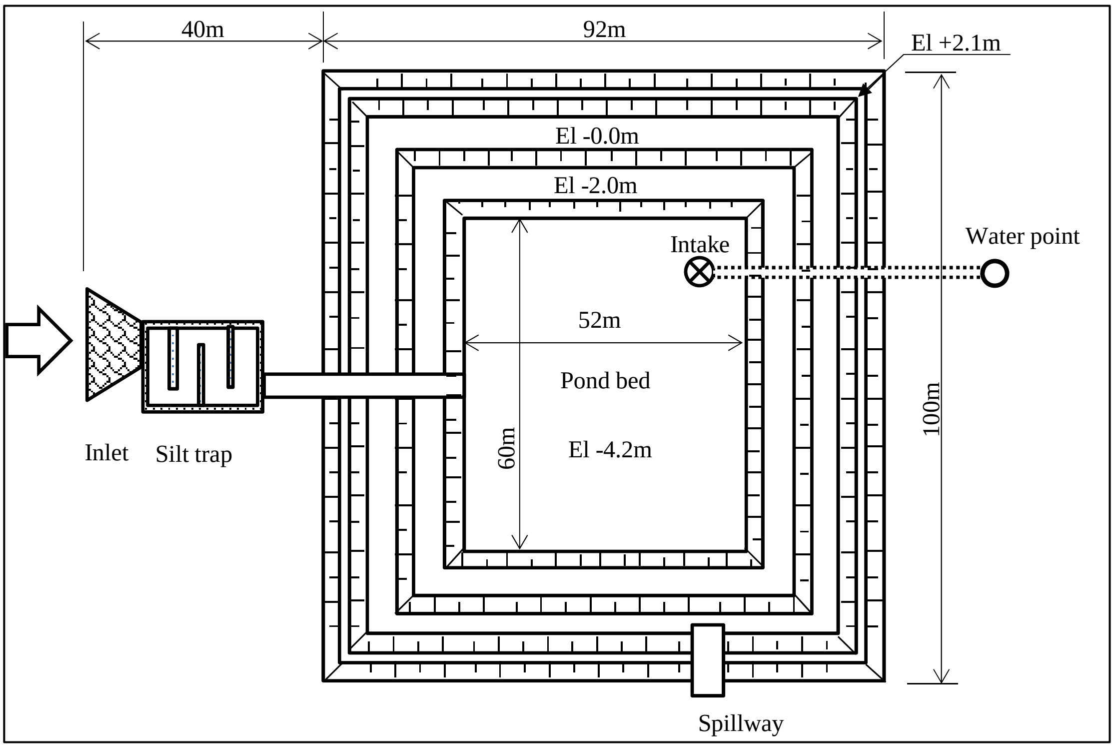
3.5.3 Haffir dam

It is also regulated by the guideline of the Ministry of Water and Energy that one haffir dam shall provide water for 2,500 persons. Thus, one haffir dam shall be designed for 2,500 beneficiaries.

It is the rectangular type excavated pond and dike surrounds outside of the body. Each side is more than 90m. Maximum water depth is 5.7m and the storage capacity is 27,000m^3. Runoff water flows into the inlet. Sand and soil particles are stored at the silt trap next to the inlet and water flows in the pond. The intake pipe is installed at the pond bottom, water is supplied through it. In case that inflow water is overloaded for haffir dam, excess water flows out from the spillway (refer to Table 3.9 and Figure 3.4).

Table 3.9: Major Features of Haffir Dam

No	Description	Specifications
1	Shape	Rectangular type
2	Length	92m x 100m
3	Bottom elevation	-4.2m
4	Dike height	+2.1m
5	Maximum water level	+1.5m
6	Storage Capacity	27,000m^3



Source: SRWDB

Figure 3.4: Haffir Dam Plan

3.5.4 River water

River water supply facilities consist of intake pumps with generators, sedimentation tanks, rough filters, treated water reservoirs, surface pumps, transmission pipelines, reservoirs, distribution pipelines, public taps, and cattle troughs. All components employ the same structure for both urban and rural water supply systems. However, mechanical specifications, facilities' capacity, and pipeline length are different in each project (refer to Figure 3.5). The same design as the borehole/shallow well water supply system was applied to pipelines, reservoir volume, public taps and cattle troughs (refer to section 3.5.1, b~f).

Design water supply volume for river water development system is not "the water demand in 2020 minus 80% of water demand in 2015" defined in section 2.2.2 b, but it is the water demand in 2020, as an exception.

For this reason, firstly, river water development facilities along the Shebele River hardly exist according to the socio-economic survey results. In this case, the existing water supply facilities are assumed to be birkas. Birkas are not stable water supply facilities. If the water supply plan is implemented by river water development following the above rule of basic design water supply volume determination, the unstable water supply facilities (birkas) will still be supplying most of the water. Thus, the entire water supply will be unstable. For this reason, it is practical that all water supply volume shall be developed by the river water system, which can provide stable water supply to satisfy the entire water demands.

Secondly, river water supply facilities are permanent structures with their life being about 50 years. It would be rather expensive to supply only 30% of the total water supply volume by such permanent structures. Thus, it is necessary to design the structures of a certain structural scale to take advantage of the scale merit. Thus, it will be an efficient water supply plan if the design water supply volume is set to be the whole water demand in 2020.

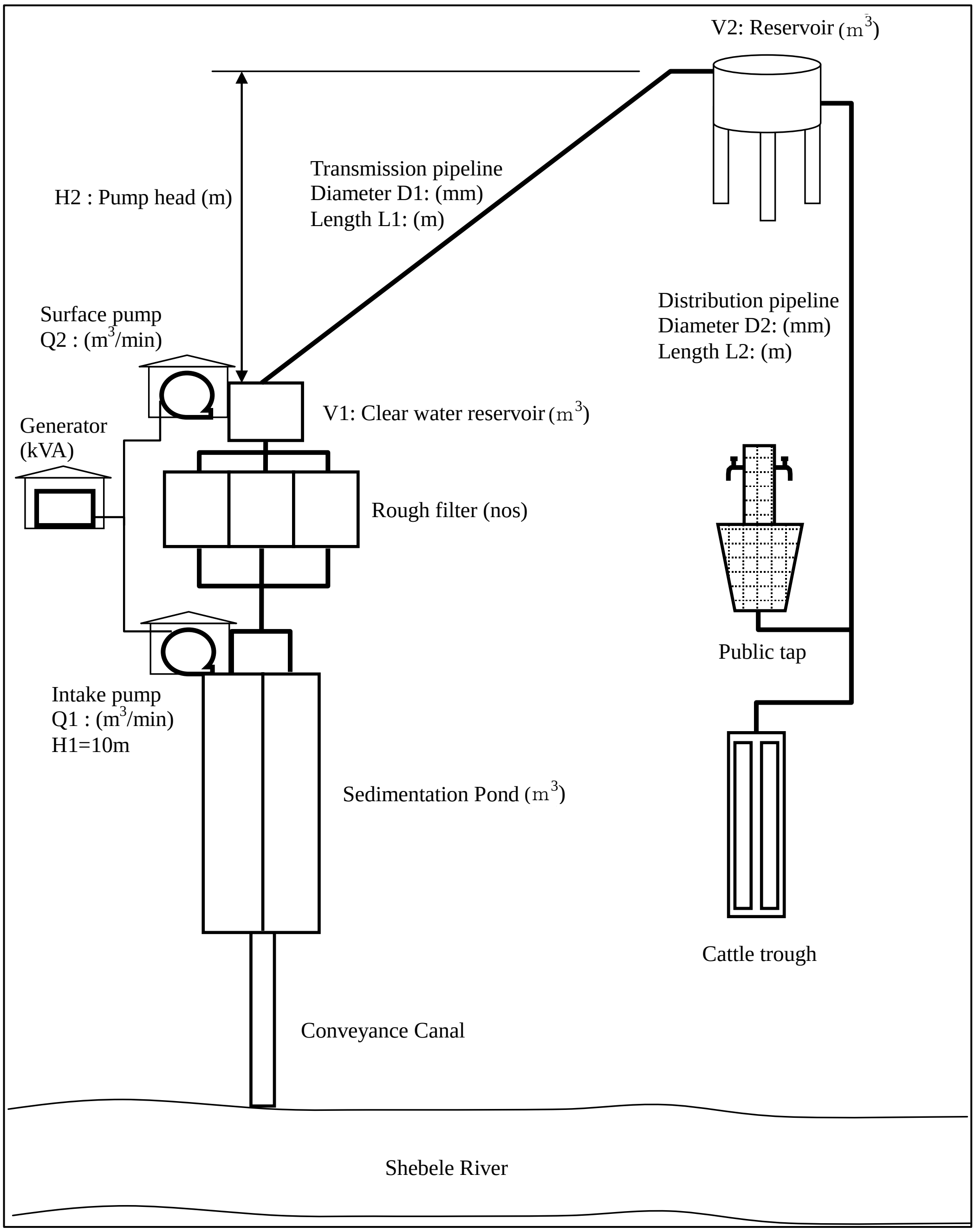


Figure 3.5: Rural Water Supply by River Water

a. Intake pump

Socio-economic survey result indicates that some existing intake facilities cannot function presently. Intake facility shall be the permanent structure, it is not easy to develop additionally once it is constructed. Therefore, intake pump capacity shall be designed to cover total water demand in 2020. Two peak factors were adopted depending on population scale as described in 3.5.1 a.2. Also, additional volume of 10% of Q_p was included because the river water system needed water for flushing at the water purification facility. Pump head shall be set to be 10m for lifting water up to the purification facility. Generator outputs were designed following the same criteria as in section 3.5.1 a.3.

(1) Height : 10m

(2) Pump capacity : $Q_q = Q_p$ (P×2020 water demand)×1.1/10hrs (m^3/min)

Where;

P : Daily max. peak factor : 1.2 or 1.5 refer to a.1.2

(3) Generator output refer to section 3.5.1 a.1.3

b. Sedimentation tank

The Shebele River water has high content of turbidity and thus, sedimentation tank must be provided. Two sedimentation tanks were designed. Sufficient purification capacity is attained with only one of the two tanks and the other one is provided as a backup. The detention time in the tank was designed to be 3 hours. The height of the tank was designed to be one meter (1m) for easy maintenance. The purification volumes and dimensions are tabulated in Table 3.10.

Table 3.10: Sedimentation Tank Design Dimensions

Q	Width	Length	Height	Detention time
(m^3/day)	(m)	(m)	(m)	(hour)
100	3.0	12.0	1.0	3.6
200	4.0	16.0	1.0	3.2
300	5.0	20.0	1.0	3.3
400	6.0	24.0	1.0	3.6
500	7.0	28.0	1.0	3.9
600	7.0	28.0	1.0	3.3
700	8.0	32.0.	1.0	3.7
1,600	11.0	44.0	1.0	3.0
1,800	12.0	48.0	1.0	3.0

Reference: Surface water treatment by rough filter

c. Rough filter

Project sites are mostly in rural areas where continuous electricity supply cannot be expected. In this sense, rough filter system, which does not use electricity, is the only method that can be employed as the water purification system. There are two maintenance operations for the rough filter. One is the manual maintenance and the other one is hydraulic maintenance that takes advantage of the flow of water in the facility. Since the filters are provided in rural areas, maintenance method should be a simple and easy one. Thus, the manual maintenance was adopted. Also, the type of the filter was the dynamic filter, which could be maintained manually. Filter design conditions and its dimensions are summarized in Table 3.11.

Table 3.11: Rough Filter Design Dimensions

Design condition			
	Item	Condition	Remark
1	Filtration rate	< 1.0m/sec	Hydraulic load (m^3/hr)/Surface area (m^2)
Dimensions			
	Item	Condition	Remark
1	Surface area	$30m^2$	25~$30m^2$ per one filter
2	Length	6.0m	5.0~7.0m
3	Width	5.0m	$30m^2$/6m
4	Height	1.0m	For easy filter material maintenance
5	Filter material thickness	0.6m	0.4~0.6m per one filter

Reference: Surface water treatment by rough filter

d. Treated water reservoir

It is provided to store treated water. The storage volume was designed to be equal to 2 hours of purification volume. Rectangular type with cover was designed in the Study.

e. Surface pump

Pumps should be provided to supply treated water to the reservoir in the service area in kebele. The pump capacity was designed to be the same as the intake pump. Lift height was calculated based on the distance between the Shebele River and each kebele. The generator output design followed the same rule as in section 3.5.1 a.3.

Chapter 4

Water Supply Plan, Cost Estimation and Implementation Plan of Each Woreda

4 Water Supply Plan, Cost Estimation and Implementation Plan of Each Woreda

4.1 Kabribeyah woreda (Rural area)

4.1.1 Water supply plan

Water supply master plan in Kabribeyah woreda is illustrated in Figure 4.1. Borehole development is planned for 8 kebeles along the Jarar River and 1 kebele, No.1 Aleybadley, located at the border to Somalia. One borehole has been developed in Aleybadley and it is used, therefore, boreholes will also be developed. There are no existing boreholes for other areas, rainwater development is adopted for the remaining 20 kebeles. Served population of No.18 Hartasheekha was set as 5,013 persons in 2020. It exceeds 2,500 beneficiaries for haffir dam planning and two haffir dams are planned. No.8 Duriya also exceeds 2,500 served population, haffir dam and birka are planned. Only birka is planned for the other 18 kebeles. Served population ranges from 1,159 to 2,319 persons and quantities are from 4 to 8 birkas. General features of each kebele water supply plan are tabulated in Table 4.1.

Table 4.1: Features of Kabribeyah Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served Pop. persons	Facilitie s No.	Q m^3/m	Gen. kVA	Pipe dia. mm	Dis. Pipe m	Public tap No.	Cattle trough No.
1	Aleybadey	Borehole	1,964	1	0.20	59	65	600	3	1
2	Bariisle	Borehole	1,931	1	0.20	59	65	600	3	1
3	Calandhgeley	Borehole	1,159	1	0.10	37	40	400	2	1
4	Dalaandhige	Borehole	1,159	1	0.10	37	40	400	2	1
5	Daynaba	Birka	1,952	7						
6	Dhurwale	Borehole	2,361	1	0.25	74	65	600	3	1
7	Dibiile	Birka	2,071	7						
8	Duriya	Haffir dam	2,790	1						
9	Eegato	Birka	1,976	7						
10	Fadeyge	Birka	1,986	7						
11	Farda	Borehole	2,902	1	0.30	81	80	800	4	1
12	Ganbi	Birka	1,946	7						
13	Garbiile	Borehole	2,824	1	0.30	81	80	800	4	1
14	Gitlo	Birka	2,319	8						
15	Golgeno	Birka	1,934	7						
16	Guyow	Birka	1,949	7						
17	Harre	Birka	2,024	7						
18	Hartasheekha	Haffir Dam	5,013	2						
19	Horo Khalif	Borehole	3,276	2	0.20	59	65	400	2	1
20	Jingadle	Birka	1,935	7						
22	Labashaag	Birka	1,933	7						
23	Mara-gaaji	Birka	1,935	7						
24	Oomen	Birka	1,159	4						
25	Qaaxa	Borehole	1,934	1	0.20	59	65	600	3	1
26	Qabri Hanteen	Birka	1,869	7						
27	Qooraan	Birka	1,932	7						
28	Qoto-roble	Birka	1,935	7						
29	Risle	Birka	2,118	8						
30	Warabogiro	Birka	1,976	7						

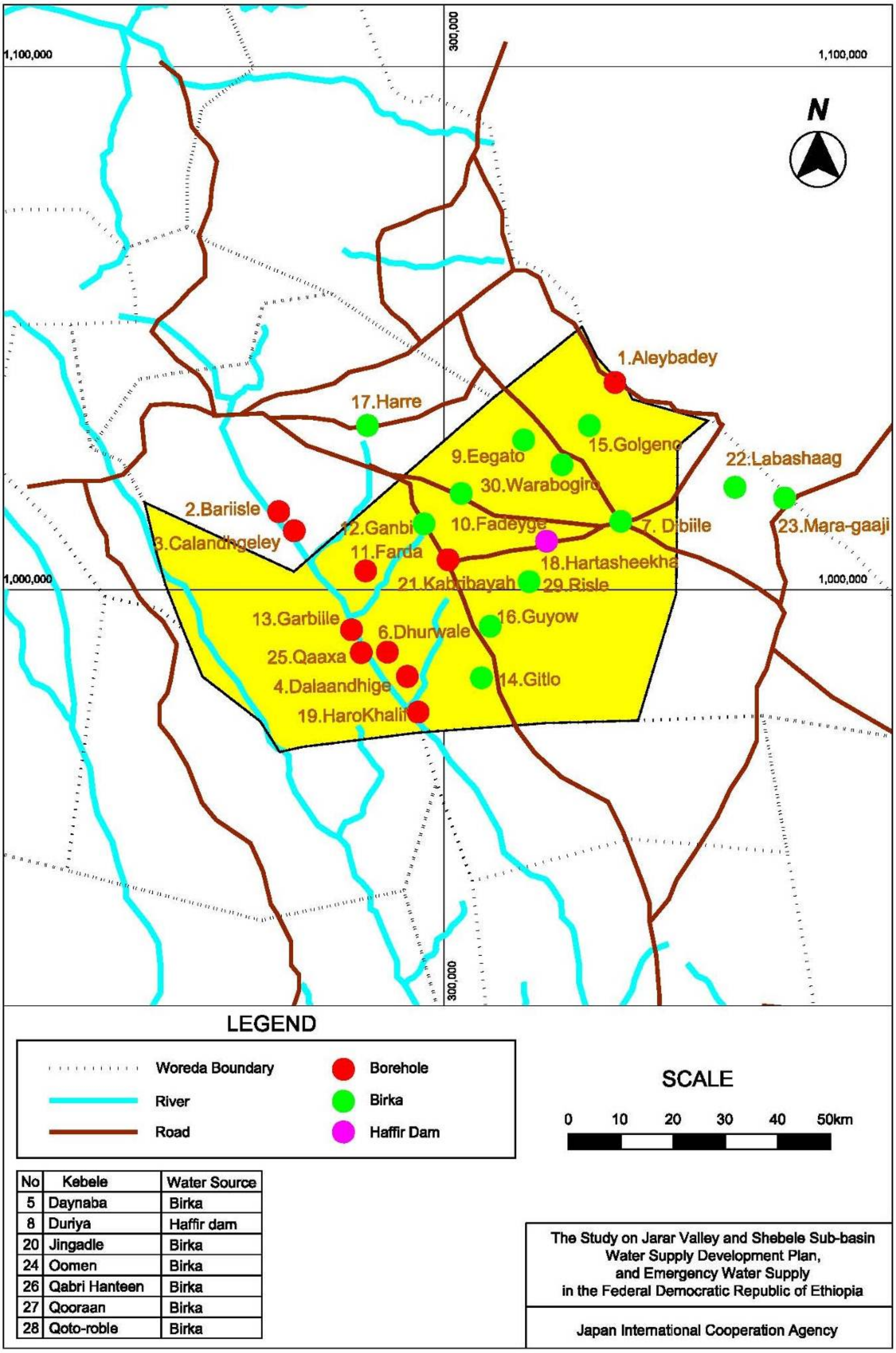


Figure 4.1: Kabribeyah Woreda Water Supply Plan

4.1.2 Cost estimation

The following subsections of “composition of the project cost”, “method of cost estimation”, “conditions for the cost estimation” apply to the cost estimation for all the woredas.

a. Composition of the project cost

The structure of project costs is illustrated in Figure 4.2.

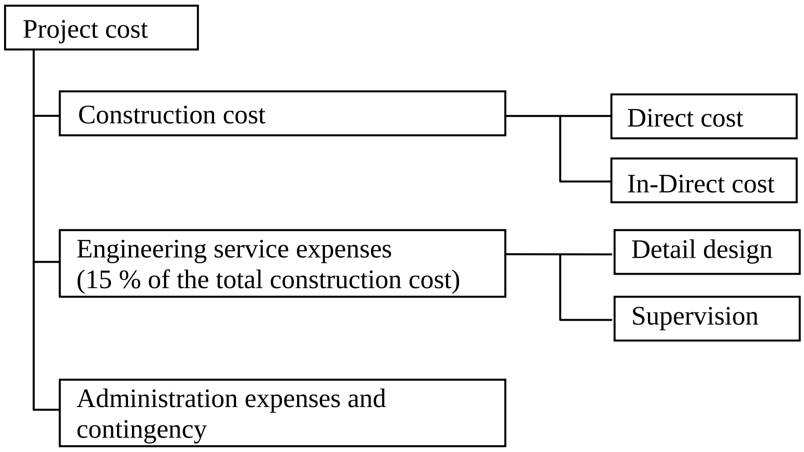


Figure 4.2: Component of the Project Cost

b. Method of cost estimation

b.1 Construction cost

Construction cost is mainly classified into direct cost and in-direct cost.

Direct cost means that the cost is needed directly to construct objects. Direct cost is estimated by multiplying the quantity of each construction item calculated based on the design by the unit cost of each construction item. Then the entire direct cost is estimated by totaling each estimated cost of construction items. In this study, the unit cost of each construction item was estimated based on the record of the pilot projects of water supply facilities construction and on price quotations from local construction companies. The unit cost of piping work greatly differs depending on the type of pipes. The pipes and fittings that will be used for the structural part of the intake, purification and transmission facilities and for the pipes of more than D200 diameter, are considered especially important components. Therefore, the pipes that have superior strength and durability such as ductile iron pipe (DIP) and stainless steel pipes were assumed to be employed for these important facilities. Unplasticized polyvinyl chloride pipe (uPVC pipe) and galvanized iron pipe (GI pipe) which are manufactured in Ethiopia, were selected for all the facilities that are less important.

In-direct cost comprises mainly of common temporary construction costs, field office expenses, and general management cost. In-direct cost is not directly related to work performance amount of the construction objects. In-direct cost is the cost that will be used commonly for the entire construction works. In-direct cost is estimated based on the cost estimation standard book that is published by Japan Small-scale Water Works Association. Calculation formula of in-direct cost is shown below.

In-direct cost = Common temporary construction cost (C) +Field office expenses (F)

+General management cost (G)

Common temporary construction cost (C) = Direct cost (D) * ratio of C
Ratio of C (%) = 485.4*D^ (-0.2231) + 1.0

Field office expenses (F) = (D+C) * ratio of F
Ratio of F (%) = 103.1*(D+T) ^ (-0.0977) + 0.5

General management cost (G) = (D+C+F) * ratio of G
Ratio of G (%) = -2.57651*Log (D+C+F) + 0.3163531

In-direct cost for Birka construction was estimated to be 15 % of the direct cost. In-direct cost for Haffir Dam construction was estimated to be 25 % of the direct cost.

b.2 Engineering service expenses

Engineering service expenses are estimated uniformly as 15 % of the construction cost.

b.3 Administration expenses and contingency

Administration expenses and contingency were estimated uniformity to be 10 % of the construction cost for expenses such as procedure of contract of design and construction works, consultation with the concerned parties, and contingency budget.

c. Condition for the cost estimation

- The project cost does not include value added tax (VAT) and land acquisition cost.
- The cost estimation is based on prices in May 2013.
- Exchange rate of local currency is USD 1.00 = 18.53 ETB as the average control rate from November 1, 2012 to April 30, 2013.
- Engineering service and the construction are assumed to be implemented by Ethiopian local companies.

d. Cost estimation

Estimated project cost of Kabribeyah woreda based on the water supply plan is shown in the following Table 4.2.

Table 4.2: Estimated Project Cost of Kabribeyah Woreda (Rural Area)

1. Kabribeyah

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Aleybadey	BH	1	346,000	52,000	35,000	433,000
2	Bariisle	BH	1	346,000	52,000	35,000	433,000
3	Calandhgeley	BH	1	308,000	46,000	31,000	385,000
4	Dalaandhige	BH	1	308,000	46,000	31,000	385,000
5	Daynaba	Birka	7	399,000	60,000	40,000	499,000
6	Dhurwale	BH	1	351,000	53,000	35,000	439,000
7	Dibiile	Birka	7	399,000	60,000	40,000	499,000
8	Duriya	Harrif dam	1	391,000	59,000	39,000	489,000
		Birka	1	57,000	9,000	6,000	72,000
9	Eegato	Birka	7	399,000	60,000	40,000	499,000
10	Fadeyge	Birka	7	399,000	60,000	40,000	499,000
11	Farda	BH	1	373,000	56,000	37,000	466,000
12	Ganbi	Birka	7	399,000	60,000	40,000	499,000
13	Garbiile	BH	1	373,000	56,000	37,000	466,000
14	Gitlo	Birka	8	456,000	68,000	46,000	570,000
15	Golgeno	Birka	7	399,000	60,000	40,000	499,000
16	Guyow	Birka	7	399,000	60,000	40,000	499,000
17	Harre	Birka	7	399,000	60,000	40,000	499,000
18	Hartasheekha	Haffir dam	2	782,000	117,000	78,000	977,000
19	Horo Khalif	BH	2	621,000	93,000	62,000	776,000
20	Jingadle	Birka	7	399,000	60,000	40,000	499,000
22	Labashaag	Birka	7	399,000	60,000	40,000	499,000
23	Mara-gaaji	Birka	7	399,000	60,000	40,000	499,000
24	Oomen	Birka	4	228,000	34,000	23,000	285,000
25	Qaaxa	BH	1	346,000	52,000	35,000	433,000
26	Qabri Hanteen	Birka	7	399,000	60,000	40,000	499,000
27	Qooraan	Birka	7	399,000	60,000	40,000	499,000
28	Qoto-roble	Birka	7	399,000	60,000	40,000	499,000
29	Risle	Birka	8	456,000	68,000	46,000	570,000
30	Warabogiro	Birka	7	399,000	60,000	40,000	499,000
(1) BH			10	3,372,000	506,000	338,000	4,216,000
(2) Birka			126	7,182,000	1,079,000	721,000	8,982,000
(3) Haffir dam			3	1,173,000	176,000	117,000	1,466,000
Total				11,727,000	1,761,000	1,176,000	14,664,000

4.1.3 Implementation Plan

The following policy of formulation of implementation plans and the resultant implementation plans for each type of facility are equally applied to all the woredas.

a. Policy of formulation for implementation plan

The implementation of water supply plans of this study is scheduled to commence from the year 2014 and to complete in order to achieve water demand of the target year of 2020. The following policy was taken into consideration in the formulation of implementation plan of all the water supply plans.

- To give priority of implementation of different facilities/plans in the following order: Urban water supply facility, borehole water supply facility and river water supply facility.

- To avoid concentration of facilities design and tender work in a specific year.
- To keep annual project cost as level as possible
- To divide the total construction cost of Birkas and Haffir Dams by implementation period of seven (7) years if construction of many Birkas and Haffir Dams are planned in a woreda.

b. Implementation schedule for each type of facility

b.1 Implementation schedule of borehole water supply facility

The implementation of the construction of a borehole water supply system is classified mainly into the design stage (design, tender documents preparation, tender, contract with a construction company), the well drilling stage (drilling and supervising), and the construction stage (implementation of the construction, experimental operation of the facility, completion, supervising of the construction). After well drilling is successfully completed, a pumping test is conducted. The specifications of the submersible pump will be decided based on the result of the pumping test, and then, the design of whole of water supply system will be conducted.

Implementation schedule of the designing, the well drilling (one - two wells for a facility) and the construction was estimated as shown in the following Table 4.3. The implementation will take 24 months.

Table 4.3: Implementation Schedule of Borehole Water Supply Facility

Item		Month 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Engineering service																									
1.1 Outline discussion of water supply facility		■	■																						
1.2 Selection of drilling site and point				■																					
1.3 Tender and contract for drilling works					■																				
1.4 Design of water supply facility										■	■														
1.5 Tender and contract for water supply construction works													■												
1.6 Supervision of the construction						■	■	■	■	■				■	■	■	■	■	■	■	■	■	■	■	■
2. Well drilling and construction																									
2.1 Well drilling																									
2.1.1 Preparation						■																			
2.1.2 Drilling works and pumping test							■	■	■																
2.1.3 Inspection and completion of drilling works										■															
2.2 Water supply facility construction																									
2.2.1 Preparation														■	■										
2.2.2 Pump house (Generator house), Reservoir	a. Main reinforced concrete works															■	■	■	■						
	b. Procurement of pump and generator													■	■	■	■	■	■						
	c. Installation of pump and generator																			■					
	d. Finishing works																				■	■			
2.2.3 Transmission・Distribution pipeline	a. Pipe and fittings procurement													■	■	■									
	b. Pipe installation																■	■	■	■					
2.2.4 Publictap and cattle trough	a. Public tap construction																			■	■	■			
	b. Cattle trough construction																						■	■	
	c. Pipe and fittings procurement													■	■	■									
2.2.5 Experimental operation・Inspection																								■	
2.2.6 Completion																									■

b.2 Implementation schedule of shallow well water supply facility

Implementation schedule of shallow well water supply facility is basically the same as the implementation schedule of the borehole water supply facility. Drilling depth of shallow well is shallower compared to that of the borehole water supply facility. Therefore, the implementation schedule is shorter by two months.

The implementation schedule of the design, the well drilling (one well for a facility) and the construction was estimated as shown in the following Table 4.4. The implementation will take 22 months.

Table 4.4: Implementation Schedule of Shallow Well Water Supply Facility

Item		Month																					
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1. Engineering service																							
1.1 Outline discussion of water supply facility		■	■																				
1.2 Selection of drilling site and point				■																			
1.3 Tender and contract for drilling works					■																		
1.4 Design of water supply facility								■	■														
1.5 Tender and contract for water supply construction works											■												
1.6 Supervision of the construction						■	■	■				■	■	■	■	■	■	■	■	■	■	■	■
2. Well drilling and construction																							
2.1 Well drilling																							
2.1.1 Preparation						■																	
2.1.2 Drilling works and pumping test							■																
2.1.3 Inspection and completion of drilling works								■															
2.2 Water supply facility construction																							
2.2.1 Preparation												■	■										
2.2.2 Pump house (Generator house), Reservoir	a. Main reinforced concrete works													■	■	■	■						
	b. Procurement of pump and generator											■	■	■	■	■	■						
	c. Installation of pump and generator																	■					
	d. Finishing works																		■	■			
2.2.3 Transmission・Distribution pipeline	a. Pipe and fittings procurement											■	■	■									
	b. Pipe installation														■	■	■	■					
2.2.4 Publictap and cattle trough	a. Public tap construction																	■	■	■			
	b. Cattle trough construction																			■	■		
	c. Pipe and fittings procurement											■	■	■									
2.2.5 Experimental operation・Inspection																						■	
2.2.6 Completion																							■

b.3 Implementation schedule of river water supply facility

The implementation of the construction of the river water supply facility consists mainly of the design stage (design, tender documents preparation, tender, contract with a construction company) and the construction stage (implementation of the construction, experimental operation of the facility, completion, supervising of the construction). For the implementation of the construction of a river water supply facility, it will take 12 months for the design and 18 months for the construction, thus a total of 30 months.

The implementation schedule of a river water supply facility is shown in the following Table 4.5.

Table 4.5: Implementation Schedule of River Water Supply Facility

Item		Month																													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
1. Engineering service																															
1.1 Design		■	■	■	■	■	■																								
1.2 Tender preparation								■	■																						
1.3 Tender												■																			
1.4 Contract with a local contractor													■																		
1.5 Supervision of the construction														■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2. Construction																															
2.1 Preparation														■	■																
2.2 Intake・Purification・Transmission facilities	a. Survey															■															
	b. Intake facility construction																■	■	■				■	■	■						
	c. Purification facility construction																			■	■	■				■	■	■	■		
	d. Transmission facility construction																■	■	■				■	■	■						
	e. Pump/Generator procurement																	■	■	■	■	■									
	f. Pump/Generator install																						■	■							
	g. Pipe and fittings procurement in Ethiopia																	■	■	■											
	h. Pipe and fittings procurement from foreign countries																	■	■	■	■	■									
2.3 Distribution facilities	a. Survey															■	■														
(including transmission pipe)	b. Facility construction																	■	■				■	■	■						
	c. Pipe and fittings procurement																	■	■	■											
	d. Pipe installation																				■	■	■	■							
2.4 Publictap and cattle trough	a. Survey															■	■														
	b. Public tap construction																			■	■	■									
	c. Cattle trough construction																									■					
	d. Pipe and fittings procurement in Ethiopia																	■	■	■											
2.5 Experimental operation・Inspection																														■	
2.6 Completion																															■

b.4 Implementation schedule of Birka

The implementation schedule of design and construction of a Birka is shown in Table 4.6 below. It will take 12 months to construct one facility.

Table 4.6: Implementation Schedule of Birka

Item		Month											
		1	2	3	4	5	6	7	8	9	10	11	12
1.Engineering service													
1.1 Outline discussion of water supply facility													
1.2 Sellection of site and design													
1.3 Tender and contract with a local contractor													
1.4 Supervision of the construction													
2. Birka construction													
2.1 Preparation													
2.2 Construction	a. Excavation												
	b. Finishing works												
2.3 Experimental operation・Inspection													
2.4 Completion													

b.5 Implementation schedule of Haffir Dam

The implementation schedule of design and construction of a Haffir Dam is shown in the following Table 4.7. It will take 24 months to construct one facility. The total amount of excavation for the construction of a Haffir Dam will be approximately 27,000 m^3 due to the large reservoir capacity. Therefore the excavation will especially take time.

Table 4.7: Implementation Schedule of Haffir Dam

Item		Month																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1.Engineering service																									
1.1 Outline discussion of water supply facility																									
1.2 Sellectio of site and design																									
1.3 Tender and contract with a local contractor																									
1.6 Supervision of the construction																									
2. Haffir Dam construction																									
2.1 Preparation																									
2.2 Construction	a. Excavation																								
	b. Finishing works																								
2.3 Experimental operation・Inspection																									
2.4 Completion																									

c. Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated project cost for each year are shown in the following Table 4.8. Nine borehole systems will be designed and be constructed from 2015 to 2020. As for the birkas and haffir dams, the required numbers will be constructed during the implementation period (2014 - 2020).

Table 4.8: Implementation Schedule and Estimated Project Cost for Each Year

1. Kabribeyah woreda (not including town)		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Borehole water supply facility									
2015~2016 implementation	2 facility								
2016~2017 implementation	2 facility								
2017~2018 implementation	2 facility								
2018~2019 implementation	2 facility								
2019~2020 implementation	2 facility								
total	10 facility								
Construction cost			337,000	674,000	674,000	674,000	674,000	339,000	3,372,000
Engineering service expenses			51,000	101,000	101,000	101,000	101,000	51,000	506,000
Administration expenses and contingency			34,000	67,000	67,000	67,000	67,000	36,000	338,000
sub-total			**422,000**	**842,000**	**842,000**	**842,000**	**842,000**	**426,000**	**4,216,000**
(2) Birka									
average per year	18 facility								
Total	126 facility								
Construction cost		1,026,000	1,026,000	1,026,000	1,026,000	1,026,000	1,026,000	1,026,000	7,182,000
Engineering service expenses		154,000	154,000	154,000	154,000	154,000	154,000	155,000	1,079,000
Administration expenses and contingency		103,000	103,000	103,000	103,000	103,000	103,000	103,000	721,000
sub-total		**1,283,000**	**1,283,000**	**1,283,000**	**1,283,000**	**1,283,000**	**1,283,000**	**1,284,000**	**8,982,000**
(3) Haffir dam									
average per year	0.4 facility								
Total	3 facility								
Construction cost		168,000	168,000	168,000	168,000	168,000	168,000	165,000	1,173,000
Engineering service expenses		25,000	25,000	25,000	25,000	25,000	25,000	26,000	176,000
Administration expenses and contingency		17,000	17,000	17,000	17,000	17,000	17,000	15,000	117,000
sub-total		**210,000**	**210,000**	**210,000**	**210,000**	**210,000**	**210,000**	**206,000**	**1,466,000**
Total		**1,493,000**	**1,915,000**	**2,335,000**	**2,335,000**	**2,335,000**	**2,335,000**	**1,916,000**	**14,664,000**

4.2 Araarso woreda

4.2.1 Water supply plan

a. Urban water supply

The urban area (town) of Araarso woreda is located along the highway and it is approximately 10km away from the Jarar River. Served population in 2020 was set as 8,106 persons. Design average daily supply is estimated to be 255m^3/day and water supply facilities were designed to be 383m^3/day. The existing boreholes are developed around 4km away from the town. New boreholes are planned to be developed near the existing boreholes. Six boreholes with 1.8lit/sec yield and 250m depth are planned to supply water to the town population. Due to long distance from the boreholes to the town, transmission pipeline for the reservoir shall be required. Raw water from boreholes is to be stored at the surface pump station temporarily and then transmitted to the reservoir in the town like Kabribeyah water supply system. Surface pump station is planned to provide 2 pumps with 0.6m^3/min discharge volume and 130m height. One pump can have enough capacity to supply water to the reservoir and the other is provided for backup purposes. Raw water is lifted up to the town reservoir with 500m^3 volume through 4km transmission pipeline with 110mm diameter. Water is stored at the reservoir and is distributed through the existing pipelines. 10 public taps and 2 cattle troughs are provided in the town in order that beneficiaries can access to water. Major features of the Araarso water supply plan are summarized in Table 4.9.

Table 4.9: Features of Araarso Town Water Supply System General Design

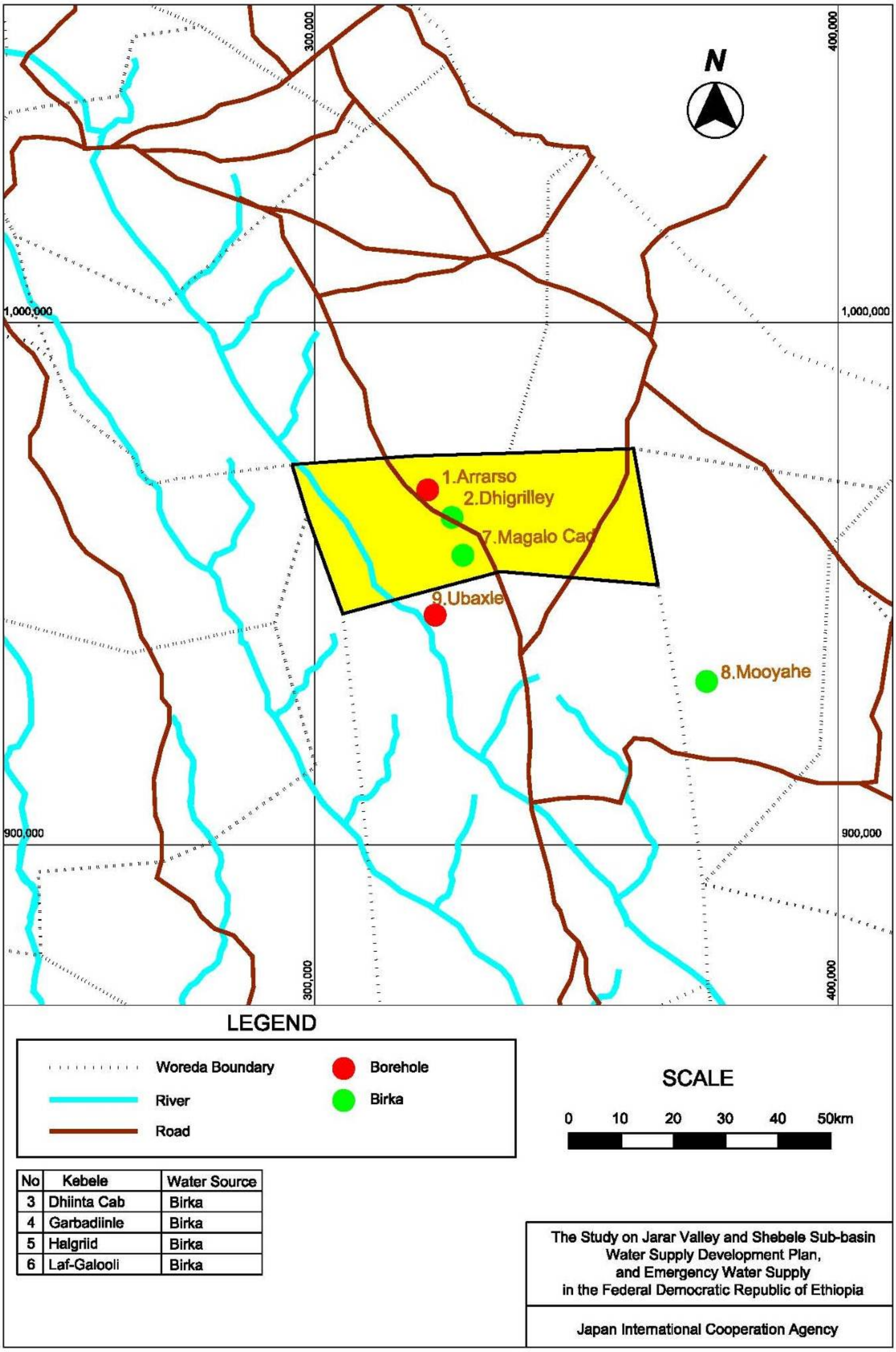
No.	Item	Specifications	Unit	Q'ty
1.	Submergible pump	Q=0.10m^3/min, H=240m	No.	6
2.	Generator	40kVA	No.	6
3.	Transmission pipeline from BH to pump station			
3.1		90mm	m	3,200
3.2		110mm	m	3,500
4.	Surface pump station			
4.1	Reservoir		m^3	70
4.2	Surface pump	Q=0.60m^3/min, H=130m	No.	2
4.3	Generator	81kVA	No.	1
5.	Transmission pipeline from surface pump station to reservoir			
5.1		110mm	m	4,000
6.	Reservoir	500m^3	No.	1
7.	Distribution system			-
7.1	Pipeline	90mm	m	5,000
7.2	Public tap		No.	10
7.3	Cattle trough		No.	2

b. Rural water supply

Water supply master plan in Araarso woreda is illustrated in Figure 4.3. Borehole development is planned for No.9 Ubaxle only where it is located along the Jarar River. Other 7 kebeles are apart from the river, therefore it is in difficult condition to develop groundwater for them. Rainwater development is the sole water resource for them. Served population is between 900 and 1,200 persons for all kebeles, and four birkas are designed for all kebeles. General features of each kebele water supply plan are tabulated in Table 4.10.

Table 4.10: Features of Araarso Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served Pop.	Facilities	Q	Gen.	Pipe dia.	Dis. Pipe	Public tap	Cattle trough
			person	No.	m^3/m	kVA	mm	m	No.	No.
2	Dhigrilley	Birka	965	4						
3	Dhiinta Cab	Birka	965	4						
4	Garbadiinle	Birka	965	4						
5	Halgriid	Birka	965	4						
6	Laf-Galooli	Birka	965	4						
7	Magalo Cad	Birka	965	4						
8	Mooyahe	Birka	1,196	4						
9	Ubaxle	Borehole	965	1	0.1	40	40	400	2	1



No	Kebele	Water Source
3	Dhiinta Cab	Birka
4	Garbadiinle	Birka
5	Halgriid	Birka
6	Laf-Galooli	Birka

Figure 4.3: Araarso Woreda Water Supply Plan

4.2.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.11.

Table 4.11: Estimated Project Cost for Araarso Woreda

2. Araarso

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	**Araarso**	BH	1	2,526,000	379,000	253,000	3,158,000
2	Dhigrilley	Birka	4	228,000	34,000	23,000	285,000
3	Dhiinta Cab	Birka	4	228,000	34,000	23,000	285,000
4	Garbadiinle	Birka	4	228,000	34,000	23,000	285,000
5	Halgriid	Birka	4	228,000	34,000	23,000	285,000
6	Laf-Galooli	Birka	4	228,000	34,000	23,000	285,000
7	Magalo Cad	Birka	4	228,000	34,000	23,000	285,000
8	Mooyahe	Birka	4	228,000	34,000	23,000	285,000
9	Ubaxle	BH	1	319,000	48,000	32,000	399,000
(1) Urban water supply			1	2,526,000	379,000	253,000	3,158,000
(2) Borehole			1	319,000	48,000	32,000	399,000
(3) Birka			28	1,596,000	238,000	161,000	1,995,000
Total				4,441,000	665,000	446,000	5,552,000

4.2.3 Implementation Plan

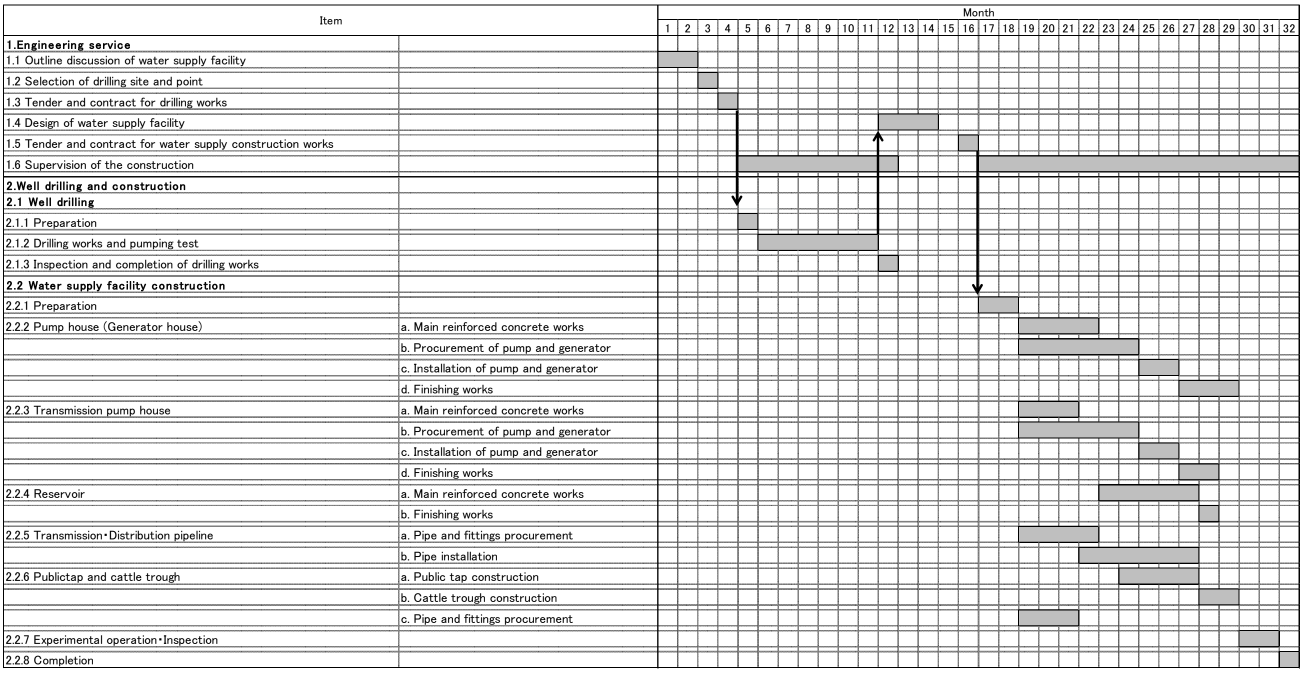
a. Implementation schedule of water supply plan

a.1 Implementation schedule of urban water supply plan

The implementation of the construction of the water supply facility comprises mainly of the design stage (design, tender documents preparation, tender, contract with a construction company), the well drilling stage (drilling and supervising), and the construction stage (implementation of the construction, experimental operation of the facility, completion, supervising of the construction). After successful well drilling, pumping test is conducted. The specification of submersible pumps will be decided based on the result of the pumping test, and the design of whole water supply facility will be prepared.

For the implementation of the construction of urban water supply system, it will take 16 months for the design including drilling of six (6) wells and 16 months for the construction, thus a total of 32 months. The implementation schedule of the urban water supply system is shown in the following Table 4.12.

Table 4.12: Implementation Schedule of Urban Water Supply System



a.2 Implementation schedule of rural water supply

It will take 24 months to design and construct a borehole water supply facility (refer to Table 4.13). It will take 12 months to design and construct a Birka (refer to Table 4.6).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated annual project cost are shown in the following Table 4.13.

Table 4.13: Implementation Schedule and Estimated Project Cost for Each Year

2. Araarso		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (BH)									
2015~2017 implementation	1 facility								
Construction cost			842,000	842,000	842,000				2,526,000
Engineering service expenses			126,000	126,000	127,000				379,000
Administration expenses and contingency			84,000	84,000	85,000				253,000
sub-total			**1,052,000**	**1,052,000**	**1,054,000**				**3,158,000**
(2) Borehole water supply facility									
2018~2019 implementation	1 facility								
Construction cost						160,000	159,000		319,000
Engineering service expenses						24,000	24,000		48,000
Administration expenses and contingency						16,000	16,000		32,000
sub-total						**200,000**	**199,000**		**399,000**
(3) Birka									
average per year	4 facility								
Total	28 facility								
Construction cost		228,000	228,000	228,000	228,000	228,000	228,000	228,000	1,596,000
Engineering service expenses		34,000	34,000	34,000	34,000	34,000	34,000	34,000	238,000
Administration expenses and contingency		23,000	23,000	23,000	23,000	23,000	23,000	23,000	161,000
sub-total		**285,000**	**285,000**	**285,000**	**285,000**	**285,000**	**285,000**	**285,000**	**1,995,000**
Total		**285,000**	**1,337,000**	**1,337,000**	**1,339,000**	**485,000**	**484,000**	**285,000**	**5,552,000**

4.3 Dagahbur woreda

4.3.1 Water supply plan

a. Urban water supply

Dagahbur town is located close to the Jarar River and its distance is less than 1km. It is also along the highway. Served population in 2020 was set as 26,829 persons. Design average daily supply is estimated to be 851m^3/day. Projected population in 2020 is 87,425 persons. Due to more than 50,000 people in 2020, peak factor, 1.2, is adopted and water supply facilities were designed to be 1,021m^3/day. There are six existing boreholes to supply water to the Dagahbur town and surrounding areas, however, they cannot satisfy the water demand in 2020. Thus, new boreholes are planned along with the Jarar River. Six boreholes with 4.7lit/sec yield and 70m depth are planned additionally for the Dagahbur town water supply. Because the Dagahbur town stands close to the Jarar River, raw water from each borehole flows to trunk transmission pipeline and pours into the reservoir. The town has two existing elevated reservoirs with a capacity of 100m^3 and 250m^3 respectively. The reservoir volume of 2020 is 900m^3, therefore, 550m^3 capacity reservoir is planned for the water supply plan. The existing distribution pipeline system is about 12km ranging from 50mm to 100mm diameter. They are dead end type and do not cover much of the town. It is not adequate to use the present distribution pipeline system for the plan in comparison with the town scale. SRWDB has prepared the distribution pipeline system design. It covers whole Dagahbur town and is appropriate to improve the town water supply system. Thus, it is adopted as the distribution pipeline general design. SRWDB estimated that 7 public taps shall be necessary by 2024. The Study follows their design, 7 public taps and 2 cattle troughs are planned for Dagahbur town. Major features of the Dagahbur water supply plan are summarized in Table 4.14 and its outline is illustrated in Figure 4.4.

Table 4.14: Features of Dagahbur Town Water Supply System General Design

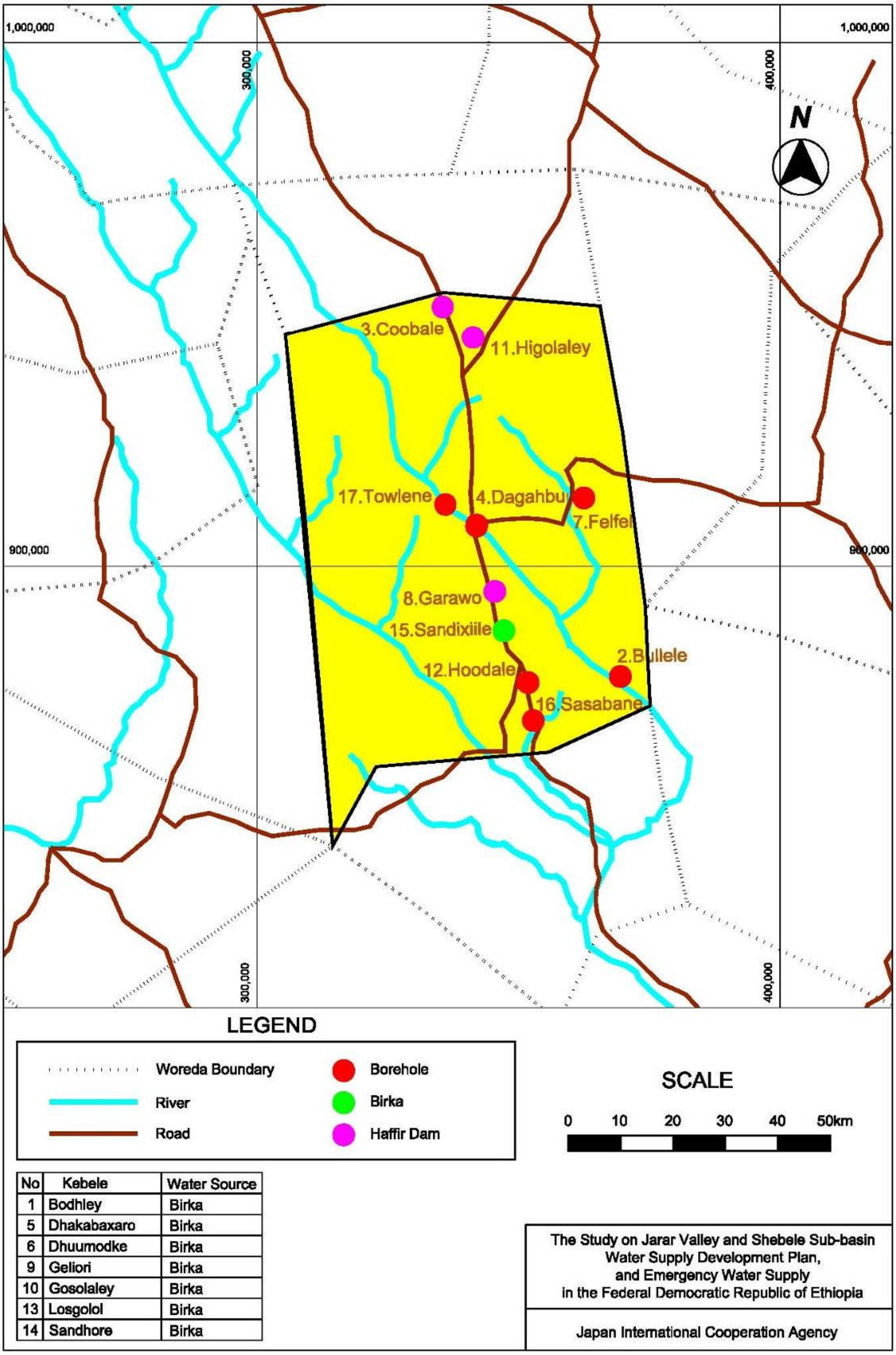
No.	Item	Specifications	Unit	Q'ty
1.	Submergible pump	Q=0.30m^3/min, H=60m	No.	6
2.	Generator	37 kVA	No.	6
3.	Transmission pipeline from BH to pump station			
3.1		90 mm	m	3,200
3.2		110 mm	m	3,000
3.3		160 mm	m	1,500
4.	Reservoir	550 m^3	No.	1
5.	Distribution system			-
5.1	Pipeline	50 mm	m	5,980
5.2		90 mm	m	9,590
5.3		110 mm	m	3,190
5.4		160 mm	m	1,970
5.5		200 mm	m	700
5.6		250 mm	m	870
5.7		300 mm	m	320
5.8	Public tap		No.	7
5.9	Cattle trough		No.	2

b. Rural water supply

There are 16 kebeles in total. Borehole development is applied to 5 kebeles because they are located along the Jarar River and its branch rivers. Other 11 kebeles have to depend on rainwater development. Beneficiaries of No.3 Coobale, No.8 Garawo and No.11 Higolaley exceed 2,500 persons, haffir dam is planned for them. No.3 Coobale is the biggest population in the Dagahbur woreda. Their service population is 6,208 persons, 2 haffir dams and 4 birkas are planned for them. No.8 Garawo and No.11 Higolaley plan 1 haffir dam and several birkas. Remaining 8 kebeles are supplied by birka and its quantities range from 1 to 3 birkas. General features of each kebele water supply plan are tabulated in Table 4.15.

Table 4.15: Features of Dagahbur Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Q	Gen.	Pipe dia.	Dis. Pipe	Public tap	Cattle trough
			person	No.	m^3/m	kVA	mm	m	No.	No.
1	Bodhley	Birka	544	2						
2	Bullele	Borehole	2,327	1	0.20	27	65	600	3	1
3	Coobale	Haffir dam Birka	6,208	2 4						
5	Dhakabaxaro	Birka	671	3						
6	Dhuumodke	Birka	567	2						
7	Felfel	Borehole	506	1	0.10	17	40	200	1	1
8	Garawo	Haffir dam Birka	3,621	1 6						
9	Geliori	Birka	336	2						
10	Gosolaley	Birka	776	3						
11	Higolaley	Haffir dam Birka	4,139	1 4						
12	Hoodale	Borehole	4,656	1	0.30	37	80	1200	6	2
13	Losgolol	Birka	85	1						
14	Sandhore	Birka	54	1						
15	Sandixiile	Birka	622	3						
16	Sasabane	Borehole	1,034	1	0.10	17	40	400	2	1
17	Towlene	Borehole	216	1	0.10	17	40	200	1	1



No	Kebele	Water Source
1	Bodhley	Birka
5	Dhakabaxaro	Birka
6	Dhuumodke	Birka
9	Geliori	Birka
10	Gosolaley	Birka
13	Losgolol	Birka
14	Sandhore	Birka

Figure 4.4: Dagahbur Woreda Water Supply Plan

4.3.2 Cost estimation

Estimated project cost for this woreda is shown in the following Table 4.16.

Table 4.16: Estimated Project Cost of Dagahbur Woreda

3. Dagahbur

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Bodhley	Birka	2	114,000	17,000	11,000	142,000
2	Bullele	BH	1	233,000	35,000	23,000	291,000
3	Coobale	Haffir dam	2	782,000	117,000	78,000	977,000
		Birka	4	228,000	34,000	23,000	285,000
4	**Dagahbur**	BH	1	2,720,000	408,000	272,000	3,400,000
5	Dhakabaxaro	Birka	3	171,000	26,000	17,000	214,000
6	Dhuumodke	Birka	2	114,000	17,000	11,000	142,000
7	Felfel	BH	1	189,000	28,000	19,000	236,000
8	Garawo	Haffir dam	1	391,000	59,000	39,000	489,000
		Birka	6	342,000	51,000	34,000	427,000
9	Geliori	Birka	2	114,000	17,000	11,000	142,000
10	Gosolaley	Birka	3	171,000	26,000	17,000	214,000
11	Higolaley	Haffir dam	1	391,000	59,000	39,000	489,000
		Birka	4	228,000	34,000	23,000	285,000
12	Hoodale	BH	1	292,000	44,000	29,000	365,000
13	Losgolol	Birka	1	57,000	9,000	6,000	72,000
14	Sandhore	Birka	1	57,000	9,000	6,000	72,000
15	Sandixiile	Birka	3	171,000	26,000	17,000	214,000
16	Sasabane	BH	1	211,000	32,000	21,000	264,000
17	Towlene	BH	1	200,000	30,000	20,000	250,000
(1) Urban water supply			1	2,720,000	408,000	272,000	3,400,000
(2) Borehole			5	1,125,000	169,000	112,000	1,406,000
(3) Birka			31	1,767,000	266,000	176,000	2,209,000
(4) Haffir dam			4	1,564,000	235,000	156,000	1,955,000
Total				7,176,000	1,078,000	716,000	8,970,000

4.3.3 Implementation Plan

a. Implementation schedule of water supply plan

a.1 Implementation schedule of urban water supply plan

The implementation schedule of this urban water supply system is the same as that of Araarso woreda. It will take 32 months to construct the system (refer to Table 4.12).

a.2 Implementation schedule of rural water supply plan

It will take 24 months to design and construct a borehole water supply facility (refer to Table 4.3). It will take 12 months to design and construct a Birka (refer to Table 4.6). It will take 24 months to design and construct a Haffir dam (refer to Table 4.7)..

b. Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated annual project cost are shown in the following Table 4.17.

Table 4.17: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

3. Dagahbur		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (BH)									
2015~2017 implementation	1 facility								
Construction cost			907,000	907,000	906,000				2,720,000
Engineering service expenses			136,000	136,000	136,000				408,000
Administration expenses and contingency			91,000	91,000	90,000				272,000
sub-total			**1,134,000**	**1,134,000**	**1,132,000**				**3,400,000**
(2) Borehole water supply facility									
2015~2016 implementation	1 facility								
2017~2018 implementation	2 facility								
2019~2020 implementation	2 facility								
Total	5 facility								
Construction cost			113,000	113,000	225,000	225,000	225,000	224,000	1,125,000
Engineering service expenses			17,000	17,000	34,000	34,000	34,000	33,000	169,000
Administration expenses and contingency			11,000	11,000	23,000	23,000	23,000	21,000	112,000
sub-total			**141,000**	**141,000**	**282,000**	**282,000**	**282,000**	**278,000**	**1,406,000**
(3) Birka									
average per year	4.4 facility								
Total	31 facility								
Construction cost		252,000	252,000	252,000	252,000	252,000	252,000	255,000	1,767,000
Engineering service expenses		38,000	38,000	38,000	38,000	38,000	38,000	38,000	266,000
Administration expenses and contingency		25,000	25,000	25,000	25,000	25,000	25,000	26,000	176,000
sub-total		**315,000**	**315,000**	**315,000**	**315,000**	**315,000**	**315,000**	**319,000**	**2,209,000**
(3) Haffir dam									
average per year	0.6 facility								
Total	4 facility								
Construction cost		223,000	223,000	223,000	223,000	223,000	223,000	226,000	1,564,000
Engineering service expenses		34,000	34,000	34,000	34,000	34,000	34,000	31,000	235,000
Administration expenses and contingency		22,000	22,000	22,000	22,000	22,000	22,000	24,000	156,000
sub-total		**279,000**	**279,000**	**279,000**	**279,000**	**279,000**	**279,000**	**281,000**	**1,955,000**
Total		**594,000**	**1,869,000**	**1,869,000**	**2,008,000**	**876,000**	**876,000**	**878,000**	**8,970,000**

4.4 Birqod woreda

4.4.1 Water supply plan

a. Urban water supply

The urban area (town) of Birqod woreda is located on the highway and the Jarar River flows from north-east to south direction of the town. The distance between the Birqod town and the Jarar River is about 400m. Served population in 2020 was set as 3,861 persons. Design average daily supply was estimated to be 127m^3/day and water supply facilities were designed to be 190m^3/day. There is one existing borehole supplying water for the Birqod town. Two boreholes with 2.6lit/s and 60m depth are planned along the Jarar River. Due to short distance from borehole location to the town, raw water from each borehole flows to transmission pipeline and pours into the reservoir. The reservoir volume is designed to be 200m^3. The distribution pipeline with 90mm extends from the existing distribution pipeline and connects to public taps and a cattle trough. 5 public taps and 1 cattle trough are planned for Birqod town. Major features of the Birqod water supply plan are summarized in Table 4.18.

Table 4.18: Features of Birqod Town Water Supply System General Design

No.	Item	Specifications	Unit	Q'ty
1.	Submergible pump	Q=0.20m^3/min, H=50m	No.	2
2.	Generator	13 kVA	No.	2
3.	Transmission pipeline from BH to pump station			
3.1		90 mm	m	1,400
3.2		110 mm	m	1,000
4.	Reservoir	200 m^3	No.	1
5.	Distribution system			-
5.1	Pipeline	90 mm	m	2,500
5.2	Public tap		No.	5
5.3	Cattle trough		No.	1

b. Rural water supply

Water supply master plan in Birqod woreda is illustrated in Figure 4.5. There are 6 kebeles in total. Borehole development is planned for 4 kebeles. Three of them are located along the Jarar River streams. Though No.5 Gorgain kebele is not located on the Jarar River streams, the existing borehole is functioning and supplies water to population. Therefore, borehole development is formulated. Remaining 2 kebeles do not exist close to the river, rainwater development is applied and 2 birkas are designed. General features of each kebele water supply plan are tabulated in Table 4.19.

Table 4.19: Features of Birqod Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Q	Gen.	Pipe dia.	Dis. Pipe	Public tap	Cattle trough
			person	No.	m^3/m	kVA	mm	m	No.	No.
1	Baka	Borehole	890	1	0.10	8	40	200	1	1
3	Cellxaer	Birka	579	2						
4	Goomaar	Borehole	579	1	0.10	8	40	200	1	1
5	Gorgain	Borehole	579	1	0.10	8	40	200	1	1
6	Hiigley	Borehole	579	1	0.10	8	40	200	1	1
7	Xidhgalool	Birka	579	2						

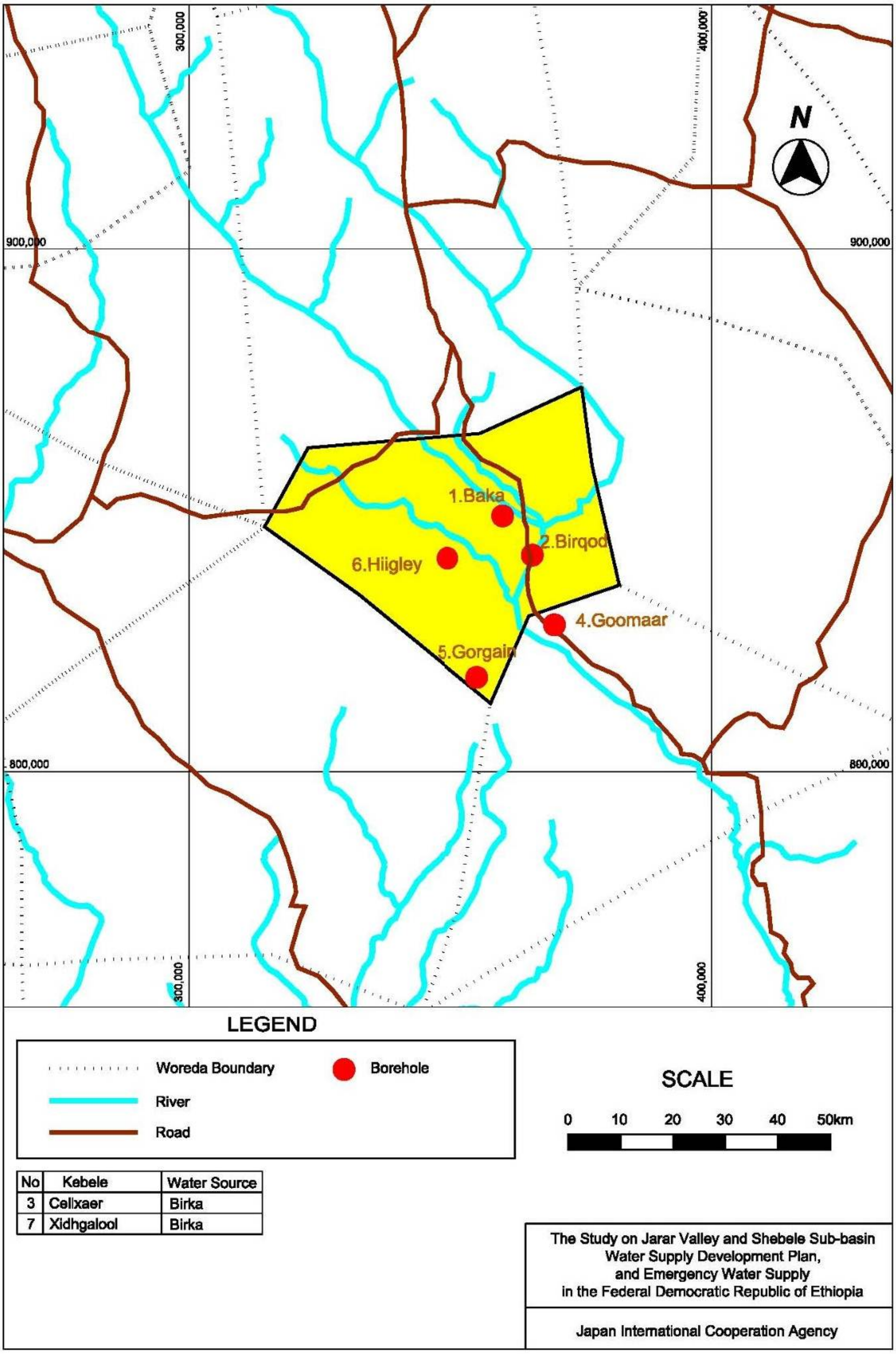


Figure 4.5: Birqod Woreda Water Supply Plan

4.4.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.20.

Table 4.20: Estimated Project Cost for Birqod Woreda

4. Birqod

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Baka	BH	1	152,000	23,000	15,000	190,000
2	**Birqud**	BH	1	513,000	77,000	51,000	641,000
3	Cellxaer	Birka	2	114,000	17,000	11,000	142,000
4	Goomaar	BH	1	152,000	23,000	15,000	190,000
5	Gorgain	BH	1	152,000	23,000	15,000	190,000
6	Hiigley	BH	1	152,000	23,000	15,000	190,000
7	Xidhgalool	Birka	2	114,000	17,000	11,000	142,000
(1) Urban water supply			1	513,000	77,000	51,000	641,000
(2) Borehole			4	608,000	92,000	60,000	760,000
(3) Birka			4	228,000	34,000	22,000	284,000
Total				1,349,000	203,000	133,000	1,685,000

4.4.3 Implementation Plan

a. Implementation schedule of water supply plan

It will take 24 months to design and construct a urban water supply system and a borehole water supply facility (refer to Table 4.3). A birka will take 12 months from design to completion (refer to Table 4.6).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated project cost for each year is shown in the following Table 4.21.

Table 4.21: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

4. Birqod		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (BH)									
2015~2016 implementation	1 facility								
Construction cost			257,000	256,000					513,000
Engineering service expenses			39,000	38,000					77,000
Administration expenses and contingency			26,000	25,000					51,000
sub-total			**322,000**	**319,000**					**641,000**
(2) Borehole water supply facility									
2017~2018 implementation	2 facility								
2019~2020 implementation	2 facility								
Total	4 facility								
Construction cost					152,000	152,000	152,000	152,000	608,000
Engineering service expenses					23,000	23,000	23,000	23,000	92,000
Administration expenses and contingency					15,000	15,000	15,000	15,000	60,000
sub-total					**190,000**	**190,000**	**190,000**	**190,000**	**760,000**
(3) Birka									
average per year	0.6 facility								
Total	4 facility								
Construction cost		33,000	33,000	33,000	33,000	33,000	33,000	30,000	228,000
Engineering service expenses		5,000	5,000	5,000	5,000	5,000	5,000	4,000	34,000
Administration expenses and contingency		3,000	3,000	3,000	3,000	3,000	3,000	4,000	22,000
sub-total		**41,000**	**41,000**	**41,000**	**41,000**	**41,000**	**41,000**	**38,000**	**284,000**
Total		**41,000**	**363,000**	**360,000**	**231,000**	**231,000**	**231,000**	**228,000**	**1,685,000**

4.5 Shaygosh woreda

4.5.1 Water supply plan

a. Urban water supply

The urban area (town) of Shaygosh woreda is located on the highway and the Jarar River flows from north-west to south east direction 4km away from the town. Served population in 2020 was set as 4,826 persons. Design average daily supply was estimated to be 167m^3/day and water supply facilities were designed to be 251m^3/day. There are three borehole developments conducted and one developed borehole is still functional where it is around 400m away from the highway. The water supply plan formulates that two boreholes with 3.5lit/s and 140m depth will be developed and their location is close to the existing one. Shaygosh water supply system is similar to the Birqod water supply system. Both flow diagrams are the same style, each specification is different. For example, Shaygosh plan has deeper borehole and large yield. Major features of the Shaygosh town water supply plan are summarized in Table 4.22.

Table 4.22: Features of Shaygosh Water Supply System General Design

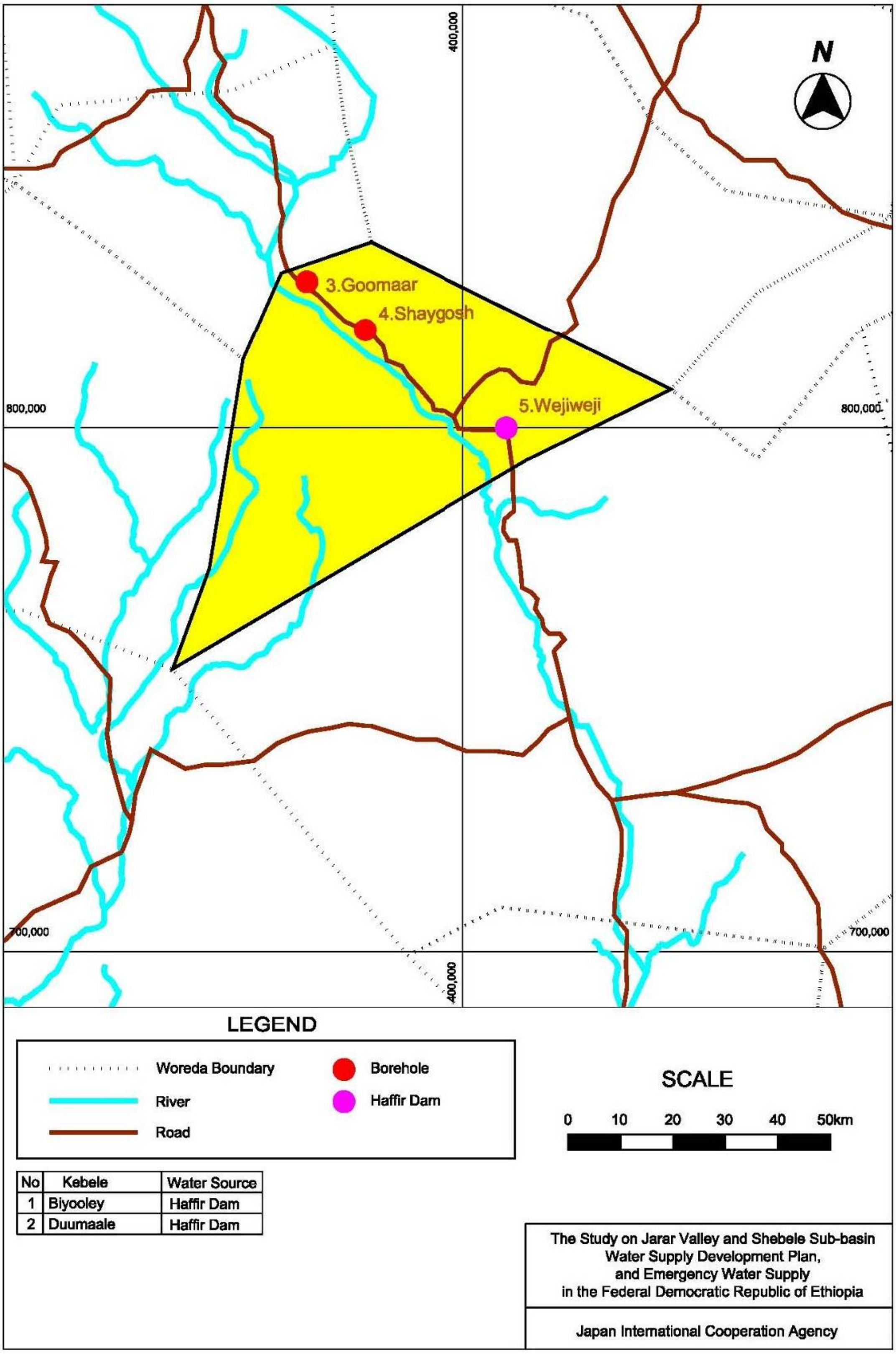
No.	Item	Specifications	Unit	Q'ty
1.	Submersible pump	Q=0.25m^3/min,H=130m	No.	2
2.	Generator	44kVA	No.	2
3.	Transmission pipeline from BH to pump station			
3.1		90mm	m	1,400
3.2		110mm	m	1,500
4.	Reservoir	300m^3	No.	1
5.	Distribution system			-
5.1	Pipeline	90mm	m	3,000
5.2	Public tap		No.	6
5.3	Cattle trough		No.	2

b. Rural water supply

Water supply master plan in Shaygosh woreda is illustrated in Figure 4.6. There are 4 kebeles in total. Borehole development is applied to No.3 Goomaar since it is located close to the Jarar River. Other 3 kebeles are not near the river, therefore rainwater development is adopted. Served population of them are more than 4,000 persons, therefore haffir dams were adopted. No.5 Wejiweji has the largest beneficiaries 5,373 persons and is planned to develop 2 haffir dams. General features of each kebele water supply plan are tabulated in Table 4.23.

Table 4.23: Features of Shaygosh Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Q	Gen.	Pipe dia.	Dis. Pipe	Public tap	Cattle trough
			person	No.	m^3/m	kVA	mm	m	No.	No.
1	Biyooley	Haffir dam Birka	4,459	1 7						
2	Duumaale	Haffir dam Birka	4,459	1 7						
3	Goomaar	Borehole	5,373	2	0.20	35	65	600	3	1
5	Wejiweji	Haffir dam Birka	5,373	2 2						



No	Kebele	Water Source
1	Biyooley	Haffir Dam
2	Duumaale	Haffir Dam

Figure 4.6: Shaygosh Woreda Water Supply Plan

4.5.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.24.

Table 4.24: Estimated Project Cost of Shaygosh Woreda

5. Shaygosh

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Biyooley	Haffir dam	1	391,000	59,000	39,000	489,000
		Birka	7	399,000	60,000	40,000	499,000
2	Duumaale	Haffir dam	1	391,000	59,000	39,000	489,000
		Birka	7	399,000	60,000	40,000	499,000
3	Goomaar	BH	2	486,000	73,000	49,000	608,000
4	**Shaygosh**	BH	1	724,000	109,000	72,000	905,000
5	Wejiweji	Haffir dam	2	782,000	117,000	78,000	977,000
		Birka	2	114,000	17,000	11,000	142,000
(1) Urban water supply			1	724,000	109,000	72,000	905,000
(2) Borehole			2	486,000	73,000	49,000	608,000
(3) Birka			16	912,000	137,000	91,000	1,140,000
(4) Haffir dam			4	1,564,000	235,000	156,000	1,955,000
Total				3,686,000	554,000	368,000	4,608,000

4.5.3 Implementation Plan

a. Implementation schedule of water supply plan

It will take 24 months to design and construct a borehole water supply facility (refer to Table 4.3). It will take 12 months to design and construct a Birka (refer to Table 4.6). It will take 24 months from the design to completion of a Haffir dam (refer to Table 4.7). Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated project cost for each year are shown in the following Table 4.25.

Table 4.25: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

5. Shaygosh		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (BH)									
2015~2016 implementation	1 facility								
Construction cost			362,000	362,000					724,000
Engineering service expenses			55,000	54,000					109,000
Administration expenses and contingency			36,000	36,000					72,000
sub-total			**453,000**	**452,000**					**905,000**
(2) Borehole water supply facility									
2017~2020 implementation	2 facility								
Construction cost					122,000	122,000	122,000	120,000	486,000
Engineering service expenses					18,000	18,000	18,000	19,000	73,000
Administration expenses and contingency					12,000	12,000	12,000	13,000	49,000
sub-total					**152,000**	**152,000**	**152,000**	**152,000**	**608,000**
(3) Birka									
average per year	2.3 facility								
Total	16 facility								
Construction cost		130,000	130,000	130,000	130,000	130,000	130,000	132,000	912,000
Engineering service expenses		20,000	20,000	20,000	20,000	20,000	20,000	17,000	137,000
Administration expenses and contingency		13,000	13,000	13,000	13,000	13,000	13,000	13,000	91,000
sub-total		**163,000**	**163,000**	**163,000**	**163,000**	**163,000**	**163,000**	**162,000**	**1,140,000**
(4) Haffir dam									
average per year	0.6 facility								
Total	4 facility								
Construction cost		223,000	223,000	223,000	223,000	223,000	223,000	226,000	1,564,000
Engineering service expenses		34,000	34,000	34,000	34,000	34,000	34,000	31,000	235,000
Administration expenses and contingency		22,000	22,000	22,000	22,000	22,000	22,000	24,000	156,000
sub-total		**279,000**	**279,000**	**279,000**	**279,000**	**279,000**	**279,000**	**281,000**	**1,955,000**
Total		**442,000**	**895,000**	**894,000**	**594,000**	**594,000**	**594,000**	**595,000**	**4,608,000**

4.6 Kabridahar

4.6.1 Water supply plan

a. Urban water supply

Kabridahar town is about 2km from the western side of the Jarar River. The highway passes through the middle part of the town from north to south direction. Served population in 2020 was set as 19,689 persons. Design average daily supply was estimated to be 621m^3/day. Kabridahar town population projection in 2020 of 64,155 persons is also more than 50,000 persons, therefore a peak factor of 1.2 is applied and water supply facilities were designed to 745m^3/day. There are five existing boreholes to supply water to the Kabridahar town, however, they cannot satisfy the water demand in 2020 under the current conditions. Thus, new boreholes are planned along with the Jarar River. Six boreholes with 3.7lit/sec yield and 130m depth are planned for the Kabridahar town water supply plan. Due to short distance from the boreholes to the Kabridahar town center area, raw water from each borehole is collected to trunk transmission pipeline with 160mm diameter and it flows into the reservoirs directly. The town has three reservoirs, of which two are elevated type with 100m^3 and 250m^3 capacities and one is ground type with 200m^3. These existing reservoirs are functioning well, they are used for 2020 water supply plan. The design reservoir volume of 2020 is 900m^3, therefore, 350m^3 capacity reservoir is planned. The existing distribution pipeline system is 8.34 km ranging from 50mm to 100mm diameters. It covers small areas of the Kabridahar town only, it does not function well. Besides, pipe size is also not adequate in some areas and distribution pipeline system is not network type. SRWDB has prepared the distribution pipeline system design. It covers the whole of Kabridahar town and is adequate to improve the whole town water supply system. Thus, it applies to the distribution pipeline general design. SRWDB estimated that 36 public taps shall be necessary and the water supply plan follows their design, 36 public taps and 8 cattle troughs are planned for Kabridahar town. Major features of the Kabridahar town water supply plan are summarized in Table 4.26.

Table 4.26: Features of Kabridahar Town Water Supply System General Design

No.	Item	Specifications	Unit	Q'ty
1.	Submergible pump	Q=0.25m^3/min, H=120m	No.	6
2.	Generator	40 kVA	No.	6
3.	Transmission pipeline from BH to pump station			
3.1		90 mm	m	3,200
3.2		110 mm	m	3,000
3.3		160 mm	m	3,000
4.	Reservoir	350 m^3	Nos.	1
5.	Distribution system			-
5.1	Pipeline	50 mm	m	7,200
5.2		90 mm	m	15,090
5.3		110 mm	m	16,270
5.4		160 mm	m	6,690
5.5		200 mm	m	270
5.6		250 mm	m	160
5.7	Public tap		No.	36
5.8	Cattle trough		No.	8

b. Rural water supply

Water supply master plan in Kabridahar woreda is illustrated in Figure 4.7. There are 9 kebeles in total. Borehole development is planned for three kebeles where they are located along the Jarar River. Though No.10 Maraato is also located along the Jarar River, the distance from the river to Maraato is around 10km. Initial investment is large as rural water supply and Maraato water supply plan is formulated by rainwater development. Rainwater development is adopted for other six kebeles. Served population of all kebeles is more than 2,500 persons. Haffir dam is planned for them. Served population ranges from 3,938 persons to 8,223 persons, quantities of haffir dam are from one to three structures. General features of each kebele water supply plan are tabulated in Table 4.27.

Table 4.27: Features of Kabridahar Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Q	Gen.	Pipe dia.	Dis. Pipe	Public tap	Cattle trough
			person	No.	m^3/m	kVA	mm	m	No.	No.
1	Buundat	Haffir dam Birka	5,250	2 1						
2	Carabacite	Haffir dam Birka	5,250	2 1						
3	Ceelxaar	Borehole	5,250	2	0.20	32	65	600	3	1
4	Dalaad	Haffir dam Birka	5,250	2 1						
5	Dhuure	Haffir dam Birka	5,250	2 1						
6	Galadiid	Borehole	3,938	1	0.25	40	65	1000	5	1
8	Karanbicite	Borehole	5,250	2	0.20	32	65	600	3	1
9	Lasdhankheyre	Haffir dam Birka	8,223	3 3						
10	Maraato	Haffir dam Birka	3,938	1 5						

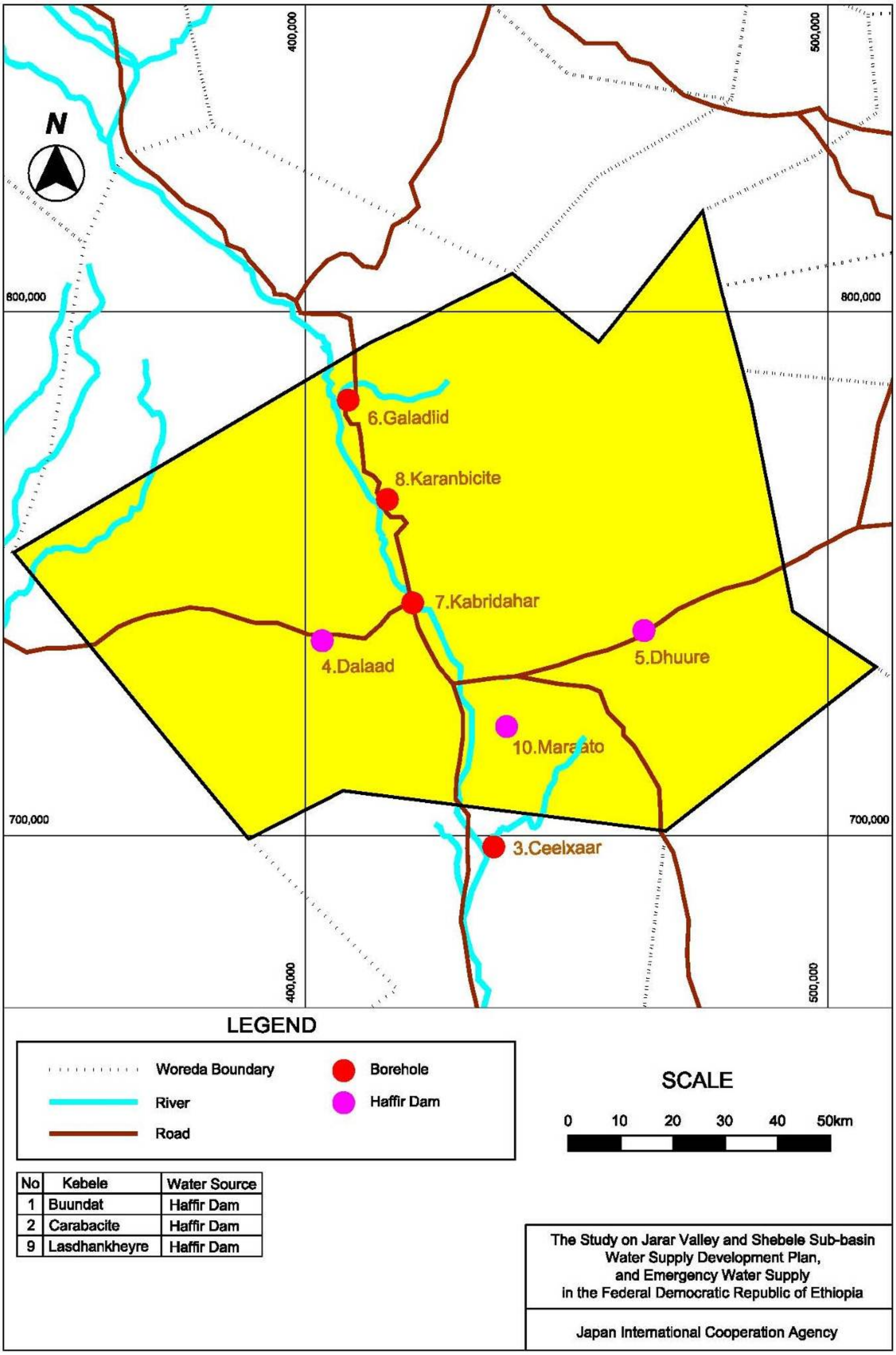


Figure 4.7: Kabridahar Woreda Water Supply Plan

4.6.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.28.

Table 4.28: Estimated Project Cost for Kabridahar Woreda

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Buundat	Haffir dam	2	782,000	117,000	78,000	977,000
		Birka	1	57,000	9,000	6,000	72,000
2	Carabacite	Haffir dam	2	782,000	117,000	78,000	977,000
		Birka	1	57,000	9,000	6,000	72,000
3	Ceelxaar	BH	2	470,000	71,000	47,000	588,000
4	Dalaad	Haffir dam	2	782,000	117,000	78,000	977,000
		Birka	1	57,000	9,000	6,000	72,000
5	Dhuure	Haffir dam	2	782,000	117,000	78,000	977,000
		Birka	1	57,000	9,000	6,000	72,000
6	Galadiid	BH	1	276,000	41,000	28,000	345,000
7	**Kabridahar**	BH	1	3,481,000	522,000	348,000	4,351,000
8	Karanbicite	BH	2	470,000	71,000	47,000	588,000
9	Lasdhankheyre	Haffir dam	3	1,173,000	176,000	117,000	1,466,000
		Birka	3	171,000	26,000	17,000	214,000
10	Maraato	Haffir dam	1	391,000	59,000	39,000	489,000
		Birka	5	285,000	43,000	29,000	357,000
(1)	Urban water supply		1	3,481,000	522,000	348,000	4,351,000
(2)	Borehole		5	1,216,000	183,000	122,000	1,521,000
(3)	Birka		12	684,000	105,000	70,000	859,000
(4)	Haffir dam		12	4,692,000	703,000	468,000	5,863,000
Total				10,073,000	1,513,000	1,008,000	12,594,000

4.6.3 Implementation Plan

a. Implementation schedule of water supply plan

a.1 Implementation schedule of urban water supply plan

The implementation schedule of this urban water supply system is the same as that of Araarso woreda. It will take 32 months to implement the system (refer to Table 4.12).

a.2 Implementation schedule of rural water supply plan

It will take 24 months to design and construct a borehole water supply facility (refer to Table 4.3). It will take 12 months to design and construct a Birka (refer to Table 4.6). It will take 24 months from the design to completion of a Haffir dam (refer to Table 4.7).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated project cost for each year are shown in the following Table 4.29.

Table 4.29: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

6. Kabridahar		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (BH)									
2015~2017 implementation	1 facility								
Construction cost			1,160,000	1,160,000	1,161,000				3,481,000
Engineering service expenses			174,000	174,000	174,000				522,000
Administration expenses and contingency			116,000	116,000	116,000				348,000
sub-total			**1,450,000**	**1,450,000**	**1,451,000**				**4,351,000**
(2) Borehole water supply facility									
2015~2016 implementation	1 facility								
2017~2018 implementation	2 facility								
2019~2020 implementation	2 facility								
Total	5 facility								
Construction cost			113,000	113,000	225,000	225,000	225,000	315,000	1,216,000
Engineering service expenses			17,000	17,000	34,000	34,000	34,000	47,000	183,000
Administration expenses and contingency			11,000	11,000	23,000	23,000	23,000	31,000	122,000
sub-total			**141,000**	**141,000**	**282,000**	**282,000**	**282,000**	**393,000**	**1,521,000**
(3) Birka									
average per year	1.7 facility								
Total	12 facility								
Construction cost		98,000	98,000	98,000	98,000	98,000	98,000	96,000	684,000
Engineering service expenses		15,000	15,000	15,000	15,000	15,000	15,000	15,000	105,000
Administration expenses and contingency		10,000	10,000	10,000	10,000	10,000	10,000	10,000	70,000
sub-total		**123,000**	**123,000**	**123,000**	**123,000**	**123,000**	**123,000**	**121,000**	**859,000**
(4) Haffir dam									
average per year	1.7 facility								
Total	12 facility								
Construction cost		670,000	670,000	670,000	670,000	670,000	670,000	672,000	4,692,000
Engineering service expenses		100,000	100,000	100,000	100,000	100,000	100,000	103,000	703,000
Administration expenses and contingency		67,000	67,000	67,000	67,000	67,000	67,000	66,000	468,000
sub-total		**837,000**	**837,000**	**837,000**	**837,000**	**837,000**	**837,000**	**841,000**	**5,863,000**
Total		**960,000**	**2,551,000**	**2,551,000**	**2,693,000**	**1,242,000**	**1,242,000**	**1,355,000**	**12,594,000**

4.7 Doba wein woreda

4.7.1 Water supply plan

a. Urban water supply

The urban area (town) of Doba wein woreda is on the eastern side of the Jarar River about 700m. Distance from the river to the town center is about 450m. Served population in 2020 was set as 13,031 persons. Design average daily supply was estimated to be 431m^3/day and water supply facilities were designed to be 646m^3/day. Trunk road passes along with the Jarar River and it crosses the town from northwest to southeast direction. Six wells have been developed for the Doba wein town. They are mostly shallow wells. One borehole was drilled, however, it was not functional at the time of writing this report. Thus, the water supply plan is formulated to develop shallow wells. According to hydrogeological survey results, groundwater potential at Doba wein town is limited to 1.0lit/s. Thus, shallow wells with 1.0lit/s and 25m depth will be developed. It is not practical to design piped water supply system for small yield. Therefore, Doba wein town shall adopt spot water supply system like rural water scheme and standard rural water supply system is also applied. Eighteen components are planned to supply for 2020 served population. Major features of the Doba wein town water supply plan are summarized in Table 4.30

Table 4.30: Features of Doba Wein Town Water Supply System General Design

No.	Item	Specifications	Q'ty
1.	Submergible pump	Q=0.06m^3/min, H=20m	18
2.	Generator	3 kVA	18
3.	Transmission pipeline	32 mm with 100m	18
4.	Reservoir	10 m^3	18
5.	Distribution system		
5.1	Pipeline	32 mm with 200m	18
5.2	Public tap		18
5.3	Cattle trough		18

b. Rural water supply

Water supply master plan in Doba wein woreda is illustrated in Figure 4.8. There are 4 kebeles in total. Groundwater development is planned for 3 kebeles, which are located along the Jarar River. Shallow well development has been conducted for Doba wein woreda due to geological condition. Therefore, the water supply plan is also formulated by shallow well development. Rainwater development is adopted for No.5 Nagar Weyne only. Served population of is 2,896 persons, 1 haffir dam is planned. General features of each kebele water supply plan are tabulated in Table 4.31.

Table 4.31: Features of Doba Wein Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Q	Gen.	Pipe dia.	Dis. Pipe	Public tap	Cattle trough
			person	No.	m^3/m	kVA	mm	m	No.	No.
2	Jidale	Shallow well	3,474	3	0.06	3	32	400	2	1
3	Haaraano	Shallow well	3,763	3	0.06	3	32	400	2	1
4	Higloley	Shallow well	5,793	5	0.06	3	32	400	2	1
5	Nagar Weyne	Haffir dam Birka	2,896	1 1						

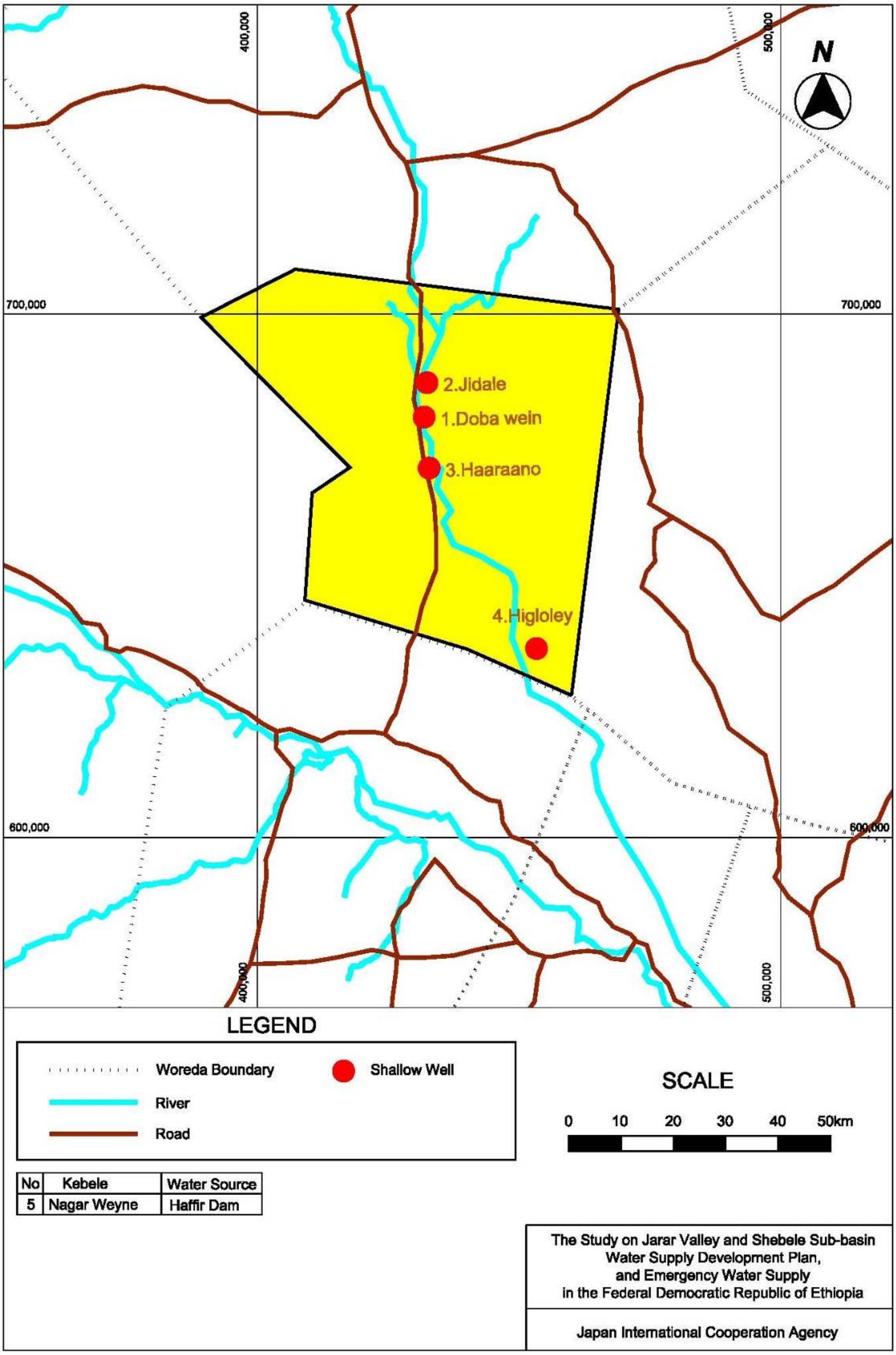


Figure 4.8: Doba Wein Woreda Water Supply Plan

4.7.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.32.

Table 4.32: Estimated Project Cost of Doba wein Woreda

7. Doba wein

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	**Doba wein**	SW	18	1,906,000	286,000	191,000	2,383,000
2	Jidale	SW	3	384,000	58,000	38,000	480,000
3	Haaraano	SW	3	384,000	58,000	38,000	480,000
4	Higloley	SW	5	621,000	93,000	62,000	776,000
5	Nagar Weyne	Haffir dam	1	391,000	59,000	39,000	489,000
		Birka	1	57,000	9,000	6,000	72,000
(1) Urban water supply			18	1,906,000	286,000	191,000	2,383,000
(2) Shallow well			11	1,389,000	209,000	138,000	1,736,000
(3) Birka			1	57,000	9,000	6,000	72,000
(4) Haffir dam			1	391,000	59,000	39,000	489,000
Total				3,743,000	563,000	374,000	4,680,000

4.7.3 Implementation Plan

a. Implementation schedule of water supply plan

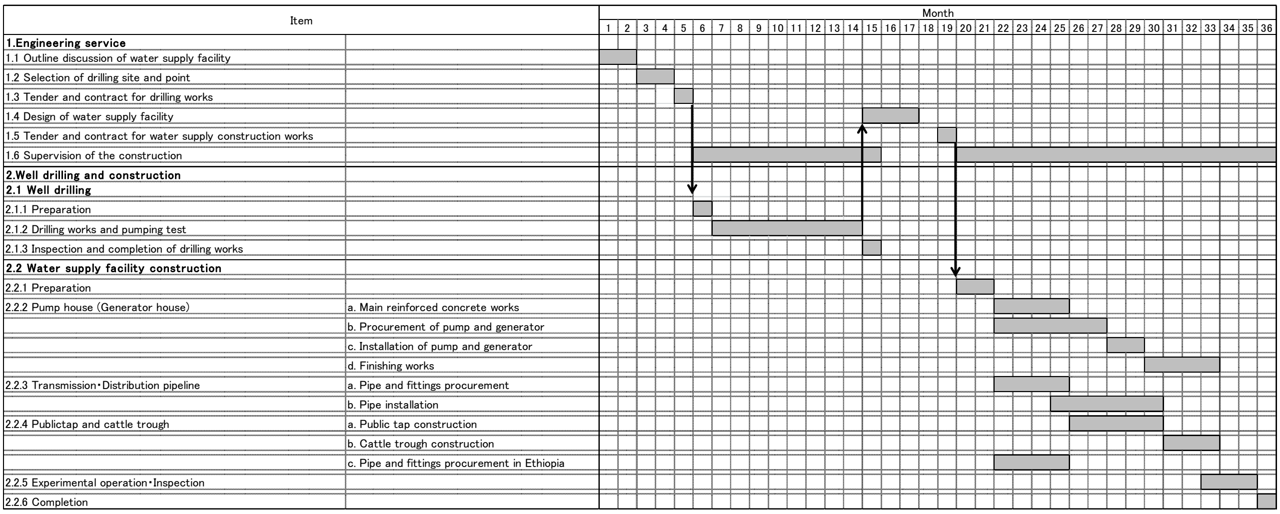
a.1 Implementation schedule of urban water supply plan

This urban water supply system comprises of the construction of eighteen (18) shallow well water supply facilities.

The implementation of the construction of the water supply system is composed mainly of the design stage (design, tender documents preparation, tender, contract with a construction company), the well drilling stage (drilling and supervising), and the construction stage (implementation of the construction, experimental operation of the facility, completion, supervising of the construction). After successful well drilling, pumping test is conducted. The specification of the submersible pumps will be determined based on the result of the pumping test, and the design of the entire water supply facility will be conducted.

The implementation of the construction of the urban water supply system will take 19 months to design including well drillings and 17 months to construct. Thus, the total implementation period is 36 months. The implementation schedule of the urban water supply system is shown in the following Table 4.33.

Table 4.33: Implementation Schedule of Urban Water Supply System



a.2 Implementation schedule of rural water supply plan

It will take 24 months to design and construction a shallow well water supply facility (refer to Table 4.4). It will take 12 months from the design to completion of a Birka (refer to Table 4.6). It will take 24 months to design and construct a Haffir dam (refer to Table 4.7).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and estimated project cost for each year is shown in the following Table 4.34.

Table 4.34: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

7. Doba wein		Western calendar (year)							Estimated
		2014	2015	2016	2017	2018	2019	2020	project cost
(1) Urban water supply system (SW)									
2015~2017 implementation	18 facility								
Construction cost			635,000	635,000	636,000				1,906,000
Engineering service expenses			95,000	95,000	96,000				286,000
Administration expenses and contingency			64,000	64,000	63,000				191,000
sub-total			**794,000**	**794,000**	**795,000**				**2,383,000**
(2) Shallow well water supply facility									
2017~2018 implementation	3 facility								
2019~2020 implementation	8 facility								
	11 facility								
Construction cost					189,000	189,000	505,000	506,000	1,389,000
Engineering service expenses					28,000	28,000	76,000	77,000	209,000
Administration expenses and contingency					19,000	19,000	50,000	50,000	138,000
sub-total					**236,000**	**236,000**	**631,000**	**633,000**	**1,736,000**
(3) Birka									
2014 implementation	1 facility								
Total	1 facility								
Construction cost		57,000							57,000
Engineering service expenses		9,000							9,000
Administration expenses and contingency		6,000							6,000
sub-total		**72,000**							**72,000**
(4) Haffir dam									
2018~2019 implementation	1 facility								
Total	1 facility								
Construction cost						196,000	195,000		391,000
Engineering service expenses						30,000	29,000		59,000
Administration expenses and contingency						20,000	19,000		39,000
sub-total						**246,000**	**243,000**		**489,000**
Total		**72,000**	**794,000**	**794,000**	**1,031,000**	**482,000**	**874,000**	**633,000**	**4,680,000**

4.8 East Ime

4.8.1 Water supply plan

a. Urban water supply

The urban area (town) of East Ime woreda is located about 1,900m away from the Shebele River. Currently East Ime town uses the Shebele River water, however, there are no permanent river water intake structures for the town. Thus, water supply plan is formulated by the river water development. Served population in 2020 is set as 11,717 persons. Design average daily supply is estimated to be 374m^3/day and water supply facilities are designed to be 617m^3/day. East Ime town water supply system by river water development has the same structure as the rural water supply system by river water development mentioned in the section 3.5.4. It is the difference that urban water supply system provides two pumps taking into consideration backup purposes. Water supply system consists of intake canal, sedimentation tank with 256m^3 capacity, 4 rough filters, treated water reservoir with 140m^3, and 2 places of pumps with capacity of 1.2m^3/min each. Treated water is transmitted to the reservoir in the town through transmission pipeline. East Ime is 1.9km away from the river, it is the farthest from the river except Godey town. Treated water is distributed through the existing pipeline. New distribution pipeline is connected to the existing ones and 14 public taps and 3 cattle troughs are provided at the end of the pipe. Major features of the East Ime town water supply plan are summarized in Table 4.35 and are illustrated in Figure 4.9.

Table 4.35: Features of East Ime Water Supply System General Design

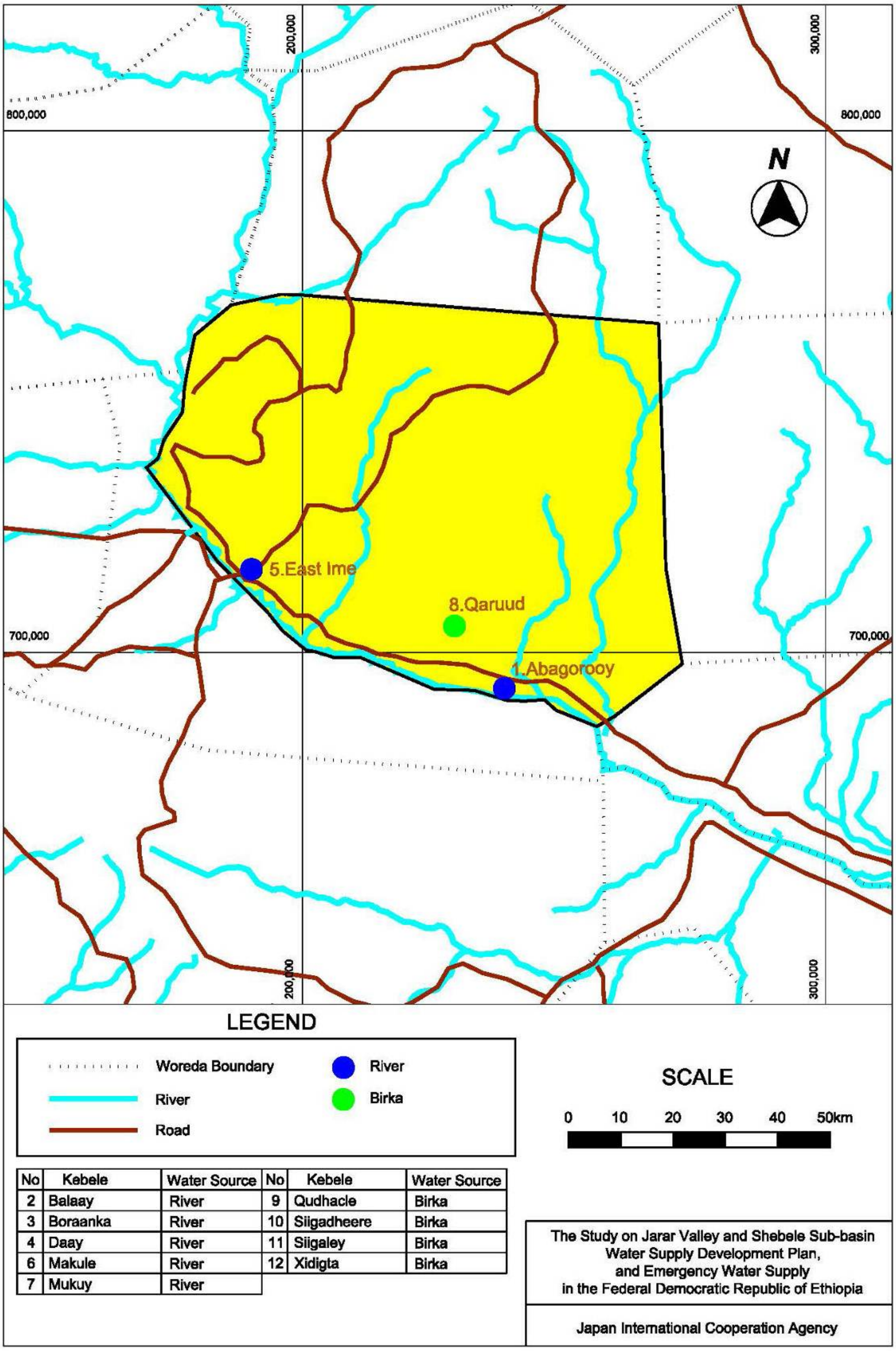
No.	Item	Specifications	Unit	Q'ty
1.	Intake canal		No.	1
2.	Sedimentation tank	V=256m^3	No.	2
3.	Intake pump	Q=1.2m^3/min, H=10m	No.	2
4.	Rough filter	V=30m^3/hr	No.	4
5.	Treated water reservoir	V=140m^3	No.	1
6.	Surface pump	Q=1.2m^3/min, H=20m	No.	2
7.	Generator	36 kVA	No.	1
8.	Transmission pipeline	200 mm	m	1,900
9.	Reservoir	V=300m^3	No.	1
10.	Distribution system			
10.1	Pipeline	90 mm	m	7,000
10.2	Public tap		No.	14
10.3	Cattle trough		No.	3

b. Rural water supply

Water supply master plan in East Ime woreda is illustrated in Figure 4.9. There are 11 kebeles in total. Six kebeles are located along the Shebele River. No.1 Abagorooy is located 200m from the river. According to the socio-economic survey result, East Ime woreda water supply office answered that other five kebeles except Abagorooy take water from the river. Thus, the water supply plan is formulated to use the river water for these six kebeles. Rainwater development is adopted for the remaining five kebeles. Served population ranges from 2,050 to 3,335 persons. Birka is applied to the Shebele sub-basin area and quantities range from 7 to 12 birkas. General features of each kebele water supply plan are tabulated in Table 4.36.

Table 4.36: Features of East Ime Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Sed. Tank	Rough Filter	Pump H1 H2	Pump Q1 Q2	Gen.	Rev. V1 V2	Pipe D1 D2	Pipe L1 L2	Public tap
			person	No.	m^3	No.	m	m^3/m	kVA	m^3	mm	m	No.
1	Abagorooy	River intake	8,693	1	144	3	10 20	0.80 0.80	25	80 50	90 90	200 2000	10
2	Balaay	River intake	6,516	1	100	2	10 30	0.60 0.60	25	60 40	90 90	500 1600	8
3	Boraanka	River intake	14,202	1	196	3	10 30	1.10 1.10	44	120 80	110 90	500 3200	16
4	Daay	River intake	6,680	1	100	2	10 30	0.60 0.60	25	60 40	90 90	500 1600	8
6	Makule	River intake	10,856	1	144	3	10 40	0.80 0.80	41	80 60	90 90	500 2600	13
7	Mukuy	River intake	6,680	1	100	2	10 30	0.60 0.60	25	60 40	90 90	500 1600	8
8	Qaruud	Birka	3,335	12									
9	Qudhacle	Birka	2,050	7									
10	Siigadheere	Birka	3,078	11									
11	Siigaley	Birka	3,078	11									
12	Xidigta	Birka	3,332	12									



No	Kebele	Water Source	No	Kebele	Water Source
2	Balaay	River	9	Qudhacle	Birka
3	Boraanka	River	10	Siigadheere	Birka
4	Daay	River	11	Siigaley	Birka
6	Makule	River	12	Xidigta	Birka
7	Mukuy	River			

Figure 4.9: East Ime Woreda Water Supply Plan

4.8.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.37.

Table 4.37: Estimated Project Cost for East Ime Woreda

8. East Ime

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Abagorooy	River intake	1	627,000	94,000	63,000	784,000
2	Balaay	River intake	1	551,000	83,000	55,000	689,000
3	Boraanka	River intake	1	794,000	119,000	79,000	992,000
4	Daay	River intake	1	551,000	83,000	55,000	689,000
5	**East Ime**	River intake	1	1,166,000	175,000	117,000	1,458,000
6	Makule	River intake	1	707,000	106,000	71,000	884,000
7	Mukuy	River intake	1	551,000	83,000	55,000	689,000
8	Qaruud	Birka	12	684,000	103,000	68,000	855,000
9	Qudhacle	Birka	7	399,000	60,000	40,000	499,000
10	Siigadheere	Birka	11	627,000	94,000	63,000	784,000
11	Siigaley	Birka	11	627,000	94,000	63,000	784,000
12	Xidigta	Birka	12	684,000	103,000	68,000	855,000
(1) Urban water supply			1	1,166,000	175,000	117,000	1,458,000
(2) River intake			6	3,781,000	568,000	378,000	4,727,000
(3) Birka			53	3,021,000	454,000	302,000	3,777,000
Total				7,968,000	1,197,000	797,000	9,962,000

4.8.3 Implementation Plan

a. Implementation schedule of water supply plan

a.1 Implementation schedule of urban water supply plan

This urban water supply system of this woreda is the river water supply facility. It will take 30 months to design and construct a single river water supply facility (refer to Table 4.5).

a.2 Implementation schedule of rural water supply plan

It will take 30 months to design and construct a river water supply facility (refer to Table 4.5). It will take 12 months to design and construct a Birka (refer to Table 4.6). It will take 24 months to design and construct a Haffir dam (refer to Table 4.7).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated project cost for each year are shown in the following Table 4.38.

Table 4.38: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

8. East Ime		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (River)									
2015~2017 implementation	1 facility								
Construction cost			389,000	389,000	388,000				1,166,000
Engineering service expenses			58,000	58,000	59,000				175,000
Administration expenses and contingency			39,000	39,000	39,000				117,000
sub-total			**486,000**	**486,000**	**486,000**				**1,458,000**
(2) River water supply facility									
2015~2017 implementation	2 facility								
2018~2020 implementation	4 facility								
Total	6 facility								
Construction cost			420,000	420,000	420,000	840,000	840,000	841,000	3,781,000
Engineering service expenses			63,000	63,000	63,000	126,000	126,000	127,000	568,000
Administration expenses and contingency			42,000	42,000	42,000	84,000	84,000	84,000	378,000
sub-total			**525,000**	**525,000**	**525,000**	**1,050,000**	**1,050,000**	**1,052,000**	**4,727,000**
(3) Birka									
average per year	7.6 facility								
Total	53 facility								
Construction cost		432,000	432,000	432,000	432,000	432,000	432,000	429,000	3,021,000
Engineering service expenses		65,000	65,000	65,000	65,000	65,000	65,000	64,000	454,000
Administration expenses and contingency		43,000	43,000	43,000	43,000	43,000	43,000	44,000	302,000
sub-total		**540,000**	**540,000**	**540,000**	**540,000**	**540,000**	**540,000**	**537,000**	**3,777,000**
Total		**540,000**	**1,551,000**	**1,551,000**	**1,551,000**	**1,590,000**	**1,590,000**	**1,589,000**	**9,962,000**

4.9 Danan

4.9.1 Water supply plan

a. Urban water supply

The urban area (town) of Danan woreda is located approximately 60km from the Shebele River, but is near a branch of the Shebele River. Served population in 2020 was set as 3,784 persons. Design average daily supply was estimated to be 122m^3/day and water supply facilities were designed to be 182m^3/day. Three wells have been developed for the Danan town and two are functional. There has been no river water development until now. Hydrogeological study estimates that groundwater level is about 30m from the ground. Thus, water supply plan is formulated by shallow well development. Danan town water supply system plan is similar to the one of Doba wein town. Yield is 1.0lit/s and 30m depth, then five shallow wells will be developed. Danan is also applied to spot water supply system by standard rural water supply scheme like Doba wein. Major features of the Danan town water supply plan are summarized in Table 4.39.

Table 4.39: Features of Danan Town Water Supply System General Design

No.	Item	Specifications	Q'ty
1.	Submergible pump	Q=0.06m^3/min, H=25m	5
2.	Generator	4 kVA	5
3.	Transmission pipeline	32 mm with 100m	5
4.	Reservoir	10 m^3	5
5.	Distribution system		
5.1	Pipeline	32 mm with 200m	5
5.2	Public tap		5
5.3	Cattle trough		5

b. Rural water supply

Water supply master plan in Danan woreda is illustrated in Figure 4.10. There are 4 kebeles in total. Two kebeles are supplied water by shallow well development with 30m depth. No.1 Burqayar and No.2 Dambarweyne kebele have low groundwater potential so that their water will be supplied by birka. General features of each kebele water supply plan are tabulated in Table 4.40.

Table 4.40: Features of Danan Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facility	Q	Gen.	Pipe dia.	Dis. Pipe	Public tap	Cattle trough
			person	No.	m^3/m	kVA	mm	m	No.	No.
1	Burqayar	Birka	1,527	6						
2	Dambarweyne	Birka	2,089	7						
4	Qore	Shallow well	2,059	2	0.06	4	32	400	2	1
5	Shinile	Shallow well	2,177	2	0.06	4	32	400	2	1

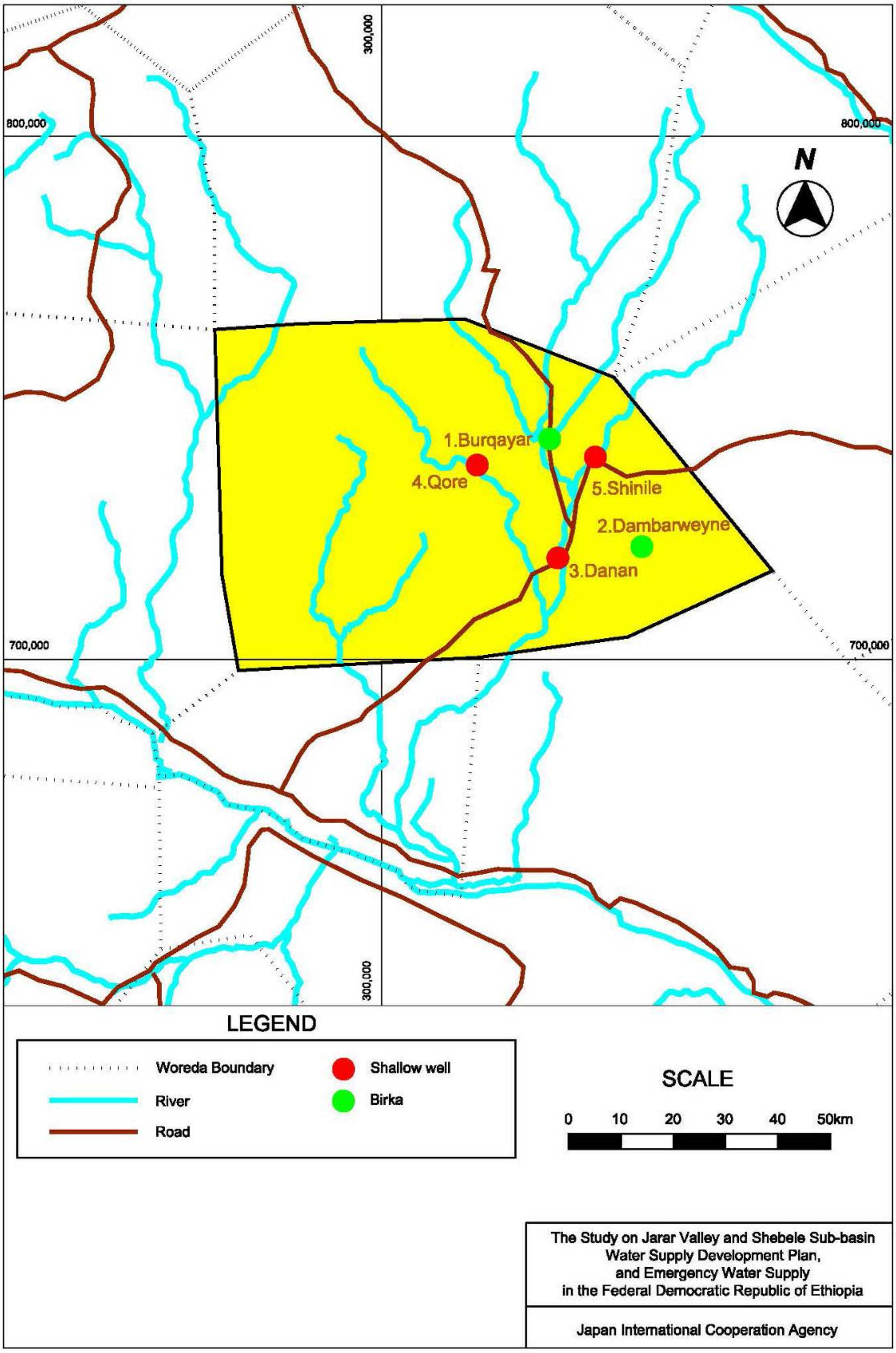


Figure 4.10: Danan Woreda Water Supply Plan

4.9.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.41.

Table 4.41: Estimated Project Cost for Danan Woreda

9. Danan

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Burqayar	Birka	6	342,000	51,000	34,000	427,000
2	Dambarweyne	Birka	7	399,000	60,000	40,000	499,000
3	**Danan**	SW	5	578,000	87,000	58,000	723,000
4	Qore	SW	2	281,000	42,000	28,000	351,000
5	Shinile	SW	2	281,000	42,000	28,000	351,000
(1) Urban water supply			5	578,000	87,000	58,000	723,000
(2) Shallow well			4	562,000	84,000	56,000	702,000
(3) Birka			13	741,000	111,000	74,000	926,000
Total				1,881,000	282,000	188,000	2,351,000

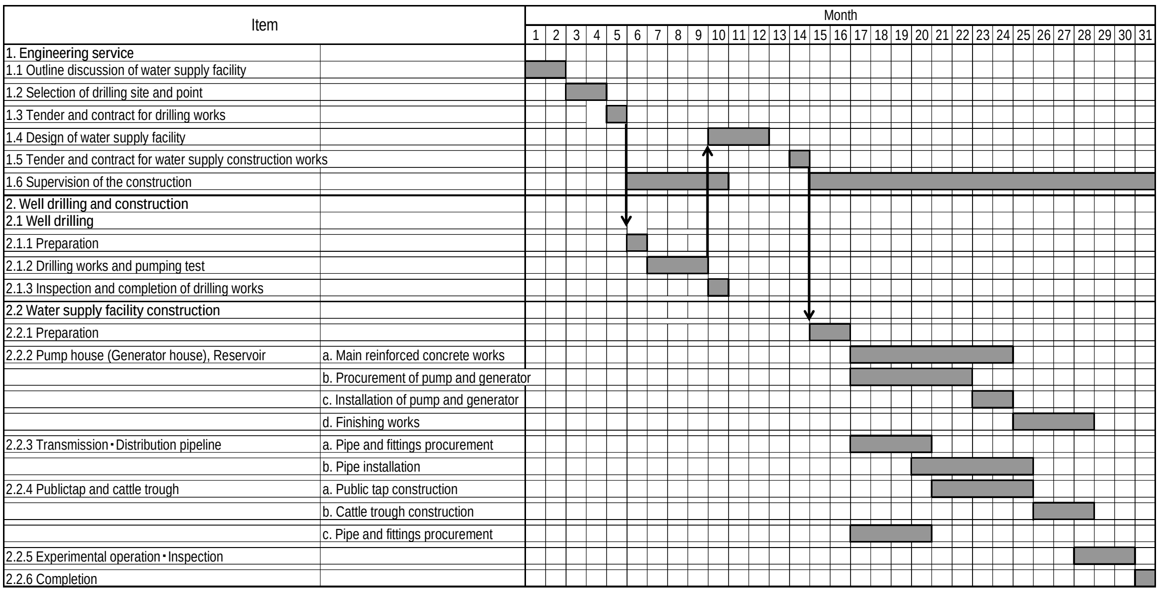
4.9.3 Implementation Plan

a. Implementation schedule of water supply plan

a.1 Implementation schedule of urban water supply plan

This urban water supply system is the construction of five (5) shallow well water supply facilities. To implement the urban water supply system, it will take 14 months to design (including well drilling) and 17 months for construction. Thus the total is 31 months. The implementation schedule of the urban water supply system is shown in the following Table 4.42.

Table 4.42: Implementation Schedule of Urban Water Supply System



a.2 Implementation schedule of rural water supply plan

It will take 24 months to design and construct a shallow well water supply facility (refer to Table 4.4). It will take 12 months from the design to completion of a Birka (refer to Table

4.6).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and estimated project cost for each year is shown in the following Table 4.43.

Table 4.43: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

9. Danan		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (SW)									
2015~2017 implementation	5 facility								
Construction cost			193,000	193,000	192,000				578,000
Engineering service expenses			29,000	29,000	29,000				87,000
Administration expenses and contingency			19,000	19,000	20,000				58,000
sub-total			**241,000**	**241,000**	**241,000**				**723,000**
(2) Shallow well water supply facility									
2017~2018 implementation	2 facility								
2019~2020 implementation	2 facility								
Total	4 facility								
Construction cost					141,000	141,000	141,000	139,000	562,000
Engineering service expenses					21,000	21,000	21,000	21,000	84,000
Administration expenses and contingency					14,000	14,000	14,000	14,000	56,000
sub-total					**176,000**	**176,000**	**176,000**	**174,000**	**702,000**
(3) Birka									
average per year	1.9 facility								
Total	13 facility								
Construction cost		106,000	106,000	106,000	106,000	106,000	106,000	105,000	741,000
Engineering service expenses		16,000	16,000	16,000	16,000	16,000	16,000	15,000	111,000
Administration expenses and contingency		11,000	11,000	11,000	11,000	11,000	11,000	8,000	74,000
sub-total		**133,000**	**133,000**	**133,000**	**133,000**	**133,000**	**133,000**	**128,000**	**926,000**
Total		**133,000**	**374,000**	**374,000**	**550,000**	**309,000**	**309,000**	**302,000**	**2,351,000**

4.10 Beercaano woreda

4.10.1 Water supply plan

a. Urban water supply

The urban area (town) of Beercaano woreda is located about 500m away from the Shebele River and has the condition to take the river water easily. Then, water supply plan by the Shebele River development was formulated. Served population in 2020 was set as 7,926 persons. Design average daily supply was estimated to be 248m^3/day and water supply facilities were designed to be 410m^3/day. Beercaano water supply system is the smallest river water development project in the Study. It consists of intake canal, sedimentation tank with 196m^3 capacity, 3 rough filters, treated water reservoir with 100m^3, and 2 places of pumps with capacity of 0.9m^3/min each. Terated water is transmitted to the reservoir with 200m^3 in the town and is distributed through the existing pipeline. New distribution pipeline is connected to the existing ones and 9 public taps and 2 cattle troughs are provided at the end of the pipe. The design of water supply facilities for Beercaano town is compiled in Table 4.44.

Table 4.44: Features of Beercaano Town Water Supply System General Design

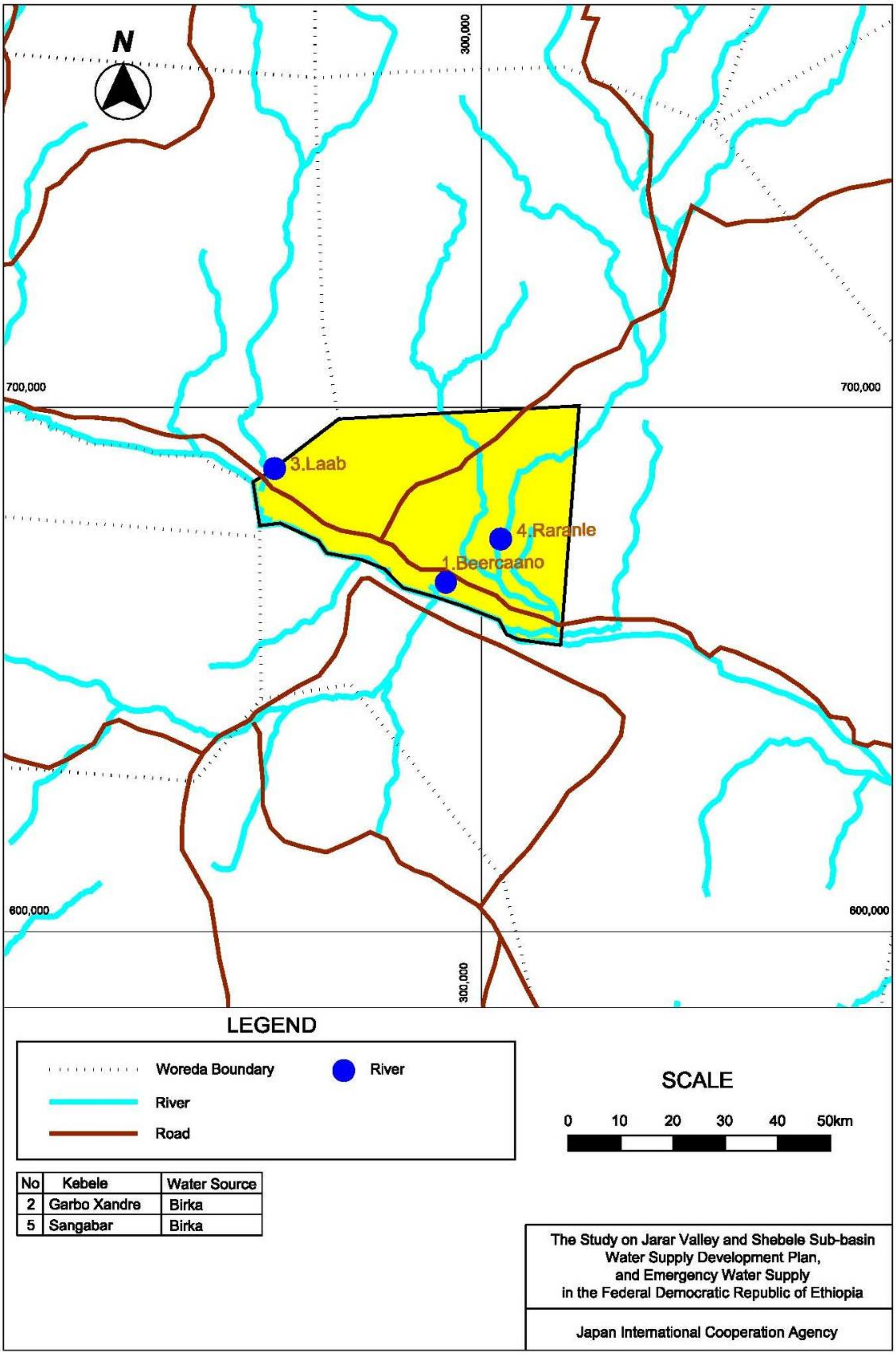
No.	Item	Specifications	Unit	Q'ty
1.	Intake canal		No.	1
2.	Sedimentation tank	V=196m^3	No.	2
3.	Intake pump	Q=0.9m^3/min, H=10m	No.	2
4.	Rough filter	V=30m^3/hr	No.	3
5.	Treated water reservoir	V=100m^3	No.	1
6.	Surface pump	Q=0.9m^3/min, H=20m	No.	2
7.	Generator	27 kVA	No.	1
8.	Transmission pipeline	110 mm	m	500
9.	Reservoir	V=200m^3	No.	1
10.	Distribution system			
10.1	Pipeline	90 mm	m	4,500
10.2	Public tap		No.	9
10.3	Cattle trough		No.	2

b. Rural water supply

Water supply master plan in Beercaano woreda is illustrated in Figure 4.11 and is tabulated in Table 4.45. There are 4 kebeles in total. Two kebeles are supplied water by river water development. Though No.3 Laab is located 3.8km away from the Shebele River main stream, it still has advantage rather than birka construction considering permanent water supply and investment cost. Rainwater development is adopted for the remaining 2 kebeles.

Table 4.45: Features of Beercaano Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Sed. Tank	Rough Filter	Pump H1 H2	Pump Q1 Q2	Gen.	Rev. V1 V2	Pipe D1 D2	Pipe L1 L2	Public tap
			person	No.	m^3	No.	m	m^3/m	kVA	m^3	mm	m	No.
2	Garbo Xandre	Birka	1,352	5									
3	Laab	River intake	5,662	1	100	2	10 70	0.60 0.60	51	60 40	110 90	3800 1400	7
4	Raranle	River intake	10,316	1	144	3	10 30	0.80 0.80	33	80 60	90 90	300 2400	12
5	Sangabar	Birka	1,814	7									



No	Kebele	Water Source
2	Garbo Xandre	Birka
5	Sangabar	Birka

Figure 4.11: Beercaano Woreda Water Supply Plan

4.10.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.46.

Table 4.46: Estimated Project Cost for Beercaano Woreda

10. Beercaano

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Beercaano	River intake	1	869,000	130,000	87,000	1,086,000
2	Garbo Xandre	Birka	5	285,000	43,000	29,000	357,000
3	Laab	River intake	1	767,000	115,000	77,000	959,000
4	Raranle	River intake	1	680,000	102,000	68,000	850,000
5	Sangabar	Birka	7	399,000	60,000	40,000	499,000
(1) Urban water supply			1	869,000	130,000	87,000	1,086,000
(2) River intake			2	1,447,000	217,000	145,000	1,809,000
(3) Birka			12	684,000	103,000	69,000	856,000
Total				3,000,000	450,000	301,000	3,751,000

4.10.3 Implementation Plan

a. Implementation schedule of water supply plan

It will take 30 months to design and construct to a river water supply facility (refer to Table 4.5) and 12 months to design and construct a Birka (refer to Table 4.6).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated project cost for each year are shown in the following Table 4.47.

Table 4.47: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

10. Beercaano		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (River)									
2015~2017 implementation	1 facility								
Construction cost			290,000	290,000	289,000				869,000
Engineering service expenses			43,000	43,000	44,000				130,000
Administration expenses and contingency			29,000	29,000	29,000				87,000
sub-total			**362,000**	**362,000**	**362,000**				**1,086,000**
(2) River water supply facility									
2018~2020 implementation	2 facility								
Total	2 facility								
Construction cost						482,000	482,000	483,000	1,447,000
Engineering service expenses						72,000	72,000	73,000	217,000
Administration expenses and contingency						48,000	48,000	49,000	145,000
sub-total						**602,000**	**602,000**	**605,000**	**1,809,000**
(3) Birka									
2014~2017 implementation	12 facility								
Total	12 facility								
Construction cost		171,000	171,000	171,000	171,000				684,000
Engineering service expenses		26,000	26,000	26,000	25,000				103,000
Administration expenses and contingency		17,000	17,000	17,000	18,000				69,000
sub-total		**214,000**	**214,000**	**214,000**	**214,000**				**856,000**
Total		**214,000**	**576,000**	**576,000**	**576,000**	**602,000**	**602,000**	**605,000**	**3,751,000**

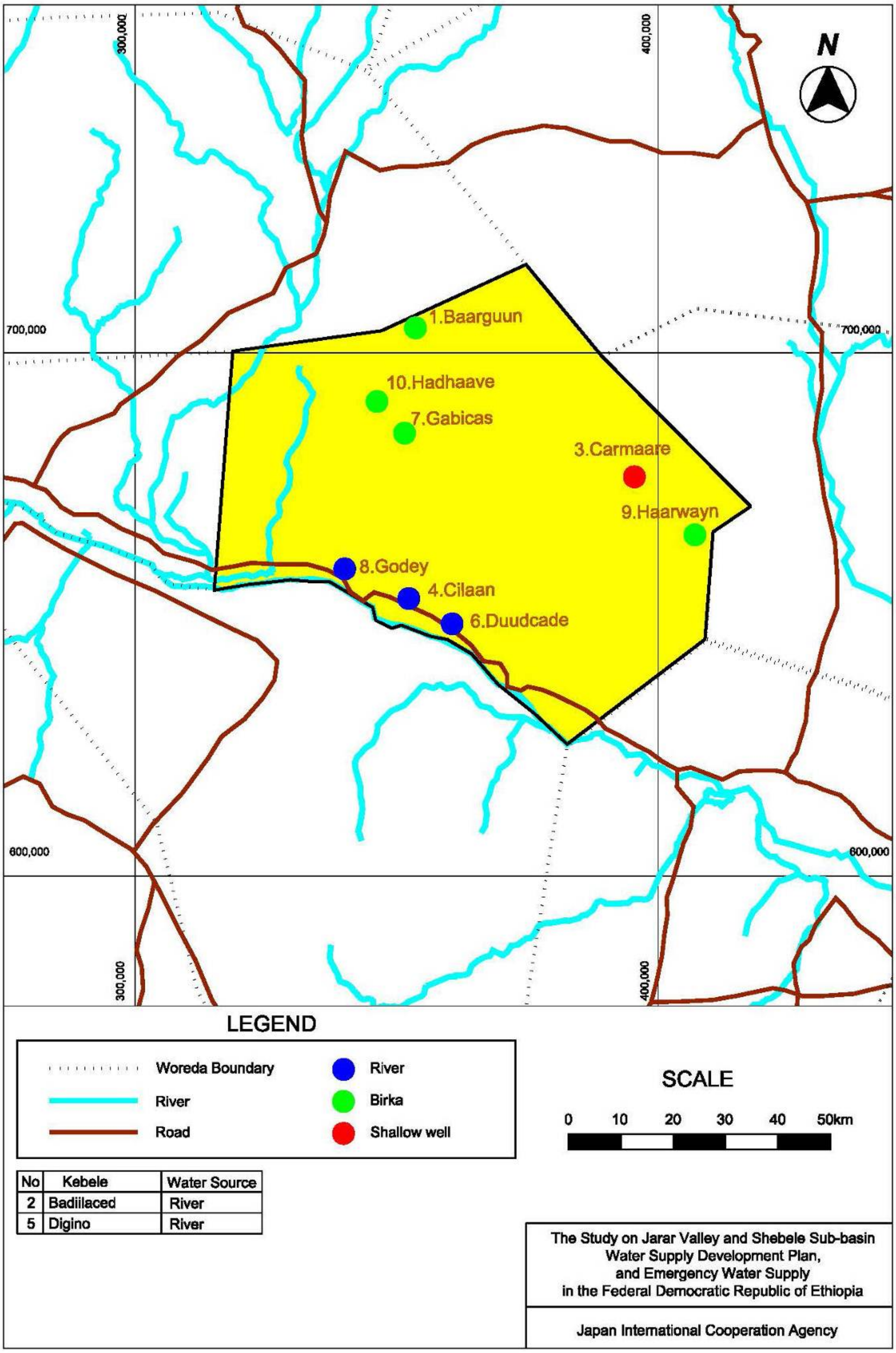
4.11 Godey woreda (Rural area)

4.11.1 Water supply plan

Water supply master plan in Godey woreda is illustrated in Figure 4.12 and is tabulated in Table 4.48. There are 9 kebeles in total. Four kebeles are supplied water by river water development. Socio-economic survey indicated that No.2 Badiilaced and No.5 Digino use river water as their water resource and their water supply plan is for river water development. No.3 Carmaare has the existing well so that their water supply plan is for shallow well development with 1.0 lit/s yield and 30 m depth. No groundwater has been developed in the other four kebeles.. Rainwater is the only water resource viable and rainwater development is adopted for them.

Table 4.48: Features of Godey Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Sed. Tank	Rough Filter	Pump H1 H2	Pump Q1 Q2	Gen.	Rev. V1 V2	Pipe D1 D2	Pipe L1 L2	Public tap
			person	No.	m^3	No.	m	m^3/m	kVA	m^3	mm	m	No.
1	Baarguun	Birka	3,054	11									
2	Badiilaced	River intake	6,343	1	100	2	10 30	0.60 0.60	25	60 40	90 90	500 1600	8
3	Carmaare	Shallow well	1,383	1			25	0.06	4	10	32 32	100 400	2
4	Cilaan	River intake	8,955	1	144	3	10 40	0.80 0.80	41	80 50	90 90	500 2000	10
5	Digino	River intake	4,751	1	64	2	10 20	0.40 0.40	14	40 30	90 90	500 1200	6
6	Duudcade	River intake	9,278	1	144	3	10 40	0.80 0.80	41	80 50	90 90	500 2200	11
7	Gabicas	Birka	2,900	10									
9	Haarwayn	Birka	1,131	4									
10	Hadhaave	Birka	4,069	14									



No	Kebele	Water Source
2	Badiilaced	River
5	Digino	River

Figure 4.12: Godey Woreda Water Supply Plan

4.11.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.49.

Table 4.49: Estimated Project Cost for Godey Woreda

11 Godey

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Baarguun	Birka	11	627,000	94,000	63,000	784,000
2	Badiilaced	River intake	1	540,000	81,000	54,000	675,000
3	Carmaare	SW	1	146,000	22,000	15,000	183,000
4	Cilaan	River intake	1	691,000	104,000	69,000	864,000
5	Digino	River intake	1	529,000	79,000	53,000	661,000
6	Duudcade	River intake	1	707,000	106,000	71,000	884,000
7	Gabicas	Birka	10	570,000	86,000	57,000	713,000
9	Haarwayn	Birka	4	228,000	34,000	23,000	285,000
10	Hadhaave	Birka	14	798,000	120,000	80,000	998,000
(1) Shallow well			1	146,000	22,000	15,000	183,000
(2) River intake			4	2,467,000	370,000	247,000	3,084,000
(3) Birka			39	2,223,000	334,000	223,000	2,780,000
Total				4,836,000	726,000	485,000	6,047,000

4.11.3 Implementation Plan

a. Implementation schedule of water supply plan

It will take 24 months to design and construct a shallow well water supply facility (refer to Table 4.4). It will take 30 months to design and construction a river water supply facility (refer to Table 4.5) and 12 months for a Birka (refer to Table 4.6).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and estimated project cost for each year are shown in the following Table 4.50.

Table 4.50: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

11 Godey (not including town)		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Shallow well water supply facility									
2015~2017 implementation	1 facility								
Construction cost			73,000	73,000					146,000
Engineering service expenses			11,000	11,000					22,000
Administration expenses and contingency			8,000	7,000					15,000
sub-total			**92,000**	**91,000**					**183,000**
(2) River water supply facility									
2015~2017 implementation	2 facility								
2018~2020 implementation	2 facility								
Total	4 facility								
Construction cost			411,000	411,000	411,000	411,000	411,000	412,000	2,467,000
Engineering service expenses			62,000	62,000	62,000	62,000	62,000	60,000	370,000
Administration expenses and contingency			41,000	41,000	41,000	41,000	41,000	42,000	247,000
sub-total			**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**514,000**	**3,084,000**
(3) Birka									
average per year	5.6 facility								
Total	39 facility								
Construction cost		318,000	318,000	318,000	318,000	318,000	318,000	315,000	2,223,000
Engineering service expenses		48,000	48,000	48,000	48,000	48,000	48,000	46,000	334,000
Administration expenses and contingency		32,000	32,000	32,000	32,000	32,000	32,000	31,000	223,000
sub-total		**398,000**	**398,000**	**398,000**	**398,000**	**398,000**	**398,000**	**392,000**	**2,780,000**
Total		**398,000**	**1,004,000**	**1,003,000**	**912,000**	**912,000**	**912,000**	**906,000**	**6,047,000**

4.12 Adadle woreda

4.12.1 Water supply plan

a. Urban water supply

The urban area (town) of Bohelxagare woreda is located at about 12km away from the Shebele River and is currently supplied water by rainwater. Served population in 2020 is set as 5,793 persons. Design average daily supply is estimated to be 184m^3/day. There has been borehole development for the Bohelxagare town but it seems to be not functioning well. The Shebele River water development was conducted in 2008 but it is abandoned now. At this moment, rainwater is the sole option to supply water for the Bohelxagare town. Dry season in the Shebele sub-basin is 4 months. In case that water supply is managed by birka for 4 months, required storage volume shall be 22,080m^3=184m^3/day×120days. As mentioned in the section 3.5.2 in chapter 3, one birka storage volume is 1,000 m^3, and required quantity is 23 places. Though 19 birkas are necessary calculating from beneficiaries, water supply plan shall consider securing drinking water as first priority, therefore 23 birkas are planned as shown in Table 4.51.

Table 4.51: Features of Bohelxagare Town Water Supply System General Design

No.	Item	Specifications	Q'ty
1.	Birka	21m x 14m x 3.5m	23

b. Rural water supply

Water supply master plan in Adadle woreda is illustrated in Figure 4.13 and is compiled in Table 4.52. There are 10 kebeles in total. Two kebeles are located along the Shebele River and are supplied water by river water development. No.6 Hilaguduudo is located about 10km away from the Shebele River. It is possible to supply river water to there, however, it is not feasible in view of electricity consumption and operational cost increment. Further, initial investment cost is much larger than other kebeles. Thus, water supply plan of Hilaguduudo is formulated to provide birka. No.11 Todob has the existing borehole, however, water quality is not suitable as drinking water and it is impossible to use as water resource. Birka will be planned for No.11 Todob. Other seven kebeles have not been conducted groundwater development and there is no possibility from geological point of view. Therefore, rainwater development is adopted for them. Served population ranges from 2,685 to 5,219 persons and birka construction is requested from 9 to 18 structures.

Table 4.52: Features of Adadle Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Sed. Tank	Rough Filter	Pump H1 H2	Pump Q1 Q2	Gen.	Rev. V1 V2	Pipe D1 D2	Pipe L1 L2	Public tap
			person	No.	m^3	No.	m	m^3/m	kVA	m^3	mm	m	No.
2	Biyoolow	Birka	2,685	9									
3	Buursareedo	River intake	10,568	1	144	3	10 110	0.80 0.80	99	80 60	90 90	1400 2400	12
4	Gabal	River intake	12,507	1	196	3	10 100	0.90 0.90	101	100 70	90 90	1000 2800	14
5	Higlow	Birka	2,690	9									
6	Hilaguduudo	Birka	2,899	10									
7	Jeeray	Birka	3,225	11									
8	Maka Salar	Birka	5,219	18									
9	Maroodile	Birka	3,784	13									
10	Siigoole	Birka	2,694	9									
11	Todob	Birka	4,321	15									

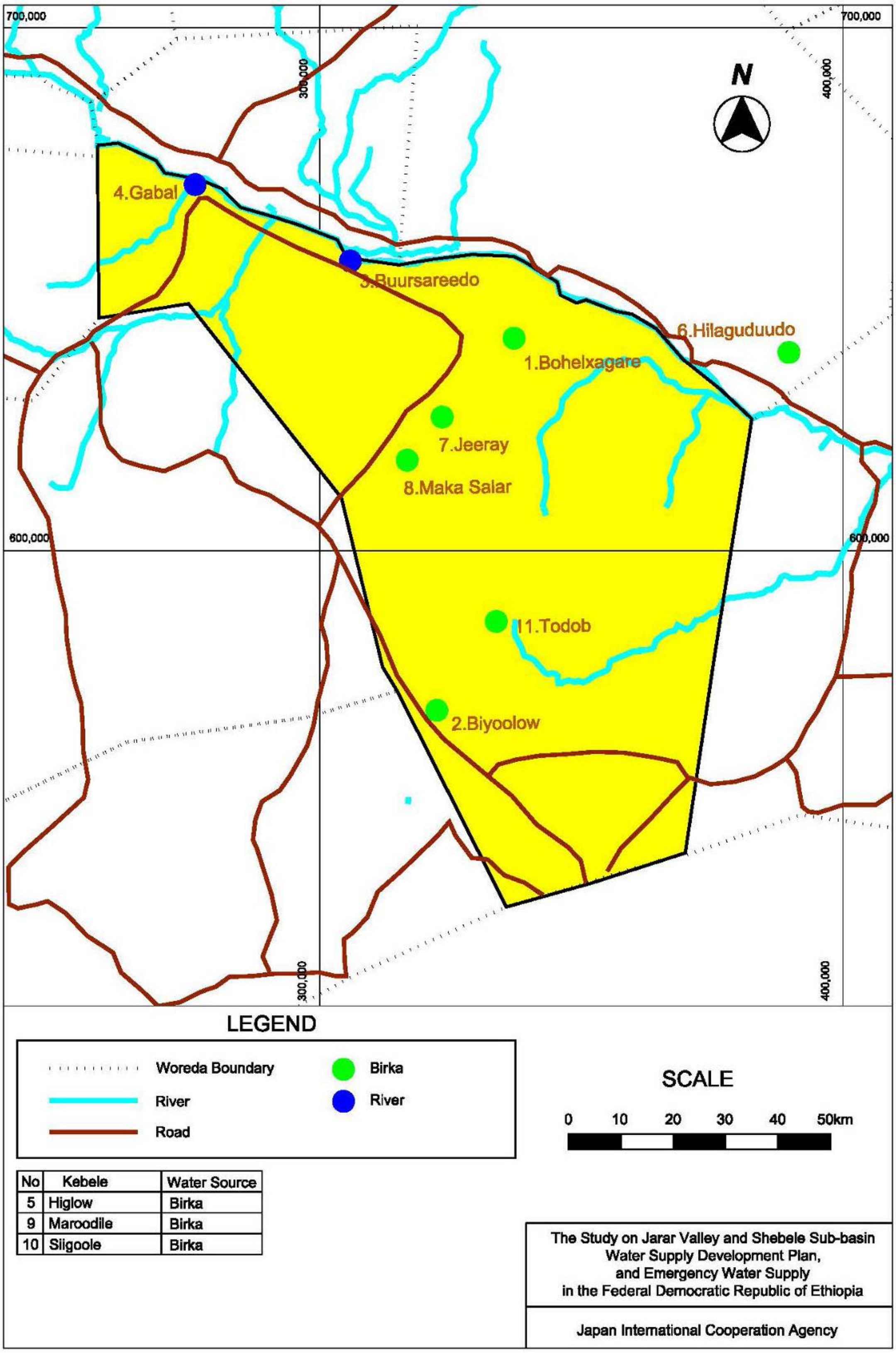


Figure 4.13: Adadle Woreda Water Supply Plan

4.12.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.53.

Table 4.53: Estimated Project Cost for Adadle Woreda

12 Adadle

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Biyoolow	Birka	9	513,000	77,000	51,000	641,000
2	**Bohelxagare**	Birka	23	1,311,000	197,000	131,000	1,639,000
3	Buursareedo	River intake	1	815,000	122,000	82,000	1,019,000
4	Gabal	River intake	1	859,000	129,000	86,000	1,074,000
5	Higlow	Birka	9	513,000	77,000	51,000	641,000
6	Hilaguduudo	Birka	10	570,000	86,000	57,000	713,000
7	Jeeray	Birka	11	627,000	94,000	63,000	784,000
8	Maka Salar	Birka	18	1,026,000	154,000	103,000	1,283,000
9	Maroodile	Birka	13	741,000	111,000	74,000	926,000
10	Siigoole	Birka	9	513,000	77,000	51,000	641,000
11	Todob	Birka	15	855,000	128,000	86,000	1,069,000
(1) River intake			2	1,674,000	251,000	168,000	2,093,000
(2) Birka			117	6,669,000	1,001,000	667,000	8,337,000
Total				8,343,000	1,252,000	835,000	10,430,000

4.12.3 Implementation Plan

a. Implementation schedule of water supply plan

It will take 30 months to design and construction a river water supply facility (refer to Table 4.5). It will take 12 months to design and construct a Birka (refer to Table 4.6).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and estimated project cost for each year are shown in the following Table 4.54.

Table 4.54: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

12 Adadle		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (Birka)									
average per year	3 facility								
	23 facility								
Construction cost		187,000	187,000	187,000	187,000	187,000	187,000	189,000	1,311,000
Engineering service expenses		28,000	28,000	28,000	28,000	28,000	28,000	29,000	197,000
Administration expenses and contingency		19,000	19,000	19,000	19,000	19,000	19,000	17,000	131,000
sub-total		**234,000**	**234,000**	**234,000**	**234,000**	**234,000**	**234,000**	**235,000**	**1,639,000**
(2) River water supply facility									
2015~2017 implementation	1 facility								
2018~2020 implementation	1 facility								
Total	2 facility								
Construction cost			279,000	279,000	279,000	279,000	279,000	279,000	1,674,000
Engineering service expenses			42,000	42,000	42,000	42,000	42,000	41,000	251,000
Administration expenses and contingency			28,000	28,000	28,000	28,000	28,000	28,000	168,000
sub-total			**349,000**	**349,000**	**349,000**	**349,000**	**349,000**	**348,000**	**2,093,000**
(3) Birka									
average per year	13.4 facility								
Total	94 facility								
Construction cost		765,000	765,000	765,000	765,000	765,000	765,000	768,000	5,358,000
Engineering service expenses		115,000	115,000	115,000	115,000	115,000	115,000	114,000	804,000
Administration expenses and contingency		77,000	77,000	77,000	77,000	77,000	77,000	74,000	536,000
sub-total		**957,000**	**957,000**	**957,000**	**957,000**	**957,000**	**957,000**	**956,000**	**6,698,000**
Total		**1,191,000**	**1,540,000**	**1,540,000**	**1,540,000**	**1,540,000**	**1,540,000**	**1,539,000**	**10,430,000**

4.13 Kalafo woreda

4.13.1 Water supply plan

a. Urban water supply

The urban area (town) of Kalafo woreda is located about 400m away from the Shebele River and it is the closest town among the target towns. It is the easiest to access to the river water. Therefore a water supply plan utilizing Shebele River development is formulated. Served population in 2020 is set as 33,848 persons. Design average daily supply is estimated to be 1,124m^3/day and water supply facilities are designed to be 1,855m^3/day. Kalafo town water supply system is the second largest river water development project following the Godey town one. The project component is similar to other river water urban water supply systems. Water purification facilities consist of intake canal, sedimentation tank with 576m^3 capacity, 8 rough filters, treated water reservoir with 380m^3, and 2 sets of pumps with capacity of 3.2m^3/min each. Water stored at the treated water reservoir is transmitted to the reservoir in the town with 700m^3 capacity through the transmission pipeline, which is 160mm diameter. Water in the reservoir is distributed through the existing pipeline. New distribution pipeline is connected to the existing ones and 38 public taps and 8 cattle troughs are provided at the end of the pipe. Major features of the Kalafo town water supply plan are summarized in Table 4.55.

Table 4.55: Features of Kalafo Town Water Supply System General Design

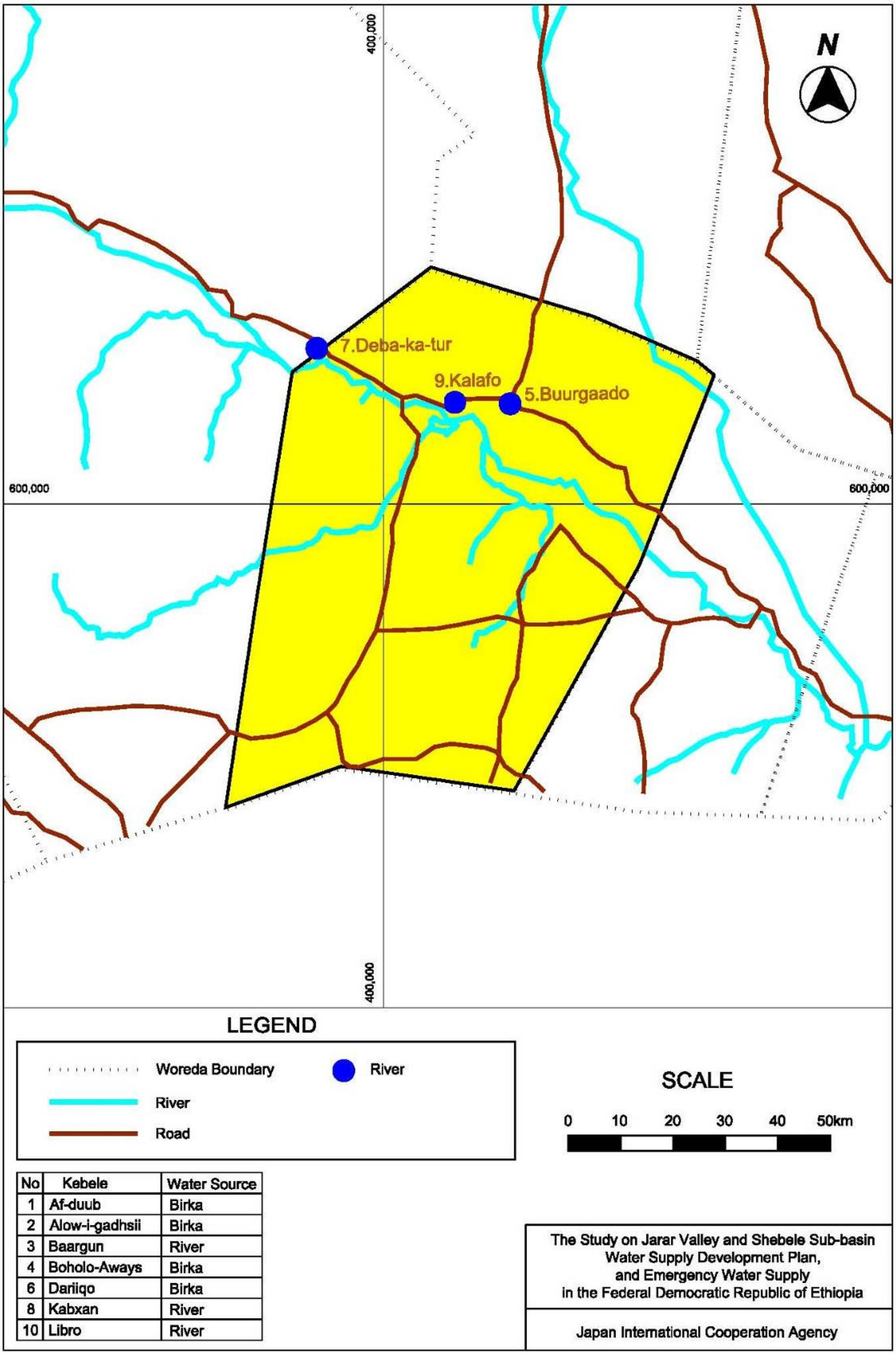
No.	Item	Specifications	Unit	Q'ty
1.	Intake canal		No.	1
2.	Sedimentation tank	V=576 m^3	No.	2
3.	Intake pump	Q=3.2m^3/min, H=10m	No.	2
4.	Rough filter	V=30m^3/hr	No.	8
5.	Treated water reservoir	V=380m^3	No.	1
6.	Surface pump	Q=3.2m^3/min, H=30m	No.	2
7.	Generator	116 kVA	No.	1
8.	Transmission pipeline	160 mm	m	400
9.	Reservoir	V=700m^3	No.	1
10.	Distribution system			
10.1	Pipeline	90 mm	m	19,000
10.2	Public tap		No.	38
10.3	Cattle trough		No.	8

b. Rural water supply

Water supply master plan in Kalafo woreda is illustrated in Figure 4.14 and is summarized in Table 4.56. There are 9 kebeles in total. Five kebeles are supplied water by river water development. Two kebeles, No.5 Buurgaado and No.7 Deba-ka-tur, are located along the Shebele River, from which they are within 1km of. River water was planned to be utilized at the three other kebeles based on the socio-economic survey results. There is no groundwater development in Kalafo woreda so rainwater development is adopted for the remaining 4 kebeles. Served population ranges from 3,053 to 4,129 persons and Birka is planned in 11 to 14 places by target kebele.

Table 4.56: Features of Kalafo Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Sed. Tank	Rough Filter	Pump H1 H2	Pump Q1 Q2	Gen.	Rev. V1 V2	Pipe D1 D2	Pipe L1 L2	Public tap
			person	No.	m^3	No.	m	m^3/m	kVA	m^3	mm	m	No.
1	Af-duub	Birka	4,129	14									
2	Alow-i-gadhsii	Birka	3,053	11									
3	Baargun	River intake	8,497	1	144	3	10 40	0.80 0.80	41	80 50	90 90	500 2000	10
4	Boholo-Aw ays	Birka	3,911	14									
5	Buurgaado	River intake	8,497	1	144	3	10 70	0.80 0.80	66	80 50	90 90	800 2000	10
6	Dariiqo	Birka	3,588	12									
7	Deba-ka-tur	River intake	13,100	1	196	3	10 10	0.90 0.90	18	100 80	90 90	100 3000	15
8	Kabxan	River intake	8,497	1	144	3	10 40	0.80 0.80	41	80 50	90 90	500 2000	10
10	Libro	River intake	9,384	1	144	3	10 40	0.80 0.80	41	80 60	90 90	500 2200	11



No	Kebele	Water Source
1	Af-duub	Birka
2	Alow-i-gadhsii	Birka
3	Baargun	River
4	Boholo-Aways	Birka
6	Dariiqo	Birka
8	Kabxan	River
10	Libro	River

Figure 4.14: Kalafo Woreda Water Supply Plan

4.13.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.57.

Table 4.57: Estimated Project Cost for Kalafo Woreda

13 Kalafo

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Af-duub	Birka	14	798,000	120,000	80,000	998,000
2	Alow-i-gadhsii	Birka	11	627,000	94,000	63,000	784,000
3	Baargun	River intake	1	756,000	113,000	76,000	945,000
4	Boholo-Aways	Birka	14	798,000	120,000	80,000	998,000
5	Buurgaado	River intake	1	734,000	110,000	73,000	917,000
6	Dariiqo	Birka	12	684,000	103,000	68,000	855,000
7	Deba-ka-tur	River intake	1	761,000	114,000	76,000	951,000
8	Kabxan	River intake	1	691,000	104,000	69,000	864,000
9	**Kalafo**	River intake	1	2,202,000	330,000	220,000	2,752,000
10	Libro	River intake	1	713,000	107,000	71,000	891,000
(1) Urban water supply			1	2,202,000	330,000	220,000	2,752,000
(2) River intake			5	3,655,000	548,000	365,000	4,568,000
(3) Birka			51	2,907,000	437,000	291,000	3,635,000
Total				8,764,000	1,315,000	876,000	10,955,000

4.13.3 Implementation Plan

a. Implementation schedule of water supply plan

It will take 30 months to design and construct a river water supply facility (refer to Table 4.5). It will take 12 months to design and construct a Birka (refer to Table 4.6).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated project cost for each year are shown in the following Table 4.58.

Table 4.58: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

13 Kalafo		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (River)									
2015~2017 implementation	1 facility								
Construction cost			734,000	734,000	734,000				2,202,000
Engineering service expenses			110,000	110,000	110,000				330,000
Administration expenses and contingency			73,000	73,000	74,000				220,000
sub-total			**917,000**	**917,000**	**918,000**				**2,752,000**
(2) River water supply facility									
2016~2018 implementation	2 facility								
2018~2020 implementation	3 facility								
Total	5 facility								
Construction cost				487,000	487,000	1,218,000	731,000	732,000	3,655,000
Engineering service expenses				73,000	73,000	183,000	110,000	109,000	548,000
Administration expenses and contingency				49,000	49,000	122,000	73,000	72,000	365,000
sub-total				**609,000**	**609,000**	**1,523,000**	**914,000**	**913,000**	**4,568,000**
(3) Birka									
average per year	7.3 facility								
Total	51 facility								
Construction cost		415,000	415,000	415,000	415,000	415,000	415,000	417,000	2,907,000
Engineering service expenses		62,000	62,000	62,000	62,000	62,000	62,000	65,000	437,000
Administration expenses and contingency		42,000	42,000	42,000	42,000	42,000	42,000	39,000	291,000
sub-total		**519,000**	**519,000**	**519,000**	**519,000**	**519,000**	**519,000**	**521,000**	**3,635,000**
Total		**519,000**	**1,436,000**	**2,045,000**	**2,046,000**	**2,042,000**	**1,433,000**	**1,434,000**	**10,955,000**

4.14 Mustahil woreda

4.14.1 Water supply plan

a. Urban water supply

The urban area (town) of Mustahil woreda is located about 800m away from the Shebele River and can access to the river water. Thus, river water was selected as water resource. Served population in 2020 was set as 29,537 persons. Design average daily supply was estimated to be 932m^3/day and water supply facilities were designed to be 1,538m^3/day. Mustahil water supply system is almost the same scale as Kalafo's one, it is a relatively large-scale urban water supply system among the target towns. Project component is similar to other town water supply systems by river water development. Water purification facilities consist of intake canal, sedimentation tank with 484m^3 capacity, 7 rough filters, treated water reservoir with 320m^3, and 2 places of pumps with capacity of 2.7m^3/min each. Water stored at the treated water reservoir is transmitted to the reservoir in the town with 600m^3 capacity through the transmission pipeline, which is 160mm diameter. Water in the reservoir is distributed through the existing pipeline. New distribution pipeline is connected to the existing ones and 33 public taps and 7 cattle troughs are provided at the end of the pipe. The summary of the town water supply system is presented in Table 4.59 below.

Table 4.59: Features of Mustahil Town Water Supply System General Design

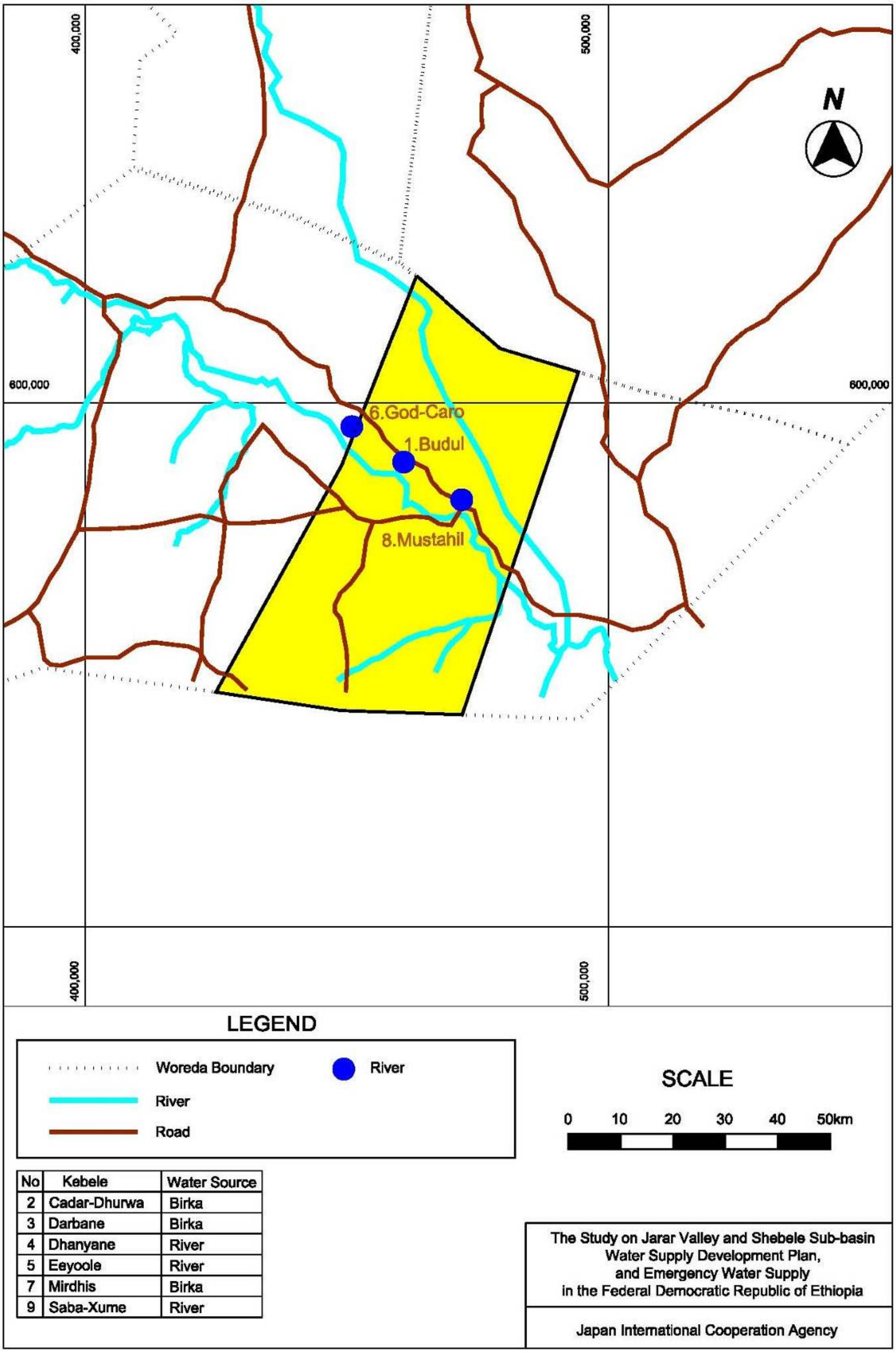
No.	Item	Specifications	Unit	Q'ty
1.	Intake canal		No.	1
2.	Sedimentation tank	V=484m^3	No.	2
3.	Intake pump	Q=2.7m^3/min, H=10m	No.	2
4.	Rough filter	V=30m^3/hr	No.	7
5.	Treated water reservoir	V=320m^3	No.	1
6.	Surface pump	Q=2.7m^3/min, H=40m	No.	2
7.	Generator	124 kVA	No.	1
8.	Transmission pipeline	160 mm	m	800
9.	Reservoir	V=600m^3	No.	1
10.	Distribution system			
10.1	Pipeline	90 mm	m	16,500
10.2	Public tap		No.	33
10.3	Cattle trough		No.	7

b. Rural water supply

Water supply master plan in Mustahil woreda is illustrated in Figure 4.15 and is summarized in Table 4.60. There are 8 kebeles in total. No.1 Budul and No.6 God-Caro are identified to be located within 1km from the river. Other 3 kebeles use the river water from the socio-economic survey result and water resource is developed by river water. Rainwater development is adopted for the remaining 3 kebeles and quantities of birka are planned to 7 and 10 places.

Table 4.60: Features of Mustahil Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Sed. Tank	Rough Filter	Pump H1 H2	Pump Q1 Q2	Gen.	Rev. V1 V2	Pipe D1 D2	Pipe L1 L2	Public tap
			person	No.	m^3	No.	m	m^3/m	kVA	m^3	mm	m	No.
1	Budul	River	9,469	1	144	3	10 30	0.80 0.80	33	80 60	110 90	800 2200	11
2	Cadar-Dhurwa	Birka	2,080	7									
3	Darbane	Birka	2,028	7									
4	Dhanyane	River	6,608	1	100	2	10 30	0.60 0.60	25	60 40	90 90	500 1600	8
5	Eeyoole	River	7,954	1	100	2	10 30	0.60 0.60	25	60 50	90 90	500 1800	9
6	God-Caro	River	6,230	1	100	2	10 10	0.60 0.60	12	60 40	90 90	200 1400	7
7	Mirdhis	Birka	2,957	10									
9	Saba-Xume	River	9,300	1	144	3	10 40	0.80 0.80	41	80 50	90 90	500 2200	11



No	Kebele	Water Source
2	Cadar-Dhurwa	Birka
3	Darbane	Birka
4	Dhanyane	River
5	Eeyoole	River
7	Mirdhis	Birka
9	Saba-Xume	River

Figure 4.15: Mustahil Woreda Water Supply Plan

4.14.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.61.

Table 4.61: Estimated Project Cost of Mustahil Woreda

14 Mustahil

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Budul	River intake	1	724,000	109,000	72,000	905,000
2	Cadar-Dhurwa	Birka	7	399,000	60,000	40,000	499,000
3	Darbane	Birka	7	399,000	60,000	40,000	499,000
4	Dhanyane	River intake	1	616,000	92,000	62,000	770,000
5	Eeyoole	River intake	1	637,000	96,000	64,000	797,000
6	God-Caro	River intake	1	578,000	87,000	58,000	723,000
7	Mirdhis	Birka	10	570,000	86,000	57,000	713,000
8	**Mustahil**	River intake	1	2,013,000	302,000	201,000	2,516,000
9	Saba-Xume	River intake	1	707,000	106,000	71,000	884,000
(1) Urban water supply			1	2,013,000	302,000	201,000	2,516,000
(2) River intake			5	3,262,000	490,000	327,000	4,079,000
(3) Birka			24	1,368,000	206,000	137,000	1,711,000
Total				6,643,000	998,000	665,000	8,306,000

4.14.3 Implementation Plan

a. Implementation schedule of water supply plan

It will take 30 months to design and construct a river water supply facility (refer to Table 4.5). It will take 12 months to design and construct a Birka (refer to Table 4.6).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated project cost for each year are shown in the following Table 4.62.

Table 4.62: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

14 Mustahil		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (River)									
2015~2017 implementation	1 facility								
Construction cost			671,000	671,000	671,000				2,013,000
Engineering service expenses			101,000	101,000	100,000				302,000
Administration expenses and contingency			67,000	67,000	67,000				201,000
sub-total			**839,000**	**839,000**	**838,000**				**2,516,000**
(2) River water supply facility									
2016~2018 implementation	2 facility								
2018~2020 implementation	3 facility								
Total	5 facility								
Construction cost				487,000	487,000	1,218,000	731,000	339,000	3,262,000
Engineering service expenses				73,000	73,000	183,000	110,000	51,000	490,000
Administration expenses and contingency				49,000	49,000	122,000	73,000	34,000	327,000
sub-total				**609,000**	**609,000**	**1,523,000**	**914,000**	**424,000**	**4,079,000**
(3) Birka									
average per year	3.4 facility								
Total	24 facility								
Construction cost		195,000	195,000	195,000	195,000	195,000	195,000	198,000	1,368,000
Engineering service expenses		29,000	29,000	29,000	29,000	29,000	29,000	32,000	206,000
Administration expenses and contingency		20,000	20,000	20,000	20,000	20,000	20,000	17,000	137,000
sub-total		**244,000**	**244,000**	**244,000**	**244,000**	**244,000**	**244,000**	**247,000**	**1,711,000**
Total		**244,000**	**1,083,000**	**1,692,000**	**1,691,000**	**1,767,000**	**1,158,000**	**671,000**	**8,306,000**

4.15 Rasso woreda

4.15.1 Water supply plan

a. Urban water supply

The urban area (town) of Rasso woreda is located about 1,500m away from the Shebele River branch stream. Though Rasso can take the river water, the branch river is a wadi river and it does not have permanent flow in dry season. It is not practical to use river water as water supply plan. Therefore, river water development is not adopted for Rasso town. As for groundwater development, there is no existing borehole around Rasso town and it is less possibility to receive groundwater for them. Groundwater is also excluded from water resource and rainwater is the only one practical water resource for the Rasso town. Thus, the Rasso water supply plan is formulated to construct birka. Served population in 2020 is set as 3,050 persons. Design average daily supply is estimated to be 96m^3/day. Dry season in the Shebele sub-basin is 4 months as explained in the section 4.12.1, required storage volume shall be 11,520m^3=96m^3/day×120days and required quantity is 12 places. Though 11 birkas are necessary calculating from beneficiaries, water supply plan shall choose 12 birkas as shown in Table 4.63.

Table 4.63: Features of Rasso Town Water Supply System General Design

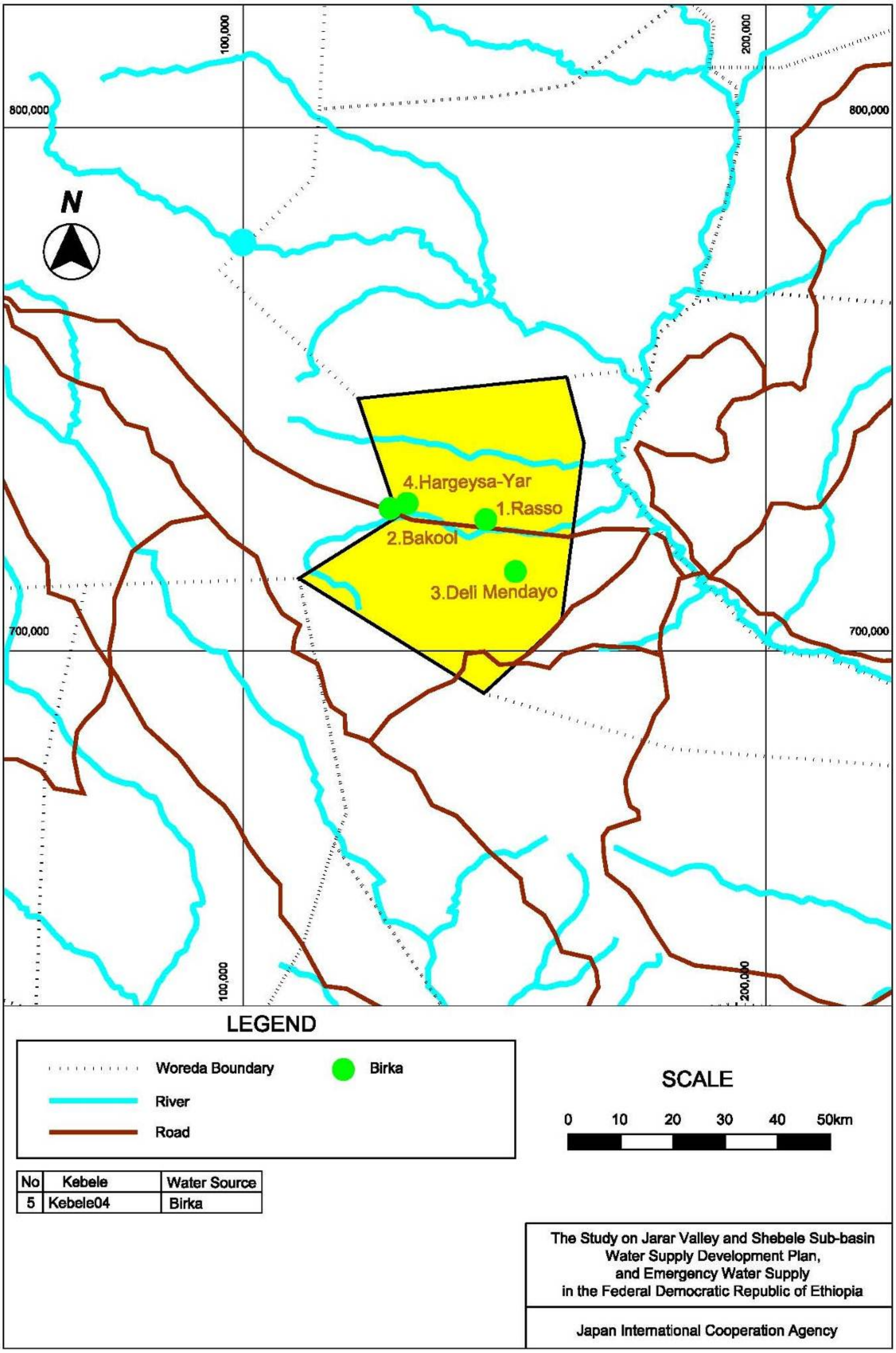
No.	Item	Specifications	Q'ty
1.	Birka	21m x 14m x 3.5m	12

b. Rural water supply

Water supply master plan for Rasso woreda is illustrated in Figure 4.16 and is summarized in Table 4.64. There are 4 kebeles in total and all of them are supplied water by birka due to limitation of river water and groundwater. Served population is 2,124 persons and birka is planned for 8 places.

Table 4.64: Features of Rasso Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities
			person	No.
1	Bakool	Birka	2,124	8
2	Deli Mendayo	Birka	2,124	8
3	Hargeysa-Yar	Birka	2,124	8
4	Kebele04	Birka	2,124	8



No	Kebele	Water Source
5	Kebele04	Birka

Figure 4.16: Rasso Woreda Water Supply Plan

4.15.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.65.

Table 4.65: Estimated Project Cost of Rasso Woreda

15.Rasso

ID	Kebele	Structure	No. of facility	Project cost (USD)			
				Construction cost	Engineering service	Administration Contingency	Total
1	Bakool	Birka	8	456,000	68,000	46,000	570,000
2	Deli Mendayo	Birka	8	456,000	68,000	46,000	570,000
3	Hargeysa-Yar	Birka	8	456,000	68,000	46,000	570,000
4	Kebele04	Birka	8	456,000	68,000	46,000	570,000
5	**Rasso**	Birka	12	684,000	103,000	68,000	855,000
(1) Birka			44	2,508,000	375,000	252,000	3,135,000
Total				2,508,000	375,000	252,000	3,135,000

4.15.3 Implementation Plan

a. Implementation schedule of water supply plan

It will take 12 months to design and construct to a Birka (refer to Table 4.6).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and estimated project cost for each year are shown in the following Table 4.66.

Table 4.66: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

15.Rasso		Western calendar (year)							Estimated project cost
		2014	2015	2016	2017	2018	2019	2020	
(1) Urban water supply system (Birka)									
average per year	1.7 facility								
Total	12 facility								
Construction cost		98,000	98,000	98,000	98,000	98,000	98,000	96,000	684,000
Engineering service expenses		15,000	15,000	15,000	15,000	15,000	15,000	13,000	103,000
Administration expenses and contingency		10,000	10,000	10,000	10,000	10,000	10,000	8,000	68,000
sub-total		**123,000**	**123,000**	**123,000**	**123,000**	**123,000**	**123,000**	**117,000**	**855,000**
(2) Birka									
average per year	4.6 facility								
Total	32 facility								
Construction cost		261,000	261,000	261,000	261,000	261,000	261,000	258,000	1,824,000
Engineering service expenses		39,000	39,000	39,000	39,000	39,000	39,000	38,000	272,000
Administration expenses and contingency		26,000	26,000	26,000	26,000	26,000	26,000	28,000	184,000
sub-total		**326,000**	**326,000**	**326,000**	**326,000**	**326,000**	**326,000**	**324,000**	**2,280,000**
Total		**449,000**	**449,000**	**449,000**	**449,000**	**449,000**	**449,000**	**441,000**	**3,135,000**

4.16 West Ime woreda

4.16.1 Water supply plan

a. Urban water supply

The urban area (town) of West Ime woreda is located about 900m away from the Shebele River. It is possible to take the river water to the West Ime town so that water supply plan was formulated by the river water development. Served population in 2020 was set as 9,938 persons. Design average daily supply was estimated to be 284 m^3/day and water supply facilities were designed to be 469m^3/day. West Ime town water supply system is a small-scale urban water supply system; it is almost the same as Beercaano's one. The project component is similar to other town water supply systems that utilize river water development. It consists of intake canal, sedimentation tank with 196m^3 capacity, 3 rough filters, treated water reservoir with 100m^3, and 2 sets of pumps with capacity of 0.9m^3/min each at intake site. Treated water is transmitted to the reservoir with 200m^3 in the town and transmission pipeline length is 900m with 110mm diameter. The reservoir water is distributed through the existing pipeline. New distribution pipeline is connected to the existing ones and 10 public taps and 2 cattle troughs are provided at the end of the pipe. General features of West Ime town water supply system are summarized in Table 4.67.

Table 4.67: Features of West Ime Town Water Supply System General Design

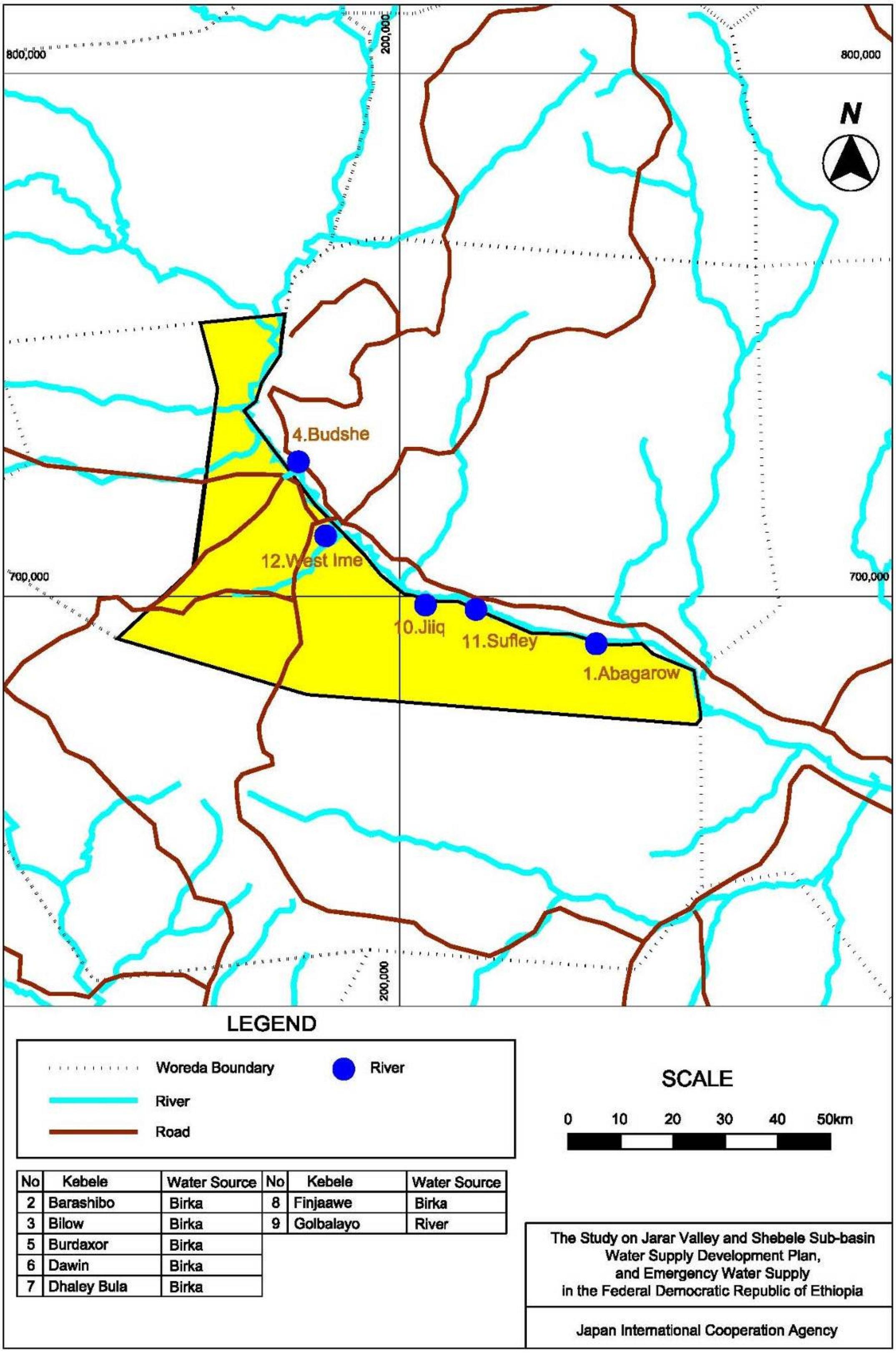
No.	Item	Specifications	Unit	Q'ty
1.	Intake canal		No.	1
2.	Sedimentation tank	V=196m^3	No.	2
3.	Intake pump	Q=0.9m^3/min, H=10m	No.	2
4.	Rough filter	V=30m^3/hr	No.	3
5.	Treated water reservoir	V=100m^3	No.	1
6.	Surface pump	Q=0.9m^3/min, H=40m	No.	2
7.	Generator	46 kVA	No.	1
8.	Transmission pipeline	110 mm	m	900
9.	Reservoir	V=200m^3	No.	1
10.	Distribution system			
10.1	Pipeline	90 mm	m	5,000
10.2	Public tap		No.	10
10.3	Cattle trough		No.	2

b. Rural water supply

Water supply master plan in West Ime woreda is illustrated in Figure 4.17 and is summarized in Table 4.68. There are 11 kebeles in total. Four kebeles are located along the Shebele River and are supplied water by river water development. No.9 Golbalayo is also supplied by river water because socio-economic survey result indicates that they take river water as domestic water. There is no borehole development in West Ime woreda and no possibility of groundwater development. Then, rainwater development is adopted for the 6 kebeles. Due to the small served population, quantities of birka are moderate in comparison with other woreda. Their served population ranges from 567 to 945 persons and birka is planned for 2 to 4 places.

Table 4.68: Features of West Ime Woreda Rural Water Supply Plan

ID	Kebele	Structure	Served pop.	Facilities	Sed. Tank	Rough Filter	Pump H1 H2	Pump Q1 Q2	Gen.	Rev. V1 V2	Pipe D1 D2	Pipe L1 L2	Public tap
			person	No.	m^3	No.	m	m^3/m	kVA	m^3	mm	m	No.
1	Abagarow	River intake	3,690	1	64	2	10 20	0.40 0.40	14	40 20	90 90	700 1000	5
2	Barashibo	Birka	945	4									
3	Bilow	Birka	756	3									
4	Budshe	River intake	3,076	1	64	2	10 40	0.40 0.40	23	40 20	90 90	1500 800	4
5	Burdaxor	Birka	945	4									
6	Dawin	Birka	756	3									
7	Dhaley Bula	Birka	567	2									
8	Finjaawe	Birka	756	3									
9	Golbalayo	River intake	4,308	1	64	2	10 20	0.40 0.40	14	40 30	90 90	500 1000	5
10	Jiiq	River intake	2,462	1	36	2	10 10	0.20 0.20	6	20 20	90 90	700 600	3
11	Sufley	River intake	1,846	1	36	2	10 10	0.20 0.20	6	20 10	90 90	100 600	3



No	Kebele	Water Source	No	Kebele	Water Source
2	Barashibo	Birka	8	Finjaawe	Birka
3	Bilow	Birka	9	Golbalayo	River
5	Burdaxor	Birka			
6	Dawin	Birka			
7	Dhaley Bula	Birka			

Figure 4.17: West Ime Woreda Water Supply Plan

4.16.2 Cost estimation

The estimated project cost for this woreda is shown in the following Table 4.69.

Table 4.69: Estimated Project Cost of West Ime Woreda

16 West Ime

ID	Kebele	Structure	No. of facility	Project cost (USD) Construction cost	Engineering service	Administration Contingency	Total
1	Abagarow	River intake	1	475,000	71,000	48,000	594,000
2	Barashibo	Birka	4	228,000	34,000	23,000	285,000
3	Bilow	Birka	3	171,000	26,000	17,000	214,000
4	Budshe	River intake	1	594,000	89,000	59,000	742,000
5	Burdaxor	Birka	4	228,000	34,000	23,000	285,000
6	Dawin	Birka	3	171,000	26,000	17,000	214,000
7	Dhaley Bula	Birka	2	114,000	17,000	11,000	142,000
8	Finjaawe	Birka	3	171,000	26,000	17,000	214,000
9	Golbalayo	River intake	1	475,000	71,000	48,000	594,000
10	Jiiq	River intake	1	416,000	62,000	42,000	520,000
11	Sufley	River intake	1	389,000	58,000	39,000	486,000
12	**West Ime**	River intake	1	913,000	137,000	91,000	1,141,000
(1) Urban water supply			1	913,000	137,000	91,000	1,141,000
(2) River intake			5	2,349,000	351,000	236,000	2,936,000
(3) Birka			19	1,083,000	163,000	108,000	1,354,000
Total				4,345,000	651,000	435,000	5,431,000

4.16.3 Implementation Plan

a. Implementation schedule of water supply plan

It will take 30 months to design and construct a river water supply facility (refer to Table 4.5) and 12 months for a Birka (refer to Table 4.6).

b. Implementation schedule and estimated project cost for each year

The implementation schedule and the estimated project cost for each year are shown in the following Table 4.70.

Table 4.70: Implementation Schedule and Estimated Project Cost for Each Year

(Unit:USD)

16 West Ime		Western calendar (year) 2014	2015	2016	2017	2018	2019	2020	Estimated project cost
(1) Urban water supply system (River)									
2015~2017 implementation	1 facility		■	■	■				
Construction cost			304,000	304,000	305,000				913,000
Engineering service expenses			46,000	46,000	45,000				137,000
Administration expenses and contingency			30,000	30,000	31,000				91,000
sub-total			**380,000**	**380,000**	**381,000**				**1,141,000**
(2) River water supply facility									
2016~2018 implementation	2 facility			■	■	■			
2018~2020 implementation	3 facility					■	■	■	
Total	5 facility								
Construction cost				313,000	313,000	783,000	470,000	470,000	2,349,000
Engineering service expenses				47,000	47,000	117,000	70,000	70,000	351,000
Administration expenses and contingency				31,000	31,000	79,000	47,000	48,000	236,000
sub-total				**391,000**	**391,000**	**979,000**	**587,000**	**588,000**	**2,936,000**
(3) Birka									
average per year	2.7 facility	■	■	■	■	■	■	■	
Total	19 facility								
Construction cost		155,000	155,000	155,000	155,000	155,000	155,000	153,000	1,083,000
Engineering service expenses		23,000	23,000	23,000	23,000	23,000	23,000	25,000	163,000
Administration expenses and contingency		15,000	15,000	15,000	15,000	15,000	15,000	18,000	108,000
sub-total		**193,000**	**193,000**	**193,000**	**193,000**	**193,000**	**193,000**	**196,000**	**1,354,000**
Total		**193,000**	**573,000**	**964,000**	**965,000**	**1,172,000**	**780,000**	**784,000**	**5,431,000**

4.17 Economic and financial evaluation of each woreda

4.17.1 Economic evaluation

a. Target woredas and beneficiaries

The water supply plans have been designed to satisfy the basic human needs of the community people in the 16 target woredas located in Somali region. The project aims to provide and distribute sufficient and safe water to meet the needs of domestic water users in the target woredas by the year 2020. The total population of all the target woredas will reach 1,533,444 persons in 2020, of which the number of beneficiaries is estimated at 469,681 persons as presented in Table 4.71 below.

Table 4.71: Number of Beneficiaries and Households in the Proposed Plan

Woreda	Total Population in 2020		Beneficiaries in 2020	
	Population	Household	Beneficiaries	Household
Kabribeyah (Rural)	202,882	40,576	64,197	12,839
Araarso	52,330	10,466	16,057	3,211
Dagahbur	173,329	34,666	53,191	10,638
Birqod	24,915	4,983	7,646	1,529
Shaygosh	79,802	15,960	24,490	4,898
Kabridahar	219,259	43,852	67,288	13,458
Debo wein	94,348	18,870	28,957	5,791
East Ime	113,804	22,761	34,925	6,985
Danan	37,911	7,582	11,636	2,327
Beercaano	34,220	6,844	10,503	2,101
Godey (Rural)	70,185	14,037	21,537	4,307
Adadle	131,612	26,322	40,390	8,078
Kalafo	129,665	25,933	39,789	7,958
Mustahil	92,118	18,424	25,418	5,084
Rasso	39,447	7,889	11,546	2,309
West Ime	37,618	7,524	12,111	2,422
Total	1,533,444	306,689	469,681	93,936

Note: Urban population data of Kabribeyah and Godey towns are not included.

b. Basic assumptions for economic evaluation

The economic evaluation has been undertaken on the basis of the following assumptions:

(1) The exchange rate of USD 1.00 = Birr 18.53, that is the average exchange rate during November 2012 and April 2013, has been applied.

(2) The base year for the costs is 2013.

(3) Only direct and tangible benefits have been quantified over the project life of 20 years for the calculation of the economic indicators.

(4) Discount rate of 10 % has been applied as a proxy of opportunity cost of capital in Ethiopia.

(5) Transfer payments such as interest and taxes, and price escalation are not included in the calculation.

c. Economic project cost

c.1 Project costs

The economic project costs comprise of the costs for the construction of water supply facilities, engineering services, physical contingency and administration costs. Taxes and price contingency are not included in the economic costs. Conversion factors to convert the financial prices into economic prices have not been applied in this analysis due to lower percentage of local currency portion. The economic project costs for the 16 woredas thus estimated amount to US$113,121,000 as presented in Table 4.72.

Table 4.72: Project Costs for Water Supply Plans for the Target Woredas

Unit: U.S. Dollar

Woreda	2014	2015	2016	2017	2018	2019	2020	Total
Kabribeyah	1,493,000	1,915,000	2,335,000	2,335,000	2,335,000	2,335,000	1,916,000	14,664,000
Araarso	285,000	1,337,000	1,337,000	1,339,000	485,000	484,000	285,000	5,552,000
Dagahbur	594,000	1,869,000	1,869,000	2,008,000	876,000	876,000	878,000	8,970,000
Birqud	41,000	363,000	360,000	231,000	231,000	231,000	228,000	1,685,000
Shaygosh	442,000	895,000	894,000	594,000	594,000	594,000	595,000	4,608,000
Kabridahar	960,000	2,551,000	2,551,000	2,693,000	1,242,000	1,242,000	1,355,000	12,594,000
Doba wein	72,000	794,000	794,000	1,031,000	482,000	874,000	633,000	4,680,000
East Ime	540,000	1,551,000	1,551,000	1,551,000	1,590,000	1,590,000	1,589,000	9,962,000
Danan	133,000	374,000	374,000	550,000	309,000	309,000	302,000	2,351,000
Beercaano	214,000	576,000	576,000	576,000	602,000	602,000	605,000	3,751,000
Godey	398,000	1,004,000	1,003,000	912,000	912,000	912,000	906,000	6,047,000
Adadle	1,191,000	1,540,000	1,540,000	1,540,000	1,540,000	1,540,000	1,539,000	10,430,000
Kalafo	519,000	1,436,000	2,045,000	2,046,000	2,042,000	1,433,000	1,434,000	10,955,000
Mustahil	244,000	1,083,000	1,692,000	1,691,000	1,767,000	1,158,000	671,000	8,306,000
Rasso	449,000	449,000	449,000	449,000	449,000	449,000	441,000	3,135,000
West Ime	193,000	573,000	964,000	965,000	1,172,000	780,000	784,000	5,431,000
Total	7,768,000	18,310,000	20,334,000	20,511,000	16,628,000	15,409,000	14,161,000	113,121,000

Note: Project costs for Kabribeyah and Godey Towns are not included.

c.2 Operation and maintenance costs

The annual operation and maintenance (O&M) costs of the water supply plans include spare parts, power supply, personnel, chemical, consumables and others. The O&M costs of each plan are presented in Table 4.73.

Table 4.73: Operation and Maintenance Costs for Water Supply Plans

Unit: U.S. Dollar

Water Supply Plans	Construction Cost	Annual O & M Cost	Percentage of O&M
Kabribeyah	14,664,000	762,942	5.2%
Araarso	5,552,000	202,461	3.6%
Dagahbur	8,970,000	346,345	3.9%
Birqod	1,685,000	106,378	6.3%
Shaygosh	4,608,000	146,256	3.2%
Kabridahar	12,594,000	350,063	2.8%
Doba wein	4,680,000	213,803	4.6%
East Ime	9,962,000	414,163	4.2%
Danan	2,351,000	86,083	3.7%
Beercaano	3,751,000	187,646	5.0%
Godey	6,047,000	271,857	4.5%
Adadle	10,430,000	172,865	1.7%
Kalafo	10,955,000	400,108	3.7%
Mustahil	8,306,000	350,087	4.2%
Rasso	3,135,000	66,233	2.1%
West Ime	5,431,000	248,095	4.6%

d. Economic Benefits

Out of several economic benefits of the project, only benefits of time saving for fetching water and health improvement benefits have been included in the calculation of economic indicators, as other benefits (e.g. improvement of quality of daily life) are considered to be difficult to quantify.

Time savings benefits for fetching water will arise immediately at the start of the operation of the project facilities. Health improvement benefits will arise from the second year after commencement of the project. Annual benefits have been calculated as the total of time savings and health improvement benefits.

d.1 Benefits of time savings for fetching water

Benefits of time savings for fetching water are derived as a result of shorter distance to water sources after implementation of the project. Time savings from reduction in time spent fetching water is the difference between time for water collection “with” and “without” the project. Time for fetching water consists of travel, queuing and filling time.

Time for fetching water “without the project” is assumed to be the same as the time spent for fetching water in the dry season, namely 3.8 hours on average per household.[1] Time for fetching water “with the project” is assumed to be the same as the time spent fetching water in the rainy season, namely 1.4 hours on average per household. Time saving, therefore, will be the difference between the time spent in the rainy season and the same in the dry season, namely 2.4 hours on average per household.

Value of time savings is measured from the average time saved multiplied by the economic labor cost. It is assumed that 50% of time saved will be used on productive activities and the remaining 50 % will have no value. The value of productive activities is assumed to be 100 Birr per day on the basis of the unskilled labor cost in the study area. The value of time saved on fetching water will be 50 Birr (100 Birr x 50%) per day or 6.25 Birr per hour. Consequently, time saved of 2.4 hours on average per day will have the value of 15 Birr per day per each household. Assuming that there will be at least 300 days of productive activities in a year, the value of time saving will be 4,500 Birr per year.

Benefits of time savings will arise immediately at the start of operation of the project facilities and will increase year by year, reaching its maximum amount in 2021.

d.2 Health improvement benefits

Health improvement benefits are derived as a result of an improvement in water quality and increased supply of water. The benefits can be measured from the difference of medical expenses between “with” and “without” the project.

Provision of a clean water supply and hygiene education will lead to the reduction in per capita health costs by 10 %.[2] As a result, the rural population in the target woredas will be able to reduce their medical expenses at that ratio. Estimated health benefits by woreda are presented in Table 4.74.

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[1] Socio-economic Survey conducted by SHAAC in 2012

[2] Annex 9, Project Appraisal Report, Water Supply and Sanitation Project, World Bank, 2004

Table 4.74: Estimated Health Improvement Benefits

Unit: Birr

Woreda	Medical costs "without the project"	Medical costs "with the project"	Health benefits per household
Kabribeyah	1,362	1,226	136
Dagahbur	950	855	95
Araarso	750	675	75
Birqod	1,000	900	100
Shaygosh	1,855	1,670	186
Kabridahar	1,948	1,753	195
Debo wein	1,310	1,179	131
Godey	4,395	3,956	440
East Ime	2,642	2,378	264
Adadle	498	448	50
Danan	300	270	30
Beercaano	600	540	60
Kalafo	2,108	1,897	211
Mustahil	3,286	2,957	329
West Ime	2,429	2,186	243
Rasso	750	675	75

Source: Socio-economic Survey, SHAAC, October 2012

e. Cost and Benefit Analysis

Economic evaluation has been conducted on the basis of the annual costs and benefits stream as estimated in the preceding sections. The result of economic evaluation of the proposed projects in terms of Economic Internal Rate of Return (EIRR) and Net Present Value (NPV) is presented in Table 4.75 below.

Table 4.75: Summary of Cost Benefit Analysis

Woreda Water Supply Schemes	Estimated No. of Beneficiaries	Economic Internal Rate of Return (EIRR)
Kabribeyah (Rural)	64,197	12.5 %
Araarso	16,057	8.2 %
Dagahbur	53,191	7.2 %
Birqod	7,646	17.3 %
Shaygosh	24,490	26.0 %
Kabridahar	67,288	21.0 %
Debo wein	28,957	25.9 %
East Ime	34,925	12.0 %
Danan	11,636	16.3 %
Beercaano	10,503	2.8 %
Godey (Rural)	21,537	13.9 %
Adadle	40,390	13.7 %
Kalafo	39,789	10.4 %
Mustahil	25,418	7.0 %
Rasso	11,546	12.4 %
West Ime	12,111	11.2 %

The economic indicators mentioned above signify the economic viability of the majority of the projects as the EIRR exceeds the opportunity cost of capital of 10%. However, the projects in some woredas such as Araarso, Dagahbur, Beercaano and Mustahil are considered to be not economically feasible as the EIRR does not exceed the opportunity cost of capital.

Cash flow data for the calculation of economic indicators for master plans of the target woredas are presented in Table 4.76 to Table 4.91.

Table 4.76: Cash Flow for the Projects in Kabribeyah Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O&M Cost	Total Cost			
2014	0	0	0	1,493,000	0	1,493,000	-1,493,000	0.909	-1,357,273
2015	317,622	9,599	327,221	1,961,000	77,636	2,038,636	-1,711,415	0.826	-1,414,393
2016	734,806	22,207	757,013	2,429,000	179,608	2,608,608	-1,851,595	0.751	-1,391,131
2017	1,251,552	37,825	757,013	2,429,000	305,916	2,734,916	-1,977,903	0.683	-1,350,934
2018	1,768,299	53,442	1,289,377	2,429,000	432,224	2,861,224	-1,571,847	0.621	-975,993
2019	2,285,046	69,059	1,821,741	2,195,000	558,532	2,753,532	-931,791	0.564	-525,972
2020	2,752,011	83,172	2,354,105	1,728,000	672,672	2,400,672	-46,567	0.513	-23,896
2021	3,119,627	94,282	2,835,183	0	762,528	762,528	2,072,655	0.467	966,909
2022	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.424	1,039,625
2023	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.386	945,113
2024	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.350	859,194
2025	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.319	781,086
2026	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.290	710,078
2027	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.263	645,525
2028	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.239	586,841
2029	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.218	533,492
2030	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.198	484,993
2031	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.180	440,902
2032	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.164	400,820
2033	3,119,627	94,282	3,213,909	0	762,528	762,528	2,451,381	0.149	364,382
	40,305,606	1,218,124	42,280,744	14,664,000	9,851,868	24,515,868	0.125		1,719,369
EIRR	12.5 %								

Table 4.77: Cash Flow for the Projects in Ararrso Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O&M Cost	Total Cost			
2014	0	0	0	285,000	0	285,000	-285,000	0.909	-259,091
2015	40,055	668	40,723	1,337,000	10,260	1,347,260	-1,306,537	0.826	-1,079,783
2016	227,965	3,799	231,764	1,337,000	58,392	1,395,392	-1,163,628	0.751	-874,251
2017	415,874	6,931	422,805	1,339,000	106,524	1,445,524	-1,022,719	0.683	-698,531
2018	604,064	10,068	614,132	485,000	154,728	639,728	-25,596	0.621	-15,893
2019	672,229	11,204	683,432	484,000	172,188	656,188	27,244	0.564	15,379
2020	740,253	12,337	752,590	285,000	189,612	474,612	277,978	0.513	142,647
2021	780,308	13,005	793,313	0	199,872	199,872	593,441	0.467	276,845
2022	780,308	13,005	793,313	0	199,872	199,872	593,441	0.424	251,677
2023	780,308	13,005	793,313	0	199,872	199,872	593,441	0.386	228,797
2024	780,308	13,005	793,313	0	199,872	199,872	593,441	0.350	207,997
2025	780,308	13,005	793,313	0	199,872	199,872	593,441	0.319	189,089
2026	780,308	13,005	793,313	0	199,872	199,872	593,441	0.290	171,899
2027	780,308	13,005	793,313	0	199,872	199,872	593,441	0.263	156,272
2028	780,308	13,005	793,313	0	199,872	199,872	593,441	0.239	142,065
2029	780,308	13,005	793,313	0	199,872	199,872	593,441	0.218	129,150
2030	780,308	13,005	793,313	0	199,872	199,872	593,441	0.198	117,409
2031	780,308	13,005	793,313	0	199,872	199,872	593,441	0.180	106,736
2032	780,308	13,005	793,313	0	199,872	199,872	593,441	0.164	97,032
2033	780,308	13,005	793,313	0	199,872	199,872	593,441	0.149	88,211
	780,308	13,005	793,313	0	199,872	199,872	593,441	0.123	72,902
EIRR	8.2 %								

Table 4.78: Cash Flow for the Projects in Dagahbur Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Disco unt Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	594,000	0	594,000	-594,000	0.909	-540,000
2015	78,811	3,614	82,424	1,869,000	23,166	1,892,166	-1,809,742	0.826	-1,495,654
2016	326,785	14,984	341,769	1,869,000	96,057	1,965,057	-1,623,288	0.751	-1,219,601
2017	574,760	26,354	601,113	2,008,000	168,948	2,176,948	-1,575,835	0.683	-1,076,316
2018	841,176	38,569	879,746	876,000	247,260	1,123,260	-243,514	0.621	-151,203
2019	957,402	43,898	1,001,300	876,000	281,424	1,157,424	-156,124	0.564	-88,128
2020	1,073,628	49,227	1,122,855	878,000	315,588	1,193,588	-70,733	0.513	-36,297
2021	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.467	417,458
2022	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.424	379,507
2023	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.386	345,006
2024	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.350	313,642
2025	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.319	285,129
2026	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.290	259,208
2027	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.263	235,644
2028	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.239	214,222
2029	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.218	194,747
2030	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.198	177,043
2031	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.180	160,948
2032	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.164	146,316
2033	1,190,119	54,569	1,244,687	0	349,830	349,830	894,857	0.149	133,015
	19,324,106	886,037	20,210,143	8,970,000	5,680,233	14,650,233	0.063		-1,345,315
EIRR	6.3 %								

Table 4.79: Cash Flow for the Projects in Birqod Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Disco unt Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	442,000	0	442,000	-442,000	0.909	-401,818
2015	28,958	201	29,159	895,000	27,846	922,846	-893,687	0.826	-738,584
2016	285,346	1,979	287,325	894,000	84,231	978,231	-690,906	0.751	-519,088
2017	539,615	3,743	543,358	747,000	140,553	887,553	-344,195	0.683	-235,090
2018	702,770	4,875	707,646	745,000	187,614	932,614	-224,968	0.621	-139,688
2019	865,926	6,007	871,933	442,000	234,549	676,549	195,384	0.564	110,289
2020	1,029,082	7,139	1,036,221	443,000	262,395	705,395	330,826	0.513	169,766
2021	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.467	423,622
2022	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.424	385,111
2023	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.386	350,101
2024	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.350	318,273
2025	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.319	289,339
2026	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.290	263,036
2027	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.263	239,123
2028	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.239	217,385
2029	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.218	197,623
2030	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.198	179,657
2031	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.180	163,325
2032	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.164	148,477
2033	1,190,119	8,256	1,198,375	0	290,304	290,304	908,071	0.149	134,979
	18,923,242	131,272	19,054,514	4,608,000	4,711,140	9,319,140	0.169		1,555,837
EIRR	16.9 %								

Table 4.80: Cash Flow for the Projects in Shaygosh Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O&M Cost	Total Cost			
2014	0	0	0	442,000	0	442,000	-442,000	0.909	-401,818
2015	110,016	4,547	114,563	895,000	14,144	909,144	-794,581	0.826	-656,678
2016	402,360	16,631	418,991	894,000	42,784	936,784	-517,793	0.751	-389,026
2017	694,704	28,714	723,418	747,000	71,392	818,392	-94,974	0.683	-64,868
2018	1,003,321	41,471	1,044,792	745,000	95,296	840,296	204,496	0.621	126,976
2019	1,088,698	45,000	1,133,697	442,000	119,136	561,136	572,561	0.564	323,196
2020	1,139,351	47,093	1,186,444	443,000	133,280	576,280	610,164	0.513	313,111
2021	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.467	515,956
2022	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.424	469,051
2023	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.386	426,410
2024	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.350	387,646
2025	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.319	352,405
2026	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.290	320,368
2027	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.263	291,244
2028	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.239	264,767
2029	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.218	240,697
2030	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.198	218,816
2031	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.180	198,924
2032	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.164	180,840
2033	1,190,119	49,192	1,239,310	0	133,312	133,312	1,105,998	0.149	164,400
	19,909,994	822,946	20,732,940	4,608,000	2,209,088	6,817,088	0.258		3,282,416
EIRR	25.8 %								

Table 4.81: Cash Flow for the Projects in Kabridahar Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at 10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	960,000	0	960,000	-960,000	0.909	-872,727
2015	50,307	2,180	52,487	2,551,000	26,880	2,577,880	-2,525,393	0.826	-2,087,102
2016	605,078	26,221	631,299	2,551,000	98,308	2,649,308	-2,018,009	0.751	-1,516,160
2017	1,159,849	50,262	1,210,110	2,693,000	169,736	2,862,736	-1,652,626	0.683	-1,128,766
2018	1,880,213	81,478	1,961,691	1,242,000	245,140	1,487,140	474,551	0.621	294,659
2019	2,216,988	96,072	2,313,060	1,242,000	279,916	1,521,916	791,144	0.564	446,580
2020	2,827,656	122,535	2,950,191	1,355,000	314,692	1,669,692	1,280,499	0.513	657,098
2021	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.467	1,439,588
2022	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.424	1,308,716
2023	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.386	1,189,742
2024	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.350	1,081,584
2025	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.319	983,258
2026	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.290	893,871
2027	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.263	812,610
2028	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.239	738,736
2029	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.218	671,578
2030	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.198	610,526
2031	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.180	555,023
2032	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.164	504,567
2033	3,269,935	141,701	3,411,637	0	325,752	325,752	3,085,885	0.149	458,697
	51,249,247	2,220,867	53,470,114	12,594,000	5,369,448	17,963,448	0.206		7,042,079
EIRR	20.6 %								

Table 4.82: Cash Flow for the Projects in Doba wein Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	72,000	0	72,000	-72,000	0.909	-65,455
2015	21,649	630	22,279	794,000	3,312	797,312	-775,033	0.826	-640,523
2016	260,392	7,580	267,972	794,000	39,836	833,836	-565,864	0.751	-425,142
2017	499,134	14,530	513,665	1,031,000	76,360	1,107,360	-593,695	0.683	-405,502
2018	809,139	23,555	832,694	482,000	123,786	605,786	226,908	0.621	140,892
2019	954,068	27,774	981,842	874,000	145,958	1,019,958	-38,116	0.564	-21,515
2020	1,216,865	35,424	1,252,290	633,000	186,162	819,162	433,128	0.513	222,263
2021	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.467	575,149
2022	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.424	522,863
2023	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.386	475,330
2024	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.350	432,118
2025	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.319	392,835
2026	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.290	357,122
2027	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.263	324,657
2028	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.239	295,142
2029	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.218	268,311
2030	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.198	243,919
2031	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.180	221,745
2032	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.164	201,586
2033	1,407,198	40,965	1,448,163	0	215,280	215,280	1,232,883	0.149	183,260
	22,054,822	642,039	22,696,861	4,680,000	3,374,054	8,054,054	0.257		3,299,055
EIRR	25.7 %								

Table 4.83: Cash Flow for the Projects in East Ime Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	540,000	0	540,000	-540,000	0.909	-490,909
2015	91,999	5,397	97,397	1,551,000	22,680	1,573,680	-1,476,283	0.826	-1,220,069
2016	356,242	20,900	377,142	1,551,000	87,822	1,638,822	-1,261,680	0.751	-947,919
2017	620,485	36,402	656,887	1,551,000	152,964	1,703,964	-1,047,077	0.683	-715,168
2018	884,728	51,904	936,632	1,590,000	218,106	1,808,106	-871,474	0.621	-541,117
2019	1,155,615	67,796	1,223,411	1,590,000	284,886	1,874,886	-651,475	0.564	-367,741
2020	1,426,502	83,688	1,510,191	1,589,000	351,666	1,940,666	-430,475	0.513	-220,902
2021	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.467	643,027
2022	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.424	584,570
2023	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.386	531,427
2024	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.350	483,116
2025	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.319	439,196
2026	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.290	399,269
2027	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.263	362,972
2028	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.239	329,975
2029	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.218	299,977
2030	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.198	272,706
2031	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.180	247,915
2032	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.164	225,377
2033	1,697,219	99,570	1,796,789	0	418,404	418,404	1,378,385	0.149	204,888
	26,599,422	1,560,499	28,159,922	9,962,000	6,557,376	16,519,376	0.113		520,591
EIRR	11.3 %								

Table 4.84: Cash Flow for the Projects in Danan Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	133,000	0	133,000	-133,000	0.909	-120,909
2015	31,987	213	32,200	374,000	4,921	378,921	-346,721	0.826	-286,546
2016	121,934	813	122,746	374,000	18,759	392,759	-270,013	0.751	-202,864
2017	211,881	1,413	122,746	550,000	32,597	582,597	-459,851	0.683	-314,084
2018	344,156	2,294	213,293	309,000	52,947	361,947	-148,654	0.621	-92,302
2019	418,470	2,790	346,450	309,000	64,380	373,380	-26,930	0.564	-15,201
2020	492,785	3,285	421,260	302,000	75,813	377,813	43,447	0.513	22,295
2021	565,416	3,769	496,070	0	86,987	86,987	409,083	0.467	190,840
2022	565,416	3,769	569,185	0	86,987	86,987	482,198	0.424	204,499
2023	565,416	3,769	569,185	0	86,987	86,987	482,198	0.386	185,908
2024	565,416	3,769	569,185	0	86,987	86,987	482,198	0.350	169,007
2025	565,416	3,769	569,185	0	86,987	86,987	482,198	0.319	153,643
2026	565,416	3,769	569,185	0	86,987	86,987	482,198	0.290	139,676
2027	565,416	3,769	569,185	0	86,987	86,987	482,198	0.263	126,978
2028	565,416	3,769	569,185	0	86,987	86,987	482,198	0.239	115,434
2029	565,416	3,769	569,185	0	86,987	86,987	482,198	0.218	104,940
2030	565,416	3,769	569,185	0	86,987	86,987	482,198	0.198	95,400
2031	565,416	3,769	569,185	0	86,987	86,987	482,198	0.180	86,728
2032	565,416	3,769	569,185	0	86,987	86,987	482,198	0.164	78,843
2033	565,416	3,769	569,185	0	86,987	86,987	482,198	0.149	71,676
	7,275,371	48,499	7,446,616	2,351,000	1,119,287	3,470,287	0.163		713,960
EIRR	16.3 %								

Table 4.85: Cash Flow for the Projects in Beercaano Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	214,000	0	214,000	-214,000	0.909	-194,545
2015	29,125	388	29,513	576,000	10,700	586,700	-557,187	0.826	-460,485
2016	107,517	1,434	108,951	576,000	39,500	615,500	-506,549	0.751	-380,578
2017	185,909	2,479	108,951	576,000	68,300	644,300	-535,349	0.683	-365,651
2018	264,301	3,524	188,388	602,000	97,100	699,100	-510,712	0.621	-317,112
2019	346,232	4,617	267,826	602,000	127,200	729,200	-461,374	0.564	-260,434
2020	428,163	5,709	350,849	605,000	157,300	762,300	-411,451	0.513	-211,139
2021	510,502	6,807	433,872	0	187,550	187,550	246,322	0.467	114,911
2022	510,502	6,807	517,309	0	187,550	187,550	329,759	0.424	139,850
2023	510,502	6,807	517,309	0	187,550	187,550	329,759	0.386	127,136
2024	510,502	6,807	517,309	0	187,550	187,550	329,759	0.350	115,579
2025	510,502	6,807	517,309	0	187,550	187,550	329,759	0.319	105,071
2026	510,502	6,807	517,309	0	187,550	187,550	329,759	0.290	95,519
2027	510,502	6,807	517,309	0	187,550	187,550	329,759	0.263	86,836
2028	510,502	6,807	517,309	0	187,550	187,550	329,759	0.239	78,942
2029	510,502	6,807	517,309	0	187,550	187,550	329,759	0.218	71,765
2030	510,502	6,807	517,309	0	187,550	187,550	329,759	0.198	65,241
2031	510,502	6,807	517,309	0	187,550	187,550	329,759	0.180	59,310
2032	510,502	6,807	517,309	0	187,550	187,550	329,759	0.164	53,918
2033	510,502	6,807	517,309	0	187,550	187,550	329,759	0.149	49,017
	6,466,268	86,221	6,661,439	3,751,000	2,375,600	6,126,600	0.028		-1,026,849
EIRR	2.8 %								

Table 4.86: Cash Flow for the Projects in Godey Woreda (Rural)

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O&M Cost	Total Cost			
2014	0	0	0	398,000	0	398,000	-398,000	0.909	-361,818
2015	242,635	2,082	244,717	1,004,000	63,090	1,067,090	-822,373	0.826	-679,647
2016	416,219	7,333	423,552	1,003,000	108,225	1,111,225	-687,673	0.751	-516,659
2017	574,053	12,579	586,632	912,000	149,265	1,061,265	-474,633	0.683	-324,181
2018	731,887	17,349	749,236	912,000	172,395	1,084,395	-335,159	0.621	-208,107
2019	889,721	22,119	911,840	912,000	149,265	1,061,265	-149,425	0.564	-84,346
2020	1,046,517	26,889	1,073,406	906,000	231,345	1,137,345	-63,939	0.513	-32,811
2021	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.467	376,019
2022	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.424	341,835
2023	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.386	310,759
2024	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.350	282,509
2025	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.319	256,826
2026	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.290	233,478
2027	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.263	212,253
2028	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.239	192,957
2029	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.218	175,416
2030	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.198	159,469
2031	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.180	144,972
2032	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.164	131,792
2033	1,046,517	31,628	1,078,145	0	272,115	272,115	806,030	0.149	119,811
	17,505,752	499,515	18,005,268	6,047,000	4,411,080	10,458,080	0.133		730,526
EIRR	13.3 %								

Table 4.87: Cash Flow for the Projects in Adadle Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at 0%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	1,191,000	0	1,191,000	-1,191,000	0.909	-1,082,727
2015	224,131	2,490	226,622	1,540,000	20,247	1,560,247	-1,333,625	0.826	-1,102,170
2016	513,940	5,710	519,651	1,540,000	46,427	1,586,427	-1,066,776	0.751	-801,485
2017	803,749	8,931	519,651	1,540,000	72,607	1,612,607	-1,092,956	0.683	-746,504
2018	1,093,558	12,151	812,680	1,540,000	98,787	1,638,787	-826,107	0.621	-512,947
2019	1,383,367	15,371	1,105,709	1,540,000	124,967	1,664,967	-559,258	0.564	-315,687
2020	1,673,176	18,591	1,398,738	1,539,000	151,147	1,690,147	-291,409	0.513	-149,539
2021	1,962,797	21,809	1,691,767	0	177,310	177,310	1,514,457	0.467	706,505
2022	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.424	766,470
2023	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.386	696,791
2024	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.350	633,446
2025	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.319	575,860
2026	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.290	523,509
2027	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.263	475,918
2028	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.239	432,652
2029	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.218	393,320
2030	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.198	357,564
2031	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.180	325,058
2032	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.164	295,507
2033	1,962,797	21,809	1,984,606	0	177,310	177,310	1,807,296	0.149	268,643
	25,319,893	281,334	26,120,878	10,430,000	2,287,282	12,717,282	0.137		1,740,186
EIRR	13.7 %								

Table 4.88: Cash Flow for the Projects in Kalafo Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at 10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	519,000	0	519,000	-519,000	0.909	-471,818
2015	91,607	4,295	95,903	1,436,000	19,203	1,455,203	-1,359,300	0.826	-1,123,389
2016	345,072	16,180	361,252	2,045,000	72,335	2,117,335	-1,756,083	0.751	-1,319,371
2017	706,030	33,105	361,252	2,046,000	148,000	2,194,000	-1,832,748	0.683	-1,251,792
2018	1,067,164	50,038	739,135	2,042,000	223,702	2,265,702	-1,526,567	0.621	-947,878
2019	1,427,592	66,938	1,117,202	1,433,000	299,256	1,732,256	-615,054	0.564	-347,182
2020	1,680,527	78,798	1,494,530	1,434,000	352,277	1,786,277	-291,747	0.513	-149,712
2021	1,933,639	90,666	1,759,325	0	405,335	405,335	1,353,990	0.467	631,646
2022	1,939,639	90,666	2,024,305	0	405,335	405,335	1,618,970	0.424	686,601
2023	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.386	626,496
2024	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.350	569,542
2025	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.319	517,766
2026	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.290	470,696
2027	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.263	427,905
2028	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.239	389,005
2029	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.218	353,641
2030	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.198	321,492
2031	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.180	292,265
2032	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.164	265,696
2033	1,939,639	90,666	2,030,305	0	405,335	405,335	1,624,970	0.149	241,541
	24,708,383	1,156,014	26,225,649	10,955,000	5,168,123	16,123,123	0.104		183,151
EIRR	10.4 %								

Table 4.89: Cash Flow for the Projects in Mustahil Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at 10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	244,000	0	244,000	-244,000	0.909	-221,818
2015	36,289	2,653	38,942	1,083,000	10,248	1,093,248	-1,054,306	0.826	-871,327
2016	197,359	14,429	211,788	1,692,000	55,734	1,747,734	-1,535,946	0.751	-1,153,979
2017	449,002	32,827	211,788	1,691,000	126,798	1,817,798	-1,606,010	0.683	-1,096,927
2018	700,497	51,214	481,829	1,767,000	197,820	1,964,820	-1,482,991	0.621	-920,821
2019	963,294	70,427	751,711	1,158,000	272,034	1,430,034	-678,323	0.564	-382,896
2020	1,135,518	83,019	1,033,722	671,000	320,670	991,670	42,052	0.513	21,579
2021	1,235,313	90,315	1,218,537	0	348,852	348,852	869,685	0.467	405,715
2022	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.424	422,730
2023	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.386	384,300
2024	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.350	349,364
2025	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.319	317,604
2026	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.290	288,731
2027	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.263	262,482
2028	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.239	238,620
2029	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.218	216,927
2030	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.198	197,207
2031	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.180	179,279
2032	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.164	162,981
2033	1,235,313	90,315	1,325,628	0	328,852	328,852	996,776	0.149	148,164
	15,835,089	1,157,720	17,204,596	8,306,000	4,291,824	12,597,824	0.070		-1,052,085
EIRR	7.0 %								

Table 4.90: Cash Flow for the Projects in Rasso Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	449,000	0	449,000	-449,000	0.909	-408,182
2015	80,353	1,339	81,693	449,000	9,429	458,429	-376,736	0.826	-311,352
2016	160,707	2,679	163,385	449,000	18,858	467,858	-304,473	0.751	-228,755
2017	241,060	4,018	163,385	449,000	28,287	477,287	-313,902	0.683	-214,399
2018	321,414	5,357	245,078	449,000	37,716	486,716	-241,638	0.621	-150,038
2019	401,767	6,696	326,771	449,000	47,145	496,145	-169,374	0.564	-95,607
2020	482,120	8,036	408,463	441,000	56,574	497,574	-89,111	0.513	-45,728
2021	561,042	9,351	490,156	0	65,835	65,835	424,321	0.467	197,949
2022	561,042	9,351	570,393	0	65,835	65,835	504,558	0.424	213,982
2023	561,042	9,351	570,393	0	65,835	65,835	504,558	0.386	194,529
2024	561,042	9,351	570,393	0	65,835	65,835	504,558	0.350	176,845
2025	561,042	9,351	570,393	0	65,835	65,835	504,558	0.319	160,768
2026	561,042	9,351	570,393	0	65,835	65,835	504,558	0.290	146,152
2027	561,042	9,351	570,393	0	65,835	65,835	504,558	0.263	132,866
2028	561,042	9,351	570,393	0	65,835	65,835	504,558	0.239	120,787
2029	561,042	9,351	570,393	0	65,835	65,835	504,558	0.218	109,807
2030	561,042	9,351	570,393	0	65,835	65,835	504,558	0.198	99,824
2031	561,042	9,351	570,393	0	65,835	65,835	504,558	0.180	90,749
2032	561,042	9,351	570,393	0	65,835	65,835	504,558	0.164	82,499
2033	561,042	9,351	570,393	0	65,835	65,835	504,558	0.149	74,999
	7,297,841	121,635	7,582,861	3,135,000	856,359	3,991,359	0.124		347,694
EIRR	12.4 %								

Table 4.91: Cash Flow for the Projects in West Ime Woreda

Unit: U.S. Dollar

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at10%	Present Value at 10%
	Time saving	Health	Total	Project Cost	O & M Cost	Total Cost			
2014	0	0	0	449,000	0	449,000	-449,000	0.909	-408,182
2015	84,286	4,551	88,837	449,000	20,654	469,654	-380,817	0.826	-314,725
2016	168,572	9,103	177,675	449,000	41,308	490,308	-312,633	0.751	-234,886
2017	252,857	13,654	177,675	449,000	61,962	510,962	-333,287	0.683	-227,640
2018	337,143	18,206	266,512	449,000	82,616	531,616	-265,104	0.621	-164,609
2019	421,429	22,757	355,349	449,000	103,270	552,270	-196,921	0.564	-111,157
2020	505,715	27,309	444,186	441,000	123,924	564,924	-120,738	0.513	-61,958
2021	588,499	31,779	533,024	0	144,210	144,210	388,814	0.467	181,384
2022	588,499	31,779	620,278	0	144,210	144,210	476,068	0.424	201,899
2023	588,499	31,779	620,278	0	144,210	144,210	476,068	0.386	183,545
2024	588,499	31,779	620,278	0	144,210	144,210	476,068	0.350	166,859
2025	588,499	31,779	620,278	0	144,210	144,210	476,068	0.319	151,690
2026	588,499	31,779	620,278	0	144,210	144,210	476,068	0.290	137,900
2027	588,499	31,779	620,278	0	144,210	144,210	476,068	0.263	125,364
2028	588,499	31,779	620,278	0	144,210	144,210	476,068	0.239	113,967
2029	588,499	31,779	620,278	0	144,210	144,210	476,068	0.218	103,606
2030	588,499	31,779	620,278	0	144,210	144,210	476,068	0.198	94,188
2031	588,499	31,779	620,278	0	144,210	144,210	476,068	0.180	85,625
2032	588,499	31,779	620,278	0	144,210	144,210	476,068	0.164	77,841
2033	588,499	31,779	620,278	0	144,210	144,210	476,068	0.149	70,764
	7,654,992	413,370	8,246,037	3,135,000	1,875,834	5,010,834	0.112		171,477
EIRR	11.2 %								

4.17.2 Financial evaluation

a. Financial project costs

The financial project costs comprise of the costs for the construction of water supply facilities, engineering services, physical contingency and administration costs. Cost estimation is based on the price level of May 2013. The total capital costs of the projects covering 16 target woredas amounts to USD113,121,000 as presented in Table 4.72.

It is the policy of the Government of Ethiopia that the Government shall finance the capital costs of water supply projects under the condition that each local community will be responsible for operation and maintenance costs of the water supply facilities.

b. Financial evaluation

Financial evaluation in terms of Financial Internal Rate of Return (FIRR) has not been applied in this analysis as water revenues generated from the proposed projects are not sufficient to cover the whole project costs.

c. Recovery of Operation and Maintenance Cost

One of the most important issues for sustainable operation of the project is full cost recovery of operation and maintenance activities. The beneficiaries in the target woredas and towns of the master plan are expected to organize their water supply organizations (e.g. WASHCOs) to conduct periodical operation and maintenance works and to collect water fee for the recovery of the operation and maintenance expenses.

The following three different water fees have been considered to determine appropriate price of water:

1) Proposed rate by the federal government to each woredas :12.5 Birr/m^3
2) Suggested rate by SRWDB :20 Birr/m^3
3) Average terminal rate from this study :50 Birr/m^3

The amount of money that is expected to be collected for each case of the water fees was calculated to determine how much recovery ratio will be necessary to cover the O&M cost (see Table 4.92 to Table 4.94). The water demand (amount supplied to the beneficiary) was assumed to be composed of household consumption (15L/day for rural and 20L/day for urban) and livestock water consumption (20% of the total water consumption). The industrial, institutional, and commercial consumptions were omitted because they take up only small portion of the total water demand and thus are negligible.
Since no data on the recovery of O&M cost at present was obtained in this study, it is difficult to predict the future recovery ratio with a high certainty. However, the calculated recovery ratio can be used as an indicator to determine if the project is financially feasible in terms of O&M cost recovery. In the case of the water fee being 12.5 Birr, there will a few woredas that can not cover the O&M cost fully even if a 100% recovery is attained (Berrcano and West Ime).

Table 4.92: Comparison of Water Revenue and O&M Costs (12.5 Birr case)

Woreda	Water demand (m^3/year)	Water fee collection at 100 % recovery (USD)	Recovery ratio at 100% coverage of O&M cost (%)	Annual O&M costs (USD)
Kabribeyah (Rural)	1,332,935	899,173	85	762,942
Arrarso	401,659	270,952	75	202,461
Dagahbur	1,330,232	897,350	39	346,345
Birqod	191,240	129,007	83	106,378
Shaygosh	558,735	376,912	39	146,256
Kabridahar	1,581,031	1,066,535	33	350,063
Doba wein	712,847	480,874	45	213,803
East Ime	773,353	521,689	80	414,163
Danan	276,074	186,234	47	86,083
Beercanno	242,183	163,372	More than100%	187,646
Godey (Rural)	461,115	311,060	88	271,857
Adadle	906,018	611,183	29	172,865
Kalafo	926,026	624,680	65	400,108
Mustahil	669,901	451,903	78	350,087
Rasso	278,178	187,654	36	66,233
West Ime	268,914	181,405	More than100%	248,095

Note: Water demand is the actual amount of water supplied to the community
Kabribeyah and Godey woredas in this table do not include town water supply of respective towns

Table 4.93: Comparison of Water Revenue and O&M Costs (20 Birr case)

Woreda	Water demand (m^3/year)	Water fee collection at 100 % recovery (USD)	Recovery ratio at 100% coverage of O&M cost (%)	Annual O&M costs (USD)
Kabribeyah (Rural)	1,332,935	1,438,678	54	762,942
Arrarso	401,659	433,523	47	202,461
Dagahbur	1,330,232	1,435,761	25	346,345
Birqod	191,240	206,411	52	106,378
Shaygosh	558,735	603,060	25	146,256
Kabridahar	1,581,031	1,706,456	21	350,063
Doba wein	712,847	769,398	28	213,803
East Ime	773,353	834,703	50	414,163
Danan	276,074	297,975	29	86,083
Beercanno	242,183	261,396	72	187,646
Godey (Rural)	461,115	497,696	55	271,857
Adadle	906,018	977,894	18	172,865
Kalafo	926,026	999,489	41	400,108
Mustahil	669,901	723,045	49	350,087
Rasso	278,178	300,246	23	66,233
West Ime	268,914	290,248	86	248,095

Note: Water demand is the actual amount of water supplied to the community
Kabribeyah and Godey woredas in this table do not include town water supply of respective towns

Table 4.94: Comparison of Water Revenue and O&M Costs (50 Birr case)

Woreda	Water demand (m^3/year)	Water fee collection at 100 % recovery (USD)	Recovery ratio at 100% coverage of O&M cost (%)	Annual O&M costs (USD)
Kabribeyah (Rural)	1,332,935	3,596,694	22	762,942
Arrarso	401,659	1,083,808	19	202,461
Dagahbur	1,330,232	3,589,402	10	346,345
Birqod	191,240	516,027	21	106,378
Shaygosh	558,735	1,507,649	10	146,256
Kabridahar	1,581,031	4,266,139	9	350,063
Doba wein	712,847	1,923,495	12	213,803
East Ime	773,353	2,086,758	20	414,163
Danan	276,074	744,937	12	86,083
Beercanno	242,183	653,490	29	187,646
Godey (Rural)	461,115	1,244,240	22	271,857
Adadle	906,018	2,444,734	8	172,865
Kalafo	926,026	2,498,721	17	400,108
Mustahil	669,901	1,807,613	20	350,087
Rasso	278,178	750,616	9	66,233
West Ime	268,914	725,619	35	248,095

Note: Water demand is the actual amount of water supplied to the community
Kabribeyah and Godey woredas in this table do not include town water supply of respective towns

Chapter 5

Water Supply Plan and General Design, Cost Estimation and Implementation Plan for Kabribeyah Town

5 Water Supply Plan and General Design, Cost Estimation and Implementation Plan for Kabribeyah Town

5.1 Present condition of existing water supply facilities

Since 1990, several boreholes have been developed in the Jarar valley area and are supplying water to the local residents. The piped water supply system was planned for the Kabribeyah town and the UNHCR refugee camps in late 1990's and the project was implemented afterward. The construction work was done in 2001 and water could be supplied to these areas through water pipeline. General features of the current water supply system in the Kabribeyah town are illustrated in Figure 5.1.

a. Water resource

Water resource in Kabribeyah town is boreholes. Seven boreholes have been developed since 1990. LBH1 is the independent water supply system and is used mainly for livestock around the site. Water does not flow to the water purification plant. Power source of the pumps is the commercial electrical line except LBH1. Besides, they have the generator as stand-by power source equipment. Several boreholes, NBH2 and EB2, provide public tap and cattle trough at the sites. These are used for neighboring residents and pastoralists, and are deployed around 0.5~1.0km intervals from community (refer to Table 5.1).

Table 5.1: General Characteristics of Boreholes in Jarar Valley

No.	Item	Unit	NBH1	NBH2	NBH3	EB1	EB2	LBH1	PB2
1.	Constructed date		Jul. 2000	Nov. 2000	Apr. 2004	Jul. 1990	1990	Dec. 1991	Dec. 1991
2.	Pump position	m	185.00	185.00	185.00	130.36	129.20	131.25	141.00
3.	Flow rate	lit/sec	10.0	6.0	4.2	5.0	3.4	3.7	4.0
4.	Pump output	kW	15	13	7.5	9.2	11	7.5	11
5.	Water supply facilities at site								
5.1	Public tap		1	1	0	0	1	1	0
5.2	Cattle trough		1	1	0	6	1	2	0
5.3	Water tanker tap		0	0	0	0	1	0	0

Source: UNHCR JIJIGA Office

UNHCR developed two more boreholes in 2012 to support water demand increase. Borehole development was completed as of April 2013. They will implement pump and generator procurement work and pipeline installation work. Another two boreholes, which were 5.0lit/s yield respectively, were developed by the JICA Study and they started operation from April 2013 (Refer to Table 5.2).

Table 5.2: General Characteristics of Additional Boreholes

No.	Item	Unit	UNHCR1	UNHCR2	JICA BH1	JICA BH2
1.	Constructed date		Under construction	Under construction	Apr. 2013	Apr. 2013
2.	Pump position	m			135.00	135.00
3.	Flow rate	lit/sec			5.0	5.0
4.	Pump output	kW			37.5	37.5
5.	Water supply facilities at site					
5.1	Public tap				1	1
5.2	Cattle trough				0	0
5.3	Water tanker tap				0	0

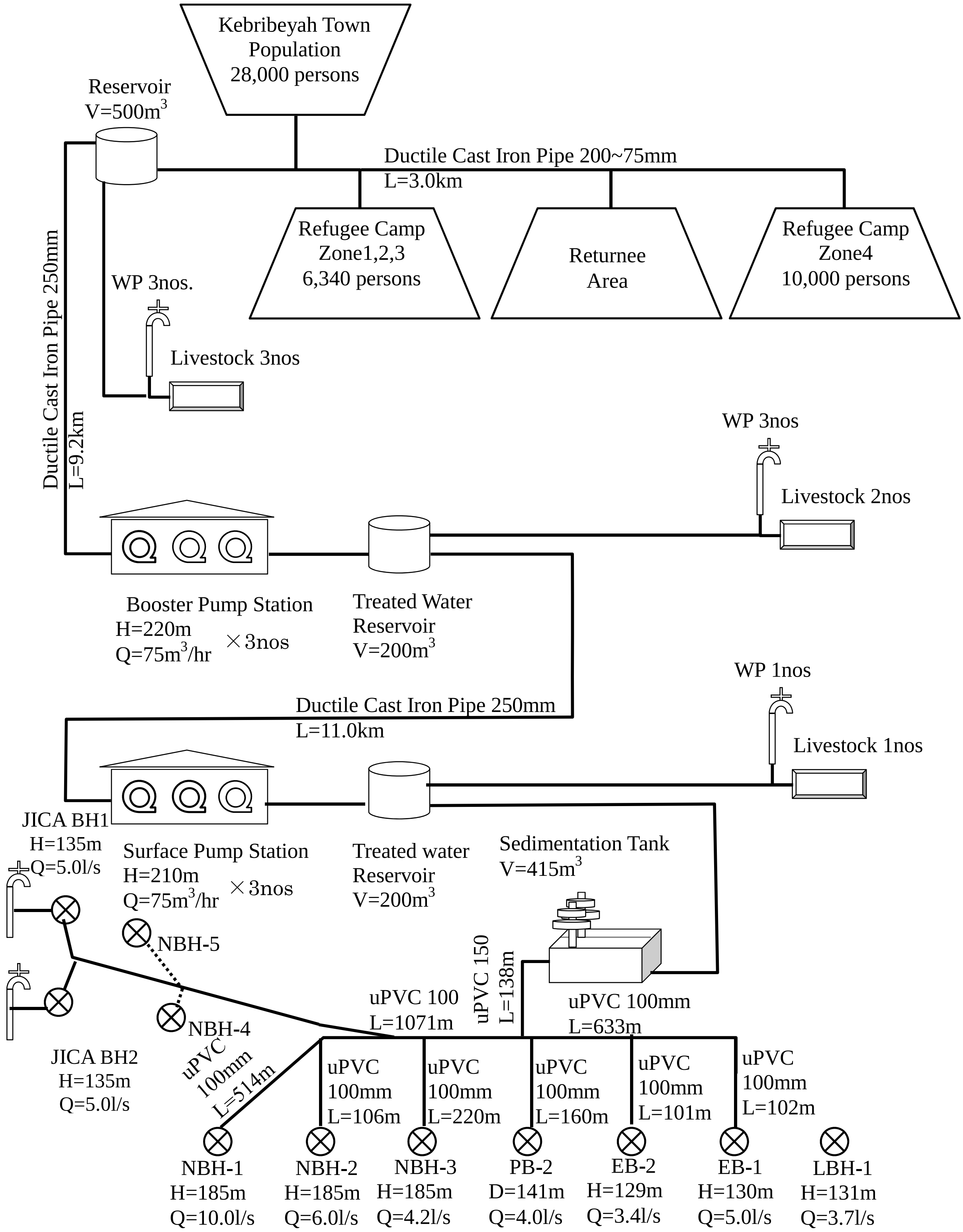


Figure 5.1: Current Kabribeyah Town Water Supply System

According to the Kabribeyah water supply utility office, galvanized steel pipe inside the borehole is easily corroded and they have to replace often within short period. In order to avoid pipe corrosion issue, they recommend applying stainless steel pipe to riser pipe. Though stainless steel pipe has longer life than galvanized steel pipe for corrosion, it also needs periodical maintenance and replacement after certain period. Further, stainless steel pipe is not commonly distributed in Ethiopian market; it takes quite a long time for pipe procurement. On the other hand, galvanized steel pipe is easily procured in Somali region. It is practical to apply galvanized steel pipe with enough thickness considering synthetically and to conduct periodical maintenance of riser pipe. When Kabribeyah water supply utility office finds severe pipe corrosion, they replace it with new pipe and aim to ensure long term operation.

b. Transmission pipeline

Transmission pipelines can be divided into two sections. The first section is between each borehole and the water purification plant. uPVC pipe is used as the pipe material to protect from pipe corrosion. Presently, only NBH3 installs water meter, there is no way to monitor exact flow rate from each borehole pump to the water purification plant. Veolia Environment Foundation assessed water leakage for the above section in 2011. They found that 37% of water sources had leaks. Major reasons are; a) source water pours into unused boreholes due to valves failure, and b) water is used for neighboring farming purpose.

The second section is between the surface pump station and the reservoir in Kabribeyah town. Ductile cast iron pipe with 250mm diameter is used in the section. The pipe is installed along the existing road in this section (refer to Table 5.3).

Table 5.3: Transmission Pipeline Length

Diameter	Material	Length
250mm	Ductile Iron	20,200m
150mm	uPVC	1,209m
100mm	uPVC	1,836m
Total		23,245m

Source: UNHCR JIJIGA Office

c. Water purification plant

Raw water from the boreholes contains high iron value. It exceeds WHO guidelines for Drinking-water Quality (0.3mg/l). Aeration tray with column and sedimentation basin with 415m^3 capacity is constructed to remove iron from raw water (Figure 5.2). Raw water comes out of a spout on the top and runs down a series of aeration trays. Aeration provides oxygen to water, iron in the raw water changes to insoluble oxidized ferric and it precipitates in the reaction basin under the tray. Oxidation of aerated water proceeds in the reaction basin, it continues to the sedimentation basin. Further insoluble oxidized ferric precipitates in the sedimentation basin, clear water overflows to the clarification basin. When this facility is functioning fully, iron value in aerated water is less than WHO guideline.

After passing through the iron removal facility, water goes to the treated water, which has 200m^3 capacity, and stores it to flow into the surface pump station.

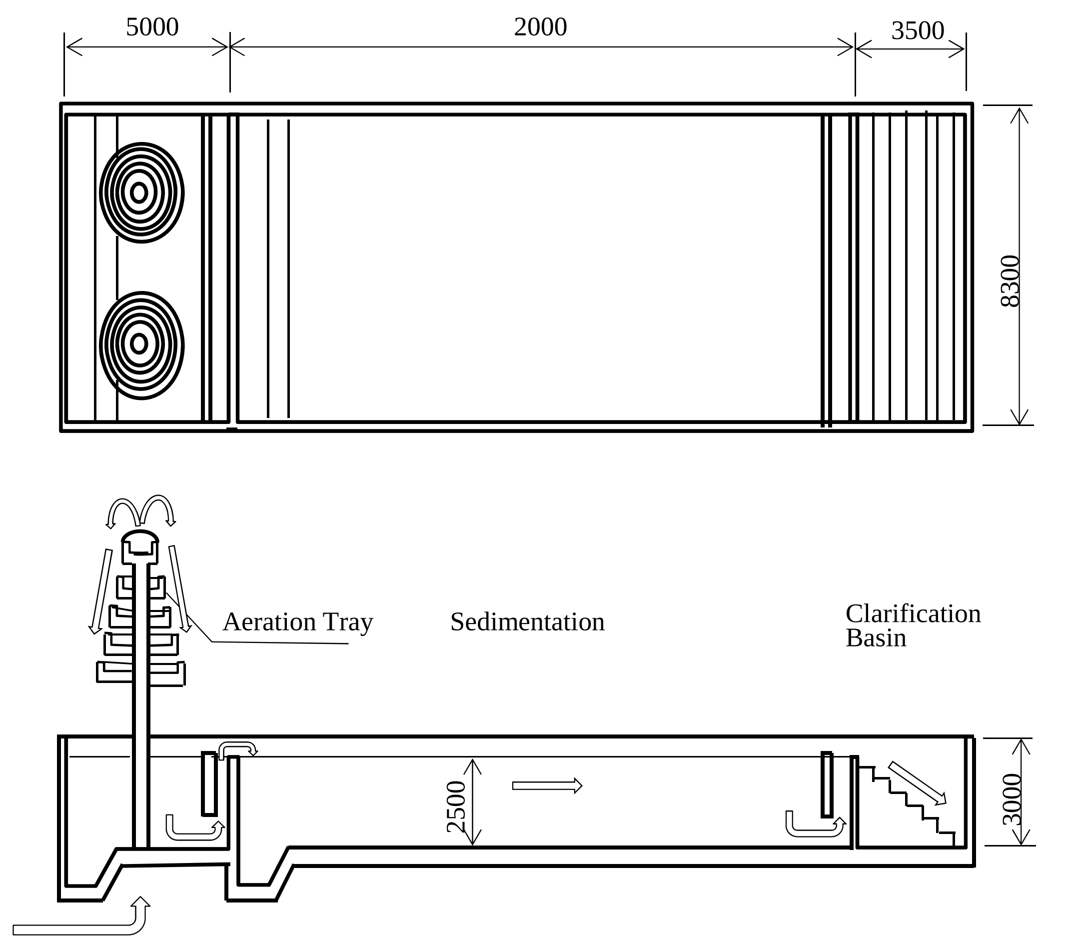


Figure 5.2: Iron Removal Facility

Though aeration process functions well, this process causes calcium scaling generation. According to Veolia Environment Foundation report, its mechanism is explained as follows:

a) Aeration causes the removal of carbon dioxide from raw water,
b) The pH of raw water increases,
c) Calcium carbonate is saturated in the water,
d) Calcium scaling ($CaCO_3$) is generated, and
e) It adheres to inside pipe and pump.

Solution for calcium scaling is one of the most important technical issues.

d. Surface and booster pump station

Once treated water is stored at the treated water reservoir, it flows into the pump station and lifts it up. The height difference between the surface pump station and the reservoir in the Kabribeyah town is 330m, the booster pump station has been provided in the middle. Both pump stations have the same structure. Major features of the pumps are summarized in Table 5.4 below.

Table 5.4: Major Features of the Pumps

Item	Surface pump station	Booster pump station
1. Type	Horizontal multistage	Horizontal multistage
2. Number	3	3
3. Flow rate (m^3/hr)	75	75
4. Height (m)	210	220
5. Output (kW)	75	75
6. Horse power (HP)	100	100

Source: UNHCR JIJIGA Office

The both pumps are almost same condition in view of maintenance easiness and convenience of the spare parts' procurement.

As mentioned above, calcium scale adheres inside the pump within a couple of years when they install new pump. As a result, the life of the pump is shorter than under normal conditions.

There are several methods to remove calcium scale inside the pipe. They are; 1) install magnetic equipment around the pipe, 2) washing by hydrochloric acid, and 3) remove manually. Magnetic equipment is mainly used for industrial water. Water passes inside the pipe with magnetic equipment and calcium scaling is hard to be generated. However, it is not clarified theoretically why calcium scale is reduced by magnetic. Washing by hydrochloric acid is widely used method to remove calcium scale. It is a powerful and dangerous substance, and pipes must be cleaned deliberately after using it. Taking into consideration of human health, it shall not be used for drinking water. Manual removal is currently applied by the operation and maintenance team. However, they do not work periodically. When water flow has trouble, they dismantle flanged pipes at the surface pump station and remove scale inside the pipe. Only several pieces of pipes can be removed in the present pump stations. Branched pipes from the trunk pipes are welded, calcium scale removal work is quite tough job for the team. It is not practical to replace the welded pipes to flanged pipes in view of construction cost and pump life time. Periodical removal work is the best way at the moment. When the new pump station is planned to increase water supply volume, flanged piping system shall be applied to the pump station.

e. Distribution pipeline

e.1 Operation system

The distribution pipeline system in the Kabribeyah town starts from the reservoir where it is located at the entrance of the town. Water in the distribution pipelines basically flows by gravity. However, height between the reservoir and water connections is less than 10m for most of the places so that water pressure is secured around several meters only. Because of this situation, once water demands increase like in dry season, much of the population faces water shortages and low water pressure. In order to secure water pressure at water connections, the Kabribeyah water supply utility office closes the gate valve, which enters water into the reservoir, and diverts transmission pipeline water to the distribution pipeline directly. Water keeps pressured flow into the distribution pipelines.

e.2 Initial distribution pipeline system

The distribution pipelines were constructed in 2001 shown in Figure 5.3. Major serviced area is the town center residential area. The main distribution pipeline passes through the highway from the north to south direction and reaches to south end reservoir. Branched pipelines extend from the mainline to west and east directions and end at each water connection. Total distribution pipeline length is about 11,300m and diameters range from 37.5mm to 200mm as tabulated in Table 5.5.

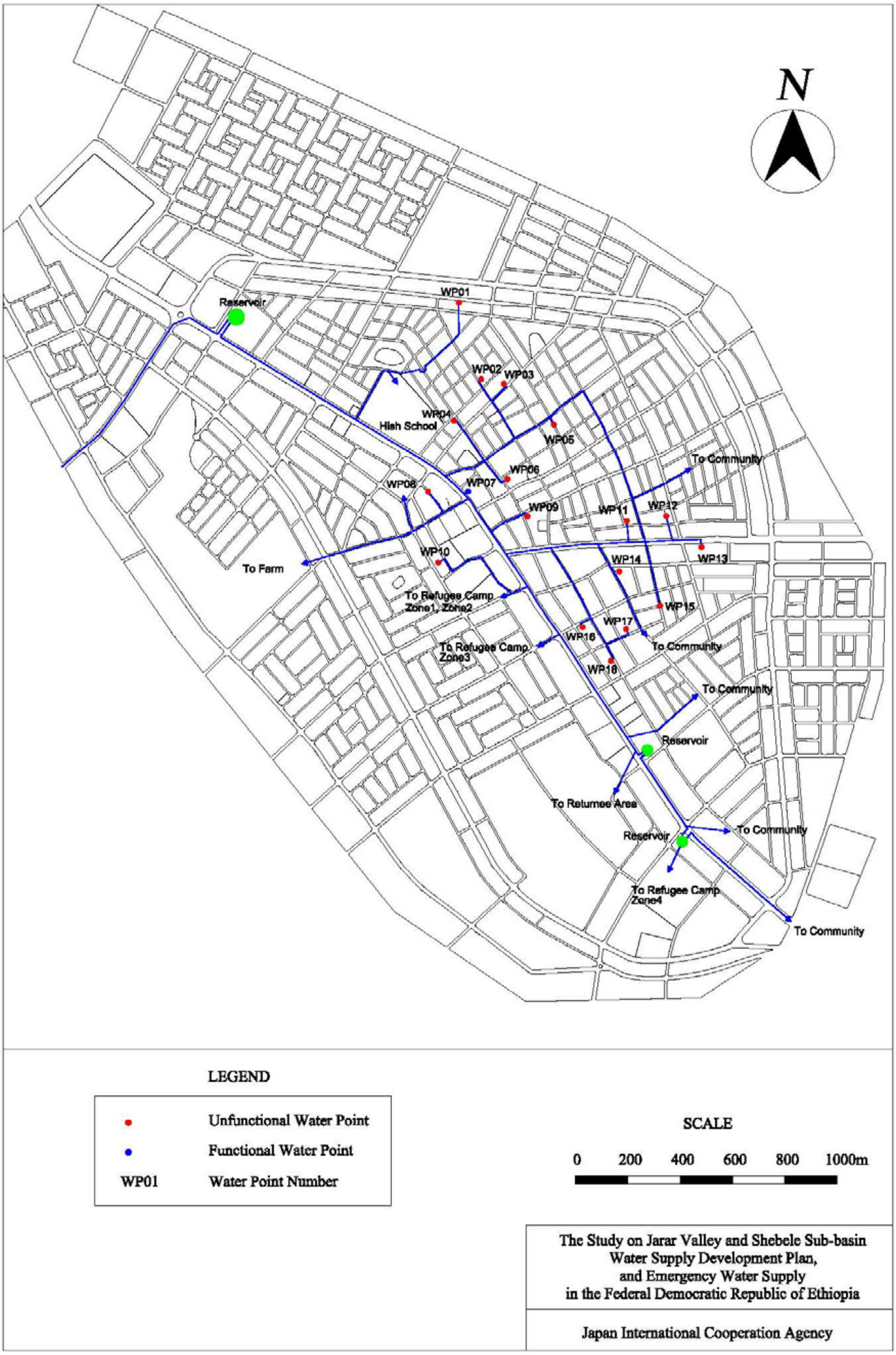


Figure 5.3: Initial Distribution Pipeline System

Table 5.5: Distribution Pipeline Length by Initial Distribution Pipelines

Diameter	Material	Length
200mm	Ductile Iron	1,010m
150mm	uPVC	650m
110mm	uPVC	2,200m
90mm	uPVC	1,900m
80mm	uPVC	1,020m
75mm	uPVC	740m
67.5mm	uPVC	520m
50mm	uPVC	2,010m
37.5mm	uPVC	1,250m
Total		11,300m

There are 20 public taps in the Kabribeyah town. All of them are not functioning well. Three reasons were picked up according to the Kabribeyah water supply utility office.

I Households changed to house connection with water meter.

The Kabribeyah water supply utility office planned to supply water through the public taps. Since water was provided to each household, some preferred to fetch water through individual house connection. As a result, public taps were used less and less and finally were not used at all. Households, which do not have enough money to install water meters, buy water from houses with a connection.

II Road development authority broke public taps because they were inside the road master plan area.

Some public taps were constructed inside the road alignment. Road was under management of Road Development Authority, they did not allow to construct public taps inside the road boundary. Thus, they demolished such public taps. However, they did not compensate alternative public taps outside the road boundary, local population uses service pipe with water meter and one water faucet. The Kabribeyah water supply utility office also has not reconstructed them.

III The Kabribeyah water supply utility office could not replace large sized diameter water meter when it broke.

According to the Kabribeyah water supply utility office's explanation, large diameter water meters had been installed at several public taps. Once they were broken, they could not replace new water meter due to its cost and those were difficult to find in the Kabribeyah town. As a result, they abandoned operating them.

Further, distribution pipelines extend to the refugee camps. 48 public taps are provided inside the camps and all of them are functional. No house connection has been provided inside the camp so that population has to keep public taps in a good condition for public purposes.

f. Danish funded distribution pipelines

Due to increase in the town population, the existing distribution pipeline networks could not supply water for the serviced area fully. The Kabribeyah water supply utility office requested Denmark to allocate fund for the distribution network expansion project. The project was accepted and implemented by the Danish fund. The Kabribeyah water supply utility office conducted the project and Denmark purchased the materials, which were used for the project. The construction was completed by the end of 2010 and water was supplied from the beginning of 2011 (Figure 5.4). Pipeline length and diameter are summarized in Table 5.6.

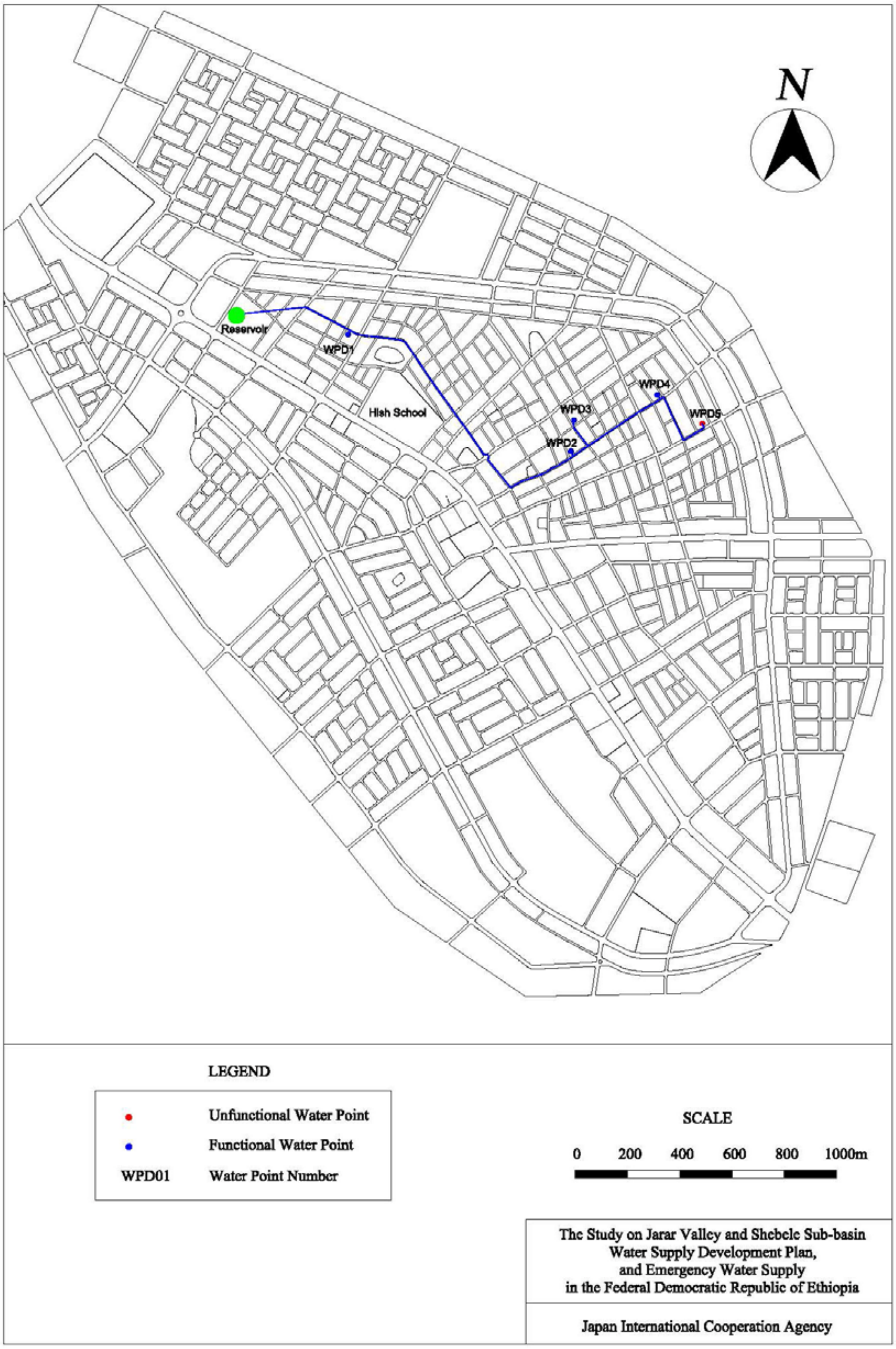


Figure 5.4: Distribution Pipeline System by Danish Project

Table 5.6: Distribution Pipeline Length by Danish Project

Diameter	Material	Length
225mm	uPVC	1,310m
150mm	uPVC	620m
110mm	uPVC	120m
75mm	uPVC	300m
Total		2,350m

The service area is the same as the initial pipelines, namely the center of Kabribeyah town. The pipeline runs through the road mostly where the existing pipelines were not installed. Five public taps are installed along the pipeline and four of them are functional. Due to low rate of house connection compared with the existing distribution pipelines, most of the public taps are still functional. The cause of not functional public taps is clogging.

g. Issues and countermeasures

The Kabribeyah water supply system has the following issues and their countermeasures are summarized in Table 5.7.

Table 5.7: Issues and Countermeasures on Current Water Supply System

No.	Issue	Countermeasure
1	Uncertainty of the boreholes' condition	Monitoring by borehole camera
2	Uncertainty of the flow rate between the boreholes and the water purification plant	Installation of water meter at each borehole outlet
3	Calcium scaling generation and impact on the pumps	Periodical manual pipe cleaning by staffs
4	Short life of the pumps	Periodical pipe cleaning, and proper maintenance and training
5	Low water pressure at distribution pipelines especially in dry season	Planning on new elevated reservoir to increase water pressure
6	Increase of usage of public taps	Permanent water supply and Establishment of WASHCO for operation

Current issues are mainly caused by inadequate operation and maintenance works. Particularly, issues on boreholes and pump station will be improved when the operation and maintenance works conduct properly. Countermeasures to be solved by water supply plan are detachable piping plan at the new pump station and new elevated reservoir.

5.2 Water supply plan

5.2.1 Water demand

Water demand calculation is carried out to follow the 2020 population projection, 50,373 persons, and planning criteria. Piped water supply system has been already developed in Kabribeyah town, and some houses receive water by yard connection. Thus, daily average supply per capita by house connection, 50 lit/cap/day, and the one by yard connection water demand, 25 lit/cap/day, is adopted for Kabribeyah town population. In Godey town, the rate of house connection, yard connection, public tap in 2020 is estimated to 1:49:50 based on the present yard connection numbers. Kabribeyah town applies to the same rate. In addition, Kabribeyah town water supply plan includes refugee camps. Refugee population is 16,340 persons, these people also included in the water demand calculation. Total water demand in

2020 is 2,249m^3/day (Refer to Table 5.8).

Table 5.8: Water Demand of Kabribeyah Town in 2020

No	Item	Unit	Quantity	Unit demand	Total
				lit/cap/d	m^3/day
1	Domestic water				
1.1	House connection	person	504	50	25.20
1.2	Yard connection	person	24,683	25	617.08
1.3	Public tap	person	25,186	20	503.72
	Sub-total				1,146.00
2	Institutional water				
2.1	Government officers	person	369	5	1.85
2.2	Primary school	person	2,488	5	12.44
2.3	Secondary school	person	1,029	5	5.15
	Sub-total				19.44
3	Commercial water				
3.1	Hotel	bed	100	25	2.50
4	Industrial water				
4.1	Restaurant	seat	90	10	0.90
4.2	Factory	employee	75	5	0.38
4.3	Fuel Station	user	60	5	0.30
	Sub-total				1.58
	Sub-total 1				1,169.52
5	Livestock	m^3/day	1,170	20%	233.90
6	Refugee camp	person	16,340	20	326.80
	Sub-total	m^3/day			1,730.22
7	Water loss	m^3/day	1,730	30%	519.07
8	Grand total				2,249.29

5.2.2 Design water supply

Water supply facilities were designed based on multiplying this water demand by the peak factor. Kabribeyah water town population is greater than 50,000 persons, peak factor of 1.2 is applied. Water supply facilities' design water volume is 2,699m^3/day.

5.2.3 Facility plan

a. Borehole development

Presently, 3 boreholes are used to supply water to Kabribeyah town. In 2013, additional 4 boreholes are connected to the existing transmission pipeline to increase water supply volume to the town and the refugee camps. Two boreholes of each 5.0lit/sec yield are developed by JICA Study, and another two of each 20.0lit/sec yield are developed by UNHCR. The existing total borehole yield is calculated as 63.2lit/sec. Pump operation hours are designed as 11 hours, the current design maximum daily supply is 2,503m^3/day. Water supply volume of 166m^3/day, equivalent to 4.5lit/sec, will be additionally developed by 2020. Average yield of borehole development in Jarar valley water supply system is 7.8 lit/sec for all boreholes and 4.5lit/sec for less than 10lit/sec boreholes. Therefore, 1 new borehole development with 4.5lit/sec yield is planned also. New borehole expands to north direction along with the Jarar River. There is no commercial electrical line so that generator is set at the site as power source.

b. Water purification plant and pump station

The existing sedimentation tank has 415m^3 capacity. According to Urban Water Supply Design Criteria, horizontal flow sedimentation tank detention period is regulated from 1.5 to 4.0 hours. Full amount of water supply volume is 245m^3/hr, design detention period in the sedimentation pond is 1.7hours. Thus, no additional facility is designed.

The existing each surface and booster pumps has 75m^3/hr flow capacity. In case that all pumps operate simultaneously, design maximum daily water supply can flow 12.0hours. It is not critical situation to provide additional pumps taking into consideration flow capacity. Further there is no space to install additional pump at the existing pump house. If additional pump will be designed, new pump house with several pumps must be designed to aim at longer design period. At this point, no additional pumps and pump house are designed.

c. Transmission pipeline

c.1 Between boreholes and water purification plant

100 mm diameter uPVC pipe is installed between NBH-3 and PB-2. Large friction loss occurs in this section if the full amount of water, 58.7lit/sec, flows into this section and full amount of water cannot go to the sedimentation tank. The transmission pipeline section between NBH3 and the sedimentation pond shall be replaced with larger diameter pipes accompanying with new transmission pipeline installation.

c.2 Between surface pump station and reservoir at the town

The existing transmission pipeline between the surface pump and the reservoir at the town is ductile cast iron pipe with 250mm diameter. In case of flowing 225m^3/hr, velocity in the pipe is calculated to 1.3m/s, which is normal. There is no additional pipe required in the design.

d. Distribution pipeline system

d.1 Reservoir

The reservoir volume in 2020 is calculated to follow the section 3.5.1 c.1. The design water maximum daily supply is 2,699m^3/day, the reservoir volume in 2020 shall be designed to 900m^3 ~890m^3 = 2,699m^3/day×0.3×(1+10%).

The existing reservoir has 500m^3 capacity and 400m^3 reservoir shall be required to satisfy with the water supply plan. Therefore, it is designed in the Study. One of the serious issues on water supply system in the town is that not enough water pressure can be secured because there is no high elevation area in the town. The existing reservoir location is one of the highest elevation areas in the town. The new reservoir is also planned in the same area. In order to secure water pressure for distribution pipeline network, new reservoir shall be elevated type with 10 m height.

d.2 Distribution pipeline

The existing distribution pipeline network is concentrated in north-east side of the town since it is the main residential area. This area is the highest elevation in the town so that water from the elevated tank will be supplied to this area where it is bounded by the highway to Dagahbur and the road toward to Hartasheekha. West side area of the highway and south side of the Hartasheekha road are supplied by the existing 500m^3 reservoir. Valves shall be provided newly for distribution pipes and distribution areas will be separated. Each distribution area will be an independent area and can secure water pressure (refer to Figure 5.5).

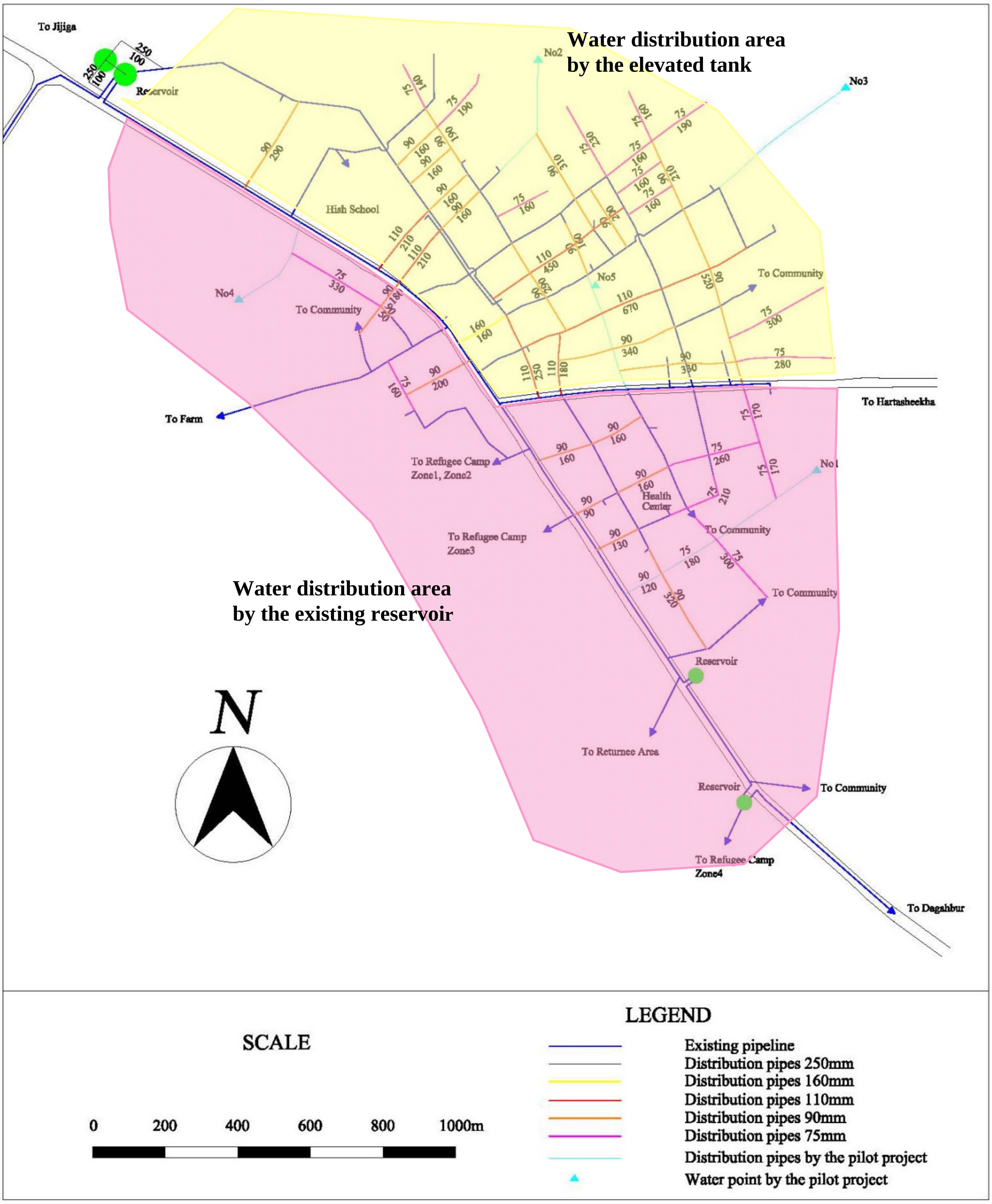


Figure 5.5: Kabribeyah Town Distribution Pipeline System Plan

5.3 General design

General design of the Kabribeyah water supply plan is described as follows (Refer to Table 5.9 and Figure 5.6).

a. Submersible pump

One submersible pump is designed for newly developed borehole. Flow rate shall be $0.3m^3$/min following the planned yield. Pump head follows the existing deepest pump position, which is 185m depth from the ground.

b. Generator

Generator output is designed to apply to the following equation regulated in 3.5.1 a.3. It shall be 68kVA.

$$R = \frac{0.163\,Q_p H}{\eta}(1+\alpha)\times 3 = \frac{0.163\times 0.3\times 185}{0.55}\times(1+0.1)\times 3 = 54$$

kVA = 1.25×R = 1.25×54 = 67.5 ~ 68

Where;

R : Generator output (54kW)

Q_p : Pump yield (0.3 m^3/min)

H : Total pump head (185m)

η : Pump efficiency (0.55)

α : Safety factor (0.1)

The pilot project has constructed the generator house. The Kabribeyah water supply plan also provides the same specifications' generator house.

c. Transmission pipeline between boreholes and water purification plant

A new transmission pipeline is planned from the new borehole to the existing pipeline connection point. Yield is 4.5lit/s, it is less than JICA boreholes' ones. The pilot project applies to 90mm diameter uPVC pipe; this transmission pipe is also designed as 90mm diameter. The abandoned NBH-1 borehole is located around 900m away from the connection point. The new borehole is planned about 1km north side of NBH-1; the pipeline length shall be planned as 2km.

The length between the existing pipeline connection point and the sedimentation pond outlet is 1,892m. Currently, 100mm and 150mm diameter pipes are installed. Flow rate of this section ranges from 58.7lit/sec to 67.7lit/sec. In case of pipe diameter 200mm, velocity in this section ranges from 2.31m/sec to 2.66m/sec. It is less than 3.0m/sec, appropriate level as water supply system. Therefore, 200mm pipe is designed with this 1,892m section.

d. Elevated reservoir

The existing reservoir is a circular type made of concrete. The planned elevated reservoir follows this design, it is a circular type made of concrete. Design volume and height are $400m^3$ and 10m as described in the previous section. Purified water flows from the booster pump station into the elevated reservoir. It provides two outlet pipes. One is supplied for higher elevation area and the other one is supplied to the existing reservoir. In order to conduct effective operation, flow control to the existing reservoir is important. O&M staffs shall control flow rate by the existing reservoir's water level.

e. Distribution pipelines

The existing distribution pipelines are functioning well, they will be used for the distribution pipeline plan. The new distribution pipes will be installed for the roads where pipes are not installed and to expand water supply areas, where they are mainly northeast and southeast of the town. Pipe diameters are mostly less than 110mm.

Table 5.9: Features of Kabribeyah Town Water Supply System General Design

No.	Item	Specifications	Unit	Q'ty
1.	Submergible pump	Q=0.30m^3/min, H=185m	No.	1
2.	Generator	68kVA	No.	1
3.	Transmission pipeline from BH to water purification plant			
3.1		90mm	m	2,000
3.2		200mm	m	1,892
4.	Reservoir	V = 400m^3, H=10m, Circular type	No.	1
5.	Distribution pipeline			-
5.1		75mm	m	3,760
5.2		90mm	m	4,970
5.3		110mm	m	1,970
5.4		160mm	m	160
5.5		250mm	m	200

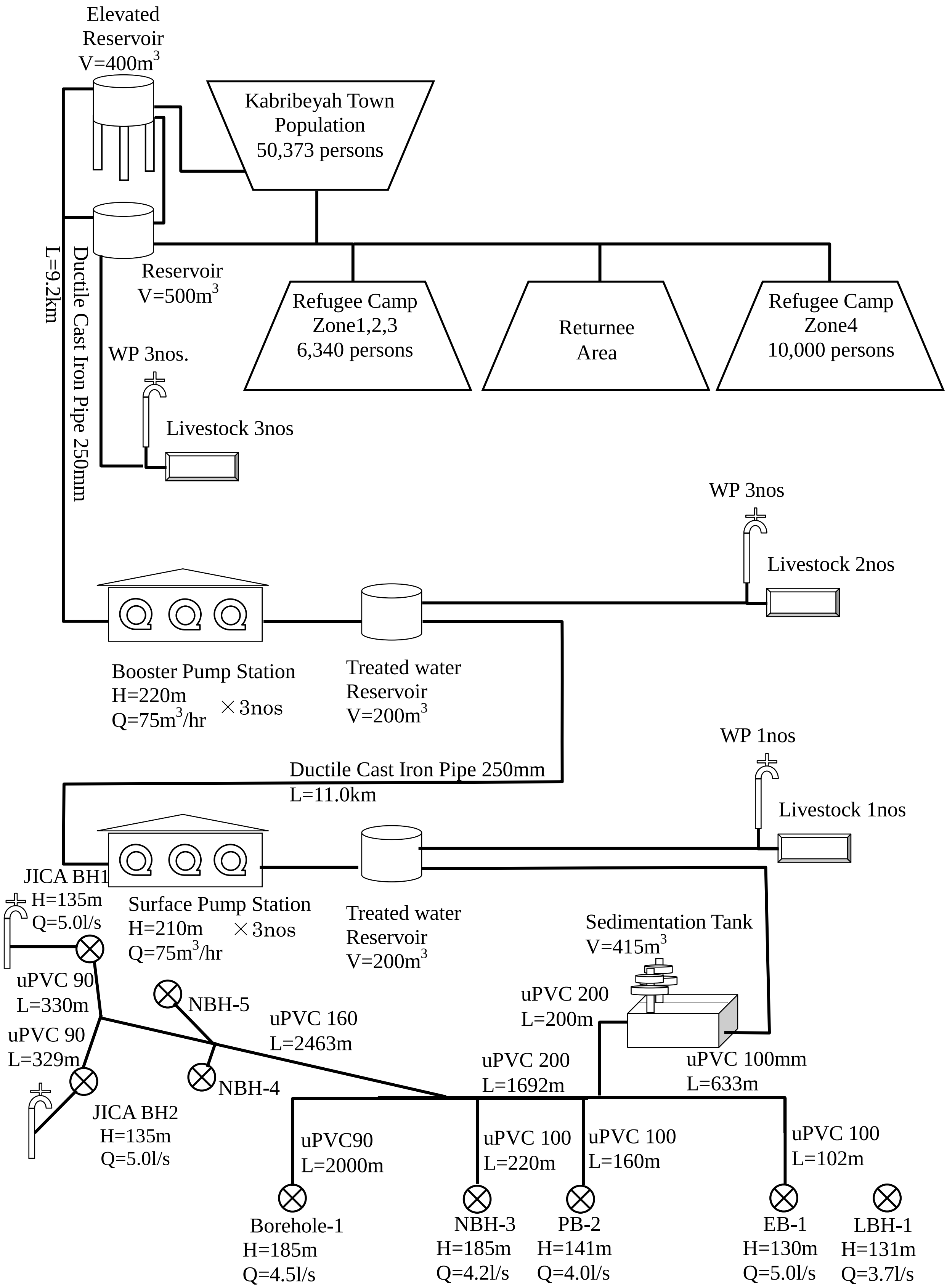


Figure 5.6: Kabribeyah Town Water Supply System Plan

5.4 Cost estimation

5.4.1 Composition of the project cost, method and condition for the cost estimation

a. Composition of the project cost

The project cost was estimated based on the following cost components (refer to Figure 5.7 below).

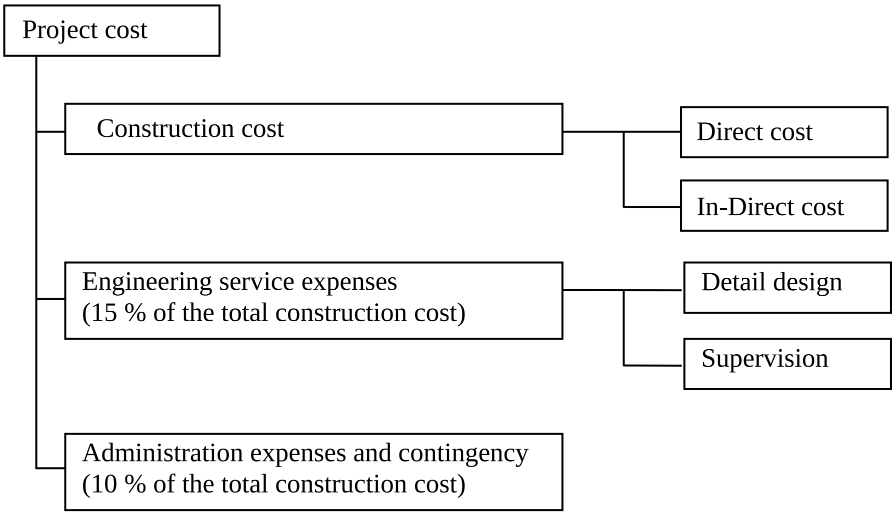


Figure 5.7: Components of the Project Cost

b. Method of cost estimation

b.1 Construction cost

Construction cost is composed mainly of the direct cost and the indirect cost.

Direct cost means that the cost is needed directly to construct objects. Direct cost is estimated by multiplying the quantity of the each construction item calculated based on the design by the unit cost of each construction item. Then direct cost is estimated by totaling each estimated cost of construction item. In this study, the unit cost of each construction item was estimated based on the results of the pilot project of water supply facilities construction and quotation from local construction companies. The unit cost of piping work differs depending on the type of pipes. The pipes and fittings that will be used for the structural part of the intake, purification and transmission facilities, and the pipes with more than D200 in diameter, are considered important components. Therefore, pipes that have superior strength and durability such as ductile iron pipe (DIP) and stainless steel pipes were proposed to be used for these important facilities. Unplasticized polyvinyl chloride pipes (uPVC pipe) and galvanized iron pipes (GI pipe) which are manufactured in Ethiopia, are selected for the other facilities that are less important.

Indirect cost consists mainly of the common temporary construction costs, the field office expenses and the general management cost. Indirect cost is not directly related to the work performance amount of the construction works. It is the cost that will be used commonly for all construction work items. In this study, the indirect cost was estimated based on the cost estimation standard book that is published by Japan Small Scale Water Works Association. The calculation formula of indirect cost is shown as below.

In-direct cost = Common temporary construction cost (C) +Field office expenses (F)
+General management cost (G)

Common temporary construction cost (C) = Direct cost (D) * ratio of C
Ratio of C (%) = 485.4*D^ (-0.2231) + 1.0

Field office expenses (F) = (D+C) * ratio of F
Ratio of F (%) = 103.1*(D+T) ^ (-0.0977) + 0.5

General management cost (G) = (D+C+F) * ratio of G
Ratio of G (%) = -2.57651*Log (D+C+F) + 0.3163531

b.2 Engineering service expenses

Engineering service expenses were estimated uniformly as 15 % of the construction cost.

b.3 Administration expenses and contingency

Administration expenses and contingency were estimated uniformly as 10 % of the construction cost for expenses such as procedure of contract of design and construction works, consultation with the concerned parties, and contingency budget.

c. Conditions for the cost estimation

- The project cost does not include value added tax (VAT) and land acquisition cost.
- The cost estimation is based on the prices as of May 2013.
- Exchange rate of local currency is USD1.00 = 18.53 ETB as an average of control rate from November 1, 2012 to April 30, 2013.
- Engineering service and the construction are assumed to be implemented by Ethiopia local companies.

5.4.2 Cost estimation

The project cost of Kabribeyah town water supply system plan was estimated as in Table 5.10 below.

Table 5.10: Estimated Project Cost for Kabribeyah Town

(Unit:USD)

Item		Cost
1. Construction cost		
	1.1 Direct cost	
	(1) Well drilling	84,000
	(2) Pump house	11,000
	(3) Pump and generator etc. procurement and installation	48,000
	(4) Reservoir	58,000
	(5) Transmission and distribution pipeline	715,000
	(6) Other	137,000
	sub-total	1,053,000
	1.2 In-direct cost	
		442,000
	Construction cost total	**1,495,000**
2. Engineering service expenses		
(15% of construction cost, rounding up of the last three digits)		
		225,000
3. Administration expenses and Contingency		
(15% of construction cost, rounding up of the last three digits)		
		150,000
Total cost		**1,870,000**

5.5 Implementation Plan

5.5.1 Contents of implemented project for each year

a. Implementation schedule

Implementation of the construction of water supply facility consists mainly of the design stage (design, tender documents preparation, tender, contract with a construction company), the well drilling stage (drilling and supervising), and the construction stage (implementation of the construction, trial operation of the facility, completion, supervising of the construction). After successful well drilling, pumping test is conducted. The specifications of the submersible pumps will be decided based on the result of the pumping test. Then, the designing of the entire water supply facility will be conducted.

The implementation schedule of the plan is shown in the following Table 5.11.

Table 5.11: Implementation Schedule of Kabribeyah Town Water Supply System Plan

Item		Month																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1.Engineering service																									
1.1 Outline discussion of water supply facility		■	■																						
1.2 Selection of drilling site and point				■																					
1.3 Tender and contract for drilling works					■																				
1.4 Design of water supply facility										■	■														
1.5 Tender and contract for water supply construction works													■												
1.6 Supervision of the construction						■	■	■	■	■				■	■	■	■	■	■	■	■	■	■	■	■
2.Well drilling and construction																									
2.1 Well drilling																									
2.1.1 Preparation						■																			
2.1.2 Drilling works and pumping test							■	■	■																
2.1.3 Inspection and completion of drilling works										■															
2.2 Water supply facility construction																									
2.2.1 Preparation														■	■										
2.2.2 Pump house	(1) Main reinforced concrete works															■	■	■	■						
	(2) Procurement of pump and generator													■	■	■	■	■	■						
	(3) Installation of pump and generator																			■					
	(4) Finishing works																				■	■			
2.2.3 Reservoir	(1) Main reinforced concrete works															■	■	■	■	■					
	(2) Finishing works																				■	■	■		
2.2.4 Transmission・Distribution pipeline	(1) Pipe and fittings procurement													■	■	■	■	■	■						
	(2) Pipe installation																■	■	■	■	■	■	■		
2.2.5 Trail operation・Inspection																								■	
2.2.6 Completion																									■

b. The annual project cost

The project of Kabribeyah town water supply system construction is planned to be implemented starting with the design and tender in 2015. After the tender, the construction will start and it will be completed in 2016. The project of Kabribeyah town water supply system takes 24 months from the design stage to the construction stage. The construction cost, engineering service expenses, and administration expenses and contingency are divided into the 2 years. The estimated cost for each year to implement the project is shown in the following Table 5.12.

Table 5.12: Estimated Annual Project Cost

(Unit:USD)

Western calendar	2015	2016	total
1.Construction cost	748,000	747,000	1,495,000
2.Engineering service expenses	113,000	112,000	225,000
3.Administration expenses and Contingency	75,000	75,000	150,000
Total	936,000	934,000	1,870,000

5.5.2 Budgeting schedule

Table 5.13 shows the budget and annual work/action plan of SRWDB for 2004 Ethiopian Fiscal year (EFY) (July 2011 ~ June 2012), and Table 5.14 shows the budget and annual work/action plan of SRWDB for 2005 EFY (July 2012 ~ June 2013). According to these budgets, it is estimated that the annual budget of SRWDB is approximately US$ 3,640,000. Approximately US$ 3,000,000 out of the annual budget is financed by assistance from external donors such as the African Development Bank (AfDB), the World Bank (WB) and the Department for International Development (DFID). In addition, it was also confirmed by SRWDB that some amount of budget for construction of birkas in target woredas is available outside the budget of SRWDB. The annual amount (July 2011 ~ June 2012) of this external budget for birka construction was estimated to be approximately US$ 1,350,000 for the 16 target woredas.

Table 5.13: Budget and Annual Work/Action Plan of SRWDB for 2004 EFY

	Project name	Budget(ETB)	Convert ETB into USD
1	Government Capital Budget		
1.1	On-going Project	3,500,000	
1.2	New Project	2,000,000	
	Sub - total	5,500,000	297,000
2	WASH Program		
2.1	Extension granted town finance implementation program	29,556,553	
2.2	AfDB financing projects	3,200,000	
2.3	WB-DFID assisted program	16,811,468	
2.4	UNICEF support program	242,512	
2.5	Pastoral community & development project (PCDP)	4,750,000	
2.6	Water Section Sedentarization Program	7,500,000	
	Sub - total	62,060,533	3,349,000
Total		67,560,533	3,646,000

Table 5.14: Budget and Annual Work/Action Plan of SRWDB for 2005 EFY

	Project name	Budget(ETB)	Convert ETB into USD
1	Government Capital Budget		
1.1	On-going Project	7,319,205	
1.2	New Project	7,900,000	
	Sub-total	15219205	821,000
2	WASH Program		
2.1	AfDB financing projects	25,579,175	
2.2	WB-DFID assisted program	21,181,375	
2.3	Pastoral community & development project (PCDP)	5,533,333	
	Sub-total	52,293,883	2,822,000
Total		67,513,088	3,643,000

Source: SRWDB

The project cost for Kabribeyah town water supply system plan for each year was estimated to be approximately US$ 930,000 as shown in Table 5.12. On the other hand, the annual budget of SRWDB is approximately US$ 3,640,000 as mentioned already. Thus, the annual project cost accounts for 25 % of the annual budget of SRWDB. Therefore, it is possible for SRWDB to implement Kabribeyah town water supply system plan on its own in terms of the budget.

However, the total project cost of all water supply plans for 16 woredas proposed by the study is approximately US$ 130,000,000 and the project cost for each year is estimated to be within US$ 7,700,000 to US$ 25,000,000 range. Therefore, it is unrealistic to implement the project of Kabribeyah town water supply system plan only by the budget of SRWDB taking into consideration of implementation of other water supply projects and other regular work required in the region. However, it is still desirable that some part of the project implementation budget is prepared by SRWDB.

In order to secure the budget for the implementation of the project of Kabribeyah town water supply system plan, two means can be considered in principle: one is to recover the cost of the project of Kabribeyah town by the income from water tariff in the course of operation of the system, and another is to secure budget as the aid from donors etc. Regarding the cost recovery, it will be difficult to finance the project fund that should be secured after paying for the operation and maintenance cost of the system from the income of water tariff. This is because the water tariff is determined in consideration of affordability of the residents and social condition in Kabribeyah town and it is difficult to raise the tariff. Therefore, as a realistic means, it is preferable to cover the budget shortage from donors as the aid for implementation of the project.

5.6 O&M and management plan of designed facilities

In this section, the results of the study of operation and maintenance work and personnel required for the proposed water supply system of the master plan are presented based on the examination of the proposed facilities in the systems. The proposal is at the master plan level. In addition, the cost of the proposed operation and maintenance plan of the water supply systems based on the details of the facilities and the implementation plan have been estimated.

The detailed data used to calculate the cost is attached in the Data Book in a separate volume.

5.6.1 Proposed systems and required O&M work and cost

a. Conditions of planning and cost estimation

The operation and maintenance plan for the proposed water supply systems has been prepared in consideration of the following conditions.

- Specific O&M work corresponding to the specification, size, and level of technology employed of the proposed facilities was proposed.

- To realize appropriate O&M work in future, it is a prerequisite to improve the existing organizations and staff concerned with operation and maintenance of water supply facilities. Thus, in every type of work the operators do, they were designed to work as a group and a leader was assigned and provision of appropriate training was planned, especially for the leader. Such member with sufficient qualification should probably be newly recruited from outside and their employment condition should also be improved.

- In order to supply materials and equipment necessary in operation and maintenance work, SRWDB is expected to procure such items according to the schedule and deliver them to site on time. Especially, the master plan requires the use of a large amount of chlorination chemicals to disinfect water for all the target woredas. Therefore, SRWDB should buy a large amount of the chemical in Addis Ababa and distribute them to each woreda.

The cost of implementation of the proposed operation and maintenance plan was calculated in consideration of the following conditions.

- The O&M cost covers both the newly planned facilities and the existing facilities for all woredas and towns.
- The cost of O&M of the terminal water supply facilities such as public water supply points that are normally operated and maintained by WASHCO was not included because WASHCO is solely responsible for it.
- Staff assignment at each facility is in principle based on the existing operation of the same facility to propose realistic number of people required.
- The annual O&M cost is calculated as an annual average of 10 year operation. Thus, the cost that occurs every few years was distributed over the 10 years.
- The cost of replacing over-used equipment is separately calculated for corresponding years.
- The cost does not consider accidental expenses but only regular expenses.

b. Target of O&M plan and details of the plan and cost

The basic information for the planned system for Kabribeyah town and basic approaches of determining the type of work and assignment of staff required are concisely described in Table 5.15. The type of work and number of staff members required for each of the component facilities of the proposed system are shown in more detail in Table 5.17. The cost of O&M for the town was calculated based on the data following the cost items below.

1) Personnel (stationed field staff directly involved in O&M of the facilities and day workers)
2) Materials (tools, materials and equipment necessary for O&M)
3) Fuel and electricity (Fuel for generators and electricity bill for pumps)
4) Chemicals (chlorine for household use, and treatment chemicals for the plant)
5) Spare parts (consumables and spare parts for generators and pumps)

In the cost estimation, actual price data was used as much as possible to make the values realistic. However, the amount of chemicals, whose cost has a great impact in the total O&M cost, should be verified at the time of the training after the detailed design. Then the O&M cost should be reviewed along with the other costs and revised accordingly. As for the fuel and electricity cost, the use of commercial electric supply was confirmed in Kabribeyah town. Thus, the power supply was planned with both generators and commercial power supply in Kabribeyah town.

Table 5.15: Policy of O&M of the Facilities in Kebribeyah Town

1 Basic conditions	Water supply amount: 2,699 m^3/day (maximum value including 30% leakage loss) Pump operation: 11 hours/day at intake wells, 12 hours/day at pump stations Facilities and equipment: ・8 borehole deep wells (5 are driven by generator) ・6 surface pumps (3 in pump house, 3 in booster pump house） ・Sedimentation tank, reservoir tanks, elevated reservoir tanks
2 Staff assignment	The assignment of staff was proposed based on the staff assignment at existing facilities and their work status. It also took into account the size and required work at the planned facilities as follows. Some operators should have some basic theoretical knowledge on their work and work as a leader. One person who has at least TVETC level education as a leader (technician) of operator is assigned. Technically more intricate work such as determination of chemical dosage and high level maintenance of work will be assisted by an engineer from the town water supply utility office as required. The staff should avoid excessive over work and their assignment was proposed to realize average 8 hour/day work by working in shifts. The staff assignment was proposed to minimize interruption of water supply even when maintenance such as reservoir cleaning is conducted.
3 Generator fuel and commercial electricity	The fuel efficiency of the existing generators is reported to be 5 to 6 L/h and that of the new ones procured in the pilot project was measured to be 4 to 5L/h. Thus the value of 5L/h was adopted for the generator of same size. 2 JICA wells, 2 UNHCR wells and one newly planned well (total 5 wells) will be driven by generators. The other 3 wells will be powered by commercial electric supply. The electricity bill of “General (Active Reactive)” of Ethiopian Electric Power Corporation was applied. The operation of the wells are continuous 10 hours Diesel fuel is available in Jijiga town.
4 Chemicals for water treatment and input of	In Kabribeyah town, only chlorine is used to disinfect water. Calcium hypochlorite is easy to handle and relatively safe and also it lasts

the chemicals	longer in storage. Thus, calcium hypochlorite power is used as disinfectant. First the powder is mixed with water to prepare high concentration solution. Then it is pored into chemical tank to be released (drip) at a constant rate. This chlorine chemical is available in Addis Ababa. Dosage will have to be determined based on the test at site but it is assumed to be 2mg/L
5 Spare parts of equipment	In consideration of the fact that the existing equipment mostly breakdown around 3 years, and the maintenance capacity will also be improved, the realistic life of equipment was set as follows: Submersible pump: 5 years, Ground pump: 5 years, Generator: 7 years The following spare parts for generator were assumed Engine oil（every 6 month） Fuel filter（every 6 month） Oil filter（every 6 month） Air cleaner（every 6 month） Fan belt（once in 2 years） Assumed spare parts for ground pump are as follows: Gland packing (once a year) Mechanical seal (once a year) Bearing (once in 3 years)
6 Large equipment	They are replaced right after their life years are reached starting from 2020. These large equipment will be procured with assistance from donors and thus free from customs tax. <u>This cost is not included in the regular O&M but separately handled</u>
7 Cleaning of sedimentation tank	In consideration of power supply conditions at site and difficulty in maintenance of the associated small equipment, the cleaning work should be conducted all manually. The assignment of works was determined based on the existing condition and the size of the planned facilities. Daily workers are employed to work under the supervision of the operator. Actual facilities to be cleaned are shown in another table and the following tools may be used. Shovel, deck brush, scraper (made from iron pipe), dewatering pump, bucket,
8 Other maintenance work (scale removal)	The short pipes and valves are taken part from the ground pumps and the accumulated scale in the pipes and valves are carefully removed. The work is all done manually. The assignment of works was determined based on the existing condition and the size of the planned facilities. Daily workers are employed to the work of cleaning the pipes and valves under the supervision of the operator. The engineer and plumber from the water supply utility office will detach the pipes and valves. Scale inside the pipes is physically removed with the use of scrapers.

c. Kabribeyah Town

c.1 Work required and staff assignment

The staff engaged in the operation and maintenance of the water supply system is divided into stationed field staff and non-stationed temporary staff. The former regularly operates the facilities in charge and the latter is involved mainly in maintenance work when it is necessary.

For the operators, as the stationed field staff, who are the major players of O&M work, the study team has proposed to newly assign leader of operators to supervise them at each facility. These leaders are named technicians. Such members can be recruited from outside and should have at least TVETC level educational background. Also, once employed, appropriate technical training should be given from the stage of construction of the facilities. Also, comparatively low salary scale for the staff may discourage the newly recruited employees. Thus, the staff salary should be raised by 50 to 100% to raise morale of the staff members. In the planning and cost estimation work, all the regular O&M work was assumed to be conducted by Kabribeyah town water supply utility office for convenience, although most of the maintenance work of the major part of the system is being conducted by UNHCR and JWSO as a contractor.

As a representation of O&M plan of the water supply system, the tasks required, frequency of the task, and assigned staff for the set of facilities constituting the water supply system that will be managed by the town water supply utility office from 2020 are presented in Table 5.17. The conditions of preparation of work plan are shown in Table 5.15. Based on this detailed O&M plan, the total number of staff required to operate the water supply system in Kabribeyah town can be determined as in Table 5.16 below. The number of current staff members assigned are also shown as a reference.

Table 5.16: Total Number of Staff Required for Operation of Planned System in Kabribeyah Town

<table>
<tr><th rowspan="2">Facility cluster</th><th colspan="3">Stationed field staff</th><th colspan="2">Temporary staff</th></tr>
<tr><th>Technician</th><th>Operator</th><th>Guard</th><th>Day worker
(man-day /year)</th><th>WD staff
(man-day /year)</th></tr>
<tr><td>Borehole wells（Fac.1）</td><td rowspan="3">5 [0]</td><td>4 [2]</td><td>6 [2]</td><td>18 [0]</td><td>6</td></tr>
<tr><td>Treatment plant, Treated reservoir, Pump st.（Fac. 2, 3, 4）</td><td>4 [3]</td><td>3 [2]</td><td>671 [640]</td><td>36</td></tr>
<tr><td>Treated reservoir, Pump st.（Fac. 5, 6）</td><td>2 [2]</td><td>3 [2]</td><td>105 [96]</td><td>24</td></tr>
<tr><td>Reservoir（Fac. 7,8）</td><td>0 [0]</td><td>2 [0]</td><td>3 [2]</td><td>170 [180]</td><td>0</td></tr>
<tr><td>Distribution pipeline system（Fac. 9）</td><td>0 [0]</td><td>0 [0]</td><td>0 [0]</td><td>160 [67]</td><td>0</td></tr>
<tr><td>Sub-total</td><td>5 [0]</td><td>12 [7]</td><td>15 [8]</td><td rowspan="2">1124 [983]</td><td rowspan="2">66</td></tr>
<tr><td>Total</td><td colspan="3">32 [15]</td></tr>
</table>

Note: the numbers under the header “Facility cluster” signify the facility number in Table 5.17.
The numbers shown signify the total number of field staff to be employed under the system of working in shift.
The shaded entries are temporary staff members from water desk (WD) and not calculated in the O&M cost.
The numbers in brackets “[ ]” signify the total number of current staff employed.

Although, the basic composition of the facilities in the system will not change after the completion of the project, the number of wells to operate will increase. In addition, the task of input of water treatment chemicals and removal of scale from the pipes and valves should be properly conducted. For this reason, mainly the technicians and operators have been augmented.

Table 5.17: Regular Operation and Maintenance Activities for Each Set of Planned Facilities in Kabribeyah Town

Facility (operation)	Capacity / (Dimension)	Detail Activity	Frequency (duration)	No. of staff assigned (work shift)	Remark
1. Borehole wells *5 with generators (pump operation)	8 wells total 67.7 L/s	1) Pump switch on and off	2 times / day (10 min each) x 8 pumps Morning – on Evening - off	3 operator (4 in shifts)	-Design supply amount is 2,699m^3/day. -11 to 12 hour operation - 5 driven by generator - 3 clusters of wells (UN, JICA, existing)
		2) Generator maintenance	2 times / year 1 time / year (3 days)	1 engineer 1 technician 1 operator 3 workers	Oil, Air and Oil filters (2 times/year) Belt replacement (1 time/year) 1 engineer from Kebribayah Water Desk
		3) General guarding	Every day (24 hrs)	3 guard (6 in shift)	- 3 clusters of wells
2. Treatment plant (Iron scale removal)	(V=415m^3)	1) Minor cleaning (scale removal in pipes and valves)	2 times / month (1 day)	1 technician 2 operators 2 plumbers 2 workers	The plumbers come from Kebribayah Water Desk
		2) Major cleaning (scale/sludge removal in reservoir)	1 time /3 month (3 days)	1 technician 2 operators 45 daily workers	
		3) General guarding	Every day (24 hrs)	1 guard (3 in shift)	Together with facilities 3 & 4
3. Treated reservoir (cleaning and chlorination)	(V=200m^3)	1) Cleaning (scale removal)	1 time / 3 month (1 day)	2 operators 1 technician 20 daily workers	
		2) Chlorine dosing	1 time / day (30 min)	2 operators (4 in shifts)	
4. Pump station (pump operation)	3 pumps total 225 m^3/h 75kW x 3 pumps	1) Pump switch on and off	2 times / day (20 min) 8:00 – on 18:00 - off	2 operators (4 in shifts)	12 hour continuous operation
		2) Valve open and closing	2 times / day (10 min)	2 operators (4 in shifts)	

		3) Pump packing replacement	1 time /year (3 days)	1 engineer 1 technician 1 plumber 1 daily worker	3 pumps, one after another 1 engineer comes from Kabribeyah Water Desk
		4) General guarding	Every day (24 hrs)	1 guard (3 in shifts)	Same guard as 2-3)
5. Treated reservoir	(V=200m^3)	1) Cleaning (scale/sludge removal)	1 time / 3 month (1 day)	1 technician 1 operator 20 daily workers	The 1 technician comes from Kebribayah Water Desk
6. Booster Pump St. (pump operation)	3 pump total 225m^3/h 75 kW	1) Pump switch on and off	2 times / day (5 min) 9:00 – on 19:00 – off	1 operator (2 in shifts)	
		2) Valve and pipe scale removal	2 time / year (3 day)	1 technician 1 operator 1 plumber 4 daily workers	The plumber comes from Kabribeyah Water Desk
		3) Pump maintenance	1 time / year (1 day)	1 engineer 1 technician 1 plumber 1 daily worker	Gland packing replacement 1 engineer from Kabribeyah Water Desk
		4) General guarding	Every day (24hr)	1 guard (3 in shifts)	
7. Reservoir 1 (Cleaning)	(V=500m^3)	1) Cleaning (Scale/sludge removal)	1 time / 6 month (1 day)	1 operator 45 daily labor	
8. Reservoir 2 (Cleaning)	Elevated reservoir (V=400m^3)	1) Cleaning (Scale/sludge removal)	1 time / 6 month (1 day)	1 operator 40 daily labor	
		2) General guarding	Every day (24hr)	1 guard (3 in shifts)	Together with tank 1
9. Pipeline system (repair)	Transmission and distribution	1) repair by welding, replacement, scale removal	1 time / 6 month (4 day)	1 engineer 2 technician 3 plumber 20 daily worker	Scale removal is done only in the pipe between the purification plant and the reservoir immediately down stream

Note: Water Desk = Town water supply utility office

c.2 Estimated cost

In Kabribeyah town, as explained in the section of water supply planning, major part of the existing water supply system will be used to supply water but the newly constructed facilities and this existing portion of the system were handled together to conduct the cost estimation. It was assumed that the existing system would be properly managed and maintained until 2020 and that the old equipment would be all replaced at the beginning of 2020, the target year of the master plan. Namely the system was assumed to be fully functional at the start of the year 2020. As for the personnel cost, only the stationed field staff and day workers were calculated as cost but not the temporary staff members from the water desk. The calculated annual O&M cost is 3,915,960 Birr in 2013 price and it is equivalent to about US$ 211,000.

The O&M cost of the system was calculated accordingly using the price of 2013 and is presented in Table 5.18. The fuel cost accounts for as much as 80% of the total cost.

5.6.2 Points of consideration in project implementation

It is highly important that all the organizations concerned with water supply play their roles properly in order to realize appropriate O&M of the water supply facilities that are completed. In the previous section of O&M planning and cost estimation, only the work and cost that are directly required to operate and maintain the facilities planned in the master plan were considered. However, the organizations and work that are indirectly involved in the O&M of the facilities are important as well and should also be considered.

In this sense, SRWDB plays a special and significant role in managing the water supply in the region as a responsible agency in water supply issues. The bureau should take care of the issues that woreda water office or town water supply utility office cannot cope with. SRWDB should also deal with tasks that the government offices at woreda or town level cannot handle or those that would be highly inefficient if handled by these offices. For example, procurement of a large amount of water treatment chemicals or spare parts for equipment from Addis Ababa and their distribution to woredas should be their duty. It was assumed that the cost of the water treatment chemicals itself should be recovered form the water offices of woreda or town level and eventually through WASHCO. The money is naturally raised by running the system in the woredas and towns. However, the other associated costs should be shouldered by SRWDB.

Also, at woreda level, when materials have to be transported to sites or when there is an issue that the operators at the site cannot handle, technical staff members of woreda water office are expected to attend to the site immediately. In such cases, it is necessary for woreda water offices to have a means of transportation such as a motor cycle.

On the other hand, WASHCO, the terminal group of residents that has not been considered in O&M planning and cost estimation, plays an important role in the O&M of water supply systems. In that, the group should be responsible for proper management of the terminal water supply facilities and should make sure that the money is duly collected from the users. The money so collected should be, then, used for O&M activities or be handed over to the water supply utility office in charge. These are the main duties of WASHCO in O&M of water supply facilities. However, the current WASHCOs are not yet existent and even where they exist, their capacity is far from satisfactory. Therefore, appropriate technical training should be provided to raise their motivation and work skills.

As will be described in the following sections, various training will be required for the organizations mentioned above in order to realize proper operation of maintenance of the water supply systems/facilities after their completion. Since the cost of the training is not included in the O&M cost calculated earlier, the government of Somali Region should secure the budget for the training at any cost and conduct the training. SRWDB is the organization that should take on this responsibility to conduct the training on time. It is expected to allocate its own budget to implement the training or to win assistance from external aid organizations such as NGOs to make it possible.

Table 5.18: O&M Cost of the Water Supply System in Kabribeyah Towns

Kabribeyah Town		
Cost item	Amount (Birr/year)	Remarks
Spare parts	41,796	spare parts for generators and ground pumps
Power supply	3,258,540	fuel and electricity bill for generators and pumps
Personnel	456,000	salary of stationed field staff and daily workers
Chemical	116,592	cost of water treatment chemicals (chlorination agent)
Consumable	43,032	tools for cleaning of facilities and engine oil for generators
Others	0	
Total	3,915,960	Equivalent to approx. US$ 211,000

Conditions of estimation

- Cost includes VAT and based on 2013 prices
- Cost was calculated as annual average over 10 year
- Cost covers all the facilities in Jarar valley includig those constructed by UNHCR until April 2013
- Cost is for the regular operation of the system and does not include major facilities/equipment replacement

5.7 Financial and economic evaluation

The cost benefit analysis has been applied to assess economic and financial viability of the water supply project in Kabribeyah town. In economic evaluation, the economic project costs and benefits are compared, and in financial evaluation, the financial costs and benefits are compared using cash flow data for a 20 year period.

Based on the cash flow data as mentioned above, the economic and financial indicators such as internal rate of return (IRR), net present value (NPV) and benefit cost ratio (B/C) are calculated.

5.7.1 Economic evaluation

a. Basic assumptions

The economic analysis has been undertaken on the basis of the following assumptions:

(1) The exchange rate of USD 1.00 = Birr 18.53, that is the average exchange rate during November 2012 and April 2013, has been applied.

(2) The base year for the costs is 2013.

(3) Only direct and tangible benefits have been quantified over the project life of 20 years for the calculation of the economic indicators.

(4) Discount rate of 10 % has been applied as a proxy of opportunity cost of capital in Ethiopia.

(5) Transfer payments such as interest and taxes, and price escalation are not included in the calculation.

b. Economic project cost

The economic project costs are composed of the investment costs and operation and maintenance costs as mentioned below.

b.1 Project costs

The economic project costs comprise of the costs for the construction of water supply facilities, engineering services and administration costs. Taxes and price contingency are not included in the economic costs. Conversion factors to convert the financial prices into economic prices have not been applied in this analysis due to lower percentage of local currency portion.

The economic project costs estimated accordingly amount to US$ 1,870,000 (refer to Table 5.19 below).

Table 5.19: Economic Project Costs of Kabribeyah Town Water Supply Project

Unit: USD

Item	2015	2016	Total
1. Construction cost	748,000	747,000	1,495,000
2. Engineering services	113,000	112,000	225,000
3. Administration and Physical contingency	75,000	75,000	150,000
Total	936,000	934,000	1,870,000

Note: See details in Section 5.5 of Chapter 5

b.2 Operation and maintenance costs

O&M costs are annual operation and maintenance costs for the equipment and other facilities amount to US$ 211,000 including the costs for spare parts, power supply, personnel, chemicals, consumables, and others.

c. Economic benefits

Out of several economic benefits of the project, only benefits of time saving for fetching water and health improvement benefits have been included in the calculation of economic indicators, as other benefits (e.g. improvement of quality of daily life) are difficult to quantify.

Time saving benefits for fetching water will arise immediately at the start of the operation of the project facilities. Health improvement benefits will arise from the second year after commencement of the project. Annual benefits have been calculated as the total of both time saving and health improvement benefits.

c.1 Benefits of time saving for fetching water

Benefits of time saving for fetching water are derived as a result of shorter distance to water sources after implementation of the project. Time saving from reduction in time spent fetching water is the difference between time for water collection “with” and “without” installation of improved water supply facilities. Time for fetching water consists of travel, queuing and filling time.

Time for fetching water “without the project” is assumed to be the same as the time spent for fetching water in the dry season, namely 3.8 hours on average per household. Time for fetching water “with the project” is assumed to be the same as the time spent fetching water in the rainy season, namely 1.4 hours on average per household. Time saving, therefore, will be the difference between the time spent in the rainy season and the same in the dry season, namely 2.4 hours on average per household.

Value of time saving is measured from the average time saved multiplied by the economic labor cost. It is assumed that 50% of time saved will be used on productive activities and the remaining 50 % will have no value. The value of productive activities is assumed to be 100 Birr per day on the basis of the unskilled labor cost in the study area. The value of time saved on fetching water will be 50 Birr (100 Birr x 50 %) per day or 6.25 Birr per hour. Consequently, time saved of 2.4 hours per day will have the value of 15 Birr per day per each household. Assuming that there will be at least 300 days of productive activities in a year, the value of time saving will be 4,500 Birr (US$ 242.85) per year.

Benefits of time savings will arise immediately at the start of operation of the project facilities and will increase year by year, reaching its maximum amount in 2020.

c.2 Benefits of health improvement

Health improvement benefits are derived as a result of an improvement in water quality and increased supply of water. The benefits can be measured from the difference of medical expenses between “with” and “without” installation of improved water supply systems.

Provision of a clean water supply will lead to the reduction in the incidence of water related diseases. It is assumed that provision of clean water supply will lead to 10% reduction in medical expenses every year in the target communities. Based on the results of the Socio-economic Survey in 2012, the annual medical cost is estimated at 1,501 Birr per household on average. The medical cost will be reduced by 150 Birr (US$ 8.09) per each year per household.

Health improvement benefits will arise from the second year after commencement of the project and will reach its maximum amount in 2021.

d. Economic evaluation

Economic analysis has been conducted on the basis of the annual costs and benefits stream as estimated in the preceding sections. The result of economic analysis of the proposed project in terms of Economic Internal Rate of Return (EIRR) is 79.5 % as presented in Table 5.20.

Table 5.20: Cash Flow for Calculation of Economic Indicators

Unit: USD

Calendar Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at 10%	Present Value at 10%
	Time saving	Health	Total	Investment Cost	O & M Cost	Total Cost			
2014	0	0	0	936,000	0	936,000	-936,000	0.909	-850,909
2015	0	0	0	934,000	0	934,000	-934,000	0.826	-771,901
2016	2,181,483	65,929	2,247,412	0	211,331	211,331	2,036,081	0.751	1,529,738
2017	2,244,964	67,848	2,247,412	0	211,331	211,331	2,036,081	0.683	1,390,671
2018	2,310,293	69,822	2,312,812	0	211,331	211,331	2,101,481	0.621	1,304,854
2019	2,377,522	71,854	2,380,115	0	211,331	211,331	2,168,784	0.564	1,224,222
2020	2,446,708	73,945	2,449,376	0	211,331	211,331	2,238,045	0.513	1,148,471
2021	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.467	1,077,316
2022	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.424	979,378
2023	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.386	890,344
2024	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.350	809,403
2025	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.319	735,821
2026	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.290	668,928
2027	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.263	608,117
2028	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.239	552,833
2029	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.218	502,576
2030	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.198	456,887
2031	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.180	415,352
2032	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.164	377,593
2033	2,446,708	73,945	2,520,653	0	211,331	211,331	2,309,322	0.149	343,266
Total	36,028,050	1,310,683	44,405,616	1,870,000	3,803,958	5,673,958	0.795		13,392,960
EIRR	79.5 %								

The result of the computation indicates that the project is economically feasible as the EIRR exceeds the opportunity cost of capital of 10 %.

5.7.2 Financial evaluation

a. Financial project cost

The total capital costs of the project amount to 1,870,000 U.S. dollars (USD) including engineering services and administration costs. Out of the total costs, foreign portion accounts for 69.1% and local portion 30.9%. It is the policy of the Government of Ethiopia that the Government shall finance the capital costs of water supply projects under the condition that each local community will be responsible for operation and maintenance costs of the water supply facilities.

b. Water revenue

Financial benefits will be the water revenue to be paid by the water users of the improved water supply system in the town. Water revenue is calculated from the water volume supplied multiplied by the water tariff.

Water tariff of 10 Birr per cubic meter which is the existing water tariff in Kabribeyah town has been used for the calculation of financial indicators.

c. Financial evaluation

c.1 Cost benefit analysis

Financial cost benefit analysis has been conducted on the basis of the annual costs and benefits stream as estimated in the preceding sections.

The result of the computation, as presented in Table 5.21, indicates that the project has the Financial Internal Rate of Return (FIRR) of 6.1 % under the condition that the recovery of water fee collection will be 100 %.

Table 5.21: Cash Flow for Calculation of Financial Indicators

Unit: USD

Year	Incremental Net Benefit			Incremental Costs			Net Cash Flow	Discount Factor at 10%	Present Value at 10%
	Water Demand (m^3)	Water Tariff (USD/m^3)	Water Revenue (USD)	Investment Cost	O & M Cost	Total Cost			
2014	0	0	0	936,000	0	936,000	-936,000	0.909	-850,909
2015	0	0	0	934,000	0	934,000	-934,000	0.826	-771,901
2016	661,607	0.540	357,046	0	211,311	211,311	145,735	0.751	109,493
2017	680,860	0.540	367,436	0	211,311	211,311	156,125	0.683	106,636
2018	700,673	0.540	378,129	0	211,311	211,311	166,818	0.621	103,581
2019	721,062	0.540	389,132	0	211,311	211,311	177,821	0.564	100,375
2020	742,045	0.540	400,456	0	211,311	211,311	189,145	0.513	97,061
2021	742,045	0.540	400,456	0	211,311	211,311	189,145	0.467	88,238
2022	742,045	0.540	400,456	0	211,311	211,311	189,145	0.424	80,216
2023	742,045	0.540	400,456	0	211,311	211,311	189,145	0.386	72,924
2024	742,045	0.540	400,456	0	211,311	211,311	189,145	0.350	66,294
2025	742,045	0.540	400,456	0	211,311	211,311	189,145	0.319	60,267
2026	742,045	0.540	400,456	0	211,311	211,311	189,145	0.290	54,789
2027	742,045	0.540	400,456	0	211,311	211,311	189,145	0.263	49,808
2028	742,045	0.540	400,456	0	211,311	211,311	189,145	0.239	45,280
2029	742,045	0.540	400,456	0	211,311	211,311	189,145	0.218	41,163
2030	742,045	0.540	400,456	0	211,311	211,311	189,145	0.198	37,421
2031	742,045	0.540	400,456	0	211,311	211,311	189,145	0.180	34,019
2032	742,045	0.540	400,456	0	211,311	211,311	189,145	0.164	30,927
2033	742,045	0.540	400,456	0	211,311	211,311	189,145	0.149	28,115
	13,152,831	0.81	5,896,760	1,870,000	2,861,100	4,731,100	0.061		-416,203
FIRR	6.1 %								

c.2 Sensitivity analysis

Sensitivity analysis has been made on the basis of different scenarios on the project. The scenarios include: (i) a 10 % increase in total costs; (ii) a 10 % reduction in benefits; and (iii) a combination of 10 % increase in total costs and 10% reduction in benefits.

The result of the sensitivity analysis is presented in Table 5.22 below.

Table 5.22: Result of Sensitivity Analysis

	Financial Internal Rate of Return (FIRR)
Basic assumptions	6.1 %
10 % higher costs	3.6 %
10 % reduction in benefits	3.3 %
Combination of costs increase and reduction in benefits	0.7 %

Chapter 6

Water Supply Plan and General Design, Cost Estimation and Implementation Plan for Godey Town

6 Water Supply Plan and General Design, Cost Estimation and Implementation Plan for Godey Town

6.1 Present condition of existing water supply facilities

a. Development of the water supply facilities

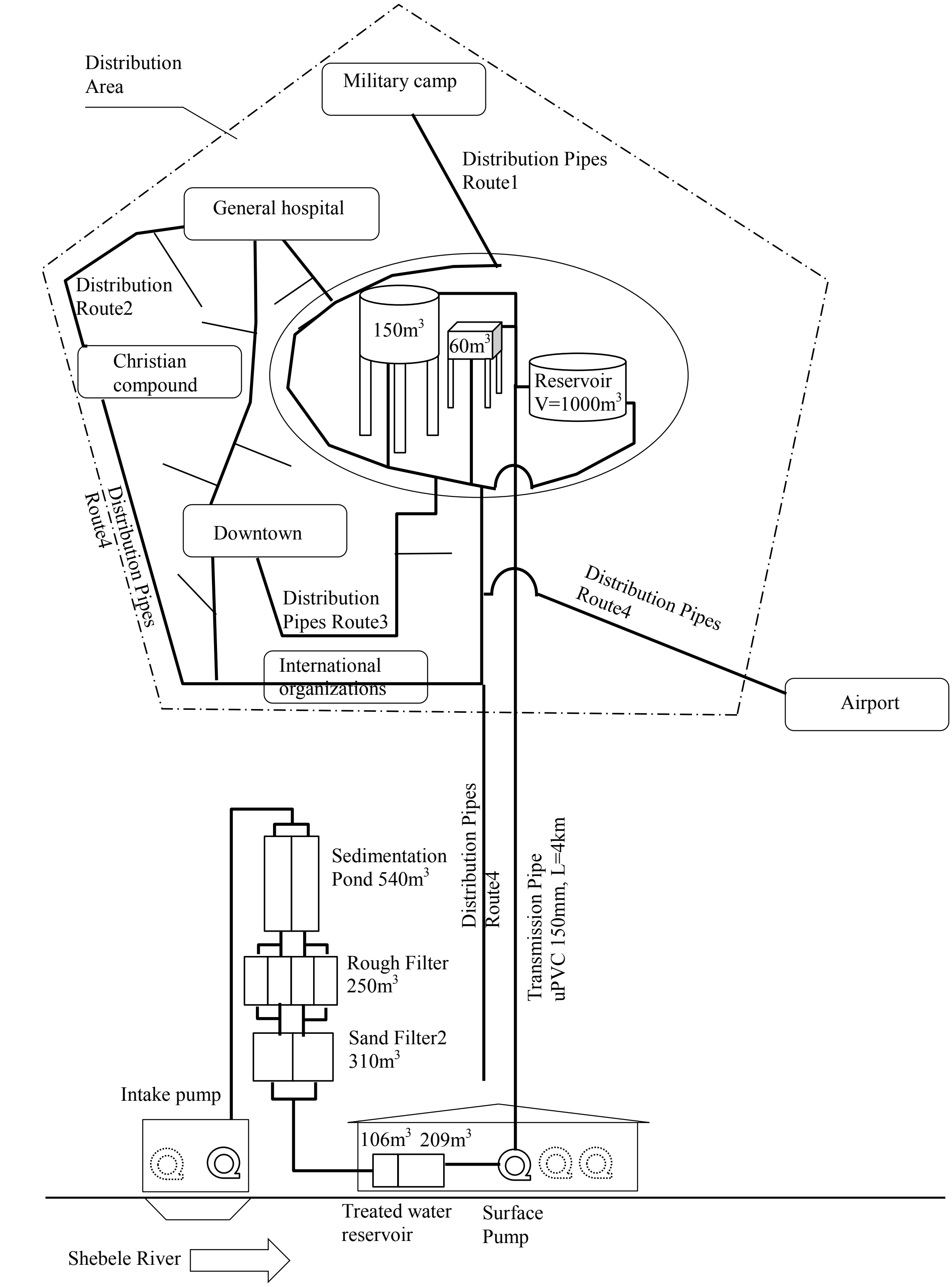
a.1 Initial development

The oldest operational water supply facilities in Godey town were constructed in 1959. Initial water supply system had the objective to provide water to the major government offices and the public facilities such as the zonal administrator residence, government office, hospital, and Christian compound. The water intake, filter equipment, and chlorination reservoir were constructed near the Shebele River and the elevated reservoirs were constructed in places with the highest elevation in the town. One distribution pipeline with three (3) public taps was installed from the reservoir to the Christian compound.

a.2 Expansion of the water supply facilities

The water supply facilities were expanded in 1996 in accordance with the growth of the town. Major reasons of the town growth are 1) settlement of pastoralists and 2) immigration of Somali refugees. The intake pump station was replaced at the Shebele River to increase water supply volume. Besides, the sedimentation tanks were constructed corresponding to the new intake pump station in order to increase the purified water volume. The distribution pipelines were also expanded and six (6) public taps were provided for the Godey town population.

After the year of 2000, the sand filter ponds in the water purification plant, concrete reservoir with 1000m^3 volume, and the six (6) public taps were constructed. However, it still could not supply sufficient amounts of water for the Godey town population. General layout of the Godey town water supply system is shown in Figure 6.1.



Note: the objects in dotted line signify they are non-functional

Figure 6.1: General Layout of the Godey Town Existing Water Supply system

b. Raw water intake pump station

Originally, two raw water intake pumps were installed inside the pump station. Due to lack of spare parts, raw water intake pump has not been repaired efficiently. Godey water supply utility office does not have any stand-by pumps. They operate one raw water intake pump only. When they replace intake pump, they normally install used pump due to budgetary limitations. As a result, replaced pump cannot expect long working life and it sometimes broke within quite a short term. According to Godey water supply utility office, they do not operate the raw water pump in case that river water level is higher than the settled pump elevation and raw water is turbid. It seems that the raw water intake pump station does not provide screen and the raw water intake pump has to take raw water directly so that pump sucks soil grains unnecessarily into the water purification plant. In which case raw water cannot be purified effectively and they stop operation.

c. Water purification plant

Due to intermittent electricity supply, the Godey water supply system adopts the slow sand filter system even though raw water contains high turbidity especially in rainy season. All water purification systems are operated by gravity flow without using electricity (refer to Table 6.1).

Table 6.1: Features of the Water Purification Plant Facilities

No.	Facility	Year	Dimension	No.	Total Vol.
1	Sedimentation tank	1996	25.0m x 4.5m x 2.4m/cell	2	540.0m^3
2	Rough filter	2009	11.5m x 3.5m x 1.6m/cell	4	257.6m^3
3	Slow Sand filter pond 2	2009	12.5m x 8.5m x 1.5m/cell	2	318.8m^3
4	Drying bed	2009	6.2m x 4.4m x 0.7m/cell	1	19.1m^3

The slow sand filter pond 1 was constructed in 2007, but it is not currently operational. According to Godey water supply utility office explanation, the tank was clogged by floc and raw water overflowed into the sand filter pond 1. This phenomenon occurred often so that they quit operation. Afterward, the SRWDB planned and constructed the rough filter pond and the slow sand filter 2.

d. Treated water reservoir

The treated water reservoir stands at the Shebele riverine area close to the intake pump station approximately 70m away from it. Purified water from the sand filter 2 flows into the treated water reservoir by gravity and chlorine shall be added there. Dimensions and capacities are summarized in Table 6.2 below:

Table 6.2: Features of the Treated Water Reservoir

Reservoir	Dimensions	Capacity
Cell No.1	9.5m x 5.5m x 4.0m	209m^3
Cell No.2	4.8m x 5.5m x 4.0m	106m^3

Originally, it had three (3) transmission pumps to flow water to the reservoir in the town. However, two of them are broken presently, only one pump can operate.

Water tanker also accesses to the treated water reservoir and purchases purified water into their water tanks for vending to population.

e. Power station

The generator house is built next to the treated water reservoir and two generators are settled. However, one generator is not in good condition; the only one generator supply electricity to the raw water intake pump and transmission pump. In survey time they supplied electricity for the raw intake pump in morning time and the transmission pump in afternoon time. Water supply volume was limited to half day. Godey water supply utility office procured additional generator in 2012 and two generators operated as of April 2013. One is used for the raw intake pump and the other one is used for surface pump. They currently supply water for whole day.

f. Transmission pipeline

uPVC pipe with 6 inch diameter is installed from the treated water reservoir to the reservoirs in the town. Total length is about 3,450m. The transmission pipeline route is almost in a straight line, the shortest distance is selected as the pipeline route. The transmission pipeline was installed before residential area's development. Now several houses especially near to the reservoir area have been constructed on the transmission pipeline route and stand over it. It cannot be repaired in such places even if leaks occur.

g. Reservoir

Three reservoirs stand at the site. The oldest reservoir was constructed as one part of the initial water supply development. Due to increase of the water demand, the additional elevated reservoir was developed in 2009 by USAID, however, it could not solve water shortage in Godey town. Because the additional elevated reservoir did not have enough capacity to satisfy water consumption. Further investment was conducted by the SRWDB and the largest capacity reservoir with 1,000m^3 was completed in September 2010. However, it cannot satisfy water pressure for peripheral area of the town, Godey water supply utility office still has to use the oldest elevated reservoir. The oldest reservoir capacity corresponds to the current daily water consumption approximately 150m^3/day. Characteristics of the reservoirs are tabulated as following Table 6.3.

Table 6.3: Features of the Reservoirs

No.	Type	Year	Capacity	Funded by
1	Cylinder type elevated reservoir	1959	150m^3	Federal gov.
2	Rectangular type elevated reservoir	2009	60m^3	USAID
3	Cylinder type ground reservoir	2010	1,000m^3	SRWDB

h. Distribution pipelines

There are four (4) distribution pipeline routes installed in the Godey town. uPVC pipes are mainly applied to the distribution pipeline. In case that pipeline shall be installed on the ground, galvanized steel pipes are applied. Total pipeline length is about 20,020m and its diameter ranges from 37.5mm to 125mm (refer to Table 6.4 and Figure 6.2).

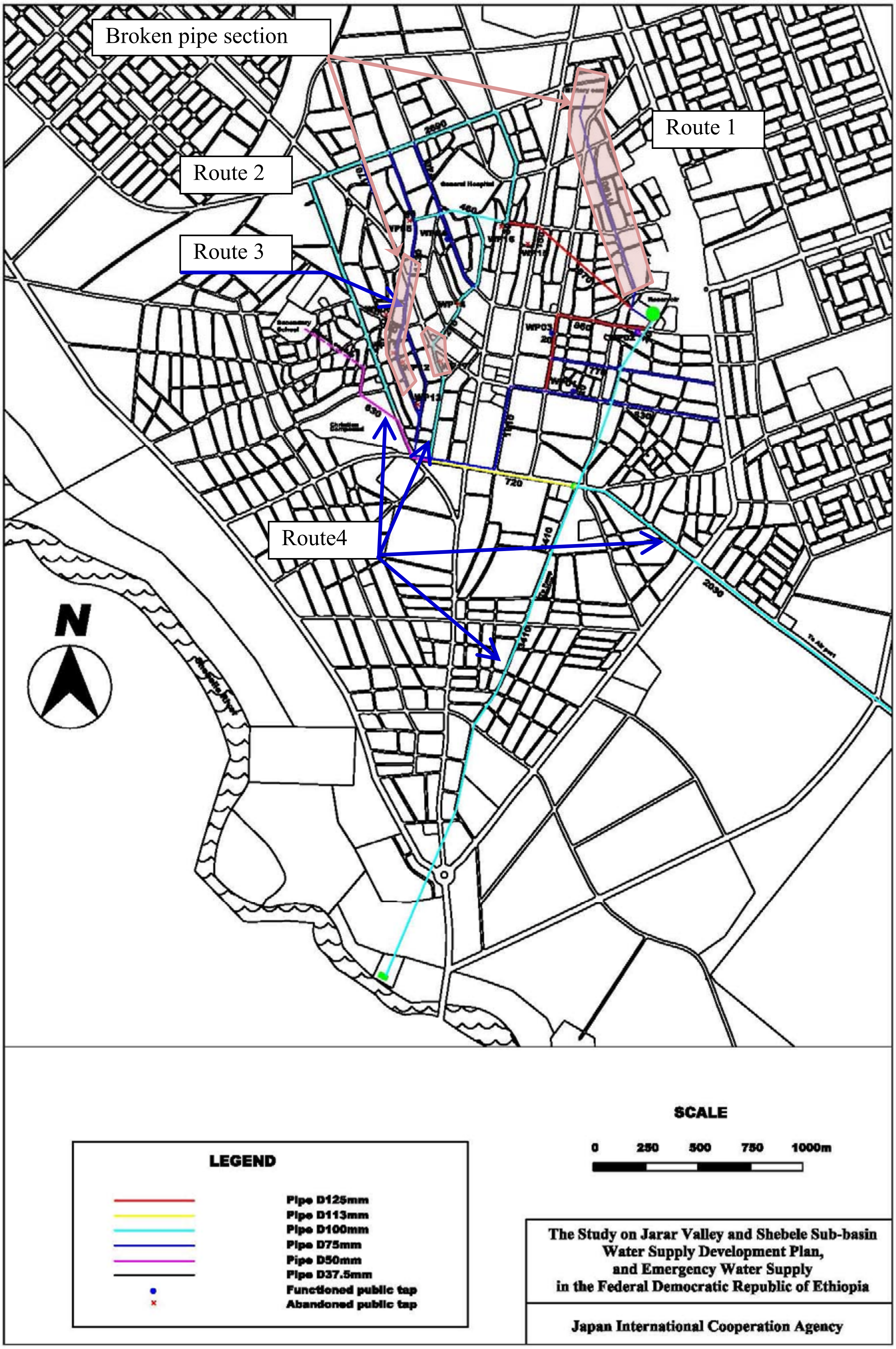


Figure 6.2: Existing Distribution Pipelines and Public Taps

Table 6.4: Distribution Pipeline Length in the Godey Town

Diameter	Material	Length
125mm	uPVC	1,730m
113mm	uPVC	720m
100mm	uPVC	9,860m
75mm	uPVC	6,640m
50mm	uPVC	630m
37.5mm	uPVC	440m
Total		20,020m

Major facilities, which are supplied by each distribution pipeline route, are summarized in Table 6.5 below:

Table 6.5: Water Supply Area in Godey Town by Each Distribution Pipeline Route

No.	Direction	Major facilities
Route1	North	Military camp
Route2	North-west	General hospital Christian compound
Route3	South South-west	Downtown Small market shops
Route4	South South-east South-west	Airport International organizations Christian compound General hospital Downtown

Several distribution pipelines are totally broken. They were identified by the site survey with Godey water supply utility office (Refer to Figure 6.2). These sections are urgently required to reinstall distribution pipe and shall be recovered.

i. Public taps and house connection

There are 15 public taps in the distribution pipeline network. Initial three public taps and additional six are not operational because they are broken. According to Godey water supply utility office, once distribution pipes broke and stopped operation, public taps were also not operated spontaneously and such situation continues until now. The latest six public taps were constructed in 2010 when the reservoir was constructed. Three of them are currently functional.

j. Issues

Current issues and their countermeasures of the Godey water supply system are summarized in Table 6.6.

Table 6.6: Issues and Countermeasures on Current Water Supply System

No.	Issue	Countermeasure
1	Insufficient water supply volume	Increase of intake water volume
2	High turbidity of raw river water	Formulation of proper turbidity removal measure
3	Insufficient water pressure at the distribution pipelines	Planning on new elevated reservoir to increase water pressure
4	Expansion of water supply coverage area	Expansion of distribution pipeline network
5	Increase of usage of public taps	Permanent water supply and Establishment of WASHCO for operation

The most critical issue for the Godey water supply system is that current water supply capacity is far too little to compare with town population. Even if all the water supply facilities function correctly, it is supposed that water supply access rate does not reach to 30% of total population. Therefore, it is the first priority to formulate the detailed water supply plan and implementation plan concretely, and then increase water supply coverage. As for engineering issue, the Shebele River water contains high turbidity, it shall be formulated to proper turbidity removal measure suitable for Godey water supply utility office operation and maintenance staffs.

6.2 Water supply plan

6.2.1 Water demand

Projected population in 2020 is estimated to 36,958 persons, this figure is used for the water demand calculation.

The target population served by water supply as percent of total population for Godey water supply plan sets to be 100% water access rate in 2020, each population belongs to any of piped water connection. Based on the current water access ratio percentages, house connection, yard connection, and public tap of 2020 are estimated to 1:49:50. Unit water demand of above three categories is regulated in the urban water supply design criteria, they shall be 50lit/cap/day, 25lit/cap/day, and 20lit/cap/day respectively. Other water demands are estimated based on the socio-economic survey results. Livestock water demand is added to 20% of above water demands. Finally, water loss is estimated to 30% of whole water demands (Refer to Table 6.7).

Table 6.7: Water Demand of Godey Town in 2020

No	Item	Unit	Quantity	Unit demand (lit/cap/day)	Total (m^3/day)
1	Domestic water				
1.1	House connection	person	370	50	18.50
1.2	Yard connection	person	18,109	25	452.73
1.3	Public tap	person	18,479	20	369.58
	Sub-total				840.81
2	Institutional water				
2.1	Government officers	person	300	5	1.50
2.2	Primary school	person	5,902	5	29.51
2.3	Secondary school	person	3,643	5	18.22
2.4	High school	person	2,484	5	12.42
2.5	Hospital	bed	15	50	0.75
	Sub-total				62.40
3	Commercial water				
3.1	Hotel	bed	90	25	2.25
4	Industrial water				
4.1	Restaurant	seat	310	10	3.10
4.2	Factory	employee	0	5	0.00
4.3	Fuel Station	user	60	5	0.30
	Sub-total				3.40
	Sub-total 1				908.86
5	Livestock	m^3/day	909	20%	181.77
6	Water loss	m^3/day	1,091	30%	327.19
7	Grand total				1,417.82

6.2.2 Design water supply

Water supply facilities need to be planned by design maximum daily supply. In Ethiopia, design water supply is multiplied design average daily supply by seasonal peak factor, daily peak factor, and hourly peak factor. All of them are regulated in the urban water supply design criteria (Table 6.8). The Study applies to mean figures, 1.2 for seasonal peak and 1.3 for daily peak. Design maximum daily supply is 2,211.79m^3/day.

Table 6.8: Applied Peak Factors and Water Supply volumes

Peak factor	Design criteria	Applied figure	Design water Supply (m^3/day)
Seasonal peak	1.0~1.2	1.2	1,701.38
Daily peak	1.0~1.3	1.3	2,211.79

As for firefighting water demand, it is set to be 10% of reservoir volume to follow the urban water supply design criteria.

6.2.3 Facility plan

a. Water supply resources

Presently, the Shebele River water is the only water resource for Godey town. Due to high turbidity of the river water, possibility of shallow groundwater development was studied by the Study. Geological situation in Godey town only expects groundwater from several meters below the ground level. However, such sites can hardly expect to be recharged by river water because normal river water level is lower than expected groundwater aquifer. Further, there is no information granted to use shallow groundwater in Godey town. Therefore, the water supply plan shall only use the Shebele River water.

There are 5 major public water intake points from the Shebele River in Godey town. Free water access point is located the most upstream and the existing Godey town water supply system is the most downstream point. It does not affect to negative impact for water quality even though drinking water intake point is downstream of free access water point because river water is enough diluted. However, people have negative connotations about taking water at downstream point. A new water intake site is proposed upstream of the free access water intake point (Refer to Figure 6.3). And summary of the Godey town water supply plan is shown in Figure 6.4.

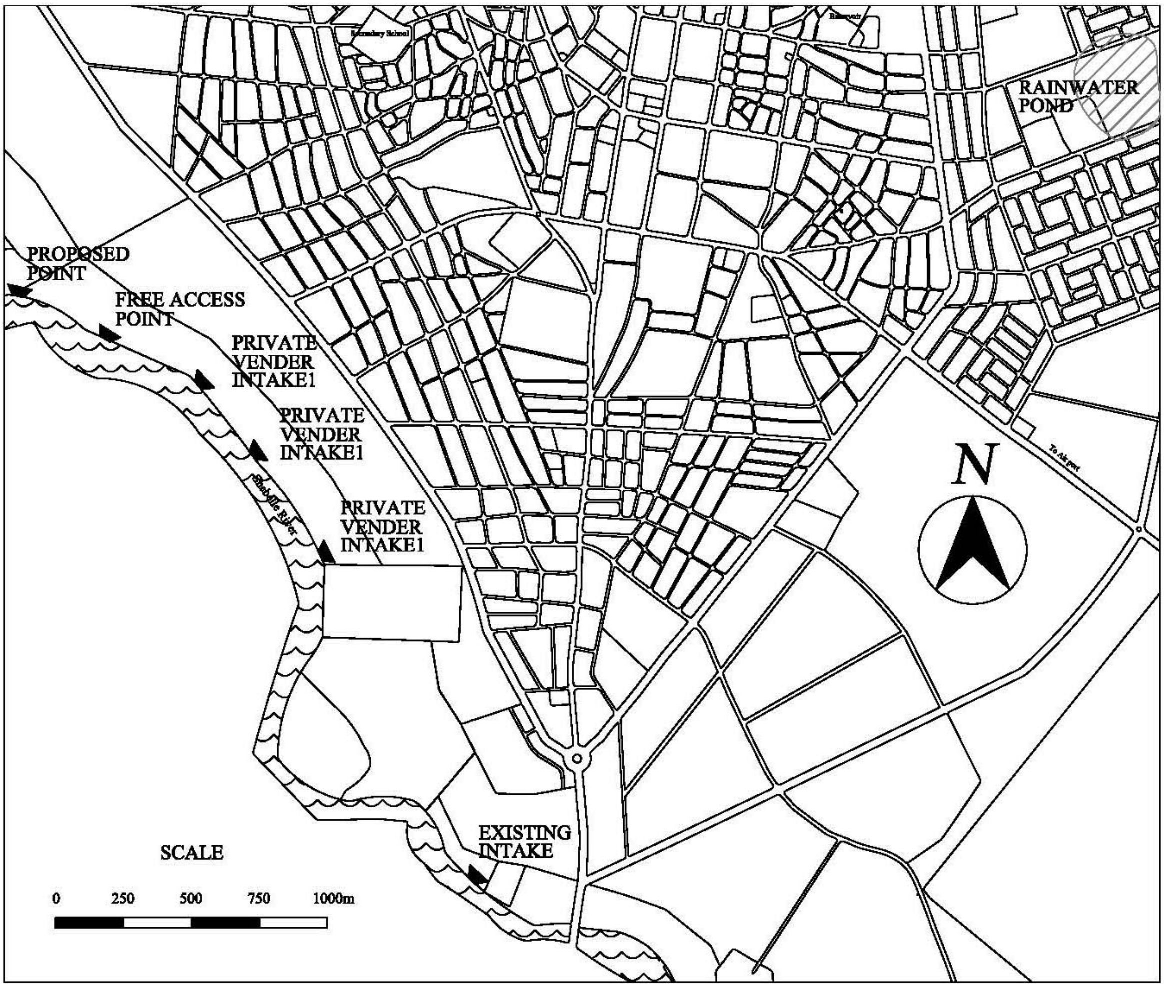


Figure 6.3: Godey Water Intakes

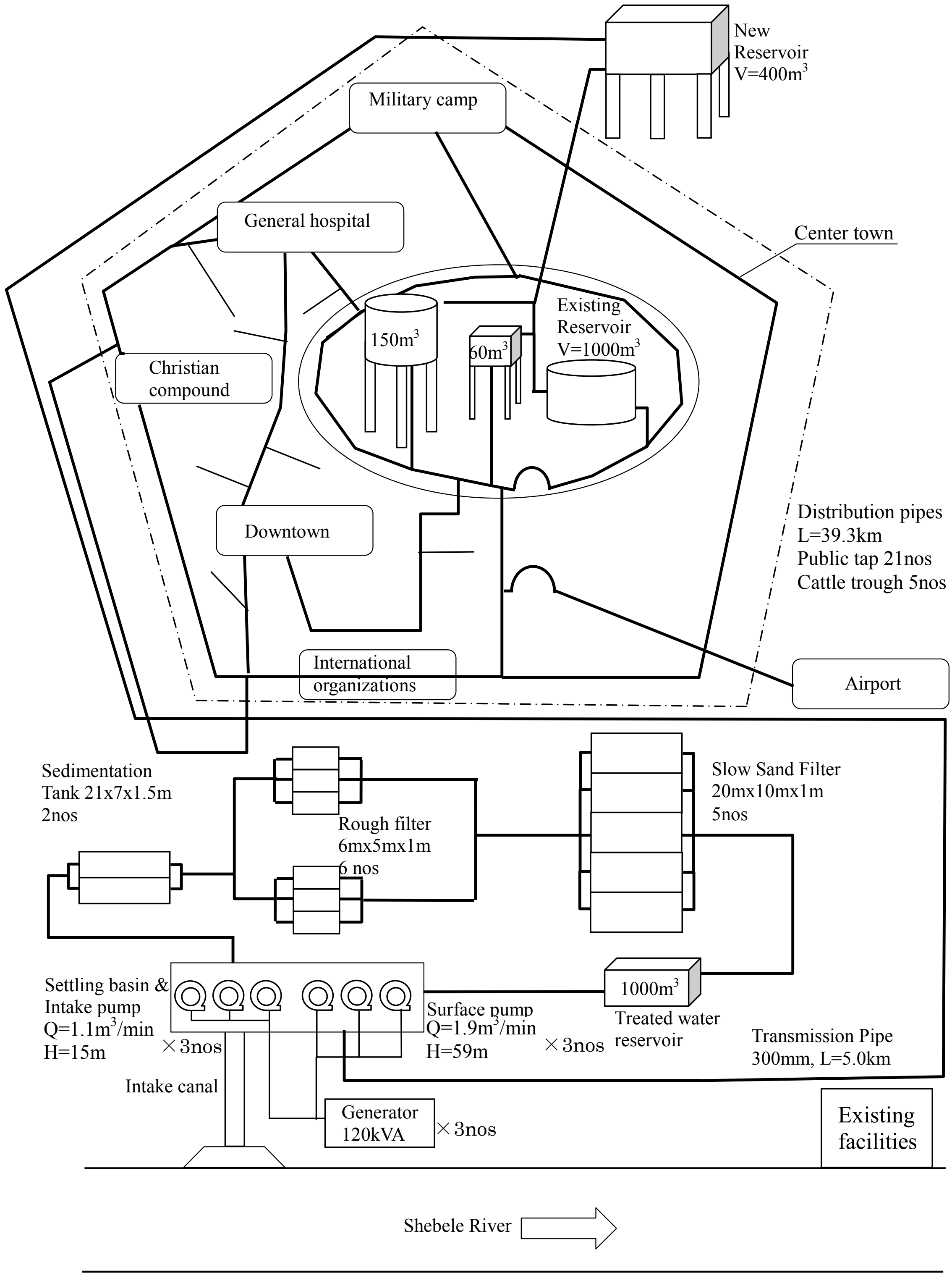


Figure 6.4: Godey Town Water Supply System Plan

b. Pump station

Two alternatives were studied for pump station arrangement. The first plan is that the surface pump station is planned between the water purification plant and the town. The second plan is that the surface pump station is planned at the intake pump station. The second plan is superior to the first one in the operation stage. One facility is more efficient in view of low operation and maintenance cost. Thus, the second plan is selected in view of operation and maintenance cost, and the intake pump and surface pump are installed at the same place.

c. Power supply

Current power supply capacity is 700kW in Godey town and power supply is limited to night time. Ethiopia electrical company is preceding power line project and it is under construction. This on-going project needs at least 1 year up to completion as of March 2013. It is risky to rely on uncertain power source at this moment and a power supply plan is formulated accordingly. Therefore a generator is used as power source in the study.

d. Purification plant

It is the point to consider for the purification plant planning in Godey town that electricity is not stable. The existing purification plant does not rely on commercial electricity to flow purified water. As a result, they use elevation difference and flow water by gravity. The same concept is applied to the purification plant plan in the study. One hill stands and it is the highest point in the site. The purification plant is planned to use slope elevation difference, purify raw water, and flow by gravity.

The water purification facilities consist of sedimentation tank, rough filter, and slow sand filter, and treated water reservoir.

Slow sand filter is planned to improve water quality and satisfy the condition that turbidity is below the standard value. Normally, slow sand filter is not recommended intermittent operation and is planned with 24-hour operation as a precondition. However, it is quite difficult to establish 24-hour operation system by supplying planned hourly water supply volume under the current Godey town's electricity situation. One pump is operated for night time 14 hours in order to maintain biofilm activity ate the slow sand filter surface. It shall be necessary to conduct sufficient management of the slow sand filters in night time because the existing water purification facilities are only operated in day time. Besides, too vast area is required for slow sand filter system in comparison with rough filter system. It shall be also necessary to conduct manual maintenance works for all filters. Operation and maintenance works are largely affected to slow sand filter's operation at this moment. Therefore, it shall be necessary to establish and strengthen operation and maintenance organization. It is quite difficult to conduct effective slow sand filter operation if their capacity will not be improved. General layout of the water purification facilities is shown in Figure 6.5.

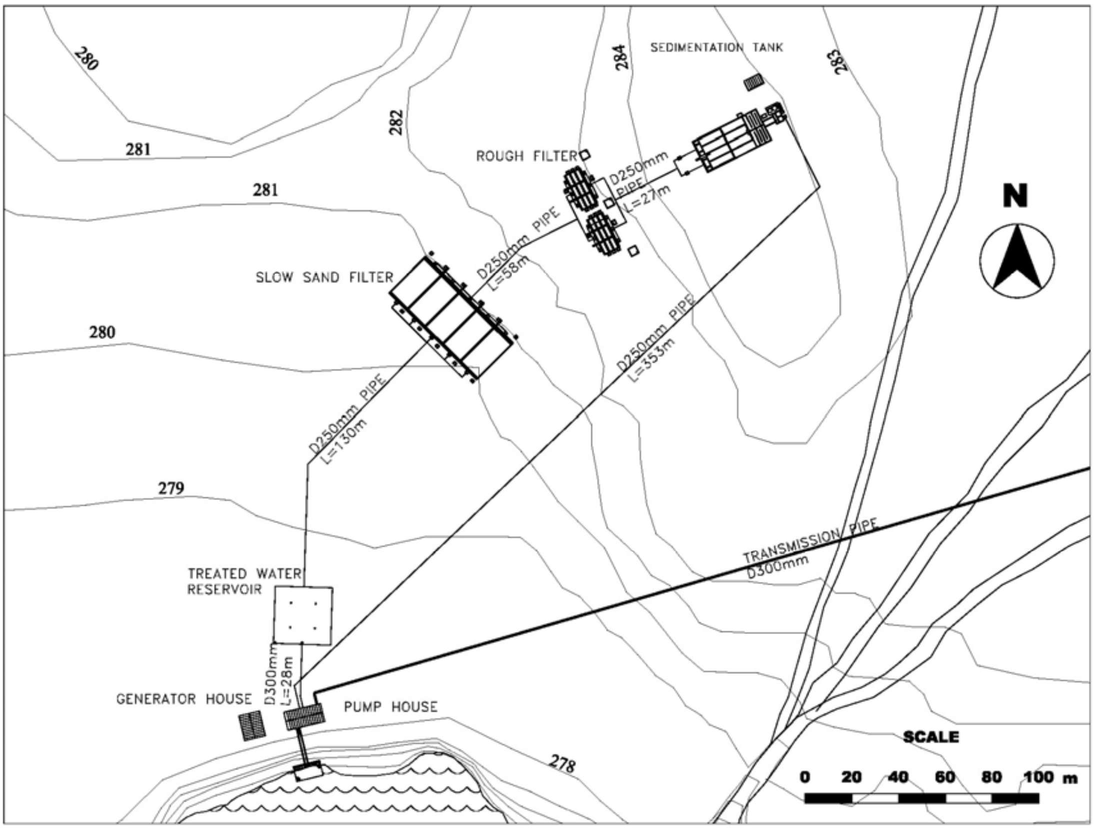


Figure 6.5: General Layout of the Water Purification Facilities

The topographic map of the water purification plant site was prepared based on the existing data. The topographic survey shall be conducted before detailed design works and it shall be necessary to confirm the actual topographic elevations. Afterward, location of planned each water purification facility shall be reviewed and it is necessary to discuss the facilities' location plan again.

e. Transmission pipeline

The pipeline route is planned along the existing roads as the first priority because this will result in no land acquisition issues arising. Secondly, the route is planned to be as short a distance as possible. Thirdly, the route is along road in consideration with the ease of construction.

The transmission pipeline extends from the surface pump station to eastern direction and passes through north side of the Christian compound. When the pipeline meets the peripheral trunk road of the town, it turns to left direction. It is installed along this road and runs the peripheral area of the town, then reaches to the reservoir. Total length is 4,998m (Refer to Figure 6.6).

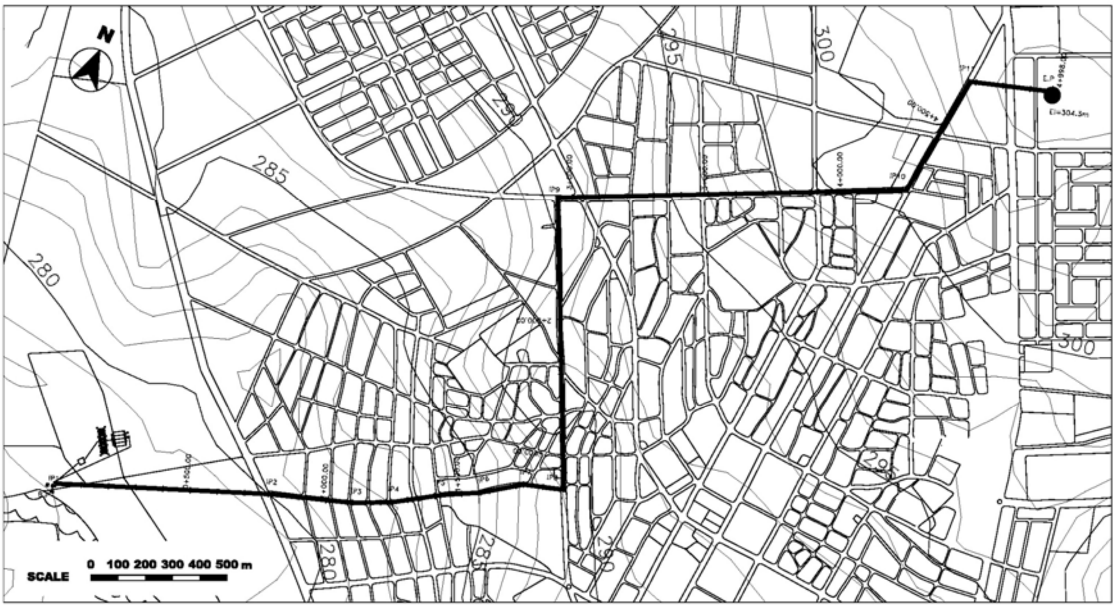


Figure 6.6: Transmission Pipeline Route

The topographic map of the transmission pipeline route was formulated based on the existing data and it was not the topographic survey result. Topographic profile was not prepared by the Study. The topographic survey shall be conducted before the detailed design work and the transmission pipeline route profile shall be confirmed. Afterward, air valve shall be arranged at high elevation point and drain valve shall be arranged at lowland.

f. Reservoir

Though the new reservoir will be planned at the highest elevation point in the town, there is no clear height difference with surrounding area. Thus, the new reservoir is planned to be elevated type

g. Distribution pipeline system

The existing distribution pipelines have been already deteriorated and do not function well. The distribution pipelines are planned to replace the existing ones and expand the distribution area. Particularly, there is no distribution pipeline system in western side of the town. The water supply plan provides distribution pipelines in this area. Besides, 5 public taps constructed by the JICA Study are located surrounding Godey town. There is no pipeline close to them. New distribution pipeline extends to each public tap and connects to them. Water can flow to each public tap after connection to the distribution pipeline.

Generally, topography in Godey town increases the elevation from south to north direction. Water stored at the new reservoir is distributed to 2 directions. One is transmitted water for the existing reservoir and the other is distributed water for higher elevation area in the town. Boundary of the water supply area is set at elevation 293m. Water stored at the existing reservoir is supplied for less than 293m elevation area. Valves shall be provided at distribution pipes and distribution areas will be separated. Each distribution area will be independent area and can secure water pressure. Distribution pipeline layout and water supply area by each reservoir is shown in Figure 6.7.

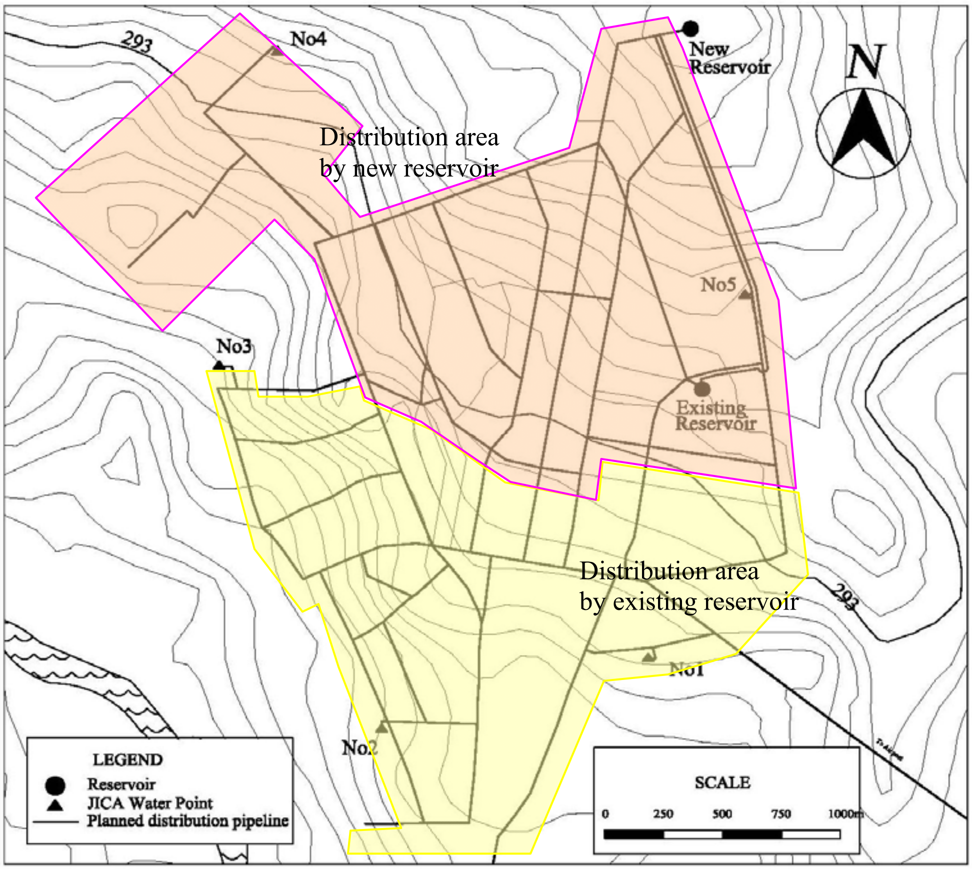


Figure 6.7: Distribution Area by Each Reservoir

h. Public tap

Public tap design is modified from the pilot project, it does not provide water tank because water can reach to each public tap 24 hours from the distribution pipe.

i. Cattle trough

Cattle trough design is the revised one applied to the pilot project. It is provided with public tap.

6.3 General design

All the design works are illustrated in Figure 6.4.

a. Water intake

a.1 Stone pitching

It is provided around the intake canal inlet. Dimensions are 12.6m in length and 5.0m in width. Stone thickness is 0.5m. The site is in wet condition all the time, water diversion must be necessary for the work.

a.2 Retaining wall

The retaining wall is made of stone masonry. It is planned at a length of 5m for both sides of the intake canal. The height is 4.5m up to the ground level, whole slope section can be protected.

a.3 Inlet canal

Concrete open channel is designed. Dimensions are 20m in length, 2m in width, and 0.5m in height. Slope is protected by stone masonry with 4.2 m height. Steel screen is provided at the both ends of canal to protect from solid waste entering into the settling basin. Further, stop log is provided in front of the screen.

a.4 Settling basin

It is provided under the intake pump station. River water flows into the chamber part that is 5.7m in length, 1.5m in width, and 5.35m in height. Base slab elevation is 0.5m lower than the inlet canal to store river water constantly.

b. Pump station

Two pumps are designed to supply water and one additional pump is provided as stand-by. Three pumps are installed as the intake pump and surface pump. Daily pump operation period of the surface pump is set to 10 hours to follow the water supply master plan. The intake pump is set to 24 hours operation in order to activate the slow sand filter. One pump is operated for 14 hours in night time while the surface pump is not operated aiming to maintain biofilm activity at the slow sand filter. Table 6.9 shows the specifications of each pump.

Table 6.9: Intake and Surface Pump Specifications

Item	Unit	Intake pump	Surface pump
Flow rate	m^3/min	1.1	1.9
Total head	m	15	54
Motor output	kW	4	25
Pump rotation No.	rpm	1500	3000
Quantity	No.	3	3

c. Power supply

It is calculated using the equation in the section 3.5.1 a.3. Calculation results are as follows:

(1) One intake pump

$$R = \frac{0.163 \times 1.1 \times 15}{0.67} \times 1.1 \times 3 = 13.2 \approx 14$$

14 kW×1.2 = 16.8≈17 kVA

(2) One surface pump

$$R = \frac{0.163 \times 2.1 \times 59}{0.73} \times 1.1 \times 3 = 82.6 \approx 83$$

83×1.2 = 99.6 kVA ≈ 100kVA

Total output is 120 kVA ≈ 117 kVA = 17 kVA+ 100 kVA

The water supply system is operated 2 pumps, 2 sets of 120kVA generator are necessary as the power source. One generator is added as back up and total generator is 3 sets.

d. Purification plant

d.1 Receiving well

It consists of three chambers. Water pressure is released at the inlet chamber. When water flows into the outlet chamber, flow rate can be measured by weir. At the outlet chamber, coagulation and alkalinity liquids are dosed. It has $5m^3$ and $3m^3$ chemical dosing tanks.

d.2 Flocculation basin

Raw water is rapidly mixed with coagulant through the connection canal (length 5.0m ×width 2.25m ×height 0.8m) and is further mixed slowly with coagulant at the flocculation basin. Horizontal flow flocculation basin is adopted. Specifications are length 28.0m ×width 1.0m ×height 2.5m and retention time is around 26 minutes.

d.3 Sedimentation tank

Sedimentation tank is designed to follow "Surface Water Treatment by Roughing Filters" which was issued by Swiss Centre for Development Cooperation in Technology and Management. Design criteria and applied figures to design sedimentation tank is summarized in Table 6.10.

Table 6.10: Sedimentation Tank Design Criteria and Applied Figures

No.	Item	Equation	Unit	Design criteria	Applied figure
1	Length and Width ratio	L:W		3:1~8:1	3:1
2	Tank height	H	m	1.0~1.5	1.5
3	Surface loading	Q/(LW)	m/hr	0.2-1.0	0.45
4	Detention time	(LWH)/Q	hr	1.0-3.0	3.3

Relation between the number of tank and its performance is summarized in Table 6.11.

Table 6.11: Relation between Number of Tanks and Performance

No. Of ponds	W (m)	L (m)	H (m)	So (m^2/hr.)	T (hr.)	Selected
1	7	21	1.50	0.45	3.3	○
2	5	15	1.50	0.59	2.6	
3	5	15	1.50	0.44	3.4	
4	4	12	1.50	0.54	2.8	
5	4	12	1.50	0.46	3.3	

There is no remarkable decrease in tank dimensions after decision of the two tanks installation. It is less merit to have many tanks. Operation and maintenance works are easier if the number of tank is fewer. In addition, the largest scale pond is not so different from the existing tanks (25m in length, 4.5m in width, and 2.4m in height). Thus, one sedimentation tank with 21m in length, 7m in width, and 1.5m in height is selected from Table 6.11. One additional tank is planned as a stand-by used during tank maintenance time. Two sedimentation tanks are designed in total.

d.4 Rough filter

Rough filter has two types; vertical type and horizontal type. Alternative filter type review study is conducted to select the planned type. Study results are summarized in Table 6.12.

Table 6.12: Alternative Study of Rough Filter Selection

No.	Item	Vertical filter	Horizontal filter
1	Dimension	6m x5m x 1.0m	7m x 6m x 1.2m
2	Applied turbidity	50-150 NTU	5000-1000 NTU
3	Filtration rate	0.3~1.0m/hr	0.3~1.5m/hr
4	Required filter area	132~400m^2	88~440m^2
5	Filtered area	30.0m^2	7.2m^2
6	Required filter numbers	> 5nos	> 13nos

Though horizontal filter can purify high turbidity water, it is rather than large scale to plan 14 filters. It is therefore that vertical filter is selected. Rough filter has one stand-by for maintenance. 6 rough filters (3 rough filters x 2 places) are designed in total.

d.5 Slow sand filter

According to “Manual of Design for Slow Sand Filtration” issued by AWWA Research Foundation, the dimensions are applied to maximum area 200m^2 and maximum thickness 1.0m, namely 20m x 10m x 1.0m. Required filter area is 660m^2 = 132m^3/hr. ÷ 0.2m/hr. and 4 filters ≈ 3.3 = 660m^2 ÷ 200m^2 must be necessary. One filter is added to substitute during maintenance work. 5 slow sand filters are planned in total.

d.6 Treated water reservoir

The design storage volume is decided to night time water volume, 924m^3 (= one intake pump 1.1m^3/min x 60min x 14hours). Effective volume is set to 1,037m^3 = 24m x 24m x 1.8m to satisfy the design volume.

e. Transmission pipeline

In order to decide the pipe diameter, hydraulic gradient is calculated applying to the William-Hazen formula.

$I = 10.666 \times C^{-1.85} \times D^{-4.85} \times Q^{1.85}$

Where;

C : Coefficient (110)

D : Pipe diameter (0.3m)

Q : Flow rate (3.8m^3/min = 0.06m^3/sec)

$I = 10.666 \times 110^{-1.85} \times 0.3^{-4.85} \times 0.06^{1.85} = 0.0034 \approx 0.34\%$

$H = 0.34\% \times 1000 = 3.4m$

Total head loss is 17m in the pipeline section. The surface pump design is included 17m head loss.

f. Reservoir

The reservoir volume calculation applies to the following equation, which is the same as the water supply master plan.

$V = 0.5 \times Q_d \times (1+10\%)$

Where;

Q_d : Average daily supply in 2020 (1,418m^3/day)

10% : Firefighting water demand

$V = 0.5 \times 1{,}418 \times (1+10\%) = 780m^3 \approx 800m^3$

The new elevated reservoir volume and height are designed to be 400m^3 and 10m.

g. Distribution pipeline system

Distribution pipe is applied to uPVC pipe. Each pipeline route is along the existing road to avoid unnecessary private land acquisition. Total pipeline length is 39.3km and each of them is summarized in Table 6.13.

h. Public tap

The number of planned public tap users will be 18,479 persons. A public tap is provided for 900 persons, 21 public taps ~ 20.5 = 18,479 persons ÷ 900 persons are planned.

i. Cattle trough

Livestock water demand is calculated to 20% of drinking water demands. The number of cattle troughs is also 20% of public tap numbers and is between 5 ~ 4.2 = 21 taps × 20%.

Summary of the Godey town water supply plan is shown in Table 6.13.

Table 6.13: Major Features of Godey Town Water Supply System General Design

No.	Item	Specifications	Unit	Q'ty
1.	Intake canal	L=20m, W=2m, H=0.5m	No.	1
2.	Intake pump	Q=1.1m^3/min, H=15 m	No.	3
3.	Sedimentation tank	L=21m, W=7m, H=1.5m	No.	2
4.	Rough filter	L=6m, W=5m, H=1m	No.	6
5.	Slow sand filter	L=20m, W=10m, H=1m	No.	5
6.	Treated water reservoir	V=1,000 m^3	No.	1
7.	Surface pump	Q=1.9m^3/min, H=59 m	No.	3
8.	Generator	120 kVA	No.	3
9.	Transmission pipeline	300 mm	m	4,998
10.	Elevated Reservoir	H=10m, V=400m^3	No.	1
11.	Distribution system			
11.1	Pipeline	63 mm	m	23,751
11.2		90 mm	m	7,218
11.3		110 mm	m	4,187
11.4		160 mm	m	1,884
11.5		200 mm	m	1,384
11.6		300 mm	m	2,797
11.7	Public tap		No.	21
11.8	Cattle trough		No.	5

6.4 Cost estimation

6.4.1 Composition of the project cost, method and condition for the cost estimation

a. Composition of the project cost

The project cost is estimated by the following component (refer to the following figure).

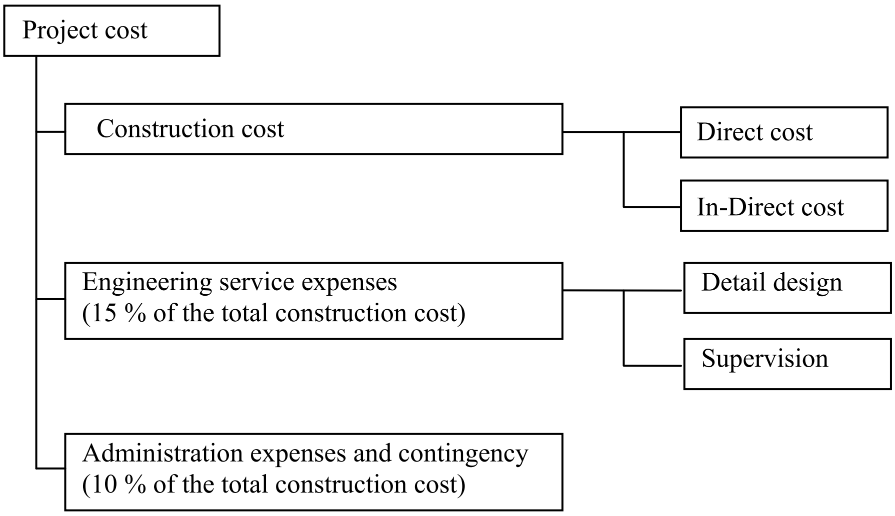


Figure 6.8: Component of the Project Cost

b. Method for the cost estimation

b.1 Construction cost

Construction cost is mainly classified direct cost and in-direct cost.

Direct cost means that the cost is needed directly for the construction objects. Direct cost is estimated by multiplying the quantity of the each construction works calculated based on the design by the unit cost of each construction works. Then direct cost is estimated by totaling each estimated cost of construction works. The unit cost of each construction works is estimated based on the pilot project of water supply construction and quotation from local construction company. The unit cost of piping works differ from the type of pipes. Pipe and fittings that will be used for structure part of intake, purification and transmission facilities and pipe that diameter is more than D200, are considered as important facilities. Therefore pipes that have superior intensity and durability such as ductile iron pipe (DIP) and stainless steel pipe are assumed as a pipe type for these important facilities. Unplasticized polyvinyl chloride pipe (uPVC pipe) and galvanized iron pipe (GI pipe) which are manufactured in Ethiopia, are selected as a pipe type.

In-direct cost is mainly classified as common temporary construction costs, field office expenses and general management cost. In-direct cost is not directly related to work performance amount of the construction objects. In-direct cost is the cost that will be used commonly for construction works. In-direct cost is estimated based on the cost estimation standard book that is published by Japan small scale water works association. Calculation formula of in-direct cost is shown as below.

In-direct cost = Common temporary construction cost (C) +Field office expenses (F)
+General management cost (G)

Common temporary construction cost (C) = Direct cost (D) * ratio of C
Ratio of C (%) = 485.4*D^ (-0.2231) + 1.0

Field office expenses (F) = (D+C) * ratio of F
Ratio of F (%) = 103.1*(D+T) ^ (-0.0977) + 0.5

General management cost (G) = (D+C+F) * ratio of G
Ratio of G (%) = -2.57651*Log (D+C+F) + 0.3163531

b.2 Engineering service expenses

Engineering service expenses are estimated uniformity as 15 % of the construction cost.

b.3 Administration expenses and contingency

Administration expenses and contingency are estimated uniformity as 10 % of the construction cost for expenses such as procedure of contract of design and construction works, consultation with the concerned parties, and contingency budget.

c. Condition for the cost estimation

- The project cost is not including value added tax (VAT) and land acquisition cost.
- The project cost is classified ETB and Foreign currency (USD).
- Time of the cost estimation is in May 2013.
- Price change (ETB and USD) of a period from the time of cost estimation to the commencement of design and a period from the time of cost estimation to the tender of construction of Godey town water supply plan is taken into consideration for annual cost estimation of the project of Godey town water supply plan (the project of Godey town).
- Exchange rate of local currency is USD1.00 = 18.53 ETB by the average of control rate from November 1, 2012 to April 30, 2013.
- Engineering service and the construction are assumed to be implemented by the Ethiopia local company.

6.4.2 Cost estimation

The project cost of Godey town water supply plan is estimated as following Table 6.14.

Table 6.14: The Estimated Project Cost of Godey Town Water Supply Plan

(Unit:USD)

Item	cost	Foreign Component	Foreign	Local
1. Construction cost				
1.1 Direct cost				
(1) Riverbed protection	5,500	40%	2,200	3,300
(2) Intake canal	37,500	40%	15,000	22,500
(3) Settling basin	26,300	40%	10,520	15,780
(4) Pump house				
1) Pump house	37,700	40%	15,080	22,620
2) Pump, pipe, fittings	245,900	97%	238,523	7,377
(5) Generator house				
1) Generator house	29,200	40%	11,680	17,520
2) Generator and fittings	72,800	97%	70,616	2,184
(6) Sedimentation pond				
1) Civil works	135,300	40%	54,120	81,180
2) Pipe and fittings	62,500	97%	60,625	1,875
(7) Rough filter				
1) Civil works	166,200	40%	66,480	99,720
2) Pipe and fittings	157,400	97%	152,678	4,722
(8) Slow sand filter				
1) Civil works	320,100	40%	128,040	192,060
2) Pipe and fittings	119,000	97%	115,430	3,570
(9) Clear water reservoir				
1) Civil works	132,000	40%	52,800	79,200
2) Pipe and fittings	47,000	97%	45,590	1,410
(10) Transmission pipeline	1,429,600	70%	1,000,720	428,880
(11) Elevated reservoir				
1) Civil works	229,500	40%	91,800	137,700
2) Pipe and fittings	32,200	70%	22,540	9,660
(12) Distribution pipeline	1,660,700	70%	1,162,490	498,210
(13) Public tap	56,700	40%	22,680	34,020
(14) Cattle trough	13,500	40%	5,400	8,100
(15) Other	251,400	70%	175,980	75,420
sub-total	5,268,000		3,520,992	1,747,008
Average			67%	33%
1.2 In-direct cost				
	1,775,000	67%	1,189,250	585,750
Construction cost total	**7,043,000**		**4,710,000**	**2,333,000**
2. Engineering service (15% of construction cost, rounding up of the last three digits)				
	1,057,000	**67%**	**708,000**	**349,000**
3. Administration and Contingency (15% of construction cost, rounding up of the last three digits)				
	705,000	**67%**	**472,000**	**233,000**
Total cost	**8,805,000**		**5,890,000**	**2,915,000**

6.5 Implementation Plan

6.5.1 Contents of implemented project for each year

a. Implementation schedule

Implementation of the construction of water supply facilities is classified as mainly design stage (design, tender documents preparation, tender, contract with a construction company) and construction stage (implementation of the construction, trial operation of the facility, completion, supervising of the construction).

It is considered that design stage for the project of Godey town will take 16 months. Duration of the construction will differ depending on the formation of construction team. In this plan, it is assumed that one team is arranged for intake, purification and transmission facilities construction, two teams are arranged for distribution facility construction (including transmission pipe), one team is arranged for public taps and cattle trough construction, therefore the construction will be implemented by a total of four (4) teams. Under this construction team, implementation of the construction will take 26 months.

In the implementation of construction, procurement of materials and equipment that are needed for the construction, will be dominant critical for the implementation schedule and length of the implementation. Materials and equipment which it not manufactured in Ethiopia and not easy to procure in the Ethiopia local market such as ductile iron pipe (DIP) and steel use stainless (SUS) pipe, submersible and surface pump and generator must be procured from foreign countries, therefore it is considered to need time. Especially on the pipeline works of the project of Godey town, total pipeline is estimated more than 46 km, thus procurement of pipe materials will need time regardless of procurement in Ethiopia or from foreign countries. In addition to this, total main pipeline as important facilities is approximately 8 km and DIP will be used for this main pipeline. DIP is not manufactured in Ethiopia therefore it will be needed to be procured from foreign countries. Implementation schedule is considered taking into account procurement of these materials and equipment.

Implementation schedule is shown in the following Table 6.15.

Table 6.15: Implementation Schedule of Godey Town Water Supply Plan

Item		Month																																							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
1. Engineering service																																											
1.1 Design																																											
	a. Discussion of Design policy	■	■																																								
	b. Survey			■	■	■																																					
	c. Detail design of purification facility	■	■	■	■	■																																					
	d. Detail design of facilities						■	■	■	■	■																																
1.2 Preparation of tender documents												■	■																														
1.3 Tender																■																											
1.4 Contract with a local contractor																	■																										
1.5 Supervision of the construction																		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
2.Construction																																											
2.1 Preparation																		■	■	■																							
2.2 Intake・Purification・Transmission facilities	a. Survey																				■	■																					
	b. Intake facility construction																						■	■	■	■				■	■	■	■										
	c. Purification facility construction																										■	■	■					■	■	■	■	■	■	■			
	d. Transmission facility construction																						■	■	■	■				■	■	■	■										
	e. Pump/Generator procurement																						■	■	■	■	■	■															
	f. Pump/Generator install																												■	■	■												
	g. Pipe and fittings procurement in Ethiopia																						■	■	■	■																	
	h. Pipe and fittings procurement from foreign countries																						■	■	■	■	■	■															
2.3 Distribution facilities	a. Survey																				■	■																					
(including transmission pipe)	b. Facility construction																						■	■	■				■	■	■	■											
	c. Pipe and fittings procurement in Ethiopia																						■	■	■	■	■	■															
	d. Pipe and fittings procurement from foreign countries																						■	■	■	■	■	■															
	e. Pipe installation (procurement in Ethiopia)																										■	■	■	■	■	■	■	■	■	■	■	■	■	■			
	f. Pipe installation (procurement from foreign countries)																												■	■	■	■	■	■	■	■	■	■	■				
2.4 Public tap and cattle trough	a. Survey																				■	■																					
	b. Public tap construction																												■	■	■	■	■	■	■	■	■	■	■				
	c. Cattle trough construction																						■	■	■	■	■	■	■	■	■												
	d. Pipe and fittings procurement in Ethiopia																						■	■	■	■	■	■															
2.5 Experimental operation・Inspection																																									■	■	■
2.6 Completion																																											■

b. The project cost of Godey town for each year

b.1 Contents of the project and estimated project cost for each year

The project of Godey town is planned to implement a design in 2015 and a tender in 2016. After the tender, the construction starts, and will be completed in 2018. The project of Godey town will take 42 months from the design stage to the construction stage. Engineering service expenses, and Administration expenses and contingency are divided by 4 years. Construction cost is divided by 3 years. Estimated project cost for each year for the implementation of the project of Godey town is shown in the following Table 6.16.

Table 6.16: Estimated Project Cost of Godey Town for Each Year

(Unit:USD)

Western calendar (year)	2015	2016	2017	2018	Total
1.Construction cost		2,348,000	2,348,000	2,347,000	7,043,000
2.Engineering service expenses	264,000	264,000	264,000	265,000	1,057,000
3.Administration expenses and contingency	176,000	176,000	176,000	177,000	705,000
Total	440,000	2,788,000	2,788,000	2,789,000	8,805,000

b.2 Ratio of price change and the project cost including price change

b.2.1 Ratio of price change

Ratio of price change is estimated in Ethiopian local currency (ETB) and foreign currency (USD).

Ratio of price change in local currency (ETB) is estimated based on a consumer price index published by the Central Statistical Agency of Ethiopia (CSA). Ratio of price change in local currency (ETB) is estimated 11.3 % per year based on the consumer price index from January 2012 to March 2013.

Ratio of price change in foreign currency (USD) is estimated based on the projection of a consumer price index of Major advanced economies published by the International Monetary Fund (IMF). In the projection, 2013 is 1.6 % and 2014 is 2.0 %. Therefore based on this projection, ratio of price change is set as 1.8 % per year on average 2013 and 2014.

Detail of ratio of price change estimation is shown in the Appendix.

b.2.2 The project cost of Godey town including price change

Price change of the engineering service is taken into consideration of the period from May 2013 (time of the cost estimation) to estimated commencement of the design stage. And price change of the construction cost was taken into consideration from May 2013 to estimated date of tender for the construction (refer to Table 6.17 below).

Table 6.17: Number of Months for Price Change Consideration

Time of the cost estimation	Estimated date of commencement of design stage	Estimated date of tender for the construction
May, 2013	January, 2015	March, 2016
Number of months	20 months	34 months

Table 6.18: The Project Cost for Each Year including Price Change

(Unit:USD)

Western calendar (year)	2015	2016	2017	2018	Total including price change	Total not including price change
1.Construction cost		2,680,000	2,680,000	2,669,000	8,029,000	7,043,000
Foreign		1,650,000	1,650,000	1,650,000	4,950,000	4,710,000
Local		1,030,000	1,030,000	1,019,000	3,079,000	2,333,000
2.Engineering service expenses	282,000	282,000	282,000	297,000	1,143,000	1,057,000
Foreign	182,000	182,000	182,000	183,000	729,000	708,000
Local	100,000	100,000	100,000	114,000	414,000	349,000
3.Administration expenses and contingency	192,000	192,000	192,000	186,000	762,000	705,000
Foreign	122,000	122,000	122,000	120,000	486,000	472,000
Local	70,000	70,000	70,000	66,000	276,000	233,000
Total	474,000	3,154,000	3,154,000	3,152,000	9,934,000	8,805,000

6.5.2 Budgeting schedule

Table 6.19 shows a budget and annual work/action plan of SRWDB for 2004 Ethiopian Fiscal year (EFY) (July 2011 ~ June 2012), and Table 6.20 shows a budget and annual work/action plan of SRWDB for 2005 EFY (July 2012 ~ June 2013). According to these budgets, it is estimated that approximately 3,640,000 USD is annual budget of SRWDB. Approximately 3,000,000 USD out of annual budget of SRWDB is allocated by assistance from donors such as the African Development Bank (AfDB), the World Bank (WB) and the Department for International Development (DFID). In addition to this, it is also confirmed by SRWDB that some amount of budget for construction of birkas targeted Woreda level is prepared not as a budget of SRWDB. The annual budget (July 2011 ~ June 2012) of this budget for birka is estimated approximately 1,350,000 USD for 15 target woredas of the project.

Table 6.19: Budget and Annual Work/Action Plan of SRWDB for 2004 EFY

	Project name	Budget (ETB)	Convert ETB into USD
1	Government Capital Budget		
1.1	On-going Project	3,500,000	
1.2	New Project	2,000,000	
	Sub - total	5,500,000	297,000
2	WASH Program		
2.1	Extension granted town finance implementation program	29,556,553.78	
2.2	AfDB financing projects	3,200,000	
2.3	WB-DFID assisted program	16,811,468	
2.4	UNICEF support program	242,512	
2.5	Pastoral community & development project (PCDP)	4,750,000	
2.6	Water Section Sedentarization Program	7,500,000	
	Sub - total	62,060,533.78	3,349,000
Total		67,560,533.61	3,646,000

Source: SRWDB

Table 6.20: Budget and Annual Work/Action Plan of SRWDB for 2005 EFY

	Project name	Budget (ETB)	Convert ETB into USD
1	Government Capital Budget		
1.1	On-going Project	7,319,205	
1.2	New Project	7,900,000	
	Sub-total	15,219,205	821,000
2	WASH Program		
2.1	AfDB financing projects	25,579,175	
2.2	WB-DFID assisted program	21,181,375	
2.3	Pastoral community & development project (PCDP)	5,533,333	
	Sub-total	52,293,883.43	2,822,000
Total		67,513,088.43	3,643,000

Source: SRWDB

Project cost of Godey town water supply plan is estimated approximately 3,150,000 USD in each year from 2016 to 2018 as shown in Table 6.18. On the other hand, annual budget of SRWDB for Somali region is approximately 3,640,000 USD as mentioned already. If all annual budget of SRWDB was allocated for the project of Godey town, it is possible to be covered by the Godey town budget. However in reality, it will be difficult to implement the project of Godey town only by the annual budget of SRWDB.

In order to secure of the budget for the implementation of the project of Godey town, two means are considered: one is to recover the cost of the project of Godey town from the income of water tariff in the operation of new facility, another is to secure budget as the aid from donors etc.

Regarding the cost recovery, it will be difficult to finance the fund that should be secured after paying for the operation and maintenance cost of the facility from the income of water tariff, which is set as taking into consideration of affordability of residents and social condition in Godey town (detail of social condition is refer to “Feasibility Study Godey Town”). Therefore, as realistic means, it is preferable to secure the budget from the aid of donors for the implementation of the project of Godey town. In addition to this, although it is difficult to secure all of budget for the project of Godey town by SRWDB itself, it is desirable that some amount of budget is prepared by SRWDB and rest of budget is prepared by donors, etc.

6.6 O&M and management plan of designed facilities

In this section, the results of the study of operation and maintenance work and personnel required for each of the proposed water supply systems of the master plan are presented based on the examination of the proposed facilities in the systems. The proposal is at the master plan level. In addition, the cost of the proposed operation and maintenance plan of the water supply systems based on the details of the facilities and the implementation plan have been estimated. The detailed data used to calculate the cost is attached in the Data Book in a separate volume.

6.6.1 Proposed systems and required O&M work and cost

a. Conditions of planning and cost estimation

The operation and maintenance plan for the proposed water supply systems have been prepared in consideration of the following conditions.

- Specific O&M work corresponding to the specifications, size, and level of technology employed of the proposed facilities was proposed.

- To realize appropriate O&M work in future, it is a prerequisite to improve the existing organizations and staff concerned with operation and maintenance of water supply facilities. Thus, in every types of work the operators do, they were designed to work as a group and a leader was assigned and provision of appropriate training was planned especially for the leader. Such member with sufficient qualification can probably be newly recruited from outside and their employment condition should also be improved.

- In order to supply materials and equipment necessary in operation and maintenance work, SRWDB is expected to procure such items according to the schedule and deliver them to site on time. Especially, the master plan requires the use of a large amount of chlorination chemicals to disinfect water for all the target woredas. Therefore, SRWDB should buy a large amount of the chemical in Addis Ababa and distribute them to each woreda.

The cost of implementation of the proposed operation and maintenance plan was calculated in consideration of the following conditions.

- The O&M cost covers both the newly planned facilities and the existing facilities for all woredas and towns.

- The cost of O&M of the terminal water supply facilities such as public water supply points that are normally operated and maintained by WASHCO was not included because WASHCO is solely responsible for it.

- Staff assignment at each facility is in principle based on the existing operation of the same facility to propose realistic number of people required.

- The annual O&M cost is calculated as an annual average of 10 year operation. Thus, the cost that occurs every few years was distributed over the 10 years.

- The cost of replacing over used equipment is separately calculated for corresponding years.

- The cost does not consider accidental expanses but only regular expenses.

b. Target of O&M plan and details of the plan and cost

The basic information of the planned water supply system in Godey town and basic approaches of determining the type of work and assignment of staff required for the system is concisely described in Table 6.22 and Table 6.23. The type of work and number of staff members required for each of the component facilities of the water supply system are also shown in more detail in Table 6.24 to Table 6.26. The cost of O&M for the system was calculated based on the data following the cost items below.

1) Personnel (stationed field staff directly involved in O&M of the facilities and day workers)
2) Materials (tools, materials and equipment necessary for O&M)
3) Fuel and electricity (Fuel for generators and electricity bill for pumps)
4) Chemicals (chlorine for household use, and treatment chemicals for the plant)
5) Spare parts (consumables and spare parts for generators and pumps)

In the cost estimation, actual price data was used as much as possible to make the values realistic. However, the amount of chemicals, whose cost has a great impact in the total O&M cost, should be verified at the time of the training after the detailed design. Then the O&M cost should be reviewed along with the other costs and revised accordingly. As for the fuel and electricity cost, the use of commercial electric supply was either unconfirmed or instable except in Kabribeyah town. Thus, the power supply was planned with generators in all areas other than Kabribeyah town.

c. Godey Town

c.1 Work required and staff assignment

The staff engaged in the operation and maintenance of the water supply system is divided into stationed field staff and non-stationed temporary staff. The former regularly operates the facilities in charge and the latter is involved mainly in maintenance work when it is necessary. For the operators, as stationed filed staff, who mainly deals with O&M work, the study team has proposed to newly assign a leader of operators to supervise them at each facility. These leaders are named technicians. Such members can be recruited from outside and should have at least TVETC level educational background. Also, once employed, appropriate technical training should be given from the stage of construction of the facilities. The operation of the new system in Godey town involves input of water treatment chemicals such as coagulant and pH adjusting agent that the staff is not familiar with. The daily dose of these chemicals should be determined based on a simple lab test and the dose should be adjusted according to the flow conditions. One of the main tasks for the technician is to supervise this work. The treatment of turbid water involves a large amount of chemicals and thus, some assistant should assist the operators. Also, one laboratory technician is assigned to engage in daily checking of water quality and lab testing of water to determine the dosage of the chemicals.

As the O&M plan, the tasks required and assigned staff for the set of facilities constituting the water supply system that will be managed by the town water supply utility office are presented in Table 6.24 to Table 6.26. The conditions of the work planning at each facility are presented in Table 6.22 and Table 6.23. Based on this detailed O&M plan, the total number of staff required to operate the water supply system in Godey town was determined as in Table 6.21 below. The numbers of current staff members assigned are also shown as a reference.

Table 6.21: Total Number of Staff Required for Operation of Planned System in Godey Town

<table>
<tr><th rowspan="2">Facility cluster</th><th colspan="5">Stationed field staff</th><th colspan="2">Temporary staff</th></tr>
<tr><th>Technician</th><th>Operator</th><th>Assistant. Operator</th><th>Lab. Technician</th><th>Guard</th><th>Day worker (man-day /year)</th><th>WD staff (man-day /year)</th></tr>
<tr><td>Intake, Pump st., Generator house, Sedimentation tank, Rough filter, Slow filter (Fac. 1-6)</td><td rowspan="3">5 [2]</td><td>6 [2]</td><td>3 [0]</td><td>0 [0]</td><td>18 [6]</td><td>4950[4580]</td><td>8</td></tr>
<tr><td>Treated water reservoir (Fac. 7)</td><td>2 [0]</td><td>2 [0]</td><td>2 [0]</td><td>3 [1]</td><td>20 [216]</td><td>0</td></tr>
<tr><td>Distribution reservoir (Fac.8,9)</td><td>3 [0]</td><td>0 [0]</td><td>0 [0]</td><td>6 [0]</td><td>21 [96]</td><td>0</td></tr>
<tr><td>Back up distribution reservoir (Fac. 10)</td><td>0 [0]</td><td>0 [0]</td><td>0 [0]</td><td>0 [0]</td><td>[NA]</td><td>0 [NA]</td><td>0</td></tr>
<tr><td>Transmission and distribution pipeline system (Fac. 11)</td><td>0 [0]</td><td>0 [0]</td><td>0 [0]</td><td>0 [0]</td><td>[NA]</td><td>200 [NA]</td><td>60</td></tr>
<tr><td>Sub-total</td><td>5 [2]</td><td>11 [2]</td><td>5 [0]</td><td>2 [0]</td><td>27 [7]</td><td rowspan="2">5191 [4892]</td><td rowspan="2">68</td></tr>
<tr><td>Total</td><td colspan="5">50 [15]</td></tr>
</table>

Note: the numbers under the header “Facility cluster” signify the facility number in Table 6.24 to Table 6.26.
The numbers shown signify the total number of field staff to be employed under the system of working in shift.
The shaded entries are temporary staff members from water desk (WD) and not calculated in the O&M cost.
The numbers in brackets “[ ]” signify the total number of current staff employed.

Although, the basic procedure of water treatment and distribution in the system will be similar to the existing one after the completion of the project, the operation is not currently properly done and the size of the system will increase. In the O&M plan, the task of input of water treatment chemicals and removal of sludge from the sedimentation tank should be properly conducted. For this reason, the numbers of technicians and operators have been increased. Also, new positions of assistant operator and lab technician have been created to support the operator’s work that is expected to be more complex and labor intensive at the same time. On the other hand, the number of day workers required increased only a little due to improved efficiency of the proposed system. The technical staffs (engineers and plumbers) of Water Desk as temporary staff mainly engage in the maintenance of distribution pipelines for 68 man-day.

c.2 Estimated cost

In Godey town, as explained in the section of water supply planning, almost entire system will be newly constructed. However, the small existing facilities that will be continued to be used were also considered together to conduct the cost estimation. It was assumed that the existing system will be properly managed and maintained until 2020 and that the old equipment will be all replaced at the beginning of 2020, the target year of the master plan. Namely the system was assumed to be fully functional at the start of the year 2020. As for the personnel cost, only the stationed field staff and day workers were calculated but not the temporary staff from water desk (town water supply utility office) of the shaded columns in

Table 6.24 to Table 6.26.

The O&M cost of the system was calculated accordingly using the current price and is presented in Table 6.27. The calculated annual O&M cost is 3,929,000 Birr in 2013 price and it is equivalent to about US$ 212,000. Approximately 60% of the total O&M cost is the fuel cost, which is followed by chemical cost and personnel cost of about 20%.

6.6.2 Points of consideration in project implementation

It is highly important that all the organizations concerned with water supply play their roles properly in order to realize appropriate O&M of the water supply facilities that are completed. In the previous section of O&M planning and cost estimation, only the work and cost that are directly required to operate and maintain the facilities planned in the master plan were considered. However, the organizations and work that are indirectly involved in the O&M of the facilities are important as well and should also be considered.

In this sense, SRWDB plays a special and significant role in managing the water supply in the region as a responsible agency in water supply issues. The bureau should take care of the issues that woreda water supply utility office or town water supply utility office cannot cope with. SRWDB should also deal with tasks that the government offices at woreda or town level cannot handle or those that would be highly inefficient if handled by these offices. For example, procurement of a large amount of water treatment chemicals or spare parts for equipment from Addis Ababa and their distribution to woredas should be their duty. It was assumed that the cost of the water treatment chemicals itself should be recovered form the water supply utility offices of woreda or town level and eventually through WASHCO. The money is naturally raised by running the system in the woredas and towns. However, the other associated costs should be shouldered by SRWDB.

Also, at woreda level, when materials have to be transported to sites or when there is an issue that the operators at the site cannot handle, technical staff members of woreda water supply utility office are expected to attend to the site immediately. In such cases, it is necessary for woreda water supply utility offices to have a means of transportation such as a motor cycle.

On the other hand, WASHCO, the terminal group of residents that was not considered in O&M planning and cost estimation, plays an important role in the O&M of water supply systems. In that, the group should be responsible for proper management of the terminal water supply facilities and should make sure that the money is duly collected from the users. The money so collected should be, then, used for O&M activities or be handed over to the water supply utility office in charge. These are the main duties of WASHCO in O&M of water supply facilities. However, the current WASHCOs are not yet existent and even where they exist, their capacity is far from satisfactory. Therefore, appropriate technical training should be provided to raise their motivation and work skills.

As will be described in the following sections, various training will be required for the organizations mentioned above in order to realize proper operation of maintenance of the water supply systems/facilities after their completion. Since the cost of the training is not included in the O&M cost calculated earlier, the government of Somali Region should secure the budget for the training at any cost and conduct the training. SRWDB is the organization that should take on this responsibility to conduct the training on time. It is expected to allocate its own budget to implement the training or to win assistance from external aid organizations such as NGOs to make it possible.

Table 6.22: Policy of O&M of the Facilities in Godey Town (1)

1 Basic conditions	Water supply amount: 2,212 m^3/day (maximum value including 30% leakage loss) Pump operation: 24 hours/day Facilities and equipment: Intake pump x 2 (driven by two 120kVA generators) Distribution pump x 2 (driven by two 120kVA generators) Sedimentation pond, Rough filter, Slow sand filter, Clear water reservoir, Elevated water tanks
2 Staff assignment	The assignment of staff was proposed based on the staff assignment at existing facilities and their work status. It also took into account the size and required work at the planned facilities as follows. Some operators should have some basic theoretical knowledge on their work and leadership skills. One person who has at least TVETC level education as a leader (technician) of operator is assigned. Technically more intricate work such as determination of chemical dosage and high level maintenance of work will be assisted by an engineer from the town water supply utility office as required. One lab technician is assigned to conduct water tests to determine appropriate dose of water treatment chemicals. The staff should avoid excessive over work and their assignment was proposed to realize average 8 hour/day work by working in shifts. The staff assignment was proposed to minimize interruption of water supply even when maintenance such as tank cleaning is conducted.
3 Generator fuel and commercial electricity	The fuel efficiency of the existing generators is reported to be 5 to 6 L/h and that of the new ones procured in the pilot project was measured to be 4 to 5L/h. Thus the value of 5L/h was adopted for the generator of same size. For others, figures (70% load) from product catalogues were used. - The operation of one intake pump is continuous 10 hours and second 24 hours - Diesel fuel is available in Godey town
4 Water treatment chemicals	In Godey town water supply system, coagulant, pH adjuster, and chlorine disinfectant are used. Calcium hypochlorite is easy to handle and relatively safe and also it lasts longer in storage. Thus, calcium hypochlorite powder is used as a disinfectant. It is available in Addis Ababa. The dosage will have to be determined based on the test at site but it is assumed to be 3mg/L Aluminum sulfate powder, easy to procure in Ethiopia, is used as coagulant. The dosage will have to be determined based on the jar test at the site every day. It was however, assumed to be 100mg/L based on data from several water treatment plants including AAWSA, Ethiopia. In order to adjust pH of water after input of aluminum sulfate, lime (Calcium hydroxide) will be added. The dosage is assumed to be 40mg/L Note that sufficient training should be given to the staff who deal with the chemicals.

Table 6.23: Policy of O&M of the Facilities in Godey Town (2)

5 Spare parts for equipment	In consideration of the fact that the existing equipment mostly breaks down in around 3 years, and the maintenance capacity will also be improved, the realistic life of equipment and frequency of parts replacement was set as follows: Ground pump: 5 years, Generator: 7 years The following spare parts for generator were assumed Engine oil（every 6 months） Fuel filter（every 6 months） Oil filter（every 6 months） Air cleaner（every 6 months） Fan belt（once every 2 years） Assumed spare parts for ground pump are as follows: Gland packing (once a year) Mechanical seal (once a year) Bearing (once every 3 years)
6 Large equipment	They are replaced right after their estimated life years are reached starting from 2020. The large equipment will be procured with assistance from donors and thus free from customs tax. <u>This cost is not included in the regular O&M but separately handled</u>
7 Cleaning of reservoir tanks	In consideration of power supply conditions at site and difficulty in maintenance of the associated small equipment, the cleaning work should be conducted all manually. The assignment of works was determined based on the existing conditions and the size of the planned facilities. Daily workers are employed to work under the supervision of the operator. Actual facilities to be cleaned are shown in another table and the following tools may be used. Shovel, deck brush, scraper (made from iron pipe), dewatering pump, bucket, soil carrier
8 Sludge removal in slow sand filtration pond	The condition of the filter layer in the slow sand filtration pond should be maintained through adjusting in response to the surrounding environment in order to assure the best performance. Since the work is highly technical and requires experience, the work will be done under the supervision of 2 technicians who have received necessary training. The technicians will instruct the operators and day workers. The work is done all manually.
9 Other maintenance work	The short pipes and valves attached to the ground pumps are taken apart and the accumulated scale is removed carefully.

Table 6.24: Regular Operation and Maintenance Activities for Each Set of Planned Facilities in Godey Town (1)

Facility	Spec/Capacity (Dimension)	Detailed O&M tasks	Frequency (duration)	No. of Staff assigned (Work shift)	Remark
1. Intake canal	Concrete channel with 2 screens (W: 2 m, Depth: 5.5 m) L = 16 m)	1) Sludge removal	1 time / year (6 hours)	1 technician 1 operator 20 daily workers	Cleaning of the channel is only done at the peak of dry season.
		2) Screen cleaning	4 times / month (2 hours each)	1 technician 1 operator 2 daily workers	Large debris stuck in the screen is removed
Settling basin	$V = 46m^3$ 1.5m x5.7m x 5.4m Including the receiving well	3) Sludge and garbage removal	4 times/year (4 hours each)	1 technician 1 operator 4 daily workers	The bottom of the chamber is roughly cleaned Intake filter cleaning
2. Pump house	2 intake pumps (Q =66 m^3 /h, H = 15m) x 2 pump 2 surface distribution pumps (Q =114 m^3/h, H = 59)x 2 pump	1) Pump switch on and off	2 times/day 8:00 - on 18:00 - off (15 min each)	2 Operators (4 in shift)	Design supply amount is 2212m^3/day. 24 hour continuous operation 2) Gland packing, mechanical seal, and bearing will be replaced.
		2) Pump spare parts replacement	1 time / year (1 day) x 4 pump 1 time / 3 years (1 day) x 4 pump	1 technician (5 in shift) 1 operator 2 plumbers 2 daily workers	
		3) General guarding	Every day (24 hrs)	1 guard (3 in shifts)	
3. Generator house	2 generators 120kVA x 2 generator 1 back-up generator	1) Generator operation	2 times/day 8:00 - on 18:00 - off (15 min each)	2 Operators (3 in shift)	One generator is standing by as a backup
		2) Spare parts replacement	2 times / year 1 time / year (2 hour) x 2 generators	1 technician 1 operator 1 daily workers	Engine oil, Oil filter, Air filter, Belt,
		3) General guarding	Every day (24 hrs)	1 guard (3 in shifts)	

Table 6.25: Regular Operation and Maintenance Activities for Each Set of Planned Facilities in Godey Town (2)

Facility	Spec/Capacity (Dimension)	Detailed O&M tasks	Frequency (duration)	No. of Staff assigned (Work shift)	Remark
4. Sedimentation pond	Sedimentation pond 2 ponds in parallel (21 x 7 x 1.5m) x 2 V= 220m^3 x 2 One pond for backup	1) Sludge removal	Dry: 1 time/ 6 months (2 days each) x 3 pond	1 technician (5 in shift) 1 operator (2 in shift) 15 daily workers	1 out of 2 ponds are regularly used Sludge removal is done for one pond at a time
			Rainy: 1 time/ 2 months (5 days each) x 3 ponds		
		2) Coagulant and lime dosing	1 time / day (60 min)	1 technician (5 in shift) 1 operator 2 assistant operator (3 in shift) 1 lab-technician (2 in shift)	
		3) Store room management	Every day	2 assistant operators	Handling of chemicals
		4) General guarding	Every day (24 hrs)	1 guard (3 in shifts)	Same as 3 – 3)
5. Rough filter	Q = 132 m^3/h (6 x 5 x 1 m) x 6 chambers with 1 for backup	1) Surface sludge removal	1 time / year (2 days) x 5 time	1 technician 1 operator 5 daily workers	5 out of 6 chambers are used regularly 1), 2) Cleaning is done for 1 chambers at a time
		2) Filter cleaning	1 time / 2 years (5 days) x 5 times		
		3) General guarding	Every day (24 hrs)	2 guards (3 in shifts)	
6. Slow sand filtration pond	One sand filter system Q = 132 m^3/h (20 x 10 x 1 m) x 5 chambers with 1 for backup	1) Surface sludge removal, conditioning of the filter layer	6 time / year (2 days) x 5 time	2 technician 2 operator 20 daily workers	Out of 5 chambers, 4 will be regularly used. One is for backup. 1), 2) the cleaning is done for 1 chamber as a unit. This is probably the most technically difficult work in this system
		2) Filter cleaning	1 time / year (5 days) x 5 times		
		3) General guarding	Every day (24 hrs)	2 guards (6 in shifts)	

Table 6.26: Regular Operation and Maintenance Activities for Each Set of Planned Facilities in Godey Town (3)

Facility	Spec/Capacity (Dimension)	Detailed O&M tasks	Frequency (duration)	No. of Staff assigned (Work shift)	Remark
7. Treated water reservoir	1 reservoir (24 x 24 x 1.8 m) V= 1,000m^3	1) Cleaning	1 time / year (6 hours)	1 technician (5 in shift) 1 operator 20 daily workers	
		2) Chlorine dosing	1 time/day (30 min)	1 operator 1 assistant operator	
		3) General guarding	Every day (24hrs)	1 guard (3 in shifts)	
8. Reservoir 1	V= 400 m^3 11.8 x 11.8 x 3 m Elevated 10 m	1) Tank cleaning	1 time / year (4 hrs)	1 operator 6 daily workers	
		2) Level check and valve operation	2 times/day (20 min each)	1 operator	
		3) General guarding	Every day (24hrs)	1 guard (3 in shift)	
9. Reservoir 2 (Existing)	V= 1,000 m^3	1) Tank cleaning	1 time/ year (4 hrs) x 1 tank	1 operator 12 daily workers	
		2) Level check and valve operation	1 time/day (15 min)	1 operator	
		3) General guarding	Every day (24hrs)	1 guard (3 in shift same as 8-3))	
10. Reservoir 3 & 4 (Existing)	2 tanks for backup $V_1 = 60m^3$ $V_2 = 150m^3$	1) Tank cleaning	1 time/ year (4 hrs) x 2 tank	1 operator 12 daily workers	These 2 tanks are used as backups
11. Pipeline system	Transmission pipe D300 (L= 4,998m) Distribution pipe D 300: 2,797m D 200: 1,384m D 160 less (L = 37km)	1) repair and replacement of pipes	1 time/ 6 months (5 day)	1 operator 2 Engineers from WD 4 plumbers from WD 20 daily worker	Repair is done based on observation and reports Engineers and plumbers from WD

Note: Water Desk = Town water supply utility office,
* The number of assigned staff members indicated signifies the number required for each facility and thus the same members may work at other facilities.
* Assigned staff and shift: the number after the staff title signifies the number of persons who work at the facility on a given day while the number in "shift" is the total number of the staff members who work in shift.

Table 6.27: O&M Cost of the Water Supply Systems of Godey Town

Cost item	Amount (Birr/year)	Remarks
Spare parts	22,272	spare parts for generators and ground pumps
Power supply	2,211,840	fuel and electricity bill for generators and pumps
Personnel	954,096	salary of field staff and daily workers
Chemical	707,724	cost of water treaement chemicals
Consumable	33,372	tools for cleaning work
Others	0	
Total	3,929,304	Equivalent to approx. US$ 212,000

Conditions of estimation

- Cost includes VAT and based on 2013 prices
- Cost was calculated as annual average over 10 year
- Cost covers all the facilities in Jarar valley includig those constructed by UNHCR until April 2013
- Cost is for the regular operation of the system and does not include major facilities/equipment replacement

Chapter 7

Conclusions

7 Conclusions

The conclusions for the water supply plan based on the survey and analysis results are presented in this chapter.

7.1 Summary of the results

According to the design criteria in the revised UAP strategy, the water access ratio in Ethiopia is 100% for 2015 for both urban and rural areas. In accordance with the target year (2015) and the progress in improvement of access ratio in Somali Region, the target year of the water supply plan was set as 2020, and the proposed water supply access ratio was set as 100% for the target year of 2020. The population growth rate employed is 2.91% per annum, which was estimated from the review of CSA data, for both urban and rural areas.

The per capita water demand figures of the revised UAP of 20 lit/capita/day for urban water supply and 15 lit/capita/day for rural water supply were adopted. Other water demands such as the institutional and commercial water use were also discussed along with the industrial water use, water for livestock, water for firefighting, and water loss. As the result of estimation of each demand item, the water demand of each woreda was estimated for 2020.

The design water supply volume was determined to be the total water demand in 2020 minus 80% of the water demand to be attained in 2015 based on the projection of UAP access ratio of water supply. However, the areas using river water have simply adopted the water demand value of 2020 for the design water supply volume in consideration of the current utilization of river water.

The data from the socio-economic survey was used to grasp the condition of existing water sources. In consideration of this data, utilization/development plan of new water sources was drawn up. In this plan, it was recommended to develop deep borehole wells (deeper than 60m) in Jarar Valley area and to use river water as a priority in Shebele River basin area in consideration of existing water supply system. As for the size of birka and haffir dams, their standard design and sizes were employed and required numbers were determined based on the population of the users at one site.

7.2 Conclusions

The plan and design of water supply facilities for each one of urban and rural areas of the 16 woerdas were illustrated as design outline maps that took into consideration not only the basic approach for facilities designing but also geomorphological, geological, and water resources information based on the results of the survey and analysis for water supply plan.

The project cost was estimated based on the number of materials. The implementation plan of the projects were prepared in reference to the cost estimation. The period of project implementation was planned to be seven years from 2014 to 2020. The main project costs are 1,870,000USD (project term: 2 years) for Kabribeyah town, and 8,805,000USD (Project term: 4 year) for Godey town. The project cost of woredas including urban area is 1,685,000 USD for Birqod woreda as the minimum cost, and the highest project cost is 14,664,000USD for Kabribeyah woreda excluding its urban area.

The cost of the proposed operation and maintenance plan of the water supply systems based on the details of the facilities and the implementation plan have been estimated. The cost of

O&M was calculated based on the cost items such as personnel, materials, fuel and electricity, chemicals and spare parts. The replacement cost was also calculated separately from the O&M cost. The ratio of O&M cost to the project cost is about 3.4% on average as the whole woreda. The ratio of O&M cost to the project costs of the main towns are 9.6% for Kabribeyah town, and 4.5% for Godey town in consideration of price change. Those for the main woredas are 5.4% for Birqod woreda, and 4.4% for Kabribeyah woreda. The ratio of O&M cost of Kabribeyah town project is a little higher. This is because the O&M cost is applied to the existing facilities as well, while the size of the project (new construction) for Kabribeyah town is small.

In the entire woredas, the benefits of time saving for water fetching and health improvement have been included as economic benefits. The value of time savings was measured from the average time saved multiplied by the economic labor cost. Consequently, the saved time of 2.4 hours per day on average was converted to the value of 15 Birr per day (100 x 0.5 x 2.4/8) per each household. Health improvement benefits were derived from an improvement in water quality and increased supply of water. It was assumed that provision of clean water supply would lead to a 10% reduction in medical expenses every year in the target communities.

The results of the economic analysis signify that the economic viability of the majority of the projects is secured as the EIRR exceeds the opportunity cost of capital of 10%. This evaluation is considered appropriate.

The total capital costs of the projects covering 16 target woredas amounts to about US$ 110,000,000. It is the policy of the government of Ethiopia that the government shall finance the capital costs of water supply projects under the condition that each local community will take on the duty of operation and maintenance work and pay for the O&M costs. However, it is better to discuss possibility of obtaining donor assistance in case the capital costs are considered too large.

Financial evaluation in terms of Financial Internal Rate of Return (FIRR) has not been applied to analyze the recovery of the project cost, as the revenue generated from the proposed projects is far from sufficient to cover the whole project cost. The comparison of the expected water fee to be collected from the water users at 20 Birr per cubic meter (m^3) and the amount of operation and maintenance (O&M) cost required each year indicates that the former exceeds the latter every year. The calculation also shows that even if the water fee recovery rate is max 86% and min 18% in the 16 woredas, the collected water fee will be sufficient to cover the annual O&M cost.

In Kabribeyah town, benefits of time saving in water fetching and health improvement have also been included in the calculation of economic indicators. The result of the computation indicates that the project is economically feasible as the EIRR exceeds the opportunity cost of capital of 10 %. This procedure is considered appropriate.

The total capital costs of the project for Kabribeyah town amounts to 1,870,000 U.S. dollars including engineering services and administration costs. It is the policy of the government of Ethiopia that the government shall finance the capital cost of water supply projects under the condition that each local community will be responsible for operation and maintenance costs of the water supply facilities. However, it is desirable to discuss possibility of obtaining donor assistance if the project cost is judged too large. Water tariff of 10 Birr per cubic meter

(m^3) which is the current tariff in Kabribeyah town was used to calculate the financial indicators. The result of the computation revealed that the project has a FIRR of 6.1 % under the condition that the recovery of water fee is 100 %. However 100% collection of water fee is not realistic.

To sum up, it is better to discuss receiving financial assistance from donors, even if the budget of SRWDB is partly utilized to realize the project.