Ministry of Agriculture, Irrigation and Water Development
The Republic of Malawi

Preparatory Survey Report

on

The Project for Selected Market Centres and Rural Water Supply in Mchinji and Kasungu District

in

The Republic of Malawi

February 2012

JAPAN INTERNATIONAL COOPERATION AGENCY

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

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PREFACE

Japan International Cooperation Agency (JICA) decided to conduct the preparatory survey and entrust the survey to Eight – Japan engineering Consultants Inc.

The survey team held a series of discussions with the officials concerned of the Government of Malawi, and conducted a field investigation. As a result of further studies in Japan, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Malawi for their close cooperation extended to the survey team.

February, 2012

Shinya Ejima
Director General,
Global Environment Department
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SUMMARY

1. Outline of the Recipient Country

The Republic of Malawi (hereinafter referred to as "Malawi") is an agricultural country with a total population of 15.26 million (2009) and 80% of the working population is engaged in either agriculture or agriculture-related businesses. The GNI per capita of US$ 330 in 2010 puts Malawi among the least developed countries (162nd among 165 countries listed by the World Bank). From 2007 to 2009, the national economy enjoyed a healthy annual growth rate of 7.6% - 9.7% due to favourable weather and stabilisation of the international price of tobacco which is the leading export product, maintaining a single digit inflation rate. In 2011, the sharp price drop of tobacco, which earns some 70% of foreign currency, produced an insufficient foreign currency reserve, resulting in disruption of the distribution of fuel which relies on imports. As the foreign currency earning potential is overwhelmingly determined by the international prices of agricultural products, the economic foundations of the country are vulnerable. The widely recognised development themes to achieve poverty reduction through sustainable economic growth include departure from the dependence on tobacco in the agricultural sector, improvement of productivity, development of economic infrastructure and promotion of small businesses.

2. Background and Brief Outline of the Project

The access rate of people to safe water in Malawi was 72% in 2006, and the rate in rural area was about 50% in 2008. However borehole construction has been promoted with assistances of development partners, the low operating rate of boreholes, particularly in rural areas, has the effect of lowering the real water supply rate. As the water supply system in market centres which are small centres of local economic activities still rely on boreholes with hand pumps and traditional shallow wells as in the case of rural areas, the number of water supply points is insufficient to cater for the population. Residents in these areas who cannot secure a nearby source of safe water have no choice but to spend much time and labour fetching safe water for their daily lives. Because of various constraints, many of them tend to rely on groundwater from shallow wells or surface water. The poor state of water supply facilities is partly responsible for the persistent poverty in rural areas as the shortage of safe water supply facilities nearby has serious adverse socio-economic impacts in Malawi which has been promoting a growth strategy in recent years. The supply of safe water is a common issue which is closely connected to the development of rural areas, basic education and health care as well as the local economy.

The drive of the Government of Malawi to construct boreholes nationwide led to the existence of more than 23,000 boreholes (2005). At the same time, however, it was found that many boreholes had broken down without any care in addition to their general deterioration, lowering the actual water supply rate. To improve the low operating rate of the existing boreholes in Mchinji where Japan had assisted the construction of boreholes in the early 1990's, the Government of Malawi made a request in 2009 to the Government of Japan for the repair, if possible, of broken down boreholes and for the replacement of those boreholes found to be beyond repair.

Meanwhile, in its Malawi Growth and Development Strategy (MGDS) 2006 – 2011, the Government of Malawi defines the key areas for local economic activities as "market centres" as part of its strategy to develop rural areas and upholds these market centres as targets for social infrastructure development to rectify the situation of the development of these areas lagging behind the development of purely rural and urban areas. In regard to water supply facilities, a feasibility study on a piped water supply system was conducted in 1998 for 26 small local cities in the Central Region under the National Water Development Project (NWDP) funded by the World Bank and others.

The Government of Malawi made a request to the Government of Japan for assistance for the construction of a piped water supply system combining individual household taps and communal taps for three market centres (Santhe in the Kasungu District, Mkanda in the Mchinji District and Namitete/Chileka in the Lilongwe District) located to the west of the subject small local cities in response to a strong request by the respective district governments.

As the target areas of these two projects are close to each other with some overlapping areas, it was decided to conduct a single survey to cover both project areas for the formulation of an appropriate project for grant aid.

3. Outline of the Survey Findings and Project Contents

The Japan International Cooperation Agency (JICA) dispatched the Preparatory Survey Team to Malawi from 29th August to 2nd November, 2010. This was followed by the dispatch of the Second Field Survey Team to Malawi from 17th April to 22nd June, 2011. During these field surveys, the contents of the original request were confirmed through discussions with the stakeholders in Malawi and a survey was conducted on the natural conditions, social conditions, existing water supply facilities and systems, their operation and maintenance system and preferable construction plan for the forthcoming project.

Based on the findings of these field surveys, the JICA prepared the outline design in Japan and sent a team to explain the contents of this outline design to the Malawi side from 16th to 25th October, 2010. The ensuing discussions led to the acceptance of the contents of the outline design and of its obligations by the Malawi side. The finalised project contents are summarised next.

(1) Project for Water Supply Systems for Market Centres

1) The ministry responsible for the Project will be the Ministry of Agriculture, Irrigation and Water Development (MoAIWD) while the Central Region Water Board (CRWB) will operate and maintain the newly constructed facilities.
2) The Malawi side will be physically and financially responsible for the development of an O & M system for the new facilities and for the service connection work to individual household taps.
3) The water source will be groundwater in Mkanda and Santhe where raw water pumped up from boreholes will be disinfected using chlorine and will be supplied to the planned service area using the gravity method after temporary storage at an elevated water tank or distribution basin. Namitete/Chileka

is excluded from the scope of the Project as neither the sufficient availability of surface water or groundwater nor good water quality was confirmed by the field survey.

Requested Site	Originally Proposed Water Source	Planned Water Source	Reason for Selection/Non-Selection
Mkanda	River (Liwelezi)	Two boreholes (691 m^3/day x 2)	River water requires a rapid filtration system. Groundwater is advantageous in terms of economy and the required maintenance skills and its sufficient quantity and quality were confirmed by the test drilling.
Santhe	Groundwater	Six boreholes (total: 714 m^3/day)	While six test boreholes should be sufficient to meet the water demand in the target year, a reserve borehole(s) is required in preparation for the suspended operation of some boreholes for inspection or other reasons.
Namitete/ Chileka	River (Namitete River)	-	Checking of the surface water data and the test drilling of three boreholes could not confirm the availability of a sufficient water quantity. Consequently, this market centre has been removed from the scope of the Project.

4) The basic planning conditions are given below.

- Target year : 2020
- Planned service population : 7,051 in Mkanda; 7,485 in Santhe
  Estimated based on the actual population of each market centre in 2008 and the annual population growth rate of their respective districts
- Unit water supply volume : 46.2 litres/person/day in Mkanda
  57.1 litres/person/day in Santhe
  Weighted average of the unit water supply volume by housing density type and population ratio of each housing density type
- Public sector consumption : Estimated to be 25% of the household water consumption (unit water supply volume x service population)
- Leakage rate : 10% (new distribution pipelines will be laid under the Project)
- Load factor and time factor : 1.20 and 2.40 (Malawi standards)
- Planned water supply volume (maximum supply volume) : 544 m^3/day for Mkanda; 712 m^3/day for Santhe
- Treatment method : Disinfection using a high purity bleaching powder only

5) The planned facilities for construction with Japanese assistance are summarised below.

Facility		Mkanda	Santhe
Water Intake Facilities	Intake pump	2	2
	Cubicle (outdoor type)	2 sets	2 sets
	Perimeter fencing and gate	2 sets	2 sets
Water Transmission Facilities	Transmission pipe	∅ 100 mm x 0.4 km	∅ 150 – 75 mm x 2.5 km
	Water meter	1 set	1 set
Water Treatment Facilities	Chlorination device	2 sets	2 sets
Water Distribution Facilities	Water tank	Elevated tank 180 m3 x 1	Ground tank 240 m3 x 1
	Distribution pipe	∅ 150 – 75 mm x 11.3 km	∅ 150 – 75 mm x 16.1 km
	Public tap (2 faucet type)	At 6 places	At 8 places
Buildings	Control Building and office building	1 each	1 each

(2) Project for the Rehabilitation of Boreholes in Mchinji

The borehole survey found that out of the 300 boreholes constructed some 15 – 17 years ago, 211 boreholes (70%) are still operational, including 10 boreholes with a reduced capacity, and 89 boreholes (30%) are out of order. 14 boreholes are clogged through the falling of various objects. Other than these, the main causes for the boreholes which are out of order is deterioration of the pump assembly beyond the expected service life, including damage to and the deformation and abrasion of various parts. Some operational boreholes are judged to have an inherent risk of a reduced pumping capacity in the near future if the siltation process at the bottom of the boreholes continues. Even though emergency repair by means of replacing problematic expendable parts could be conducted for the temporary resumption of operation of many of the inoperable boreholes, the fact that not only expendable parts but also many sections of the pump assembly itself are damaged suggests that all of the pumps surveyed have reached the point of their renewal. In Malawi, the users (residents) are, in principle, responsible for the pump maintenance cost and the surveyed pumps showed much evidence of repeated repair by residents. However, renewal of the entire pump assembly involves a huge cost for residents. As missing the timing for renewal could lead to the fatal breakdown of a borehole, all 300 boreholes will be included in the scope of the rehabilitation project.

In the case of those boreholes where the pump assembly can be safely extracted, a new hand pump (Afridev type) will be installed. While the new pump will be installed at the original depth, the pump rod and plunger will be made of stainless steel and brass respectively in view of longer durability. Some of the existing boreholes, however, will not be rehabilitated. These include boreholes of which the repair has not been requested by residents, boreholes which are not expected to provide safe water even after their

rehabilitation and boreholes located in the target area for the Project for Water Supply Systems for Market Centres.

In the case of those boreholes where the pump assembly cannot be extracted for rehabilitation, a replacement borehole will be constructed in the same village area. For those boreholes of which the rehabilitation viability is unclear at present, trial rehabilitation work will be conducted at the detailed design stage to determine whether or not the construction of a replacement borehole is necessary. When a rehabilitated or replacement borehole is insufficient to meet the demand of the intended service population, one additional borehole will be constructed in the same village.

One set of rehabilitation equipment, the principal purpose of which is the removal of the deposits at the bottom of boreholes, will be provided for use during the rehabilitation work to prolong the service life of the rehabilitated boreholes and to improve the borehole rehabilitation capacity in Malawi.

Project for the Rehabilitation of Boreholes in Mchinji
(Including the Construction of Replacement and Additional Boreholes)

Item	Target and Planned Work	No. of Boreholes	No. of Villages
Boreholes constructed under the Groundwater Development Project in Mchinji		300	276
1) Rehabilitation Work	Borehole cleaning and pump renewal (excluding the pump stand)	272	250
	Borehole cleaning and pump renewal (including replacement of the pump stand)	8	8
2) Construction of Replacement Borehole	Boreholes which are clogged beyond rehabilitation and boreholes of which the rehabilitation viability is unclear: new replacement borehole in the same village	Maximum 15	Maximum 15
3) Trial Rehabilitation (at the Detailed Design Stage)	Trial rehabilitation work, including the removal of fallen objects from the boreholes, will be conducted at boreholes of which the rehabilitation viability is unclear. If rehabilitation is found to be viable, the borehole in question will be removed from 2) above.	4 among the above 15	4 among the above 15
4) Boreholes Not to be Rehabilitated	Duplication with the market centre water supply project (two boreholes); replacement borehole already in place (one borehole); groundwater contamination by bacteria, etc. (two boreholes)	5	4
Villages in which the above borehole(s) will be overloaded due to an increased village population			
5) Construction of Additional Borehole	Construction of one additional borehole in villages where the service population is estimated to be more than 450 per borehole	39	39

Equipment Procurement List for the Project for Rehabilitation of Boreholes in Mchinji

	Equipment	Quantity
1	Cargo truck with a 3 ton crane	1
2	Air compressor	1
3	Diesel engine generator	1
4	Electric winch	1
5	Submersible pump and standard accessories	1 set
6	Tools for development (bailer and air lift tools)	1 set
7	Equipment for water analysis	1 set
8	Supporting vehicle (pick-up truck with a single cabin)	1
9	Other equipment for pumping test	1 set

More than 95% of the surveyed boreholes show signs of pump repair by the users. Many of the Water Point Committees (WPCs) which will be responsible for the maintenance of the rehabilitated and newly constructed boreholes under the Project have problems in terms of fund management and borehole maintenance skills. It is, therefore, essential to strengthen the capability of all WPCs, including those to be newly established for the newly constructed boreholes and community training for residents and the training of trainers will be included in the Project as a soft component. The MoAIWD will be responsible for such training based on the CBM Programme in Malawi and the Japanese consultant will provide technical assistance for (1) application of standard activities for new boreholes to the rehabilitated boreholes, (2) utilisation of mechanics in the private sector, (3) planning of community training in correspondence with the capacity of the WPCs and different requirements for rehabilitated and new boreholes, (4) collaboration with the JICA's technical cooperation project targeting the same area, (5) evaluation of the implementation situation and (6) measures to prevent the theft of the pumps.

4. Project Duration and Estimated Project Cost

The Project, consisting of two sub-projects, will be implemented as a single year grant aid project of the Government of Japan. The total duration is expected to be 20 months consisting of five months for the detailed design stage and 15 months for the construction of the facilities and procurement of equipment. The estimated financial contribution of the Malawi side towards the project cost is approximately ¥28.6 million.

5. Evaluation of the Project

(1) Project for Water Supply Systems for Market Centres

Water supply at local market centres of which the development is prioritised in the social infrastructure development efforts of the Government of Malawi predominantly relies on boreholes and shallow wells as in the case of rural areas. Some market centres are forced to use river water because of the absence of

alternative water sources. In Mkanda (population of 4,666 in 2008) and Santhe (population of 5,437 in 2008), the total number of boreholes which are considered to be safe water sources is 21 with an estimated total service population of 5,250. The water supply ratio of approximately 52% (5,250 persons out of 10,103 persons in 2008) is much lower than the current average safe water supply rate (72%) for rural Malawi. As the project will enable safe water supply for these two areas (with a target service population of 14,536 in 2020), it is an urgent project from the viewpoint of BHN to stabilise people's livelihoods and to improve the daily lives of rural people. Moreover, the Project conforms to Malawi's development policy of promoting the local economy.

(2) Project for the Rehabilitation of Boreholes in Mchinji

This Project aims at increasing the service population and prolonging the service life of boreholes in rural areas of the Mchinji District through the rehabilitation of existing boreholes and the construction of replacement and additional boreholes. It will reduce the users' cost for maintenance. The Government of Malawi is hoping to reduce the rate of non-working boreholes, which is currently said to be 30%, to 25% by 2015. With the implementation of the Project, the functionality of borehole will be improved in the Mchinji District, contributing to the overall achievement of one of Malawi's development plans. Along with the rehabilitation work, the Project will provide community training for WPC members with a view to developing a sense of ownership on the part of users. Such encouragement of the self-reliant operation and maintenance of boreholes by users conforms to Japan's aid policy of developing the village level operation and maintenance capability.

The implementation of above two projects will also contribute to the achievement of the goals in MGDS which is aiming at improvement of coverage of safe water and making accessing to safe water point not more than 500 m.

Furthermore, these two projects will be the measures against the risks of interruption to safe water use caused by drought or flood which may be occurred by climate changes. The Malawi government also recognised this relevance.

(3) Quantitative Effects

The planned Japanese assistance will involve the construction of a water supply system capable of supplying 544 m^3/day at the Mkanda Market Centre and 712 m^3/day at the Santhe Market Centre, the rehabilitation of a minimum of 280 existing boreholes and the construction of a maximum of 54 new boreholes in the Mchinji District.

The only available safe water supply sources at the targeted market centres at present are 21 boreholes. With the implementation of the Project, all the residents (planned population of 14,536) of these two market centres will receive safe water through a piped water supply system. Meanwhile in the Mchinji District, only 209 boreholes are currently operational out of 300 boreholes originally constructed under a Japanese grant aid project in the past. With the implementation of the Project, there will be a total of 334 working

boreholes (rehabilitated, replacement and additional boreholes). Based on a unit service population of 250 persons per borehole (standard unit service population in Malawi), it is expected that an additional 31,250 persons will receive a reliable supply of safe water.

Quantitative Effects of the Project

Indicator	Project	Reference Figure (2010)	Target Figure (2015)
Population receiving safe water supply (persons)	Construction of a piped water supply system in each of the Mkanda and Santhe Market Centres	5,250 (water supply from boreholes)	14,536*
	Rehabilitation and construction of boreholes in the Mchinji District	52,250	83,500

*This figure is the planned figure for 2020 in line with the design target year.

(4) Qualitative Effects

1) Thanks to the supply of safe and stable water, it is expected that sanitary conditions will be improved and water-borne diseases will be reduced.
2) As water drawing labour will be mitigated, it is expected that children will have more opportunities to obtain education and there will be more work opportunities for women, thus making it easier to participate in productive and economic activities.
3) Due to the renewal of hand pumps that have been used beyond their service life and are breaking down frequently, the frequency of breakdowns will decline and borehole operating conditions will be improved over the long term.
4) The operation and maintenance system of boreholes in Mchinji District is expected to be improved through the implementation of the soft component of the Project.

Based on the evaluations above, it is judged that the Project is expected to be highly relevant and effective.

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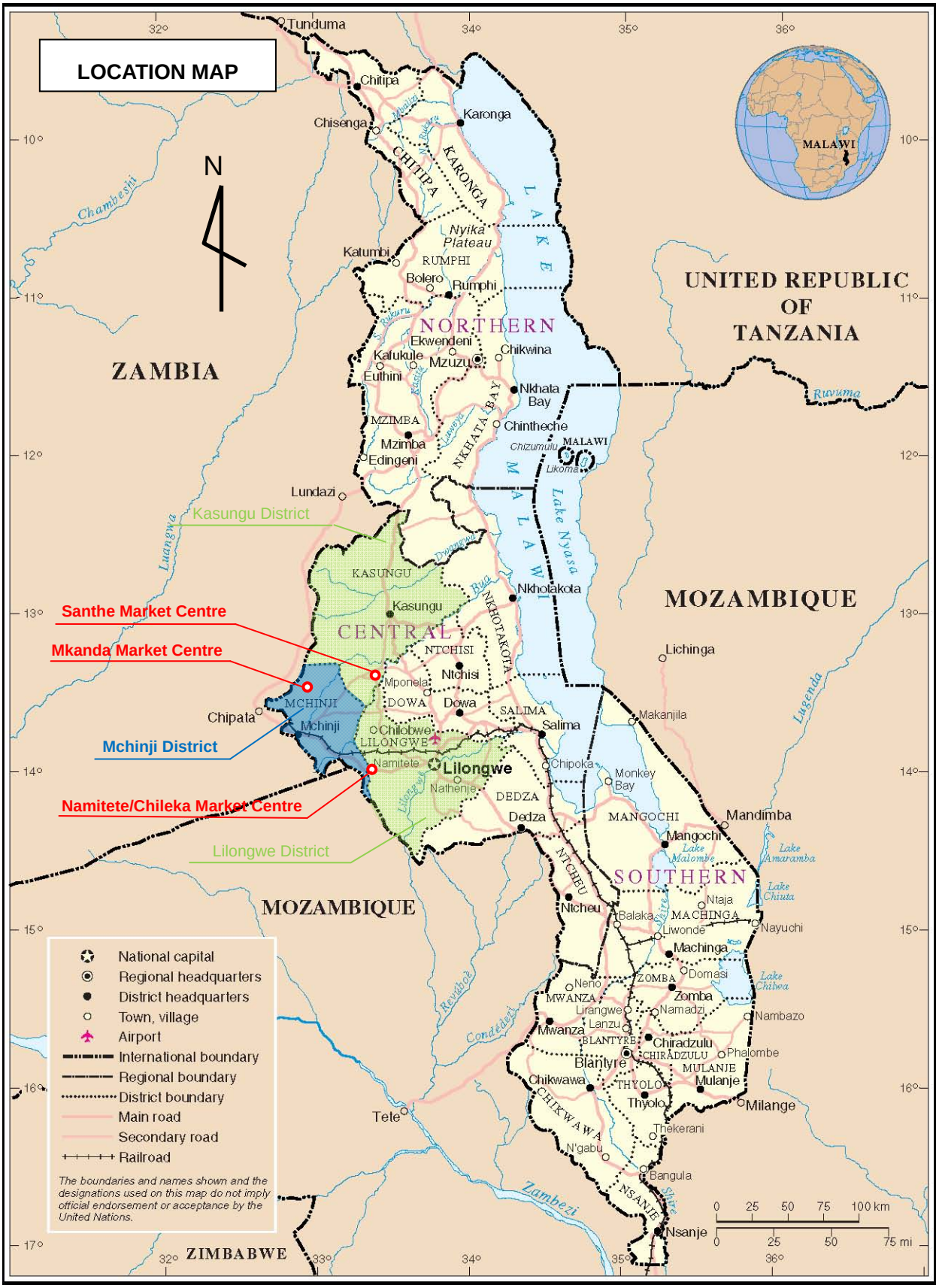


Map No. 3858 Rev. 3 UNITED NATIONS Department of Peacekeeping Operations January 2004 Cartographic Section

PERSPECTIVE (Water Supply System for Market Centres)

PERSPECTIVE (Rehabilitation of Boreholes in Mchinji)

List of Figures & Tables

ABBREVIATION

ADMARC	: Agricultural Development and Marketing Corporation
AfDB	: African Development Bank
BHN	: Basic Human Needs
CBM	: Community Based Management
CDA	: Community Development Assistant
CIDA	: Canadian International Development Agency
CRWB	: Central Regional Water Board
DCT	: District Coordination Team
DfID	: Department for International Development
EIB	: European Investment Bank
EU	: Europe Union
ESCOM	: Electricity Supply Commission of Malawi
HSA	: Health Surveillance Assistant
IDA	: International Development Association
JICA	: Japan International Development Agency
JSR	: Joint Sector Review
NWDP	: National Water Development Programme
MASAF	: Malawi Social Action Fund
MGDS	: Malawi Growth and Development Strategy
MoAIWD	: Ministry of Agriculture Irrigation and Water Development
OPEC	: Organization of Petroleum Exporting Countries
PMU	: Programme Management Unit
RWB	: Regional Water Board
SWAp	: Sector Wide Approach
UNICEF	: UN International Children’s Emergency Fund
VHWC	: Village Health Water Committee
WMA	: Water Monitoring Assistant
WPC	: Water Point Committee
WRB	: Water Resources Board

Chapter 1 Background of the Project

1-1 Background and Brief Outline of the Project

In the Republic of Malawi (hereinafter referred to as "Malawi"), the access rate of people to safe water was 72% in 2006, and the rate in rural area was about 50% in 2008. However borehole construction has been promoted with assistances of development partners, the low operating rate of boreholes, particularly in rural areas, has the effect of lowering the real water supply rate. As the water supply system in market centres which are small centres of local economic activities still rely on boreholes with hand pumps and traditional shallow wells as in the case of rural areas, the number of water supply points is insufficient to cater for the population. Residents in these areas who cannot secure a nearby source of safe water have no choice but to spend much time and labour fetching safe water for their daily lives. Because of various constraints, many of them tend to rely on groundwater from shallow wells or surface water. The poor state of water supply facilities is partly responsible for the persistent poverty in rural areas as the shortage of safe water supply facilities nearby has serious adverse socioeconomic impacts in Malawi which has been promoting a growth strategy in recent years. The supply of safe water is a common issue which is closely connected to the development of rural areas, basic education and health care as well as the local economy.

The Government of Malawi has been earnestly implementing measures designed to improve the water supply in both urban and rural areas. The fact that the government budget predominantly consists of the recurrent budget means that there is a difficulty to find additional funding to make the necessary investment. Under these circumstances, the Government of Japan has so far constructed more than 1,200 boreholes in rural areas since 1987 in five phases under its grant aid scheme.

The drive of the Government of Malawi to construct boreholes nationwide with the active support of Japan and other donors led to the existence of more than 23,000 boreholes (2005[1]) in rural areas. At the same time, however, it was found that many boreholes had broken down without any care in addition to their general deterioration, lowering the actual water supply rate. To improve the low operating rate of the existing boreholes in Mchinji where Japan had assisted the construction of boreholes in the early 1990's, the Government of Malawi made a request in 2009 to the Government of Japan for the repair, if possible, of broken down boreholes and for the replacement of those boreholes found to be beyond repair.

Meanwhile, in its Malawi Growth and Development Strategy (MGDS) 2006 – 2011, the Government of Malawi defines the key areas for local economic activities as "market centres" as part of its strategy to develop rural areas and upholds these market centres as targets for social infrastructure development to rectify the situation of the development of these areas lagging behind the development of purely rural and urban areas. In regard to water supply facilities, a feasibility study on a piped water supply system was

[1] Government of Malawi (2008), Integrated Water Resources Management and Water Efficiency (IWRM/ME) Plan 2008 – 2012, Abridged Version

conducted in 1998 for 26 small local cities in the Central Region under the National Water Development Project (NWDP) funded by the World Bank and others.

The Government of Malawi made a request to the Government of Japan for assistance for the construction of a piped water supply system combining individual household taps and communal taps for three market centres (Santhe in the Kasungu District, Mkanda in the Mchinji District and Namitete/Chileka in the Lilongwe District) located to the west of the subject small local cities in response to a strong request by the respective district governments.

As the target areas of these two projects are close to each other with some overlapping areas, it was decided to conduct a single survey to cover both project areas for the formulation of an appropriate project for grant aid.

1-2 Natural Conditions

(1) Climate

Malawi belongs to the tropical savannah climate zone with a rainy season from December to March and a dry season for the rest of the year. The annual rainfall is around 1,000 mm and most of the land can be cultivated except that in the mountain ranges. The topography of the country is generally divided into the Great Rift Valley occupying the eastern and southern parts of the country and narrowly stretching from north to south, mountain ranges to the east and west of the Great Rift Valley and highland plateaus lying beyond these mountain ranges.

The survey area is situated on a highland plateau (elevation of 1,050 m to 1,300 m) to the west of the Great Rift Valley. The Mchinji Ridge (highest elevation of 1,750 m) which constitutes the border with Zambia is the western-most topographical feature of the survey area. At Tembwe located at the centre of the survey area, the mean annual rainfall for the last eight years is 922 mm with a drought year (annual rainfall < 800 mm) occurring every few years. 94% of the rainfall is recorded in the rainy season (December to March) during which 29 days record daily rainfall of 10 mm or more.

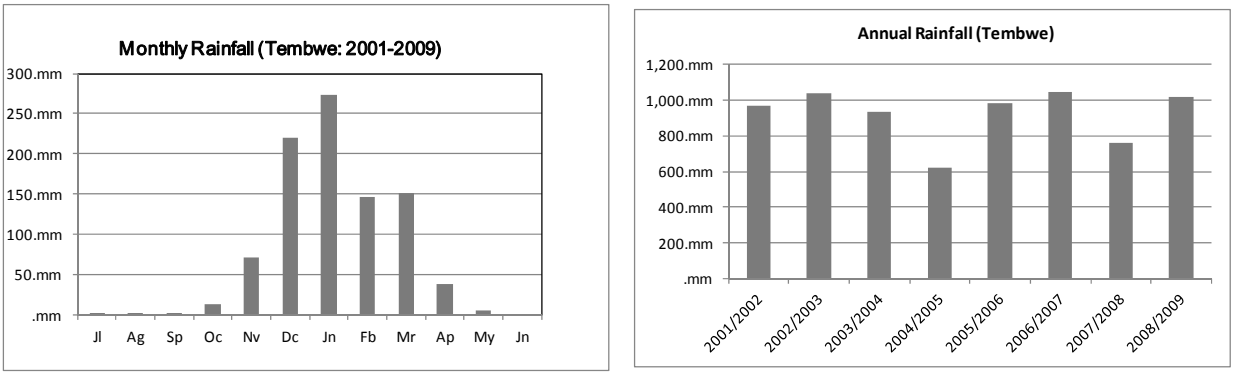


Fig. 1-2-1 Mean Monthly Rainfall and Annual Rainfall (Tembwe in the Mchinji District)

(2) Rivers and Hydrology

A river originating from a plateau in the hinterland of a mountain range tends to have a gentle stream gradient with dendritic drainage. In Malawi, a main river absorbs many tributaries and steeply descends to empty into Lake Malawi in the Great Rift Valley or lowland after forming a small number of gorges in the mountain area. Because of these topographical features, rainwater falling on to a plateau tends to stay on the ground surface, creating many swampy areas called “dambo” in the river system.

The project areas are located in the basin of Bua River which empties into Lake Malawi. The nearest river to each subject market centre is listed below (Fig. 1-2-2).

Namitete/Chileka : Namitete River
Santhe : Bua River
Mkanda : Liwelezi River

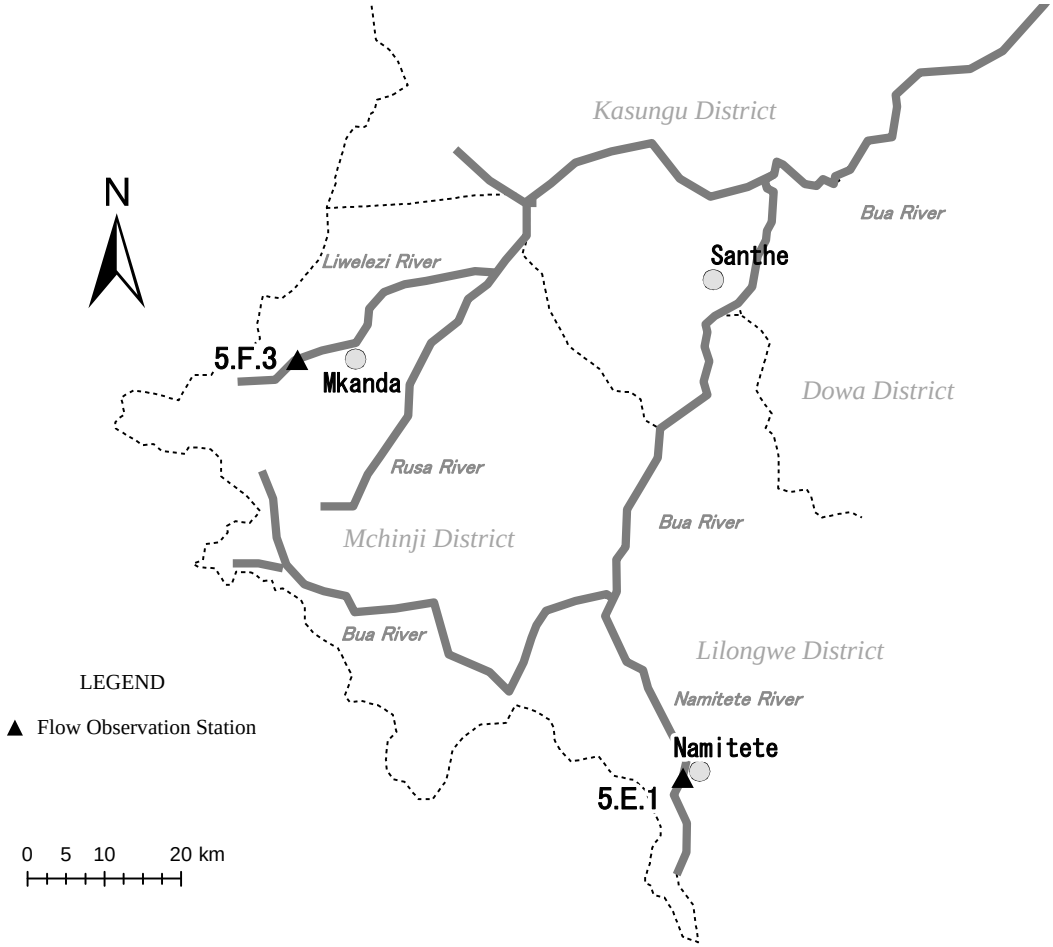


Fig. 1-2-2 River Systems

Table 1-2-3 shows the mean monthly discharge at the Nametite River Observation Station (catchment area of 147 km2) and Liwelezi River Observation Station (catchment area of 278 km^2) in 1998. Compared to Liwelezi River, the runoff rate is high with a huge flow difference between the rainy season and the dry season. The maximum monthly flow is 0 litres/sec for the last four months (August to November) of the dry season.

With Liwelezi River, the lowest observed flow of 0.054 m^3/sec in the 10 year period from 1992 to 2001 was actually observed as the minimum monthly flow in 10 different months. In November, 1992, October, 1995 and November, 1995, this flow value was also recorded as the maximum monthly flow. These records imply that 0.054 m^3/sec may be the lowest observable level or accuracy limit and that the actual flow may well be lower.

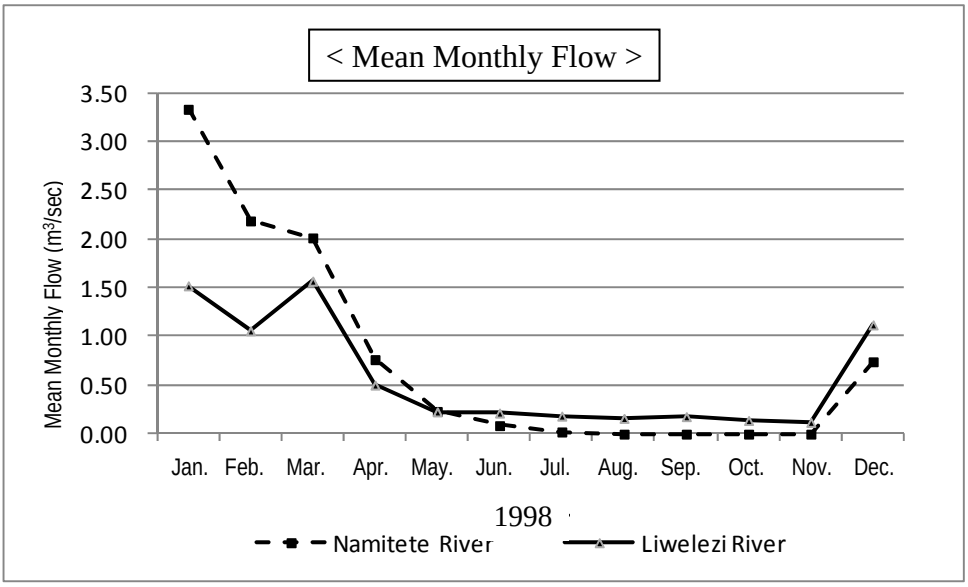


Fig. 1-2-3 Monthly Flow at Namitete River and Liwelezi River

1-3 Current Conditions of Water Supply Facilities

(1) Project for Water Supply Systems for Market Centres

The results of the questionnaire survey conducted with market centre residents (Table 1-3-1) show that residents use many different water supply sources, including boreholes, protected shallow wells, unprotected shallow wells and surface water from small streams or reservoirs. Although a piped water supply system is provided at the Namitete Secondary School and the ADMARC premises in Chileka, both are in-house systems which are not accessible by the general public. The actual usage rate of each of these sources varies from one market centre to another. In Chileka, all residents (100%) use groundwater from boreholes which is considered to be safe water. The proportion drops to two-thirds in Namitete and Santhe

and one-third in Mkanda. Those using groundwater from unprotected shallow wells or surface water, both of which are clearly unhygienic, account for 16% of all users in Namitete, 10% in Santhe and as many as nearly 30% in Mkanda. In the case of protected shallow wells which are used by one-fifth up to one-third of local residents in three areas except Chileka, while water contamination by human contact and dust, etc. is prevented because of the provision of a lid and the use of a hand pump, there is still concern regarding contamination by seepage water from the ground surface and/or depletion due to season water level fluctuations.

Table 1-3-1 Current Water Supply Sources

	Borehole		Protected Shallow Well		Unprotected Shallow Well		Surface Water	
	No. of Users	%	No. of Users	%	No. of Users	%	No. of Users	%
Namitete	32	64.0	10	20.0	8	16.0	0	0.0
Chileka	51	100,0	0	0.0	0	0.0	0	0.0
Santhe	33	66.0	12	24.0	3	6.0	2	4.0
Mkanda	19	37.3	17	33.3	11	21.6	4	7.8

The questionnaire survey with residents of the target market centres found that some 90% of them want a piped water supply system. For the preferred type of tap, 22% opted for a communal tap, 48% for an outdoor yard tap and 30% for an indoor house connection. Some 80% of the residents were found to be willing to pay the likely water charge calculated on the basis of their present water consumption to the CRWB in return for the installation of a piped water supply system.

(2) Project for the Rehabilitation of Boreholes in Mchinji

1) Existing Water Supply Facilities in the Mchinji District

With the construction of 300 boreholes by a Japanese grant aid project from 1992 to 1995, the number of boreholes in the Mchinji District dramatically increased from far below 100 as shown in Fig. 1-3-1. The construction of more boreholes by the Government of Malawi and other donors in subsequent years pushed up the number to approximately 1,100 by 2010. These boreholes constructed by Japan account for some 27% and now belong to the group of oldest boreholes.

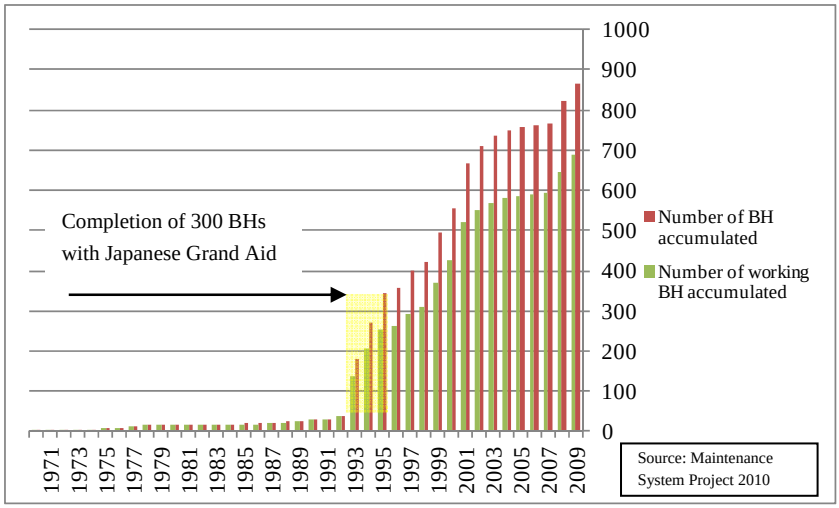


Fig. 1-3-1 Accumulated Number of Boreholes in Mchinji District by Year of Construction

2) Rate of Existing Working Boreholes

There have been several recent inventory surveys featuring water supply facilities in the Mchinji District, such as the Water Point Mapping (WSSCC, 2003), District Water Atlas (UNICEF, 2008) and Maintenance System Project (InterAid, January, 2010). The ratio of working boreholes has been changing from 79% to 76%, and more than 20% of the existing boreholes were not operational continuously.

Table 1-3-2 Water Supply Facilities Inventory Survey Results for the Mchinji District

Type of Facility	WPM (2003)	DWA (2008)	MSP (2010)
Borehole	862 (79%)	923 (76%)	1,118 (79%)
Protected Shallow Well (with Hand Pump)	16 (75%)	31 (65%)	25 (100%)
Communal Tap (Stand Pipe)	150 (60%)	107 (67%)	152 (74%)
Other (No Description)	3	-	38
Total	1,046 (77%)	1,061 (74%)	1,333 (78%)

Note: Figures in brackets are the ratios of working facilities. WPM: Water Point Mapping (WSSCC: 2003); DWA: District Water Atlas (UNICEF: 2008); MSP: Maintenance System Project (InterAid: 2010/01)

3) Current Conditions of Boreholes Constructed Under the Groundwater Development Project in Mchinji

The latest survey on the 300 boreholes constructed under the Groundwater Development Project in Mchinji (JICA grant aid project) found that the ratio of currently working boreholes is 70% which is similar to the results of the District Water Atlas Survey in 2008 (74%) and the ratio of working water supply facilities in rural areas indicated by the 2008 Joint Sector Review (70%). No clogging of the screen due to siltation or the depletion of groundwater is observed and the main cause of non-operation is malfunctioning of the hand pump system, including the riser pipe.

Table 1-3-3 Operational Status of Boreholes Constructed under the Japan's Grant Aid Project

Latest Survey (October, 2010)					Reference (DWA Survey 2008)
Condition of Borehole	Number	Judgement	Number	%	%
Operational (Pumping Capacity is 10 l/min or more)	201	Functional	211	70	74
Operational with Decreased Pumping Capacity (less than 10 l/min)	10				
Non-operational (probably reparable)*	69	Not functional	89	30	26
Non-operational (need trial for repair)**	6				
Clogged Borehole (Irreparable)	14				

* Boreholes which may be rehabilitated by means of replacing the riser pipe, the sylinder, the pump rod and consumables and/or removing foreign matters. .

** Boreholes of which the rehabilitation prospect cannot be judged unless the work to recover the fallen riser pipe to the bottom and other work are carried out first.

4) Causes of Hand Pump Breakdown

There are two principal causes of hand pump breakdown as described below.

① Abrasion of or damage to the mild steel pump rod, etc. (natural deterioration of the product)

② Abrasion of or damage to such expendables as the U-seal, bobbin or rod centraliser

The abrasion or damage observed with the mild steel pump rod and others is attributable to corrosion during more than 15 years of operation, suggesting that these parts have practically reached the end of their service life. Meanwhile, the cracks and linear scars observed with the PVC riser pipe are believed to be caused by the repeated contact of a broken or bent pump rod with the inner wall of the pipe (see Fig. 1-3-4).

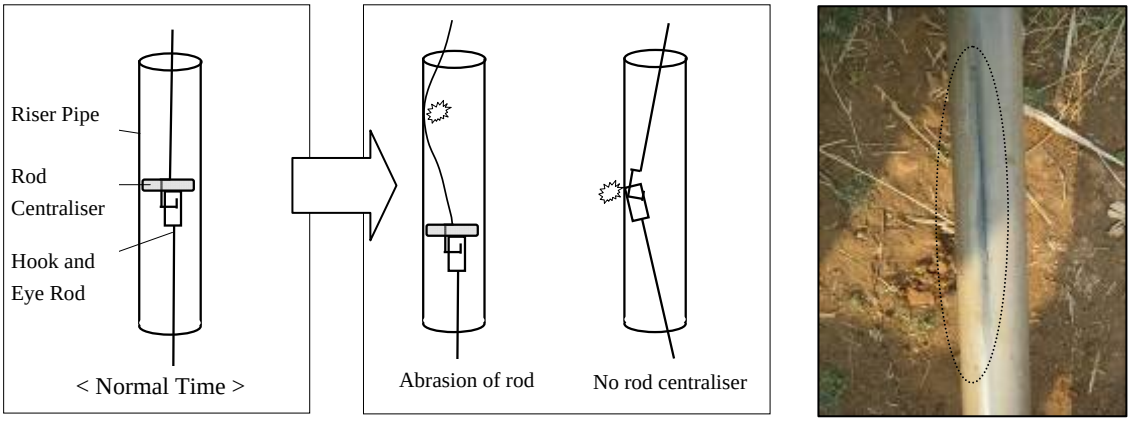


Fig. 1-3-2 Damage to Riser Pipe Due to Rod Defect

Fig. 1-3-3 is a histogramme showing the parts responsible for the non-functioning of a borehole as discovered by lifting the rod and pipe of a broken-down hand pump. Apart from the pump rod already mentioned, the U-seal appears to be the most frequent cause of borehole breakdown, followed by the rod centraliser and O-ring. These findings suggest that expendables which require regular replacement are not properly replaced. Another frequent cause is the deformation of or damage to such plastic parts as the plunger and foot valve. Such deformation or damage leads to the breakdown of borehole operation or a decline of the pumping yield due to leakage. While these parts also require replacement based on regular checks, it is important to improve the durability of parts to reduce the frequency of borehole breakdown.

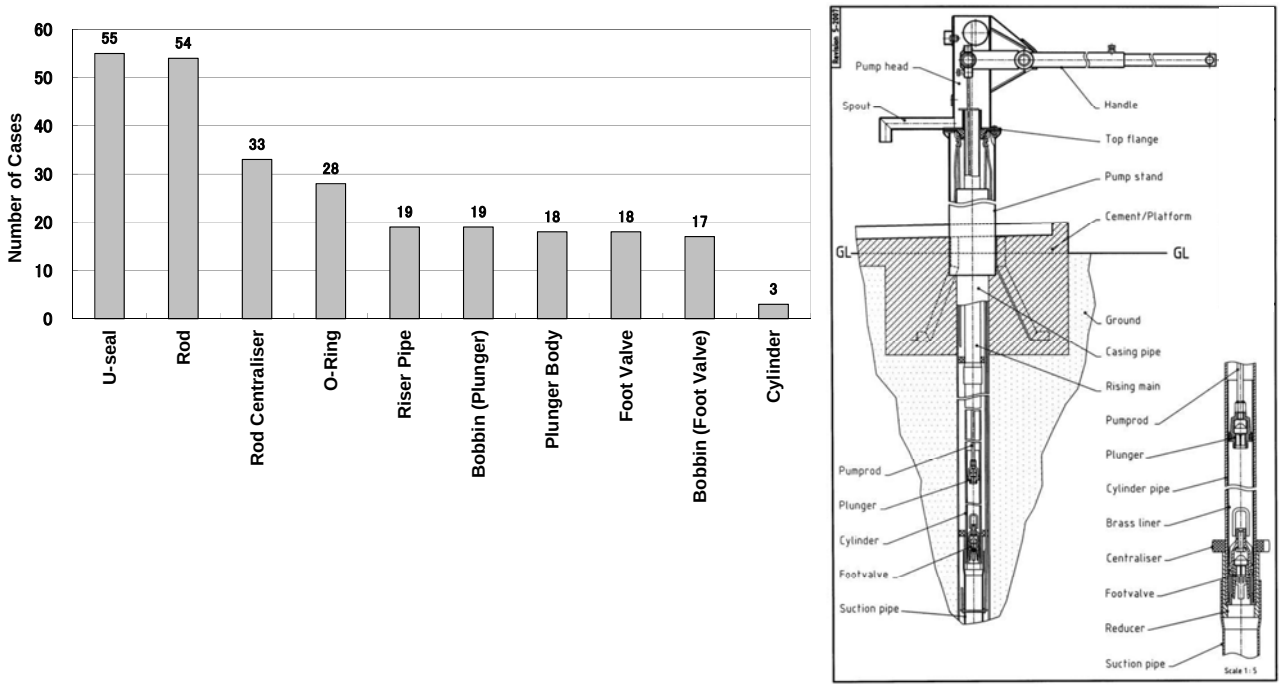


Fig. 1-3-3 Histogramme of the Breakdown Parts of a Hand Pump

5) Sediment in Borehole (Siltation)

Sampling of the sediment at the bottom of boreholes was conducted at 28 of the 300 boreholes surveyed and the analysis results are shown in Fig. 1-3-4 and Table 1-3-4. These results indicate that the deposit thickness at present is less than 1 m in the majority of boreholes. None of the sampled boreholes has a deposit thickness which covers the screen. A deposit thickness of less than 1 for boreholes which are 15 – 17 years old does not pose a serious problem. At two boreholes (No. 2-039 and No. 3-040), however, the distance from the upper end of the deposit to the lower end of the screen is 40 – 50 cm. Based on the siltation speed which is estimated based on the actual deposit thickness, clogging of the screen could start in 1 – 3 years' time at these boreholes. There is a similar concern for 5 – 10% of the entire boreholes surveyed.

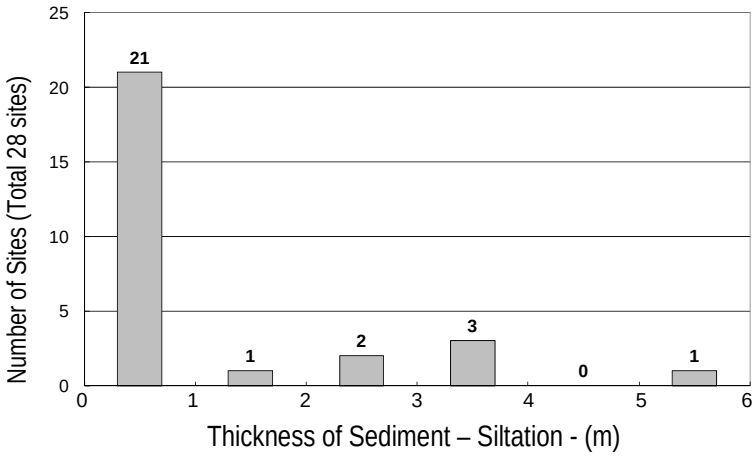


Fig. 1-3-4 Histogram of Deposit Thickness at the Bottom of Boreholes (m)

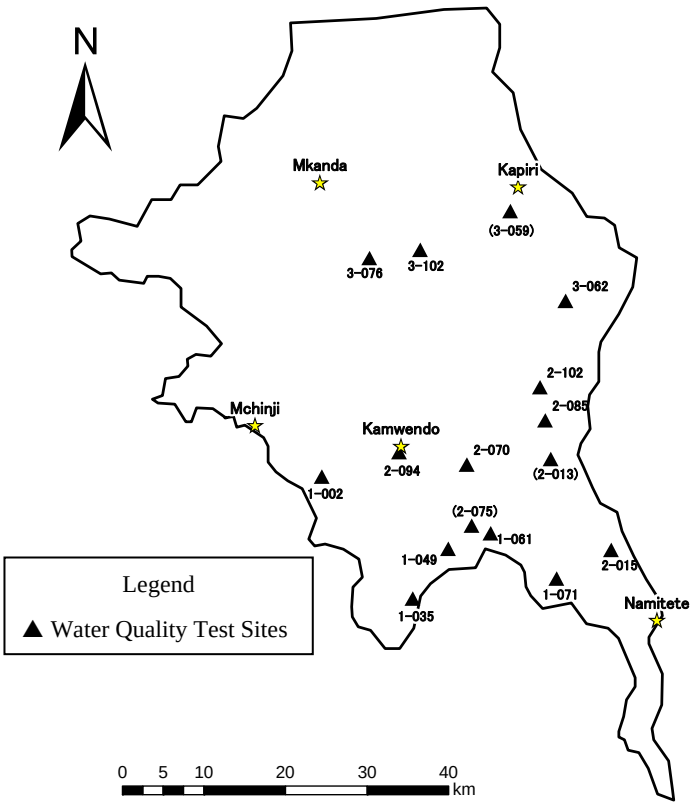
Table 1-3-4 Survey Results on Deposit in Borehole

Unit: m

Borehole No.	Original Depth	Latest Depth	Deposit Thickness	Screen Position	Distance to Lower End of Screen
1-030(2)	39	35.09	3.91	9-12, 21-24, 37-30	5.09
1-063	27	26.9	0.10	18-24	2.90
1-080	35.5	35.05	0.45	23.5-29.5	5.55
2-002	45	44.4	0.60	15-18,27-36	8.40
2-004	33	30.21	2.79	15-21, 24-27	3.21
2-020	37	36.95	0.05	22-28,31-34	2.95
2-034	30	29.2	0.80	12-15,18-24	5.20
2-039	36	33.4	2.60	15-18,24-27,30-33	0.40
2-053	36	34.8	1.20	12-15,18-21,24-27,30-33	1.80
2-067	32	31.15	0.85	20-29	2.15
2-076	30	29.8	0.20	15-21,24-27	2.80
2-079	27	26.69	0.31	6-12,15-18	8.69
2-087	23	22.65	0.35	9-15,18-21	1.65
2-103	45	44	1.00	6-18	26.00
2-108	33	30	3.00	6-18	12.00
3-024	39	38.07	0.93	27-36	2.07
3-040	36	30.5	5.50	18-24,27-30	0.50
3-065	36	36.8	-0.80	21-30	6.80
3-067	30	29.7	0.30	21-27	2.70
3-072	39	38.52	0.48	30-36	2.52
3-074	42	41.1	0.90	27-33,36-39	2.10
3-075	39	38.85	0.15	24-33	5.85
3-086	36	35.7	0.30	24-33	2.70
3-095	30	30	0.00	21-27	3.00
3-097	45	44.75	0.25	30-39	5.75
3-098	32	31.58	0.42	20-29	2.58
3-100	39	35.56	3.44	24-33	2.56
3-103	36	35.4	0.60	24-33	2.40

6) Water Quality

To determine the quality of the groundwater, a sampling survey was conducted at 24 of the 300 boreholes constructed by Japan in the Past. When a target borehole was not in working order, a groundwater sample was taken from another borehole or shallow well used as an alternative borehole. In total, this sampling was conducted at 13 boreholes subject to rehabilitation, three alternative boreholes and eight alternative shallow wells as shown in Fig. 1-3-5. When the analysis results of the sampled water in terms of the physical and chemical qualities are compared to Malawi's groundwater quality standard MS733:2005, none of the analysis results for the subject boreholes for rehabilitation exceeded the relevant reference value. In the case of the alternative boreholes, the pH value is low at one site (No. 2-075) and the turbidity value is high at another site (No. 2-013). In the case of the alternative shallow wells, the Na and K values tend to be slightly lower than those for the boreholes. In short, there are no significant differences between the boreholes and shallow wells in terms of the groundwater quality except that the turbidity value exceeds the reference value at two shallow wells.



ID No.	Name
1-002	Chiute
1-035	Chimteteka
1-049	Chimkoka
1-061	Bua T.C.
1-071	Mtonya
2-015	Mbwerera
2-070	Mazawa
2-085	Matimba
2-094	Kamwendo T.C.
2-102	Chetamba-la
3-062	Kavunguti school
3-076	Mphunda
3-102	Chitonde
(2-013)	Chamosola
(2-075)	Chiphala
(3-059)	Kapiri Roman Catholic

Those sites in brackets mean that the test was conducted at a borehole located nearby the subject borehole for the Project.

Fig. 1-3-5 Water Quality Test Results

Microbiological water quality analysis was conducted on fecal coliforms (FC) and fecal streptococci (FS) at all of the working boreholes (226) at the time of the survey. At the first stage, the water was sample in its normal usage condition (after cleaning of the spout, followed by pumping for five minutes). After initial sampling, 4 g of a chlorine agent (HTH; chlorine content of 70%) was diluted in 350 ml of water before pouring the mixture into each borehole for sterilisation. At those boreholes where the presence of FC and/or FS was confirmed, further sampling was conducted after at least two days of normal operation since sterilisation for fresh analysis. This procedure was employed to determine whether the positive detection of FC and/or FS was attributable to a contaminated borehole or contaminated groundwater.

At the first stage, FC and FS were detected at six sites each. In the resampling analysis after the injection of chlorine, FC and FS were again detected at one site each. The suspected cause of the former is groundwater contamination by a pit latrine near the borehole concerned while the suspected cause of the latter is groundwater contamination by excreta from pigs and other animals bathing in puddles of overflow water from a nearby soak pit.

Borehole where FC was detected: No. 3-043 Chalunda T.C.
Borehole where FS was detected: No. 3-102 Chitande

7) Sanitary Facilities Near Boreholes

Both the WHO Guidelines and the Installation and Maintenance Manual for Afridev Hand Pumps of the SKAT (Swiss Centre for Development Cooperation in Technology and Management) recommend that a borehole equipped with a hand pump should be constructed at least some 30 – 40 m away from a possible contamination source (the SKAT recommends 40 m from a toilet and 30 m from an animal shed). The distribution of sanitary facilities was checked as part of the present survey to determine the present conditions of such facilities around those boreholes constructed under the Groundwater Development Project in Mchinji. The types of facilities checked were pit latrines, waste disposal sites and animal sheds. Table 1-3-5 shows the check results. At 48 sites (30%), a pit latrine(s) was found within a radius of 15 m from the borehole. When the radius is increased to 30 m, as many as 156 boreholes (66%) have one or more pit latrines within this radius.

Table 1-3-5 Check Results for Sanitary Facilities Near Boreholes

Number of Contamination Sources (Number of Boreholes)	Distance from the Borehole		
	0 – 15 m	0 – 30 m	0 – 45 m
Pit Latrine	61 (48)	277 (156)	664 (209)
Rubbish Pit	3 (3)	30 (23)	54 (41)
Animal Kraal	33 (30)	122 (85)	123 (132)

(Total Number of Boreholes Checked: 236)

1- 4 Environmental and Social Consideration

(1) Environmental Impact Assessment

According to the Environmental Management Act (Act No. 23, 1996) and the Environmental Impact Assessment Guideline (Malawi), the Department of Environmental Affairs (DEA) judges the necessity of Environmental Impact Assessment (EIA) through the evaluation of the project document submitted by the developer/implementing agency for screening.

As the implementing body of the Project, MoAIWD and/or CRWB will be requested to submit the project brief to DEA for screening and to take required procedure for EIA following the suggestion from DEA. The CRWB has some experiences to conduct EIA and to take environmental measures for similar projects, and agreed to take required procedures and environmental measures.

(2) Land Acquisition and Involuntary Resettlement

Prior to the implementation of the Market Centre Project, the land acquisition will be required for construction of office buildings and water intake facilities. The planned locations for these facilities were set according to the agreement among the land owners, related group village head persons and the traditional chiefs. There are no residents and no dwellings on the proposed land. Therefore no objection is expected on the process of land acquisition which will be carried out by the implementing agency such as CRWB.

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

2-1-1 Overall Goal and Project Purpose

In Malawi, the access rate of people to safe water stood at 72% in 2006, prompting the Malawi Growth and Development Strategy (MGDS) prepared in November, 2006 to adopt a target of improving the rate in question to 80% by 2011. Another priority policy adopted by the MGDS was facilitation of the vitalisation and development of local cities and market centres throughout the country. The Joint Sector Review (JSR) in 2008 reported that the actual access rate was 65% in urban areas compared to 46% in rural areas where 31% of the water supply facilities were not functioned. Facing the critical importance of improving the functionality of water supply facilities in rural areas, the Government of Malawi (GoM) adopted a policy of reducing the ratio of non-functioning boreholes to 25% until 2016 in the draft of MGD II.

Under these circumstances, the Project aims at achieving a stable supply of safe water for people in the target areas through two sub-projects: (1) construction of water supply facilities and establishment of an operation and maintenance (O & M) system at Mkanda and Santhe Market Centres and (2) rehabilitation and construction of boreholes with a hand pump along with enhancement of O & M capacity at village level and the procurement of borehole rehabilitation equipment in Mchinji District.

Sub-Project (1) : Project for Water Supply Systems for Santhe, Mkanda and Namitete/Chileka Market Centres in Central Region
Sub-Project (2) : Project for Rehabilitation of Boreholes in Mchinji

The overall goal and project purpose are summarised below.

Overall goal : Facilitation of socio-economic development in the project areas

Project purpose : Improvement of access by local residents to safe water through the establishment of water supply facilities and system in the project areas

2-1-2 Basic Concept of the Project

2-1-2-1 Project for Water Supply Systems for Market Centres (Sub-Project (1))

Sub-Project (1) aims at the construction of new water supply facilities along with the establishment of an O & M system for these facilities to achieve its purpose. With the implementation of Sub-Project (1), new water supply facilities accompanied by an O & M system for these facilities will be provided at Mkanda and Santhe Market Centres. The requested Japanese assistance for Sub-Project (1) is the construction of the water supply facilities.

The required inputs and activities under Sub-Project (1) and the expected outputs of Sub-Project (1) are outlined below.

(1) Inputs of the Project

<Japanese Side>

[Construction of Facilities]

- Mkanda Market Centre

1) Water Intake Facility

- Intake Pump	0.38m^3/min×48m×5.5W×2 nos.
- Control Panel	2 sets (Outdoor Type)
- Exterior	2 sits (Fence and Gate)

2) Water Transmission Facility

- Transmission Pipe	DCIPφ100mm×0.4km
- Water Meter	1 set

3) Water Treatment Facility

- Chlorination Device	2 sets (Injection Pump and Storage with Mixer)

4) Water Distribution Facility

- Elevated Tank	180m^3×1 no.
- Distribution Pipe	PVCφ150mm～75mm×11.3km
- Communal tap	6 places (2-faucset type)

5) Buildings

- Control Building	1 building (6.3m×7.1m)
- Office Building	1building (9.7m×13.2m)

- Santhe Market Centre

1) Water Intake Facility

- Intake Pumps	0.120m^3/min×66m×4.0KW×3 nos.
	0.054m^3/min×92m×1.5KW×1 no.
	0.046m^3/min×87m×1.1KW×1 no
	0.036m^3/min×83m×1.1KW×1 no.
- Control Panel	6 sets (Outdoor Type)
- Exterior	6 sites (Fence and Gate)

2) Water Transmission Facility

- Transmission Pipe	DCIPφ150mm～75mm×2.5km
- Water Meter	1 no.

3) Water Treatment Facility

- Chlorination Device	2 sets (Injection Pump and Storage with Mixer)

4) Water Distribution Facility

Reservoir	$240m^3$×1 no.
Distribution Pipe	PVCφ150mm～75mm×16.1m
Communal tap	8 places (2-faucset type)

5) Buildings

Control Building	1 building (6.3m×7.1m)
Office Building	1 building (9.7m×13.2m)

[Human Resources]

Japanese Consultant

Japanese Contractor and Local Sub-contractor

<Malawi Side >

[Construction of Facility]

- Electric Power Supply to the Water Supply Facilities (Boreholes, Control Buildings, Office Building etc.)

[Human Resources]

- Counterparts of Central Region Water Board (CRWB)
- Counterparts of the Ministry of Agriculture, Irrigation and Water Development

[Local Cost]

- Project management cost of Central Region Water Board
- Project management cost of the Ministry of Agriculture, Irrigation and Water Development
- Initial Working Capital for the operation and maintenance for Water Supply Facilities in Mkanda and Santhe
- Expenses on tax exemption for imported construction equipment and materials in the Project

(2) Activities of the Project

[Construction of the Facilities]

- Construction of water supply facilities of the Project
- Wiring electricity up to the water supply facilities

[Establishment of the Operation and Maintenance (O & M) System]

- Assigning CRWB's staff for the water supply facilities in Mkanda and Santhe
- Training of the above staff for O & M and Management of the facilities
- Forming of understandings in local community on introducing water supply system through briefing of project concept for public hearing

(3) Outputs of the Project

- The water supply facilities are established in Mkanda and Santhe Market Centres
- The water supply facilities are properly operated and maintained under CRWB.

2-1-2-2 Project for Rehabilitation of Boreholes in Mchinji (Sub-Project (2))

Sub-Project (2) aims at the rehabilitation of existing boreholes in Mchinji, construction of new boreholes where necessary and procurement of rehabilitation equipment and tools for borehole. Such construction and procurement work will be accompanied by CBM activities aimed at user groups which are responsible for borehole O & M. The expected outputs are an increase of the number of people with access to facilities supplying safe water through a reduction of the rate of non-functioning boreholes, strengthening and improving the O & M capacity of users.

The required inputs and activities under Sub-Project (2) and the expected outputs of Sub-Project (2) are outlined below.

(1) Inputs of the Project

<Japanese Side>

[Rehabilitation and Construction of Facilities]

Target: The 300 boreholes constructed under Japan's Grant Aid in 1992 to 1995, and their benefited villages[1].

- Rehabilitation of boreholes (Dredging in boreholes and renewal of Pump) 280 boreholes
- Construction of substitute boreholes for boreholes unable to be rehabilitated 15 boreholes[2]
- Construction of additional boreholes for boreholes which have excessive users 39 boreholes

[Procurement of Machinery]

Machinery for borehole rehabilitation : 1 set

Items: Cargo truck with crane, Air Compressor, Diesel Engine Generator, Electric Winch, Submersible Motor Pump, Tools for Well Development (for Air lifting and Bailer), Potable Water Quality Tester/ Pumping Test Equipment, Supporting Vehicle (Pick-up Truck Single Cabin)

[Human Resources]

- Japanese Consultant
- Japanese Contractor and Local Sub-contractor

<Malawi Side>

[Construction of Facility]

- Securing land for construction of substitute boreholes and additional boreholes

[Human Resources]

[1] Following sites are excluded: two boreholes in Mkanda which is targeted by Water Supply Project for Market Centres, two boreholes affected by surrounding groundwater pollution and one borehole which the users have abandoned and constructed substitute one.

[2] Four boreholes are attempted to be rehabilitated under the Detailed Design Survey, and the rehabilitated boreholes are excluded from the targeted boreholes for construction.

- Counterparts of the Ministry of Agriculture, Irrigation and Water Development
  Department of Water Resources, Department of Water Supply Services and Regional Water Development Office (Centrre)
- District Coordination Team for Water and Sanitation (Mchinji District)

[Local Cost]

- Project management cost of the Ministry of Agriculture, Irrigation and Water Development
- Cost for execution of Community Based Management (CBM) Programme for sensitisation of operation and maintenance to borehole users
- Expenses for custom clearance and tax exemption, if necessary

(2) Activities of the Project

[Construction of the Facilities]

- Rehabilitation and Construction of boreholes of the Project
- Exploring groundwater and decision of drilling site, and getting agreement on acceptance of borehole from the village

[Establishment of the Operation and Maintenance (O & M) System]

- Establishment and Training of Water Point Committee
- Training of Extension Workers for CBM Programme applying to the Project

(3) Outputs of the Project

- Increasing access to safe water point with rehabilitation and construction of boreholes
- Reinforcement of capacity for borehole rehabilitation with procured machinery
- Improvement of water users' capacity for operation and maintenance of the targeted boreholes

2-2 Outline Design of the Japanese Assistance (Water Supply Systems for Market Centres)

2-2-1 Design Policy

(1) Basic Policies

The target areas of Sub-Project (1) are Mkanda Market Centre in the Mchinji District and Santhe Market Centre in the Kasungu District for the purpose of improving the access of residents in the target areas to safe water.

The responsible organisation for Sub-Project (1) on the Malawi side is the Ministry of Agriculture, Irrigation and Water Development (MoAIWD). The Central Region Water Board (CRWB) will conduct operation and maintenance of the facilities to be constructed under Sub-Project (1) by means of dispatching staff members to the said facilities.

The basic policies regarding the outline design of water supply facilities for market centres are described below.

1) In regard to Mkanda Market Centre, the request by the Malawi side involved a plan to take water from Liwelezi River for treatment at a water treatment facility equipped with a rapid sand filtration system. However, as the field survey found that it is feasible to develop a groundwater supply of sufficient quality and quantity in the area, it is now planned to construct a new water supply facility using a new borehole as the supply source.

2) At Santhe Market Centre, six (6) exploratory drillings conducted as part of the field survey found that the capacity of six boreholes would be sufficient to supply water up to the target year (2020). However, as the facility could not be equipped with a reserve water supply source it is required to reduce amount of water supply or water supply area when stoppage of the intake pumps due to a breakdown or periodic inspection happens.

3) Based on the result of the field survey, including analysis of river flow data and test borehole drilling, it was found that it would be extremely difficult to develop a new water supply source using either surface water (river water) or groundwater at Namitete/Chileka to cover the water demand. Consequently, the Namitete/Chileka Market Centre would be out of the scope of Sub-Project (1). (Refer to Appendix 6-1, Evaluation of Water Source for Market Centres)

4) Based on the above basic policies, water treatment facilities will be constructed to chlorinate the raw water (groundwater) from the boreholes. The treated water will then be stored at either a newly constructed elevated tank or reservoir for distribution to local residents via communal taps.

The Japanese grant aid assistance for Sub-Project (1) will be the construction of the water supply facilities described above. Meanwhile, the Malawi side will be responsible for the establishment of an O & M system (including the training and dispatch of staff members of the CRWB) for the new water supply facilities. The cost of this work will be borne by the Malawi side along with the cost of connection to any service taps other than the proposed communal taps if such taps are to be installed.

The construction work will be conducted by a Japanese contractor. Local subcontractors will also be employed to conduct the construction work under the supervision of the Japanese contractor to maximise the outputs with limited inputs. The construction work will be subject to overall supervision by a Japanese consulting firm which will provide consultancy services in terms of quality control, schedule control and other key aspects of the work.

(2) Natural Conditions

1) Climate

Malawi belongs to the tropical savannah climate zone with the rainy season lasting from December to March and the dry season for the rest of the year. The target areas of Sub-Project (1) are located on a highland plateau (elevation of 1,050 m to 1,300 m) in central Malawi and the annual rainfall is approximately 900 mm, of which some 94% falls during the four month long rainy season.

It is anticipated that the work efficiency, especially for the piping work involving the excavation of trenches, will decline during the rainy season. For this reason, the planning of the work schedule for Sub-Project (1) will incorporate anticipated off-days due to rain and other reasons. While there are unpaved local roads of which the passability by large vehicles is difficult during the rainy season, both Mkanda and Santhe Market Centres are on the paved trunk road network and, therefore, the transportation of the construction materials during the rainy season will not pose any problems for Sub-Project (1).

2) Soil and Geological Conditions

The boring survey has confirmed that a soil formation with an N value of 18 or high exists to a depth of some 2 m from the surface at the planned construction sites for the elevated tank serving Mkanda Market Centre and the reservoir serving Santhe Market Centre, suggesting a sufficient soil bearing capacity. Accordingly, spread foundations will be adopted for these facilities. As the distribution routes are expected to encounter a fairly consolidated layer of laterite, suitable machinery to conduct the trench excavation work (accounting for some 10% of the entire distribution length) will be selected to deal with this laterite layer. The cost of this work will be included in the estimated construction cost.

3) Hydrogeological Conditions and Water Quality

The exploratory drilling of the borehole serving Mkanda Market Centre confirmed the viability of constructing two boreholes with a supply capacity of 8.0 litres/sec and one borehole with a supply capacity of 3.5 litres/sec, suggesting that the available water supply capacity will comfortably exceed the design water supply volume. In contrast, the expected water supply capacity of the boreholes serving Santhe Market Centre is much lower than that of the boreholes serving Mkanda Market Centre and the construction of three boreholes with a supply capacity of 2.0 litres/sec each and three further boreholes with a supply capacity of 0.90 litres/sec, 0.76 litres/sec and 0.60 litres/sec respectively is planned. Although the total water pumping capacity of these six boreholes of 8.26 litres/sec (= 714 m^3/day) is sufficient to meet the design water supply volume for Santhe Market Centre, these boreholes will not provide any surplus capacity. In terms of the water quality, all of the planned boreholes can function as reliable tap water supply sources and disinfection by means of chlorination will be sufficient to produce safe water.

(3) Socio-economic Conditions

1) Infrastructure

Santhe Market Centre is situated along a paved trunk road. In the case of Mkanda Market Centre, the paving of the trunk road is scheduled to be completed by the end of 2011. As such, no access problems between Lilongwe, the capital of Malawi, and either area are anticipated when Sub-Project (1) starts. Meanwhile, urban and rural roads in these areas are unpaved and the use of four-wheel drive vehicles will be necessary to use these roads. While commercial power supply is currently unavailable at Mkanda Market Centre, the power grid extension work currently in progress by an electricity company (ESCOM) is scheduled to be completed by the end of 2011. Given this prospect, the use of commercial power supply is planned for the new water supply facilities to be constructed at Mkanda and Santhe Market Centres under Sub-Project (1).

2) Socioeconomic Conditions

The living environment in Malawi is classified into four types in terms of the housing density: (i) high density (traditional), (ii) high density (permanent), (iii) medium density and (iv) low density. Low density means wealthy households where there is a good distance between neighbouring households and large premises enclosed by hedging or fencing. In contrast, traditional dwelling means houses constructed with an earth floor and simple walls and roof. High density (permanent) means houses which have a simple construction but which have a more solid floor (concrete or other) compared to that of the traditional type. Medium density means a style of house which falls between a low density type house and a high density type house. At both Mkanda and Santhe Market Centres, high density (permanent and traditional) types of houses account for some 80% of the entire households.

Mkanda and Santhe Market Centres function as the economic centres of their respective areas and self-employed people engaged in commerce and people working in the commerce sector account for some 75% of the working population. Agriculture accounts for only some 22% of the local working population who are mainly engaged in the cultivation of maize or tobacco. The social condition survey conducted as part of the field survey found that the mean annual household income is MK. 146,152 for Mkanda Market Centre and MK. 167,248 for Santhe Market Centre.

3) Water Supply and Sanitation

At present, Mkanda Market Centre and Santhe Market Centre have 6 and 11 hand pump-operated boreholes respectively. The number of people using these boreholes which are thought to be relatively hygienic is estimated to be 1,700 (34%) at Mkanda Market Centre and 3,500 (61%) at Santhe Market Centre. Other local residents have to rely on traditional dug wells, small streams and storage ponds for water supply even though these are not particularly hygienic.

The principal waterborne diseases in the sub-project areas are diarrhoea, dysentery and cholera. According to data kept by Mkanda Health Centre, 485 cases of dysentery and 15 cases of cholera were reported in the three year period from 2008 to 2010 (no data for diarrhoea). In the same period, data kept by Santhe Health Centre shows 1,252 and 48 reported cases of diarrhoea and dysentery respectively. The high level of waterborne diseases in the areas illustrates the strong need for the urgent improvement of the water supply and sanitation in these areas through the implementation of Sub-Project (1).

4) Water Supply Method and Willingness to Pay

The social condition survey conducted as part of the field survey found that the water supply methods preferred by local residents of Mkanda and Santhe Market Centres are communal taps (22%) and individual connections (78%) of which a yard tap and full plumbing are preferred by 48% and 30% respectively, indicating that nearly 80% of local residents prefer individual connections. Meanwhile, 89% of the respondents showed a “willingness to pay” while only 5% and 6% said that they are “unwilling to pay” and “do not know yet” respectively, indicating a high level of willingness to pay among local residents. Those respondents preferring service connection to individual households were further asked about their willingness to pay the water charge and the estimated likely level of water charge based on their current water consumption was presented. 78% of the respondents still expressed a willingness to pay at the shown level while 9% and 13% opted for “unwilling to pay” and “do not know yet” respectively. Even though the ratio of respondents who expressed a willingness to pay declined, some 80% of the respondents still prefer to pay for house connection. Given this figure, obtaining the consent of local residents for payment for the water supply service to be developed through the implementation of Sub-Project (1) is judged to be feasible.

(4) Construction and Procurement Conditions

1) Related Laws, Standards and Regulations

In Malawi, the development of standards for the construction of water supply facilities and the standardisation of their design have been in progress and a standard design already exists for water intake facilities, reservoirs, distribution pipes, buildings and others. In view of this, the outline design of the water supply facilities to be constructed under Sub-Project (1) will incorporate the standard design for those facilities for which a local standard design is available. Meanwhile, for those facilities for which local design standards are not clearly available, the relevant design will follow the relevant Japanese design standards underline by the Guidelines for the Design of Water Supply Facilities Explained (published by the Japan Water Works Association in 2010) and the Practical Companion for Water Works (2010 Edition published by the Japan Small-Scale Water Works Association). The specifications of all materials and equipment to be used for Sub-Project (1) will meet the relevant JIS and/or ISO standards.

2) Local Construction Companies

Many local construction companies in Malawi have experience of water supply facility construction work for current or past aid projects involving donors and/or international organisations. It is, therefore, possible to select technically reliable local construction companies as subcontractors as long as the work involved is general civil engineering work and not work which requires special skills.

3) Capability of Workers

It is relatively easy in Malawi to secure the services of well-experienced local engineers and skilled workers (joiners, plasterers, reinforcing iron workers and plumbers) through local construction companies. However, they will find it difficult to meet the technical standard required of work associated with Japan's grant aid scheme without external assistance. For this reason, Japanese engineers and skilled workers in various fields will be dispatched to Malawi to provide guidance for local workers. The necessary adjustment of the project cost estimation, including an increase of the unit labour cost, will be made in view of the technical level of the local workforce.

4) Quality and Procurement of Equipment and Materials in the Local Market

In Malawi, it is possible to procure such construction materials as cement, concrete aggregates, reinforcing bars and forms as well as plumbing materials in the local market. It is also possible to procure submersible motor pumps for boreholes, steel panels for reservoirs and other equipment through agents in Malawi. As all of the planned equipment and materials for Sub-Project (1) can be procured in either Japan or Malawi, procurement from a third country will not be required.

(5) Employment of Subcontractors

As described earlier, local construction companies in Malawi are judged to have reached a certain technical standard required for the construction of water supply facilities through their current and past involvement in the relevant projects. However, their capability in terms of quality control and schedule control appears to fall short of the standard required by Japan's grant aid scheme. Although local construction companies will be employed as subcontractors for Sub-Project (1) to maximise the outputs with limited inputs, they will work as subcontractors under the control and supervision of the Japanese contractor to ensure the required quality and schedule of the construction work.

(6) Operation and Management of Sub-Project (1)

The CRWB will undertake the O & M of the water supply facilities to be constructed under Sub-Project (1). The CRWB is currently responsible for water supply in major local cities and market centres in the Central Region. From the organisational point of view, the CRWB is under the jurisdiction of the MoAIWD. Although its general manager is appointed by the MoAIWD, it can independently recruit other staff members. It is operated on a stand-alone basis and is, therefore, highly independent from the central government.

The work of the CRWB includes the O & M of water supply facilities equipped with a rapid sand filtration system and the collection of the water charge in such district capitals with a relatively large population as Mchinji and Dedza. Because of this, the CRWB has certain experience and know-how regarding the technical and operational aspects of the water supply business. The new water supply facilities to be constructed under Sub-Project (1) at Mkanda and Santhe Market Centres will be operated and maintained by the CRWB through the dispatch of its staff members who have the necessary expertise. As these new water supply facilities are simple facilities using groundwater and disinfection by means of chlorination, the provision of training on the O & M of these facilities as a separate soft component of Sub-Project (1) is judged to be unnecessary. Guidance on the operating methods of the water pumps and chlorination devices to be installed under Sub-Project (1) will be provided by an engineer(s) of the Japanese contractor at the time of completion to the Malawi side (CRWB operators to be dispatched to Mkanda and Santhe Market Centre as well as engineers at the Head Office of the CRWB) and no special technical guidance on O & M will be provided as an independent component of Sub-Project (1).

(7) Grade of Facilities and Equipment

The grade of the water supply facilities to be constructed under Sub-Project (1) shall satisfy the following conditions.

1) The facilities must have sufficient durability against the weather conditions at the project sites.

2) The facilities can be constructed using methods and specifications which the local subcontractors in Malawi are capable of following under the supervision of the Japanese contractor.

3) The facilities can be operated and maintained with the knowledge and skills possessed by the staff to be dispatched by the CRWB.

4) The facilities enable local residents to fully recognise the convenience of the water supply service in the light of their demands in terms of the quantity and quality of water, water pressure, supply hours, distance from a communal tap to the home and other aspects and promote the development of a willingness to pay for the service on the part of local residents.

5) The facilities should allow a low O & M cost and an affordable tariff for the water supply service for local residents.

(8) Construction and Procurement Methods and Construction Period

1) Construction and Procurement Methods

The envisaged construction work under Sub-Project (1) does not involve any special methods and will be conducted using general construction machinery and manual labour. In principle, such civil engineering work and building work materials as cement and reinforcing bars will be procured in Malawi along with the procurement of general construction machinery. Meanwhile, the water pumps and materials (steel panels) for the reservoir and elevated tank will be procured through agents in Malawi.

2) Construction Period

The construction work for Sub-Project (1) consists of civil engineering work, including the construction of intake facilities, reservoir and elevated tank and piping work, and building work for the Control Building and office. The total length of the planned piping work is as long as some 30 km and this work is likely to constitute a critical path when the procurement period for the piping materials is added to the period of the actual piping work. The piping work will, therefore, be conducted by multiple work parties in consideration of the overall construction schedule to allow the completion of other types of work in time. The overall construction schedule will be finalised with due consideration of the rainy season during which the work efficiency (productivity) is likely to decline and other natural conditions, etc. which may possibly affect the progress of the work.

2-2-2 Basic Plan (Construction Plan/Procurement Plan)

2-2-2-1 Overall Plan

Table 2-2-1 shows the basic plan for Market Centres (water supply area, served population, basic figures for calculation of the planned water supply volume, layout and contents of the facilities and other items) and O & M system, following the findings of the field survey.

Table 2-2-1 Basic Plan of Water Supply Facilities for Market Centres

Items	Mkanda Market Centre	Santhe Market Centre
1. Water supply area	The area agreed with Malawi side for Mkanda, Mchinji District	The area agreed with Malawi side for Santhe, Kasungu District
2. Target year	2020	- ditto -
3. Served population	7,051 - Population (2008): 4,666 - Growth rate: 3.5% per year	7,485 - Population (2008): 5,437 - Growth Rate: 2.7% per year
4. Per capita consumption	46.2lcd (litre per capita per day) for domestic consumption - Following the standardized rate by dwelling category in Malawi. The weighted average on the proportion of categorized population.	57.1lcd (litre per capita per day) for domestic consumption - ditto -
5. Public Water	Anticipated as 25% of total domestic water	- ditto -
6. Leakage Ratio	10% * All distribution lines are newly constructed	- ditto -
7. Rate of Loading	1.20 - standardised rate in Malawi	- ditto -
8. Hourly Factor	2.40 - standardised rate in Malawi	- ditto -
9. Planned water supply amount	Average daily: 453m^3/day Maximum daily: 544m^3/day Maximum hourly: 45.3m^3/hour	Average daily: 593m^3/day Maximum daily: 712m^3/day Maximum hourly: 59.3m^3/hour
10. Water Source	Two of three boreholes constructed through the Preparatory Survey, which have the capacity 8.0L/sec (= 691m^3/day) each. One of two boreholes is normally standby	Six boreholes constructed through the Preparatory Survey, which have the maximum capacity 8.26 L/sec (= 714 m3/day) in total. * Required borehole(s) for standby shall be constructed by Malawi side in future.
11. Treatment Process	Water Quality has no problem as a source of water supply according to the water quality test for borehole water. Treatment will be done by dosing Chlorinated Lime	- ditto -

Items	Mkanda Market Centre	Santhe Market Centre
12. Layout of Facilities	Intake Well: 2 boreholes Elevated Tank: 1 unit Control House: 1building Management Office 1building Communal Tap: 6 sites Layout is shown in Fig. 2-1-1	Intake Well: 6 boreholes Service Reservoir (Ground Type) 1 unit Control House: 1 building Management Office: 1 buiding Communal Tap: 8 sites Layout is shown in Fig. 2-1-2
13. Facilities and Equipment	[Water Intake] - Intake Pump 2 sets - Control Panel (Out door) 2 sets - Exterior (Fence) 2 sites [Water transmission facility] - Transmission Pipe φ100mm L=0.4km - Flow meter 1 set [Treatment Equipment] - Chlorination device 2 sets [Distribution facilities] - Elevated Tank, 180m^3 1 unit - Distribution pipe φ150-75mm L=11.3km - Communal Tap 6 sites [Buildings] - Control House 1 building - Management Office 1 building	[Water Intake] - Intake Pump 6 sets - Control Panel (Out door) 6 sets - Exterior (Fence) 6 sites [Water transmission facility] - Transmission Pipe φ150-75mm L=2.5 km - Flow meter 1 set [Treatment Equipment] - Chlorination device 2 sets [Distribution facilities] - Ground Tank 240m^3 1 unit - Distribution pipe φ150-75mm L=16.1km - Communal Tap 8 sites [Buildings] - Control House 1 building - Management Office 1 building
14. Operation and maintenance organisation	CRWB despatches his staff and manage O & M of the facilities, and undertake the service. Followings are anticipated staff - Manager: 1 person - Accountant 1 person - Maintenance and management 1 person - Operation and management 2 persons - Meter Reading 3 persons	CRWB despatches his staff and manage O & M of the facilities, and undertake the service. Followings are anticipated staff - Manager: 1 person - Accountant 2 person - Maintenance and management 2 person - Operation and management 2 persons - Meter Reading 3 persons

2-2-2-2 Basic Plan

(1) Water Supply Areas

The target water supply areas of Sub-Project (1) are the two market centres of Mkanda and Santhe and the water supply areas are the existing urbanised areas and their immediate surrounding areas as discussed and agreed between the Survey Team and the Malawi side in the course of the field survey.

(2) Target Year

Under Japan's grant aid scheme, the target year is generally set at some three years after the completion of the facilities. While the Malawi side has requested a target year of 2025 in consideration of consistency of setting projected served population with the National Water Development Programme (NWDP II) which is currently in progress with the cooperation of another donor. The target year for Sub-Project (1) is decided to be set at 2020 after discussions on the matter.

(3) Population of the Water Supply Areas

Table 2-2-2 shows the population of Mkanda Market Centre and Santhe Market Centre based on the 2008 Census and the expected population receiving the water supply service in the target year of 2020.

Table 2-2-2 Planed Served Population

Market Centre	Current Population (2008)	Growth Rate* (%)	Projected Population (2020)	Remarks
Mkanda	4,666	3.5	7,051	
Santhe	5,437	2.7	7,485	

* According to National Housing and Population Census (2008), Growth Rate in Mchinji District (1998-2008) is applied to Mkanda, and one in Kasungu District (1998-2008) for Santhe

(4) Per Capita Consumption

Table 2-2-3 shows the per capita consumption of water of households of each of the four housing density types based on the water supply criteria of the CRWB.

Table 2-2-3 Categorised Water Consumption (Domestic Water)

Category of Area	Type of Tap	Per Capita Consumption (litre/person/day)	Served persons per tap
Traditional Housing Area	Communal Tap	36	200
High Density Housing Area	Yard Tap	50	20
Medium Density Housing Area	Full Plumbing	80	6
Low Density Housing Area	Full Plumbing	125	6

Past studies on Mkanda and Santhe Market Centres used the figures shown in Table 2-2-4 as the basis for the proportion of population by housing density type for calculation of the per capita consumption of water. These figures are also used for the planning of the per capita consumption for Sub-Project (1).

Table2-2-4 Proportion of Categorised Population (Feasibility Study)

Category of Area	Mkanda *1	Santhe *2	Remarks
Traditional Housing Area	68%	30%	
High Density Housing Area	16%	43%	
Medium Density Housing Area	14%	20%	
Low Density Housing Area	2%	7%	
Total	100%	100%	

Source: *1: Detailed Design for New Urban and Rural Gravity Fed Water Schemes Report
*2: 16 New Water Supply Schemes Feasibility Study Report

(5) Water Supply for Public Facilities

The water supply criteria in Malawi identify the water consumption at schools, hospitals, hotels, government facilities, offices, commercial facilities, factories and other places as "public water consumption" to calculate the design water supply volume. The actual water supply volume for public consumption is determined using a set ratio to the household water consumption volume. This ratio, in fact, varies from one city to another depending on the characteristics of each city and there is no standard ratio. Reports for past studies have adopted a ratio of approximately 20% to 30%. The ratio of public water consumption to household water consumption is set at 25% for Sub-Project (1).

(6) Leakage Rate

The amount of water leakage from the water supply system varies depending on the degree of deterioration of the distribution pipelines, level of water supply pressure and other factors.

According to a past study for the Kasungu District (Design of Rehabilitation and Expansion Works for Kasungu Water Supply Scheme, 2009), the water leakage rate in the area in question is estimated to be 31.1%. This high level of water leakage is thought to be attributable to the old distribution pipes in the area which were laid in the 1950's through the 1970's. The gradual replacement of these old pipes by 2015 is planned with a view to reducing the water leakage rate to 18%.

There are no existing water supply facilities in Mkanda and Santhe Market Centres which are the two subject areas of Sub-Project (1) and all water supply facilities, including pipelines, will be newly

constructed under this project. For this reason, the water leakage from the planned water supply facilities should be minimal. However, a water leakage rate of 10% is employed for Sub-Project (1) in view of the eventual occurrence of water leakage with the ageing of the facilities.

(7) Load Factor and Hourly Factor

The per capita consumption at the households described in (4) above is the annual average. In fact, the water demand fluctuates throughout the year depending on the temperature and other factors, reaching a peak in hot dry periods of the dry season. When designing water supply facilities, it is essential for these facilities to be capable of supplying the "maximum water supply volume per day" which takes annual fluctuations of the water demand (load factor) into consideration.

The final decision on the size (i.e. diameter) of the distribution pipes must be determined based on the demand fluctuation rate (hourly factor) within a day so that the maximum hourly water supply volume can be distributed by means of ensuring the availability of the required water pressure during the morning and evening peak demand periods. As the relevant standards in Malawi as well as ongoing projects of other donors adopt a load factor of 1.2 and a hourly factor of 2.4, these values will also be adopted for Sub-Project (1).

(8) Planned Water Supply Volume

Using the various values which are relevant for calculation of the water supply volume as examined in (3) through (7) above, the planned water supply volume in the target year of 2020 is calculated for Mkanda and Santhe Market Centres as shown in Table 2-2-5.

Table 2-2-5 Planned Water Supply Amount

	Mkanda	Santhe	Remarks
1. Population (persons)	7,051	7,485	2020
2. Daily Consumption per capita (lcd)	46.2	57.1	Domestic Water *
3. Domestic Consumption (m^3/day)	326	427	1×2÷1000
4. Public Consumption (m^3/day)	82	107	3×25%
5. Total Demand (m^3/day)	408	534	3+4
6. Average Daily Water Supply (m^3/day)	453	593	5÷(1-0.10)
7. Maximum Daily Water Supply (m^3/day)	544	712	6×1.2
8. Maximum Hourly Water Supply (m^3/hour)	45.3	59.3	6×2.4÷24

*: Average Water Supply per capita (Domestic Water)
Mkanda Market Centre: 36×68%+50×16%+80×14%+125×2% = 46.2 lcd
Santhe Market Centre = 36×30%+50×43%+80×20%+125×7% = 57.1 lcd
Calculated according to Table 2-1-3

(9) Water Sources

As part of the field survey, the exploratory drillings of boreholes were conducted at three sites in Mkanda Market Centre and at six sites in Santhe Market Centre. The discharge of each test borehole based on the pumping test results is shown in Table 2-2-6 and Table 2-2-7.

Table 2-2-6 Discharge of Intake Well (Mkanda Market Centre)

Borehole No.	Capacity of Well		Ground Level (m)
	Litre/sec	m^3/day	
MK-1	3.5	302	1096.40
MK-2	8.0	691	1095.55
MK-3	8.0	691	1095.25
Total	19.5	1,684	

Table 2-2-7 Discharge of Intake Well (Santhe Market Centre)

Borehole No.	Capacity of Well		Ground Level (m)
	Litre/sec	m^3/day	
ST-1	2.0	173	1091.77
ST-2	2.0	173	1089.14
ST-3	2.0	173	1088.51
ST-4	0.90	78	1087.63
ST-5	0.76	65	1082.48
ST-6	0.60	52	1084.84
Total	8.26	714	

*: Dynamic Water Levels for ST4, 5 and 6 are estimated as 3.30m below the observation in May 2011

At Mkanda Market Centre, two out of three test boreholes can independently supply a maximum daily water supply volume of 544 m^3 in the target year of 2020. Because of this, these two boreholes will be developed as intake wells for Sub-Project (1) (one will act as a reserve well).

At Santhe Market Centre, the total pumping capacity of the six test boreholes is 714 m^3. This means that the maximum daily water supply volume of 712 m^3 in the target year of 2020 will be met if the need for a reserve well is ignored. These six test boreholes will, therefore, be developed as intake wells for Sub-Project (1) as part of the water supply facilities to meet the planned water supply volume in 2020. A reserve well should be constructed by the Malawi side at an appropriate time.

(10) Treatment Method

The analysis results of the raw water sampled from the test boreholes mentioned above at Mkanda and Santhe Market Centres can be used as household water supply sources without any problems. For the

supply of water under Sub-Project (1), the raw water will be treated only by the chlorination process (using a high purity bleaching powder) for disinfection.

(11) Water Supply Method

Under Sub-Project (1), water will be supplied using communal taps as well as individual connections at both market centres. 14 communal taps (two faucet type), i.e. six at Mkanda Market Centre and eight at Santhe Market Centre, will be installed under Sub-Project (1) as agreed with the Malawi side at the time of the field survey. Meanwhile, individual connections will be installed at the expense of the Malawi side.

(12) Proposed Construction Sites for Various Facilities

1) Water Intake Facilities

For the construction of the water intake facilities for Sub-Project (1), the exploratory boreholes constructed during the field survey will be developed into intake wells. The land around two (MK-2 and MK-3) out of the three exploratory boreholes at Mkanda Market Centre and the six similar boreholes at Santhe Market Centre will be acquired for the development of water intake facilities.

2) Elevated Water Tank and Reservoir

As the topography of the water supply area at Mkanda Market Centre is generally flat, an elevated tank will be constructed to obtain the necessary water pressure for distribution. In consideration of the general topography and elevation of the area based on the surveying results, it is judged to be appropriate to locate this elevated tank at the MK-1 site where an exploratory borehole was drilled. In contrast, a reservoir (on the ground type) will be introduced on a hill which is located near the proposed intake well sites.

3) Communal taps

Communal taps will be installed at six sites at Mkanda Market Centre and eight sites at Santhe Market Centre, totalling 14 communal taps, as agreed with the Malawi side as well as local residents during the field survey.

4) Water Transmission Facilities

At Mkanda Market Centre, water transmission pipelines will be constructed from the MK-2 and MK-3 boreholes, which will be developed into intake wells, to the elevated tank. As these pipelines can be laid beneath existing roads or farmland, the resettlement of residents due to the required work will be unnecessary.

5) Water Distribution Facilities

At both Mkanda Market Centre and Santhe Market Centre, a trunk road runs through the middle of the town, dividing the built-up area. At this section, the water distribution pipeline will run on both sides of the said trunk road. In the built-up area with a high population density, cross water distribution pipes will be laid at suitable intervals to create a water distribution network. As these distribution pipes will be laid beneath an existing road or right of way, the resettlement of residents due to the required work will be unnecessary. During the trench excavation work to lay the distribution pipes at both Mkanda Market Centre and Santhe Market Centre, rock excavation work (consolidated laterite with the hardness of soft rock) will be required for approximately 10% of the total length.

6) Control Building and Office Building

A Control Building normally accommodates the operating panel for the intake pumps and chlorination device for disinfection. Given the fact that several intake wells will be constructed under Sub-Project (1), however, an outdoor-type intake pump operating panel will be installed at each intake well site to avoid the centralised operation of the intake pumps. In contrast, it is rational to inject chlorine to the elevated tank and reservoir to which raw water will be conveyed from the multiple intake wells and, therefore, a Control Building accommodating the chlorination device will be constructed at these sites under Sub-Project (1). Meanwhile, an office building which also functions as a water charge payment centre will be constructed at a town centre location with the agreement of the Malawi side.

The general layout plan for the water supply facilities (intake facility, elevated tank, pipelines and others) is shown in Fig. 2-2-1 (Mkanda) and Fig. 2-2-2 (Santhe) based on the examination results described above.

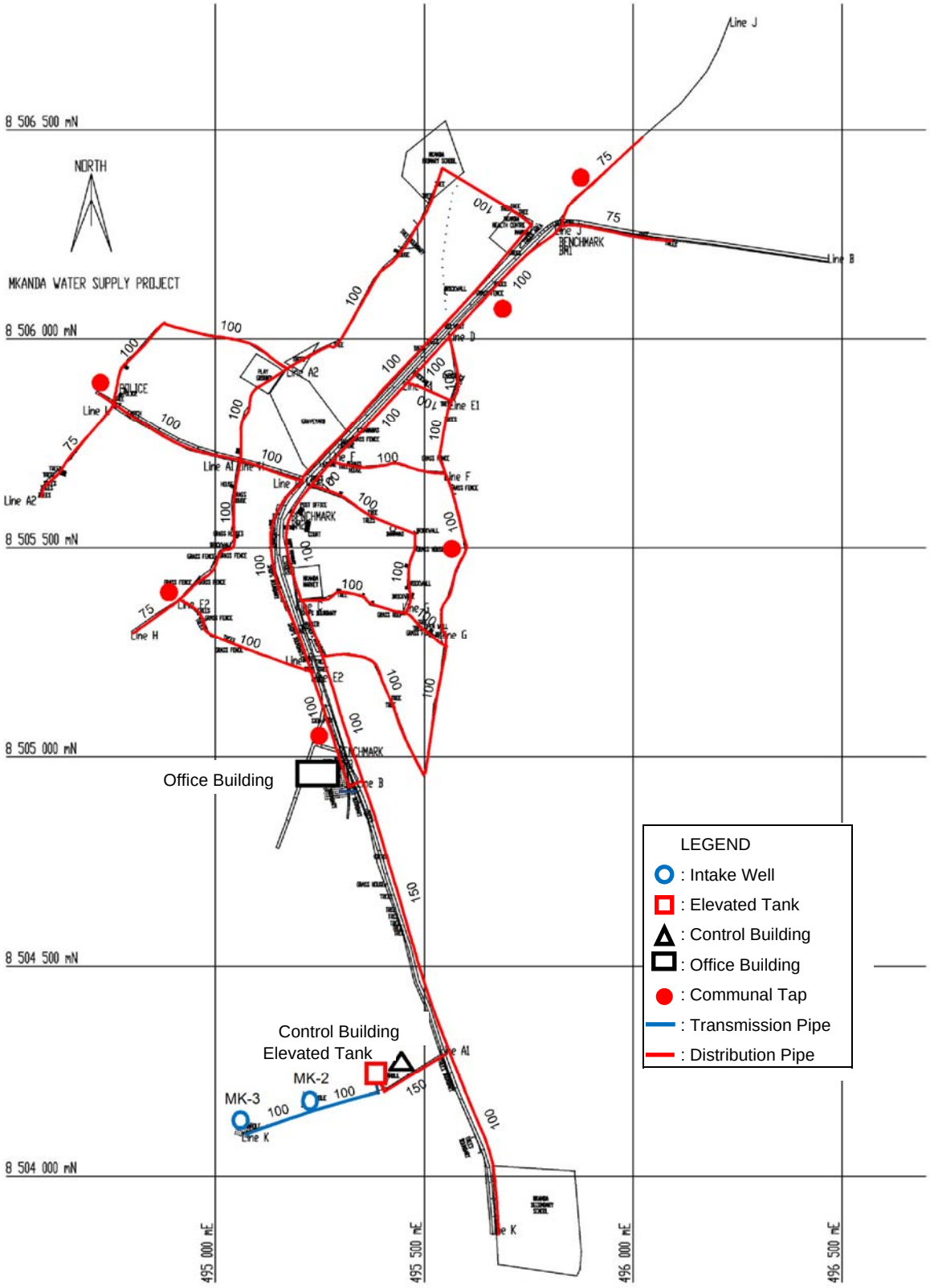


Fig. 2-2-1 Layout of Water Supply Facilities in Maknda Market Centre

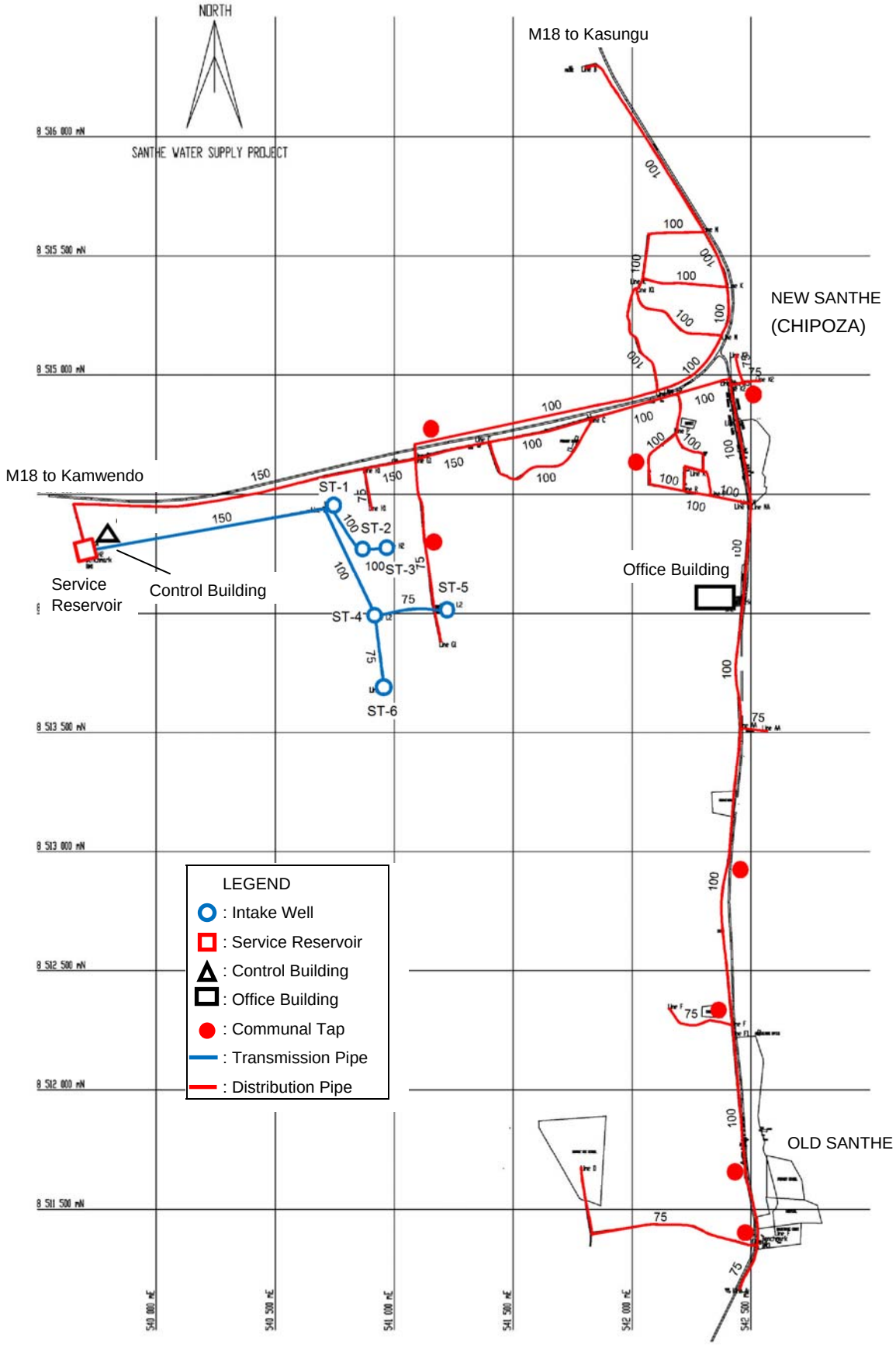


Fig 2-2-2 Layout of Water Supply Facilities in Santhe Market Centre

2-2-2-3 Outline Design

The outline design for the proposed facilities has been prepared based on the basic plan contents described in the previous section and data and information obtained through the field survey (involving surveying, geological survey and other work). The design conditions, scale and specifications of the proposed water supply facilities to be constructed under Sub-Project 1 are described below.

(1) Intake Facility

1) Intake Pump

The Pumps raise groundwater to the elevated tank or the ground tank (service reservoir) from the intake wells. Design conditions and the planned facility are as follows:

[Design conditions]

- Elevation	Actual pump head is set as a difference between H.W.L. of Elevated Tank/ Service Reservoir and dynamic water level in dry season for each intake well.
- Length (L)	Length of transmission pipe is estimated on the basis of the longitudinal survey result. Length of pipe in borehole is estimated from the pump installed 10m below the dynamic water level in dry season for each borehole. Length of pipe in the pumping yard is estimated adequately according to the layout of borehole and pipeline in the yard.
- Velocity coefficient (C)	110 (for DCIP and Steel pipe)
- Diameter (D)	Diameter of transmission pipe is set adequately according to hydraulic accounting. Nominal diameter is applied to rising main pipes in boreholes and pipes in the yards
- Pumping rate (Q)	0.38 m^3/min for each intake well in Mkanda Market Centre Maximum capacity of each intake well, shown in Table 2-1-7, is applied in Santhe Market Centre
- Head loss and total head	Head losses in the transmission pipe, the pipe in pump station yard and the intake well are added as a part of total actual head Detailed calculation of total head is shown in the hydraulic accounting sheet in Appendix

[Planned facility]

- Intake pump	Mkanda Market Centre 0.38 m^3/min x 48m x 5.5KW x 2 sets (Submersible motor pump) Santhe Market Centre 0.120 m^3/min x 66 m x 4.0KW x 3sets (Submersible motor pump) 0.054 m^3/min x 92 m x 1.5KW x1set (- ditto -) 0.046 m^3/min x 87 m x 1.1KW x 1set (- ditto -) 0.036 m^3/min x 83 m x 1.1KW x 1set (- ditto -)
- Accessories	Foot valve, sluice valve, check valve, pressure gauge
- Control Panel	Mkanda Market Centre : 2 sets (Outdoor Type) Santhe Market Centre : 6 sets (Outdoor Type)

(2) Water Transmission Facility

1) Water Transmission Pipe

Water transmission pipe between the intake wells and the elevated tank/ the service reservoir is installed to transmit the groundwater.

[Design conditions]

- Pipe selection	DCIP is applied for force main
- Velocity coefficient (C)	110 (for DCIP and Steel pipe)
- Diameter (D)	Diameter of transmission pipe is set adequately according to hydraulic accounting. For Santhe Market Centre which multiple boreholes are operated together, the diameter of pipe is examined that the pump head (or discharge) is not to be changed considerably even if the number of operating pumps is changed.
- Laying depth	1.2 m under the main road on which heavy vehicles pass 1.0 m under the other feeder roads in the market centres

[Planned facility]

- Transmission pipe	Mkanda Market Centre: φ100mm x 0.4 km Santhe Market Centre: φ150 to 75 mm x 2.5 km

Detailed dimension is shown in the hydraulic accounting sheet in Appendix

2) Flow Meter

In order to measure the water supply amount and to set the adequate volume of dosing chlorine, one flow meter is installed to inflow pipe for the elevated tank or service reservoir in each system.

[Planned facility]

- Flow metre	Mkanda Market Centre	: 1 set (ϕ 100mm)
	Santhe Market Centre	: 1 set (ϕ 150 mm)

(3) Treatment Facility

In order to disinfect the treated water bleaching powder dissolution and feeding equipment is installed.

[Design conditions]

- Flow rate	712 m^3/day (Planned daily maximum water supply of Santhe Market Centre is applied)
- Dosing rate	1 to 5mg/l
- Effective chlorine	60% (Bleaching powder/ Calcium hypo-chlorite)
- Concentration	3%
- Specific gravity	1.05
- Maximum dosing rate	712m^3/day x 5mg/l x (100%/60%) x (100/3) x (1/1.05) x (1/24)÷1,000 = 7.8 litre/hr (≒10 little/hr)

[Planned facility]

- Chlorination devices	2 sets each for Mkanda and Santhe Market Centres (1 no. standby)
- Ancillary equipment	dissolution tank (4-day capacity: 1,000 litres), agitator (0.2kW) Feeder pump (10 litre/hr)

(4) Distribution Facility

1) Elevated Tank

Because Mkanda Market Centre is topographically flat, an elevated tank is constructed to distribute water to the area. Groundwater taken from the production wells is once stored in the tank and then distributed to the area by gravity.

[Design conditions]

- Capacity	8 to 12 hours of the planned daily maximum water supply (544m^3/day)
- Depth	2 to 3m (effective depth)

[Planned facility]

- Elevated tank	180m^3 x 1 no. (=544m^3 x 8/24) Effective depth: 2.25m, Height: 10m (HWL=1,108.80m) Steel panel type (8 x 7 x 2 plates, 1.2m x 1.2m per plate) is applied

9.6 m x 8.4 m x 2.25 m = 181m^3>180m^3

2) Ground Tank

In order to distribute water to Santhe Market Centre a ground tank is constructed on the hill adjacent to the production wells. Groundwater taken from the production wells is once stored in the tank and then distributed to the area by gravity.

[Design conditions]

- Capacity	8 to 12 hours of the planned daily maximum water supply (712m^3/day)
- Depth	2 to 3m (effective depth)

[Planned facility]

- Ground tank	240m^3 x 1 no. (=712m^3 x 8/24) Effective depth: 2.32m (HWL = 1,127.32m) Steel panel type (9 x 8 x 2 plates, 1.2m x 1.2m per plate) is applied 10.8m x 9.6m x 2.32m = 241m^3>240m^3

3) Water Distribution Pipe

Water distribution pipe is installed to supply water from the elevated tank or the ground tank to the respective areas of Mkanda and Santhe Market Centres.

[Design conditions]

- Material of pipe	PVC pipe is used at the normal part of the piping route where the pipes are installed underground and at the exposed parts such as channel crossing, etc. DCIP pipe is used.
- Velocity coefficient	C=130 (PVC pipe)
- Service pressure	5m (0.5kgf/cm^2) or more at the end of the water distribution system.
- Maximum hourly supply	the maximum hourly water supply is calculated at the hourly factor of 2.4 as per the standards of Malawi.
- Diameter	based on hydraulic calculations of the distribution pipes, diameter of pipe is decided securing the minimum service pressure at the respective ends of water distribution system. The minimum diameter of the member pipes of making networks is 100mm or more.
- Depth of pipe laying	Pipe is buried at 1.20m and 1.00m in deep under main roads and feeder roads, respectively in consideration of the traffic of heavy vehicles on the roads.

[Planned facility]

- Distribution pipe	Mkanda Market Centre:	ϕ 150mm-75mm × 11.3km
	Santhe Market Centre:	ϕ 150mm-75mm × 16.1km

Water pressure and diameter of each distribution pipe are shown in Appendix 2.

4) Communal Tap

Communal taps are provided to supply water to the people.

[Design conditions]

- No. of tap: as per the request of the Malawi side and people of the Market Centres, numbers and locations of the taps are decided.
- No. of faucet at tap: 2-faucet type

[Planned facility]

- Communal tap: Mkanda Market Centre: 6 places
  Santhe Market Centre: 8 places
  Standardised design of CRWB of Malawi is applied for the tap.

(5) Building

A control building in which chlorination devices are installed and an office building (revenue office is also placed in the building) are built in Mkanda and Santhe Market Centres respectively. Required areas and designs of the buildings are subject to the standard design of CRWB of Malawi.

[Planned facility]

- Control building: 2 buildings (reinforced brick, 6.3 m × 7.1 m)
- Office building: 2 buildings (reinforced brick, 9.7 m × 13.2 m) with Guard House (9 m^3)

One each for Mkanda and Santhe Market Centres

2-2-3 Outline Design Drawings

Outline design drawings of the Sub-Project (1) consist of the followings:

Mkanda Market Centre

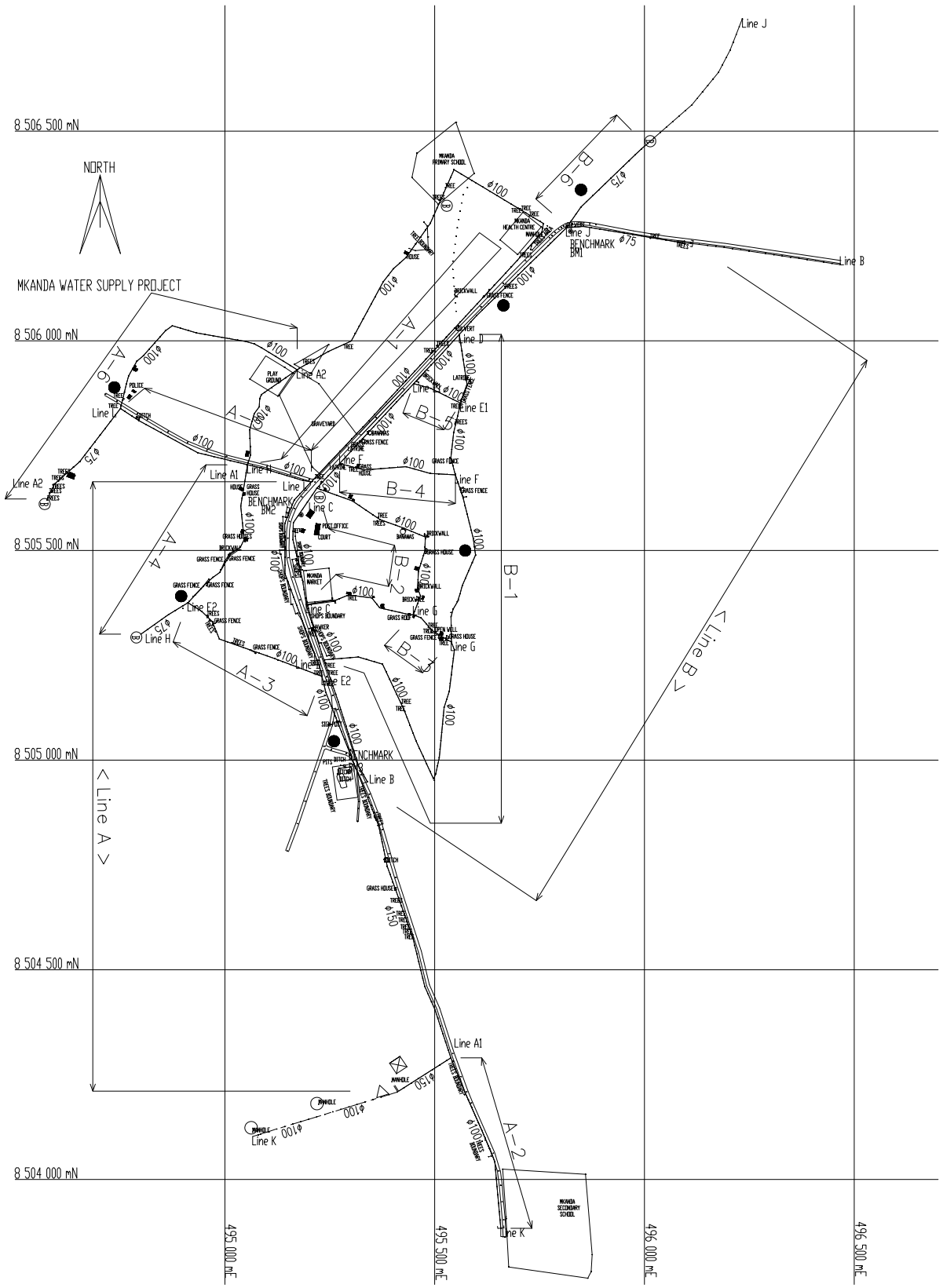
Drawing No.	Title
M001	Overall Facility Layout
M002 - 003	Intake Well Structure and Facilities
M004	Routes and Section of Water Transmission Pipe (Intake − Elevated Tank)
M005 - 006	Elevated Tank Structure and Facilities
M007 - 034	Routes and Section of Water Distribution Pipe
M035	Office Building Layout

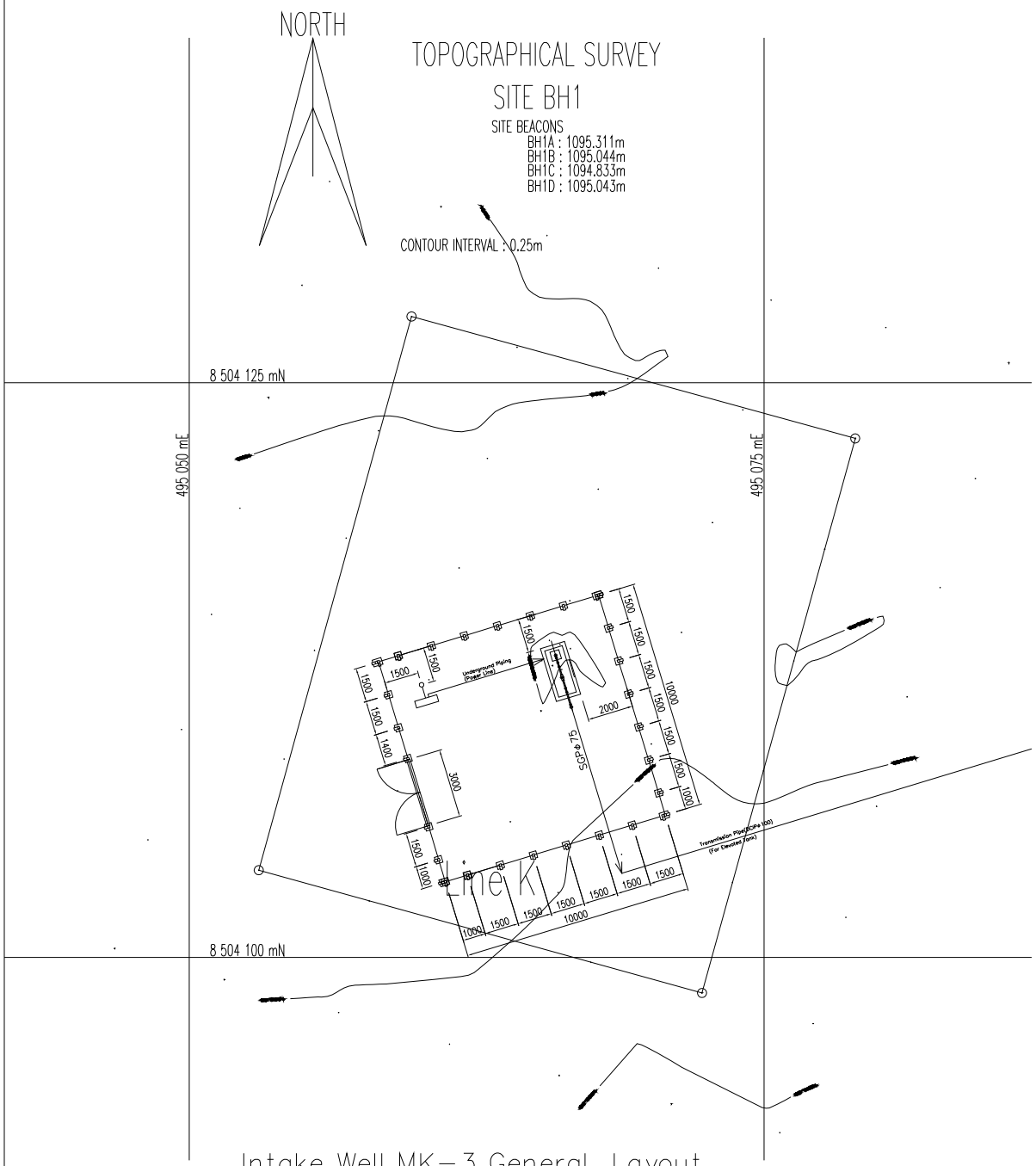
Santhe Market Centre

Drawing No.	Title
S001	Overall Facility Layout
S002 − 007	Intake Well Structure and Facilities
S008 - 013	Routes and Section of Water Transmission Pipe (Intake − Ground Tank)
S014	Ground Tank Structure and Facilities
S015 - 053	Routes and Section of Water Distribution Pipe
S054	Office Building Layout

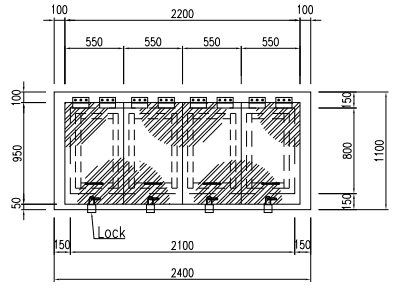
Common Drawing

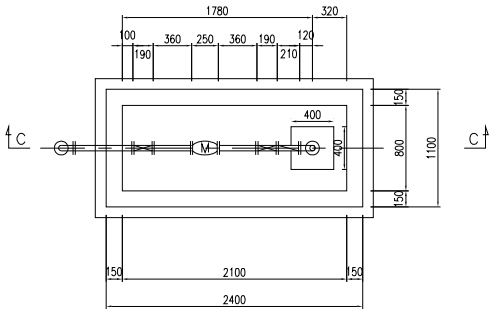
Drawing No.	Title
C001	Communal Tap Structure and Facilities

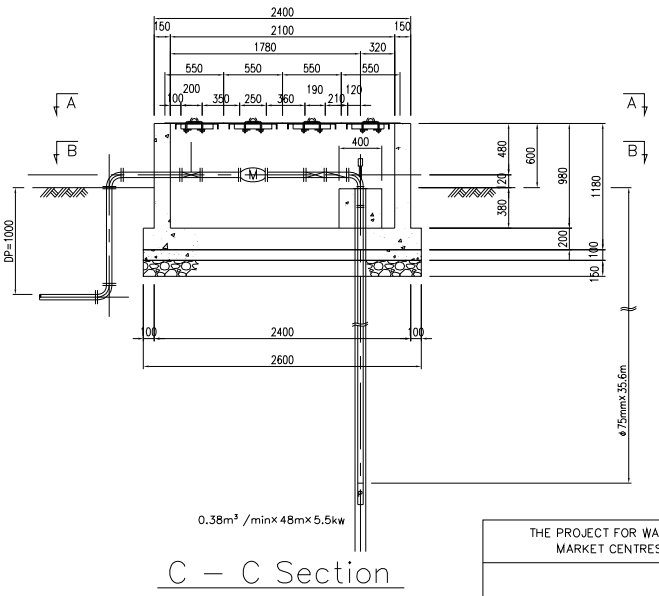

Legend
Intake Well
Elevated Tank
Control Building
Office Building
Communal Water Point
Transmission Pipe
Distribution Pipe
Blow Off
Blind Cap
THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION
Overall Facility Layout
Mkanda
Scale
Shown in the Drawing
Date
Oct. 2011
Drawing No.
M001
EIGHT-JAPAN ENGINEERING CONSULTANTS INC.
NORTH
MKANDA WATER SUPPLY PROJECT
8 506 500 mN
8 506 000 mN
8 505 500 mN
8 505 000 mN
8 504 500 mN
8 504 000 mN
495 000 mE
495 500 mE
496 000 mE
496 500 mE
Line J
Line B
Line A1
Line A2
Line C
Line D
Line E1
Line E2
Line F
Line G
Line H
Line K
BENCHMARK BM1
BENCHMARK BM2
BENCHMARK
A-1
A-2
A-3
A-4
A-5
A-6
B-1
B-2
B-3
B-4
B-5
B-6
< Line A >
< Line B >
Overall Facility Layout (Mkanda)
S=1:5000(A1) 1:10000(A3)



Intake Well MK−3 General Layout
(Mkanda)
S=1:100(A1) 1:200(A3)

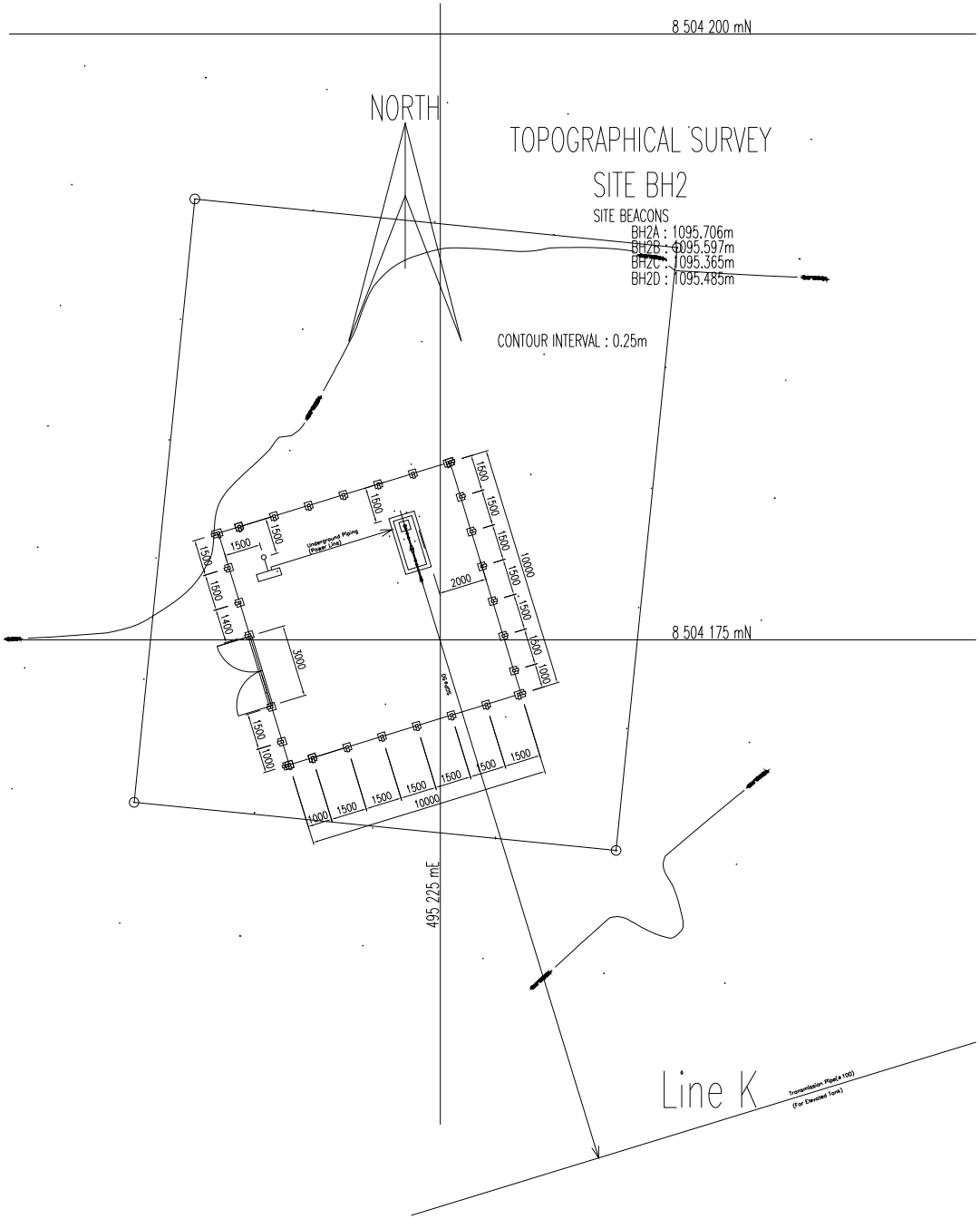




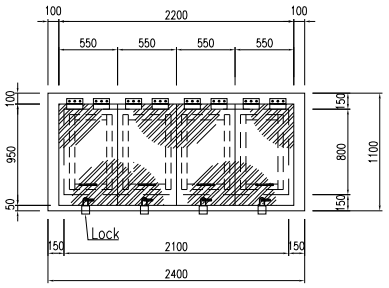


Intake Well Structure
S=1:25(A1) 1:50(A3)

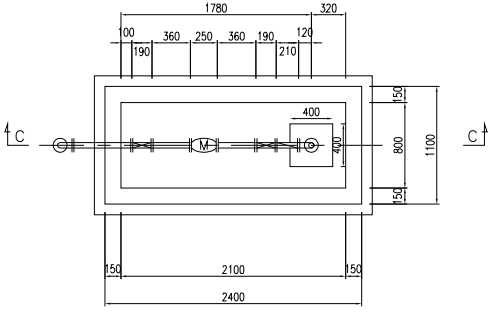
THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION			
Intake Well MK−3 Mkanda			
Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M002
EIGHT−JAPAN ENGINEERING CONSULTANTS INC.			



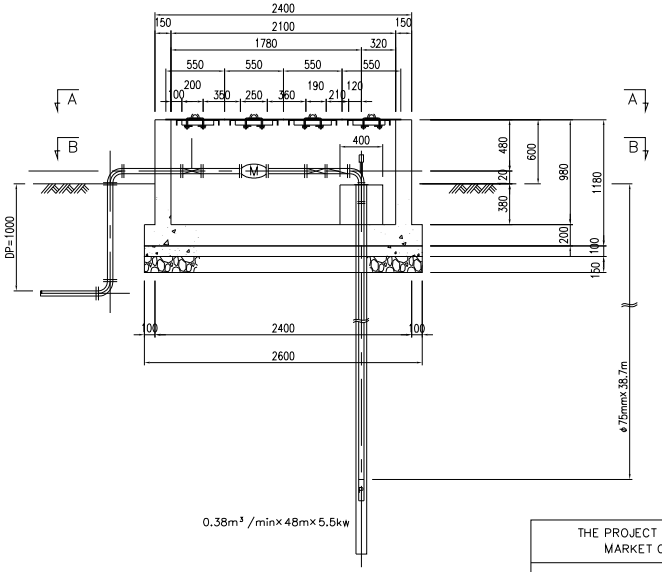
Intake Well MK−2 General Layout
(Mkanda) S=1:100(A1) 1:200(A3)



A − A Section



B − B Section



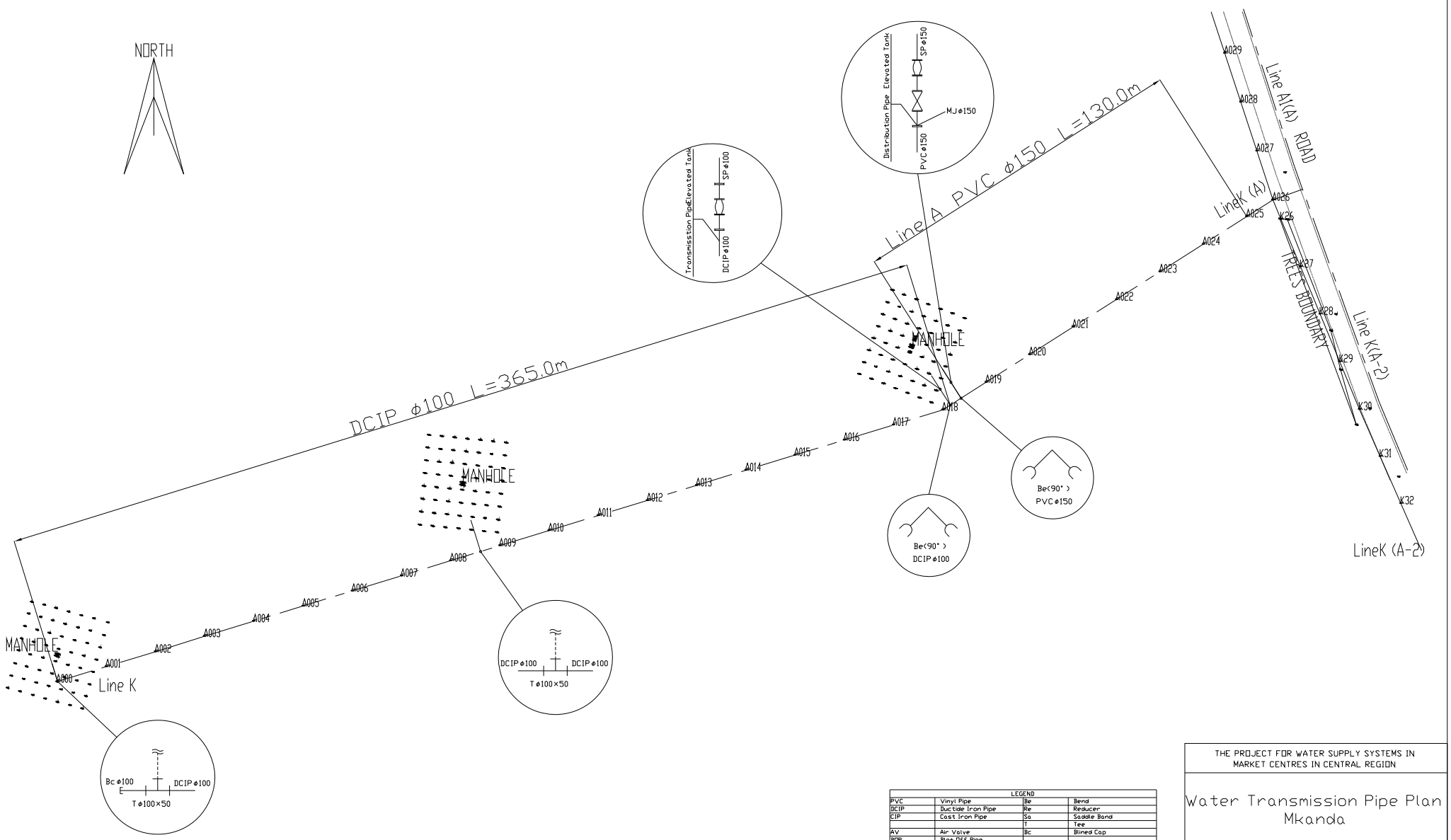
C − C Section

Intake Well Structuer
S=1:25(A1) 1:50(A3)

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION	
Intake Well MK−2 Mkanda	
Scale	Shown in the Drawing
Date	Oct. 2011
Drawing No.	M003
EIGHT−JAPAN ENGINEERING CONSULTANTS INC.	

MKANDA WATER SUPPLY SCHEME
LINE K : 0.00m to 500m

SCALE : 1 / 500 (A0)



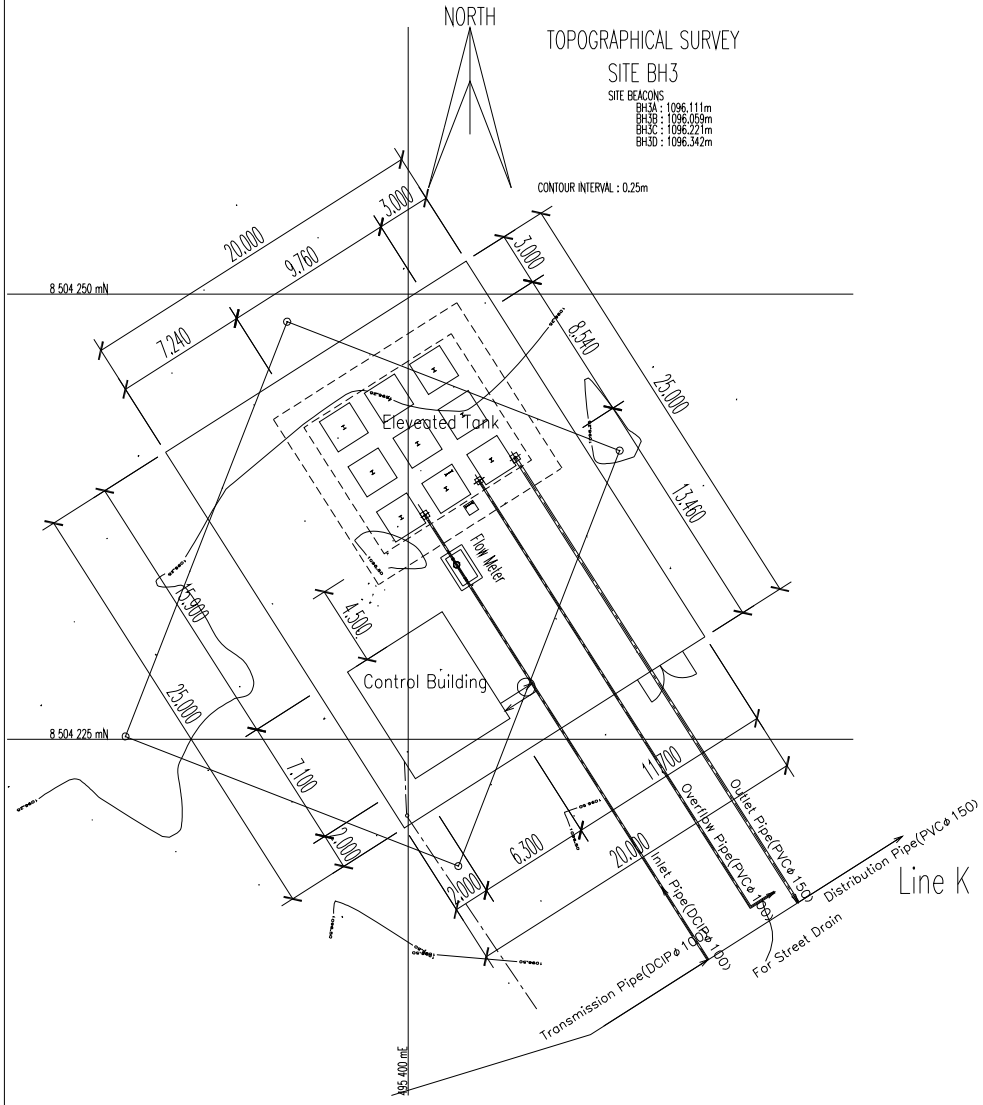
LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductile Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BDP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

Water Transmission Pipe Plan
Mkanda

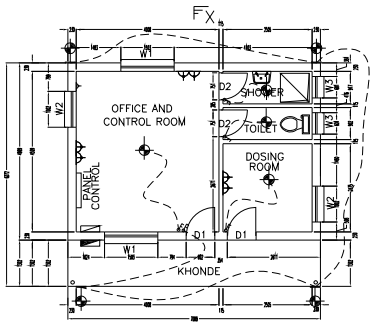
Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M004

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

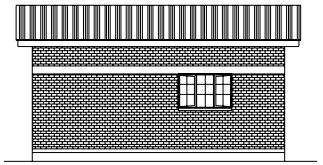


Elevated Tank and Control Building General Layout (Mkanda)

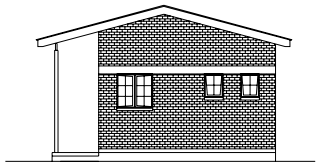
S=1:150(A1) 1:300(A3)



FLOOR PLAN

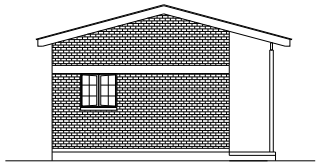


REAR ELEVATION



SIDE ELEVATION

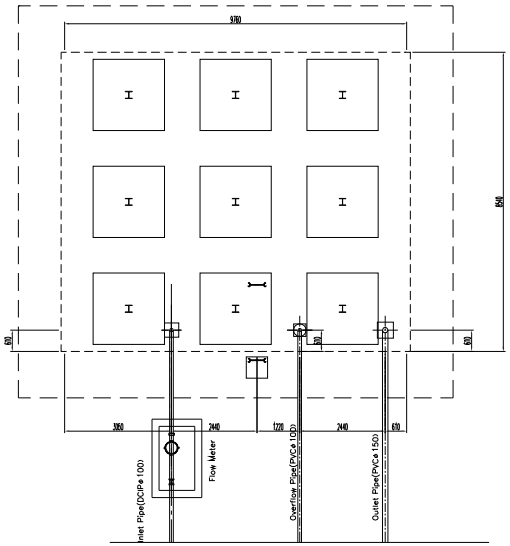
FRONT ELEVATION



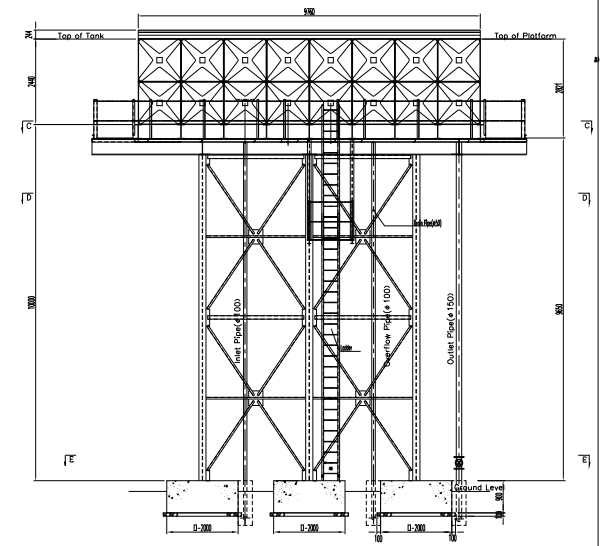
SIDE ELEVATION

Control Building Layout

S=1:75(A1) 1:150(A3)



GROUND PLAN (SECTION D-D)



SECTION A-A

Elevated Tank Structuer

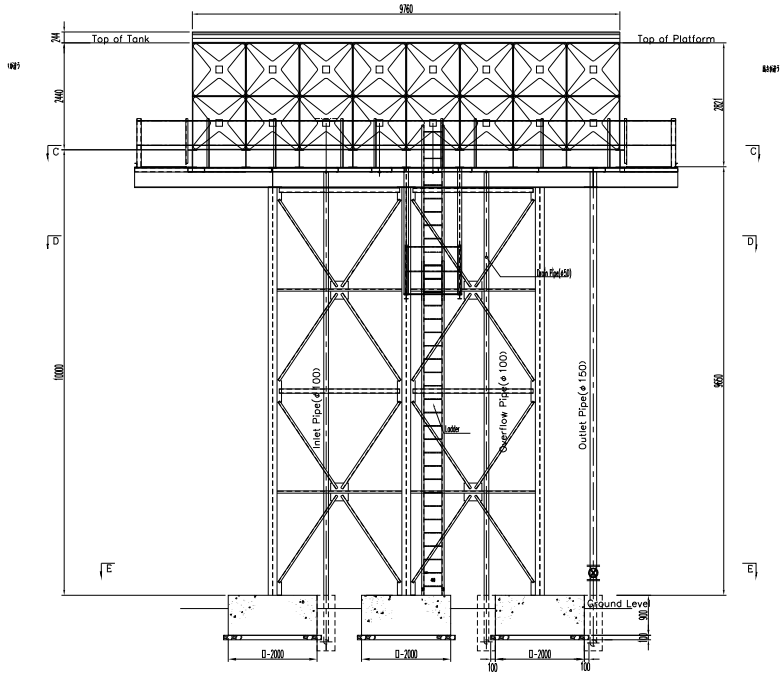
S=1:75(A1) 1:150(A3)

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

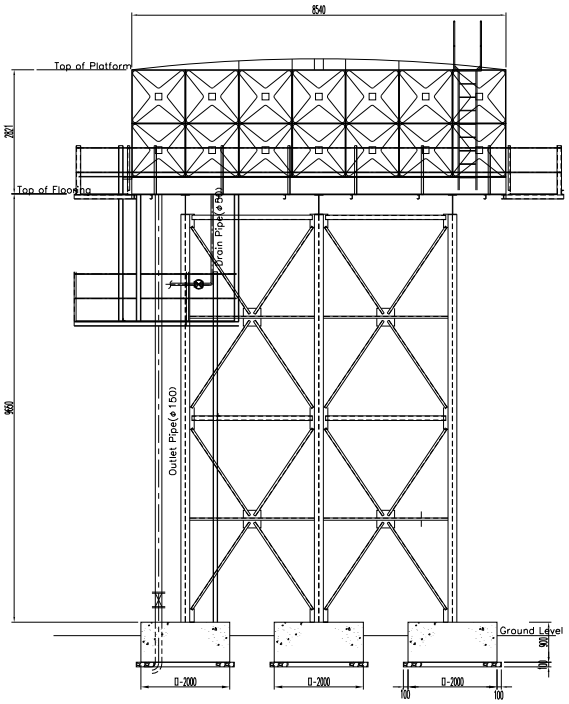
Elevated Tank and Control Building Layout Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drowing No.	M005

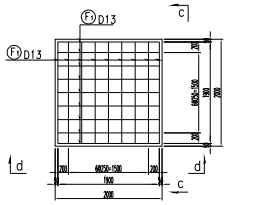
EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

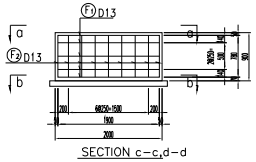


SECTION A–A



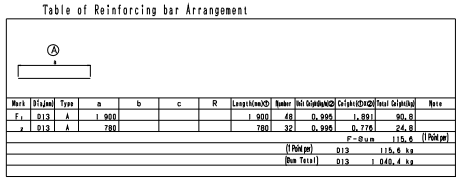
SECTION B–B



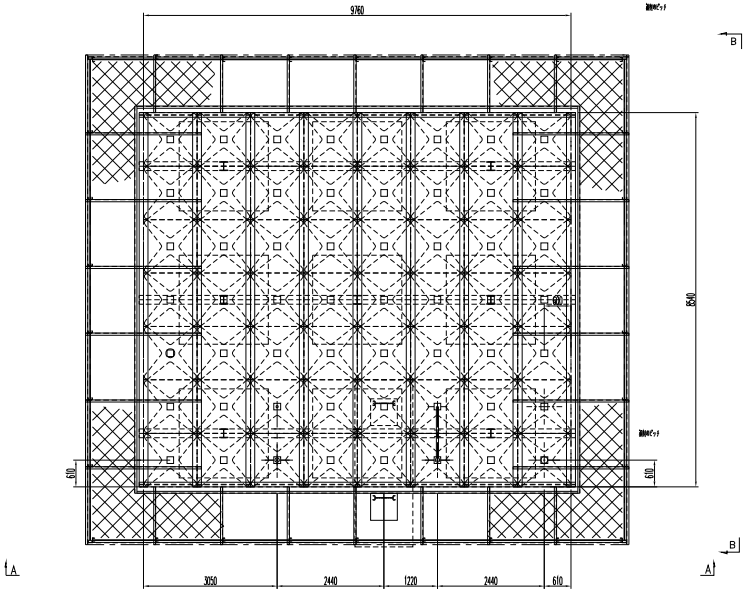


Concrete Foundation Reinforcement
S=1:50(A1) 1:100(A3)

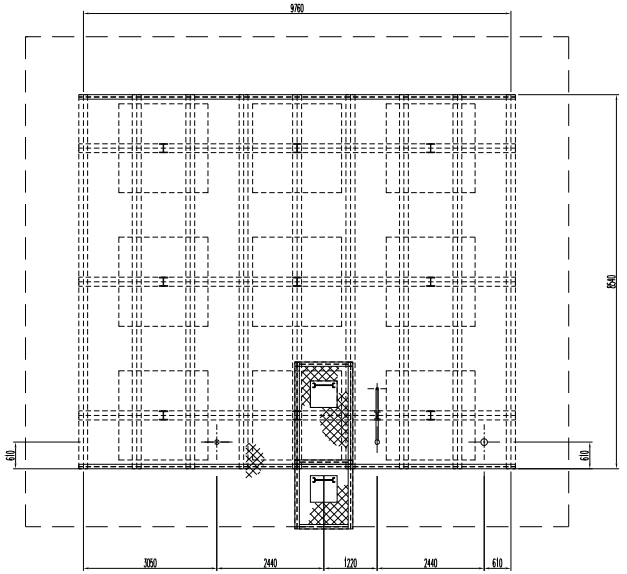
Table of Reinforcing bar Arrangement



Mark	Dia.(mm)	Type	a	b	c	R	Length(mm)(ℓ)	Number	Unit Weight(kg/m)(W)	Weight(ℓ)×(n)(kg)	Total Weight(kg)	Note
F1	D13	A	1 900				1 900	48	0.995	1.891	90.8	
F2	D13	A	780				780	32	0.995	0.776	24.8	
										2-Sum	115.6	(1 Pile)
								(1 Pile)	D13		115.6 kg	
								(Num Total)	D13		1 040.4 kg	



SECTION C–C



SECTION D–D

Elevated Tank Structuer

S=1:60(A1) 1:120(A3)

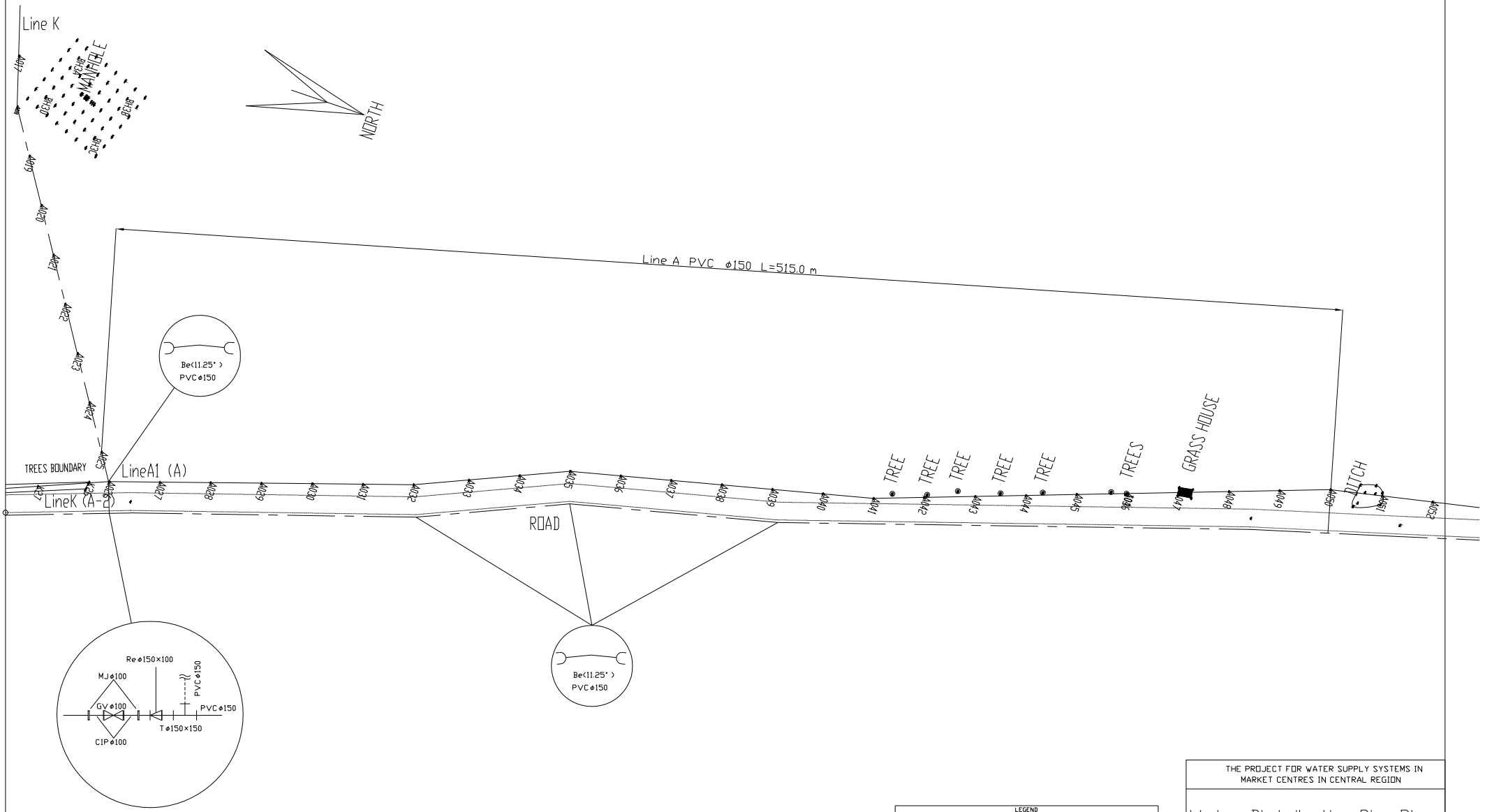
THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

Elevated Tank and Control Building Layout Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drowing No.	M006
EIGHT–JAPAN ENGINEERING CONSULTANTS INC.			

MKANDA WATER SUPPLY SCHEME
LINE A : 0.00m to 500m

SCALE : 1 / 500 (A0)



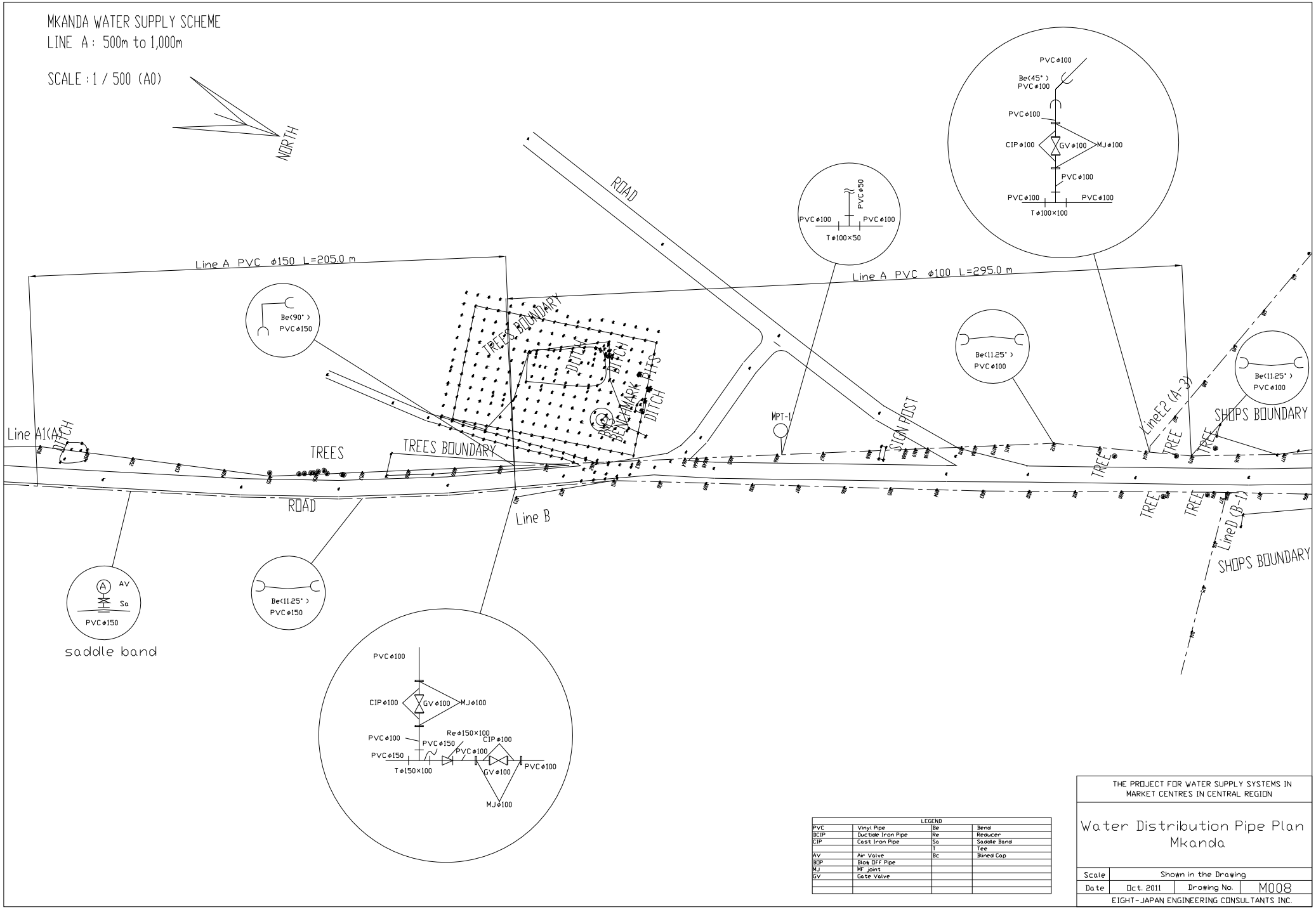
LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductile Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BDP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M007

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductile Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BDP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

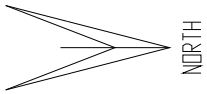
Water Distribution Pipe Plan Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M008

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

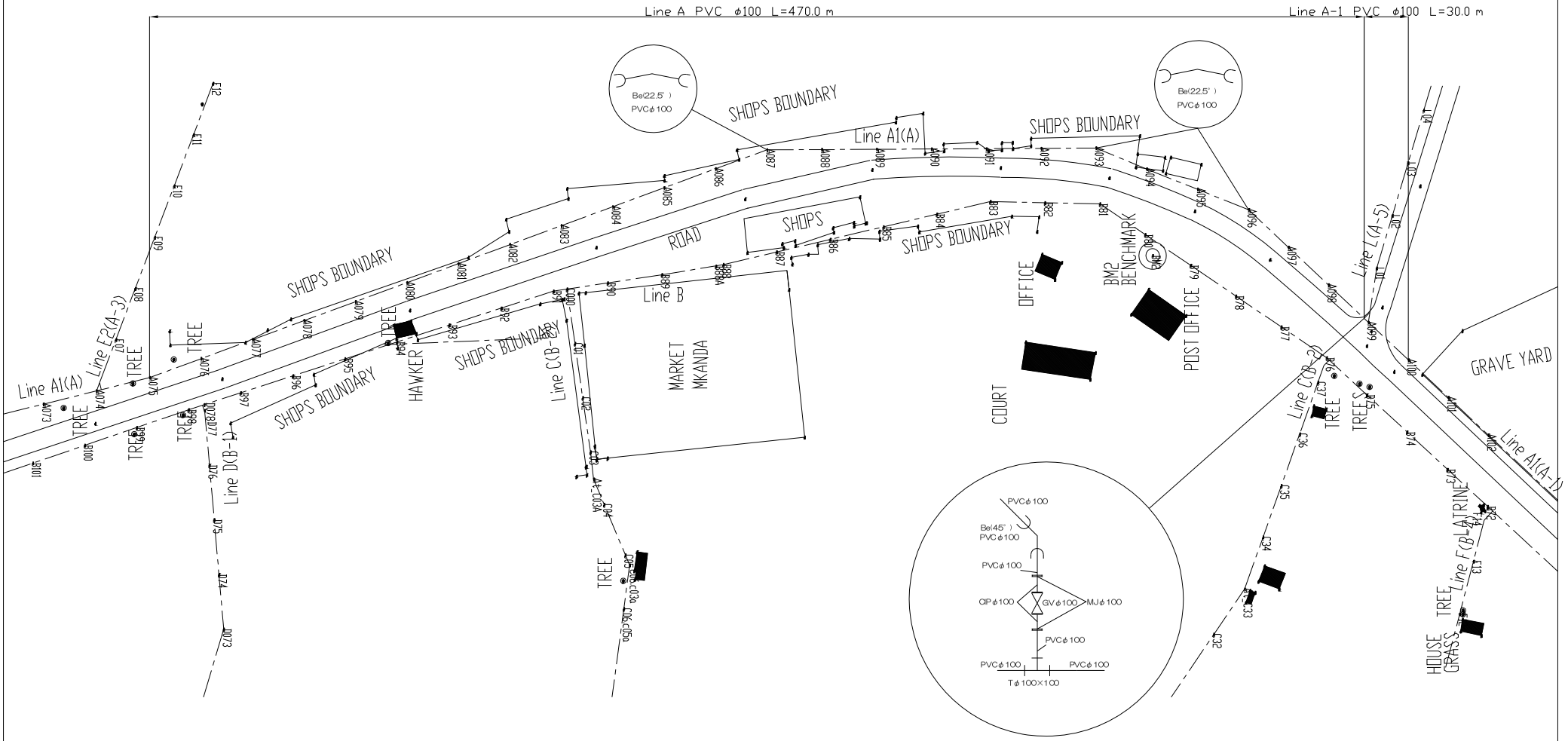
MKANDA WATER SUPPLY SCHEME
LINE A : 1,000m to 1,500m

SCALE : 1 / 500 (A0)



Line A PVC φ100 L=470.0 m

Line A-1 PVC φ100 L=30.0 m



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF Joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

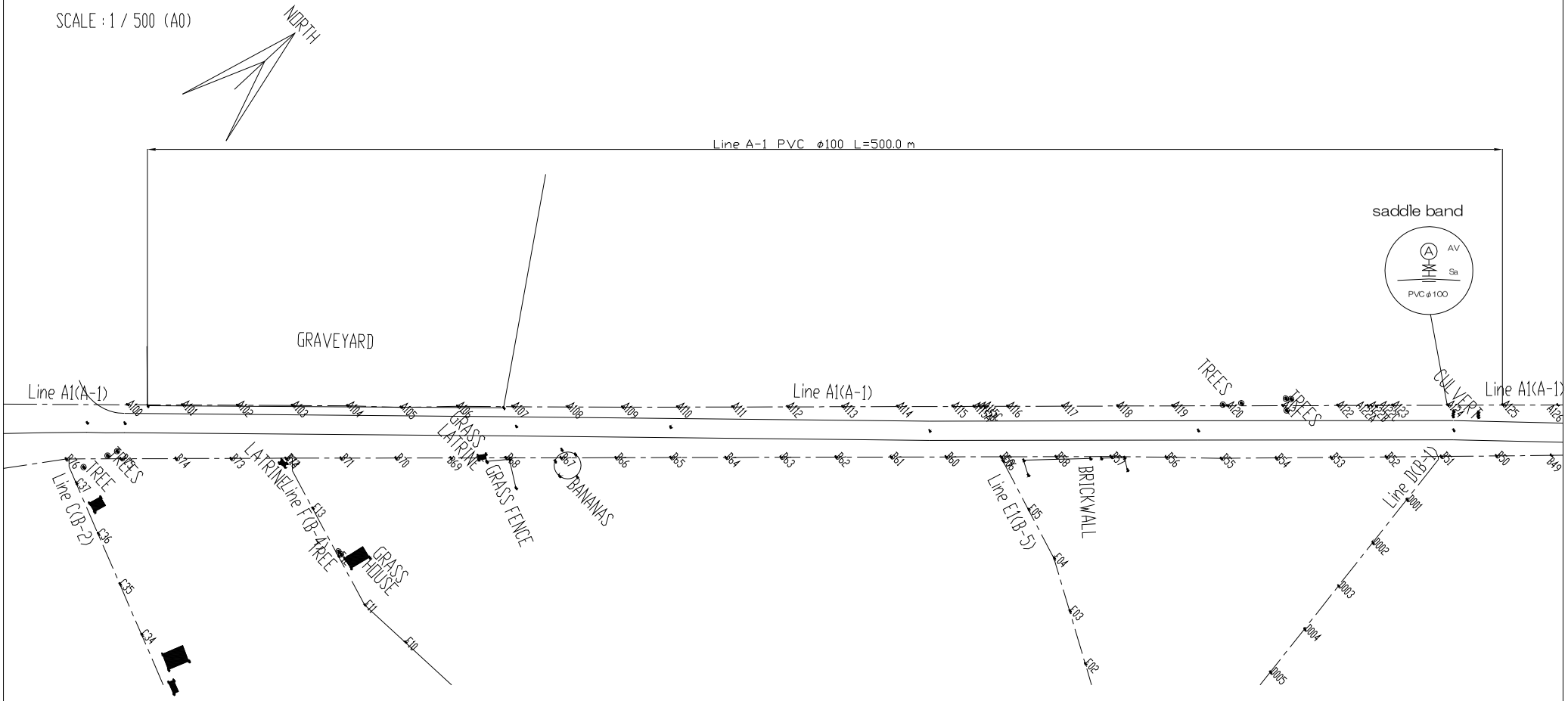
Water Distribution Pipe Plan Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M009

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE A1(A-1) : 1,500m to 2,000m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Bs	Band
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

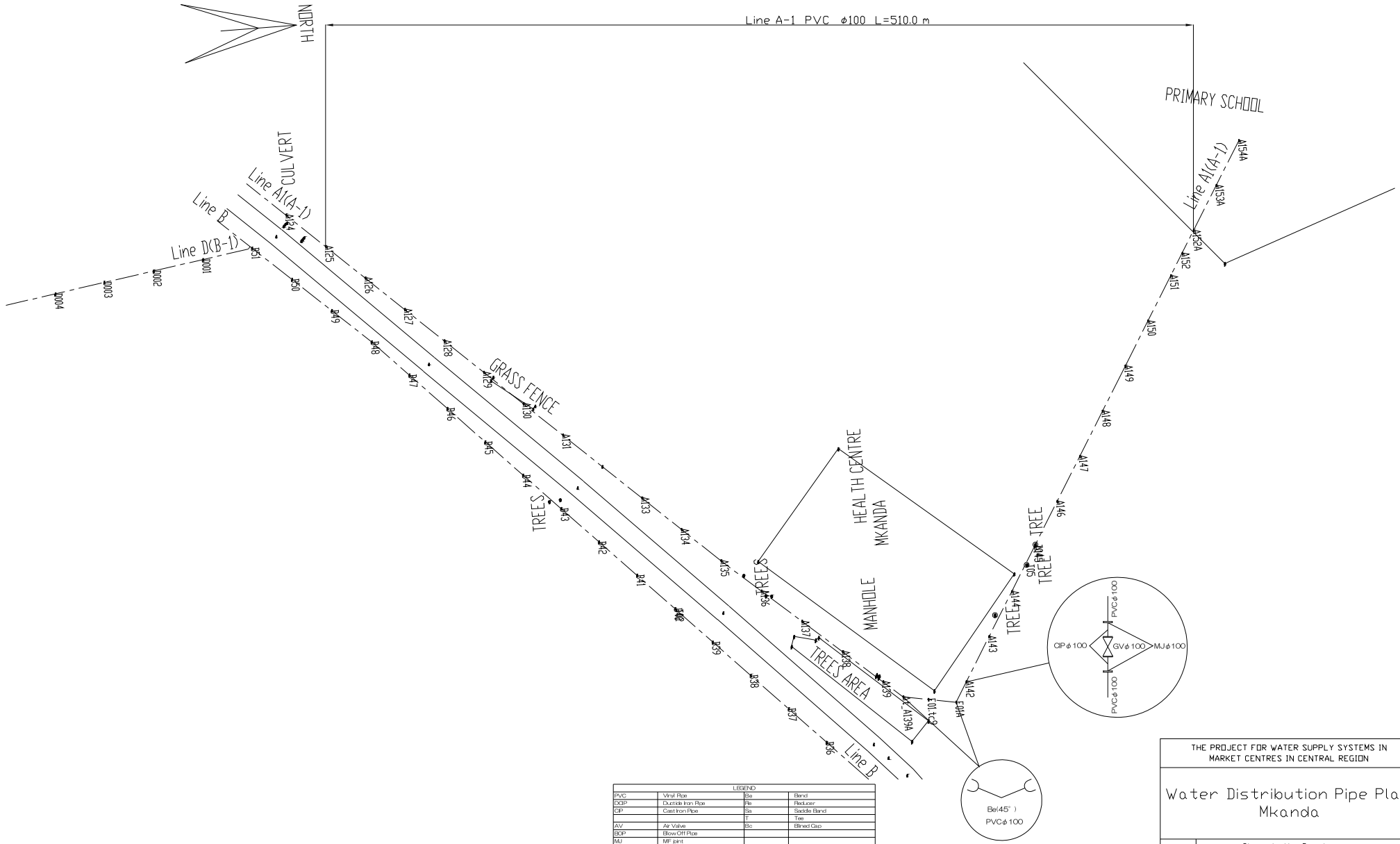
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M010

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE A1(A-1) : 2,000m to 2,500m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

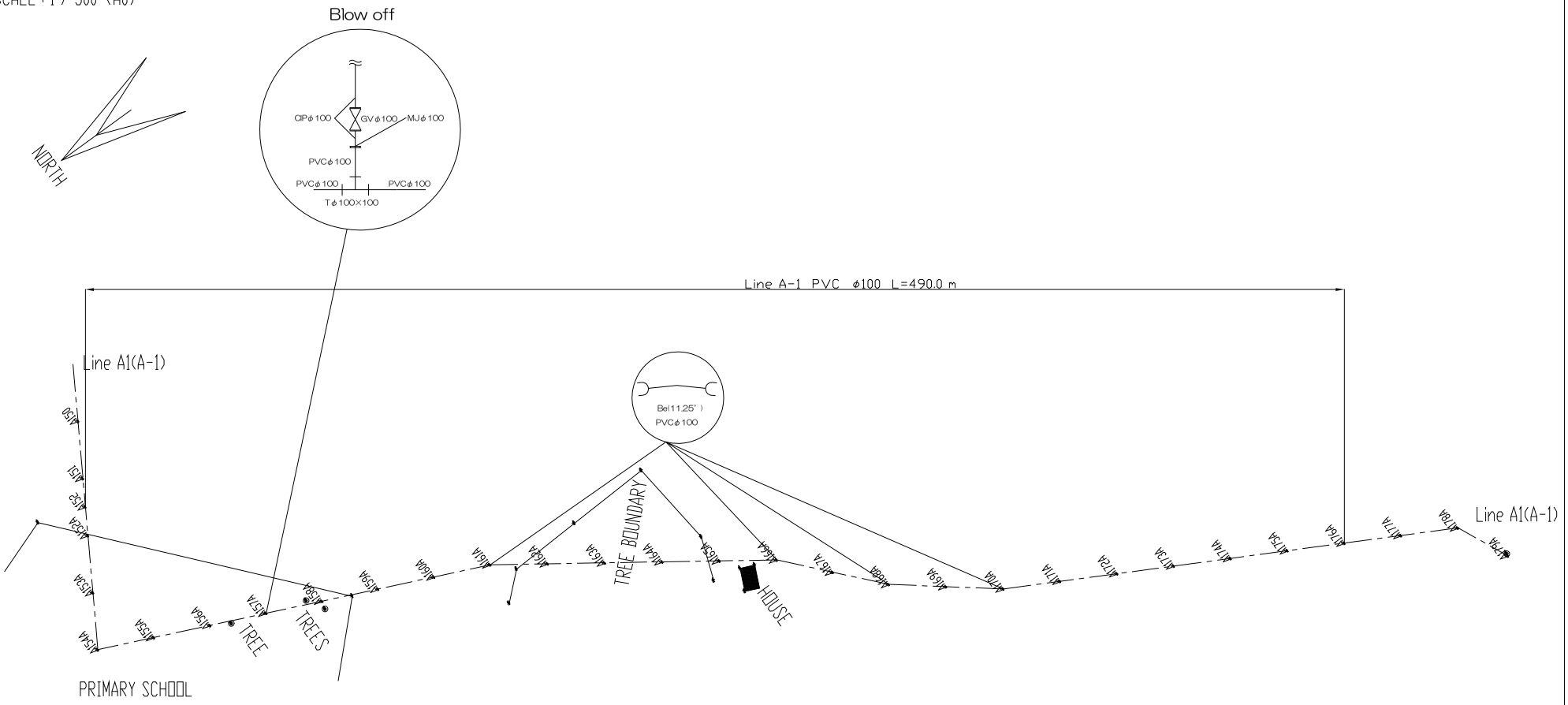
Water Distribution Pipe Plan Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M011

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE A1(A-1) : 2,500m to 3,000m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

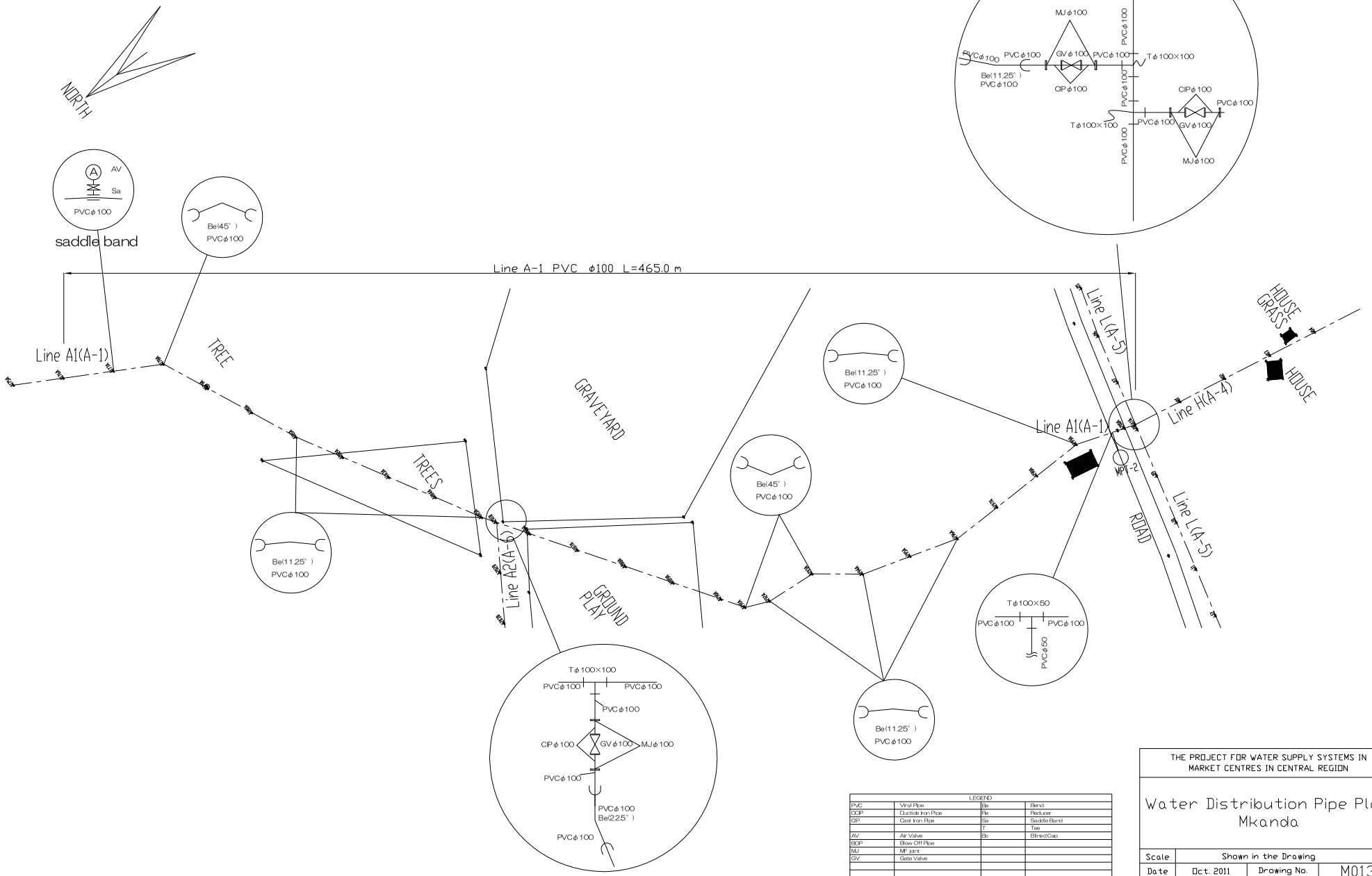
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M012

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE A1(A-1) : 3,000m to 3,447.41m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Bo	Bend
DCIP	Ductcile Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

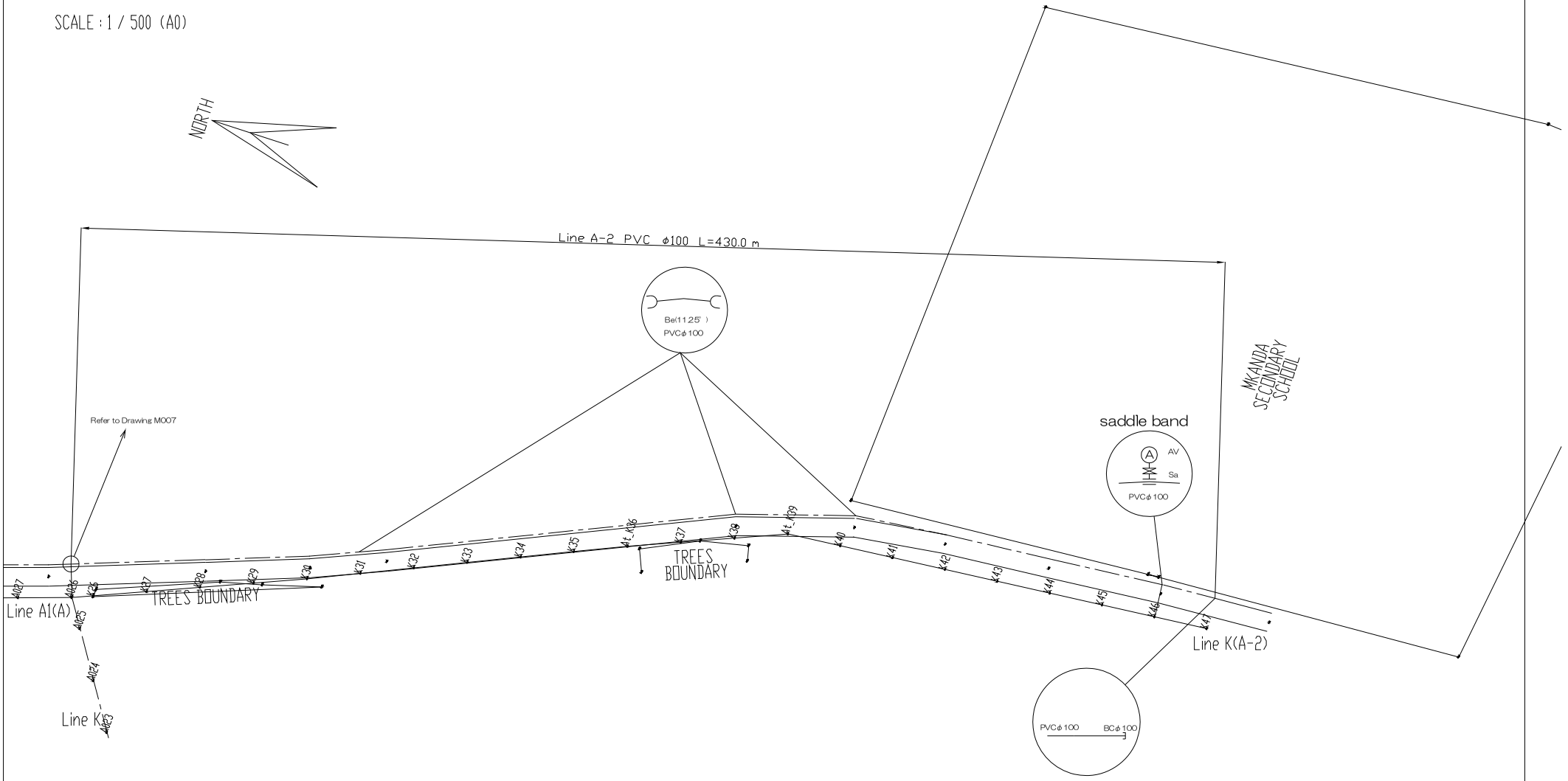
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M013

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE K(A-2) : 500m to 940.13m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

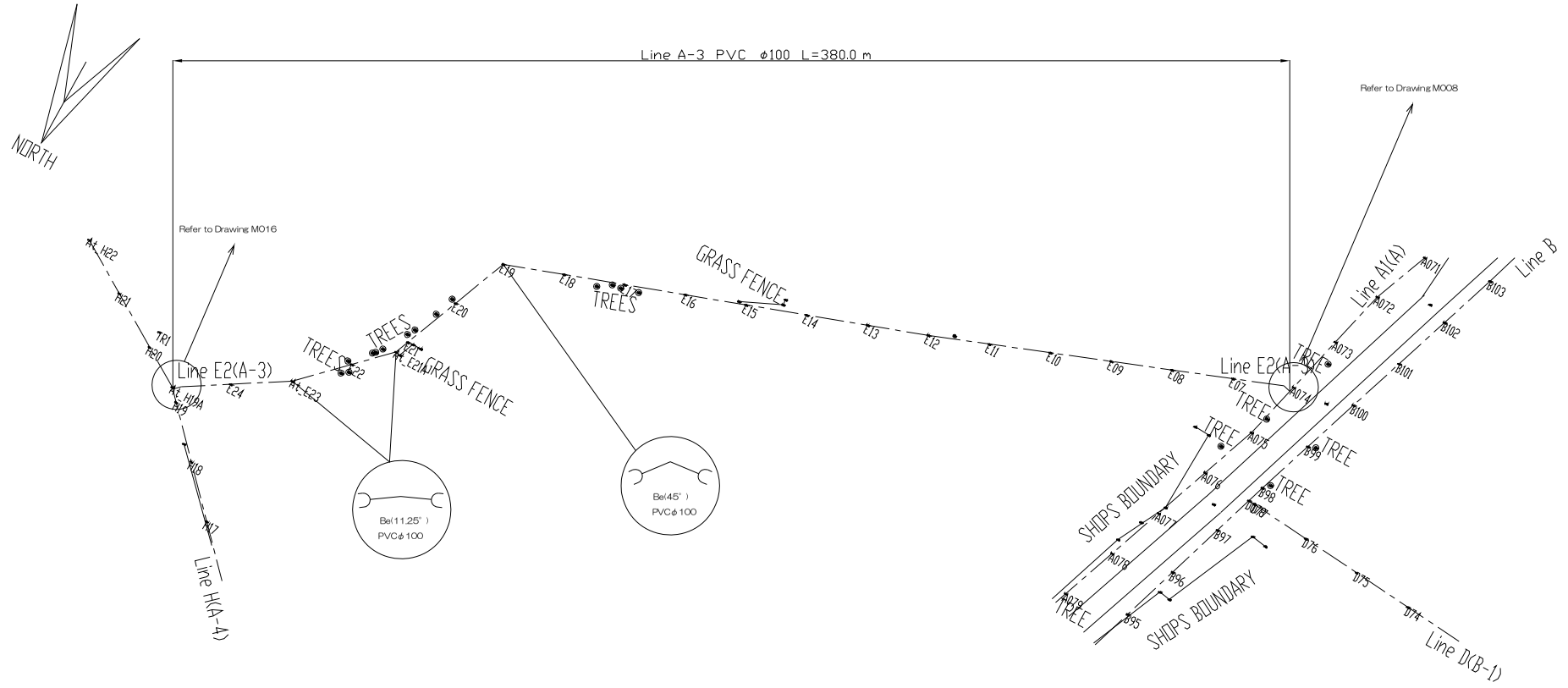
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M014

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE E2(A-3) : 0.00m to 379.08m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

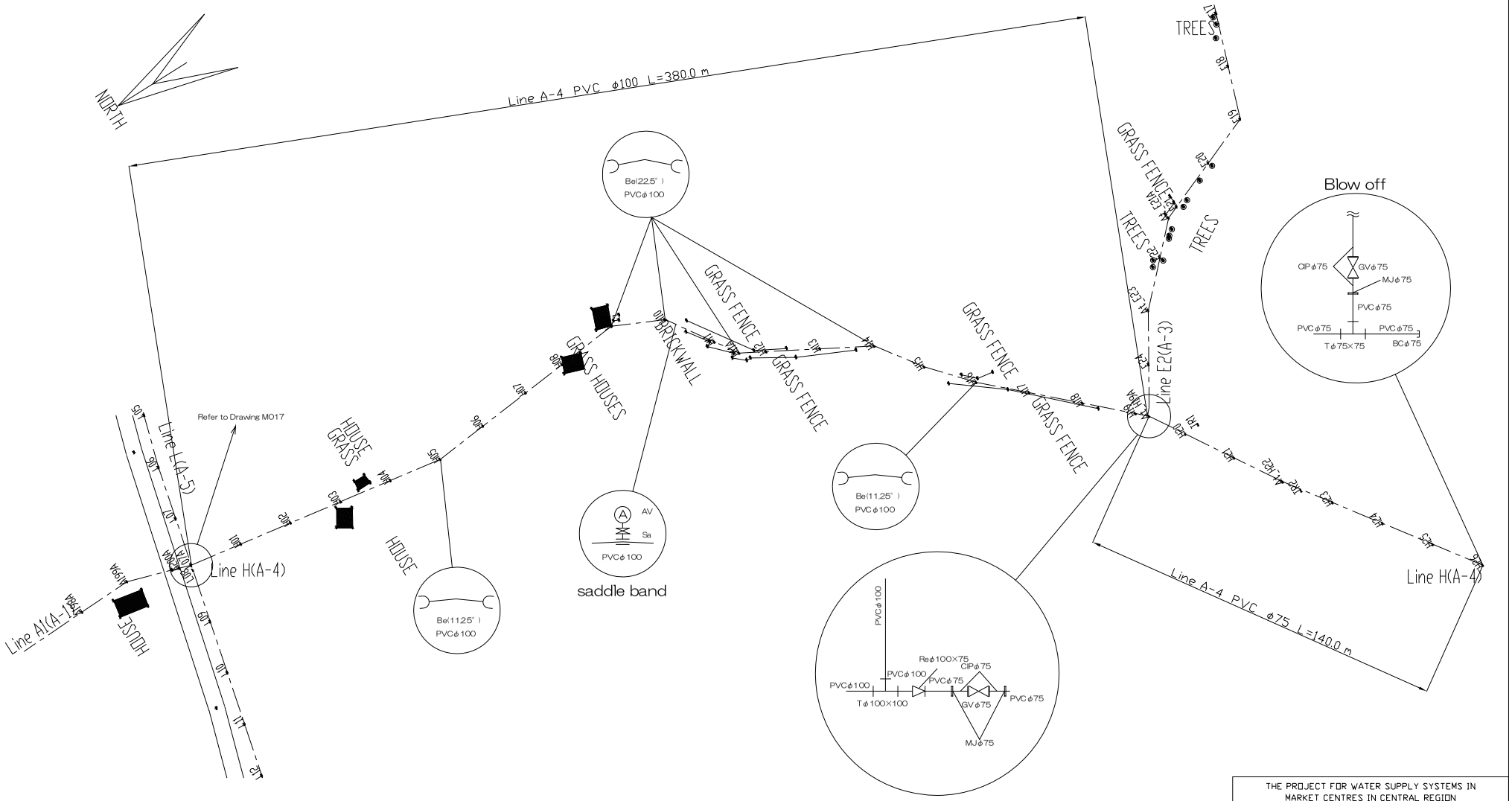
Water Distribution Pipe Plan Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M015

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE H(A-4) : 0.00m to 520.21m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Bs	Band
DCIP	Ductile Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF Joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

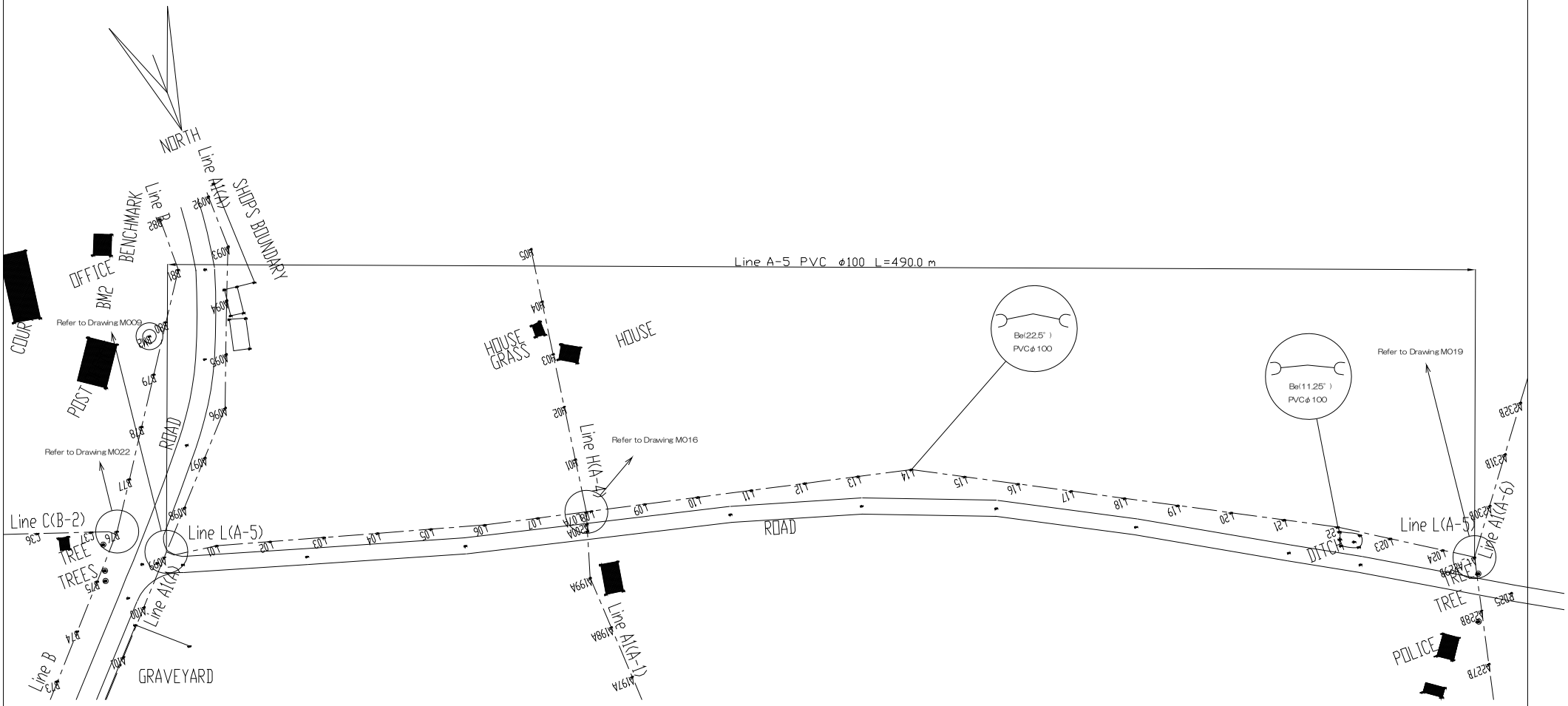
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M016

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE L(A-5) : 0.00m to 492.17m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Bn	Band
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

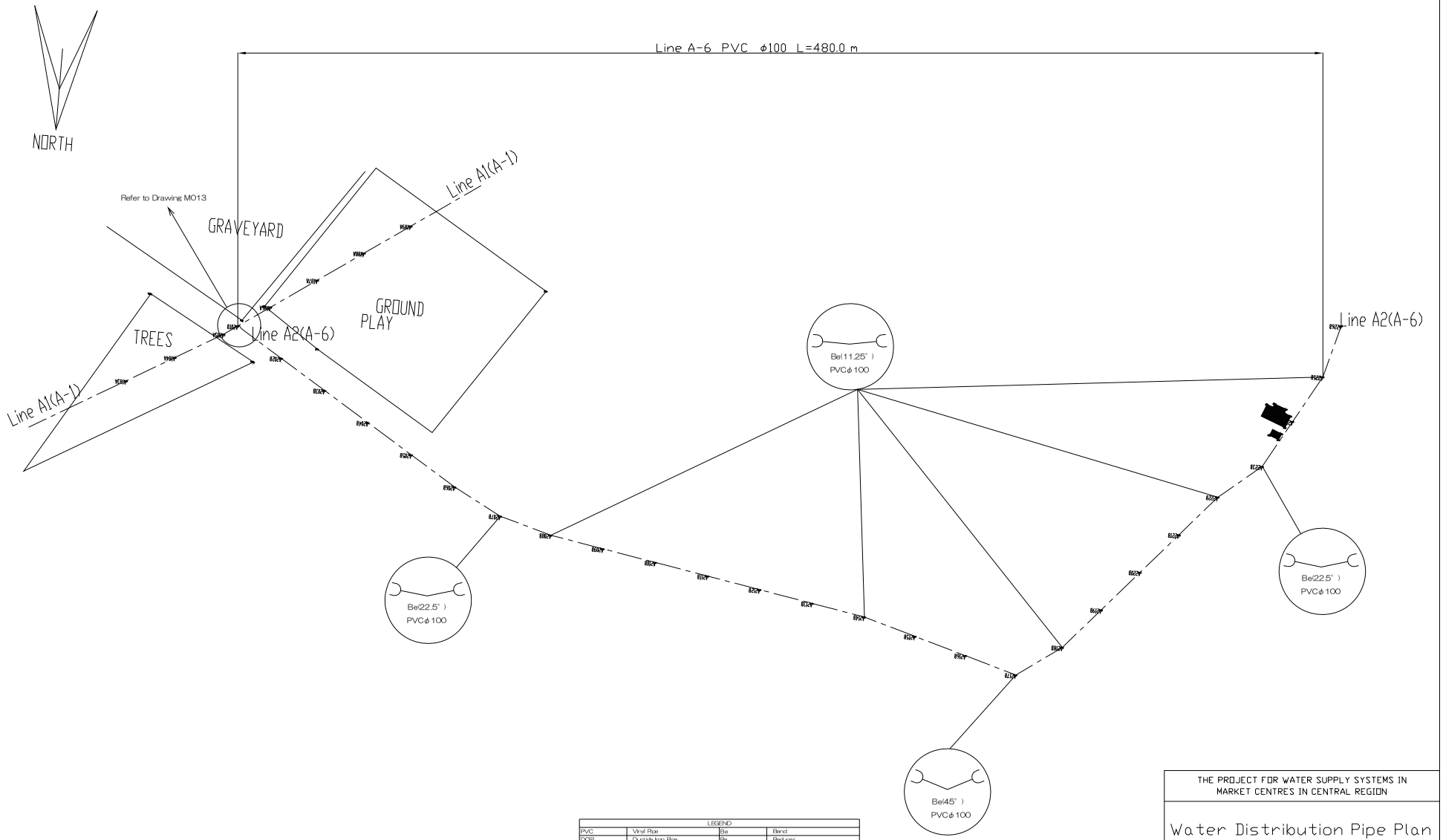
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M017

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE A2(A-6) : 0.00m to 500m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DIP	Ductile Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

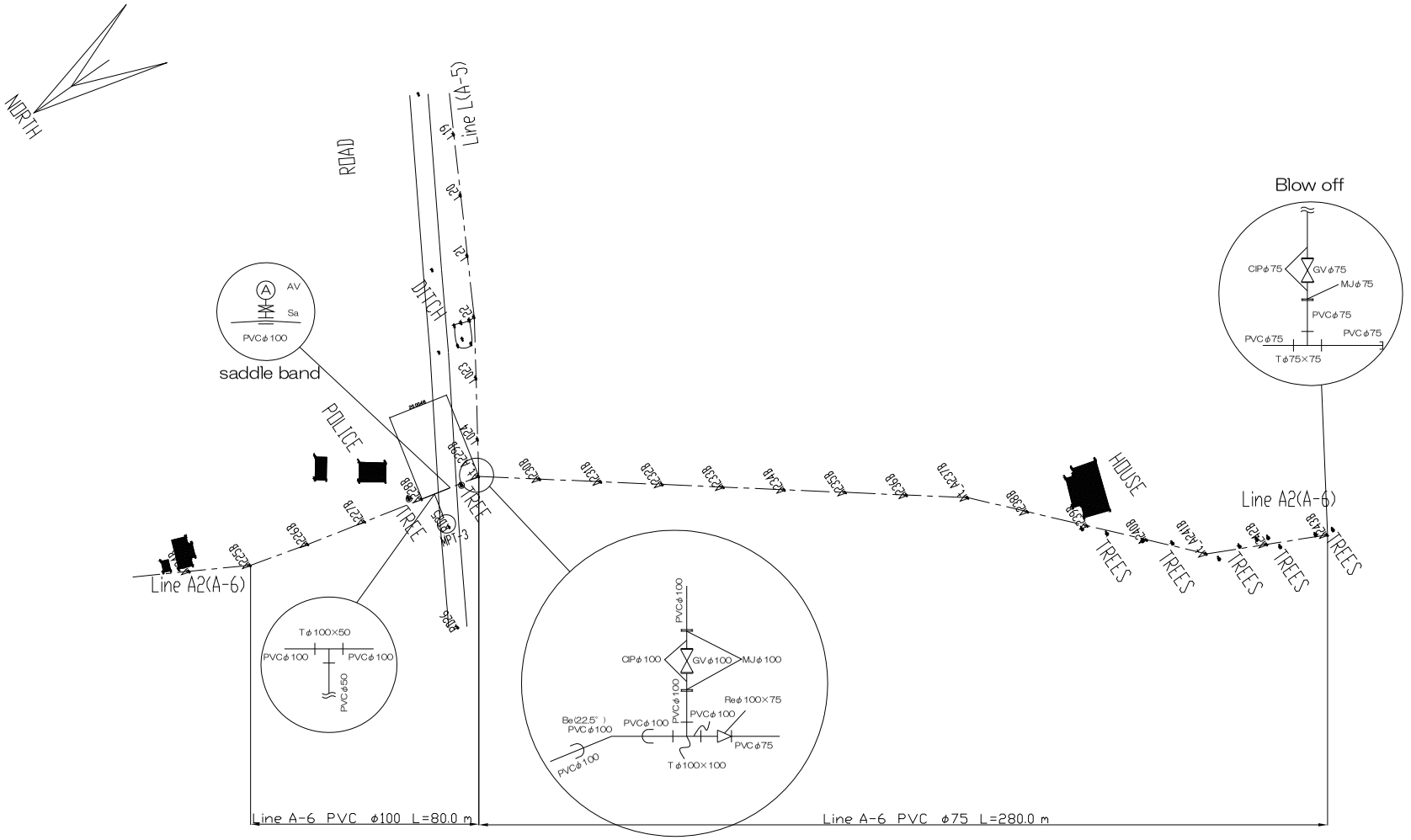
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M018

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE A2(A-6) : 500m to 840.30m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

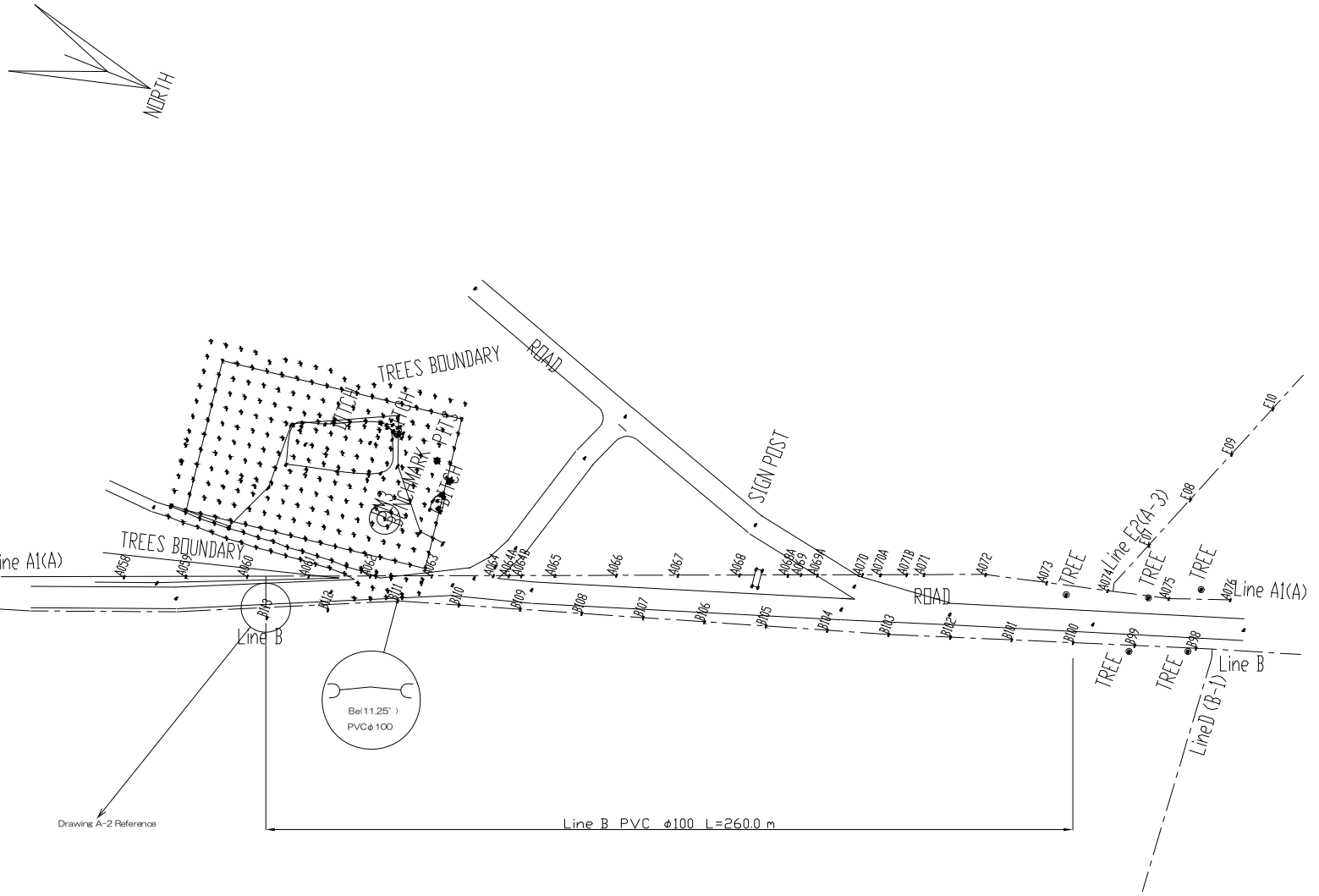
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M019

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE B : 0.00m to 262.86m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Bn	Band
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

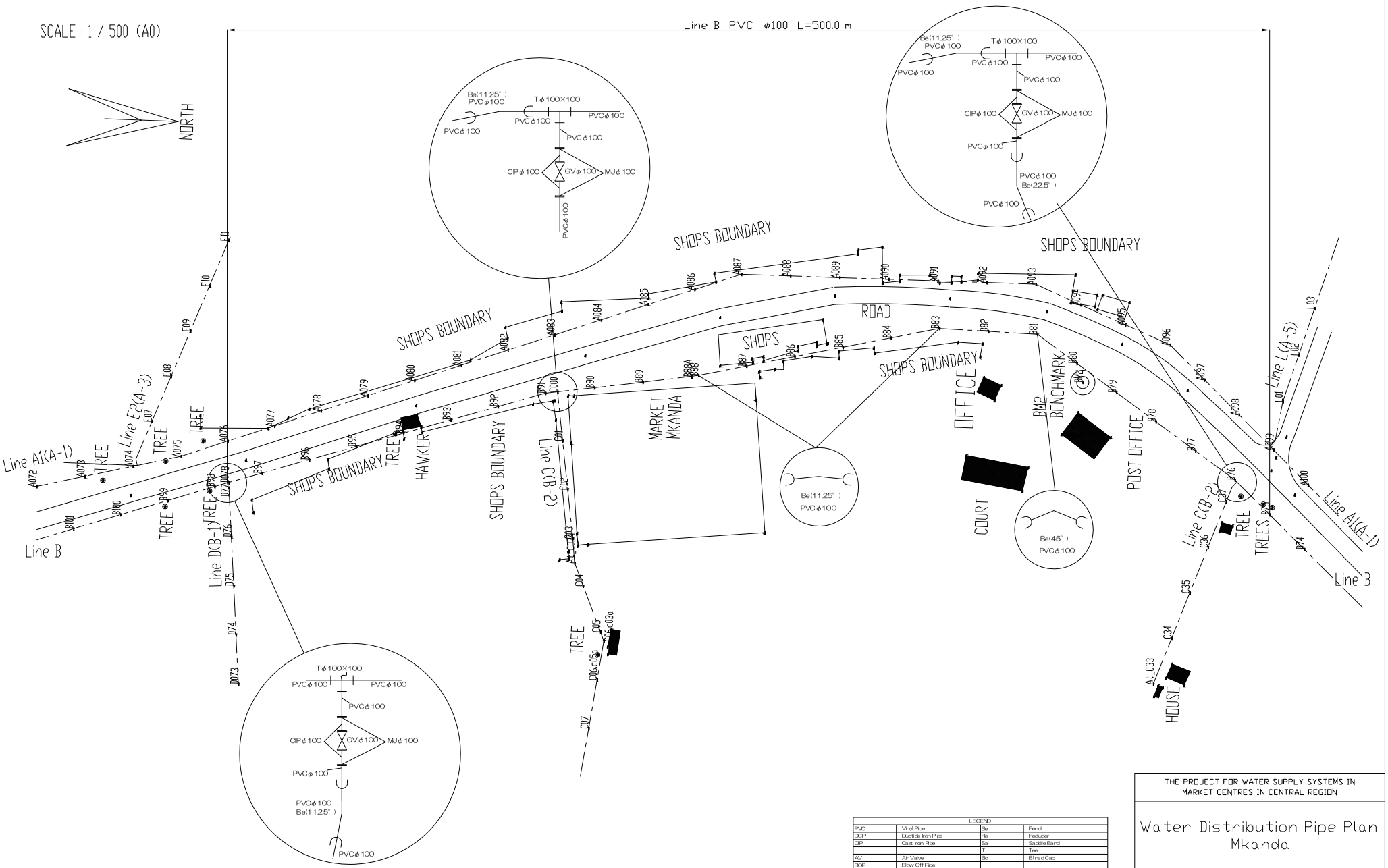
Water Distribution Pipe Plan Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M020

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE B : 262.86m to 765.65m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF Joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

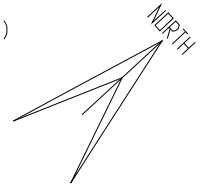
Water Distribution Pipe Plan Mkanda

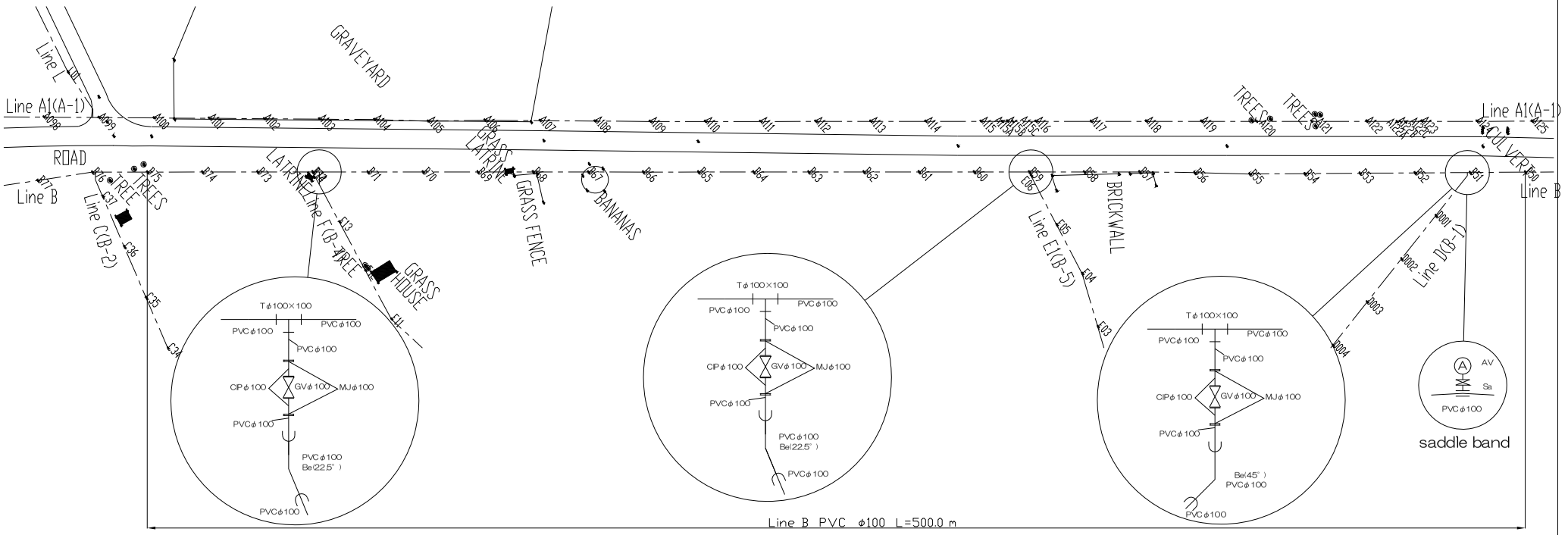
Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M021

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE B : 765.65m to 1,265.72m

SCALE : 1 / 500 (A0)





LEGEND			
PVC	Vinyl Pipe	Bo	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

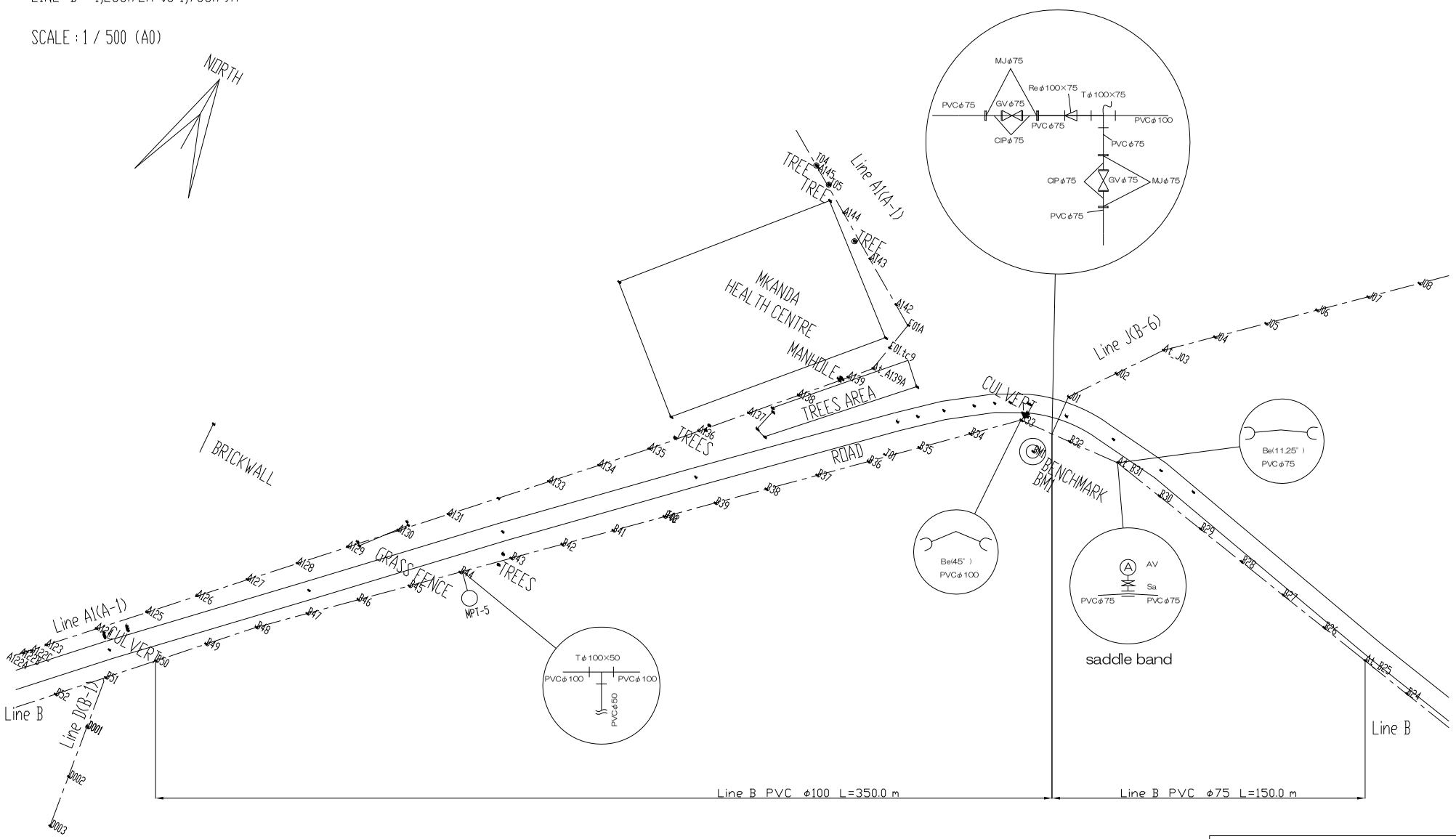
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M022

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE B : 1,265.72m to 1,765.79m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF Joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

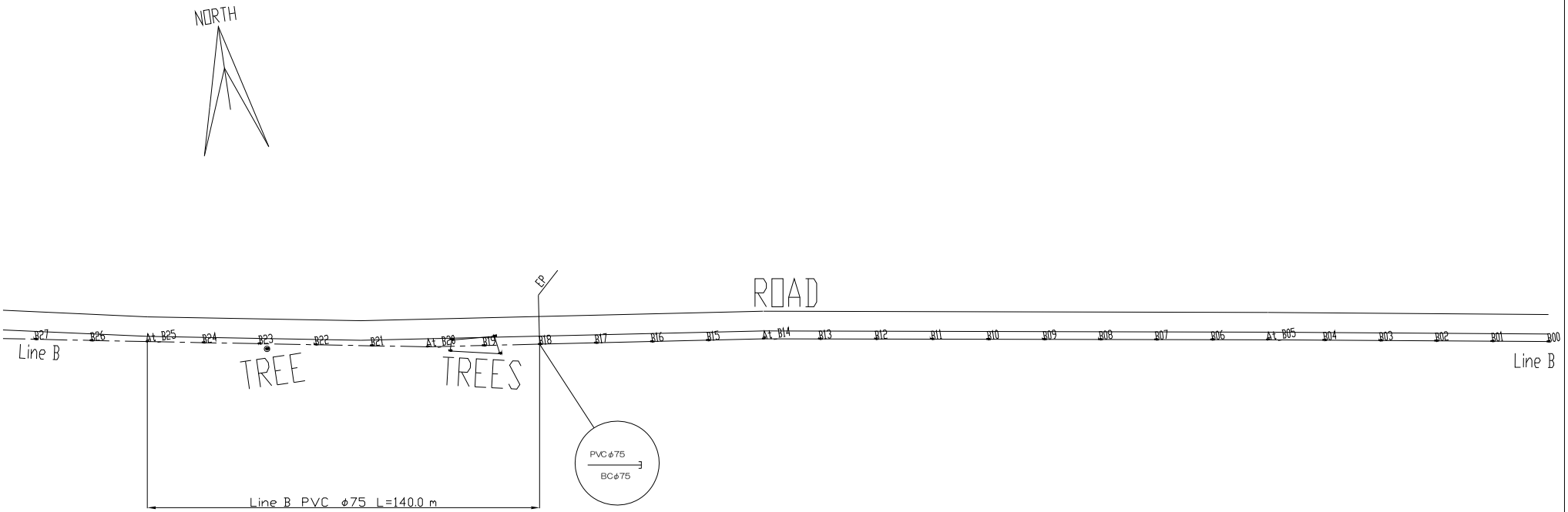
Water Distribution Pipe Plan Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M023

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE B : 1,765.79m to 1,905.86m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Bx	Band
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

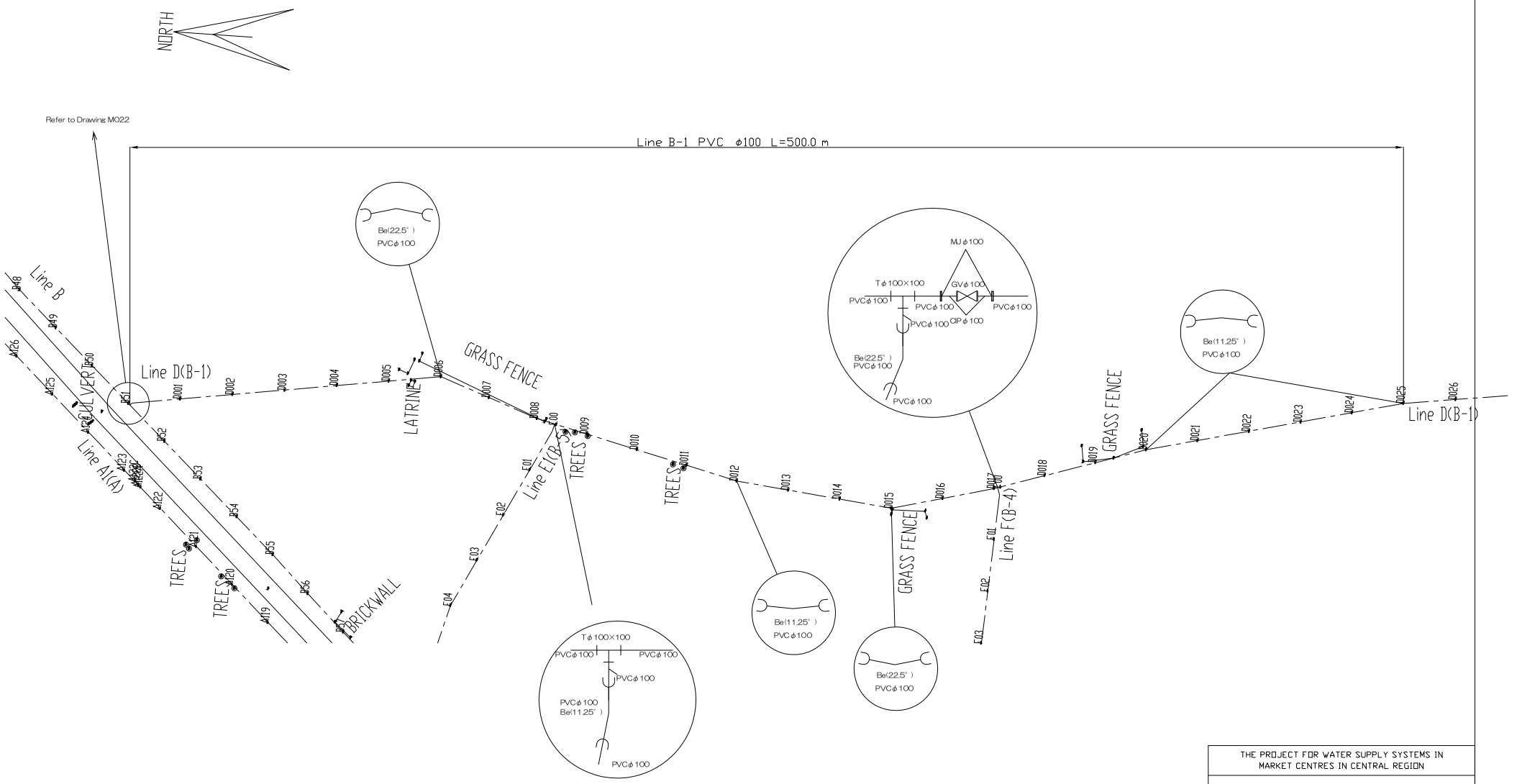
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M024

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE D(B-1) : 0.00m to 500m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Bb	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

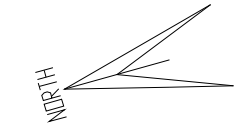
Water Distribution Pipe Plan Mkanda

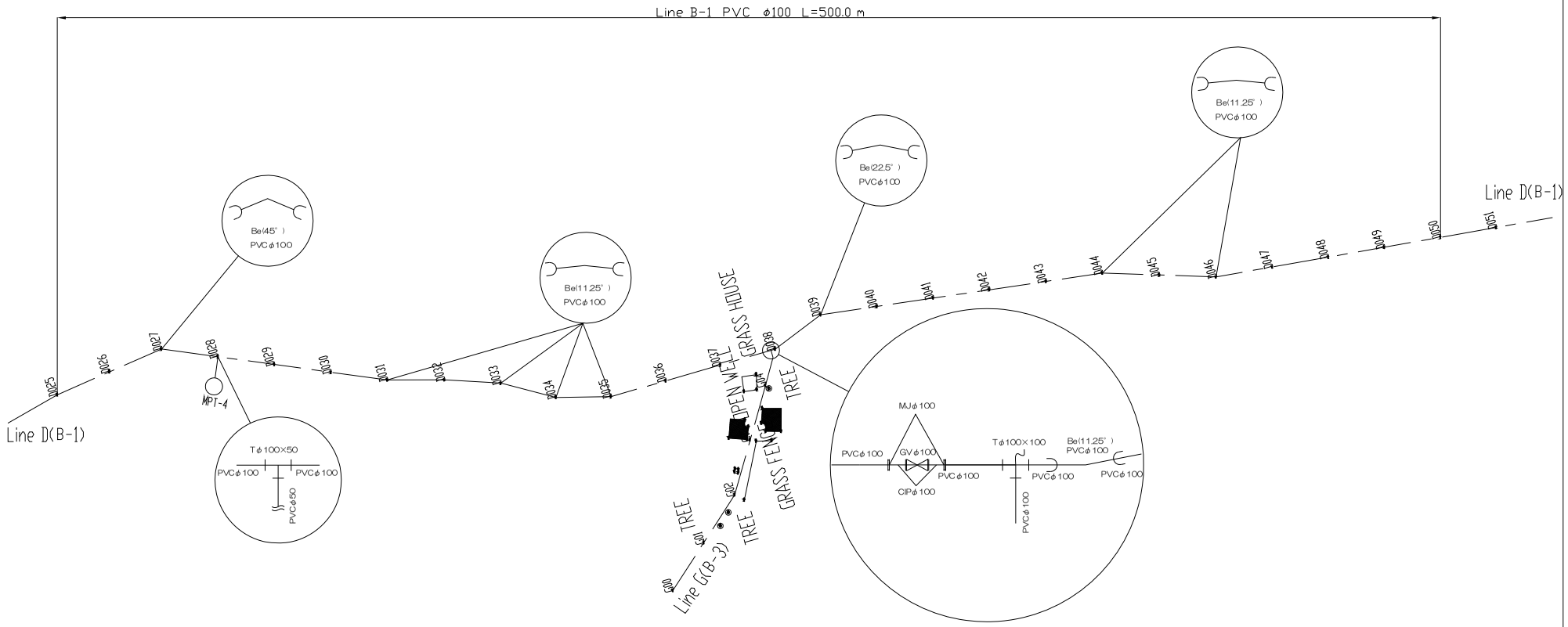
Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M025

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE D(B-1) : 500m to 1,000m

SCALE : 1 / 500 (A0)





LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF Joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

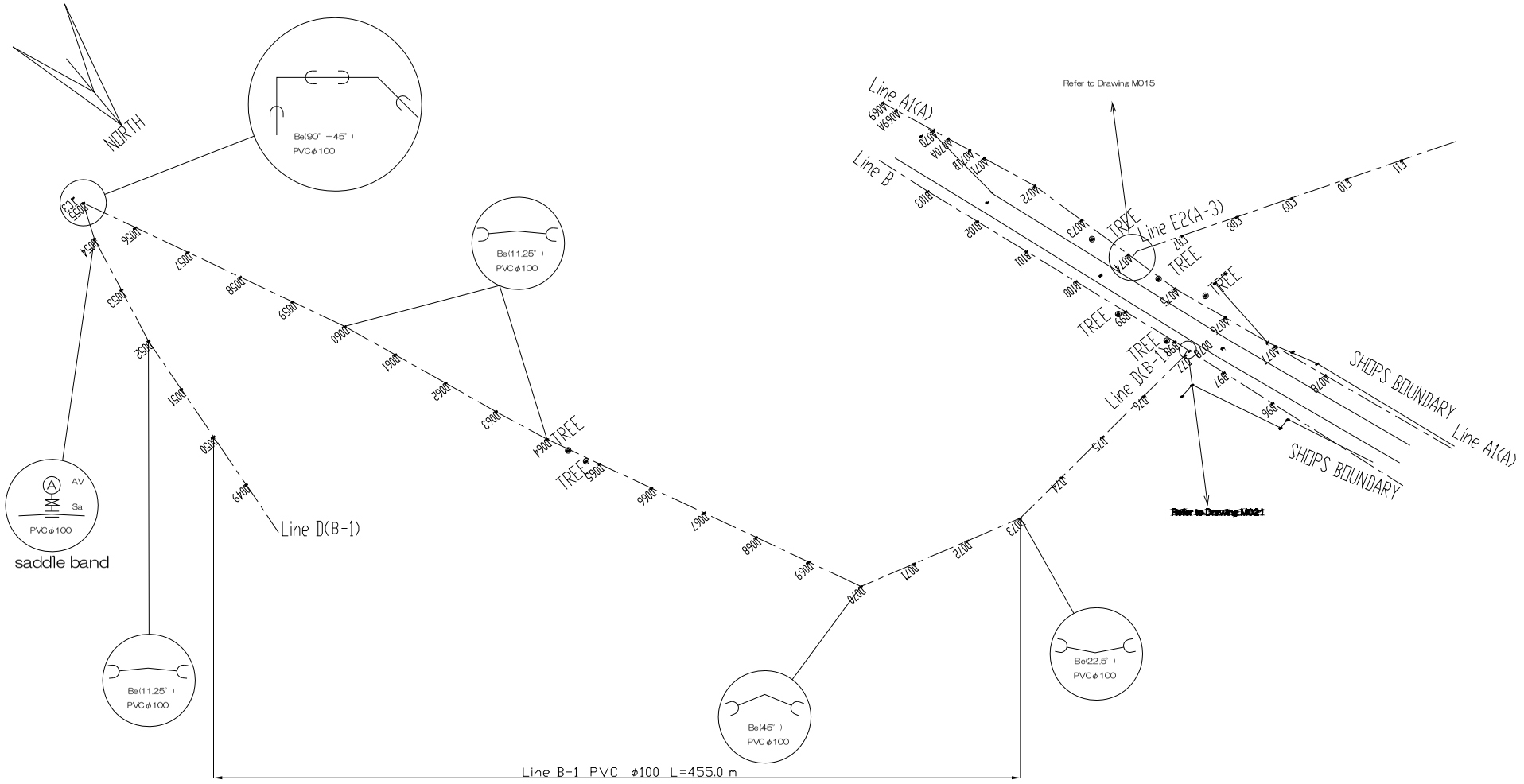
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M026

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE D(B-1) : 1,000m to 1,500m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Bo	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

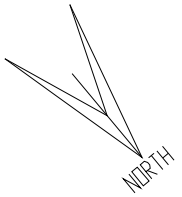
Water Distribution Pipe Plan
Mkanda

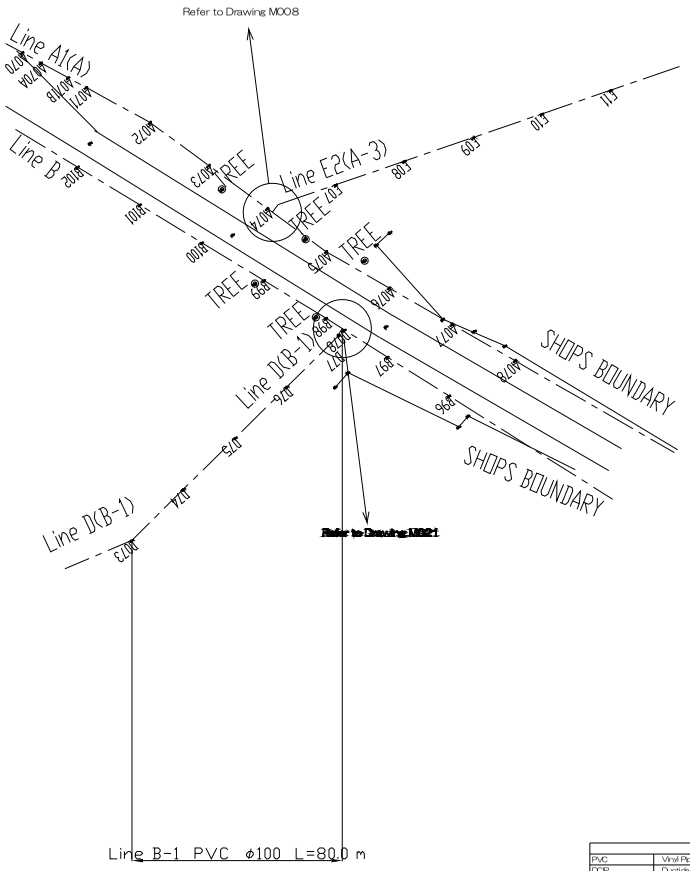
Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M027

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE D(B-1) : 1,500m to 1,534.61m

SCALE : 1 / 500 (A0)





LEGEND			
PVC	Vinyl Pipe	Bs	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

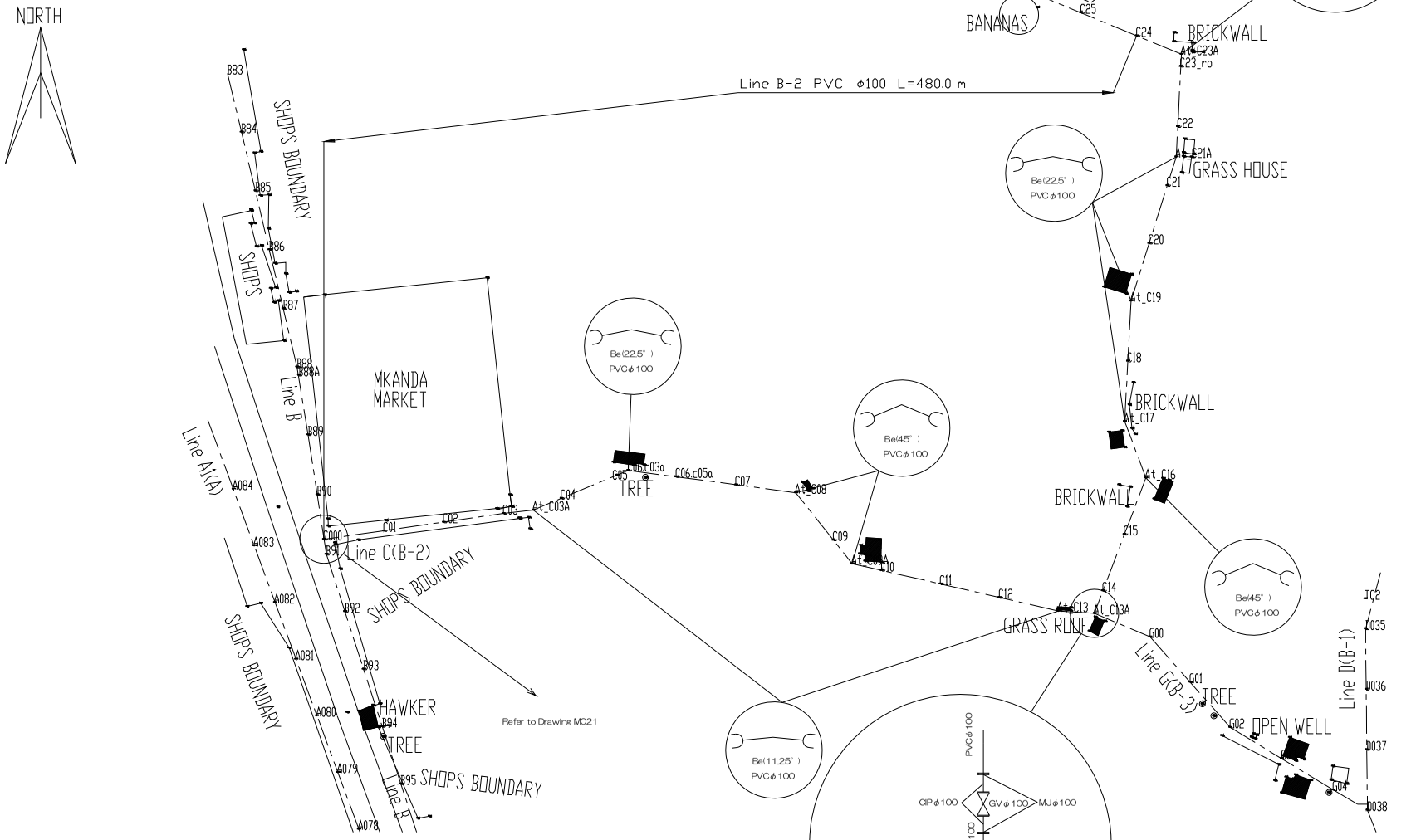
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M028

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE C(B-2) : 0.00m to 500m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blind Cap
BOP	Blow Off Pipe		
MJ	MF Joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

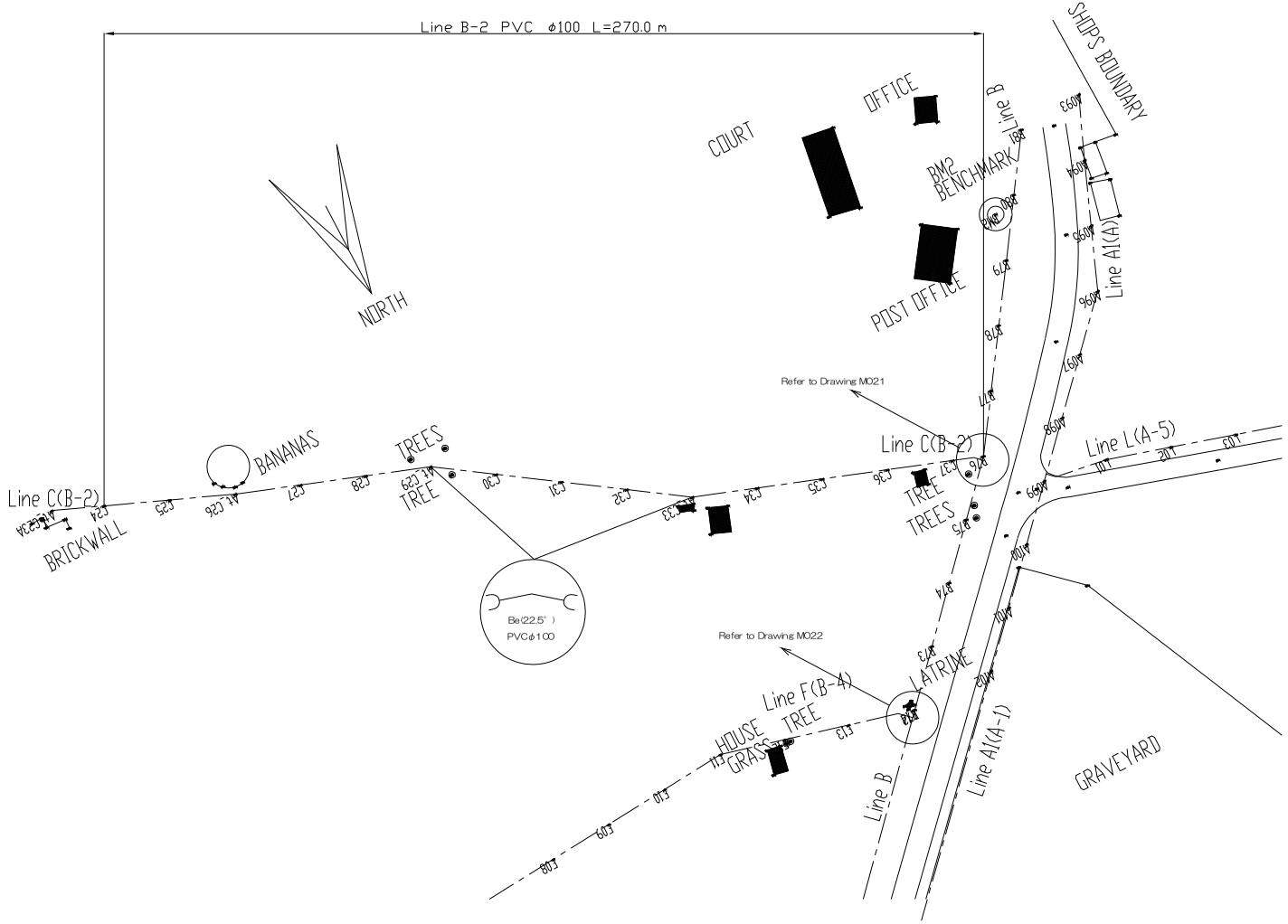
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M029

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE C(B-2) : 500m to 749.74m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Bs	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

Water Distribution Pipe Plan
Mkanda

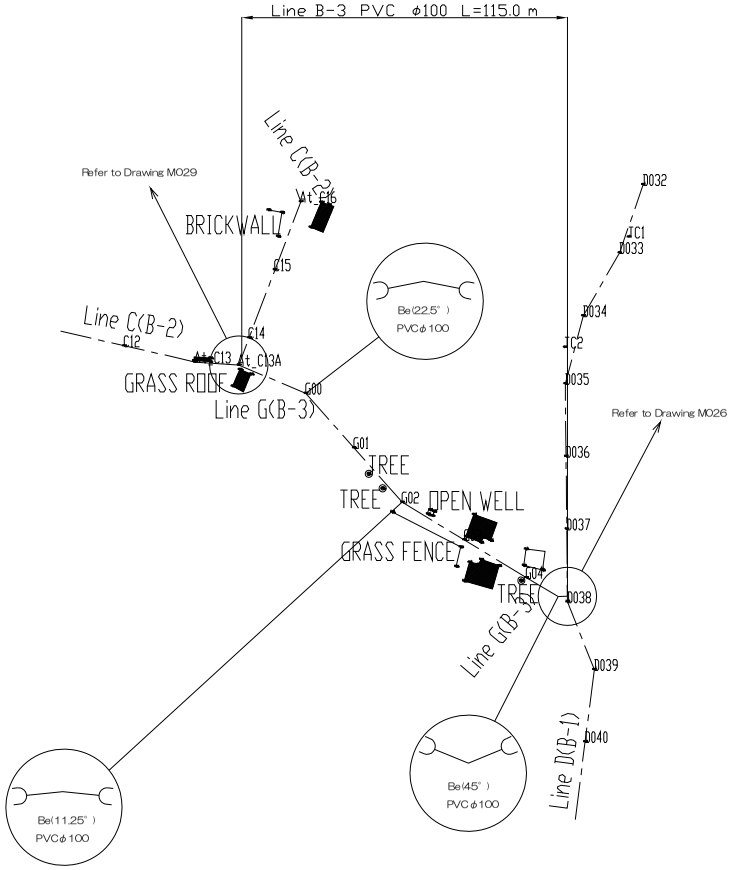
Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M030

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE G(B-3) : 0.00m to 113.11m

SCALE : 1 / 500 (A0)

NORTH



LEGEND			
PVC	Vinyl Pipe	Bo	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

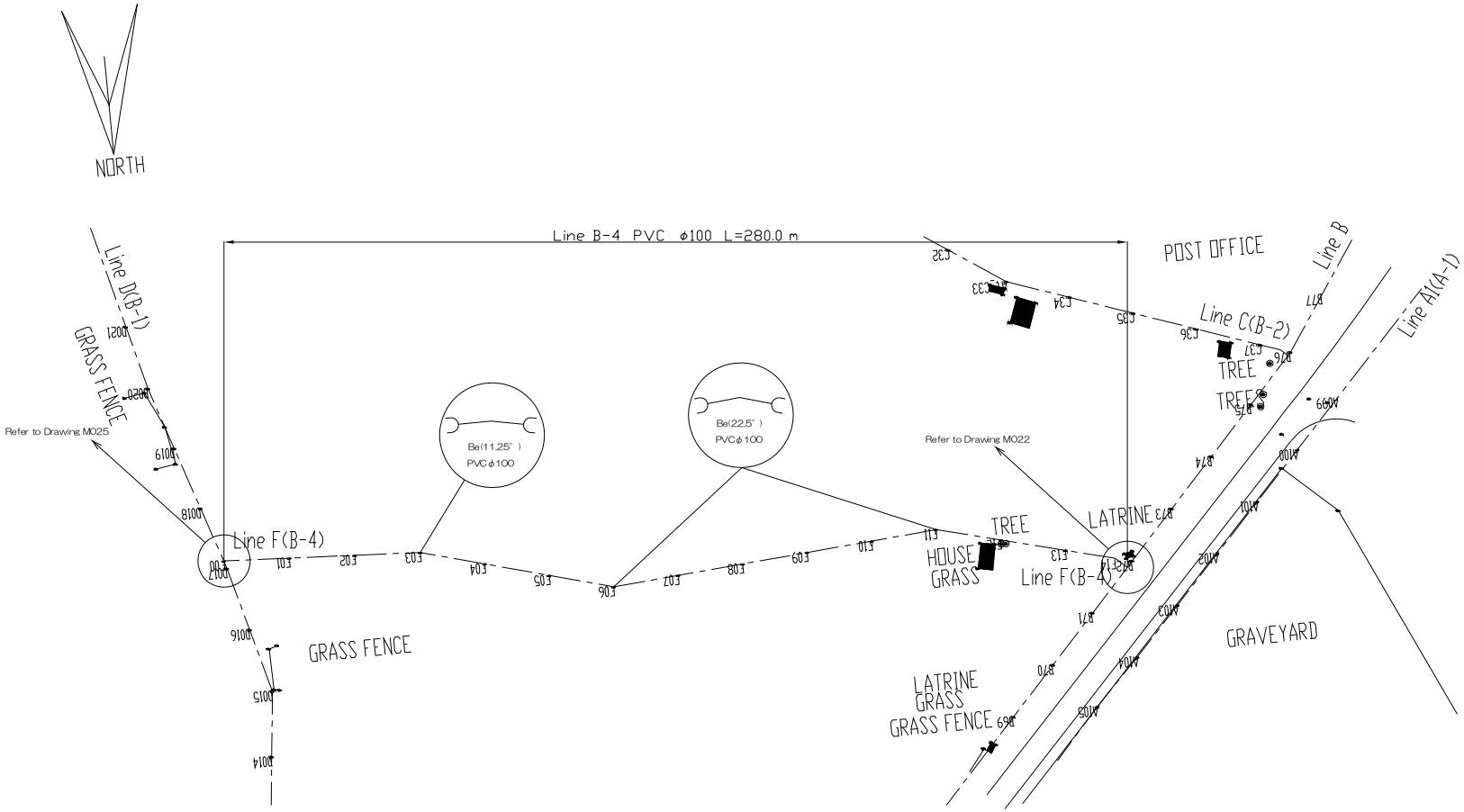
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M031

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE F(B-4) : 0.00m to 280.71m

SCALE : 1 / 500 (A0)



LEGEND			
PVC	Vinyl Pipe	Bx	Band
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

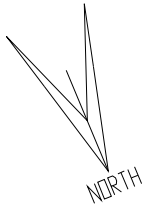
Water Distribution Pipe Plan
Mkanda

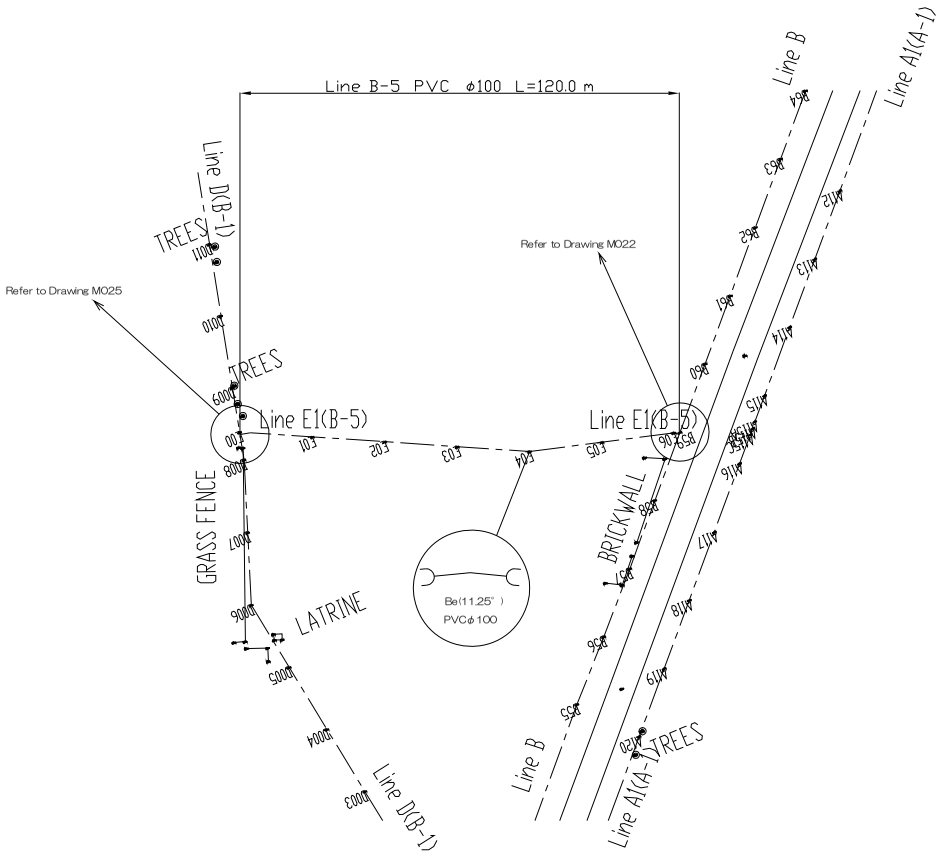
Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M032

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE E1(B-5) : 0.00m to 121.67m

SCALE : 1 / 500 (A0)





LEGEND			
PVC	Vinyl Pipe	Be	Bend
DCIP	Ductide Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV	Air Valve	Bc	Blined Cap
EOP	Blow Off Pipe		
MJ	MF joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

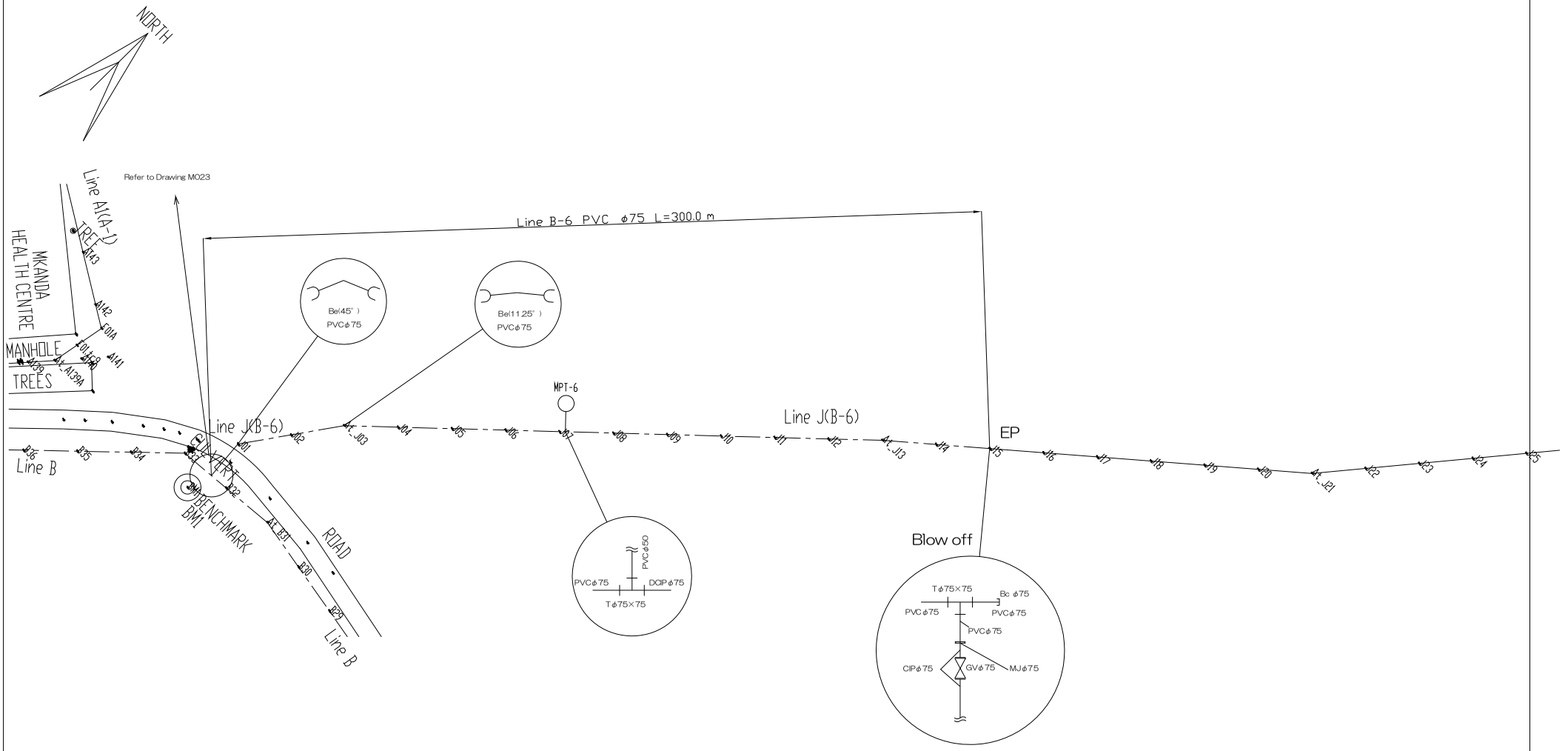
Water Distribution Pipe Plan
Mkanda

Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M033

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

MKANDA WATER SUPPLY SCHEME
LINE J(B-6) : 0.00m to 500m

SCALE : 1 / 500 (A0)



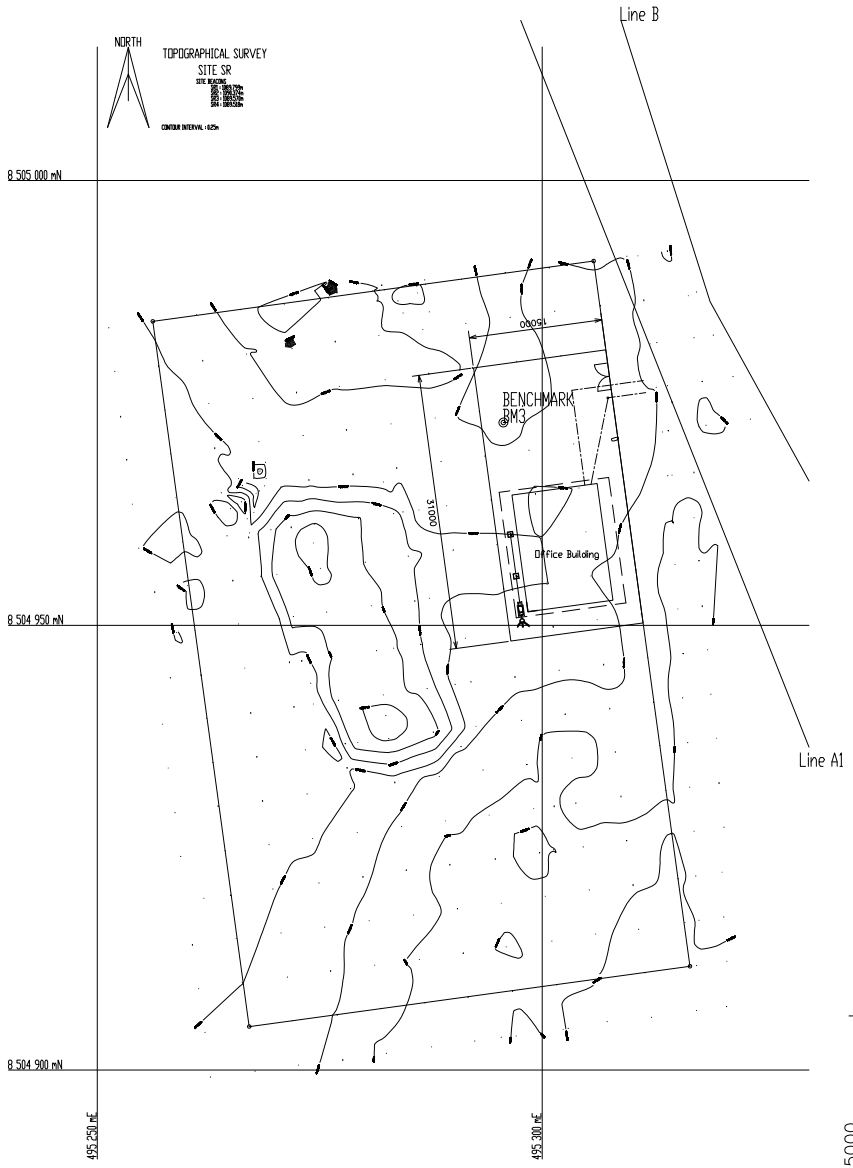
LEGEND			
PVC	Vinyl Pipe	Bc	Bend
DCIP	Ductcile Iron Pipe	Re	Reducer
CIP	Cast Iron Pipe	Sa	Saddle Band
		T	Tee
AV.	Air Valve	Bc	Blined Cap
BOP	Blow Off Pipe		
MJ.	MF Joint		
GV	Gate Valve		

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

Water Distribution Pipe Plan
Mkanda

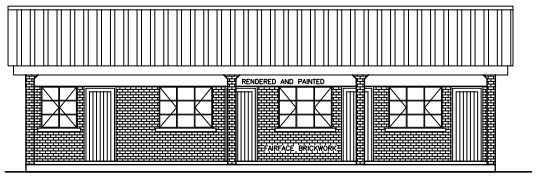
Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M034

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

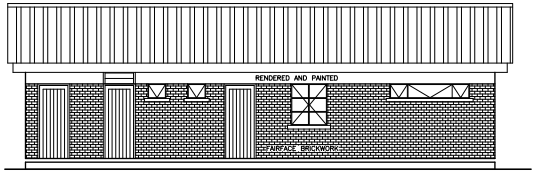


Office Building General Layout (Mkanda)

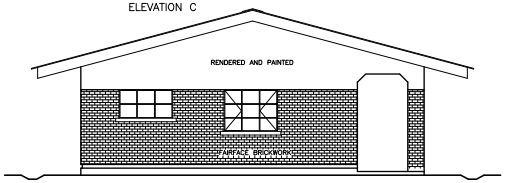
S=1:300(A1) 1:600(A3)



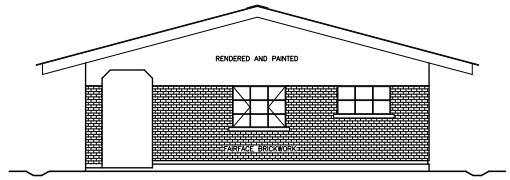
ELEVATION A



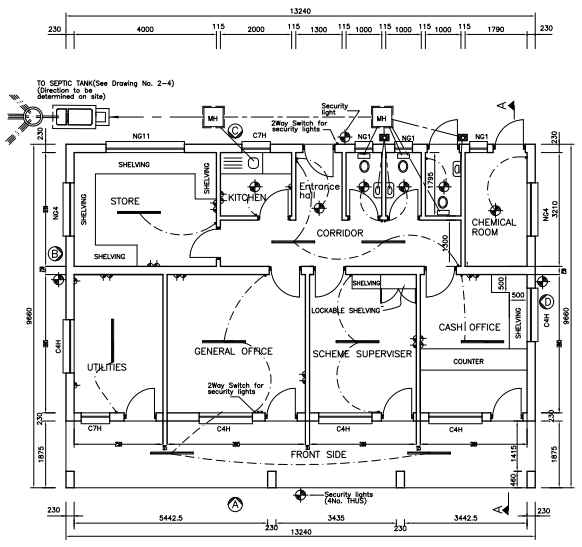
ELEVATION C



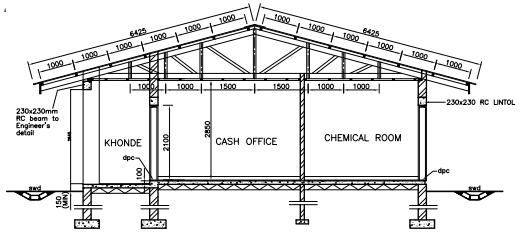
ELEVATION B



ELEVATION D

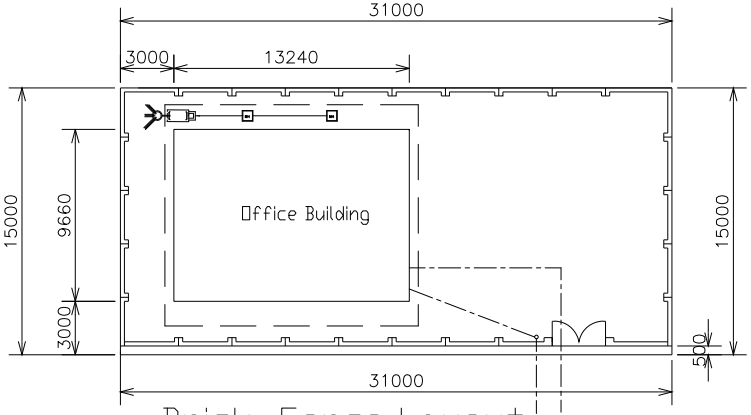


FLOOR PLAN



Office Building Layout

S=1:75(A1) 1:150(A3)



Brick Fence Layout

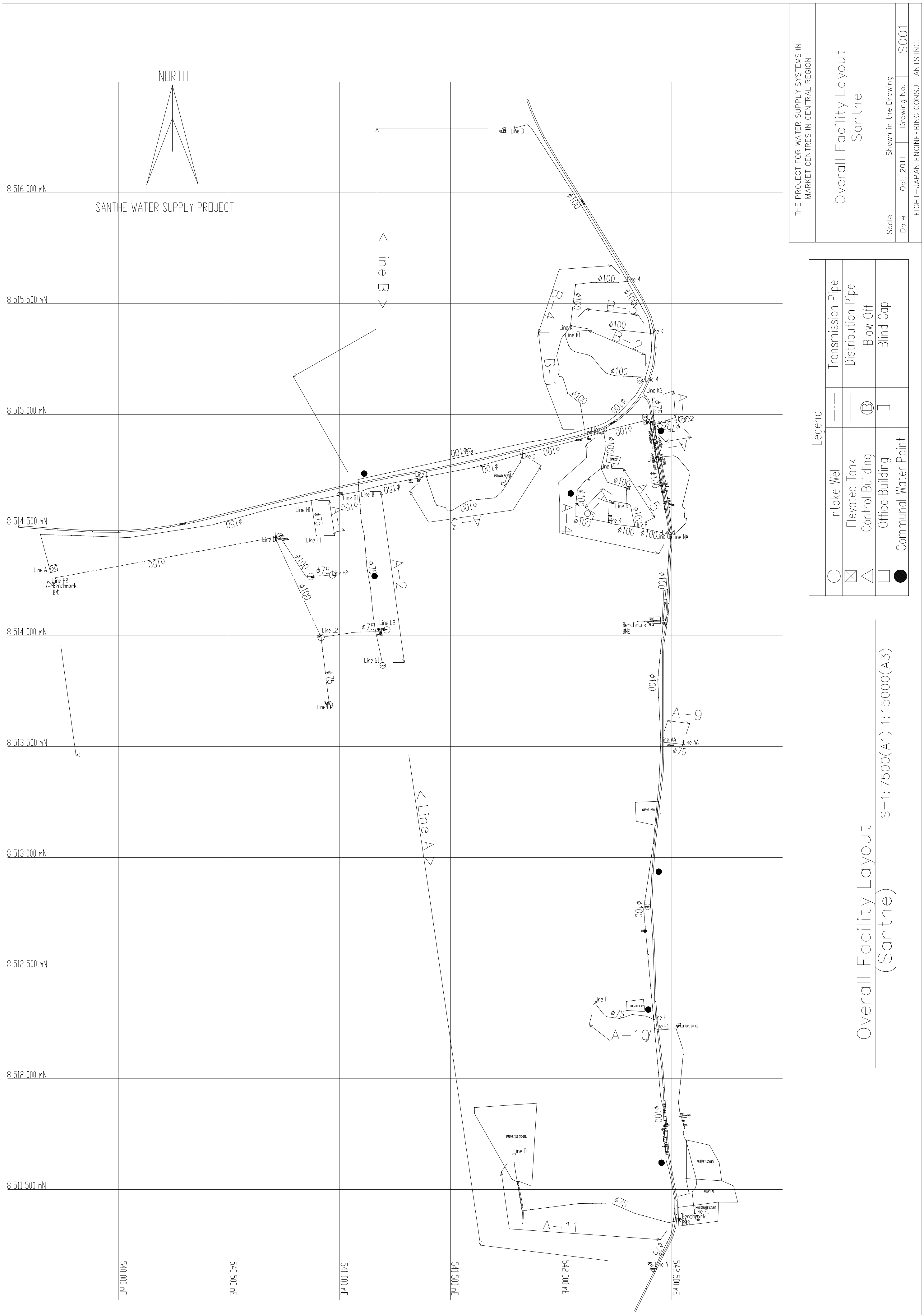
S=1:150(A1) 1:300(A3)

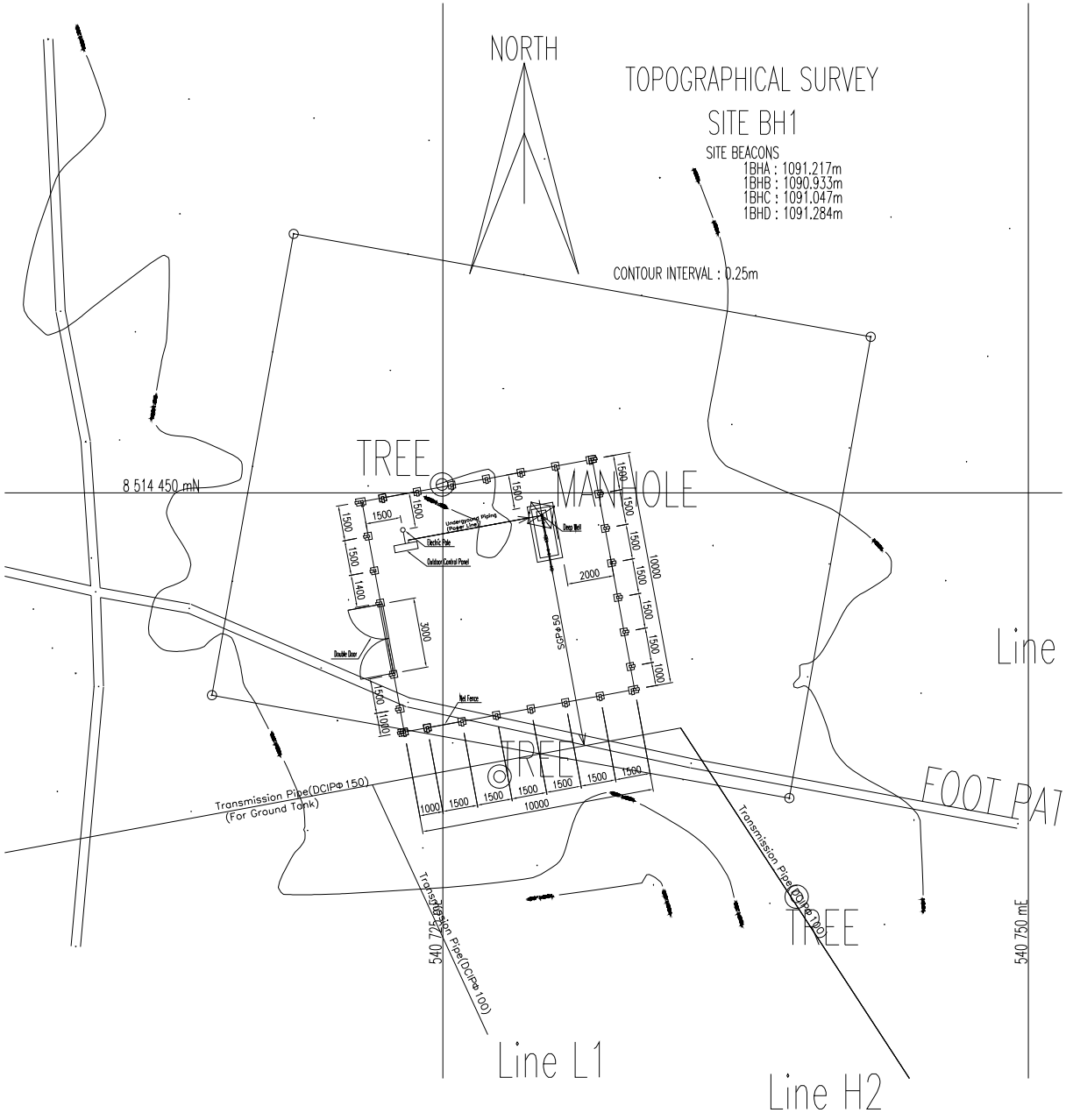
THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION

Office Building Layout
Mkanda

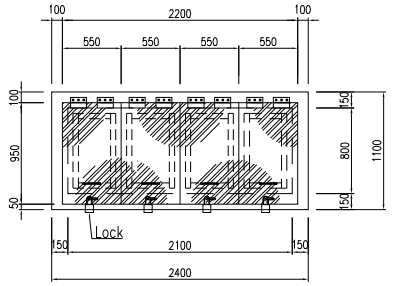
Scale	Shown in the Drawing		
Date	Oct. 2011	Drawing No.	M035

EIGHT-JAPAN ENGINEERING CONSULTANTS INC.

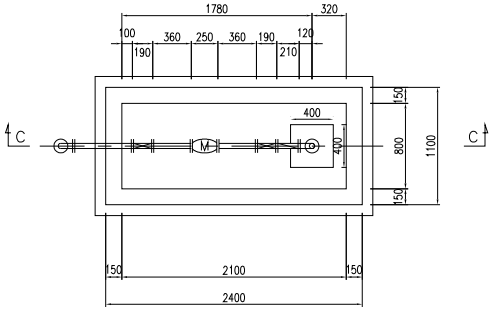

NORTH
SANTHE WATER SUPPLY PROJECT
8 516 000 mN
8 515 500 mN
8 515 000 mN
8 514 500 mN
8 514 000 mN
8 513 500 mN
8 513 000 mN
8 512 500 mN
8 512 000 mN
8 511 500 mN
540 000 mE
540 500 mE
541 000 mE
541 500 mE
542 000 mE
542 500 mE
< Line B >
< Line A >
A-2
A-3
A-4
A-5
A-9
A-10
A-11
B-1
B-2
B-3
B-4
Benchmark BM1
Benchmark BM2
Benchmark BM3
THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION
Overall Facility Layout
Santhe
Scale
Shown in the Drawing
Date
Oct. 2011
Drawing No.
S001
EIGHT-JAPAN ENGINEERING CONSULTANTS INC.
Legend
Intake Well
Elevated Tank
Control Building
Office Building
Communal Water Point
Transmission Pipe
Distribution Pipe
Blow Off
Blind Cap
Overall Facility Layout
(Santhe)
S=1:7500(A1) 1:15000(A3)



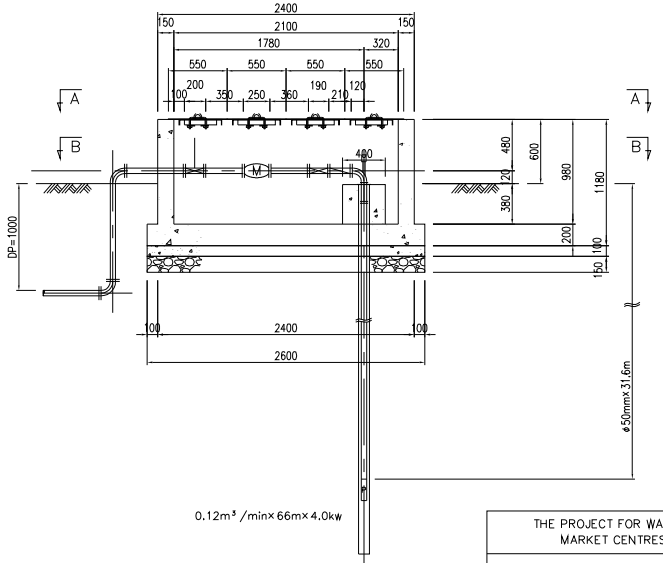
Intanke Well ST−1 General Layout
(Santhe) S=1:100(A1) 1:200(A3)



A − A Section



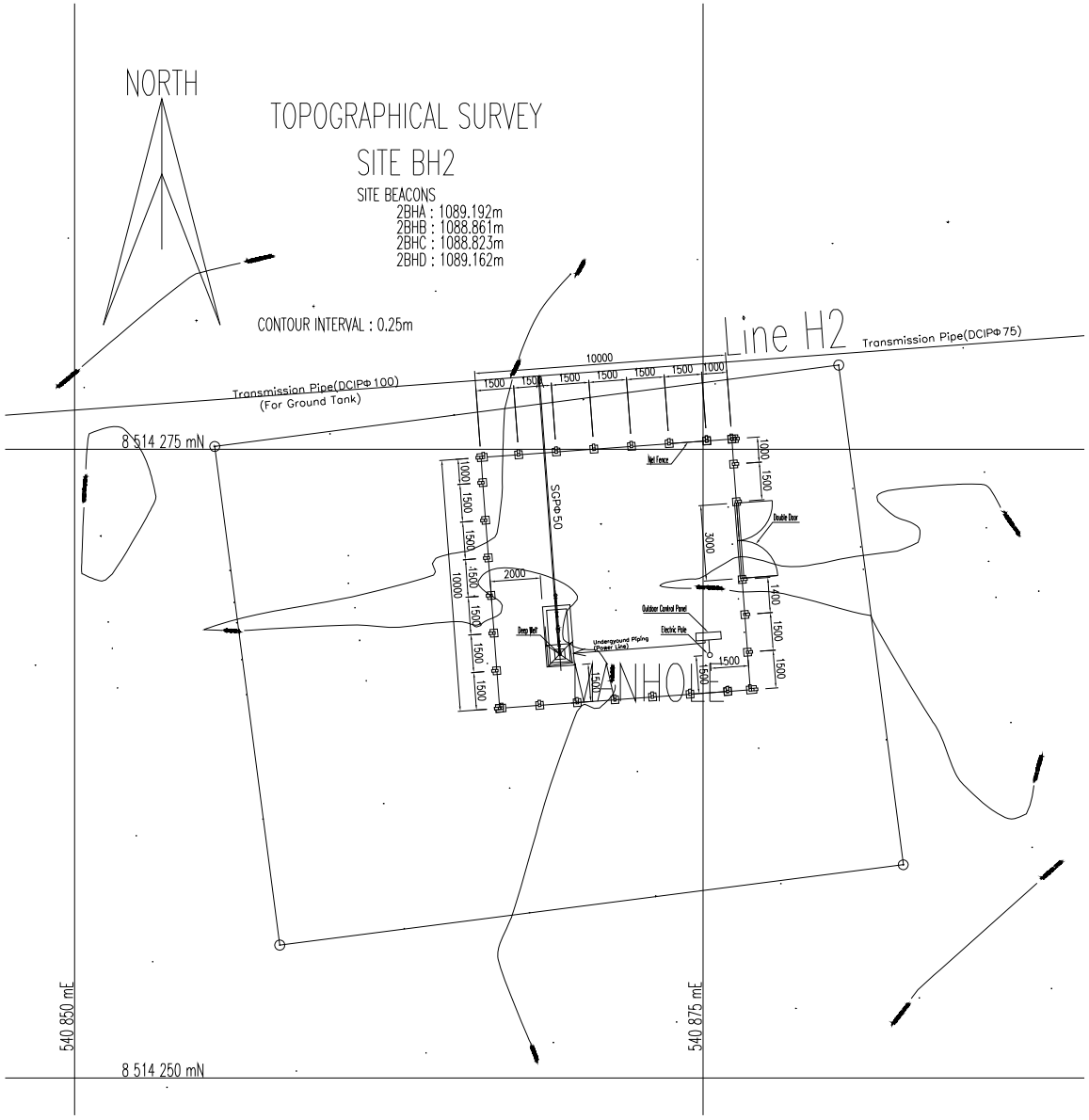
B − B Section



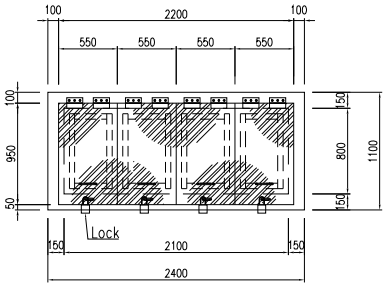
C − C Section

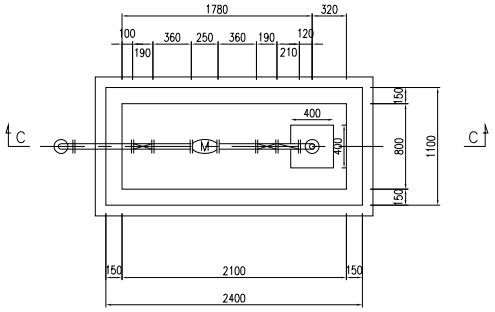
Intanke Well Structure
S=1:25(A1) 1:50(A3)

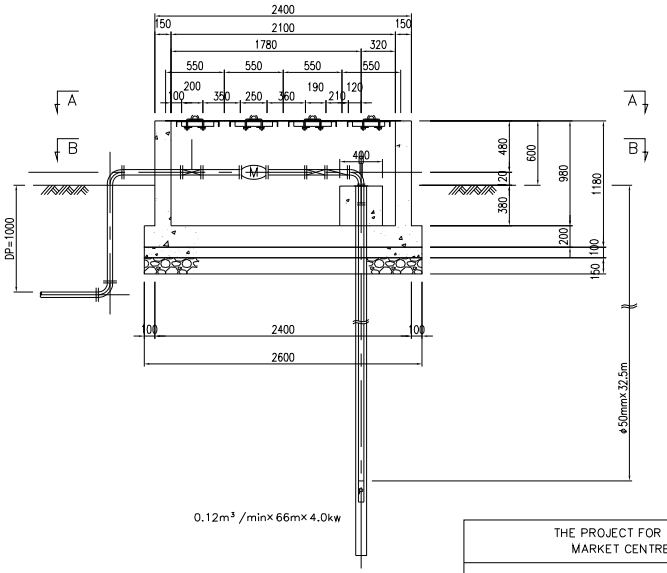
THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION	
Intake Well ST−1 Santhe	
Scale	Shown in the Drawing
Date	Oct. 2011
Drowing No.	S002
EIGHT−JAPAN ENGINEERING CONSULTANTS INC.	



Intanke Well ST-2 General Layout
(Santhe)
S=1:100(A1) 1:200(A3)

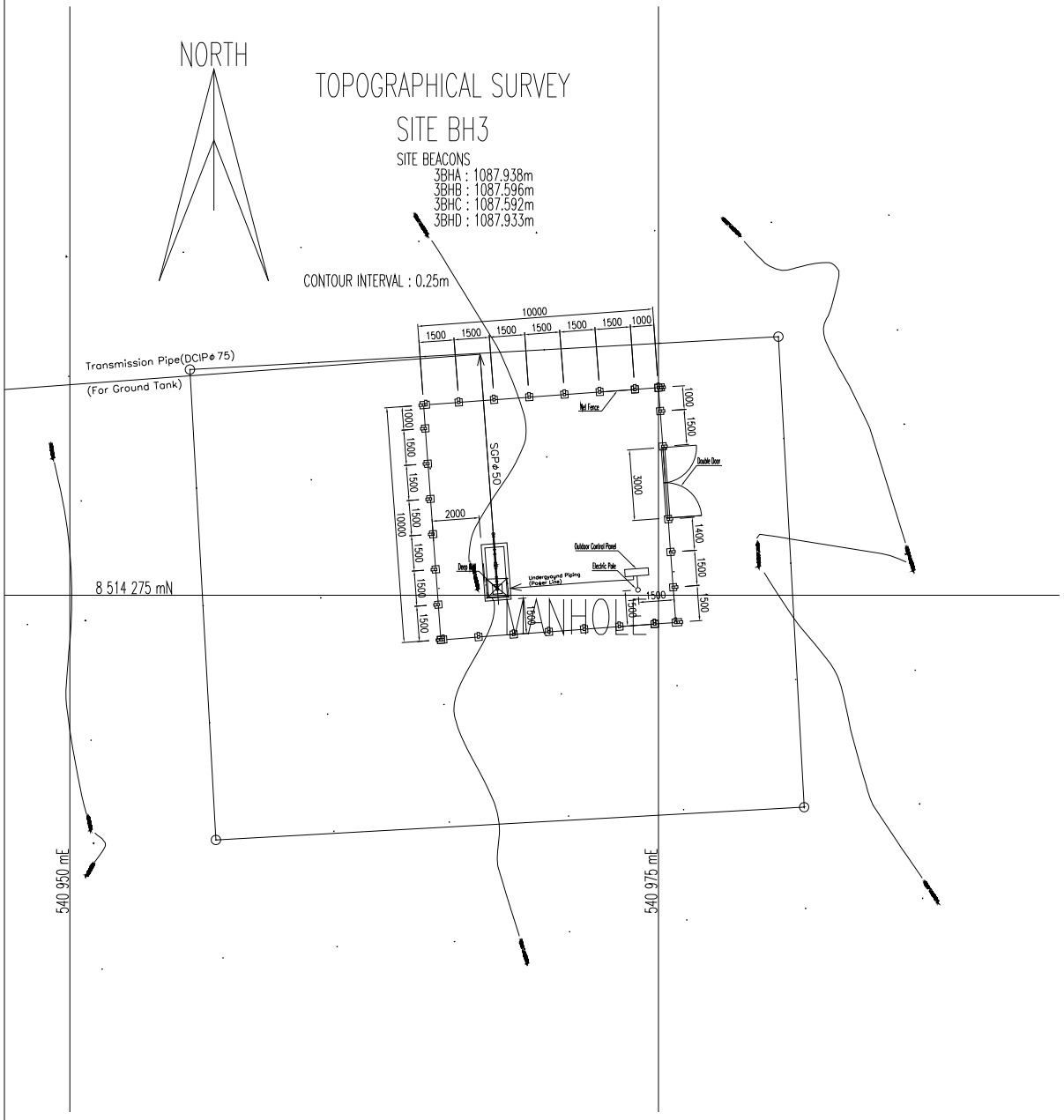




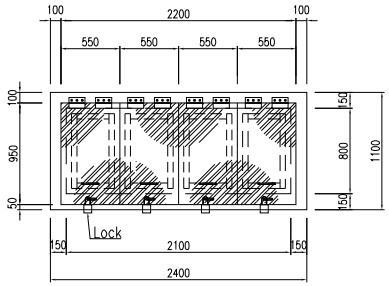


Intanke Well Structure
S=1:25(A1) 1:50(A3)

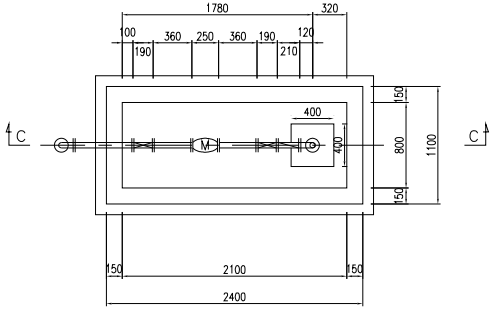
THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION	
Intake Well ST-2 Santhe	
Scale	Shown in the Drawing
Date	Oct. 2011
Drowing No.	S003
EIGHT-JAPAN ENGINEERING CONSULTANTS INC.	



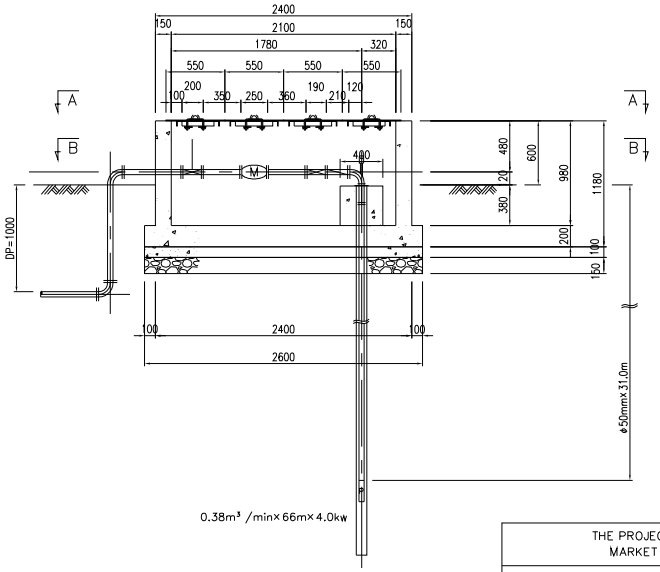
Intanke Well ST-3 General Layout
(Santhe)
S=1:100(A1) 1:200(A3)



A – A Section



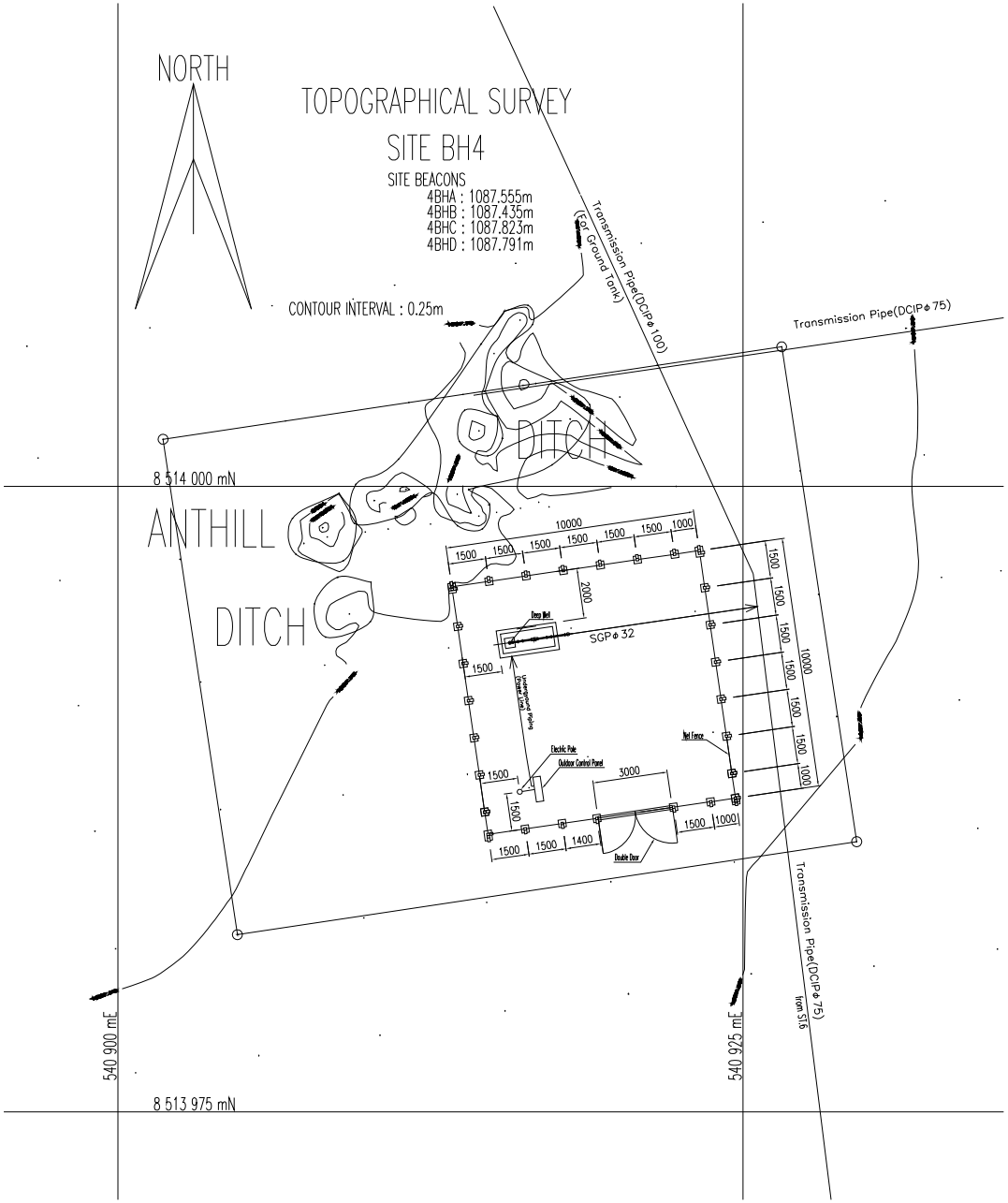
B – B Section



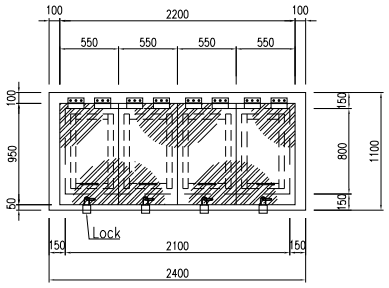
C – C Section

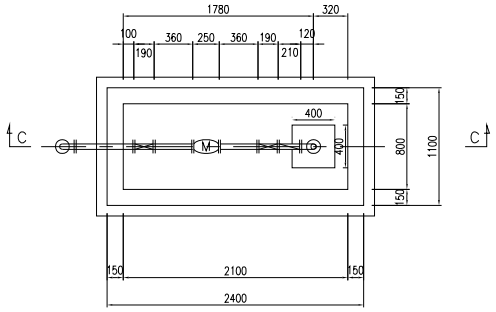
Intanke Well Structure
S=1:25(A1) 1:50(A3)

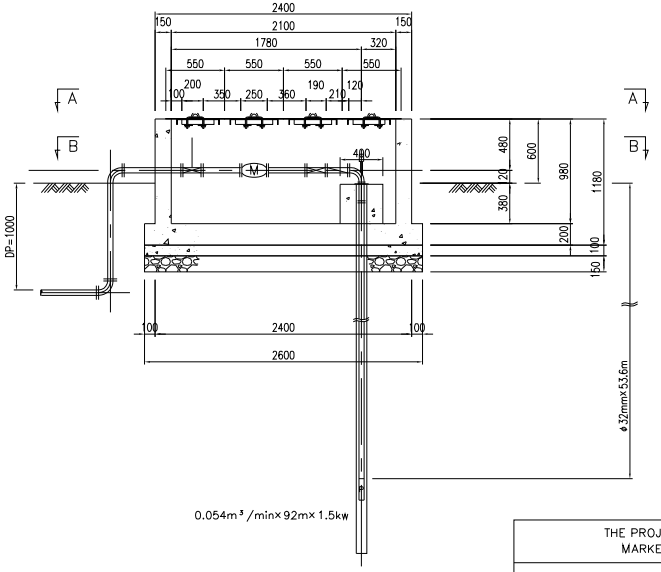
THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION	
Intake Well ST-3 Santhe	
Scale	Shown in the Drawing
Date	Oct. 2011 / Drowing No. S004
EIGHT-JAPAN ENGINEERING CONSULTANTS INC.	



Intanke Well ST−4 General Layout
(Santhe) S=1:100(A1) 1:200(A3)







Intanke Well Structure
S=1:25(A1) 1:50(A3)

THE PROJECT FOR WATER SUPPLY SYSTEMS IN MARKET CENTRES IN CENTRAL REGION			
Intake Well ST−4 Santhe			
Scale	Shown in the Drawing		
Date	Oct. 2011	Drowing No.	S005
EIGHT−JAPAN ENGINEERING CONSULTANTS INC.			