MINISTRY OF INDUSTRY, MINES AND ENERGY

KINGDOM OF CAMBODIA

THE PREPARATORY SURVEY REPORT
ON
THE PROJECT FOR REPLACEMENT AND EXPANSION OF WATER DISTRIBUTION SYSTEMS IN PROVINCIAL CAPITALS
IN
THE KINGDOM OF CAMBODIA

MARCH 2011

JAPAN INTERNATIONAL COOPERATION AGENCY

NJS CONSULTANTS CO., LTD.

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Preface

Japan International cooperation Agency (JICA) decided to conduct the preparatory survey on “The Project for Replacement and expansion of Water Distribution Systems in Provincial Capitals” in the Kingdom of Cambodia, and organized a survey team headed by Mr. Nobuki Abe of NJS Consultants Co., Ltd. between July, 2010 to February, 2011.

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

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

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

March, 2011

Shinya Ejima
Director General
Global Environment Department
Japan International Cooperation Agency

Summary

1. Outline of Cambodia

The Kingdom of Cambodia with 181,000km^2 of land area is located in Indochina Peninsula, surrounded by Vietnam in east, Thailand in west and Laos in north. Total population in 2008 is about 13.4 million (Statistic of Government of Cambodia). The climate is classified as tropical monsoon. Annual rainfall ranges about 1,000 mm to 3,000 mm according to province.

After independence in 1953, stable era continued until 1960's and unstable era by civil war occurred in 1970 to 1980's. In 1988, political stability was achieved by new administration.

As for economic aspect, economic growth rate increased after establishment of new administration, average GDP rate for 10 years until 2007 arrived at 9.4 %. According to ADB annual report 2009, GDP is about 12.24billion USD with per capita GDP of 832 USD. The ratios of GDP by industry are 34 % for primary industry (agriculture, forest and fishery), 24 % for secondary industry (industry and mines) and 42 % for tertiary industry (services). National budget in 2009 is small as about 2.13 billion USD and 30% of the budget is occupied by bilateral ODA assisted by DAC countries. Thus, it is considered that the economy of Cambodia is dependent on foreign fund.

Recently Cambodia achieved rapid economic growth, however, GDP has been delayed after September 2009 due to financial crisis beginning with Lehman Shock. As a result, GDP growth rate dropped to minus 2.0% in 2009.

2. Background of the Project

In Cambodia, water supply facilities and human resources for Phnom Penh City to uplift water supply capacity have been developed in assistance of various donors including Japan after civil war. On the other hand, water supply development in provincial cities other than Phnom Penh City is still behind.

In "National Strategic Development Plan 2006 - 2010" formulated in 2006 and then valid until 2013, it is raised to achieve a target of 80 % accessibility in urban residents to potable water. In fact, the current rate of access to potable water in Cambodia was estimated at only 51 % according to the MIME survey in 2008. Uplift of water services in provincial cities is a crucial issue presently.

In order to improve such situation, water treatment plants of Pursat, Kampong Thom, Svay Rieng, Sihanoukville and Battambang have been improved/upgraded in assistance of WB (for Sihanoukville) and ADB (for other 4 cities). Although uplifting supply capacity has been attempted in both hard and soft aspect through assistance of some donors, the capacity of the existing water treatment plants are not fully utilized, since development of distribution pipe network is still behind in these 5 cities. Water leakage occurs frequently in the deteriorated distribution pipes and financial loss by NRW is a serious problem for effective use of water supply and business management of respective waterworks.

Under such circumstances, RGC requested GOJ (Government of Japan) grant aid project including replacement and expansion of distribution pipe networks for the purpose of uplifting water services of the five (5) provincial capitals in January 2010.

3. Outline Survey Result and Scope of the Project

Under the above background, GOJ decided to conduct preparatory survey on replacement and expansion of water distribution pipes for provincial cities in Cambodia. In response to this, JICA conducted preparatory survey for the purpose of preparation of appropriate outline design suitable as a grant aid, implementation plan and project cost estimates for the selected provincial capitals based on examination of appropriateness of the project scale and prioritization.

JICA dispatched survey team for outline design from the end of July until beginning of October, 2010 and for explanation and discussions on draft outline design report from January to February, 2011. In the preparatory survey, the project was planned based on the following policies considering the request of the Government of Cambodia, results of field survey and discussions.

(1) The objective areas of the project are Pursat, Battambang and Sihanoukville

(2) The target year of the project is to be set up at 2016

(3) Replacement and expansion of distribution pipelines will be designed with priority as below.

1) The first priority shall be given to replacement of old and deteriorated pipelines,

2) The second priority shall be given to expansion of the pipelines hydraulically needed,
3) The third priority shall be given to expansion of the pipelines at urban areas where uplifting of water services is expected, and
4) The last priority shall be given to expansion of the pipelines at vicinity of urban areas together with considering density of expected service connections.

In designing the facility, basically PWSA's standard is referred to and scope of the project is to be restricted according to the design capacity of the exiting WTPs including bulk water (for Sihanoukville WS).

(4) Distribution flow monitoring system

In rehabilitation and expansion of distribution pipelines, service area will be divided into blocks and distribution flow monitoring system will be provided in order to improve operation and maintenance of water distribution facilities.

(5) Service pipe connection materials

Service pipe connection accompanied by replacement and expansion of distribution pipes will be subject to obligation of the Cambodia side. To assist this activity, Japanese side will procure service pipe connection materials.

(6) Soft component

Soft component regarding capacity enhancement on service pipe connection for the purpose of smooth implementation of service pipe connection to be shouldered by the Cambodian side as well as appropriate operation and management of distribution flow monitoring system will be planned.

① Facility

Component	Category	Major Specifications, Quantity and Contents
Facility Construction	Replacement	Pipe Length: Total 31.8 km Pipe Type: DCIP and HDPE Pipe Diameter: 50A to 350A Note: Re-connection of service pipeline is under Cambodian works.
	Expansion	Pipe Length: Total 93.2 km Pipe Type: DCIP and HDPE Pipe Diameter: 50A to 350A
	Particular Route and Major Accessory	Crossings of Road/ Railway/ River and Detour Route: 3 units Flow Meter*[1], Valves (GV, PRV, FCV, ARV, BOV): 3 units Note*[1]: Accessories will be connected to the existing pipeline partially. Note*[2]: Cambodian side shall install the primary distribution line of electric power.
	Flow Monitoring	Distribution Flow Monitoring System (Telemetric Data Processing): 3 units
	Replacement	Pipe Length: Total 31.8 km Pipe Type: DCIP and HDPE Pipe Diameter: 50A to 350A Note: Re-connection of service pipeline is under Cambodian works.
	Expansion	Pipe Length: Total 93.2 km Pipe Type: DCIP and HDPE Pipe Diameter: 50A to 350A

② Procurement

Component	Category	Major Specifications, Quantity and Contents
Procurement	Materials for Service Connection	Re-connection: Clamp Saddle, HDPE , Valves, Fittings, etc. 4,400 sets New Connection (for expansion pipes): Clamp Saddle and Water Meter: 2,400 sets New Connection (for existing pipes): Water Meter 700 peaces
	Equipment for HDPE Connector	SF Connector: for HDPE suitable with pipe diameter of 50A or below 5 sets Portable Engine Generator: 5 kVA 5 units

③ Soft Component

Category	Major Specifications, Quantity and Contents
Service pipe connection	Skill of qualified service connection and proper turn-over inspection
Flow Management	Theory and application of the flow monitoring system, preparation of the action plan

Table S1-1 Contents of the Project

Component	Category	Major Specifications, Quantity and Contents
Facility Construction	Replacement	Pipe Length: Total 31.8 km Pipe Type: DCIP and HDPE Pipe Diameter: 50A to 350A Note: Re-connection of service pipeline is under Cambodian works.
	Expansion	Pipe Length: Total 93.2 km Pipe Type: DCIP and HDPE Pipe Diameter: 50A to 350A
	Particular Route and Major Accessory	Crossings of Road/ Railway/ River and Detour Route: 3 units Flow Meter*1, Valves (GV*1, PRV*1, FCV*1/2, ARV, BOV): 3 units Note*1: Accessories will be connected to the existing pipeline partially. Note*2: Cambodian side shall install the primary distribution line of electric power.
	Flow Monitoring	Distribution Flow Monitoring System (Telemetric Data Processing): 3 units
Procurement	Materials for Connection	Re-connection: Clamp Saddle, HDPE , Valves, Fittings, etc. 4,400 sets New Connection (for expansion pipes): Clamp Saddle and Water Meter: 2,400 sets New Connection (for existing pipes): Water Meter 700 peaces
	Equipment for HDPE Connector	SF Connector: for HDPE suitable with pipe diameter of 50A or below 5 sets Portable Engine Generator: 5 kVA 5 units
Capacity Development	Connection Skill	Skill of qualified service connection and proper turn-over inspection
	Flow Management	Theory and application of the flow monitoring system, preparation of the action plan

Note: Quantity of construction and procurement in each waterworks is referred to Tables 2-4 and 2-5 in Chapter-II.
Remark*1: Some accessories will be connected to the existing pipeline partially.
Remark*2: Flow control valves will be operated by electric power.

4. Implementation Schedule and Project Cost

Required period of implementation of the project will be 28.0 months. 5.5 months for the detailed design, 5.5 months for the bid documents preparation and bidding works and 16.5 months for the facility construction including soft component are to be allotted, respectively.
Out of total project costs, the cost to be borne by the Cambodian side is estimated at about 0.06 billion Yen.

5. Project Evaluation

The adequacy of the project is highly evaluated as below.
The Project will benefit the people including poverty group in Pursat, Battambang and Sihanoukville by improvement in water supply through providing water supply facilities, which is urgently required as well as coincides with BHN. The project will surely contribute to sector development target such as uplifting service ratio in provincial cities up to 80% as stipulated in "National Strategic Development Plan"
The facilities to be provided will not produce any negative impacts on environment during construction period as well as facility operation and maintenance period after construction.
The facilities to be provided under the Grant Aid Program of Japan will not require excessively advanced type of technology and can be properly operated and maintained financially and technically with a sound operation of the respective waterworks. The project is not intended to gain excessive benefit, since operation and maintenance cost is to be covered by water tariff. In addition, since the distribution flow monitoring system to be provided in the project is similar kind of system which was introduce in PPWSA by using Japanese technology, there are advantages of using Japanese technology. Thus, the project can be implemented under the Grant Aid Program of Japan without any negative issue.
As for the project effectiveness, both quantitative and qualitative effectiveness are expected as below.

<Quantitative Effectiveness>

Indicator	Water Utility (Output)	Expected Project Effectiveness/ Action Year 2009	Year 2016
Maximum Daily Water Supply	Pursat	3,410 m^3/day	5,760 m^3/day
	Battambang	9,220 m^3/day	11,520 m^3/day
	Sihanoukville	6,200 m^3/day	12,210 m^3/day
NRW Rate*	Pursat	23.1 %	19 %～14 %
	Battambang	27.6 % (20 hrs. water supply) 35.5 % (24 hrs. water supply)	24 hrs. water supply 20 %～13 %
	Sihanoukville	18.9 %	14 %～10 %
Operation Ratio of WTP	Pursat	59 %	100 %
	Battambang	80 %	100 %
	Sihanoukville	81 % (ANCO: 0 %)**	100 % (ANCO: 45 %)
Energy Efficiency	Pursat	Diesel oil consumption: 0.222 L/m^3	0.199 L/m^3
	Battambang	Electric power consumption: 0.609 kWh/m^3	0.453 kWh/m^3
	Sihanoukville	Electric power consumption: 0.704 kWh/m^3	0.634 kWh/m^3
Water Cost Recovery	Pursat	114 %	127 %
	Battambang	149 %	200 %
	Sihanoukville	153 %	162 %
Upper No. of Connection Lower Pop. Served (estimated)	Pursat	About 3,600 connections	About 6,300 connections
		About 18,200 persons	About 31,500 persons
	Battambang	About 8,600 connections	About 11,300 connections
		About 42,900 persons	About 56,400 persons
	Sihanoukville	About 3,845 connections	About 8,045 connections
		About 23,000 persons	About 48,200 persons

* NRW Rate has a range considering the utmost case of NRW improved. Figures of other indicators are those in case that utmost reduction of NRW is considered.

** (ANCO: %) indicates ratio of water supplied from ANCO compared with maximum 10,000m^3/day stipulated in MOU (Memorandum of Understanding).

<Qualitative Effectiveness>

① Insufficient water quantity and pressure at faucets will be improved by maintaining water pressure in distribution pipes properly.

② NRW ratio will be decreased by reducing water leakage, which will contribute to improvement of management of respective waterworks.

The Preparatory Survey Report on
The Project for Replacement and Expansion of Water Distribution Systems in Provincial Capitals in the Kingdom of Cambodia

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Perspective

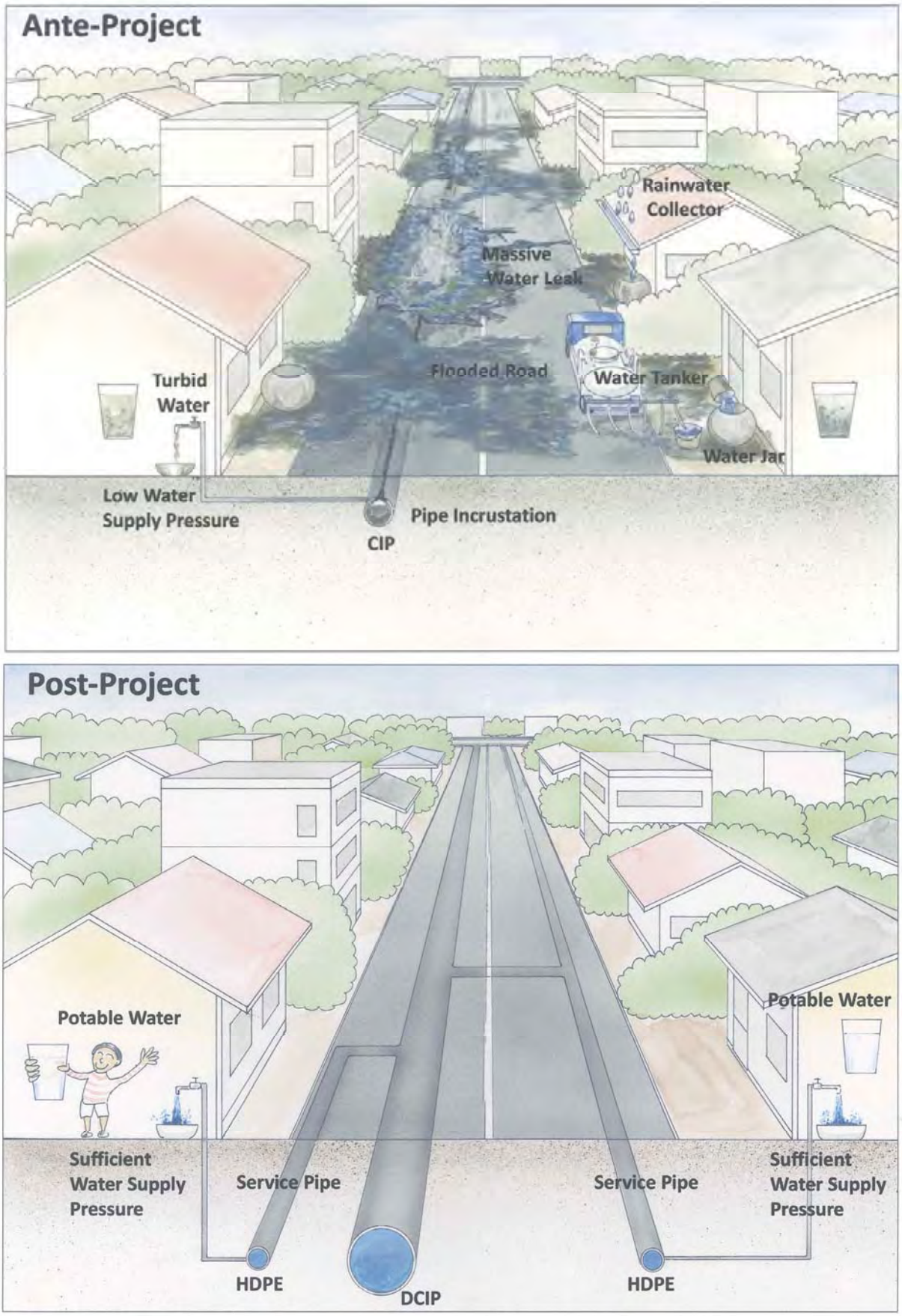

Figure-2 Perspective

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Abbreviations

1. Abbreviations

Abbreviations		Description
ADB	:	Asian Development Bank
BWWs	:	Battambang Waterworks
CDC	:	Council for Development of Cambodia
CIP	:	Cast-iron Pipe
DCIP	:	Ductile Cast-iron Pipe
DIME	:	Department of Industry, Mines and Energy
DPWS	:	Department of Potable Water Supply
EIA	:	Environmental Impact Assessment
EOJ	:	Embassy of Japan
GDP	:	Gross Domestic Product
GI	:	Galvanized Iron (Pipe)
GOJ	:	Government of Japan
HDPE	:	High Density Polyethylene (Pipe)
IEIA	:	Initial Environment Impact Assessment
IWA	:	International Water Association
JBIC	:	Japan Bank For International Cooperation
JICA	:	Japan International Cooperation Agency
JWWA	:	Japan Water Works Association
MEK-WATSAN	:	Mekon Water Supply and Sanitation
MIME	:	Ministry of Industry, Mines and Energy
M/P	:	Master Plan
NRW	:	Non Revenue Water
OBA	:	Output Based Aid
PI	:	Performance Indicator
PIU	:	Project Implementing Unit
PPWSA	:	Phnom Penh Water Supply Authority
PVC	:	Polyvinyl Chloride (Pipe)
PWWs	:	Pursat Waterworks
RGC	:	Royal Government of Cambodia
SEAWUN	:	Southeast Asia Water Utility Network
SWS	:	Sihanoukville Water Supply
WEPA	:	Water Environment Partnership in Asia
WB	:	World Bank

2. Unit

Unit		Description
cm	:	Centimeter
HHs	:	Households
KHR	:	Kampuchea Riel
km	:	Kilometer
Lpcd	:	Litter per capita day
m^2	:	Square meter
m^3/day	:	Cubic meter per day
m	:	Meter
masl	:	Meter above sea level
mbgs	:	Meter below ground surface
mg/L	:	Milligram per litter
Pa	:	Pascal = N/m^2
psi	:	Pound per square inches
US$	:	United States Dollar

Chapter 1 Background of the Project

1-1 Background of the Project

In Cambodia, uplift of water services in provincial cities is a crucial issue presently. In order to improve this situation, water treatment plants of Pursat, kampong Thom, Svay Rieng, Sihanoukville and Battambang have been improved/upgraded in assistance of WB (for Sihanoukville) and ADB (for other 4 cities). Although uplifting supply capacity has been attempted in both hard and soft aspect through assistance of some donors, the capacity of the existing water treatment plants are not fully utilized, since development of distribution pipe network is still behind in these 5 cities. Water leakage occurs frequently in the deteriorated distribution pipes and financial loss by NRW is a serious problem for effective use of water supply and business management of respective waterworks.

Under such circumstances, RGC requested GOJ (Government of Japan) grant aid project including replacement and expansion of distribution pipe networks for the purpose of uplifting water services of the five (5) provincial capitals in January 2010. The contents of the request are as below.

Construction of Facility

- Replacement of distribution pipes: Total length 60 km
- Expansion of distribution pipes: Total length 108 km
- Distribution flow monitoring system: 5 sets

Procurement of Materials

- Construction machinery: Excavator, Crane truck, Dump truck, Tamper 5 sets

Capacity Building

- Assessment of facility function: 1

Base on the above request, JICA decided to conduct preparatory survey for the purpose of preparation of appropriate outline design suitable as a grant aid, implementation plan and project cost estimates for the selected provincial capitals based on examination of appropriateness of the project scale and prioritization. In the beginning of 2nd filed survey, the both side confirmed that the development of water distribution pipes be implemented for the following three (3) provincial capitals (referred to Annex 6-1).

- Pursat
- Battambang
- Sihanoukville

1-2 Natural Conditions

Cambodia with its land area of 181,035 km^2 (about 1/2 of area of Japan) is situated in Indochina Peninsula. Southwestern part of the land extending 435 km of coastal line is facing Thailand Gulf. Inland boarders are Thailand, Lao and Vietnam from clock wise.

(1) Geomorphology

Location of the objective 3 cities classified into "Tonle Sap − Mekong Plain" and "Southwestern Highland". The highest elevation of water supply facility is 120 masl at Sihanoukville water treatment plant. The highest/lowest ground elevation base on the topographic survey result is below.

- Pursat: Plain land, 15.5 m − 19.0 m
- Battambang: Plain land, 12.6 m − 16.3 m
- Sihanoukville: Hilly land, 3.8 m − 106.2 m

(2) Geology (surface soil)

＜Pursat/Battambang＞

Flood plain prevails around lake Tonle Sap and surface soil of both cities is unconsolidated layer comprising of gravel/sand/clay. Groundwater table is relatively shallow. Thus, collapse of surface soil and flooding of groundwater may occur during excavation work may easily occur.

＜Sihanoukville＞

The existing water supply area in urban district is located at low land along coastal line and hills/highland. Sandy soil prevails at northern part of urban area and low land along coastal line in south. Thus, collapse of surface soil and flooding of ground water during excavation work. While, surface soil in central hills/highland contains limestone and the risk of collapse of surface soil will be minimized.

(3) Meteorology (rainfall)

The climate of Cambodia is classified as tropical monsoon with high temperature and humid. Annual rainfall is about 1,000 mm - 3,000 mm.

Figure 1-1 presents monthly rainfall of the objective 3 cities.

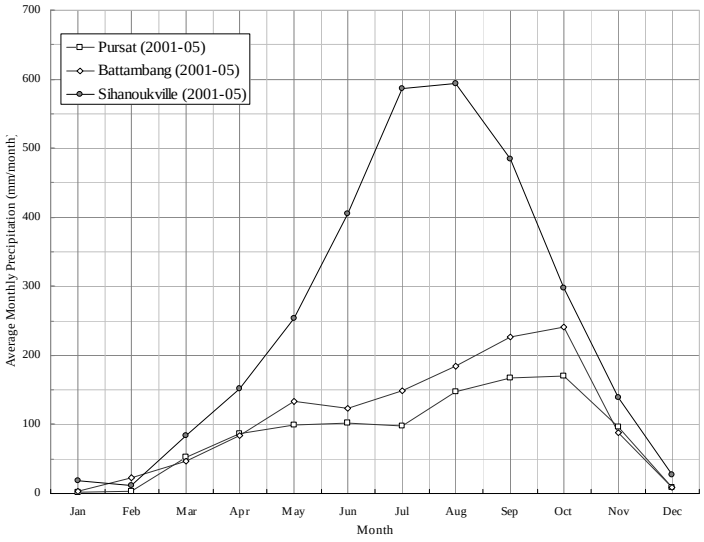


Figure 1-1 Average monthly Rainfall: 2001 – 2005 (Source: Country Report 2007）

The climate of the objective cities is generally divided in to rainy season (May – October) and dry season (November – April). Rainfall in Pursat and Battambang shows almost the same raining pattern and the rainfall of plain around Tonle Sap in which both cities are situated shows 100 mm to 250 mm/month in rainy season with peak in September - October. While, monthly rainfall in rainy season at Sihanoukville is recorded at 250 mm to 600 mm and its peak occurs in July – August.

According to provincial meteorological stations of Ministry of Water Sources, daily precipitation records in 2009 (more than 10 mm/day) are shown below. Especially, rainy days of Sihanoukville is outstanding and it is anticipated that working efficiency would be very low in rainy season at the project sites. In addition, water works grasp number of lightning damages to their electrical equipment.

	Rainy days/year> 10 mm/day	Number of lightning damage/year
• Pursat:	N.A.	35
• Battambang	42（37 during rainy season）	N.A.
• Sihanoukville	73（62 during rainy season）	9

(4) River

The data of river flows are lacking due to limited number of gauging stations and measuring period. According to Water Environment Partnership in Asia (WEPA), reference data are disclosed in "State of Water Environmental Issues" as below. It is considered that current river flow of Sangkae River declines compared to the estimated flow rate because of weir construction (2009) at upstream. Data of Prek Tob Lake was provided by Sihanoukville water works.

	Water source	Watershed	Estimated flow rate (annual ave.)
• Pursat	Pursat River	N.A.	N.A.
• Battambang	Sang Kae River	3,225 km^2	5,679 m^3/sec
• Sihanoukville	Prek Tob Lake	2.7 km^2	N.A.

With regard to water quality, surface water can be classified into river with high turbidity and lake with low turbidity as physical characteristics. As for chemical characteristics, WEPA reports copper and arsenic contained, but not level of indicating chronic toxicity. Bacteriological data such as coliform, general bacteria, etc. exists very few.

(5) Earthquake

Cambodia is situated in Eurasia continental and stable plate of Indochina. Magnitude and frequency of earthquake to be considered for facility designing are expected to be very small.

1-3 Socio-Environment Considerations

The main scope of project is rehabilitation and expansion of water distribution pipes. Generally the impact of the project is limited to project site during construction stage and it is considered that ordinary mitigation methods can be adopted. Thus, the project is to be categorized as "Category B" in "JICA Guidelines for Environmental and Social Considerations" since the impact of the project is considered to be less compared to the case of "Category A".

＜Legislation＞

The followings are legislation related to the project.

- Environmental Conservation and Natural Resources Management: Legislation on air pollution, noise, effluent water quality, etc.
- Sub-decree on Environmental Impact Assessment: legislation on environmental impact assessment

＜Environmental Impact Assessment＞

The Kingdom of Cambodia Sub-decree on Environmental Impact Assessment (EIA) Process was formally established by virtue of the Royal Government Council of Ministers No: 72 ANRK.BK on August, 1999. Projects that serve a population of 10,000 or higher need to prepare an IEIA or EIA. Although the expansion of the waterworks will involve more than 10,000 additional population to be served for each of the waterworks, from the discussions with three of the Directors of MoE at the provincial level, in their assessment, there is no need to prepare an IEIA or EIA since the project involves just a rehabilitation/expansion by pipe installation of an existing infrastructure and not a new development

＜Site survey on environmental and social considerations＞

Survey results on land use, natural environment, economic and social conditions in objective 3 cities are shown in Table 1-1.

Table 1-1 Environmental and Social Conditions in Provincial Capitals

Item/City	Pursat	Battambang	Sihanoukville
City Development Plan/ Existing and Planned Land Use	No development plan for the City. Proposed expansion area in fringe follows strip development pattern and is sparsely populated. Off-road on both sides are rice fields with houses of non-permanent materials.	No development plan for the City. Rapid development is taking place in the city with a number of hotels, commercial establishments and residential areas being built. Proposed expansion areas cater to all income groups: high, medium and poor communities.	City Development Plan has just been completed. Awaiting approval by the Council of Ministries. Rapid development is taking place with the construction of new hotels, commercial and residential areas. On- going construction of the special economic zone will jump-start economic activities in the area.
Resettlement	No resettlement is expected since pipe laying is planned to be on the side of the road. Hence, no housing and building structures will be affected.		
Living Condition/ Income/Livelihood	No potential negative impact since there is no new water source development in the project.		
Heritage	No heritage sites will be affected by the project.		
Landscape	Minimal impact on the landscape since the pipes will be laid underground.		
Ethnic Minority/ Indigenous Peoples	No IPs or ethnic groups will be affected by the construction of the project.		
Working Conditions	No potential impact on the working conditions of the waterworks staff.		
Potential Conflict on Water Use/ Water Rights	Existing river uses: Upstream of water supply intake - private HHs According to WWs, flow rate is sufficient for existing WTP. No policy on water rights / use.	Existing Sangke River uses: Upstream of water supply intake – private HHs and commercial users, traditional site for holidays, on-going construction of irrigation dam Downstream of intake - irrigation, traditional site for festivities (boat racing), navigation, sustenance fishing. Dam construction for irrigation about 30kms upstream part of Sangke River is on-going. According to WWs water level of the river decreases during and WWs provides temporary weir to secure required water intake water. Hydrologic study of the river is needed in case of additional water source development for water supply. No policy on water rights / use.	Lake dedicated for water supply use. According to WWs water level of reservoir decreases during dry season. WWs has used bulk water from ANCO from 2009. No policy on water rights / use.
Sewerage/Sludge Management	No wastewater treatment plant. Effluent overflows from septic tanks combine with drainage and drain into canals/river.	Presence of wastewater treatment plant Treated wastewater is used for irrigation. No sludge management.	Presence of wastewater treatment plant Treated wastewater flows into a stream. No sludge management.
Drainage	No drainage plan for the city.	No drainage plan for the city.	No drainage plan for the city.
Water Quality of Water Sources (Existing waterworks water supply source	Water quality of water source met the standard for its use since treated water complied with drinking water quality standard of Cambodia. Sampling point is 3 kms from the intake of water supply.	Water quality result of Sangke River (2009) met the standard for its use since treated water complied with drinking water quality standard of Cambodia. Parameters tested were pH, EC, DO, BOD5, TDS, Cd, Pb, Cr, Ar	Water source of waterworks is a pond. Quality of raw water meets the standard for its use since treated water complied with drinking water quality standard of Cambodia.
Other water sources	Other water sources: - Tube wells: Subject to bacteriological contamination - Rainwater collectors - with no proper handling, subject to bacterial contamination.	Other water sources: - Tube wells: Subject to bacteriological contamination - Rainwater collectors - with no proper handling, subject to bacterial contamination.	Other water sources: - Tube wells: Subject to bacteriological contamination - Rainwater collectors – with no proper handling, subject to bacterial contamination.
Protected Area for Nature Conservation/ Environmental Conservation Plan	No protected / conservation areas/plans within or surrounding the proposed project area.		
Residents' willingness to connect/pay for water service	Definite number of households willing to connect	High willingness to pay based on housing structures.	High willingness to for high, medium and low income residential areas.

＜Scoping on environmental and social impact＞

With regard to environmental and social impacts to be anticipated in implementation of the project, scoping and confirmation of environmental considerations were prepared according to JBIC guidelines (details are referred to Annex 6-2).

The factors of environmental and social impacts accompanied by installation of distribution pipes are considered as below.

- Air pollution: dust, emission gas, etc.
- Wastes: excess soil, debris, etc.
- Noise and vibration
- Traffic near construction sites

＜Mitigation measures for environmental and social impact＞

In construction stage of the project, the typical impacts of the above mentioned impacts may occur, although they are temporal. Implementing agencies and Contractor/s are required to take countermeasures in order to minimize the impacts through proper operation of construction machinery, education/instruction to workers and staffs, etc.

＜Monitoring plan for environmental and social impact＞

Monitoring shall be carried out in cooperation with Cambodian and Japanese side. Table 1-2 is a provisional monitoring plan to be conceivable at this moment and its finalization will be required by PIU of Cambodian side in cooperation with the Consultant. As for countermeasures for construction environment shall be embodied in "Implementation Plan" to be prepared by the Contractor and "Implementation Management Plan" to be prepared by the Consultant.

Table 1-2 Provisional Monitoring Plan

<table>
<tr><th colspan="2">Identification</th><th colspan="4">Measurement (Contractor)</th><th colspan="2">Monitoring Frequency</th></tr>
<tr><th>Category</th><th>Item</th><th>Value or Status</th><th>Application</th><th>Method</th><th>Place</th><th>Weekly</th><th>Monthly</th></tr>
<tr><td>Noise</td><td>Construction Machinery</td><td rowspan="14">To be recorded daily at every subject sites during the construction period. Staffs from the WWs and the Consultant will supervise the activities.</td><td>Cambodian Standard</td><td rowspan="2">Meter</td><td rowspan="3">Near the site where construction machinery is being used.</td><td rowspan="14">Daily records will be analyzed every week statistically by the Consultant.</td><td rowspan="14">Monthly meeting will be held at MIME HQ at Phnom Penh. Joint site visit will be done according to the meeting result.</td></tr>
<tr><td>Generator</td><td rowspan="3">To be proposed by the Consultant using Japan Standard (local government code).</td></tr>
<tr><td>Vibration</td><td>Construction Machinery</td></tr>
<tr><td></td><td>Generator</td><td rowspan="2">Visual and Smell</td></tr>
<tr><td>Air Pollution</td><td>Emission Gas</td></tr>
<tr><td></td><td>Dust</td><td rowspan="4">To be coordinated with the local government concerned.</td><td rowspan="4">Visual</td><td rowspan="2">The site where pipe laying works were completed.</td></tr>
<tr><td>Wastes</td><td>Fragments</td></tr>
<tr><td></td><td>Excess soil</td></tr>
<tr><td></td><td>Debris</td></tr>
<tr><td>Traffic</td><td>Signboard</td><td rowspan="2">The circumference site where pipe laying works are on-going.</td></tr>
<tr><td></td><td>Traffic Guard</td></tr>
</table>

Chapter 2 Contents of the Project

2-1 Basic Concept of the Project

According to the National Strategic Development Plan 2006 - 2010, RGC (Royal Government of Cambodia) aims to achieve a target of 80 % accessibility in urban residents to potable water source. In fact, the current rate of access to potable water source in Cambodia was estimated at only 51 % according to the MIME survey in 2008. In this regard, MIME holds up the same target by 2015 in the next plan.

The project aims at uplifting water services in 3 provincial capitals i.e. Pursat, Battambang and Sihanoukville through developing water supply facilities of the said areas.

In order to attain the above objectives, replacement and expansion of distribution pipelines, procurement of materials of service connection and technical support for capacity development on service pipe connection and distribution flow management will be implemented in the project.

The project scope is shown in Table 2-1. Detailed figures of the scope for each waterworks are referred to Tables 2-4 and 2-5 in Chapter-II.

Table 2-1 Contents of the Project

Component	Category	Major Specifications, Quantity and Contents
Facility Construction	Replacement	Pipe Length: Total 31.8 km Pipe Type: DCIP and HDPE Pipe Diameter: 50A to 350A Note: Re-connection of service pipeline is under Cambodian works.
	Expansion	Pipe Length: Total 93.2 km Pipe Type: DCIP and HDPE Pipe Diameter: 50A to 350A
	Particular Route and Major Accessory	Crossings of Road/ Railway/ River and Detour Route: 3 units Flow Meter*[1], Valves (GV*[1], PRV*[1], FCV*[1/2], ARV, BOV): 3 units Note*[1]: Accessories will be connected to the existing pipeline partially. Note*[2]: Cambodian side shall install the primary distribution line of electric power.
	Flow Monitoring	Distribution Flow Monitoring System (Telemetric Data Processing): 3 units
Procurement	Materials for Connection	Re-connection: Clamp Saddle, HDPE , Valves, Fittings, etc. 4,400 sets New Connection (for expansion pipes): Clamp Saddle and Water Meter: 2,400 sets New Connection (for existing pipes): Water Meter 700 peaces
	Equipment for HDPE Connector	SF Connector: for HDPE suitable with pipe diameter of 50A or below 5 sets Portable Engine Generator: 5 kVA 5 units
Capacity Development	Connection Skill	Skill of qualified service connection and proper turn-over inspection
	Flow Management	Theory and application of the flow monitoring system, preparation of the action plan

Note: Quantity of construction and procurement in each waterworks is referred to Tables 2-4 and 2-5 in Chapter-II.
Remark*1: Some accessories will be connected to the existing pipeline partially.
Remark*2: Flow control valves will be operated by electric power.

By the implementation of the Project, it will be possible to improve the water supply service level by project outputs such as the operation rate of WTP (water treatment plant) and the NRW (non revenue water) rate at the maximum. Moreover, introduction of flow monitoring system with capacity development will contribute to acquire the direction from operation to management.

In addition, provision of service connection materials would support pro-poor for mitigation of connection fee for the poor households, majority of which have presently accessed to un-sanitary water sources, through the new activity of the Cambodian side. Likewise, provision of service connection equipment would change the quality of skilled works together with relevant capacity development program. Finally, the NRW rate would be considerably reduced in future.

Particularly in Pursat WWs, MEK-WATSAN Project for pro-poor using the sector assistance in water supply and sanitation is on-going by the support from UN-Habitat with target completion year of 2011. The synergistic effect would be expected by cooperation of both donors and MIME. In this regard, appropriate coordination shall be done at each milestone in this Project.

2-2 Outline Design of the Japanese Assistance

2-2-1 Design Policy

(1) Basic Concepts

The Project composed of facility construction and consultancy services will be expected to complete by June 2013. Thus, target year is desirable to set up at 2016, three (3) years after completion considering urgent improvement of water distribution systems in accordance with increase of water demands. In this connection, output of the project is to accomplish full operation rate of the existing water treatment plants (WTPs).
Facility construction will be implemented with following prioritization.

1. The first priority shall be given to replacement of old and deteriorated pipelines,
2. The second priority shall be given to expansion of the pipelines hydraulically needed,
3. The third priority shall be given to expansion of the pipelines at urban areas where uplifting of water services is expected, and
4. The last priority shall be given to expansion of the pipelines at vicinity of urban areas together with considering density of expected service connections.

Scope of the project is restricted according to the design capacity of the exiting WTPs including bulk water (for Sihanoukville WS). Outputs of the project shall be evaluated using monitoring indicators with target figures in 2016.

Service areas at respective project sites are city proper of provincial capitals and surrounding suburbs. Water demands are projected referring to the amount for domestic use, new housing development and economic zones (commercial and industrial needs). Distribution facilities are designed by considering both water demands and supply capacity in future. Especially, water demand of special economic zone (SEZ) being developed in Sihanoukville shall be excluded in the project, since required water source is to be developed by SEZ.

Replacement of the pipelines has a first priority, which is accompanied by re-connection of service connections. There might be a high risk of inconvenience to current subscribers to secure water supply in re-connection works, in case that the burden of the Cambodian side is in excesses of present financial capacity. In this regard, the both sides will share re-connection works; (a) Japanese side provides the major materials and (b) Cambodian side re-installs the service connections using the said materials. While, the existing water meters will be re-used and the waterworks shall undertake necessary works for resuming water supply.
Existing pipelines to be replaced by this project will be abandoned at the same underground intact. There are no asbestos pipes in the existing pipe networks. Thus, protection measures by non-scattering and grout blocking are not considered in this project.

(2) Natural Conditions

< Geomorphology (topography) >

Present water distribution is done by gravity system. For the distribution facility having high water pressure in night time due to topographic condition, “Pressure Reducing Valve (PRV)” will be provided.

< Geology (surface soil) >

Surface soil in target areas is un-consolidated and collapsible. To secure safety construction of piping works, earth retaining method shall be adopted for necessary sites.
Soil acidity at Pursat and Battambang has very low pH value due to the influences from old seawater blocked and stagnated since geological long term. Wind erosion with seawater affects to the life of pipes at Sihanoukville. Particular pipelines crossing bridge and river will be placed using the hard corrosive materials of stainless steel.

< Meteorology (rainfall) >

Working efficiency would be very low in rainy season at the project sites, especially at Siha-

noukville. Working efficiency and progress with water drainage system shall be considered. There is a high risk of lighting damage to the flow monitoring system, if power source for telemetric equipment is designed as general power supply. Built-in-battery shall be designed to avoid the lighting harms.

(3) Social Conditions

< Pro-poor >

Provincial DOPs (department of planning) issue the planning fundamentals relating to pro-poor. Poverty rate in subject provincial level (urban and rural) was estimated 30 % to 50 % depending on the provincial government in 2008. The waterworks also judged that the said poverty rate was applicable to their service areas. Pro-poor measure, which shall be operated and managed by the Cambodian side, would be to reduce service connection charge; because present connection fee is composed of the direct costs on installation material and personnel expenses.

< Communications (broadband) >

There is no problem in use of cellular phone in the provincial capital. However, the signal stability and intensity of broadband is not suitable for the stable operation of telemetric monitoring system comparing to Phnom Penh of the national capital. Mitigation measures for the said localities were considered in "(2) Telemetric Flow Monitoring System, 2-2-1 Facility Construction Plan."

< Transportation >

The place of arrival by marine transportation from Japan or the third countries is Sihanoukville seaport. Land transportation to each project site will be scheduled after the custom clearance. Re-packing at Sihanoukville seaport is costly, because number of the project sites is three (3). Shipping of the construction materials shall be divided according to its destination with designated packing style.

< Traffic Condition in Service Areas >

Installation method of pipeline shall be selected considering safety of pedestrian and vehicle traffics. Basically, excavated site shall be back filled daily for security reasons. To minimize leaving open trench, the following joint type will be applied for Ductile Cast-iron Pipe (DCIP) for thrust force protection without concrete support.

- Restrained Joint: mechanical or restrained connection (K or T type) with retainer grand
- Non-thrust Joint: push-on connection (T type)

Number of working groups for pipe installation is designed taking account of the waterworks capability of service pipe re-connection of WWs, mitigation measure of congestion in city proper, total length of pipelines and available water for piping works.
WWs occasionally connect the clamp saddle to DCIP of large diameter and or to install service pipes up to the road opposite. In this project, HDPE service pipe with small diameter will be placed beside DCIP to minimize connection cost and complexity of congested pipelines.

(4) Law, Institution and Standard

< Planning Fundamentals >

Standard methods and reference values for drawing up of the basic plan are not consolidated in Cambodia. Thus, in preparing basic plan, PWSA's standard, previously employed design flows (Average daily water supply/Maximum daily water supply/Maximum hourly water supply) and unit water consumption of past 3 years are referred to this basic plan was prepared using following reference materials.

< Design Standard >

In Cambodia, generally, water supply facilities have been designed depending on the donor's standard, however, PPWSA has prepared the pipe installation standard in 2007 and updated un-

til now. In this basic plan, PPWSA standards were referred basically. The items in PPWSA standards are:

- Pipe Selection: Type by pipe diameter size
- Connection Method for DCIP: Type and Fittings for thrust portion
- Installation Standard: Excavation Standard, Thickness of Compaction layer
- Standard Materials for Connection: Clamp Saddle, Water Meter and HDPE Pipes

< Road and Railway >

Administration agencies of road and railway are Ministry of Public Works and Transportation with provincial department, provincial police and city development authority. Method of road and railway crossings is designed in accordance with the relative institutions.

< Taxation System >

Exemption from import taxation is to be applied with procedures to submit the packing list for the Council for Development of Cambodia (CDC) through MIME.

< National Holidays >

Numbers of national holidays in wet and dry season are shown below. Substitute holidays can be transferred to Monday and deducted from working days.

- Wet Season from May to October: Fixed 8 days and substitute 5 days
- Dry Season from November to April: Fixed 2 days and substitute 10 days

(5) Utilization of Local Contractors and Materials

There is no problem with use and supply of local labor/ contractors under management of the engineer having international qualification. The local contractors for road restoration, mechanical and electrical works/ installation are available in Cambodia.

In terms of construction materials such as cement, crushed stone, etc., these can be procured in Cambodia. Service pipe materials are to be procured in Cambodia. Construction machines are also available for lease from the local contractors.

(6) Capacity of Operation and Maintenance

The Cambodian side needs new recruits for re-connection works of service pipes during the implementation period of the project, since outsourcing personnel are not available in the project sites. The Japanese side will transfer the kills to connect the service pipe for permanent and casual plumbers with due consideration of NRW reduction in future. Additionally, testing method of water passing including the offset recording memos will be transferred for permanent staffs from WWs.

Flow monitoring system to be provided in the project is to be expected as future direction of operation and management of WWs. Operation and maintenance manuals will be prepared by the contractor. Additionally, operation and management ability of the system and application to future planning shall be required for the waterworks. Japanese side will dispatch the trainer team to the waterworks twice upon the system turnover (interim inspection).

As for Sihanoukville WS, provision of flow control system is considered in order to enable daily operation of water sources (WTP of WS and bulk water of ANCO Brothers Co., Ltd.) and water supply allocation to two water supply areas (downtown and seaport blocks). The flow control system has two types of control valves, which were designed as motorized valves with remote control for witching water sources and manual valves for the said two areas.

(7) Quality Level of Facility and Equipment

Facility and equipment shall have simple operation and maintenance to minimize the consumption of power.

(8) Construction Method, Procurement Process and Schedule

As for pipe installation, open-cut method is adopted as a general construction method. Project sites are provincial capitals with heavy traffic of pedestrians and vehicles. Safety management is to be fully considered in project implementation.

Labor and construction materials and machinery are basically procured in Cambodia. Materials and equipment which are not available in Cambodia shall be procured from Japan or third countries considering the costs as well as transportation cost.

Implementation of the project shall be commenced in 3 provincial capitals at the same time. Project implementation system to emphasize the safety management as well as shortest construction period shall be established effectively.

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

2-2-2-1 Facility Construction Plan

(1) Distribution Facility

< Replacement of the Existing Distribution Pipes >

The historical information of the existing distribution pipe network was collected from the waterworks, which includes type and diameter of pipes, and information of water leakages and repair works in recent 3 years. These kinds of information were examined for selection of the candidate pipelines to be replaced.

It was revealed that major water leakage frequently occurred at pipe networks made of Cast-iron Pipe (CIP), pipes of which were installed in 3 cities before civil war. In addition, Battambang WWs among them has taken over the pipe networks of PVC (Polyvinyl Chloride) from a total of eight (8) private water providers for recent years. According to leakage information, six (6) networks have mass points of water leakage (yellow marks in Figure 2-1). The waterworks replaced some portions of these pipelines partially and has a plan of replacement of PVC pipes of small diameter by its own effort.

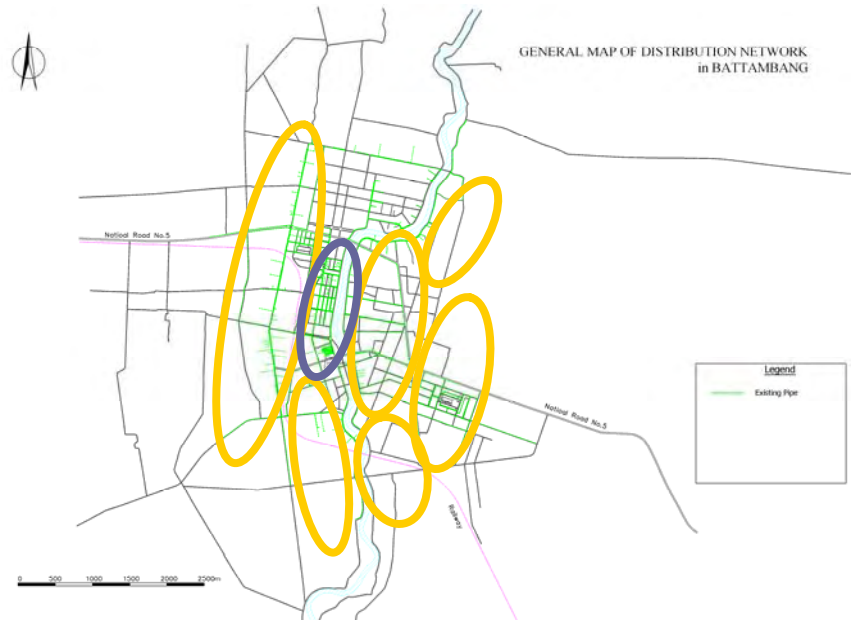


Figure 2-1 Battambang WWs System: original ○, ex-private ○ (to be replaced)

From results of the above field survey and analysis in homework, the concept of pipe replacement is described as below together with those presented in Table 2-2 and Figure 2-2.

- Distribution pipelines of WWs: CI pipelines with frequent water leakages occurred recently.
- Pipelines transferred from private water providers: PVC pipe lines of frequent water leakage at specific 6 areas of Battambang

Table 2-2 Selection Criteria on Replacement Pipeline with Surface Leakage Information

Existing Pipeline Network		Pursat WWs			Battambang WWs			Sihanoukville WS		
Age	Type	A	B	C	A	B	C	A	B	C
Old	CIP	53	4.7 km	GA	57	3.2 km	GA	22	8.2 km	GA
			1.0 km	TC		1.0 km	TC		1.0 km	TC
	GI	-			0	7.4 km		0	25.2 km	
	PVC	0	24.3 km		-			-		
New	DCIP	0	33.6 km		0	8.6 km		-		
	HDPE	0			0	37.7 km		0	18.7 km	
Private	PVC: Large	-			11	15.6 km	GA	-		
					0	13.6 km				
	PVC: Small	-			14	39.1 km	WWs	-		
No. of Repair Site		53			68			22		

Legend: A: number of pipe repair site for surface leakage, B: length of pipeline, C: organization who will replace, GA: to be considered under JICA Grant Aid, TC: to be replaced under JICA Technical Cooperation Project "Human Resources Development Project Phase 2", WWs: to be replaced by waterworks, CIP: cast-iron pipe, DCIP: ductile cast-iron pipe, GI: galvanized iron pipe, HDPE: high density polyethylene pipe, PVC: polyvinyl chloride pipe, Large: 50A or more, Small: less than 50A

Note: Pipelines with hatching are subject to replacement in the project.

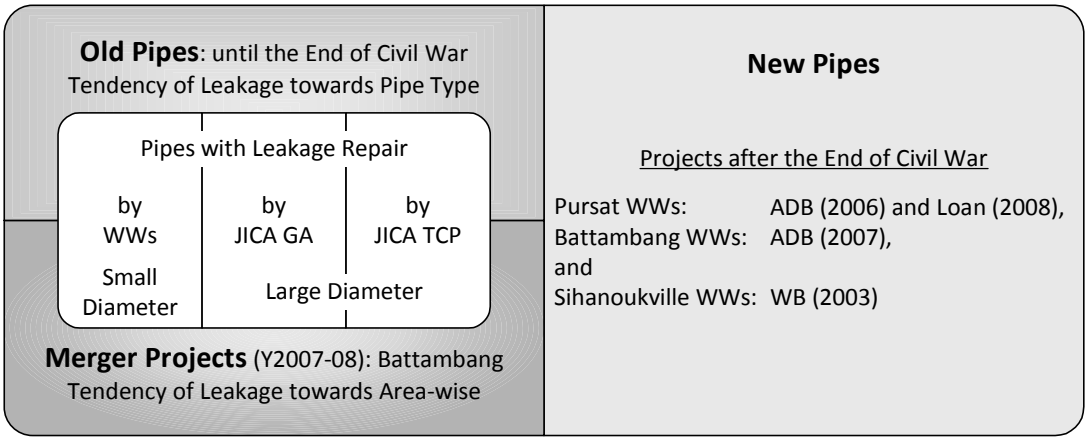


Figure 2-2 Demarcation Image of Pipe Replacement

Type and length of pipelines shown in Table 2-2 were provided from the waterworks and water supply authority. This information was used only for preparation of the basic plan, because the latest maps of distribution pipeline were not fully prepared. Project scope was designed using the results of route and field surveys. In this regard, lengths of pipeline in Table 2-1 are unconformity with designed lengths in this basic plan.

< Expansion of Distribution Pipes >

As for the pipelines for expansion, the first priority is given to the main pipelines hydraulically needed, even if those were not requested. The second and third priorities are given to the pipelines in town proper and suburbs respectively based on the criteria (referred to Figure 2-3).

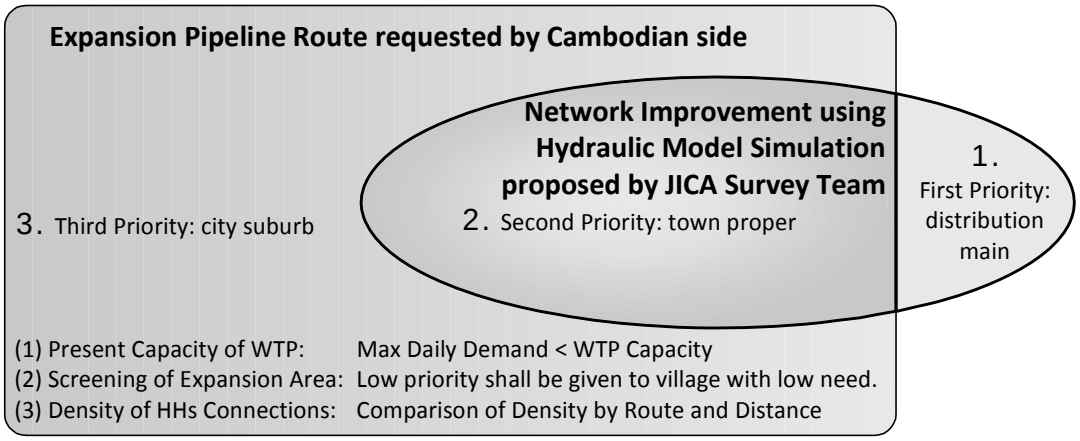


Figure 2-3 Selective Prioritizations on the Requested Expansion Pipelines

<Planning Fundamentals >

Planning fundamentals are shown in Table 2-3. The basic plan is prepared by using projected water demand and expected NRW rate in 2016 and hydraulic analysis by WaterCAD.

Unit consumption is assumed referring to actual records of respective WWs and poor HHs rate by hearing, which is assumed at "Poor HHs : General HHs = 7 : 10".

	Poor HHs	General HHs	Record of WWs (2009)
• Pursat:	95 Lpcd	125 Lpcd	121 Lpcd
• Battambang:	105 Lpcd	140 Lpcd	133 Lpcd
• Sihanoukville	100 Lpcd	135 Lpcd	130 Lpcd

Family size is set up at 5 for Pursat/Battambang and 6 for Sihanoukville according to respective WWs.

Table 2-3 Planning Fundamentals

Parameters	Pursat WWs	Battambang WWs	Sihanoukville WS
Distribution (Daily Max.)	Design capacity of existing WTPs (including ANCO water for Sihanoukville)		
	5,760 m^3/day	11,520 m^3/day	17,680 m^3/day
	Pipeline capacity was considered within a capacity of present WTP. Distribution main pipelines were designed with due consideration of future expansion of present WTP.		
Unit Consumption	General HHs: 125 Lpcd	General HHs: 140 Lpcd	General HHs: 135 Lpcd
	Poor HHs: 95 Lpcd	Poor HHs: 105 Lpcd	Poor HHs: 100 Lpcd
Peak factor	Peak Hour Flow ÷ Daily Average Flow = 1.79		
Min. Pressure	Network in city proper: 150 kPa (0.15MPa or 15 mH_2O) or equivalent Single line at suburb: 100 kPa (0.10MPa or 10 mH_2O) or equivalent		
Max. Pressure	Water supply area: 600 kPa (0.60MPa or 60 mH_2O) or equivalent		
Hydraulic Simulation	WaterCAD (Hazen Williams): $H=10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85} \times L$ H: Pressure Loss (m), C: Friction Coefficient (none), D: Inside Diameter (m), Q: Flow Rate (m^3/s), L: Length (m)		

As for peak factor, actual data is available at only PPWSA and which shows 1.72. However, considering differences in scale of utility and type of water demand between Phnom Penh and provincial cities, peak factor of 1.72 is not applicable for the provincial cities. While, in the M/Ps prepared by the respective WWs with assistance of JICA "The Project on Capacity Building for Water Supply System in Cambodia Phase 2", peak factor of 1.79 is adopted, which is almost

same value of water supply utilities having service population of 4,000 up to 20,000 in Japan. Thus, this peak factor is to be adopted for the basic plan.

As for minimum water pressure, 150 kPa is considered to be appropriate for the downtown areas of provincial capitals. For surrounding areas supplied by single pipeline, it is anticipated that water pressure is lower than that in downtown. Measure of pressure improvement by the scope of distribution facility is only to increase pipe diameter, which is costly. Economical way to increase the service pressure is to change the elevated tank; for example (a) higher elevation and (b) construction site within the said low pressure area. In this connection, pressure improvement along the single pipeline was limited to minimum 100 kPa.

For maximum water pressure, 600 kPa is adopted taking account of O/M including NRW reduction. Especially for Sihanoukville, pressure reducing valves are to provided in order to regulate water pressure within appropriate level.

< Results of Hydraulic Analysis >

The contents of the project are presented in the general plan (referred to 2-3 "Basic Design Drawings" in Chapter-II) dividing into the schemes of replacement and expansion with water distribution blocks. Un-adopted pipeline routes are indicated the number in grey color.

According to planning concepts described in the previous Figures 2-2 and 2-3, the pipeline routes are categorized into the schemes of "replacement" and "expansion with 1st priority, 2nd priority and 3rd priority" using the numbers indicated in the general maps (referred to Figures 2-12 to 2-14) as shown in Table 2-4.

Table 2-4 Pipeline No. categorized by Planning Scheme (referred to General Maps)

General Map		Pursat WWs	Battambang WWs	Sihanoukville WS
Replacement (blue lines)		R1-13, R15-20, Ra: by the type of pipe	R1-18	R2-5
Expansion (red lines)	The first priority Distribution Main	Ea: additional line E10: looping line	E2-3, E6: looping (partially double lines)	Ea1-2, Eb: in stead of 2 CIPs E2-2': additional and new pipelines
	The second priority Town Proper	E1-2, E4-5, E7-8	E7-8, E9-1/ E9-2: change pipe diameter Ea/ Eb: additional line	E5-8
	The third priority City suburb	E11	E1/ E5: along the national road (high density)	E3～4、E9～13
Un-adopted (grey line)		R14: private land (to be closed), E3/ E6/ E9/ E12-19: over demand	E4: alternation by looping, E10: low density and single line	R1: out of scope E1-2: to be changed by Ea1-2/ Eb

Results of hydraulic analysis (referred to Figures 2-4 to 2-6) were compared in cases of "without project" and "with project" in 2016 by each waterworks. "Without case" means the status quo until 2016, then "with case" is to improve the facility and service areas at 2016.

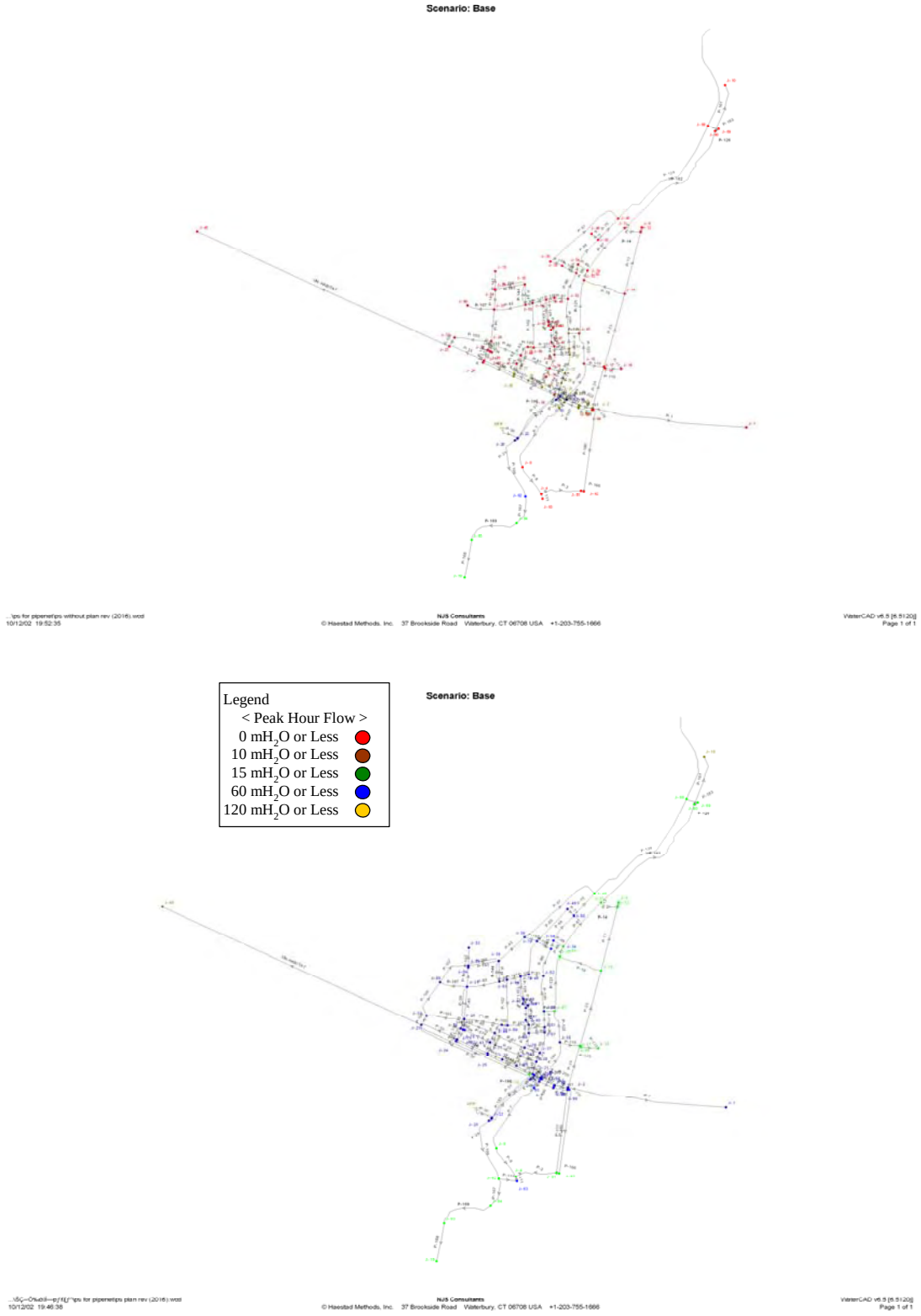


Figure 2-4 Pursat: Predictive Network Simulation in 2016 (without: upper, with: lower)

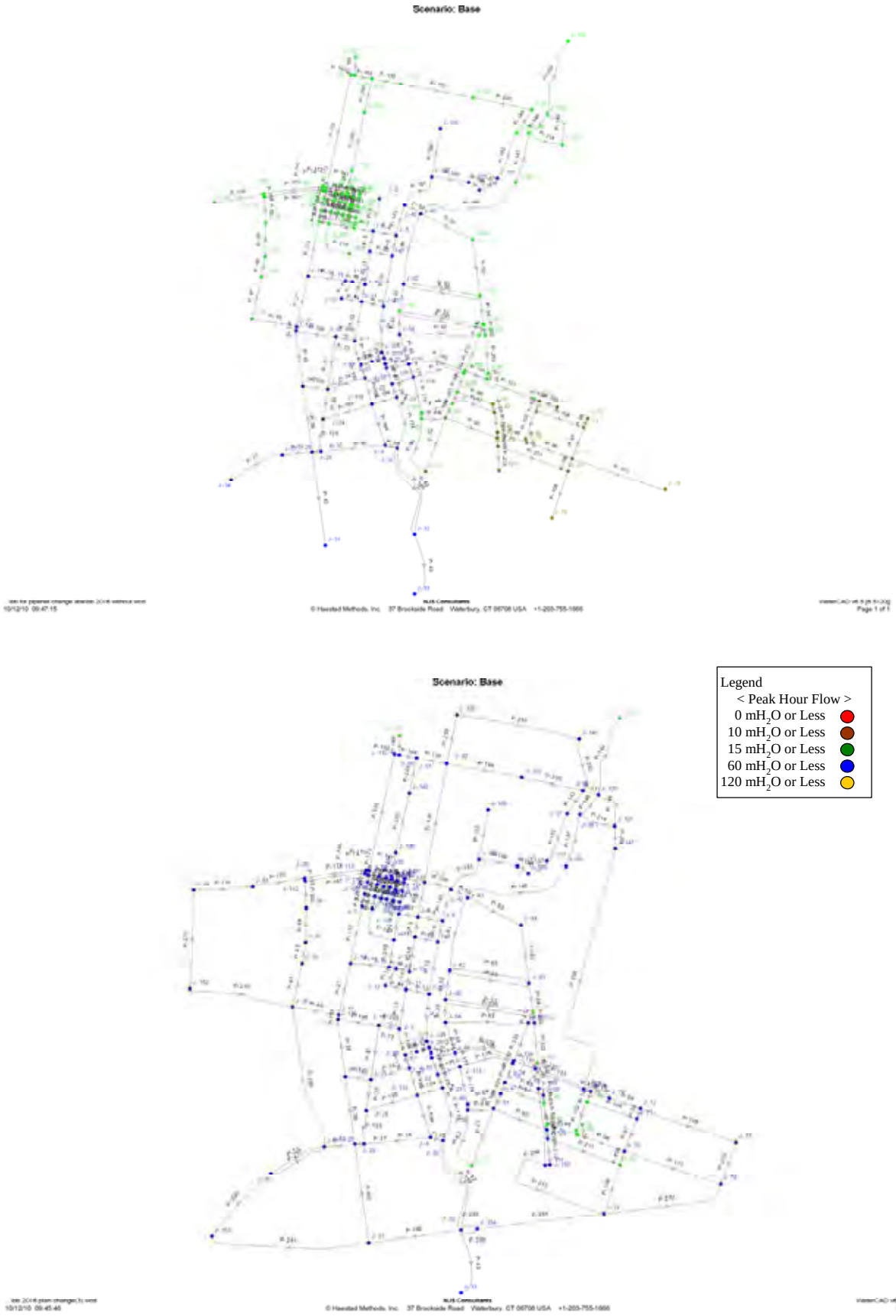


Figure 2-5 Battambang: Predictive Network Simulation in 2016 (without: upper, with: lower)

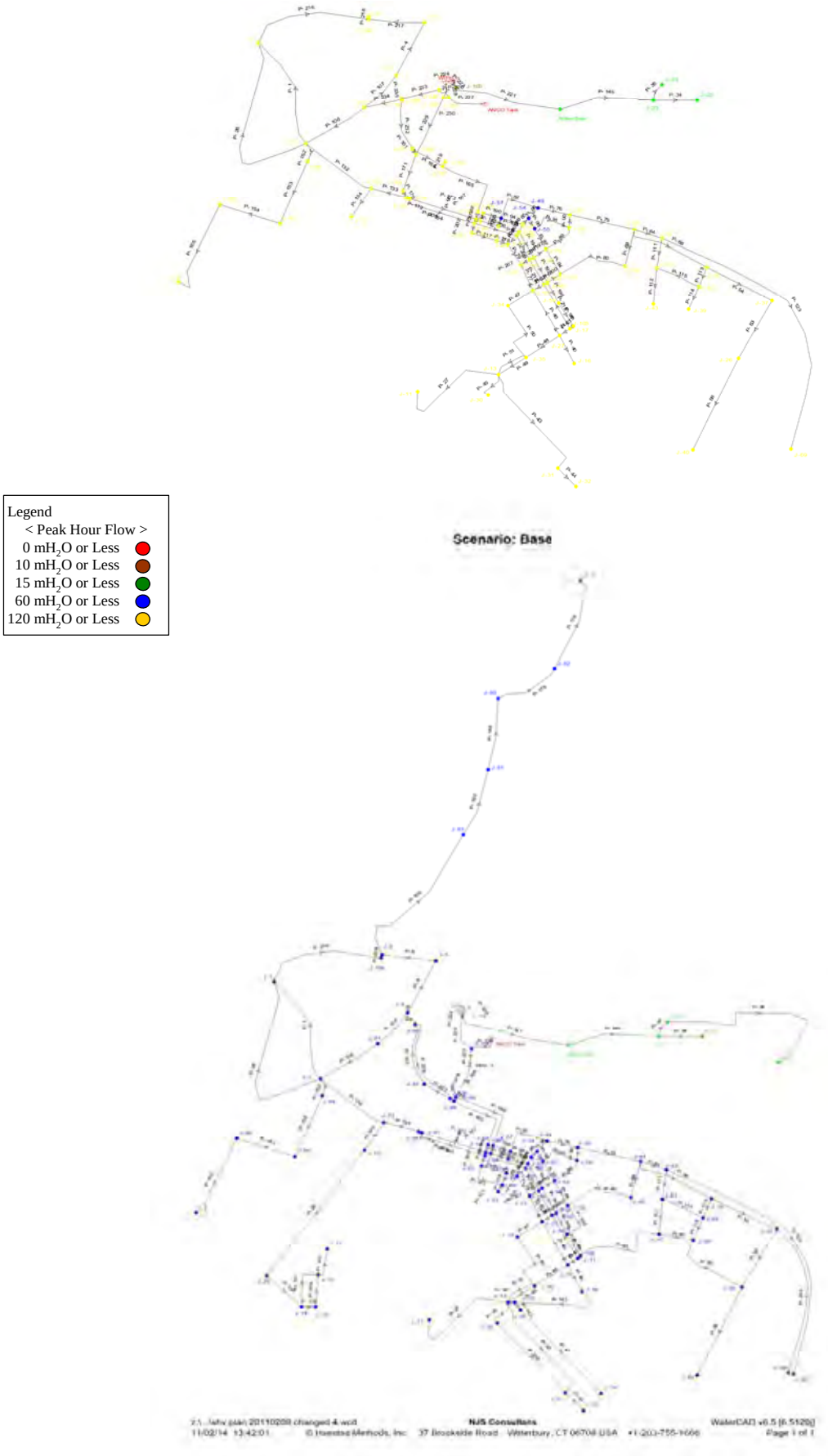


Figure 2-6 Sihanoukville: Predictive Network Simulation in 2016 (without: upper, with: lower)

Following are the reasons of what were changed from the original request of the Cambodian side. Initial "R" and "E" means the schemes of "replacement" and "expansion", respectively.

Pursat WWs (referred to Figure 2-4)
Route "Ra" was not included in the request, but which will be replaced according to type of the pipe with leakages. Route "R14" is CI to be replaced but which is positioned under the house together with service pipe connections. In this basic plan, it is proposed that "R14" shall be closed for avoidance of leakage and re-connected with other nearby pipe by the WWs.
Route "Ea" will be reinforced considering that the existing trunk main is insufficient to deliver design flow of the existing WTP. Route "E10" will be also reinforced hydraulically for additional supply to the eastside block. By this project, water supply pressure in the downtown area will satisfy 150 kPa or more. Un-adopted pipelines have the reason of low connection density and insufficient capacity of the existing WTP.

Battambang WWs (referred to Figure 2-5)
As for replacement, among originally requested pipelines, this project adopts all the pipelines except for the pipes which were already replaced and planned to be replaced by WWs confirmed during the 1st field survey.
Elevation difference between existing elevated tank and service areas is only 22 m to 23m. It is effective to replace and expand the distribution mains to maintain water pressure properly. Routes "Ea" and "Eb" are designed to improve low pressure in the eastside block to maintain 145 kPa.
Route "E4" was requested by placing double pipelines. However, it was excluded because sufficient water pressure is maintained when loop mains are installed. Route "E10" toward the new suburb area using single pipeline is not adopted because hydraulic advantages are not expected to networks as well as over demand compared to the existing WTP capacity.
According to WWs, the expected number of new service connections is counted at 6,045 along the expansion pipelines except for "E4" and "E10". However, as shown in the project effectiveness (referred to 2-2-4 in Chapter-II), 2,000 HHs of new service connections are estimated as limitation even in case that reduction of NRW rate is realized at maximum. On the other hand, the provision of ring mains are considered as indispensable for maintaining water pressure of the entire service areas properly. In this regard, number of new connections along the new pipelines shall be limited to 2,000 HHs until the time when new WTP will be constructed.

Sihanoukville WS (referred to Figure 2-6)
Route "R1" is out of scope because it was installed as raw water conveyance pipeline by the WB assisted project and there is no leakage report.
The most important 2 distribution mains from the existing WTP were installed by CI pipes connecting with HDPE pipelines which convey water from ANCO reservoir. Because of old CI distribution main pipes, the Cambodian side requested to replace these 2 main pipes. New proposed routes of "Ea1 and Eb" were designed to have the better function of water sources control (from WTP and ANCO) without replacement of the said two CI pipes.
Routes "E10" and "E11" were requested for expansion of service area in downtown block. According to the WS, these pipelines may have a limited new connection numbers with low density less than 0.1 connection/ m. In this regard, these pipeline routes are not included in the project.
To improve current high water pressure (930 kPa: analyzed by WaterCAD) shall be reduced to maximum 600 kPa by installing PRV (pressure reducing valve). In addition, the valves available for flow control shall be provided in order to allocate water supply amount between 2 blocks of seaport and downtown.
As for highland service area along National road No.4, water is supplied from WTP. There is the place with static water pressure of 10 m or lower, where water from ANCO reservoir cannot reach by gravity. To improve water pressure for this area, construction of booster pump station is required. Considering the scale of service area (population served of 4,300: 530 HHs), it is considered that the WS bears a heavy burden for booster pump station comparing with tar-

iff income. It is exceptional case to follow the present situation with pressure of 90 kPa.

(2) Flow Monitoring System

By introducing the system, it is considered that respective WWs will have advantages of rational facility operation, NRW reduction activity and accumulation of base data for customer management. Flow monitoring system will be provided in the project. To attain sustainability, the following measures are considered; (a) capacity strengthening, (b) saving for maintenance cost, (c) equipment with built-in battery and (d) backup period of GSM (global system for mobile) modem.

< Dividing Blocks of Service Area>

Distribution area for flow management is generally set up by phased tasks from large, medium and small zones according to the requirements from the WWs and customers. Generally, service areas in terms of large distribution blocks can be divided based on the amount of water supply with served population of several ten thousands. For example, PPWSA adopts the block scale of about 30,000 to 50,000 served population each for 41 blocks. Small distribution blocks with a served population of several thousands have advantage for night flow measurement and leakage detection along the particular pipeline route. Large block system can be grouped into district systems using gate valves within short time period, which will be helpful to detect the underground leakage.

Block distribution system together with flow monitoring system are the first experience for the WWs. The service area is divided into large blocks to minimize the project cost.

Following factors were considered for dividing blocks.

- Crossing: river and road: low density of crossing (limited to crossing number)
- Topography: high and low area: distribution by gravity, security of proper pressure
- Administration: commune boundary: positioning information for customer management, conformity with administrative population

Details of distribution blocks in each waterworks are described below.

Pursat WWs

Service area can be partitioned into 4 blocks by river and road. Downtown area is concentrated at northwest side of river and road. The WWs expanded the service area toward northeast side using the loan project in 2008. Topography of service area is flat and its administrations are; (a) 1 commune at downtown and (b) 7 communes at other suburb. Majority of water demand is allocated in downtown area including along the national road (target area of MEK-WATSA project). Distribution blocks are designed as following.

- Downtown Block: Pop. Served 18,800, Distribution of 3,440 m^3/day (60 %), 1 commune
- Suburb Block: Pop. Served 12,700, Distribution of 2,330 m^3/day (40 %), 7 communes

Battambang WWs

Service area can be partitioned into 4 blocks by river and road. There are 2 downtown areas located at west and east sides of the Sangker River. According to WWs, the areas of high population growth are located along national road at both sides of river. Administrative areas are: (a) 1 commune at westside downtown, (b) 2 communes at eastside of downtown and (c) 4 communes at other suburb, respectively. Most consumable area of water demand is westside downtown.

Water pressure is comparatively low due to the elevation of the existing tank, because the original service area of Battambang WWs was limited (see Figure 2-1). The WWs intends to organize medium – small block system with flow meters for monitoring and control. In this case, however, it is anticipated that water pressure might decrease due to isolation by valves and flow meters, aside from necessity of additional distribution mains.

Considering the objectives of the project (NRW reduction and improvement of WTP operation rate), service area is grouped into 2 blocks and flow meters are installed at bridge crossing

points.

- Westside Block: Pop. Served 32,100, Distribution of 6,540 m^3/day (57 %), 2 communes
- Eastside Block: Pop. Served 24,300, Distribution of 4,960 m^3/day (43 %), 4 communes

Sihanoukville WS

Service area can be partitioned into 2 blocks by the ridge in limestone hills, line of which is located from the reservoir to route E8 shown in Figure 2-14 Sihanoukville: General Map of Distribution Network. There is another service area along the national road No.4 with different topography and water demand.

The reservoir of Sihanoukville WS is located at the top of ridge (120 masl) and ANCO reservoir has the almost same location with 100 masl. On the other hand, elevation of highland area is about 100 to 105 masl. Highland block could not be merged due to difficulty in pressure control; area of which was designed as separated. Administrative areas are; (a) 1 commune at seaport and economic zone, (b) 2 communes at downtown and tourist area, and (c) 1 commune at highland area along the national road No.4.

- Seaport Block: Pop. Served 20,500, Distribution of 5,460 m^3/day (45 %), 1 commune
- Downtown Block: Pop. Served 23,400, Distribution of 4,300 m^3/day (35 %), 2 communes
- Highland Block: Pop. Served 4,300, Distribution of 2,450 m^3/day (20 %), 1 commune

(3) Outline of Distribution Facility

Specifications and quantity of distribution facility are shown in Table 2-5.

Table 2-5 Outline of the Distribution Facility

		Specifications/ Size/ Form		Quantity			
				Pursat	Battambang	Sihanoukville	unit
Replacement	DCIP ISO 2531	Strait Portion	T Type				
		Thrust Portion	T/ K with Retained Grand				
		Diameter:	350A	0	0	0	m
			300A	0	0	3,040	m
			250A	0	5,470	3,440	m
			Sub-total	0	5,470	6,480	m
		Grand-total			11,950		m
	HDPE ISO 4427	Pipe	PE-100				
		Diameter:	200A	0	0	0	m
			150A	0	750	0	m
			100A	880	8,040	0	m
			50A	3,600	6,550	0	m
			Sub-total	4,480	15,340	0	m
		Grand-total			19,820		m
Expansion	DCIP ISO 2531	Strait Portion	T Type				
		Thrust Portion	T/ K with Retained Grand				
		Diameter:	350A	0	0	1,300	m
			300A	930	0	870	m
			250A	0	23,340	260	m
			Sub-total	930	23,340	2,430	m
		Grand-total			26,700		m
	HDPE ISO 4427	Pipe	PE-100				
		Diameter:	200A	0	0	6,320	m
			150A	3,100	0	8,280	m
			100A	4,310	850	6,700	m
			50A	1,030	28,630	7,200	m
			Sub-total	8,440	29,480	28,500	m
		Grand-total			66,420		m
Particular Route	Road Crossing	Placement in Casing (National Road)		1	6	1	site
	Railway Crossing	The same to above		2	3	1	site
	Bridge Crossing	Attached to the existing bridge by clamps		3	2	3	site
	River Crossing	Crossing the waterway by self-support		0	0	1	site
	Detour Route	Under-pass and over-pass		51	104	52	site
Accessory	Flow Meter	Flow meter for monitoring (digital meter)		3	4	5	site
	Gate valve	For blockage and districts		97	171	44	site
	PRV	Pressure releasing valve		0	0	1	site
	FCV	Flow control valve (3-motorized, 4-manual)		0	0	7	site
	Air Valve	Air release		12	23	34	site
	Drain Valve	Drainage		7	10	9	site
Flow	Central Station	Panel Receiver, PC, Printer		1	1	1	site
	Local Station	GMS Logger and Transmitter		3	4	5	site

2-2-2-2 Procurement Plan

As for construction machines originally requested for maintenance purpose, it is considered to be not effective considering low frequency of machine usage, decreasing old pipes by this project, risks to damage to underground utilities and securing operators.

On the other hand, the materials and equipment for service pipe connection requested during the 1st field survey will be helpful to push through the project as below.

- Costs for re-connection of service pipes accompanied by replacement of distribution pipes are not heavy burden for the Cambodian side,
- Connection fee will be mitigated for poor HHs (households) to promote new service connection, and
- Quality control of service pipe connection will be improved and water leakage from service pipes is expected to be reduced for a long period.

Procurement plan is divided into 2 categories of materials and equipment. Furthermore, materials are grouped into: (a) re-connection for replacement of distribution pipes and (b) new connection for expansion and existing distribution pipes. Basic concept for procurement plan is

as follow.

- Materials: Measures for the project progress and promotion of service connection with due consideration of pro-poor.
- Equipment: Contribution to sustainable quality control especially for service connection to reduce NRW on a long-term basis.

Contents of the procurement plan are shown below. Size and number of clamp saddles is designed based on pipe diameters in hydraulic analysis and data collected from the waterworks during the field survey. Water meters for new connection under this plan have a size of 15A which is enough for poor subscribers.

- Materials

Re-connection (replacement):	present users (clamp saddle, pipes, fittings, etc.)	4,400	units
New connection (expansion):	poor subscribers (clamp saddle and water meter)	2,400	units
New connection (existing):	poor subscribers (water meter)	700	sets

- Equipment: SF connector and potable generator 5 units

(1) Materials for Service Connection

< for Re-connection: replacement of pipelines >

Number of materials is designed by the number of subscribers counted during the field survey. Materials include (a) clamp saddles, (b) major fittings and (c) HDPE pipes.

Re-connection works shall be born by the recipient side (waterworks).

Pursat WWs:	No. of subscriber	626 HHs	700 units for re- connection
Battambang WWs:	No. of subscriber	2,618 HHs	2,700 units for re- connection
Sihanoukville WS:	No. of subscriber	987 HHs	1,000 units for re-connection

< for New Connection: expansion and existing pipelines >

Major materials will be procured and provided for pro-poor scheme under this project. Quantity of materials was estimated using the expected HHs number to be connected during the post-project period until the target year of 2016 (almost 3.5 years) and poor rate information from the result of social survey.

The aim of this scheme is to promote the pro-poor measure with mitigation of connection fee system for poor HHs needs. This plan will be finally judged whether to push though or not by JICA before July 2011 on conditions that following activities and outputs of the recipient side.

The Cambodian side, especially for DIME and the WWs, is requested to prepare the IRR (implementation rule and regulation) related to the promotion activities with reference to the methods of PPWSA and OBA (output base aid) of WB. Waterworks will be requested to have progressive and selective access to poor HHs for offering the entry of service connection, activity of which will be realized with coordinating to on-going MEK-WATSAN project by UN-Habitat. This action may be independent process to poor HHs apart from general customers.

The IRR would be constituted; (a) to enact the definition of poor HHs, (b) to prepare the lucid forms for selection/ offering/ promotion activities and (c) to authorize the system for mitigation of connection fee

The following directions will be recommended to DIME and WWs in coordinating with provincial department of planning in each site.

- (a) Definition of Poor HHs: Poor line and level should be set up with due reference to “Assessment for Poor, WB 2006” and “Proposed Poverty Line, Ministry of Planning, 2008.” Simple criteria for poverty line are considered as “house form” and “presence of child without getting education” by MOP.
- (c) Mitigation of Connection Fee: New connection fee system should be approved by DIME including (i) fee mitigation and (ii) reduction rate referring to PPWSA (clean water supply to the poor).

The Consultant will assist the WWs to prepare (b) the lucid forms with PDM (project design matrix) and PO (plan of operation), when the above 2 items will be confirmed in July 2011.

- New Connection (expansion): Clamp saddle and water meter will be provided for poor HHs. Poor rates were obtained from the social survey result conducted in 2010. Poor rate is defined as "occupation rate of HHs below the international poverty line in un-served area (referred to Table A6-3-8, Annex 6)".

Pursat WWs:	Poor Rate 60 %, expected	550 HHs	330 HHs	400 units
Battambang WWs:	Poor Rate 70 %, expected	2,000 HHs	1,400 HHs	1,400 units
Sihanoukville WS:	Poor Rate 20 %, expected	3,150 HHs	630 HHs	600 units

- New Connection (existing): Water meter will be provided for poor HHs. Poor rates were defined as "occupation rate of HHs below the international poverty line within subscribers (referred to Table A6-3-8, Annex 6)".

Pursat WWs:	Poor Rate 55 %, expected	800 HHs	440 HHs	500 units
Battambang WWs:	Poor Rate 20 %, expected	400 HHs	80 HHs	100 units
Sihanoukville WS:	Poor Rate 15 %, expected	600 HHs	90 HHs	100 units

(2) Equipment for Connection Works

The following number of Socket Fusion Connector for service connection will be provided.

- Pursat WWs 1 unit
- Battambang WWs 2 units
- Sihanoukville WS 2 units

(3) Design Quantity of Procurement

Table 2-6 shows the quantity of materials and equipment to be provided by this project according to the basic plan and design.

Table 2-6 Quantity of Materials and Equipment

Category		Description	Size	Pursat	Battambang	Sihanoukville
Re-connection		Clamp Saddle for HDPE Outlet: 15A	50A	550	1,550	1,000
			100A	150	950	-
			150A	-	200	-
			200A	-	-	-
			Sub Total	700	2,700	1,000
		Ball Valve	15A	700	2,700	1,000
		Short Nipple	15A	700	2,700	1,000
		Valve Socket	15A	700	2,700	1,000
		HDPE	PE-100 (m)	1,400	5,400	2,000
Promotion of Pro-poor	Expansion	Clamp Saddle for HDPE Outlet: 15A	50A	50	1,350	-
			100A	200	50	250
			150A	150	-	250
			200A	-	-	100
			Sub Total	400	1,400	600
		Water Meter	C-15A	400	1,400	600
	Existing	Water Meter	C-15A	500	100	100
HDPE Connector		SF Connector	15A-65A	1	2	2
		Potable Generator	5 kVA	1	2	2

2-2-2-3 Soft Component Plan

(1) Skill of Service Pipe Connection

This activity is planned to improve the quality of service connection works including clamp saddle re-installation attaching on the replaced pipes and connecting to the existing water meters. In addition, this capacity development will help to reduce the NRW from the new service connection

in future.

Water supply engineer manages the entire activities and schedule. The team, composed of water supply engineer together with Cambodian engineer and two senior plumbers, goes round the waterworks weekly. Workshop materials in Khmer are used for basic theory and demonstration materials are prepared for practices. Training progress is judged by pressure test and such practices are repeated until qualified work is performed.

The trainees are engineer and plumbers appointed by the waterworks and casual plumbers temporarily hired for project implementing. Most important subject among the trainings is felled on the field practices. Simultaneously, seminar for customer services including the metering tests with subscriber that is transferred for waterworks engineer and plumbers.

Operation of this activity is scheduled totally 1.5 months including one week preparation, three times of weekly practices at field, one week follow up and one week reporting. This plan starts from the middle of April in 2012 tentatively depending on the schedule of project procurement.

(2) Management on Flow Monitoring System

This activity is indispensable for operation of the system and monitoring flow, since the system is introduced to each waterworks for the first time. Eligible manager in charge should understand the potential of system performance and prepare his action plan on flow monitoring. The staff in charge is required for Pursat and Battambang Waterworks, and the concerned staff can be assigned among the present personnel in Sihanoukville Water Supply Authority.

Water supply engineer controls the entire activities and schedule. The team, composed of water supply engineer together with each Cambodian manager and analyst, goes round twice the waterworks weekly. Workshop materials in Khmer are used for preparation of the action plan including basic theory and data formatting. In the second trip period, counsel to the draft action plan and technical knack are transferred. Participants are system manager, two analysts and manager of the water treatment plant.

Operation of this activity is scheduled totally 2.0 months including one week preparation, two times of three weeks round and one week reporting. This plan starts from the beginning of November in 2012 tentatively according to the turn-over schedule of the telemetric distribution flow monitoring system.

2-2-2-4 Project Effectiveness

Base on the above plan, project effectiveness of various indicators will be expected as shown in Table 2-7, which are to be target figures of the project.

Table 2-7 Project Effectiveness

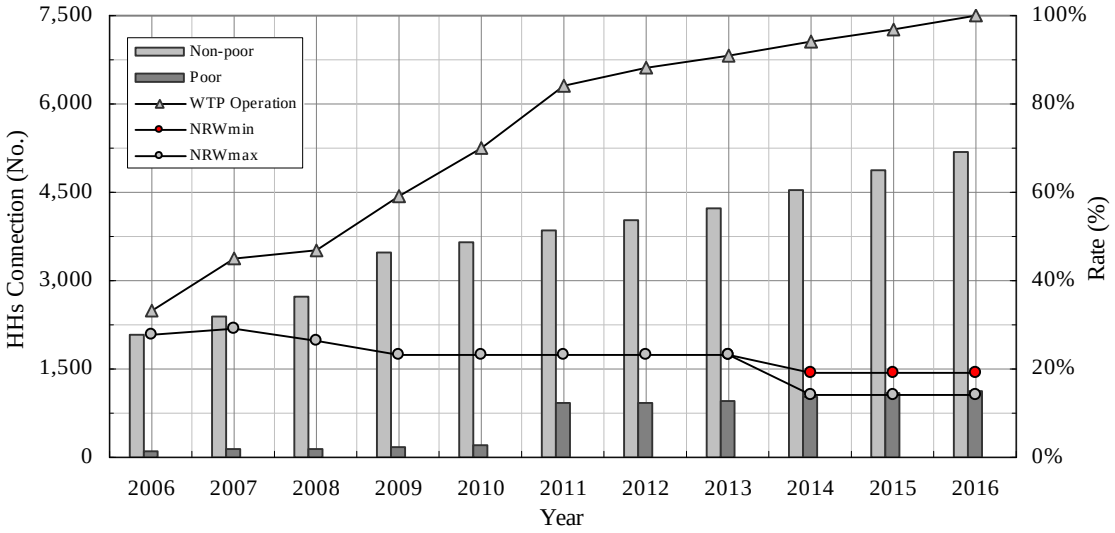
Indicator	Water Utility (Output)	Expected Project Effectiveness/ Action Year 2009	Year 2016
Maximum Daily Water Supply	Pursat	3,410 m^3/day	5,760 m^3/day
	Battambang	9,220 m^3/day	11,520 m^3/day
	Sihanoukville	6,200 m^3/day	12,210 m^3/day
NRW Rate*	Pursat	23.1 %	19 %～14 %
	Battambang	27.6 % (20 hrs. water supply) 35.5 % (24 hrs. water supply)	24 hrs. water supply 20 %～13 %
	Sihanoukville	18.9 %	14 %～10 %
Operation Ratio of WTP	Pursat	59 %	100 %
	Battambang	80 %	100 %
	Sihanoukville	81 % (ANCO: 0 %)**	100 % (ANCO: 45 %)
Energy Efficiency	Pursat	Diesel oil consumption: 0.222 L/m^3	0.199 L/m^3
	Battambang	Electric power consumption: 0.609 kWh/m^3	0.453 kWh/m^3
	Sihanoukville	Electric power consumption: 0.704 kWh/m^3	0.634 kWh/m^3
Water Cost Recovery	Pursat	114 %	127 %
	Battambang	149 %	200 %
	Sihanoukville	153 %	162 %
Upper No. of Connection Lower Pop. Served (estimated)	Pursat	About 3,600 connections	About 6,300 connections
		About 18,200 persons	About 31,500 persons
	Battambang	About 8,600 connections	About 11,300 connections
		About 42,900 persons	About 56,400 persons
	Sihanoukville	About 3,845 connections	About 8,045 connections
		About 23,000 persons	About 48,200 persons

* NRW Rate has a range considering the utmost case of NRW improved. Figures of other indicators are those in case that utmost reduction of NRW is considered.

** (ANCO: %) indicates ratio of water supplied from ANCO compared with maximum 10,000m^3/day stipulated in MOU (Memorandum of Understanding).

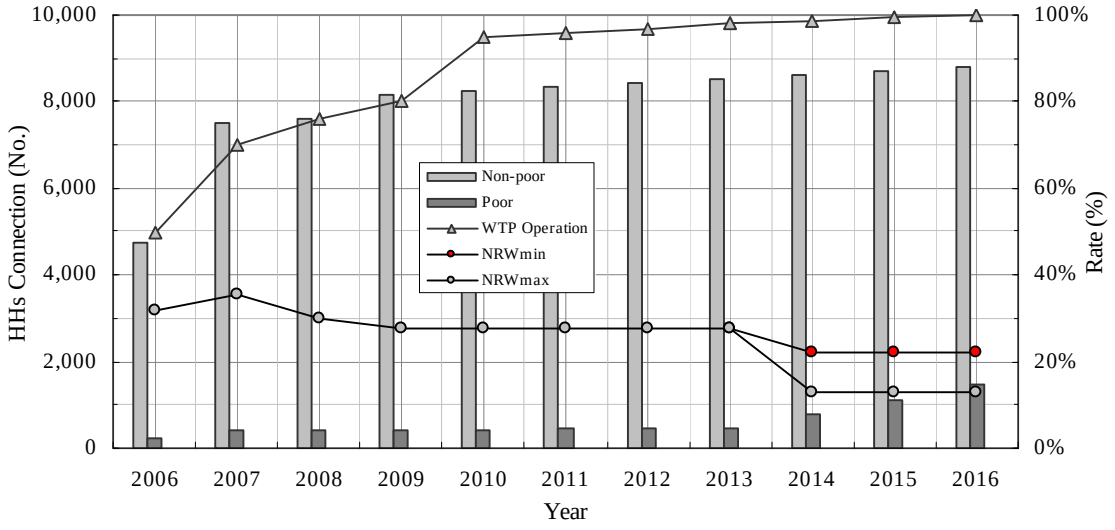
Among the indicators of project monitoring, the key targets are shown in Figures 2-7 to 2-9. Articles under the said figures are used for assumptions or conditions to the basic planning.

1. Maximum Daily Water Supply: 100% of WTP capacity (Pursat and Battambang), 100% of WTP + bulk water from ANCO Brothers.
2. Rate (WTP Operation): Bulk water from ANCO Brothers is included for Sihanoukville WS.
3. Rate (NRW): It shall be analyzed in each block upon completion of the project.
4. HHs Connections: No. of subscribers of poor HHs is related to the project procurement.



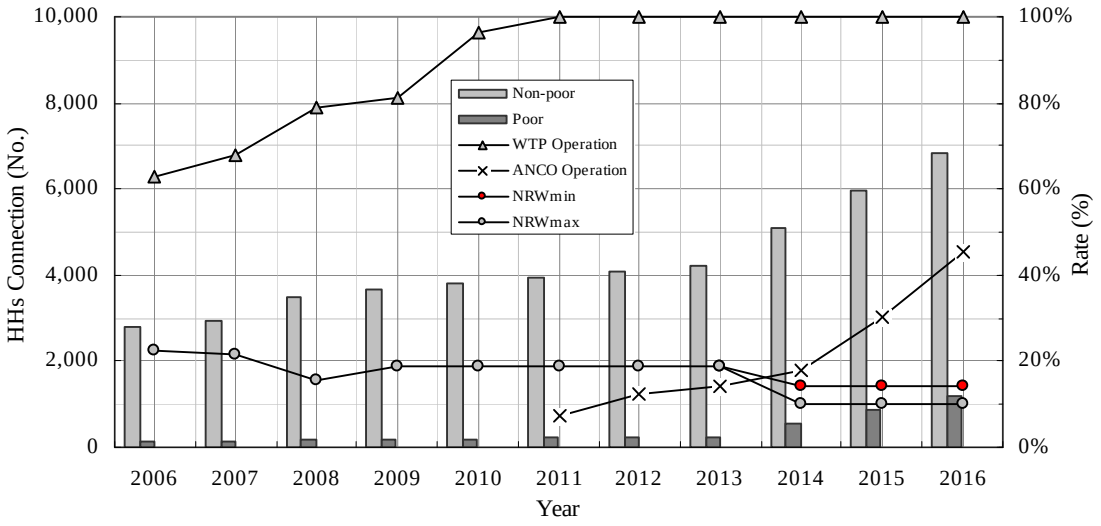
- MEK-WATSAN Project will be completed in 2011 with pro-poor scheme. 723 HHs by 2011
- No. of New Service Connections along the new pipeline: 550 HHs by 2016
- No of New Service Connections along the replacement/ existing pipeline: 800 HHs by 2016

Figure 2-7 Pursat WWs: Basic Plan (indicators under max. effectives excluding NRW)



- Waterworks of 8 private providers were merged into the Battambang WWs. by 2009
- No. of New Service Connections along the new pipeline: 2,000 HHs by 2016
- No of New Service Connections along the replacement/ existing pipeline: 400 HHs by 2016

Figure 2-8 Battambang WWs: Basic Plan (indicators under max. effectives excluding NRW)



- Bulk water supply from ANCO was agreed with max.10,000 m^3/day from December 2009
- No. of New Service Connections along the new pipeline: 2,850 HHs by 2016
- No of New Service Connections along the replacement/ existing pipeline: 600 HHs by 2016

Figure 2-9 Sihanoukville WS: Basic Plan (indicators under max. effectives excluding NRW)

Following are methodologies to set up the planning target of (1) Rate of NRW, (2) Rate of WTP Operation, (3) Energy of unit Water Production and (4) Rate of Cost Recovery under project implementing.

(1) Rate of NRW

Present NRW rate was estimated by the total amounts of distribution and revenue water. As an assumption for prediction on NRW rate in 2016, NRW is considered as a physical loss which is composed of distribution and service pipes. Also, new distribution and service pipes are supposed to have no leakage due to be newly installed. Table 2-8 indicates the water balance defined by IWA (International Water Association) as a reference.

Under these conditions, the following NRW rate can be expressed as project effectiveness.

- Leakage from distribution pipe:
  - Length: replacement pipes ÷old pipes — Rate of pipe length
  - Leakage Amount: surface ÷ (underground + surface) — Rate of leakage
- Leakage from service pipe:
  - No. of Connection: re-connection ÷ present connection — Rate of connection

Physical loss is generally assumed with “distribution: service = 80 %: 20 %” in Japanese water utilities, which is considered different in developing countries. In this regard, project effectiveness with physical loss extending to “distribution: service = 70 %: 30 %” is applied.

Table 2-8 Water Balance by IWA Definition

Amount of Raw Water	Amount of Water Distribution	Author-ized	Valid Consumption	Revenue Metered	RW	1. Billing Water
				Revenue Non-metered		2. Revenue from O/M cost
			Non-revenue Consumption	Non-revenue Metered	NRW	3. Intervention (hydrant)
				Non-revenue Non-metered		4. Used by Water Utility
		Water Loss	Apparent	Non-authorized		5. Illegal Connection
				Meter Error		6. Accuracy of Water Meter
			Physical	Leakage from Distribution Pipes		7. Leakage from Distribution
				Leakage from Reservoir		8. Leakage from Reservoir
				Leakage from Service Pipes		9. Leakage before Water Meter
	Water Loss during Treatment Process					10. Back-wash Water

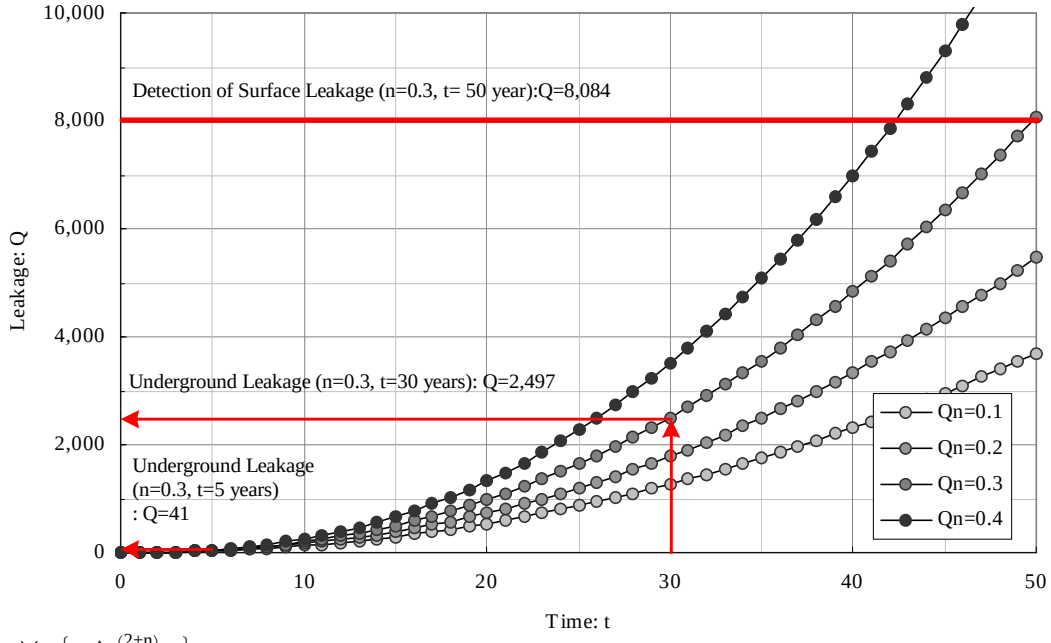
At the first, historical pipe age information is listed in Table 2-9. For this categorization, 1 km of pipe replacement under JICA technical assistance will be completed by 2011, which will be included in project effectiveness.

Table 2-9 List of Distribution Pipe Length

Category by Pipe Age		Pursat WWs	Battambang WWs	Sihanoukville WS	Note
Old Pipes	Placed by WWs	30.0 km	11.6 km	34.4 km	Before the Civil War
	Merged from Private	-	29.2 km	-	
	Sub-total	30.0 km	40.8 km	34.4 km	
	Replaced by the Project Length*	4.7 km	18.8 km	8.2 km	
	Replaced by the Project Ration	15.7 %	46.1 %	23.8 %	
New Pies	WB Project	-	-	18.7 km	After the Civil War
	ADB Project	14.2 km	46.3 km	-	
	Loan Project	19.3 km	-	-	
	Sub-total	33.5 km	46.3 km	18.7 km	
Total Length		63.6 km	87.1 km	53.1 km	-

*There is difference in pipe length between pipes to be replaced and design quantity due to route survey result and pipes to be abandoned in the requested pipelines.

Amounts from underground leakage and surface leakage are estimated to calculate the rate of leakage. Underground leakages are added from old pipes excluding replacement pipes and new pipes. Surface leakage is outlet from subject old pipes to be replaced.
Underground leakage will increase shortly by erosion and indirect influence such as traffic load and civil works in surrounding field, if the early detection of underground leakage and initial maintenance cannot be carried out, and become surface leakage affecting with soil permeability and groundwater level. Finally, water leakage is located and repaired.
Leakage amount from the damaged pipe and or connection varies according to the conditions of many factors as shown in Figure 2-10. Generally, quantitative characteristic of pipe leakage has an increasing trend acceding to time.



$Q = a \times \{ t^{\wedge (2+n)} \}$

Where: Q amount of leakage
a coefficient
t time
n variable (0.2 to 0.4: by pressure, type of pipe, surface of pipe, connection, placement quality…)

Figure 2-10 Relationships between Pipe Age and Leakage (underground and surface)

Growth rend from the specific location is grasped as total leakage from un-identified points in pipeline network. Rate of leakages between underground and surface can be estimated as following with conditions of (A) surface leakage from old pipes: 60 years, (B) underground leakage from old pipes: 30 years, (C) underground leakage from new pipes: 5 years as shown in Table 2-6 and variable "n" is 0.3.

- (A): (B): (C) = 200: 60: 1

Rate of NRW reduction can be estimated according to the rate of pipe lengths and replacement of surface leakage pipes as shown in Table 2-10.

Table 2-10 Reduction of Leakage and NRW Rate by the Length of Existing Pipeline

Index of Assumption		Pursat WWs	Battambang WWs	Sihanoukville WS
Surface Leakage from Ole Pipes	Pipe Length	5.7 km	19.8 km	9.2 km
	Ratio of Leakage		200	
	Imaginary Leakage Amount	1,140	2,960	1,840
	Rate of NRW Reduction	43 %	75 %	54 %
Underground Leakage from Old Pipes	Pipe Length	24.3 km	21.0 km	25.2 km
	Ratio of Leakage		60	
	Imaginary Leakage Amount	1,458	1,260	1,512
	Rate of NRW Reduction	56 %	24 %	45 %
Underground Leakage from New Pipes	Pipe Length	33.5 km	46.3 km	18.7 km
	Ratio of Leakage		1	
	Imaginary Leakage Amount	33	46	19
	Rate of NRW Reduction	1 %	1 %	1 %

The rates of NRW reduction are expected below.

	Reduction rate of distribution pipe	Reduction rate of service pipe
• Pursat WWs:	19 % to 43 %	22 %
• Battambang WWs:	49 % to 75 %	31 %
• Sihanoukville WS:	27 % to 54 %	32 %

Leakage amounts from distribution and service pipes are estimated using NRW rate experiences of "80 %: 20 %" and "70 %: 30 %." Following rates of NRW reduction are expected when the project is implemented. As a result, the same amount of water can be distributed to the networks in 2016.

	Target of NRW rate: present in 2009 → Plan in 2016	Secondary water source
• Pursat WWs:	23.1 % → 19 to 14 % (improved 4 to 9)	236 to 454 m^3/day
• Battambang WWs	35.5 % → 20 to 13 % (improved 15 to 22)	1,555 to 2,242 m^3/day
• Sihanoukville WS:	18.9 % → 14 to 10 % (improved 5 to 9)	376 to 651 m^3/day

Revenue water ratios of Japanese water utilities which cover the service population from 18,000 up to 65,000 (similar to subject waterworks in Cambodia) are shown in Figure 2-11. Expected ratios of revenue water of subject waterworks are within the range of 80 % to 90 %, which are considered appropriate compared to the case in Japan.

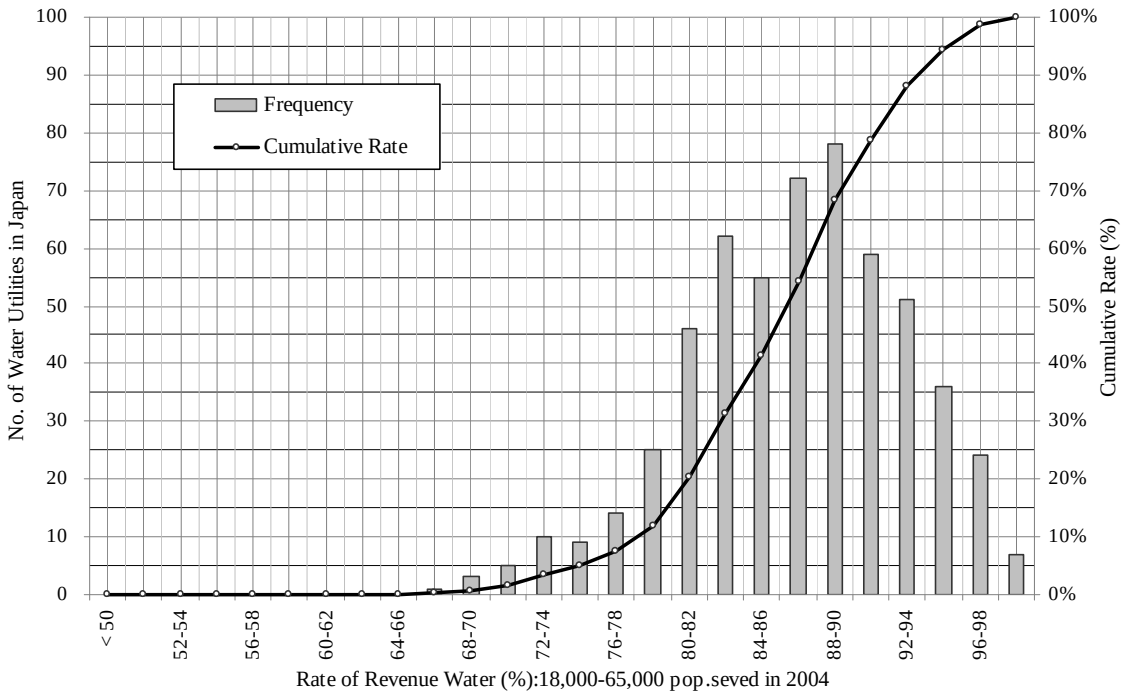


Figure 2-11 Histogram of Revenue Water Ratio in Japan 2004 (source: JWRC)

(2) Rate of WTP Operation

The operation rate of WTP can be calculated with following procedures.

- WTP Operation Rate = Daily Max. Demand ÷ Capacity of WTP (Design Capacity)
- Daily Max. Demand = Average Daily Demand ÷ Rate of Loading (referred to M/P)
- Ave. Daily Demand = {(Lpcd × Connection × HH Pop.) + other Consumer} ÷ Revenue Rate

<Ratio of Poor Household and Unit Consumption>

As described in Subsection '2-2-2-1 Facility Construction Plan'

< Number of Service Connection >

Number of new service connections is allotted to the households of poor and others. According to the pro-poor scheme in the MWK-WATSAN project, number of connection is felled on poor consumption category.

< Revenue Rate >

Revenue rate is applied using present NRW rate until 2013 (project completion year), then the expected rate of NRW is adopted until the planned year of 2016. For Battambang WWs, NRW rate when WTP was operated for 24 hours is applied.

< Rate of Loading: Daily Average Demand ÷ Daily Maximum Demand >

The rate of loading is adopted referring to the Master Plan. The waterworks shall analyze the rate with due consideration of localities such as climate condition, availability of other water sources, economic level, etc., after completion of this project.

- Pursat and Battambang WWs: 0.77 (equivalent value to WWs of population 30,000 to 50,000 pop. in Japan)
- Sihanoukville WS: 0.80 (equivalent value to WWs of population 50,000 to 100,000 pop. in Japan)

Based on the above, expected rate of WTP operation in 2016 is shown below. In the Sihanouk-

ville WS, bulk water supply from ANCO Brothers was started from December 2009.

	Present 2009	Basic Plan 2016
• Pursat WWs	59 %	100 %
• Battambang WWs	80 %	100 %
• Sihanoukville WS:	81 %	100 %
Bulk Water from ANCO:	0 %	42 %

(3) Energy of unit Water Production

Energy efficiency is estimated using the revenue rate and power/ fuel consumption. For Battambang WWs and Sihanoukville WS, power consumption is adopted. For Pursat WWs, the fuel consumption is calculated. Saving of electric power and fuel are expected according to the improvement of NRW rate.

	Present 2009	Basic Plan in 2016	Saving Rate
• Pursat WWs (fuel):	0.222 L/m^3	0.199 L/m^3	10.48 %
• Battambang WWs (electric):	0.609 kWh/m^3	0.453 kWh/m^3	25.56 %
• Sihanoukville WS (electric):	0.704 kWh/m^3	0.634 kWh/m^3	9.87 %

It is noted that energy efficiency of Sihanoukville WS would vary according to distribution blocks and bulk water from ANCO.

(4) Rate of Cost Recovery

This parameter is defined as "water selling cost ÷ water production cost" according to Japan PI system (JWWA Q-100: Japan Waterworks Association). Based on the current financial data provided from the waterworks, the rates of cost recovery are estimated as shown in Table 2-11. Conditions of estimation are constant of water selling cost (water tariff and collection rate) and water production cost (energy, chemicals, O/M and salary). Rate of cost recovery would be more improved if the O/M cost can be saved comparing the present cost. For the case of Sihanoukville WS, low improvement of cost recovery is anticipated because of ANCO bulk water supply.

Table 2-11 Project Effectiveness on Cost Recovery Rate

Target Year	Pursat WWs	Battambang WWs	Sihanoukville WS
2009 (present)	113.6 %	148.6 %	153.2 %
2016 (target)	127.0 %	200.4 %	162.1 %
Rate of Improvement	12 %	35 %	6 %

Improvement of financial statement can not be evaluated by only the cost recovery. Cash flow condition would be better than the present situation in the subject waterworks. Financial conditions would be improved when the waterworks start to make the rolling action plan (project cycle) for achievement of water supply level as a public service sector.

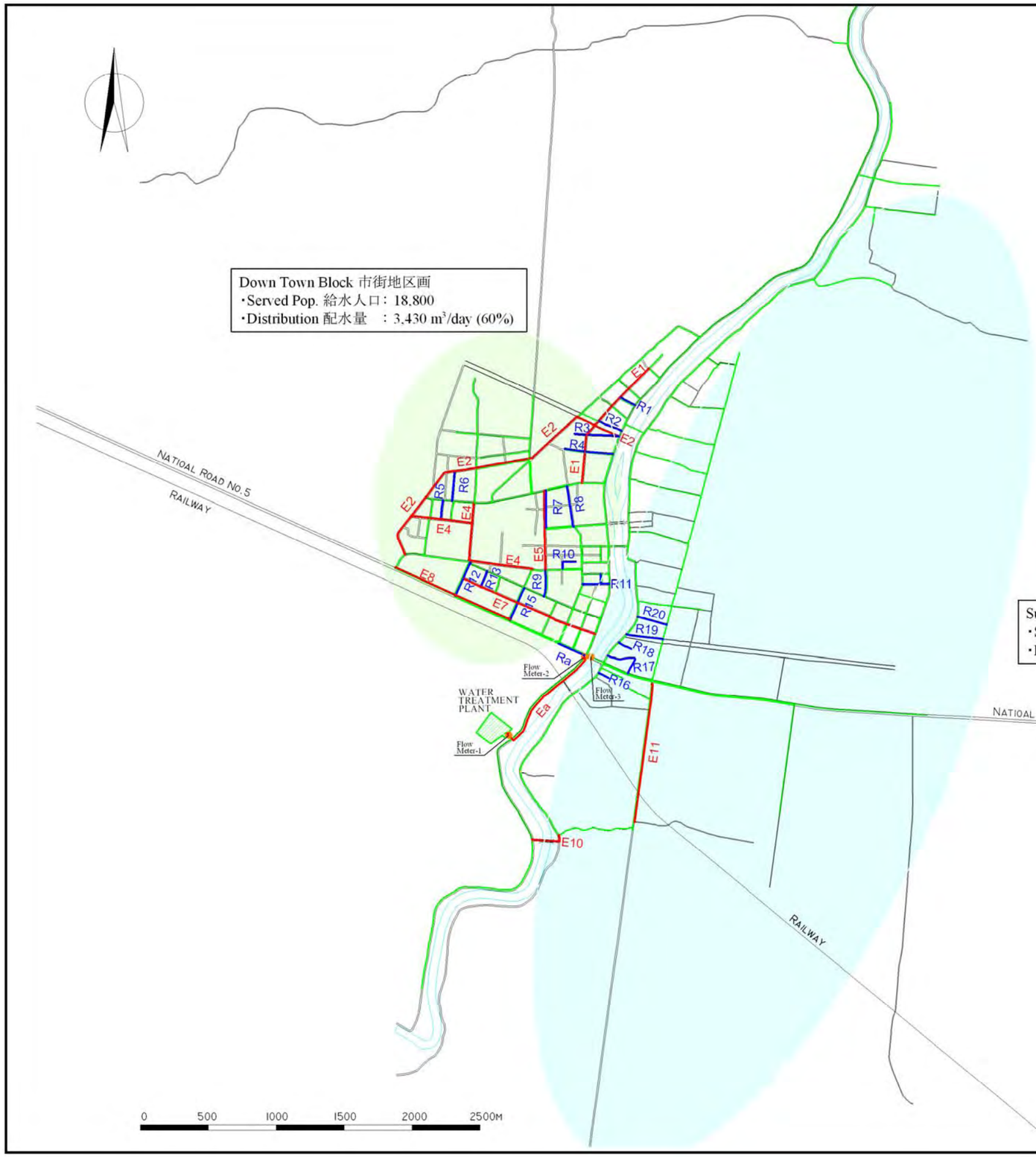
2-2-3 Outline Design Drawing

Table 2-12 shows the list of outline design drawings. Each drawing is attached later.

Table 2-12 List of Outline Design Drawing

Category	Name of Drawing	No. of Figure with Contents
Particular	General Map of Distribution Pipeline in PURSAT	Figure 2-12 to 2-16: PURSAT WWs Contents: Existing/ Replacement/ Expansion, etc.
	General Map of Distribution Pipeline in BATTAMBANG	Figure 2-17 to 2-27: BATTAMBANG WWs Contents: Existing/ Replacement/ Expansion, etc.
	General Map of Distribution Pipeline in SIHANOUKVILLE	Figure 2-28 to 2-39: SIHANOUKVILLE WWs Contents: Existing/ Replacement/ Expansion, etc.
Standard	General Earth Works for Pipe Laying	Figure 2-40 Contents: Excavation/ backfill, road restoration, etc.
	Typical Drawing for Structure Crossing	Figure 2-41 Contents: Structures, under crossing, etc.
	Typical Drawing for River and Bridge Crossing	Figure 2-42 Contents: Structures
	Typical Drawing for Instruction of Flow Meter	Figure 2-43 Contents: By-pass, pit structures
	Typical Drawing for Gate Valve	Figure 2-44 Contents: Gate valve with pit structures
	Typical Drawing for Instruction of PRV	Figure 2-45 Contents: Pressure reducing valve, strainer, by-pass, etc.
	Typical Drawing for Instruction of FCV	Figure 2-46 Contents: Flow control valve, pit structures, etc.
	Typical Drawing for Instruction of ARV and BOV	Figure 2-47 Contents: Air release valve, brow off valve, etc.
	Flow Control Valve Control System	Figure 2-48 Contents: System flow (local and central)

General Map of Distribution Network in PURSAT



Legend

- Existing Pipe
- Replacement Pipe (Total Length L=4,480m)
- Expansion Pipe (Total Length L=9,370m)
- Flow Meter (3 places) (Local Station of Telemeter System)
- Flow Control Valve (0 place)
- Pressure Reducingl Valve (0 place)

Route No. 路線 No.	Pipe/Dia 管種/口径			Distribution Pipe 配水管
R: Replacement(更新) E: Expansion(拡張)	DI(ダクタイル鋳鉄管) HDPE(高密度ポリエチレン管)			Length 延長
	Pipe 管種	Nominal Dia 呼径(mm)	Outside Dia 外径(mm)	(m)
PS-R1	HDPE	50	63	130
PS-R2	HDPE	50	63	190
PS-R3	HDPE	50	63	330
PS-R4	HDPE	50	63	360
PS-R5	HDPE	50	63	140
PS-R6	HDPE	50	63	230
PS-R7	HDPE	50	63	280
PS-R8	HDPE	100	125	320
PS-R9	HDPE	50	63	200
PS-R10	HDPE	50	63	110
PS-R11	HDPE	50	63	270
PS-R12	HDPE	100	125	290
PS-R13	HDPE	50	63	130
PS-R15	HDPE	100	125	270
PS-R16	HDPE	50	63	90
PS-R17	HDPE	50	63	330
PS-R18	HDPE	50	63	110
PS-R19	HDPE	50	63	270
PS-R20	HDPE	50	63	220
PS-Ra	HDPE	50	63	210
Sub total(R) 小計(R)	-	-	-	4,480
PS-E1	HDPE	100	125	1,030
PS-E2	HDPE	150	180	2,160
PS-E4	HDPE	100	125	1,370
PS-E5	HDPE	100	125	590
PS-E7	HDPE	100	125	1,060
PS-E8	HDPE	150	180	940
PS-E10	HDPE	100	125	260
PS-E11	HDPE	50	63	1,030
PS-Ea	DI	300	-	930
Sub total(E) 小計(E)	-	-	-	9,370
Grand total 合計	-	-	-	13,850

Service pipes along the DCIP are not listed in the above table.

PROJECT NAME:
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DRAWING TITLE:
General Map of Distribution Network in PURSAT
プルサット　配水管全体平面図

SCALE: Not To Scale

DWG No.: -

Figure 2-12　General Map of Distribution Network in PURSAT

PURSAT Distribution Pipe Route Plan (1)

0 100 200 300 400 500m

E1 E2 R1 R2 R3 R4 R7 R8

PE⌀110, L=1170m
PE⌀63, L=144m
PE⌀63, L=110m
PE⌀63, L=214m
R1 PE⌀63, L=123m
CI⌀60, L=114m
PE⌀63, L=264m
PE⌀110, L=204m
PE⌀63, L=135m
E2 PE⌀160, L=343m
R2 PE⌀63, L=181m
CI⌀60, L=181m
PE⌀63, L=416m
PE⌀110, L=158m
PE⌀63, L=509m
R3 PE⌀63, L=328m
CI⌀60, L=328m
Bridge Mount Rack
E2 PE⌀160, L=446m
PE⌀63, L=422m
PE⌀110, L=458m
PE⌀110, L=543m
R4 PE⌀63, L=353m
CI⌀60, L=353m
PE⌀160, L=236m
F.H-⌀150
E1 PE⌀110, L=1,029m
PE⌀90, L=309m
PE⌀63, L=172m
PE⌀110, L=188m
PE⌀110, L=393m
PE⌀110, L=264m
PE⌀110, L=242m
PE⌀110, L=410m
PE⌀225,L=450m
PE⌀63, L=553m
PE⌀63, L=146m
PE⌀63, L=236m
PE⌀63, L=541m
PE⌀110, L=886m
R7 PE⌀63, L=272m
CI⌀60, L=272m
R8 PE⌀110, L=320m
CI⌀60, L=673m
DI⌀250, L=1524m
E5 PE⌀63, L=584m
PE⌀63, L=199m
PE⌀160, L=444m
PE⌀63, L=205m
PE⌀63, L=185m

Key Plan

Legend

- Existing Pipe
- Replacement Pipe
- Expansion Pipe
- Flow Meter
- Flow Control Valve
- Pressure Reducingl Valve
- Sluice Valve

PROJECT NAME:
THE PREPARATORY SURVEY ON PROJECT ON
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カンボジア国 地方州都における配水管改修及び拡張計画準備調査

DRAWING TITLE:
PURSAT Distribution Pipe Route Plan (1)
プルサット 配水管路線平面図 (1)

SCALE:
Not To Scale

DWG No.:
-

Figure 2-13 PURSAT Distribution Pipe Route Plan (1)

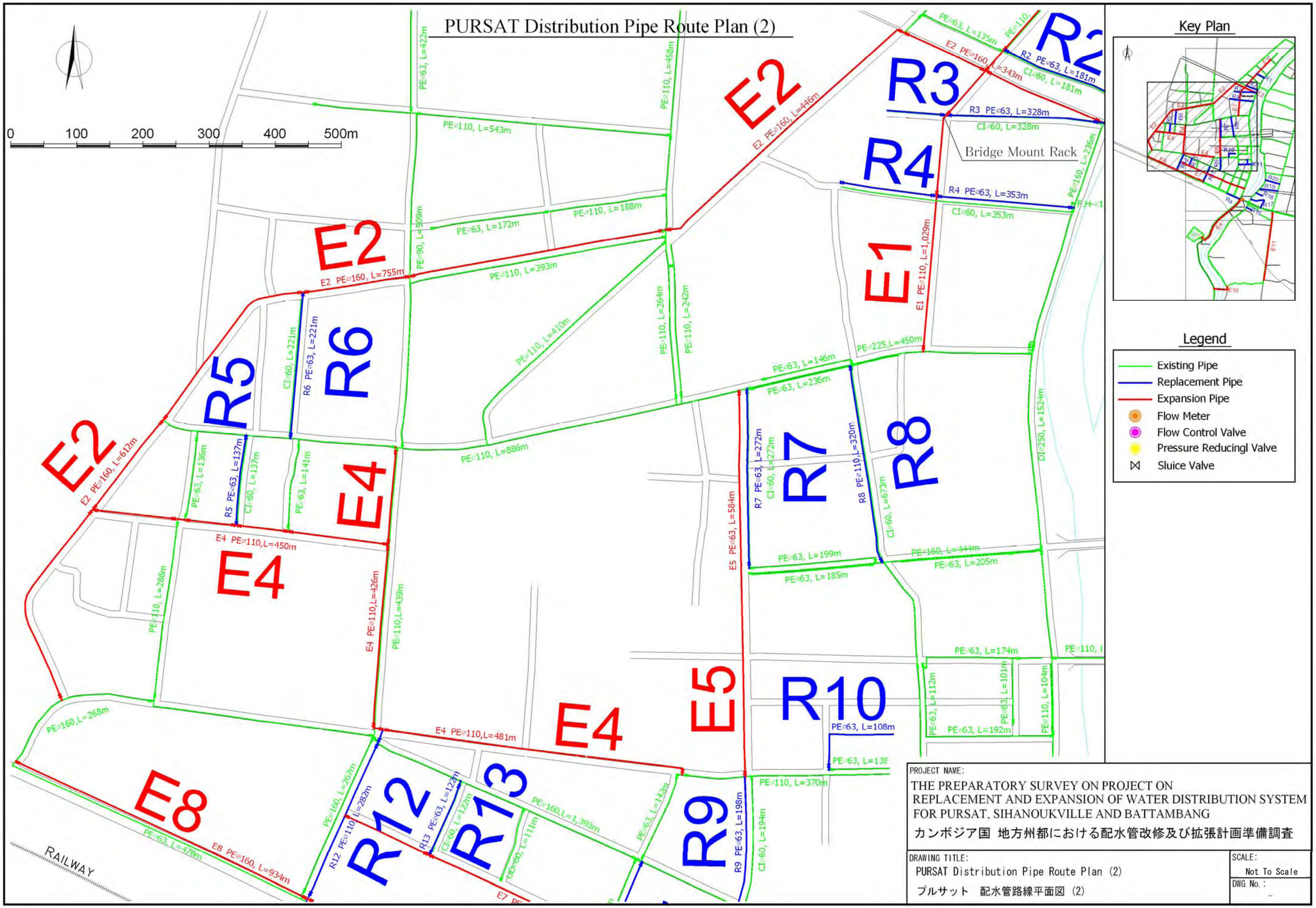


Figure 2-14 PURSAT Distribution Pipe Route Plan (2)

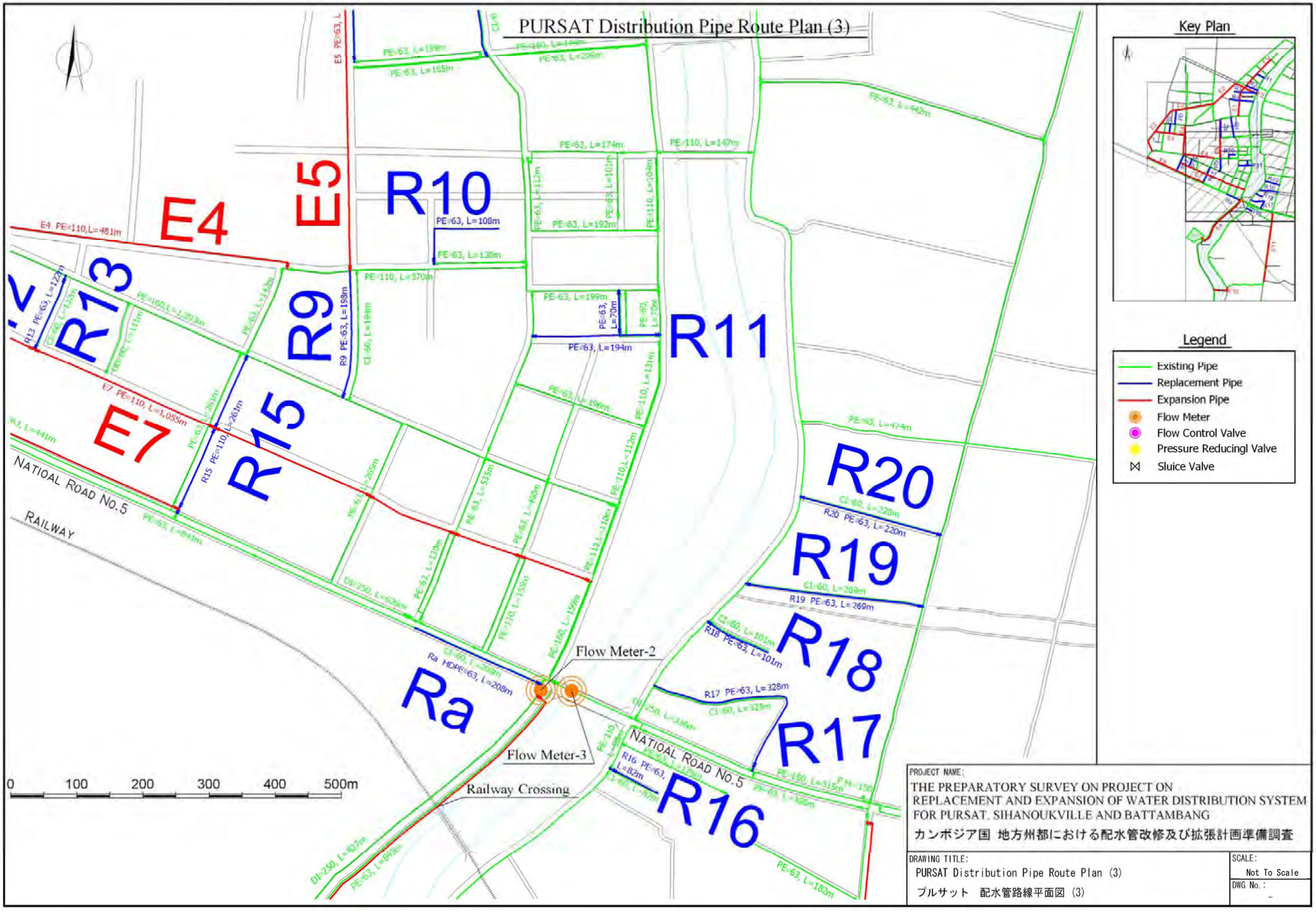


Figure 2-15 PURSAT Distribution Pipe Route Plan (3)

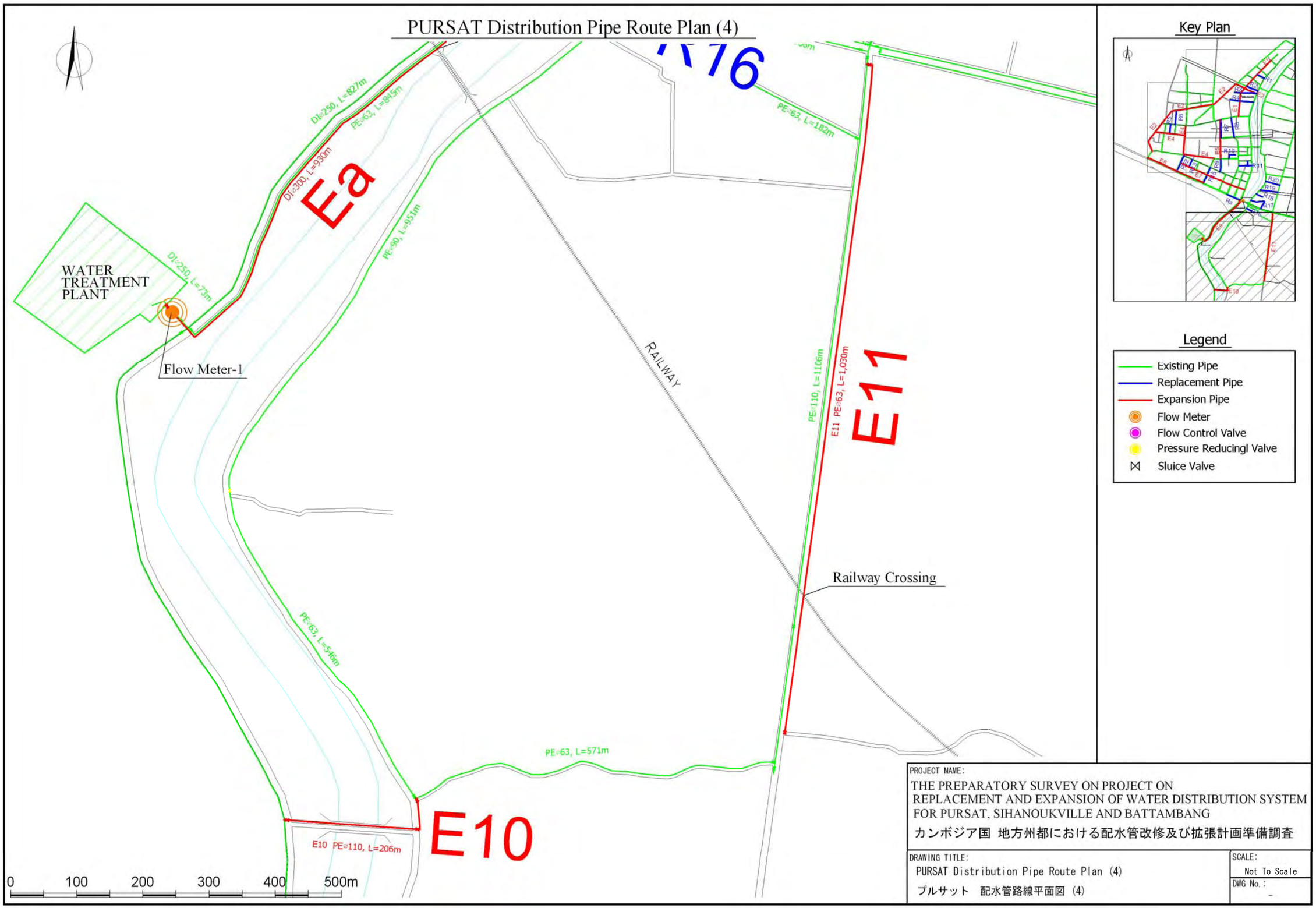
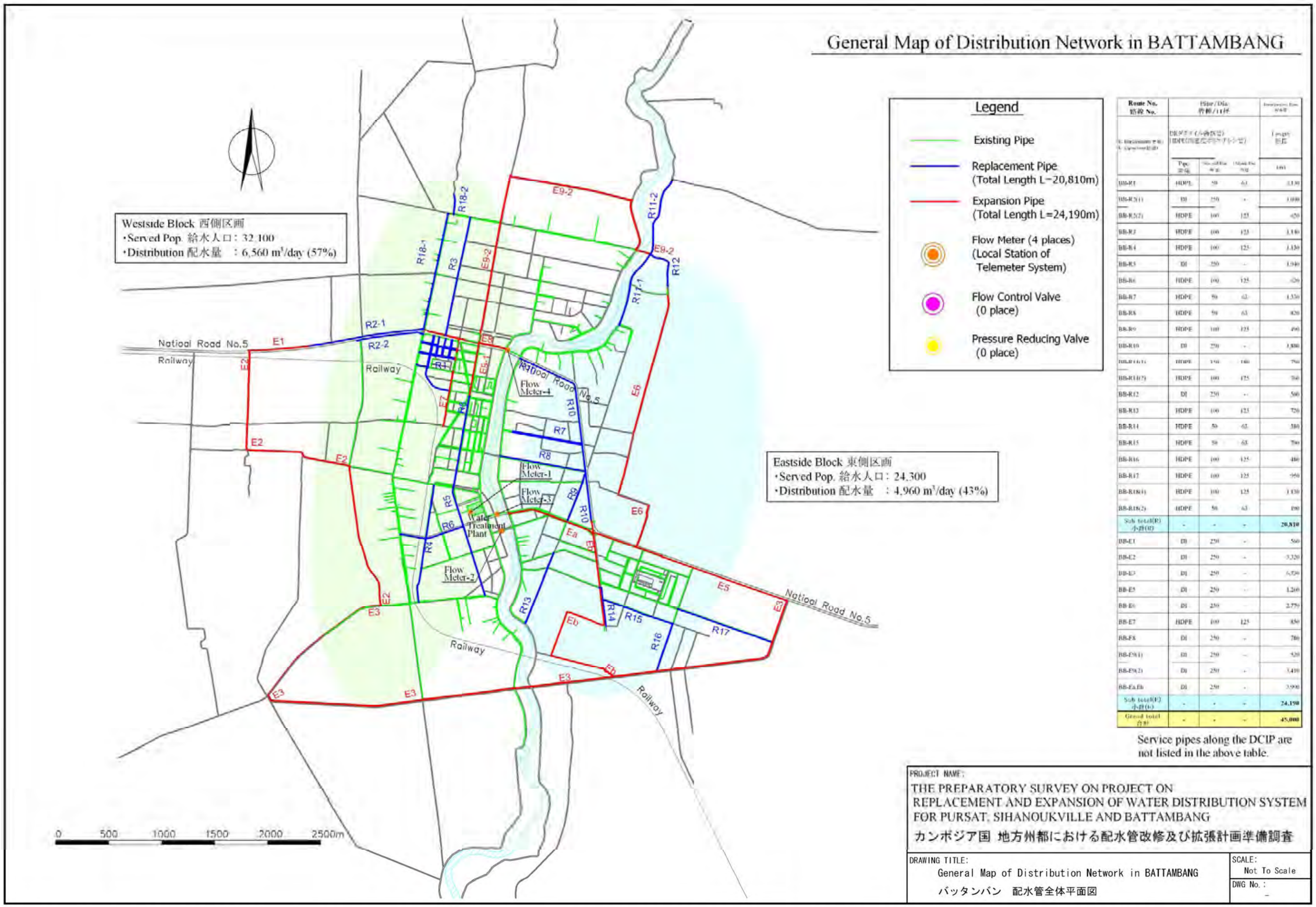


Figure 2-16 PURSAT Distribution Pipe Route Plan (4)



Route No. 管路 No.	Pipe / Dia. 管種 / 口径			Pipe Length 管長
	DCIP ダクタイル鋳鉄管 HDPE 高密度ポリエチレン管			Length 管長
	Type 管種	Nominal Dia 呼び径	Outside Dia 外径	(m)
BB-R1	HDPE	50	63	130
BB-R2(1)	DI	250	-	1,000
BB-R2(2)	HDPE	100	125	450
BB-R3	HDPE	100	125	1,110
BB-R4	HDPE	100	125	1,020
BB-R5	DI	250	-	1,940
BB-R6	HDPE	100	125	420
BB-R7	HDPE	50	63	1,350
BB-R8	HDPE	50	63	820
BB-R9	HDPE	100	125	490
BB-R10	DI	250	-	1,880
BB-R11(1)	HDPE	150	160	700
BB-R11(2)	HDPE	100	125	360
BB-R12	DI	250	-	500
BB-R13	HDPE	100	125	720
BB-R14	HDPE	50	63	380
BB-R15	HDPE	50	63	700
BB-R16	HDPE	100	125	480
BB-R17	HDPE	100	125	950
BB-R18(1)	HDPE	100	125	1,030
BB-R18(2)	HDPE	50	63	890
Sub total(R) 小計(R)	-	-	-	20,810
BB-E1	DI	250	-	560
BB-E2	DI	250	-	3,320
BB-E3	DI	250	-	6,520
BB-E5	DI	250	-	1,260
BB-E6	DI	250	-	2,770
BB-E7	HDPE	100	125	850
BB-E8	DI	250	-	780
BB-EW(1)	DI	250	-	520
BB-EW(2)	DI	250	-	3,410
BB-Ea,Eb	DI	250	-	2,990
Sub total(E) 小計(E)	-	-	-	24,190
Grand total 合計	-	-	-	45,000

Service pipes along the DCIP are not listed in the above table.

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DRAWING TITLE:
General Map of Distribution Network in BATTAMBANG
バッタンバン 配水管全体平面図

SCALE: Not To Scale
DWG No. : -

Figure 2-17 General Map of Distribution Network in BATTAMBANG

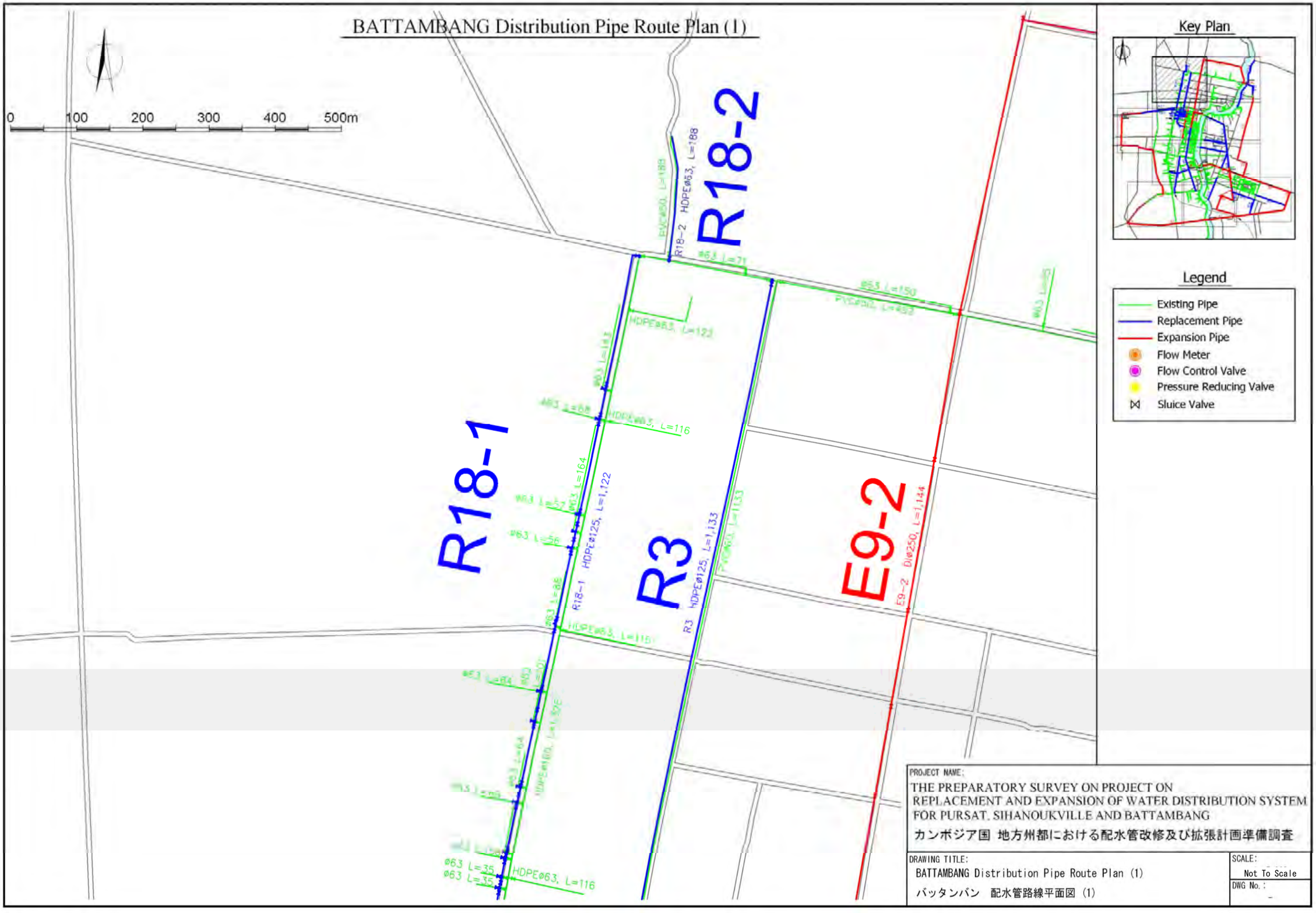


Figure 2-18 BATTAMBANG Distribution Pipe Route Plan (1)

BATTAMBANG Distribution Pipe Route Plan (2)

E9-2 DIø250, L=1,625

E9-2

E9-2 DIø250, L=493

R11-2

R11-2 HDPEø125, L=755

PVCø60, L=755

Bridge Mount Rack

E9-2

E9-2 DIø250, L=144

R12

R12 DIø250, L=555

PVCø60, L=408

R11-1

R11-1 HDPEø180, L=750

HDPEø63, L=448

ø63 L=158

ø63 L=271

ø63 L=152

ø63 L=158

HDPEø110, L=1308

ø63 L=279

ø63 L=133

ø63 L=122

ø63 L=23

ø63 L=75

ø63 L=141

ø63 L=170

ø63 L=116

ø63 L=252

ø63 L=114

ø63 L=162

ø63 L=166

ø63 L=169

HDPEø225, L=476

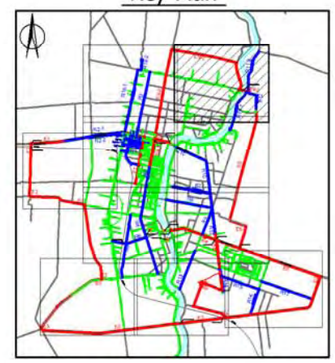
ø63 L=76

HDPEø110, L=729

HDPEø110, L=244

0 100 200 300 400 500m

Key Plan



Legend

- Existing Pipe
- Replacement Pipe
- Expansion Pipe
- Flow Meter
- Flow Control Valve
- Pressure Reducing Valve
- Sluice Valve

PROJECT NAME:
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DRAWING TITLE:
BATTAMBANG Distribution Pipe Route Plan (2)
バッタンバン 配水管路線平面図 (2)

SCALE:
Not To Scale

DWG No.:

Figure 2-19 BATTAMBANG Distribution Pipe Route Plan (2)