CHAPTER 1

BACKGROUND OF THE PROJECT

1.1 Background of the Project

Phnom Penh City, the capital of the Kingdom of Cambodia, is located at the west side of the confluence of the Mekong and Tonle Sap rivers. It is the political, economic and cultural center of the country with the population of about 1.38 million people in 2004.

The construction of the outer ring dikes for the protection of Phnom Penh City from flooding of neighboring rivers, lakes and swamps was started in the 1960's, and urban drainage facilities having the function of draining storm water and domestic wastewater were improved gradually in accordance with the development plan of the city. However, all of the drainage facilities constructed from the beginning of the 1900's are not functioning well due to old age, as well as poor maintenance after the 1970's. As a result, the city suffers from habitual inundation and poor environmental conditions caused by stagnant wastewater in lowland areas, which are serious constraints to the improvement of residents' living environment, as well as social and economic development, not only of Phnom Penh City but the whole country in general.

The Government of Cambodia had made a request for assistance from the Government of Japan in order to formulate a master plan of flood protection and urban drainage improvement for Phnom Penh City and suburbs. In response, the Government of Japan had dispatched a study team through the Japan International Cooperation Agency (hereinafter referred to as "JICA") to formulate the Master Plan and to conduct the Feasibility Study on priority projects selected from the Master Plan. That study was conducted from March 1998 to August 1999 and, as a result of the Feasibility Study, urgently necessary components of the priority projects were selected.

Based on these priority projects, "The Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh" was carried out under the Japan's Grant Aid Scheme from 2001 to 2004. This project included the improvement of drainage channels and the construction of a new pumping station focusing on the improvement of the southwestern area of the city. Although drainage conditions in the southwestern area have greatly improved, the city center and the eastside of the city such as the Central Market, the Royal Palace, Wat Phnom and the Trabek area are still flooded in the rainy season.

In order to implement the remaining priority projects, technical and financial assistance for the **Project for Flood Protection and Drainage Improvement in the Municipality of Phnom Penh (Phase II)** (hereinafter referred to as **"the Project")** was requested in July 2004 by the Cambodian Government. In response, the Government of Japan decided to implement the Basic Design Study to examine the viability of the Project and entrusted the study to Japan International Cooperation Agency (JICA), which dispatched a study team to Cambodia to conduct the Basic Design Study from January 10 to February 22, 2006.

1.2 Contents of the Request

The Project aims at the reinforcement and improvement of drainage and flood protection facilities in Phnom Penh City to protect the city from inundation and flood damage. In this regard, the Government of Cambodia had requested technical cooperation through the Japan's Grant Aid Scheme for the Project, which consists of facility construction works, as shown in the table below.

Table 1.2.1 Contents of the Request for Japan's Grant Aid

Requested Components	Quantity	Specification
1. Construction of Stone Pitching Type Revetment along the Tonle Sap River		
Revetment Works	Longitudinal Length: 1.5 km	Type of Revetment: Grid Pattern Concrete Type Type of Foot Protection: Boulder Riprap and Cut-off Sheet Piling Environmental Measures: Planting, Provision of promenade, etc.
2. Improvement of Central Market Area Drainage System		
Drainage Pipe	Length: 3.4 km	North: -640 m of Ø800 mm (Monivong Road) -350 m of Ø1,000 mm (Road No. 110) -860 m of Ø1,500 mm (Road No. 108) Center: -250 m of Ø1,500 mm (Road No. 148) South: -600 m of Ø1,000 mm (Norodom Road) -700 m of Ø1,500 mm (Road No. 154)
Drainage Pumping Station	2 stations	North - Discharge Capacity: 2,500 m^3/h Center -Discharge Capacity: 5,000 m^3/h
Underground Reservoir	3 locations	North - Retention Capacity: 4,500 m^3 Center - Retention Capacity: 3,000 m^3 South - Retention Capacity: 4,500 m^3

Table 1.2.1 Contents of the Request for Japan's Grant Aid (Cont'd.)

Requested Components	Quantity	Specification
3. Improvement of Royal Palace and National Museum Area Drainage System		
Drainage Box Culvert	Length: 0.7 km	North - 300 m of Box Culvert (2 m x 1.5 m) (Road No. 184) to the river South - 400 m of Box Culvert (2 m x 1.5 m) (Road No. 240) to the river
Drainage Pumping Station	2 stations	North - Discharge Capacity: 5,000 m^3/h South - Discharge Capacity: 2,500 m^3/h
Underground Reservoir	2 locations	North - Retention Capacity: 7,400 m^3 South - Retention Capacity: 1,100 m^3
4. Improvement of Road Drainage System and Road Rehabilitation in Trabek Basin and Adjacent Area		
Drainage Pipe	Length: 19.0 km	-
Rehabilitation of Road Pavement	Pavement Area: 200 ha	Asphalt Pavement
5. Improvement of Wat Phnom Basin Drainage System		
Drainage Pipe	Length: 9.05 km	9,050 m including road rehabilitation -900 m of Ø1,500 mm (Road No. 47) -200 m of Ø1,500 mm (Road No. 90) -100 m of Ø1,000 mm -500 m of Ø800 mm (Road No. 79) -300 m of Ø 600 mm (Road No. 86)
Drainage Pumping Station	1 station	Discharge Capacity: 2,500 m^3/h
Underground Reservoir	1 location	Retention Capacity: 6,000 m^3
6. Procurement of Maintenance Equipment of Drainage System		
Maintenance Equipment	1 set	Sludge Vacuum Loader High Water Pressure Jetting Machine

1.3 Present Condition of the Project Area

1.3.1 Natural Condition

(1) Topographic Survey

Topographic surveys mentioned below have been conducted to supply the basic data for the design and planning of facilities and the supervision of construction work.

- Existing drainage pipe network and road (Length: 32.8 km) including 261 points of existing manholes.
- Dike and riverfront of Tonle Sap River (Length: 1.66 km), and pumping station and underground reservoir (6 places).

The quantities of topographic survey are as given in Table 1.3.1 and the survey locations are as indicated in Figure 1.3.1. The results of manhole survey are described the following section.

Table 1.3.1 Quantities of Topographic Survey

Work Item		Survey Item	Quantity
Existing drainage pipe network and road	Existing drainage pipe network	Longitidinal profile	32.80 km
		Manhole	261 points
	Road	Longitidinal profile	32.80 km
		Cross section (L=20 m)	756 sections (Interval of every 50 meters)
	Underground facilities	Collection for all data	Approx. 1 km^2 (Electric cable, Telephone cable, Water distribution/Transmission pipe, Drainage pipe)
Dike and riverfront of Tonle Sap River, and pumping station & Underground Reservoir	Dike and riverfront of Tonle Sap River	Longitudinal profile	1.66 km
		Cross section (L=50 m)	38 sections (Interval of every 50 meters)
		Cross section (L=80 m)	21 sections (Interval of every 80 meters)
	Pumping station & Underground Reservoir	Plan survey	31,200 m^2
	Underground facilities	Collection for all data	Approx. 1 km^2 (Electric cable, Telephone cable, Water distribution/Transmission pipe, Drainage pipe)

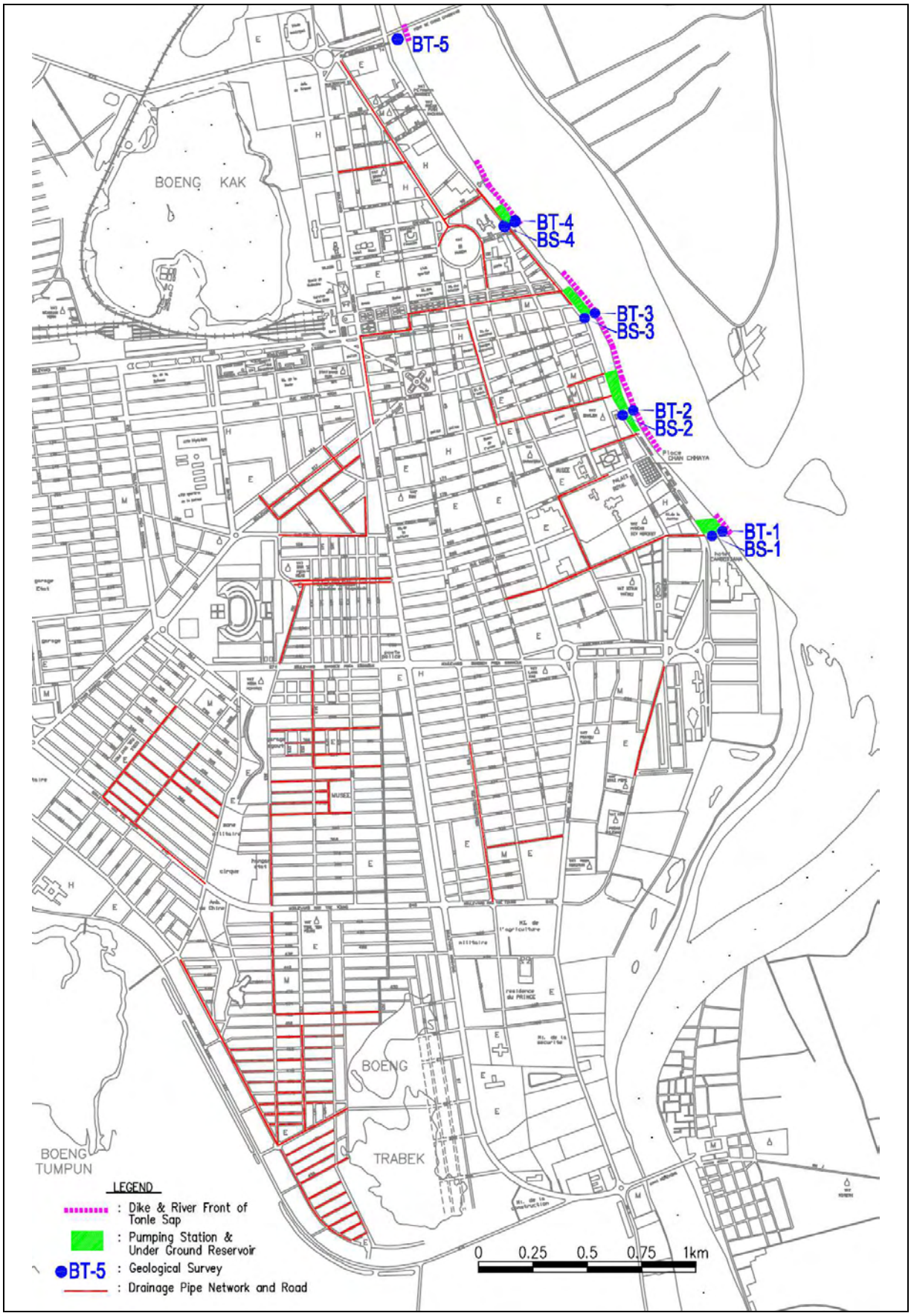

Figure 1.3.1 Location of Topographic and Geological Survey

(2) Geological Survey

Machine boring and laboratory tests have been conducted to clarify the soil condition at the foundations of dike and the riverfront of Tonle Sap River. Survey locations are as indicated in Figure 1.3.1.

(a) Machine Boring

Machine boring has been conducted at 9 locations, 4 locations of which were at the dike shoulder and the others were at the dike toe. The summary of machine boring test results is given in Table 1.3.2. The distribution of N-value in each borehole is as shown in Figure 1.3.2.

In each borehole, in situ tests were also carried out. The test items were: 1) Standard Penetration Test (SPT); 2) Groundwater Level Survey; 3) Sampling for Every Layer; and 4) Geological Columns.

Table 1.3.2 Results of Boring Survey

Location	Boring of Dike Shoulder			Boring of Dike Toe		
	Hole No.	Elevation (El.m)	Depth (m)	Hole No.	Elevation (El.m)	Depth (m)
Downstream of Japan Bridge	-		-	BT-5	6.050	25
Wat Phnom Area	BS-4	10.851	23	BT-4	7.102	18
Central Market Area	BS-3	10.546	29	BT-3	5.160	16
	BS-2	12.039	21	BT-2	4.609	15
Royal Palace/National Museum Area	BS-1	10.358	30	BT-1	3.607	20
Total	4 holes	-	103	5 holes		94

Remarks: Depth: Confirmation of supporting layer: 3 meters thickness with N-value of more than 50

(b) Laboratory Test

In the machine boring, several samples were taken from each borehole for the laboratory tests. The test items were: 1) Consolidation Test; 2) Direct Shear Test; 3) Unconfined Compression Test; 4) Unit Weight Analysis; and 5) Grain Size Analysis.

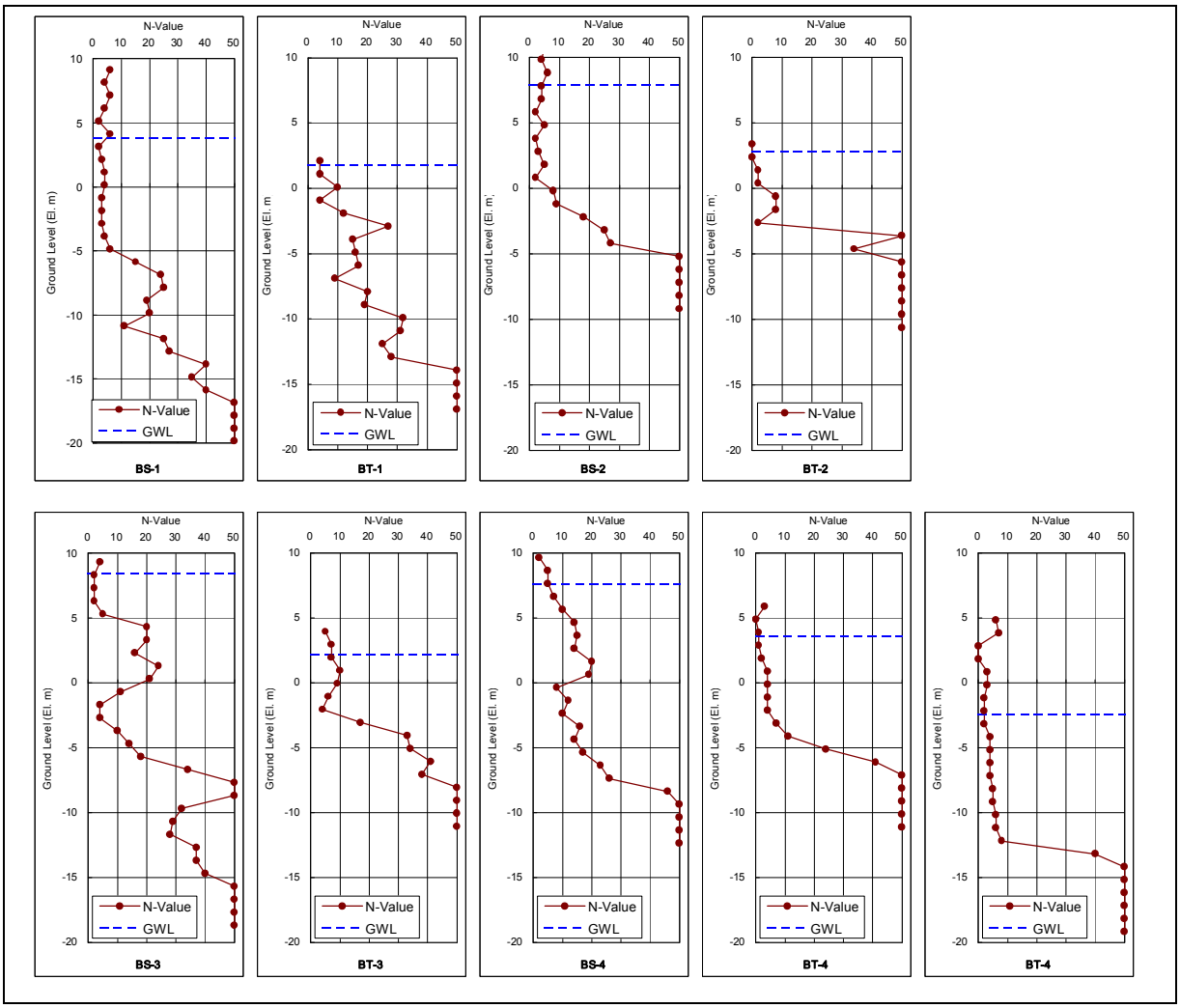

Figure 1.3.2 Distribution of N-value in Each Borehole

(c) Outline of Geological Survey Results

(i) Royal Palace/National Museum Area (BS-1, BT-1)

Clay layers with N-value of less than 10 are distributed until EL. +0 m, while sandy soil layers are distributed at BS-1. At BT-1, sandy soil layers are distributed at the depth of 4 m from the surface. The supporting layer is found at the depth of about EL. -14 m in both boreholes.

(ii) Central Market Area (BS-2, BT-2, BS-3, BT-3)

At BS-2 and BT-2, soft clay layers (N-value: <5) are distributed from the surface to about EL. +0 m, and the supporting layers are distributed at the depth of about EL. –5 m. At BS-3, the layer with N value of <10 and the layer with N value of around 20 are distributed alternately until about EL. –5 m. At BT-3, the layer

with N-value of <10 is distributed until about EL. –3 m, and then the compacted sandy clay layer is found. The supporting layers are distributed at the depth of about EL. –7 m at both boreholes.

(iii) Wat Phnom Area (BS-4, BT-4)

At BS-4, sandy and soil layers with N-value of less than 20 are found alternately. At BT-4, clay layers with N-value of less than 5 are distributed until around EL. –3 m. The supporting layers of both boreholes are found at the depth of about EL. –8 m.

(iv) Downstream of Japan Bridge (BT-5)

Soft clay layers with N-value of <10 are distributed until around EL. –12 m. Subsequently, hard compacted clay layers are found up to the supporting layer.

(3) Meteorological Survey

Meteorological and water level data of the Tonle Sap River for the last 5 years (2001-2005) have been collected. The meteorological data were collected from the Pochentong Station, while the water level data were collected from 2 stations on the Tonle Sap River, namely; Chakt Mukh and Phnom Penh Port stations. The results are as shown in Figure 1.3.3 and Figure 1.3.4.

(a) Precipitation

Average annual rainfall for the last 5 years was around 1,400 mm. Annual maximum rainfall and rainy days were recorded in 2001 with values of 1,604 mm and 154 days respectively. On a year-round basis, precipitation and rainy days from December to April are around 50 mm/month and 5 days/month respectively, while those from March to November are more than 100 mm/month and 10 days/month, respectively. In general, the monthly maximum of precipitation and rainy days is recorded in either September or October.

(b) Temperature and Humidity

In general, the annual fluctuation range of temperature was less than 10 degrees centigrade and the monthly maximum temperature was more than 30 degrees centigrade. From March to May, especially, the highest temperature persists. The maximum

temperature of 40.0 degrees centigrade was recorded in 2005, while the minimum temperature of 17.2 degrees centigrade was recorded in 2001. The monthly average of humidity ranges from 65% to 86%.

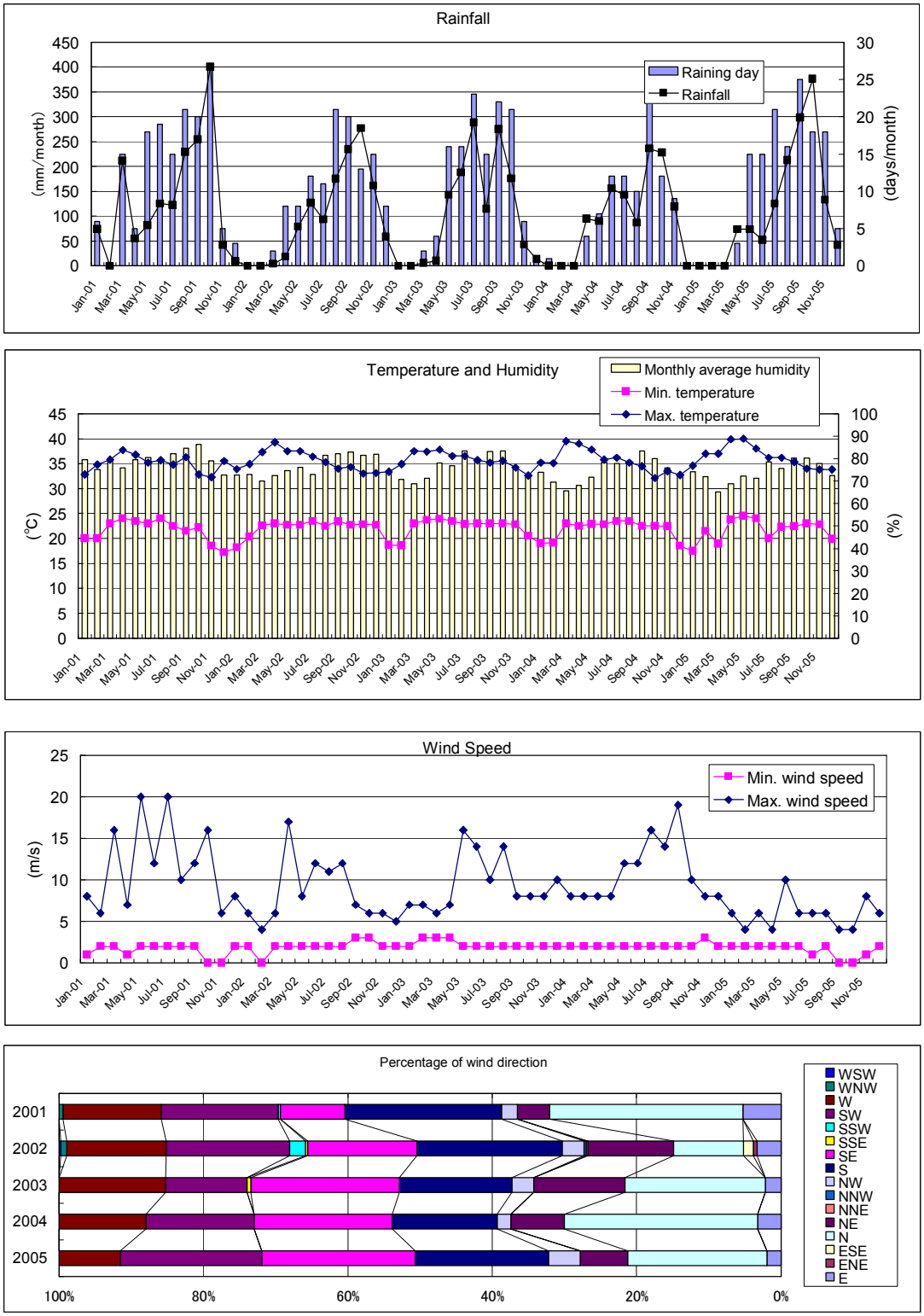

Figure 1.3.3 Meteorological Data at Pochentong Station (2001-2005)

(c) Wind Speed and Wind Direction

In general, high wind speed is recorded in the dry season. The maximum wind speed was 20 m/s in 2001. As for wind direction, it varies with the season: northerly from October to January, southeasterly from February to April, and southwesterly from May to September.

(4) Water Level

The water level of the Tonle Sap River is maintained at more than EL. +7.00 m from October to November, and the water level from March to June drops to less than EL. +2.00 m. Maximum and minimum water levels in the last 5 years at the Chakt Mukh Station were EL. +9.73 m in September 2001 and EL. +0.33 m in May 2005. Mean annual maximum and mean annual minimum water levels were EL. +8.73 m and EL. +0.71 m, respectively. The maximum high water level was EL. +10.18 m at Chakt Mukh station on 20 September 2000.

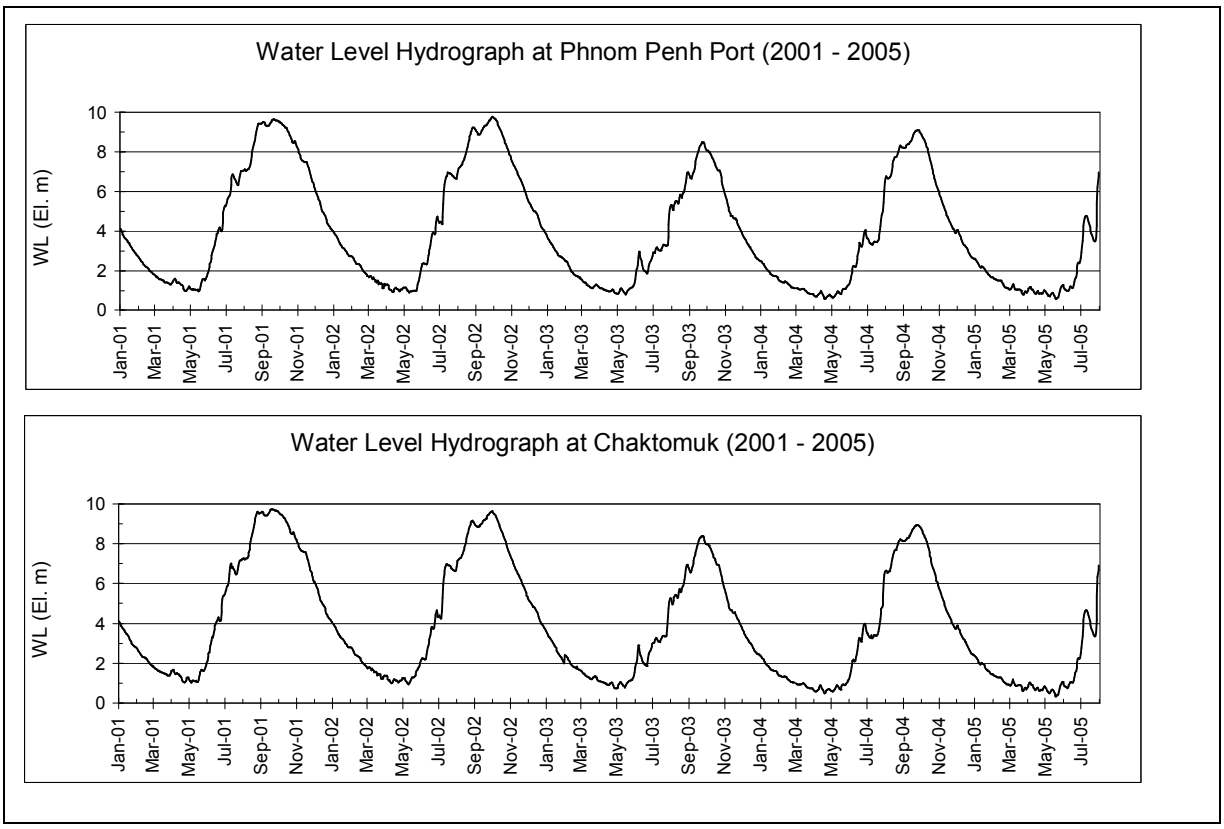

Figure 1.3.4 Water Level of Tonle Sap River (2001-2005)

1.3.2 Underground Facilities Survey

Data collection on location and dimension of underground facilities that will affect the construction work have been conducted. The facilities and their management authorities are given in Table 1.3.3. Site survey has also been carried out to clarify the condition of facilities.

In the detailed design stage, test excavations have to be conducted to identify the exact location and dimension of underground facilities in the construction area.

Table 1.3.3 Surveyed Underground Facilities

Underground Facility	Public/ Private	Management Authority
Water distribution/ Transmission pipe	Public	PPWSA
Drainage pipe	Public	DPWT
Electric cable	Public	EDC
Telephone cable	Public	Telecom Cambodia
	Private	Camintel
Television	Private	PPFO TV
Radio	Public	National Radio of Cambodia

(1) Water Distribution/Transmission Pipe

Water transmission pipes with diameters of 1,200 mm and 700 mm convey raw water from the Tonle Sap River to the water treatment plant through Wat Phnom. Water distribution pipes with diameters of 1,400 mm and 900 mm have been installed under Monivong Street. In addition, small water disitribution pipes with diameters of 50 mm to 500 mm are also found all over Phnom Penh. In general, the water distribution pipes were installed at depths of 0.8 m to 1.5 m.

(2) Drainage Pipe

Drainage pipes collect and convey wastewater as well as stormwater. The wastewater is discharged directly into Tonle Sap River because no wastewater plant has been constructed in Phnom Penh.

The following items were surveyed in the course of manhole survey: 1) top elevation of manhole; and 2) dimension, flow direction and invert elevation of pipe connected to the manhole. The locations of the 261 surveyed manholes points are as indicated in Figure 1.3.5.

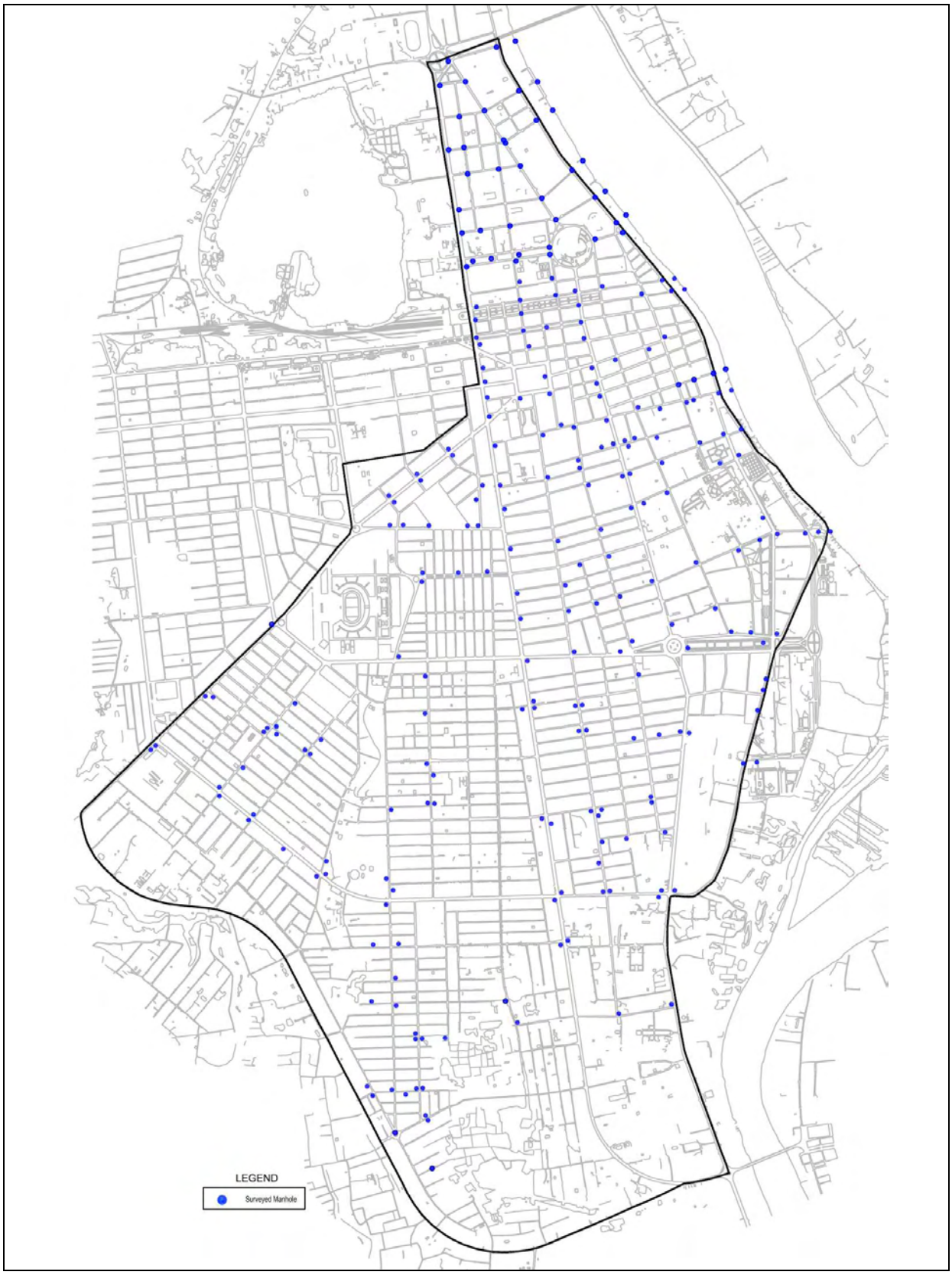

Figure 1.3.5 Locations of Manhole Survey

(3) Electric Cable

Electric cables consist of high and low voltage cables. High voltage cables are the main distribution cables connected to substations, while low voltage cables are the sub-distribution cables connecting substations to each household or office. The depth of high voltage cables under roadways and walkways is about 0.9 m and 0.7 m respectively, while that of the low voltage cables ranges from 0.5 m to 0.8 m. Some portions of the low voltage cables are installed on electric poles.

(4) Telephone Cable

There are two (2) telephone cables: one is owned by Telecom Cambodia (a public facility) and the other is owned by Camintel (a private company). Telecom Cambodia has three (3) kinds of cables: Primary Cable, Secondary Cable and Fiber Optics Cable. The primary cables have nine (9) cables having the diameter of 100 mm inside a rectangle cable box.

As to the cables of Camintel, the main cables are installed under Mao Tse Toung Street, Samdach Sothearos, St. 63 and St. 163. However, the exact locations and depths are unclear.

(5) Television Cable

The television cables for Cable TV belong to PPFO TV (a private company).

(6) Radio Cable

Radio cables are installed in a vast area of Phnom Penh. However, these cables will not affect the construction work in this Project because the cables are presently out of service.

1.3.3 Inundation Condition Survey in South Area

(1) Objective

The inundation condition survey was carried out to identify the flooding area and condition, as well as social considerations for the drainage improvement in Trabek and adjacent areas.

(2) Methodology

The survey was carried out in two (2) stages, as discussed below.

(a) Stage I (Interview with Sangkat Chiefs)

The Stage I Survey was carried out to visualize the general condition of flooding in the area through the interview with 23 Sangkat Chiefs who were supposed to be familiar with the flooding situation. The questionnaire consisted of the following:

- Name, length and degree of damage of road (Degree of damage was judged as high, middle and low),
- Locations and length of existing drainage, and
- High-priority road to be improved (Road name and length).

(b) Stage II (Interview with Households)

Based on the result of the Stage I Survey, the Study Team was able to identify the areas where inundation occurred. After identification of the flooding area, the Study Team visited each household in the area and conducted an interview survey to clarify the flooding condition and social considerations for the drainage improvement in detail. Furthermore, the Study Team was able to identify the high-priority areas to be improved. The questionnaire to the interviewees contained questions, as discussed below.

- General Questions: Type of interviewee, Address, Employment; Number of persons in the house; Number of dwelling years at the place; Type of dwelling (own or rent house), House rent; and Total expenditures of house per month.
- Inundation Situation: Experience of inundation; Frequency, depth, and time of inundation.
- Sanitary Condition: Experience and condition of sanitation after flooding; Treatment method of night soil; and Disease occurrence caused by flooding
- Social Condition: For or against the improvement of drainage in their road; For or against the improvement even if it requires construction work in front of their house; and Benefit they expect from the drainage improvement.

(3) Outline of the Survey Result

The survey results are as discussed briefly below.

(a) Stage I (Interview with Sangkat Chiefs)

The results of this interview are as shown in Figure 1.3.6.

(b) Stage II (Interview with Households)

Based on the result of the Stage I Survey, the Study Team was able to determine the area for the Stage II Survey, as shown in Figure 1.3.7. The interview was conducted for a total of 441 households. The survey results are as discussed briefly below.

(i) General Questions

- The ranking of type of interviewee is as follows: 1st: - Master (260 samples: 59%); 2nd: - Children (63 samples: 14%); 3rd: - Housewife (61 samples: 14%).
- As for employment, the number of tertiary industries stands out (305 samples: 69%), which implies that the area has an urban-type career structure.
- Distribution of number of persons in household is as follows: 0 to 4 persons = (117 samples: 27%); 5 to 8 persons = (277 samples: 63%); more than 9 persons = (47 samples: 10%).
- As for the number of dwelling years, more than 20 years (185 samples: 42%) is the maximum, and 10 to 19 years (129 samples: 29%) is second-ranked.
- Own house (382 samples: 87%) is the most popular type of dwelling in the project area.
- House rental ranges from US$ 150 to US$ 400.
- The ranking of total expenditures of household is as follows: 1st. - I do not know (213 samples: 48%); 2nd. - US$ 101 to US$ 200 (105 samples: 24%); 3rd. - less than 100 (75 samples: 17%).

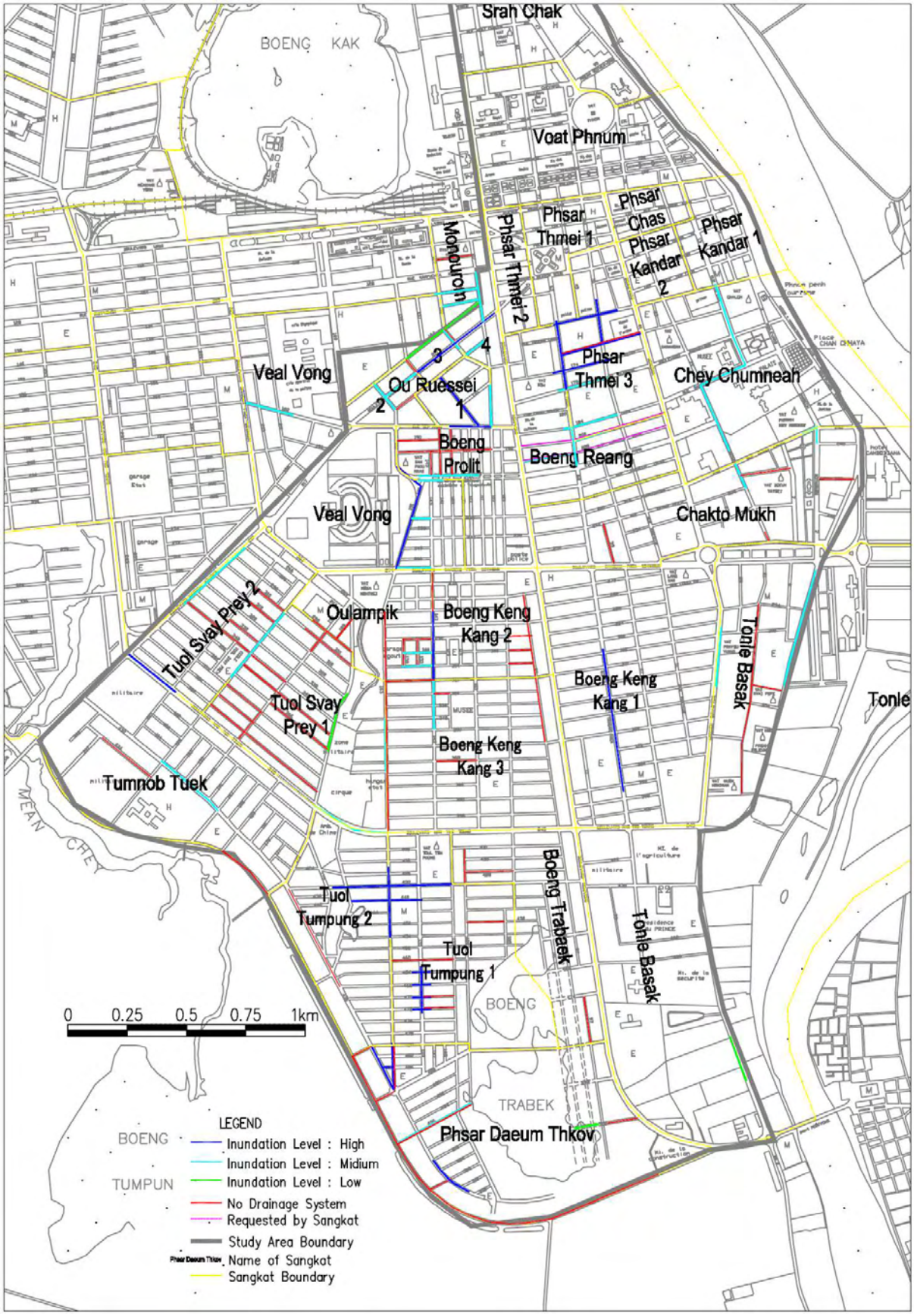

Figure 1.3.6 Result of Interview Survey (Stage I: Interview with Sangkat Chiefs)

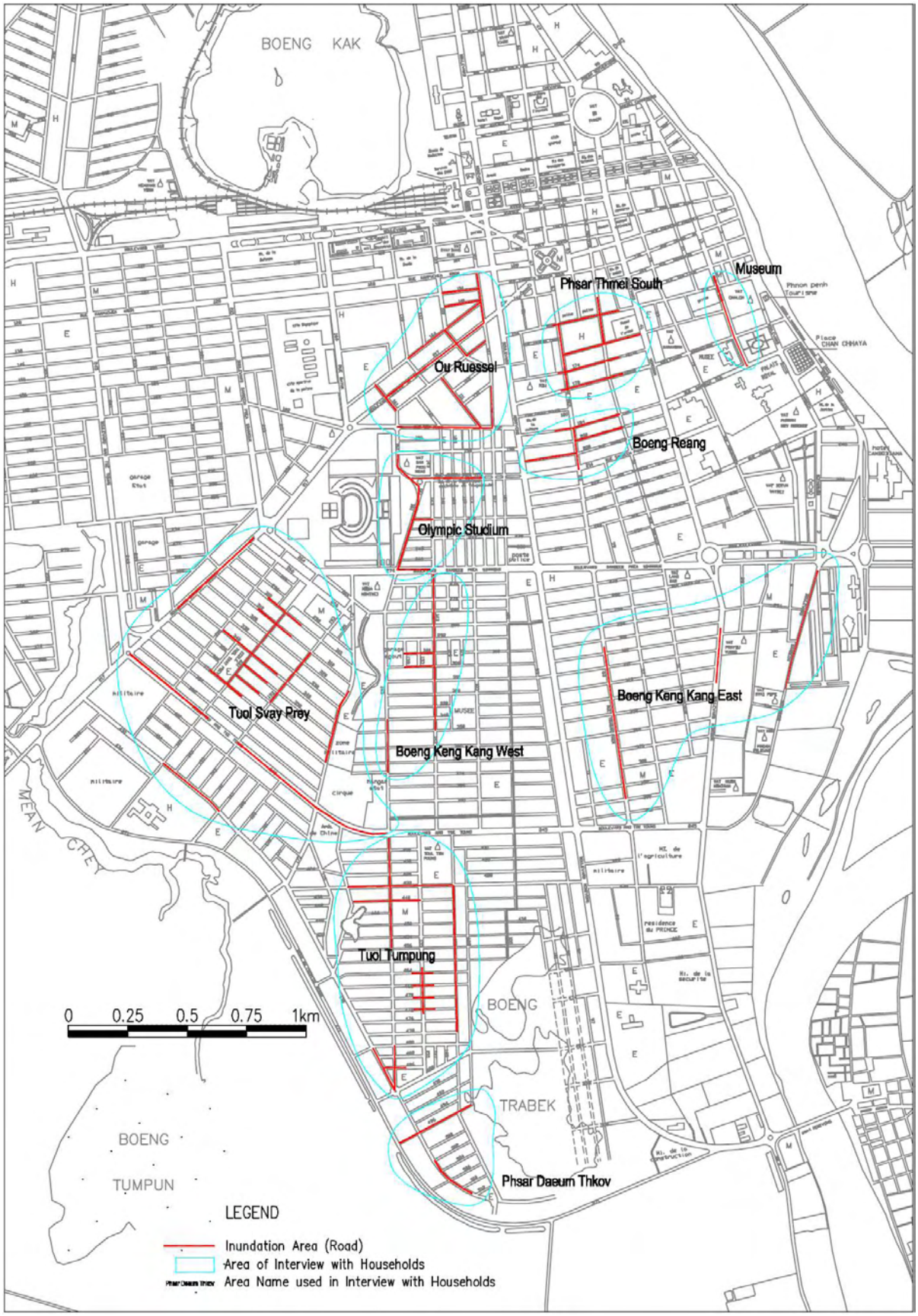

Figure 1.3.7 Target Area and Road of Stage II (Interview with Households)

(ii) Inundation Situation

- Total number of interviewees who experienced inundation is 408 samples, which is equivalent to 93% of all samples.
- The frequency of inundation is as follows: 1 time/year (15 samples); 2 to 3 times/year (99 samples); and more than 4 times/year (294 samples). More than 4 times/year was the maximum in the interview.
- Names of the area and road where inundations occurred more than 4 times/year in all samples are listed in Table 1.3.4. Total length is around 7.8 km.

Table 1.3.4 Inundation Occurrence of More than Four Times /Year in All Samples (South Area)

Area	Road	Length (m)
Ou Ruessei	107 (170-182), 166	280
Phsar Thmei South	51, 172, 174, 178	900
Boeng Reang	200	150
Boeng Keng Kang West	304	247
Tuol Tumpung	135, 163 (418-456), 163 (480-488)	2,330
	430(480-488), 432, 440, 464, 472, 486	
Tuol Svay Prey	173, 193, 199, 245 (199-217)	3,280
	245 (173-183), 245(163-173)	
	310, 318, 348, 366, 374, 430 (187-199)	
Phsar Daeum Thkov	430 (502-512), 496	565
Total	-	7,752

- The ranking of inundation depth is as follows: 1st. - Up to shin (153 samples: 38%); 2nd.- Up to knee (104 samples: 25%); 3rd. - Up to ankle (91 samples: 22%); 4th. - Up to thigh (2 samples: 0.5%).
- Name of areas and roads where more than 50% of the samples were above the knee are as listed in Table 1.3.5. Total length is around 5.8 km.

Table 1.3.5 Inundation Depth of Above the Knee in More than 50% of the Samples (South Area)

Area	Road	Length(m)
Ou Ruessei	107 (170-182)	180
Phsar Thmei South	51, 63 (154-178), 154, 172, 178	1,200
Boeng Reang	208	150
Museum	13	350
Olympic Studium	214	250
Boeng Keng Kang East	63 (302-398), Sothearuos	1,100
Boeng Keng Kang West	143 (310-350), 300	390
Tuol Tumpung	155, 163 (418-456), 163 (480-488)	830
	470, 486	
Tuol Svay Prey	245 (199-217), 245(173-183)	770
	430 (187-199)	
Phsar Daeum Thkov	430 (502-512), 496	565
Total	-	5,785

- The ranking of inundation time is as follows: 1st. - 2 to 3 hours (162 samples: 40%); 2nd. - 30 minutes to 1 hour (133 samples: 33%); 3rd. - Less than 0.5 hour (42 samples: 10%); 4th. - 4 to 6 hours (41 samples: 10%): 5th. - More than 6 hours (30 samples: 7%).

- Name of areas and roads where more than 50% of the samples were more than 4 hours are listed in Table 1.3.6. Total length is around 1.6 km.

Table 1.3.6 Inundation Time of More than Four Hours in More than 50% of the Samples (South Area)

Area	Road	Length(m)
Ou Ruessei	107 (170-182)	180
Boeng Keng Kang East	63 (302-398)	600
Boeng Keng Kang West	300	180
Tuol Tumpung	470	80
Phsar Daeum Thkov	430 (502-512), 496	565
Total	-	1,605

The results of Tables 1.3.4, 1.3.5 and 1.3.6 are as illustrated in Figure 1.3.8.

(iii) Sanitary Condition

- 85% of the interviewees had been inconvenienced caused by inundation.

- In general, people had experienced soiled household belongings, residual odor, business interruption and commuting inconvenience.

- Most of the interviewees (338 samples: 77%) treat their night soil by septic tank; other interviewees (97 samples: 22%) drain their night soil into the drainage pipe.

- As for disease occurrence, more than 50% of the interviewees (239 samples: 54%) had not experienced any disease. The remaining interviewees had experienced diseases such as skin disease (181 samples), flu (87 samples), diarrhea (38 samples), dysentery (29 samples), and typhoid (13 samples).

(iv) Social Condition

- Nearly all interviewees (439 samples) agreed on the improvement of drainage in front of their houses and 438 of these interviewees agreed on the improvement even if it requires construction work in front of their houses. The results reflect the very strong support of the inhabitants to the implementation of drainage improvement.

- A majority of the supporters of drainage improvement have a number of expectations such as 1) better sanitary condition (no outbreak of insects, waterborne diseases, etc.); 2) better environmental condition (air, dust, odor, etc.); better traffic condition; and better business condition.

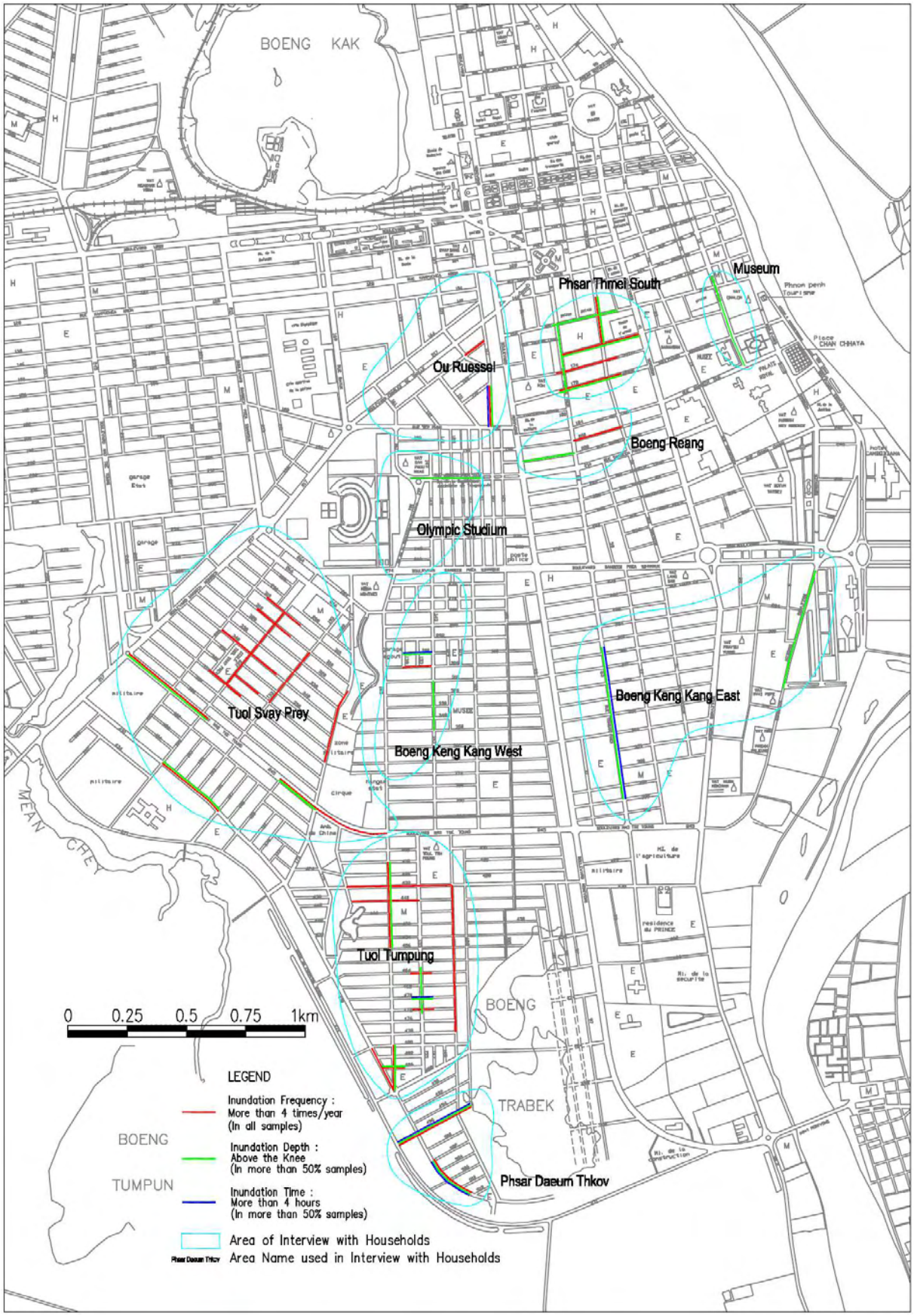

Figure 1.3.8 Present Inundation Condition Identified in the Stage II Survey

1.3.4 Inundation Condition Survey in North Area

(1) Objective

The inundation condition survey was carried out to identify the flooding area and condition, as well as the social considerations for drainage improvement in the north area. The result of this survey is to be utilized as project evaluation indicator.

(2) Methodology

The Study Team visited each household in the project area (see Figure 1.3.9) and conducted an interview survey to identify the flooding condition in detail as well as the social considerations for drainage improvement. The questionnaire to the interviewees was the same as the one used for the Stage II survey in the south area.

(3) Outline of the Survey Result

The interview was conducted for a total of 221 households. The survey results are as discussed briefly below.

(i) General Questions

- The ranking of type of interviewee is as follows: 1st: - Master (89 samples: 40%); 2nd: - Housewife (58 samples: 26%); 3rd: - Children (33 samples: 15%).
- As for employment, the number of tertiary industries stands out (139 samples: 63%), which implies that the area has an urban-type career structure.
- Distribution of number of persons in household is as follows: 0 to 4 persons = (59 samples: 27%); 5 to 8 persons = (124samples: 58%); more than 9 persons = (32 samples: 15%).
- As for the number of dwelling years, less than 5 years (69 samples: 31%) is the maximum, and more than 20 years (58 samples: 26%) is second-ranked.
- Own house (163 samples: 75%) is the most popular type of dwelling in the project area.
- House rental ranges from US$ 150 to US$ 400.

- The ranking of total expenditures of household is as follows: 1st. - US$ 101 to US$ 200 (85 samples: 39%); 2nd. - US$ 201 to US$ 500 (74 samples: 34%); 3rd. - less than US$ 100 and more than US$ 2,001 (19 samples: 9%, respectively).

(ii) Inundation Situation

- Total number of interviewees who experienced inundation is 214 samples, which is equivalent to 97% of all samples.
- The frequency of inundation is as follows: 1 time/year (5 samples); 2 to 3 times/year (27 samples); and more than 4 times/year (182 samples). More than 4 times/year was the maximum in the interview.
- Names of the area and road where inundations occurred more than 4 times/year in all samples are listed in Table 1.3.7. Total length is around 9.5 km.

Table 1.3.7 Inundation Occurrence of More than Four Times /Year in All Samples (North Area)

Area	Road	Length (m)
Block A	86, Monivong, 80(47A), 84, 47B, 102, 19, 90, 92, 94	3,340
Block B	Monivong, 53(B), 126(B), 136, 126/67 142/217, 67	1,270
Block C	13, 154	1,130
Block D	81, 63	1,200
Block E	184, Sothearuos(A), 240, Sothearuos(B), 214	2,530
Total	-	9,470

- The ranking of inundation depth is as follows: 1st. - Up to shin (100 samples: 47%); 2nd.- Up to ankle (52 samples: 24%); 3rd.- Up to knee (46 samples: 22%); 4th.- Up to thigh (15 samples: 7%).
- Name of areas and roads where more than 50% of the samples were above the knee are as listed in Table 1.3.8. Total length is around 5.7 km.

Table 1.3.8 Inundation Depth of Above the Knee in More than 50% Samples (North Area)

Area	Road	Length(m)
Block B	53(A), 53(B), 126(B), 136	620
Block C	13, 154, 144&148	1,940
Block D	63	1,050
Block E	184, Sothearuos(B), 214, 19	2,110
Total	-	5,720

- The ranking of inundation time is as follows: 1st.- 30 minutes to 1 hour (79 samples: 37%); 2nd. - 2 to 3 hours (71 samples: 33%); 3rd. - Less than 0.5 hour (32 samples: 15%); 4th. - 4 to 6 hours (16 samples: 8%): 5th.- More than 6 hours (16 samples: 8%).

- Name of areas and roads where more than 50% of the samples were more than 4 hours are listed in Table 1.3.9. Total length is around 2.3 km.

Table 1.3.9 Inundation Time of More than Four Hours in More than 50% of the Samples (North Area)

Area	Road	Length(m)
Block B	53(A)	170
Block C	13	520
Block E	178, 214, 19	1,600
Total	-	2,290

The results of Tables 1.3.7, 1.3.8 and 1.3.9 are as illustrated in Figure 1.3.10.

(iii) Sanitary Condition

- 83% of the interviewees had been inconvenienced caused by inundation.

- In general, people had experienced soiled household belongings, residual odor, business interruption and commuting inconvenience.

- Most of the interviewees (135 samples: 66%) drain their night soil into the drainage pipe; other interviewees (69 samples: 33%) treat their night soil by septic tank.

- As for disease occurrence, around 16% of the interviewees (35 samples) had not experienced any disease. The remaining interviewees had experienced

diseases such as flu (149 samples), skin disease (125 samples), diarrhea (37 samples), typhoid (12 samples), and dysentery (5 samples).

(iv) Social Condition

- Nearly all interviewees (211 samples) agreed on the improvement of drainage in front of their houses and all of these interviewees (211 samples) agreed on the improvement even if it requires construction work in front of their houses. The results reflect the very strong support of the inhabitants to the implementation of drainage improvement.

- A majority of the supporters of drainage improvement have a number of expectations such as 1) better sanitary condition (no outbreak of insects, waterborne diseases, etc.); 2) better environmental condition (air, dust, odor, etc.); better traffic condition; and better business condition.

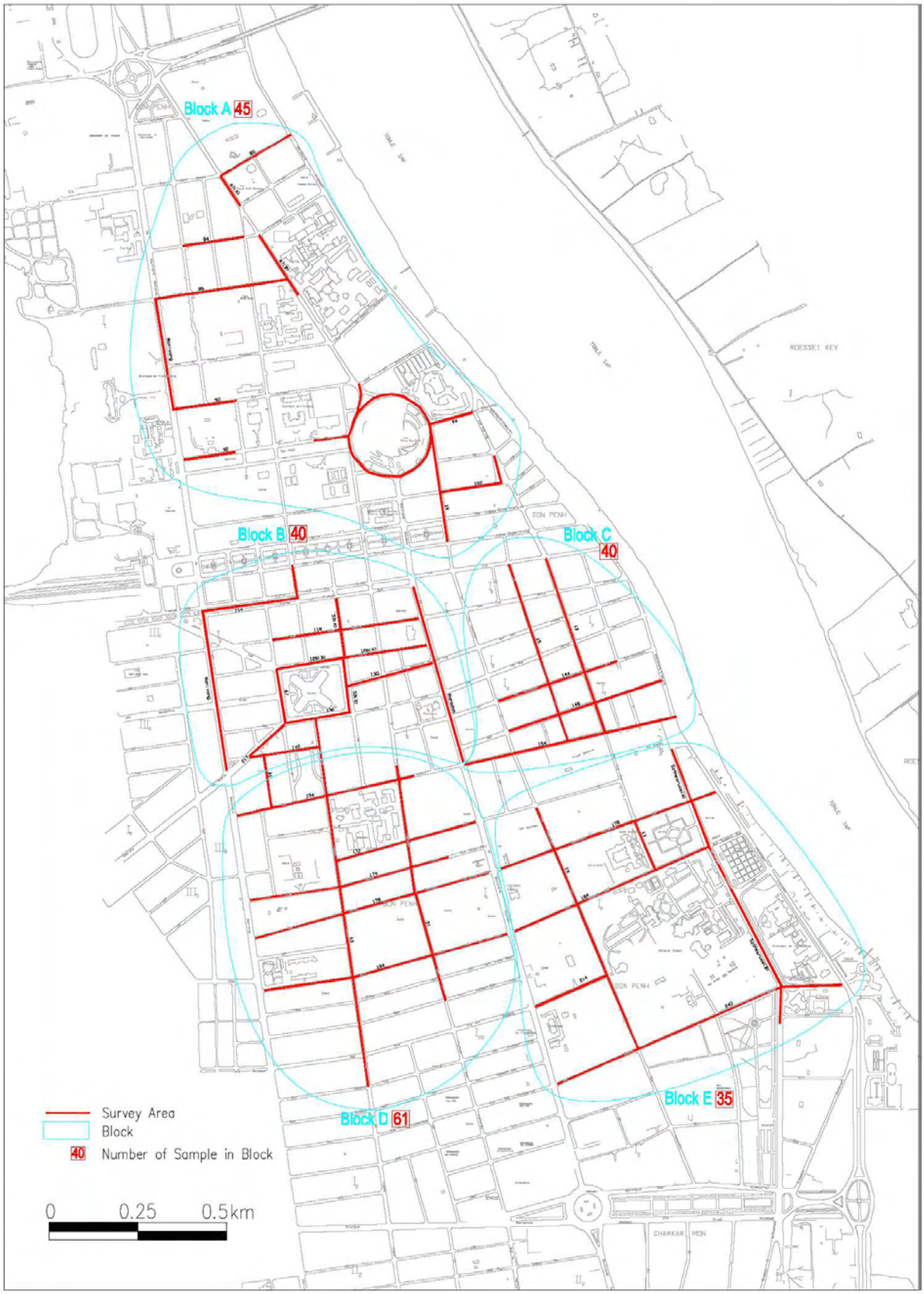

Figure 1.3.9 Target Area and Road in North Area

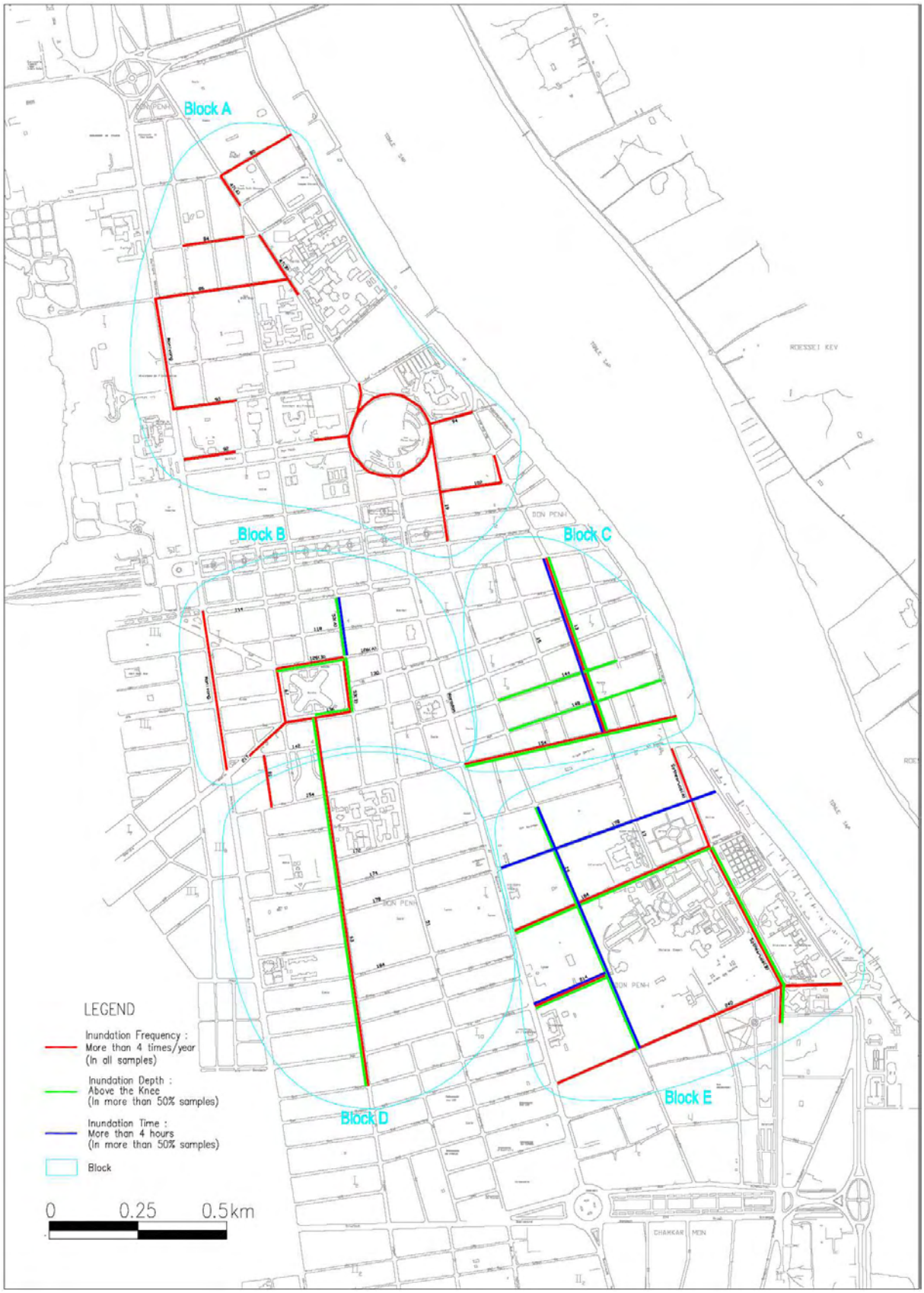

Figure 1.3.10 Present Inundation Condition Identified in North Area