EFFECTS OF INFRASTRUCTURE ON STORM DRAINAGE SYSTEM AND FLOOD PROTECTION IN HILLSIDE COASTAL PLAIN: CASE STUDY OF HUA – HIN MUNICIPALITY, PRACHUABKIRIKHUN PROVINCE

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A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering Program in Infrastructure in Civil Engineering
Department of Civil Engineering
Faculty of Engineering
Chulalongkorn University
Academic Year 2009

โครงสร้างพื้นฐานที่มีผลกระทบต่อระบบระบายน้ำและป้องกันน้ำท่วมสำหรับพื้นที่ราบเชิงเขาชายฝั่งทะเล: กรณีศึกษา เทศบาลบาลเมืองหัวหิน จังหวัดประจวบคีรีขันธ์

นายรัฐกร สังข์ทอง

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรวิศวกรรมศาสตรมหาบัณฑิต
สาขาวิชาโครงสร้างพื้นฐานทางวิศวกรรมโยธา ภาควิชาวิศวกรรมโยธา
คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2552

Thesis Title	EFFECTS OF INFRASTRUCTURE ON STORM DRAINAGE SYSTEM AND FLOOD PROTECTION IN HILLSIDE COASTAL PLAIN: CASE STUDY OF HUA – HIN MUNICIPALITY, PRACHUABKIRIKHUN PROVINCE
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Field of Study	Infrastructure in Civil Engineering
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5071622421 : MAJOR INFRASTRUCTURE IN CIVIL ENGINEERING
KEYWORDS : INFRASTRUCTURE / DRAINAGE SYSTEM / FLOOD PROTECTION / HUA – HIN MUNICIPALITY

RATTAKORN SANGTHONG : EFFECTS OF INFRASTRUCTURE ON STORM DRAINAGE SYSTEM AND FLOOD PROTECTION IN HILLSIDE COASTAL PLAIN: CASE STUDY OF HUA – HIN MUNICIPALITY, PRACHUABKIRIKHUN PROVINCE. THESIS ADVISOR : ASSOC. PROF. THARES SRISATIT, Ph.D., 109 pp.

Flood problem is a chronic problem, which frequently occurs in Hua – Hin Municipality, where is the most famous of seaside tourism of Thailand. Flood problem directly affects the socio – economic and transportation system of this area and it trend to increase the severity if there is no plan to intentionally solve the problem. The main objectives of this research are study of the causes of flood problem, and determine the adequacy of drainage system of the city.

The methodology was divided into 2 parts; 1) open - channel or waterway system, and 2) pipe system in downtown. According to the research, there are 10 existing natural canals in this area. In the first part, the total canals were analyzed the efficiency by calculating each canal individually. Then the results were compared to the existing condition of canals. The outcomes of the field survey indicate that all of canals were obstructed by the most of infrastructure of the city which include; 1) irrigation canal, 2) railway, and 3) highway No.4 (Petchkasem Road). The most of intersections - between canals and infrastructures are hydraulic structures which are channel, tunnel, or culvert etc. These hydraulic structures changed the cross – section of canal which was the result of decreasing the efficiency of drainage system extremely.

In the conclusion, the effects of infrastructure could be separated into 2 main categories; 1) the effects of open channel or waterway system that there are the obstruction of channel of irrigation canal, the tunnel of railway, and Highway No.4 that are culverts. These infrastructures are the neck bottle of open - channel so that it cannot instantly drain runoff when it was in flood condition. And 2) The expansion of Highway No.4 - between the section 207+600 km to 235+800 to be 6 lanes road from the original 2 lanes road - affects directly to the length of culverts, so, runoff cannot be drained immediately when there is a heavy rainfall or flood condition.

Department : Civil Engineering Student's Signature ....

Field of Study : Infrastructure in CE Advisor's Signature T. Srisatit

Academic Year : 2009

รัฐกร สังข์ทอง : โครงสร้างพื้นฐานที่มีผลกระทบต่อระบบระบายน้ำและป้องกันน้ำท่วม สำหรับพื้นที่ราบเชิงเขาชายฝั่งทะเล: กรณีศึกษา เทศบาลเมืองหัวหิน จังหวัดประจวบคีรีขันธ์ (EFFECTS OF INFRASTRUCTURE ON STORM DRAINAGE SYSTEM AND FLOOD PROTECTION IN HILLSIDE COASTAL PLAIN: CASE STUDY OF HUA – HIN MUNICIPALITY, PRACHUABKIRIKHUN PROVINCE) อ.ที่ปรึกษาวิทยานิพนธ์: รศ.ดร. ธเรศ ศรีสถิตย์ ; 109 หน้า

ปัญหาน้ำท่วมเป็นปัญหาเรื้อรังที่เกิดขึ้นในเทศบาลเมืองหัวหินซึ่งเป็นเมืองท่องเที่ยวตากอากาศที่สำคัญแห่งหนึ่งของประเทศไทย ปัญหาน้ำท่วมก่อให้เกิดผลกระทบโดยตรงต่อระบบเศรษฐกิจและสังคมและการคมนาคมของเมืองและมีแนวโน้มจะรุนแรงมากขึ้นหากไม่มีการดำเนินการเร่งแก้ไขปัญหาอย่างจริงจังการศึกษานี้มีวัตถุประสงค์หลักเพื่อศึกษาความพอเพียงของระบบระบายน้ำของเมือง โดยตั้งสมมติฐานไปที่ผลกระทบจากโครงสร้างพื้นฐานของเมืองที่น่าจะเป็นปัญหาสำคัญที่ทำให้ประสิทธิภาพของระบบระบายน้ำลดลง

สำหรับขั้นตอนวิธีการศึกษานั้นจะแยกการวิเคราะห์ระบบระบายน้ำออกเป็น 2 ส่วน คือ 1) ระบบระบายน้ำแบบรางเปิด หรือตามแนวลำน้ำ และ 2) ระบบระบายน้ำแบบท่อปิดในเขตเมือง จากการศึกษาพบว่าเดิมเทศบาลเมืองหัวหินมีคลองระบายน้ำตามธรรมชาติจำนวน 10 คลอง ซึ่งในเบื้องต้นจะวิเคราะห์ประสิทธิภาพการระบายน้ำของคลองทั้งหมด โดยแยกวิเคราะห์ความสามารถของการระบายน้ำในแต่ละคลองแล้วเปรียบเทียบกับประสิทธิภาพของคลองตามสภาพปัจจุบัน ผลที่ได้จากการสำรวจพบว่าแนวลำน้ำของคลองทุกสายจะต้องผ่านโครงสร้างพื้นฐานของเมือง อันได้แก่ 1.คลองชลประทาน 2.ทางรถไฟสายใต้ และ 3. ทางหลวงแผ่นดินหมายเลข 4 ซึ่งบริเวณที่แนวลำน้ำผ่านโครงสร้างพื้นฐานเหล่านี้พบโครงสร้างชลศาสตร์ต่างๆ เช่น ลำราง, อุโมงค์, หรือท่อลอด เป็นต้น ซึ่งเป็นสาเหตุที่ทำให้พื้นที่หน้าตัดของลำน้ำเปลี่ยนไป และบั่นทอนประสิทธิภาพของการระบายน้ำลดลงอย่างมาก

งานวิจัยนี้สามารถสรุปผลกระทบหลักที่เกิดจากโครงสร้างพื้นฐานได้เป็น 2 กลุ่มใหญ่ๆ คือ 1. ผลกระทบต่อระบบระบายน้ำแบบรางเปิดหรือลำน้ำ ซึ่งพบว่ามีการกีดขวางลำน้ำในส่วนที่ตัดกับคลองชลประทาน ที่บริเวณจุดตัดจะเป็นลำรางคอนกรีตที่ขวางคลองระบายน้ำ ทำให้พื้นที่หน้าตัดของคลองลดลง, จุดต่อไปจะอยู่ที่บริเวณจุดลอดทางรถไฟสายใต้ซึ่งบริเวณจุดตัดเป็นอุโมงค์ที่มีการลดหน้าตัดลงจากขนาดหน้าตัดคลองเดิม, และจุดสุดท้ายคือบริเวณจุดลอดถนนเพชรเกษม ซึ่งมีจุดที่เป็นทั้งสะพาน และท่อลอดถนน ซึ่งโครงสร้างพื้นฐานเหล่านี้ก่อให้เกิดปัญหาคอขวดของระบบระบายน้ำแบบรางเปิดหรือแบบลำน้ำ ทำให้คลองไม่สามารถระบายน้ำได้ทันในช่วงน้ำหลาก 2.การขยายถนนเพชรเกษมช่วงบริเวณหลักกิโลเมตรที่ 207+600 ถึง 235+800 เป็นถนน 6 ช่องทางจราจร จากเดิม 2 ช่องทางจราจร ซึ่งทำให้ท่อลอดบริเวณใจกลางเมืองยาวขึ้น แต่ไม่มีการขยายขนาดของท่อระบายน้ำ ทำให้ไม่สามารถระบายน้ำได้ทันก่อให้เกิดปัญหาน้ำท่วมขังในช่วงฤดูน้ำหลาก หรือช่วงฝนตกหนักได้

ภาควิชา : วิศวกรรมโยธา ลายมือชื่อนิสิต ....

สาขาวิชา : โครงสร้างพื้นฐานทางวิศวกรรมโยธา ลายมือชื่ออาจารย์ที่ปรึกษา ....

ปีการศึกษา : 2552

ACKNOWLEDGEMENTS

This thesis certainly would not have been accomplished without the encouragement and support of many people. First of all, I would like to extend my grateful and sincere thanks to Assoc. Prof. Dr. Thares Srisatit, my advisor, for his dedicated guidance, cooperation, encouragement, suggestion, friendly discussions and invaluable advices. His comments, suggestions and criticisms have always been enlightening and inspiring.

In addition, I also would like to take this opportunity to acknowledge to the thesis committee members, Assistant Professor Dr. Kanchit Likitdecharote as chairman, Associate Professor Dr.Wanpen Wirojanagud, Assistant Professor Dr. Suched Likitlersuang, and Dr. Aksara Putthividhya for several generous suggestions and recommendations to my individual study. I am grateful to all respondents for valuable information given.

Appreciation is also expressed to Dr. Julapot Chiravacharadej, Professor of King Mongkut’s University of Technology Thonburi, who give a lot of helpful, his valuable suggestions and invaluable chance for my life. Grateful acknowledgement is extended to the following government agencies, namely, Department of Public Works and Towns and Country Planning, Royal Irrigation Department, Hua – Hin Weather Station, Thai Meteorological Department, Department of Land Development, Department of Highway, Hydrologic Department of Royal Thai Navy, and Hua – Hin Municipality. Special thanks are extended to the staffs of the Master of Infrastructure in Civil Engineering Program for their kindness and help throughout the period of the study.

Finally, I am greatly indebted and wish to dedicate this thesis to my beloved parents, and friends for their cheerful support, love and care which inspired us and encouraged my achievement.

CONTENTS

Page

LISTS OF TABLE

Page

LISTS OF FIGURES

Page

CHAPTER 1

INTRODUCTION

1.1 Statement of Problem

The area where is under the authority of Hua – Hin Municipality has the significant factors which can occasionally cause flooding according to characteristic of its topography, Hua – Hin Municipality locates nearby the Gulf of Thailand in the east and the mountain range in the west. Also it is influenced on the 2 typical monsoons which are the north – east monsoon in winter which causes the heavy rain in the southern part of Thailand. Furthermore, there is no mountain to obstruct the effects of this monsoon, so, Hua – Hin Municipality also receives these effects. Another monsoon is the south – west monsoon in rainy season which comes from Indian Ocean. This monsoon also generates the heavy rain; however Hua – Hin Municipality is not affected from this monsoon because it is obstructed by Ta Nao Sri mountain range.

Most of rainfall in Hua – Hin Municipality occurs in winter which is between October - November and the effects from the movement of low depression, so, it has an opportunity to rain heavily in rainy season during the middle of May - the middle of October, then it will consequently be a severe flood. However, the eastern area connected to the Gulf of Thailand, so, it tends to drain storm water rapidly into the sea if there is no effect from the tidal at that time.

Furthermore Hua – Hin Municipality has many factors which support the economical investments, so, there are a lot of investors, and labors consequently migrate to this area. Including the encouragement of local government, the investment for developing the network of infrastructure service consequently generate the land development in rural area because it is easy to access and the land price still low, so, the agricultural community was continuously changed to be Real Estate area, commerce, and other services. By the observation, the condition in this area nowadays no matter the growth of shopping mall, land properties, residences, and any projects indicated the growth and development continuously.

Although, there are many factors which support the potentiality in development but its topography is hillside coastal plain which its elevation closes to Mean Sea Level. In addition, it is a natural watershed area before drain to the Gulf of Thailand. As its topography looks like basin, when it was in the flood condition, sea water flood tide, and heavy rain in this area, it has high risk in severe flood condition. In the present day, Hua - Hin Municipality in the early winter - October to November - rain heavily, so, it frequently flood. And each flood severely damages to properties and inhabitants.

Ten years ago, there was a severe flood situation in 1999. During that time, there is no flood protection project in this area, so, the flood problem spread widely. Another serious flood problem had occurred in 2005 which the flood problem was less severe than the flood problem in 1999 because there were a lot of flooding protection project were constructed and operated after the flood situation in 1999.

1) Flood Problem in 1999

There was a heavy rain during 14th - 16th October 1999. The daily amounts of rainfall which were measured at Hua – Hin Station including 38.7, 146.2, and 152.0 mm respectively. So, the flooding problems spread widely through this area including the downtown and Klai Kung Won palace whose are the important places of Hua – Hin Municipality. (*Figure 1.1*)

In 1999, Hua - Hin Municipality faced with the flood problems widely in the western area of Petchkasem road and some parts of the Eastern area of Petchkasem Road such as Klai Kung Won palace etc. The causes of problem could be identified that the existing drainage systems were not enough, furthermore, there is a trespass of private sector which their buildings obstruct the flow of storm water drainage. Also the tidal effect affects the flooding problem at that time.

2) Flood Problem in 2005

There was a heavy rain during 18th - 20th November 2005 which can be summarized as follows by *Figure 1.2*

In this year, Hua - Hin Municipality was flooded less severe than flood problem in 1999 because the Royal Irrigation Department had improved the drainage system and provided the new drainage system to prevent flooding in communities. The flood problem was mitigated, however, there were some parts still flood when there was the heavy rain.

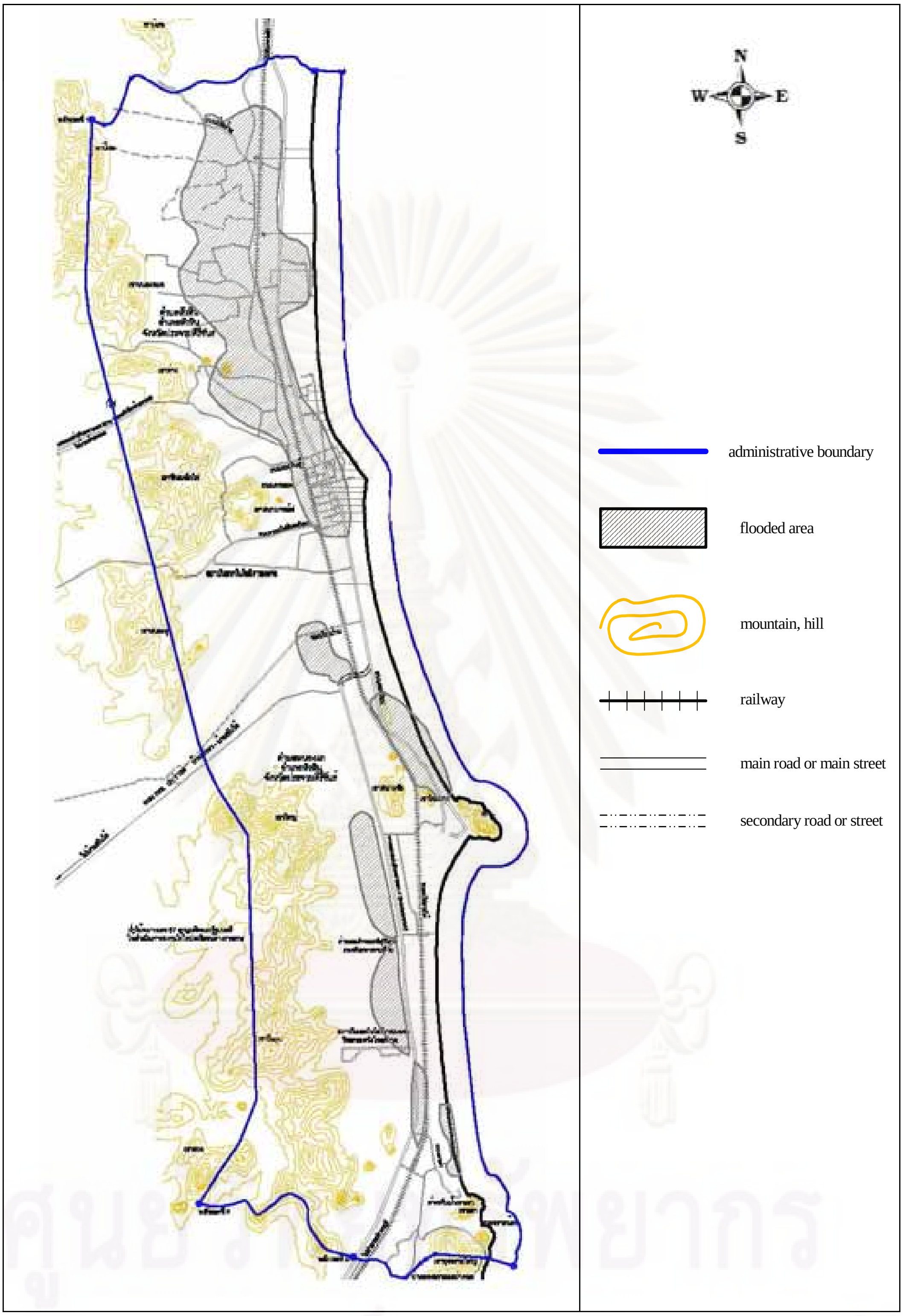

Figure 1.1 Flood Area of Hua – Hin Municipality in 1999
Source: Technical Bureau, Hua - Hin Municipality, 2007

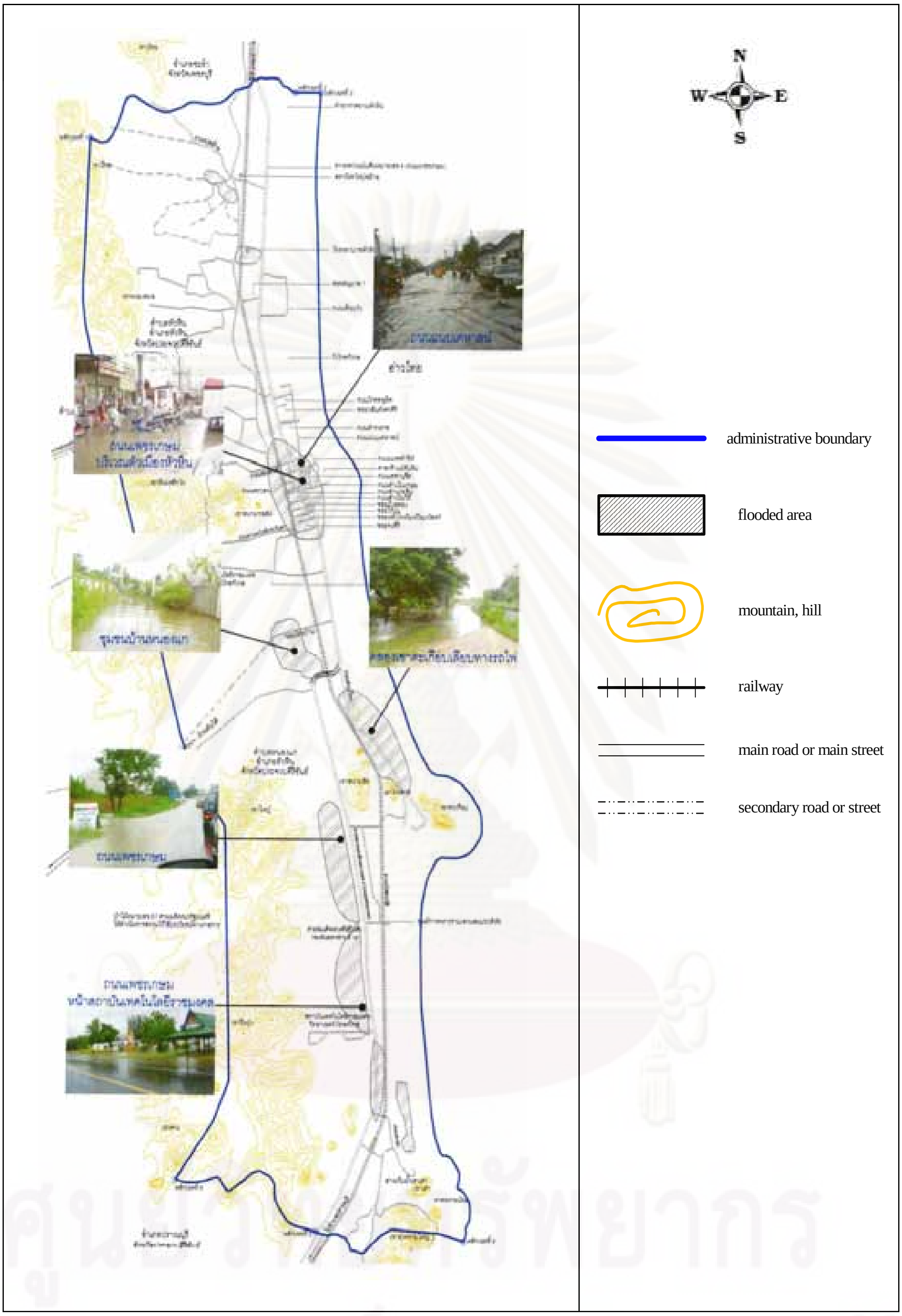

Figure 1.2 Flood Area of Hua – Hin Municipality in 2005
Source: Technical Bureau, Hua - Hin Municipality, 2007

Figure 1.3A Flood Problem
This is in Kao Takiab Community. This figure looked from the north to the south. The flood duration is more than 3 hours and the highest of water level is 1.10 m.

Figure 1.3B Flood Problem
This is in front of Hua – Hin Vithayalai School(on the left hand side of this figure). This figure looked from the south to the north. At this point, it always floods when it was heavy rain because the elevation of road is too high.

Figure 1.3C Flood problem
This is on Decha Nuchit road (or the famous night market of Hua – Hin municipality). This figure looked from the west to the east. The culvert on this road cannot drain excess runoff when it was heavy rain.

Figure 1.3D Flood problem
This is in front of Hua Na community. This figure looked from the south to the north. At this point, highway No.4 obstructed the flood route and there is no open – channel to drain excess runoff.

Figure 1.3 Flood Events in Hua – Hin Municipality
Source: Technical Bureau, Hua - Hin Municipality, 2005

1.2 Objectives

1. To study the condition problems of storm drainage system
2. To study the adequacy of storm drainage system and flood protection
3. To study the existing infrastructure concerning storm drainage and flood protection

1.3 Scopes of Study

Scope of study cover following subjects;

1. Geography including topography, waterway, ground level, and sewage system.
2. Precipitation and channel routing including rainfall intensity, ditch, and canal in normal period, and in flood condition.
3. Development, land use, and public utilities and constructions including the development of governmental area, private sector, regulation of growth control of the city, construction and renovation, transportation network, and flood protection and storm drainage systems.
4. Rational Method to determine the adequacy of drainage system.
5. Manning's equation to determine the flow condition and the adequacy of existing channel system.

1.4 Expected Benefits

This research uses the knowledge in hydrology, hydraulics engineering, Statistic, and city plan in order to identify the malfunctions of storm drainage system and flood protection of Hua – Hin Municipality. The use of these results is expected to be a data to improve efficiently the storm drainage system and flood protection. Also, the results are expected to use as an approach to solve these problems in the areas – where have the same topography, climate, and flood problems. Moreover this study is expected to be the prototype of this field of study in the future. In addition, the expectations for the future use are to develop the methodology by adding the economic part, the analysis of rainfall by itself, and the forecasting of water demand and wastewater in the same study.

CHAPTER 2

LITERATURE REVIEWS

The studied drainage systems that were use to solve the flood problems in the existing condition and are also used for the change of land use in future. Especially the undeveloped areas, the planning to design the drainage system is easier than the developed area because there are lower constraints. Hence, this research will study the problems and analyze data as the conclusion to improve the existing drainage system in the study area. And also study the possibility to protect and solve the flood problem in some parts of study area where have not had the drainage systems. This chapter relates to the approaches, methods, and theories for design the drainage systems.

2.1 Physical Characteristics of Hua – Hin Municipality

2.1.1 Location and Size

Hua – Hin municipality locates in Hua- Hin district, Prachuabkirikhun province where connect to Cha – Am district, Petchburi province at Boh Fai Commercial Airport in latitude N12°50’ and longitude E99°55’ along the western coast of the Gulf of Thailand. The administrative area of Hua – Hin municipality is totally 87 km^2 which is divided into 2 parts that are inland, and sea front. The area of inland is 76 km^2.The total length of this area is 22 km. from the north to the south. The territories which connect with many places including,

Northern part: Cha – Am municipality, Cha – Am district, Petchburi province.
Southern part: Kao Noi locality, Pranburi district.
Eastern part: The Gulf of Thailand.
Western part: Tub Tai locality, and Hin Lek Fire locality, Hua – Hin district.

The physical characteristic of Hua - Hin municipality is narrow and long, its shape look like rectangular lay down from the north to the south parallel to the western coast of the Gulf of Thailand. The total length is about 22 km, and the total width is about 3.5 km. There is the railway and the highway No.4, or Petchkasem Road, pass through this area. Hence, this area can be divided into 2 parts which are eastern area of Petchkasem road, and western area of Petchkasem road.

1. Eastern area of Petchkasem road

It is approximately 25% of total area. The most of land is plain and community section. This area locates along the coast of the Gulf of Thailand which is approximately 22 km. length and 400 - 800 m width.

2. Western Area of Petchkasem road

It is approximately 75% of total area. Some communities are in the middle. There is a low hillside along the west. The slope inclines from the west to the east.

2.1.2 Topographical Characteristics

This area is coastal plain connect to the Gulf of Thailand. There is hill from the north to the south in the western area of Prachuabkirikhun province which has the slope elevation inclines from the west to the east. The length of coast is 22 km, the width of beach is approximately 50 m. The elevation of this area is 2 – 15 m above mean sea level. The main transportation is Highway No.4 or Petchkasem road and the rail transportation. These characteristics will limit the tendency of development in North – South direction.

According to the use of land, though the total area of Hua – Hin Municipality is 87 km^2, but the inland is only 76 km^2 and the left is sea front. However, only 41 km of land can be used because it is plain while the left is the mountainous area.

2.1.3 Geology

1. Characteristic of Soil

Soil characteristic is sandy soil formed by the stream flows includes gravel, soil, sand, and fossil which is appropriate to be used as the agricultural area. In the shoreline area, it formed by the stream flows with gravel, soil, sand, and fossil. The lower layer mostly consists of rock and some parts rise up above surface area.

2. Soil Mechanics

Regarding to geological and geotechnical characteristics, soil layer in Hua-Hin district has high strength which can resist the high load from the building and/or any structure. The essential elements are used to minimize the construction cost of foundation comparing to the soft soil area.

3. Types of Soil

Soil in plain area mostly consists of sand or sandy soil which has high permeability, contains medium to high acid and low soil fertility. Furthermore, some places also contain High Sodium. The characteristics of soil in this area are appropriate to plant coconuts, pineapples and maniocs etc.

2.1.4 Climate

The typical climate of Hua – Hin municipality can be concluded as follow *Table 2.1*;

Table 2.1 Typical Climate of Hua – Hin Municipality

Variable	Value
Average Temperature (°C)	27.6
Average Relative Humidity (%)	74.0
Annual Evaporation (mm.)	1,725.6
Annual Rainfall (mm.)	965.7

Source: Hua – Hin Weather Station, Thai Meteorological Department (2007)

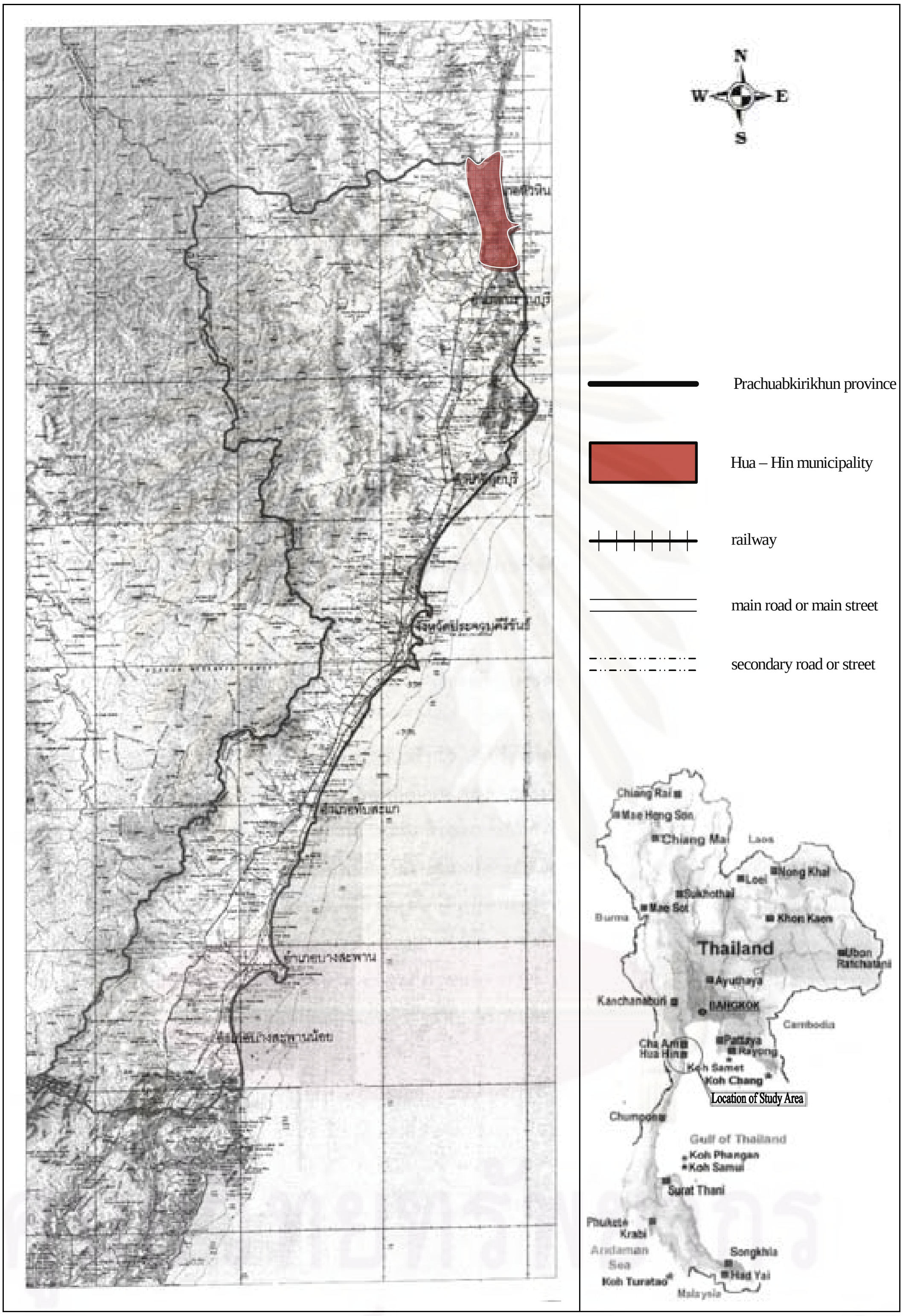

Figure 2.1 Location of Hua – Hin Municipality in Map of Thailand
Source: Department of Highway (2005)
Department of Publics Works and Towns and Country Planning (2007)

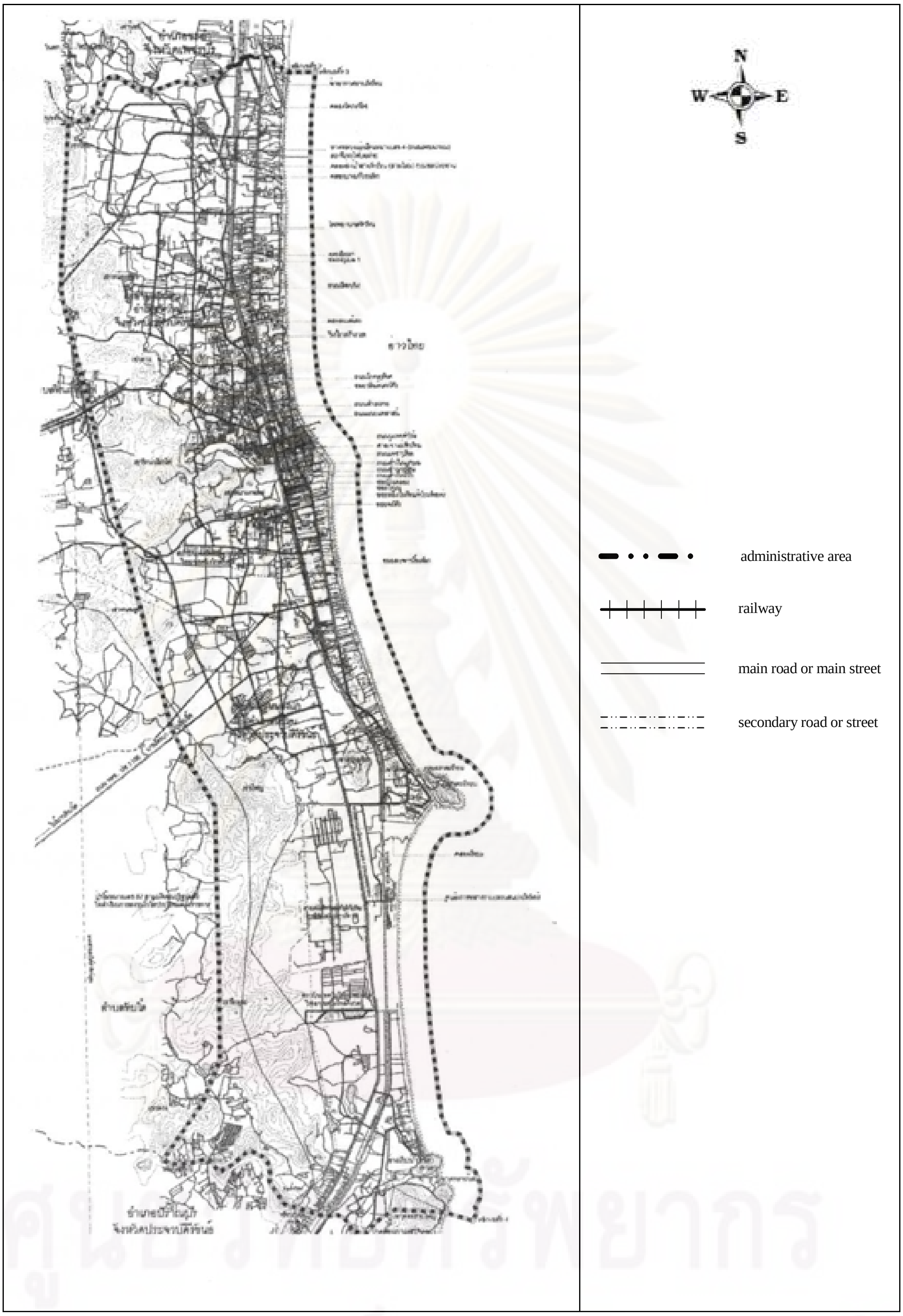

Figure 2.2 Administrative Area of Hua – Hin Municipality
Source: Department of Publics Works and Towns and Country Planning (2007)

1. Wind

There are 3 types of wind in Hua – Hin municipality which are; (1)North – Eastern monsoon (2) South – Western monsoon and (3) Depression. The maximum wind speed 4.0 knots occur in March and the lowest 2.0 knots occur in September.

2. Seasons

There are 3 seasons in this area which are;

Summer Season: February – April

This is the season of South – Eastern monsoon which lead heat and dry into this area. This monsoon rather blows uniformly in the afternoon and the evening, when it combines with the regular wind in the sea, so, the wind strength is quite high. Consequently, wave in sea is also strength. The sea level in this season, in the late morning until the evening, the sea level will decrease gradually until the night, and then it will increase gradually until the early morning.

Rainy Season: May – November

This season is the season of South – Western monsoon. In the first period of this season, it is influenced with South – Western monsoon which lead moisture from Andaman Sea that causes rainfall. There is a heavy rain in November.

Winter Season: December – January

This is the season of North – Eastern monsoon which lead cold and dry into this area. The sea level in this season, in the late morning until the evening, the sea level will increase gradually until the night, and then it will decrease gradually until the early morning.

2.5 Hydrology

1. Maximum Precipitation

Maximum annual rainfall of any return period are shown in *Table 2.2***.**

Table 2.2 Maximum Average Rainfall of any Periods

Return Period (Year)	**Maximum Rainfall(mm.)**		
	1 Day	**3 Day**	**5 Day**
2	97.7	144.6	170.6
5	163.9	250.3	288.1
10	207.8	320.3	365.9
25	260.9	405.2	460.3
50	304.3	474.3	537.2
100	345.1	539.5	609.6

Source: Hua – Hin Weather Station, Thai Meteorological Department (2007)

2. Watershed and Stream System

Table 2.3 Sub – Catchments of Hua – Hin Municipality

No.	Name	Code	Area (km^2)
1	Huay Noi	CA.1	4.72
2	Klong Sanarm Bin	CA.2	7.23
3	Klong Bang Kwian Huk	CA.3	5.63
4	Klong Nin	CA.4	6.04
5	Klong Talay Noi	CA.5	5.97
6	Kao Hin Lek Fire	CA.6	6.69
7	Klong Boh Ma – Prao	CA.7	2.26
8	Klong Kao Ta – Kiab	CA.8	24.23
9	Klong Tian	CA.9	8.54
10	Kao E-Lun	CA.10	5.21
11	Klong Kao Tao	CA.11	7.25
12	Kao Tung Saay Yai	CA.12	1.23
Total			**84.55**

Source: Royal Irrigation Department (2007)

3. Oceanography

The characteristic of sea water tidal is diurnal which has 1 flood tide, and 1 ebb tide in 1 day. The maximum flood tide is about 1.4 m above mean sea level, and the maximum ebb tide is 1.81 m below mean sea level.

The seawater current is parallel to the coastline of Hua – Hin beach. The maximum velocity of seawater current in Spring tide period is approximately 0.4 m/s and 0.2 m/s in Neap tide period.

The statistical data of sea water level can be concluded below;

- mean high water spring (MHWS)	=	1.1	m.MSL
- mean high water (MHW)	=	0.87	m.MSL
- mean high water neap (MHWN)	=	0.62	m.MSL
- mean sea level (MSL)	=	0.00	m.MSL
- mean low water neap (MLWN)	=	-0.52	m.MSL
- mean low water (MLW)	=	-1.11	m.MSL
- mean low water spring (MLWS)	=	-1.47	m.MSL
- mean spring range	=	2.57	m
- mean range	=	1.97	m
- mean neap range	=	1.14	m
- highest high water (HHW)	=	1.41	m.MSL
- lowest low water (LLW)	=	-1.79	m.MSL

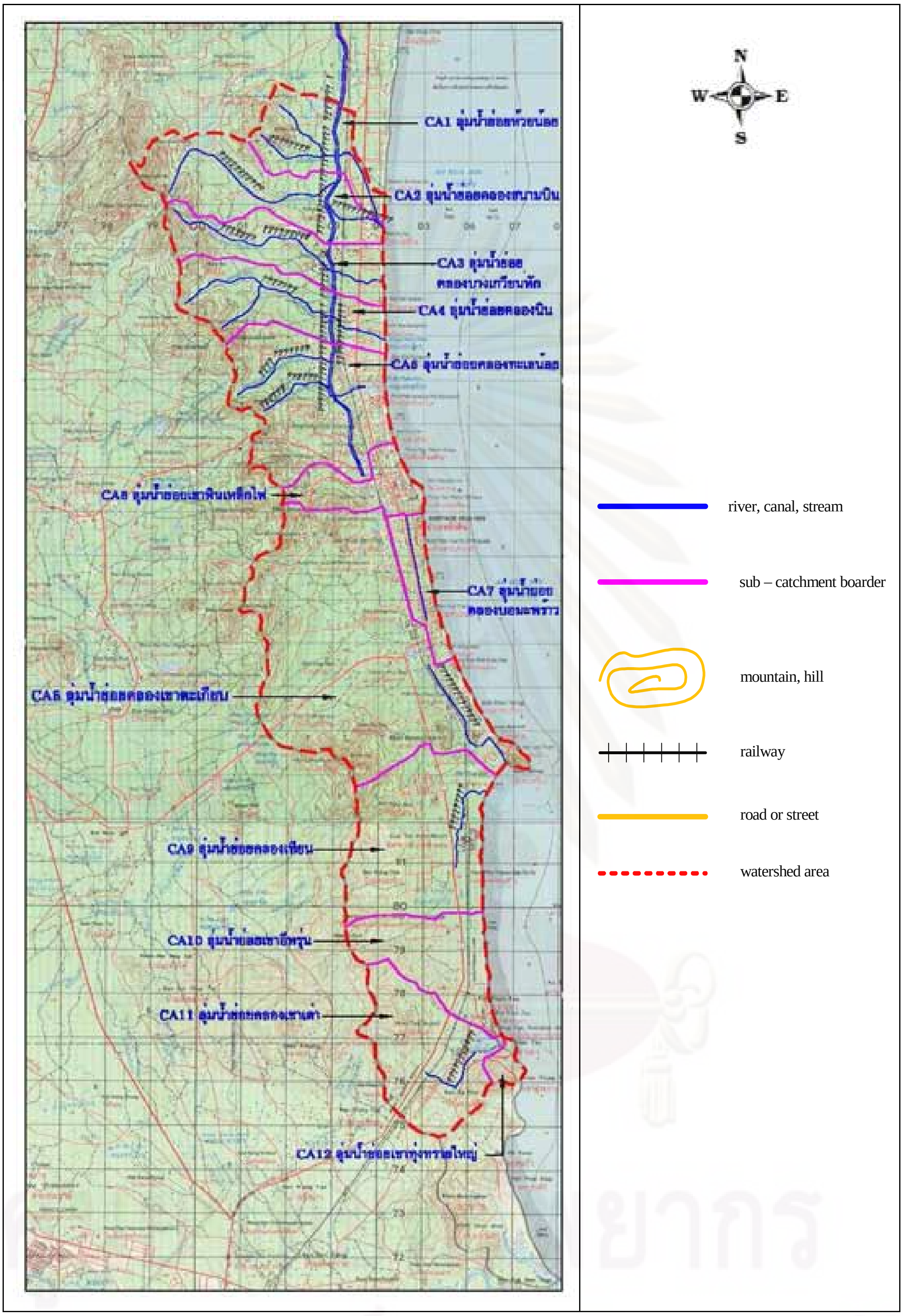

Figure 2.3 Map of Sub – catchments of Hua – Hin Municipality
Source: Royal Irrigation Department (2007)

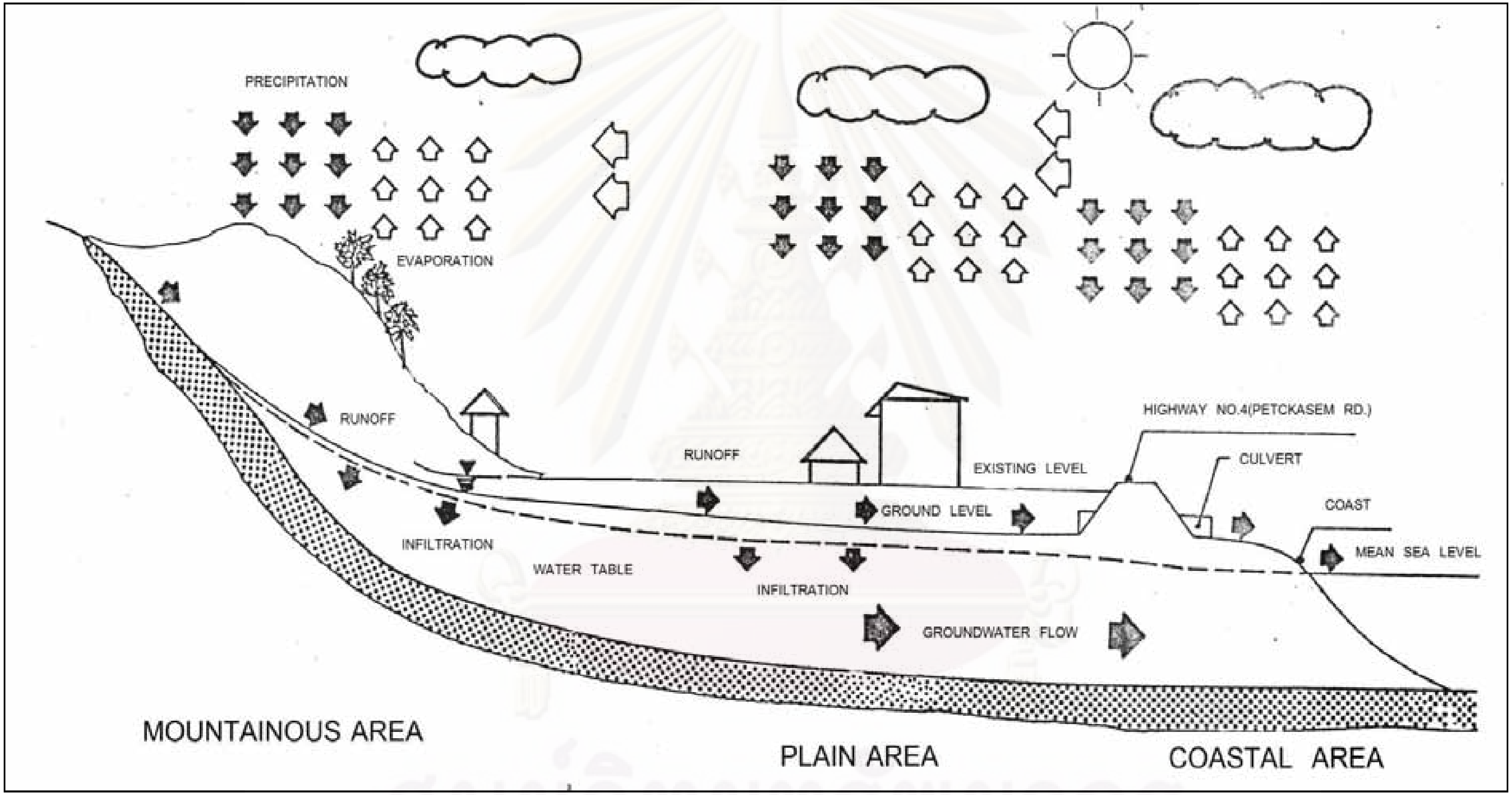

Figure 2.4 Model Profile of Hua – Hin Municipality

Table 2.4 Average Sea Water Level of Hua – Hin Municipality

Month	Mean Sea Level (MSL)	Month	Mean Sea Level (MSL)
JAN	0.151	JUL	-0.278
FEB	0.123	AUG	-0.227
MAR	0.095	SEP	-0.071
APR	0.034	OCT	0.090
MAY	-0.072	NOV	0.182
JUN	-2.10	DEC	0.188

Source: Hydrologic Service Department (2007)

2.2 Concepts and Concerned Researches

2.2.1 Infrastructure and Land Use Concepts

Korapin SUKANAN(2001) cited the meaning of infrastructure from Encyclopedia of Urban Planning(1974), infrastructure is any structures which are provided to service the local people consists of transportation system, Irrigation System, Power and Electricity System etc.

Dictionary of Economic Term defines the definition of Infrastructure, Infrastructure is any invested structures such as transportation system, provided water resource etc. which are constructed for the undeveloped areas.

These definitions of Infrastructure can be concluded that Infrastructure is the utilized structures which influent the daily life of human. It is very important structures which government has to provide to service people in order to increase the quality of life and it is the fundamental structures to develop the country. Hence, government has to plan for infrastructures to reach the breakeven point because infrastructure has very high investment and affect for a long time within the area and the vicinity such as land use, the decision of private sector, and the development of Infrastructure etc.

Sitthiporn PIROMRUEN(1998) mentioned the need of planning of infrastructure that it is the powerful tools for the community to develop the area that will be the pattern of land use in the future. The investment of government in infrastructure projects will directly affect the pattern and characteristic of land use. Moreover, the investment of government will extremely influent the pattern of land development of private sector. It will transform the possibility pattern in economy and the decision of private sector.

In the most of communities, all of lands are owned and developed by private sector, so, the continuous effects will control the market for the decision of private sector in the investment. Consequently, the result is very important and obviously affects the pattern of land use in that area.

Figure 2.5 Directions and Period of Typical Monsoons and Storms
Source: Thai Meteorological Department (2007)

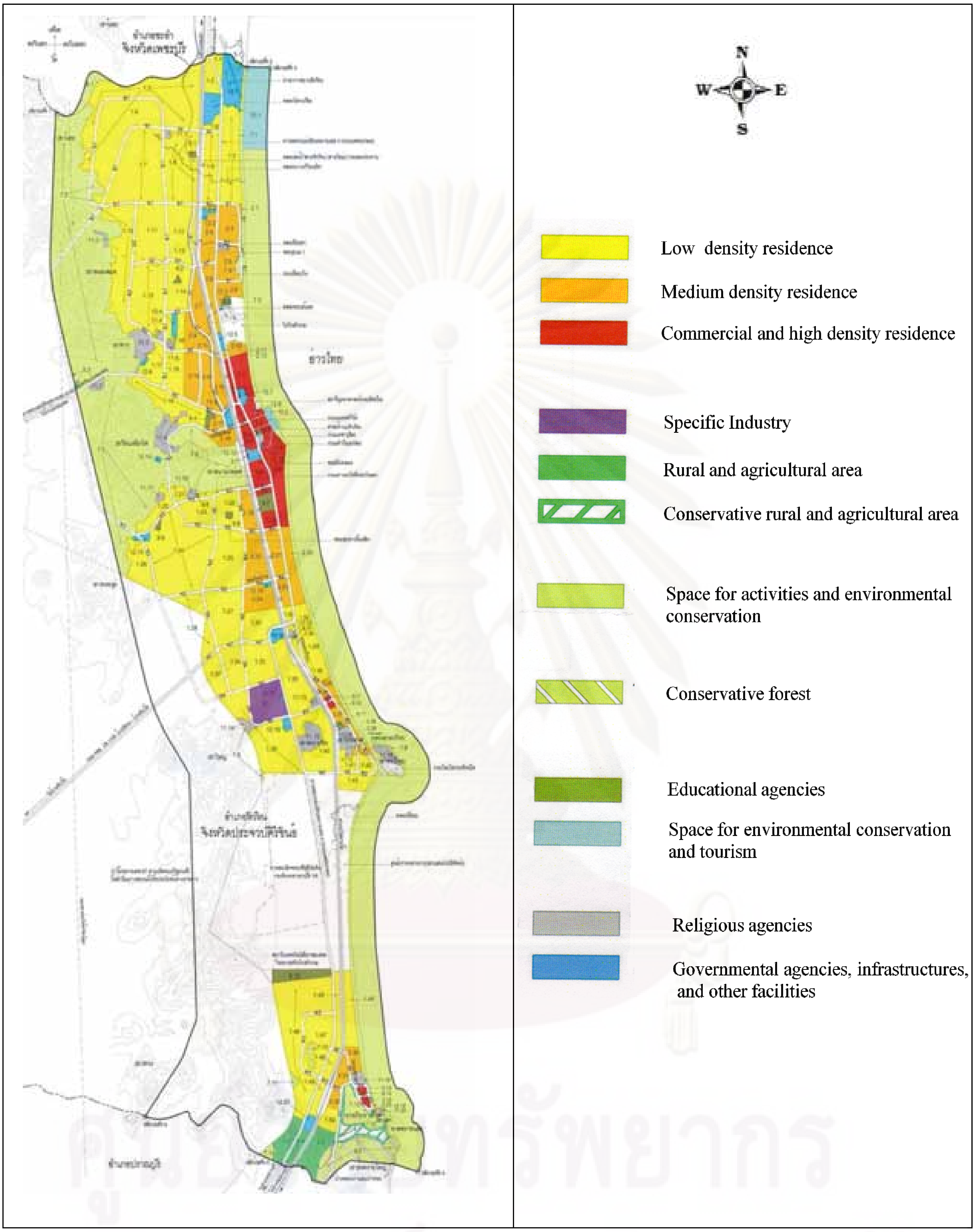

Figure 2.6 The Pattern of Land Use of Hua –Hin Municipality
Source: Department of Publics Works and Towns and Country Planning (2002)

Table 2.5 Types of Land Use of Hua - Hin Municipality

Type of Land Use	Area (km^2)	Percentage
Low density residences(Yellow)	17.98	20.66
Medium density residence(Orange)	3.35	3.36
Commercial and high density residence(red)	1.77	2.03
Rural and agricultural area(green)	0.72	0.83
Conservative rural and agricultural area(White with green)	0.32	0.37
Space for activities and environmental conservation(Light green)	22.21	25.53
Space for environmental conservation and tourism(Light blue)	0.81	0.93
Governmental institutes, Infrastructure, and utilities(Blue)	0.25	0.29
Religious institutes(Grey)	1.29	1.48
Educational Institutes(Olive green)	0.56	0.64
Military area(White)	8.47	9.74
Royal summer palace(White)	0.35	0.40
Specific Industry(Light purple)	0.49	0.56
Royal State Railway Area(White)	1.97	2.26
Forest due to Cabinet's resolution(White)	14.19	16.31
Conservative forest(Light green with white stripe)	0.92	1.06
Roads, streets, river, channels, and others	11.35	13.05
TOTAL	87.00	100

Source: Public Works and Towns and Country Planning Bureau, Prachuabkirikhun Province (2002)

2.2.2 Flood Protection Concepts

Luckchai(1990) cited on his research that hydrologic characteristics of flood in any areas relate to the size of watershed area, climate, physical characteristic of watershed etc., so, each watershed has a uniqueness. Hence, the operation of flood mitigation and flood control has to consider any factors such as location, time, and economy. The successful flood control method which is used in a watershed may not succeed in another watershed. Sometimes the successful methods which were used in the past may not be used in the present day or in the future. Generally, the approaches of flood mitigation can be classified into 2 methods which are;

1. Avoidance of floodplain area by do not absolutely use that area. The result of this method also completely solves the flood problems. However, the use of this method will lose the opportunities in economic affairs. Therefore, the avoidance may be defined as the limitation of land use.
2. According to the design of drainage system, this method will be used in case of unavoidable use of the floodplain area. The flood mitigation is only avoid or drain water from this area either flood condition or normal condition. By the world experiences in flood control, the successful and popular methods that are used in control and mitigation of flood are;
    1. Construct dike or embankment in floodplain
    2. Change the direction of stream flow
    3. Pump and drain water from flood area
    4. Excavate, dredge, extend, or improve streams or channels to increase the efficiency of drainage system
    5. Increase canal or channel

6. Construct reservoir to store water from water source before flow into that area.
7. State the land use around water sources and provide the zone for flood way.
8. State the types of land use to reduce the flood problem by conservative soil and water.

2.2.3 City Plan Concepts

Chalerm KAEWKUNGWARN(1993) had given the new concept to provide the regulations of land use for city plan. Each city has own unique in the pattern of road network, the buildings, topography, and land use. Hence, each city will has own problems such as flood, traffic jam etc. but every city will have the same city structures which are downtown and their vicinities, every road ways will link the vicinities to downtown.

The city planning will be used to construct the structural pattern and the prominent characteristics as the distributed core to develop the outer bound in the future. The city planning will covers the area which will be developed as the city in the future where will economically merge the policy and/or obstacle altogether and also essentially considers the efficiency. These city plans will illustrate the types of land use in each area including; the expansion and road way improvement to satisfy the change of land use of surrounding area and any projects that are provided for the expansion of the city in the future. For example the expansion of residential area or industrial estate project etc.

2.3 Concerned Theories

The study of drainage system has to use the theories such as hydrology, hydraulic engineering to explain any phenomena of flood because it is a study of hydrologic cycle.

This study will use any theories applied to be used in the main process which has topics and abstraction of theories including;

2.3.1 Drainage System Theories

The amount of storm water which must be drained is the important parts that have to be assessed into numerical data. These data are used to design the adequacy of drainage system that depends on any factor such as physical condition, topography, geology, climate, and hydrologic characteristic etc. Generally the main amounts of drainage water include; (1) the amount of rainfall, (2) the amount of wastewater, and (3) the amount of infiltrated groundwater. Consequently, the equation of the combined drainage system is;

$$Q = Q_R + Q_W + Q_i \qquad (1)$$

Where;

$Q = the\ total\ amount\ of\ drained\ water\,(m^3/s)$

$Q_R = the\ amount\ of\ runoff\,(m^3/s)$

$Q_W = the\ amount\ of\ wastewater\,(m^3/s)$

$Q_i = the\ amount\ of\ infiltrated\ groundwater\,(m^3/s)$

1. The Amount of Rainfall – Runoff

Runoff is the excess water from precipitation that flow overland to lake or stream during or after a precipitation event, so, the amount of runoff is very important in design of storm drainage system. The method which will be used to define the amount of runoff is *Rational Method.*

The *Rational Method* is still probably the most widely used method for design of storm sewers. This is the *Rational Method* formula.

$$Q_R = CiA \tag{2}$$

Where;

$Q_R = the\ amount\ of\ runoff\,(m^3/s)$

$C = runoff\ coefficient$

$i = rainfall\ intensity\,(mm/hr)$

$A = watershed\ area\,(m^2)$

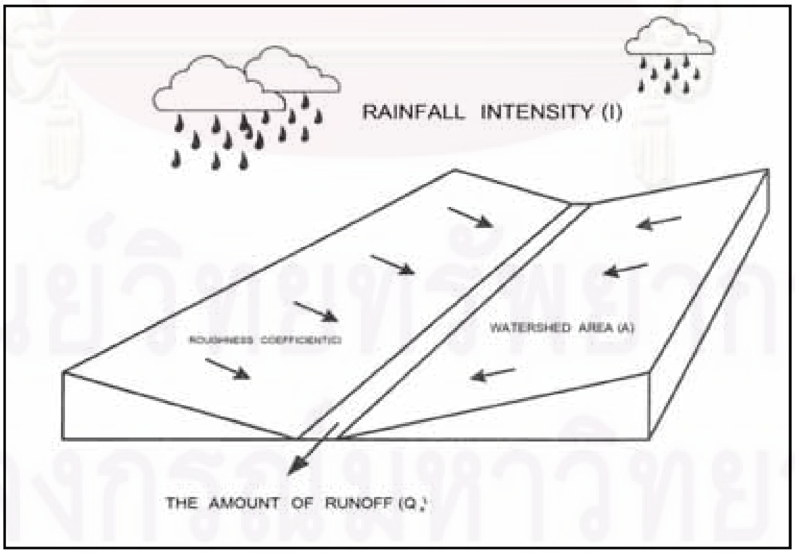

Figure 2.7 Illustration the Use of Rational Method
Source: Linsley, R. K. (1975)

If the surface of sub – catchments were different such as resident, or university, so the equation in this case is;

$$Q_R = I\sum_{j=1}^{n} C_j A_j \tag{3}$$

Where;

C_j = *runoff coefficient of any subcatchments*

A_j = *area of any subcatchments*

Table 2.6 Runoff Coefficient(*C*) for Rational Method

Character of Surface	Return Period(Years)						
	2	**5**	**10**	**25**	**50**	**100**	**500**
Developed							
Asphaltic	0.73	0.77	0.81	0.86	0.90	0.95	1.00
Concrete/Roof	0.75	0.80	0.83	0.88	0.92	0.97	1.00
Grass Area(Lawns, Parks, etc.)							
Poor Condition(Grass Cover Less Than 50% of The Area)							
Flat, 0 – 2%	0.32	0.34	0.37	0.40	0.44	0.47	0.58
Average, 2 – 7%	0.37	0.40	0.43	0.46	0.49	0.53	0.61
Steep, Over 7%	0.40	0.43	0.45	0.49	0.52	0.55	0.62
Fair Condition(Grass Cover 0n 50% to 75% of The Area)							
Flat, 0 – 2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2 – 7%	0.33	0.36	0.38	0.42	0.45	0.49	0.58
Steep, Over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
Good Condition(Grass Cover Larger 75% of The Area)							
Flat, 0 – 2%	0.21	0.23	0.25	0.29	0.32	0.36	0.49
Average, 2 – 7%	0.29	0.32	0.35	0.39	0.42	0.46	0.56
Steep, Over 7%	0.34	0.37	0.40	0.44	0.47	0.51	0.58
Undeveloped							
Cultivated Land							
Flat, 0 – 2%	0.31	0.34	0.36	0.40	0.43	0.47	0.57
Average, 2 – 7%	0.35	0.38	0.41	0.44	0.48	0.51	0.60
Steep, Over 7%	0.39	0.42	0.44	0.48	0.51	0.54	0.61
Pasture/Range							
Flat, 0 – 2%	0.25	0.28	0.30	0.34	0.37	0.41	0.53
Average, 2 – 7%	0.35	0.36	0.38	0.42	0.45	0.49	0.58
Steep, Over 7%	0.37	0.40	0.42	0.46	0.49	0.53	0.60
Forest/Woodland							
Flat, 0 – 2%	0.22	0.25	0.28	0.31	0.35	0.39	0.48
Average, 2 – 7%	0.31	0.34	0.36	0.40	0.47	0.47	0.56
Steep, Over 7%	0.35	0.39	0.41	0.45	0.52	0.52	0.58

Source: Linsley, R.K., Franzini, B.J., and Fregbery, L.D. (1992)

The time of concentration to any point in a storm drainage system can be calculated from;

$$T_c = T_i + T_d \qquad (4)$$

Where;

T_c = *the time of concentration*
T_i = *the sum of inlet time from the remotest point to the inlet*
T_d = *the flow time in the upstream sewers connected to the outer point*

T_i can be calculated from Kirpich Equation;

$$T_i = 0.019L^{0.77}S^{-0.385} \qquad (5)$$

Where;

L = *length of channel / ditch from headwater to outlet* (m)
$S = H / L$ = *average watershed slope* (m/m)
H = *elevation difference between divide and outlet* (m)

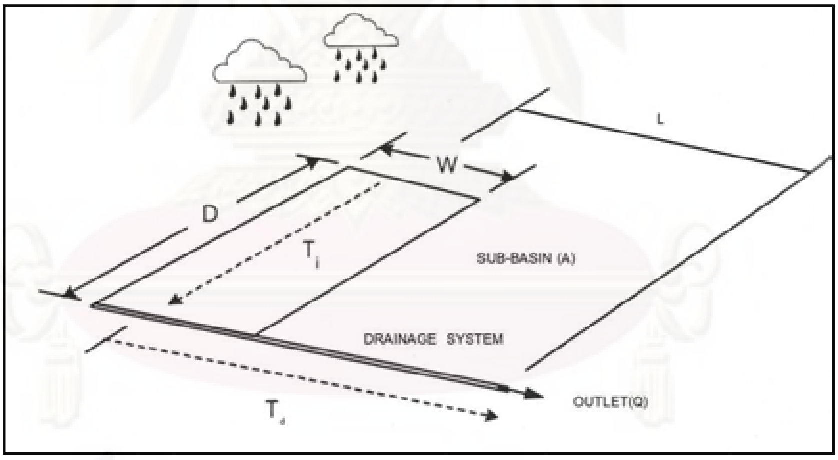

Figure 2.8 Illustrate the Definition of Time Concentration
Source: Linsley, R. K. (1975)

2. The Amount of Wastewater

The design amount of waste water relates to the amount of daily water consumption which is normally about 80% of water consumption. This value depends on the types of building as shown in table;

The consideration of the design amount of waste water includes;

1. The maximum rate of flow
2. The average rate of flow
3. The minimum rate of flow

According to Hermans's Equation, the amount of waste water except the amount of rainfall can be calculated by using the equation below;

$$M = 1 + \frac{14}{1 + \sqrt{P}} \tag{6}$$

Where;

$$M = \frac{the\ maximum\ amount\ of\ waste\ water}{the\ average\ amount\ of\ waste\ water}$$

$$P = \frac{population}{1{,}000}$$

2.1 Wastewater in Dry Season

Typically the characteristic of wastewater flow in sewage pipe is partial flow, so, it must use the open-channel flow equation;

$$Area\ of\ Sector = \frac{\pi r^2}{360}\theta = \frac{1}{2}r^2\theta \tag{7}$$

Where;

θ *is in radian*

$A = area\ of\ flow\ section = area\ of\ sector + triangular\ area$

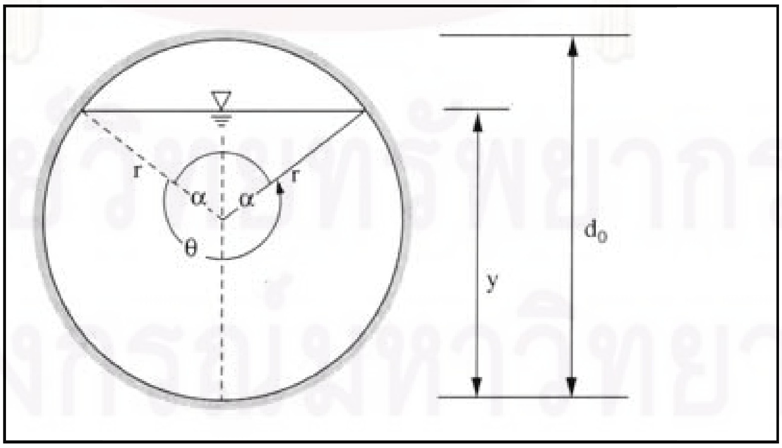

Figure 2.9 Parameters of Flow in Pipe
Source: Linsley, R. K.(1949)

So,

$$A = \frac{D^2}{8}(\theta - sin\theta) \tag{8}$$

$$P = r\theta = \frac{D}{2}\theta \tag{9}$$

$$R = \frac{A}{P} = \frac{D}{4}\left[1 - \frac{sin\theta}{\theta}\right] \tag{10}$$

And,

$$y = \frac{D}{2}\left[1 - cos\frac{\theta}{2}\right] \tag{11}$$

Finally the flow of wastewater equation in dry season is;

$$Q = AV = \left[\frac{D^2}{8}(\theta - sin\theta)\right] . \frac{1}{n} . \frac{D}{4}\left[1 - \frac{sin\theta}{\theta}\right]^{2/3} . S_0^{1/2} \tag{12}$$

2.2 Wastewater in Monsoon Season

The characteristic of wastewater flow in monsoon season is fully flow, so, the equation which is used in this case is the flow in pipeline

$$Q_0 = \frac{1}{n} . \left[\frac{\pi D^2}{4}\right] . \left[\frac{D}{4}\right]^{2/3} . S_0^{1/2} \tag{13}$$

Where;

V = the flow rate of wastewater (m^3/s)
n = Manning's roughness coefficient
D = diameter of pipe (m)
S_0 = bed slope

Typically, the maximum velocity of flow must not exceed 3 m/s, that is, to prevent the erosion of inner surface of pipe.

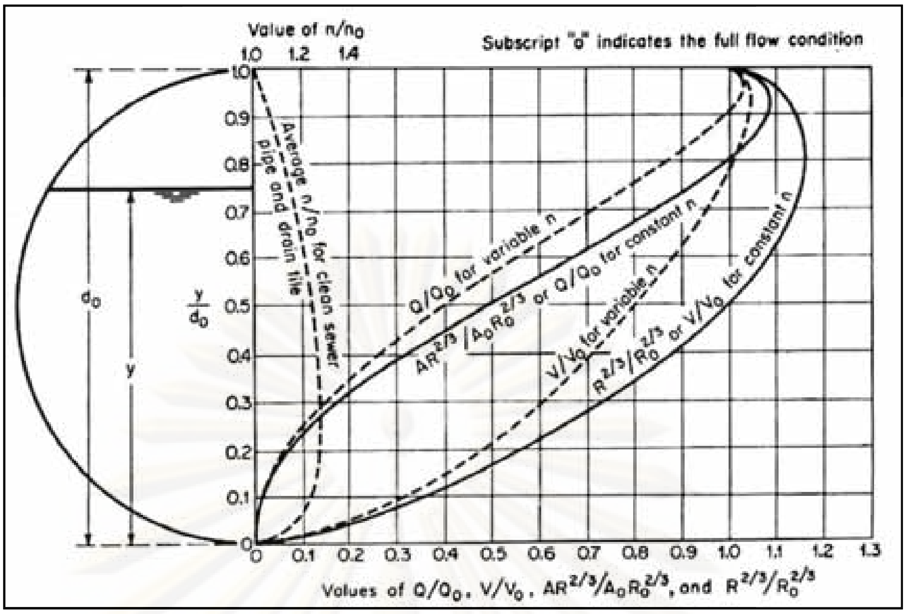

Figure 2.10 Flow Characteristics of Circular Section
Source: Chow, V.T. (ed.). (1959)

2.3 The Amount of Infiltrated Groundwater

The amount of infiltrated water will occur in case of water table is higher than the bed of pipe especially in rainy season. The recommended rate of infiltrated groundwater is shown in table 3.7

Table 2.7 The Rate of Infiltrated Groundwater

Diameter of Pipe (m)	Rate of Infiltration (m^3/day/km)
0.20	8 – 12
0.30	10 – 14
0.50	23 – 28

Source: Kriangsuk Udomsinroj.(1994)

3. Criteria and Regulations in Design Drainage System

Generally the design of drainage system will consider the cross sectional area of pipe or channel that adequate for the total discharge. Furthermore, there are many criteria and regulations in design drainage system includes;

1. The minimum rate of flow to prevent the sedimentation of dregs and reduce the reaction of H_2S. The recommended value of concrete waste water pipe is in between 0.6 - 0.9 m/s.
2. The maximum rate of flow to prevent the erosion of pipe inner surface. The recommended value does not exceed 3.0 m/s.
3. The minimum diameter of pipe is at least 20 cm.
4. The minimum of bed slope is at least 0.0008 or 1 : 1,250

2.3.2 Opened – Channel Flow Theories

An open – channel is a conduit in which water flow with a free surface. Classification according to its origin, a channel may be either *natural* or *artificial.*

Natural channels include all of watercourses that exist naturally on the earth. The hydraulic properties of natural channels are generally very irregular.

Artificial channels are those constructed or developed by human effort: navigation channels, power canals, irrigation canals, drainage ditches, through spillway, floodways, gutters etc. The hydraulic properties of such channels can be either controlled to the extent desired or designed to meet the given requirements. The applications of hydraulic theories to artificial channels will, therefore, produce results fairly close to actual conditions and, hence, are reasonably accurate for practical design purposes.

1. Manning's Equation

In 1889, The Irish engineer, Robert Manning, presented the uniform flow equation which is mostly accept from users that is;

$$V = \frac{1}{n} R^{2/3} S^{1/2} \tag{14}$$

Where;

$V = average\ velocity\,(m/s)$

$n = Manning's\ roughness\ coefficient$

$R = hydraulic\ radius\,(m)$

$S = hydraulic\ gradient = \frac{H_f}{L};\ H_f = major\ losses, L = length\ of\ pipe$

Table 2.8 Manning "n" Roughness Coefficients in any Conditions

Channel Condition	n
Plastic, Glass, Drawn tubing	0.009
Neat Cement, Smooth Metal	0.010
Planed Timber, Asbestos Pipe	0.011
Wrought Iron, Welded Steel, Canvas	0.012
Ordinary Concrete, Asphalted Cast Iron	0.013
Unplanned Timber, Vitrified Clay, Glazed Brick	0.014
Cast-iron Pipe, Concrete Pipe	0.015
Riveted Steel, Brick, Dressed Stone	0.016
Rubble Masonry	0.017
Smooth Earth	0.018
Firm Gravel	0.020
Corrugated Metal Pipe and Flumes	0.023
Natural Channels:	
• Clean, Straight, Full Stage, no Pools	0.029
• As above with Weeds and Stones	0.035
• Winding, Pools and Shallows, Clean	0.039
• As above at low stages	0.047
• Winding, Pools and Shallows, Weeds and Stones	0.042
• As above, Shallow Stage, Large Stones	0.052
• Sluggish, Weedy, with deep pool	0.065
• Very Weedy and Sluggish	0.112
Values quoted are averages of any determinations; variation of as much as 20 percent must be expected	

Source: Linsley, R. K. (1975)

CHAPTER 3

METHODOLOGY

3.1 Methodology

This research divides the methodology from the beginning until the summation thus;

1. Located the area of study by cite on the administrative area of Hua - Hin municipality.

2. Study of geology, hydrology, including the ability of runoff storage and natural drainage of this area by documents, map, aerial photograph translation, and field survey as follow;
   - 2.1 Geography which are topography, ground level and slope.
   - 2.2 Meteorology which are rainfall intensity, the existing flood condition of river, ditch, and canal.
   - 2.3 The ability of sewage system and natural drainage system which are number of ditches, canals, and sewage network.

   This information would be studied in order to know about the roles and obligations also the ability of sewage system and natural drainage due to geography which are the limitation in the development.

3. Study the developed condition and overall drainage system in order to get the sources and water quantity including discharge of ground water in this area. Compare to the consistency, difference, and efficiency in executing the improvement of flood problems and drainage system.

4. Study the development of private sector which include of any activities, construction of building, soil excavation and fill up, flood protection and water drainage in order to know the development and the change of land use, flood protection and water drainage, and the change of geography by the activities of private sector.

5. Study the developments of government which are any projects that are being executed by central government and local government in order to know roles and obligations of water storage and drainage due to the flood protection and water drainage plan of this area to compare the actual condition which is developed by private sector.

6. Analyze the tendency of development and problems which will cause drainage system in this area from the original data in order to know the requirement and potentiality of the extreme development in this area so that cannot halt the change of land use that consequently reduce the ability of storm drainage system.

7. Analysis and summation existing data which are the causes of flood from the effect of land use, former data which indicate the flood history from the relation between runoff and rainfall etc.

3.2 Step of Research

This research is going to study the adequacy of drainage system in monsoon season of study area including the effects of infrastructure acting on the drainage system and also the problems in order to the change of land use. The steps of methodology are;

Step 1: Located the study area by refer to the authority of Hua - Hin municipality. There is 76 km^2 of inland of totally 84 km^2. This research would study the pipe drainage system in downtown and overall open – channel system.

Step 2: Surveyed the existing conditions in the study area including geography, hydrology, infrastructure, land use, and the ability of artificial and natural drainage. These data would be studied from the documents, maps, aerial photographs, and field survey.

Step 3: Compiled data from the both of existing data and field data to analyze the results. Using rational method to analyze the maximum discharge of runoff from the catchments, using Manning’s equation to determine the optimizing size of pipeline of the drainage system in the city, and also the open - channel drainage system.

Step 4: Compared the results with the existing condition of drainage systems both of pipe drainage system and open - channel drainage system.

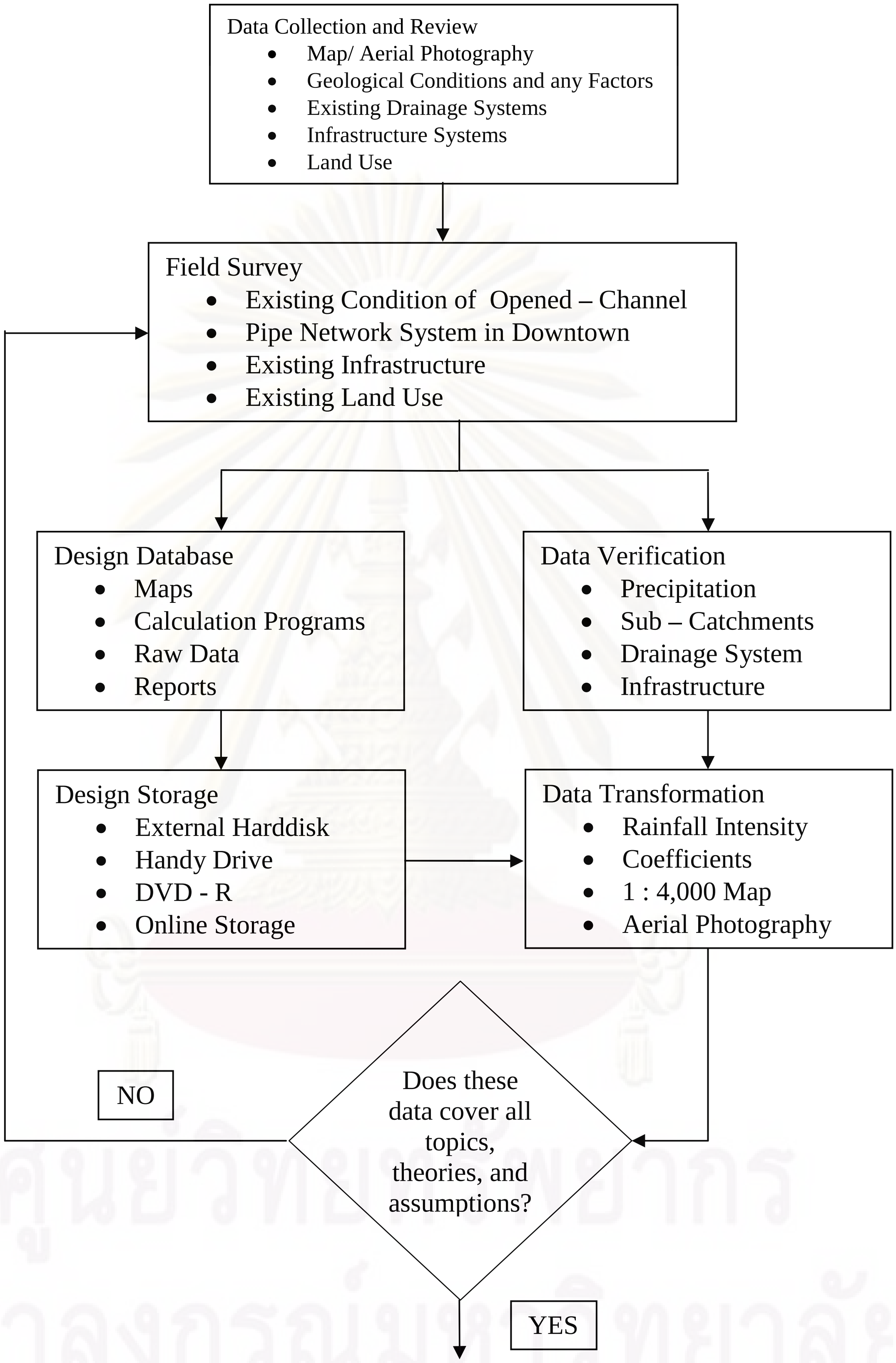

Figure 3.1 Schematic Diagram Illustrate the Process of Study

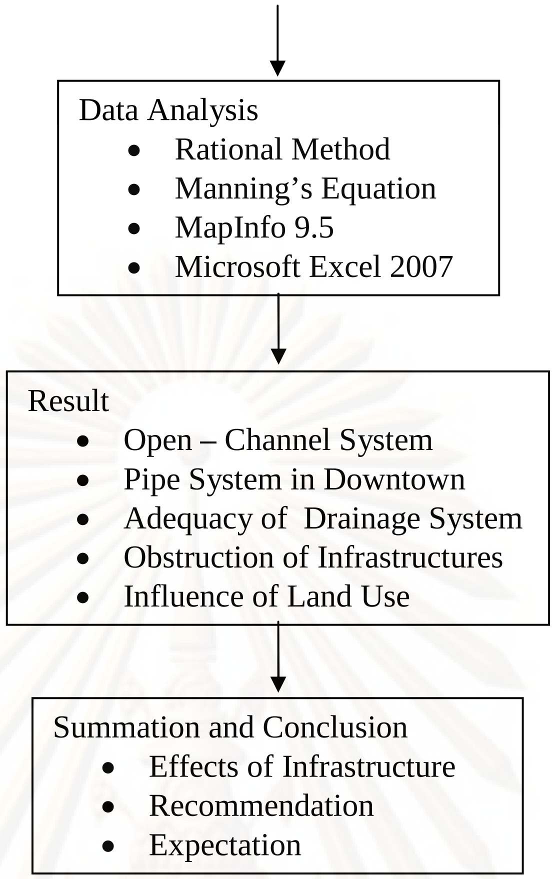

Figure 3.1 Schematic Diagram Illustrate the Process of Study (Continue)

3.3 Analysis of Data

This research uses a lot of essential basic data which must be gathered from many institutes and also the field data from survey. The data will be interpreted into the patterns that suitable for analysis and assessment of the drainage system in order to know the existing drainage system and also the effects of infrastructure and the change of land use later on.

The basic data which are gathered from the institutes include hydrological data, meteorological data, topography, climate, soil condition, infrastructures, and the tendency of land use. These data can be categorized which is shown in table 3.9. Regarding to field survey, the collected data includes meteorology, hydrology, existing condition, existing land use, existing infrastructure, location and the existing condition of drainage system.

These data, both of field data and instant data, would be verified and transformed into curve and/or unit hydrograph but this step will not be more concentrated on because they would be only indicated the concerned factors.

After verifying the adequacy of data, the analyzing process would be provided. In this step, the theories of rational method, and Manning's equation would be applied to use. Rational method would analyze the adequacy of the pipe drainage system in downtown which can effectively drain the amount of runoff. On the other hand, Manning's equation will analyze the optimizing size of canals which can contain the amount of storm water drainage.

Finally, the results would be used to compare with the existing drainage system which may ensure that infrastructures might affect the efficiency of drainage systems.

Table 3.1 Details and the Sources Data

Item	Institute(s)	Usage
Data Collection of Mapping System		
Map of Geology 1 : 50,000	Royal Thai Survey Department	Study of topographic characteristics and general location.
Map of Topography 1 : 4,000	Department of City Planning	Study of topography, channel, road, and located obviously the boundary of study area.
Map of Aerial Photograph 1 : 4,000	Royal Thai Survey Department	Study of past topography, and consider of the change of land use and channel.
Map of Land Use 1 : 4,000	Department of Public Works and Towns and Country Planning	Study of the existing Land Use and located the study area in case of Land Use.
Map of Future Land Use 1 : 4,000	Department of Public Works and Towns and Country Planning	The approaches of drainage system solution and prevent the future flood due to Land Use.
Map of Soil Characteristics 1 : 4,000	Lend Development Department	Study of Soil Conditions to be analyzed the flow rate or others.
Map of Sea Water Level 1 : 20,000	Hydrographic Department Royal Thai Navy	Data of Sea water level in any period of time.
Map of Highway No.4 STA. 235+622.057 - STA.250+966.982	Department of Highway	Study of position, size, distance, and number of highway's culverts in order to know the outlet of water.
Data Collection of Hydrology and Meteorology		
Hydrological Statistics	Thai Meteorological Department	Study general climate
Rainfall Statistic in any Periods	Thai Meteorological Department	Analyze data to construct IDF Curve
Rainfall Data Between October - December	Thai Meteorological Department	Study of Rainfall condition to compare with field data.
Hydrographic Statistic	Hydrographic Department Royal Thai Navy	Study of general Hydrographic characteristics and the results of sea water level.
Hydrographic Data Between October - December	Hydrographic Department Royal Thai Navy	Study of the influence of sea water level which affect the drainage system.

3.4 The Expectation of Results

1. The characteristic, intensity, and frequency of rainfall might affect the amount and discharge of stream flow in channels. If the intensity and frequency of rainfall is high, the discharge in stream is also high. Especially the characteristic, topography, location, and the influence of monsoon of study area may generate the tendency of high intensity and frequency of rainfall.

2. The characteristics of topography that are the large watershed area, high slope, short channel lines, and covering condition is difficult to infiltrate will affect the rate of stream flow in channels.

3. Land use will affect the change of topographic conditions such as soil covering condition, the existing retention storage, the sizing and direction of channels.

4. Water table in this area where located on the coastal of the western of the gulf of Thailand, therefore, the water table and sea water level will affect the drainage systems.

5. Infrastructures which obstruct the flow direction of runoff will affect the drainage systems in case of the drainage system does not adequate for the flow rate of runoff in flood period, therefore, it will be in flood problem.

CHAPTER 4

DRAINAGE SYSTEM ANALYSIS

According to drainage system analysis of Hua – Hin municipality, the result will identify the certain effects of infrastructures in the city. Hence, this study divides the case of study into two groups which are; 1) Open – Channel system analysis, and 2) Sewage (or Pipe) system analysis especially in downtown. The processes of analysis would assess the efficiency of the existing drainage system which adequate for the 25 – Year – Return Period or not. If the existing system did not adequate, the new design would replace.

Table 4.1 Maximum Average Rainfall

Return Period (Year)	Maximum Rainfall(mm)		
	1 Day	3 Day	5 Day
2	97.7	144.6	170.6
5	163.9	250.3	288.1
10	207.8	320.3	365.9
25	260.9	405.2	460.3
50	304.3	474.3	537.2
100	345.1	539.5	609.6

Source: Hua – Hin Weather Station, Thai meteorological Department (2007)

Or can be tabulated into formulae as;

Table 4.2 Formulae of Maximum Rainfall

Duration	Formula
1 Day	$y = 62.557ln(x) + 59.582$
3 Day	$y = 99.842ln(x) + 83.767$
5 Day	$y = 111ln(x) + 102.96$

4.1 Open – Channel Analysis

Arise from the study of existing drainage system's documents and field survey involve the study of the position of canals from aerial photographs, the research found that; 100 years ago before the area - where is administrated by Hua – Hin municipality nowadays – would be developed to be the residential area, there were 10 natural canals which are the natural drainage system in this area. These canals include; 1) Klong Sanam Bin, 2) Klong Kok Kluer, 3) Klong Bang Kwian Huk, 4) Klong Nin, 5) Klong Jum Nian, 6) Klong Talay Noi, 8) Klong E Lun, 9) Klong Tian, 10) Klong Kao Tao. Furthermore, within 15 years ago, there were the artificial canals which were constructed by Royal Irrigation Department include; 1) Klong Rabaay Saay 1(or Klong Hua – Hin 1), 2) Klong Rabaay Saay 2(or Klong Hua – Hin 2) - in the northern area of Hua – Hin municipality- and the recently constructed(3 years ago) 3) the canal under the king's instruction which located from Hua – Hin railway station to Klong Kao Takiab in the southern area of Hua – Hin municipality.

According to the field survey, the most of canals in this area were deconstructed by both of government and private sector. For example, Klong Talay Noi, which passed through royal ground, were deconstructed to prevent flood problem in Klai Kung Won Palace. And Klong Nin, which passed through private's land, were deconstructed by private sector for residential area.

The example of calculation for the open – channel system is shown below. These system located in the most north of Hua - Hin municipality. It includes 3 main canals which are 1) Klong Sanam Bin, 2) Klong Kok Kluer, which are connected by 3) Klong Hua – Hin 1. In the research, the using return period, this is used to control the size of drainage system, for open – channel system is 2, 5, 10, 25, 50, and 100 years respectively. The reason of using a lot of return period is to compare the existing drainage system in this area. However, the example will show only the calculation of 100 – Year – Return Period but will show the comparison of result in the conclusion. The maximum rainfall intensity is 107 mm/hr.

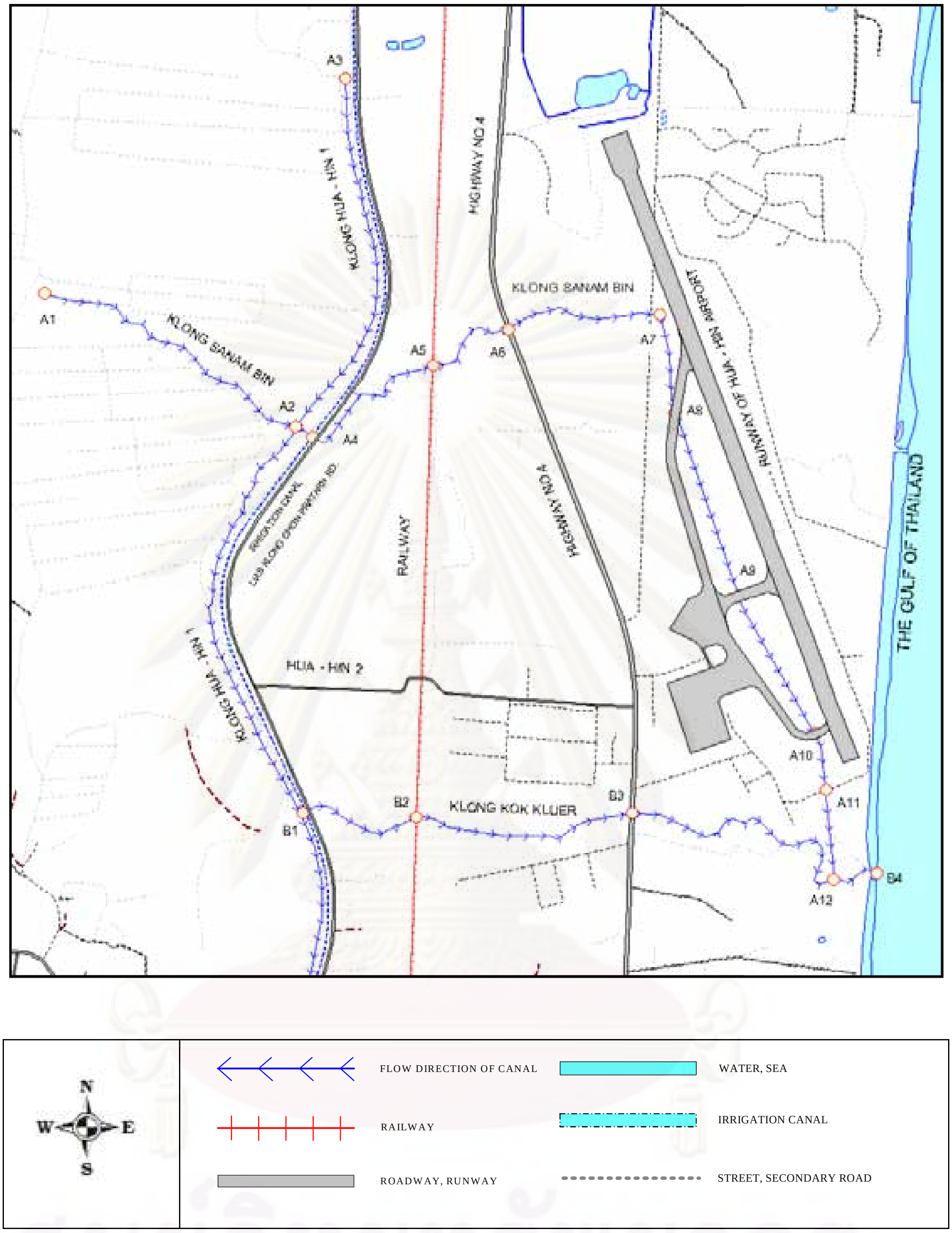

Figure 4.1 Open – Channel System of Klong Sanam Bin

Consider at point A1.

At this point, there is some runoff from Cha – Am municipality combine in Klong Sanam Bin because they are in the same watershed area.

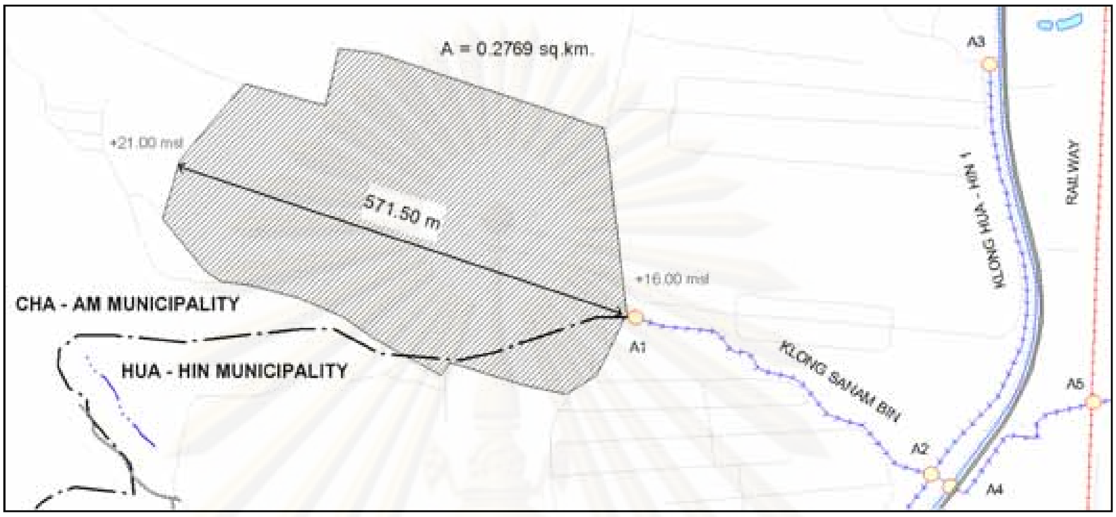

Figure 4.2 Sub – Catchment of Klong Sanam Bin at Point A1

1. The Amount of Runoff (Q_d)

   Rational method would be used to determine the amount of runoff in any sub-catchments.

$$Q_d = CiA \tag{15}$$

Where;

Q_d = $maximum\ amount\ of\ runoff\ (m^3/s)$
C = $runoff\ coefficient$
i = $rainfall\ intensity (mm/hr)$
A = $sub-catchment\ area (m^2)$

According to the known parameters, C = 0.49(see Table 3.6, pasture/ range steep area 2 -7%, and 100 years return period), i = 107 mm/hr, and A = 0.2769 km^2 (or 276,900 m^2). Therefore, the amount of maximum runoff is;

$$Q_d = (0.49\, x \frac{107}{1,000}\, x\, 276,900)$$
$$= 14,517.87\ m^3/hr$$
$$= 4.04\ m^3/s$$

2. Determine the Cross Sectional Area of Channel (*A*)

According to Manning's equation, this equation would be used to determine the maximum cross-section of canal due to the amount of maximum runoff (or designed discharge) as follows;

$$V = (\frac{R^{2/3}\sqrt{S}}{n}) \tag{16}$$

Where;

V = velocity of flow (m/s)
n = Manning's roughness coefficient
R = hydraulic radius (m)
S = slope of channel = $\frac{\Delta H}{L}$
H = different height of channel, L = length of channel

The maximum of flow to prevent erosion as follow the table below;

Table 4.3 Allowable Velocity of Flow in Open - Channel

Type of Bottom Material of Channel	Allowable Velocity of Flow (m/s)
Smooth and dense grass	1.83
Loose grass	0.60 – 1.22
Soil type(without grass)	
• Fine sand	0.30 – 0.62
• Hard clay	1.22
• Clayey sand	1.22
• gravel	1.22
• Shale	1.52

Source: Pitoon K., Suppakorn S., Ummares B. (2009)

In this research, the value of allowable velocity of flow is 1.22 m/s, so, rearrange the previous equation;

$$V = (\frac{R^{2/3}\sqrt{S}}{n})$$

$$R = \sqrt{\left(\frac{(V)(n)}{\sqrt{S}}\right)^3} = \sqrt{\left(\frac{(1.22)(0.035)}{\sqrt{(\frac{21-16}{571.5})}}\right)^3}$$

$$= 0.308\ m$$

And then determine the maximum cross sectional area as follow;

$$Q_d = VA \tag{17}$$

$$A_{Max} = \frac{Q_d}{V} = \frac{4.04}{1.22}$$

$$= 3.32\ m^2$$

According to another research, they found that the best cross – section of open – channel refer to hydraulic engineering must;

1. That section must has less obstruction of flow
2. That section must has less wetted perimeter(Half circle is the best but not prefer)
3. So, the trapezoidal is preferred.

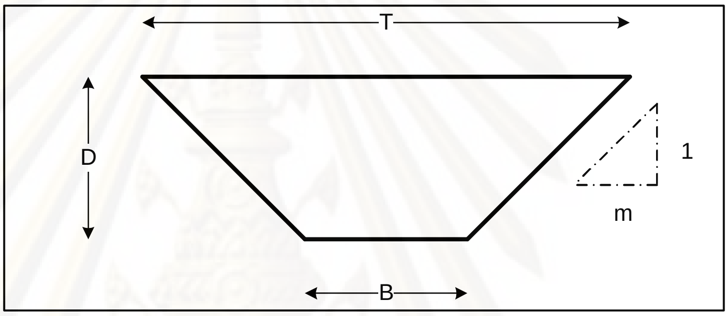

Figure 4.3 Geometric of Trapezoidal Section

According to the figure above, the calculations of this section include;

$$A\ =\ area = (B + mD).D$$

$$P\ = wetted\ perimeter = B + 2D\sqrt{1 + m^2}$$

$$R\ =\ hydraulic\ radius = \frac{A}{P} = \frac{(B + mD).D}{B + 2D\sqrt{1 + m^2}}$$

$$T\ =\ top\ width = B + 2mD$$

$$D =\ hydraulic\, depth\ =\ \frac{A}{T} = \frac{(B + mD).D}{B + 2mD}$$

Table 4.4 Appropriated Slope of the Canal's Banks (m value of Trapezoidal Section)

Type of Material	Appropriated Slope 1 : m
Gravel or Rock	Almost Vertical
Clay	1 : 0.25
Hard Clay	1 : 0.5
Large Earth Canal	1 : 1
Dense Clay or Small Canal	1 : 1.5
Loose Clayey Sand	1 : 2
Sandy Soil	1 : 3

Source: Pitoon K., Suppakorn S., Ummares B. (2009)

According to the maximum cross sectional area, A_{Max} = 3.32 m^2, the wetted perimeter of this section should be;

$$P = \frac{A}{R} \tag{18}$$

$$= \frac{3.32}{0.308}$$

$$= 10.78\ m$$

According to the geometry of trapezoidal section, so,

$$P = B + 2D\sqrt{1+m^2}\ ;\ assume\ D = 2.5\ m,\ m = 1$$

$$B = P - 2D\sqrt{1+m^2}$$

$$= 10.78 - (2x2.5)\sqrt{1+1^2}$$

$$= 3.71m$$

$$T = B + 2mD$$

$$= 3.71 + 2(1)(2.5)$$

$$= 8.71\ m$$

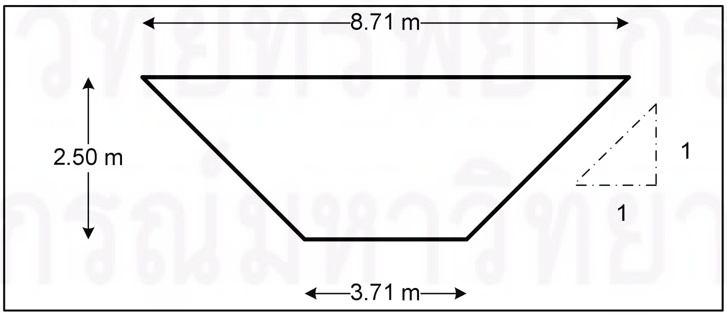

Figure 4.4 the Required Cross – Section of Point A1

Table 4.5 Result from Analysis the Design of Klong Sanam Bin

Section	Return Period	5	10	25	50	100
A1	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.36	0.38	0.42	0.45	0.49
	$A(m^2)$	0.2769	0.2769	0.2769	0.2769	0.2769
	$Q_d(m^3/s)$	1.58	2.02	2.71	3.29	4.03
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00875	0.00875	0.00875	0.00875	0.00875
	R	0.308	0.308	0.308	0.308	0.308
	A_{max}	1.29	1.65	2.22	2.70	3.31
	P	4.19	5.36	7.21	8.74	10.72
	D	0.80	1.00	1.50	2.00	2.50
	m	1.00	1.00	1.00	1.00	1.00
	B	1.93	2.53	2.97	3.08	3.65
	T	3.53	4.53	5.97	7.08	8.65
A3	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.36	0.38	0.42	0.45	0.49
	$A(m^2)$	0.0771	0.0771	0.0771	0.0771	0.0771
	$Q_d(m^3/s)$	0.44	0.56	0.76	0.92	1.12
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00418	0.00418	0.00418	0.00418	0.00418
	R	0.185	0.185	0.185	0.185	0.185
	A_{max}	0.73	0.94	1.26	1.53	1.87
	P	3.95	5.05	6.80	8.24	10.10
	D	0.50	0.70	1.00	1.25	1.50
	m	1.00	1.00	1.00	1.00	1.00
	B	2.54	3.07	3.97	4.70	5.86
	T	3.54	4.47	5.97	7.20	8.86
A3 - A2	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.36	0.38	0.42	0.45	0.49
	$A(m^2)$	0.1316	0.1316	0.1316	0.1316	0.1316
	$Q_d(m^3/s)$	1.19	1.52	2.05	2.48	3.04
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00418	0.00418	0.00418	0.00418	0.00418
	R	0.399	0.399	0.399	0.399	0.399
	A_{max}	1.19	1.52	2.05	2.48	3.04
	P	2.98	3.81	5.13	6.22	7.62
	D	1.00	1.25	1.50	1.75	2.00
	m	1.00	1.00	1.00	1.00	1.00
	B	0.16	0.28	0.89	1.27	1.97
	T	2.16	2.78	3.89	4.77	5.97

Table 4.5 Result from Analysis the Design of Klong Sanam Bin (Continue)

Section	Return Period	5	10	25	50	100
A1 - A2	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.36	0.38	0.42	0.45	0.49
	$A(m^2)$	0.1562	0.1562	0.1562	0.1562	0.1562
	$Q_d(m^3/s)$	2.47	3.15	4.24	5.14	6.31
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00525	0.00525	0.00525	0.00525	0.00525
	R	0.452	0.452	0.452	0.452	0.452
	A_{max}	2.02	2.59	3.48	4.22	5.17
	P	4.47	5.71	7.69	9.32	11.43
	D	0.80	1.00	1.50	2.00	2.50
	m	1.00	1.00	1.00	1.00	1.00
	B	2.21	2.89	3.45	3.66	4.36
	T	3.81	4.89	6.45	7.66	9.36
A2 - A4	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.36	0.38	0.42	0.45	0.49
	$A(m^2)$	0.0200	0.0200	0.0200	0.0200	0.0200
	$Q_d(m^3/s)$	1.94	2.48	3.34	4.05	4.96
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00775	0.00775	0.00775	0.00775	0.00775
	R	0.338	0.338	0.338	0.338	0.338
	A_{max}	1.59	2.04	2.74	3.32	4.07
	P	4.71	6.02	8.11	9.82	12.05
	D	1.00	2.00	2.00	2.00	2.50
	m	1.00	1.00	1.00	1.00	1.00
	B	1.89	0.37	2.45	4.16	4.97
	T	3.89	4.37	6.45	8.16	9.97
A4 - A5	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.36	0.38	0.42	0.45	0.49
	$A(m^2)$	0.0924	0.0924	0.0924	0.0924	0.0924
	$Q_d(m^3/s)$	2.47	3.16	4.25	5.15	6.31
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00695	0.00695	0.00695	0.00695	0.00695
	R	0.367	0.367	0.367	0.367	0.367
	A_{max}	2.02	2.59	3.48	4.22	5.17
	P	5.52	7.06	9.49	11.50	14.11
	D	0.80	1.00	1.50	2.50	3.50
	m	1.00	1.00	1.00	1.00	1.00
	B	3.26	4.23	5.25	4.43	4.21
	T	4.86	6.23	8.25	9.43	11.21

Table 4.5 Result from Analysis the Design of Klong Sanam Bin (Continue)

Section	Return Period	5	10	25	50	100
A5 - A6	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.40	0.43	0.46	0.49	0.53
	$A(m^2)$	0.1562	0.1562	0.1562	0.1562	0.1562
	$Q_d(m^3/s)$	3.46	4.44	5.92	7.17	8.77
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00505	0.00505	0.00505	0.00505	0.00505
	R	0.466	0.466	0.466	0.466	0.466
	A_{max}	2.84	3.64	4.85	5.87	7.19
	P	6.09	7.82	10.42	12.61	15.44
	D	0.80	1.00	1.50	2.00	2.50
	m	1.00	1.00	1.00	1.00	1.00
	B	3.83	4.99	6.18	6.95	8.37
	T	5.43	6.99	9.18	10.95	13.37
A6 - A7	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.36	0.38	0.42	0.45	0.49
	$A(m^2)$	0.1698	0.1698	0.1698	0.1698	0.1698
	$Q_d(m^3/s)$	4.43	5.68	7.59	9.18	11.24
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00496	0.00496	0.00496	0.00496	0.00496
	R	0.472	0.472	0.472	0.472	0.472
	A_{max}	3.63	4.66	6.22	7.53	9.22
	P	7.69	9.86	13.17	15.94	19.52
	D	2.00	2.50	3.00	3.50	4.00
	m	1.00	1.00	1.00	1.00	1.00
	B	2.03	2.79	4.69	6.04	8.21
	T	6.03	7.79	10.69	13.04	16.21
A7 - A8	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.77	0.81	0.86	0.90	0.95
	$A(m^2)$	0.0399	0.0399	0.0399	0.0399	0.0399
	$Q_d(m^3/s)$	4.91	6.30	8.39	10.13	12.37
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00492	0.00492	0.00492	0.00492	0.00492
	R	0.872	0.872	0.872	0.872	0.872
	A_{max}	2.68	3.44	4.58	5.54	6.76
	P	3.08	3.95	5.26	6.35	7.75
	D	0.50	0.50	0.50	0.50	1.00
	m	1.50	1.50	1.50	1.50	1.50
	B	1.28	2.14	3.45	4.54	4.15
	T	2.78	3.64	4.95	6.04	7.15

Table 4.5 Result from Analysis the Design of Klong Sanam Bin (Continue)

Section	Return Period	5	10	25	50	100
A8 - A9	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.77	0.81	0.86	0.90	0.95
	A(m^2)	0.0765	0.0765	0.0765	0.0765	0.0765
	Q_d(m^3/s)	5.85	7.49	9.92	11.95	14.53
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00272	0.00272	0.00272	0.00272	0.00272
	R	1.359	1.359	1.359	1.359	1.359
	A_{max}	3.19	4.09	5.42	6.53	7.94
	P	2.35	3.01	3.99	4.80	5.84
	D	0.50	0.50	0.50	1.00	1.00
	m	1.50	1.50	1.50	1.50	1.50
	B	0.55	1.21	2.19	1.20	2.24
	T	2.05	2.71	3.69	4.20	5.24
A9 - A10	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.77	0.81	0.86	0.90	0.95
	A(m^2)	0.0385	0.0385	0.0385	0.0385	0.0385
	Q_d(m^3/s)	6.31	8.08	10.69	12.86	15.62
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00331	0.00331	0.00331	0.00331	0.00331
	R	1.175	1.175	1.175	1.175	1.175
	A_{max}	3.45	4.42	5.84	7.03	8.53
	P	2.94	3.76	4.97	5.98	7.26
	D	0.80	1.00	1.25	1.50	2.00
	m	1.00	1.00	1.00	1.00	1.00
	B	0.67	0.93	1.44	1.74	1.60
	T	2.27	2.93	3.94	4.74	5.60
A10 - A11	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.77	0.81	0.86	0.90	0.95
	A(m^2)	0.0115	0.0115	0.0115	0.0115	0.0115
	Q_d(m^3/s)	6.46	8.26	10.93	13.13	15.94
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00925	0.00925	0.00925	0.00925	0.00925
	R	0.543	0.543	0.543	0.543	0.543
	A_{max}	3.53	4.52	5.97	7.18	8.71
	P	6.49	8.31	10.99	13.21	16.03
	D	1.00	1.00	1.00	1.00	1.00
	m	1.50	1.50	1.50	1.50	1.50
	B	2.89	4.70	7.38	9.60	12.42
	T	5.89	7.70	10.38	12.60	15.42

Table 4.5 Result from Analysis the Design of Klong Sanam Bin (Continue)

Section	Return Period	5	10	25	50	100
A11 - A12	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.36	0.38	0.42	0.45	0.49
	$A(m^2)$	0.0087	0.0087	0.0087	0.0087	0.0087
	$Q_d(m^3/s)$	6.50	8.33	11.01	13.24	16.07
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00590	0.00590	0.00590	0.00590	0.00590
	R	0.761	0.761	0.761	0.761	0.761
	A_{max}	3.55	4.55	6.02	7.23	8.78
	P	4.67	5.98	7.90	9.50	11.54
	D	0.50	0.50	0.50	1.00	1.00
	m	1.50	1.50	1.50	1.50	1.50
	B	2.87	4.17	6.10	5.90	7.93
	T	4.37	5.67	7.60	8.90	10.93
A2 - B1	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.36	0.38	0.42	0.45	0.49
	$A(m^2)$	0.2178	0.2178	0.2178	0.2178	0.2178
	$Q_d(m^3/s)$	3.07	3.92	5.28	6.40	7.85
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00242	0.00242	0.00242	0.00242	0.00242
	R	0.809	0.809	0.809	0.809	0.809
	A_{max}	2.52	3.22	4.33	5.24	6.43
	P	3.11	3.98	5.35	6.48	7.95
	D	0.50	0.80	1.00	1.50	2.00
	m	1.00	1.00	1.00	1.00	1.00
	B	1.70	1.71	2.52	2.24	2.29
	T	2.70	3.31	4.52	5.24	6.29
B1	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.36	0.38	0.42	0.45	0.49
	$A(m^2)$	0.0777	0.0777	0.0777	0.0777	0.0777
	$Q_d(m^3/s)$	0.44	0.57	0.76	0.92	1.13
	n	0.035	0.035	0.035	0.035	0.035
	S	0.01315	0.01315	0.01315	0.01315	0.01315
	R	0.227	0.227	0.227	0.227	0.227
	A_{max}	0.36	0.46	0.62	0.76	0.93
	P	1.60	2.04	2.75	3.33	4.08
	D	0.30	0.50	0.70	1.00	1.25
	m	1.00	1.00	1.00	1.00	1.00
	B	0.75	0.63	0.77	0.50	0.55
	T	1.35	1.63	2.17	2.50	3.05

Table 4.5 Result from Analysis the Design of Klong Sanam Bin (Continue)

Section	Return Period	5	10	25	50	100
B1 - B2	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.23	0.25	0.29	0.32	0.36
	$A(m^2)$	0.0803	0.0803	0.0803	0.0803	0.0803
	$Q_d(m^3/s)$	2.27	2.91	3.94	4.80	5.91
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00438	0.00438	0.00438	0.00438	0.00438
	R	0.518	0.518	0.518	0.518	0.518
	A_{max}	1.86	2.39	3.23	3.93	4.85
	P	3.59	4.61	6.24	7.60	9.36
	D	0.80	1.00	1.25	1.50	2.00
	m	1.00	1.00	1.00	1.00	1.00
	B	1.33	1.78	2.71	3.35	3.70
	T	2.93	3.78	5.21	6.35	7.70
B2 - B3	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.28	0.30	0.34	0.37	0.41
	$A(m^2)$	0.1495	0.1495	0.1495	0.1495	0.1495
	$Q_d(m^3/s)$	3.63	4.66	6.27	7.62	9.36
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00462	0.00462	0.00462	0.00462	0.00462
	R	0.498	0.498	0.498	0.498	0.498
	A_{max}	2.97	3.82	5.14	6.24	7.67
	P	5.97	7.67	10.32	12.54	15.42
	D	0.50	0.80	1.00	1.50	2.00
	m	1.00	1.00	1.00	1.00	1.00
	B	4.56	5.41	7.50	8.30	9.76
	T	5.56	7.01	9.50	11.30	13.76
B3 - A12	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.23	0.25	0.29	0.32	0.36
	$A(m^2)$	0.0647	0.0647	0.0647	0.0647	0.0647
	$Q_d(m^3/s)$	3.86	4.97	6.71	8.16	10.05
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00190	0.00190	0.00190	0.00190	0.00190
	R	0.719	0.719	0.719	0.719	0.719
	A_{max}	3.86	4.97	6.71	8.16	10.05
	P	5.37	6.91	9.33	11.35	13.98
	D	1.00	1.50	2.50	1.00	4.00
	m	1.00	1.00	1.00	1.00	1.00
	B	2.54	2.67	2.26	8.52	2.67
	T	4.54	5.67	7.26	10.52	10.67

Table 4.5 Result from Analysis the Design of Klong Sanam Bin (Continue)

Section	Return Period	5	10	25	50	100
A12 - B4	i(mm/hr)	57.00	69.00	84.00	95.00	107.00
	C	0.23	0.25	0.29	0.32	0.36
	$A(m^2)$	0.0021	0.0021	0.0021	0.0021	0.0021
	$Q_d(m^3/s)$	10.38	13.31	17.73	21.41	26.15
	n	0.035	0.035	0.035	0.035	0.035
	S	0.00542	0.00542	0.00542	0.00542	0.00542
	R	0.928	0.928	0.928	0.928	0.928
	A_{max}	5.19	6.65	8.87	10.71	13.07
	P	5.59	7.17	9.56	11.54	14.09
	D	0.80	1.00	1.25	1.50	4.00
	m	1.00	1.00	1.00	1.00	1.00
	B	3.33	4.34	6.02	7.30	2.78
	T	4.93	6.34	8.52	10.30	10.78

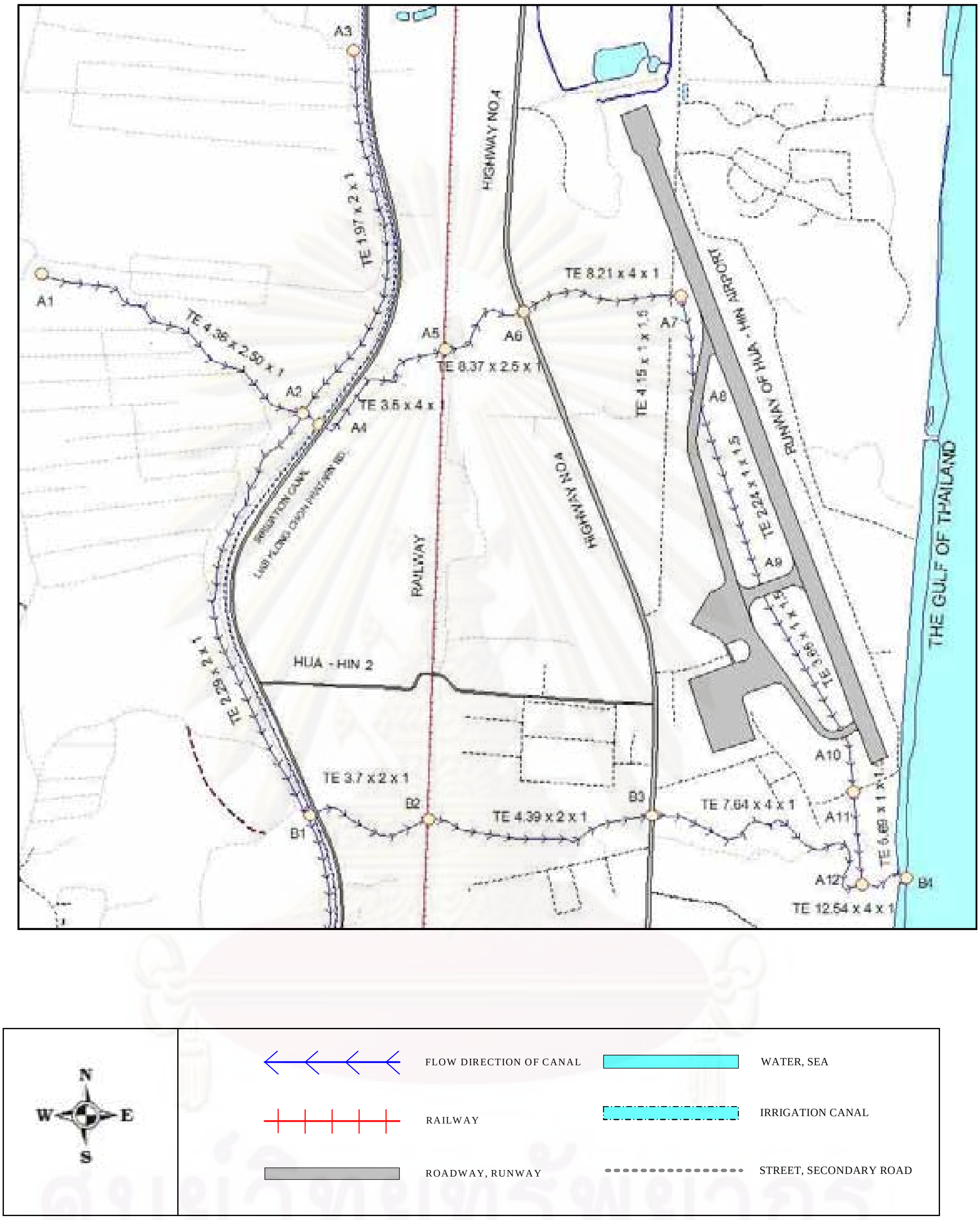

Figure 4.5 the Required Cross – Section of the Total System of Klong Sanam Bin

3 Comparison Between Maximum Cross-section and The Existing Section

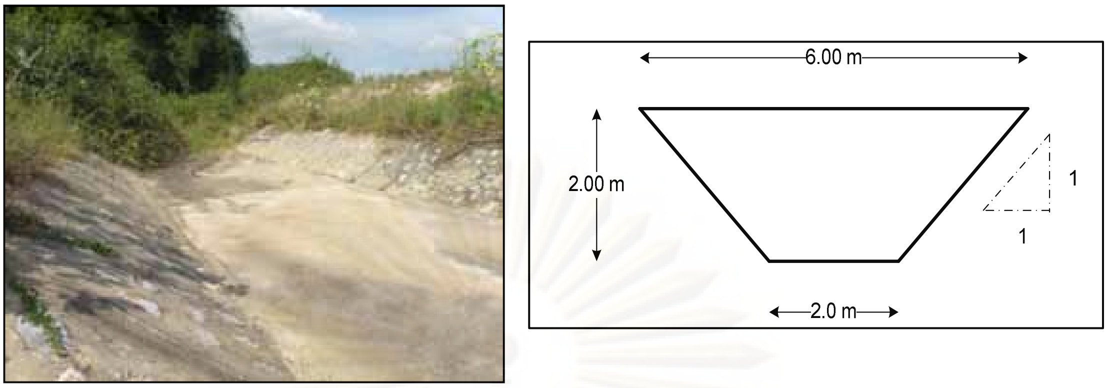

Figure 4.6 Existing Condition of Klong Sanam Bin at Point A1 – A2

Re-calculation of this section;

$$P = B + 2D\sqrt{1+m^2} = (2)+(2\,x\,2)\sqrt{1+(1)^2}$$
$$= 7.66\ m$$

$$R = \sqrt{\left(\frac{(V)(n)}{\sqrt{S}}\right)^3} = \sqrt{\left(\frac{(2.2)(0.01)}{\sqrt{(\frac{21-16}{571.5})}}\right)^3}$$

$$R = 0.114$$

$$P = \frac{A}{R}$$

$$A = PR = 7.66x0.114$$
$$= 0.87\ m^2$$

$$Q_d = VA;\ V = 2.2\,(bottom\ of\ canal\ is\ concrete)$$
$$= 2.2\,x\,0.87$$
$$= 1.92\ m^3/s$$

Therefore, the efficiency of the existing canal is;

$$Efficiency = \frac{Q_d - Q}{Q_d}$$
$$= \frac{4.04-1.92}{4.04}\ x100$$
$$= 52.48\%$$

The condition of existing system and the discussions are shown in *Figure 4.7*;

Figure 4.7A: At Point A1

The farthest west of the canal. At the starting of Klong Sanam Bin, there is no maintenance of the canal. Some of them are filled back by PS, and some of them are obstructed by the trees. This is the true failure of this section. However, runoff still flow in it.

Figure 4.7B: At Section A1 – A2

This figure is looked the west from A2. The length of the existed section has less than 15 m from the totally 571.5 m which is shown in master plan of Hua – Hin Municipality.

Figure 4.7C: At Section A2 – A4

This figure was look from the east to the west. This is the intersection point of Klong Sanam Bin and Klong Hua – Hin 1. That trench is irrigation canal (see more in Figure 4.7d) and the bridge is on Liab Klong Chonpratan Road.

Figure 4.7D: At Point A4

This is the obstruction of the trench. This figure was look from the north to the south. This photo tells something more than words. The flume of irrigation canal is more 90% of flow in Klong Sanam Bin.

Figure 4.7 Existing Condition of the overall system of Klong Sanam Bin

Figure 4.7E: At point A4 (another side)

This figure is look from the east to the west. This bridge has a little bit effect to the efficiency of Klong Sanam Bin by its pier at the center of canal's section

Figure 4.7F: At Section A4 – A5

This figure is look from the north to the south. This section of canal still is in the good condition. There are some plants in the bottom of this section but it's still acceptable.

Figure 4.7G: At Point A5

This figure is look from the east to the west. The culvert of railway obstructs the canal. This condition is moderate. There are loose plants in the canal, but, another side (not seen in the figure) quite poor because it is an earth canal.

Figure 4.7H: At SectionA5 – A6

This figure is look from the east to the west. The condition of canal is good, however, that stagnate water does not flow(as survey) because the culvert is higher than the bed slope of this canal(see in the next figure)

Figure 4.7 Existing Condition of the overall system of Klong Sanam Bin (Continue)

Figure 4.7I: At Point A6

This figure is look from the west to the east. This is the road culvert of highway No.4 at km. 224 + 332. The bed slope of this culvert incline from the west to the east (as survey), that is why stagnate water cannot thoroughly flow.

Figure 4.7J: At Section A6 – A7

This figure is look from the west to the east. This section of canal is on the eastern side of highway No.4. Its condition is quite poor. There are some loose plants in the bottom of canal.

Figure 4.7K: At Point A7

This figure is look from the west to the east. At this point, the canal is reduced the section (approximately 85% of the total section is reduced). The airport area is behind the wall.

Figure 4.7L: At Point A12

This figure is look from the south to the north. This is the connection of Klong Sanam Bin and Klong Kok Kluer. The airport is behind the gate. The condition at this point is quite poor. There are a lot of medium height of plants.

Figure 4.7 Existing Condition of the overall system of Klong Sanam Bin (Continue)

Figure 4.7M: At Section A2 – B1

This figure is look from the north to the south. This is Klong Saay Rabaay 1(or Klong Hua – Hin 1). It is an absolutely earth section. The condition is very good. The canal is wide which can contain a lot of excess runoff.

Figure 4.7N: At the end of Section A2 – B1

This figure is look from the north to the south. The section is reduced, so the efficiency is also reduced. However, it is in very good condition.

Figure 4.7O: At Point B1 (the eastern side)

This figure is look from the west to the east. This canal is the link of Klong Kok Kluer. The trench of irrigation canal (see more detail in the next Figure) is also obstruct the canal as same as Klong Sanam Bin.

Figure 4.7P: At Point B1 (enlarged view)

This figure is look from the north to the south. The flume obstructs almost 100% of the existing section.

Figure 4.7 Existing Condition of the overall system of Klong Sanam Bin (Continue)

Figure 4.7Q: At Section B1 – B2

This figure is look from the west to the east. There are a lot of narrow-leaved cattails in the bottom of this canal. The condition is quite poor due to the plants in the canal.

Figure 4.7R: At Point B2

This figure is look from the west to the east. This is the hydraulic structure of railway. That stagnate water cannot flow because the elevation of tunnel is higher than the bed of canal. The condition at this point is quite good.

Figure 4.7S: At Section B2 – B3

This figure is look from the east to the west. There are loose plants in the canal. The canal is quite shallow and the condition is quite poor.

Figure 4.7T: At Point B3

This figure is look from the west to the east. The culvert of highway No.4 (at Km 225+290) at this point is quite small and its length is quite long. The condition at this point is quite poor.

Figure 4.7 Existing Condition of the overall system of Klong Sanam Bin (Continue)

Figure 4.7U: At Section B3 – A12

This figure is look from the west to the east. This section is on the eastern side of highway No.4. There are dense plants in the canal. The condition in this section is poor due to the lack of maintenance.

Figure 4.7V: At Point A12

This figure is look from the north to the south. This point of canal is the connection of 2 canals but the canal is very narrow and shallow. Its condition is poor there are some plants in the canal.

Figure 4.7W: At Section A12 – B4

This figure is looked from the south to the west. The condition of canal at this section is quite good. The canal is quite shallow but wide.

Figure 4.7X: At Point B4

This figure is looked from the west to the east. This is the end of the system. This system is linked to the sea. However, the canal is reduced the section before it flows into the sea.

Figure 4.7 Existing Condition of the overall system of Klong Sanam Bin (Continue)

4. Determine the efficiency of Hydraulic Structure’s Infrastructure

Table 4.6 The Effect of Infrastructures due to The Efficiencies

Point	Type Of Infrastructure	Existing Cross Section Area(m^2)	Required Cross Sectional Area(m^2)	Efficiency
A4	Irrigation Canal	2.10 x 10(OST)	18.675	16.06%
A5	Railway Tunnel	2.1 x 3.0	26.985	23.35%
A6	Road Culvert	3(2.1x1.1)	27.175	25.50%
B1	Irrigation Canal	2.10 x 8(OST)	2.25	142.22%
B2	Railway Tunnel	2.1 x 3.0	11.40	55.26%
B3	Road Culvert	2(1.2 x 1.5)	23.52	15.31%

*OST = Obstruction, others are reduce section

4.2 Pipe System in Downtown Analysis

The network of pipe system in downtown is shown in Figure 4.8 – 4.10. The example of calculation the adequacy of pipe system is shown below. The section of pipe which is selected is the culvert of Highway No.4 on the intersection of Decha Nuchit Road. At this point, it is considered to be the most critical pipe in downtown because it always floods after heavy rainfall.

1. Return Period

As mentioned, this study want to determine the adequacy of existing drainage system, so, there are a lot of Return Period would be considered which are 2 years, 5 years, 10 years, and 25 years respectively. In fact, Return Period is used to state the size of drainage system. However, this calculation will show only the use of 25 Year - Return – Period. Hence, the rainfall intensity (i), and runoff coefficient(c) are;

2. Time of Concentration (t_c)

$$t_C = t_0 + t_d \tag{19}$$

Where;

t_C = $time\ of\ concentration(min)$

t_0 = $time\ of\ the\ remostest\ distance(min)$

t_d = $time\ of\ flow\ in\ pipe(min)$

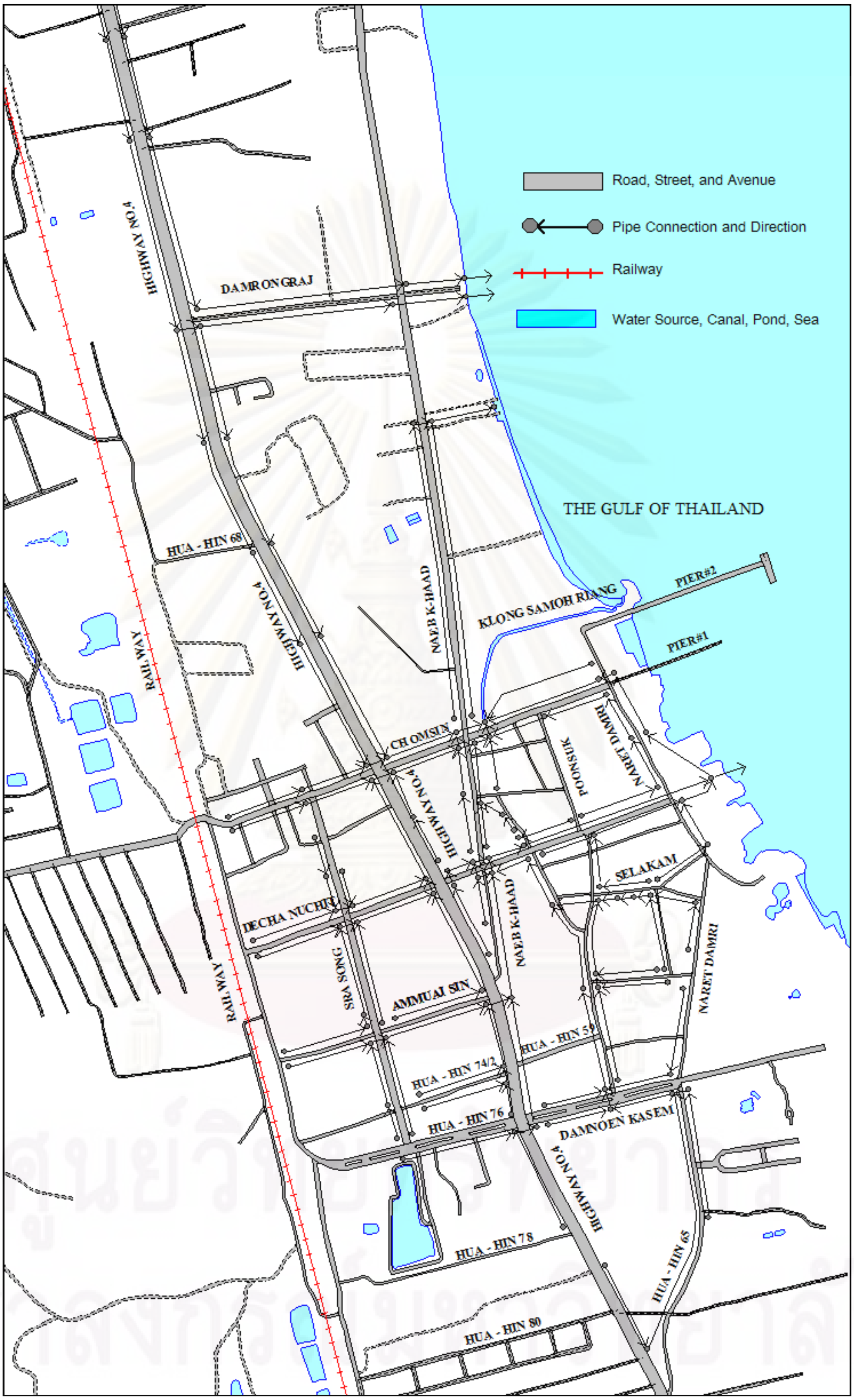

Figure 4.8 Detail of Downtown of Hua – Hin Municipality and Pipe Network

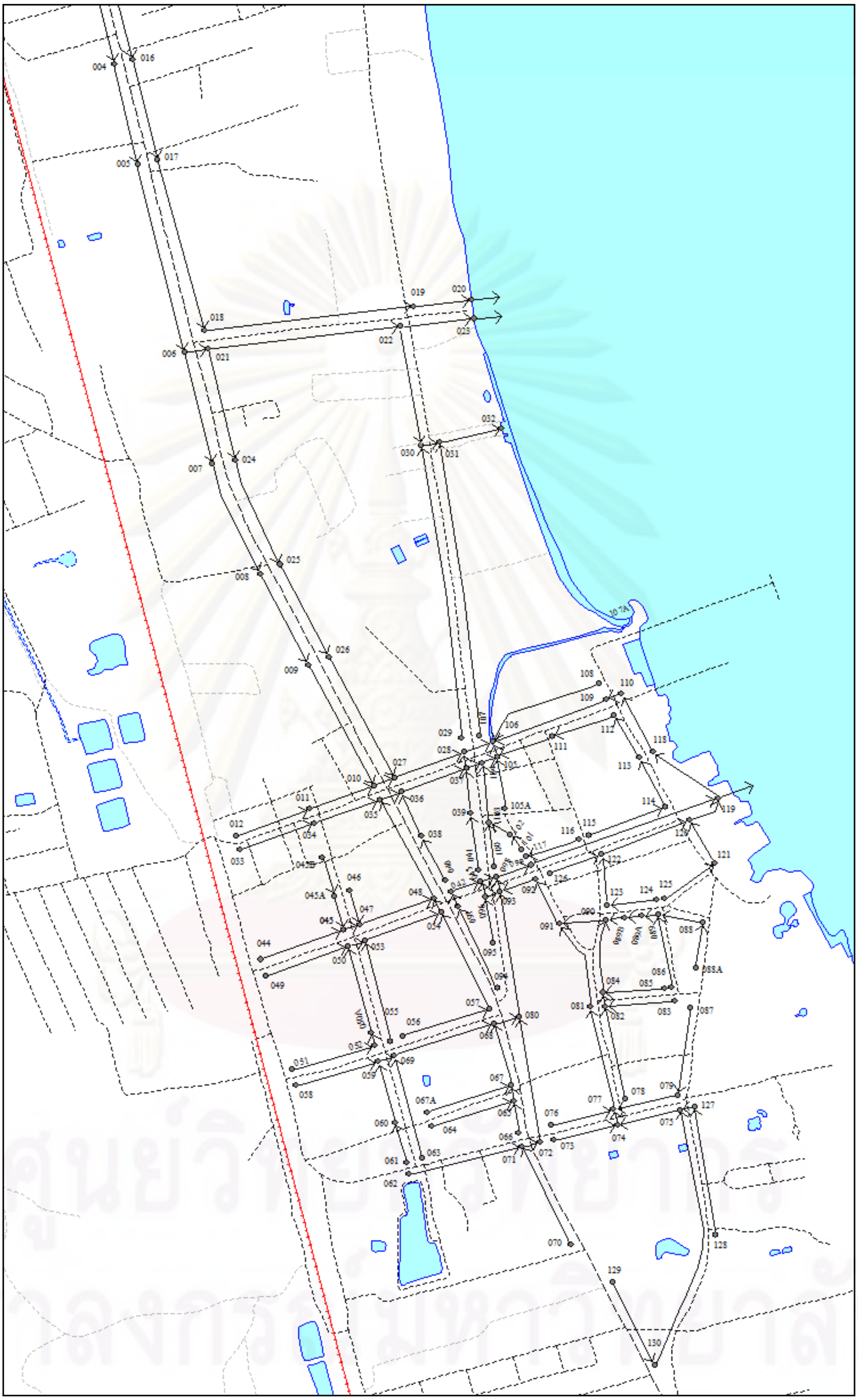

Figure 4.9 The Network of Pipe System in Downtown of Hua – Hin Municipality

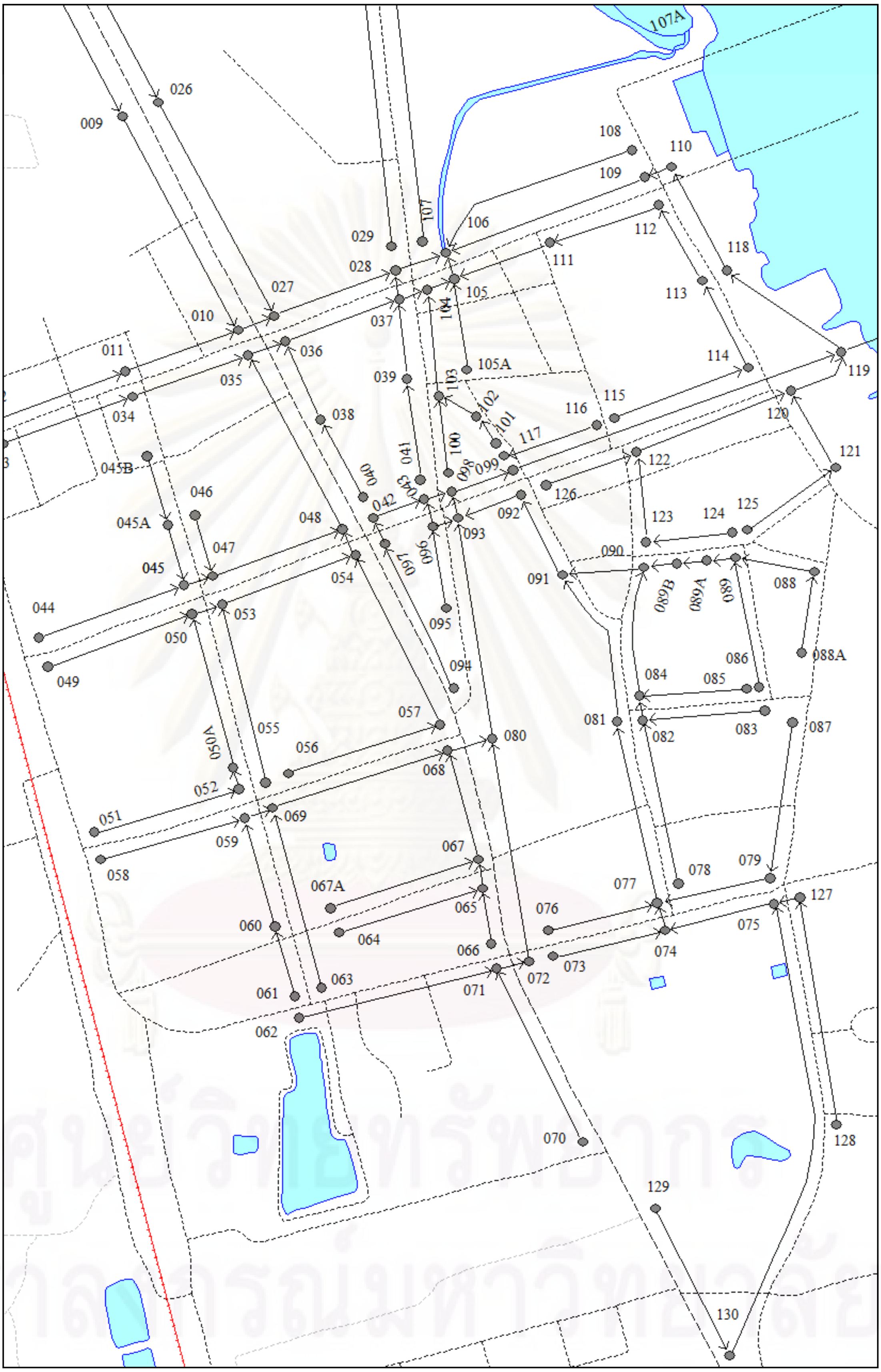

Figure 4.10 The Enlarge View of Network of Pipe System

a. Time of the remotest distance(t_0)

$$t_0 = \left[\frac{(0.067n'l)}{S}\right]^{0.467} \tag{20}$$

$$= \left[\frac{(0.067)(0.015)(95)}{(0.40)}\right]^{0.467}$$

$$= 0.51\ minute$$

Where;

t_0 = *time of the remostest distance(min)*

n' = *flow resistance coefficient*

l = *the remostest distance in sub-catchment(m)*

S = *slope of sub-catchment(m/m)*

b. Time of Flow in Pipe (t_d)

According to flow in pipeline, before the time of flow in pipe can be determined, the velocity of flow must be calculated first by using;

$$v_f = \frac{(\sqrt[3]{R^2}\ .\ \sqrt{S})}{n} \tag{21}$$

$$= \frac{\left(\sqrt[3]{\left(\frac{1.0}{4}\right)^2}\ .\ \sqrt{0.004}\right)}{0.015}$$

$$= 1.67\ m/s$$

Where;

v_f = *velocity of flow in pipe(m/s)*

R = *hydraulic radius(m)*

s = *bed slope of pipe(m)*

n = *Manning's "n" roughness*

So, the time of flow in pipe can be calculated by using;

$$t_d = \frac{L}{v_f} = \left(\frac{25}{1.67}\right) second \quad (22)$$

$$= \frac{14.97}{60} = 0.25\ minute$$

Where;

t_d = time of flow in pipe (min)

L = length of pipe (m)

v_f = velocity of flow in pipe (m/s)

3. Rainfall Intensity(i)

Rainfall intensity can be identified from the curve of relationship between rainfall intensity and return period. This curve can be determined from the statistic in each local area. This research uses the data from Hua – Hin Weather station. In this case, the maximum rainfall intensity of 25 Year – Return – Period at 1 day, so, rainfall intensity at 25 years return period is 127 mm/hr.

4. Maximum Flow of Runoff

The maximum flow rate of runoff can be calculated by using

$$Q_f = CiA \quad (23)$$

$$= \frac{0.88 x 127 x 186,000}{1,000 x 3,600} = 5.77\ m^3/s$$

Where;

Q_f = maximum flow rate (m^3/s)

C = runoff coefficient

i = rainfall intensity (mm/hr)

A = sub-catchment area (m^2)

5. Waste Water Flow

The average flow rate of waste water and maximum flow rate of wastewater can be calculated as;

$$ADF = [AWW + AIF] \quad (24)$$

$$= [(500x200x0.8) + (500x200x0.8x0.2)]$$

$$= 96,000\ litres/day = 0.001\ m^3/s$$

Where;

$$ADF = average\ daily\ flow$$
$$AWW = amount\ of\ wastewater$$
$$= 80\%\ of\ [population(capita)\ x\ water\ consumption(l/capita/day)]$$
$$AIF = amount\ of\ infltrated\ groundwater$$
$$= 20\%\ of\ AWW$$

The maximum hourly flow rate is 1.8 times of the average daily flow, so, it is;

$$Q_{max}.h = 1.8\ x\ ADF \quad (25)$$
$$= 1.8\ x\ 0.001$$
$$= 0.002\ m^3/s$$

6. Design Flow Rate (Q_d)

$$Q_d = Q_f + Q_{max}.h + \sum Q_f$$
$$= 5.77 + 0.002 + 39.35$$
$$= 45.12\ m^3/s$$

Where;

$$\sum Q = cumulative\ discharge\ from\ the\ former\ pipe\ network$$

7. Design Size and Slope of Pipe

The size of pipe no. 035 - 035 has the diameter of 1.0 m, and bed slope of pipe is 1:250(or 0.00025 m/m). And then, this size and slope of pipe would be checked by compare with the minimum and maximum velocity of flow in pipe which is 0.60 and 3.00 m/s respectively.

1. In case of fully flow

$$Q_f = v_{min}\ .\ A = v_{min}\ .(\frac{\pi D^2}{4}) \quad (26)$$
$$= (1.67)(\frac{\pi(1.0)^2}{4})$$
$$= 1.31\ m^3/s$$

2. In case of Design Maximum Flow Rate(Q_d)

$$\frac{Q_d}{Q_f} = \frac{45.12}{1.31} = 34.33$$

$$\frac{d}{D_f} = (\frac{Q_d}{Q_f} x\, 0.7235) + 0.1151 = 24.96$$

$$\frac{v}{v_f} = \frac{(\frac{d}{D_f} + 0.1079)}{0.6337} = 39.55$$

This can be explained as;

$$Water\ Level\,(d) = d_p . \frac{d}{D_f} = 1.0\ x\ 24.96$$

$$= 24.96\ m$$

$$Velocity\ of\ Flow = v_f . \frac{v}{v_f} = 39.55\ x 1.67$$

$$= 66.18\ m/s\ (Underdesign)$$

8. Result

After all of data were analyzed as shown in Table 4.7 – 4.10. The pipe sections which are affected by Highway No. 4 include; Pipe no. 010 – 027, 035 – 036, 068 – 080, and 071 – 072.

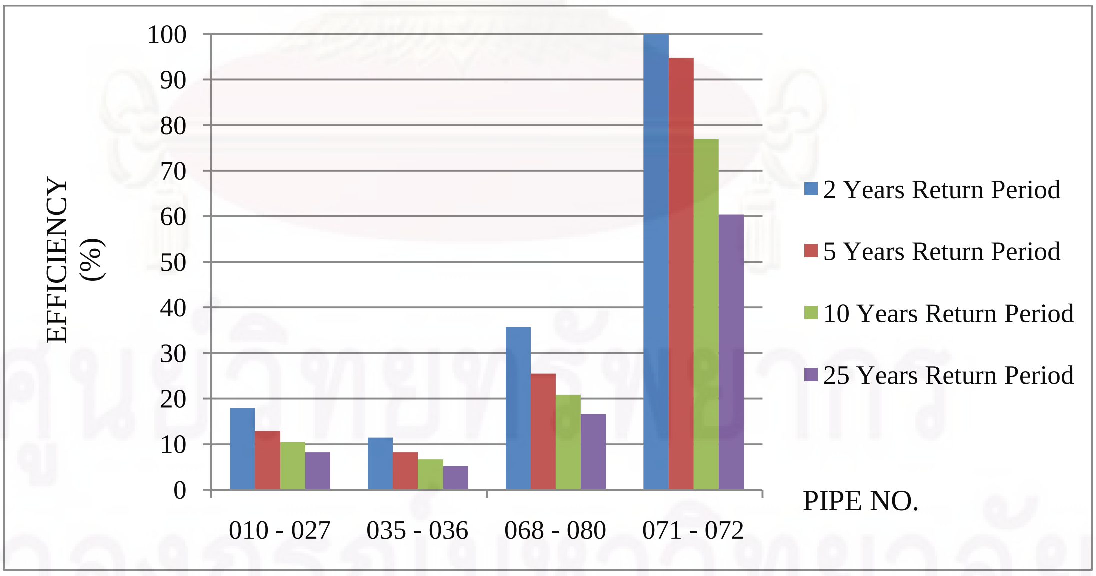

Figure 4.11 The Comparison of the Efficiency of Pipe System in any Return Period

Table 4.7 The Efficiency of Culverts in Downtown by 2 Year Return Periods

Section	Q_{max} (m^3/s)	L (m)	A_{exist} (m^2)	$A_{require}$ (m^2)	Efficiency (%)	Recommendation (m)
010 – 027	13.14	25	0.785	4.38	17.92	2.1x2.1
035 – 036	20.60	25	0.785	6.87	11.43	2.65x2.65
068 – 080	4.29	35	0.510	1.43	35.66	Ø1.6
071 – 072	1.78	20	0.785	0.59	133.05	Ø1.0

Table 4.8 The Efficiency of Culverts in Downtown by 5 Year Return Periods

Section	Q_{max} (m^3/s)	L (m)	A_{exist} (m^2)	$A_{require}$ (m^2)	Efficiency (%)	Recommendation (m)
010 – 027	18.34	25	0.785	6.11	12.85	2.5x2.5
035 – 036	28.76	25	0.785	9.57	8.20	2(2.20x2.20)
068 – 080	6.00	35	0.510	2.00	25.50	Ø1.6
071 – 072	2.49	20	0.785	0.83	94.76	Ø1.2

Table 4.9 The Efficiency of Culverts in Downtown by 10 Year Return Periods

Section	Q_{max} (m^3/s)	L (m)	A_{exist} (m^2)	$A_{require}$ (m^2)	Efficiency (%)	Recommendation (m)
010 – 027	22.45	25	0.785	7.48	10.49	2.75x2.75
035 – 036	35.20	25	0.785	11.73	6.69	2(2.45x2.45)
068 – 080	7.34	35	0.510	2.45	20.82	Ø2.0
071 – 072	3.05	20	0.785	1.02	76.96	Ø1.2

Table 4.10 The Efficiency of Culverts in Downtown by 25 Year Return Periods

Section	Q_{max} (m^3/s)	L (m)	A_{exist} (m^2)	$A_{require}$ (m^2)	Efficiency (%)	Recommendation (m)
010 – 027	28.60	25	0.785	9.53	8.24	2(2.20x2.20)
035 – 036	45.14	25	0.785	15.05	5.22	2(2.75x2.75)
068 – 080	9.19	35	0.510	3.06	16.67	Ø2.0
071 – 072	3.91	20	0.785	1.30	60.38	Ø1.6

Remark;

$$Efficiency = \left| \frac{A_{exist} - A_{require}}{A_{exist}} \right| x100$$

All of calculations of total pipe section in downtown are tabulated in appendix D.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Another important factor of the growth of Hua – Hin municipality is the development of infrastructures. According to its characteristics, Hua – Hin municipality is a city of Thailand which has completed the development of infrastructures for instance the passing of Highway No.4, railway, the eastern side is belong the gulf of Thailand which suitable to develop as port for commercial and tourism, and also irrigation canal for the development of agriculture and consumption of the city. Hence, many developments of the city can be praised as the development of these infrastructures.

However, the development of infrastructures is important to study the accuracy of construction and absolutely designed network to receive the extreme benefits of them. Although infrastructures advantage to the city but if there was less management efficiently, infrastructures would be the double – edges sword which can extremely disadvantage to the city.

This study can conclude the effects of infrastructure in Hua – Hin municipality as, though, Hua – Hin municipality has complete the components of infrastructure but the lack of management consequently cause the severe problem to this city.

The externalities which cause flood problem in Hua – Hin municipality include that the slope of its topography influent the velocity of excess runoff due to hillside area in the west. Moreover, Hua – Hin municipality receive the excess runoff from its vicinity such as the excess runoff from Huay Noi Sub – catchment which locate in Cha – Am municipality. The change of land use also influent the runoff coefficient of the city such as field area was changed to be hotel and also the seaside hotel and residences always fill up the land which will obstruct the flood way in this area.

The main infrastructures which cause the flood problem are 1) Highway No.4, 2) Railway, and 3) irrigation canal. As mentioned in previous chapter, this area is the natural drainage system which all of excess runoff will flow from the west to the east by both of natural canals and on ground. The study found that these infrastructures act like the walls obstructing the flood way, so, flood problem spread widely along these infrastructure. Moreover, they also obstruct the flow of runoff in canals which consider as the bottle neck that cause the flood problem between the banks of these canals.

The existing drainage system can be used efficiently do not exceed 50% of their total efficiency. The recommendations of opened – channel system, this system should avoid the obstruction of irrigation canal, enlarge the size of tunnel under railway, and. For the improvement of pipe system in downtown, it should be changed the culverts of Highway No.4 from pipes to be box culverts, and also re-design the cross – section of Highway No.4 to replace the canal in the middle of road, or design the inclination of it from the west to the east in the both sides or in the same direction.

As mentioned in the calculation part, the efficiency of these infrastructures quite low, so, they cannot be used effectively when there was a very heavy rain as it used to be in the past.

Naturally, the area in hillside coastal plain is the specific area where is the natural drainage system, so, the development of the city or city plan should consider significantly to the drainage system. Although flood problem does not occur every year, however, when it occurred, it will severely destroy that city. Finally, for the permanently development, all of the city where are in hillside coastal plain should consider the development of drainage system first of all.

5.2 Limitations under the Use of Data

1. The lack of uniformity of collected data from the different government agencies. For example, the collected data based on administrative boundaries differs instead of hydrological boundaries. The short period to collect more data is also the main problems in this study. Also the collected data from any agencies differ in the system or database storage. Hence, the data which are obtained from those agencies are not adequate enough for analysis, and some of them indicated the errors and inaccurate results.

2. The velocity of runoff data is not available. So, the flood analysis of this study does not include of the identification of lag time.

3. The out – of – date maps is also the main problems. Within 10 years, Hua – Hin municipality has the high growth rate in development, so, all of maps which were gathered from the agencies do not accurate, even though in the remote area of the study area.

5.3 Recommendations for Future Studies

This study is carried out as a preliminary study in indentifying the effects of infrastructures and checking the drainage systems of the developing city in hillside coastal plain and/or the similar conditions of the study area. Therefore the improvement may be made as follows;

1. The detail of study on the effects of flood control structures, such as reservoirs, floodway, and dike etc. on the changing condition of inundation area. The flood conditions should be undertaken made in order to develop the definite flood area under the influence of the flood control.

2. The duration of flood should be estimated for each sub – catchment if there is enough information.

3. The history and recording data are important for analysis and identifications of flood. Therefore, all of the information and data, if available, should be fully integrated in the future.

4. The rainfall frequency analysis in terms of different rainfall return periods can be further used in the evaluation of scale or magnitude of flood in Hua – Hin municipality because all of sub – catchments of rainfall data in this area have already been recorded.

5. The extreme value analysis used for any flood of specific return period does not entirely based on rainfall or flood. The return periods can be computed separately for synthetic flood peaks and lag time.

6. The analysis of economic should be employed in this kind of study. This is also the important factor to develop the city. Although, the design of drainage system is enough but there is no fund or investment enough to develop the drainage system.

7. The use of Saint - Venant’s equation should be applied in order to use the stimulated programs such as MIKE11, hydro work, SWMM, etc.

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APPENDICES

APPENDIX A

Typical Information of Hua – Hin Municipality

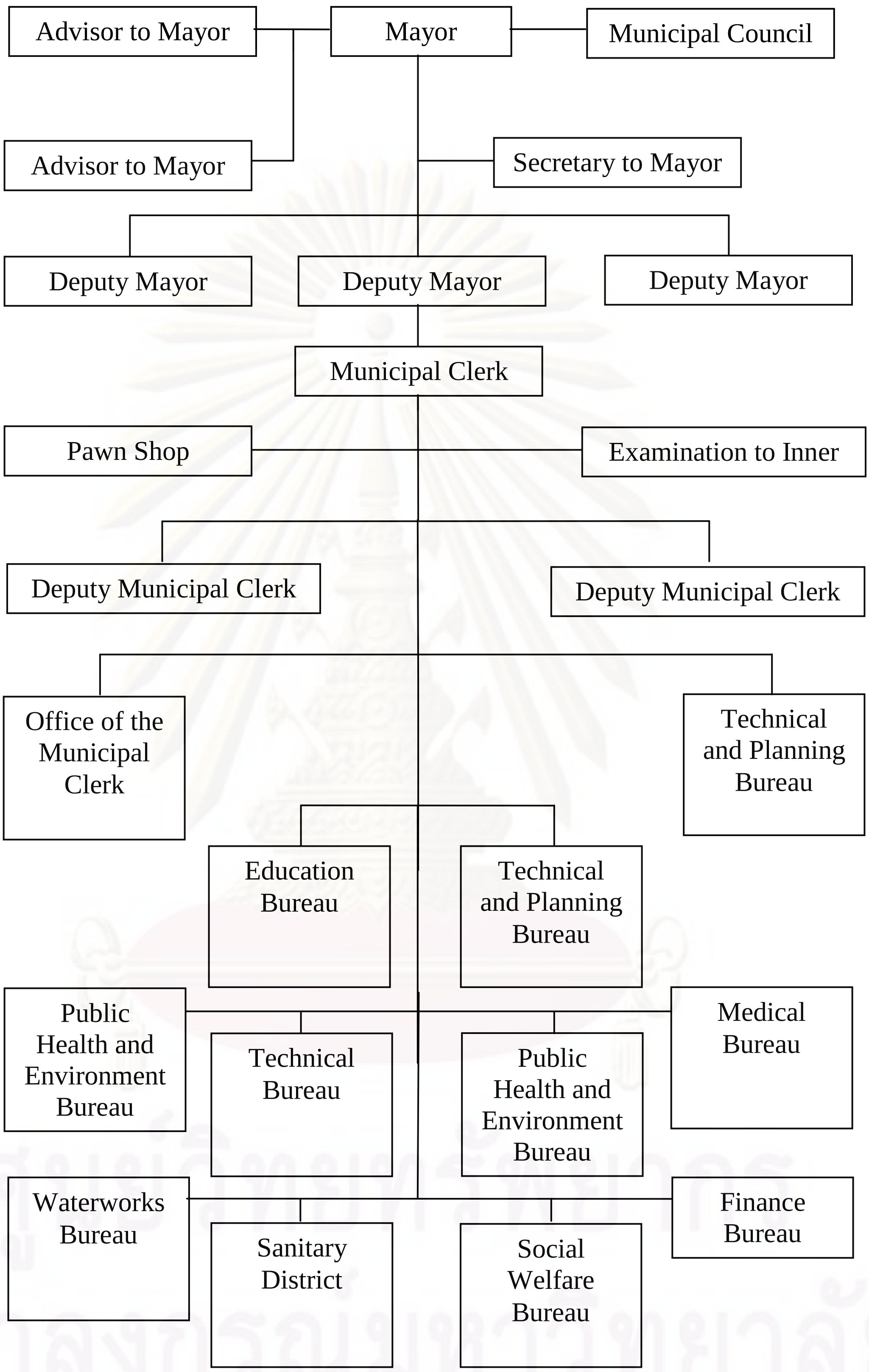

Figure A1 Management Structure of Hua – Hin Municipality
Source: Hua – Hin Municipality, or www.huahin.go.th

Table A1 Data of Visitors in Hua – Hin Municipality in 2004

Descriptions		Domestics	Foreigners	Total
Visitor		1,675,143	329,460	2,004,603
Tourists		854,700	299,702	1,154,402
Excursionist		820,443	29,758	850,201
Number of Visitors Categorize by Travelling				
Types Of Travelling	Airplane	144	169	313
	Train	271,733	63,394	335,127
	Bus	659,753	107,906	767,659
	Car	743,513	157,991	901,504
Number of Tourists Categorize by Types of Accommodations				
Hotel		348,754	236,222	584,976
Guesthouse		24,955	39,309	64,264
Bungalow/Resort		52,162	19,390	71,552
House of Relatives/Friend		396,902	-	396,902
National Park Accommodation		11,069	2,302	14,160
Motel		20,069	2,479	22,548

Source: The Tourism Authority of Thailand

Table A2 Future Populations of Hua – Hin Municipality

Year	Population(R = 1.69)			Population(R = 2.05)		
	Registration	Conceal	Total	Registration	Conceal	Total
2004	45,363	25,736	71,099	45,363	25,736	71,099
2007	47,700	27,400	75,100	48,200	27,344	75,544
2009	51,900	28,500	80,400	53,400	30,294	83,694
2014	56,500	31,600	88,100	59,200	33,584	92,784
2019	61,500	35,000	96,500	65,600	37,215	102,815
2024	66,900	38,800	105,700	72,700	41,243	113,943

Source: 1. The Bureau of Registration Administration Department of Provincial Administration
2. www.dopa.go.th
3. Future Populations by Department of Public Works and Towns and Country Planning

Table A3 Forecast of Visitors in Hua – Hin Municipality

Year	Number of Visitors	Average Growth (%)
1993	1,264,933	-
1994	1,546927	22.29
1995	3,088,700	99.67
1996	3,712,893	20.21
1997	3,626,009	-2.34
1998	4,192,707	15.63
1999	4,557,226	8.69
2000	4,669,080	2.45
2001	4,780,432	2.38
2002	5,004,984	4.70
2003	5,139,196	2.68
2004	6,023,317	17.20
2005	6,397,156	6.21
2006	6,770,996	5.84
2007	7,144,835	5.52
2008	7,518,674	5.23
2009	7,892,514	4.97
2010	8,266,353	4.74
2011	8, 640,192	4.52
2012	9,014,032	4.33
2013	9,387,871	4.15
2014	9,761,710	3.98
2015	10,135,550	3.83
2016	10,509,389	3.69
2017	10,883,229	3.56
2018	11,257,068	3.44
2019	11,630,907	3.32
2020	12,004,747	3.21
2021	12,378,586	3.11
2022	12,752,425	3.02
2023	13,126,265	2.93
2024	13,500,104	2.85

Source: The Tourism Authority of Thailand

Table A4 Water Demand Forecasting for Residential Area of Hua – Hin Municipality

Year	Populations			Water Consumption (m^3/day)	Average Water Demand (m^3/day)
	Registration	Conceal	Total		
2004	45,363	25,736	71,099	230	16,353
2009	50,300	28,500	78,800	242	19,049
2014	55,700	31,600	87,300	254	22,180
2019	61,700	35,000	96,700	267	25,821
2024	68,400	38,800	107,200	270	28,911

Source: Future Populations by Department of Public Works and Towns and Country Planning

Table A5 Total Water Demand Forecasting of Hua – Hin Municipality

Year	Average Water Demand (m^3/day)			
	Resident	Business	Government	Total
2004	16,353	1,238	6,226	23,817
2009	19,049	1,238	7,165	27,452
2014	22,180	1,238	8,246	31,664
2019	25,821	1,238	9,490	36,549
2024	28,911	1,238	11,031	41,180

Source: Future Populations by Department of Public Works and Towns and Country Planning

Table A6 Wastewater Forecasting of Hua – Hin Municipality

Year	Average Wastewater Water (m^3/day)			
	Resident	Business	Government	Total
2004	15,699	1,188	5,977	22,864
2009	18,287	1,188	6,879	26,354
2014	21,293	1,188	7,916	30,397
2019	24,788	1,188	9,111	35,087
2024	27,755	1,188	10,590	39,533

Source: Future Populations by Department of Public Works and Towns and Country Planning

APPENDIX B

Hydrological Information of Hua – Hin Municipality

Table B1 The Amount of Average Runoff of Sub – Catchments during April - September

No.	Sub – Catchment	Area	The Amount of Average Monthly Runoff						Rate of Runoff
			APR	MAY	JUN	JUL	AUG	SEP	
1	HUAY NOI	4.27	0.06	0.10	0.09	0.10	0.07	0.07	3.83
2	KLONG SANAM BIN	7.23	0.10	0.16	0.15	0.17	0.11	0.11	3.69
3	KLONG BANG KWIEN HUK	5.63	0.08	0.13	0.12	0.13	0.09	0.09	3.79
4	KLONG NIN	6.04	0.09	0.13	0.13	0.14	0.09	0.09	3.70
5	KLONG TALAY NOI	5.97	0.09	0.13	0.13	0.14	0.09	0.09	3.74
6	KAO HIN LEK FIRE	6.69	0.09	0.15	0.14	0.16	0.10	0.10	3.69
7	KLONG BOH MA-PROW	2.26	0.04	0.06	0.05	0.06	0.04	0.04	4.28
8	KLONG KAO TA-KIAB	24.23	0.30	0.47	0.45	0.49	0.33	0.33	3.26
9	KLONG TIAN	8.54	0.12	0.18	0.17	0.19	0.13	0.13	3.59
10	KAO E- LUN	5.21	0.08	0.12	0.11	0.12	0.08	0.08	3.77
11	KLONG KAO TAO	7.25	0.10	0.16	0.15	0.17	0.11	0.11	3.68
12	KAO TUNG SINE YAI	1.23	0.02	0.03	0.03	0.03	0.02	0.02	4.07
Total		84.55	1.17	1.82	1.72	1.90	1.26	1.26	3.60

Source: Hua – Hin Weather Station, Thai Meteorological Department

Table B2 The Amount of Average Runoff of Sub – Catchments during October - March

No.	Sub – Catchment	Area	The Amount of Average Monthly Runoff						Rate of Runoff
			OCT	NOV	DEC	JAN	FEB	MAR	
1	HUAY NOI	4.27	0.33	0.43	0.10	0.03	0.01	0.12	7.96
2	KLONG SANAM BIN	7.23	0.53	0.68	0.15	0.05	0.02	0.20	7.51
3	KLONG BANG KWIEN HUK	5.63	0.42	0.54	0.12	0.04	0.02	0.16	7.70
4	KLONG NIN	6.04	0.45	0.58	0.13	0.04	0.02	0.17	7.67
5	KLONG TALAY NOI	5.97	0.44	0.57	0.13	0.04	0.02	0.17	7.65
6	KAO HIN LEK FIRE	6.69	0.49	0.64	0.14	0.05	0.02	0.19	7.62
7	KLONG BOH MA-PROW	2.26	0.19	0.24	0.05	0.02	0.01	0.07	8.55
8	KLONG KAO TA-KIAB	24.23	1.55	2.02	0.45	0.15	0.06	0.59	6.63
9	KLONG TIAN	8.54	0.61	0.79	0.18	0.06	0.03	0.23	7.42
10	KAO E- LUN	5.21	0.39	0.51	0.11	0.04	0.02	0.15	7.81
11	KLONG KAO TAO	7.25	0.53	0.68	0.15	0.05	0.02	0.20	7.49
12	KAO TUNG SINE YAI	1.23	0.11	0.14	0.03	0.01	0.00	0.04	8.94
Total		84.55	6.04	7.82	1.74	0.58	0.25	2.29	7.38

Source: Hua – Hin Weather Station, Thai Meteorological Department

Table B3 The Maximum Amount of Rainfall at Specific Date for 30 Years

YEAR	1 – DAY		2 – DAY		3 - DAY	
	mm	Date	mm	Date	mm	Date
1952	72	FEB 10	87	OCT 15	97	OCT 14
1953	141	FEB 7	145	FEB 7	167	FEB 7
1954	52	JAN 12	83	FEB 2	102	JAN 30
1955	83	JUL 4	126	JUL 18	126	JUL 18
1956	96	AUG 6	140	AUG 14	143	AUG 14
1957	49	MAR 3	69	JUL 29	69	JUL 29
1958	70	JUL 7	100	JUL 18	112	JUL 16
1959	76	AUG 7	109	AUG 24	109	AUG 24
1960	97	JUL 5	150	JUL 4	172	JUL 3
1961	78	AUG 4	130	AUG 21	145	AUG 20
1962	44	MAY 3	47	MAY 12	50	MAY 10
1963	87	AUG 8	97	AUG 3	124	AUG 2
1964	95	AUG 1	179	AUG 1	215	AUG 1
1965	85	JUL 5	112	JUL 14	119	JUL 14
1966	58	APR 11	85	JUL 5	128	JUL 5
1967	142	JUL 8	204	JUL 26	212	JUL 25
1968	117	JUL 3	125	JUL 20	134	JUL 19
1969	429	AUG 2	603	AUG 2	726	AUG 1
1970	208	AUG 12	239	AUG 29	270	AUG 29
1971	63	JUL 3	71	JUL 11	76	JUL 10
1972	169	AUG 9	169	AUG 26	172	AUG 25
1973	119	AUG 3	206	AUG 12	235	AUG 12
1974	53	AUG 5	82	JUL 8	119	JUL 7
1975	95	AUG 4	129	AUG 4	142	AUG 3
1976	89	AUG 1	133	JUL 31	151	JUL 30
1977	122	JUL 10	162	JUL 10	176	JUL 9
1978	108	JUL 5	132	JUL 23	165	FEB 11
1979	90	APR 7	95	APR 15	104	APR 16
1980	66	JUL 5	72	APR 31	72	APR 31
1981	176	DEC 9	182	DEC 26	195	AUG 6
1982	39	JAN 10	49	DEC 6	52	AUG 8
1983	88	AUG 7	149	AUG 16	206	AUG15
1984	48	MAY 9	56	APR 11	61	APR 11
1985	70	JUL 3	95	APR 18	114	APR 17
1986	225	FEB 8	262	FEB 7	262	FEB 7
1987	120	AUG 8	162	AUG 7	181	AUG 8
1988	104	JUL 10	104	JUL 19	115	FEB 3
1989	34	JUN 5	39	JUN 23	56	AUG 2
1990	76	JUL 10	98	JUL 27	99	JUL 27
1991	86	APR 6	111	JUL 27	112	JUL 26

Source: Hua – Hin Weather Station, Thai Meteorological Department

Table B4 The Amount of Monthly Rainfall for 30 Years

Station Code: 45043
Source: 45043 A. Hua-Hin ; RID
Province: Prachuabkhirikhan

Year	Monthly Rainfall (mm)												Annual 365
	APR 30	MAY 31	JUN 30	JUL 31	AUG 31	SEP 30	OCT 31	NOV 30	DEC 31	JAN 31	FEB 28	MAR 31	
1952	0.0	113.7	47.4	40.2	56.6	77.6	340.7	21.8	23.6	170.8	51.5	1.6	946
1953	96.2	263.8	93.4	60.2	168.9	63.9	159.7	317.7	2.2	2.3	0.0	0.0	1,228
1954	61.5	166.1	103.1	80.1	141.8	126.1	146.3	5.1	0.8	4.8	30.5	7.3	874
1955	4.1	59.6	144.7	57.2	78.7	147.3	450.4	180.8	0.0	0.0	0.0	51.2	1,174
1956	97.1	159.6	105.5	87.8	121.1	164.4	241.1	184.2	0.2	0.0	0.0	0.0	1,161
1957	11.6	43.0	134.2	90.9	148.1	196.3	168.6	46.1	0.8	1.9	33.5	0.2	875
1958	2.1	21.5	71.7	97.9	116.3	156.6	374.7	4.2	0.0	0.0	17.8	64.9	928
1959	28.1	48.3	26.2	141.7	86.0	149.9	201.4	148.2	15.1	6.6	33.3	0.0	885
1960	5.9	73.9	88.6	61.1	57.4	122.4	285.5	164.1	12.5	0.0	98.4	0.9	971
1961	97.9	151.2	50.9	73.2	117.7	107.8	375.9	159.4	2.9	2.5	6.1	122.9	1,268
1962	2.2	71.2	63.5	67.6	149.1	114.2	42.8	22.1	18.7	0.0	0.6	7.1	559
1963	1.2	29.2	97.3	84.5	64.8	142.0	173.4	317.6	1.4	78.7	27.5	0.8	1,018
1964	8.1	169.7	15.9	29.9	137.9	110.1	264.4	219.2	5.4	0.0	0.0	0.0	961
1965	28.2	109.6	41.1	61.2	251.6	122.5	176.4	87.2	63.6	0.0	17.2	1.2	960
1966	2.0	167.7	78.5	129.2	167.5	103.1	301.8	63.6	61.3	1.3	8.0	11.8	1,096
1967	8.6	101.2	48.8	114.7	45.2	82.5	410.2	17.4	0.2	1.0	44.9	58.2	933
1968	76.0	37.5	108.1	63.1	46.1	90.4	369.1	27.4	0.0	55.5	15.6	21.5	910
1969	80.4	31.7	49.0	81.3	102.3	158.2	250.5	790.4	0.5	115.5	65.4	41.1	1,766
1970	6.0	66.0	79.8	112.8	48.0	314.0	160.9	258.7	69.1	4.7	1.3	24.5	1,146
1971	0.9	88.2	55.5	74.4	59.9	129.7	205.5	55.7	34.3	0.0	9.7	38.3	752
1972	115.4	60.0	141.0	62.6	117.7	62.7	121.0	658.7	149.1	0.2	0.9	15.5	1,505
1973	11.7	114.0	161.8	76.5	83.3	229.5	240.2	419.0	8.9	0.0	2.1	12.9	1,360
1974	90.7	94.2	48.0	88.9	75.9	81.8	240.6	172.6	5.8	55.9	1.2	0.0	956
1975	85.5	163.2	36.8	62.7	80.3	164.3	170.4	162.0	10.5	0.0	0.3	1.8	938
1976	9.4	105.2	114.2	96.6	205.5	173.8	217.0	248.9	9.7	0.0	11.5	27.7	1,220
1977	40.3	119.4	64.2	152.1	92.2	130.1	259.7	30.6	17.6	3.0	103.4	0.0	1,013
1978	14.0	254.7	78.1	164.8	46.4	155.5	231.6	7.3	0.8	2.8	1.3	0.0	957
1979	3.0	28.7	29.2	131.4	87.4	99.8	67.9	1.1	0.0	0.0	27.3	8.5	484
1980	55.6	21.7	96.7	95.3	146.4	58.3	215.8	80.1	6.7	1.2	5.9	22.7	806
1981	63.7	146.5	90.4	30.2	82.0	151.1	168.2	283.3	0.2	0.0	53.1	184.2	1,253
1982	54.4	85.1	72.4	73.5	46.1	61.1	81.0	98.9	2.2	4.5	0.0	48.7	628
1983	0.0	63.3	52.0	66.8	193.3	43.4	260.8	394.1	48.4	6.4	16.2	5.4	1,150
1984	12.1	31.4	126.6	128.6	71.5	87.8	126.7	7.1	0.0	2.2	25.7	19.5	639
1985	43.6	141.3	96.9	272.7	69.2	101.9	246.2	167.2	0.0	0.0	0.0	0.0	1,139
1986	46.6	300.1	16.7	104.2	39.8	90.0	179.3	125.7	20.3	0.0	0.0	20.4	943
1987	31.7	33.8	81.4	62.0	107.3	47.8	137.5	595.9	0.0	0.9	3.7	9.1	1,111
1988	49.4	252.2	133.6	172.8	76.4	121.7	240.7	54.9	0.0	9.5	33.0	16.2	1,160
1989	2.1	45.4	35.6	31.4	89.1	83.7	0.0	95.3	0.1	0.0	0.0	16.6	399
1990	4.8	111.4	10.5	31.7	41.3	79.8	219.7	89.9	0.0	0.0	16.8	3.5	609
1991	75.0	106.0	85.5	120.3	125.6	196.9	328.0	8.3	0.0	1.7	3.5	0.0	1,051
Average	35.7	106.3	76.9	90.9	101.0	122.5	221.3	169.8	14.8	13.3	19.2	21.7	993
σ	35.2	70.3	37.8	46.0	49.3	52.9	97.4	183.5	28.3	34.7	25.3	35.6	264
Max	115.4	300.1	161.8	272.7	251.6	314.0	450.4	790.4	149.1	170.8	103.4	184.2	1,766
Min	0.0	21.5	10.5	29.9	39.8	43.4	0.0	1.1	0.0	0.0	0.0	0.0	399
Upper	70.9	176.6	114.7	136.9	150.3	175.4	318.7	353.3	43.1	48.0	44.5	57.2	1,258
Lower	0.4	35.9	39.0	44.8	51.8	69.6	123.9	-13.8	-13.4	-21.3	-6.1	-13.9	729

Source: Hua – Hin Weather Station, Thai Meteorological Department

APPENDIX C

Roadway Information of Hua – Hin Municipality

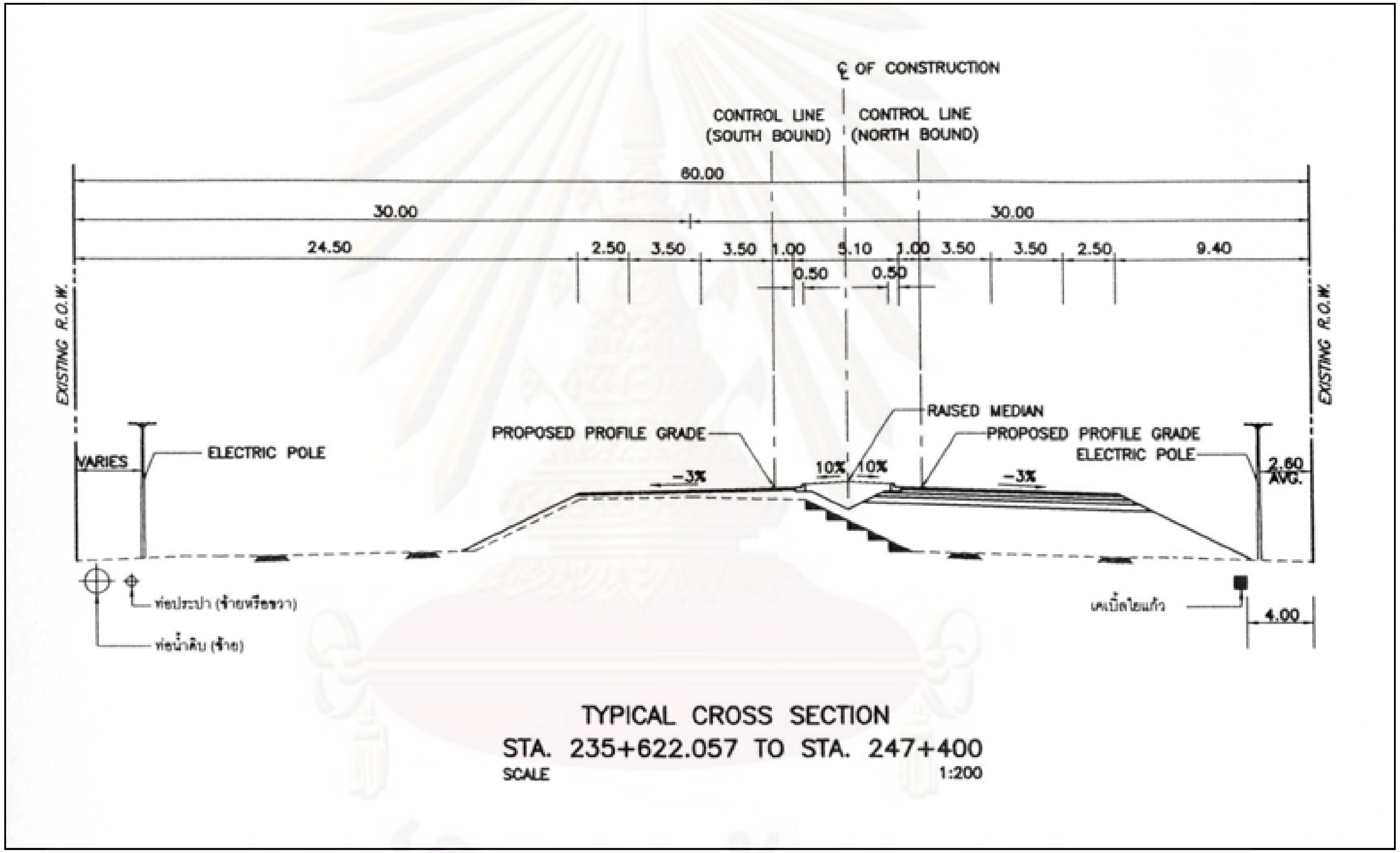

Figure C1 Typical Cross Section of Highway No.4
Source: Department of Highway

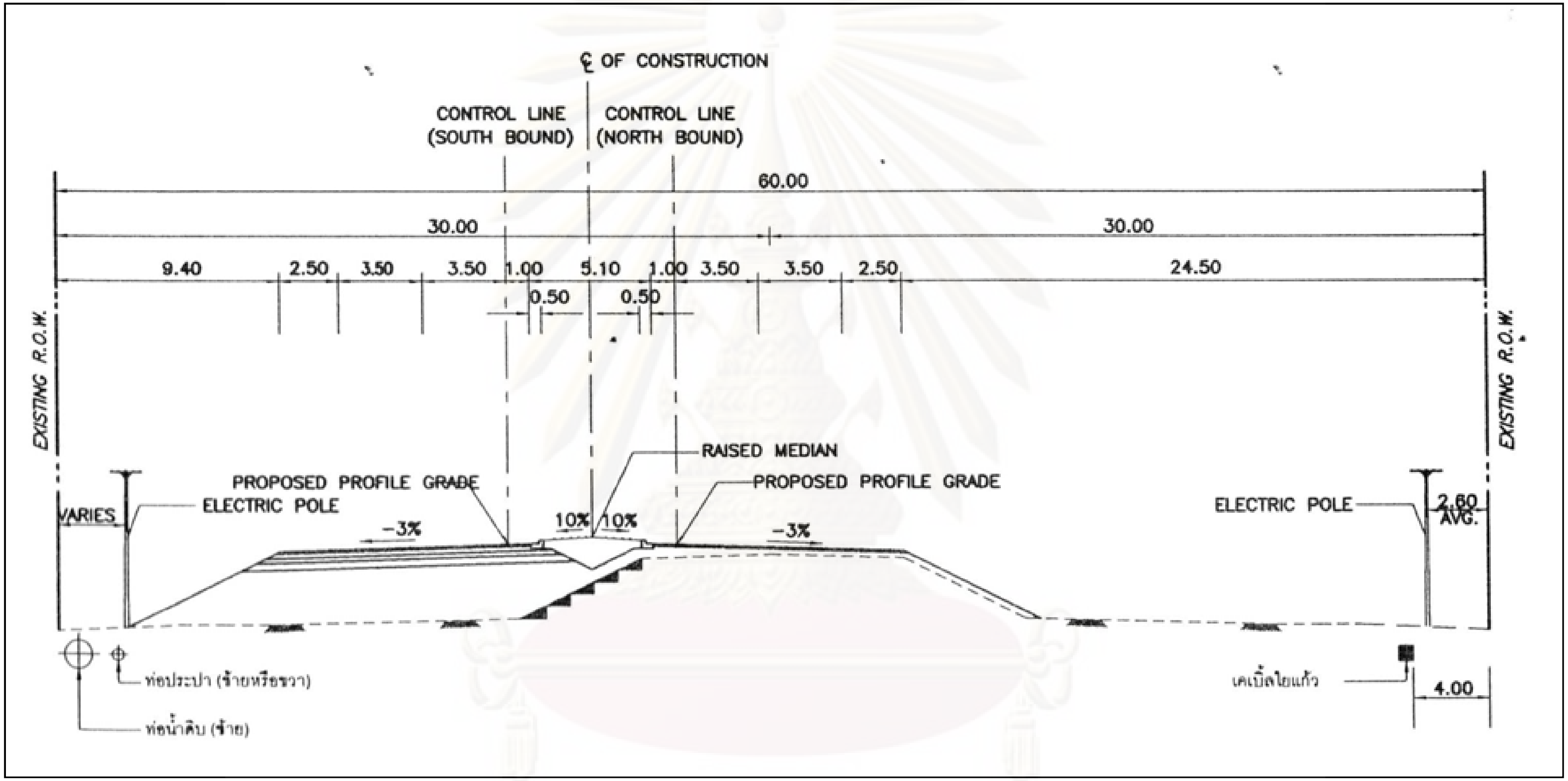

Figure C2 Typical Cross Section of Highway No.4
Source: Department of Highway

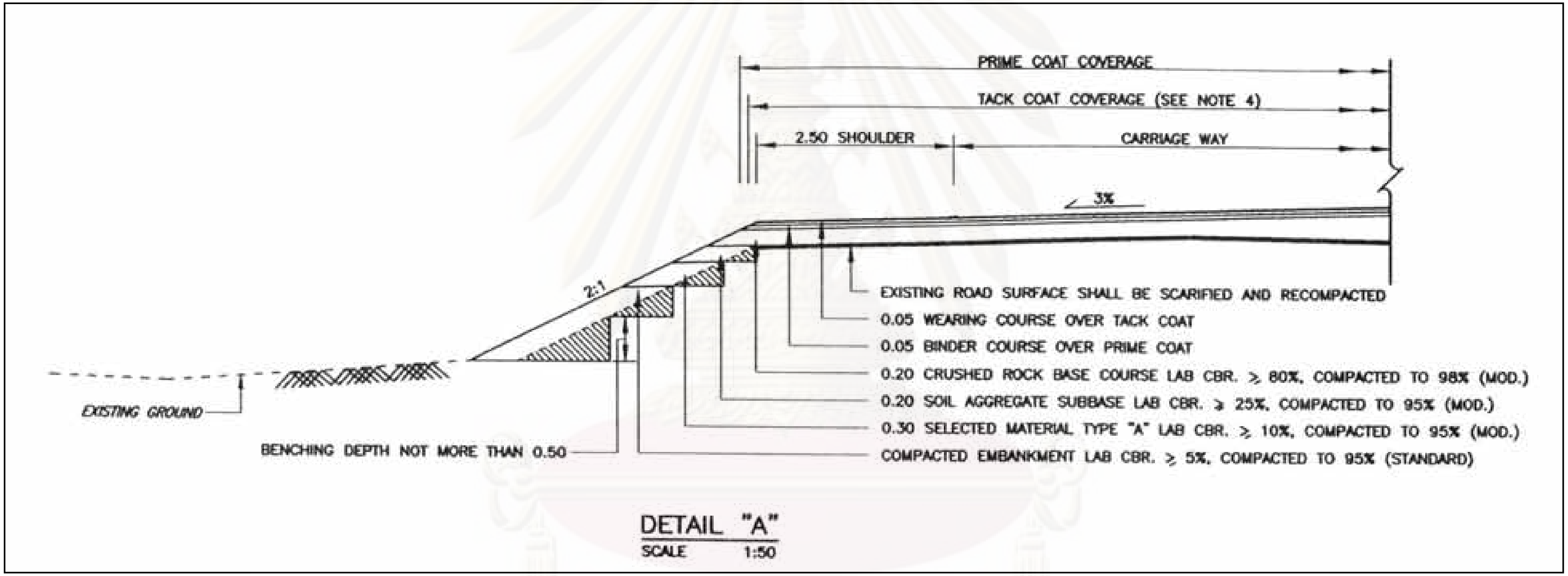

Figure C3 Typical Pavement Structure Detail A
Source: Department of Highway

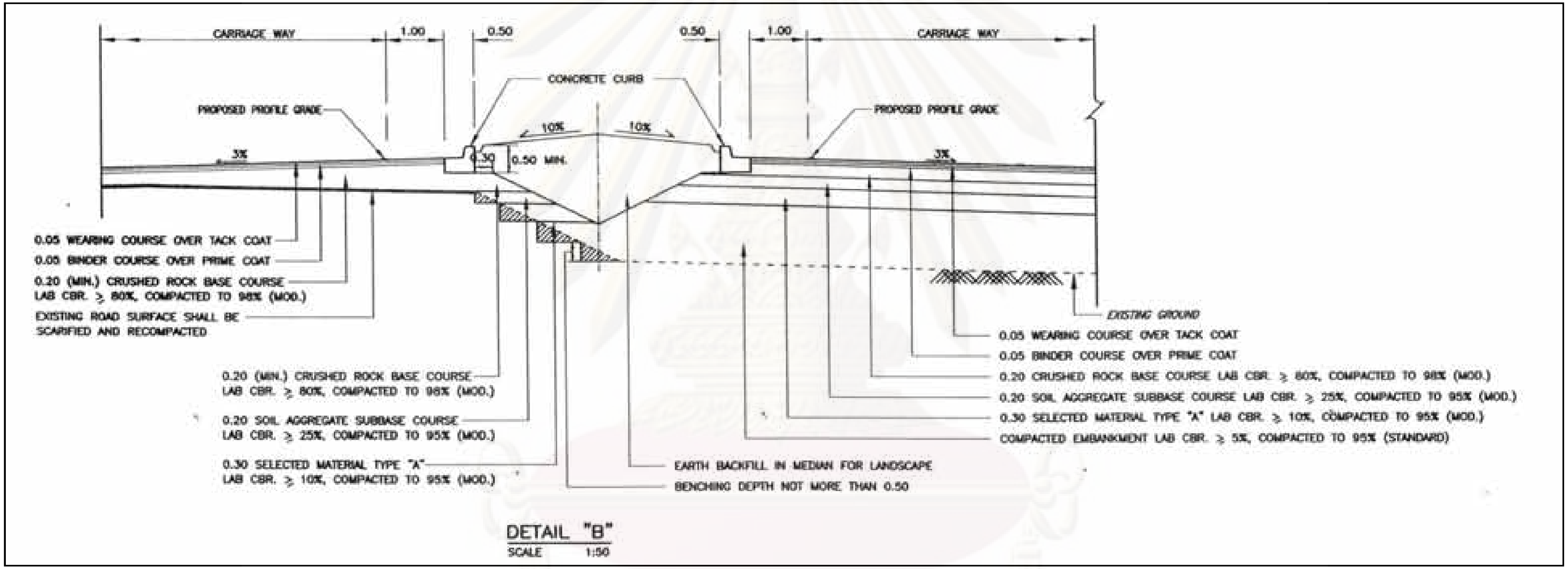

Figure C4 Typical Pavement Structure Detail B
Source: Department of Highway

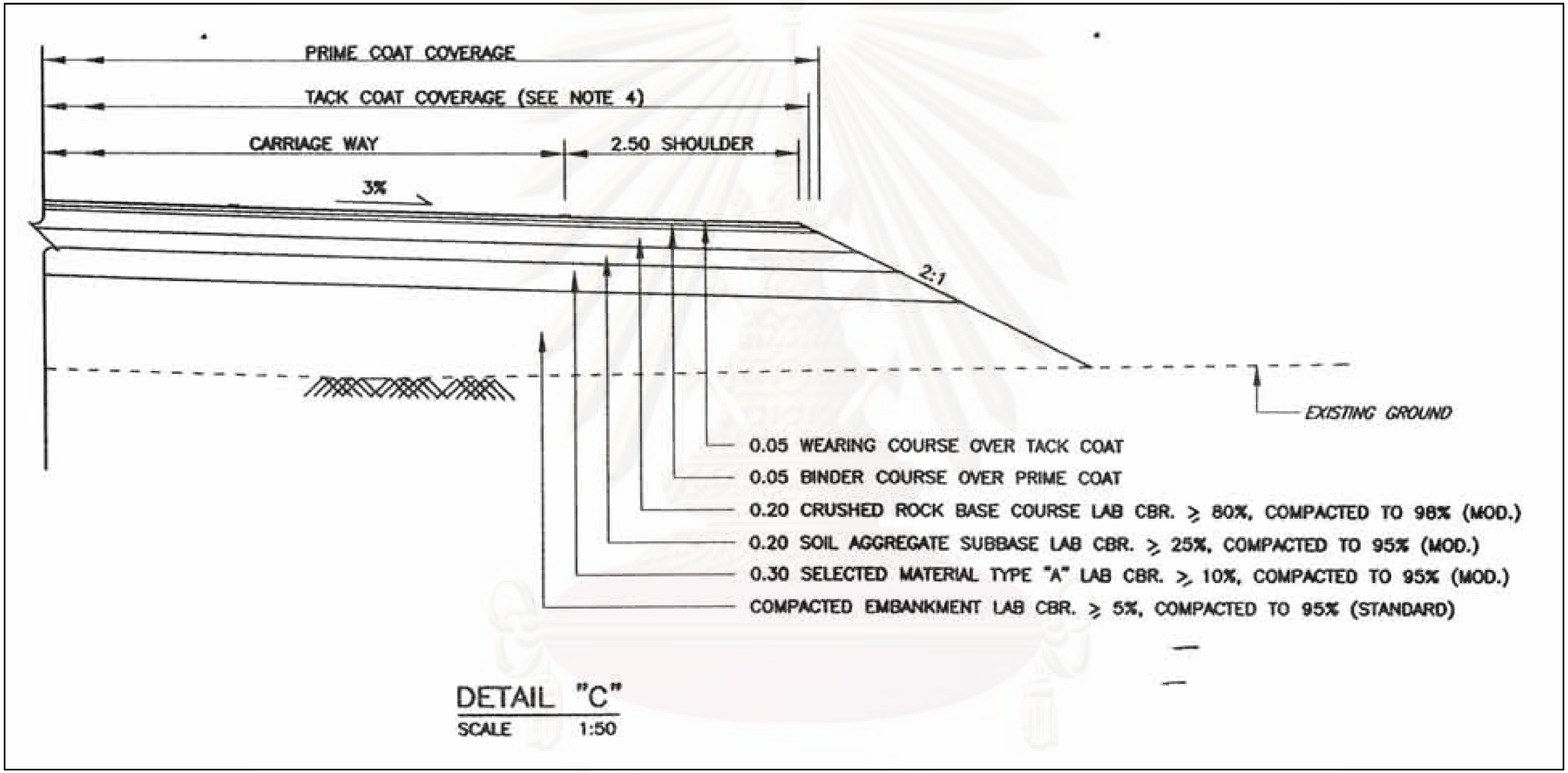

Figure C5 Typical Pavement Structure Detail C
Source: Department of Highway

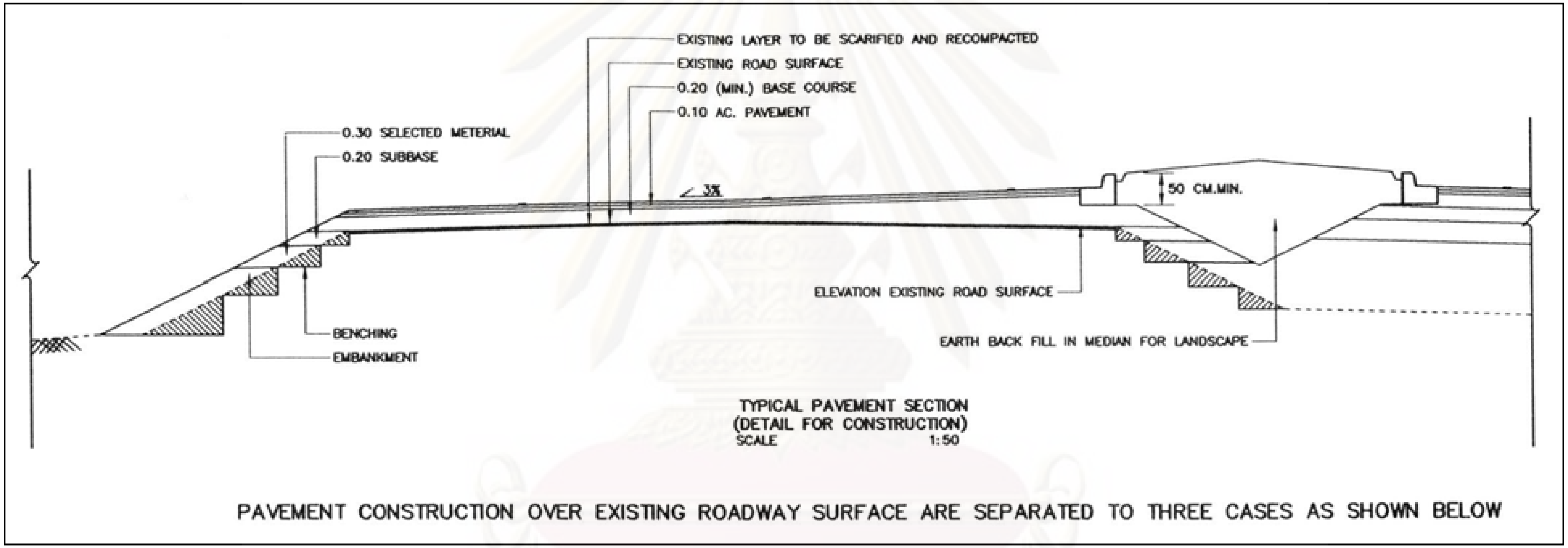

Figure C6 Typical Pavement Section
Source: Department of Highway

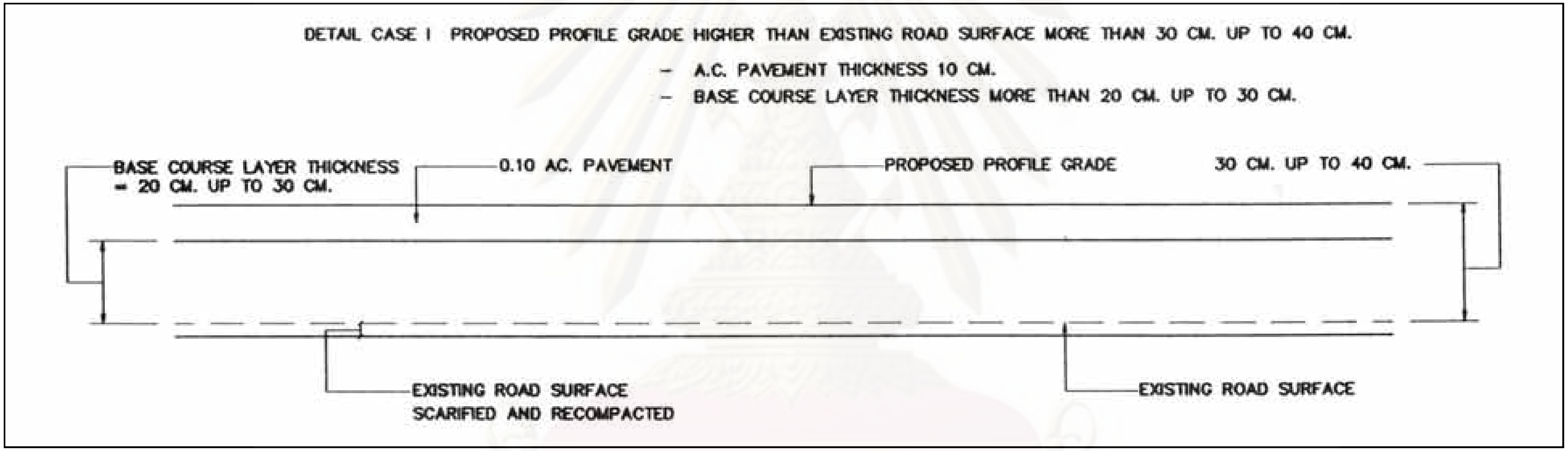

Figure C7 Typical Pavement Section Detail Case I
Source: Department of Highway

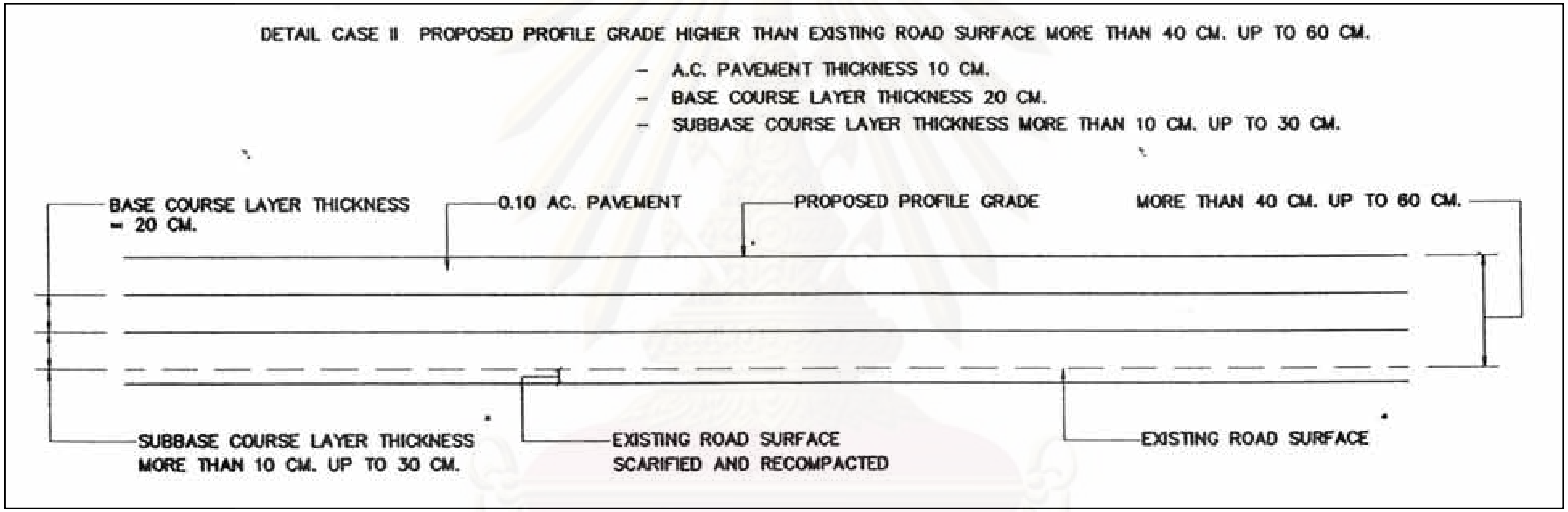

Figure C8 Typical Pavement Section Detail Case II
Source: Department of Highway

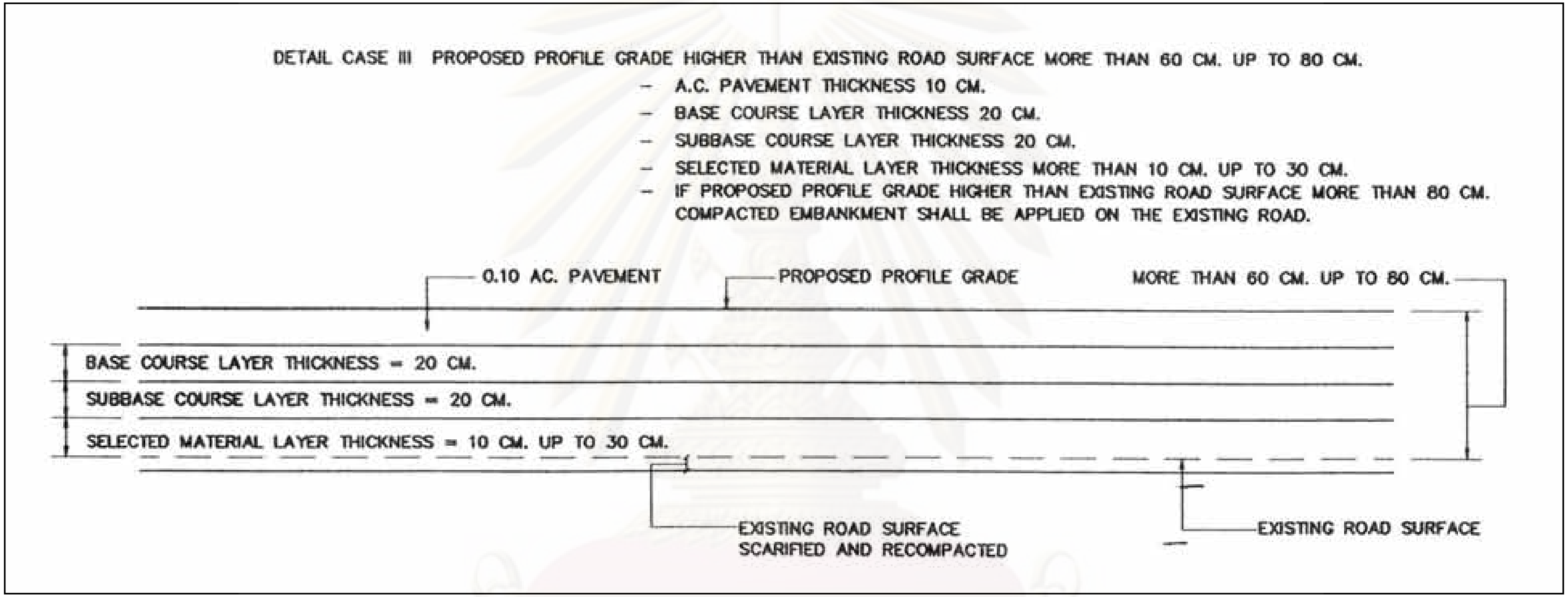

Figure C9 Typical Pavement Section Detail Case III
Source: Department of Highway

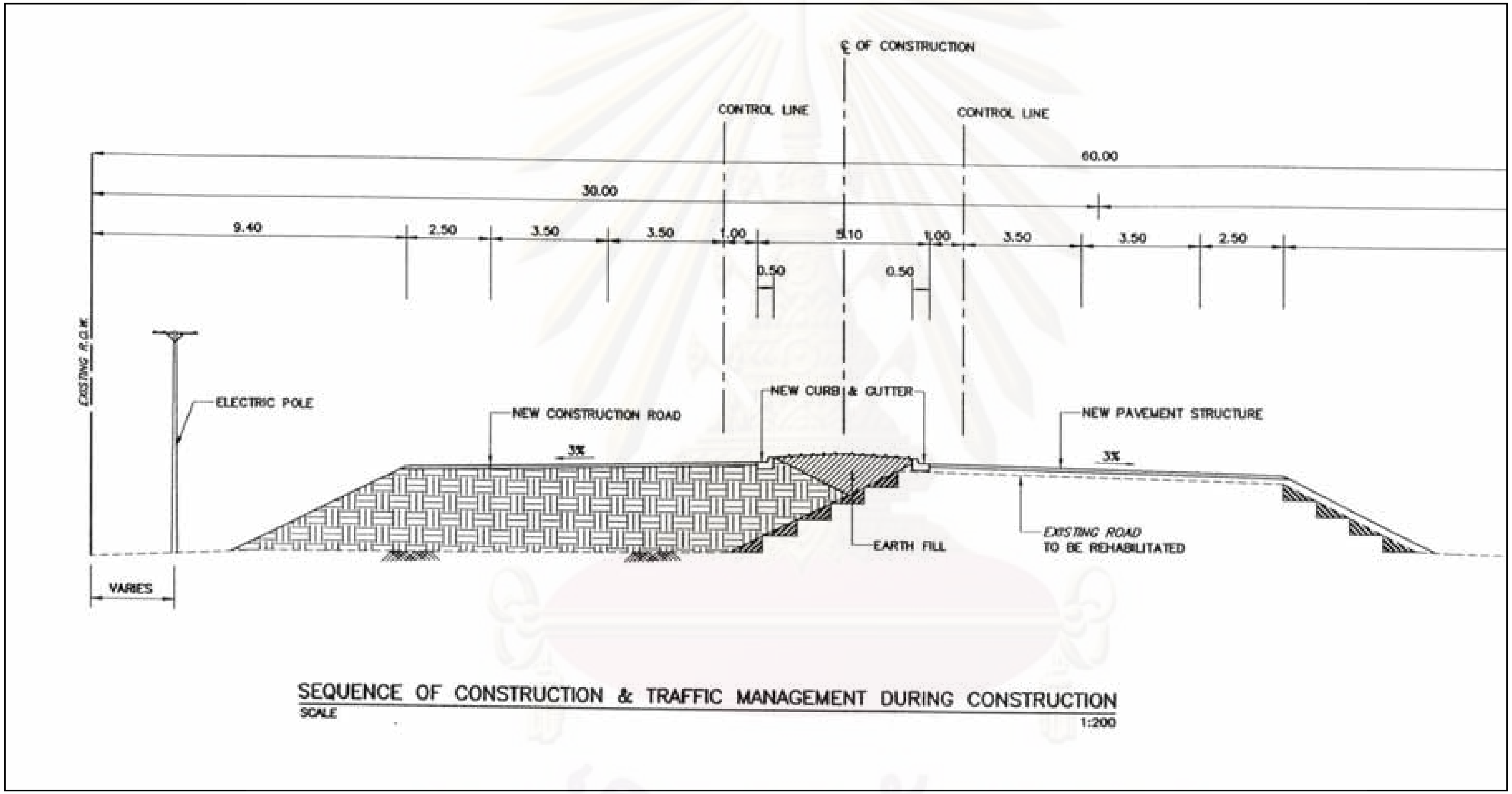

Figure C10 Sequence of Construction and Traffic Management during Construction
Source: Department of Highway

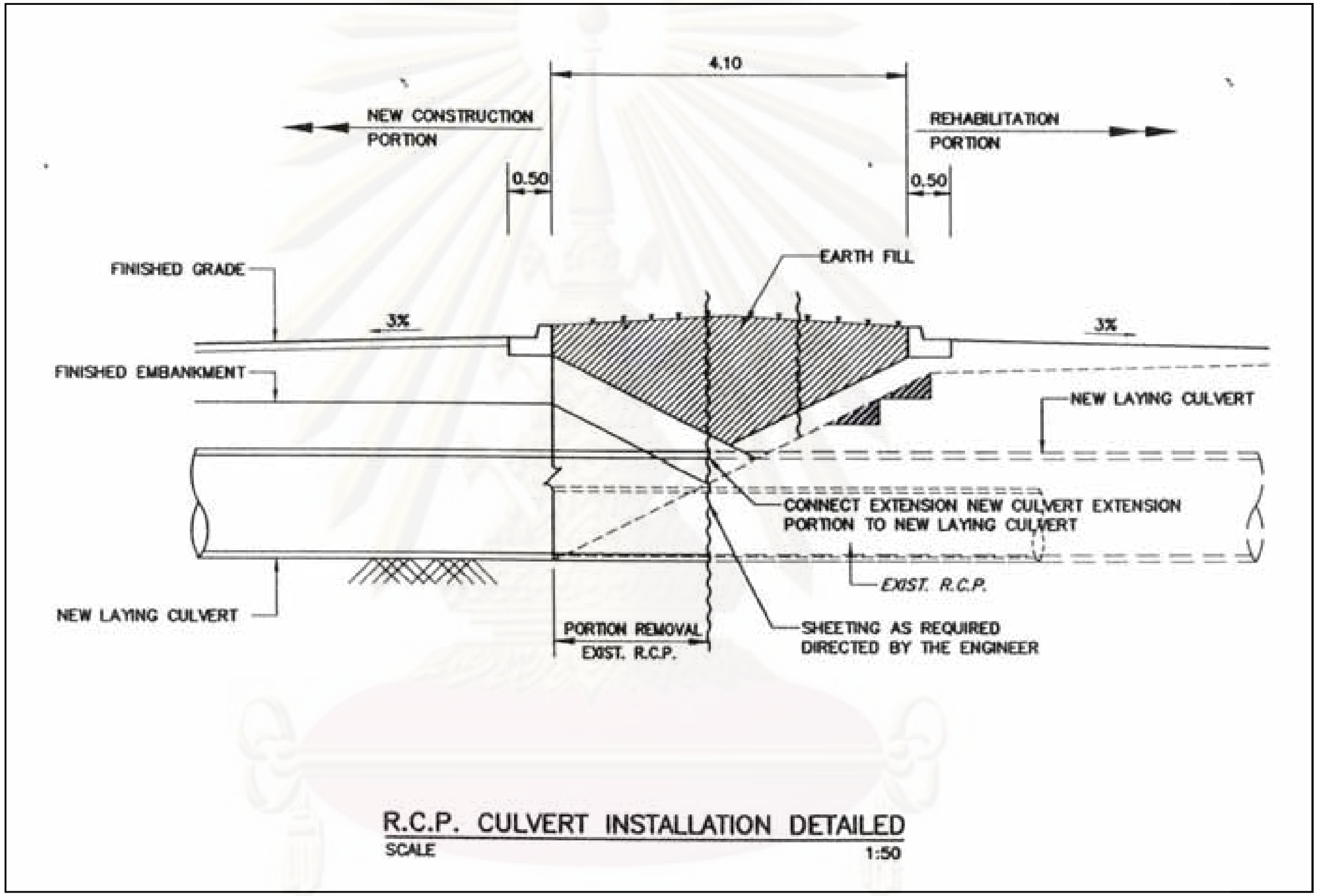

Figure C11 Culvert Installation Detail
Source: Department of Highway

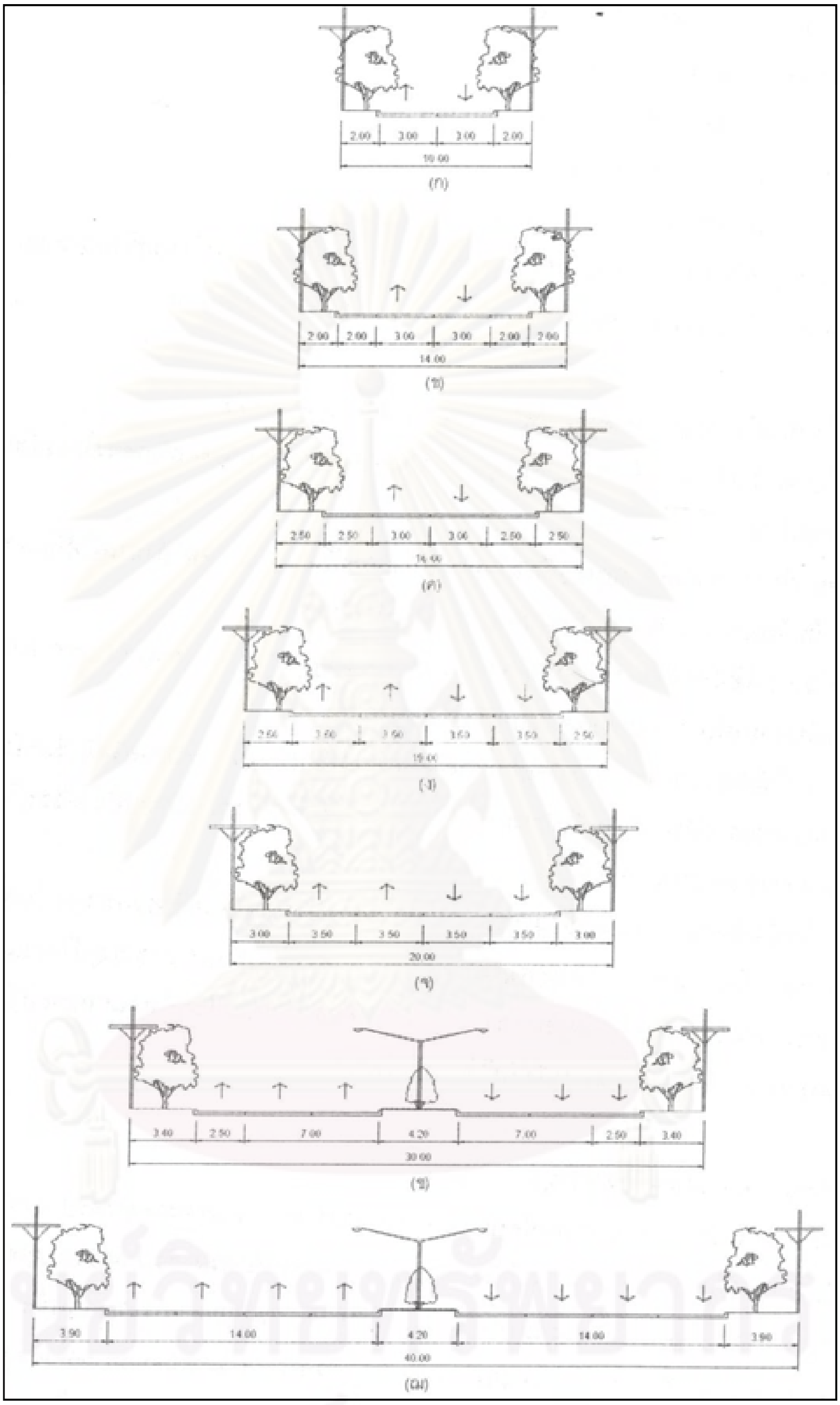

Figure C12 Typical Cross Section of Roads in Hua – Hin Municipality
Source: Hua – Hin Municipality

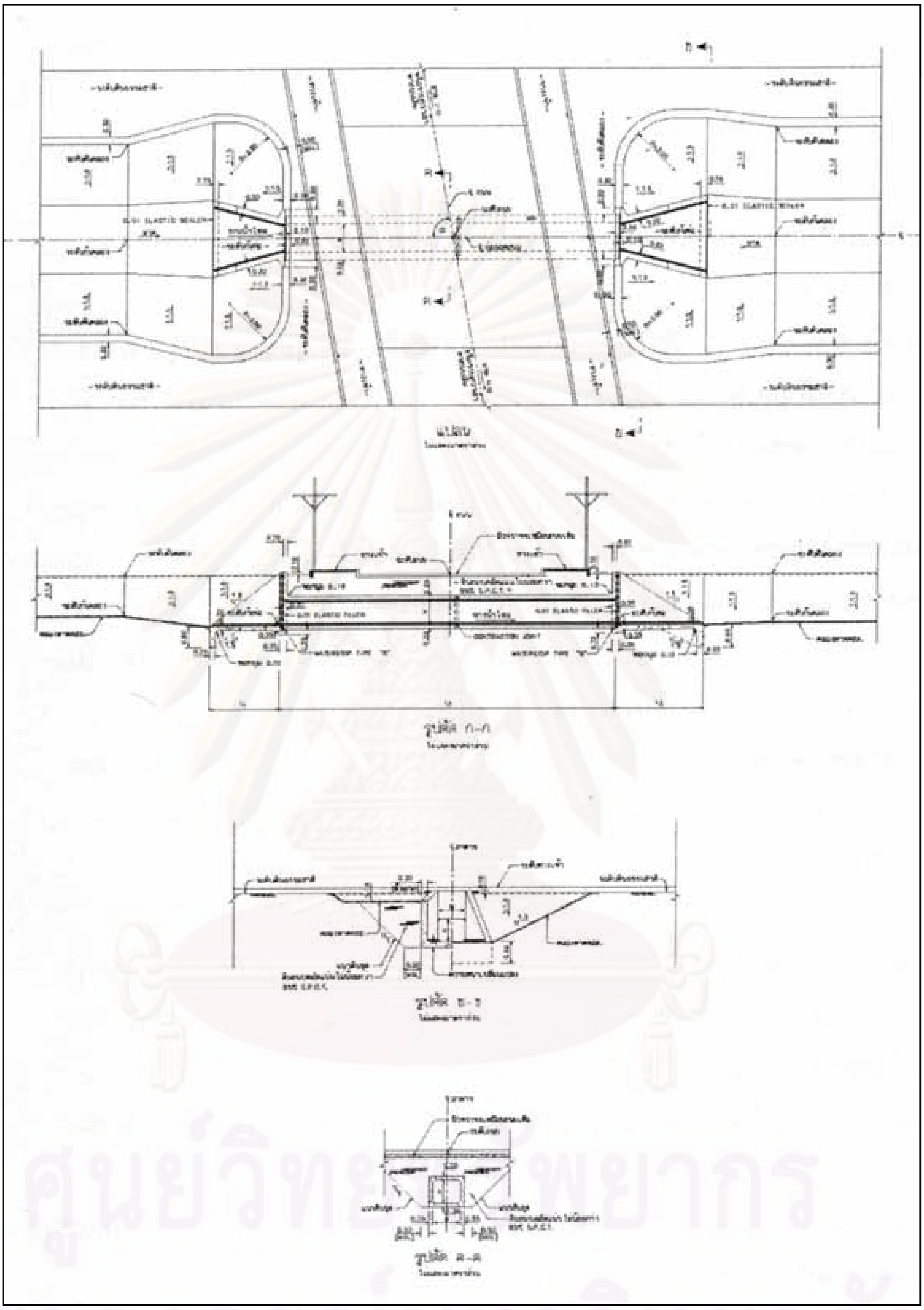

Figure C13 Standard Intersection of Highway No.4 and Canals
Source: Hua – Hin Municipality

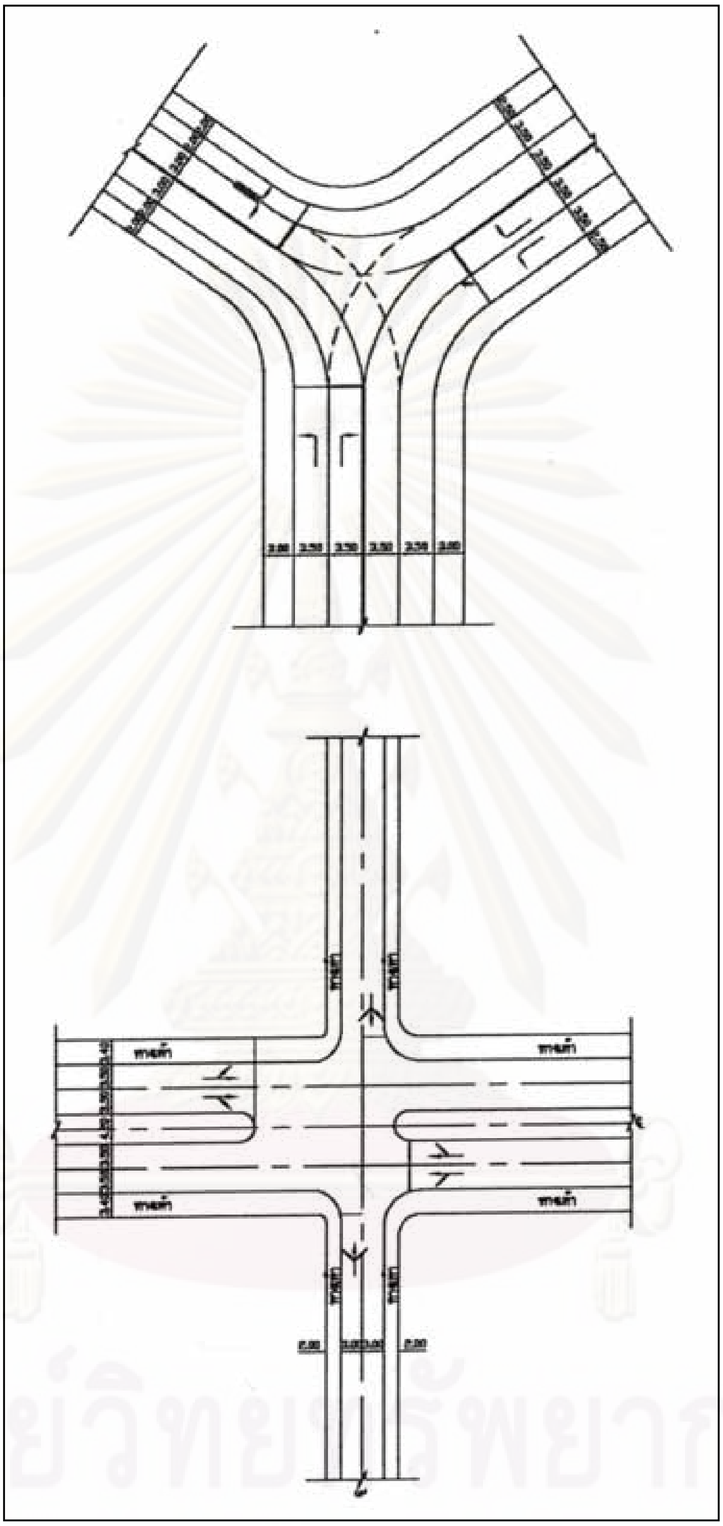

Figure C14 Standard Intersection with Different Width of Lanes
Source: Hua – Hin Municipality

APPENDIX D

Calculation Results of Pipe System in Downtown

Table D1 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 2 Years Return Periods

Section		Size	L	SLOPE	Q_f	v_f	t_d	l	S_A	n'	t_0	t_c	i	C	A	Q_r	ΣQ_r	DWF	Σ DWF	Q_{max}.h	Q_d	Q_d/Q_f	d/D	d	v/v_f	v	Result
		(m.)	(m.)	1: xxx	(m^3/s)	(m/s)	(min)	(m)	%		(min)	(min)	(mm/hr)		(m^2)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)			(m.)		(m/s)	
001	002	1.0	517	16,667	0.16	0.20	42.05	180	0.00600	0.015	4.91	46.95	68	0.75	81,000	1.1475	1.1475	0.00005	0.00005	0.00009	1.14759	7.13	5.27	5.27	8.49	1.74	Acceptable
002	003	1.0	208	16,667	0.16	0.20	16.92	170	0.00600	0.015	4.78	21.69	68	0.75	119,000	1.6858	2.8333	0.00005	0.00010	0.00018	2.83351	17.60	12.85	12.85	20.44	4.19	Under
003	004	1.0	208	14,286	0.17	0.22	15.66	170	0.00700	0.015	4.45	20.11	68	0.75	155,000	2.1958	5.0292	0.00005	0.00015	0.00027	5.02944	28.92	21.04	21.04	33.37	7.39	Under
004	005	1.0	208	14,286	0.17	0.22	15.66	165	0.00700	0.015	4.38	20.05	68	0.75	191,000	2.7058	7.7350	0.00005	0.00020	0.00036	7.73536	44.48	32.29	32.29	51.13	11.32	Under
005	006	1.0	250	11,111	0.20	0.25	16.60	165	0.00900	0.015	3.90	20.50	68	0.75	235,000	3.3292	11.0642	0.00005	0.00025	0.00045	11.06462	56.11	40.71	40.71	64.41	16.17	Under
006	021	1x1	21	417	1.57	1.57	0.22	160	0.23981	0.015	0.83	1.05	68	0.75	235,000	3.3292	8.8613	0.00005	0.00018	0.00032	8.86157	5.65	4.20	4.20	6.80	10.67	Under
021	022	1x1	292	113	3.02	3.02	1.61	180	0.88496	0.015	0.48	2.09	68	0.75	252,000	3.5700	8.0006	0.00005	0.00014	0.00025	8.00087	2.65	2.04	2.04	3.38	10.20	Under
022	023	1x1	92	637	1.27	1.27	1.21	140	0.15699	0.015	0.95	2.16	68	0.75	259,000	3.6692	11.6698	0.00005	0.00019	0.00034	11.67013	9.19	6.76	6.76	10.84	13.77	Under
013	014	1.0	417	1,282	0.58	0.74	9.41	215	0.07800	0.015	1.61	11.02	68	0.75	56,000	0.7933	0.7933	0.00005	0.00005	0.00009	0.79342	1.37	1.10	1.10	1.91	1.41	Acceptable
014	015	1.0	208	1,266	0.58	0.74	4.66	275	0.07899	0.015	1.79	6.46	68	0.75	87,000	1.2325	2.0258	0.00005	0.00010	0.00018	2.02601	3.47	2.62	2.62	4.31	3.21	Under
015	016	1.0	208	1,282	0.58	0.74	4.69	240	0.07800	0.015	1.69	6.39	68	0.75	123,000	1.7425	3.7683	0.00005	0.00015	0.00027	3.76860	6.49	4.81	4.81	7.76	5.74	Under
016	017	1.0	208	1,266	0.58	0.74	4.66	200	0.07899	0.015	1.55	6.21	68	0.75	173,000	2.4508	6.2192	0.00005	0.00020	0.00036	6.21953	10.65	7.82	7.82	12.51	9.30	Under
017	018	1.0	225	1,282	0.58	0.74	5.08	230	0.07800	0.015	1.66	6.74	68	0.75	209,000	2.9608	9.1800	0.00005	0.00025	0.00045	9.18045	15.81	11.56	11.56	18.41	13.60	Under
018	019	1x1	292	222	2.15	2.15	2.26	210	0.45045	0.015	0.70	2.96	68	0.75	267,000	3.7825	12.9625	0.00005	0.00030	0.00054	12.96304	6.03	4.48	4.48	7.23	15.56	Under
019	020	1x1	92	242	2.06	2.06	0.74	220	0.41322	0.015	0.75	1.49	68	0.75	274,000	3.8817	16.8442	0.00005	0.00035	0.00063	16.84480	8.18	6.03	6.03	9.69	19.96	Under
006	007	1.0	155	130	1.82	2.32	1.11	170	0.76923	0.015	0.50	1.61	68	0.75	36,000	0.5100	6.0421	0.00005	0.00018	0.00032	6.04240	3.31	2.51	2.51	4.14	9.60	Under
007	008	1.0	185	130	1.82	2.32	1.33	160	0.76923	0.015	0.48	1.81	68	0.75	69,000	0.9775	7.0196	0.00005	0.00023	0.00041	7.01999	3.85	2.90	2.90	4.75	11.02	Under
008	009	1x1	190	226	2.13	2.13	1.49	180	0.44248	0.015	0.66	2.14	68	0.75	105,000	1.4875	8.5071	0.00005	0.00028	0.00050	8.50758	3.99	3.00	3.00	4.91	10.46	Under
009	010	1x1	165	403	1.60	1.60	1.72	215	0.24814	0.015	0.94	2.66	68	0.75	127,000	1.7992	10.3063	0.00005	0.00033	0.00059	10.30684	6.46	4.79	4.79	7.72	12.33	Under
012	011	0.8	110	70	1.37	2.73	0.67	145	1.42857	0.015	0.34	1.02	68	0.75	19,000	0.2692	0.2692	0.00005	0.00005	0.00009	0.26926	0.20	0.26	0.21	0.50	1.35	Acceptable
011	010	1.0	110	31	3.73	4.75	0.39	120	3.22581	0.015	0.22	0.60	68	0.75	27,000	0.3825	0.6517	0.00005	0.00010	0.00018	0.65185	0.17	0.24	0.24	0.55	2.62	Acceptable
010	027	1.0	25	227	1.38	1.76	0.24	130	0.44053	0.015	0.57	0.80	68	0.75	154,000	2.1817	13.1396	0.00005	0.00048	0.00086	13.14044	9.52	7.01	7.01	11.23	19.71	Under
021	024	1x1	155	380	1.64	1.64	1.57	175	0.26316	0.015	0.83	2.40	68	0.75	28,000	0.3967	4.8273	0.00005	0.00014	0.00025	4.82754	2.94	2.24	2.24	3.70	6.09	Under
024	025	1x1	185	380	1.64	1.64	1.88	170	0.26316	0.015	0.82	2.69	68	0.75	28,000	0.3967	5.2240	0.00005	0.00019	0.00034	5.22430	3.18	2.41	2.41	3.98	6.54	Under
025	026	1x1	375	380	1.64	1.64	3.80	155	0.26316	0.015	0.78	4.58	68	0.75	78,000	1.1050	6.3290	0.00005	0.00024	0.00043	6.32939	3.85	2.90	2.90	4.75	7.80	Under
026	027	1x1	176	116	2.98	2.98	0.99	160	0.86207	0.015	0.46	1.44	68	0.75	95,000	1.3458	7.6748	0.00005	0.00029	0.00052	7.67531	2.58	1.98	1.98	3.30	9.81	Under
027	028	1x1	36	176	2.42	2.42	0.25	245	0.56818	0.015	0.68	0.93	68	0.75	260,000	3.6833	24.4977	0.00005	0.00081	0.00146	24.49917	10.14	7.45	7.45	11.93	28.82	Under
028	106	1x1	1560	36	5.34	5.34	4.87	150	2.77778	0.015	0.26	5.12	68	0.75	260,000	3.6833	55.8485	0.00005	0.00211	0.00380	55.85234	10.46	7.68	7.68	12.29	65.65	Under
029	030	1x1	575	1,560	0.81	0.81	11.81	150	0.06410	0.015	1.49	13.30	68	0.75	31,000	0.4392	0.4392	0.00005	0.00005	0.00009	0.43926	0.54	0.51	0.51	0.97	0.79	Acceptable
022	030	0.8	833	575	0.48	0.95	14.60	165	0.17391	0.015	0.98	15.58	68	0.75	31,000	0.4392	4.4395	0.00005	0.00012	0.00021	4.43969	9.29	6.83	5.47	8.80	8.36	Under
030	031	1x1	813	833	1.11	1.11	12.20	270	0.12005	0.015	1.46	13.67	68	0.75	78,000	1.1050	5.9836	0.00005	0.00022	0.00039	5.98404	5.39	4.01	4.01	6.50	7.22	Under
107	31	1x1	176	813	1.12	1.12	2.61	270	0.12300	0.015	1.45	4.06	68	0.75	28,000	0.3967	0.3967	0.00005	0.00005	0.00009	0.39676	0.35	0.37	0.37	0.75	0.85	Acceptable
052A	050	0.8	40	176	0.86	1.72	0.39	150	0.56818	0.015	0.54	0.93	68	0.75	28,000	0.3967	0.5950	0.00005	0.00010	0.00018	0.59518	0.69	0.61	0.49	0.94	1.62	Acceptable
049	050	0.8	752	40	1.81	3.60	3.48	95	2.50000	0.015	0.22	3.69	68	0.75	14,000	0.1983	0.1983	0.00005	0.00005	0.00009	0.19842	0.11	0.19	0.16	0.42	1.50	Acceptable
050	053	0.8	15	752	0.42	0.83	0.30	105	0.13298	0.015	0.90	1.20	68	0.75	42,000	0.5950	1.3883	0.00005	0.00020	0.00036	1.38869	3.32	2.52	2.01	3.35	2.78	Acceptable
055	053	0.8	155	207	0.80	1.58	1.63	115	0.48309	0.015	0.51	2.14	68	0.75	14,000	0.1983	0.1983	0.00005	0.00005	0.00009	0.19842	0.25	0.30	0.24	0.54	0.86	Acceptable
053	054	0.7x0.6	150	170	0.71	1.69	1.48	115	0.58824	0.015	0.47	1.94	68	0.75	640,000	9.0667	10.6533	0.00005	0.00030	0.00054	10.65387	14.98	10.95	7.67	12.27	20.78	Under
056	057	0.8	170	210	0.79	1.57	1.80	105	0.47619	0.015	0.49	2.30	68	0.75	11,000	0.1558	0.1558	0.00005	0.00005	0.00009	0.15592	0.20	0.26	0.21	0.50	0.78	Acceptable
057	054	1x1	175	213	2.20	2.20	1.33	115	0.46948	0.015	0.52	1.85	68	0.75	33,000	0.4675	0.6233	0.00005	0.00010	0.00018	0.62351	0.28	0.32	0.32	0.68	1.48	Acceptable
054	048	1x1	20	285	1.90	1.90	0.18	95	0.35088	0.015	0.54	0.72	68	0.75	97,000	1.3742	12.6508	0.00005	0.00045	0.00081	12.65164	6.66	4.94	4.94	7.96	15.11	Under
044	045	0.8	135	39	1.84	3.65	0.62	115	2.56410	0.015	0.24	0.85	68	0.75	14,000	0.1983	0.1983	0.00005	0.00005	0.00009	0.19842	0.11	0.19	0.15	0.41	1.51	Acceptable
045B	045A	0.8	50	201	0.81	1.61	0.52	145	0.49751	0.015	0.56	1.08	68	0.75	56,000	0.7933	0.7933	0.00005	0.00005	0.00009	0.79342	0.98	0.82	0.66	1.21	1.95	Acceptable
045A	045	0.8	175	201	0.81	1.61	1.81	145	0.49751	0.015	0.56	2.38	68	0.75	19,000	0.2692	1.0625	0.00005	0.00010	0.00018	1.06268	1.31	1.07	0.85	1.52	2.44	Acceptable
045	047	0.8	20	667	0.44	0.88	0.38	100	0.14993	0.015	0.83	1.21	68	0.75	33,000	0.4675	1.7283	0.00005	0.00020	0.00036	1.72869	3.89	2.93	2.35	3.87	3.42	Under
046	047	0.8	55	550	0.49	0.97	0.94	85	0.18182	0.015	0.70	1.65	68	0.75	6,000	0.0850	0.0850	0.00005	0.00005	0.00009	0.08509	0.17	0.24	0.19	0.47	0.46	Over

Table D1 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 2 Years Return Periods (Continue)

Sction		Size (m.)	L (m.)	SLOPE 1: xxx	Q_f (m^3/s)	v_f (m/s)	t_d (min)	l (m)	S_A %	n'	t_0 (min)	t_c (min)	i (mm/hr)	C	A (m^2)	Q_r (m^3/s)	ΣQ_r (m^3/s)	DWF (m^3/s)	Σ DWF (m^3/s)	$Q_{max}.h$ (m^3/s)	Q_d (m^3/s)	Q_d/Q_f	d/D	d (m.)	v/v_f	v (m/s)	Result
047	048	0.8	125	147	0.95	1.88	1.11	105	0.68027	0.015	0.42	1.53	68	0.75	47,000	0.6658	2.4792	0.00005	0.00030	0.00054	2.47971	2.62	2.01	1.61	2.71	5.10	Under
048	035	1x1	175	1,163	0.94	0.94	3.10	120	0.08598	0.015	1.17	4.27	68	0.75	164,000	2.3233	22.3724	0.00005	0.00080	0.00144	22.37384	23.81	17.34	17.34	27.53	25.88	Under
033	034	0.8	135	42	1.77	3.52	0.64	95	2.38095	0.015	0.22	0.86	68	0.75	14,000	0.1983	0.1983	0.00005	0.00005	0.00009	0.19842	0.11	0.20	0.16	0.42	1.47	Acceptable
034	035	1.0	95	50	2.94	3.74	0.42	120	2.00000	0.015	0.27	0.69	68	0.75	22,000	0.3117	0.5100	0.00005	0.00010	0.00018	0.51018	0.17	0.24	0.24	0.55	2.06	Acceptable
035	036	1.0	25	250	1.31	1.67	0.25	95	0.40000	0.015	0.51	0.76	68	0.75	186,000	2.6350	25.5174	0.00005	0.00095	0.00171	25.51911	19.41	14.16	14.16	22.51	37.67	Under
040	038	0.8x1	95	474	0.75	0.94	1.68	85	0.21097	0.015	0.66	2.34	68	0.75	7,000	0.0992	0.0992	0.00005	0.00005	0.00009	0.09926	0.13	0.21	0.21	0.50	0.47	Over
038	036	0.8x1	80	400	0.82	1.03	1.30	40	0.25000	0.015	0.43	1.73	68	0.75	14,000	0.1983	0.2975	0.00005	0.00010	0.00018	0.29768	0.36	0.38	0.38	0.77	0.79	Acceptable
036	037	1x1	115	230	5.13	5.13	0.37	95	0.43478	0.015	0.49	0.87	68	0.75	228,000	3.2300	29.0449	0.00005	0.00110	0.00198	29.04688	5.66	4.21	4.21	6.81	34.97	Under
037	028	1x1	25	100	11.01	11.01	0.04	100	1.00000	0.015	0.34	0.38	68	0.75	228,000	3.2300	32.5866	0.00005	0.00125	0.00225	32.58881	2.96	2.26	2.26	3.73	41.08	Under
041	039	0.8	125	192	0.83	1.65	1.27	85	0.52083	0.015	0.43	1.70	68	0.75	11,000	0.1558	0.1558	0.00005	0.00005	0.00009	0.15592	0.19	0.25	0.20	0.49	0.80	Acceptable
039	037	0.8	25	132	1.00	1.98	0.21	40	0.75758	0.015	0.25	0.46	68	0.75	11,000	0.1558	0.3117	0.00005	0.00010	0.00018	0.31185	0.31	0.34	0.27	0.60	1.19	Acceptable
100	103	0.8	125	521	0.50	1.00	2.09	40	0.19194	0.015	0.48	2.57	68	0.75	3,000	0.0425	0.0425	0.00005	0.00005	0.00009	0.04259	0.08	0.18	0.14	0.39	0.39	Over
101	102	0.8	75	112	1.08	2.15	0.58	30	0.89286	0.015	0.21	0.79	68	0.75	7,000	0.0992	0.1842	0.00005	0.00010	0.00018	0.18435	0.17	0.24	0.19	0.47	1.01	Acceptable
102	103	1x1	75	112	3.03	3.03	0.41	30	0.89286	0.015	0.21	0.62	68	0.75	14,000	0.1983	0.3825	0.00005	0.00015	0.00027	0.38277	0.13	0.21	0.21	0.50	1.50	Acceptable
113	112	0.8	55	1,099	0.35	0.69	1.33	120	0.09099	0.015	1.14	2.47	68	0.75	3,000	0.0425	0.5100	0.00005	0.00015	0.00027	0.51027	1.48	1.18	0.95	1.66	1.14	Acceptable
116	117	0.8	75	1,493	0.30	0.59	2.12	100	0.06698	0.015	1.21	3.33	68	0.75	6,000	0.0850	0.0850	0.00005	0.00005	0.00009	0.08509	0.29	0.32	0.26	0.58	0.34	Over
115	114	0.8	135	246	0.73	1.45	1.55	100	0.40650	0.015	0.52	2.07	68	0.75	14,000	0.1983	0.1983	0.00005	0.00005	0.00009	0.19842	0.27	0.31	0.25	0.56	0.82	Acceptable
114	113	0.8	135	193	0.83	1.64	1.37	155	0.51813	0.015	0.57	1.94	68	0.75	19,000	0.2692	0.4675	0.00005	0.00010	0.00018	0.46768	0.57	0.53	0.42	0.83	1.37	Acceptable
119	118	0.8	50	91	1.20	2.39	0.35	85	1.09890	0.015	0.30	0.65	68	0.75	3,000	0.0425	0.5100	0.00005	0.00015	0.00027	0.51027	0.42	0.42	0.34	0.70	1.68	Acceptable
105A	105	0.8	230	5,882	0.15	0.30	12.89	95	0.01700	0.015	2.24	15.13	68	0.75	44,000	0.6233	0.6233	0.00005	0.00005	0.00009	0.62342	4.17	3.13	2.51	4.12	1.23	Acceptable
103	104	1x1	25	417	1.57	1.57	0.27	50	0.23981	0.015	0.48	0.75	68	0.75	72,000	1.0200	1.4450	0.00005	0.00025	0.00045	1.44545	0.92	0.78	0.78	1.40	2.20	Acceptable
104	105	1x1	15	1,493	0.83	0.83	0.30	80	0.06698	0.015	1.09	1.39	68	0.75	300,000	4.2500	6.6442	0.00005	0.00030	0.00054	6.64471	8.01	5.91	5.91	9.50	7.88	Under
105	106	0.8	25	535	0.50	0.99	0.42	105	0.18692	0.015	0.77	1.19	68	0.75	14,000	0.1983	0.1983	0.00005	0.00005	0.00009	0.19842	0.40	0.40	0.32	0.68	0.67	Acceptable
109	106	0.8	15	23	2.39	4.75	0.05	53	4.34783	0.015	0.13	0.18	68	0.75	314,000	4.4483	5.5250	0.00005	0.00040	0.00071	5.52571	2.31	1.79	1.43	2.43	11.54	Under
111	105	1.0	130	289	1.22	1.56	1.39	105	0.34602	0.015	0.57	1.97	68	0.75	3,000	0.0425	0.9492	0.00005	0.00025	0.00045	0.94962	0.78	0.68	0.68	1.24	1.93	Acceptable
118	110	1.2	80	320	1.89	1.67	0.80	25	0.31250	0.015	0.31	1.11	68	0.75	6,000	0.0850	1.0342	0.00005	0.00030	0.00054	1.03471	0.55	0.51	0.61	1.14	1.90	Acceptable
112	111	1.0	195	433	1.00	1.27	2.56	133	0.23095	0.015	0.77	3.33	68	0.75	28,000	0.3967	0.9067	0.00005	0.00020	0.00036	0.90703	0.91	0.77	0.77	1.39	1.77	Acceptable
108	106	0.6x0.6	175	389	0.30	0.82	3.55	38	0.25707	0.015	0.41	3.96	68	0.75	19,000	0.2692	0.2692	0.00005	0.00005	0.00009	0.26926	0.91	0.77	0.46	0.90	0.74	Acceptable
070	071	0.6	85	532	0.23	0.82	1.74	205	0.18797	0.015	1.04	2.78	68	0.75	17,000	0.2408	0.2408	0.00005	0.00005	0.00009	0.24092	1.04	0.87	0.52	0.99	0.81	Acceptable
129	130	1x1	235	725	1.19	1.19	3.29	142	0.13793	0.015	1.02	4.31	68	0.75	36,000	0.5100	0.5100	0.00005	0.00005	0.00009	0.51009	0.43	0.43	0.43	0.84	1.00	Acceptable
071	072	1.0	20	67	2.54	3.23	0.10	180	1.49254	0.015	0.37	0.48	68	0.75	53,000	0.7508	1.7850	0.00005	0.00015	0.00027	1.78527	0.70	0.62	0.62	1.15	3.73	Under
062	071	1.2	180	599	1.38	1.22	2.46	160	0.16694	0.015	0.98	3.44	68	0.75	56,000	0.7933	0.7933	0.00005	0.00005	0.00009	0.79342	0.57	0.53	0.64	1.18	1.43	Acceptable
061	060	0.8	25	192	0.83	1.65	0.25	135	0.52083	0.015	0.53	0.79	68	0.75	7,000	0.0992	0.0992	0.00005	0.00005	0.00009	0.09926	0.12	0.20	0.16	0.43	0.70	Acceptable
060	059	0.8	180	195	0.82	1.63	1.84	145	0.51282	0.015	0.56	2.39	68	0.75	25,000	0.3542	0.4533	0.00005	0.00010	0.00018	0.45351	0.55	0.51	0.41	0.82	1.34	Acceptable
058	059	0.6	75	44	0.80	2.84	0.44	120	2.27273	0.015	0.25	0.69	68	0.75	14,000	0.1983	0.1983	0.00005	0.00005	0.00009	0.19842	0.25	0.29	0.18	0.45	1.27	Acceptable
051	052	0.8	110	60	1.48	2.94	0.62	68	1.66667	0.015	0.23	0.85	68	0.75	14,000	0.1983	0.1983	0.00005	0.00005	0.00009	0.19842	0.13	0.21	0.17	0.44	1.29	Acceptable
059	069	0.8	15	150	0.94	1.86	0.13	175	0.66667	0.015	0.54	0.67	68	0.75	53,000	0.7508	1.4025	0.00005	0.00020	0.00036	1.40286	1.50	1.20	0.96	1.68	3.14	Under
063	069	0.8	150	163	0.90	1.79	1.40	101	0.61350	0.015	0.43	1.83	68	0.75	6,000	0.0850	0.0850	0.00005	0.00005	0.00009	0.08509	0.09	0.18	0.15	0.40	0.72	Acceptable
069	068	0.8	170	236	0.75	1.48	1.91	100	0.42373	0.015	0.51	2.42	68	0.75	70,000	0.9917	2.4792	0.00005	0.00030	0.00054	2.47971	3.32	2.52	2.02	3.35	4.97	Under
064	065	0.3	160	139	0.07	1.01	2.65	65	0.71942	0.015	0.33	2.98	68	0.75	6,000	0.0850	0.0850	0.00005	0.00005	0.00009	0.08509	1.20	0.98	0.29	0.63	0.64	Acceptable
066	065	0.8	75	578	0.48	0.95	1.32	83	0.17301	0.015	0.71	2.03	68	0.75	3,000	0.0425	0.0425	0.00005	0.00005	0.00009	0.04259	0.09	0.18	0.14	0.40	0.38	Over
065	067	0.8	10	200	0.81	1.61	0.10	108	0.50000	0.015	0.49	0.59	68	0.75	8,000	0.1133	0.2408	0.00005	0.00015	0.00027	0.24110	0.30	0.33	0.26	0.59	0.95	Acceptable
067A	067	0.8	165	150	0.94	1.86	1.48	82	0.66667	0.015	0.38	1.85	68	0.75	11,000	0.1558	0.1558	0.00005	0.00005	0.00009	0.15592	0.17	0.24	0.19	0.47	0.87	Acceptable
067	068	0.8	105	877	0.39	0.77	2.27	108	0.11403	0.015	0.98	3.25	68	0.75	22,000	0.3117	0.7083	0.00005	0.00025	0.00045	0.70878	1.83	1.44	1.15	1.99	1.53	Acceptable
068	080	0.8	35	117	1.06	2.11	0.28	170	0.85470	0.015	0.47	0.75	68	0.75	78,000	1.1050	4.2925	0.00005	0.00060	0.00108	4.29358	4.05	3.05	2.44	4.02	8.46	Under

Table D1 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 2 Years Return Periods (Continue)

Section		Size (m.)	L (m.)	SLOPE 1: xxx	Q_f (m^3/s)	v_f (m/s)	t_d (min)	l (m)	S_A %	n'	t_0 (min)	t_c (min)	i (mm/hr)	C	A (m^2)	Q_r (m^3/s)	Σ Q_r (m^3/s)	DWF (m^3/s)	Σ DWF (m^3/s)	Q_{max}.h (m^3/s)	Q_d (m^3/s)	Q_d/Q_f	d/D	d (m.)	v/v_f	v (m/s)	Result
080	093	1.25x1.5	195	132	6.24	3.33	0.98	118	0.75901	0.015	0.42	1.40	68	0.75	92,000	1.3033	6.7150	0.00005	0.00080	0.00144	6.71644	1.08	0.89	1.34	2.29	7.61	Under
072	080	0.8	110	250	0.73	1.44	1.27	215	0.40000	0.015	0.75	2.02	68	0.75	6,000	0.0850	1.1192	0.00005	0.00015	0.00027	1.11944	1.54	1.23	0.99	1.73	2.49	Acceptable
077	081	1.0	60	1,000	0.66	0.84	1.20	135	0.10000	0.015	1.15	2.35	68	0.75	8,000	0.1133	6.6867	0.00005	0.00045	0.00081	6.68748	10.17	7.48	7.48	11.97	10.01	Under
081	091	0.8	110	225	0.76	1.52	1.21	105	0.44500	0.015	0.51	1.72	68	0.75	600	0.0085	6.6952	0.00005	0.00050	0.00090	6.69607	8.76	6.45	5.16	8.31	12.64	Under
096	093	1.0	25	40	3.29	4.18	0.10	50	2.50000	0.015	0.16	0.26	68	0.75	14,000	0.1983	6.8935	0.00005	0.00055	0.00099	6.89449	2.10	1.63	1.63	2.75	11.49	Under
092	093	0.8	65	118	1.06	2.10	0.52	172	0.84746	0.015	0.48	0.99	68	0.75	3,000	0.0425	6.9360	0.00005	0.00060	0.00108	6.93708	6.57	4.87	3.90	6.32	13.26	Under
042	043	1.25x1.5	15	300	3.47	1.85	0.14	107	0.33333	0.015	0.59	0.72	68	0.75	94,000	1.3317	1.7992	0.00005	0.00013	0.00023	1.79939	0.52	0.49	0.74	1.33	2.46	Acceptable
098	099	1.25x2	65	282	9.78	3.91	0.28	45	0.35461	0.015	0.38	0.66	68	0.75	109,000	1.5442	22.8735	0.00005	0.00180	0.00324	22.87674	2.34	1.81	3.61	5.87	22.98	Under
093	098	0.8	150	130	4.49	4.49	0.56	136	0.76923	0.015	0.45	1.00	68	0.75	28,000	0.3967	23.2702	0.00005	0.00185	0.00333	23.27350	5.18	3.86	3.09	5.05	22.68	Under
130	075	1.0	465	220	1.40	1.78	4.34	240	0.45455	0.015	0.74	5.09	68	0.75	56,000	0.7933	1.3033	0.00005	0.00010	0.00018	1.30351	0.93	0.79	0.79	1.41	2.52	Acceptable
128	127	0.6	250	926	0.17	0.62	6.74	200	0.10799	0.015	1.34	8.07	68	0.75	28,000	0.3967	0.3967	0.00005	0.00005	0.00009	0.39676	2.27	1.76	1.05	1.83	1.13	Acceptable
127	075	0.6	15	658	0.21	0.73	0.34	210	0.15198	0.015	1.17	1.51	68	0.75	28,000	0.3967	0.7933	0.00005	0.00010	0.00018	0.79351	3.82	2.88	1.73	2.90	2.13	Acceptable
075	074	0.8x0.8	100	500	1.43	1.43	1.16	175	0.20000	0.015	0.94	2.10	68	0.75	97,000	1.3742	2.6775	0.00005	0.00020	0.00036	2.67786	1.87	1.47	1.17	2.02	2.90	Acceptable
079	078	0.8x0.8	120	333	1.76	1.76	1.14	90	0.30030	0.015	0.57	1.71	68	0.75	8,000	0.1133	2.2808	0.00005	0.00010	0.00018	2.28101	1.30	1.05	0.84	1.50	2.64	Acceptable
074	077	1.0	20	364	1.09	1.39	0.24	160	0.27473	0.015	0.78	1.02	68	0.75	106,000	1.5017	4.2925	0.00005	0.00030	0.00054	4.29304	3.94	2.97	2.97	4.85	6.73	Under
073	074	0.8x1	125	200	2.27	2.27	0.92	175	0.50000	0.015	0.61	1.53	68	0.75	8,000	0.1133	0.1133	0.00005	0.00005	0.00009	0.11342	0.05	0.15	0.15	0.41	0.93	Acceptable
076	077	0.6x0.6	265	313	1.81	1.81	2.44	163	0.31949	0.015	0.73	3.17	68	0.75	17,000	0.2408	0.2408	0.00005	0.00005	0.00009	0.24092	0.13	0.21	0.13	0.37	0.67	Acceptable
094	097	0.8x0.8	100	286	0.90	1.41	1.18	143	0.34965	0.015	0.66	1.84	68	0.75	22,000	0.3117	0.3117	0.00005	0.00005	0.00009	0.31176	0.35	0.37	0.29	0.63	0.89	Acceptable
097	042	0.8x0.8	20	25	3.05	4.76	0.07	62	4.00000	0.015	0.14	0.21	68	0.75	22,000	0.3117	0.4675	0.00005	0.00008	0.00014	0.46764	0.15	0.23	0.18	0.46	2.17	Acceptable
087	079	1.0	220	440	0.99	1.26	2.91	93	0.22727	0.015	0.66	3.57	68	0.75	153,000	2.1675	2.1675	0.00005	0.00005	0.00009	2.16759	2.19	1.70	1.70	2.85	3.59	Under
095	096	1.0	75	440	0.99	1.26	0.99	76	0.22727	0.015	0.60	1.59	68	0.75	153,000	2.1675	2.1675	0.00005	0.00005	0.00009	2.16759	2.19	1.70	1.70	2.85	3.59	Under
096	043	0.8x0.8	20	440	0.73	1.13	0.29	69	0.22727	0.015	0.57	0.87	68	0.75	153,000	2.1675	3.2513	0.00005	0.00008	0.00014	3.25139	4.48	3.35	2.68	4.40	5.00	Under
083	082	0.6	160	641	0.21	0.74	3.59	90	0.15601	0.015	0.78	4.36	68	0.75	8,000	0.1133	0.1133	0.00005	0.00005	0.00009	0.11342	0.54	0.51	0.30	0.65	0.48	Over
082	084	0.4	140	187	0.13	1.05	2.22	95	0.53476	0.015	0.45	2.67	68	0.75	3,000	0.0425	0.3117	0.00005	0.00015	0.00027	0.31194	2.36	1.82	0.73	1.32	1.39	Acceptable
078	082	0.6	10	200	0.38	1.33	0.13	88	0.50000	0.015	0.45	0.57	68	0.75	11,000	0.1558	0.1558	0.00005	0.00005	0.00009	0.15592	0.41	0.41	0.25	0.56	0.75	Acceptable
085	084	0.4	110	275	0.11	0.87	2.12	82	0.36364	0.015	0.50	2.62	68	0.75	3,000	0.0425	0.0425	0.00005	0.00005	0.00009	0.04259	0.39	0.40	0.16	0.42	0.37	Over
084	090	0.8	125	275	0.69	1.37	1.52	73	0.36364	0.015	0.47	1.99	68	0.75	17,000	0.2408	0.5950	0.00005	0.00025	0.00045	0.59545	0.86	0.74	0.59	1.10	1.52	Acceptable
089B	090	0.6	100	500	0.24	0.84	1.98	59	0.20000	0.015	0.57	2.55	68	0.75	6,000	0.0850	0.7508	0.00005	0.00035	0.00063	0.75146	3.16	2.40	1.44	2.44	2.05	Acceptable
089A	089B	0.6	85	500	0.24	0.84	1.68	64	0.20000	0.015	0.59	2.27	68	0.75	22,000	0.3117	0.6658	0.00005	0.00030	0.00054	0.66637	2.80	2.14	1.28	2.20	1.85	Acceptable
086	089	0.6	125	192	0.38	1.36	1.53	81	0.52083	0.015	0.42	1.95	68	0.75	3,000	0.0425	0.0425	0.00005	0.00005	0.00009	0.04259	0.11	0.20	0.12	0.36	0.48	Over
088A	088	0.6	65	40	0.84	2.98	0.36	51	2.50000	0.015	0.16	0.53	68	0.75	3,000	0.0425	0.0850	0.00005	0.00010	0.00018	0.08518	0.10	0.19	0.11	0.35	1.04	Acceptable
089	089A	0.8	175	474	0.53	1.05	2.79	69	0.21097	0.015	0.59	3.38	68	0.75	8,000	0.1133	0.3542	0.00005	0.00025	0.00045	0.35462	0.67	0.60	0.48	0.93	0.97	Acceptable
124	123	0.6	100	500	0.24	0.84	1.98	60	0.20000	0.015	0.57	2.55	68	0.75	3,000	0.0425	0.0425	0.00005	0.00005	0.00009	0.04259	0.18	0.24	0.15	0.40	0.34	Over
123	122	0.8	90	599	0.47	0.93	1.61	93	0.16694	0.015	0.76	2.37	68	0.75	6,000	0.0850	0.1275	0.00005	0.00010	0.00018	0.12768	0.27	0.31	0.25	0.56	0.53	Over
122	120	0.8	90	529	0.50	0.99	1.51	82	0.18904	0.015	0.68	2.19	68	0.75	8,000	0.1133	0.2833	0.00005	0.00020	0.00036	0.28369	0.57	0.53	0.42	0.84	0.83	Acceptable
091	092	1x1	75	578	1.33	1.33	0.94	106	0.17301	0.015	0.80	1.74	68	0.75	191,000	2.7058	10.8602	0.00005	0.00125	0.00225	10.86242	8.15	6.01	6.01	9.65	12.87	Under
090	091	0.8	75	1,493	0.30	0.59	2.12	72	0.06698	0.015	1.04	3.16	68	0.75	3,000	0.0425	1.4592	0.00005	0.00070	0.00126	1.46043	4.92	3.68	2.94	4.81	2.84	Acceptable
126	122	0.8	135	79	1.29	2.57	0.88	50	1.26582	0.015	0.22	1.10	68	0.75	3,000	0.0425	0.0425	0.00005	0.00005	0.00009	0.04259	0.03	0.14	0.11	0.35	0.89	Acceptable
088	089	0.6	65	32	0.94	3.33	0.33	62	3.12500	0.015	0.16	0.49	68	0.75	8,000	0.1133	0.1983	0.00005	0.00015	0.00027	0.19860	0.21	0.27	0.16	0.42	1.41	Acceptable
125	121	0.6	65	163	0.42	1.47	0.73	54	0.61350	0.015	0.32	1.06	68	0.75	6,000	0.0850	0.0850	0.00005	0.00005	0.00009	0.08509	0.20	0.26	0.16	0.42	0.62	Acceptable
121	120	0.8	90	67	1.40	2.79	0.54	96	1.49254	0.015	0.28	0.82	68	0.75	19,000	0.2692	0.5525	0.00005	0.00025	0.00045	0.55295	0.39	0.40	0.32	0.68	1.88	Acceptable
099	119	1.25x2	220	160	21.84	8.73	0.42	47	0.62500	0.015	0.30	0.72	68	0.75	403,000	5.7092	28.5827	0.00005	0.00185	0.00333	28.58600	1.31	1.06	2.12	3.52	30.77	Under
031	032	1x1	85	833	1.11	1.11	1.28	190	0.12005	0.015	1.24	2.52	68	0.75	26,500	0.3754	6.3591	0.00005	0.00027	0.00048	6.35955	5.73	4.26	8.52	13.61	15.11	Under
093	098	1x1	25	132	2.79	2.79	0.15	151	0.75758	0.015	0.47	0.62	68	0.75	18,000	0.2550	16.0735	0.00005	0.00150	0.00270	16.07620	5.76	0.12	0.12	0.17	0.47	Over
043	098	0.8	15	282	0.96	1.91	0.13	112	0.35461	0.015	0.59	0.72	68	0.75	14,500	0.2054	5.2558	0.00005	0.00025	0.00045	0.00000	0.00	0.12	0.00	0.17	0.32	Over
110	109	0.8	15	23	3.36	6.68	0.04	77	4.34783	0.015	0.15	0.19	68	0.75	3,000	0.0425	1.0767	0.00005	0.00035	0.00062	0.00000	0.00	0.12	0.00	0.17	1.14	Over
037	104	0.8	15	1,493	0.42	0.83	0.30	77	0.06698	0.015	1.07	1.37	68	0.75	3,000	0.0425	0.9492	0.00005	0.00025	0.00044	0.00000	0.00	0.12	0.00	0.17	0.14	Over

Table D2 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 5 Years Return Periods

Section		Size (m.)	L (m.)	SLOPE 1: xxx	Q_f (m^3/s)	v_f (m/s)	t_d (min)	l (m)	S_A %	n'	t_0 (min)	t_c (min)	i (mm/hr)	C	A (m^2)	Q_r (m^3/s)	ΣQ_r (m^3/s)	DWF (m^3/s)	Σ DWF (m^3/s)	Q_{max}.h (m^3/s)	Q_d (m^3/s)	Q_d/Q_f	d/D	d (m.)	v/v_f	v (m/s)	Result
001	002	1.0	517	16,667	0.16	0.20	42.05	180	0.00600	0.015	4.91	46.95	89	0.80	81,000	1.6020	1.6020	0.00005	0.00005	0.00009	1.60209	9.95	7.31	7.31	11.71	2.40	Acceptable
002	003	1.0	208	16,667	0.16	0.20	16.92	170	0.00600	0.015	4.78	21.69	89	0.80	119,000	2.3536	3.9556	0.00005	0.00010	0.00018	3.95574	24.57	17.89	17.89	28.40	5.82	Under
003	004	1.0	208	14,286	0.17	0.22	15.66	170	0.00700	0.015	4.45	20.11	89	0.80	155,000	3.0656	7.0211	0.00005	0.00015	0.00027	7.02138	40.37	29.32	29.32	46.44	10.28	Under
004	005	1.0	208	14,286	0.17	0.22	15.66	165	0.00700	0.015	4.38	20.05	89	0.80	191,000	3.7776	10.7987	0.00005	0.00020	0.00036	10.79903	62.09	45.04	45.04	71.24	15.77	Under
005	006	1.0	250	11,111	0.20	0.25	16.60	165	0.00900	0.015	3.90	20.50	89	0.80	235,000	4.6478	15.4464	0.00005	0.00025	0.00045	15.44689	78.33	56.79	56.79	89.78	22.53	Under
006	021	1x1	21	417	1.57	1.57	0.22	160	0.23981	0.015	0.83	1.05	89	0.80	235,000	4.6478	12.3710	0.00005	0.00018	0.00032	12.37132	7.88	5.82	5.82	9.35	14.68	Under
021	022	1x1	292	113	3.02	3.02	1.61	180	0.88496	0.015	0.48	2.09	89	0.80	252,000	4.9840	11.1695	0.00005	0.00014	0.00025	11.16975	3.70	2.80	2.80	4.58	13.81	Under
022	023	1x1	92	637	1.27	1.27	1.21	140	0.15699	0.015	0.95	2.16	89	0.80	259,000	5.1224	16.2919	0.00005	0.00019	0.00034	16.29228	12.83	9.40	9.40	15.00	19.05	Under
013	014	1.0	417	1,282	0.58	0.74	9.41	215	0.07800	0.015	1.61	11.02	89	0.80	56,000	1.1076	1.1076	0.00005	0.00005	0.00009	1.10765	1.91	1.50	1.50	2.53	1.87	Acceptable
014	015	1.0	208	1,266	0.58	0.74	4.66	275	0.07899	0.015	1.79	6.46	89	0.80	87,000	1.7207	2.8282	0.00005	0.00010	0.00018	2.82840	4.84	3.62	3.62	5.88	4.37	Under
015	016	1.0	208	1,282	0.58	0.74	4.69	240	0.07800	0.015	1.69	6.39	89	0.80	123,000	2.4327	5.2609	0.00005	0.00015	0.00027	5.26116	9.06	6.67	6.67	10.70	7.90	Under
016	017	1.0	208	1,266	0.58	0.74	4.66	200	0.07899	0.015	1.55	6.21	89	0.80	173,000	3.4216	8.6824	0.00005	0.00020	0.00036	8.68280	14.86	10.87	10.87	17.32	12.88	Under
017	018	1.0	225	1,282	0.58	0.74	5.08	230	0.07800	0.015	1.66	6.74	89	0.80	209,000	4.1336	12.8160	0.00005	0.00025	0.00045	12.81645	22.08	16.09	16.09	25.56	18.88	Under
018	019	1x1	292	222	2.15	2.15	2.26	210	0.45045	0.015	0.70	2.96	89	0.80	267,000	5.2807	18.0967	0.00005	0.00030	0.00054	18.09721	8.41	6.20	6.20	9.96	21.42	Under
019	020	1x1	92	242	2.06	2.06	0.74	220	0.41322	0.015	0.75	1.49	89	0.80	274,000	5.4191	23.5158	0.00005	0.00035	0.00063	23.51641	11.41	8.37	8.37	13.38	27.57	Under
006	007	1.0	155	130	1.82	2.32	1.11	170	0.76923	0.015	0.50	1.61	89	0.80	36,000	0.7120	8.4352	0.00005	0.00018	0.00032	8.43554	4.63	3.46	3.46	5.63	13.07	Under
007	008	1.0	185	130	1.82	2.32	1.33	160	0.76923	0.015	0.48	1.81	89	0.80	69,000	1.3647	9.7999	0.00005	0.00023	0.00041	9.80029	5.38	4.00	4.00	6.49	15.06	Under
008	009	1x1	190	226	2.13	2.13	1.49	180	0.44248	0.015	0.66	2.14	89	0.80	105,000	2.0767	11.8766	0.00005	0.00028	0.00050	11.87705	5.57	4.15	4.15	6.71	14.31	Under
009	010	1x1	165	403	1.60	1.60	1.72	215	0.24814	0.015	0.94	2.66	89	0.80	127,000	2.5118	14.3883	0.00005	0.00033	0.00059	14.38892	9.01	6.64	6.64	10.64	16.99	Under
012	011	0.8	110	70	1.37	2.73	0.67	145	1.42857	0.015	0.34	1.02	89	0.80	19,000	0.3758	0.3758	0.00005	0.00005	0.00009	0.37587	0.27	0.31	0.25	0.57	1.54	Acceptable
011	010	1.0	110	31	3.73	4.75	0.39	120	3.22581	0.015	0.22	0.60	89	0.80	27,000	0.5340	0.9098	0.00005	0.00010	0.00018	0.90996	0.24	0.29	0.29	0.63	2.99	Acceptable
010	027	1.0	25	227	1.38	1.76	0.24	130	0.44053	0.015	0.57	0.80	89	0.80	154,000	3.0458	18.3439	0.00005	0.00048	0.00086	18.34474	13.30	9.73	9.73	15.53	27.27	Under
021	024	1x1	155	380	1.64	1.64	1.57	175	0.26316	0.015	0.83	2.40	89	0.80	28,000	0.5538	6.7393	0.00005	0.00014	0.00025	6.73953	4.10	3.08	3.08	5.03	8.27	Under
024	025	1x1	185	380	1.64	1.64	1.88	170	0.26316	0.015	0.82	2.69	89	0.80	28,000	0.5538	7.2931	0.00005	0.00019	0.00034	7.29339	4.44	3.32	3.32	5.42	8.91	Under
025	026	1x1	375	380	1.64	1.64	3.80	155	0.26316	0.015	0.78	4.58	89	0.80	78,000	1.5427	8.8357	0.00005	0.00024	0.00043	8.83615	5.37	4.00	4.00	6.49	10.67	Under
026	027	1x1	176	116	2.98	2.98	0.99	160	0.86207	0.015	0.46	1.44	89	0.80	95,000	1.8789	10.7146	0.00005	0.00029	0.00052	10.71513	3.60	2.72	2.72	4.46	13.28	Under
027	028	1x1	36	176	2.42	2.42	0.25	245	0.56818	0.015	0.68	0.93	89	0.80	260,000	5.1422	34.2007	0.00005	0.00081	0.00146	34.20218	14.16	10.36	10.36	16.52	39.90	Under
028	106	1x1	1560	36	5.34	5.34	4.87	150	2.77778	0.015	0.26	5.12	89	0.80	260,000	5.1422	77.9689	0.00005	0.00211	0.00380	77.97275	14.60	10.68	10.68	17.02	90.90	Under
029	030	1x1	575	1,560	0.81	0.81	11.81	150	0.06410	0.015	1.49	13.30	89	0.80	31,000	0.6131	0.6131	0.00005	0.00005	0.00009	0.61320	0.76	0.66	0.66	1.21	0.99	Acceptable
022	030	0.8	833	575	0.48	0.95	14.60	165	0.17391	0.015	0.98	15.58	89	0.80	31,000	0.6131	6.1979	0.00005	0.00012	0.00021	6.19807	12.96	9.49	7.60	12.16	11.56	Under
030	031	1x1	813	833	1.11	1.11	12.20	270	0.12005	0.015	1.46	13.67	89	0.80	78,000	1.5427	8.3536	0.00005	0.00022	0.00039	8.35403	7.52	5.56	5.56	8.94	9.93	Under
107	31	1x1	176	813	1.12	1.12	2.61	270	0.12300	0.015	1.45	4.06	89	0.80	28,000	0.5538	0.5538	0.00005	0.00005	0.00009	0.55387	0.49	0.47	0.47	0.91	1.03	Acceptable
052A	050	0.8	40	176	0.86	1.72	0.39	150	0.56818	0.015	0.54	0.93	89	0.80	28,000	0.5538	0.8307	0.00005	0.00010	0.00018	0.83085	0.96	0.81	0.65	1.19	2.05	Acceptable
049	050	0.8	752	40	1.81	3.60	3.48	95	2.50000	0.015	0.22	3.69	89	0.80	14,000	0.2769	0.2769	0.00005	0.00005	0.00009	0.27698	0.15	0.23	0.18	0.46	1.64	Acceptable
050	053	0.8	15	752	0.42	0.83	0.30	105	0.13298	0.015	0.90	1.20	89	0.80	42,000	0.8307	1.9382	0.00005	0.00020	0.00036	1.93858	4.64	3.47	2.78	4.55	3.78	Under
055	053	0.8	155	207	0.80	1.58	1.63	115	0.48309	0.015	0.51	2.14	89	0.80	14,000	0.2769	0.2769	0.00005	0.00005	0.00009	0.27698	0.35	0.37	0.29	0.63	1.00	Acceptable
053	054	0.7x0.6	150	170	0.71	1.69	1.48	115	0.58824	0.015	0.47	1.94	89	0.80	640,000	12.6578	14.8729	0.00005	0.00030	0.00054	14.87343	20.92	15.25	10.67	17.01	28.81	Under
056	057	0.8	170	210	0.79	1.57	1.80	105	0.47619	0.015	0.49	2.30	89	0.80	11,000	0.2176	0.2176	0.00005	0.00005	0.00009	0.21765	0.28	0.31	0.25	0.57	0.89	Acceptable
057	054	1x1	175	213	2.20	2.20	1.33	115	0.46948	0.015	0.52	1.85	89	0.80	33,000	0.6527	0.8702	0.00005	0.00010	0.00018	0.87040	0.40	0.40	0.40	0.80	1.77	Acceptable
054	048	1x1	20	285	1.90	1.90	0.18	95	0.35088	0.015	0.54	0.72	89	0.80	97,000	1.9184	17.6616	0.00005	0.00045	0.00081	17.66237	9.30	6.85	6.85	10.97	20.83	Under
044	045	0.8	135	39	1.84	3.65	0.62	115	2.56410	0.015	0.24	0.85	89	0.80	14,000	0.2769	0.2769	0.00005	0.00005	0.00009	0.27698	0.15	0.22	0.18	0.45	1.66	Acceptable
045B	045A	0.8	50	201	0.81	1.61	0.52	145	0.49751	0.015	0.56	1.08	89	0.80	56,000	1.1076	1.1076	0.00005	0.00005	0.00009	1.10765	1.37	1.11	0.88	1.57	2.52	Acceptable
045A	045	0.8	175	201	0.81	1.61	1.81	145	0.49751	0.015	0.56	2.38	89	0.80	19,000	0.3758	1.4833	0.00005	0.00010	0.00018	1.48351	1.83	1.44	1.15	1.99	3.20	Under
045	047	0.8	20	667	0.44	0.88	0.38	100	0.14993	0.015	0.83	1.21	89	0.80	33,000	0.6527	2.4129	0.00005	0.00020	0.00036	2.41325	5.44	4.05	3.24	5.28	4.66	Under
046	047	0.8	55	550	0.49	0.97	0.94	85	0.18182	0.015	0.70	1.65	89	0.80	6,000	0.1187	0.1187	0.00005	0.00005	0.00009	0.11876	0.24	0.29	0.23	0.54	0.52	Over

Table D2 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 5 Years Return Period (Continue)

Section		Size (m.)	L (m.)	SLOPE 1: xxx	Q_f (m^3/s)	v_f (m/s)	t_d (min)	l (m)	S_A %	n'	t_0 (min)	t_c (min)	i (mm/hr)	C	A (m^2)	Q_r (m^3/s)	Σ Q_r (m^3/s)	DWF (m^3/s)	Σ DWF (m^3/s)	Q_{max}.h (m^3/s)	Q_d (m^3/s)	Q_d/Q_f	d/D	d (m.)	v/v_f	v (m/s)	Result
047	048	0.8	125	147	0.95	1.88	1.11	105	0.68027	0.015	0.42	1.53	89	0.80	47,000	0.9296	3.4611	0.00005	0.00030	0.00054	3.46165	3.66	2.76	2.21	3.66	6.88	Under
048	035	1x1	175	1,163	0.94	0.94	3.10	120	0.08598	0.015	1.17	4.27	89	0.80	164,000	3.2436	24.3662	0.00005	0.00080	0.00144	24.36766	25.93	18.87	18.87	29.95	28.15	Under
033	034	0.8	135	42	1.77	3.52	0.64	95	2.38095	0.015	0.22	0.86	89	0.80	14,000	0.2769	0.2769	0.00005	0.00005	0.00009	0.27698	0.16	0.23	0.18	0.46	1.61	Acceptable
034	035	1.0	95	50	2.94	3.74	0.42	120	2.00000	0.015	0.27	0.69	89	0.80	22,000	0.4351	0.7120	0.00005	0.00010	0.00018	0.71218	0.24	0.29	0.29	0.63	2.35	Acceptable
035	036	1.0	25	250	1.31	1.67	0.25	95	0.40000	0.015	0.51	0.76	89	0.80	186,000	3.6787	28.7569	0.00005	0.00095	0.00171	28.75860	21.87	15.94	15.94	25.33	42.38	Under
040	038	0.8x1	95	474	0.75	0.94	1.68	85	0.21097	0.015	0.66	2.34	89	0.80	7,000	0.1384	0.1384	0.00005	0.00005	0.00009	0.13853	0.18	0.25	0.25	0.56	0.53	Over
038	036	0.8x1	80	400	0.82	1.03	1.30	40	0.25000	0.015	0.43	1.73	89	0.80	14,000	0.2769	0.4153	0.00005	0.00010	0.00018	0.41551	0.51	0.48	0.48	0.93	0.95	Acceptable
036	037	1x1	115	230	5.13	5.13	0.37	95	0.43478	0.015	0.49	0.87	89	0.80	228,000	4.5093	33.6816	0.00005	0.00110	0.00198	33.68354	6.56	4.86	4.86	7.85	40.26	Under
037	028	1x1	25	100	11.01	11.01	0.04	100	1.00000	0.015	0.34	0.38	89	0.80	228,000	4.5093	38.6260	0.00005	0.00125	0.00225	38.62825	3.51	2.65	2.65	4.36	47.98	Under
041	039	0.8	125	192	0.83	1.65	1.27	85	0.52083	0.015	0.43	1.70	89	0.80	11,000	0.2176	0.2176	0.00005	0.00005	0.00009	0.21765	0.26	0.31	0.24	0.56	0.91	Acceptable
039	037	0.8	25	132	1.00	1.98	0.21	40	0.75758	0.015	0.25	0.46	89	0.80	11,000	0.2176	0.4351	0.00005	0.00010	0.00018	0.43529	0.44	0.43	0.34	0.71	1.42	Acceptable
100	103	0.8	125	521	0.50	1.00	2.09	40	0.19194	0.015	0.48	2.57	89	0.80	3,000	0.0593	0.0593	0.00005	0.00005	0.00009	0.05942	0.12	0.20	0.16	0.42	0.42	Over
101	102	0.8	75	112	1.08	2.15	0.58	30	0.89286	0.015	0.21	0.79	89	0.80	7,000	0.1384	0.2571	0.00005	0.00010	0.00018	0.25729	0.24	0.29	0.23	0.53	1.15	Acceptable
102	103	1x1	75	112	3.03	3.03	0.41	30	0.89286	0.015	0.21	0.62	89	0.80	14,000	0.2769	0.5340	0.00005	0.00015	0.00027	0.53427	0.18	0.24	0.24	0.55	1.68	Acceptable
113	112	0.8	55	1,099	0.35	0.69	1.33	120	0.09099	0.015	1.14	2.47	89	0.80	3,000	0.0593	0.7120	0.00005	0.00015	0.00027	0.71227	2.06	1.61	1.28	2.20	1.51	Acceptable
116	117	0.8	75	1,493	0.30	0.59	2.12	100	0.06698	0.015	1.21	3.33	89	0.80	6,000	0.1187	0.1187	0.00005	0.00005	0.00009	0.11876	0.40	0.40	0.32	0.68	0.40	Over
115	114	0.8	135	246	0.73	1.45	1.55	100	0.40650	0.015	0.52	2.07	89	0.80	14,000	0.2769	0.2769	0.00005	0.00005	0.00009	0.27698	0.38	0.39	0.31	0.66	0.96	Acceptable
114	113	0.8	135	193	0.83	1.64	1.37	155	0.51813	0.015	0.57	1.94	89	0.80	19,000	0.3758	0.6527	0.00005	0.00010	0.00018	0.65285	0.79	0.69	0.55	1.04	1.70	Acceptable
119	118	0.8	50	91	1.20	2.39	0.35	85	1.09890	0.015	0.30	0.65	89	0.80	3,000	0.0593	0.7120	0.00005	0.00015	0.00027	0.71227	0.59	0.54	0.44	0.86	2.05	Acceptable
105A	105	0.8	230	5,882	0.15	0.30	12.89	95	0.01700	0.015	2.24	15.13	89	0.80	44,000	0.8702	0.8702	0.00005	0.00005	0.00009	0.87031	5.82	4.33	3.46	5.63	1.67	Acceptable
103	104	1x1	25	417	1.57	1.57	0.27	50	0.23981	0.015	0.48	0.75	89	0.80	72,000	1.4240	2.0173	0.00005	0.00025	0.00045	2.01778	1.29	1.05	1.05	1.82	2.86	Acceptable
104	105	1x1	15	1,493	0.83	0.83	0.30	80	0.06698	0.015	1.09	1.39	89	0.80	300,000	5.9333	9.2758	0.00005	0.00030	0.00054	9.27632	11.18	8.21	8.21	13.12	10.88	Under
105	106	0.8	25	535	0.50	0.99	0.42	105	0.18692	0.015	0.77	1.19	89	0.80	14,000	0.2769	0.2769	0.00005	0.00005	0.00009	0.27698	0.56	0.52	0.42	0.83	0.81	Acceptable
109	106	0.8	15	23	2.39	4.75	0.05	53	4.34783	0.015	0.13	0.18	89	0.80	314,000	6.2102	7.7133	0.00005	0.00040	0.00071	7.71405	3.23	2.45	1.96	3.26	15.51	Under
111	105	1.0	130	289	1.22	1.56	1.39	105	0.34602	0.015	0.57	1.97	89	0.80	3,000	0.0593	1.3251	0.00005	0.00025	0.00045	1.32556	1.08	0.90	0.90	1.59	2.47	Acceptable
118	110	1.2	80	320	1.89	1.67	0.80	25	0.31250	0.015	0.31	1.11	89	0.80	6,000	0.1187	1.4438	0.00005	0.00030	0.00054	1.44432	0.76	0.67	0.80	1.44	2.40	Acceptable
112	111	1.0	195	433	1.00	1.27	2.56	133	0.23095	0.015	0.77	3.33	89	0.80	28,000	0.5538	1.2658	0.00005	0.00020	0.00036	1.26614	1.27	1.03	1.03	1.80	2.29	Acceptable
108	106	0.6x0.6	175	389	0.30	0.82	3.55	38	0.25707	0.015	0.41	3.96	89	0.80	19,000	0.3758	0.3758	0.00005	0.00005	0.00009	0.37587	1.27	1.03	0.62	1.15	0.94	Acceptable
070	071	0.6	85	532	0.23	0.82	1.74	205	0.18797	0.015	1.04	2.78	89	0.80	17,000	0.3362	0.3362	0.00005	0.00005	0.00009	0.33631	1.46	1.17	0.70	1.28	1.04	Acceptable
129	130	1x1	235	725	1.19	1.19	3.29	142	0.13793	0.015	1.02	4.31	89	0.80	36,000	0.7120	0.7120	0.00005	0.00005	0.00009	0.71209	0.60	0.55	0.55	1.03	1.23	Acceptable
071	072	1.0	20	67	2.54	3.23	0.10	180	1.49254	0.015	0.37	0.48	89	0.80	53,000	1.0482	2.4920	0.00005	0.00015	0.00027	2.49227	0.98	0.83	0.83	1.47	4.76	Under
062	071	1.2	180	599	1.38	1.22	2.46	160	0.16694	0.015	0.98	3.44	89	0.80	56,000	1.1076	1.1076	0.00005	0.00005	0.00009	1.10765	0.80	0.70	0.83	1.49	1.82	Acceptable
061	060	0.8	25	192	0.83	1.65	0.25	135	0.52083	0.015	0.53	0.79	89	0.80	7,000	0.1384	0.1384	0.00005	0.00005	0.00009	0.13853	0.17	0.24	0.19	0.47	0.77	Acceptable
060	059	0.8	180	195	0.82	1.63	1.84	145	0.51282	0.015	0.56	2.39	89	0.80	25,000	0.4944	0.6329	0.00005	0.00010	0.00018	0.63307	0.77	0.67	0.54	1.02	1.67	Acceptable
058	059	0.6	75	44	0.80	2.84	0.44	120	2.27273	0.015	0.25	0.69	89	0.80	14,000	0.2769	0.2769	0.00005	0.00005	0.00009	0.27698	0.35	0.36	0.22	0.52	1.46	Acceptable
051	052	0.8	110	60	1.48	2.94	0.62	68	1.66667	0.015	0.23	0.85	89	0.80	14,000	0.2769	0.2769	0.00005	0.00005	0.00009	0.27698	0.19	0.25	0.20	0.49	1.43	Acceptable
059	069	0.8	15	150	0.94	1.86	0.13	175	0.66667	0.015	0.54	0.67	89	0.80	53,000	1.0482	1.9580	0.00005	0.00020	0.00036	1.95836	2.09	1.63	1.30	2.23	4.14	Under
063	069	0.8	150	163	0.90	1.79	1.40	101	0.61350	0.015	0.43	1.83	89	0.80	6,000	0.1187	0.1187	0.00005	0.00005	0.00009	0.11876	0.13	0.21	0.17	0.44	0.78	Acceptable
069	068	0.8	170	236	0.75	1.48	1.91	100	0.42373	0.015	0.51	2.42	89	0.80	70,000	1.3844	3.4611	0.00005	0.00030	0.00054	3.46165	4.64	3.47	2.78	4.55	6.76	Under
064	065	0.3	160	139	0.07	1.01	2.65	65	0.71942	0.015	0.33	2.98	89	0.80	6,000	0.1187	0.1187	0.00005	0.00005	0.00009	0.11876	1.67	1.32	0.40	0.80	0.80	Acceptable
066	065	0.8	75	578	0.48	0.95	1.32	83	0.17301	0.015	0.71	2.03	89	0.80	3,000	0.0593	0.0593	0.00005	0.00005	0.00009	0.05942	0.12	0.21	0.16	0.43	0.41	Over
065	067	0.8	10	200	0.81	1.61	0.10	108	0.50000	0.015	0.49	0.59	89	0.80	8,000	0.1582	0.3362	0.00005	0.00015	0.00027	0.33649	0.42	0.42	0.33	0.69	1.12	Acceptable
067A	067	0.8	165	150	0.94	1.86	1.48	82	0.66667	0.015	0.38	1.85	89	0.80	11,000	0.2176	0.2176	0.00005	0.00005	0.00009	0.21765	0.23	0.28	0.23	0.53	0.98	Acceptable
067	068	0.8	105	877	0.39	0.77	2.27	108	0.11403	0.015	0.98	3.25	89	0.80	22,000	0.4351	0.9889	0.00005	0.00025	0.00045	0.98934	2.56	1.96	1.57	2.65	2.04	Acceptable
068	080	0.8	35	117	1.06	2.11	0.28	170	0.85470	0.015	0.47	0.75	89	0.80	78,000	1.5427	5.9927	0.00005	0.00060	0.00108	5.99375	5.65	4.21	3.37	5.48	11.55	Under

Table D2 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 5 Years Return Periods (Continue)

Section		Size	L	SLOPE	Q_f	v_f	t_d	l	S_A	n'	t_0	t_c	i	C	A	Q_r	ΣQ_r	DWF	Σ DWF	Q_{max}.h	Q_d	Q_d/Q_f	d/D	d	v/v_f	v	Result
		(m.)	(m.)	1: xxx	(m^3/s)	(m/s)	(min)	(m)	%		(min)	(min)	(mm/hr)		(m^2)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)			(m.)		(m/s)	
080	093	1.25x1.5	195	132	6.24	3.33	0.98	118	0.75901	0.015	0.42	1.40	89	0.80	92,000	1.8196	9.3747	0.00005	0.00080	0.00144	9.37611	1.50	1.20	1.80	3.01	10.04	Under
072	080	0.8	110	250	0.73	1.44	1.27	215	0.40000	0.015	0.75	2.02	89	0.80	6,000	0.1187	1.5624	0.00005	0.00015	0.00027	1.56271	2.16	1.67	1.34	2.28	3.29	Under
077	081	1.0	60	1,000	0.66	0.84	1.20	135	0.10000	0.015	1.15	2.35	89	0.80	8,000	0.1582	9.3351	0.00005	0.00045	0.00081	9.33592	14.20	10.39	10.39	16.57	13.86	Under
081	091	0.8	110	225	0.76	1.52	1.21	105	0.44500	0.015	0.51	1.72	89	0.80	600	0.0119	9.3470	0.00005	0.00050	0.00090	9.34788	12.22	8.96	7.17	11.48	17.46	Under
096	093	1.0	25	40	3.29	4.18	0.10	50	2.50000	0.015	0.16	0.26	89	0.80	14,000	0.2769	9.6239	0.00005	0.00055	0.00099	9.62486	2.93	2.23	2.23	3.70	15.46	Under
092	093	0.8	65	118	1.06	2.10	0.52	172	0.84746	0.015	0.48	0.99	89	0.80	3,000	0.0593	9.6832	0.00005	0.00060	0.00108	9.68428	9.18	6.75	5.40	8.70	18.25	Under
042	043	1.25x1.5	15	300	3.47	1.85	0.14	107	0.33333	0.015	0.59	0.72	89	0.80	94,000	1.8591	2.5118	0.00005	0.00013	0.00023	2.51200	0.72	0.64	0.96	1.68	3.11	Under
098	099	1.25x2	65	282	9.78	3.91	0.28	45	0.35461	0.015	0.38	0.66	89	0.80	109,000	2.1558	31.9332	0.00005	0.00180	0.00324	31.93644	3.26	2.48	4.95	7.99	31.26	Under
093	098	0.8	150	130	4.49	4.49	0.56	136	0.76923	0.015	0.45	1.00	89	0.80	28,000	0.5538	32.4870	0.00005	0.00185	0.00333	32.49031	7.23	5.35	4.28	6.92	31.09	Under
130	075	1.0	465	220	1.40	1.78	4.34	240	0.45455	0.015	0.74	5.09	89	0.80	56,000	1.1076	1.8196	0.00005	0.00010	0.00018	1.81974	1.30	1.05	1.05	1.83	3.27	Under
128	127	0.6	250	926	0.17	0.62	6.74	200	0.10799	0.015	1.34	8.07	89	0.80	28,000	0.5538	0.5538	0.00005	0.00005	0.00009	0.55387	3.17	2.41	1.44	2.45	1.51	Acceptable
127	075	0.6	15	658	0.21	0.73	0.34	210	0.15198	0.015	1.17	1.51	89	0.80	28,000	0.5538	1.1076	0.00005	0.00010	0.00018	1.10774	5.34	3.98	2.39	3.94	2.89	Acceptable
075	074	0.8x0.8	100	500	1.43	1.43	1.16	175	0.20000	0.015	0.94	2.10	89	0.80	97,000	1.9184	3.7380	0.00005	0.00020	0.00036	3.73836	2.61	2.00	1.60	2.70	3.87	Under
079	078	0.8x0.8	120	333	1.76	1.76	1.14	90	0.30030	0.015	0.57	1.71	89	0.80	8,000	0.1582	3.1842	0.00005	0.00010	0.00018	3.18440	1.81	1.43	1.14	1.97	3.46	Under
074	077	1.0	20	364	1.09	1.39	0.24	160	0.27473	0.015	0.78	1.02	89	0.80	106,000	2.0964	5.9927	0.00005	0.00030	0.00054	5.99321	5.50	4.09	4.09	6.63	9.20	Under
073	074	0.8x1	125	200	2.27	2.27	0.92	175	0.50000	0.015	0.61	1.53	89	0.80	8,000	0.1582	0.1582	0.00005	0.00005	0.00009	0.15831	0.07	0.17	0.17	0.43	0.98	Acceptable
076	077	0.6x0.6	265	313	1.81	1.81	2.44	163	0.31949	0.015	0.73	3.17	89	0.80	17,000	0.3362	0.3362	0.00005	0.00005	0.00009	0.33631	0.19	0.25	0.15	0.41	0.74	Acceptable
094	097	0.8x0.8	100	286	0.90	1.41	1.18	143	0.34965	0.015	0.66	1.84	89	0.80	22,000	0.4351	0.4351	0.00005	0.00005	0.00009	0.43520	0.48	0.46	0.37	0.76	1.07	Acceptable
097	042	0.8x0.8	20	25	3.05	4.76	0.07	62	4.00000	0.015	0.14	0.21	89	0.80	22,000	0.4351	0.6527	0.00005	0.00008	0.00014	0.65280	0.21	0.27	0.22	0.51	2.43	Acceptable
087	079	1.0	220	440	0.99	1.26	2.91	93	0.22727	0.015	0.66	3.57	89	0.80	153,000	3.0260	3.0260	0.00005	0.00005	0.00009	3.02609	3.05	2.32	2.32	3.84	4.84	Under
095	096	1.0	75	440	0.99	1.26	0.99	76	0.22727	0.015	0.60	1.59	89	0.80	153,000	3.0260	3.0260	0.00005	0.00005	0.00009	3.02609	3.05	2.32	2.32	3.84	4.84	Under
096	043	0.8x0.8	20	440	0.73	1.13	0.29	69	0.22727	0.015	0.57	0.87	89	0.80	153,000	3.0260	4.5390	0.00005	0.00008	0.00014	4.53914	6.25	4.64	3.71	6.02	6.84	Under
083	082	0.6	160	641	0.21	0.74	3.59	90	0.15601	0.015	0.78	4.36	89	0.80	8,000	0.1582	0.1582	0.00005	0.00005	0.00009	0.15831	0.75	0.66	0.40	0.80	0.59	Over
082	084	0.4	140	187	0.13	1.05	2.22	95	0.53476	0.015	0.45	2.67	89	0.80	3,000	0.0593	0.4351	0.00005	0.00015	0.00027	0.43538	3.30	2.50	1.00	1.75	1.84	Acceptable
078	082	0.6	10	200	0.38	1.33	0.13	88	0.50000	0.015	0.45	0.57	89	0.80	11,000	0.2176	0.2176	0.00005	0.00005	0.00009	0.21765	0.58	0.53	0.32	0.68	0.90	Acceptable
085	084	0.4	110	275	0.11	0.87	2.12	82	0.36364	0.015	0.50	2.62	89	0.80	3,000	0.0593	0.0593	0.00005	0.00005	0.00009	0.05942	0.55	0.51	0.20	0.49	0.43	Over
084	090	0.8	125	275	0.69	1.37	1.52	73	0.36364	0.015	0.47	1.99	89	0.80	17,000	0.3362	0.8307	0.00005	0.00025	0.00045	0.83112	1.20	0.98	0.79	1.41	1.94	Acceptable
089B	090	0.6	100	500	0.24	0.84	1.98	59	0.20000	0.015	0.57	2.55	89	0.80	6,000	0.1187	1.0482	0.00005	0.00035	0.00063	1.04885	4.41	3.30	1.98	3.30	2.78	Acceptable
089A	089B	0.6	85	500	0.24	0.84	1.68	64	0.20000	0.015	0.59	2.27	89	0.80	22,000	0.4351	0.9296	0.00005	0.00030	0.00054	0.93010	3.91	2.94	1.76	2.96	2.49	Acceptable
086	089	0.6	125	192	0.38	1.36	1.53	81	0.52083	0.015	0.42	1.95	89	0.80	3,000	0.0593	0.0593	0.00005	0.00005	0.00009	0.05942	0.15	0.23	0.14	0.39	0.52	Over
088A	088	0.6	65	40	0.84	2.98	0.36	51	2.50000	0.015	0.16	0.53	89	0.80	3,000	0.0593	0.1187	0.00005	0.00010	0.00018	0.11885	0.14	0.22	0.13	0.38	1.12	Acceptable
089	089A	0.8	175	474	0.53	1.05	2.79	69	0.21097	0.015	0.59	3.38	89	0.80	8,000	0.1582	0.4944	0.00005	0.00025	0.00045	0.49489	0.94	0.80	0.64	1.17	1.23	Acceptable
124	123	0.6	100	500	0.24	0.84	1.98	60	0.20000	0.015	0.57	2.55	89	0.80	3,000	0.0593	0.0593	0.00005	0.00005	0.00009	0.05942	0.25	0.30	0.18	0.45	0.38	Over
123	122	0.8	90	599	0.47	0.93	1.61	93	0.16694	0.015	0.76	2.37	89	0.80	6,000	0.1187	0.1780	0.00005	0.00010	0.00018	0.17818	0.38	0.39	0.31	0.66	0.62	Acceptable
122	120	0.8	90	529	0.50	0.99	1.51	82	0.18904	0.015	0.68	2.19	89	0.80	8,000	0.1582	0.3956	0.00005	0.00020	0.00036	0.39592	0.79	0.69	0.55	1.04	1.03	Acceptable
091	092	1x1	75	578	1.33	1.33	0.94	106	0.17301	0.015	0.80	1.74	89	0.80	191,000	3.7776	15.1616	0.00005	0.00125	0.00225	15.16389	11.37	8.34	8.34	13.34	17.78	Under
090	091	0.8	75	1,493	0.30	0.59	2.12	72	0.06698	0.015	1.04	3.16	89	0.80	3,000	0.0593	2.0371	0.00005	0.00070	0.00126	2.03837	6.87	5.09	4.07	6.59	3.89	Under
126	122	0.8	135	79	1.29	2.57	0.88	50	1.26582	0.015	0.22	1.10	89	0.80	3,000	0.0593	0.0593	0.00005	0.00005	0.00009	0.05942	0.05	0.15	0.12	0.36	0.92	Acceptable
088	089	0.6	65	32	0.94	3.33	0.33	62	3.12500	0.015	0.16	0.49	89	0.80	8,000	0.1582	0.2769	0.00005	0.00015	0.00027	0.27716	0.29	0.33	0.20	0.48	1.60	Acceptable
125	121	0.6	65	163	0.42	1.47	0.73	54	0.61350	0.015	0.32	1.06	89	0.80	6,000	0.1187	0.1187	0.00005	0.00005	0.00009	0.11876	0.28	0.32	0.19	0.47	0.70	Acceptable
121	120	0.8	90	67	1.40	2.79	0.54	96	1.49254	0.015	0.28	0.82	89	0.80	19,000	0.3758	0.7713	0.00005	0.00025	0.00045	0.77178	0.55	0.51	0.41	0.82	2.28	Acceptable
099	119	1.25x2	220	160	21.84	8.73	0.42	47	0.62500	0.015	0.30	0.72	89	0.80	403,000	7.9704	39.9036	0.00005	0.00185	0.00333	39.90697	1.83	1.44	2.87	4.71	41.11	Under
031	032	1x1	85	833	1.11	1.11	1.28	190	0.12005	0.015	1.24	2.52	89	0.80	26,500	0.5241	8.8778	0.00005	0.00027	0.00048	8.87823	8.00	5.90	11.80	18.79	20.87	Under
093	098	1x1	25	132	2.79	2.79	0.15	151	0.75758	0.015	0.47	0.62	89	0.80	18,000	0.3560	22.4399	0.00005	0.00150	0.00270	22.44257	8.05	0.12	0.12	0.17	0.47	Over
043	098	0.8	15	282	0.96	1.91	0.13	112	0.35461	0.015	0.59	0.72	89	0.80	14,500	0.2868	7.3376	0.00005	0.00025	0.00045	0.00000	0.00	0.12	0.00	0.17	0.32	Over
110	109	0.8	15	23	3.36	6.68	0.04	77	4.34783	0.015	0.15	0.19	89	0.80	3,000	0.0593	1.5031	0.00005	0.00035	0.00062	0.00000	0.00	0.12	0.00	0.17	1.14	Over
037	104	0.8	15	1,493	0.42	0.83	0.30	77	0.06698	0.015	1.07	1.37	89	0.80	3,000	0.0593	1.3251	0.00005	0.00025	0.00044	0.00000	0.00	0.12	0.00	0.17	0.14	Over

Table D3 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 10 Years Return Periods

Section		Size (m.)	L (m.)	SLOPE 1: xxx	Q_f (m^3/s)	v_f (m/s)	t_d (min)	l (m)	S_A %	n'	t_0 (min)	t_c (min)	i (mm/hr)	C	A (m^2)	Q_r (m^3/s)	Σ Q_r (m^3/s)	DWF (m^3/s)	Σ DWF (m^3/s)	Q_{max}.h (m^3/s)	Q_d (m^3/s)	Q_d/Q_f	d/D	d (m.)	v/v_f	v (m/s)	Result
001	002	1.0	517	16,667	0.16	0.20	42.05	180	0.00600	0.015	4.91	46.95	105	0.83	81,000	1.9609	1.9609	0.00005	0.00005	0.00009	1.96097	12.18	8.93	8.93	14.26	2.92	Acceptable
002	003	1.0	208	16,667	0.16	0.20	16.92	170	0.00600	0.015	4.78	21.69	105	0.83	119,000	2.8808	4.8417	0.00005	0.00010	0.00018	4.84185	30.07	21.87	21.87	34.68	7.11	Under
003	004	1.0	208	14,286	0.17	0.22	15.66	170	0.00700	0.015	4.45	20.11	105	0.83	155,000	3.7523	8.5940	0.00005	0.00015	0.00027	8.59423	49.42	35.87	35.87	56.77	12.57	Under
004	005	1.0	208	14,286	0.17	0.22	15.66	165	0.00700	0.015	4.38	20.05	105	0.83	191,000	4.6238	13.2178	0.00005	0.00020	0.00036	13.21811	76.00	55.10	55.10	87.12	19.28	Under
005	006	1.0	250	11,111	0.20	0.25	16.60	165	0.00900	0.015	3.90	20.50	105	0.83	235,000	5.6890	18.9067	0.00005	0.00025	0.00045	18.90716	95.87	69.48	69.48	109.81	27.56	Under
006	021	1x1	21	417	1.57	1.57	0.22	160	0.23981	0.015	0.83	1.05	105	0.83	235,000	5.6890	15.1423	0.00005	0.00018	0.00032	15.14263	9.65	7.10	7.10	11.37	17.84	Under
021	022	1x1	292	113	3.02	3.02	1.61	180	0.88496	0.015	0.48	2.09	105	0.83	252,000	6.1005	13.6717	0.00005	0.00014	0.00025	13.67190	4.53	3.40	3.40	5.53	16.67	Under
022	023	1x1	92	637	1.27	1.27	1.21	140	0.15699	0.015	0.95	2.16	105	0.83	259,000	6.2700	19.9416	0.00005	0.00019	0.00034	19.94195	15.70	11.48	11.48	18.28	23.21	Under
013	014	1.0	417	1,282	0.58	0.74	9.41	215	0.07800	0.015	1.61	11.02	105	0.83	56,000	1.3557	1.3557	0.00005	0.00005	0.00009	1.35576	2.34	1.80	1.80	3.02	2.23	Acceptable
014	015	1.0	208	1,266	0.58	0.74	4.66	275	0.07899	0.015	1.79	6.46	105	0.83	87,000	2.1061	3.4618	0.00005	0.00010	0.00018	3.46197	5.93	4.40	4.40	7.12	5.29	Under
015	016	1.0	208	1,282	0.58	0.74	4.69	240	0.07800	0.015	1.69	6.39	105	0.83	123,000	2.9776	6.4394	0.00005	0.00015	0.00027	6.43969	11.09	8.14	8.14	13.02	9.62	Under
016	017	1.0	208	1,266	0.58	0.74	4.66	200	0.07899	0.015	1.55	6.21	105	0.83	173,000	4.1880	10.6275	0.00005	0.00020	0.00036	10.62782	18.19	13.28	13.28	21.12	15.70	Under
017	018	1.0	225	1,282	0.58	0.74	5.08	230	0.07800	0.015	1.66	6.74	105	0.83	209,000	5.0595	15.6870	0.00005	0.00025	0.00045	15.68745	27.02	19.66	19.66	31.20	23.06	Under
018	019	1x1	292	222	2.15	2.15	2.26	210	0.45045	0.015	0.70	2.96	105	0.83	267,000	6.4636	22.1506	0.00005	0.00030	0.00054	22.15117	10.30	7.57	7.57	12.11	26.05	Under
019	020	1x1	92	242	2.06	2.06	0.74	220	0.41322	0.015	0.75	1.49	105	0.83	274,000	6.6331	28.7837	0.00005	0.00035	0.00063	28.78434	13.97	10.22	10.22	16.30	33.59	Under
006	007	1.0	155	130	1.82	2.32	1.11	170	0.76923	0.015	0.50	1.61	105	0.83	36,000	0.8715	10.3249	0.00005	0.00018	0.00032	10.32517	5.66	4.21	4.21	6.82	15.82	Under
007	008	1.0	185	130	1.82	2.32	1.33	160	0.76923	0.015	0.48	1.81	105	0.83	69,000	1.6704	11.9952	0.00005	0.00023	0.00041	11.99563	6.58	4.88	4.88	7.86	18.25	Under
008	009	1x1	190	226	2.13	2.13	1.49	180	0.44248	0.015	0.66	2.14	105	0.83	105,000	2.5419	14.5371	0.00005	0.00028	0.00050	14.53760	6.82	5.05	5.05	8.14	17.35	Under
009	010	1x1	165	403	1.60	1.60	1.72	215	0.24814	0.015	0.94	2.66	105	0.83	127,000	3.0745	17.6116	0.00005	0.00033	0.00059	17.61215	11.03	8.10	8.10	12.95	20.67	Under
012	011	0.8	110	70	1.37	2.73	0.67	145	1.42857	0.015	0.34	1.02	105	0.83	19,000	0.4600	0.4600	0.00005	0.00005	0.00009	0.46005	0.34	0.36	0.29	0.62	1.70	Acceptable
011	010	1.0	110	31	3.73	4.75	0.39	120	3.22581	0.015	0.22	0.60	105	0.83	27,000	0.6536	1.1136	0.00005	0.00010	0.00018	1.11376	0.30	0.33	0.33	0.69	3.29	Under
010	027	1.0	25	227	1.38	1.76	0.24	130	0.44053	0.015	0.57	0.80	105	0.83	154,000	3.7281	22.4532	0.00005	0.00048	0.00086	22.45408	16.27	11.89	11.89	18.93	33.25	Under
021	024	1x1	155	380	1.64	1.64	1.57	175	0.26316	0.015	0.83	2.40	105	0.83	28,000	0.6778	8.2490	0.00005	0.00014	0.00025	8.24924	5.02	3.75	3.75	6.08	10.00	Under
024	025	1x1	185	380	1.64	1.64	1.88	170	0.26316	0.015	0.82	2.69	105	0.83	28,000	0.6778	8.9268	0.00005	0.00019	0.00034	8.92716	5.43	4.04	4.04	6.55	10.77	Under
025	026	1x1	375	380	1.64	1.64	3.80	155	0.26316	0.015	0.78	4.58	105	0.83	78,000	1.8883	10.8151	0.00005	0.00024	0.00043	10.81550	6.58	4.87	4.87	7.86	12.93	Under
026	027	1x1	176	116	2.98	2.98	0.99	160	0.86207	0.015	0.46	1.44	105	0.83	95,000	2.2998	13.1149	0.00005	0.00029	0.00052	13.11538	4.41	3.30	3.30	5.38	16.02	Under
027	028	1x1	36	176	2.42	2.42	0.25	245	0.56818	0.015	0.68	0.93	105	0.83	260,000	6.2942	41.8623	0.00005	0.00081	0.00146	41.86372	17.33	12.65	12.65	20.14	48.65	Under
028	106	1x1	1560	36	5.34	5.34	4.87	150	2.77778	0.015	0.26	5.12	105	0.83	260,000	6.2942	95.4353	0.00005	0.00211	0.00380	95.43910	17.87	13.04	13.04	20.75	110.84	Under
029	030	1x1	575	1,560	0.81	0.81	11.81	150	0.06410	0.015	1.49	13.30	105	0.83	31,000	0.7505	0.7505	0.00005	0.00005	0.00009	0.75055	0.92	0.78	0.78	1.41	1.14	Acceptable
022	030	0.8	833	575	0.48	0.95	14.60	165	0.17391	0.015	0.98	15.58	105	0.83	31,000	0.7505	7.5863	0.00005	0.00012	0.00021	7.58650	15.87	11.60	9.28	14.81	14.08	Under
030	031	1x1	813	833	1.11	1.11	12.20	270	0.12005	0.015	1.46	13.67	105	0.83	78,000	1.8883	10.2250	0.00005	0.00022	0.00039	10.22539	9.21	6.78	6.78	10.86	12.07	Under
107	31	1x1	176	813	1.12	1.12	2.61	270	0.12300	0.015	1.45	4.06	105	0.83	28,000	0.6778	0.6778	0.00005	0.00005	0.00009	0.67792	0.60	0.55	0.55	1.04	1.17	Acceptable
052A	050	0.8	40	176	0.86	1.72	0.39	150	0.56818	0.015	0.54	0.93	105	0.83	28,000	0.6778	1.0168	0.00005	0.00010	0.00018	1.01693	1.18	0.97	0.77	1.39	2.39	Acceptable
049	050	0.8	752	40	1.81	3.60	3.48	95	2.50000	0.015	0.22	3.69	105	0.83	14,000	0.3389	0.3389	0.00005	0.00005	0.00009	0.33901	0.19	0.25	0.20	0.49	1.75	Acceptable
050	053	0.8	15	752	0.42	0.83	0.30	105	0.13298	0.015	0.90	1.20	105	0.83	42,000	1.0168	2.3724	0.00005	0.00020	0.00036	2.37278	5.68	4.22	3.38	5.50	4.57	Under
055	053	0.8	155	207	0.80	1.58	1.63	115	0.48309	0.015	0.51	2.14	105	0.83	14,000	0.3389	0.3389	0.00005	0.00005	0.00009	0.33901	0.43	0.42	0.34	0.70	1.12	Acceptable
053	054	0.7x0.6	150	170	0.71	1.69	1.48	115	0.58824	0.015	0.47	1.94	105	0.83	640,000	15.4933	18.2047	0.00005	0.00030	0.00054	18.20521	25.60	18.64	13.05	20.76	35.15	Under
056	057	0.8	170	210	0.79	1.57	1.80	105	0.47619	0.015	0.49	2.30	105	0.83	11,000	0.2663	0.2663	0.00005	0.00005	0.00009	0.26638	0.34	0.36	0.29	0.62	0.98	Acceptable
057	054	1x1	175	213	2.20	2.20	1.33	115	0.46948	0.015	0.52	1.85	105	0.83	33,000	0.7989	1.0652	0.00005	0.00010	0.00018	1.06535	0.49	0.47	0.47	0.91	1.99	Acceptable
054	048	1x1	20	285	1.90	1.90	0.18	95	0.35088	0.015	0.54	0.72	105	0.83	97,000	2.3482	21.6180	0.00005	0.00045	0.00081	21.61885	11.39	8.35	8.35	13.35	25.35	Under
044	045	0.8	135	39	1.84	3.65	0.62	115	2.56410	0.015	0.24	0.85	105	0.83	14,000	0.3389	0.3389	0.00005	0.00005	0.00009	0.33901	0.18	0.25	0.20	0.48	1.77	Acceptable
045B	045A	0.8	50	201	0.81	1.61	0.52	145	0.49751	0.015	0.56	1.08	105	0.83	56,000	1.3557	1.3557	0.00005	0.00005	0.00009	1.35576	1.68	1.33	1.06	1.85	2.97	Acceptable
045A	045	0.8	175	201	0.81	1.61	1.81	145	0.49751	0.015	0.56	2.38	105	0.83	19,000	0.4600	1.8156	0.00005	0.00010	0.00018	1.81581	2.25	1.74	1.39	2.37	3.81	Under
045	047	0.8	20	667	0.44	0.88	0.38	100	0.14993	0.015	0.83	1.21	105	0.83	33,000	0.7989	2.9534	0.00005	0.00020	0.00036	2.95378	6.65	4.93	3.94	6.39	5.64	Under
046	047	0.8	55	550	0.49	0.97	0.94	85	0.18182	0.015	0.70	1.65	105	0.83	6,000	0.1453	0.1453	0.00005	0.00005	0.00009	0.14534	0.30	0.33	0.26	0.59	0.57	Over

Table D3 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 10 Years Return Periods (Continue)

Section		Size	L	SLOPE	Q_f	v_f	t_d	l	S_A	n'	t_0	t_c	i	C	A	Q_r	Σ Q_r	DWF	Σ DWF	$Q_{max}.h$	Q_d	Q_d/Q_f	d/D	d	v/v_f	v	Result
		(m.)	(m.)	1: xxx	(m^3/s)	(m/s)	(min)	(m)	%		(min)	(min)	(mm/hr)		(m^2)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)			(m.)		(m/s)	
047	048	0.8	125	147	0.95	1.88	1.11	105	0.68027	0.015	0.42	1.53	105	0.83	47,000	1.1378	4.2365	0.00005	0.00030	0.00054	4.23700	4.48	3.36	2.69	4.41	8.29	Under
048	035	1x1	175	1,163	0.94	0.94	3.10	120	0.08598	0.015	1.17	4.27	105	0.83	164,000	3.9702	29.8247	0.00005	0.00080	0.00144	29.82611	31.74	23.08	23.08	36.59	34.38	Under
033	034	0.8	135	42	1.77	3.52	0.64	95	2.38095	0.015	0.22	0.86	105	0.83	14,000	0.3389	0.3389	0.00005	0.00005	0.00009	0.33901	0.19	0.25	0.20	0.49	1.73	Acceptable
034	035	1.0	95	50	2.94	3.74	0.42	120	2.00000	0.015	0.27	0.69	105	0.83	22,000	0.5326	0.8715	0.00005	0.00010	0.00018	0.87168	0.30	0.33	0.33	0.69	2.58	Acceptable
035	036	1.0	25	250	1.31	1.67	0.25	95	0.40000	0.015	0.51	0.76	105	0.83	186,000	4.5028	35.1989	0.00005	0.00095	0.00171	35.20063	26.77	19.49	19.49	30.92	51.74	Under
040	038	0.8x1	95	474	0.75	0.94	1.68	85	0.21097	0.015	0.66	2.34	105	0.83	7,000	0.1695	0.1695	0.00005	0.00005	0.00009	0.16955	0.22	0.28	0.28	0.61	0.57	Over
038	036	0.8x1	80	400	0.82	1.03	1.30	40	0.25000	0.015	0.43	1.73	105	0.83	14,000	0.3389	0.5084	0.00005	0.00010	0.00018	0.50856	0.62	0.56	0.56	1.06	1.09	Acceptable
036	037	1x1	115	230	5.13	5.13	0.37	95	0.43478	0.015	0.49	0.87	105	0.83	228,000	5.5195	41.2268	0.00005	0.00110	0.00198	41.22877	8.03	5.93	5.93	9.52	48.88	Under
037	028	1x1	25	100	11.01	11.01	0.04	100	1.00000	0.015	0.34	0.38	105	0.83	228,000	5.5195	47.2789	0.00005	0.00125	0.00225	47.28113	4.30	3.22	3.22	5.26	57.85	Under
041	039	0.8	125	192	0.83	1.65	1.27	85	0.52083	0.015	0.43	1.70	105	0.83	11,000	0.2663	0.2663	0.00005	0.00005	0.00009	0.26638	0.32	0.35	0.28	0.61	1.00	Acceptable
039	037	0.8	25	132	1.00	1.98	0.21	40	0.75758	0.015	0.25	0.46	105	0.83	11,000	0.2663	0.5326	0.00005	0.00010	0.00018	0.53276	0.53	0.50	0.40	0.80	1.59	Acceptable
100	103	0.8	125	521	0.50	1.00	2.09	40	0.19194	0.015	0.48	2.57	105	0.83	3,000	0.0726	0.0726	0.00005	0.00005	0.00009	0.07272	0.14	0.22	0.18	0.45	0.45	Over
101	102	0.8	75	112	1.08	2.15	0.58	30	0.89286	0.015	0.21	0.79	105	0.83	7,000	0.1695	0.3147	0.00005	0.00010	0.00018	0.31489	0.29	0.33	0.26	0.58	1.25	Acceptable
102	103	1x1	75	112	3.03	3.03	0.41	30	0.89286	0.015	0.21	0.62	105	0.83	14,000	0.3389	0.6536	0.00005	0.00015	0.00027	0.65390	0.22	0.27	0.27	0.60	1.81	Acceptable
113	112	0.8	55	1,099	0.35	0.69	1.33	120	0.09099	0.015	1.14	2.47	105	0.83	3,000	0.0726	0.8715	0.00005	0.00015	0.00027	0.87177	2.52	1.94	1.55	2.62	1.80	Acceptable
116	117	0.8	75	1,493	0.30	0.59	2.12	100	0.06698	0.015	1.21	3.33	105	0.83	6,000	0.1453	0.1453	0.00005	0.00005	0.00009	0.14534	0.49	0.47	0.38	0.76	0.45	Over
115	114	0.8	135	246	0.73	1.45	1.55	100	0.40650	0.015	0.52	2.07	105	0.83	14,000	0.3389	0.3389	0.00005	0.00005	0.00009	0.33901	0.46	0.45	0.36	0.74	1.07	Acceptable
114	113	0.8	135	193	0.83	1.64	1.37	155	0.51813	0.015	0.57	1.94	105	0.83	19,000	0.4600	0.7989	0.00005	0.00010	0.00018	0.79906	0.97	0.82	0.65	1.20	1.97	Acceptable
119	118	0.8	50	91	1.20	2.39	0.35	85	1.09890	0.015	0.30	0.65	105	0.83	3,000	0.0726	0.8715	0.00005	0.00015	0.00027	0.87177	0.73	0.64	0.51	0.98	2.34	Acceptable
105A	105	0.8	230	5,882	0.15	0.30	12.89	95	0.01700	0.015	2.24	15.13	105	0.83	44,000	1.0652	1.0652	0.00005	0.00005	0.00009	1.06526	7.13	5.27	4.22	6.82	2.03	Acceptable
103	104	1x1	25	417	1.57	1.57	0.27	50	0.23981	0.015	0.48	0.75	105	0.83	72,000	1.7430	2.4693	0.00005	0.00025	0.00045	2.46970	1.57	1.25	1.25	2.15	3.37	Under
104	105	1x1	15	1,493	0.83	0.83	0.30	80	0.06698	0.015	1.09	1.39	105	0.83	300,000	7.2625	11.3537	0.00005	0.00030	0.00054	11.35425	13.69	10.02	10.02	15.98	13.26	Under
105	106	0.8	25	535	0.50	0.99	0.42	105	0.18692	0.015	0.77	1.19	105	0.83	14,000	0.3389	0.3389	0.00005	0.00005	0.00009	0.33901	0.68	0.61	0.49	0.94	0.93	Acceptable
109	106	0.8	15	23	2.39	4.75	0.05	53	4.34783	0.015	0.13	0.18	105	0.83	314,000	7.6014	9.4413	0.00005	0.00040	0.00071	9.44196	3.95	2.97	2.38	3.92	18.65	Under
111	105	1.0	130	289	1.22	1.56	1.39	105	0.34602	0.015	0.57	1.97	105	0.83	3,000	0.0726	1.6220	0.00005	0.00025	0.00045	1.62241	1.33	1.08	1.08	1.87	2.91	Acceptable
118	110	1.2	80	320	1.89	1.67	0.80	25	0.31250	0.015	0.31	1.11	105	0.83	6,000	0.1453	1.7672	0.00005	0.00030	0.00054	1.76775	0.94	0.79	0.95	1.67	2.79	Acceptable
112	111	1.0	195	433	1.00	1.27	2.56	133	0.23095	0.015	0.77	3.33	105	0.83	28,000	0.6778	1.5493	0.00005	0.00020	0.00036	1.54969	1.55	1.24	1.24	2.12	2.70	Acceptable
108	106	0.6x0.6	175	389	0.30	0.82	3.55	38	0.25707	0.015	0.41	3.96	105	0.83	19,000	0.4600	0.4600	0.00005	0.00005	0.00009	0.46005	1.55	1.24	0.74	1.34	1.11	Acceptable
070	071	0.6	85	532	0.23	0.82	1.74	205	0.18797	0.015	1.04	2.78	105	0.83	17,000	0.4115	0.4115	0.00005	0.00005	0.00009	0.41163	1.78	1.41	0.84	1.50	1.22	Acceptable
129	130	1x1	235	725	1.19	1.19	3.29	142	0.13793	0.015	1.02	4.31	105	0.83	36,000	0.8715	0.8715	0.00005	0.00005	0.00009	0.87159	0.73	0.64	0.64	1.19	1.41	Acceptable
071	072	1.0	20	67	2.54	3.23	0.10	180	1.49254	0.015	0.37	0.48	105	0.83	53,000	1.2830	3.0503	0.00005	0.00015	0.00027	3.05052	1.20	0.98	0.98	1.72	5.57	Under
062	071	1.2	180	599	1.38	1.22	2.46	160	0.16694	0.015	0.98	3.44	105	0.83	56,000	1.3557	1.3557	0.00005	0.00005	0.00009	1.35576	0.98	0.83	0.99	1.73	2.12	Acceptable
061	060	0.8	25	192	0.83	1.65	0.25	135	0.52083	0.015	0.53	0.79	105	0.83	7,000	0.1695	0.1695	0.00005	0.00005	0.00009	0.16955	0.20	0.26	0.21	0.50	0.83	Acceptable
060	059	0.8	180	195	0.82	1.63	1.84	145	0.51282	0.015	0.56	2.39	105	0.83	25,000	0.6052	0.7747	0.00005	0.00010	0.00018	0.77485	0.94	0.80	0.64	1.18	1.92	Acceptable
058	059	0.6	75	44	0.80	2.84	0.44	120	2.27273	0.015	0.25	0.69	105	0.83	14,000	0.3389	0.3389	0.00005	0.00005	0.00009	0.33901	0.42	0.42	0.25	0.57	1.61	Acceptable
051	052	0.8	110	60	1.48	2.94	0.62	68	1.66667	0.015	0.23	0.85	105	0.83	14,000	0.3389	0.3389	0.00005	0.00005	0.00009	0.33901	0.23	0.28	0.22	0.52	1.54	Acceptable
059	069	0.8	15	150	0.94	1.86	0.13	175	0.66667	0.015	0.54	0.67	105	0.83	53,000	1.2830	2.3966	0.00005	0.00020	0.00036	2.39699	2.56	1.97	1.57	2.65	4.94	Under
063	069	0.8	150	163	0.90	1.79	1.40	101	0.61350	0.015	0.43	1.83	105	0.83	6,000	0.1453	0.1453	0.00005	0.00005	0.00009	0.14534	0.16	0.23	0.19	0.46	0.83	Acceptable
069	068	0.8	170	236	0.75	1.48	1.91	100	0.42373	0.015	0.51	2.42	105	0.83	70,000	1.6946	4.2365	0.00005	0.00030	0.00054	4.23700	5.68	4.22	3.38	5.50	8.16	Under
064	065	0.3	160	139	0.07	1.01	2.65	65	0.71942	0.015	0.33	2.98	105	0.83	6,000	0.1453	0.1453	0.00005	0.00005	0.00009	0.14534	2.04	1.59	0.48	0.92	0.93	Acceptable
066	065	0.8	75	578	0.48	0.95	1.32	83	0.17301	0.015	0.71	2.03	105	0.83	3,000	0.0726	0.0726	0.00005	0.00005	0.00009	0.07272	0.15	0.23	0.18	0.45	0.43	Over
065	067	0.8	10	200	0.81	1.61	0.10	108	0.50000	0.015	0.49	0.59	105	0.83	8,000	0.1937	0.4115	0.00005	0.00015	0.00027	0.41181	0.51	0.48	0.39	0.78	1.26	Acceptable
067A	067	0.8	165	150	0.94	1.86	1.48	82	0.66667	0.015	0.38	1.85	105	0.83	11,000	0.2663	0.2663	0.00005	0.00005	0.00009	0.26638	0.28	0.32	0.26	0.58	1.07	Acceptable
067	068	0.8	105	877	0.39	0.77	2.27	108	0.11403	0.015	0.98	3.25	105	0.83	22,000	0.5326	1.2104	0.00005	0.00025	0.00045	1.21087	3.13	2.38	1.90	3.17	2.44	Acceptable
068	080	0.8	35	117	1.06	2.11	0.28	170	0.85470	0.015	0.47	0.75	105	0.83	78,000	1.8883	7.3351	0.00005	0.00060	0.00108	7.33621	6.92	5.12	4.10	6.64	13.99	Under

Table D3 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 10 Years Return Periods (Continue)

Section		Size (m.)	L (m.)	SLOPE 1: xxx	Q_f (m^3/s)	v_f (m/s)	t_d (min)	l (m)	S_A %	n'	t_0 (min)	t_c (min)	i (mm/hr)	C	A (m^2)	Q_r (m^3/s)	ΣQ_r (m^3/s)	DWF (m^3/s)	Σ DWF (m^3/s)	$Q_{max}.h$ (m^3/s)	Q_d (m^3/s)	Q_d/Q_f	d/D	d (m.)	v/v_f	v (m/s)	Result
080	093	1.25x1.5	195	132	6.24	3.33	0.98	118	0.75901	0.015	0.42	1.40	105	0.83	92,000	2.2272	11.4748	0.00005	0.00080	0.00144	11.47619	1.84	1.45	2.17	3.59	11.96	Under
072	080	0.8	110	250	0.73	1.44	1.27	215	0.40000	0.015	0.75	2.02	105	0.83	6,000	0.1453	1.9125	0.00005	0.00015	0.00027	1.91273	2.64	2.02	1.62	2.72	3.93	Under
077	081	1.0	60	1,000	0.66	0.84	1.20	135	0.10000	0.015	1.15	2.35	105	0.83	8,000	0.1937	11.4263	0.00005	0.00045	0.00081	11.42714	17.38	12.69	12.69	20.20	16.90	Under
081	091	0.8	110	225	0.76	1.52	1.21	105	0.44500	0.015	0.51	1.72	105	0.83	600	0.0145	11.4409	0.00005	0.00050	0.00090	11.44176	14.96	10.94	8.75	13.98	21.26	Under
096	093	1.0	25	40	3.29	4.18	0.10	50	2.50000	0.015	0.16	0.26	105	0.83	14,000	0.3389	11.7798	0.00005	0.00055	0.00099	11.78077	3.58	2.71	2.71	4.44	18.59	Under
092	093	0.8	65	118	1.06	2.10	0.52	172	0.84746	0.015	0.48	0.99	105	0.83	3,000	0.0726	11.8524	0.00005	0.00060	0.00108	11.85348	11.23	8.24	6.59	10.57	22.19	Under
042	043	1.25x1.5	15	300	3.47	1.85	0.14	107	0.33333	0.015	0.59	0.72	105	0.83	94,000	2.2756	3.0745	0.00005	0.00013	0.00023	3.07468	0.89	0.76	1.13	1.96	3.63	Under
098	099	1.25x2	65	282	9.78	3.91	0.28	45	0.35461	0.015	0.38	0.66	105	0.83	109,000	2.6387	39.0868	0.00005	0.00180	0.00324	39.09002	4.00	3.01	6.01	9.66	37.79	Under
093	098	0.8	150	130	4.49	4.49	0.56	136	0.76923	0.015	0.45	1.00	105	0.83	28,000	0.6778	39.7646	0.00005	0.00185	0.00333	39.76794	8.85	6.52	5.21	8.40	37.74	Under
130	075	1.0	465	220	1.40	1.78	4.34	240	0.45455	0.015	0.74	5.09	105	0.83	56,000	1.3557	2.2272	0.00005	0.00010	0.00018	2.22735	1.59	1.26	1.26	2.17	3.86	Under
128	127	0.6	250	926	0.17	0.62	6.74	200	0.10799	0.015	1.34	8.07	105	0.83	28,000	0.6778	0.6778	0.00005	0.00005	0.00009	0.67792	3.88	2.92	1.75	2.93	1.81	Acceptable
127	075	0.6	15	658	0.21	0.73	0.34	210	0.15198	0.015	1.17	1.51	105	0.83	28,000	0.6778	1.3557	0.00005	0.00010	0.00018	1.35585	6.53	4.84	2.91	4.75	3.49	Under
075	074	0.8x0.8	100	500	1.43	1.43	1.16	175	0.20000	0.015	0.94	2.10	105	0.83	97,000	2.3482	4.5754	0.00005	0.00020	0.00036	4.57574	3.19	2.42	1.94	3.23	4.63	Under
079	078	0.8x0.8	120	333	1.76	1.76	1.14	90	0.30030	0.015	0.57	1.71	105	0.83	8,000	0.1937	3.8975	0.00005	0.00010	0.00018	3.89772	2.22	1.72	1.38	2.34	4.11	Under
074	077	1.0	20	364	1.09	1.39	0.24	160	0.27473	0.015	0.78	1.02	105	0.83	106,000	2.5661	7.3351	0.00005	0.00030	0.00054	7.33567	6.73	4.99	4.99	8.04	11.15	Under
073	074	0.8x1	125	200	2.27	2.27	0.92	175	0.50000	0.015	0.61	1.53	105	0.83	8,000	0.1937	0.1937	0.00005	0.00005	0.00009	0.19376	0.09	0.18	0.18	0.45	1.02	Acceptable
076	077	0.6x0.6	265	313	1.81	1.81	2.44	163	0.31949	0.015	0.73	3.17	105	0.83	17,000	0.4115	0.4115	0.00005	0.00005	0.00009	0.41163	0.23	0.28	0.17	0.43	0.79	Acceptable
094	097	0.8x0.8	100	286	0.90	1.41	1.18	143	0.34965	0.015	0.66	1.84	105	0.83	22,000	0.5326	0.5326	0.00005	0.00005	0.00009	0.53267	0.59	0.54	0.43	0.86	1.20	Acceptable
097	042	0.8x0.8	20	25	3.05	4.76	0.07	62	4.00000	0.015	0.14	0.21	105	0.83	22,000	0.5326	0.7989	0.00005	0.00008	0.00014	0.79901	0.26	0.30	0.24	0.56	2.64	Acceptable
087	079	1.0	220	440	0.99	1.26	2.91	93	0.22727	0.015	0.66	3.57	105	0.83	153,000	3.7039	3.7039	0.00005	0.00005	0.00009	3.70397	3.74	2.82	2.82	4.62	5.83	Under
095	096	1.0	75	440	0.99	1.26	0.99	76	0.22727	0.015	0.60	1.59	105	0.83	153,000	3.7039	3.7039	0.00005	0.00005	0.00009	3.70397	3.74	2.82	2.82	4.62	5.83	Under
096	043	0.8x0.8	20	440	0.73	1.13	0.29	69	0.22727	0.015	0.57	0.87	105	0.83	153,000	3.7039	5.5558	0.00005	0.00008	0.00014	5.55595	7.65	5.65	4.52	7.30	8.29	Under
083	082	0.6	160	641	0.21	0.74	3.59	90	0.15601	0.015	0.78	4.36	105	0.83	8,000	0.1937	0.1937	0.00005	0.00005	0.00009	0.19376	0.92	0.78	0.47	0.91	0.68	Acceptable
082	084	0.4	140	187	0.13	1.05	2.22	95	0.53476	0.015	0.45	2.67	105	0.83	3,000	0.0726	0.5326	0.00005	0.00015	0.00027	0.53285	4.04	3.03	1.21	2.09	2.19	Acceptable
078	082	0.6	10	200	0.38	1.33	0.13	88	0.50000	0.015	0.45	0.57	105	0.83	11,000	0.2663	0.2663	0.00005	0.00005	0.00009	0.26638	0.71	0.63	0.38	0.76	1.02	Acceptable
085	084	0.4	110	275	0.11	0.87	2.12	82	0.36364	0.015	0.50	2.62	105	0.83	3,000	0.0726	0.0726	0.00005	0.00005	0.00009	0.07272	0.67	0.60	0.24	0.55	0.47	Over
084	090	0.8	125	275	0.69	1.37	1.52	73	0.36364	0.015	0.47	1.99	105	0.83	17,000	0.4115	1.0168	0.00005	0.00025	0.00045	1.01720	1.47	1.18	0.94	1.66	2.28	Acceptable
089B	090	0.6	100	500	0.24	0.84	1.98	59	0.20000	0.015	0.57	2.55	105	0.83	6,000	0.1453	1.2830	0.00005	0.00035	0.00063	1.28367	5.39	4.02	2.41	3.97	3.34	Under
089A	089B	0.6	85	500	0.24	0.84	1.68	64	0.20000	0.015	0.59	2.27	105	0.83	22,000	0.5326	1.1378	0.00005	0.00030	0.00054	1.13833	4.78	3.57	2.14	3.55	2.99	Acceptable
086	089	0.6	125	192	0.38	1.36	1.53	81	0.52083	0.015	0.42	1.95	105	0.83	3,000	0.0726	0.0726	0.00005	0.00005	0.00009	0.07272	0.19	0.25	0.15	0.41	0.56	Over
088A	088	0.6	65	40	0.84	2.98	0.36	51	2.50000	0.015	0.16	0.53	105	0.83	3,000	0.0726	0.1453	0.00005	0.00010	0.00018	0.14543	0.17	0.24	0.14	0.40	1.18	Acceptable
089	089A	0.8	175	474	0.53	1.05	2.79	69	0.21097	0.015	0.59	3.38	105	0.83	8,000	0.1937	0.6052	0.00005	0.00025	0.00045	0.60566	1.15	0.95	0.76	1.37	1.43	Acceptable
124	123	0.6	100	500	0.24	0.84	1.98	60	0.20000	0.015	0.57	2.55	105	0.83	3,000	0.0726	0.0726	0.00005	0.00005	0.00009	0.07272	0.31	0.34	0.20	0.49	0.41	Over
123	122	0.8	90	599	0.47	0.93	1.61	93	0.16694	0.015	0.76	2.37	105	0.83	6,000	0.1453	0.2179	0.00005	0.00010	0.00018	0.21806	0.47	0.45	0.36	0.74	0.69	Acceptable
122	120	0.8	90	529	0.50	0.99	1.51	82	0.18904	0.015	0.68	2.19	105	0.83	8,000	0.1937	0.4842	0.00005	0.00020	0.00036	0.48453	0.97	0.82	0.65	1.20	1.19	Acceptable
091	092	1x1	75	578	1.33	1.33	0.94	106	0.17301	0.015	0.80	1.74	105	0.83	191,000	4.6238	18.5581	0.00005	0.00125	0.00225	18.56036	13.92	10.19	10.19	16.25	21.66	Under
090	091	0.8	75	1,493	0.30	0.59	2.12	72	0.06698	0.015	1.04	3.16	105	0.83	3,000	0.0726	2.4935	0.00005	0.00070	0.00126	2.49472	8.41	6.20	4.96	7.99	4.72	Under
126	122	0.8	135	79	1.29	2.57	0.88	50	1.26582	0.015	0.22	1.10	105	0.83	3,000	0.0726	0.0726	0.00005	0.00005	0.00009	0.07272	0.06	0.16	0.12	0.37	0.94	Acceptable
088	089	0.6	65	32	0.94	3.33	0.33	62	3.12500	0.015	0.16	0.49	105	0.83	8,000	0.1937	0.3389	0.00005	0.00015	0.00027	0.33919	0.36	0.38	0.23	0.53	1.75	Acceptable
125	121	0.6	65	163	0.42	1.47	0.73	54	0.61350	0.015	0.32	1.06	105	0.83	6,000	0.1453	0.1453	0.00005	0.00005	0.00009	0.14534	0.35	0.37	0.22	0.52	0.76	Acceptable
121	120	0.8	90	67	1.40	2.79	0.54	96	1.49254	0.015	0.28	0.82	105	0.83	19,000	0.4600	0.9441	0.00005	0.00025	0.00045	0.94458	0.67	0.60	0.48	0.93	2.59	Acceptable
099	119	1.25x2	220	160	21.84	8.73	0.42	47	0.62500	0.015	0.30	0.72	105	0.83	403,000	9.7560	48.8427	0.00005	0.00185	0.00333	48.84606	2.24	1.73	3.47	5.64	49.27	Under
031	032	1x1	85	833	1.11	1.11	1.28	190	0.12005	0.015	1.24	2.52	105	0.83	26,500	0.6415	10.8665	0.00005	0.00027	0.00048	10.86700	9.79	7.20	14.39	22.88	25.41	Under
093	098	1x1	25	132	2.79	2.79	0.15	151	0.75758	0.015	0.47	0.62	105	0.83	18,000	0.4358	27.4668	0.00005	0.00150	0.00270	27.46948	9.85	0.12	0.12	0.17	0.47	Over
043	098	0.8	15	282	0.96	1.91	0.13	112	0.35461	0.015	0.59	0.72	105	0.83	14,500	0.3510	8.9813	0.00005	0.00025	0.00045	0.00000	0.00	0.12	0.00	0.17	0.32	Over
110	109	0.8	15	23	3.36	6.68	0.04	77	4.34783	0.015	0.15	0.19	105	0.83	3,000	0.0726	1.8398	0.00005	0.00035	0.00062	0.00000	0.00	0.12	0.00	0.17	1.14	Over
037	104	0.8	15	1,493	0.42	0.83	0.30	77	0.06698	0.015	1.07	1.37	105	0.83	3,000	0.0726	1.6220	0.00005	0.00025	0.00044	0.00000	0.00	0.12	0.00	0.17	0.14	Over

Table D4 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 25 Years Return Periods

Section		Size	L	SLOPE	Q_f	v_f	t_d	l	S_A	n'	t_0	t_c	i	C	A	Q_r	Σ Q_r	DWF	Σ DWF	Q_{max}.h	Q_d	Q_d/Q_f	d/D	d	v/v_f	v	Result
		(m.)	(m.)	1: xxx	(m^3/s)	(m/s)	(min)	(m)	%		(min)	(min)	(mm/hr)		(m^2)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)	(m^3/s)			(m.)		(m/s)	
001	002	1.0	517	16,667	0.16	0.20	42.05	180	0.00600	0.015	4.91	46.95	127	0.88	81,000	2.5146	2.5146	0.00005	0.00005	0.00009	2.51469	15.62	11.41	11.41	18.18	3.73	Under
002	003	1.0	208	16,667	0.16	0.20	16.92	170	0.00600	0.015	4.78	21.69	127	0.88	119,000	3.6943	6.2089	0.00005	0.00010	0.00018	6.20907	38.56	28.01	28.01	44.38	9.09	Under
003	004	1.0	208	14,286	0.17	0.22	15.66	170	0.00700	0.015	4.45	20.11	127	0.88	155,000	4.8119	11.0208	0.00005	0.00015	0.00027	11.02105	63.37	45.96	45.96	72.70	16.09	Under
004	005	1.0	208	14,286	0.17	0.22	15.66	165	0.00700	0.015	4.38	20.05	127	0.88	191,000	5.9295	16.9503	0.00005	0.00020	0.00036	16.95063	97.46	70.63	70.63	111.63	24.71	Under
005	006	1.0	250	11,111	0.20	0.25	16.60	165	0.00900	0.015	3.90	20.50	127	0.88	235,000	7.2954	24.2457	0.00005	0.00025	0.00045	24.24616	122.95	89.07	89.07	140.72	35.32	Under
006	021	1x1	21	417	1.57	1.57	0.22	160	0.23981	0.015	0.83	1.05	127	0.88	235,000	7.2954	19.4183	0.00005	0.00018	0.00032	19.41862	12.37	9.07	9.07	14.48	22.72	Under
021	022	1x1	292	113	3.02	3.02	1.61	180	0.88496	0.015	0.48	2.09	127	0.88	252,000	7.8232	17.5324	0.00005	0.00014	0.00025	17.53260	5.82	4.32	4.32	6.99	21.08	Under
022	023	1x1	92	637	1.27	1.27	1.21	140	0.15699	0.015	0.95	2.16	127	0.88	259,000	8.0405	25.5729	0.00005	0.00019	0.00034	25.57320	20.14	14.69	14.69	23.34	29.64	Under
013	014	1.0	417	1,282	0.58	0.74	9.41	215	0.07800	0.015	1.61	11.02	127	0.88	56,000	1.7385	1.7385	0.00005	0.00005	0.00009	1.73858	2.99	2.28	2.28	3.77	2.79	Acceptable
014	015	1.0	208	1,266	0.58	0.74	4.66	275	0.07899	0.015	1.79	6.46	127	0.88	87,000	2.7009	4.4394	0.00005	0.00010	0.00018	4.43954	7.60	5.61	5.61	9.03	6.71	Under
015	016	1.0	208	1,282	0.58	0.74	4.69	240	0.07800	0.015	1.69	6.39	127	0.88	123,000	3.8185	8.2578	0.00005	0.00015	0.00027	8.25809	14.22	10.41	10.41	16.59	12.26	Under
016	017	1.0	208	1,266	0.58	0.74	4.66	200	0.07899	0.015	1.55	6.21	127	0.88	173,000	5.3707	13.6285	0.00005	0.00020	0.00036	13.62887	23.33	16.99	16.99	26.99	20.07	Under
017	018	1.0	225	1,282	0.58	0.74	5.08	230	0.07800	0.015	1.66	6.74	127	0.88	209,000	6.4883	20.1168	0.00005	0.00025	0.00045	20.11725	34.65	25.18	25.18	39.91	29.49	Under
018	019	1x1	292	222	2.15	2.15	2.26	210	0.45045	0.015	0.70	2.96	127	0.88	267,000	8.2889	28.4057	0.00005	0.00030	0.00054	28.40621	13.21	9.67	9.67	15.43	33.19	Under
019	020	1x1	92	242	2.06	2.06	0.74	220	0.41322	0.015	0.75	1.49	127	0.88	274,000	8.5062	36.9118	0.00005	0.00035	0.00063	36.91247	17.92	13.08	13.08	20.81	42.87	Under
006	007	1.0	155	130	1.82	2.32	1.11	170	0.76923	0.015	0.50	1.61	127	0.88	36,000	1.1176	13.2405	0.00005	0.00018	0.00032	13.24077	7.26	5.37	5.37	8.64	20.06	Under
007	008	1.0	185	130	1.82	2.32	1.33	160	0.76923	0.015	0.48	1.81	127	0.88	69,000	2.1421	15.3825	0.00005	0.00023	0.00041	15.38293	8.44	6.22	6.22	9.98	23.17	Under
008	009	1x1	190	226	2.13	2.13	1.49	180	0.44248	0.015	0.66	2.14	127	0.88	105,000	3.2597	18.6422	0.00005	0.00028	0.00050	18.64268	8.74	6.44	6.44	10.34	22.03	Under
009	010	1x1	165	403	1.60	1.60	1.72	215	0.24814	0.015	0.94	2.66	127	0.88	127,000	3.9426	22.5848	0.00005	0.00033	0.00059	22.58542	14.15	10.35	10.35	16.50	26.35	Under
012	011	0.8	110	70	1.37	2.73	0.67	145	1.42857	0.015	0.34	1.02	127	0.88	19,000	0.5898	0.5898	0.00005	0.00005	0.00009	0.58993	0.43	0.43	0.34	0.71	1.93	Acceptable
011	010	1.0	110	31	3.73	4.75	0.39	120	3.22581	0.015	0.22	0.60	127	0.88	27,000	0.8382	1.4280	0.00005	0.00010	0.00018	1.42822	0.38	0.39	0.39	0.79	3.75	Under
010	027	1.0	25	227	1.38	1.76	0.24	130	0.44053	0.015	0.57	0.80	127	0.88	154,000	4.7808	28.7937	0.00005	0.00048	0.00086	28.79458	20.87	15.21	15.21	24.18	42.46	Under
021	024	1x1	155	380	1.64	1.64	1.57	175	0.26316	0.015	0.83	2.40	127	0.88	28,000	0.8692	10.5784	0.00005	0.00014	0.00025	10.57864	6.43	4.77	4.77	7.70	12.66	Under
024	025	1x1	185	380	1.64	1.64	1.88	170	0.26316	0.015	0.82	2.69	127	0.88	28,000	0.8692	11.4476	0.00005	0.00019	0.00034	11.44798	6.96	5.15	5.15	8.30	13.65	Under
025	026	1x1	375	380	1.64	1.64	3.80	155	0.26316	0.015	0.78	4.58	127	0.88	78,000	2.4215	13.8691	0.00005	0.00024	0.00043	13.86953	8.44	6.22	6.22	9.98	16.41	Under
026	027	1x1	176	116	2.98	2.98	0.99	160	0.86207	0.015	0.46	1.44	127	0.88	95,000	2.9492	16.8183	0.00005	0.00029	0.00052	16.81885	5.65	4.20	4.20	6.80	20.25	Under
027	028	1x1	36	176	2.42	2.42	0.25	245	0.56818	0.015	0.68	0.93	127	0.88	260,000	8.0716	53.6836	0.00005	0.00081	0.00146	53.68507	22.22	16.19	16.19	25.72	62.14	Under
028	106	1x1	1560	36	5.34	5.34	4.87	150	2.77778	0.015	0.26	5.12	127	0.88	260,000	8.0716	#######	0.00005	0.00211	0.00380	122.38876	22.91	16.69	16.69	26.51	141.61	Under
029	030	1x1	575	1,560	0.81	0.81	11.81	150	0.06410	0.015	1.49	13.30	127	0.88	31,000	0.9624	0.9624	0.00005	0.00005	0.00009	0.96247	1.19	0.97	0.97	1.71	1.38	Acceptable
022	030	0.8	833	575	0.48	0.95	14.60	165	0.17391	0.015	0.98	15.58	127	0.88	31,000	0.9624	9.7286	0.00005	0.00012	0.00021	9.72877	20.35	14.84	11.87	18.90	17.97	Under
030	031	1x1	813	833	1.11	1.11	12.20	270	0.12005	0.015	1.46	13.67	127	0.88	78,000	2.4215	13.1124	0.00005	0.00022	0.00039	13.11279	11.81	8.66	8.66	13.83	15.36	Under
107	31	1x1	176	813	1.12	1.12	2.61	270	0.12300	0.015	1.45	4.06	127	0.88	28,000	0.8692	0.8692	0.00005	0.00005	0.00009	0.86933	0.77	0.67	0.67	1.23	1.39	Acceptable
052A	050	0.8	40	176	0.86	1.72	0.39	150	0.56818	0.015	0.54	0.93	127	0.88	28,000	0.8692	1.3039	0.00005	0.00010	0.00018	1.30405	1.51	1.21	0.97	1.69	2.91	Acceptable
049	050	0.8	752	40	1.81	3.60	3.48	95	2.50000	0.015	0.22	3.69	127	0.88	14,000	0.4346	0.4346	0.00005	0.00005	0.00009	0.43471	0.24	0.29	0.23	0.53	1.93	Acceptable
050	053	0.8	15	752	0.42	0.83	0.30	105	0.13298	0.015	0.90	1.20	127	0.88	42,000	1.3039	3.0424	0.00005	0.00020	0.00036	3.04272	7.28	5.38	4.30	6.96	5.79	Under
055	053	0.8	155	207	0.80	1.58	1.63	115	0.48309	0.015	0.51	2.14	127	0.88	14,000	0.4346	0.4346	0.00005	0.00005	0.00009	0.43471	0.55	0.51	0.41	0.81	1.29	Acceptable
053	054	0.7x0.6	150	170	0.71	1.69	1.48	115	0.58824	0.015	0.47	1.94	127	0.88	640,000	19.8684	23.3454	0.00005	0.00030	0.00054	23.34596	32.83	23.87	16.71	26.53	44.93	Under
056	057	0.8	170	210	0.79	1.57	1.80	105	0.47619	0.015	0.49	2.30	127	0.88	11,000	0.3415	0.3415	0.00005	0.00005	0.00009	0.34158	0.43	0.43	0.34	0.71	1.12	Acceptable
057	054	1x1	175	213	2.20	2.20	1.33	115	0.46948	0.015	0.52	1.85	127	0.88	33,000	1.0245	1.3660	0.00005	0.00010	0.00018	1.36614	0.62	0.57	0.57	1.06	2.33	Acceptable
054	048	1x1	20	285	1.90	1.90	0.18	95	0.35088	0.015	0.54	0.72	127	0.88	97,000	3.0113	27.7227	0.00005	0.00045	0.00081	27.72350	14.60	10.68	10.68	17.02	32.32	Under
044	045	0.8	135	39	1.84	3.65	0.62	115	2.56410	0.015	0.24	0.85	127	0.88	14,000	0.4346	0.4346	0.00005	0.00005	0.00009	0.43471	0.24	0.29	0.23	0.53	1.94	Acceptable
045B	045A	0.8	50	201	0.81	1.61	0.52	145	0.49751	0.015	0.56	1.08	127	0.88	56,000	1.7385	1.7385	0.00005	0.00005	0.00009	1.73858	2.15	1.67	1.34	2.28	3.67	Under
045A	045	0.8	175	201	0.81	1.61	1.81	145	0.49751	0.015	0.56	2.38	127	0.88	19,000	0.5898	2.3283	0.00005	0.00010	0.00018	2.32851	2.88	2.20	1.76	2.95	4.74	Under
045	047	0.8	20	667	0.44	0.88	0.38	100	0.14993	0.015	0.83	1.21	127	0.88	33,000	1.0245	3.7874	0.00005	0.00020	0.00036	3.78778	8.53	6.29	5.03	8.11	7.16	Under
046	047	0.8	55	550	0.49	0.97	0.94	85	0.18182	0.015	0.70	1.65	127	0.88	6,000	0.1863	0.1863	0.00005	0.00005	0.00009	0.18636	0.38	0.39	0.31	0.66	0.65	Acceptable

Table D4 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 25 Years Return Periods (Continue)

Section		Size (m.)	L (m.)	SLOPE 1: xxx	Q_f (m^3/s)	v_f (m/s)	t_d (min)	l (m)	S_A %	n'	t_0 (min)	t_c (min)	i (mm/hr)	C	A (m^2)	Q_r (m^3/s)	ΣQ_r (m^3/s)	DWF (m^3/s)	Σ DWF (m^3/s)	$Q_{max}.h$ (m^3/s)	Q_d (m^3/s)	Q_d/Q_f	d/D	d (m.)	v/v_f	v (m/s)	Result
047	048	0.8	125	147	0.95	1.88	1.11	105	0.68027	0.015	0.42	1.53	127	0.88	47,000	1.4591	5.4328	0.00005	0.00030	0.00054	5.43332	5.75	4.27	3.42	5.56	10.46	Under
048	035	1x1	175	1,163	0.94	0.94	3.10	120	0.08598	0.015	1.17	4.27	127	0.88	164,000	5.0913	38.2468	0.00005	0.00080	0.00144	38.24820	40.70	29.56	29.56	46.82	44.00	Under
033	034	0.8	135	42	1.77	3.52	0.64	95	2.38095	0.015	0.22	0.86	127	0.88	14,000	0.4346	0.4346	0.00005	0.00005	0.00009	0.43471	0.25	0.29	0.23	0.54	1.90	Acceptable
034	035	1.0	95	50	2.94	3.74	0.42	120	2.00000	0.015	0.27	0.69	127	0.88	22,000	0.6830	1.1176	0.00005	0.00010	0.00018	1.11778	0.38	0.39	0.39	0.79	2.94	Acceptable
035	036	1.0	25	250	1.31	1.67	0.25	95	0.40000	0.015	0.51	0.76	127	0.88	186,000	5.7743	45.1386	0.00005	0.00095	0.00171	45.14033	34.33	24.96	24.96	39.55	66.18	Under
040	038	0.8x1	95	474	0.75	0.94	1.68	85	0.21097	0.015	0.66	2.34	127	0.88	7,000	0.2173	0.2173	0.00005	0.00005	0.00009	0.21740	0.29	0.32	0.32	0.68	0.64	Acceptable
038	036	0.8x1	80	400	0.82	1.03	1.30	40	0.25000	0.015	0.43	1.73	127	0.88	14,000	0.4346	0.6519	0.00005	0.00010	0.00018	0.65211	0.79	0.69	0.69	1.26	1.29	Acceptable
036	037	1x1	115	230	5.13	5.13	0.37	95	0.43478	0.015	0.49	0.87	127	0.88	228,000	7.0781	52.8687	0.00005	0.00110	0.00198	52.87067	10.30	7.57	7.57	12.11	62.17	Under
037	028	1x1	25	100	11.01	11.01	0.04	100	1.00000	0.015	0.34	0.38	127	0.88	228,000	7.0781	60.6298	0.00005	0.00125	0.00225	60.63205	5.51	4.10	4.10	6.64	73.10	Under
041	039	0.8	125	192	0.83	1.65	1.27	85	0.52083	0.015	0.43	1.70	127	0.88	11,000	0.3415	0.3415	0.00005	0.00005	0.00009	0.34158	0.41	0.41	0.33	0.69	1.14	Acceptable
039	037	0.8	25	132	1.00	1.98	0.21	40	0.75758	0.015	0.25	0.46	127	0.88	11,000	0.3415	0.6830	0.00005	0.00010	0.00018	0.68316	0.68	0.61	0.49	0.94	1.87	Acceptable
100	103	0.8	125	521	0.50	1.00	2.09	40	0.19194	0.015	0.48	2.57	127	0.88	3,000	0.0931	0.0931	0.00005	0.00005	0.00009	0.09322	0.19	0.25	0.20	0.49	0.48	Over
101	102	0.8	75	112	1.08	2.15	0.58	30	0.89286	0.015	0.21	0.79	127	0.88	7,000	0.2173	0.4036	0.00005	0.00010	0.00018	0.40376	0.37	0.38	0.31	0.66	1.41	Acceptable
102	103	1x1	75	112	3.03	3.03	0.41	30	0.89286	0.015	0.21	0.62	127	0.88	14,000	0.4346	0.8382	0.00005	0.00015	0.00027	0.83847	0.28	0.32	0.32	0.67	2.02	Acceptable
113	112	0.8	55	1,099	0.35	0.69	1.33	120	0.09099	0.015	1.14	2.47	127	0.88	3,000	0.0931	1.1176	0.00005	0.00015	0.00027	1.11787	3.23	2.45	1.96	3.27	2.25	Acceptable
116	117	0.8	75	1,493	0.30	0.59	2.12	100	0.06698	0.015	1.21	3.33	127	0.88	6,000	0.1863	0.1863	0.00005	0.00005	0.00009	0.18636	0.63	0.57	0.46	0.89	0.52	Over
115	114	0.8	135	246	0.73	1.45	1.55	100	0.40650	0.015	0.52	2.07	127	0.88	14,000	0.4346	0.4346	0.00005	0.00005	0.00009	0.43471	0.59	0.55	0.44	0.86	1.25	Acceptable
114	113	0.8	135	193	0.83	1.64	1.37	155	0.51813	0.015	0.57	1.94	127	0.88	19,000	0.5898	1.0245	0.00005	0.00010	0.00018	1.02465	1.24	1.01	0.81	1.45	2.38	Acceptable
119	118	0.8	50	91	1.20	2.39	0.35	85	1.09890	0.015	0.30	0.65	127	0.88	3,000	0.0931	1.1176	0.00005	0.00015	0.00027	1.11787	0.93	0.79	0.63	1.17	2.78	Acceptable
105A	105	0.8	230	5,882	0.15	0.30	12.89	95	0.01700	0.015	2.24	15.13	127	0.88	44,000	1.3660	1.3660	0.00005	0.00005	0.00009	1.36605	9.14	6.73	5.38	8.66	2.58	Acceptable
103	104	1x1	25	417	1.57	1.57	0.27	50	0.23981	0.015	0.48	0.75	127	0.88	72,000	2.2352	3.1665	0.00005	0.00025	0.00045	3.16698	2.02	1.58	1.58	2.66	4.17	Under
104	105	1x1	15	1,493	0.83	0.83	0.30	80	0.06698	0.015	1.09	1.39	127	0.88	300,000	9.3133	14.5598	0.00005	0.00030	0.00054	14.56038	17.55	12.82	12.82	20.39	16.92	Under
105	106	0.8	25	535	0.50	0.99	0.42	105	0.18692	0.015	0.77	1.19	127	0.88	14,000	0.4346	0.4346	0.00005	0.00005	0.00009	0.43471	0.88	0.75	0.60	1.12	1.10	Acceptable
109	106	0.8	15	23	2.39	4.75	0.05	53	4.34783	0.015	0.13	0.18	127	0.88	314,000	9.7480	12.1073	0.00005	0.00040	0.00071	12.10805	5.06	3.78	3.02	4.94	23.49	Under
111	105	1.0	130	289	1.22	1.56	1.39	105	0.34602	0.015	0.57	1.97	127	0.88	3,000	0.0931	2.0800	0.00005	0.00025	0.00045	2.08043	1.70	1.35	1.35	2.29	3.57	Under
118	110	1.2	80	320	1.89	1.67	0.80	25	0.31250	0.015	0.31	1.11	127	0.88	6,000	0.1863	2.2662	0.00005	0.00030	0.00054	2.26678	1.20	0.98	1.18	2.03	3.39	Under
112	111	1.0	195	433	1.00	1.27	2.56	133	0.23095	0.015	0.77	3.33	127	0.88	28,000	0.8692	1.9868	0.00005	0.00020	0.00036	1.98720	1.99	1.55	1.55	2.62	3.33	Under
108	106	0.6x0.6	175	389	0.30	0.82	3.55	38	0.25707	0.015	0.41	3.96	127	0.88	19,000	0.5898	0.5898	0.00005	0.00005	0.00009	0.58993	1.99	1.56	0.93	1.64	1.35	Acceptable
070	071	0.6	85	532	0.23	0.82	1.74	205	0.18797	0.015	1.04	2.78	127	0.88	17,000	0.5278	0.5278	0.00005	0.00005	0.00009	0.52785	2.29	1.77	1.06	1.85	1.51	Acceptable
129	130	1x1	235	725	1.19	1.19	3.29	142	0.13793	0.015	1.02	4.31	127	0.88	36,000	1.1176	1.1176	0.00005	0.00005	0.00009	1.11769	0.94	0.79	0.79	1.42	1.69	Acceptable
071	072	1.0	20	67	2.54	3.23	0.10	180	1.49254	0.015	0.37	0.48	127	0.88	53,000	1.6454	3.9116	0.00005	0.00015	0.00027	3.91187	1.54	1.23	1.23	2.11	6.82	Under
062	071	1.2	180	599	1.38	1.22	2.46	160	0.16694	0.015	0.98	3.44	127	0.88	56,000	1.7385	1.7385	0.00005	0.00005	0.00009	1.73858	1.26	1.03	1.23	2.11	2.58	Acceptable
061	060	0.8	25	192	0.83	1.65	0.25	135	0.52083	0.015	0.53	0.79	127	0.88	7,000	0.2173	0.2173	0.00005	0.00005	0.00009	0.21740	0.26	0.31	0.24	0.56	0.91	Acceptable
060	059	0.8	180	195	0.82	1.63	1.84	145	0.51282	0.015	0.56	2.39	127	0.88	25,000	0.7761	0.9934	0.00005	0.00010	0.00018	0.99360	1.21	0.99	0.79	1.42	2.32	Acceptable
058	059	0.6	75	44	0.80	2.84	0.44	120	2.27273	0.015	0.25	0.69	127	0.88	14,000	0.4346	0.4346	0.00005	0.00005	0.00009	0.43471	0.54	0.51	0.30	0.65	1.85	Acceptable
051	052	0.8	110	60	1.48	2.94	0.62	68	1.66667	0.015	0.23	0.85	127	0.88	14,000	0.4346	0.4346	0.00005	0.00005	0.00009	0.43471	0.29	0.33	0.26	0.58	1.72	Acceptable
059	069	0.8	15	150	0.94	1.86	0.13	175	0.66667	0.015	0.54	0.67	127	0.88	53,000	1.6454	3.0734	0.00005	0.00020	0.00036	3.07376	3.28	2.49	1.99	3.31	6.17	Under
063	069	0.8	150	163	0.90	1.79	1.40	101	0.61350	0.015	0.43	1.83	127	0.88	6,000	0.1863	0.1863	0.00005	0.00005	0.00009	0.18636	0.21	0.27	0.21	0.51	0.90	Acceptable
069	068	0.8	170	236	0.75	1.48	1.91	100	0.42373	0.015	0.51	2.42	127	0.88	70,000	2.1731	5.4328	0.00005	0.00030	0.00054	5.43332	7.28	5.38	4.31	6.97	10.34	Under
064	065	0.3	160	139	0.07	1.01	2.65	65	0.71942	0.015	0.33	2.98	127	0.88	6,000	0.1863	0.1863	0.00005	0.00005	0.00009	0.18636	2.62	2.01	0.60	1.12	1.13	Acceptable
066	065	0.8	75	578	0.48	0.95	1.32	83	0.17301	0.015	0.71	2.03	127	0.83	3,000	0.0878	0.0878	0.00005	0.00005	0.00009	0.08793	0.18	0.25	0.20	0.48	0.46	Over
065	067	0.8	10	200	0.81	1.61	0.10	108	0.50000	0.015	0.49	0.59	127	0.83	8,000	0.2342	0.5084	0.00005	0.00015	0.00027	0.50862	0.63	0.57	0.46	0.89	1.43	Acceptable
067A	067	0.8	165	150	0.94	1.86	1.48	82	0.66667	0.015	0.38	1.85	127	0.83	11,000	0.3221	0.3221	0.00005	0.00005	0.00009	0.32218	0.34	0.36	0.29	0.63	1.17	Acceptable
067	068	0.8	105	877	0.39	0.77	2.27	108	0.11403	0.015	0.98	3.25	127	0.83	22,000	0.6442	1.4746	0.00005	0.00025	0.00045	1.47506	3.81	2.87	2.30	3.80	2.92	Acceptable
068	080	0.8	35	117	1.06	2.11	0.28	170	0.85470	0.015	0.47	0.75	127	0.83	78,000	2.2839	9.1913	0.00005	0.00060	0.00108	9.19235	8.67	6.39	5.11	8.24	17.36	Under

Table D4 The Results of Pipe System in Downtown of Hua – Hin Municipality by using 25 Years Return Periods (Continue)

ection		Size (m.)	L (m.)	SLOPE 1: xxx	Q_f (m^3/s)	v_f (m/s)	t_d (min)	l (m)	S_A %	n'	t_0 (min)	t_c (min)	i (mm/hr)	C	A (m^2)	Q_r (m^3/s)	Σ Q_r (m^3/s)	DWF (m^3/s)	Σ DWF (m^3/s)	Q_{max}.h (m^3/s)	Q_d (m^3/s)	Q_d/Q_f	d/D	d (m.)	v/v_f	v (m/s)	Result
080	093	1.25x1.5	195	132	6.24	3.33	0.98	118	0.75901	0.015	0.42	1.40	127	0.88	92,000	2.8561	14.4999	0.00005	0.00080	0.00144	14.50131	2.32	1.80	2.69	4.42	14.72	Under
072	080	0.8	110	250	0.73	1.44	1.27	215	0.40000	0.015	0.75	2.02	127	0.88	6,000	0.1863	2.4525	0.00005	0.00015	0.00027	2.45278	3.38	2.56	2.05	3.41	4.91	Under
077	081	1.0	60	1,000	0.66	0.84	1.20	135	0.10000	0.015	1.15	2.35	127	0.88	8,000	0.2484	14.6530	0.00005	0.00045	0.00081	14.65379	22.29	16.24	16.24	25.80	21.59	Under
081	091	0.8	110	225	0.76	1.52	1.21	105	0.44500	0.015	0.51	1.72	127	0.88	600	0.0186	14.6716	0.00005	0.00050	0.00090	14.67250	19.18	14.00	11.20	17.84	27.13	Under
096	093	1.0	25	40	3.29	4.18	0.10	50	2.50000	0.015	0.16	0.26	127	0.88	14,000	0.4346	15.1062	0.00005	0.00055	0.00099	15.10722	4.60	3.44	3.44	5.60	23.42	Under
092	093	0.8	65	118	1.06	2.10	0.52	172	0.84746	0.015	0.48	0.99	127	0.88	3,000	0.0931	15.1994	0.00005	0.00060	0.00108	15.20044	14.40	10.53	8.43	13.47	28.27	Under
042	043	1.25x1.5	15	300	3.47	1.85	0.14	107	0.33333	0.015	0.59	0.72	127	0.88	94,000	2.9182	3.9426	0.00005	0.00013	0.00023	3.94287	1.14	0.94	1.41	2.39	4.42	Under
098	099	1.25x2	65	282	9.78	3.91	0.28	45	0.35461	0.015	0.38	0.66	127	0.88	109,000	3.3838	49.9092	0.00005	0.00180	0.00324	49.91241	5.10	3.81	7.61	12.18	47.68	Under
093	098	0.8	150	130	4.49	4.49	0.56	136	0.76923	0.015	0.45	1.00	127	0.88	28,000	0.8692	50.7784	0.00005	0.00185	0.00333	50.78174	11.30	8.29	6.63	10.64	47.80	Under
130	075	1.0	465	220	1.40	1.78	4.34	240	0.45455	0.015	0.74	5.09	127	0.88	56,000	1.7385	2.8561	0.00005	0.00010	0.00018	2.85627	2.04	1.59	1.59	2.68	4.78	Under
128	127	0.6	250	926	0.17	0.62	6.74	200	0.10799	0.015	1.34	8.07	127	0.88	28,000	0.8692	0.8692	0.00005	0.00005	0.00009	0.86933	4.97	3.71	2.23	3.68	2.28	Acceptable
127	075	0.6	15	658	0.21	0.73	0.34	210	0.15198	0.015	1.17	1.51	127	0.88	28,000	0.8692	1.7385	0.00005	0.00010	0.00018	1.73867	8.38	6.18	3.71	6.02	4.42	Under
075	074	0.8x0.8	100	500	1.43	1.43	1.16	175	0.20000	0.015	0.94	2.10	127	0.88	97,000	3.0113	5.8674	0.00005	0.00020	0.00036	5.86776	4.09	3.08	2.46	4.05	5.81	Under
079	078	0.8x0.8	120	333	1.76	1.76	1.14	90	0.30030	0.015	0.57	1.71	127	0.88	8,000	0.2484	4.9982	0.00005	0.00010	0.00018	4.99834	2.85	2.17	1.74	2.91	5.12	Under
074	077	1.0	20	364	1.09	1.39	0.24	160	0.27473	0.015	0.78	1.02	127	0.88	106,000	3.2907	9.4065	0.00005	0.00030	0.00054	9.40701	8.63	6.36	6.36	10.21	14.16	Under
073	074	0.8x1	125	200	2.27	2.27	0.92	175	0.50000	0.015	0.61	1.53	127	0.88	8,000	0.2484	0.2484	0.00005	0.00005	0.00009	0.24845	0.11	0.19	0.19	0.48	1.08	Acceptable
076	077	0.6x0.6	265	313	1.81	1.81	2.44	163	0.31949	0.015	0.73	3.17	127	0.88	17,000	0.5278	0.5278	0.00005	0.00005	0.00009	0.52785	0.29	0.33	0.20	0.48	0.87	Acceptable
094	097	0.8x0.8	100	286	0.90	1.41	1.18	143	0.34965	0.015	0.66	1.84	127	0.88	22,000	0.6830	0.6830	0.00005	0.00005	0.00009	0.68307	0.76	0.66	0.53	1.01	1.42	Acceptable
097	042	0.8x0.8	20	25	3.05	4.76	0.07	62	4.00000	0.015	0.14	0.21	127	0.88	22,000	0.6830	1.0245	0.00005	0.00008	0.00014	1.02460	0.34	0.36	0.29	0.62	2.96	Acceptable
087	079	1.0	220	440	0.99	1.26	2.91	93	0.22727	0.015	0.66	3.57	127	0.88	153,000	4.7498	4.7498	0.00005	0.00005	0.00009	4.74989	4.79	3.58	3.58	5.82	7.35	Under
095	096	1.0	75	440	0.99	1.26	0.99	76	0.22727	0.015	0.60	1.59	127	0.88	153,000	4.7498	4.7498	0.00005	0.00005	0.00009	4.74989	4.79	3.58	3.58	5.82	7.35	Under
096	043	0.8x0.8	20	440	0.73	1.13	0.29	69	0.22727	0.015	0.57	0.87	127	0.88	153,000	4.7498	7.1247	0.00005	0.00008	0.00014	7.12484	9.81	7.21	5.77	9.28	10.53	Under
083	082	0.6	160	641	0.21	0.74	3.59	90	0.15601	0.015	0.78	4.36	127	0.88	8,000	0.2484	0.2484	0.00005	0.00005	0.00009	0.24845	1.18	0.97	0.58	1.09	0.81	Acceptable
082	084	0.4	140	187	0.13	1.05	2.22	95	0.53476	0.015	0.45	2.67	127	0.88	3,000	0.0931	0.6830	0.00005	0.00015	0.00027	0.68325	5.17	3.86	1.54	2.61	2.74	Acceptable
078	082	0.6	10	200	0.38	1.33	0.13	88	0.50000	0.015	0.45	0.57	127	0.88	11,000	0.3415	0.3415	0.00005	0.00005	0.00009	0.34158	0.91	0.77	0.46	0.90	1.20	Acceptable
085	084	0.4	110	275	0.11	0.87	2.12	82	0.36364	0.015	0.50	2.62	127	0.88	3,000	0.0931	0.0931	0.00005	0.00005	0.00009	0.09322	0.86	0.73	0.29	0.63	0.55	Over
084	090	0.8	125	275	0.69	1.37	1.52	73	0.36364	0.015	0.47	1.99	127	0.88	17,000	0.5278	1.3039	0.00005	0.00025	0.00045	1.30432	1.89	1.48	1.18	2.04	2.80	Acceptable
089B	090	0.6	100	500	0.24	0.84	1.98	59	0.20000	0.015	0.57	2.55	127	0.88	6,000	0.1863	1.6454	0.00005	0.00035	0.00063	1.64599	6.91	5.12	3.07	5.02	4.22	Under
089A	089B	0.6	85	500	0.24	0.84	1.68	64	0.20000	0.015	0.59	2.27	127	0.88	22,000	0.6830	1.4591	0.00005	0.00030	0.00054	1.45963	6.13	4.55	2.73	4.48	3.77	Under
086	089	0.6	125	192	0.38	1.36	1.53	81	0.52083	0.015	0.42	1.95	127	0.88	3,000	0.0931	0.0931	0.00005	0.00005	0.00009	0.09322	0.24	0.29	0.17	0.45	0.61	Acceptable
088A	088	0.6	65	40	0.84	2.98	0.36	51	2.50000	0.015	0.16	0.53	127	0.88	3,000	0.0931	0.1863	0.00005	0.00010	0.00018	0.18645	0.22	0.28	0.17	0.43	1.28	Acceptable
089	089A	0.8	175	474	0.53	1.05	2.79	69	0.21097	0.015	0.59	3.38	127	0.88	8,000	0.2484	0.7761	0.00005	0.00025	0.00045	0.77656	1.47	1.18	0.95	1.66	1.74	Acceptable
124	123	0.6	100	500	0.24	0.84	1.98	60	0.20000	0.015	0.57	2.55	127	0.88	3,000	0.0931	0.0931	0.00005	0.00005	0.00009	0.09322	0.39	0.40	0.24	0.55	0.46	Over
123	122	0.8	90	599	0.47	0.93	1.61	93	0.16694	0.015	0.76	2.37	127	0.88	6,000	0.1863	0.2794	0.00005	0.00010	0.00018	0.27958	0.60	0.55	0.44	0.86	0.80	Acceptable
122	120	0.8	90	529	0.50	0.99	1.51	82	0.18904	0.015	0.68	2.19	127	0.88	8,000	0.2484	0.6209	0.00005	0.00020	0.00036	0.62125	1.25	1.02	0.81	1.45	1.44	Acceptable
091	092	1x1	75	578	1.33	1.33	0.94	106	0.17301	0.015	0.80	1.74	127	0.88	191,000	5.9295	23.7987	0.00005	0.00125	0.00225	23.80092	17.85	13.03	13.03	20.74	27.64	Under
090	091	0.8	75	1,493	0.30	0.59	2.12	72	0.06698	0.015	1.04	3.16	127	0.88	3,000	0.0931	3.1976	0.00005	0.00070	0.00126	3.19884	10.78	7.91	6.33	10.16	6.00	Under
126	122	0.8	135	79	1.29	2.57	0.88	50	1.26582	0.015	0.22	1.10	127	0.88	3,000	0.0931	0.0931	0.00005	0.00005	0.00009	0.09322	0.07	0.17	0.13	0.38	0.98	Acceptable
088	089	0.6	65	32	0.94	3.33	0.33	62	3.12500	0.015	0.16	0.49	127	0.88	8,000	0.2484	0.4346	0.00005	0.00015	0.00027	0.43489	0.46	0.45	0.27	0.60	1.98	Acceptable
125	121	0.6	65	163	0.42	1.47	0.73	54	0.61350	0.015	0.32	1.06	127	0.88	6,000	0.1863	0.1863	0.00005	0.00005	0.00009	0.18636	0.45	0.44	0.26	0.59	0.86	Acceptable
121	120	0.8	90	67	1.40	2.79	0.54	96	1.49254	0.015	0.28	0.82	127	0.88	19,000	0.5898	1.2107	0.00005	0.00025	0.00045	1.21118	0.86	0.74	0.59	1.11	3.08	Under
099	119	1.25x2	220	160	21.84	8.73	0.42	47	0.62500	0.015	0.30	0.72	127	0.88	403,000	12.5109	62.4201	0.00005	0.00185	0.00333	62.42341	2.86	2.18	4.37	7.06	61.68	Under
031	032	1x1	85	833	1.11	1.11	1.28	190	0.12005	0.015	1.24	2.52	127	0.88	26,500	0.8227	13.9351	0.00005	0.00027	0.00048	13.93556	12.55	9.19	18.39	29.19	32.41	Under
093	098	1x1	25	132	2.79	2.79	0.15	151	0.75758	0.015	0.47	0.62	127	0.88	18,000	0.5588	35.0078	0.00005	0.00150	0.00270	35.01053	12.55	0.12	0.12	0.17	0.47	Over
043	098	0.8	15	282	0.96	1.91	0.13	112	0.35461	0.015	0.59	0.72	127	0.88	14,500	0.4501	11.5175	0.00005	0.00025	0.00045	0.00000	0.00	0.12	0.00	0.17	0.32	Over
110	109	0.8	15	23	3.36	6.68	0.04	77	4.34783	0.015	0.15	0.19	127	0.88	3,000	0.0931	2.3594	0.00005	0.00035	0.00062	0.00000	0.00	0.12	0.00	0.17	1.14	Over
037	104	0.8	15	1,493	0.42	0.83	0.30	77	0.06698	0.015	1.07	1.37	127	0.88	3,000	0.0931	2.0800	0.00005	0.00025	0.00044	0.00000	0.00	0.12	0.00	0.17	0.14	Over

BIOGRAPHY

Mr. Rattakorn SANGTHONG was born on 30th December 1983 in Hua – Hin district, Prachuabkirikhun Province. He graduated the Bachelor Degree of Engineering from the International and Twinning Program in Civil Engineering, Department of Civil Engineering, Faculty of Engineering, King Mongkut’s University of Technology Thonburi in the academic year 2005.

After that he worked as a Civil Engineer in SDB Construction Co., Ltd, the vendor list of The Shell Company of Thailand. 1 year later, he decided to further his study which leading to the Master Degree of Infrastructure in Civil Engineering, International School of Engineering, Faculty of Engineering, Chulalongkorn University in the academic year 2007.