HATHI
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JOGJA, SEPTEMBER 6TH - 8TH, 2013

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Volume 1

INTERNATIONAL SEMINAR ON

"Water Related Disaster Solutions"

SHERATON MUSTIKA YOGYAKARTA, INDONESIA
SEPTEMBER 6TH - 8TH, 2013

HATHI
Indonesian Association of Hydraulic Engineers

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PREFACE

The International Seminar with special focus on "Water Related Disaster Solutions" was implemented successfully from 6th to 8th September 2013 in Yogyakarta attended by experts and professionals from many countries including Indonesian as the host.

The discussions of the Seminar had covered the entire aspects of the water related disaster solutions including its risk management, the innovation in disaster mitigation and adaptation, as well capacity building and community participation aspects, involving highly notified professionals with numerous technical models, state of the arts as well as scientific and empirical deliberations.

The overall presentations, discussions and debates during the Seminar concluded that the outputs will undoubtedly contribute to remarkable concepts, strategies, lessons learned, and sharing of experiences on the water related disaster solutions, particularly on the environmentally sound technologies and sustainable practices on the years to come. Based on this fact, I believe that the proceeding of this Seminar will be valuable document for the implementation of the adaptation and mitigation to the climate change.

I would like to thank the organizing committee, peers and writers, seniors and all members of HATHI for enormous supports to the Seminar. May God bless you all.

Dr. Ir. Moch. Amron, M.Sc., PU-SDA

Chairman of HATHI,
September, 2013

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THE APPLICATION OF RETENTION POND SYSTEM TO CONTROL FLOODING IN SOUTHERN PONTIANAK CITY

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Abstract

Southern Pontianak is generally situated on lowland area with elevation varies between –0,224 m and +1,959 m. Due to its low elevation, this area is strongly affected by tidal flow. Compared to the highest tide elevation observed by PT. Barunadri Engineering Consultant at +0,213 m, it is obvious that the area is also vulnerable to inundation. Worse situation occurs as there are two channel, Sungai Jawi channel and Sungai Raya Dalam channel, which are frequently flooded during high rainfall intensity. An integrated and sustainable water management is therefore required to mitigate the flooding. Started by identifying the channel capacity to deliver flood flow, the analysis is extended to estimation of series of retention pond to control the flood. The 1-D Duflow model is employed here to simulate the water surface profile along the channels reach and estimate the capacity of ponds. Based on the simulation results, the dimension of two retention ponds required at Sungai Jawi Channel and Sungai Raya Dalam Channel are 700x 700 x 4 m^3 and 350 x 350 x 4 m^3 respectively. These two retention ponds are designed to control 5 years flood with maximum amount of 1,750,650 m^3 and 454,740 m^3 under maximum tidal condition.

Keywords: flood control, retention pond, Pontianak City

INTRODUCTION

General Background

Pontianak City is located at the downstream of Kapuas River about 13 kilometers from the estuary of Kapuas River. At the southern side, the land is generally situated on lowland area with elevation varies between –0,224 m and +1,959 m. As it is located on low land, the slope is generally very mild and strongly affected by tidal flow. Compared to the highest tide elevation observed by PT. Barunadri Engineering Consultant at +0,213 m, it is obvious that the area is vulnerable to inundation. In addition, under such situation, the river flow will also be interferred by sea level fluctuation. Under high intensity of rainfall and maximum tide, the inundation may get even worse as the channel is unable to deliver the flood flow properly. At the same time, the drainage system may not be effectively employed due to insufficient capacity and again enhance to more inundations within the area. Flood control management is therefore absolutely crucial to provide security from any inundations. To do so, optimizing retention pond is proposed here as an alternative solution to the flood problems.

Data Availability

Besides the daily rainfall data collected from Supadio Station for duration of 44 years (1956 – 1999), other data that also available to conduct this study includes some data obtained from the field measurement such as channel geometry and sea tide fluctuation measured at downstream of Kapuas Besar River for 73 hours (Dep. Pekerjaan Umum, 1994). While for the hydrograph information which is necessary to be included as upstream boundary, unfortunately, is not available. To estimate the required hydrograph, this study makes use of Duflow model to simulate the acquiring netto discharge of both Kapuas Kecil River (node J) and Landak River (node R). These acquiring netto discharges are then added with value of 2,000 m^3/s that is estimated based on the bank full capacity of the related channels. Illustration of the whole drainage system as mentioned above is presented in the following Figure 1.

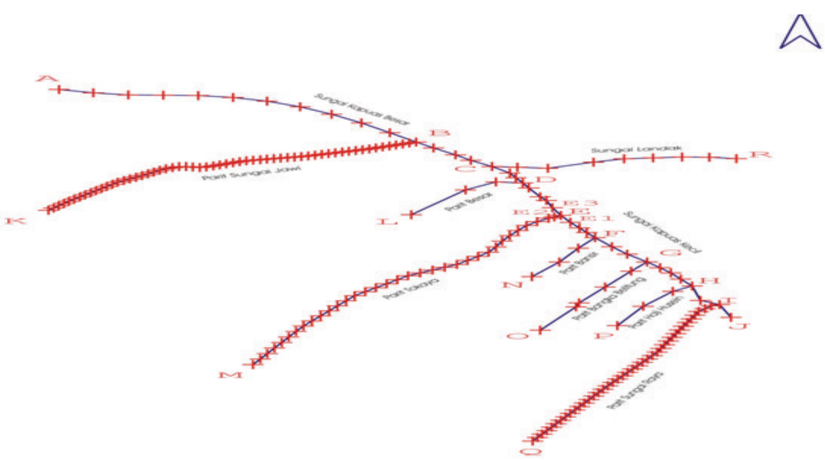


Figure 1. Channel System of Kapuas River

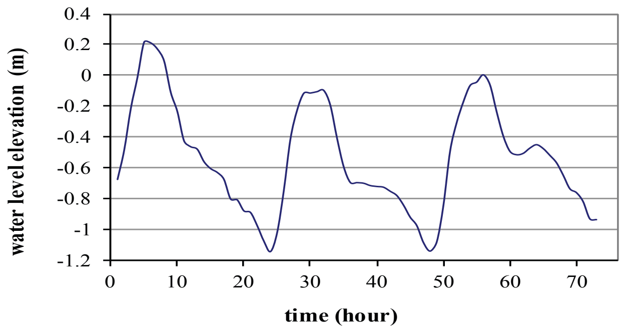
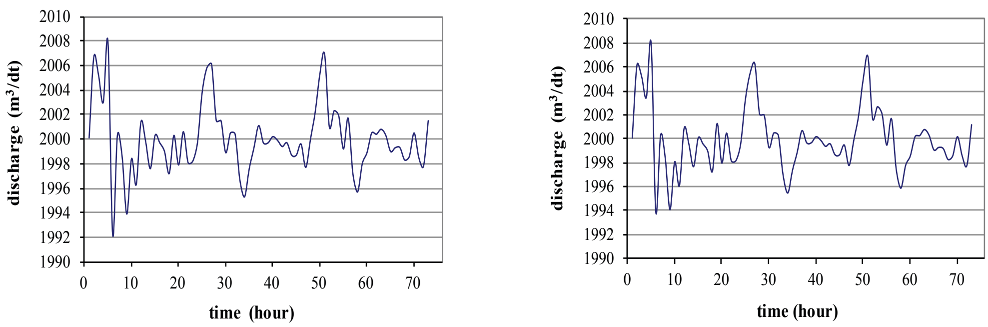


Figure 2. Sea tide fluctuation measured at Kapuas Besar River



(a) Kapuas Kecil River (b) Landak River

Figure 3. Hydrographs of Kapuas Kecil River and Landak River

LITERATURE STUDY

Hydrology Review

Hydrological analysis is generally a part of pre-eliminary analysis in designing waterworks. The hydrological analysis usually represents the relationship between rainfall, basin, and runoff. As it is a stochastic phenomena, asumptions taken are very critical to the next stage analysis. As regard to that, risk will always be part of hydrological analysis. Basically, waterworks have to be designed in accordance to standard designing method. By this way, it is expected the design will fit to the requirement for the setting of period. To choose the appropriate designed flood discharge with a certain period, it involves social and economic factors. It means the highest serviceability or maximum benefit with a minimum cost will basically be prioritized. According to the design standard, for the development of urban drainage, the return period that must be considered is minimum 5 years (Sri Harto, 1993).

Unsteady Flow Analysis

In analyzing the capacity of channel as regard to the influences of sea tide, the water flow analysis must be performed as unsteady flow analysis. By considering one dimensional analysis, the modeling of such hydrodynamics process can be done by help of a numerical model of Duflow (IHE Delft, 1992). Besides it provides water surface profile along the channel, it includes the ability to estimate optimum volume of retention pond. The basic equations that govern one dimensional analysis is the equation of continuity and momentum or as called as St. Venant equation.

Continuity equation : $\frac{\partial Q}{\partial x}+\frac{\partial A}{\partial t}=q$ .... (1)

Momentum equation : $\frac{\partial Q}{\partial t}+\frac{\partial\left(\alpha\frac{Q^2}{A}\right)}{\partial x}+gA\frac{\partial h}{\partial x}+\frac{gQ|Q|}{C^2AR}=0$ .... (2)

Using finite difference method, the above equations are then discreted into differential equations. Here, the implicit scheme of Preismann is applied to solve the problem (Cahyono, 1999). To do so, the input data required to perform the simulation are model scheme, channel geometry, initial condition, and boundary condition.

Retention Pond

In a matter a fact, the flooding management can perform either structural or non structural. Retaining facility is one of structural approach that has been widely used to control the flood flow. Referring to its function, this retaining facility can be divided into two categories: storage type and infiltration type (Doddi, 2009). Retention pond and retarding pond or regulation pond are the examples of storage type [Suripin, 2004].

The dimension of retention pond can be determined by conducting the flood routing. Many methods have been sought for predicting the characteristic features of the movement of a flood wave along a river in order to determine the actions necessary for protecting life and property from the effects of flooding and to improve the management of water related systems along natural or manmade watercourses. Flow routing may be classified as either lumped or distributed. In lumped flow routing or hydrologic routing, the flow is computed as a function of time at one location along a watercourse. While in distributed flow routing or hydraulic routing, the flow is computed as a function of time simultaneously at several cross sections along a watercourse (Maidment, 1993).

RESULTS AND DISCUSSION

Designed Rainfall

Based on the result of frequency analysis of maximum annual daily rainfall data, the 5 years designed rainfalls obtained for various distribution probabilities are found vary from 163.908 – 176.320 mm. As shown in Table 1, it can be noticed that Gumbel probability distribution gives the best fitted value. The 5 years designed rainfall in accordance to Gumbel distribution is 170.247 mm.

Table 1. Designed rainfall under various return periods

Probability P(x >= Xm)	Return Period	Normal	Log Normal	Gumbel	Log Pearson III
0.9	1	70.774	84.439	79.782	87.273
0.5	2	134.482	127.385	126.316	122.630
0.2	5	176.320	166.874	170.247	163.908
0.1	10	198.189	192.172	199.334	195.248
0.05	20	216.250	215.929	227.234	228.506
0.02	50	236.576	246.200	263.349	276.731
0.01	100	250.128	268.702	290.411	317.189
0.001	1,000	288.102	343.331	379.835	483.557
Chi square value		2.136	1.227	0.545	1.227
Chi critical value		5.991	5.991	5.991	3.841
Smirnov value		0.153	0.101	0.090	0.053

Rainfall Distribution

In order to estimate the rainfall distribution, this study employs Alternating Block Method (ABM) based on the available intensity duration curve (IDF). As it is derived from the short term of rainfall data, therefore, this distribution can be considered to represent the situation of local rainfall. The rainfall distribution percentage is presented in the Table 2 and Figure 4.

Table 2. Hourly Designed Rainfall for 5 Years Return Period

t (hour)	Δt (hour)	It (mm/ hour)	ΣIt (mm)	ΔP (mm)	%Pt	Pt
1	0-1	25.29	25.29	25.29	8.15	13.882
2	1-2	19.17	38.33	13.04	9.45	16.091
3	2-3	16.30	48.89	10.56	11.99	20.410
4	3-4	14.53	58.10	9.21	28.72	48.891
5	4-5	13.29	66.43	8.32	14.81	25.214
6	5-6	12.35	74.10	7.68	10.46	17.807
7	6-7	11.61	81.29	7.18	8.72	14.845
8	7-8	11.01	88.07	6.78	7.70	13.108
Total rainfall				88.1		170.247

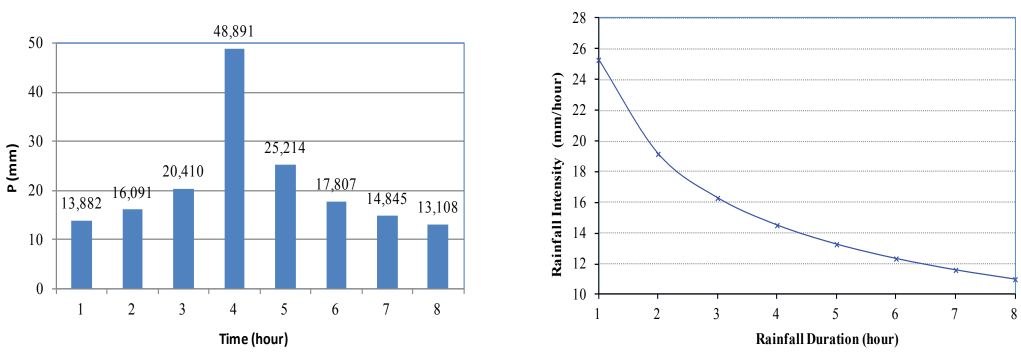


Figure 4. Hyetograph of Designed Rainfall and IDF Curve for 5 Years of Return Period

METHODOLOGY OF STUDY

This study is mainly focused on the hydraulics analysis of water surface profile and the estimation of retention pond capacity. Due to its complexity, Duflow model is therefore employed here to simulate the whole hydraulics analyses. Started from the construction of model scheme, the analyses will include the estimation of channel capacity, volume of runoff, and dimension estimation of retention pond.

RESULTS AND DISCUSSION

Based on the simulation results, it is known that there are four channels that have been experiencing flooding. Those channels are Sungai Jawi, Tokaya, Bansir and Sungai Raya. According the available master plan, the retention ponds were initially recommended to be built at Tokaya channel and Bansir channel. Due to at those both locations have insufficient space and may be densely populated in the future, however, the location is then moved to the other two locations: Sungai Jawi channel and Sungai Raya channel. The average heights of overspill above the channel levee of Sungai Jawi channel and Sungai Raya channel are 0.211 m and 0.227 m respectively. As presented in the following Figure 5 and Figure 6, the total inundated area for both locations are 583.55 ha for Sungai Jawi channel and 151.58 ha for Sungai Raya channel.

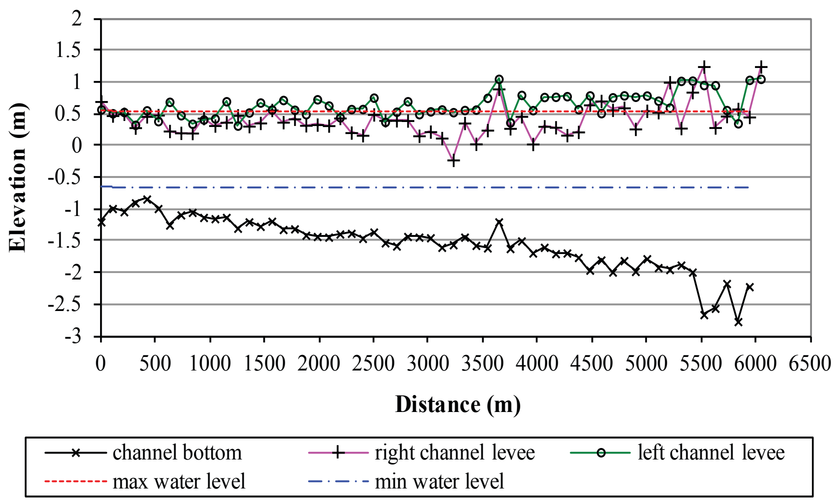


Figure 5. Water Surface Profile of Sungai Jawi Channel

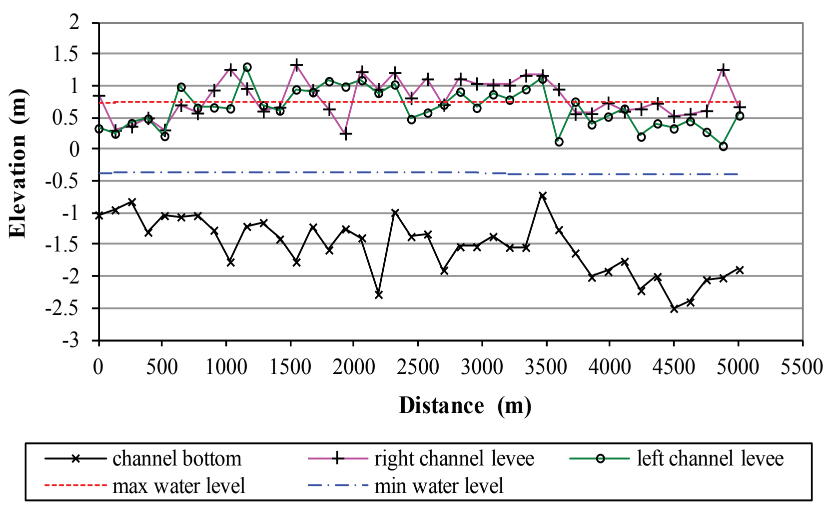


Figure 6. Water Surface Profile of Sungai Raya Channel

Retention ponds are located at upstream of the channel as it is required to have water level within flooded area can reach the retention pond and still has adequate space to cover the flooding. Based on that, it is critical to set a gate at the entrance of retention pond to control the level of inundation. Similarly for the downstream, automatic gate is also required to avoid backwater effect coming from sea tide. By considering the level of inundation within the area, the volume of retention pond is estimated through flood routing. As regard to the inundation map which is defined by surfer software, the amount of excess runoff for Sungai Jawi drainage that must be stored at the retention is 1.750.650 m^3. While for Sungai Raya Dalam, the amount of excess runoff reaches 454.740 m^3. The dimensions of retention pond required for that purpose are 700 m x 700 m x 4 m and 350 m x 350 m x 4m respectively. As presented in Figure 7 below is the inundation map and sketch of required retention ponds.

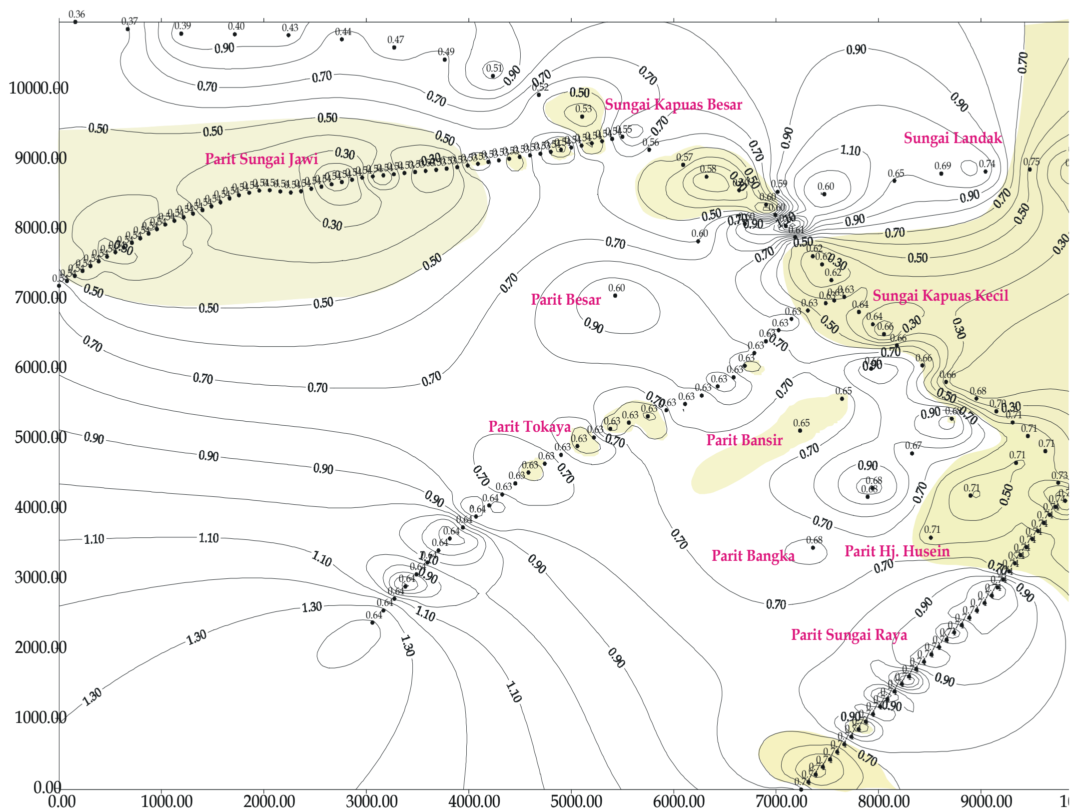


Figure 7. Inundation Map and Sketch of Required Retention Ponds

CONCLUSION AND RECOMMENDATION

The implementation of retention pond is found effective to solve the inundation problem in Southern Pontianak City. Unfortunately, the results obtained in this study cannot be further verified due to limited data available. Besides the observed river flow data, to gain better accuracy, it is necessary to have series of recorded water level information and detail topographical map.

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