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Development Of Real-Time System For Urban Flooding By Surcharge Of Storm Drainge And River Inundation

DEVELOPMENT OF REAL-TIME SYSTEM FOR URBAN FLOODING BY SURCHARGE OF STORM DRAINGE AND RIVER INUNDATION

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ABSTRACT

Korea experiences frequent flood disasters, which cause considerable economic losses and damages to town and farm. Especially, 2 years ago, it was regional torrential rain about 98.5mm/hr on 21[th] September 2010 in Seoul. It was reason to be occurred 9,419 flooded houses and it was more excessive quantity than design quantity for urban drainage system (75mm/hr). How to monitor and control the urban flood disasters are an important problem in Korea recently. In this sense, we have been studied customizing system to estimate urban flooding and inundation using integrated with drainage system data and river information database those are managed by local governments and national agency.

Figure 1 Urban flood disasters in Seoul, Korea

In the case of Korean urban city, there are a lot of detention ponds and drainage pumping stations on end of drainage system and flood is going out river. The drainage pumping station, it is very important hydraulic facility for flood control between river and drainage system. Because, which are possible to be different patterns of flood inundation according to operation rule of drainage pumping station. That is flood disaster is different damage as how to operate drainage pumping station and plan operation rule.

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1. INTRODUCTION

The objective of this study is to develop system for real time forecasting of flood inundation with integrated hydrologic models and real hydrologic data. We will use and couple among SWMM (Storm Water Management Model) for urban run-off analysis, real-time data and operation rule of pumping station. Of course, we will suggest new operation rules and modules of detention ponds and drainage pumping stations by self-development. Output of SWMM that is back data for development of operation rules. The study area is Seocho pumping station basin, which is the terrain consists of complex areas with forested mountain on the upper basin and residential/commercial area on the lower basin.

Figure 2 Concept of Real-time estimation system for urban flooding.

2. CONSTRUCTION AND INTERPOLATION OF SWMM

We have collected drainage data and model input data through the field survey for construction of SWMM at study area which is located in Seocho-gu, Seoul, KOREA. And we have simulated for model interpolation and calibration based on constructed model, observed rainfall data, GIS data and inflow data of pumping station.

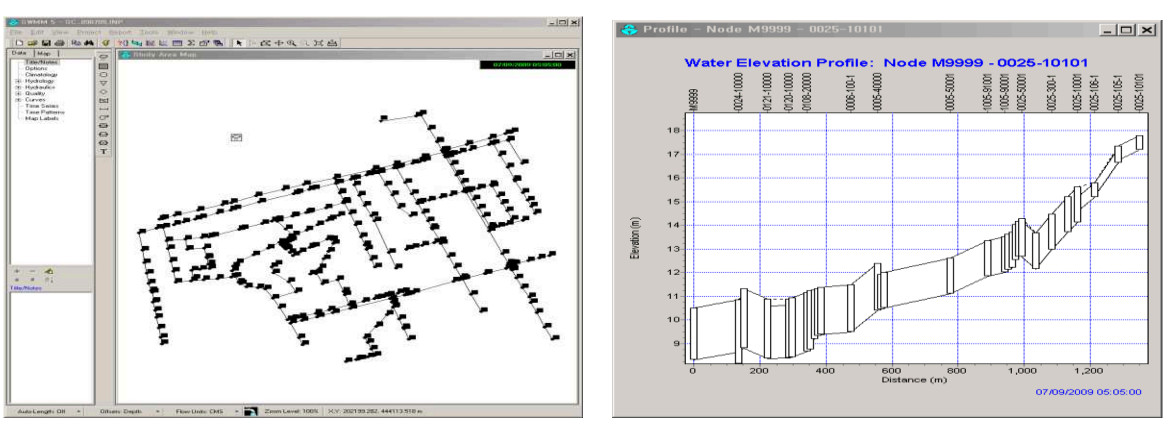

Figure 3 EPA SWMM model input data

In the case of rainfall data around pumping station, it is collected AWS(Auto Weather System) data at Seocho-gu district office and also forecasting inflow data of pumping station which is derived using pumping operation data of detention pond with water level and detention pond area with capacity rating curve. So we have collected all data such as real time rainfall data, gate operation data, in-out water level data and pumping operation data through the field survey. The observed rainfall and forecasting inflow are below graphs.

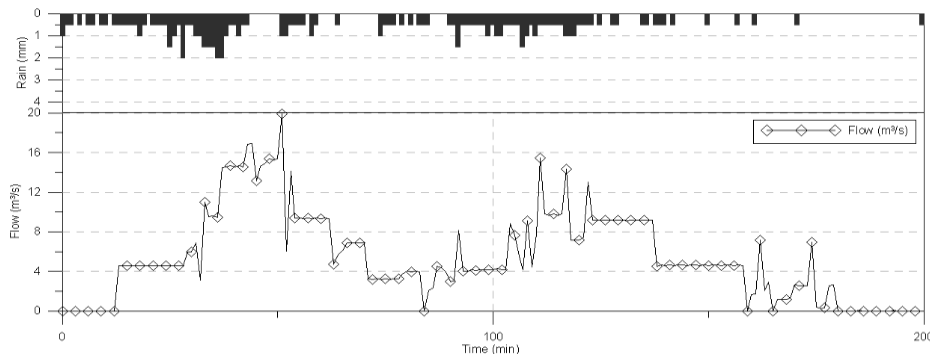

Figure 4 Observed rainfall and forecasting inflow data, 14th July 2009

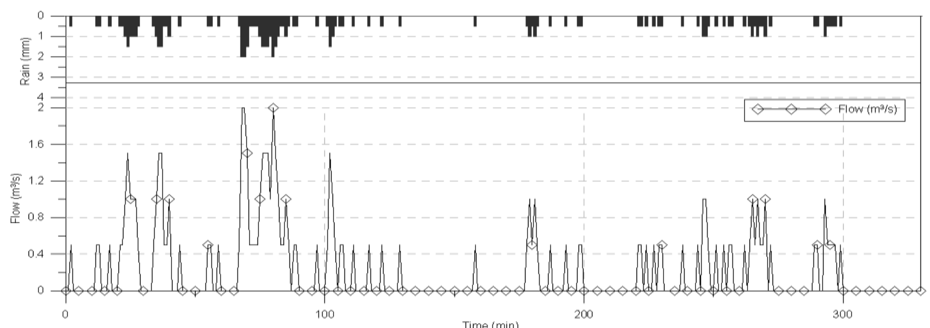

Figure 5 Observed rainfall and forecasting inflow data, 7th July 2011

In this study, we have been automatic interpolation of runoff model at Seocho pumping station basin using objective function. The automatic interpolation rainfall event is 14th July, 2009, at that time accumulated rainfall is 73 mm and maximum rainfall intensity is 35 mm/hr. And it needs to be estimation index for model estimation as composition condition of objective function output.

In this sense, we considered NSF(nash-sutcliffe efficiency), PBIAS(percent bias), PEE(proportional error of estimate), ROV(ratio of volume), RMSE(root mean square error) and error of peak flow in this study. Consequently, NSE is 0.82, PBIAS is 2.12% about model calibration, that is reasonable result about the rainfall event.

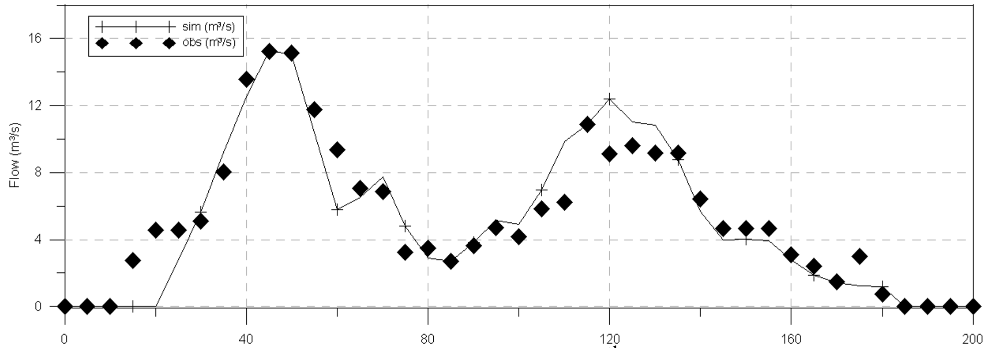

Figure 6 Model calibration, 14th July 2009

Table 1 Objective function output

Storm Event	NSE	PBIAS(%)	PEE	ROV	RMSE(m³/s)	Error of Peak Flow (m³/s)
2009.07.14	0.82	2.12	2.00	0.98	1.59	0.04

We have been model verification and comparison of rainfall event, 26th July, 2011 using Seocho pumping station observed inflow data and verified model inflow data.

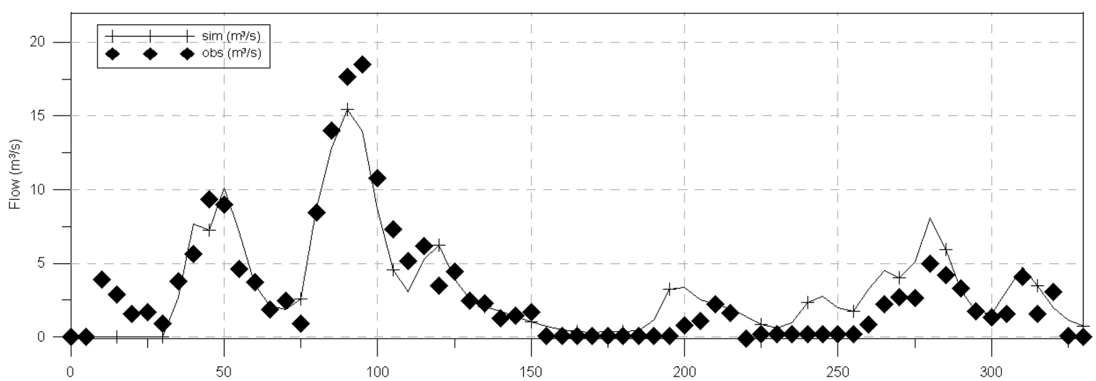

Figure 7 Model verification, 26th July 2009

3. EFFECTIVE ANALYSIS EACH OPERATION RULE OF PUMPING STATION

The pumping operation rule is automatic operation at Seocho pumping station. In this study, we called Rule 0 which is existing operation rule at Seocho pumping station and additional new operation rules are called rule 1, rule 2 and rule 3.

The rule 1 which is simple pumping operation step by step after n minutes based on forecasting water level of detention pond. The rule 2 which is similar with rule 1 but if there is surcharge at upper drainage line, all inflow until n minutes later is pumped against inundation at upper basin. The rule 3 which is pumped all inflow over initial operating water level after n minutes. In the case of Seocho pumping station, operating pumps are 5 and pumping operation water level is E.L. 6.3 m and pumping stop water level is E.L. 6.2 m. All rules are described at below table.

Table 2 Pumping operation rule

Classification	Operation Rule	Pump operation
Rule 1	EL. 6.3m ≤ water level < EL. 6.6m	1st pump operation
	EL. 6.6m ≤ water level < EL. 6.9m	2nd pump operation
	EL. 6.9m ≤ water level < EL. 7.2m	3rd pump operation
	EL. 7.2m ≤ water level < EL. 7.5m	4st pump operation
	EL. 7.5m ≤ water level	5st pump operation
	water level ≤ EL. 6.2m	pumping stop
Rule 2	ordinary	Rule 1
	Surcharge at upper drainage line	All pump operation
Rule 3	EL. 6.3m ≤ water level	All pump operation
common	water level = EL. 6.2m	pumping stop

The result of comparison between existing rule and new rules which is maximum water level is 7.27 m of rule 0, 6.47 m of rule 1, 6.59 m of rule 2 and 6.19 m rule 3. That is means that the water level of new rules is decreased 0.8 m – 1.08 m than rule 0.

Table 3 Water level by pumping operation rules

Rainfall Event	Water level (EL. m)			
	Rule0	Rule1	Rule2	Rule3
21st September 2009	7.27	6.47	6.29	6.19

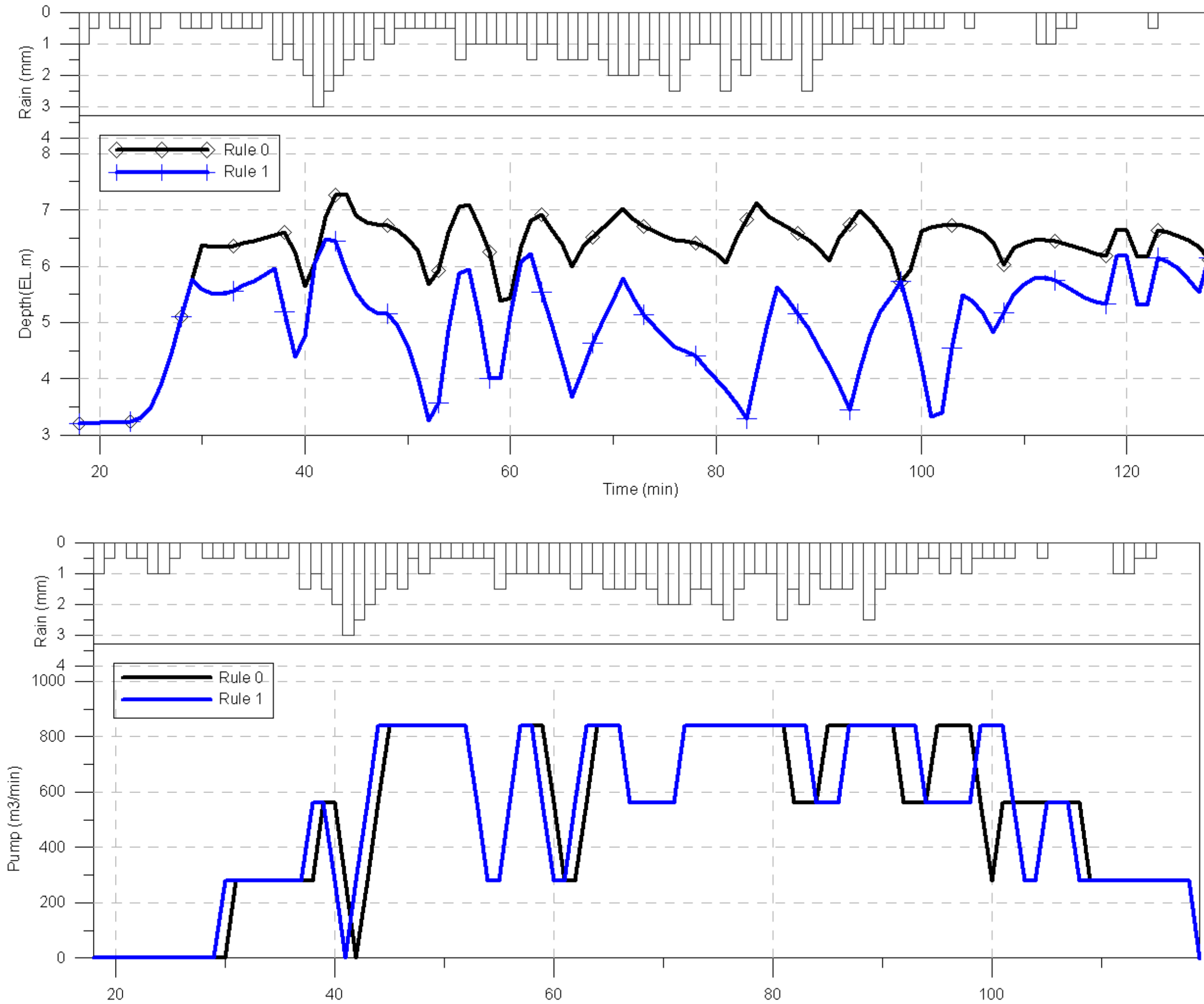

Figure 8 Water level and pumping outflow by pumping operation rule

4. REAL-TIME OPTIMIZED OPERATION SYSTEM DEVELOPMENT

In this study, developed optimized operation system was installed at Seocho pumping station after merging MMI system. And the system is now operating during rainy season in KOREA. And also the system is collecting rainfall data and water level data directly and real-time optimized operation system is using those data each described rule. The system main page is following figure.

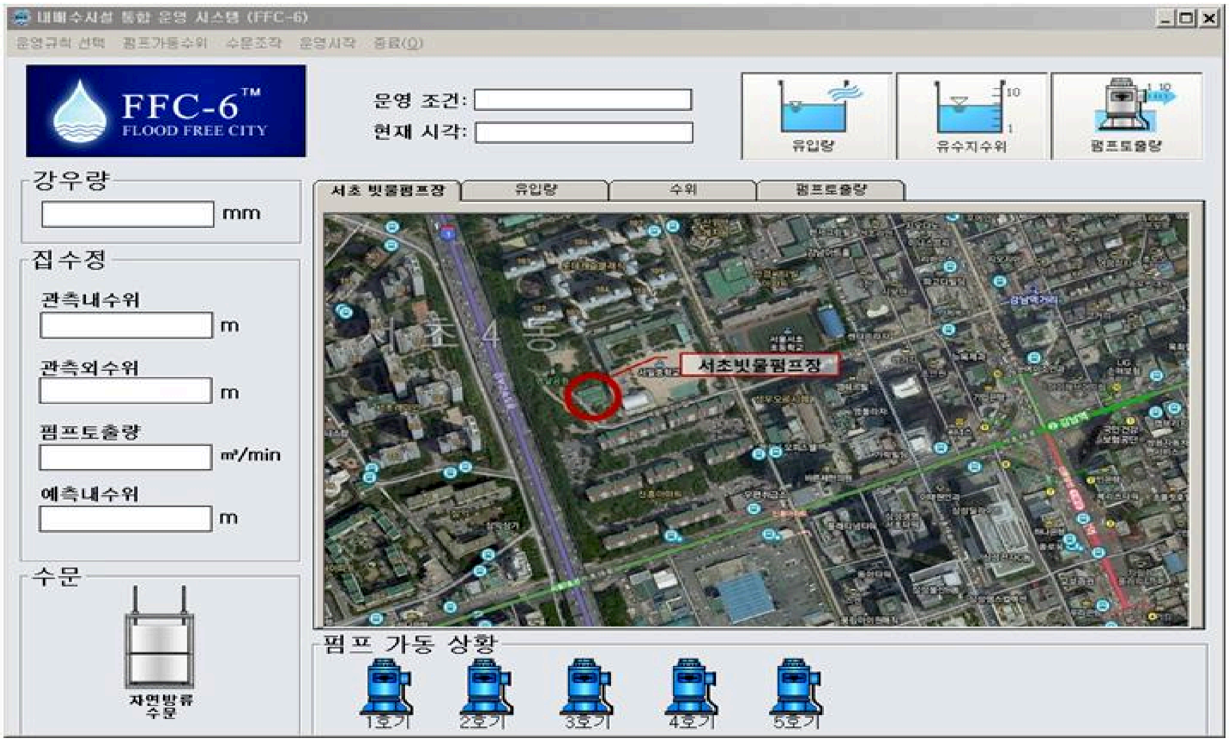

Figure 9 Real-time optimized operation system development (Korea university, 2011)

5. CONCLUSIONS

The real-time optimized operation system provides various rules for prevention of urban flood disaster and also those rules are using at pumping station. That is useful to operate pump and prevent urban flood damage. Additionally, we are developing another algorithm for integration between this system and river discharge model by real-time. In near future, another new integrated system will be expected to increase capability of flood prevention around urban basin.

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