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HYDRAULIC AND HYDROLOGIC ANALYSIS FOR WASHLAND CONSTRUCTION IN WOOPO WETLAND AREA, KOREA

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ABSTRACT

In Korea, recently, we have a growing interest in the washland construction for the function of flood control in flood season and also for the function of a wetland in non-flood season. Therefore this study performed the hydraulic and hydrologic analysis for washland construction plan as sustainable flood defense alternative in flood season and a wetland which can protect the ecosystem of a study area. The study area is Topyung-cheon basin in Changnyeong-gun, Gyeongnam province in Korea. A Topyung-cheon basin including a Woopo wetland is selected and a Topyung-cheon is one of the tributaries of Nakdong river, Korea.

We assume the artificial washland is constructed in upperstream and downstream of Woopo wetland. In flood season, the hydraulic analysis for the investigation of the effectiveness of flood level mitigation is performed by HEC-RAS model and the analysis is performed for 7 scenarios of washland construction. As the result in flood season, the flood level is reduced by maximum 0.56 meter as we construct the washlands by 7 scenarios. Also, we performed hydrologic analysis for the investigation of water balance in washland in non-flood season using SWAT model. If the water can be maintained in washland in non-flood season we can consider this washland as a wetland. From the result of water balance analysis, we found that the minimum water level of washland was maintained in about 1.3 meter for one year

Keywords: washland, Woopo wetland, flood season, non-flood season, HEC-RAS, SWAT

1. INTRODUCTION

The traditional approach to flood defense strategy has been fast release into the sea through the straight waterway which improves river passing capacity. However, the urbanization and the concentration of population near the stream watershed have increased the potential of the flood damage. Also, the flood increase due to the the increase of impervious areas and abnormal meterological phenomena shows the limitation of flood defense. Therefore, there are many efforts to assign a part of flood discharge into the basins through the Watershed Based Integrated Flood Control Plan in Korea. Recently, the government's plan is to reduce a load of flood discharge of the river and potential flood damage due to the inundation. Still, many of the lands near a river are used for farmlands, and the river turned into more straightly because of the pre-existence flood control policy. Hence, it is very difficult to obtain an artificial washland site. Some cities that adapt the Watershed Based

Integrated Flood Control Plan examine washlands, but most of them studies only in the size aspect, not in the application aspect which includes the ecological function and so on.

Thus, we suggest the hydraulic and hydrologic analysis scheme for artificial washlands that are used as a storage area in flood season and as an ecological site in non-flood season.

2. THE STUDY SITE

The study site is the Topyung-cheon basin where the Woopo wetland is located. Area of Topyung-cheon basin is 123.97km2, and river length is 29.57km. Also, average annual temperature and average annual precipitation of this study site are 13.2°C and 1,112.5mm. The Woopo wetland which is the largest natural wetland in Korea, is located in Changnyeong-gun. These wetlands include Yueo-myeon Daedae-ri and Sejin-ri, Ibang-myeon An-ri, Deahab-myeon Jume-ri, and Ibang-myeon Okcheon-ri. The Woopo wetland is made up of four smaller wetlands-Woopo, Mokpo, Sajipo, Jjokjibeol. All together, Woopo wetland is 2.5km wide, 1.6km long, and covers 2,132,926m2. Woopo is the largest of the four, and this is why the wetlands are collectively known as the Woopo wetland. And the Woopo wetland is designated as a 'Protected Wetland' in accordance with the international Ramsar Treaty.

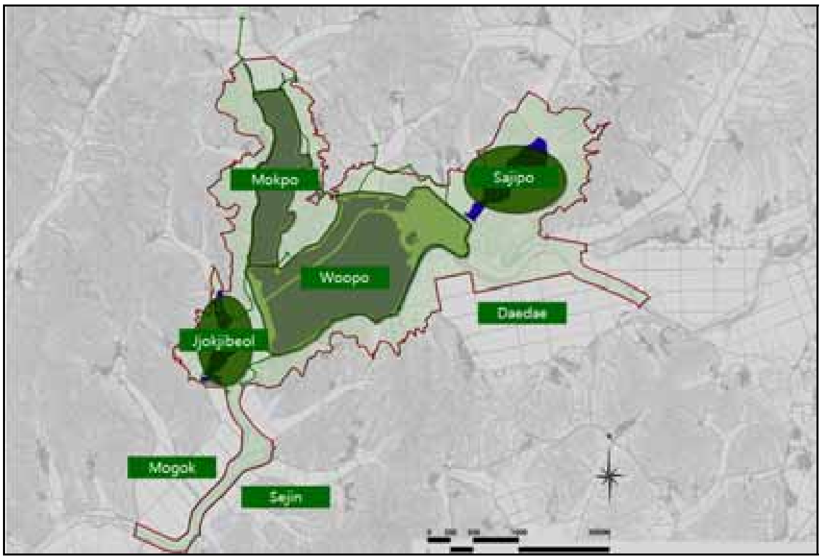

Figure 1 The Woopo wetland in study area

In this study, location of artificial washland is Daedae, Mogok, Sejin near the Woopo wetland. Now, Daedae, Mogok and Sejin sites are used for farmlands. Area of these sites calculated from DEM data are 2,806,200m^2(Mogok), 2,426,400m^2(Sejin), 3,627,900m^2(Daedae).

3. Flood season model of artificial washland

A storage area module of HEC-RAS 3.1.2 model was used to estimate the reduction efficiency of the flood level with the unsteady analysis. And figure 2 shows procedures of HEC-RAS model for the unsteady analysis.

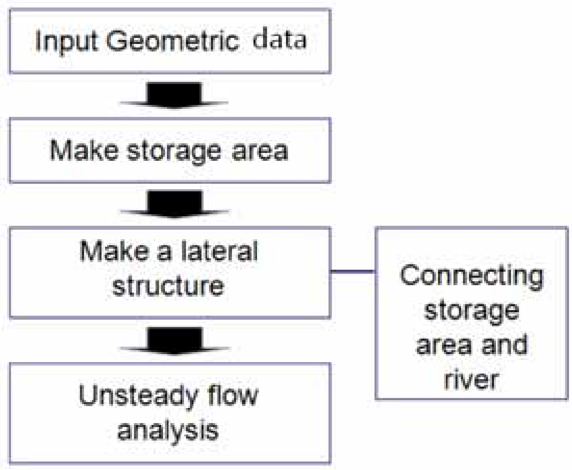

Figure 2 Procedures of HEC-RAS Model

We considered low frequency precipitations(2yr and 10yr). There are many unsteady models like a Dwoper, Fldwave, U-net, Branch, and these model's main equation is Saint-venant equation. U-net model suggested by the HEC(Hydrology Engineering Center) in US army corps of engineers was added to HEC-RAS Package in 2001.

In this study, we assume that weir is connected in between river and washland. Considering the flood level of 80yr precipitation frequency is between 18m to 19m, we can assume that the height of the weir is between 16m to 20m for the estimation of the optimum height of the weir. Then, simulation of model was performed by change of the weir level with intervals of 0.1m. As the result of model simulation, the optimum height of the weir was estimated as 17.1m(Mogok, Sejin) and 16.9m(Daedae). Figure 3 shows the geometric data window of HEC-RAS and the polygon is the washland obtained from a storage area module.

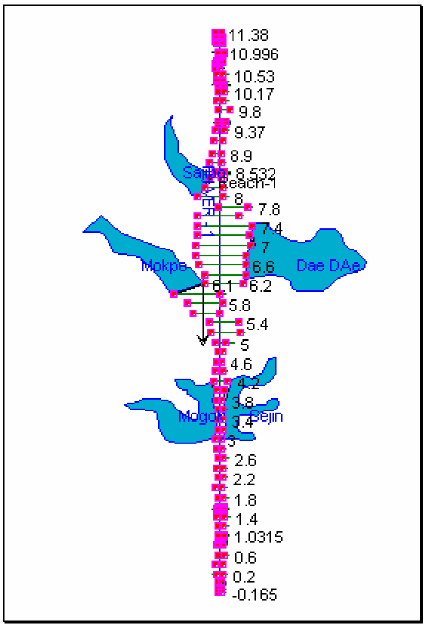

Figure 3 Geometric data windows of HEC-RAS

In HEC-RAS model, data of storage is supposed to input accumulation volume for each altitude. Table 1 shows accumulation volume according to altitude of water level of washlands.

Table 3 Geometric data windows of HEC-RAS

Altitude	Accumulation volume(m^3)				
	Mogok	Sejin	Daedae	Sajipo	Mokpo
9	-	0	0	-	-
10	0	104,930	139,265.6	0	0
11	72,259.65	351,522.1	466,548.7	20,093.45	38,641.73
12	291,283.6	668,742.8	887,571.7	94,896.77	159,581.5
13	658,895.8	1,061,994	1,409,504	261,612.7	443,052.5
14	1,190,811	1,548,291	2,054,929	580,322.6	1,024,743
15	1,873,279	2,153,833	2,858,619	1,092,009	1,958,339
16	2,626,042	2,841,887	3,771,821	1,762,056	3,114,051
17	3,399,290	3,565,188	4,731,804	2,561,815	4,372,119
18	4,191,621	4,328,327	5,744,661	3,497,254	5,732,249
19	5,003,873	5,134,141	6,814,156	4,588,865	7,217,743
20	5,839,422	-	-	5,918,017	8,916,504

To estimate the reduction efficiency of the flood level, we assume 7 scenarios for the Analysis scenario in HEC-RAS model. Table 4 shows Analysis scenario of HEC-RAS model.

Table 4 Analysis scenario of HEC-RAS model

Scenario	Content of Scenario
CASE 1	Nothing Washland
CASE 2	Washland construct in Mogok
CASE 3	Washland construct in Sejin
CASE 4	Washland construct in Daedae
CASE 5	Connection Sajipo and Woopo
CASE 6	Connection Mokpo and Woopo
CASE 7	Simulation from CASE 2 to CASE 6

4. Non-flood season model for artificial washland

Water-balance analysis is applied to estimate the instream flow in the artificial washland to be constructed for expanding the Woopo wetland ecology. According to the water-balance analysis, the proposed site is tested for the possibility of maintaining a certain water level(or instream flow), using SWAT model. Figure 4 shows procedures of SWAT model for water-balance analysis.

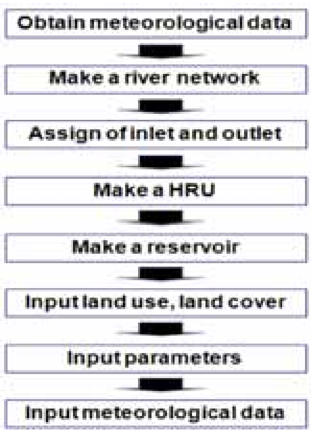

Figure 4 Procedures of SWAT Model

For a SWAT model simulation, precipitation, wind speed, humidity, solar radiation and temperature are used as the input data. In this study, precipitation, wind speed, humidity, and temperature data from 2003 to 2005 in Miryang, Jinju, and youngcheon gage stations are used. But, the solar radiation data is obtained from Jinju gage station because Miryang and youngcheon gage stations do not offer the solar radiation data. Also, 2yr and 10yr storage volumes of proposed site are used as the input data in SWAT model calculated by HEC-RAS model.

SWAT model has a wetland module, but its capacity is too small to input the storage volume. So, a reservoir module in SWAT model is used as a washland. Tabel 5 and 6 shows the parameters related reservoir at 2yr and 10yr frequencies.

Table 5 Reservoir parameters(2yr)

	Sajipo	Mokpo	Sejin	Mogok	Daedae
Inflow(m^3)	784,000	1,396,000	1,606,279	1,462,000	2,374,000
RES_ESA(ha)	49.2	89.9	35.7	67.0	169.5
REA_EVOL(m^3)	1,033,121.4	1,854,802.8	1,117,462.8	1,837,078.8	4,673,098
RES_PSA(ha)	44.5	68.9	35.7	45.8	74.4
RES_PVOL(m^3)	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
RES_VOL(m^3)	100,000	159,581.5	100,000	100,000	100,000
RES_RR(mm/hr)	-	-	-	-	-

Table 6 Reservoir parameters(10yr)

	Sajipo	Mokpo	Sejin	Mogok	Daedae
Inflow(m^3)	1,921,000	3,365,000	2,481,625	2,780,000	3,963,000
RES_ESA(ha)	75.8	89.9	45.7	76.7	192
REA_EVOL(m^3)	2,506,110.2	1,854,802.8	2,039,870.4	3,390,871.8	8,524,113.8
RES_PSA(ha)	44.5	68.9	45.5	45.8	74.4
RES_PVOL(m^3)	1,000,000	1,000,000	1,000,000	1,000,000	1,000,000
RES_VOL(m^3)	100,000	159,581.5	100,000	100,000	100,000
RES_RR(mm/hr)	-	-	-	-	-

SWAT model has many parameters related to an outflow and evapotranspiration. Among these parameters, 4 parameters of Ground-water, 1 parameter of HRU-General, 2 parameters of Soil, 3 parameters of Main-channel, 3 parameters of Management, which influence our study, are selected. To estimate a parameter, we perform the sensitivity analysis, and then calibrate the parameters using trial and error method. Table 7 shows parameter calibration value in SWAT model.

Table 7 Parameter calibration in SWAT model

Classification	Parameter	The lowest value	The upper value	Calibration value
Ground Water	ALPHA_BF	0	1	0.1
	GWQMN	0	5000	4000
	GW_REVAP	0.02	0.2	0.02
	REVAPMN	0	500	100
HRU General	ESCO	0	1	0.95
Soil	TLAPS	0	50	-
	SOL_AWC	0	1	∇25
Main channel	CH_K2	-0.01	150	93.74
Management	BIOMIX	0	1	0.3
	USLE_P	0.1	1	0.23
	CN_2	35	98	∇

5. Results

5.1 The effect of an artificial washland in flood season

We calculate the reduction of the flood level for each case. These result values are flood levels of control points for 80yr and 100yr frequencies as shown in the Table 8 ;

Table 8 Flood level mitigation

(unit : m)

Control Point	Frequency (year)	CASE 2 (Mogok)	CASE 3 (Sejin)	CASE 4 (Daedae)	CASE 5 (Sajipo)	CASE 6 (Mokpo)	CASE 7 (All site)
Point 3.0	80	0.20	0.19	0.23	0.06	0.08	0.43
	100	0.20	0.20	0.24	0.06	0.08	0.45
Point 5.4	80	0.24	0.25	0.29	0.07	0.10	0.54
	100	0.24	0.25	0.30	0.07	0.10	0.56
Point 11.38	80	0.16	0.16	0.19	0.07	0.09	0.35
	100	0.16	0.17	0.20	0.08	0.10	0.37

To show change of flood level, we draw graph for CASE 7 about the maximum reduction efficiency of the flood level. Figure 5 and 6 show change of flood level at control point for 80yr and 100yr frequencies.

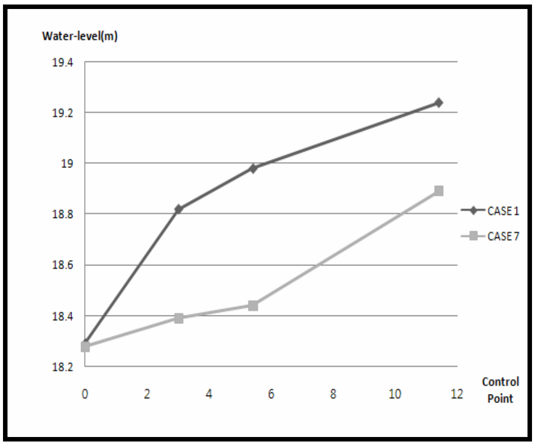

Figure 5 Water-level graph (80 years)

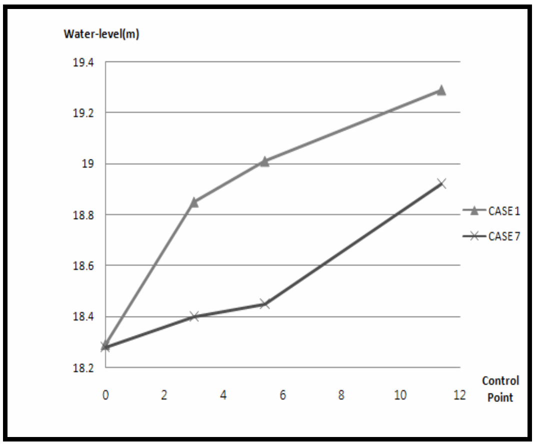

Figure 6 Water-level graph (100 years)

5.2 Wetland function of artificial washland in non-flood season

To analyze the water-balance at the proposed area, weather and soil data are applied to the SWAT model, and actual precipitation data from August 2004 to July 2005 are also used as an input data. Also the model simulation is performed to estimate the instream flow of wetlands for a year. First of all, evapotranspirations of no washland are compared to evapotranspirations when the washland is constructed in the Deadae site, a relatively large site. Also, Figure 8 shows evaporation of Deada, Mogok and Sejin sites for a year.

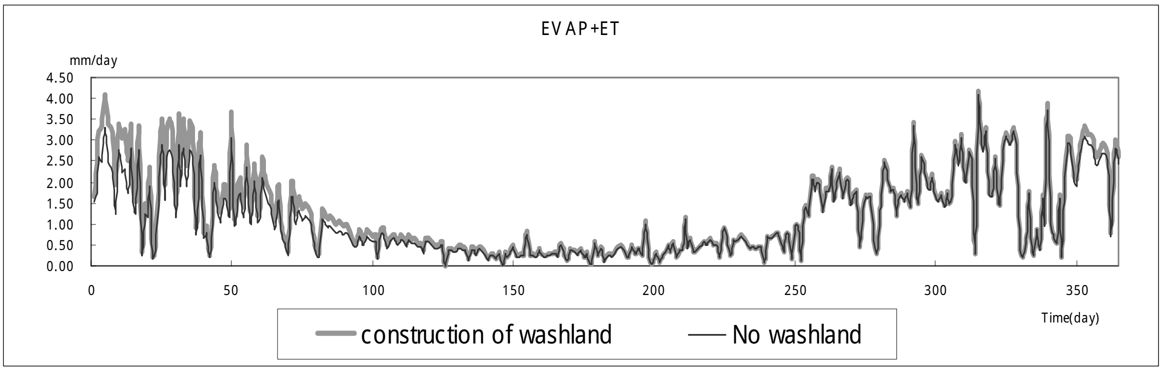

Figure 7 Evapotranspirations of the Daedae

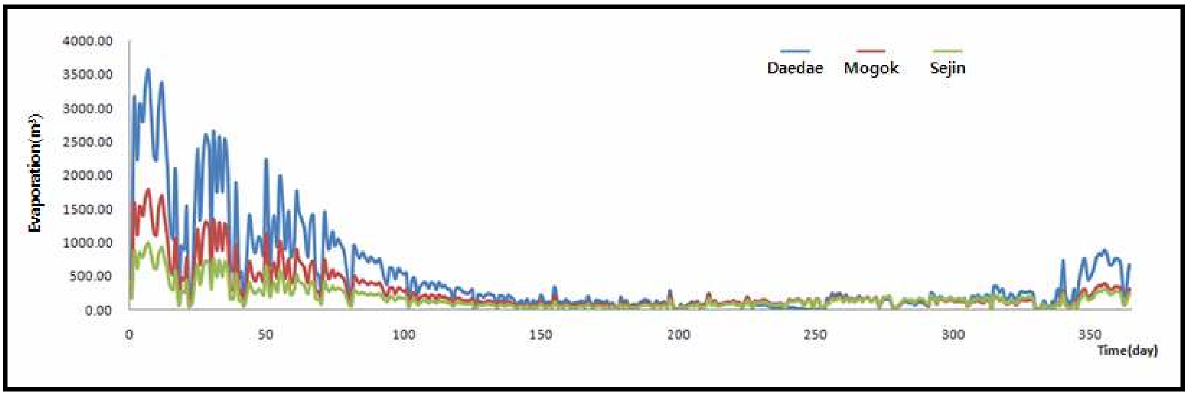

Figure 8 Evaporation of artificial washland for a year

As you can see the figure 7, the evapotranspirations are increased if we construct the washland. Also, we studied the probability of maintainning wetland function with water in Mogok, Sejin, and Daedae. Below figures show the variation of water depth from August 2004 to Junly 2005.

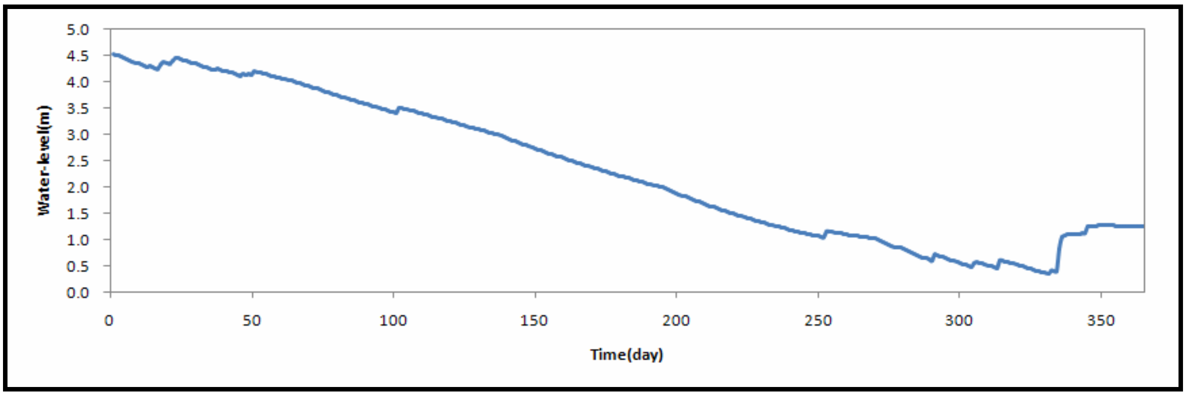

Figure 9 Variation of water depth in Mogok site

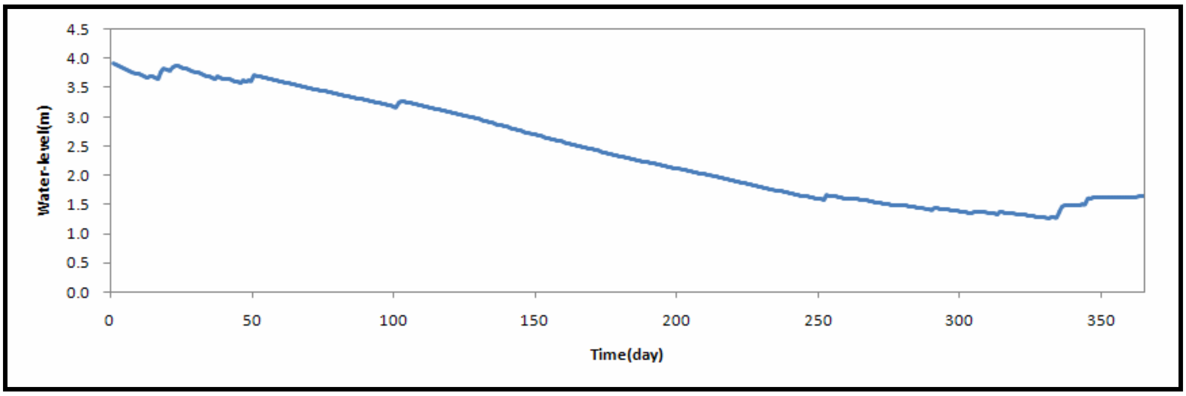

Figure 10 Variation of water depth in Sejin site

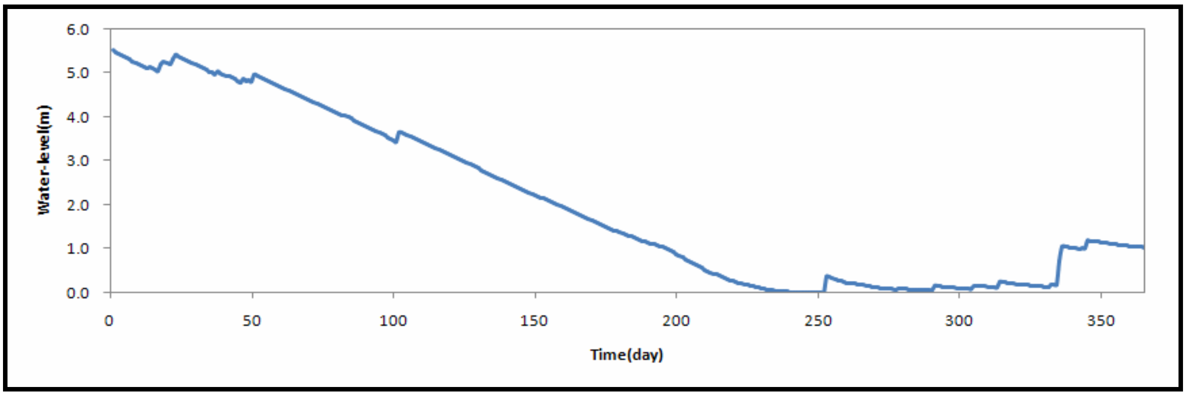

Figure 11 Variation of water depth in Daedae site

Figures 9 and 10 illustrate that the water depths are always higher than 0.5m and 1.5m respectively for a year. Thus, Mogok and Sejin sites would be used as a wetland. Actually, when applying washlands to a form of a wetland with the ecological purpose, the most important thing is to keep an appropriate water depth in chosen ecosystem after selecting the target ecosystem.

6. Conclusions

In this study, we designed an articial washland containing the flood defense and ecological function, and examined the reduction of flood level and maintenance potential as a wetland. To estimate the flood defense ability and storage volume at the low frequency, HEC-RAS model is used. And the maintenance potential as a wetland is examined through the SWAT model based on the water-balance analysis.

If the washlands are designed respectively, the flood control effect is very small except in the Daedae site (the maximum flood control effect of Daedae site is 0.28m). But when all proposed sites were utilized as an artificial washland, the maximum flood control effect of washlands is 0.56 meter.

In this study, the stream and storage area are connected by only a weir. So, to maximize the flood control ability, the study of optimization technique for the weir operation is demanded.

To examine the maintenance potential as a wetland, SWAT model is used based on the water-balance analysis. As a result of the model, Mogok and Sejin sites contain a certain amount of water for a year. Thus, the ecosystem of the Woopo wetlands could be expanded.

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