Advances in Engineering Research, volume 198
International Seminar of Science and Applied Technology (ISSAT 2020)

Control of Upstream Bekasi River Floods by Building a Dry Dam Series in Cikeas River and Cileungsi River, West Java

Edy Sriyono[1,*] Ilham Purnomo[1] Tania Edna Bhakty[1] Azhari[1]

[1]*Civil Engineering Master Program, Janabadra University, Yogyakarta 55231, Indonesia*
[*]*Corresponding author. Email: edysriyono@janabadra.ac.id*
E-mail: ilham.purnomo@janabadra.ac.id, tania@janabadra.ac.id, azhari.sipil82ugm@gmail.com

ABSTRACT

The Upstream Bekasi River flood covering an area of 326 ha in 15 inundation points covers five sub-districts of Bekasi City. The Upstream Bekasi River has 2 (two) tributaries, namely Cikeas River and Cileungsi River. The Upstream Bekasi River flood was caused by a relatively small cross-sectional capacity of the river, namely 391.79 m^3/s, while the flood discharge that occurred was relatively enormous, namely 708.75 m^3/s. The flood was caused by the Cikeas River at 199.47 m^3/s and the Cileungsi River at 509.28 m^3/s. In order to control floods in Upstream Bekasi River, a dry dam series is planned in Cikeas River and Cileungsi River. At Cikeas River, the Ck-227 weir was built, while at the Cileungsi River the Cl-1 weir was built. The methods used consist of data collection (rain, map of the earth; and the topography of Cikeas and Cileungsi River and the capacity of Upstream Bekasi River), determining the flood discharge design for Cikeas River and Cileungsi River, determining the location; high; the number and dimensions of the weir outlet doors, as well as the flood simulation until the Cikeas River discharge + the Cileungsi River discharge < Bekasi Hulu River discharge. Based on the results of the flood simulation, it is found that at the Cl-1 dam, with the input of the peak flood discharge of 509.28 m3/s, the peak flood output becomes 198.40 m3/s. While at the CK-227 Dam, with a peak flood discharge input of 199.47 m^3/s, the peak flood output is 170.40 m^3/s. The simulated flood discharge of Cikeas River and Cileungsi River is 368.80 m^3/s, smaller than the channel capacity of the Upstream Bekasi River, which is 391.79 m^3/s. So it can be concluded that the flood in Upstream Bekasi River can be controlled by building dry dam series in Cikeas River and Cileungsi River.

Keywords: *flood discharge, flood control, dry dam series*

1. INTRODUCTION

Flood is a condition in which water cannot be collected in the drain (river) or water flow is obstructed in the drain [1]. Many factors cause flooding. Rainfall can cause flooding if it falls with high intensity, long duration, and occurs over a large area [2]. Physiography or physical geography of rivers such as shape, slope of the watershed, river slope also affects the occurrence of flooding [3]. Erosion and sedimentation in watersheds (DAS) also have an effect on reducing the cross-sectional capacity of rivers resulting in inundation and flooding in rivers [4]. If the surface flow rate that enters the river exceeds the capacity of the river flow, there will also be an overflow of flow from the river and can cause flooding in an area [5]. Sea tides can also slow down the flow of rivers to the sea. When the flood coincides with high tide, the inundation or flood height becomes large due to backwater. This puddle can occur throughout the year both in the rainy season and in the dry season [5]. Inadequate drainage capacity is also a frequent habit of flooding in the rainy season [6].

To reduce the occurrence of flooding in Upstream Bekasi River, which is the parent of Cikeas River and Cileungsi River, there is a need for technical engineering in the form of dry dam series in the Cikeas River and Cileungsi River channels, to slow down the arrival of floods downstream and take advantage of reservoirs of dam for conservation needs or raw water which is currently indispensable. By controlling the flood discharge in the upper reaches of the river with dry dams, it is hoped that the time lag of the passing floods will be longer.

To calculate the flood simulation through dry dam can use the HEC-RAS program [7]. Dry dam has also been proven to be a solution for flood management [8]. In addition, dry dams have been built and operated to withstand floods in Japan since 2007 and in the USA since 1920 [9].

Flood control is carried out by building dry dam series [10] in Cikeas River and Cileungsi River so that there will be a decrease in flood discharge in Cikeas River and in Cileungsi River so that the flood discharge entering Upstream Bekasi River is smaller than the channel capacity of the river.

The concept of peak flood reduction is carried out in the following manner [10]:

1) Reducing the hydrograph peaks that enter Bekasi River so that it is in accordance with the capacity of the existing Bekasi River.
2) Damping is done by minimizing the hydraulic gradient and temporarily accommodating the volume of flooding downstream into river basins and floodplains.
3) Issue it by arrangement so that when entering Bekasi River the discharge is in accordance with the current Bekasi River capacity or according to the planned discharge of Bekasi River.

The selection of the location of the dry weir is carried out by considering the following points [8].

1) Inundated areas of non-productive land and settlements (a decreasing hydraulic gradient will cause the water level to increase).
2) Has a relatively large capacity so that it can reduce the number of dry weirs (riverbeds and potential floodplains).
3) The sediment collected in the weir must be removed gradually when the discharge is small, if necessary assisted by Operation and Maintenance activities (periodic excavation).

While the hydraulic analysis process for flood simulation is carried out in the following manner [7].

1) Estimated maximum capacity of Bekasi River (Qp).
2) Suppose n dry dams will be built, namely: Dd1, Dd2, Dd3,…., Ddn.
3) Determine the location of each dry dam from the results of a satellite map study and field visits.
4) Graph the elevation relationship with the area and volume of inundation for each of these weirs.
5) Planned flood hydrograph input at the upstream dry dam Dd.
6) Input discharge hydrograph out of Dd1 (discharge function with set elevation, area and threshold elevation).
7) Calculate changes in volume and water level in the weir.
8) Running stages 4 to 6 during a flood (length of hydrograph).
9) If the water level is still below the design water level, then the discharge in stage 5 is reduced (by changing the dimensions of the hole).
10) Or by lowering the design water level so that construction costs can be reduced.
11) Trial stages 8 and 9 are carried out until the ideal elevation is achieved.
12) When item 10 is terminated, we have obtained the elevation of the weir, the dimensions of the hole and the output hydrograph of the Dd1 weir.
13) Calculate the flood hydrograph for the catchment area between Dd1 and Dd2.
14) Superpose the hydrograph of steps 11 and 12 to become the input hydrograph Dd2.
15) Repeat process steps 4 to 11 for Dd2.
16) And so on, so we get the hydrograph out of Ddn.
17) The hydrograph peak that comes out of the Ddn weir (Qn must be smaller than Qp), so that Bekasi River does not overflow.

2. METHODOLOGY

The research method consists of 4 activities, namely: data collection, analysis of the flood discharge of Cikeas River and Cileungsi River, designing dry dams in Cikeas River and Cileungsi River, and flood simulation until Cikeas River discharge plus Cileungsi River discharge is smaller than Upstream Bekasi River discharge.

2.1. Data collection

The data collected is in the form of rain data, earth map, topographic map and the capacity of Upstream Bekasi River. The capacity of Upstream Bekasi River is 391.79 m^3/s. While the map of research location and the dry dam locations Ck-227 and Cl-1 can be seen in Figure 1 and 2.

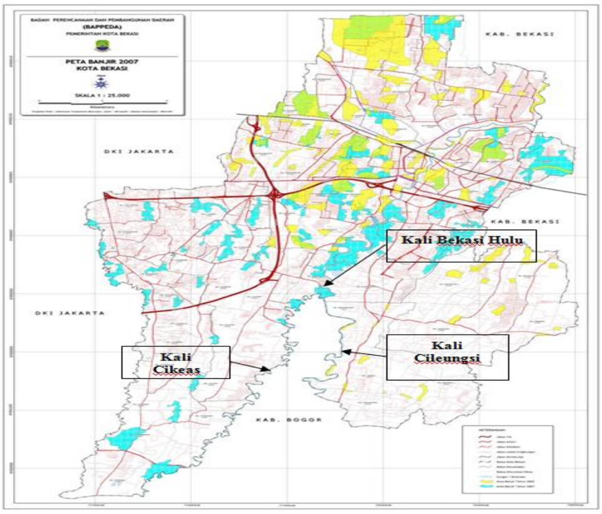

Figure 1 The map of research location

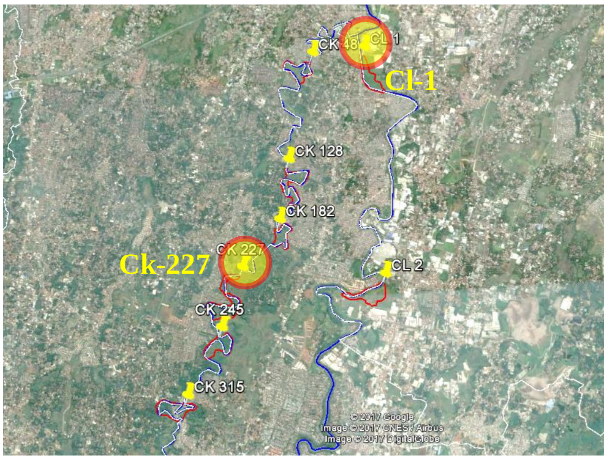

Figure 2 Alternative dry dam locations in Cikeas River and Cileungsi River

The map of the rain station can be seen in Figure 3, while the rain data can be seen in Table 1 and hydrograph of Bekasi river flood can be seen in Figure 4

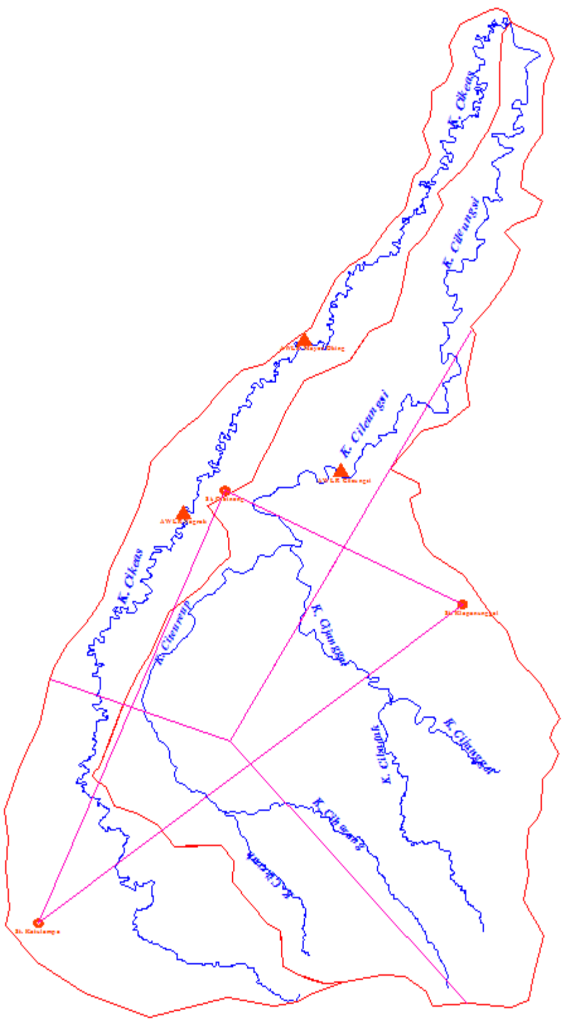

Figure 3 Upstream Bekasi watershed rain station

Table 1 Rain data

Year	Cibinong Sta.	Kelapa Nunggala Sta.	Katulampa Sta.
2016	135	68	169
2015	70	65	129
2014	81	60	109
2013	82	97	92
2012	89	69	71
2011	90	132	102
2010	75	111	145
2009	74	210	112
2008	132	141	92
2007	80	175	89

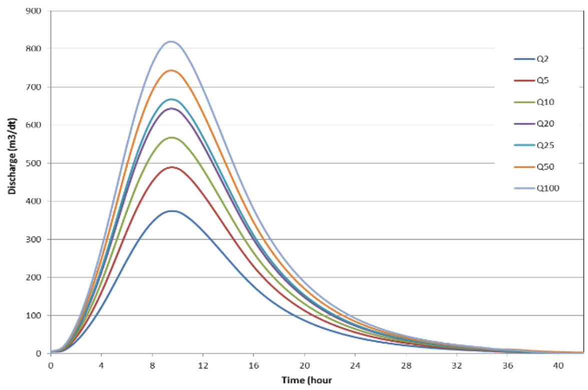

Figure 4 Hydrograph of Bekasi river flood

2.2. Analysis of the flood discharge of Cikeas River and Cileungsi River

The analysis was carried out in order to obtain the flood discharge designed for Cikeas River and Cileungsi River. Based on the results of the analysis on the dry dam Ck-227, the peak flood discharge input hydrograph was obtained of 199.47 m^3/s. Meanwhile, based on the results of the analysis on the Cl-1 dry dam, the hydrograph of the peak flow discharge input is 509.28 m^3/s.

2.3. Designing dry dam series in Cikeas River and Cileungsi River

Floods in Upstream Bekasi River can be controlled by constructing dry dam series in Cikeas River and Cileungsi River. In Cikeas River a dry dam Ck-227 was built, while in Cileungsi River a Cl-1 dry dam was built. The dry dam series scheme can be seen in Figure 5 below. Dry dam design includes determining dry dam dimensions and outlet door dimensions. Lay out, cross section and long section of dry dam, then can be seen in Figure 6 below.

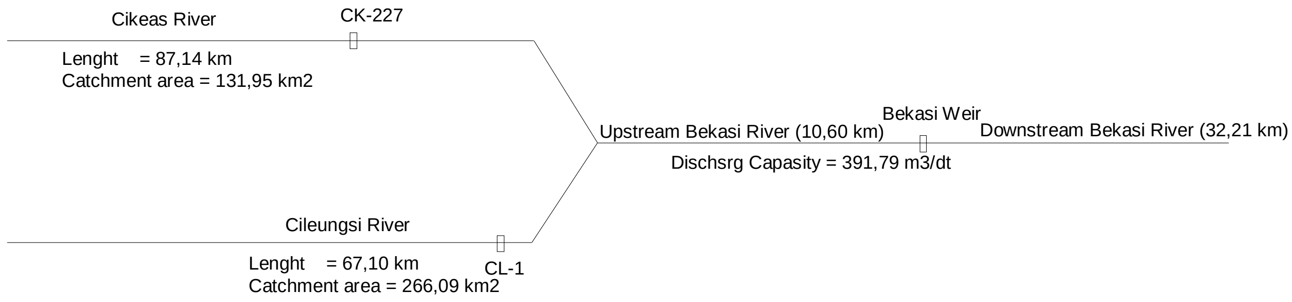

Figure 5 River scheme and dry dam series building layout

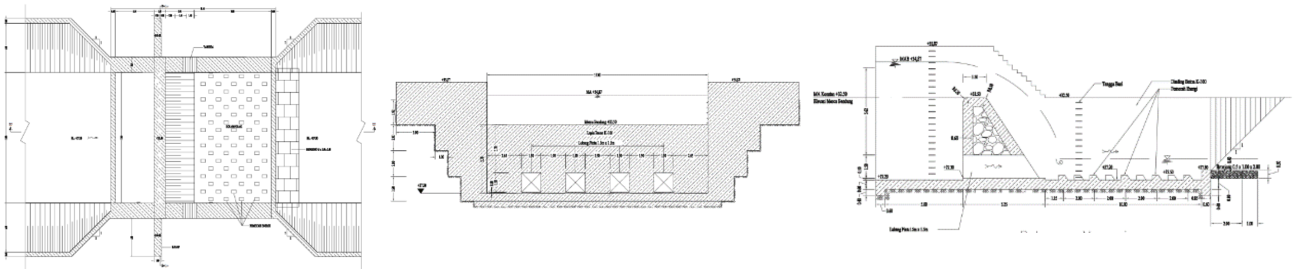

Figure 6 (a) Lay out (b) cross section (c) long section of dry dam

After the dry dam functions, there will be a water storage as shown in Figure 7 below.

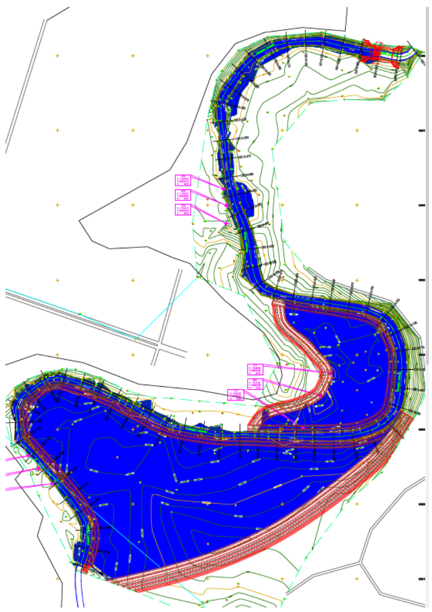

Figure 7 Storage area after the dry dam functions

2.4. Flood simulation

The basis for simulating the water balance of the weir is a function of the input discharge, the output discharge and the reservoir volume which can be presented in the following equation: I - O = ds/dt, where I = input discharge, O = output discharge, and ds/dt = ΔS is the change of storage.

In more detail, the formula above can be written as follows: St + 1 = St + It - Ot, where St = reservoir storage in period t, St + 1 = reservoir storage in period t + 1, It = reservoir input discharge in period t, and Ot = discharge from overflow.

Based on the above concept, a simulation was carried out to see the effectiveness of the dry dam system in reducing flooding, especially floods with a 25 year return period (Q25).

Flood simulations were carried out until the Cikeas River discharge plus the Cileungsi River flow was smaller than the Bekasi Hulu River discharge. Dry dam flood simulation using Excell.

The following are the simulation results of the Ck-227 and Cl-1 dry dams:

1) Dry dam Ck-227:
   Dam height = 7,30 m
   Dam width = 22 m
   The number of holes = 4
   Hole dimensions = 2,25 m^2
   The input flood hydrograph CK-227 is:

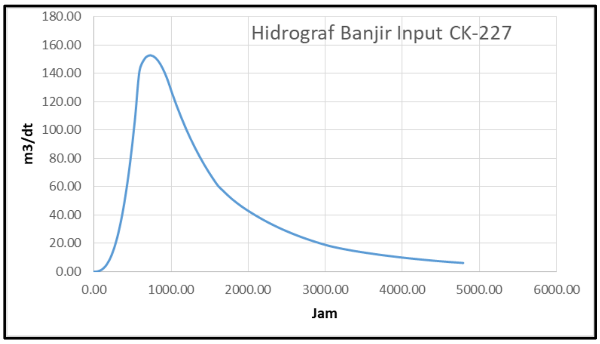

Figure 8 The input hidrograph of dry dam Ck-227

2) Dry dam Cl-1:
   Dam height = 10,13 m
   Dam width = 25 m
   The number of holes = 4
   Hole dimensions = 4 m^2
   The input flood hydrograph Cl-1 is:

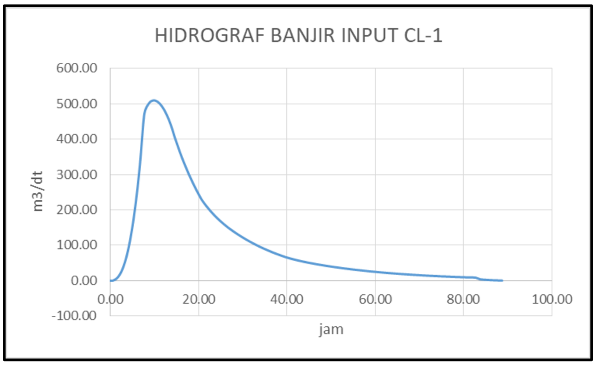

Figure 9 The input hidrograph of dry dam Cl-1

3. RESULTS AND DISCUSSION

Based on the results of the flood simulation at the Ck-227 Dam, with the dam height of 7,30 m, the dam width of 17,0 m, the slope of the river bed = 0,0006, and area of the retarding basin of 16,0 Ha, the peak flood discharge input hydrograph of 199.47 m^3/s, the peak flood output hydrograph was obtained of 170.40 m^3/s, so that there was a decrease in the flood peak of 29.07 m^3/s. Furthermore, it can be seen in Figure 10.

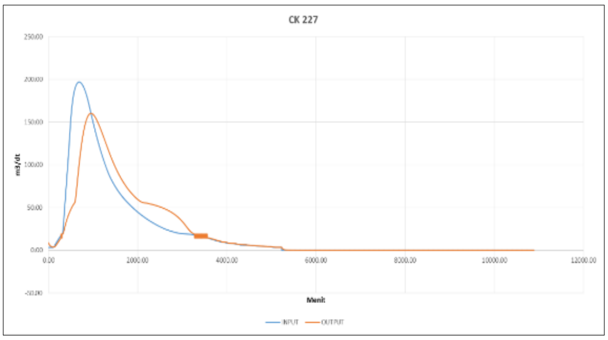

Figure 10 Simulation results of flood discharge in dry dam Ck-227

Dry dam Ck-227 has a maximum discharge through the spillway112.60 m^3/s, a total discharge (spillway + door hole) of 170.40 m^3/s and a discharge through the door hole of 57.80 m^3/s. The door hole has contributed to the reduction of flood discharge by 33.92 %. Furthermore, it can be seen in Figure 11.

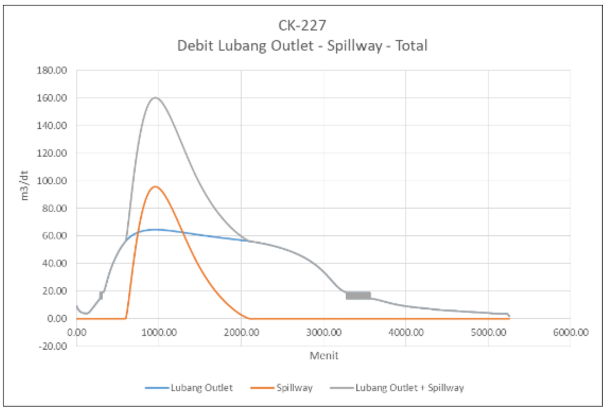

Figure 11 The door hole discharge, spillway, and dry dam total discharge Ck-227

The area of retarding basin dry dam Ck-227 can be seen in Figure 12.

Figure 12 Area of retarding basin dry dam Ck-227

Based on the results of the flood simulation at the Cl-1 Dam, with the dam height of 10,13 m, the dam width of 25,0 m, the peak flood discharge hydrograph of 509.28 m^3/s, the peak flood output hydrograph was obtained of 198.40 m^3/s, so that there was a decrease in the flood peak of 310.88 m^3/s. Furthermore, it can be seen in Figure 13.

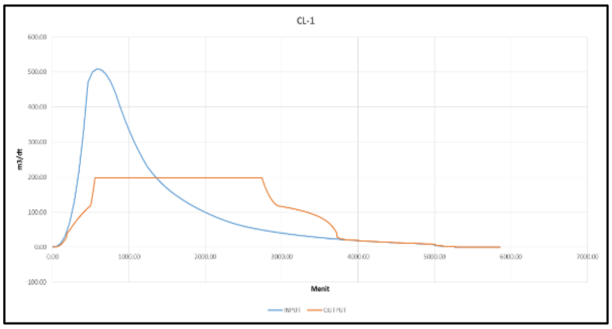

Figure 13 The simulation results of flood discharge in the Cl-1 dry dam

Dry dam Cl-1 has a maximum discharge through the spillway 72.16 m^3/s, a total discharge (spillway + door hole) of 198.40 m^3/s and a discharge through the door hole of 125.24 m^3/s. The door hole has contributed to the reduction of flood discharge by 63.53 %. Furthermore, it can be seen in Figure 14.

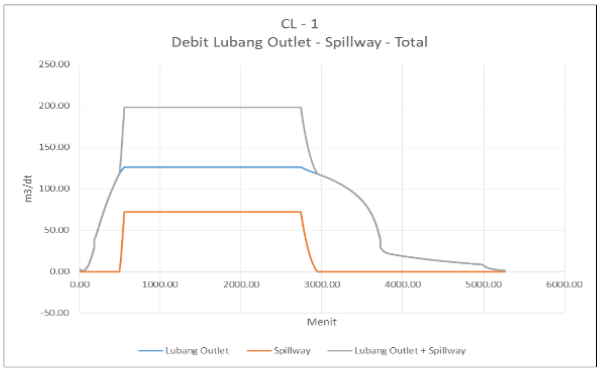

Figure 14 The door hole discharge, spillway, and dry dam total discharge Cl-1

The area of retarding basin dry dam Cl-1 can be seen in Figure 15.

Figure 15 Area of retarding basin dry dam Cl-1

4. CONCLUSION

Based on the research results, it can be concluded that the following are some of the things.

1) The decrease in peak flood discharge is influenced by the dry dam storage volume.
2) The number and dimensions of dry dam door holes have implications for the emptying time of the weir reservoir. The more the number and dimensions of the door holes, the faster the emptying time, thus the smaller the flood reduction discharge.
3) Flood control in Bekasi River where the cross-sectional capacity of the river is 391.79 m^3/s can be done by building dry dam Ck-227 in Cikeas River and dry dam Cl-1 in Kali Cileungsi, where the total discharge discharge from the two weirs is 368, 80 m^3/s.

5. RECOMMENDATIONS

In order to control flooding in Upstream Bekasi River, based on the results of the analysis and discussion, it can be recommended that the construction of the Ck-227 dry dam in Cikeas River and the Cl-1 dry dam in the Cileungsi River can be recommended.

ACKNOWLEDGMENT

Thank you very much to Ir. Edy Sulistiyono, M.Eng., For his suggestions in the discussion on dry dam series.

REFERENCES

[1] Suripin, Sistem Drainase Perkotaan yang Berkelanjutan. Andi Offset, 2004.

[2] Guhathakurta, P., Sreejith, O. P., & Menon, P. A., Impact of climate change on extreme rainfall events and flood risk in India, 2011, 3, 359–373.

[3] Minea, G., Assessment of the Flash Flood Potential of Bâsca River Catchment (Romania) Based on

Physiographic Factors, 2013, 5(3), 344–353. https://doi.org/10.2478/s13533-012-0137-4.

[4] Mananoma, T., & Manalip, H., Analisis angkutan sedimen pada sungai mansahan, 2013, 3(1), 54–57.

[5] Suharyanto, A., Prediksi titik banjir berdasarkan kondisi geometri sungai, 2014, 8(167).

[6] Fairizi, D., Analisis dan Evaluasi Saluran Drainasi Pada Kawasan Perumnas Talang Kelapa di Sub DAS Lambidaro Kota Palembang, 2015, 3(1).

[7] Gruss, L., Glowski, R. & Wiatkowski, M., Modeling of water flows through a designed dry dam using the HEC-RAS program, 2018, https://doi.org/10.1051/itmconf/20182300012.

[8] Poulard, C., Lafont, M., Matyas, A.L., Lapuszek, M., Ratomski, J., Witkowska, H., Jezequel, C. & Breil, P., Co-conception of flood management solutions: riverscapes to facilitate dialog between dry dam designers and biologists, 2010, https://hal.archives-ouvertes.fr/hal-00494518.

[9] Sumi, T., Designing and Operating of Flood Retention Dry Dams in Japan and USA. Deparment of Civil and Earth Resources Engineering. Kyoto University, 2010.

[10] Hideo, O., Tomohiko, I., & Toshimitsu, K., Study on The Flood Control Ability of A dry Dam Used as A Flood Retarding Basin in A River, Journal of Japan Society of Civil Engineers, Ser. B1 (Hydraulic Engineering), Volume 67, Issue 4, pp. I_667-I_672, 2011.