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Effect of the Nanjung tunnel construction against flood inundation in Dayeuhkolot

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Abstract. Floods that occur in the Upper Citarum River Basin are generally caused by flood discharge that exceeds the capacity of the Citarum River. Dayeuhkolot is one of the areas that is often flooded in the Upper Citarum River Basin. The Citarum River Authority has made efforts to handle floods in Upper Citarum by constructing the Nanjung Tunnel. When floods occur, Nanjung Tunnel will function to divide the water partially into the tunnel and through the Curug Jompong. SOBEK Model was utilized to find out the effect of the Nanjung Tunnel against flood inundation in Dayeuhkolot. This flood modelling also accommodates other efforts that have been made by BBWS Citarum such as the Cieunteung Pond and Cisangkuy Floodway. A 20-year return period was used for modelling. From the results of the modelling, it was found that difference in flood inundation area with and without the Nanjung Tunnel was 12.5 Ha or 3.5 %, with the duration of the overall inundation being reduced by 4.9 hours. Nanjung Tunnel does not have a great influence on the area of inundation, but it has an effect on reducing the duration of floods that occur in Dayeuhkolot.

Keywords: Nanjung Tunnel, Dayeuhkolot, SOBEK, Flood Inundation

1. Introduction

Citarum River is a strategic river based on Ministry of Public Works and Housing Regulation No. 04/PRT/M/2015 on the Criteria and Designation of River Areas, because Citarum River is a water source that supports the sustainability of the Saguling, Cirata, and Jatiluhur Reservoirs. The current condition of the Citarum watershed has been greatly decreased, or more accurately badly damaged, from its upstream to its downstream parts and involving various very complex problems. One of the problems that often occurs is the problem of flooding.

The construction of the Nanjung Tunnel is one of the efforts undertaken by the government through the Citarum River Basin Authority (BBWS Citarum) to deal with the frequent floods, especially in the Dayeuhkolot area. This region is one of the sub-districts in Bandung Regency, which is one of the areas prone to flooding. This tunnel consists of two channels with a length of 230 meters and a channel diameter of 8 meters that cuts the Citarum River through the Curug Jompong area.

The purpose of constructing the Nanjung Tunnel is to divert some of the water flowing into Curug Jompong, which is a rocky narrow river channel that can inhibit the flow of the Citarum River, causing inundation in the Dayeuhkolot area. The Nanjung Tunnel is expected to increase the capacity of water flowing into the area, thereby reducing the water level in Curug Jompong and Dayeuhkolot. In addition to reduce the water level, another purpose of constructing the Nanjung Tunnel is to slow the sedimentation of the Citarum River so that the profile of the Citarum River does not quickly change.

2. Method

This study on the tunnel influence was made based on the Dayeuhkolot Final Report, Upper Citarum Basin Flood Management 2013 Feasibility Study, JICA No. IP-559, a study that examined more deeply the SOBEK Model that is utilized to model floods in the Upper Citarum Region, especially in the Dayeuhkolot area. SOBEK is a flood management software for rivers. From the software that has been developed to carry out flood simulations, SOBEK has the advantage of simulating floods in two dimensions (with a 2D grid) and can calculate and display four kinds of information: 1) flood depth, 2) inundation area, 3) flood direction, and 4) flow velocity. Because the feasibility study was conducted in 2015, the SOBEK model that had been used in that study was updated to include data of the latest cross-section measurement data up to 2018 as well as of the infrastructure that had been built for flood control in the Upper Citarum, one of them being the Cieunteung Retention Pond. The parameters of watershed, rainfall, and return period were still based on the feasibility study.

3. Results and Discussion

3.1 Model Scenario and Schematisation

In conducting flood simulations, there were two simulated scenarios. The first simulation was without the Nanjung tunnel, and the second simulation was with the Nanjung tunnel. The simulation was carried out using schematisation for the entire Upper Citarum with a study of flood inundation only for the Dayeuhkolot Region.

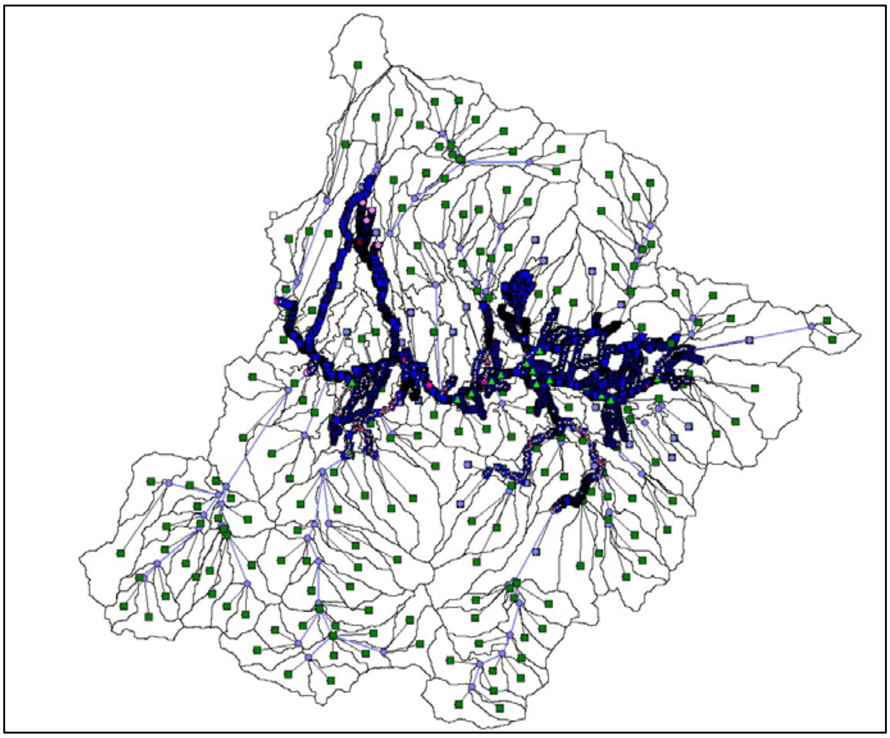

Figure 1. SOBEK Model Schematisation of the Upper Citarum

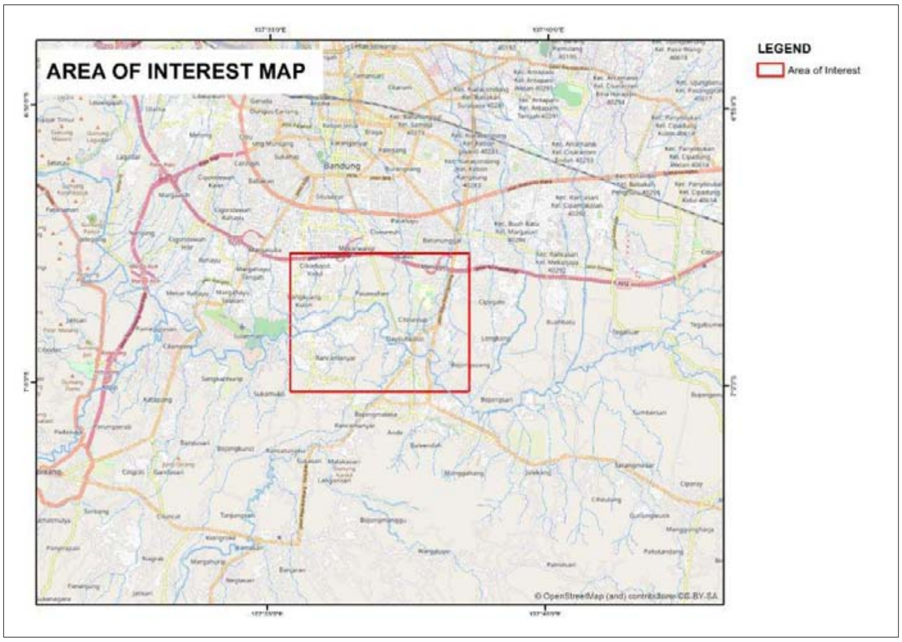

Figure 2. Area of Interest Map for Dayeuhkolot

3.2 Model Calibration

The Sacramento hydrology model was used in the flood simulation with SOBEK. This model had been calibrated in the feasibility study using the Citarum-Nanjung river gauge data with the event data from November 2014 to January 2015.

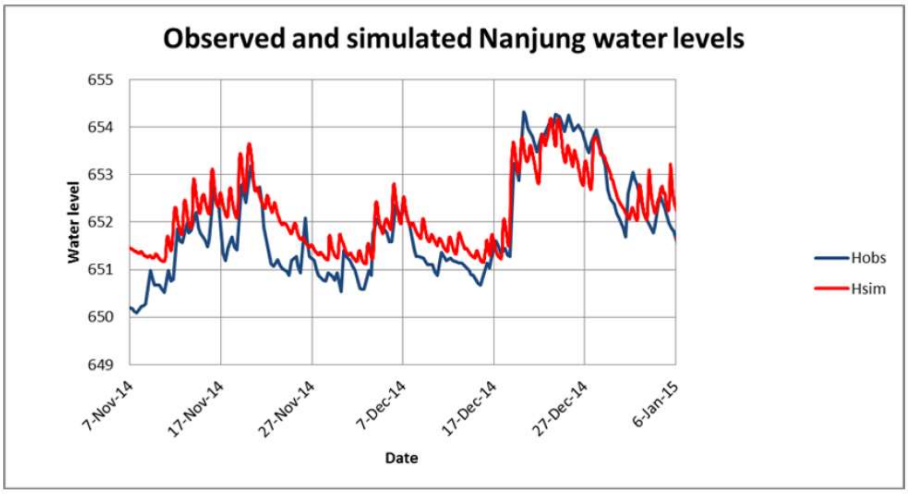

Figure 3. Calibration Simulation and Field Measurement for the Citarum-Nanjung River Gauge (*source: Final Report Dayeuhkolot Feasibility Study)*

In addition to calibration using data from the river gauge, calibration was also carried out through field calibration based on inundation maps from the SOBEK model and field checking by interviewing local residents. Field verification was carried out at 18 points scattered in the Upper Citarum. From the survey results, three points were found to be inappropriate because in the simulation, the area was flooded, but in fact, the area had never been flooded.

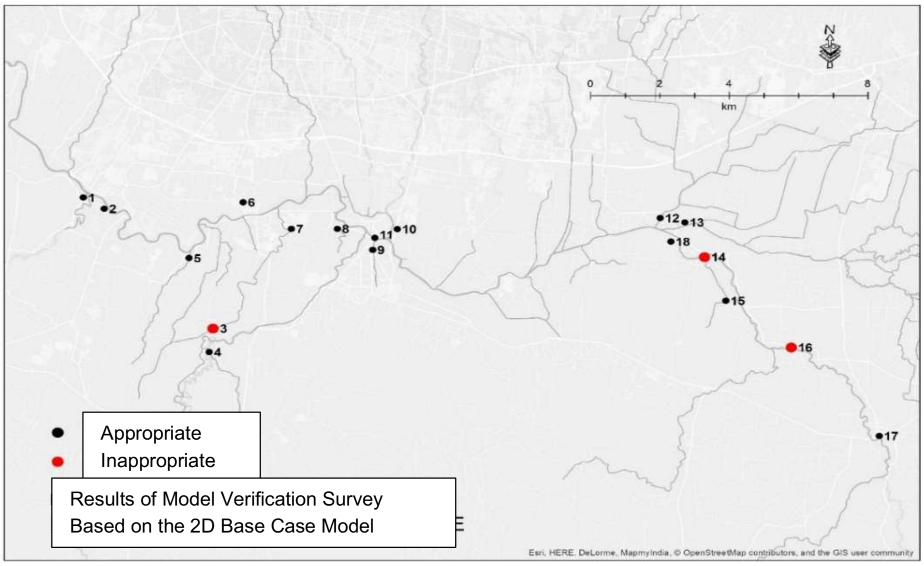

Figure 4. The results of field verification related to flood inundation results of the simulation

3.3 Water level analysis

One of the ways to display the parameters to show the performance of the model is to present the flood peak as the maximum water level at all observation points.

The observation points for the analysis are composed of the Nanjung inlet, the Nanjung Bridge after the drop into Curug Jompong and partly into the Nanjung Tunnel, the Upper Daraulin, the Cibeurem River outlet, the Ciwidey River outlet, the Ciranjeng River outlet downstream of the Cisangkuy Floodway, the Citepus Outlet, the lower part of Cisangkuy, and the Dayeuhkolot Bridge.

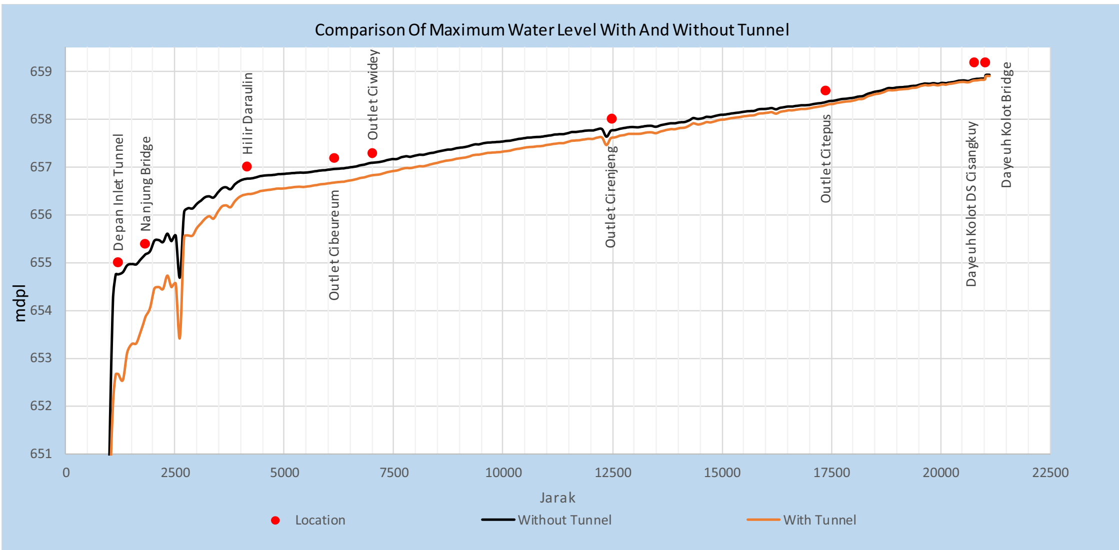

Figure 5. Maximum water level from Dayeuhkolot to Nanjung

Table 1. Maximum water level

Location	Without Tunnel (m)	With Tunnel (m)
Nanjung Inlet Tunnel	654.752	652.666
Nanjung Bridge	655.169	653.856
Upper Daraulin	656.754	656.435
Cibeureum Outlet	656.956	656.678
Ciwidey Outlet	657.089	656.833
Cirenjeng Outlet	657.755	657.608
Citepus Outlet	658.350	658.290
Dayeuhkolot, Lower Cisangkuy	658.830	658.809
Dayeuhkolot Bridge	658.860	658.840

The difference between water levels with the tunnel and water levels without the tunnel has a major effect on the Nanjung region and decreases in the downstream parts. The difference in water level in the Nanjung area can reach 1.3 m, but for Dayeuhkolot, it was only reduced by 0.03 m. This is because the location is indeed far from the Nanjung tunnel and the Dayeuhkolot area

3.4 Flood Inundation Area

Modelling using SOBEK was performed in 2D to obtain the resulting potential area of inundation. Assessment of the area of potential inundation is to examine how different parts would be inundated to different flood depths, with and without the Nanjung tunnel.

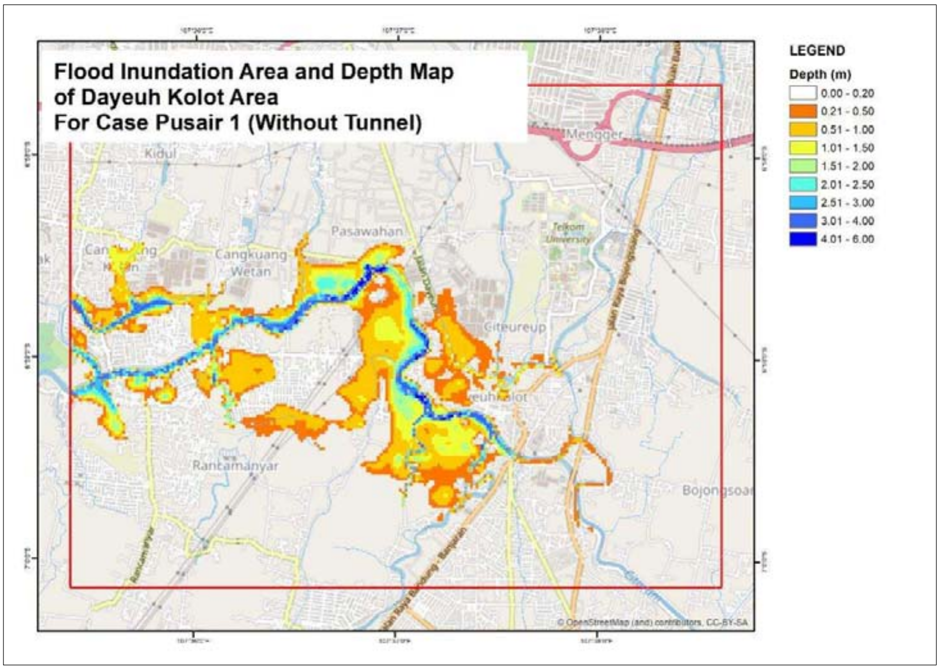

Figure 6. Flood Inundation Area Map without the Nanjung Tunnel

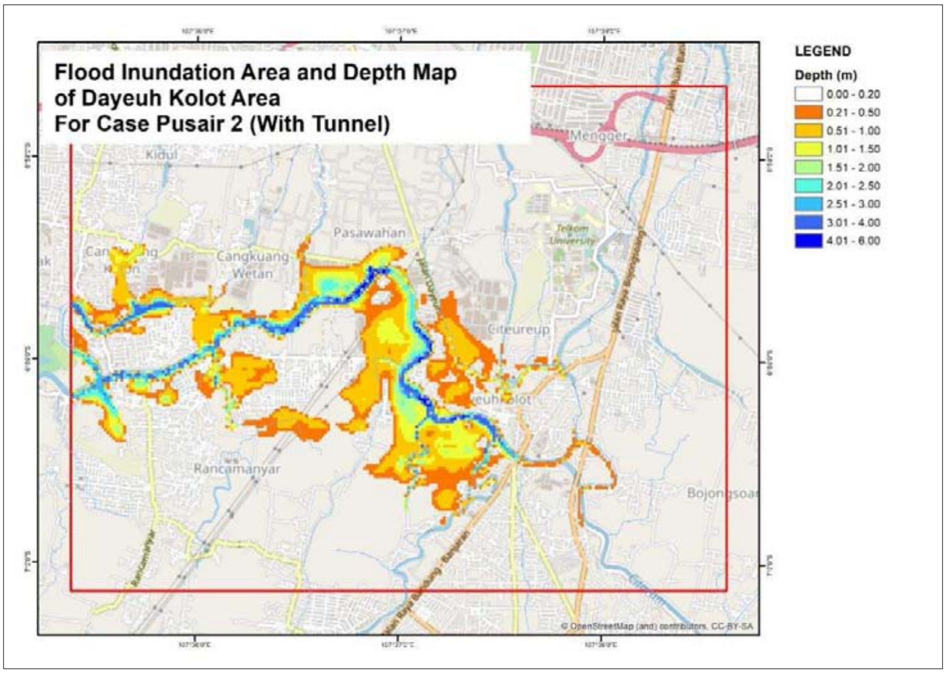

Figure 7. Flood Inundation Area Map with the Nanjung Tunnel

Table 2. Inundation area based on flood depths in Dayeuhkolot

Depth of Inundation	Without Tunnel (ha)	With Tunnel (ha)
0.5	99.13	102.69
1.0	129.31	120.56
1.5	50.06	45.94
2.0	25.00	24.06
2.5	15.13	14.56
3.0	12.50	12.88
4.0	21.63	20.06
6.0	3.63	3.13
Total	**356.38**	**343.88**

The total flooded area in Dayeuhkolot as a whole was reduced by 12.5 hectares. However, looking at each individual flood depth, the decrease in flooding is dominated by flooding reductions of depths of 1 to 2 meters. Flood conditions for depths of 0.5 to 2 meters can be categorized as flooding in fields, while floods with depths greater than 2 meters as in the results of the model tend to be in the river or in the oxbows.

The Nanjung Tunnel reduced the effect by 3.5% compared to without the tunnel. The effectiveness of the Nanjung Tunnel itself can be increased if assisted with infrastructure development or other efforts to accelerate the flow towards Nanjung, such as performing the normalization plan, increasing the slope of the Citarum River, and constructing the floodway in Cisangkuy.

3.5 Flood Duration

To find out the effectiveness of the Nanjung tunnel, aside from examining the reduction in the area and depth of flood inundation, the extent and duration of the floods that would occur can also be compared. The Nanjung Tunnel was built to accelerate the flow of the Citarum River to reduce the duration of the flow until it can reach the Saguling Reservoir.

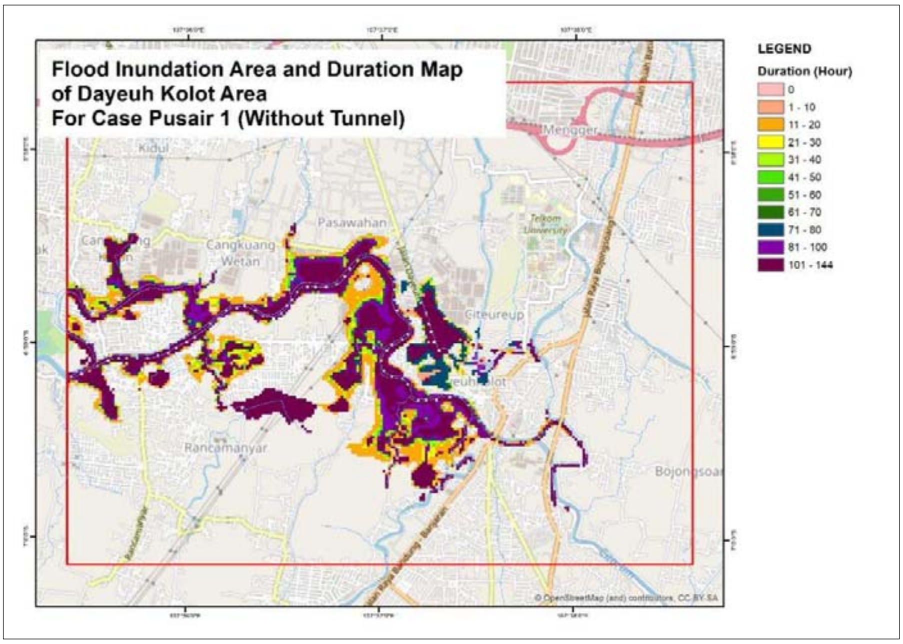

Figure 8. Map of Flood Duration without Nanjung Tunnel

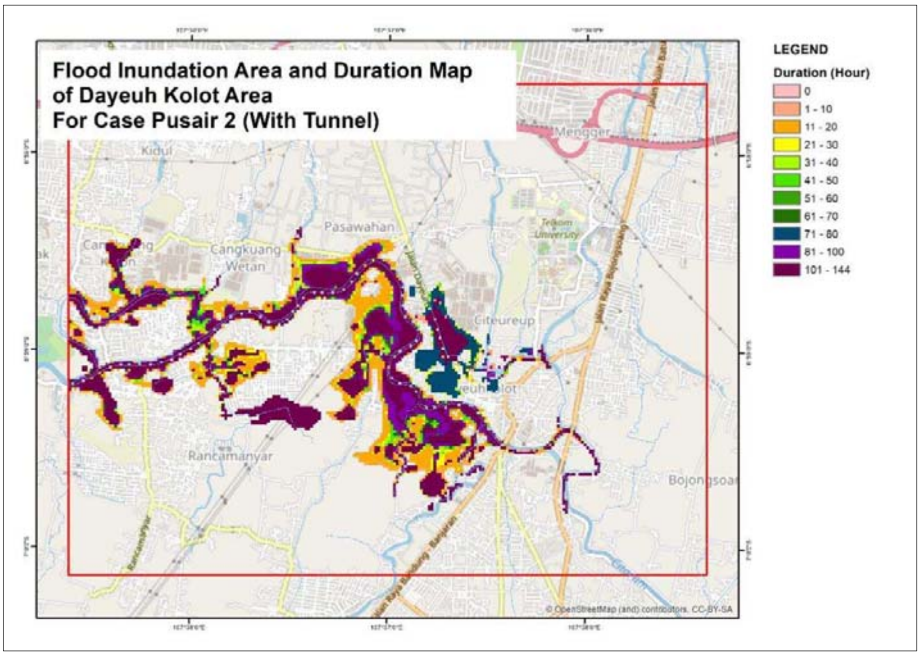

Figure 9. Map of Flood Duration with Nanjung Tunnel

Table 3 Inundation area based on Flood Duration in Dayeuhkolot

Duration (Hour)	Without Tunnel (ha)	With Tunnel (ha)
0	6.13	8.75
10	67.94	75.94
20	9.38	10.31
30	20.94	14.56
40	7.19	9.88
50	0.44	0.44
60	1.38	3.13
70	19.63	23.56
80	43.44	32.31
100	179.94	165.00
Total	**356.38**	**343.88**

Overall, flooding with a duration of 80-100 hours tends to decrease. Flooding with a duration of 100 hours was reduced to 165 ha from 179.94 ha, a reduction by 14.94 ha. Whereas, 80-hour floods decreased from 43.44 ha to 32.31 ha, a reduction 11.31 ha. Areas with floods of lower duration did increase, being floods with durations of 0.10, 20, 30, 40, 60, and 70 hours. This shows that the overall durations of flooding did decrease. On average, the overall flooding duration was reduced by 4.9 hours.

4. Conclusion

Flood modelling using the SOBEK model was performed to determine the effectiveness of the Nanjung Tunnel for flood control of the Dayeuhkolot region by examining the maximum water level, flood inundation area, and flood duration. With the presence of the Nanjung Tunnel, the area of flood inundation was reduced by 12.5 hectares or 3.5%, while the overall flood duration decreased by 4.9 hours. The effectiveness of the Nanjung Tunnel can be increased with assistance from infrastructure development or other efforts to accelerate the river flow towards the Nanjung Tunnel.

Acknowledgments
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