Design of drainage system on industrial area Kampung Cina, Dobo City, Aru Islands Regency, based on Eco drainage using with HEC-RAS 4.0

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Abstract. This study aim to plan a drainage system in the Industrial area of Kampung Cina Dobo City that can overcome the problems of inundation occurred. The inundation is caused by the drainage channel that has not been properly arranged and is still in the form of a natural drainage channel, most of which still use the road drainage network whose condition is not functioning properly due to sediment and garbage which results in many drainage channels being cut off. Data processing is carried out with two analyzes including hydrological analysis and hydraulic analysis. The hydraulics analysis includes channel section planning and drainage system modeling with HEC-RAS 4.0 software. In conventional drainage discharge flowing in the channel before the end of drain amounted to 1,136 m³/sec. Once added a retention pond with a capacity of 10.358 m³ with 5 scenario dimensions spillway. The results of modeling obtained by the reduction of the maximum flood flow is 1,07 m³/sec with dimensions of aperture is 8 m x 0,8 m and lower the water level in the upstream channel by 31 cm and 44 cm in the downstream channel.

1. Introduction

The existing condition of the drainage system in Dobo City drainage channel is still not well defined, it is still a natural drainage channel. Most use a network of drainage path is not functioning properly because it was covered by sediment, trash, and the number of drainage channels cut off, especially in the area of Industrial Estate Kampung China Dobo City, therefore some areas or settlements in the Industrial Area Kampung China frequent inundation in case of heavy rains, and coupled with relatively gentle topography, so that the flow rate is relatively slow water runoff, as well as the conditions of inundation will increase when high tide the sea can result in rainfall runoff water can not be directly discharged into the sea.

Based on information compiled from the information media in the city of Maluku, describing "Dobo has ocean and land surface are almost equivalent. That means Dobo land is flat, so if there is a big wave when the tide will surely be creeping up on land once flooded residential areas. The high sea levels as well as one of the problems which results in inundation because the drainage channel is no longer able to accommodate the volume of water from the overflowing tide and rainwater [8]. For resolve problems that occurred in the city, especially in the Industrial Area Kampung China Dobo City, should be a good drainage system planning and an environmental insightful.

Unavailability of a drainage system that is able to overcome the problems puddle in the industrial area of Kampung China City Dobo make planning and rebuilding a new drainage channel is needed. Especially with the existing drainage conditions during which it was unable to avoid the influence of
tides increasingly urgent for the construction of a drainage system that is able to overcome the problem of backflow or back water caused by tidal sea water. The drainage system in the wake granted based on a sustainable drainage system or Eco Drainage to meet existing demands on zero delta Q policy and utilization of the water before it is released into the ocean in order to more beneficial for society [1].

2. Methodology
The method used in this project is analysis covering the primary data and secondary data. The primary data used in this planning includes the measurement of the topography of the area and survey the population about inundation occurred. While secondary data used in this planning includes daily rainfall data, land use data, the data watershed area, sea level height data pairs, the data geometric regions.

In the data processing is done by two analysis includes analysis of hydrology and hydraulics analysis [5]. Hydrological analysis was conducted on the analysis of the probability distribution, the probability distribution of the test, the calculation of rainfall plan, analysis of the concentration time, rainfall intensity analysis, and the latter is the calculation of design flood to divide the area into several sub-watershed planning (sub-catchment) [4]. In the analysis of a cross-channel hydraulics include planning and drainage network modeling with HEC-RAS software 4.0 to know the profile of water level does occur backflow (back water) or not, and to know the dimensions of the planned able to accommodate the flood flow or not [3].

Furthermore, the planning of eco drainage system by adding a retention pond to the planned drainage channel [2]. Planning is done to determine the extent and volume of the planned retention pond. Following that is to do modeling for disposing of water through the channel into an overflow bin with the building, will be obtained in the form of technical data storage capacity and reduction of the discharge channel [6]. Based on modeling results of the planning phase was completed followed by making inferences and suggestions.

3. Analysis and Discussion
Flood discharge plan is an important part and the basis for determining the capacity and dimensions of buildings water [9]. In determining the amount of design flood are done by using rational method whereby flow used at peak flow flood with rain return period of 25 years.

| No. | Channel | Q (m³/s) | No. | Channel | Q (m³/s) | No. | Channel | Q (m³/s) |
|-----|---------|----------|-----|---------|----------|-----|---------|----------|
| 1   | S1.Ka   | 0.080    | 25  | Box S9  | 0.085    | 49  | S19.Ka  | 0.087    |
| 2   | S1.Ki   | 0.075    | 26  | S10.Ka  | 0.055    | 50  | S19.Ki  | 0.047    |
| 3   | Box S1  | 0.080    | 27  | S10.Ki  | 0.059    | 51  | Box S19 | 0.0628   |
| 4   | S2.Ka   | 0.066    | 28  | Box S10 | 0.0151   | 52  | S20.Ka  | 0.0395   |
| 5   | S2.Ki   | 0.057    | 29  | S11.Ka  | 0.057    | 53  | S20.Ki  | 0.093    |
| 6   | Box S2  | 0.066    | 30  | Box S11 | 0.0155   | 54  | Box S16 | 0.0624   |
| 7   | S3.Ka   | 0.061    | 31  | S11.Ki.1| 0.016    | 55  | S21.Ka  | 0.0882   |
| 8   | S3.Ki   | 0.055    | 32  | S11.Ki.2| 0.043    | 56  | S21.Ki  | 0.0191   |
| 9   | S4.Ka   | 0.066    | 33  | S12.Ka  | 0.006    | 57  | Box S15 | 1.059    |
| 10  | S3.Ki   | 0.068    | 34  | S12.Ki  | 0.0010   | 58  | S22.Ka  | 1.136    |
| 11  | S5.Ka   | 0.052    | 35  | S13.Ka  | 0.0541   | 59  | S22.Ki  | 0.0267   |
| 12  | S5.Ki   | 0.044    | 36  | S13.Ki  | 0.0167   | 60  | S23.Ka.1| 0.0657   |
| 13  | S6.Ka   | 0.098    | 37  | S14.Ka  | 0.0509   | 61  | S24.Ka  | 0.0078   |
| 14  | S6.Ki   | 0.095    | 38  | S14.Ki.1| 0.025    | 62  | Box S24 | 0.0736   |
| 15  | S7.Ka1  | 0.046    | 39  | S14.Ki.2| 0.034    | 63  | S24.Ki  | 0.0043   |
| 16  | Box S4  | 0.0212   | 40  | S15.Ka  | 0.0176   | 64  | S23.Ka.2| 1.131    |
Hydraulics analysis performed to plan the dimensions of the channel capable of design flood. Hydraulics analysis includes the calculation of channel capacity, flow rate, and the amount of flow that is able to be streamed by the channel.

### Table 2. Calculation of hydraulics analysis

| Channel name | Width (m) | Height (m) | Q (m³/s) | Channel name | Width (m) | Height (m) | Q (m³/s) |
|--------------|-----------|------------|----------|--------------|-----------|------------|----------|
| Box S1       | 0.4       | 0.3        | 0.117    | S13.Ka       | 0.8       | 0.7        | 0.0740   |
| S2.Ka        | 0.4       | 0.3        | 0.117    | S13.Ki       | 0.5       | 0.4        | 0.0225   |
| S2.Ki        | 0.3       | 0.3        | 0.072    | S14.Ka       | 0.8       | 0.8        | 0.0740   |
| Box S2       | 0.4       | 0.3        | 0.117    | S14.Ki.1     | 0.4       | 0.3        | 0.0117   |
| S3.Ka        | 0.4       | 0.3        | 0.117    | S14.Ki.2     | 0.4       | 0.3        | 0.0117   |
| S3.Ki        | 0.4       | 0.3        | 0.117    | S15.Ka       | 0.6       | 0.5        | 0.0382   |
| S4. Ka       | 0.5       | 0.4        | 0.225    | S15.Ki       | 0.5       | 0.4        | 0.0225   |
| S4. Ki       | 0.5       | 0.4        | 0.225    | S16.Ka       | 0.6       | 0.5        | 0.0382   |
| S5.Ka        | 0.4       | 0.3        | 0.117    | S16.Ki       | 0.6       | 0.5        | 0.0382   |
| S5.Ki        | 0.4       | 0.3        | 0.117    | S17.Ka       | 0.4       | 0.3        | 0.0117   |
| S6.Ka        | 0.4       | 0.3        | 0.117    | S17.Ki       | 0.4       | 0.3        | 0.0117   |
| S6.Ki        | 0.4       | 0.3        | 0.117    | S18.Ka       | 0.4       | 0.3        | 0.0117   |
| S7.Ka.1      | 0.4       | 0.3        | 0.117    | S18.Ki       | 0.4       | 0.3        | 0.0117   |
| Box S4       | 0.6       | 0.5        | 0.0305   | Box S18      | 0.6       | 0.5        | 0.0382   |
| S7.Ka.2      | 0.6       | 0.5        | 0.0458   | S19.Ka       | 0.4       | 0.3        | 0.0117   |
| S7.Ki        | 0.4       | 0.3        | 0.117    | S19.Ki       | 0.4       | 0.3        | 0.0117   |
| Box S7       | 0.8       | 0.7        | 0.0740   | Box S19      | 0.8       | 0.7        | 0.0740   |
| S8.Ka        | 0.4       | 0.3        | 0.117    | S20.Ka       | 0.8       | 0.7        | 0.0458   |
| S8.Ki        | 0.4       | 0.3        | 0.117    | S20.Ki       | 0.4       | 0.3        | 0.0117   |
| Box S8       | 0.4       | 0.3        | 0.117    | Box S16      | 0.8       | 0.7        | 0.0863   |
| S9. Ka       | 0.4       | 0.3        | 0.117    | S21.Ka       | 1         | 0.9        | 0.0987   |
| S9. Ki       | 0.4       | 0.3        | 0.117    | S21.Ki       | 0.6       | 0.5        | 0.0382   |
| Box S9       | 0.4       | 0.3        | 0.117    | Box S15      | 1         | 0.9        | 1.431    |
| S10. Ka      | 0.4       | 0.3        | 0.117    | S22.Ka       | 1         | 0.9        | 1.431    |
| S10. Ki      | 0.4       | 0.3        | 0.117    | S22.Ki       | 0.6       | 0.5        | 0.0382   |
| Box S10      | 0.5       | 0.4        | 0.0225   | S23.Ka.1     | 0.8       | 0.7        | 0.0740   |
| S11.Ka       | 0.5       | 0.4        | 0.0225   | S24.Ka       | 0.5       | 0.4        | 0.0225   |
| Box S11      | 0.5       | 0.4        | 0.0225   | Box S24      | 1         | 0.9        | 0.0987   |
| S11.Ki.1     | 0.4       | 0.3        | 0.117    | S24.Ki       | 0.6       | 0.5        | 0.0382   |
| S11.Ki.2     | 0.4       | 0.3        | 0.117    | S23.Ka.2     | 1         | 0.98       | 1.431    |
| S12.Ka       | 0.4       | 0.3        | 0.117    | S23.Ki       | 0.6       | 0.5        | 0.0382   |
| S12.Ki       | 0.4       | 0.3        | 0.117    | S25.Ka       | 0.8       | 0.7        | 0.0863   |
The dimensions used for calculating the hydraulic discharge are able to accommodate the planned flood discharge, it is then added with a free board of 10 cm on each channel. Material used in the channel using precast concrete (U-ditch).

**Table 3. Channel dimension**

| Channel name | Length Channels | Dimensions Channel | Channel name | Length Channels | Dimensions Channel |
|--------------|-----------------|--------------------|--------------|-----------------|--------------------|
| S1.Ki        | 117.9           | 400 X 400          | S13.Ki       | 53.7            | 500 X 500          |
| S1.Ki        | 118.3           | 400 X 400          | S14.Ka       | 95              | 800 X 800          |
| Box S1       | 8               | 400 X 400          | S14.Ki.1     | 38              | 400 X 400          |
| S2.Ka        | 65.9            | 400 X 400          | S14.Ki.2     | 49.5            | 400 X 400          |
| S2.Ki        | 66.7            | 400 X 400          | S15.Ka       | 73.8            | 600 X 600          |
| Box S2       | 8               | 400 X 400          | S15.Ki       | 77.0            | 500 X 500          |
| S3.Ka        | 61.2            | 400 X 400          | S16.Ka       | 36.8            | 600 X 600          |
| S3.Ki        | 61.9            | 400 X 400          | S16.Ki       | 38.3            | 600 X 600          |
| S4. Ka       | 36.9            | 500 X 500          | S17.Ka       | 28.3            | 400 X 400          |
| S4. Ki       | 37.8            | 500 X 500          | S17.Ki       | 25.1            | 400 X 400          |
| S5.Ka        | 48.             | 400 X 400          | S18.Ka       | 84.2            | 400 X 400          |
| S5.Ki        | 48.7            | 400 X 400          | S18.Ki       | 81.2            | 400 X 400          |
| S6.Ka        | 54.3            | 400 X 400          | Box S18      | 5               | 600 X 600          |
| S6.Ki        | 48.5            | 400 X 400          | S19.Ka       | 71.2            | 400 X 400          |
| S7.Ka.1      | 40.5            | 400 X 400          | S19.Ki       | 69.7            | 400 X 400          |
| Box S4       | 8               | 600 X 600          | Box S19      | 5               | 800 X 800          |
| S7.Ka.2      | 29.2            | 600 X 600          | S20.Ka       | 49              | 800 X 800          |
| S7.Ki        | 77.7            | 400 X 400          | S20.Ki       | 48              | 400 X 400          |
| Box S7       | 8               | 800 X 800          | Box S16      | 5               | 800 X 800          |
| S8.Ka        | 78.9            | 400 X 400          | S21.Ka       | 54.9            | 1000 X 1000        |
| S8.Ki        | 79.3            | 400 X 400          | S21.Ki       | 58.8            | 600 X 600          |
| Box S8       | 8               | 400 X 400          | Box S15      | 5               | 1000 X 1000        |
| S9. Ka       | 37.2            | 400 X 400          | S22.Ka       | 74.6            | 1000 X 1000        |
| S9. Ki       | 37.2            | 400 X 400          | S22.Ki       | 81.4            | 600 X 600          |
| Box S9       | 8               | 400 X 400          | S23.Ka.1     | 33.1            | 800 X 800          |
| S10. Ka      | 71.1            | 400 X 400          | S24.Ka       | 63.2            | 500 X 500          |
| S10. Ki      | 72.6            | 400 X 400          | Box S24      | 5               | 800 X 800          |
| Box S10      | 8               | 500 X 500          | S24.Ki       | 66.6            | 600 X 600          |
| S11.Ka       | 116             | 500 X 500          | S23.Ka.2     | 113.8           | 1000 X 1000        |
| Box S11      | 6               | 500 X 500          | S23.Ki       | 70.3            | 600 X 600          |
| S11.Ki.1     | 50.5            | 400 X 400          | S25.Ka       | 37.8            | 800 X 800          |
| S11.Ki.2     | 59              | 400 X 400          | Box S22      | 5               | 1200 X 1200        |
| S12. Ka      | 63              | 400 X 400          | S25.Ki       | 32.8            | 400 X 400          |
| S12. Ki      | 59              | 400 X 400          | S26          | 71.4            | 1000 X 1000        |
Eco drainage modeling in this drainage planning use to eliminate or reduce the flood flow through a channel that does not occur in the event of advance puddle tide[7]. Eco drainage type that will be used in drainage planning in Industrial Area Kampung Cina Dobo City is the type of pitcher capacity is an interim (retarding Basin). With the division of two zones, where zone A using Eco drainage retention pond type (retarding Basin) and while zone B can not use the retention pond type because of the limited land can be used for pond reservoirs are relatively small and tekendala with public facilities such as churches, schools, health centers and others.

Retarding basin planned depth of 5.00 meters which can accommodate the flood flow at 10358.3 m³ is equipped with inlet channels and outlet channels. In this plan that will be reviewed is the amount of inflow into retarding basin that is affected by the scenario dimension of building openings spillway channel (S22.Ka). Retarding basin also comes with disposal channels (outlet) with dimensions of 1.4 meter x 1.2 meter and planned with 2 doors with dimensions of 0.8 meters x 0.5 meters.

Scenario dimension opening side spillway and comparing the dimensions of the opening scenario building side spillway with inflow value into retarding basin and water level on the downstream channel S22.Ka. Modeling performed with 5 scenario opening dimension building side spillway.

- **Scenario 1 with an opening spillway b = 2 m, h = 0.8 m**
  In modeling the scenario 1 can reduce the water level in the upstream channel of = 0.14 m and 0.29 m in the downstream channel. As well as data obtained with flow passing through the channel is Q US = 1.14 m³ / sec and a flow that comes out or overflow into the retarding basin is Q Leaving = 0.60 m³ / sec, the obtained values of flood flow remaining in the channel at Q DS = 0.54 m³ / sec. It can be concluded based on the value of the output obtained from scenario 1, which can overwhelm the flood flow into the retarding basin of 0.60 m³ / sec, so that the remaining flow on channel is 0.52 m³ / sec.

- **Scenario 2 with openings spillway b = 4 m, h = 0.6 m**
  In the second scenario modeling can reduce the water level in the upstream channel of = 0.14 m and 0.25 m in the downstream channel. As well as data obtained with flow passing through the channel is Q US = 1.14 m³ / sec and a flow that comes out or overflow into the retarding basin is Q Leaving = 0.54 m³ / sec, the obtained values of flood flow remaining in the channel at Q DS = 0.60 m³ / sec. It can be concluded based on the value of the output obtained from the second scenario that can bestow flow flow into retarding basin are 0.54 m³ / sec, so that the remaining flow on channel is 0.60 m³ / sec.

- **Scenario 3 with openings spillway b = 6 m, h = 0.8 m**
  In the third scenario modeling can lower the water level in the upstream channel is = 0.26 m and 0.41 m in the downstream channel. As well as data obtained with flow passing through the channel is Q US = 1.14 m³ / sec and a flow that comes out or overflow into the retarding basin is Q Leaving = 0.99 m³ / sec, the obtained values of flood flow remaining in the channel is Q DS = 0.15 m³ / sec. It can be concluded based on the value of the output obtained from third scenario can bestow flood flow into the retarding basin is 0.99 m³ / sec, thus remaining flow on the channel is 0.15 m³ / sec.

- **Scenario 4 with openings spillway b = 8 m, h = 0.8 m**
  In the fourth scenario modeling can reduce the water level in the upstream channel is = 0.31 m and 0.44 m in the downstream channel. As well as data obtained with flow passing through the channel is Q US = 1.14 m³ / sec and a flow that comes out or overflow into the retarding basin
is $Q_{	ext{Leaving}} = 1.07 \text{ m}^3 / \text{sec}$, the obtained values of flood flow remaining in the channel is $Q_{DS} = 0.06 \text{ m}^3 / \text{sec}$. It can be concluded based on the output value obtained from the four scenarios can bestow flood flow into the retarding basin is $1.07 \text{ m}^3 / \text{sec}$, so that the remaining flow on the channel is $0.06 \text{ m}^3 / \text{sec}$.

**Figure 1.** Graphic of comparison with inflow and reducing discharge

Here is the water level in the channel S22.Ka with scenario variations in the show at 5.17 picture is the scenario 1, 2, 3, 4 and 5:

- Blue = without a retarding basin
- Black = Scenario 1
- Red = Scenario 2
- Yellow = Scenario 3
- Pink = Scenario 4
- Red = Scenario 5

**Figure 2.** Water surface elevation condition

- **Scenario 5 with spillway openings $b = 10 \text{ m}, h = 0.6 \text{ m}**
  
  In the fifth scenario modeling can reduce the water level in the upstream channel is $0.17 \text{ m}$ and $0.32 \text{ m}$ in the downstream channel. As well as data obtained with flow passing through the channel is $Q_{US} = 1.14 \text{ m}^3 / \text{sec}$ and a flow that comes out or overflow into the retarding basin...
of $Q$ leaving = 0.73 $m^3 / sec$, the obtained values of flood flow remaining in the channel is $Q_{DS} = 0.41 m^3 / sec$. It can be concluded based on the value of output obtained from 5 scenarios that can bestow flood flow into the retarding basin is 0.73 $m^3 / sec$, so that the remaining flow on the channel is 0.41 $m^3 / sec$.

4. Results and conclusion

Based on the results of data analysis planning and modeling results in software HEC-RAS 4.0 can be concluded that:

- Based on the calculation results obtained design flood obtained flow on the downstream drainage channel of outlet 1 is 1,926 $m^3 / sec$ and Outlet 2 amounted to 1,592 $m^3 / sec$.
- Channel section dimension planned has the smallest dimensions 0.4 mx 0.4 m and the dimensions of the largest cross-section of the channel is 1.4 mx 1.4 m. has met and is able to accommodate design flood with 25 years return period rainfall.
- In conventional drainage without retarding basin obtained of water level in the upstream channel S22.Ka as high as 0.97 m from the bottom of the channel, in the upstream and downstream as high as 0.51 m from the base of the channel.
- Planned retarding basin with depth 5 meters can accommodate the flood flow at 10358.3 $m^3$
- In this planning area A can only use this type of Eco Drainage retarding basin because area B does not have enough land for the retarding basin and the location also bordering public facilities.
- After the addition of eco drainage retarding basin and be equipped with spillway building with different dimensions, retarding basin can reduce flood flow through the channel which was originally 1.13 $m^3 / sec$ can reduce flood flow to 1.07 $m^3 / sec$ in the scenario 4 with dimensions of side spillway $b = 8 m$ and $h = 0.8 m$.

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