

Poster



Application HEC-HMS to Predict Hydrograph (Case Study in Lebak Petal Sub Basin)

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ABSTRACT

A hydrograph is a graph showing changes in the discharge of a river over a period of time. The main factors that influence hydrograph are imperviousness and curve number. Imperviousness is a very useful indicator which to measure the impact of land development on aquatic systems. The value of imperviousness is defined as the sum of roads, parking lots, sidewalks, rooftops, and other impermeable surfaces of the urban landscapes. The curve number is used to determine the amount of precipitation excess that results from a rainfall event over the basin. The purpose of this study is to predict unit hydrograph due to imperviousness and curve number changes.

Based on the result, increasing impervious areas lead to reduce infiltration and thereby increased surface runoff within catchments. It makes an effort to volume and peak discharge. From these values make an effort to time of peak discharge. The bigger value of imperviousness and curve number make time of peak early. The bigger value of imperviousness and curve number, make bigger value of peak discharge and volume. It means that imperviousness correlates highly with changes in hydrological indicators time to peak, peak discharge and volume. The outlet value indicates the amount of water flowing to the main channel. The bigger value of imperviousness and curve number make the bigger value of discharge.

Keyword :hydrograph, imperviousness, curve number

I. Introduction

1.1 Background

A hydrograph is a graph showing changes in the discharge of a river over a period of time. It can also refer to a graph showing the volume of water reaching a particular outfall, or location in a sewerage network, related to time. Hydrographs are commonly used in the design of sewerage, more specifically, the design of surface water sewerage systems and combined systems. The main factors that influence hydrograph are imperviousness and curve number.

Imperviousness is a very useful indicator which to measure the impact of land development on aquatic systems. The value of imperviousness is defined as the sum of roads,

parking lots, sidewalks, rooftops, and other impermeable surfaces of the urban landscapes. Imperviousness is composed of two primary components: the *rooftops* under which we live, work and shop; the *transport system* (roads, driveways and parking lots) that we use to get one roof to another.

The curve number is an index developed by the Soil Conservation Service (SCS), now called the Natural Resource Conservation Service (NRCS), to represent the potential for storm water runoff within a drainage area. In calculating the quantity of runoff from a drainage basin, the curve number is used to determine the amount of precipitation excess that results from a rainfall event over the basin.

1.2 The Purpose

The purpose of this study is to predict unit hydrograph due to imperviousness and curve number changes

II. Materials and Methods

2.1 Area Boundary

The study area is a part of the Lebak Petal sub basin in Musi Watershed. The geographic location of this study area is around 103° 34' 12" - 105° 0' 36" BT and 02° 58' 12" - 04° 59' 24". Based on the study of watershed management priority in 2006, the sub basin is the second priority sub basin. The study area is shown in figure 1.

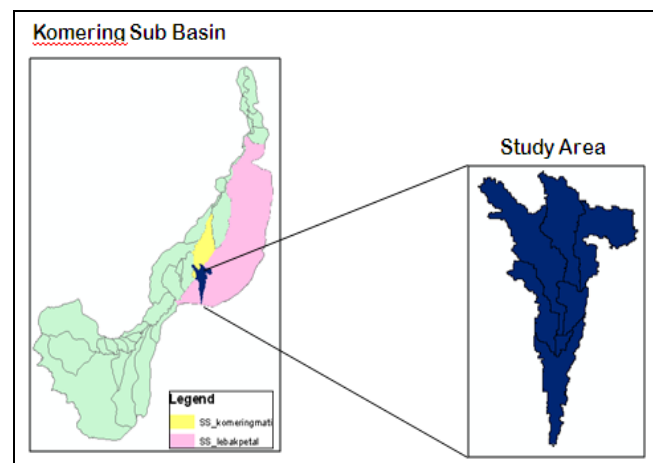


Figure 1. The study area

2.2 Area Characteristics

The sub basin has 79.396,938 Ha areas. It consists of seven purposes of land use namely housing, local plantation, irrigated-paddy field, dry land, small lake, plantation estate and forest. Table 1 shows land use study area in Ha, the percentage of landuse purposes is dry land (71.45%), irrigated-paddy field (12.17%), local plantation (9.53%), plantation estate (3.24%), housing (1.75%), small lake (1.27%) and forest (0,59%).

Table 1. Land use purposes in study area

Land Use	Area (Ha)
Housing	1.387,967
Local plantation	7.563,405
Irrigated-paddy field	9.659,486
Dry land	56.735,238
Plantation estate	2.576,515
Small lake	1.007,138
Forest	467,189
Total Area	79.396,938

2.3 Data Preparation

The data that used to this study are:

1. Digital Elevation Model (DEM) of The Komering Sub Basin, can be obtained from www.cgiar.com (free download)
2. Soil Type Data of The Komering Sub Basin, can be obtained from Musi Watershed Management Agency, Ministry of Forest, 2009
3. Land Use Data of The Komering Sub Basin, can be obtained from Musi Watershed Management Agency, Ministry of Forest, 2009

2.4 Developing HEC-HMS model

2.4.1 Preprocess the Terrain Model

- Open a new empty ArcMap project.
- Add the Arc Hydro Tools toolbox to ArcToolbox.
- Load the Arc Hydro and HEC-GeoHMS toolbars.
- Load the terrain data.
- Save the project.
- Perform drainage analysis by processing the terrain using the 8-pour point approach.
- Extract project specific data.

2.4.2 Basin Processing

- Revise subbasin delineation.
- Extract physical characteristics of streams and subbasins.
- Develop hydrologic parameters.

- Develop HMS inputs.

2.4.3 Hydrologic Modeling System

- Setup an HMS model with inputs from HEC-GeoHMS.

The basin model in this modeling is generated from terrain processing and basin processing from HEC-GeoHMS embedded to ArcGIS 9.3.

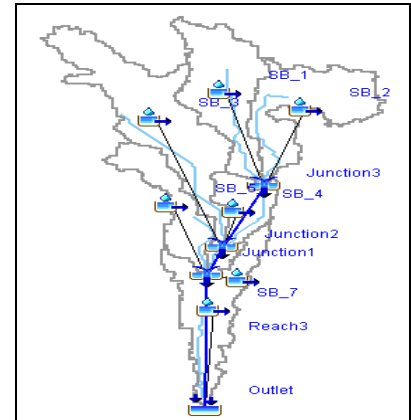


Figure 2. Basin Model in HEC-HMS

2.4 HEC-HMS Processing

Simulation of this hydrologic basin is using a SCS Curve Number Loss Rate, Snyder Unit Hydrograph Transform Method, and constant monthly base flow method.

2.4.1 Simulation by existing data (Musi).

Data for each sub-basin are listed in table 2. The data include the sub-basin area, percent of imperviousness, and values of parameters that define losses, the runoff transform and base flow. Routing criteria for the basin reaches are listed in table 3.

Table 3. Routing Criteria

From	To	Method	Sub-Reaches	Routing Parameter
SB_1	Joint	Muskingum	1	Travel time = 0,6 and $x = 0,2$
SB_2	Joint	Muskingum	1	Travel time = 0,6 and $x = 0,2$
SB_3	Joint	Muskingum	1	Travel time = 0,6 and $x = 0,2$
SB_4	Joint	Muskingum	1	Travel time = 0,6 and $x = 0,2$
SB_5	Joint	Muskingum	1	Travel time = 0,6 and $x = 0,2$
SB_6	Joint	Muskingum	1	Travel time = 0,6 and $x = 0,2$
SB_7	Outlet	Muskingum	1	Travel time = 0,6 and $x = 0,2$

Rain gage data is to be distributed in time using temporal pattern of incremental rain fall, data from precipitation gage station are listed in table 4.

Table 4. Precipitation gage data (Jan 2-3, 2008)

No	Time	Komerang (mm)
Jan 2, 2008		
1	00:00	0.0
2	01:00	0.0
3	02:00	0.0
4	03:00	0.0
5	04:00	0.0
6	05:00	0.0
7	06:00	0.0
8	07:00	0.0
9	08:00	0.0
10	09:00	0.0
11	10:00	0.5
12	11:00	0.5
13	12:00	0.5
14	13:00	0.0
15	14:00	0.0
16	15:00	0.0
17	16:00	1.0
18	17:00	1.0
19	18:00	1.0
20	19:00	0.5
21	20:00	1.0
22	21:00	2.0
23	22:00	3.0
24	23:00	4.0
25	24:00	4.0
Jan 3, 2008		
1	00:00	2.0
2	01:00	1.0
3	02:00	1.0
4	03:00	1.0
5	04:00	1.0
6	05:00	1.0
7	06:00	0.0
8	07:00	0.0
9	08:00	0.0
10	09:00	0.0
11	10:00	0.0
12	11:00	0.0
13	12:00	0.0
14	13:00	0.0
15	14:00	1.0
16	15:00	2.0

17	16:00	1.0
18	17:00	1.0
19	18:00	0.0
20	19:00	0.0
21	20:00	0.0
22	21:00	0.0
23	22:00	0.0
24	23:00	0.0

2.4.2 Simulation by changing the curve number and imperviousness (Musi_Sim)

The changing of imperviousness and curve number to this practical report is based on table 5. Table 5 presents an example of typical land use categories used for hydrologic analysis, along with corresponding curve numbers for each land use-soil group combination. The land use categories shown in Table 5 were derived from the standard categories typically used for hydrologic analysis using the SCS methodology (SCS, 1986 in Marry C. Halley *et. al*, 2010).

Hydrologic Soil Group:

- A = Soils having high infiltration rates, even when thoroughly wetted and consisting chiefly of deep, well to excessively-drained sands or gravels. These soils have a high rate of water transmission.
- B = Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately deep to deep, moderately fine to moderately coarse textures. These soils have a moderate rate of water transmission.
- C = Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.
- D = Soils having very slow infiltration rates when thoroughly wetted and consisting chiefly of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

The sub-basin characteristics data that used to Musi_Sim is listed in table 6. The changed-value is the value of imperviousness and curve number. The routing criteria and precipitation data are in table 2, 3 and 4.

III. Result and Discussion

3.1 Global Summary Results

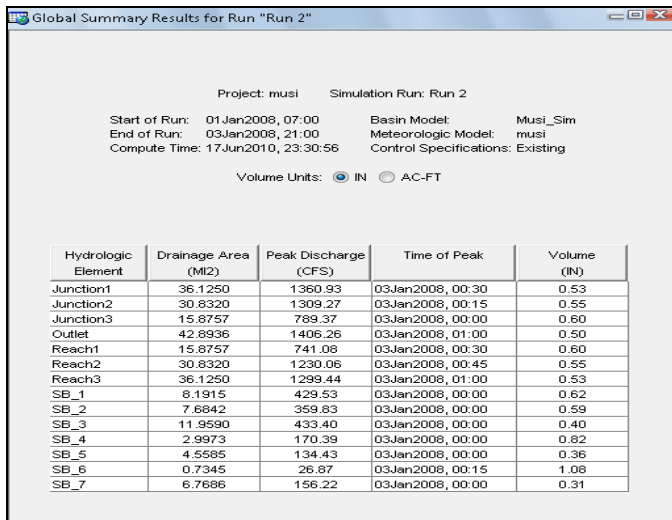
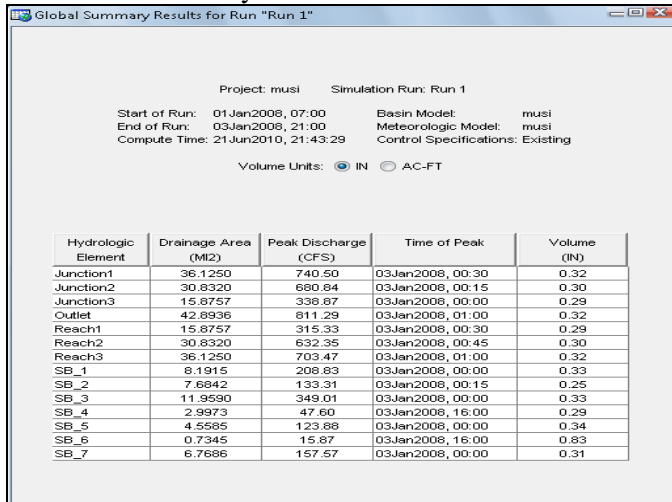


Figure 3. Global Summary Results for Musi and Musi_Sim

In fig 3. the changing of imperviousness and curve number to the sub basin area make some efforts to junction, reach and sub basin itself. Increasing impervious areas lead to reduce infiltration and thereby increased surface runoff within catchments. It makes an effort to volume and peak discharge. From these values make an effort to time of peak discharge. The bigger value of imperviousness and curve number make time of peak early. The bigger value of imperviousness and curve number, make bigger value of peak discharge and volume.

It means that imperviousness correlates highly with changes in hydrological indicators time to peak, peak discharge and volume. As illustration, because there is no opportunity for plants to absorb the moisture that falls on pavement, a much larger volume of storm water drains into streams that flows from urban areas. This large quantity of water reaches streams too quickly, flowing across roads and

through pipes that do not offer the resistance to surface flow that natural vegetation of meadow and forests.

3.2 Time-Series Results

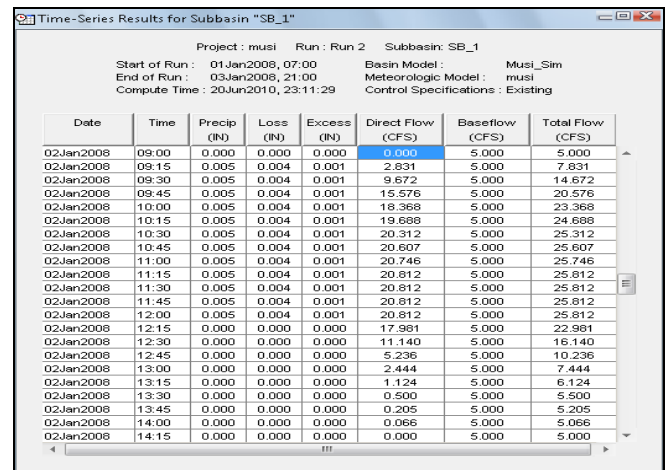
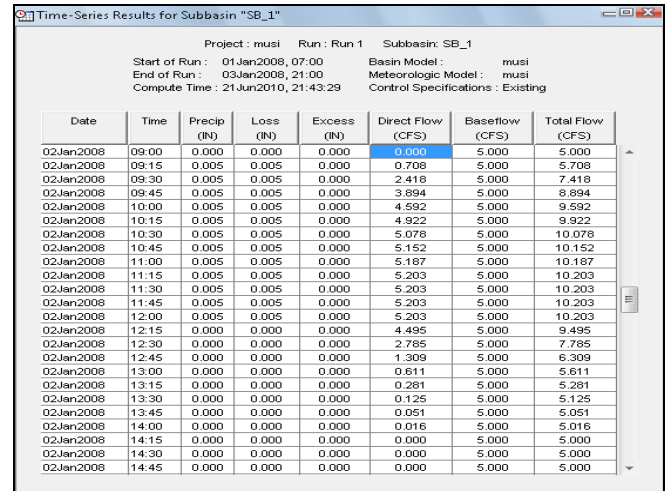


Figure 4. Time-Series Results for SB_1 in Musi and Musi_Sim

In fig 4. time series data consist of loss, excess, direct flow, base flow and total flow. In this case, only using SB_1 represents the trend of these values. In Musi result, direct flow was started on 2 January 2008 at 09.15 and had value 0.708 cfs. The excess value was still zero and the loss value was 0.005 in. In Musi_Sim result, direct flow was started on 2 January 2008 at 09.15 and had value 2,831 cfs. The excess value was 0,001 in and the loss was 0.004 in.

For the total flow, Musi_sim has bigger value than Musi result. It relate to the changing of imperviousness and curve number in Musi_sim. The bigger value of imperviousness and curve number make the bigger value of total flow. Total flow is the result of summary from direct flow and base flow.

3.3 Outlet Discharge

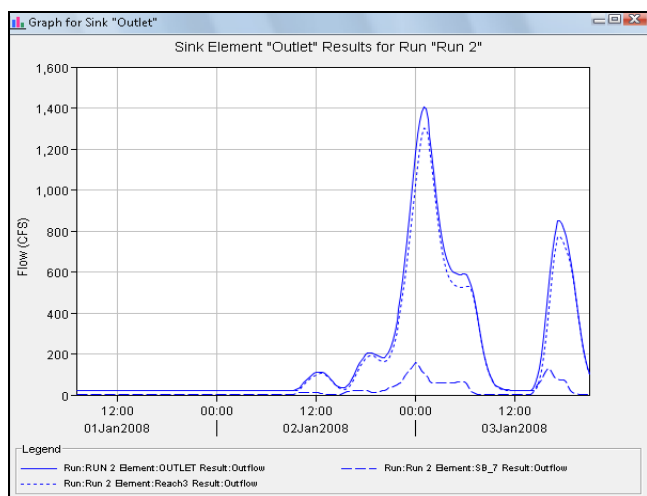
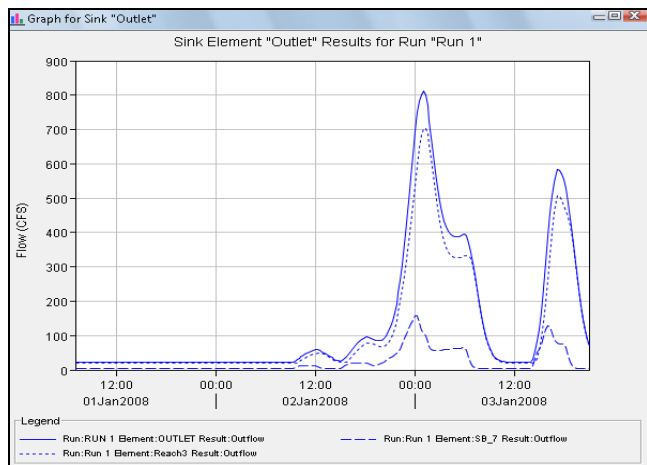


Figure 5. Outlet Discharge for Musi and Musi_Sim

In fig 5. the graphs of outlet discharge consist of outlet, reach3 and SB_7 outflow graph. Due to the outlet is related to these 3 components directly. The outlet value indicates the amount of water flowing to the main channel. The outlet value of Musi_Sim results is bigger than Musi results; it means that the imperviousness and curve number make significant different value between both. These conditions of

results are the same trends with Reach3 results. For SB_7, the outlet value in Musi_Sim is same with Musi since SB_7 isn't related to the other component of basin. Selamat

4 Conclusion

Changing in land use/land cover will affected to the curve number and imperviousness value. The small value of curve number will give low water discharge value, and the big value of curve number will produce high water discharge value.

The water discharge value indicates run off value for these catchment area. The run off value closely tracks percent impervious cover. Increasing impervious coverage makes increasing imperviousness value.

5. Acknowledgement

REFERENCES

HEC Geo-HMS Tutorial. ESRI Production.

Mary C. Halley P.E. , Suzanne O. White, and Edwin W. Watkins P.E. 2010. ArcViewGIS Extension for Estimating Curve Numbers. www.proceeding.esri.com.html

Pawitan. H, Trihono Kadri. 2010. Problem Set. ITM 616 Hydrologic Modeling. Bogor www.wikipedia.org/wiki/imperviousness

Table 2. Sub-basin characteristics / Parameter (Musi)

Sub-Basin		Loss Rate (SCS CN Method)			Transform (Snyder)		Base Flow
ID	Area	Impervious-ness	Initial Loss	Curve Number	Time to Peak	Snyder Coef.	Constants Monthly
-	mi^2	%	in	-	$hour$	-	CFS
SB_1	8,1915	5	0,2	72,833	0,43	0,62	5
SB_2	7,6842	8	0,5	76,048	0,43	0,62	2
SB_3	11,959	6	0,2	76,429	0,43	0,62	2
SB_4	2,9973	8	0,6	75,75	0,43	0,62	3
SB_5	4,5585	10	0,2	69,857	0,43	0,62	2
SB_6	0,73450	6	0,6	77	0,43	0,62	5
SB_7	6,7686	10	0,4	75,333	0,43	0,62	3

Table 5. Land Use Categories and Associated Curve Numbers

Description	Average % Impervious	Curve number by Hydrologic Soil Group				Typical Land Uses
		A	B	C	D	
Residential (high density)	65	77	85	90	92	Multi-family, Apartments, Condos, Trailer Parks
Residential (Med. Density)	30	57	72	81	86	Single-Family, Lot Size 1/4 to 1 acre
Residential (Low. Density)	15	48	66	78	83	Single-Family, Lot Size 1 acre and Greater
Commercial	83	89	92	94	93	Strip Commercial, Shopping Centre, Convenience Stores
Industrial	72	81	88	91	93	Light Industrial, Schools, Prisons, Treatment Plants
Distributed/ Transitional	5	76	85	89	91	Gravel Parking, Quarries, Land Under Development
Agricultural	5	67	77	83	87	Cultivated Land, Row crops, Broadcast Legumes
Open Land– Good	5	39	61	74	80	Parks, Golf Courses, Greenways, Grazed, Pasture
Meadow	5	30	58	71	78	Hay Fields, Tall-Grass, Un-grazed Pasture
Woods (Thick Cover)	5	30	55	70	77	Forest Litter and Brush adequately cover soil
Woods (Thin Cover)	5	43	65	76	82	Light Woods, Woods-Grass combination, Tree Farms
Impervious	95	98	98	98	98	Paved Parking, Shopping Malls, Major Roadways
Water	100	100	100	100	100	Water Bodies, Lakes, Ponds, Wetlands

Table 5. Sub-basin characteristics/parameter (Changing/simulation data)

Sub-Basin		Loss Rate (SCS CN Method)			Transform (Snyder)		Base Flow
ID	Area	Impervious-ness	Initial Loss	Curve Number	Time to Peak	Snyder Coef.	Constants Monthly
-	mi^2	%	in	-	$hour$	-	CFS
SB_1	8,1915	20	0,2	86	0,43	0,62	5
SB_2	7,6842	30	0,5	90	0,43	0,62	2
SB_3	11,959	10	0,2	80	0,43	0,62	2
SB_4	2,9973	50	0,6	90	0,43	0,62	3
SB_5	4,5585	10	0,2	73	0,43	0,62	2
SB_6	0,73450	20	0,6	90	0,43	0,62	5
SB_7	6,7686	10	0,4	75	0,43	0,62	3