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Research Article

Assessment the variation of Runoff parameters in al-dwereeg valley Basin, Iraq

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ABSTRACT

Rainfall-runoff phenomena are controlled by several complicated parameters. Each analysis model is use specific parameters as inputs for the analysis and the accuracy of the any model depend on the input parameters and processing algorithm. The relationship of rainfall-runoff is one of the most complex hydrologic phenomena; due to the great spatial and temporal variability of basin characteristics and precipitation patterns. Study area located in the eastern parts of Iraq and extended on 3731square kilometers; the basin is bounded between latitudes 32º 00’ to 33º 20’ N and longitudes 47º 10’ to 48º 00’ E. The area is suffering from the absence of gauge stations for the water discharge at the outlets of the main sub-basins, that's make the validation of estimated values of surface runoff more difficult task. The main objective of the study is to analysis the relation of rainfall– runoff using Soil Conservation Service (SCS)- Curve Number (CN) losses method. The analysis was carried by WMS v.11 software and HEC-1 model. The results of HEC-1 simulation, shows the characters of surface runoff i.e. runoff volume, peak flow, time of peak flow, Time of concentration for four sub-basins with respect to antecedent moisture conditions (AMC). The results show the effect of soil types, land use/land cover, vegetation densities, morphometric parameters and variation of rainfall intensity on the spatial variability of the surface runoff parameters in the study area.

Key words: *GIS, Basin, Runoff, SCS, Curve Number, HEC-1*

1.INTRODUCTION

Analysis of rainfall-runoff relationship in any watershed is recognized as a complicated process, because of many factors are controlling the surface runoff in the catchment like the intensity and duration of rainfall, soil conditions, land cover and terrain slope (An, 2007; Anbazhagan, Ramasamy, & Gupta, 2005; Xu et al., 2006). Schneiderman et al. (2007), Lastoria and Futura (2008) and Thomas (2015), are referred to the surface runoff as phenomenon occur when the rate of precipitation exceeds the rate of water infiltration into the soil, and depend on the amount of precipitation, initial abstraction, hydrologic characteristics of the ground, and soil and antecedent moisture conditions. Runoff is one of the important hydrologic variables used in the planning and management of water resources and estimation of water yield potential of a watershed (Amutha & Porchelvan, 2009; Shi, Chen, Fang, Qin, & Cai, 2009).Tramblay, Bouvier, Ayral, and Marchandise (2011) , Arnaud, Bouvier, Cisneros, and Dominguez (2002) mentioned the use of mean areal rainfall instead of spatially distributed rainfall tends to underestimate the volumes and the peak flows, when the rainfall-runoff model is calibrated by the same procedure.

The runoff estimation is the most important aspect in hydrologic modeling, numerous modeling techniques and methods are used in estimation of surface runoff, varied to each other by the parameters which are used in the analysis, and Soil conservation Service (SCS) method developed by U.S. Department of Agriculture (USDA-SCS, 1972), is utilized the rainfall and watershed coefficient (Curve Number; CN) as input for estimation of surface runoff (Nagarajan, 2015; Nayak & Jaiswal, 2003; Sharma & Singh, 1992). SCS-CN is one of the most popular methods for computing the volume of surface runoff for un gauged watersheds.(Nagarajan, 2015; Silveira, Charbonnier, & Genta, 2000).The CN value depends on land surface characteristics and hydro-soil conditions. The higher the CN value, the higher the volume of direct surface runoff(Fan, Deng, Hu, & Weng, 2013). al-dwereeg valley basin is one of many valleys located in eastern parts .of Missan province on sharing boundaries between Iraq and Iran and no gauge stations for measuring surface runoff . The objective of current study is to analyze the pattern of the spatial interaction of rainfall- runoff phenomena according to the rainfall storm, soil types, land use/ land cover and basin morphometric parameters, using remote sensing, GIS techniques, Soil conservation Service (SCS), Curve number (CN) and Hydrologic Engineering Center(HEC-1) model, ArcGIS and WMS software.

2. Location of study area

al-dwereeg valley basin is located in the eastern parts of Iraq and extended on 3731square kilometers; the basin is bounded between latitudes 32º 00’ to 33º 20’ N and longitudes 47º 10’ to 48º 00’ E (Figure 1). The basin is characterized by a large variation in physical setting, represented by many geology formations, soil types, landforms, land use/land cover and morphometric parameters.

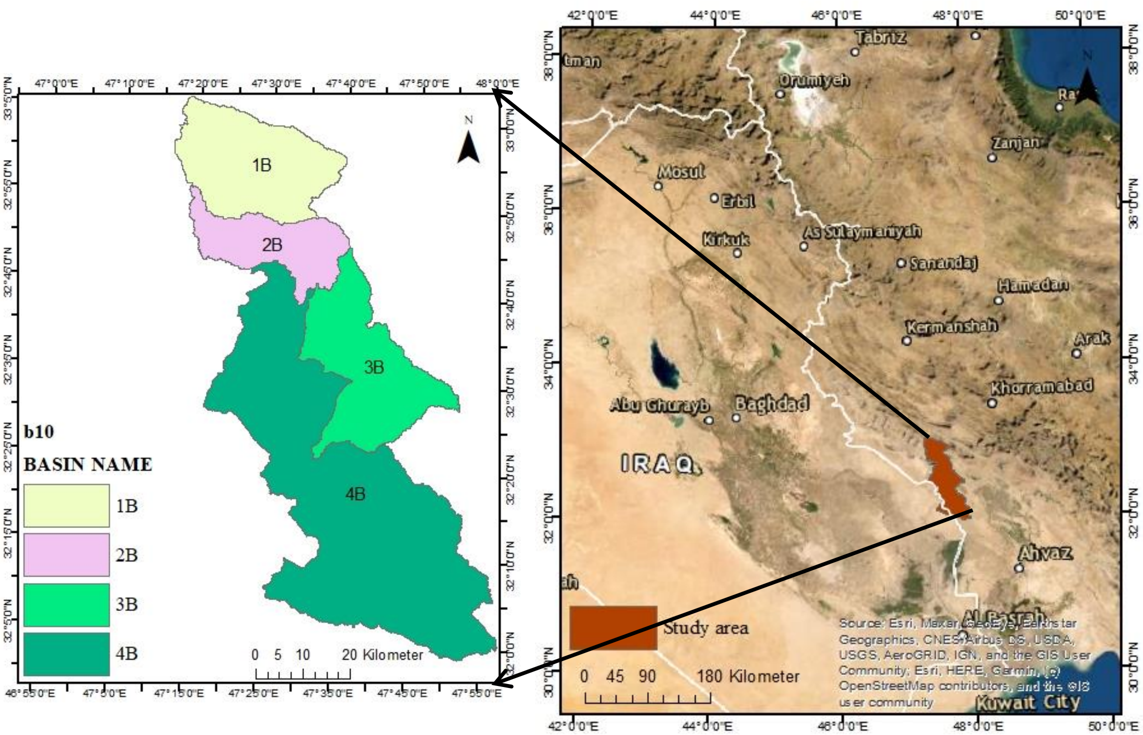

Figure 1: Location map of al-dwereeg valley basin

3. METHODOLOGY

In the present study, several steps are implemented to carry out the hydrogeological analysis of the al-dwereeg valley basin, i.e. Estimation of the surface runoff by USDA_SCS (1972)– Curve number method.In the present study HEC-1 model was employed, because the HEC-1 is suitable model to represent all the aspect of a watershed and to compute all the components of stream flow hydrographs at desired location in the river basin (Araya, 2006). The SCS curve number procedure depends on relationships between precipitation and runoff, expressed as (Silveira et al., 2000).The USDA NRCS curve method predicts direct surface runoff using the following equation (Thomas, 2015):

$$Q = \frac{(P - I_a)^2}{(P - I_a) + S}$$

and λ=initial abstraction coefficient=0.2 in the original version of the SCS-CN method. A value of λ= 0.05 has also been advocated for field use (Hawkins, Woodward, & Jiang, 2001; Mishra, Pandey, Jain, & Singh, 2007).

3.1 Digital Elevation Model (DEM)

The DEM data for al-dwereeg valley basin was prepared from Shuttle Radar Topographic Mission SRTM image of one second resolution (about 30 meters) (Figure 2a).The elevations, flow directions and flow accumulations are computed by TOPAZ tool (WMS -Tutorial, 2008).

3.2 Hydrologic Soil Groups, LULC and Rainfall storm data

In the present study the soil types and land use/land cover (LULC) are collected from websites and prepared for analysis using ArcGIS software based on selected hydrological soil groups (A, B, C, and D) (table 1) and (figure 2c) and LULC symbols (table 2) and (figure 2d) according to (Anderson 1976).

The used rainfall data (Figure 2b) was collected from website[1].

Table 1: Attributes of Hydrologic soil groups.

OBJECTID	FAOSOIL	DOMSOI	Hydgrp	Shape_Area	Area(kms)
1	I-Rc-Xk-c	I	B	860269065.6	860.3
2	I-Rc-Yk-2c	I	B	389471544.2	389.5
6	Rc33-3bc	Rc	D	759147588.7	759.1
7	Rc38-1a	Rc	A	707601496.0	707.6
9	Yk31-2/3ab	Yk	C	942358285.2	942.4
12	Zo22-2/3a	Zo	C	72369412.5	72.4

Table 2: Attribute of hydrologic Land use classes .

OBJECTID	Label	LUCODE	Shape_Area	Area(%)
1	Rainfed croplands	21	944552.4	0.9
2	Mosaic cropland (50-70%) / vegetation (grassland/shrubland/forest) (20-50%)	43	22186644.3	22.2
3	Mosaic vegetation (grassland/shrubland/forest) (50-70%) / cropland (20-50%)	22	118122858.7	118.1
5	Mosaic forest or shrubland (50-70%) / grassland (20-50%)	32	75435061.2	75.4
6	Mosaic grassland (50-70%) / forest or shrubland (20-50%)	21	848823.8	0.8
8	Sparse (<15%) vegetation	33	697166393.9	697.2

[1] https://disc.gsfc.nasa.gov/datasets?keywords=rainfall&start=2019-03-24&end=2019-03-25&page=1

9	Bare areas	77	2816197816.2	2816.2
10	Water bodies	52	315241.5	0.3

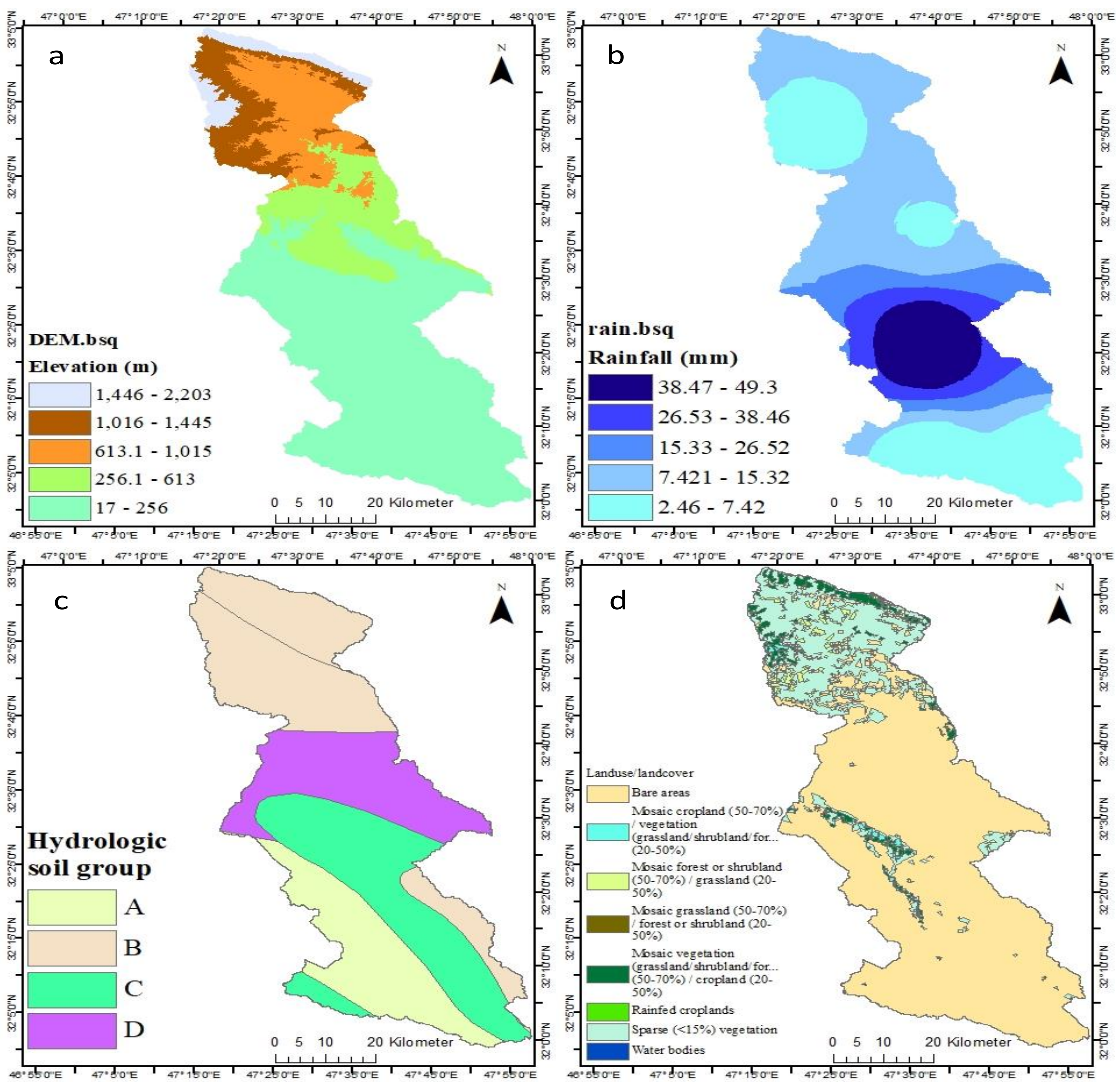

Figure 2: a). SRTM-DEM data, b). rainfall storm, c). Hydrological soil groups, and d) LULC map.

3.3 Average Curve Number (CCN)

The composite curve numbers (CCN) describe the surface potential for estimation runoff as a function of the soil type and land use. The value of curve number (CN) ranged between zero and 100; where zero as a theoretic lower limit for the surface which absorbs all precipitation, and 100 is the upper limit representing an impervious surface such as asphalt or water bodies. When the area covered by a variety of land use and soil groups the weighted CN is used as a composite curve number (CCN). It is calculated from the following equation (Anbazhagan et al., 2005; Nagarajan, 2015; Sharma & Singh, 1992).

$$CCN = \frac{1}{A}\sum_{i=1}^{n} CN_i \times A_i$$

Where CN_i is the curve number for i^{th} area, A_i is the area of i^{th} CN and A is the total area of the sub-basin. The values of CN for different land use and soil groups need to be corrected based on Antecedent Moisture Conditions (AMC) (An, 2007). Based on the amount of rainfall in a period of five days preceding a particular storm cases of Antecedent Moisture Conditions (AMC) are given in table 3.

Table 4 : Amount of rainfall for AMC cases (after SCS , 1972) .

AMC	Amount of rainfall along preceding 5 days (in mm)	
	Dormant season	Growing season
I	< 12.7	< 35.6
II	12.7 - 28	35.6 – 53.3
III	> 28	> 53.3

The following equations are used to calibrate the curve number for three conditions of dry, wet and normal conditions

$$CN_I = \frac{4.2 \times CN_{II}}{10 - 0.058 \times CN_{II}}$$ …………….for dry conditions

$$CN_{III} = \frac{23 \times CN_{II}}{10 + 0.13 \times CN_{II}}$$ ……………..for wet conditions

$$CN_{II} = CN$$ …………….for normal conditions

4. RESULTS AND DISCUSSION

The results of application HEC-1 model of WMS packages, shows the spatial and temporal domain variations in the volume of runoff (m3), peak runoff time(min), value of peak runoff (m3/s) and runoff coefficients. The surface runoff in al-dwereeg valley Basin was analyzed for all the 4 sub-basins, used daily rainfall storms as given in Table 5 and figure 3.

The seasonal and frequent floods during the rainy season are the predominant feature of the valleys located in the east of Maysan Governorate of Iraq particularly al-dwereeg valley Basin . Resulted floods from that valley together with other valleys are leave their effects on the areas located at the outlets of these valleys after every a heavy rain storm . The results of the runoff analysis will be analyzed according to the SCS-CN method performed with WMS v.10 and the implementation of the HEC-1 model based on the precipitation data as shown in Table 5. Based on the results runoff parameters estimation, most volumes of runoff come from two sub-basins 3B and 4B, in the downstream region of the basin, including about 40.8% and 42.6% of surface runoff volume, while the peak runoff of the sub-basins 3B, 4B, 2B and 1B is about of 33.9 , 20.4, 4.8 and 3.5 m3 / s, respectively. The highest time to peak is 2290 for basin 4B and the minimum time to peak is for basin 1B with 391.9 minutes, and peak runoff is 33.9 cubic meters per second. The maximum rate of runoff comes from 3B with 0.115 cubic meters per second. Indeed, the real rainfall storm play important role in the variation of runoff parameters, because the amount of rainfall was varied in intensity over the different parts of the basin.

The analysis runoff parameters results indicate the effect of soil type and land use land cover on the surface runoff from the different parts of the basin added to that the impact of morphometric parameters.

Table 5: measured Rainfall- Runoff parameters of study area.

BASINNAME	Area (kms)	Lage time (Hour)	Concentration time (TC) (Hour)	Curve number (CN)	Rainfall (mm)	Volume of runoff (m3)	Time to peak (min.)	Peak runoff (m3/sec)	Average runoff (m3/sec)	Rate of runoff (m3/sec)
1B	627.4	3.5	5.8	76.2	7.8	315479.3	391.9	3.5	0.32	0.006
2B	371.39	4.8	7.9	79.9	7.2	431699.6	536.2	4.8	0.44	0.008
4B	2071.30	20.3	33.9	82.5	18.4	1843570.5	2290	20.4	1.869	0.035
3B	661.08	6.4	10.6	88.7	17.7	1924569.6	1240	33.9	6.113	0.115

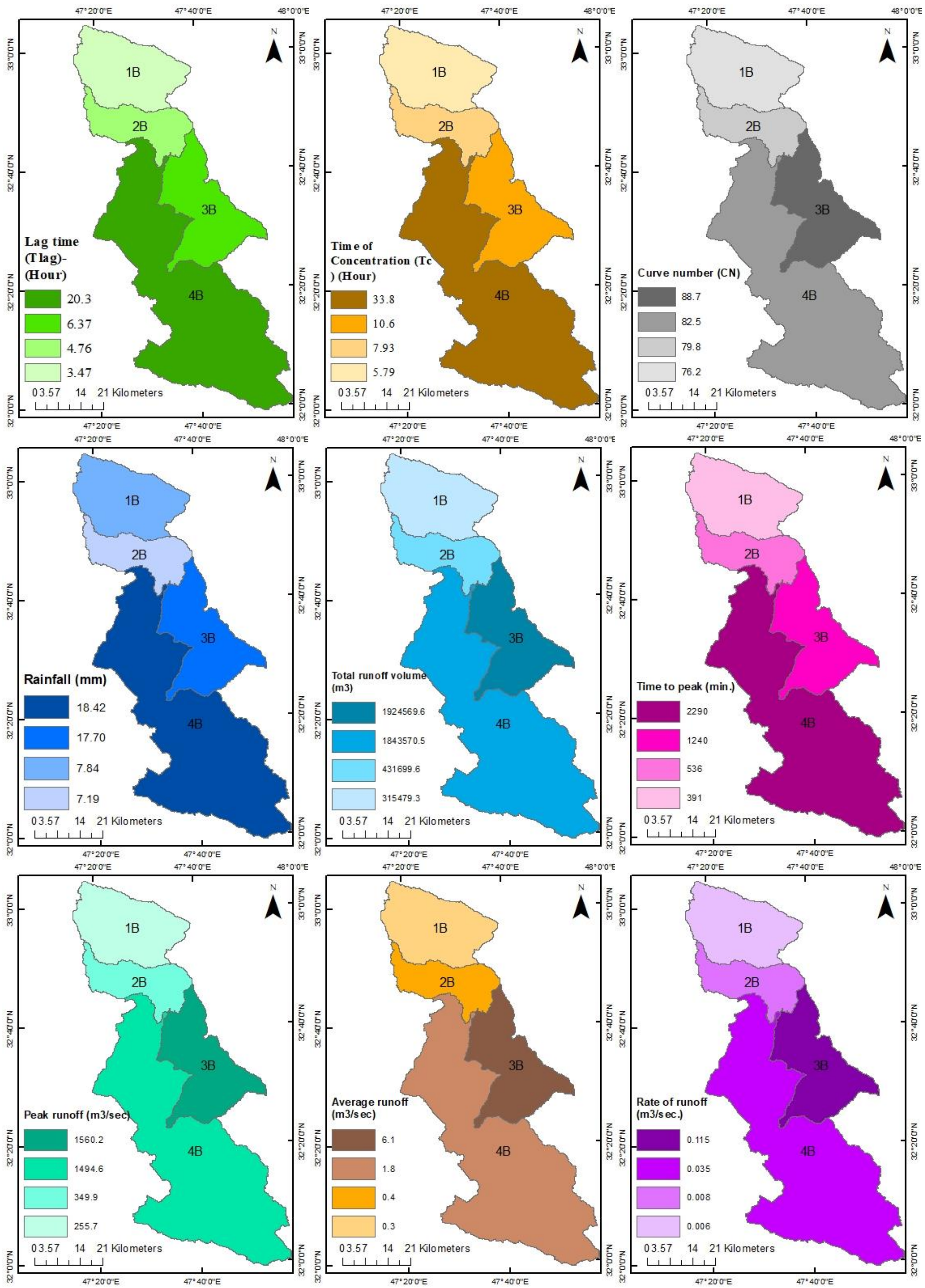

Figure 3: Spatial distribution of runoff parameters in study area.

5. CONCLUSIONS

The estimation of runoff by HEC-1 model and SCS curve number method, give more accurate and representative spatially distribution of runoff volumes and runoff parameters for the 4 sub-basins of al-dwereeg valley Basin. However the variation in runoff volumes for all four sub-basins is due to the change in the soil types, land use/land cover, slopes, area, rainfall amounts and antecedent moisture conditions (AMC) effects in the sub watersheds.

The results of hydrological analysis of rainfall-runoff, of the basin were shows low amounts of runoff volume, because the used rainfall was not intensive storm ranged from 7 to 18 millimeters, this variation in rainfall intensity is another reason of variation in runoff parameters over the basin parts instead of variation in curve number values (CN).

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