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# Estimation ofSurface Runoff and Peak Rate for some Catchments South Sabah Al-Ahmad area, Kuwait State.

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***ABSTRACT***
*Urbanization and construction of new communities is essential target nowadays in Kuwait state. In the same time, flash floods risk threat this urbanization andcoping with these flash floods requires reductionof the negative effects of these thunderstorms.South Sabah Al Ahmad Catchments(**SSAC**) inKuwait state were chosen for studying this problem since this area is under urbanization development. The minimizing of flash flood impacts in arid zones, like **SSAC**, is a highly important issue due to the damage, danger and other hazards associated to it to human life, properties, and environment.Accurate estimation for the direct runoff volumes and peak rates are essential to achieve this goal. In this paper, a highly reliable database for three small catchments lie in **SSAC**with nearly **56**annual rainfall data (1962-2018) were used. The Methodology applied in this study was using mathematical modeling technique of Watershed Modeling System (WMS) software, version 7.1.Drainage network and watershed boundaries of **SSAC** shape files were created using TOPAZ (Topographic Parameterization) technique from the Digital Elevation Model (DEMs) with 30m resolution. These data were used in WMS package to automatically delineate catchment boundaries, define stream networks, direct runoff volumes, flood hydrograph and peak rates. The direct runoff hydrograph generated by Visual HEC-1 model gave more or less acceptable results. The generated hydrograph by the two models was under-predicted the peak runoff rate of the studied event. Retention dams are recommended in the downstream of the studied catchments to prevent the loss of **213625** $m^3$ of rain water every season.*

***.KEY WORDS: Hydrology,Runoff, flood hydrograph,WMS, South Sabah Al Ahmad Catchments***

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## I. INTRODUCTION

Inthe eastern coastal zone of Kuwait state, the rainfall considers the only local water resource for domestic purposes (Alalati, 2018). Surface runoff through numerous catchments dissecting the tableland plateau to the west of the coastal plain threaten the development strategies.The determination of runoff volumes and peak runoff rates are important elements of direct runoff simulation and are also prerequisites for the future development especially urbanization strategy (Alalati, et. al.,2018). The water yield and peak runoff rates from a catchment can be computed by recorded data derived from automatic recorders. However, in Kuwait state such instruments are lacking in the majority of catchments.In addition, flash floods in the arid zone such as South Sabah Al Ahmad Catchments (**SSAC**) are generally unpredictable and infrequent as well (Reid et al. 1994). Rainfall is the most variable of meteorological measurements made in desert areas (Dolman et al. 1997). Therefore, flood frequency and severity in the desert vary from year to year as much as does the rainfall that causes the floods (Warner 2004). Desert rainfall is more spatially variable than that of humid regions and it is often described as “spotty” with the area affected often limited by the radius of the clouds (Laity 2008). Response of the surface-hydrologic system to rainfall in the desert is complex and precludes the hydrologic modeling (Reid & Frostick 1997). Warner (2004)argued that most floods in the desert occur because of the unusual character of the surface rather than that of the rainfall, since the latter is not likely to be of much greater intensity than what would be experienced from a similar type of storm in more humid areas.

However, several previous works gave special attention to the hydrologic model in areas lacking good coverage by rain gauges and/or having poor runoff records, asituation that is generally encountered in the Kuwait. In addition, sporadicthunderstorms occur near the centers of atmospheric depressions in the lower layers of the atmosphere, especially when entering the Arabian Gulf plains. In the spring, as the Earth's surface temperature increases compared to the winter, thunderstorms become more active as various air drops enter different air regions in Kuwait state.

In addition,hazards associated with flash flooding may be controlled under presence of appropriate management system. Therefore, a great intention was made to have design criteria for flash flood protection in design manuals and codes of practice (Gad et al. 2016 and Moawad et al.2016). Almost all of these manuals adopted the design recurrence interval as a measure for the safety level that will be considered during the design of flash flood protection system. This means that a flood event that may harm highly important element should have a design recurrence interval higher than that with less importance level (Stephen A. Nelson, 2004). This method of evaluating the flash flood risk level almost ignored the hydro-morphological parameters of the catchments and the flash flood event itself.

**1-1 Location of the study area**

The SSAC is an inter-mountain plain located in the south eastKuwaittable lands, and lies around 57 km far from the capital in the south. The geographic coordinates of the study area are longitudes48º 04' 15", 48º 08' 41", 48º 12' 04", 48º 09' 29" and 48º 05' 04" due east and latitudes 28º 44' 21", 28º 40' 11", 28º 41' 47", 28º 46' 19", 28º 46' 12" due north. This plain has an elevation of about 66.75 masl but it is surrounded to the west, south and east by mountains rising to about 90 masl (Fig. 1). The Basin has an area of some 282 km$^2$which forms the lower part of Sobah Al Ahmad sub-basin.

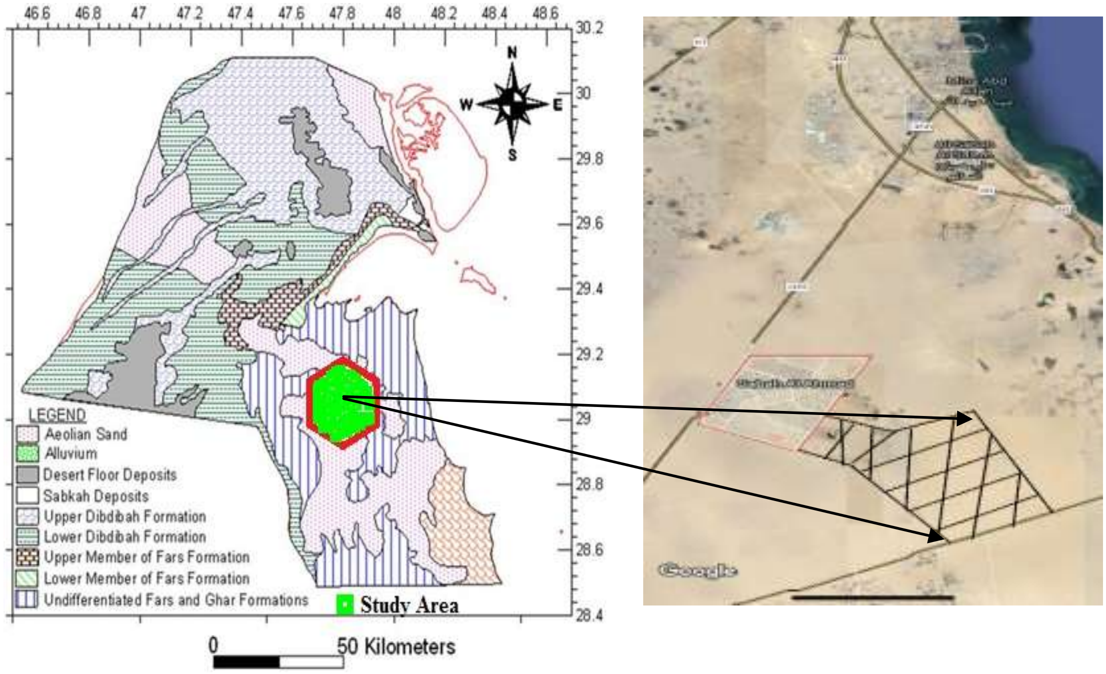



**Fig. 1:** Location map of the study area

**1-2 Climatic conditions**

The study area is characterized by a temperate Arabian Gulf climate (Alalati, (2018)). The mean monthly maximum air temperature value reaches 50 ºC at August, while the average minimum value reaches 8.9 ºC (at January) with mean annual value of 32 ºC. The average recorded value of pitch evaporation reaches 2863 mm/year. The recorded maximum relative humidity varies from 80% to 60% (in July and March respectively). The study area is characterized by short rainy season Fig. (2). Almost 65%of the seasonal rainfall occur between Nov.-Feb., while 93.3 % of the annual rainfall starts from October to March. The maximum annual rainfall was recorded in 2018 (305 mm) while the annual mean value reaches 75.45 mm Fig. (2). The climate is semi-arid with an average annual rainfall of 70 mm at Kuwait city.

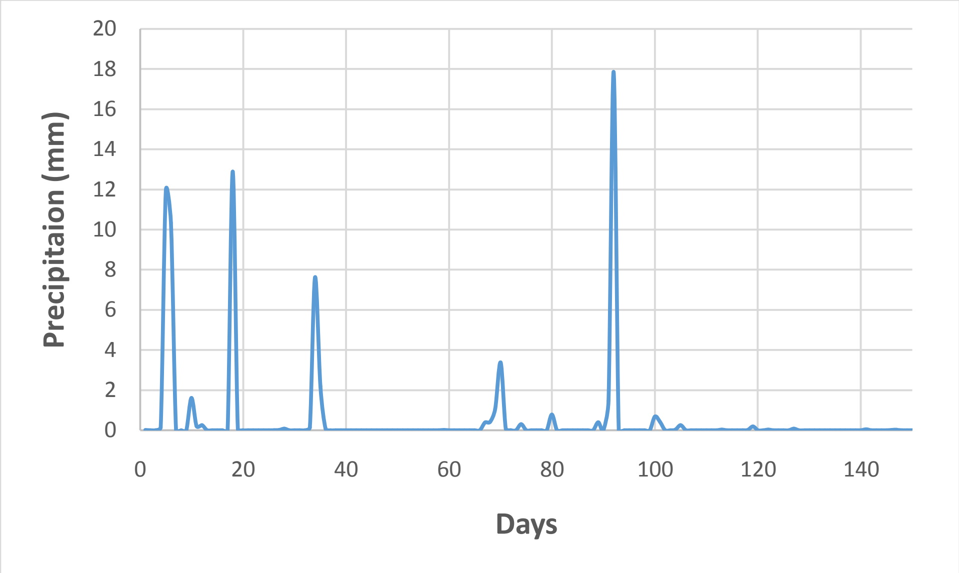



**Fig. 2:** Rainfall intensity of the studied area.

**1- 3 Geomorphological setting of SSAC**

The geomorphology of the SSACis classified into three geomorphological units, Sand dune fields, Flat desert surfaces and hydrographic catchments(Al-Sarawi 1982, El-Baz & Al-Sarawi 1996, El-Baz & Al-Sarawi 2000, Al-Sulaimi & Al-Ruwaih 2004 and Al-Alati and GAD 2018).The coastal hills occupy the northern and southern parts of Kuwait, which are a hard, flat desert with shallow depressions and small conical hills with an average height of about 40m. The sand dune fields and dust accumulation pattern occupy an area covering 350-500 $km^2$.The dunes at umm Al-Neqqa are crescent-shaped barchan dunes with an average width of 170 m and average height of 8 m. The only other valley of note is Ash Shaqq, a portion of which lies within the southern reaches of the study area. Small playas, or enclosed basins, are covered intermittently with water. The hydrographic basins form striking feature of the study area. Runoff occasionally occurs mainly in the lower part of the catchments basins and on their benches which consist of low permeable, massive calcareous crust(Al-Alati and GAD 2018).

**1-4 Geological setting**

Thesedimentary cover of Kuwait ranges in age from Quaternary to post-Eocene of about 200 m thickness. Based on the literature studies (Milton 1967, Fuchs et al.1968, Burdon & Al-Sharhan 1968, Al-Sarawi, M., (1982), Omar et al.1981, Clarke 1988, Al-Sulaimi 1988, Amer et al. 1989, Al-Sulaimi & Pitty 1995, Krishnamurthy, et al. 1996, Mukhopadhyay et al. 1996, Al-Sulaimi & Mukhopadhyay 2000, Al-Sulaimi & Al-Ruwaih 2004, Alalati, (2017). Alalati & GAD (2018) the unconsolidated to semi-consolidated clastic Dammam Formation and Kuwait Group are the major sedimentary units in Kuwait. The Dammam Formation is a limestone–dolomite sequence of Middle Eocene age. It is underlain by Middle Eocene Rus evaporites and is overlain unconformably by the clastic sediments of the Kuwait Group (Fig. 2-left).

In addition, structures associated with the Kuwait Arch noticeably control the subsurface configuration of the Dammam Formations and, hence regulate the distribution of the overlying Kuwait Group sediments (Al-Sulaimi & Al-Ruwaih 2004).

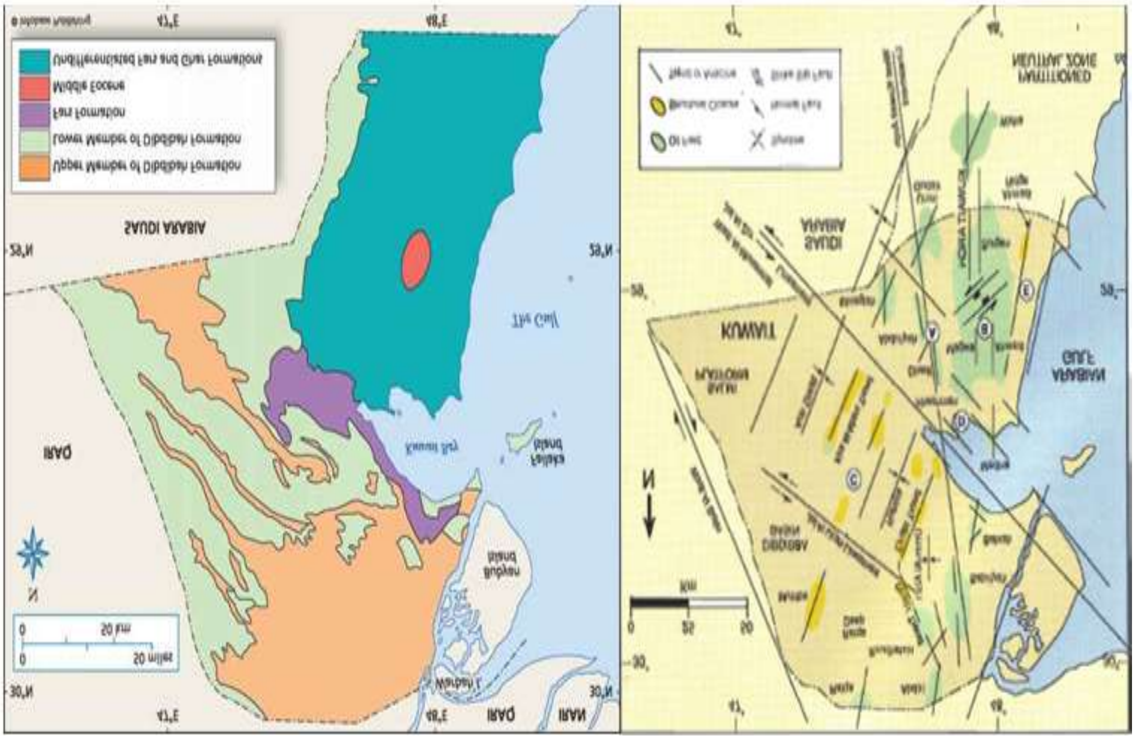


**Fig. 3:** Geological map-lift and structural map-right of Kuwait(after HGG1981)

Moreover, the structural arches in Kuwait are part of a regional set of north-trending arches known as the Arabian folds (Fig.3-right). In addition,the northwest trending anticlinal structures of the Ahmadi ridge and Bahra anticline are younger than the Arabian folds, and initiated in post-Eocene times.

In the other side, the paleo-drainage channels in SSAC, which were formed in the Pleistocene (Al-Sulaimi & Mukhopadhyay 2000), are carved in the Upper and Lower Dibdibba and the undifferentiated Fars and Ghar formations. Presently, they are filled with gravel and sand and are not readily observed on flat terrain where they are only manifested as micro-relief with the surroundings. Conversely, the paucity of wadis in the south is due to the friable sandstone of the undifferentiated Fars and Ghar Formation. The south-west-north-east trending drainage pattern closely follows the present relief variations (Al-Senafy et al. 2016).

## II. MATERIALS AND METHODS

The materials used in this paper were collected through carrying out two field trips to SSAC during the period 2017-2018 (Fig. 4). In addition, the archival data such as long term rainfall records were collected from the Metrological Authority of Kuwait library (Fig.5).

The methodological approach used in this study is based on the mathematical modeling techniques applying Watershed Modeling System (WMS, v.7) and HEC1 model Softwares programs to estimate the four dependent parameters of the runoff coefficients, i.e., the quantity of rain, the intensity of rainfall and ground configuration.


**Fig. 4:** Collected annual rainfall data from 28 sites during the period 1917-1918

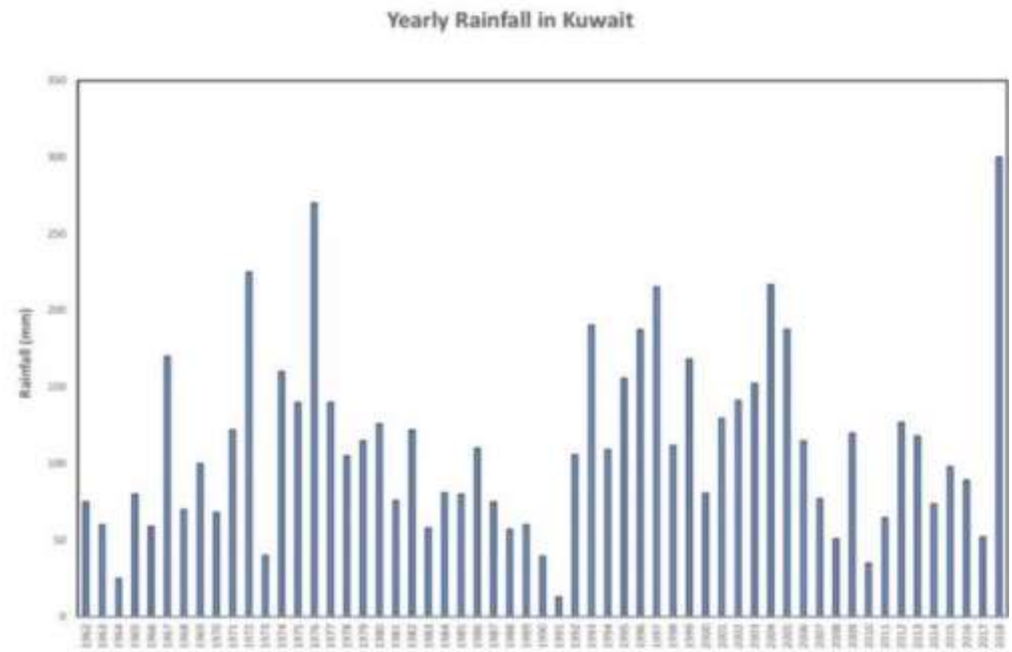



**Fig. 5:** Yearly rainfall data through the period of 57 seasons (1962-2018) collected from the Metrological Authority of Kuwait library.

**2-1 Probability analysis of rainfallevents**

Step 1; Compile a tabulation that includes the highest rainfall depth of recording rain gauge for each year. This represents the highest rainfall depth for some point in time during the year of interest, as shown in Table (1). This translates into one event for each year.

Step 2; Assign a ranking number (M) to each rainfall depth. This ranking number starts with the number "1" for the highest rainfall record proceeds to "2" for the next highest one, and so on for the number of years of record (N).

Step 3; Compute a recurrence interval for each data set by using the following relationship (Weibull formula, 1932):

**T= (N+1) / M**…………………………..………………………………………….…… (1)

Where:
T = the recurrence interval (year),
N = the number of events of record,
M = ranked position on the listing.

Step 4; Draw a graphical plot of rainfall depth (mm) on the Y-axis against probable recurrence interval (year) of high rainfall depth on the X-axis. For this purpose use either;
i) Semi-log paper (with rainfall plotted on the arithmetic scale); or
ii) Log-log paper, with ever best allows a straight-line fit to plotted data.

Step 5; Fit a straight line to plotted points.

Step 6; Extend this best-fit straight line to enable predictions to be made of longer recurrence intervals.
The probability of exceedance P(X) equals the reciprocal of the recurrence period, and is calculated using the Weibull formula 1932 (Raghunath, 1990), i.e.

**P(X) = (M*100)/(N+1)**…………………………………………………….……..…. (2)

Where **M** is the descending order rank (dimensionless) and **N** is the total number of records (dimensionless). The results are given in (Table 1).

**2.2Estimation of Surface Runoff**

To calculate the surface runoff depth, the rational method is applying using the following equation:

$$Q = \frac{C * I * A}{360}$$ …………………………………………………….. (3)

Where ***Q*** is the flood flow in cubic meter,***C***is the runoff coefficient, ***i***is the rainfall intensity in mm per hour, and ***A*** is the drainage area contributing to runoff in hectare.
In this method, the drainage area is divided into a number of sub areas and the time of concentration of different sub areas, were calculated using equation(4) below:

$$t_c = 0.00032 * L^{0.77} * S^{-0.385} \quad (4)$$

Where $t_c$ is the time of concentration in hours, **L** is the maximum length of travel of water in meter, and **S** is the slope equal to **H/L**, where **H** is the difference in elevation between the remotest point on the catchment and the outlet (m).
After that the value of rainfall intensity was determined from Multy Curve Intensity figure for the study area, the value surface runoff **(Q)** were estimated using equation (1) and by applying the procedures given in WMS.

**2.3 WMS and HEC1 models**

The Hydrological modelling system (HEC 1) is designed to simulate the precipitation-runoff processes. It is designed to be applicable in a wide range geographical areas for solving the widest possible range of problems. This includes the large basin water supply and flood hydrology, and small urban or natural watershed runoff. Hydrographs produced by the program are used directly or in shaped with other soft-ware for the studies of water availability, urban drainage flow forecasting, future urbanization impact, reservoir spillway design, flood damage reduction, flood plain regulation system approach. A model of the watershed constructed by separating the hydrologic cycle into manageable pieces and constructing boundaries around the watershed outlet.

**Table 1:** Statistical analysis of rainfall data for Kuwait state

| M | A.R | P(X) | T | M | A.R | P(X) | T |
|---|---|---|---|---|---|---|---|
| 1 | 305 | 1.72 | 58.00 | 30 | 100 | 51.72 | 1.93 |
| 2 | 275 | 3.45 | 29.00 | 31 | 100 | 53.45 | 1.87 |
| 3 | 225 | 5.17 | 19.33 | 32 | 100 | 55.17 | 1.81 |
| 4 | 220 | 6.90 | 14.50 | 33 | 90 | 56.90 | 1.76 |
| 5 | 220 | 8.62 | 11.60 | 34 | 80 | 58.62 | 1.71 |
| 6 | 200 | 10.34 | 9.67 | 35 | 80 | 60.34 | 1.66 |
| 7 | 195 | 12.07 | 8.29 | 36 | 80 | 62.07 | 1.61 |
| 8 | 195 | 13.79 | 7.25 | 37 | 80 | 63.79 | 1.57 |
| 9 | 175 | 15.52 | 6.44 | 38 | 78 | 65.52 | 1.53 |
| 10 | 165 | 17.24 | 5.80 | 39 | 75 | 67.24 | 1.49 |
| 11 | 160 | 18.97 | 5.27 | 40 | 75 | 68.97 | 1.45 |
| 12 | 160 | 20.69 | 4.83 | 41 | 75 | 70.69 | 1.41 |
| 13 | 155 | 22.41 | 4.46 | 42 | 75 | 72.41 | 1.38 |
| 14 | 140 | 24.14 | 4.14 | 43 | 75 | 74.14 | 1.35 |
| 15 | 140 | 25.86 | 3.87 | 44 | 70 | 75.86 | 1.32 |
| 16 | 140 | 27.59 | 3.63 | 45 | 70 | 77.59 | 1.29 |
| 17 | 125 | 29.31 | 3.41 | 46 | 70 | 79.31 | 1.26 |
| 18 | 125 | 31.03 | 3.22 | 47 | 62 | 81.03 | 1.23 |
| 19 | 125 | 32.76 | 3.05 | 48 | 60 | 82.76 | 1.21 |
| 20 | 120 | 34.48 | 2.90 | 49 | 60 | 84.48 | 1.18 |
| 21 | 120 | 36.21 | 2.76 | 50 | 60 | 86.21 | 1.16 |
| 22 | 120 | 37.93 | 2.64 | 51 | 50 | 87.93 | 1.14 |
| 23 | 120 | 39.66 | 2.52 | 52 | 50 | 89.66 | 1.12 |
| 24 | 110 | 41.38 | 2.42 | 53 | 45 | 91.38 | 1.09 |
| 25 | 110 | 43.10 | 2.32 | 54 | 45 | 93.10 | 1.07 |
| 26 | 110 | 44.83 | 2.23 | 55 | 40 | 94.83 | 1.05 |
| 27 | 110 | 46.55 | 2.15 | 56 | 25 | 96.55 | 1.04 |
| 28 | 110 | 48.28 | 2.07 | 57 | 20 | 98.28 | 1.02 |
| 29 | 105 | 50.00 | 2.00 | --- | --- | --- | --- |

**A.R = Annual Rainfall (mm)**, **P(X) = Probability of exceedance (year), T=Return Periods (year)**

## 2.3 PREPARATION OF THE MODEL INPUTS

For the distributed model average rainfall was calculated using WMS. The SRTM digital elevation data is used to delineate the catchment watershed and generation of stream network. Figure shows the DEM of study area and water flow direction, which is calculated using TOPAZ. Basin processing module of WMS was used for the generation of background map file of the study area which in turn was used as an input to the HEC1 model. The other model input like CN of watershed is assumed for calibration purpose. Table 2 shows the basic model inputs which is described earlier.

**Table 2:** Basic model inputs used in this study

| Input data | Source of data | Software used |
|---|---|---|
| Mean areal rainfall | Field data | WMS |
| Curve number | assumed | HEC1 |
| Boundary map and drainage network | SRTM DEM (Remote sensing) | WMS and HEC-1 |

For simulating the stream flow by the HEC1 model, SCS transform method was used to compute the direct surface runoff hydrograph, SCS CN number loss method to compute the runoff volumes. Initial abstraction and CN as calibration parameters. These model parameters were estimated using the optimization algorithm available in HEC1. After each parameter correction and corresponding simulation run, the simulated and observed stream flow hydrographs were visually compared. Thus the model was run with the model input values. In addition, function of land use, hydrological soil groups and antecedent moisture contentgive the values of CNwhich are widely documented in the literature (Chow et al., 1988 and Hromadka &Whitley, 1989).It is noticed that the values of CN were assumed due to the lack of soil type in the studied catchments.

**2-4 Ground configuration of the studied catchments.**

In the other hand, drainage network and watershed boundaries shape files of SSAC was automatically delineated by Watershed Modeling System (WMS 7.1) package using TOPAZ (Topographic Parameterization) technique (Garbrecht, and Martz, 1993) from the available DEM with 30 m resolution. In addition, Shuttle Radar Topography Mission (SRTM3) data are used to trace and convert the drainage network and catchment boundaries to lines and polygons by WMS drainage coverage (Nelson et al, 2000). Figure 6 shows the delineated catchments in SSAC while Table 2 summarizes the terrain characteristics of the three catchments extracted from DEM applying WMS model.

## III. RESULTS AND DISCUSSIONS

Based on the results of the statistical analysis of rainfall data (Table 1) it is noticed that the maximum annual rainfall depth of 305 mm more than the mean value of initial abstraction recurs every 58 years with probability of 1.72% while the minimum annual rainfall depth of 20 mm recurs after 1 year, with probability of 98%.In addition, the median annual rainfall depth of 195 mm recurs after 7 years, where the maximum daily rainfall probability reaches 14%. The great difference between recurrence periods reflects the great tendency of the climatic conditions to form flash floods.

In addition, the results of the study of catchment hydrology of SSAC applying WMS software shows that the present hydrographic basin is divided into three catchments (Fig.6 and Table 3).

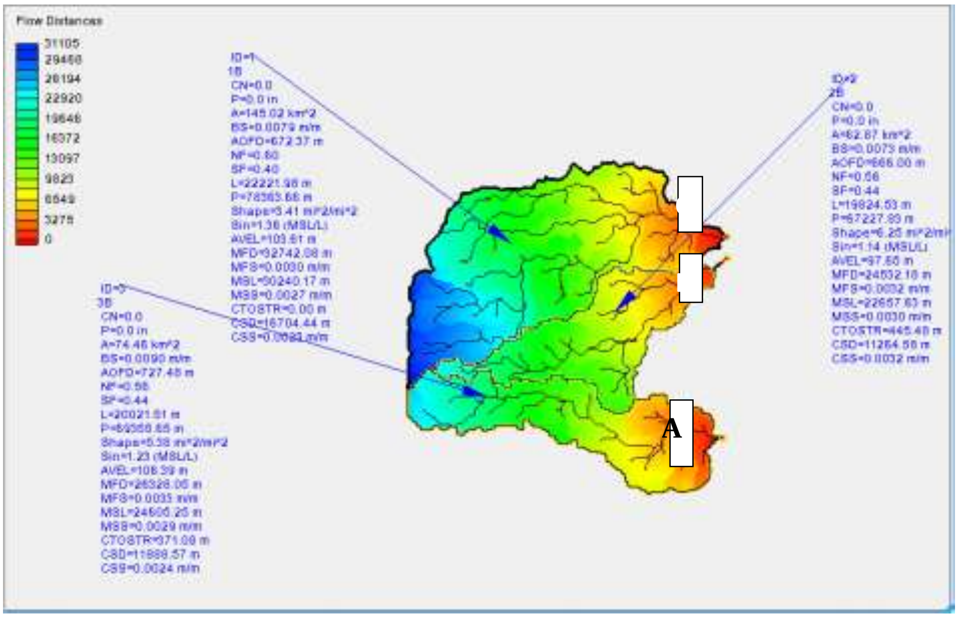



**Fig. 6:** Drainage system of the three catchments in SSAC extracted from DEM file (30x30 m Resolution)

**Table 3:** The morphometric parameters of the three chosen catchments

| Morphometric Parameter | Catchment A | Catchment B | Catchment C | Main Basin |
|---|---|---|---|---|
| **A (km$^2$)** | **74.46** | **62.87** | **145.02** | **192.41** |
| **BS (m/m)** | **0.009** | **0.0073** | **0.0079** | **0.0502** |
| **AOFD (m)** | **727.48** | **666** | **672.37** | **72.11** |
| **L (m)** | **20021.51** | **19824.53** | **22221.9** | **21875.69** |
| **P (m)** | **69355.65** | **67227.83** | **78363.66** | **118418.08** |
| **SHAPE** | **5.38** | **6.25** | **3.41** | **2.49** |
| **Sin** | **1.23** | **1.14** | **1.36** | **1.68** |
| **AVEL (m)** | **106.39** | **97.65** | **103.61** | **87.05** |
| **MFD (m)** | **26328.05** | **24532.18** | **32742.08** | **36867.25** |
| **MFS** | **0.0033** | **0.0032** | **0.003** | **0.0026** |
| **MSL (m)** | **24605.25** | **22657.63** | **30240.17** | **36684.04** |

| | | | | |
|---|---|---|---|---|
| **MSS (m/m)** | **0.0029** | **0.003** | **0.0027** | **0.0023** |
| **CTOSTR (m)** | **371.08** | **445.48** | **0** | **61.87** |
| **CSD (m)** | **11888.57** | **11264.58** | **16704.44** | **19685.17** |
| **CSS (m/m)** | **0.0024** | **0.0032** | **0.0023** | **0.0019** |

The three catchments form the headwaters of the plateau which drains into the Arabian Gulf. Both Catchment A and B are longitudinal catchments in shape while the third one is more or less circular (Fig.6). The morphometric parameters of the three catchments resulted from WMS software include 15 hydro-morphological parameters (Table 3).

**3-1 Hydro-morphological parameters of study catchments**

Any area under urbanization development that is subjected to flash flood hazards such as SSAC had to be protected against flood events, these events are estimated based on a certain recurrence interval as mentioned before. However, some catchment may be subject to more danger than others. This is why a risk assessment from the flash flood event point of view, has to be carried out prior the design or proposing the storm protection scheme (USDT, 1996). As a result, the high-risk locations will receive more intention than sub-catchment with lower risk or even their protection works may be designed with a higher recurrence interval. The criteria adopted in this study for risk analysis was based on hydro-morphological parameters that may result in more loss in surface water and damage to the crossing locations (GAD and Abdel-Latif 2003). These parameters are the drainage area (A), drainage density (D), catchment slope (BS), average overland flow (AOFD), catchment shape factor (Shape), and catchment sinuosity factor (Sin).Drainage area (A)is the area of the catchment in the units specified prior to computing catchment parameters. It is the most important watershed characteristic that affects runoff. The larger the contributing drainage area, the larger will be the flood runoff (Gad et al 2016). Regardless of the method utilized to evaluate flood flows, peak flow is directly related to the drainage area. So, catchment-C is more dangerous than Catchment A&B since it is the largest area (Table 3). Moreover,Drainage density (D)is defined as the total length of streams of different orders per unit of area (A) (Horton, 1945). This means that it has a strong influence on both the spatial and temporal response of watershed to a given precipitation event. If a watershed is well covered by a pattern of interconnected drainage channels, and the AOFD is relatively short, the watershed will respond more rapidly than if it were sparsely drained.Average Overland Flow (AOFD) is the average overland flow distance within the catchment. It is a measure of erodibility. The shorter AOFD value, the quicker the surface runoff is. So, catchment-B is quicker runoff than the others since it has 666m of AOFD (Table 3).

In addition, catchment Slope (BS)is the average catchment slope. It is very important in how quickly a drainage channel will convey water, and therefore, it influences the sensitivity of a watershed to precipitation events of various time durations. Watersheds with steep slopes will rapidly convey incoming rainfall, and if the rainfall is convective, the watershed will respond very quickly with the peak flow occurring shortly after the onset of precipitation. So, catchment-C is more dangerous than Catchment A&B since it possess 0.0079 value (Table 3).

Catchment shape factor (Shape)is the shape factor of the catchment, or the length divided by the width.catchment sinuosity factor (Sin) is defined as the length of basin path divided by the shortest distance between mouth and source of stream (Gregory and Willing, 1973). Sinuosity factor of the stream in the catchment. Defined by dividing the maximum stream length in the catchment by the length.

Catchment relief ratio (Rr)is the ratio between Mean Basin Elevation in km (AVEL) and the Basin Length in km (L) (Schumm, 1956). The circular basins with small Rr are potentially more susceptible to flash flood (Patton, 1988). So, catchment-C is more dangerous than Catchment A&B since it possess the highest Rr value.

**3-2 Estimation of Surface Runoff**

The values of runoff coefficient (C) were calculated for each sub-catchment using WMS. Then the surface runoff for each watershed was computed using equation (1) and as mentioned in (Gad 2009). The data obtained are presented in Table (4).

**Table 4**: Calculated values of surface Runoff

| **Watershed No.** | **Area (km)** | **C** | **I (mm/h)** | **Q = C*I*A / 360 ($m^3$/s)** |
|---|---|---|---|---|
| A | 74.46 | 0.15 | 35.10 | 2.206913 |
| B | 62.87 | 0.15 | 77.66 | 0.640695 |
| C | 145.02 | 0.175 | 67.4 | 0.425931 |
| | Sum | | | 3.26 |

**3-3 Catchment hydrograph Peak and time to Peak estimations.**

One of the most essential parameter in studying the catchment hydrology is the catchment hydrograph, peak and time to peak. Seven hydrographs were estimated with their peaks and time to peak applying WMS v.7 (Fig.7) and Table 5 .

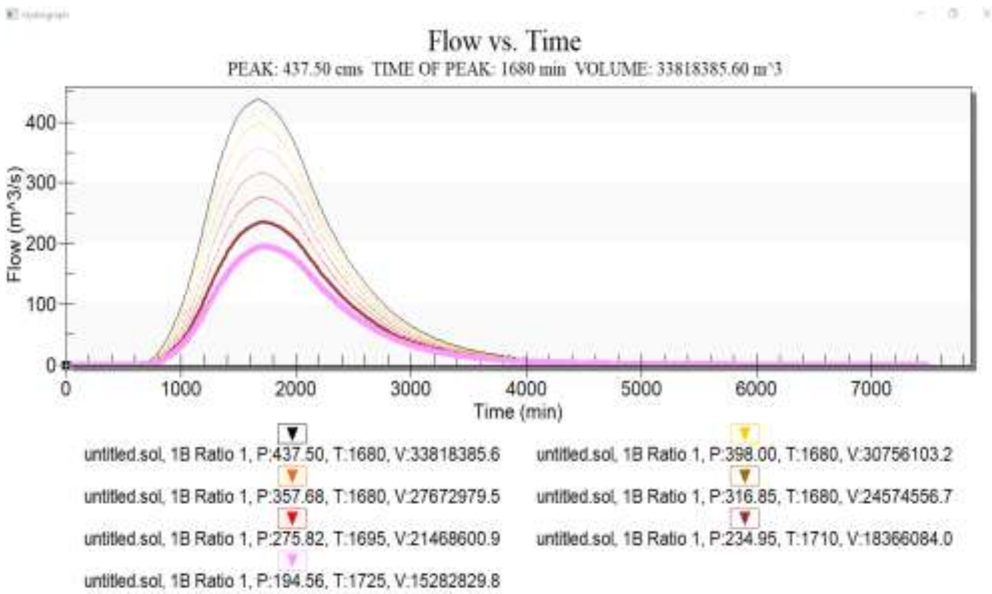


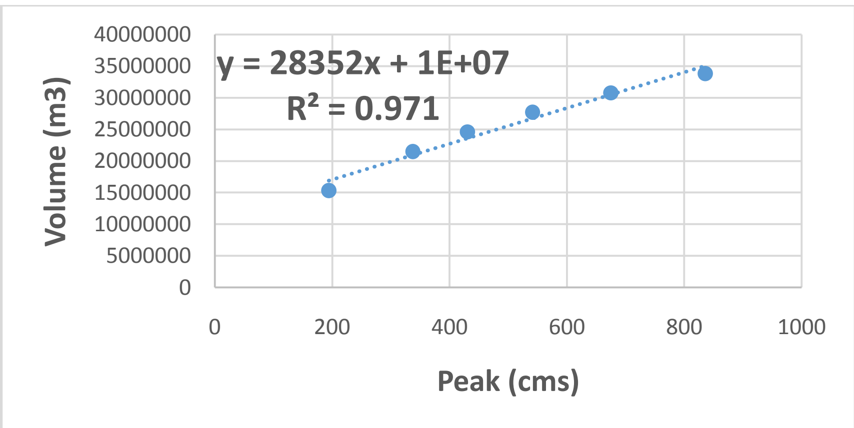

**Fig. 7:** Catchment hydrographs (flow vs. time) resulted from WMS software based on hypothetical rainfall intensities in the study area.

**Table 5:** The estimated peak and time of peak from the estimated hydrograph

| PEAK (cms) | TIME OF PEAK (min) | VOLUME ($m^3$) |
|---|---|---|
| 194.56 | 1725 | 15282829.8 |
| 541.57 | 1290 | 27672967.8 |
| 430.53 | 1380 | 24574547.7 |
| 337.81 | 1485 | 21468599.1 |
| 437.5 | 1680 | 33818385.6 |
| 675.04 | 1215 | 30756096.9 |
| 835.79 | 1140 | 33818385.6 |

It is noticed from Fig.6 and Table 5 that the estimated peaks values applying WMS range from 194.56 to 835.79 (cms) while Time to Peak range from 1140 (min) to 1725 (min). In addition, the peak volume range between 15282829.8 ($m^3$) to 33818385.6 ($m^3$). It must be mentioned that the high relative quantity of peak volumes may be related to catchment characteristics more than rainfall intensity.

In addition, the relation between volume of peak ($m^3$) and Peak(cms) was obtained with high value of $R^2$ which reflects high tendency of correlations as same as the relation between the volume of peak and time of peak (0.98) Fig. (8). These results confirm the great tendency of the effect of catchment morphology relationship more than the effect of rainfall intensity to cause the floods.



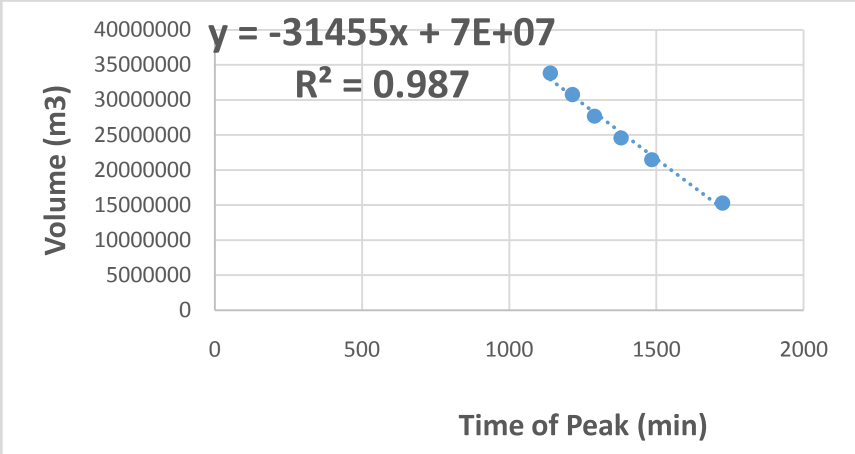



**Fig. 8:** The relation between Volume of peak v peak (higher) and between Volume of peak and time of peak (lower one).

Moreover, a trial to study the relation between precipitation and hydrograph was carried out through assuming certain CN values and precipitation applied WMS software, (Fig.9). The results show that the same trend as same as the relation between peak and volume of peak.

| PEAK | | PRECIPITATION | | | |
|---|---|---|---|---|---|
| | | 100 | 150 | 200 | 240 |
| CN | 60 | 54.17 | 140.57 | 247.62 | 342.71 |
| | 65 | 81.48 | 191.89 | 322.83 | 436.34 |
| | 70 | 118.28 | 257 | 414.68 | 548.37 |
| | 75 | 168.17 | 339.74 | 527.32 | 682.89 |
| | 80 | 236.04 | 444.59 | 665.02 | 844.83 |

| TIME OF PEAK | | PRECIPITATION | | | |
|---|---|---|---|---|---|
| | | 100 | 150 | 200 | 240 |
| CN | 60 | 1575 | 1515 | 1485 | 1485 |
| | 65 | 1440 | 1410 | 1380 | 1380 |
| | 70 | 1335 | 1305 | 1290 | 1290 |
| | 75 | 1230 | 1215 | 1215 | 1215 |
| | 80 | 1155 | 1140 | 1140 | 1140 |

| VOLUME | | PRECIPITATION | | | |
|---|---|---|---|---|---|
| | | 100 | 150 | 200 | 240 |
| CN | 60 | 3573873.0 | 9090462.6 | 15830393.4 | 21774729.6 |
| | 65 | 4848903.0 | 11156807.7 | 18535286.7 | 24900084.9 |
| | 70 | 6293867.4 | 13344180.3 | 21289750.2 | 28014921.0 |
| | 75 | 7915203.0 | 15647370.3 | 24084829.8 | 31111624.8 |
| | 80 | 9724221.0 | 18063637.2 | 26913843.0 | 34184741.4 |

**Fig. (9):** Proposed scenarios of the relation between volume of peak and CN values.

## IV. CONCLUSION

The paper presented the estimation of direct runoff volume and peak rate for some catchments related to SSAC. Rain fall intensity resulted from time to peak depending solely on recurrence interval have been adopted for long time without giving weight to the hydro morphological parameters of the watersheds that cause such floods.According to morphometric parameters of the three catchments resulted from WMS software refers to the catchment-C is the more risk than others. Drainage area (A), drainage density (D), basin slope (BS), average overland flow (AOFD), basin shape factor (Shape), and basin sinuosity factor (Sin), all these parameters affect on risk of direct runoff volume. The assumed CN helps to estimate time to peak and volume of runoff to moderately results. This may lead to some errors and needs to assure these parameters. However, further studies should be made concerning the environmental hazard of the urbanization activates and special intention should be made when trying to control floods to keep the environment. Field measurements are highly recommended to verify the results of time to peak and flood volume measurements resulted in this work.

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