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Derivation of Dimensionless Unit Hydrograph and S Curve for Mini-Watershed of Manvi Taluk Raichur District Karnataka

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Abstract- Unit Hydrograph (UH) is the most famous and generally utilized technique for analysing and deriving flood hydrograph resulting from a known storm in a basin area. For ungauged catchments, unit hydrograph are derived using either regional unit hydrograph approach. Central Water Commission (CWC) derived the regional unit hydrograph relationships for different sub-zones of India relating to the various unit hydrograph parameters with some prominent physiographic characteristics. In this study, the lately developed UH model is applied located between Latitude 15º54′2″ N to 16º16′19″ N Latitude and 76º48′40″ E to77º4′21″ E Longitude. The study area covers an area of 466.02 km^2, having maximum length of 36.5 km. The maximum and minimum elevation of the basin is 569 m and 341 m above MSL, respectively. The Peak discharge of unit hydrograph obtained is 171.58m^3/s. The final cumulative discharge is 1669.05 m^3/s.

***Keywords*:** Unit hydrograph, Flood hydrograph, Slope, Synthetic Parameter CWC.

I. INTRODUCTION

Estimation of design flood for various water resources structures, particularly for medium and major water resources schemes, has been one of the most active areas of research for the hydrologists and water resource engineers. Unit Hydrographs have been proposed by several engineers as a tool to simulate runoff hydrographs from rainfall for ungauged catchments. Traditional techniques for design flood estimation uses historical rainfall-runoff data for unit hydrograph derivation. Such techniques have been widely applied for the estimation of design flood hydrograph at the sites of gauged Catchment. The estimation of design flood hydrograph is easy if information about runoff at the site is available. In cases where the available runoff data are inadequate for the complete hydrologic analysis, for such cases the available information of the nearby catchment or the information of the region can be used to carry out the further analysis. This approach attempts to establish relationships between model parameters and physically measurable Catchment characteristics for gauged catchments. These relationships are then assumed to hold for ungauged Catchments having similar hydrologic characteristics (CWC, 1986).

Floods are caused by weather phenomena and events that deliver more precipitation to a drainage basin than can be readily absorbed or stored within the basin. An overflow or inundation that comes from a river or other body of water and causes damage. Any relatively high stream flow overtopping the natural or artificial banks in any reach of a stream is termed as flood.

The Unit Hydrograph (abbreviated as UH) of a drainage basin is defined as a hydrograph of direct runoff resulting from one unit of effective rainfall which is uniformly distributed over the basin at a uniform rate during the specified period of time known as unit time or unit duration. The unit quantity of effective rainfall is generally taken as 1mm or 1cm and the outflow hydrograph is expressed by the discharge ordinates.

II. MATERIALS AND METHODSA

A. Study Area

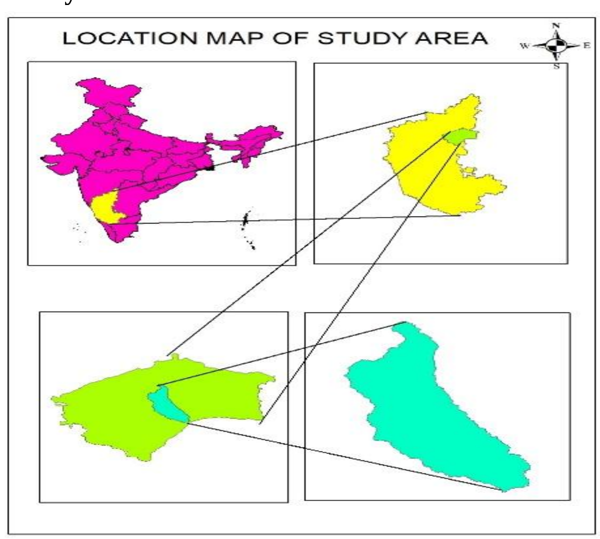

Fig 1 Location Map of Study Area

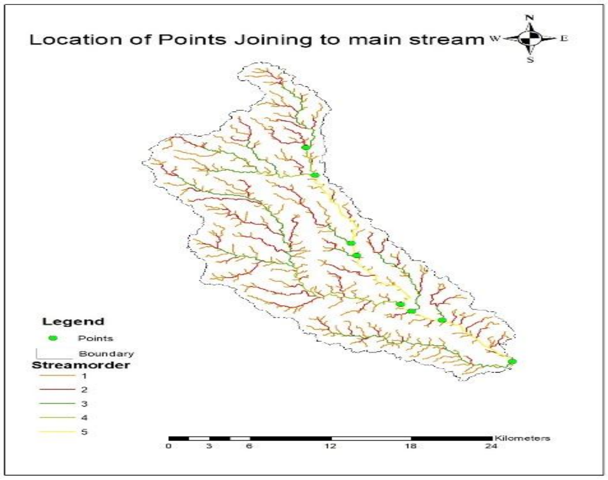

Fig 2 Location of points

The Study area located between Latitude 15º54′2″ N to 16º16′19″ N Latitude and 76º48′40″ E to77º4′21″ E Longitude. The study area covers an area of 466.02 km^2, having maximum length of 36.5 km. The maximum and minimum elevation of the basin is 569 m and 341 m above MSL, respectively.

B. Methodology

The characteristics of the watersheds and their Unit hydrographs, prepared for several watersheds in a sub-zone, is correlated by regression analysis and the equations for synthetic unit hydrograph are derived for estimating design flood for ungauged watersheds. (CWC, 1986) The unit hydrograph characteristics such as peak (Qp), time to peak (tp), width of hydrograph at 50% of peak volume (W50), width of hydrograph at 75% of peak volume (W75), width of the rising side of unit hydrograph in hours at ordinate equal to 75% of UH peak (WR75), time base (t_B) etc. has been computed on the basis of physiographic features.

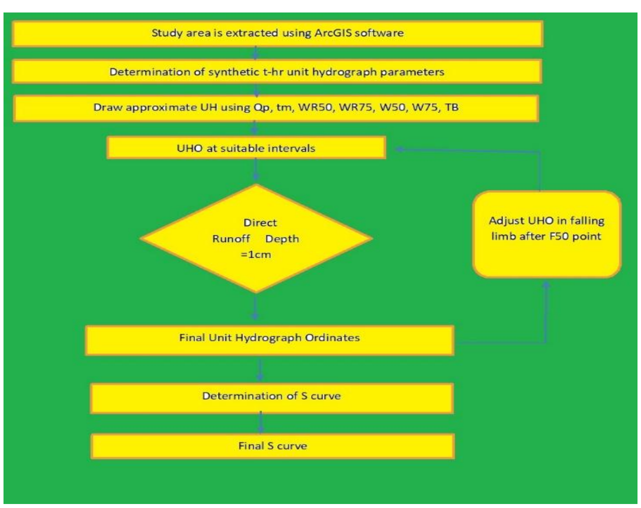

Fig 3: Methodology adopted to derive a CWC Unit Hydrograph Ordinates and S-curve

III. RESULTS AND DISCUSSIONS

No information of flood runoff is readily available for the study area, hence, to derive flood runoff or flood hydrographs, unit hydrographs were derived by CWC method by using following parameters below

A. Determination of physiographic parametersS is to be determined using the elevation of the main stream at a number of significant points along it. Usually, the length of the stream from a point where an important tributary joins it up to another where the next tributary joins it called as a stream segment. S calculated as the average slope of all the stream segments and calculated using the expression

$$S= (\sum L_i (D_{i-1}+D_i))/L^2$$

Where L_i is the length of i^{th} segment in km, D_i, D_{i-1} are the height above the datum (RL of the outlet of the basin) with respect of RL of contour at the i^{th} and $(i-1)^{th}$ locations in meters, L is the length of the longest stream in km.

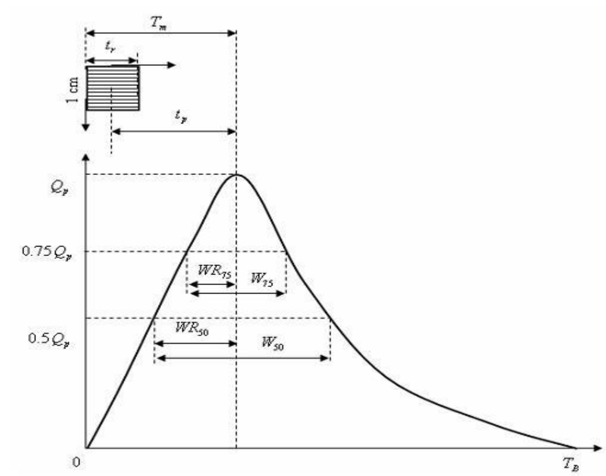

Fig 4: Typical CWC Unit Hydrograph

tp = 0.553(LLc/√s)0.405 (3.11)
qp = 2.043/(tp)0.872 …(3.12)
W50 = 2.197/(qp)1.067 …(3.13)
W75 = 1.325/(qp)1.088 …(3.14)
WR50 = 0.799/(qp)1.138 …(3.15)
WR75 = 0.536/(qp)1.109 …(3.16)
TB = 5.038(tp) 0.733 …(3.17)
Tm = tp+(tr/2) …(3.18)
Qp = qp x A … (3.19)

Table 1 Calculation of Equivalent Stream Slope for Catchment

Point No	Segment length Li in Km	Elevation from outlet Di in m	(Di + Di-1)	Li(Di+Di-1)
0				
1	11.22	104	104	1166.88
2	4.14	89	193	799.02
3	11.56	56	145	1676.2
4	1.84	53	109	200.56
5	9.26	26	79	731.54
6	1.48	21	47	69.56
7	2.92	16	37	108.04
8	9.3	1	17	158.1
Σ Li(Di+Di-1)				4909.9
S = Σ Li (Di+Di-1)/L^2			3.685 m/km	

B. Determination of synthetic t_r-hr Unit graph parameters

Table 2 Parameters of t_r- hr. Unit Hydrograph

t_p (hr)	q_p $m^3/s/km^2$	W_{50} (hr)	W_{75} (hr)	W_{R50} (hr)	W_{R75} (hr)	T_B (hr)	Tm (hr)	Q_p m^3/s
7.14	0.37	6.38	3.93	2.49	1.62	21.27	7.64	171.58

C. Preparation of t_r-hr Synthetic unit graph

A unit hydrograph is drawn using the parameters of table 2. Recession curve is smoothened to obtain the direct runoff depth equal to 1cm

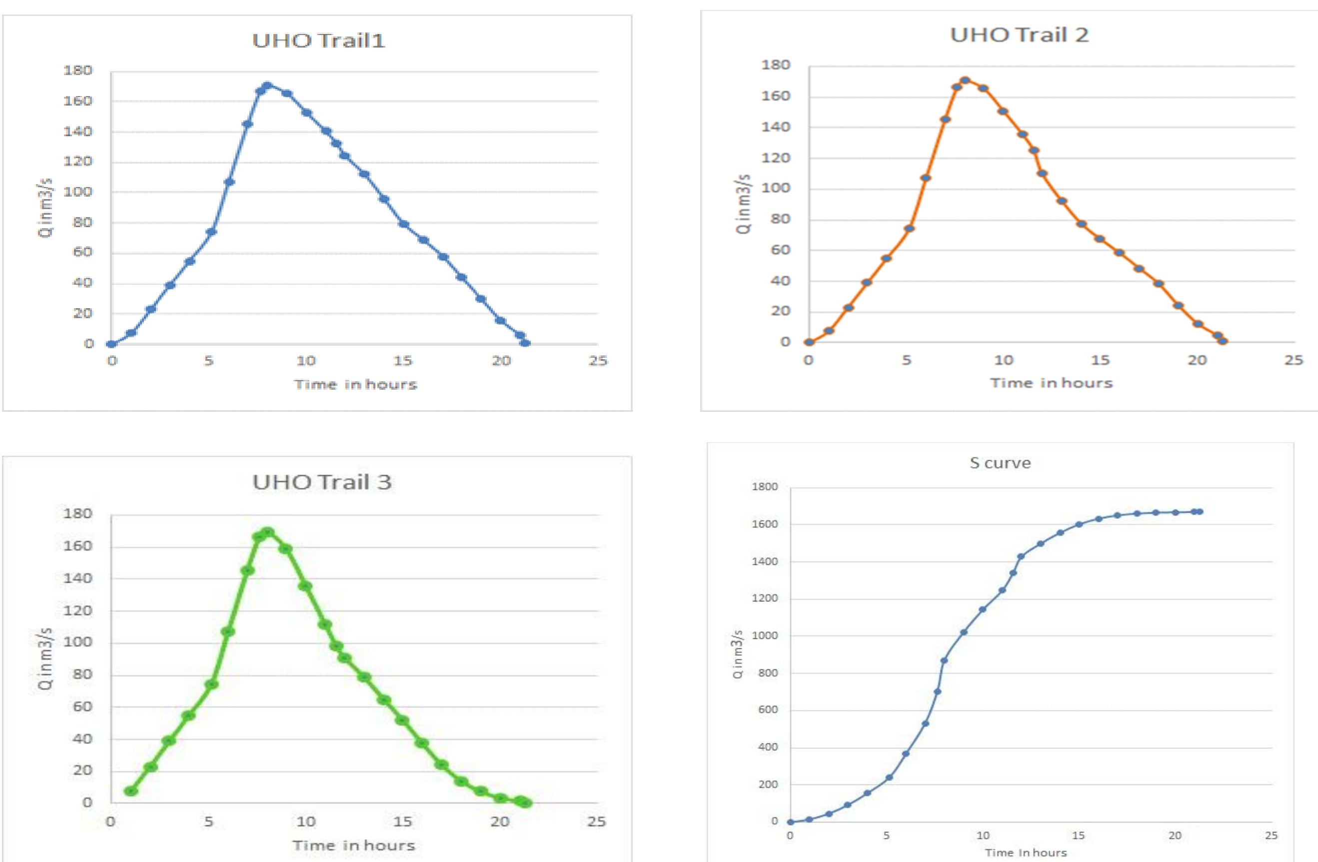

Fig 5 Unit Hydrograph and S Curve

Table 3: CWC Unit Hydrograph ordinates

Sl No	Time in hours	Trail 1				Trail 2				Trail 3			
		UHO in m3/s	(Qi+Qi+1)/2	Volume	Depth	UHO in m3/s	Qi+Qi+1)/2	Volume	Depth	UHO in m3/s	Qi+Qi+1)/2	Volume	Depth
1	0	0				0.00				0.00			
2	1	15.00	7.50	27000.00	5.79374E-05	15.00	7.50	27000.00	5.79E-05	15.00	7.50	27000	0.0001
3	2	31.00	23.00	82800.00	0.000177675	31.00	23.00	82800.00	0.000178	31.00	23.00	82800	0.0002
4	3	47.00	39.00	140400.00	0.000301275	47.00	39.00	140400.00	0.000301	47.00	39.00	140400	0.0003
5	4	63.00	55.00	198000.00	0.000424874	63.00	55.00	198000.00	0.000425	63.00	55.00	198000	0.0004
6	5.15	85.79	74.40	307995.30	0.000660906	85.79	74.40	307995.30	0.000661	85.79	74.40	307995.3	0.0007
7	6.02	128.69	107.24	335867.85	0.000720716	128.69	107.24	335867.85	0.000721	128.69	107.24	335867.9	0.0007
8	7	162.00	145.34	512768.34	0.001100314	162.00	145.34	512768.34	0.0011	162.00	145.34	512768.3	0.0011
9	7.64	171.58	166.79	384284.16	0.000824609	171.58	166.79	384284.16	0.000825	171.58	166.79	384284.2	0.0008
10	8	170.00	170.79	221343.84	0.000474966	168.00	169.79	220047.84	0.000472	170.00	170.79	220047.8	0.0005
11	9	161.00	165.50	595800.00	0.001278486	150.00	159.00	572400.00	0.001228	161.00	165.50	572400	0.0012
12	10	100.00	50.00	9000.00	1.93125E-05	122.00	136.00	489600.00	0.001051	145.00	136.84	27000.00	0.0001
13	11	87.00	93.50	336600.00	0.000722287	102.00	112.00	403200.00	0.000865	138.00	141.50	82800.00	0.0002
14	11.57	85.79	86.40	177282.54	0.000380418	95.00	98.50	202122.00	0.000434	85.79	111.90	140400.00	0.0003
15	12	120.00	102.90	159281.46	0.000341791	87.00	91.00	140868.00	0.000302	120.00	102.90	198000.00	0.0004
16	13	104.00	112.00	403200.00	0.000865199	71.00	79.00	284400.00	0.00061	104.00	112.00	307995.30	0.0007
17	14.02	85.79	94.90	348454.44	0.000747724	59.00	65.00	238680.00	0.000512	87.00	95.50	335867.85	0.0007
18	15	72.00	78.90	278341.56	0.000597274	45.00	52.00	183456.00	0.000394	72.00	79.50	512768.34	0.0011
19	16	66.00	69.00	248400.00	0.000533024	30.00	37.50	135000.00	0.00029	66.00	69.00	384284.16	0.0008
20	17	50.00	58.00	208800.00	0.000448049	18.00	24.00	86400.00	0.000185	50.00	58.00	221343.84	0.0005
21	18	38.00	44.00	158400.00	0.0003399	10.00	14.00	50400.00	0.000108	38.00	44.00	595800.00	0.0013
22	19	25.00	31.50	113400.00	0.000243337	5.00	7.50	27000.00	5.79E-05	22.00	30.00	495361.35	0.0011
23	20	15.00	20.00	72000.00	0.0001545	2.00	3.50	12600.00	2.7E-05	10.00	16.00	24631.65	0.0001
24	21	2.00	8.50	30600.00	6.56624E-05	1.00	1.50	5400.00	1.16E-05	2.00	6.00	509400.00	0.0011
25	21.27	0.00	1.00	972.00	5.79374E-05	0.00	0.50	486.00	1.04E-06	0.00	1.00	213495.66	0.0005
Total Depth in meters					0.013227	Total Depth in meters			0.012435	Total Depth in meters			0.0108

IV. CONCLUSIONS

Using very limited data makes this model very useful for an ungauged catchment aiming at event prediction. Equivalent discharge is the maximum discharge that takes place in a Catchment which can be used to design hydraulic structures. To derive flood runoff or flood hydrographs, unit hydrographs were derived by central water commission method. This information is useful to derive flood hydrograph along the stream. This drainage network analysis and application of the UH can provide a significant contribution towards flood management program. Thus, the present model could be applied to simulate flood hydrographs for the catchments that have not been studied yet. The Peak discharge of unit hydrograph obtained is $171.58 m^3/s$. The final cumulative discharge is $1669.05\ m^3/s$.

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