Flood Estimation flood Control

- Physical indications of past floods- flood marks and local enquiry
- Rational Method (CIA)
- Unit Hydrograph method
- Empirical methods
- Flood frequency methods

Empirical methods for Flood Estimation

- Dicken's formula
  - Q=C*M^3/4
    - C= 11.4 for North India
    - C= 13.9 to 19.5 for Central India
    - C= 22.5 to 25 for Western India

- Ryve's formula

  Q = CM ^(2/3)

  - Where C = varies from 6.8 to 15 kms
  - C = 6.75 if area is less than 24 kms from coast
  - C = 8.45 if area is 24 - 16 kms
  - C = 10.1 for hills
  - Q = Discharge in cumecs
  - M = Area in Sq. kms

- Ali Nawaj Jung Bahadur's formula
  - (0.993 - 1/14 Log A)
  - Q = CA
  - Value of C taken from 48 to 60
  - This is applicable mainly in Deccan plains
  - A = Area of catchment in sq. km

Ingle's formula

$$Q=123*A/SQRT(A+10.4)$$

A= Area(sq.km)

Khoslas' formula

$$R = P - (T - 32)/3.74$$

Where T = mean temp F

R & P are in cms.

Englis gave the following formulae derived from data collected from 37 catchments in Bombay Presidency

For Ghat areas

$$R = 0.85 P - 30.5$$

Where R is run off in cms

P = Precipitation cm

For non Ghat areas

$$R = \{P - 17.8\} \times P/254$$

Barlow' and Lacey have also given empirical formula as under

$R = KP$

Where R = Run off

P = Precipitation

K = Run off coefficient for different class of catchments like,

A = Flat cultivated soil

B = Flat partly cultivated

C = Average

D = Hills & plains with cultivation

E = Very hilly areas

Barlow has added another coefficient based on light rain, average rainfall with intermittent rains and continuous down pour etc.

Lacey has given a formula as

$$R = \frac{P}{1 + (304.8\, F/PS)}$$

Where S = Catchment factor

F = reservoir duration factor which is based on different classes as defined by Barlow's equation.

BARLOW'S TABLE							
CLASS	DESCRIPTION OF CATCHMENT			RUNOFF PERCENTAGE			
A	Flat , cultivated and black cotton soils				10		
B	flat partly cultivated stiff soils				15		
C	Average catchment				20		
D	Hills and plains with little cultivation				35		
E	Very hilly and steep with little or no cultivation				45		
NATURE OF SEASON			A	B	C	D	E
Light rain, no heavy down pour			0.7	0.8	0.8	0.8	0.8
Average or no continuous rain			1	1	1	1	1
continuous downpour			1.5	1.5	1.6	1.7	1.8

Rational Method:

In this method the basic equation which correlates runoff and rainfall is as follows

$$Q = C * I * A$$

Where Q = Runoff (Cubic meters per hour)

C = Runoff Coefficient

I = Intensity of rainfall in meters per hour

A = Area of the drainage basin (Sq. Meters)

Intensity of Rainfall(m/hr)(I)

$$= P/Tr\ ((Tr+1)/Tc+1)$$

P	Precipitation	meters
Tr	Storm period	hrs
Tc	Time of Concentration	hrs

if Tc is not known, then

$I = P/Tr$

Time of Concentration(Tc) is the time in hours taken by rain water that falls at the farthest point to reach the outlet of a catchment

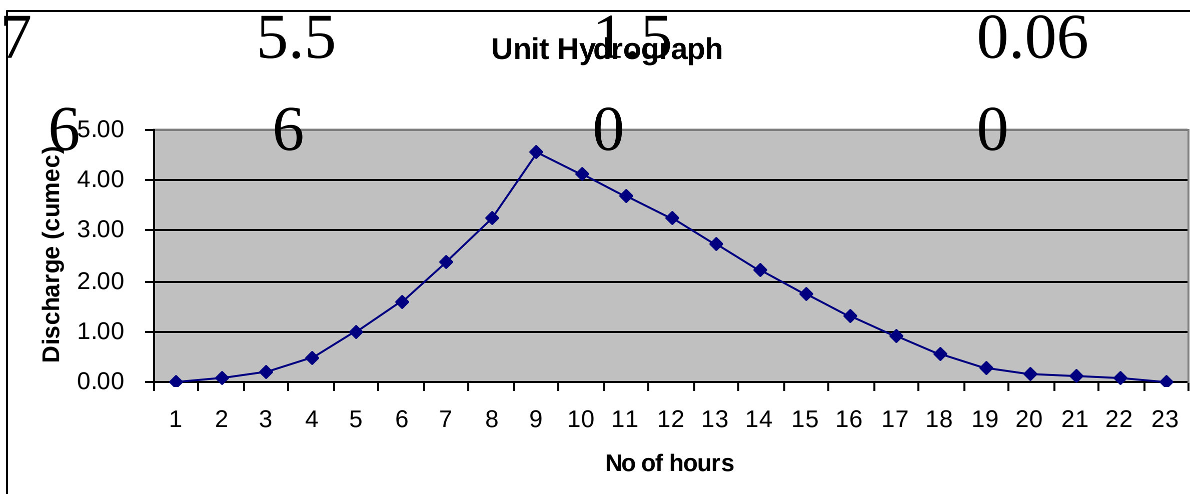
The value of runoff coefficient C depends on the characteristics of the drainage basin such as soil type, vegetation, geological features etc. For different types of drainage basins the values of C are given below in table

Table Value of C for different types of drainage basins

Types of drainage basin	Value of C
Rocky and impermeable	0.8-1.0
Slightly permeable, bare	0.6-0.8
Cultivated or covered with vegetation	0.4-0.6
Cultivated absorbent soil	0.3-0.4
Sandy soil	0.2-0.3
Heavy forest	0.1- 0.2

(unit hydrograph method)

Date	hour	Disch cumec	base flow	rdinate dir -rf	ordinate unit hyd
12 aug	6	6	6	0	0
	12	16	5	11	0.46
	18	60	3.5	56.5	2.39
	24	100	2.5	97.5	4.12
13 aug	06	68	3	65	2.75
	12	35	4	31	1.31
	18	11	4.5	6.5	0.27
	24	7	5.5	1.5	0.06
14 aug	06	6	6	0	0



Maximum flood with different formula

MFD (Area velocity method)cum/sec (Q=A* V)HFL	**349.76**
MFD at the site (Dicken)cum/sec	**135.81**
Ingle's formula	**262.99**
MFD (Rainfall intensity method (C*I*A))- rational method cum / sec	**124.35**
MFD at the site (GOG)-Standard Project flood method) cum/sec	**233.21**
Average MFLD	**221.22**

Flood frequency

Average flood?
Standard deviation?
Coefficient of variation?
Coefficient of Skewness
Coefficient of flood
Maximum flood for 100 year return period?
Maximum flood for 500 year return period?

Gumbel Method
Log pearson method

Basic Formulas	
Mean(x)=	$\bar{x}=\Sigma(x)/n$
standard Deviation(σ)=	$\sigma=sqrt(\Sigma(x-\bar{x})^2/(n-1))$
Coeff.Variation (Cv)=	$Cv=\sigma/\bar{x}$
Coef of Skewness (Cs)	$Cs=\Sigma(x-\bar{x})^3/((n-1)*\sigma^3)$
Return period(T)	$T=(n+1)/m$
m= Rank	
Percent probability or frequency	$P=1/T*100$
Value of X with respect to T	$xT=\bar{x}+K*\sigma$
K=	$(YT-\bar{Y}n)/Sn$
YT=Reduced variate	-(ln.ln(T/T-1)
$\bar{y}n$=Reduced Mean a function of N	
Sn=Reduced Standard Deviation a function of N	

Flood frequency

Gumbel Method

$(P)=1-(e^{-e^{-y}})$

$T= 1/1-(e^{-e^{-y}})$

Y(Reduced Variate)= $(1/(0.78*\sigma))*(x-\bar{x}+0.45\,\sigma$

x=Flood magnitude with probability of occurrence, P

$Qt= \bar{Q}+\sigma(0.78*\ln(T)-0.45)$ for n> 50

Gumbel Method

Sr.no	year	max.flood(cumec
1	1967	7826
2	1964	6900
3	1976	6761
4	1969	6599
5	1957	5060
6	1963	5050
7	1958	4903
8	1960	4798
9	1962	4652
10	1975	4593
11	1965	4366
12	1961	4290
13	1971	4175
14	1954	4124

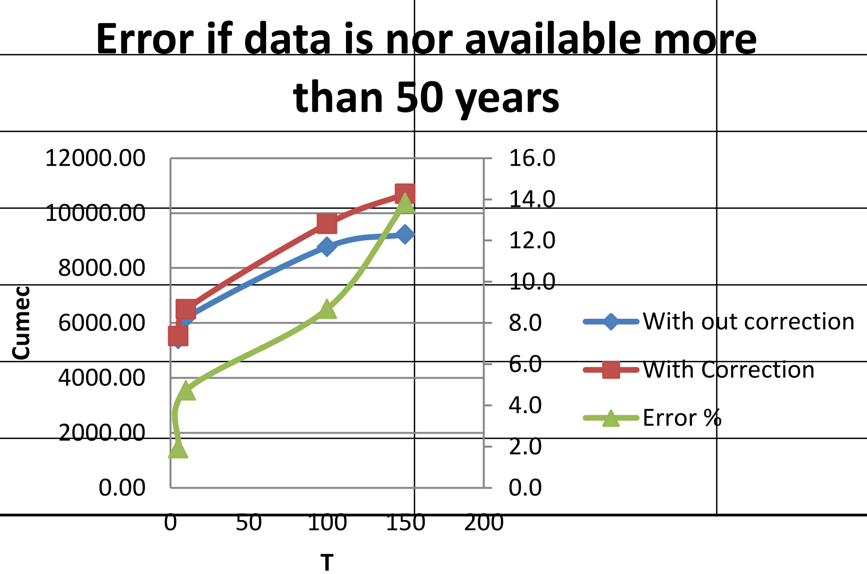
Sr.no	year	max.flood (cumec
15	1974	3873
16	1959	3757
17	1970	3700
18	1952	3521
19	1955	3496
20	1966	3380
21	1968	3320
22	1951	2947
23	1956	2947
24	1972	2947
25	1973	2709
26	1953	2399
27	1977	1971

Gumble Method of estimating frequency of floods

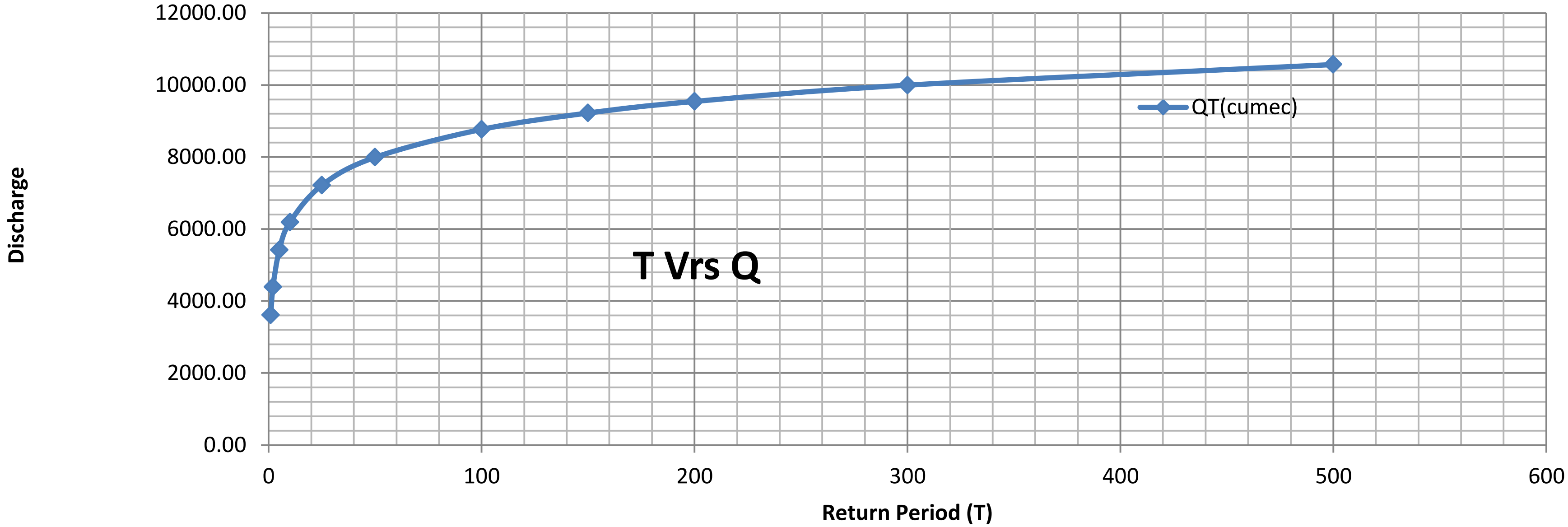
Sr.no	year	max.flood (cumec	Rank (m)	Recurrence interval (T)=n+1/m	Percent Probability (P=1/T*100	x-x¯	(x-x¯)^2	(x-x¯)^3
1	1967	7826	1.0	28.0	3.6	3564.4	12704736.1	45284385050.7
2	1964	6900	2.0	14.0	7.1	2638.4	6960998.2	18365691428.8
3	1976	6761	3.0	9.3	10.7	2499.4	6246852.2	15613197417.4
4	1969	6599	4.0	7.0	14.3	2337.4	5463300.2	12769756124.8
5	1957	5060	5.0	5.6	17.9	798.4	637395.2	508877480.4
6	1963	5050	6.0	4.7	21.4	788.4	621527.8	489994134.1
7	1958	4903	7.0	4.0	25.0	641.4	411356.0	263831519.3
8	1960	4798	8.0	3.5	28.6	536.4	287693.2	154310094.4
9	1962	4652	9.0	3.1	32.1	390.4	152389.0	59488160.5
10	1975	4593	10.0	2.8	35.7	331.4	109806.3	36386561.7
11	1965	4366	11.0	2.5	39.3	104.4	10893.2	1136924.6
12	1961	4290	12.0	2.3	42.9	28.4	804.9	22834.7
13	1971	4175	13.0	2.2	46.4	-86.6	7504.7	-650128.8
14	1954	4124	14.0	2.0	50.0	-137.6	18941.9	-2606968.7
15	1974	3873	15.0	1.9	53.6	-388.6	151033.0	-58695894.6
16	1959	3757	16.0	1.8	57.1	-504.6	254651.1	-128504471.7
17	1970	3700	17.0	1.6	60.7	-561.6	315427.8	-177153621.4
18	1952	3521	18.0	1.6	64.3	-740.6	548532.2	-406259235.9
19	1955	3496	19.0	1.5	67.9	-765.6	586188.7	-448803460.1
20	1966	3380	20.0	1.4	71.4	-881.6	777270.8	-685264970.9
21	1968	3320	21.0	1.3	75.0	-941.6	886666.4	-834911315.6
22	1951	2947	24.0	1.2	85.7	-1314.6	1728251.1	-2272010055.0
23	1956	2947	24.0	1.2	85.7	-1314.6	1728251.1	-2272010055.0
24	1972	2947	24.0	1.2	85.7	-1314.6	1728251.1	-2272010055.0
25	1973	2709	25.0	1.1	89.3	-1552.6	2410658.8	-3742860228.3
26	1953	2399	26.0	1.1	92.9	-1862.6	3469389.1	-6462187003.6
27	1977	1971	27.0	1.0	96.4	-2290.6	5246984.1	-12018897246.0
		115064					53465754.3	61764253021.0

max.flood(cumec	reduced variate y = (x-x‾) + 0.45*σ/0.78*σ	-exp(-y)	EXP(-EXP(-y))	EXP(-EXP(-y)) =e^- (e^(-y)	Recurrence Interval yr T=1/(1-e^-e^-y)	Percent probability (P=1/T*100
7826	3.76	-0.02	0.9771	0.9771	43.6	2.29
6900	2.94	-0.05	0.9483	0.9483	19.3	5.17
6761	2.81	-0.06	0.9417	0.9417	17.1	5.83
6599	2.67	-0.07	0.9329	0.9329	14.9	6.71
5060	1.29	-0.28	0.7595	0.7595	4.2	24.05
5050	1.28	-0.28	0.7576	0.7576	4.1	24.24
4903	1.15	-0.32	0.7287	0.7287	3.7	27.13
4798	1.06	-0.35	0.7063	0.7063	3.4	29.37
4652	0.93	-0.40	0.6729	0.6729	3.1	32.71
4593	0.87	-0.42	0.6586	0.6586	2.9	34.14
4366	0.67	-0.51	0.5995	0.5995	2.5	40.05
4290	0.60	-0.55	0.5784	0.5784	2.4	42.16
4175	0.50	-0.61	0.5451	0.5451	2.2	45.49
4124	0.45	-0.64	0.5299	0.5299	2.1	47.01
3873	0.23	-0.79	0.4516	0.4516	1.8	54.84
3757	0.13	-0.88	0.4140	0.4140	1.7	58.60
3700	0.07	-0.93	0.3954	0.3954	1.7	60.46
3521	-0.09	-1.09	0.3366	0.3366	1.5	66.34
3496	-0.11	-1.11	0.3284	0.3284	1.5	67.16
3380	-0.21	-1.24	0.2908	0.2908	1.4	70.92
3320	-0.26	-1.30	0.2716	0.2716	1.4	72.84
2947	-0.60	-1.82	0.1622	0.1622	1.2	83.78
2947	-0.60	-1.82	0.1622	0.1622	1.2	83.78
2947	-0.60	-1.82	0.1622	0.1622	1.2	83.78
2709	-0.81	-2.25	0.1053	0.1053	1.1	89.47
2399	-1.09	-2.97	0.0513	0.0513	1.1	94.87
1971	-1.47	-4.35	0.0129	0.0129	1.0	98.71
			1.0000			

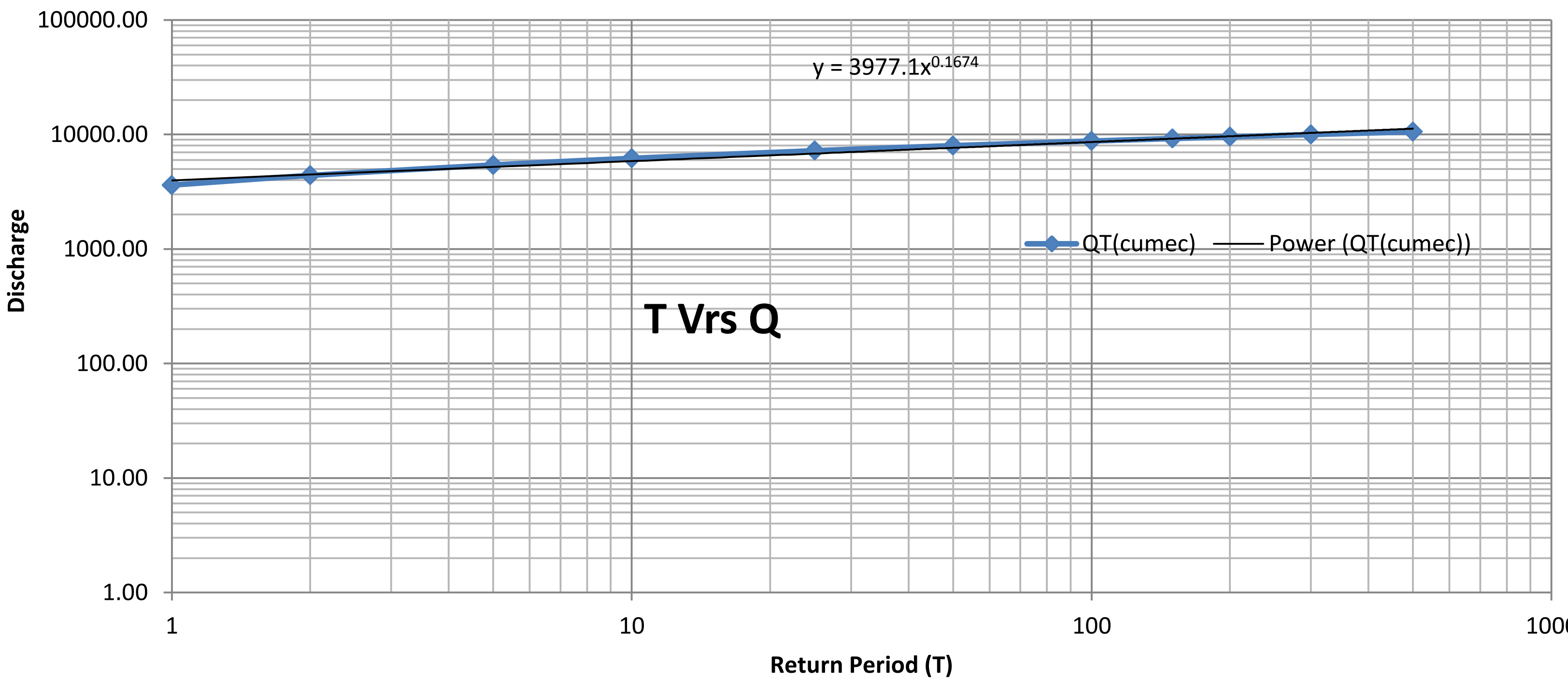
Mean (cumec)	4261.63	T(Recurring Period)	QT(cumec)	Probability (P)=(1/T)*100
n	27	500	10567.52	0.20
std	1434.01	300	9996.15	0.33
Cof var	0.34	200	9542.63	0.50
Coef of Skewness (Cs)	0.81	150	9220.85	0.67
		100	8767.33	1.00
		50	7992.02	2.00
		25	7216.72	4.00
		10	6191.83	10.00
		5	5416.52	20.00
		2	4391.63	50.00
		1	3616.33	100.00



$$QT=Qav+std(0.78*\ln(T)-0.45)$$



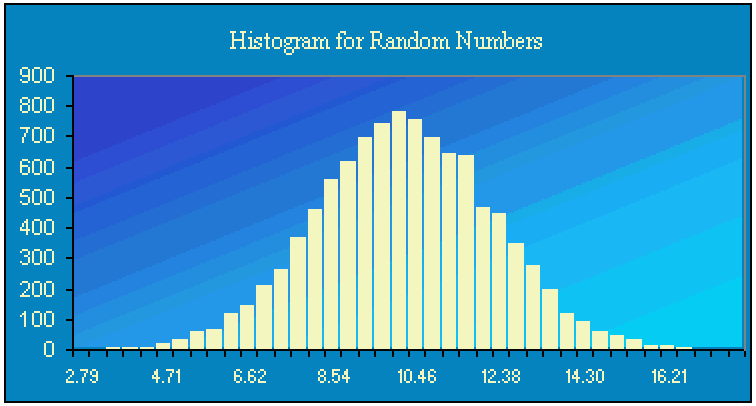
Discharge
12000.00
10000.00
8000.00
6000.00
4000.00
2000.00
0.00
0
100
200
300
400
500
600
Return Period (T)
QT(cumec)
T Vrs Q



Discharge
100000.00
10000.00
1000.00
100.00
10.00
1.00
1
10
100
1000
Return Period (T)
y = 3977.1x^0.1674
QT(cumec)
Power (QT(cumec))
T Vrs Q

Log Pearson Type III Distribution

(3)



Log Pearson Type III Distribution

Cs= N*Σ(z-z¯)^3/((n-1)*(n-2)*σz^3) or Σ(z-z¯)^3/((n-1)*(σz^3))

Cs'=Cs*((1+8.5)/N)

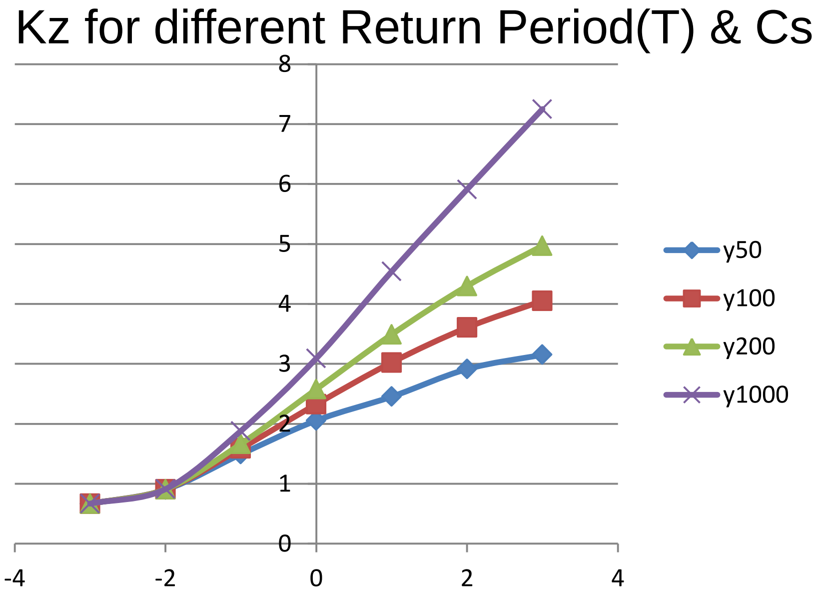
z= logx

zt=Z¯+Kz*σz

Xt= Antilog of ZT

Kz is read from tables Cs versus T

Kz for different Return Period(T) & Cs				
Cs	y50	y100	y200	y1000
3	3.152	4.051	4.970	7.250
2	2.912	3.605	4.298	5.910
1	2.452	3.022	3.489	4.540
0	2.054	2.326	2.576	3.090
-0.1	2.000	2.252	2.482	2.950
-0.2	1.945	2.178	2.388	2.810
-0.3	1.890	2.104	2.294	2.675
-1	1.492	1.588	1.664	1.880
-2	0.900	0.905	0.907	0.910
-3	0.666	0.667	0.667	0.668



Sr.no	year	x(cumec)	z=log (x)	z mean	z-z¯	(z-z¯)^2	(z-z¯)^3
1	1951	2947	3.4694	3.5675	-0.0981	0.0096	-0.0009

Sr.no	year	x	z=log (x)	z mean	z-z¯	(z-z¯)^2	(z-z¯)^3
1	1951	2947	3.4694	3.5675	-0.0981	0.0096	-0.0009
2	1952	3521	3.5467	3.5675	-0.0208	0.0004	0.0000
3	1953	2399	3.3800	3.5675	-0.1875	0.0351	-0.0066
4	1954	4124	3.6153	3.5675	0.0478	0.0023	0.0001
5	1955	3496	3.5436	3.5675	-0.0239	0.0006	0.0000
6	1956	2947	3.4694	3.5675	-0.0981	0.0096	-0.0009
7	1957	5060	3.7042	3.5675	0.1367	0.0187	0.0026
8	1958	4903	3.6905	3.5675	0.1230	0.0151	0.0019
9	1959	3757	3.5748	3.5675	0.0074	0.0001	0.0000
10	1960	4798	3.6811	3.5675	0.1136	0.0129	0.0015
			3.5675			0.1044	-0.0025

zT=Z¯+Kz*σz

Cs= N*Σ(z-z¯)^3/((n-1)*(n-2)*σz^3) or Σ(z-z¯)^3/((n-1)*(σz^3))

n=	10
mean	3.57
σ_z	0.11
Cv	1.03

Cs'=Cs*((1+8.5)/N)

Cs	-0.223218134
Cs'	-0.212057227

standard Deviation(σ)=	**σ=sqrt(Σ(x-x¯)^2/(n-1))**
Coeff.Variation (Cv)=	**Cv=σ/x¯**

Kz for different Return Period(T) & Cs				
Cs	y50	y100	y200	y1000
-0.1	2.000	2.252	2.482	2.950
-0.2	1.945	2.178	2.388	2.810
-0.3	1.890	2.104	2.294	2.675
	1.9175	2.141	2.341	2.7425

Results

T Years	Kz	Kzσ	zt	xt=antilog of zt (cumec)
50	1.92	0.21	3.77	5952.8
100	2.14	0.23	3.80	6292.2
200	2.34	0.25	3.82	6612.3
1000	2.74	0.30	3.86	7304.8

$$zT = \bar{Z} + Kz * \sigma z$$

Design Flood Estimation

- Standard Project Flood (SPF)
  - Flood likely to occur. This is normally about 0.8 of MPF
- Maximum Probable flood (MPF)
  - Maximum flood that can occur
- Spillway design floods
- Design Flood
  - The actual flood estimates for designing any structures

Special Projects Flood, GOG

Government of Gujarat

Qspf= 0.8*a*C^b

a=29.0402

b=0.9232

C=Area (sq.Km)

Factors a and b for Standard project flood method		
Area	a	b
Saurashtra	**29.0402**	**0.9232**
Loni	67.3697	0.6485
Banas	67.3697	0.6485
Kutch	67.3697	0.6485
Saurashtra	29.0402	0.9232
Sabarmati	54.5883	0.7638
Upper Narmada	54.5883	0.7638
Bhardra	54.5883	0.7638
Lower Narmada	62.2587	0.7765
Lower Tapti	62.2587	0.7765
East Tapti	53.4564	0.8812