Solutions Manual

INTRODUCTION TO HYDROLOGY

FIFTH EDITION

Warren Viessman, Jr.
University of Florida

Gary L. Lewis
Consulting Engineer

Prentice Hall

Pearson Education, Inc.
Upper Saddle River, New Jersey 07458

Acquisitions Editor: Laura Fischer
Supplement Editor: Erin Katchmar
Executive Managing Editor: Vince O'Brien
Managing Editor: David A. George
Production Editor: Barbara A. Till
Supplement Cover Manager: Daniel Sandin
Manufacturing Buyer: Ilene Kahn

Printed in the United States of America

10 9 8 7 6 5 4 3 2 1

ISBN 0-13-008100-0

Pearson Education Ltd., *London*
Pearson Education Australia Pty. Ltd., *Sydney*
Pearson Education Singapore, Pte. Ltd.
Pearson Education North Asia Ltd., *Hong Kong*
Pearson Education Canada, Inc., *Toronto*
Pearson Educación de Mexico, S.A. de C.V.
Pearson Education—Japan, *Tokyo*
Pearson Education Malaysia, Pte. Ltd.
Pearson Education, Inc., Upper Saddle River, New Jersey

Contents

1	Introduction	1
2	Hydrologic Measurements and Data Sources	2
3	Statistical Methods in Hydrology	3
4	Precipitation	26
5	Interception and Depression Storage	33
6	Evaporation and Transpiration	34
7	Infiltration	37
8	Surface Water Hydrology	42
9	Hydrographs	46
10	Groundwater Hydrology	92
11	Urban Hydrology	103
12	Hydrologic Simulation and Streamflow Synthesis	109
13	Hydrology in Design	126

CHAPTER 1

1.1 $100*10^6*0.02 = 2*10^6$ m^3
1 acre-ft = 43,560 cubic feet
cubic meters*35.31 = cubic feet
$(2*10^6*35.31)/43,560 = 1,612.2$ acre-ft

1.2 volume/volume per unit time = time
(500,000*0.3)/(0.5) = 300,000 sec.
300,000/3,600 = 83.3 hours

1.3 (450 + 500)/2 - (500 + 530)/2 = avg. inflow - avg. outflow
the change in storage is thus - 40 cfs
-40*3600/43560 = -3.31, the change in storage in acre-ft.
The initial storage is thus depleted by 3.31 ac-ft
3.31*43,560/35.31 = 4,083 cubic meters

1.4 125/365 = 0.34 cm/day = 0.035 cm/day
0.34/2.54 = 0.13 in./day

1.5 volume = 5280*5280*0.5 = 13,939,220 cubic feet
V/Q = time
13,939,220*3600/12 = 1,161,600 sec, or 322.7 hr, or 13.4 days

1.6 ET = P - R
$R = (140*3600*24*365)/(10,.000*1000^2) =$
0.44 m/yr or 44 cm/yr
ET = 105 - 44 = 61 cm/yr
This is a crude estimate.

1.7 equivalent depth = vol/area
inflow = 25*3600*24*365 = 788,400 cubic feet/yr
inflow/(3650*43560) = 4.96 ft/yr
E = 100*365/3650 = 10.0 ft/yr
Hence there is a drop in level of 5.04 ft

1.8 Iavg. - Oavg. = change in storage per unit time
(20 - 18)*3600 = 7,200 cubic meters
The storage is thus increased by 7,200 cubic meters
resulting in a final storage of 27,200 cubic meters

CHAPTER 2

Problems in this chapter are to be developed by the instructor.

CHAPTER 3

3.1 – 3.4 To be assigned by instructor.

3.5 For the James River rainfall:

Interval in.	f	Σf	P(x)	F(x)
(36-37)	2	2	0.057	0.057
(38-39)	4	6	0.114	0.171
(40-41)	7	13	0.200	0.371
(42-43)	9	22	0.257	0.628
(44-45)	5	27	0.143	0.771
(46-47)	4	31	0.114	0.885
(48-49)	2	33	0.057	0.942
(50-51)	2	35	0.057	0.999 1.000

a) $P(MAR \geq 40) = 1.000 - 0.171 = 0.829 = 82.9\%$

b) $P(MAR \geq 50) = 0.057 = 5.7\%$

c) $P(40 \leq MAR \leq 50) = 0.942 - 0.171 = 0.771 = 77.1\%$

3.6 Using the curve data for a standard normal curve (Table B.1) requires standardization of the limits of the integral,

$$z = \frac{x - \bar{x}}{S} = \frac{8 - 4}{2} = 2$$

From Table B.1, the integral is the area to the right of F(z = 2), or 0.5 - 0.4772 = 0.0228.

3.7 For the data given:

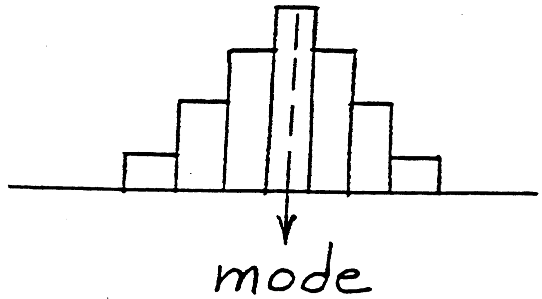
a) The area under the curve must be 1.0 to qualify as a probability density function,

$$A = \int_0^b f(x)dx = \frac{b^3}{8} \doteq 1.0$$

This gives b = 2.0

b) This is the area between 0.0 and 0.5, or $0.5^3/8 = 0.016$

3.8 The histogram is symmetric, has zero skew, and mean = median = mode.



Sketch for Prob. 3.8

Since area to right of mode is 50%, F(mode) = 50% and T = 2 yr.

3.9 Given $\bar{x} = 10.3$, $s = 1.1$, $C_v = 0.11$, $n = 20$

$$S.E.(\bar{x}) = s/\sqrt{n} = 1.1/\sqrt{20} = 0.245$$

$$S.E.(s) = s/\sqrt{2n} = 1.1/\sqrt{40} = 0.0174$$

$$S.E.(C_v) = C_v\sqrt{1+2C^2}/\sqrt{2n} = 0.11\sqrt{1+2(.11)^2}/\sqrt{40} = 0.017$$

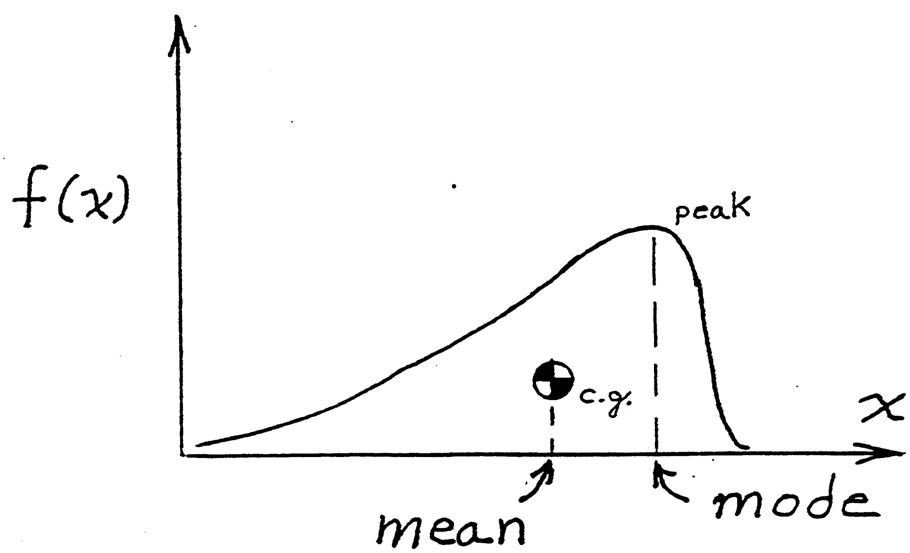
95 % C.L.: $z = \pm 1.96$

$$\bar{x} \pm 1.96\,(S.E._{\bar{x}}) = 10.3 \pm 0.48$$

$= \{10.78 \text{ to } 9.82\}$

3.10 Because the median divides the area in half, most of the area would be to the right of the median. The distribution is probably skewed right.

3.11 Sketch:



Sketch of p.d.f. for Prob. 3.11

a) Left skewed

b) Negative because Pearson skew = (mean - mode)/s_x

3.12 For the 30,000 cfs value:

$$T_r = \frac{60 \text{ yrs}}{3 \text{ times}} = \underline{\underline{20 \text{ yrs}}}$$

3.13 Frequency analysis:

a)

m rank	Peak value	$F = \frac{m}{10}$	$T_r = 1/F$
1	1000	.1	10
2	900	.2	5
3	800	.3	3.33
4	700	.4	2.5
5	600	.	.
6	500	.	.
7	400	.	
8	300		
9	200		
10	100		

By interpolation, 4-yr value is

$$800 + \frac{4 - 3.33}{5 - 3.33}(100)$$

$$= 840 \text{ cfs}$$

b) Using Table B.1,

$$Q_{4\text{-yr}} = \bar{Q} + K\, s_Q = 550 + .67(300) = 750 \text{ cfs}$$

3.14 For an annual precipitation of 30 in.

a) $P(x \geq 30) = G(30)$

$z = (30 - 27.6)/6.06 = 0.396$

$F(z) = 0.15392$

$G(30) = 0.5 - 0.15392 = 0.346$

b) Risk in 3 years $= 1 - (1 - G(30))^3$

$= 0.720$

c) P(all three years) $= G(30)^3 = 0.041$

3.15 $P(E_1 \cup E_2) = P(E_1) + P(E_2) - P(E_1 \cap E_2)$

a) If E_1 and E_2 are independent, $P(E_1|E_2) = P(E_1)$
and $P(E_1 \cap E_2) = P(E_1) \times P(E_2)$
$P(E_1 \cup E_2) = 0.3 + 0.3 - 0.3 \times 0.3 = 0.51$

b) If dependent, with $P(E_1|E_2) = 0.1$,

$P(E_1 \cap E_2) = 0.1 \times 0.3 = 0.03$
and $P(E_1 \cup E_2) = 0.3 + 0.3 - 0.03 = 0.57$

3.16 $P(A) = 0.4$, $P(\text{no } A) = P(\bar{A}) = 1 - 0.4 = 0.6$

$P(B) = 0.5$, $P(\text{no } B) = P(\bar{B}) = 1 - 0.5 = 0.5$;

A and B independent

a) $P(A \cap B) = P(A) \times P(B) = 0.4 \times 0.5 = 0.20$

b) $P(A \cap B) = P(\bar{A}) \times P(\bar{B}) = 0.6 \times 0.5 = 0.30$

3.17 $P(E_1|E_2) = 0.9$, $P(E_2|E_1) = 0.2$, $P(E_1 \cap E_2) = 0.1$
$P(E_1) = P(E_1 \cap E_2)/P(E_2|E_1) = 0.1/0.2 = 0.5$
$P(E_2) = P(E_1 \cap E_2)/P(E_1|E_2) = 0.1/0.9 = 0.111$

3.18 Two random events that are:

a) Mutually exclusive:
A: Precipitation today exceeds 4 in.
B: Precipitation today does not exceed 3"

b) Dependent:
A: Precipitation today exceeds 4 in.
B: Runoff today exceeds 1 in.

c) Mutually exclusive and dependent:
A: Precipitation today does not exceed 4 in.
B: Runoff today exceeds 6 in.

d) Neither mutually exclusive nor dependent:
A: Today's precipitation exceeds 4 in.

B: Groundwater pumpage this year will exceed 3 acre-feet per acre

3.19 $P(A) = 0.4, \; P(B) = 0.5$

a) $P(A \cap B) = P(A)\,P(B|A) = 0.4(0.5) = 0.20$

b) $P(\bar{A} \cap \bar{B}) = 0.6(0.5) = 0.30$

c) $P(\bar{A} \cap \bar{B}) = P(A)\,P(B) = 0.6(0.5) = 0.30$

3.20 For the given data:

a) Only if $P(B|A) = P(B)$

Now, $P(B) = 0.6$

$$P(B|A) = \frac{P(A \text{ and } B)}{P(A)}$$

Since $P(A \text{ and } B) = 0.2$ and $P(A) = 0.4$

$$P(B|A) = \frac{0.2}{0.4} = 0.5, \text{ Dependent}$$

b) No, mutually exclusive if $P(A \text{ and } B) = 0$, but $P(A \text{ and } B) = 0.2$

c) $P(B) = 0.6$

d) $P(\bar{A}) = 1 - 0.4 = 0.6$

e) $P(\bar{A} \text{ and } \bar{B}) = P(\bar{B}|\bar{A})\,P(\bar{A})$

From data, P(both) = 0.2

Check: $P(\bar{A} \text{ and } \bar{B}) = 1 - P(E_1) - P(E_2) - P(E_3)$

Possibles:	Warm Mar	Cold Mar	Warm Mar	Cold Mar
	Apr Flood	Apr Flood	Apr Dry	Apr Dry
	P = 0.2	P = 0.4	P = 0.2	P = 0.2

f) $P(B/A) = 0.5$

g) to make them independent,

$$P(B|A) = P(B)$$
Since $P(B) = 0.6$

$$P(B|A) = \frac{P(A \text{ and } B)}{P(A)} = \frac{0.2}{0.4} = 0.5$$

Change P(B) to 0.5, without changing P(A and B)

3.21 A: Flood
B: Ice-jam

$P(A \text{ and } B) = P(A|B)P(B)$, thus $P(A \text{ and } B) < P(A|B)$
and $P(A \text{ and } B) < P(A)$

Also $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$
Also $P(A) < P(A|B)$ because $B < S$
Ranking: Largest = P(A or B)
Second = P(A|B)
Third = P(A)
Fourth = P(A and B)

3.22 For the information given:

a) Both statements say the same thing when $\underline{\underline{n}} = \underline{\underline{t}} = T_r$ years,
or $T_r = 1$ yr

b) First:

$$\left(1 - \frac{1}{T}\right)^{t-1} = \left(1 - \frac{1}{3}\right)^{t-1} = \left(\frac{2}{3}\right)^2 = \frac{4}{9} = 0.444$$

Second: P = Probability annual precipitation value will not be equaled or exceeded in any single year,

$$P = 1 - F_X = 1 - \frac{1}{3} = \frac{2}{3}$$

$$\frac{n!}{r!\,(n-r!)} P^{n-r} (1-P)^r = \frac{3!}{1!\,(2)!} \left(\frac{2}{3}\right)^{3-1} \left(1 - \frac{2}{3}\right)^1 = \underline{\underline{4/9}}$$

3.23 For risk = 50%, $R = 0.5 = 1-(1 - 1/T)^2$

for 2 consecutive yr
Solution gives $T = 3.41$ yr
For risk = 100%, $R = 1 = 1-(1-1/T)^2$, $T = 1$ yr

3.24 For the temporary cofferdam:

a) P(overtopping in any yr) = P(F) = 1/T = /20 = 0.05

b) P(non-exceed in yr 1 and non-exceed in yr 2 and exceed in yr 3) = P(F) x P(F) x P(F) = 0.95 x 0.95 x 0.5 = 0.451

c) Risk = $1-(1 - 1/T)^n$

$$1-(1 - 1/20)^5 = 0.226$$

d) P(non-exceed in 5 consecutive yr)

$$= (1 - 1/20)^5 = 0.774$$

3.25 For N = 33, median = 17th largest flow.

Defining Q as the annual peak:

a) P(Q exceeds median) = 17/33 = 0.515

b) $T_r = 1/G(Q) = 1/0.515 = 1.94$ yrs.

c) G(Q) = 0.515 in any year.

d) 1 - G(Q) = 0.485

e) P(Q < median in all 10 yrs)

$$= P(Q \cap Q \cap Q \cap Q...) = (0.485)^{10} = 0.00072$$

f) P(Q ≥ median at least once in 10 years)

$$= 1 - (1 - G(Q))^{10} = 0.99928$$

g) P(Q_1 and Q_2 exceed median)

$$= P(Q_1)\ P(Q_2)$$
$$= G(Q)\ G(Q) = 0.265$$

h) P(Q_1 exceeds median and Q_2 does not)

$$G(Q)(1-G(Q)) = 0.250$$

3.26 For the temporary floodwall:

a) P(overtopping in any yr) = P(F) = 1/T = 1/20 = 0.05

b) P(non-exceed in 3 consecutive yr) = $(1 - P(F))^3$

$$= P(\bar{F})^3 = 0.95^3 = 0.857$$

c) Risk = $1-(1-1/T)^N = 1-(1 - 1/20)^3 = 0.143$

d) P(exceed in 1st yr only or exceed in 2nd yr only or 3rd yr only)

= P(in 1st yr only) + P(in 2nd yr only) + P(in 3rd yr only)

$$= P(F) \times P(\bar{F}) \times P(\bar{F}) + P(\bar{F}) \times P(F) \times P(\bar{F})$$
$$+ P(\bar{F}) \times P(\bar{F}) \times P(F)$$
$$= (0.05)(0.95)(0.95) + (0.95)(0.05)(0.95) + (0.95)(0.95)(0.05) = 0.135$$

e) P(exceed in 3rd yr exactly) = $P(\bar{F}) \times P(\bar{F}) \times P(F) = (0.95)(0.95)(0.05) = 0.045$

3.27 The owner's acceptance level is:

$Risk = 1 - (1 - 1/T_r)^n = 0.25$
Substitution of $n = 20$ gives $T_r = 70$ yrs, thus the wall should be between 8.5 and 10.0 ft, or interpolating, 9.1 ft.

3.28 For Oak Creek:

a) Freq. = m/N = 3/60 = 0.05
b) P(F) = freq. = 0.05
c) T = 1/P(F) = 1/0.05 = 20 yr

d) $P(\bar{F}) = 1\text{-}P(F) = 1 - 0.05 = 0.95$

e) P(non-exceed in two consecutive yr) = $P(\bar{F}) \times P(\bar{F}) = 0.95 \times 0.95 = 0.9025$

f) P(one or more exceed in 20 yr)=Risk
$= 1 - (1 - 1/T)^N$
$= 1 - (1 - 0.05)^{20} = 0.642$

g) P(non-exceed in one yr and exceed in next yr)

$= P(\bar{F}) \times P(F)$

$= 0.95 \times 0.05 = 0.0475$

h) Using Binomial Theorem, P(3 occurrences in 60 yr)
= P(x in n)
$= [n!/x!(n\text{-}x)!]p^x(1\text{-}p)^{n-x}$
$= [60!/3!\ 57!](0.05)^3(0.95)^{57} = 0.230$

i) Same as part f).

3.29 For Anniston, Alabama,

Mean rain = 57.2 in.
Standard deviation = 15.5 in.
100-yr X = 57.2 + K (15.5)
From Appendix B, K for 0.01 = 2.326,
$X_{100} = 93.2$ in.
The 1988 depth of 99 inches was the greatest depth of record. It has an apparent recurrence interval of 23 years. If the rain is normally distributed,
$99 = 57.2 + K_{99}\ (15.5)$

$K_{99} = 2.697$

The area to the right of 2.697 is .49647, giving a recurrence interval of $1/.00353 = 283$ years.

3.30 $P(\mu < x < \mu + \sigma)$ = area from $z = 0$ to $z = 1 = 0.3413 = 34.13\%$

3.31 $P(\mu - 3\sigma \le X \le \mu + 3\sigma)$ = area under standard normal from -3 to +3

From Appendix C.1:
$P(\mu - 3\sigma \le x \le \mu + 3\sigma) = 2(.4987) = 0.997$ or $= 99.74\ \%$

3.32 For Normal distribution of runoff:

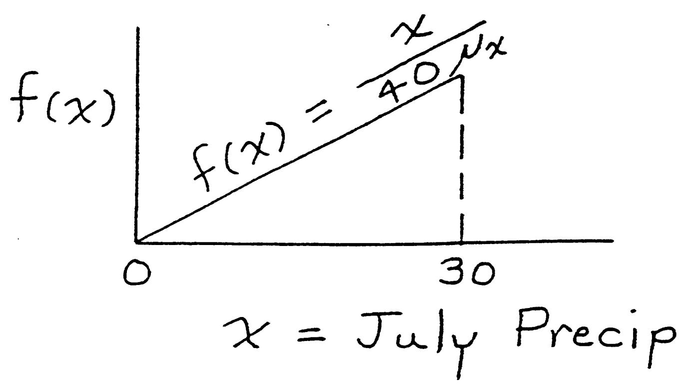
$x = \bar{x} + zs, \quad s = \sqrt{9} = 3$
$11 = 14 + 3z, \quad z = -1.0, \quad F(z) = 0.3413$
$P(x \le 11) = 0.5000 - 0.3413 = 0.1583$ in any yr
$P(x \le 11$ in 3 consecutive yrs$) = 0.1588^3 = 0.004 = 0.4\%$

3.33 From Table B.1, the standard variate, z, with area to the right of 0.330 is 0.44 (area left = $F(z) = 0.5 - 0.33 = 0.17$). Thus,

$x = \bar{x} + zs$
$= 5 + 0.44\ (1.0) = 5.44$

3.34 Since $\mu = 0$, $\sigma = 1$, then $\int_{-2}^{2} f(z)dz = 2(0.4772) = 0.9544$

3.35 Given:



Prob. 3.35 Definition Sketch

$\mu_x \approx 30$ in.

a) $P(x \leq 20 \text{ in.})$ = area left of 20 in. = 1/2bh = 0.1667

b) $P(x \geq 30 \text{ in.})$ = area right of 30 in.
= 1 - area left of 30 in.
= 1 – 15/40 = 0.625

3.36 The function is a triangle. For this shape,

a) $P(X < 20 \text{ in.})$ = area left of 20.0, or $20^2/2400$ = 0.167
b) $P(X \geq 30 \text{ in.})$ = area right of 30.0,
or 1.0 - area left of 30.0, = $1 - 30^2/2400$ = 0.625

3.37 Using Table B.1:

a.	b.	c.	d.	e.	f.	g.	h.	i.	j.
2	6	10	7	9	4	5	1	8	3

3.38 September precipitation statistics:

$\bar{x} = 65.5^\circ$, $s = \sqrt{39.3} = 6.27^\circ$

a) Approx. limits are $\bar{x} \pm s$. $F(z) = 0.33$,

$z = \pm 0.9$

$\bar{x} \pm zs = 65.5 \pm 0.97(6.27) = 65.5 \pm 6.1$

$= \{71.6 \text{ and } 59.4\}$

b) Middle 95% = 47.5% either side of mean
$F(z) = 0.475$, $z = \pm 1.96$

$\bar{x} \pm s = 65.5 \pm 1.96(6.27) = 65.5 \pm 12.3$
$= \{77.8 \text{ and } 53.2\}$

c) $F(z) = 0.80 - 0.50 = 0.30$; z 0.84

$x_{80} = \bar{x} + zs = 65.5 + 0.84(6.27)$
$= 65.5 + 5.3 = 70.8^\circ$

d) 10-yr $F(z) = 0.50 - 0.10 = 0.40$, $z = 1.28$

$x_{90} = \bar{x} + zs = 65.5 + 1.28(6.27) = 73.5^\circ$

100-yr $F(z) = 0.50 - 0.01 = 0.49$, $z = 2.33$

$x_{99} = \bar{x} + zs = 65.5 + 2.33(6.27) = 8.01°$

3.39 $\bar{x} = 3275$; s (computed) = 442, graphical est. at $(x_{84.1} - x_{15.9})/2$

3.40 30-min intensity from 60 yrs record

45 values ≥ 2.5 in./hr

5-yrs, none > 2.5 in./hr

a) T_r of 2.5 in./hr by P-D series:

$$= \frac{100}{F_{Kimball}} = \frac{100}{m/N+1} = \frac{100(61)}{85} = \underline{\underline{0.72\text{ yrs}}}$$

b) T_r of 2.5 in./hr by annual series:

$$= \frac{100}{F} = \frac{100(61)}{55} = \underline{\underline{1.11\text{ yrs}}}$$

3.41 For the peaks given:

Order (m)	Annual Series (Q)	Partial Series (Q)	T = (n + 1)/m
1	800	800	11.0
2	700	700	5.50
3	400	700	3.67
4	300	400	2.75
5	100	300	2.20
6	80	100	1.83
7	80	90	1.57
8	60	90	1.37
9	40	90	1.22
10(=n)	30	80	1.10

Q_{100} (Annual Series): T = 2.20 yrs
Q_{100} (Partial Series): T = 1.83 yrs

3.42 For the data given:

a) Annual series:

Yr	Value	T_r =N/m = 10/m
69	6"	10
71	5"	5
68	4"	3.33
66	3"	2.5
63	2"	2

Thus, 2" value has T_r = 2 years

b) Partial-Duration series:

Value	T_r = 10/m
6	10
5	3.33
5	3.33
4	2.5
3	2
2	10/6

Thus, 2" value has Tr = 10/6 yrs = 1.67 yrs

c)

Value	T_r
6"	10
5"	3.333

Interpolating, X_8 = 6 in. – 2/6.67 (1 in.) = 5.70 in.

If interpolate by frequency:

X	F_x
6"	.1
x	.125
5	.3

Giving,
X_8 = 5 + 0.175/0.2 (1) = 5.875 in.
(Either answer OK)

3.43 For the data given:

a) For partial series, the 30-min value was equaled or exceeded 85 times, thus
T = n+1/m = 61/85 = 0.72

b) For annual series, m = 55 and
T = 61/55 = 1.109

3.44 The function would be linear on:

a) Probability (Normal) paper

b) Extreme-value (Gumbel) paper
c) Rectangular coordinate paper ($Y = 3X+4$)
d) Log-probability paper (Lognormal)
e) Probability (A Pearson III with $g = 0$ is normal) paper

f) Log-Log ($\bar{Q} = 43\ A^{0.7}$)
g) Log-probability paper (same as log-normal = Log-Pearson III with $g_{logs} = 0$
h) None (Pearson III with $g = 3$)

3.45 $Cs_x = 0.879$ $Cs_y = 0.2775$

Log normal Est.	50-yr	100-yr
$K(C_s = 0)$	2.054	2.326
$y = \bar{y} + Ks_y$	3.490	3.531
$x = \log^{-1}y$	3171 cfs	3483 cfs

Log Pearson III

$K(C_s = 0.28)$	2.201	2.530
$y = \bar{y} + Ks_y$	3.5119	3.5611
$x = \log^{-1}y$	3250 cfs	3640 cfs

Gumbel

$K(n = 20) =$	3.179	3.836
$x = \bar{x} + KS_x =$	3453 cfs	3832 cfs

3.46 $\bar{R} = 14$ in.

$s = 3$ in.
$P(R < 8$ in. in yr 2 of 3 yrs)

$= P(R > 8 \cap R < 8 \cap R > 8) = P(\bar{E})\ P(E)\ P(\bar{E})$
$P(R < 8 \text{ in.}) = F(R)$
8 in. = 14 in. + K(3 in.)
$K = (8-14)/3 = -2.0$
Thus $F(8 \text{ in.}) = P(E) = 0.5 - 0.4772 = 0.0228$
Thus P(2nd yr only) = (0.9772)(0.0228)(0.9772) = 0.022

3.47 $Q = \bar{Q} + Ks$

$32{,}000 = 30{,}000 + K(1{,}000)$
$K = 2.0$
Thus $F(Q) = 0.5 + 0.4772 = 0.9772$
$G(Q) = 0.0228$
$T_r = 43.9$ yrs

3.48 For the precipitation data given:

a) The graph would plot as a straight line on probability paper, with the mean of 27.6 having a 50% exceedance probability. A second point, or any number of points, can be generated from

$$x_T = \bar{x} + z_T\, s$$

Where z_T is the standard normal variate (Table B.1) corresponding to the value $T = 1/G(x)$ where $G(x)$ is the exceedance probability. For example, an exceedance of $G(x) = 0.33$ corresponds to $z = 0.44$ from Table B.1. The corresponding T is $1/.33 = 3.03$, and $x = 27.6 + 0.44(6.06) = \underline{30.27}$

b) Assuming the 1972 drought was the smallest value in 80 years, it has an apparent frequency of $80/81 = 0.988$. For a value of 14 in., the corresponding z is -2.24. From Table B.1, $F(z) = 0.4875$. Thus the probability of exceedance is $.4875 + 0.50 = 0.9875$.

c) The apparent recurrence interval for the highest value is 81 years, using $T = N+1/m$, where m is the rank. The normal distribution gives $z = (42 - 27.6)/6.06 = 2.376$. This gives $F(z) = 0.49122$, and $G(x) = 0.00878$. Because $T = 1/G(x)$, $T = 114$ years.

3.49 For normal distribution, $T = 2$ and $P = 1/2 = 0.5$ occurs at mean: $X = 40{,}000$ cfs

For $T = 10$ and $P = 1/10 = 0.10$, $F(z) = 0.50 - 0.10 = 0.40$: $z = 1.282$

Therefore, $X = \bar{X} + zs$

$52820 = 40000 + 1.28s$, $s = 10{,}000$ cfs

For $T = 25$ and $P = 1/25 = 0.04$, $F(z) = 0.50 - 0.04 = 0.46$, thus $z = 1.75$

$X_{25} = \bar{X} + zs = 4000 + 1.75(10000) = 57{,}500$ cfs

3.50 Find 25-yr flood: