Fig. D-28 Probability of Daily Rainfall at the Mungun Morit

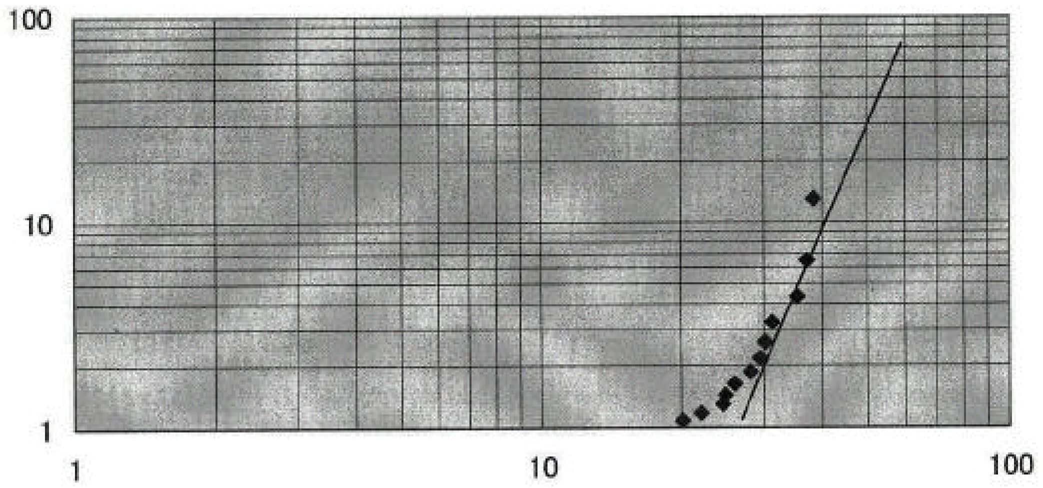


Fig. D-29 Probability of Discharge at Uiaanbaatar

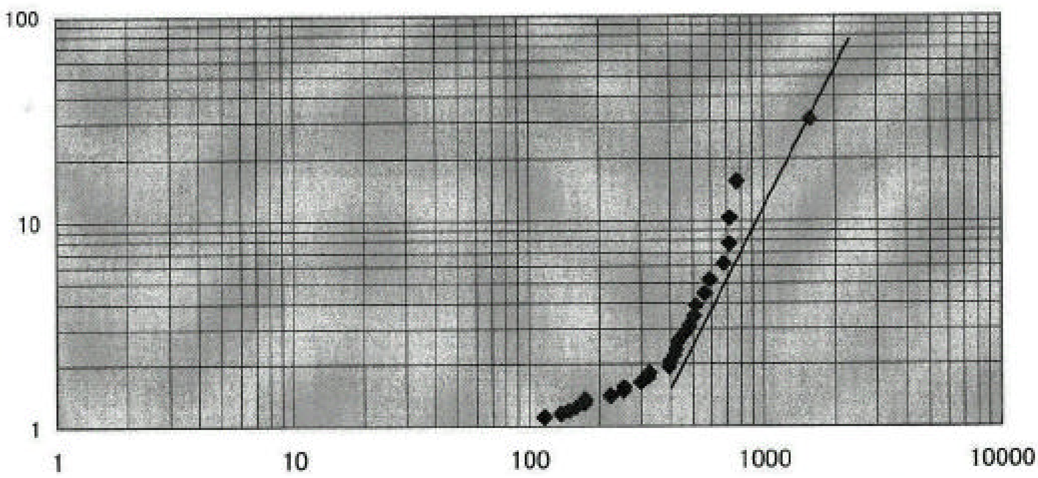
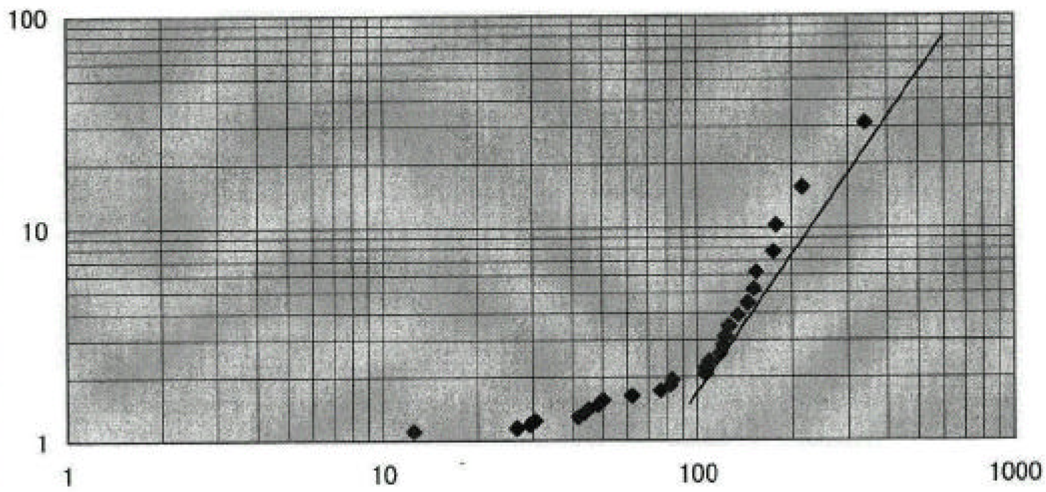


Fig. D-30 Probability of Discharge at Bosgo Bridge



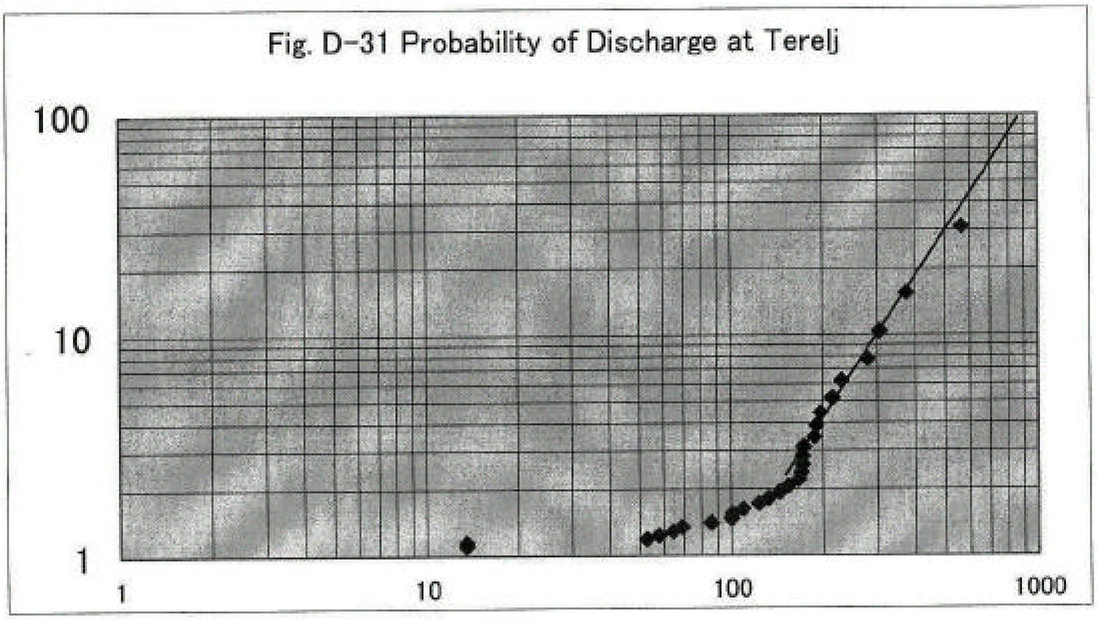


Fig. D-31 Probability of Discharge at Terelj
100
10
1
1
10
100
1000

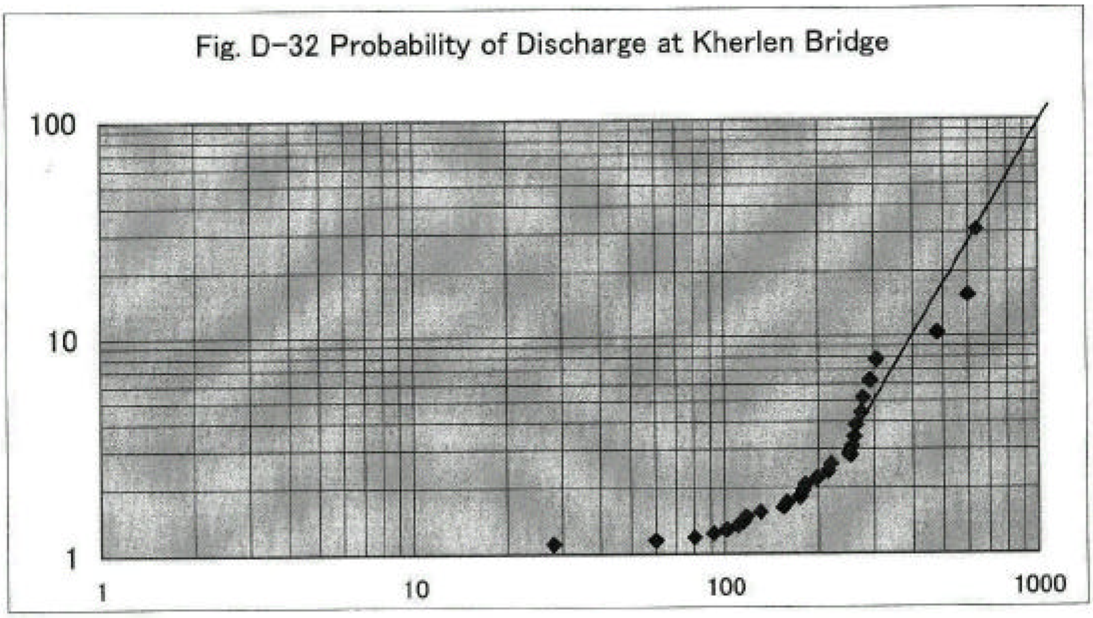


Fig. D-32 Probability of Discharge at Kherlen Bridge
100
10
1
1
10
100
1000

D-2. Precipitation and Climate Records

Table D-1 Maximum Rainfull Record in Murun River Basin

Year	Underkhaan			
	Yearly	July	Aug.	Dayly
1970	317.5	92.8	130.8	33.0
1971	294.4	59.3	57.9	29.2
1972	169.5	18.8	19.8	7.5
1973	341.1	87.4	139.6	50.9
1974	314.9	39.1	83.9	28.7
1975	392.9	76.1	52.0	17.5
1976	249.6	46.1	38.0	8.5
1977	310.7	187.4	10.6	53.8
1978	194.9	57.5	27.6	29.3
1979	197.8	51.2	38.3	10.2
1980	256.6	22.7	66.9	12.2
1981	248.3	55.9	96.2	21.8
1982	213.7	64.0	83.0	26.2
1983	301.3	105.5	106.4	39.4
1984	380.9	86.9	29.0	37.0
1985	226.4	98.7	62.8	23.2
1986	203.1	79.5	41.2	15.4
1987	287.1	95.4	66.0	36.2
1988	247.2	44.2	69.2	17.6
1989	201.6	28.6	72.7	8.1
1990	367.3	160.9	62.2	38.0
1991	211.9	38.6	59.5	22.1
1992	211.0	43.3	63.8	14.4
1993	319.9	173.3	79.6	53.5
1994	248.5	111.9	41.4	25.5
1995	167.6	33.6	46.0	37.8
1996	191.8	100.7	41.1	80.1
1997	215.4	78.7	56.1	25.6
1998	289.0	47.0	149.6	32.3
1999				97.8
2000				19.0

Table D-2 Yearly Maximum Water Level and Discharge Record

Yeary	Tuul river Basin (6380km2)						Kherlen River Basin (7100km2)			
	Ulaanbaatar S.(6380)		Bosgo BridgS(2158)		Terelj S.(1220)		K.R.B.S.(7100)		UnderkhaanS(39400)	
	W.L.Hight	Discharge	W.L.Hight	Discharge	W.L.Hight	Discharge	W.L.Hight	Discharge	W.L.Hight	Discharge
1970	158	266	77	82.1	290	-	376	-	251	127
1971	150	246	103	135	266	-	250	117	252	127
1972	52	15.9	39	12.5	169	69	254	91.9	165	23.5
1973	241	717	115	215	321	200	314	181	271	257
1974	158	370	80	126	288	93	272	79.9	243	136
1975	164	406	84	123	253	139	257	115	256	155
1976	150	360	82	106	246	116	294	260	265	159
1977	113	190	75	76.3	233	-	294	277	242	116
1978	115	194	60	48.4	225	52.7	237	130	199	48.9
1979	108	119	62	45	215	57.9	246	154	195	57.6
1980	87	80.1	48	29.3	245	123	253	178	214	79.2
1981	104	137	62	62	227	64.1	292	273	228	91
1982	140	327	94	145	242	109	269	197	234	122
1983	264	917	189	118	332	564	282	241	227	110
1984	238	345	198	151.2	264	230	325	263	279	208
1985	230	295	183	121	309	144	-	-	266	205
1986	233	291	181	109	312	279	261	110	219	94
1987	222	227	168	83.4	236	153.5	214	101	225	110.5
1988	245	375	198	154	256	196	242	-	261	135
1989	210	174	-	-	356	173	210	174	228	50.5
1990	252	507	429	343	245	166	252	638	279	248
1991	383	388	314	178	251	171	301	214	235	127
1992	208	323	330	175	223	101	358	256.4	252	154
1993	357	678	329	340	260	190	436	480	295	230
1994	461	226	372	106	243	132.1	479	292	268	189
1995	357	80.3	323	43.7	248	98.6	462	219	262	124
1996	306	35.7	274	26.6	172	43.5	371	60.1	299	35
1997	364	78.3	308	30.4	198	82.1	419	158	241	116
1998	376	76.9	310	41.8	218	84.2	237	148	268	257
1999	316	88	293	50.3	188	48.1	200	105	162	130
1966	311	795				1961	251	598		

Table D-3 Maximum Rainfull Record in Tuul River Basin

Year	Ulaanbaatar A point				Ulaanbaatar B point			
	Yearly	July	Aug	Daily	Yearly	July	Aug	Daily
1970	230.9	59.4	73.8	19.5				
1971	369.8	76.5	84.3	28.6				
1972	59.9	21.7	3.9	-				
1973	198.7	90.1	16.1	-				
1974	189.4	62.3	57.9	-				
1975	268.8	67.3	43.8	36.0				
1976	220.2	64.7	44.1	17.7				
1977	186.6	43.8	45.2	20.5				
1978	230.2	36.1	41.5	17.0				
1979	169.3	44.2	41.1	15.0				
1980	166.2	19.4	39.0	9.8				
1981	189.5	35.4	59.9	17.9				
1982	257.0	38.9	114.4	44.2				
1983	320.7	104.3	62.1	27.1	286.9	84.8	55.6	20.4
1984	344.1	98.2	133.5	51.7	344.5	130.1	106.3	56.3
1985	214.2	56.5	31.0	14.7	248.7	82.2	48.0	31.7
1986	356.4	87.7	112.0	38.0	299.5	72.4	70.6	26.1
1987	244.7	58.8	78.9	34.2	237.0	57.1	86.1	29.4
1988	268.8	51.3	135.7	19.5	340.9	47.9	127.1	18.5
1989	180.3	40.7	52.6	17.7	184.5	38.4	54.1	20.2
1990	308.1	82.8	84.6	23.0	340.7	98.4	88.4	33.0
1991	240.9	53.4	36.8	18.6	244.7	58.6	37.0	23.1
1992	301.7	84.4	89.7	31.7	270.0	74.4	82.8	22.7
1993	381.6	156.8	76.0	46.8	380.1	143.9	100.6	35.8
1994	455.6	70.0	162.6	35.4	374.0	71.2	139.4	35.3
1995	326.8	61.4	143.5	49.8	268.7	66.1	107.9	24.3
1996	216.2	84.5	61.0	21.7	206.3	77.8	64.8	20.0
1997	217.3	114.6	33.8	28.4	233.3	110.0	42.3	35.6
1998	269.2	55.4	66.7	16.6	264.3	66.3	68.7	16.9
1999	298.8	58.8	48.4	15.5	283.0	65.1	49.4	15.1
2000	328.8	59.9	137.7	29.3	249.1	57.7	109.4	13.5

Table D-4 Maximum Rainfull Record in Tuul River Basin

Year	Ulaanbaatar C point				Terelj point			
	Yearly	July	Aug	Daily	Yearly	July	Aug	Daily
1970								
1971								
1972								
1973								
1974								
1975	237.0	54.6	30.2	17.9				
1976	240.9	84.6	29.1	24.3				
1977	153.6	30.4	54.3	28.0				
1978	196.8	34.2	31.3	11.8				
1979	206.9	48.4	44.9	15.0				
1980	185.6	22.7	47.6	14.5				
1981	143.4	33.3	40.3	8.7				
1982	239.0	49.1	63.4	13.8				
1983	262.9	70.0	55.9	22.0				
1984	309.4	86.0	104.1	37.6				
1985	293.7	110.7	58.8	37.9			v	
1986	230.7	99.3	86.6	39.0	456.1	182.1	80.0	48.8
1987	231.6	56.1	80.4	32.4	359.1	75.7	122.6	35.7
1988	346.4	59.5	112.4	25.1	478.8	81.9	181.9	36.2
1989	174.7	37.6	56.7	18.1	271.0	52.8	78.4	33.1
1990	298.0	82.9	76.8	23.9	380.9	103.6	105.9	33.0
1991	243.4	59.1	45.3	23.3	358.0	128.3	48.8	51.2
1992	248.7	74.8	104.4	21.2	419.9	172.8	94.9	45.2
1993	319.5	129.4	64.4	56.2	456.5	193.3	61.5	51.7
1994	371.6	70.5	165.0	48.8	489.1	94.3	210.3	55.5
1995	293.1	114.4	76.6	60.1	368.4	79.2	150.2	45.8
1996	151.7	34.2	54.9	11.1	309.7	102.8	77.6	20.4
1997	212.9	114.2	33.7	32.5	298.5	131.6	85.3	35.8
1998	259.3	35.6	79.5	17.0	417.3	136.2	143.5	23.2
1999	296.1	48.3	49.3	14.1	343.5	77.0	69.9	28.6
2000	221.6	44.6	95.7	16.1	280.5	58.0	99.6	37.9

Table D-5 Maximum Rainfull Record in Kherlen River Basin

Year	Baganuur city point				Mungun Morit point			
	Yearly	July	Aug	Dayly	Yearly	July	Aug	Dayly
1970								
1971								
1972								
1973								
1974								
1975								
1976								
1977								
1978								
1979								
1980								
1981								
1982								
1983								
1984								
1985								
1986								
1987								
1988								
1989					247.3	81.7	76.4	24.8
1990					322.5	73.8	136.1	31.3
1991	158.5	22.1	30.7	28.0	291.6	109.4	46.1	29.5
1992	222.4	55.1	40.8	13.2	387.2	73.6	102.5	37.1
1993	235.1	89.4	61.3	33.8	405.1	208.1	59.6	38.3
1994	217.4	43.8	52.3	14.7	365.3	69.7	138.3	35.4
1995	142.5	21.4	55.1	26.3	236.3	50.1	52.4	24.5
1996	140.5	48.6	50.4	10.5	204.1	75.6	57.2	20.1
1997	215.5	105.5	47.7	24.7	227.1	104.6	66.7	22.0
1998	329.0	76.5	136.0	48.9	325.3	80.9	98.2	30.2
1999	255.1	51.1	61.8	51.1	354.0	101.1	69.8	28.1
2000	206.8	62.5	72.7	62.5	277.7	115.1	73.5	26.0

Table D-6 Monthly Max. Min. Temperature and max. Wind Velocity in Ulaanbaatar city

Year	January			February			March			April		
	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W
1991	-9.5	-33.7	12	-4.0	-28.9	10	4.0	-23.5	9	13.9	-12.3	18
1992	-6.4	-28.6	6	8.5	-26.7	12	11.0	-19.1	12	20.5	-13.3	18
1993	-7.1	-33.4	10	-1.1	-24.6	16	11.7	-21.2	22	22.3	-15.0	19
1994	-4.4	-38.8	9	-1.5	-26.9	16	15.5	-26.6	16	20.8	-9.5	18
1995	-6.1	-29.7	15	-1.8	-29.3	10	8.7	-26.1	16	18.4	-11.8	20
1996	-5.4	-31.7	13	1.4	-29.6	15	8.6	-20.3	16	23.6	-15.6	20
1997	-7.5	-31.0	14	3.8	-25.3	12	12.0	-21.9	16	19.4	-9.1	24
1998	-11.9	-36.2	14	3.0	-28.4	12	9.0	-25.4	16	22.0	-9.3	18
1999	-2.6	-34.4	14	3.0	-25.6	14	7.0	-26.2	16	23.4	-12.4	16
2000	-13.3	-35.8	11	-1.1	-31.4	7	9.8	-20.1	15	22.1	-15.1	20
Ave	**-7.4**	**-33.3**	**11.8**	**-1.02**	**-27.7**	**12.4**	**9.7**	**-23.0**	**15.4**	**20.6**	**-12.3**	**19.1**
Year	May			June			July			August		
	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W
1991	30.5	-5.4	23	32.8	1.9	19	29.0	4.0	14	34.6	4.2	18
1992	30.5	-4.5	15	28.4	-2.7	16	31.9	8.1	14	25.4	4.4	13
1993	27.8	-8.2	23	31.0	1.3	24	25.0	4.9	14	25.2	8.7	14
1994	27.7	-2.7	22	31.v7	3.1	17	31.7	5.4	16	29.5	5.7	13
1995	23.8	-8.4	20	29.3	3.9	20	31.8	5.8	14	29.3	6.7	17
1996	30.8	-6.4	19	26.2	1.1	16	29.4	8.0	19	30.6	3.3	16
1997	26.7	-2.4	18	32.8	-0.3	18	36.7	4.5	19	29.4	4.2	14
1998	27.3	-4.9	24	27.5	0.3	24	35.3	9.1	17	25.8	5.1	13
1999	30.0	-1.3	20	32.0	4.5	20	38.1	8.8	16	33.7	2.2	15
2000	27.9	-2.6	22	34.5	5.6	16	31.9	6.4	14	27.9	4.8	14
Ave	**29.3**	**-4.7**	**20.6**	**30.6**	**1.9**	**19.0**	**32.1**	**6.5**	**15.7**	**29.1**	**4.9**	**14.7**
c	Semtember			October			November			December		
	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W
1991	19.0	-2.0	15	16.5	-15.1	12	5.8	-24.1	15	-4.8	-34.5	8
1992	23.7	-4.4	16	17.0	-13.2	16	5.7	-23.3	18	-4.2	-30.5	14
1993	25.7	-4.8	14	20.5	-17.1	22	5.0	-29.7	16	-8.2	-31.2	15
1994	23.6	-5.8	18	15.0	-14.2	19	9.2	-18.2	16	-2.4	-30.6	7
1995	26.0	-6.5	14	16.3	-15.4	15	6.3	-17.7	16	-4.6	-26.6	13
1996	24.5	-3.5	16	20.6	-16.7	20	1.6	-29.1	11	-2.8	-31.0	12
1997	27.0	-3.3	16	18.0	-14.8	12	8.7	-29.7	12	-4.7	-32.1	10
1998	28.8	-0.7	15	21.7	-14.2	15	5.2	-32.2	13	-5.6	-31.7	5
1999	28.3	-2.5	16	18.4	-16.0	15	10.6	-26.1	10	-5.0	-29.1	12
2000	26.8	-2.9	14	16.4	-17.5	12	2.0	-28.5	12	-9.8	-32.6	12
Ave	**25.3**	**-3.6**	**15.4**	**16.5**	**-15.4**	**15.8**	**6.01**	**-25.9**	**13.9**	**-5.2**	**-31.0**	**10.8**

Table D-7 Monthly Max. Min. Temperature and max. Wind Velocity in Undurkhaan city

Year	January			February			March			April		
	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W
1991	-16.1	-38.2	12	-4.0	-37.0	14	0.5	-35.0	12	16.0	-17.5	20
1992	-16.0	-32.7	8	10.6	-29.1	16	12.5	-24.6	14	21.0	-19.3	20
1993	-3.5	-32.5	14	-0.1	-33.2	14	13.5	-25.0	16	23.6	-15.4	20
1994	-10.6	-36.0	10	-5.5	-32.3	14	19.0	-32.6	14	23.7	-9.0	18
1995	-4.6	-34.0	14	-1.0	-33.1	7	8.8	-26.1	18	21.1	-13.5	28
1996	-3.0	-39.5	18	-2.0	-35.4	16	15.6	-22.9	20	27.5	-16.7	24
1997	-9.5	-38.5	16	-3.2	-33.7	18	13.3	-28.0	26	20.4	-11.8	20
1998	-5.3	-33.6	14	7.4	-28.5	16	10.7	-22.2	20	24.4	-11.7	32
1999	-4.2	-36.3	16	-0.9	-29.7	14	5.4	-35.3	16	24.0	-16.8	22
2000	-14.1	-38.8	12	2.9	-34.0	14	11.3	-25.5	18	23.7	-16.1	30
Ave	**-8.7**	**-36.0**	**13.4**	**-3.8**	**-32.6**	**14.3**	**11.1**	**-27.7**	**17.4**	**22.5**	**-14.8**	**23.4**
Year	May			June			July			August		
	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W
1991	32.1	-6.1	14	34.0	-0.6	14	31.9	4.9	14	38.1	5.5	18
1992	32.6	-8.1	14	33.0	-1.5	14	35.4	7.9	14	29.0	3.6	16
1993	28.1	-4.1	20	33.2	1.7	18	27.5	3.1	16	27.2	3.6	18
1994	29.0	-3.4	18	31.8	4.4	16	30.8	7.5	22	29.9	6.4	16
1995	27.0	-6.7	20	34.4	2.3	34	33.0	4.6	28	31.8	6.7	18
1996	32.9	-10.4	34	31.5	0.0	16	30.8	6.6	16	31.2	4.2	16
1997	30.3	-5.6	20	35.9	2.9	26	38.0	6.0	18	32.9	6.6	14
1998	31.8	-4.7	30	33.2	2.6	20	33.5	10.5	14	25.3	5.7	14
1999	29.3	-3.1	18	34.4	3.2	26	38.6	9.0	22	35.2	2.5	20
2000	34.2	-4.3	20	35.9	2.7	18	37.0	7.9	24	32.9	4.0	14
Ave	**30.7**	**-5.7**	**20.8**	**33.7**	**1.8**	**20.2**	**33.7**	**6.8**	**18.8**	**31.4**	**4.9**	**16.4**
Year	Semtember			October			November			December		
	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W
1991	25.9	-6.0	18	20.0	-15.7	16	3.2	-26.0	20	-1.8	-34.9	12
1992	25.2	-3.8	15	20.6	-14.2	14	8.3	-25.9	20	-1.0	-30.3	12
1993	25.7	-3.1	18	19.6	-20.5	14	10.2	-32.9	18	-6.0	-32.3	14
1994	28.2	-6.1	20	17.6	-13.4	16	13.5	-21.9	16	-1.4	-37.8	14
1995	29.0	-7.0	20	19.4	-17.4	20	10.4	-23.6	18	-2.5	-31.2	14
1996	29.3	-8.9	18	18.9	-25.4	16	2.3	-32.4	14	-2.9	-33.9	14
1997	28.2	-4.7	16	20.1	-15.0	16	10.4	-31.7	16	0.7	-30.4	20
1998	28.3	-0.8	14	24.8	-20.3	16	9.6	-38.1	16	-5.3	-37.6	14
1999	28.6	-3.9	17	20.1	-15.4	16	9.5	-30.5	14	0.7	-31.6	14
2000	32.3	-1.9	18	17.0	-20.3	18	4.6	-34.5	22	-9.5	-35.9	14
Ave	**28.1**	**-4.6**	**17.4**	**19.8**	**-17.8**	**16.2**	**8.2**	**-29.8**	**17.4**	**-3.2**	**-33.6**	**14.2**

Table D-8 Monthly Max. Min. Temperature and max. Wind Velocity in Baganuur city

Year	January			February			March			April		
	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W
1991	-15.5	-36.3	6	-6.8	-34.5	14	1.8	-30.6	10	12.0	-16.5	18
1992	-3.2	-34.1	10	8.3	-29.5	12	9.5	-23.9	9	16.0	-18.0	15
1993	-8.9	-39.3	10	-2.8	-31.4	12	9.5	-26.3	22	21.7	-20.0	18
1994	-8.6	-38.4	16	-4.4	-32.8	14	15.5	-37.0	14	19.6	-10.4	20
1995	-7.6	-34.6	9	-2.0	-33.2	6	8.2	-28.2	20	16.5	-15.4	20
1996	-5.1	-38.5	9	3.3	-34.9	14	11.0	-25.2	14	23.0	-19.4	14
1997	-9.8	-38.0	12	1.4	-33.0	14	11.5	-28.1	18	20.1	-11.5	16
1998	-12.0	-40.0	12	3.9	-33.5	9	9.0	-23.5	17	22.0	-11.4	18
1999	-8.4	-40.5	14	-1.4	-30.0	18	2.4	-36.0	16	24.5	-17.0	16
2000	-16.0	-43.7	12	-2.0	-39.6	12	9.6	-23.5	18	20.7	-16.6	20
Ave	**-9.5**	**-38.3**	**11.0**	**-0.25**	**-33.2**	**12.5**	**8.8**	**-28.2**	**15.8**	**19.6**	**-15.6**	**17.5**

Year	May			June			July			August		
	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W
1991	28.6	-5.0	15	31.0	0.2	14	27.1	1.6	10	33.6	2.1	6
1992	27.1	-9.4	16	29.0	-6.1	10	32.0	4.6	10	23.8	-0.2	9
1993	26.6	-6.2	24	31.3	-6.1	16	24.9	5.4	16	24.5	0.4	10
1994	26.8	-4.2	16	30.2	4.0	14	28.0	5.2	9	27.4	3.8	9
1995	23.7	-11.5	14	28.1	0.2	14	31.8	2.3	9	28.4	4.3	9
1996	31.6	-9.5	14	25.9	-1.3	14	27.4	4.3	9	28.8	0.2	12
1997	31.3	-7.9	14	35.3	-1.9	14	34.7	4.4	12	28.2	1.7	10
1998	29.1	-9.3	14	26.9	-1.5	14	31.5	6.1	9	24.6	3.6	10
1999	27.5	-6.9	14	31.0	-0.4	13	35.6	5.5	9	31.2	-0.5	12
2000	28.2	-8.7	20	33.5	-0.1	12	34.2	4.5	10	27.0	0.2	16
Ave	**28.1**	**-7.9**	**16.1**	**30.2**	**-1.3**	**13.5**	**30.7**	**4.4**	**10.3**	**27.8**	**1.6**	**10.3**

Year	Semtember			October			November			December		
	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W	Max.T	Min.T	Max.W
1991	23.0	-6.8	14	16.4	-15.6	12	1.8	-29.0	12	-0.7	-20.4	8
1992	21.4	-5.7	10	16.0	-16.5	16	5.4	-26.3	12	-7.1	-33.5	14
1993	23.1	-9.8	14	19.3	-20.0	15	-0.2	-34.8	8	-9.6	-33.0	14
1994	22.6	-6.2	16	15.0	-15.2	12	8.6	-23.5	14	-3.0	-35.0	9
1995	26.0	-8.8	10	21.2	-21.9	16	8.8	-23.1	11	-5.0	-31.7	8
1996	23.5	-10.6	14	18.0	-25.0	14	3.6	-31.6	11	-0.7	-34.8	11
1997	25.5	-5.8	14	18.0	-16.3	14	7.0	-33.6	14	-8.8	-36.0	12
1998	26.2	-3.1	10	20.1	-15.1	12	5.9	-39.8	9	-4.4	-41.8	9
1999	24.4	-5.5	14	17.8	-20.9	14	7.5	-33.1	12	-3.6	-39.2	12
2000	24.6	-6.4	14	14.4	-25.5	14	3.6	-35.8	15	-10.2	-40.3	6
Ave	**24.0**	**-6.9**	**13.0**	**17.6**	**-19.2**	**13.9**	**5.2**	**-31.1**	**11.8**	**-5.3**	**-34.6**	**10.3**

Table D-9 Monthly of Rainfull Days in Underkhaan City

Year	January		February		March		April	
	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<
1991	1	-	3	-	8	-	9	-
1992	5	-	1	-	4	-	7	-
1993	3	-	3	-	5	-	1	-
1994	5	-	3	-	5	-	5	-
1995	2	-	3	-	8	-	11	-
1996	5	-	2	-	5	-	1	-
1997	3	-	4	-	1	-	3	-
1998	4	-	4	-	1	-	4	-
1999	1	-	3	-	10	-	6	-
2000	5	-	3	-	3	-	5	1
	May		June		July		August	
	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<
1991	7	-	14	1	17	-	12	2
1992	11	-	12	-	18	1	19	2
1993	6	-	13	-	13	7	15	1
1994	4	1	15	-	13	4	17	1
1995	4	-	11	2	14	1	10	1
1996	3	-	15	1	17	1	13	1
1997	8	-	13	2	18	2	13	1
1998	8	-	12	1	17	1	13	6
1999	8	-	14	2	13	-	14	2
2000	5	-	7	-	17	2	16	4
	Semtember		October		November		December	
	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<
1991	12	-	10	-	7	-	1	-
1992	7	2	5	-	4	-	7	-
1993	7	-	2	-	3	-	6	-
1994	10	-	8	-	2	-	5	-
1995	7	-	8	-	4	-	7	-
1996	5	-	6	-	8	-	4	-
1997	7	2	3	-	4	-	5	-
1998	7	1	8	-	9	-	4	-
1999	11	1	3	-	3	-	5	-
2000	4	-	8	-	10	-	4	-

Table D-10 Monthly of Rainfull Days in Ulaanbaatar City

Year	January		February		March		April	
	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<
1991	6	-	6	-	12	-	12	-
1992	4	-	6	-	2	-	8	-
1993	6	-	7	-	5	-	7	-
1994	6	-	6	-	5	-	7	-
1995	5	-	3	-	7	-	13	1
1996	6	-	5	-	10	-	5	-
1997	5	-	5	-	3	-	4	-
1998	10	-	4	-	4	-	5	-
1999	4	-	6	-	8	-	6	-
2000	10	-	3	-	6	-	10	-
	May		June		July		August	
	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<
1991	7	-	16	-	14	2	9	1
1992	9	-	12	1	17	3	23	1
1993	9	-	13	2	16	4	16	1
1994	7	-	14	1	16	2	19	4
1995	11	1	13	-	16	2	8	5
1996	8	-	14	-	12	3	16	2
1997	9	-	11	1	16	3	11	1
1998	8	-	12	2	15	2	14	3
1999	6	1	12	3	13	1	11	2
2000	9	-	11	1	14	2	14	7
	Semtember		October		November		December	
	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<
1991	12	1	10	-	12	-	9	-
1992	14	-	7	-	10	-	10	-
1993	10	1	3	-	5	-	10	1
1994	8	2	5	-	9	-	9	-
1995	8	1	7	-	5	-	10	-
1996	8	-	6	-	9	-	7	-
1997	8	-	5	-	4	-	6	-
1998	11	2	8	1	13	-	7	-
1999	8	2	6	-	6	-	11	-
2000	6	-	8	-	15	-	13	-

Table D-11 Monthly of Rainfull Days in Baganuur City

Year	January		February		March		April	
	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<
1991	1	-	3	-	6	-	8	-
1992	2	-	1	-	4	-	8	-
1993	3	-	3	-	5	-	4	-
1994	7	-	3	-	11	-	14	-
1995	1	-	1	-	7	-	9	-
1996	4	-	2	-	4	-	3	-
1997	2	-	4	-	3	-	3	-
1998	4	-	4	-	2	-	8	-
1999	2	-	1	-	11	-	5	-
2000	7	-	1	-	3	-	7	-
	May		June		July		August	
	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<
1991	3	1	11	-	17	2	13	-
1992	7	1	12	1	18	2	20	-
1993	4	-	14	1	14	3	13	3
1994	16	-	17	2	14	1	16	-
1995	8	-	14	-	16	-	11	2
1996	6	-	11	-	19	3	18	-
1997	7	-	8	-	15	3	8	2
1998	5	-	12	-	13	3	17	4
1999	8	-	16	2	15	-	18	2
2000	10	-	9	1	16	-	16	3
	Semtember		October		November		December	
	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<	0mm<	10mm<
1991	9	1	4	-	4	-	3	-
1992	9	1	2	-	7	-	3	-
1993	6	-	3	-	4	-	4	-
1994	7	-	5	-	3	-	3	-
1995	7	-	4	-	1	-	3	-
1996	7	-	4	-	5	-	3	-
1997	4	1	4	-	3	-	4	-
1998	6	2	5	1	8	-	2	-
1999	8	3	3	-	2	-	2	-
2000	2	1	5	-	8	-	8	-

Table D-12. Rainfall with 1% saturation over the course of one day (mm)

	Province	Location	Duration of observation	During one year of observation			C_v	C_s	Rainfall saturation						
				Heaviest	Least	Average			0.1	1.0	3.0	5.0	10	20	25
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1.	Sukh-baatar	Baishint/Bayandelger/	1939-90	75.4	8.9	26.7	0.51	1.52	114	81.2	64.7	57.6	48.4	39.1	36.0
2.		Erdene-tsagaan	1941-90	70.4	14.2	32.0	0.42	1.00	108	79.5	65.2	59.0	50.8	41.9	39.3
3.		Baruun-Urt	1960-90	116	12.3	33.8	0.70	3.02	184	121	91.8	79.8	63.6	48.8	44.3
4.	Bulgan	Bulgan	1941-90	128	16.6	35.2	0.46	3.98	142	104	85.2	76.1	65.0	53.3	50.0
5.		Hutag	1961-90	74.6	17.3	36.7	0.37	1.44	117	88.0	73.2	66.6	58.0	48.8	46.0
6.	Orkhon	Erdenet-Ovoo	1973-90	69.3	20.5	37.7	0.47	0.77	133	98.0	80.9	72.2	61.8	50.8	47.0
7.	Khovd	Baitag	1963-90	50.7	2.5	15.2	0.73	1.51	112	70.8	50.2	41.8	31.9	22.5	19.9
8.		Khovd	1937-90	38.5	7.9	20.3	0.40	0.74	68.9	51.0	42.0	47.9	32.7	27.1	25.2
9.		Zereg	1974-90	76.5	4.2	16.7	0.98	3.35	169	94.5	66.0	54.2	40.8	26.4	24.7
10.	Bayan-Ulgii	Bayan-Ulgii	1959-90	43.4	6.8	17.6	0.49	1.49	79.0	54.0	43.0	47.8	31.6	25.0	23.0
11.		Yalalt	1970-90	45.2	4.6	17.8	0.67	1.18	129	78.0	56.6	47.9	37.4	27.2	24.2
12.	Dornod	Tamsagbulag	1939-74	72.5	8.0	28.4	0.44	1.08	111	85.6	68.6	60.8	51.2	41.0	37.8
13.		Khalkh gol	1961-90	83.6	12.8	37.0	0.51	1.28	168	116	92.1	81.0	66.7	52.8	48.2
14.		Choibalsan	1937-90	72.2	11.3	31.8	0.39	1.00	108	80.0	65.8	59.4	51.3	42.6	39.6
15.		Chingisiin dalan	1944-55	71.3	17.6	38.0	0.35	1.15	153	111	90.4	80.7	68.0	55.2	51.2
16.	Dorno-govi	Sainshand	1939-90	121	7.6	23.1	0.74	4.02	142	91.4	69.4	60.0	48.1	46.7	33.0
17.		Zamiin-Uud	1956-90	88.7	7.0	22.4	0.57	3.00	112	74.5	58.0	51.0	41.8	32.6	29.7
18.		Mandakh	1974-90	27.8	7.7	16.1	0.34	0.20	66.7	47.2	38.0	44.0	28.6	23.1	21.3
19.		Khubsgul	1969-90	42.5	6.0	19.0	0.53	0.75	99.1	64.6	50.2	43.4	35.4	27.2	24.6
20.		Choir	1942-90	61.2	14.7	29.7	0.38	1.00	96.1	72.0	60.2	54.7	47.4	39.8	37.2
21.	Uvur-Khangai	Arvaikheer	1940-89	54.0	13.8	29.6	0.37	0.82	93.7	70.0	59.0	53.9	46.9	39.3	36.8
22.		Bogd	1976-89	41.1	7.0	19.7	0.45	1.00	89.4	60.8	48.1	42.4	35.3	27.8	25.6
23.		Khujirt	1949-90	65.2	7.6	28.8	0.35	1.24	94.6	70.2	59.0	53.4	46.4	38.6	26.2
24.	Umnu-Govi	Khanbogd	1976-90	42.7	7.0	21.1	0.54	0.93	108	71.2	55.2	48.1	39.4	30.4	28.6
25.		Gurvantes	1971-90	51.3	5.7	19.9	0.55	1.20	121	77.0	58.1	50.0	40.2	30.1	27.2
26.		Tsogt-ovoo	1963-90	42.0	7.7	17.0	0.50	1.27	80.6	54.0	44.3	37.3	30.6	44.0	21.8
27.		Saikhan	1961-90	68.2	5.8	20.1	0.64	2.05	121	78.0	58.6	50.7	40.5	30.4	27.5
28.		Dalanzadgad	1940-89	138	7.4	25.7	0.79	3.75	183	113	80.9	68.0	53.1	38.6	34.6
29.	Arkhangai	Tariat	1970-90	43.8	7.9	24.7	0.36	0.67	84.4	62.5	52.6	47.5	42.0	34.2	31.9
30.		Tsetserleg	1937-89	67.4	14.6	29.6	0.35	1.72	95.0	71.4	60.0	54.8	47.6	40.1	36.8
31.		Erdenemandal	1964-90	55.0	21.6	33.8	0.29	0.89	91.2	71.2	61.7	56.8	50.8	43.7	41.2
32.	Khuvsgul	Renchin-Lkhumbe	1974-90	48.4	11.0	26.4	0.35	0.60	115	81.2	65.1	58.0	48.8	39.7	26.7
33.		Murun	1941-90	68.4	13.5	30.4	0.37	0.90	104	77.2	63.8	57.7	49.8	41.1	38.2
34.		Khatgal	1963-90	70.5	15.3	31.9	0.44	1.66	122	88.0	71.2	63.7	54.1	44.2	41.0

35.		Tarialan	1963-90	63.4	19.5	32.0	0.36	1.64	115	84.6	69.4	62.3	53.8	44.2	41.2
36.	Bayan-Khongor	Galuut	1957-90	60.4	12.6	29.0	0.36	1.46	94.4	70.2	58.6	53.3	46.2	38.3	35.9
37.		Bayankhongor	1962-90	44.7	9.7	25.8	0.38	0.84	98.6	70.2	57.5	51.8	43.9	35.7	33.2
38.		Shinejinst	1973-90	31.4	11.3	19.1	0.31	0.39	54.8	42.3	37.0	33.0	28.9	24.6	23.2
39.		Bayanbulag	1976-90	38.0	2.8	16.0	0.20	0.59	157	76.5	59.7	48.8	36.8	25.1	21.8
40.		Ekhiin gol	1979-89	24.0	4.7	12.2	0.70	1.37	108	61.7	43.6	36.2	27.3	19.4	17.1
41.	Ulaan-baatar	Buyant-Ukhaa	1937-90	74.9	15.0	30.6	0.43	1.79	108	78.8	64.1	58.0	50.0	40.9	38.0
42.		Takhilt	1978-89	51.7	15.0	30.0	0.37	0.51	113	81.9	66.4	59.6	50.8	41.1	38.0
43.		Ulaankhuaran	1968-77	36.0	15.8	24.4	0.26	0.58	108	85.6	60.9	54.1	45.6	36.5	33.6
44.		Zuunmod	1965-90	51.9	16.7	31.1	0.32	0.63	95.2	72.7	61.3	55.9	48.8	41.3	38.9
45.	Tuv	Erdenesant	1962-90	109	14.7	32.2	0.53	3.64	107	80.0	66.1	60.0	52.0	43.1	40.3
46.		Kherlen	1942-61	62.1	12.8	32.4	0.59	0.61	119	87.6	70.6	63.2	53.9	44.2	40.9
47.		Ugtaal	1980-90	50.0	17.7	29.7	0.34	1.00	103	76.8	63.3	57.1	49.2	40.9	37.9
48.		Maanit	1957-90	61.2	11.0	30.5	0.34	0.89	93.6	70.3	59.5	54.1	47.2	29.9	27.4
49.	Govi-Altai	Altai	1955-90	57.7	6.6	20.2	0.44	2.35	73.2	53.2	43.5	39.1	33.4	27.3	25.5
50.		Tonkhil	1973-90	26.3	6.8	14.7	0.36	0.55	50.1	37.2	30.6	27.6	23.8	19.8	28.4
51.		Tooroi	1960-89	44.7	2.7	13.4	0.67	1.92	92.2	56.2	41.8	35.4	27.7	20.4	18.3
52.		Khantaishir	1978-88	48.9	9.3	25.8	0.50	0.84	143	93.0	71.2	61.6	50.0	38.0	34.6
53.	Zavkhan	Uliastai	1937-90	42.9	9.8	21.6	0.37	1.12	67.9	51.2	42.8	39.1	34.1	28.3	26.6
54.		Bayan-Uul	1962-90	33.0	9.8	19.7	0.29	0.39	55.2	42.8	36.8	33.7	29.6	25.2	23.9
55.		Durvuljin	1967-90	51.5	5.8	12.5	0.66	1.71	102	95.5	47.2	40.9	33.0	25.1	22.7
56.		Tosontsengel	1965-89	35.8	8.6	18.8	0.42	0.87	74.0	52.8	42.6	38.0	32.1	26.2	24.1
57.		Tsetsen-Uul	1976-90	36.7	10.5	21.9	0.30	0.55	71.0	53.1	44.2	40.2	34.8	28.8	27.0
58.	Dund-Govi	Mandalgovi	1944-80	82.5	6.4	26.7	0.53	2.00	118	81.4	64.0	56.6	47.1	37.3	34.2
59.		Saikhan-Ovoo	1967-90	52.3	7.9	20.6	0.51	1.69	97.2	65.5	51.7	45.1	37.3	29.1	26.7
60.	Khentei	Undurkhaan	1937-90	70.3	11.1	31.8	0.38	1.06	105	78.8	65.1	59.0	51.2	42.2	39.6
61.		Binder	1942-90	79.4	17.6	39.1	0.30	1.08	101	80.6	69.2	53.8	56.6	48.9	46.5
62.		Bayan-Ovoo	1962-90	84.4	17.6	37.8	0.47	1.27	153	108	87.2	77.1	64.4	52.1	47.9
63.		Dadal	1961-90	97.4	25.5	44.7	0.38	1.30	140	105	89.1	89.6	69.5	57.9	54.3
64.	Uvs	Ulaangom	1943-89	102	4.2	21.6	0.76	3.02	153	92.3	67.9	57.0	44.8	32.8	29.0
65.		Baruunturuun	1960-90	63.1	10.1	26.6	0.48	1.60	118	82.2	64.8	57.3	47.8	37.9	34.8
66.		Khar-Us	1963-90	58.0	6.8	22.1	0.51	1.40	97.0	66.8	53.2	47.0	49.1	31.0	28.3
67.	Selenge	Baruunkharaa	1952-90	93.2	11.6	31.8	0.43	2.50	103	77.1	64.0	58.0	50.2	41.8	39.0
68.		Eruu	1961-90	80.6	11.7	37.8	0.41	0.84	133	98.1	81.2	72.8	62.4	51.7	47.8
69.		Zuunkharaa	1965-78	75.1	16.8	35.8	0.49	1.30	177	119	93.1	81.2	66.2	51.9	47.2
70.		Sukhbaatar	1966-90	57.6	15.9	34.0	0.28	0.81	92.0	71.8	61.5	56.7	50.5	43.1	40.9
71.		Orkhon	1969-90	76.2	15.9	36.1	0.38	1.04	137	99.0	91.4	72.3	61.7	50.3	46.8

D-3. Calculation of Discharge by Mongolian and Russian

Culverts and small rivers calculation of the floodwater discharge

	Name of river	**Qp** Mongolian 100 years	**Qp** Russian 100 years
1	Togos	368.56	275.69
2	Tsenkher	384.06	341.13
3	Murun	429.06	375.58

	Name of river	**Qp** Mongolian 50 years	**Qp** Russian 50 years
1	Togos	320.65	239.85
2	Tsenkher	334.13	296.78
3	Murun	428.09	326.76

Culverts and small rivers calculation of the floodwater discharge
/ by Russian standartd around 20 years/

Calculation of the floodwater discharge for 100 years using conversion factor from Mongolian standard.

I	Name	**Qp** /m^3/sec / Russian standard 100 years	Conversion factor	**Qp** /m^3/sec / Russian standard 20 years
1	A1	17.78	0.65	11.6
2	A-BC1	98.82	0.70	69.17
3	A-BC2	51.89	0.75	38.92
4	A-BC3	40.01	0.75	30.01
5	B3	90.08	0.75	67.56
6	B-BC1	49.09	0.70	34.36
7	B-BC2	16.34	0.70	11.44
8	B4	88.56	0.70	61.99
9	B-BC3	27.28	0.70	19.09
10	B-BC4	22.11	0.70	15.48
11	TB1	126.82	0.75	95.12
12	TB2	177.17	0.75	132.88

Culverts and small rivers calculation of the floodwater discharge

I	Name	**Qp** /m^3/sec / By Mongolian standard 20 years	**Qp** /m^3/sec / By Mongolian standard 20years	**Qp** /m^3/sec / By Mongolian standard 100 years
1	A1	14.4	11.6	17.78
2	A-BC1	85.10	69.17	98.82
3	A-BC2	52.30	38.92	51.89
4	A-BC3	39.83	30.01	40.01
5	B3	77.06	67.56	90.08
6	B-BC1	34.23	34.36	49.09
7	B-BC2	13.35	11.44	16.34
8	B4	70.94	61.99	88.56
9	B-BC3	22.29	19.09	27.28
10	B-BC4	18.47	15.48	22.11
11	TB1	111.36	95.12	126.82
12	TB2	188.07	132.88	177.17

Calculation of the floodwater discharge

/ by Mongolian standard/

Estimation of maximum flow using book completed by authors of Section of Hydrology, Institute of Meteorology and Hydrology in 1999, Estimation of maximum flow using following reduction formula and Bp-regular runoff module with p% of saturation bring drawing 4.6.

$$Qp = Bp*F/(F+C)^n$$

F - catchment area, km^2
Bp - regular runoff module with p% of saturation, m^3/sec
C - factor related to the meltwater flood layer
n - reduction degree

As catchment area increases, there is a reduction in runoff module per unit if area and here n=0.4, where as C=1.

1. Togos river

F=460 km^2 –

Bp=8,1 $m^3/sec\ km^2$

$Qp = Bp*F/(F+C)^{0.4}$

Where:

$Qp = 8.1*460/(460+1)^{0.4} = 320.38\ m^3/sec$

Added some standart devation around 15percent

$Q_\wedge$ = Qp * 15% = 320.38 * 0.15 = 48.08 m^3/sec

Total maximum discharge $Q_t = Qp + Q_\wedge$

$Q_t = 320.38 + 48.08 = 368.56\ m^3/sec$

2. Tsenkher river

F=790 km^2

Bp=6.1 $m^3/sec\ km^2$

$Qp = Bp*F/(F+C)^{0.4}$

Where:

$Qp = 6.1*790/(790+1)^{0.4} = 333.96\ m^3/sec$

Added some standard deviation around 15percent

$Q_\wedge$ = Qp * 15% = 333.96 * 0.15 = 50.09 m^3/sec

Total maximum discharge Q_t = Qp + $Q_\wedge$

Q_t = 333.96 + 50.09 = 384.06 m^3/sec

3. Murun river

$F=3160\ km^2$

$Bp=3,4\ m^3/sec\ km^2$

$Qp = Bp*F/(F+C)^{0.4}$

Where:

$Qp = 3.4*3160/(3160+1)^{0.4} = 427.88\ m^3/sec$

Added some standard deviation around 15percent

$Q_\wedge$ = Qp * 15% = 427.88 * 0.15 = 64.18 m^3/sec

Total maximum discharge Q_t = Qp + $Q_\wedge$

Q_t = 427.88 + 64.18 = 492.06 m^3/sec

Calculation of the floodwater discharge

/ by Russian standard/

Estimation of maximum flow calculated by Russian standard, in 1983 . Estimation of maximum flow using following reduction formula:

$$Qp = 16.7 a_p \alpha_p F \varphi K_y K_\phi \delta_p$$

Where $a_p = a_{hour} k_t K_F$ $\alpha_p = \alpha_0\ \delta_e$ $k_\phi = \phi + (1 - \phi) C_B$

a_p - estimated intensity of precipitation, applicable to BÏ to discharge

α_p - estimated coefficient for down hill discharge

F - catchment area, km^2

Φ - coefficient for reduction of maximum rainwater discharge, derived from the index of reduction level / table 7.2/

K_y - coefficient, accounting catchment area ascent / table 7.3/

K_ϕ - coefficient, accounting the shape (form) of the catchment area

δ_p - coefficient, accounting natural (or artificial) coordination of the maximum discharge / see parts 3.3 and 3.4/

a_{hour} - maximum hourly intensity of precipitation / table 7.4/ for the defined rainfall region / picture 7.1/ mm/min

k_t - reduction coefficient of the hourly intensity of precipitation table 7.5/

K_F - coefficient, accounting uneven distribution of rainfall over the catchment area / table 7.6/

α_0 - coefficient for downhill discharge with complete saturation of the soil with water /table 7.7/

δ_e - coefficient for downhill natural accumulation of rainwater discharge on the surface of catchment area, which is dependable on the type of soil and loess level of the ground

C_B - coefficient accounting the reduction of influence of the catchmant area shape on the estimated maximum discharge

Ô - coefficient accounting the changes in the shape of catchment area

Coffiicient accounting natural accumulation of rainwater discharge is calculated out using he following formula:

$$\delta_e = 1 - \gamma_{ä}\, \beta Ï$$

$\gamma_{ä}$ - coefficient accounting infiltration rate of soil and ground of catchment area under given conditions for formation of meltwater runoff /table 7.8/

β - coefficient for accounting the state (conditions) of the soil and ground at the time when meltwater formation started /table 7.9/

Ï - correction coefficient for the infiltration reduction of soil and ground /table 7.10/

1. Togos river

$F = 460\ km^2$

$J = 0.013$

$\Psi = 0.15$ $\quad Ky = 0.98$ $\quad a_{hour} = 1.01$ $\quad k_t = 0.67$ $\quad K_F = 0.85$ $\quad \alpha_0 = 0.5$

$\delta_p = 1$ $\quad \phi = 1$ $\quad C_B = 1$ $\quad F/L = 10.22$ $\quad \delta_e = 1$

$a_p = a_{hour}\, k_t\, K_F = 1.01*0.67*0.85 = 0.58$

$\alpha_p = \alpha_0\, \delta_e = 0.5*1 = 0.5$

$k_{\phi} = 0.7 + (1\text{-}0.7)*1 = 1$

$Q_{1\%} = 16.7 * 0.58 * 0.5 * 460 * 0.15 * 0.825 * 1 * 1 =$ **275.69 m^3/sec**

2. **Tsenkher river**

$F = 790\ km^2$

$J = 0.01$

$\Phi = 0.13$ $Ky = 0.75$ $a_{hour} = 1.01$ $k_t = 0.63$ $K_F = 0.80$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 1$ $F/L = 14.36$ $\delta_e = 1$

$\alpha_p = \grave{a}_{hour}\, \hat{E}_t\, K_F = 1.01*0.63*0.80 = 0.51$

$\alpha_p = \alpha_0\, \delta_e = 0.5*1 = 0.5$

$K\phi = 0.7 + (1\text{-}0.7)*1 = 1$

$Q_{1\%} = 16.7 * 0.51 * 0.5 * 790 * 0.13 * 0.78 * 1 * 1 =$ **341.13 m^3/sec**

3. **Murun river**

$F = 3160\ km^2$

$J = 0.0071$

$\Phi = 0.11$ $Ky = 0.79$ $a_{hour} = 1.01$ $k_t = 0.57$ $K_F = 0.73$ $\alpha_0 = 0.5$

$\delta_p = 0.39$ $C_B = 1$ $F/L = 31.60$ $\delta_e = 1$

$\alpha_p = a_{hour}\, k_t\, K_F = 1.01*0.57*0.73 = 0.42$

$\alpha_p = \alpha_0\, \delta_e = 0.5*1 = 0.5$

$Ky = 0.7 + (1\text{-}0.7)*1 = 1$

$Q_{1\%} = 16.7 * 0.42 * 0.5 * 3160 * 0.11 * 0.79 * 1 * 0.39 =$ **375.58 m^3/sec**

Calculation of the floodwater discharge

/ by Mongolian standard around 50 years/

Calculation of the floodwater discharge for 50 years using conversion factor from Mongolian standard.

1. Togos river

$Q_{2\%}$ = 368.56 * 0.87 = **320.65 m^3/sec**

2. Tsenkher river

$Q_{2\%}$ = 384.06 * 0.87 = **334.13 m^3/sec**

3. Murun river

$Q_{2\%}$ = 492.06 * 0.87 = **428.09 m^3/sec**

Calculation of the floodwater discharge

/ by Russian standard around 50 years/

Calculation of the floodwater discharge for 50 years using conversion factor from Mongolian standard.

1. Togos river

$Q_{2\%}$ = 275.69 * 0.87 = **239.85 m^3/sec**

2. Tsenkher river

$Q_{2\%}$ = 341.13 * 0.87 = **296.78 m^3/sec**

3. Murun river

$Q_{2\%}$ = 375.58 * 0.87 = **326.75 m^3/sec**

Culverts and small rivers calculation of the floodwater discharge

/ by Russian standard around 100 years/

1. A-BC2

$F = 35.48\ km^2$

$J = 0.025$

$\varphi = 0.26$ $k_y = 0.87$ $a_{hour} = 1.01$ $k_t = 0.92$ $K_F = 0.96$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 0.35$ $F/L = 3.35$ $\delta_e = 1$

$\alpha_p = a_{hour}\, k_t\, K_F = 1.01*0.92*0.96 = 0.89$

$\alpha_p = \alpha_0\, \delta_e = 0.5*1 = 0.5$

$K_\phi = 0.8 + (1-0.8)*0.35 = 0.87$

$Q_{1\%} = 16.7 * 0.89 * 0.5 * 35.48 * 0.26 * 0.87 * 0.87 * 1 =$ **51.89 m³/sec**

2. A-BC3

$F = 27.02\ km^2$

$J = 0.021$

$\varphi = 0.28$ $k_y = 0.85$ $a_{hour} = 1.01$ $k_t = 0.94$ $K_F = 0.975$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 0.27$ $F/L = 2.40$ $\delta_e = 1$

$a_p = a_{hour}\, k_t\, K_F = 1.01*0.94*0.975 = 0.92$

$\alpha_p = \alpha_0\, \delta_e = 0.5*1 = 0.5$

$k_\phi = 0.75 + (1-0.75)*0.27 = 0.81$

$Q_{1\%} = 16.7 * 0.92 * 0.5 * 27.02 * 0.28 * 0.85 * 0.81 * 1 =$ **40.01 m³/sec**

3. TB1

$F = 151.08\ km^2$

$J = 0.018$

$\varphi = 0.176$ $K_y = 0.84$ $a_{hour} = 1.01$ $k_t = 0.76$ $K_F = 0.88$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 1$ $F/L = 4.97$ $\delta_e = 1$

$\alpha_p = a_{hour}\, k_t\, K_F = 1.01*0.76*0.88 = 0.68$

$\alpha_p = \alpha_0\, \delta_e = 0.5*1 = 0.5$

$K_\phi = 0.70 + (1\text{-}0.7)*1 = 1$

$Q_{1\%} = 16.7 * 0.68 * 0.5 * 151.08 * 0.176 * 0.84 * 1 * 1 =$ **126.82 m^3/sec**

4. TB2

$F = 255.15\ km^2$

$J = 0.011$

$\varphi = 0.165$ $Ky = 0.80$ $a_{hour} = 1.01$ $k_t = 0.73$ $K_F = 0.86$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 1$ $F/L = 45.1$ $\delta_e = 1$

$\alpha_p = a_{our}\, k_t K_F = 1.01*0.73*0.86 = 0.63$

$\alpha_p = \alpha_0\, \delta_e = 0.5*1 = 0.5$

$K_\phi = 0.70 + (1\text{-}0.7)*1 = 1$

$Q_{1\%} = 16.7 * 0.63 * 0.5 * 255.15 * 0.165 * 0.80 * 1 * 1 =$ **177.17 m^3/sec**

5. B3

$F = 104\ km^2$

$J = 0.008$

$\varphi = 0.19$ $ky=0.78$ $a_{our} = 1.01$ $k_t = 0.79$ $K_F = 0.88$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 1$ $F/L = 4.97$ $\delta_e = 1$

$\alpha_p = a_{hour} k_t K_F = 1.01x.79x.88 = 0.70$

$\alpha_p = \alpha_0 \delta_e = 0.5*1 = 0.5$

$K_\phi = 0.70+ \ (1-0.7)*1 = 1$

$Q_{1\%} = 16.7 * 0.7 * 0.5 * 104 * 0.19 * 0.78 * 1 * 1 =$ **90.08 m^3/sec**

6. B-BC1

$F = 33\ km^2$

$J = 0.029$

φ= 0.26 K_y=0.87 a_{hour}= 1.01 k_t= 0.9 $K_F = 0.97$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 1$ $F/L = 5.68$ $\delta_e = 1$

$\alpha_p = a_{hour}\ k_t K_F = 1.01*0.90*0.97 = 0.88$

$\alpha_p = \alpha_0 \delta_e = 0.5*1 = 0.5$

$k_\phi = 0.895$

$Q_{1\%} = 16.7 * 0.88 * 0.5 * 33 * 0.26 * 0.87 * 0.895 * 1 =$ **49.09 m3/sec**

7. B-BC2

$F = 6.64\ km^2$

$J = 0.034$

φ= 0.36 K_y=0.90 a_{hour}= 1.01 k_t=1.06 K_F=1.0 α_o=0.5

$\delta_p = 1$ $C_B = 1$ $F/L = 5.68$ $\delta_e = 1$

$\alpha_p = \grave{a}_{hour}\ k_t\ k_F.=1.01x1.06x1=1.07$

$\alpha_p = \alpha_0 \delta_e = 0.5*1 = 0.5$

$K_\phi = 0.85$

$Q_{1\%} = 16.7 * 1.07 * 0.5 * 6.64 * 0.36 * 0.9 * 0.85 * 1 =$ **16.34 m^3/sec**

8. B4

$F = 95.79\ km^2$

$J = 0.014$

$\varphi= 0.19$ $K_y=0.82$ $a_{hour}= 1.01$ $k_t= 0.80$ $K_F = 0.9$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 0.95$ $F/L = 5.12$ $\delta_e = 1$

$\alpha_p = \grave{a}_{hour} K_t\ K_F = 1.01*0.8*0.9 = 0.72$

$\alpha_p = \alpha_0\, \delta_e = 0.5*1 = 0.5$

$K_\phi = 0.987$

$Q_{1\%} = 16.7 * 0.72 * 0.5 * 95.79 * 0.19 * 0.82 * 0.987 * 1 =$ **88.56 m^3/sec**

9. B-BC3

$F = 17.4\ km^2$

$J = 0.018$

$\varphi= 0.29$ $k_y=0.83$ $\grave{a}_{hour} = 1.01$ $k_t= 0.95$ $K_F = 0.98$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 0.15$ $F/L = 2.12$ $\delta_e = 1$

$\alpha_p = \grave{a}_{hour}\ K_t k_F = 1.01*0.95*0.98 = 0.94$

$\alpha_p = \alpha_0\, \delta_e = 0.5*1 = 0.5$

$k_\phi = 0.8+(1-0.8)*0.15=0.83$

$Q_{1\%} = 16.7 * 0.94 * 0.5 * 17.4 * 0.29 * 0.83 * 0.83 * 1 =$ **27.28 m^3/sec**

10. B-BC4

$F = 10.40 km^2$

$J = 0.038$

$\varphi = 0.33$ $k_y = 0.905$ $\grave{a}_{hour} = 1.01$ $k_t = 0.98$ $K_F = 0.99$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 0.10$ $F/L = 3.25$ $\delta_e = 1$

$\alpha_p = \grave{a}_{hour} k_t K_F = 1.01 * 0.98 * 0.99 = 0.98$

$\alpha_p = \alpha_0 \delta_e = 0.5 * 1 = 0.5$

$k_\phi = 0.86 + (1 - 0.86) * 0.10 = 0.87$

$Q_{1\%} = 16.7 * 0.98 * 0.5 * 10.40 * 0.33 * 0.905 * 0.87 * 1 =$ **22.11 m^3/sec**

11. B-BC1

$F = 115.45 km^2$

$J = 0.02$

$\varphi = 0.18$ $k_y = 0.85$ $a_{hour} = 1.01$ $k_t = 0.78$ KF=0. α o=0.

$\delta_p = 1$ $C_B = 0.30$ $F/L = 6.59$ $\delta_e = 1$

$\alpha_p = \grave{a}_{hour} k_t K_F = 1.01 * 0.78 * 0.86 = 0.67$

$\alpha_p = \alpha_0 \delta_e = 0.5 * 1 = 0.5$

$k_\phi = 1$

$Q_{1\%} = 16.7 * 0.67 * 0.5 * 115.45 * 0.18 * 0.85 * 1 * 1 =$ **98.82 m^3/sec**

12. A1

$F = 5.9\ km^2$

$J = 0.074$

$\varphi = 0.40$ $k_y = 0.97$ $a_{hour} = 1.01$ $K_t = 1.09$ $K_F = 1$ $\alpha_0 = 0.5$

$\delta_p = 1$ $C_B = 0$ $F/L = 1.69$ $\delta_e = 1$

$\alpha_p = a_{hour}\, k_t\, K_F = 1.01*1.09*1 = 1.1$

$\alpha_p = \alpha_0\, \delta_e = 0.5*1 = 0.5$

$k_\phi = 0.85+(1-0.85)*0 = 0.85$

$Q_{1\%} = 16.7 * 1.1 * 0.5 * 5.9 * 0.4 * 0.97 * 0.85 * 1 =$ **17.8 m^3/sec**

Culverts and small rivers calculation of the floodwater discharge

/ by Mongolian standard around 20 years/

Estimation of maximum flow using book completed by authors of Section of Hydrology, Institute of Meteorology and Hydrology in 1999. Estimation of maximum flow using following reduction formula and Bp-regular runoff module with p% of saturation using book.

When catchment area less than 200 km^2 using following reduction formula:

$$Qp = 16.67\Psi(\zeta\ )H_{1\%}\alpha F$$

$\Psi(\zeta)$ – average ordinate of the curve showing reduction relevance between rainfall intensity and duration /table 4.3/

α – maximum runoff ratio

$H_{1\%}$ - maximum precipitation during a day with 1% saturation , mm

1. A-BC2

$F = 35.48\ km^2$

$16.67\ \Psi(\ \zeta\ ) = 0.042$ $\alpha = h_p / H_p = 35/65 = 0.54$

$H_{5\%} = 65mm\ q_{\%} = B_{5\%} /(F+1)^{n2} = 0.25/(35.48+1)^{0.4} = 0.059 m^3/sec\ km^2$

$\zeta = 16.67\ H_{5\%}/\ q_{\%} = 16.67*65/0.059 = 306$ min

$Qp = 16.67\Psi(\zeta\ )H_{5\%}\alpha F = 0.042*65*0.54*35.48 =$ **52.30 m^3/sec**

2. A-BC3

$F = 27.02\ km^2$

$16.67\ \Psi(\zeta) = 0.042$ $\alpha = h_p / H_p = 35/65 = 0.54$

$H_{5\%} = 65mm$ $q_{\%} = B_{\%} /(F+1)^{n2} = 0.25/(27.02+1)^{0.4} = 0.065 m^3/sec\ km^2$

$\zeta = 16.67\ H_{\%}/\ q_{\%} = 16.67*65/0.065 = 278$ min

$Qp = 16.67\Psi(\zeta\ )H_{5\%}\alpha F = 0.042*65*0.54*27.02 =$ **$39.83\ m^3/sec$**

3. A-BC2

$F = 115.45\ km^2$

$16.67\ \Psi(\zeta) = 0.021$ $\alpha = h_p / H_p = 35/65 = 0.54$

$H_{\%} = 65mm$ $q_{\%} = B_{\%} /(F+1)^{n2} = 0.25/(115.45+1)^{0.4} = 0.037 m^3/sec\ km^2$

$\zeta = 16.67\ H_{\%}/\ q_{\%} = 16.67*65/0.037 = 488$ min

$Qp = 16.67\Psi(\zeta\ )H_{5\%}\alpha F = 0.$
$\zeta = 16.67\ H_{5\%}/\ q_{\%} = 16.67*65/0.033 = 547$ min

$Qp = 16.67\Psi(\zeta\ )H_{5\%}\alpha F = 0.021*65*0.54*115.45 =$ **$85.1\ m^3/sec$**

4. TB1 $F=151.45\ km^2$

$Qp = 16.67\Psi(\zeta\ )H_{5\%}\alpha F = 0.021*65*0.54*151.45=$ **$111.63 m^3/sec$**

5. TB2

$F = 255.15\ km^2$

$16.67\ \Psi(\zeta) = 0.021$ $\alpha = h_p / H_p = 35/65 = 0.54$

$H_{5\%} = 65mm$ $q_{\%} = B_{5\%} /(F+1)^{n2} = 0.25/(255.15+1)^{0.4} = 0.027 m^3/sec\ km^2$

$\zeta = 16.67\ H_{5\%}/\ q_{\%} = 16.67*65/0.027 = 669$ min

$Qp = 16.67\Psi(\zeta\ )H_{1\%}\alpha F = 0.021*65*0.54*255.15 =$ **$188.07\ m^3/sec$**

6. B3

$F = 104.0\ km^2$

$16.67\ \Psi(\zeta) = 0.030$ $\alpha = h_p / H_p = 25/65 = 0.38$

$H_{5\%} = 65mm\ q_{\%} = B_{5\%} /(F+1)^{n2} = 0.25/(104+1)^{0.4} = 0.039\ m^3/sec\ km^2$

$\zeta = 16.67\ H_{5\%}/\ q_{\%} = 16.67*65/0.039 = 669\ min$

$Qp = 16.67\Psi(\zeta)H_{5\%}\alpha F = 0.030*65*0.38*104 =$ **77.06 m^3/sec**

7. B-BC1

$F = 33.0\ km^2$

$16.67\ \Psi(\zeta) = 0.042$ $\alpha = h_p / H_p = 25/65 = 0.38$

$H_{5\%} = 65mm\ q_{\%} = B_{5\%} /(F+1)^{n2} = 0.25/(33+1)^{0.4} = 0.061 m^3/sec\ km^2$

$\zeta = 16.67\ H_{5\%}/\ q_{\%} = 16.67*65/0.061 = 296\ min$

$Qp = 16.67\Psi(\zeta)H_{5\%}\alpha F = 0.042*65*0.38*33 =$ **34.23 m^3/sec**

8. B-BC2

$F = 6.64\ km^2$

$16.67\ \Psi(\zeta) = 0.057$ $\alpha = h_p / H_p = 25/65 = 0.43$

$H_{5\%} = 82mm\ q_{\%} = B_{5\%} /(F+1)^{n2} = 0.25/(6.64+1)^{0.4} = 0.11 m^3/sec\ km^2$

$\zeta = 16.67\ H_{5\%}/\ q_{\%} = 16.67*65/0.11 = 207\ min$

$Qp = 16.67\Psi(\zeta)H_{5\%}\alpha F = 0.057*82*0.43*6.64 =$ **13.35 m^3/sec**

9. B4

$F = 95.79\ km^2$

$16.67\ \Psi(\zeta) = 0.021$ $\alpha = h_p / H_p = 25/65 = 0.43$

$H_{\%} = 82mm$ $q_{\%} = B_{5\%} / (F+1)^{n2} = 0.25/(95.79+1)^{0.4} = 0.04\ m^3/sec\ km^2$

$\zeta = 16.67\ H_{5\%} / q_{\%} = 16.67*82/0.04 = 569\ min$

$Qp = 16.67\Psi(\zeta)H_{5\%}\alpha F = 0.021*82*0.43*95.79 =$ **70.94 m^3/sec**

10. B-BC3

$F = 17.4\ km^2$

$16.67\ \Psi(\zeta) = 0.042$ $\alpha = h_p / H_p = 30/82 = 0.37$

$H_{5\%} = 82mm$ $q_{\%} = B_{5\%} / (F+1)^{n2} = 0.25/(17.4+1)^{0.4} = 0.078\ m^3/sec\ km^2$

$\zeta = 16.67\ H_{5\%} / q_{\%} = 16.67*82/0.078 = 292\ min$

$Qp = 16.67\Psi(\zeta)H_{5\%}\alpha F = 0.042*82*0.37*17.5 =$ **22.29 m^3/sec**

11. B-BC4

$F = 10.40\ km^2$

$16.67\ \Psi(\zeta) = 0.057$ $\alpha = h_p / H_p = 25/82 = 0.38$

$H_{5\%} = 82mm$ $q_{\%} = B_{5\%} / (F+1)^{n2} = 0.25/(10.4+1)^{0.4} = 0.093\ m^3/sec\ km^2$

$\zeta = 16.67\ H_{5\%} / q_{\%} = 16.67*82/0.093 = 245\ min$

$Qp = 16.67\Psi(\zeta)H_{5\%}\alpha F = 0.057*82*0.38*10.4 =$ **18.47 m^3/sec**

12. A_1

$F = 5.9\ km^2$

$16.67\ \Psi(\zeta) = 0.072$ $\alpha = h_p / H_p = 35/65 = 0.54$

$H_{5\%} = 65mm\ q_{\%} = B_{5\%} /(F+1)^{n2} = 0.25/(5.9+1)^{0.4} = 0.115\ m^3/sec\ km^2$

$\zeta = 16.67\ H_{5\%}/\ q_{\%} = 16.67*82/0.115 = 157\ min$

$Qp = 16.67\Psi(\zeta\ )H_{5\%}\alpha F = 0.072*65*0.54*5.7 =$ **$14.40\ m^3/sec$**

D-4. Results of Precipitation Analysis

Table D-13 Design Annual Precipitation

No.	Location	Altitude (m)	Number of data	1/100 (mm)	1/50 (mm)	1/20 (mm)	1/10 (mm)	Max. (mm)	Ave. (mm)	Note
1	Ulaanbaatar-A	1350	31	500	440	400	350	455.6	258.4	1970-2000
2	Ulaanbaatar-B	1350	18	500	460	410	380	380.1	280.9	1983-2000
3	Ulaanbaatar-C	1350	26	440	410	350	330	371.6	244.9	1975-2000
	Max. for A,B,C	1350	-	500	460	410	380	455.6	280.9	
4	Terelj	1800	15	600	540	520	485	489.1	379.2	1986-2000
5	Baganuur	1350	10	500	420	335	300	329.0	212.3	1991-2000
6	Mungun Morit	1450	12	500	445	420	400	405.6	303.6	1989-2000
7	Undurkhaan	1050	29	460	430	390	350	392.9	261.1	1970-1998

Table D-14 Design Monthly Precipitation (July)

No.	Location	Altitude (m)	Number of data	1/100 (mm)	1/50 (mm)	1/20 (mm)	1/10 (mm)	Max. (mm)	Ave. (mm)	Note
1	Ulaanbaatar-A	1350	31	220	165	125	105	156.8	65.8	1970-2000
2	Ulaanbaatar-B	1350	18	215	170	135	120	143.9	77.9	1983-2000
3	Ulaanbaatar-C	1350	26	165	140	125	105	129.4	64.8	1975-2000
	Max. for A,B,C	1350		220	170	135	120	156.8	77.9	
4	Terelj	1800	15	300	240	215	180	193.3	99.2	1986-2000
5	Baganuur	1350	10	200	150	120	105	105.5	57.6	1991-2000
6	Mungun Morit	1450	12	300	235	170	150	208.1	95.3	1989-2000
7	Undurkhaan	1050	29	250	215	170	150	187.4	75.3	1970-1998

Table D-15 Design Monthly Precipitation (August)

No.	Location	Altitude (m)	Number of data	1/100 (mm)	1/50 (mm)	1/20 (mm)	1/10 (mm)	Max. (mm)	Ave. (mm)	Note
1	Ulaanbaatar-A	1350	31	215	180	135	125	162.6	71.3	1970-2000
2	Ulaanbaatar-B	1350	18	200	160	130	115	139.4	79.9	1983-2000
3	Ulaanbaatar-C	1350	26	215	170	125	110	165.0	70.0	1975-2000
	Max. for A,B,C	1350		215	180	135	125	165.0	79.9	
4	Terelj	1800	15	320	270	220	180	210.3	107.4	1986-2000
5	Baganuur	1350	10	300	220	135	110	136.0	60.9	1991-2000
6	Mungun Morit	1450	12	300	230	160	140	138.3	81.4	1989-2000
7	Undurkhaan	1050	29	200	160	130	120	149.6	65.2	1970-1998

D-5. Details of Discharge Analysis (Rational Formula)

Discharge Analysis (Rational Formula) - ⑤

The Rational formula for calculating the maximum flood discharge is described as follows:

$$Q_P = 1 / 3.6 * f * R * A$$

where,

- Q_P: Maximum Flood Discharge (m^3/s)
- f: Runoff Coefficient
- R: Hourly Rainfall Intensity for duration equal to the Time of Concentration (mm/h)
- A: Catchment Area (km^2)

The value of "f" is commonly taken as "0.6" for undeveloped land in Japan. In this study a value of "0.48" is used considering the higher infiltration capacity and evaporation of Mongolia.

"R" is related to the flood time of concentration (=T).

$$R = R_T / T$$

where,

- T: Flood Time of Concentration (h)
- R_T: Rainfall Intensity for time period corresponding to "T" (mm)

To calculate "T", Rziha's formula was used. This formula is factored by 1.3 to approximate to the formula used by the Japanese Public Works Research Institute.

$$T = (L/W) * 1.3 + t, \qquad W = 20 * (h/L)^{0.6}$$

where,

- T: Flood Time of Concentration (s)
- L: Channel Length (m)
- W: Flood discharge velocity (m/s)
- t: inflow time (h) [= 0.5]
- h: Difference in elevation between river source and bridge site (m)

The Rational formula method is appropriate for river basins up to 200 km^2 and tends to overestimate relative to observed data, or predictions made by the Mongolian or Russian formulae. As an indicative method only, the method can be used on basin areas up to 1000 km^2 (Togos, Tsenkher).

D-6. Details of Discharge Analysis for Each River

1) Details of calculation:

The return period for each river is as follow:

Togos River: 50 years
Kherlen River: 100 years
Tsenkher River: 50 years
Murun River: 50 years

i) Analysis of discharge data : ①

$$A * q = Qr$$

where,

A: Catchment Area in table 5-4-5 (km^2)

q: Specific Discharge in table 5-4-6 (m^3/s km)

Records that are used are as below:

Togos River: Average of Bosgo B. and Terelj
Kherlen River: Kherlen B.
Tsenkher River: Average of Bosgo B. and Terelj
Murun River: Kherlen B.

These records are selected concerning the character of each river. It is mainly taken into account that similarity of Catchment Area and existence of reservoir in upper stream.

Qr: Design Discharge (m^3/s)

- Togos River: 460 * (0.19+0.50) / 2 = 160
- Kherlen River: 7350 * 0.15 = 1100
- Tsenkher River: 790 * (0.19+0.50) / 2 = 270
- Murun River: 3160 * 0.11 = 350

ii) Discharge calculation based on recorded water levels : ②

$$q * r = Qr$$

where,

q: Discharge data in table 5-4-7 (m^3/s)

r: Probability Ratio in table 5-4-8

Probability Ratio for each river is as same location as specific discharge. (See above)

Qr: Design Discharge (m^3/s)

- The Togos River: 100 * (2.0+2.03) / 2 = 200
- The Kherlen River: 500 * 2.75 = 1380
- The Tsenkher River: 60 * (2.0+2.03) / 2 = 120

- The Tsenkher River: 60 * (2.0+2.03) / 2 = 120
- The Murun River: 50 * 1.98 = 100

iii) Discharge analysis (Mongolian formula) : ③

Refers to another chapter in the Appendix

iv) Discharge analysis (Russian formula) : ④

Refers to another chapter in the Appendix

v) Rational formula : ⑤

- The Togos River:

$W = 20 * (h/L)^{0.6} = 20 * (600 / 45000)^{0.6} = 1.5$ (m/s)

$T = (L/W) * 1.3 + t = (45000 / 1.5) * 1.3 + 0.5 * 60 * 60$

$= 40800$ (s) $= 11.33$ (h)

$R = R_T / T = 68 / 11.33 = 6.0$ (mm/h)

$R_T = 68$ (mm)

Baganuur is selected as a reference location, as it is closest to the site. The 50 year return daily rainfall intensity is 75mm (Table 7-5-7). Hence by reference to Figure 7-5-2, the rainfall intensity, "R_T" for 11.33 hours is 68 mm.

$Q_P = 1/3.6 * f * R * A = 1 / 3.6 * 0.48 * 6.0 * 460 = 370$ (m^3/s)

- Tsenkher River:

$W = 20 * (h/L)^{0.6} = 20 * (550 / 55000)^{0.6} = 1.26$ (m/s)

$T = (L/W) * 1.3 + t = (55000 / 1.26) * 1.3 + 0.5 * 60 * 60$

$= 58500$ (s) $= 16.25$ (h)

$R = R_T / T = 72 / 16.25 = 4.43$ (mm/h)

$R_T = 72$ (mm)

Baganuur is selected as a reference location. By the same method as for the Togos River, "R_T" for 16.25 hours is 72 mm.

$QP = 1/3.6 * f * R * A = 1 / 3.6 * 0.48 * 4.43 * 790 = 470$ (m^3/s)

D-7. Reference of Calculation for Short Span Bridges and Culverts

1) Details of Calculation of Design Discharge Analysis

i) Mongolian Formula

Refers to another chapter in the Appendix

ii) Russian Formula

Refers to another chapter in the Appendix

iii) Rational Formula

The similar details with section 5.4.3 are used to calculation. The value of "f" (Runoff Coefficient) is 0.48.

To select a value for daily rainfall intensity (R_{24}), the data for Ulaanbaatar-C, Baganuur and Undurkhaan as shown in Table 5-4-7 were used. The average of Ulaanbaatar-C and Baganuur, $R_{24}=(56+65)/2$, was used for locations between Ulaanbaatar and Baganuur, and the average of Baganuur and Undurkhaan, $R_{24}=(65+82)/2$, for locations between Baganuur and Undurkhaan. The results are shown in Table 5-4-16.

The details of calculation are shown on Table D-16.

Table D-16 Details of the Calculation of Design Discharge Analysis

Rational Formula

Bridge	River	Location	W	h	L	h/L	T	t	R	R_{24}	R_T	f	A	Qpr	Qpm	Qpm/Qpr	Qp
(Box-C.)	(Valley)		m/s	m	m	-	h	h	mm/h	mm	mm	-	km2	m3/s	m3/s	m3/s	m3/s
B1	Khujirt	A-1	2.10	750	32000	0.023	5.99	0.5	8.82	65	52.9	0.48	153.6	181	-	-	111
B2	Khutsaa, Nariin	A-1	1.59	760	51600	0.015	12.20	0.5	4.84	65	59.1	0.48	321	207	-	-	128
(BC1)	(Kharzat)	B-1	2.90	200	5000	0.040	1.12	0.5	41.63	73.5	46.7	0.48	7.4	41	-	-	26
(BC2)	(Yumt)	B-1	3.08	190	4300	0.044	1.00	0.5	45.56	73.5	45.8	0.48	6	36	-	-	23
(BC3)	(Dund Bulag)	B-1	3.16	250	5400	0.046	1.12	0.5	41.83	73.5	46.7	0.48	5	28	-	-	18
(BC4)	(Shoboi)	B-1	2.77	270	7300	0.037	1.45	0.5	33.72	73.5	49.0	0.48	10.6	48	-	-	30
(BC5)	(Ust)	B-1	1.93	320	15700	0.020	3.43	0.5	16.47	73.5	56.5	0.48	56.8	125	-	-	77
(BC6)	-	B-1	3.35	260	5100	0.051	1.05	0.5	43.99	73.5	46.1	0.48	4.1	24	-	-	15
(BC7)	-	B-1	3.14	260	5700	0.046	1.16	0.5	40.65	73.5	47.0	0.48	6.3	34	-	-	21
(BC8)	-	C-1	3.31	220	4400	0.050	0.98	0.5	46.51	73.5	45.5	0.48	8	50	-	-	31
(BC9)	-	C-1	4.11	200	2800	0.071	0.75	0.5	57.85	73.5	43.2	0.48	4.4	34	-	-	21
(BC10)	-	C-1	2.87	280	7100	0.039	1.39	0.5	34.93	73.5	48.6	0.48	19.5	91	-	-	56
(BC11)	(Bor Xujir)	C-1	3.07	260	5900	0.044	1.19	0.5	39.61	73.5	47.3	0.48	13.4	71	-	-	44
(BC12)	(Ulaan Chuluun)	C-1	3.07	290	6600	0.044	1.28	0.5	37.48	73.5	47.9	0.48	15.1	75	-	-	47
(BC13)	-	TsMa	2.79	210	5600	0.038	1.23	0.5	38.78	73.5	47.5	0.48	6	31	-	-	20
(BC14)	(Bogin)	TsMa	2.68	380	10800	0.035	1.95	0.5	26.41	73.5	51.6	0.48	35	123	-	-	76
(BC15)	(Toson)	TsMa	3.71	380	6300	0.060	1.11	0.5	41.92	73.5	46.7	0.48	8.1	45	-	-	28
(BC16)	(Byatskhan Bulag)	TsMa	3.44	250	4700	0.053	0.99	0.5	45.98	73.5	45.7	0.48	7.8	48	-	-	30
(BC17)	(Urgun)	Ts-J	1.55	350	24800	0.014	6.27	0.5	9.85	73.5	61.8	0.48	104.1	137	77	0.56	84
(BC18)	-	Ts-J	3.27	230	4700	0.049	1.02	0.5	45.05	73.5	45.9	0.48	8.9	53	-	-	33
(BC19)	(Ar Khadagtai)	Ts-J	2.02	250	11400	0.022	2.54	0.5	21.23	73.5	53.9	0.48	33.1	94	34	0.36	58
(BC20)	Uvur Khadagtai	Ts-J	2.58	250	7600	0.033	1.56	0.5	31.73	73.5	49.6	0.48	20.9	88	13	0.15	55
(BC21)	(Zuulun)	Ts-J	2.52	130	4100	0.032	1.09	0.5	42.74	73.5	46.5	0.48	7	40	-	-	25
B5	(Urt)	Ts-J	1.51	340	25100	0.014	6.49	0.5	9.57	73.5	62.1	0.48	107.3	137	71	0.52	85
(BC22)	(Ulaan Khudag)	J-Ch	1.97	210	10000	0.021	2.33	0.5	22.77	73.5	53.1	0.48	28.9	88	22	0.25	54
(BC23)	-	J-Ch	2.19	110	4400	0.025	1.23	0.5	38.74	73.5	47.5	0.48	8.1	42	18	0.43	26
(BC24)	Duut	J-Ch	1.33	180	16500	0.011	4.98	0.5	12.00	73.5	59.8	0.48	65.9	105	-	-	65
(BC25)	(Duut)	J-Ch	1.92	200	9900	0.020	2.36	0.5	22.57	73.5	53.2	0.48	22.8	69	-	-	43
(BC26)	(Tsagaan Morit)	Ch-M	2.34	210	7500	0.028	1.66	0.5	30.26	73.5	50.1	0.48	22.4	90	-	-	56
(BC27)	(Del)	Ch-M	2.45	160	5300	0.030	1.28	0.5	37.37	73.5	47.9	0.48	5.8	29	-	-	18
(BC28)	-	M-U	2.44	180	6000	0.030	1.39	0.5	35.01	73.5	48.6	0.48	7.3	34	-	-	21
(BC29)	(Khatan Uul)	M-U	2.07	270	11800	0.023	2.55	0.5	21.11	73.5	53.9	0.48	22.5	63	-	-	39

Exist. Br.	Khujirt	A-1	2.10	750	32000	0.023	5.99	0.5	8.82	65	52.9	0.48	153.6	181	-	-	111
B3 required	Kherlen	Kherlen R.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1100

2) Details of Calculation of Design Cross Section

Design Riverbed slope is set to 1.0%. Manning's roughness coefficient is set to 0.015 for the reinforced concrete culvert surface and 0.03 for Bridges.

The details of calculation are shown on Table D-17.

Table D-17 Details of the Calculation of Design Cross Section

Manning formula

Bridge	Type	Location	River	H	W	N	A	P	R	i_0	i	n	v	Q	Q-Qp	JUDGE	Span
(Box-C.)			(Valley)	m	m	unit	m2	m	m	%	%	-	m/s	m3/s	m3/s	-	m
B1	Br	5	Khujirt	2.0	12.0	1	27.0	13.5	2.00	1.000	1.00	0.03	5.30	143	32	OK	1@15.0
B2	Br	6	Khutsaa, Nariin	1.8	14.5	1	28.8	13.5	2.14	0.370	1.00	0.03	5.53	159	31	OK	1@17.5
B3	Br	⑥	Kherlen	2.0	260.8	8	504.4	281.7	1.79	0.311	0.15	0.03	1.90	960	-140	CHANGE	8@33.6
(BC1)	D	7	(Kharzat)	2.0	2.5	1	5.0	6.5	0.77	1.667	1.00	0.015	5.60	28	2	OK	-
(BC2)	D	8	(Yumt)	2.0	2.5	1	5.0	6.5	0.77	0.870	1.00	0.015	5.60	28	5	OK	-
(BC3)	D	8	(Dund Bulag)	2.0	2.5	1	5.0	6.5	0.77	1.176	1.00	0.015	5.60	28	10	OK	-
(BC4)	E	8	(Shoboi)	2.0	2.5	2	10.0	13.0	0.77	1.333	1.00	0.015	5.60	56	26	OK	-
(BC5)	F	8	(Ust)	2.0	2.5	3	15.0	19.5	0.77	1.176	1.00	0.015	5.60	84	7	OK	-
(BC6)	D	9	-	2.0	2.5	1	5.0	6.5	0.77	1.818	1.00	0.015	5.60	28	13	OK	-
(BC7)	D	9	-	2.0	2.5	1	5.0	6.5	0.77	2.857	1.00	0.015	5.60	28	7	OK	-
(BC8)	E	10	-	2.0	2.5	2	10.0	13.0	0.77	2.222	1.00	0.015	5.60	56	25	OK	-
(BC9)	D	10	-	2.0	2.5	1	5.0	6.5	0.77	4.000	1.00	0.015	5.60	28	7	OK	-
(BC10)	E	11	-	2.0	2.5	2	10.0	13.0	0.77	1.667	1.00	0.015	5.60	56	0	OK	-
(BC11)	E	11	(Bor Xujir)	2.0	2.5	2	10.0	13.0	0.77	1.176	1.00	0.015	5.60	56	12	OK	-
(BC12)	E	11	(Ulaan Chuluun)	2.0	2.5	2	10.0	13.0	0.77	1.667	1.00	0.015	5.60	56	9	OK	-
(BC13)	D	12	-	2.0	2.5	1	5.0	6.5	0.77	1.111	1.00	0.015	5.60	28	8	OK	-
(BC14)	F	12	(Bogin)	2.0	2.5	3	15.0	19.5	0.77	1.818	1.00	0.015	5.60	84	8	OK	-
(BC15)	D	12	(Toson)	2.0	2.5	1	5.0	6.5	0.77	2.000	1.00	0.015	5.60	28	0	OK	-
(BC16)	E	12	(Byatskhan Bulag)	2.0	2.5	2	10.0	13.0	0.77	0.833	1.00	0.015	5.60	56	26	OK	-
(BC17)	F	13	(Urgun)	2.0	2.5	3	15.0	19.5	0.77	0.526	1.00	0.015	5.60	84	0	OK	-
(BC18)	E	13	-	2.0	2.5	2	10.0	13.0	0.77	1.667	1.00	0.015	5.60	56	23	OK	-
(BC19)	F	14	(Ar Khadagtai)	2.0	2.5	3	15.0	19.5	0.77	1.053	1.00	0.015	5.60	84	26	OK	-
(BC20)	E	14	Uvur Khadagtai	2.0	2.5	2	10.0	13.0	0.77	1.053	1.00	0.015	5.60	56	1	OK	-
(BC21)	D	15	(Zuulun)	2.0	2.5	1	5.0	6.5	0.77	1.250	1.00	0.015	5.60	28	3	OK	-
B5	Br	15	(Urt)	1.7	12.0	1	23.0	13.5	1.70	0.588	1.00	0.03	4.75	109	24	OK	1@15.0
(BC22)	E	17	(Ulaan Khudag)	2.0	2.5	2	10.0	13.0	0.77	0.690	1.00	0.015	5.60	56	2	OK	-
(BC23)	D	18	-	2.0	2.5	1	5.0	6.5	0.77	1.667	1.00	0.015	5.60	28	2	OK	-
(BC24)	F	19	Duut	2.0	2.5	3	15.0	19.5	0.77	0.833	1.00	0.015	5.60	84	19	OK	-
(BC25)	E	19	(Duut)	2.0	2.5	2	10.0	13.0	0.77	0.952	1.00	0.015	5.60	56	13	OK	-
(BC26)	E	22	(Tsagaan Morit)	2.0	2.5	2	10.0	13.0	0.77	1.200	1.00	0.015	5.60	56	0	OK	-
(BC27)	D	23	(Del)	2.0	2.5	1	5.0	6.5	0.77	0.769	1.00	0.015	5.60	28	10	OK	-
(BC28)	D	23	-	2.0	2.5	1	5.0	6.5	0.77	3.333	1.00	0.015	5.60	28	7	OK	-
(BC29)	E	23	(Khatan Uul)	2.0	2.5	2	10.0	13.0	0.77	1.250	1.00	0.015	5.60	56	17	OK	-

Exist. Br.	Br	5	Khujirt	2.5	4.0	2	20.0	18.0	1.11	1.000	1.80	0.03	4.80	96	-15	CHANGE	2@4.0
B3 required	Br	⑥	Kherlen	2.0	342.0	11	644.0	388.5	1.66	0.311	0.15	0.03	1.81	1164	64	OK	11@33.6

D-8. Details of Calculation for Rainfall Intensity

Data for hourly precipitation was not available as it is mention in the former section. For rainfall intensity for durations of less than 1 hour, data from the project for Improvement of Roads in Ulaanbaatar, JICA, is taken for reference. Values are shown in Table D-18.

Table D-18 Design Rainfall Intensity

	5min.	10min	20min.	40min.	24 hours	Remarks
Rainfall (mm)	6.4	10.0	12.8	15.3	52	Data for 12 years
Rainfall Intensity (mm/h)	77.1	60.0	38.8	23.2	-	

Data source: Mongolian Meteorological Authority (1978 to 1999)

The Talbot type intensity equation was also established in the project mentioned above. Return period is set to 12 years. The equation is as follows:

$$r = 1121 / (t + 9)$$

Where,

r : Rainfall Intensity (mm/h)

t : Time of Concentration (min)

With this equation design rainfall intensity of 12 year return period is also calculated. Values are in the table D-19.

Table D-19 Design Rainfall Intensity in Ulaanbaatar

Time of concentration	Rainfall (mm)
5min.	80
10min	59
20min.	39
30min.	29
40min.	23
60min.	16

Daily Rainfall Intensity is calculated by the method of section 5.4.2. Return periods are 3, 5 and 12 years. Values are listed in table D-20. Ratio of Daily Rainfall Intensity and Ratio of Location to Ulaanbaatar are also listed. The former values are used to calculate 3 and 5 year return period rainfall intensity and the latter is to calculate 12 year return period rainfall intensity.

Table D-20 Daily Rainfall Intensity and Ratio

Location	Baganuur		
Return Period	12 years	5 years	3 years
Daily Rainfall (mm)	60	50	30
Ratio of Daily Rainfall	1.00	0.83	0.50
Ratio of Location to Ulaanbaatar	1.15	-	-
Location	Undurkhaan		
Return Period	12 years	5 years	3 years
Daily Rainfall (mm)	70	50	35
Ratio of Daily Rainfall	1.00	0.71	0.50
Ratio of Location to Ulaanbaatar	1.35	-	-