
Appendix

Summary of Sample Calculation for Curve Number (CN), Baseflow and Direct Runoff

Appendix A

Calculation of Baseflow and Direct Runoff.

The following procedure was used to estimate the baseflow and direct runoff in Table 3-3:

1. Review rainfall records to determine periods of no rain (dry) for the month in question.
2. Review streamflow records for the corresponding period in step #1 to identify and establish the baseflow flow contribution in the creek/river for that month. During the no rain period the streamflow records show little variation in flow values. On the other hand, following a rainfall event, there was a significant variation in the recorded streamflow values indicating the runoff contribution resulting from the rainfall on the subcatchment.
3. Separate hydrograph by drawing a straight line separating the baseflow from the resulting surface runoff hydrograph to determine the direct runoff contribution from the subcatchment.
4. Determine the volume of surface runoff by calculating the area under the surface runoff hydrograph.
5. Similarly, determine the volume of baseflow by calculating the area under the baseflow curve drawn in Step #3.
6. Calculate the depth of surface runoff and baseflow by dividing the volumes calculated in Steps #4 and #5 with the area of the subcatchment.
7. Calculate the direct runoff by subtracting the baseflow from the surface runoff values determined in step #6 (see Table A-1).
8. Repeat steps #1 to #7 to calculate the baseflow, surface runoff and direct runoff for the other months in the year and determine the cumulative surface runoff, baseflow and direct runoff for the year.
9. Repeat steps #1 to #8 for the period of record (see Table A-2).

The attached Figure A-1 illustrates an example of baseflow separation for the Big Carp River for the period October/November 1984.

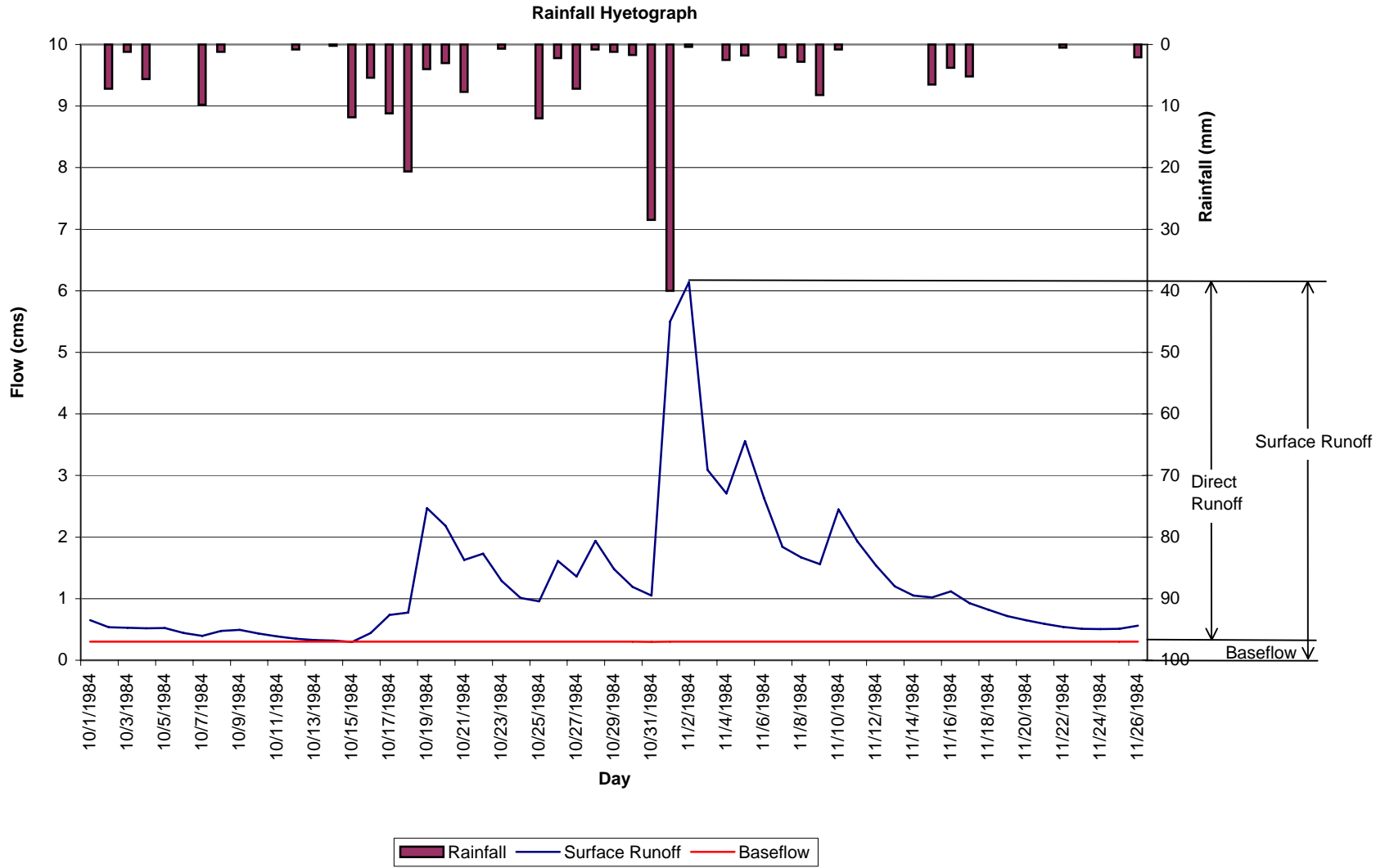
Table A-1 – Sample Calculation to Determine Surface Runoff, Baseflow and Direct Runoff for the month of October, 1984.

Year	Month	Day	Flow (m ³ /s)	Volume of Surface Runoff (m ³)	Depth of Surface Runoff (mm)	Baseflow (m ³ /s)	Volume of Baseflow (m ³)	Depth of Baseflow (mm)	Depth of Direct Runoff (mm)
1984	10	1	0.649	56,074		0.30	25,574		
1984	10	2	0.534	46,138		0.30	25,574		
1984	10	3	0.529	45,706		0.30	25,574		
1984	10	4	0.52	44,928		0.30	25,574		
1984	10	5	0.523	45,187		0.30	25,574		
1984	10	6	0.443	38,275		0.30	25,574		
1984	10	7	0.394	34,042		0.30	25,574		
1984	10	8	0.477	41,213		0.30	25,574		
1984	10	9	0.492	42,509		0.30	25,574		
1984	10	10	0.434	37,498		0.30	25,574		
1984	10	11	0.385	33,264		0.30	25,574		
1984	10	12	0.349	30,154		0.30	25,574		
1984	10	13	0.329	28,426		0.30	25,574		
1984	10	14	0.32	27,648		0.30	25,574		
1984	10	15	0.296	25,574		0.30	25,574		
1984	10	16	0.444	38,362		0.30	25,574		
1984	10	17	0.735	63,504		0.30	25,574		
1984	10	18	0.773	66,787		0.30	25,574		
1984	10	19	2.47	213,408		0.30	25,574		
1984	10	20	2.18	188,352		0.30	25,574		
1984	10	21	1.63	140,832		0.30	25,574		
1984	10	22	1.73	149,472		0.30	25,574		
1984	10	23	1.29	111,456		0.30	25,574		
1984	10	24	1.01	87,264		0.30	25,574		
1984	10	25	0.955	82,512		0.30	25,574		
1984	10	26	1.61	139,104		0.30	25,574		
1984	10	27	1.36	117,504		0.30	25,574		
1984	10	28	1.94	167,616		0.30	25,574		
1984	10	29	1.48	127,872		0.30	25,574		
1984	10	30	1.19	102,816		0.30	25,574		
1984	10	31	1.05	90,720		0.30	25,574		
Volume of Surface Runoff and Baseflow for month of October				2,464,214			792,806		
Depth of Surface Runoff, Baseflow and Direct Runoff for month of October					47.8			15.4	32.5

Table A-2 –Cumulative Surface Runoff, Baseflow and Direct Runoff for 1984.

Year	Month	Surface Runoff (mm)	Cumulative Surface Runoff (mm)	Baseflow (mm)	Cumulative Baseflow (mm)	Direct Runoff (mm)	Cumulative Direct Runoff (mm)
1984	January	12.9	12.9	10.9	10.9	2.0	2.0
1984	February	14.1	27.1	9.7	20.7	4.4	6.4
1984	March	16.0	43.1	7.8	28.5	8.2	14.6
1984	April	66.9	110.0	14.1	42.5	52.8	67.5
1984	May	25.6	135.6	7.4	49.9	18.2	85.7
1984	June	26.4	162.0	3.3	53.2	23.1	108.8
1984	July	18.0	180.0	4.0	57.2	14.0	122.8
1984	August	12.7	192.7	3.1	60.3	9.5	132.4
1984	September	57.4	250.1	6.6	66.9	50.8	183.2
1984	October	47.8	297.9	15.4	82.3	32.5	215.6
1984	November	83.5	381.4	25.4	107.7	58.1	273.7
1984	December	61.4	442.8	33.8	141.5	27.5	301.3
Cumulative Surface Runoff, Baseflow and Direct Runoff for 1984			442.8		141.5		301.3

Figure A-1: Example of Baseflow Separation
Big Carp River - October/November 1984



Appendix B

Calculation of Subwatershed CN Values.

For each subcatchment, a CN value was determined based on distinct land use, land cover and hydrologic soil type. To estimate the average CN values in Table 3-5, the following expression was used:

$$\text{Average CN} = (A1*CN1 + A2*CN2 + A3*CN3 + \dots)/(A1 + A2 + A3 + ..)$$

where:

Area of subcatchment 1 = A1
CN of subcatchment 1 = CN1

Area of subcatchment 2 = A2
CN of subcatchment 2 = CN2

Area of subcatchment 3 = A3
CN of subcatchment 3 = CN3

and so on

and the total area of the subwatershed = A1+A2+A3+...

Table B-1 - Average CN Values for the Subwatersheds.

Subwatershed ID	Land Use	Area (ha)	CN	Area*CN (ha)
1	Rural & Other	321.3	66	21208.1
1	Waterbody	3.0	0	0.0
1	Wetland	4.9	0	0.0
1		Average	CN	64.4
8	Residential	170.5	77	13129.0
8	Rural & Other	2115.3	60	126918.4
8	Waterbody	18.1	0	0.0
8	Wetland	878.7	0	0.0
8		Average	CN	44.0
29	Rural & Other	946.2	60	56774.3
29	Waterbody	65.2	0	0.0
29	Wetland	41.4	0	0.0
29		Average	CN	53.9
30	Residential	408.2	77	31433.8
30	Rural & Other	3711.9	60	222715.0
30	Waterbody	8.8	0	0.0
30	Wetland	17.8	0	0.0
30		Average	CN	61.3
31	Residential	18.6	77	1433.2
31	Rural & Other	1481.3	60	88876.0
31	Waterbody	13.8	0	0.0
31	Wetland	5.7	0	0.0
31		Average	CN	59.4
32	Residential	13.8	77	1063.0
32	Rural & Other	275.0	60	16499.2
32	Waterbody	16.4	0	0.0
32	Wetland	3.5	0	0.0
32		Average	CN	56.9
12	Rural & Other	1876.1	60	112568.3
12	Waterbody	17.9	0	0.0
12	Wetland	114.9	0	0.0
12		Average	CN	56.0
6	Industrial	545.8	81	44206.2
6	Residential	58.5	77	4507.8
6	Rural & Other	920.5	60	55231.4
6	Waterbody	12.8	0	0.0
6	Wetland	55.2	0	0.0
6		Average	CN	65.3

Subwatershed ID	Land Use	Area (ha)	CN	Area*CN (ha)
18	Industrial	15.4	81	1250.5
18	Residential	200.5	77	15439.0
18	Rural & Other	2003.9	60	120233.3
18	Waterbody	40.7	0	0.0
18	Wetland	42.7	0	0.0
18		Average	CN	59.4
3	Industrial	204.7	81	16584.0
3	Residential	32.5	59	1919.2
3	Wetland	3.4	0	0.0
3		Average	CN	76.9
14	Commercial	1.4	92	131.7
14	Institutional	0.2	88	13.9
14	Residential	188.0	85	15982.5
14	Rural & Other	1763.1	66	116363.9
14	Waterbody	26.0	0	0.0
14	Wetland	51.1	0	0.0
14		Average	CN	65.3
7	Commercial	0.4	92	39.0
7	Institutional	16.0	88	1410.5
7	Residential	88.6	85	7533.0
7	Rural & Other	166.4	60	9983.2
7		Average	CN	69.9
15	Commercial	12.3	89	1099.1
15	Industrial	156.6	81	12682.0
15	Institutional	0.0	81	1.7
15	Residential	432.8	77	33327.6
15	Rural & Other	1585.1	60	95108.6
15	Waterbody	39.3	0	0.0
15	Wetland	43.4	0	0.0
15		Average	CN	62.7
2	Industrial	80.0	81	6479.0
2	Industrial	80.6	81	6532.2
2	Residential	7.2	77	553.4
2	Waterbody	3.0	0	0.0
2		Average	CN	79.4
27	Commercial	289.4	89	25758.2
27	Industrial	291.6	81	23619.6
27	Institutional	133.5	81	10815.4
27	Residential	1588.9	77	122343.2
27	Rural & Other	678.9	60	40734.6

Subwatershed ID	Land Use	Area (ha)	CN	Area*CN (ha)
27	Waterbody	2.7	0	0.0
27		Average	CN	74.8
16	Residential	1.1	85	90.4
16	Rural & Other	2299.2	60	137952.0
16	Waterbody	146.1	0	0.0
16	Wetland	159.5	0	0.0
16		Average	CN	53.0
20	Residential	36.8	85	3132.1
20	Rural & Other	469.0	66	30953.3
20	Waterbody	174.8	0	0.0
20	Wetland	7.0	0	0.0
20		Average	CN	49.6
25	Residential	4.4	85	372.0
25	Rural & Other	1616.9	66	106715.7
25	Waterbody	203.0	0	0.0
25	Wetland	37.5	0	0.0
25		Average	CN	57.5
4	Commercial	1.0	89	91.1
4	Industrial	159.6	81	12929.1
4	Institutional	54.9	81	4445.6
4	Residential	225.6	77	17368.7
4	Rural & Other	3673.8	60	220425.4
4	Waterbody	60.4	0	0.0
4	Wetland	91.6	0	0.0
4		Average	CN	59.8
28	Commercial	1.8	89	163.3
28	Industrial	12.1	81	977.9
28	Institutional	12.9	81	1042.9
28	Residential	398.9	77	30719.1
28	Rural & Other	327.9	60	19672.5
28	Waterbody	0.8	0	0.0
28	Wetland	9.3	0	0.0
28		Average	CN	68.8

Appendix C

Calculation of Direct Runoff.

The direct runoff was calculated using the SCS Curve Number Method equation which is given by:

$$Pe = (P-Ia)^2 / (P-Ia+S)$$

where:

$$S = 25400 / (CN - 2.54)$$

The parameters in the SCS equation are defined below:

Pe is the direct runoff (mm)

P is the total precipitation (mm)

Ia is the initial abstraction (mm)

S is the potential maximum abstraction (mm)

CN is the runoff curve number based on the land use, land cover and hydrologic soil type.

The following steps were used to determine the direct runoff in Table 3-5:

1. Calculate the direct runoff for one month (see Table C-1) for sample calculation for an average CN=56 for September, 2001.
2. Calculate the direct runoff for the same month for the period of record (see Table C-2) and determine the average direct runoff for the month.
3. Repeat steps #1 and #2 for each of the months in the year.
4. Sum the direct runoff for each month to establish the annual direct runoff as shown in Table C-3.

Table C-1 – Sample Calculation to Determine the Direct Runoff for an Average CN=56 for the Month of September, 2001.

Date	Year	Month	Day	Total Rain (mm)	Total Snow (cm)	Total Precip (mm)	CN (mm)	S (mm)	Ia (mm)	P-Ia (mm)	P-Ia+S (mm)	Pe (mm)
9/1/2001	2001	9	1	1.1	0	1.1	56	7.86	1.57	-0.47	7.39	0.0
9/2/2001	2001	9	2	0.2	0	0.2	56	7.86	1.57	-1.37	6.49	0.0
9/3/2001	2001	9	3	0.4	0	0.4	56	7.86	1.57	-1.17	6.69	0.0
9/4/2001	2001	9	4	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/5/2001	2001	9	5	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/6/2001	2001	9	6	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/7/2001	2001	9	7	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/8/2001	2001	9	8	6.6	0	6.6	56	7.86	1.57	5.03	12.89	2.0
9/9/2001	2001	9	9	46	0	46	56	7.86	1.57	44.43	52.29	37.8
9/10/2001	2001	9	10	8.4	0	8.4	56	7.86	1.57	6.83	14.69	3.2
9/11/2001	2001	9	11	7.1	0	7.1	56	7.86	1.57	5.53	13.39	2.3
9/12/2001	2001	9	12	8.6	0	8.6	56	7.86	1.57	7.03	14.89	3.3
9/13/2001	2001	9	13	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/14/2001	2001	9	14	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/15/2001	2001	9	15	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/16/2001	2001	9	16	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/17/2001	2001	9	17	3.1	0	3.1	56	7.86	1.57	1.53	9.39	0.2
9/18/2001	2001	9	18	0.4	0	0.4	56	7.86	1.57	-1.17	6.69	0.0
9/19/2001	2001	9	19	19	0	19	56	7.86	1.57	17.43	25.29	12.0
9/20/2001	2001	9	20	26.7	0	26.7	56	7.86	1.57	25.13	32.99	19.1
9/21/2001	2001	9	21	0.4	0	0.4	56	7.86	1.57	-1.17	6.69	0.0
9/22/2001	2001	9	22	0.7	0	0.7	56	7.86	1.57	-0.87	6.99	0.0
9/23/2001	2001	9	23	22.4	0	22.4	56	7.86	1.57	20.83	28.69	15.1
9/24/2001	2001	9	24	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/25/2001	2001	9	25	6.1	0	6.1	56	7.86	1.57	4.53	12.39	1.7
9/26/2001	2001	9	26	0.4	0	0.4	56	7.86	1.57	-1.17	6.69	0.0
9/27/2001	2001	9	27	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/28/2001	2001	9	28	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/29/2001	2001	9	29	0	0	0	56	7.86	1.57	-1.57	6.29	0.0
9/30/2001	2001	9	30	0.4	0	0.4	56	7.86	1.57	-1.17	6.69	0.0
Average	2001	9		158.0	0.0	158.0	56	7.86	1.57	156.43	164.29	96.7

Table C-2 – Average Direct Runoff for September for the Period 1971-2001.

Year	Month	Direct Runoff (Pe) (mm)
1971	September	40.8
1972	September	27.9
1973	September	34.3
1974	September	45.5
1975	September	75.3
1976	September	20.7
1977	September	58.4
1978	September	89.7
1979	September	22.6
1980	September	43.6
1981	September	38.0
1982	September	103.4
1983	September	40.2
1984	September	0.4
1985	September	78.1
1986	September	81.2
1987	September	28.3
1988	September	48.6
1989	September	17.0
1990	September	72.9
1991	September	77.1
1992	September	93.7
1993	September	47.4
1994	September	18.4
1995	September	76.3
1996	September	84.0
1997	September	54.9
1998	September	32.0
1999	September	47.9
2000	September	20.5
2001	September	96.7
Average Direct Runoff for September over Period of Record		52.13

Table C-3 – Annual Direct Runoff for the Period 1971-2001.

Period	Month	Direct Runoff (Pe) (mm)
1971-2001	January	36.18
1971-2001	February	16.85
1971-2001	March	25.07
1971-2001	April	30.76
1971-2001	May	0.00
1971-2001	June	0.00
1971-2001	July	0.00
1971-2001	August	0.00
1971-2001	September	52.13
1971-2001	October	46.48
1971-2001	November	40.87
1971-2001	December	44.98
Average Annual Direct Runoff for Period of Record		293.32

Appendix D

Conceptual Water Budget Maps.