Appendix C

Testing WEPP-Mine: Case Application to Big Sky Mine, Colstrip, MT

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Watersheds in the Big Sky Mine, Areas A and B, were used for testing the WEPP-Mine model with the default inputs. These data, including the USGS 30-m DEM and land cover and the USDA SSURGO soil data, were presumed to be representative of the pre-mining conditions. Seven watersheds with available long-term daily streamflow data at the watershed outlets were selected, one was in Area A and the other six, nested, were along Lee Coulee in Area B (Table 1). Mining in Area A was completed in 1989. Post-mining reclamation activities, including regrading, topsoil replacement, and revegetation of the mined areas above the sediment ponds and traps in Area A were completed in 1992 (BSCC, 2009a). For Area B, the revegetation of the reclaimed mine lands above each outfall was started at different times but all during the period of 1993–2007 (BSCC, 2009b).

Table 1. Study watersheds in Areas A and B, Big Sky Mine

Obs. Point	BPSFL	BRTFL	BMMFL	BS33FL	BLFFL	BBBFL	AFL50-1
Longitude	−106.717	−106.692	−106.675	−106.633	−106.674	−106.641	−106.603
Latitude	45.824	45.815	45.806	45.79	45.802	45.8	45.835
Stream	Lee Coulee, Area B	Lee Coulee, Area B	Lee Coulee, Area B	Lee Coulee, Area B	Fossil Fork, Lee Coulee, Area B	Bad Bob Gutch, Lee Coulee, Area B	Area A
Collection Area, ha	581	992	1308	4067	760	794	168
Obs. Start	10/18/1984	3/14/1985	10/18/1984	2/17/1984	2/28/1985	3/15/1985	8/9/2000
Obs. End	12/31/2006	5/16/2001	6/15/2003	12/31/2006	5/11/1999	9/30/1989	12/31/2006
Obs. Year	22	17	19	23	15	5	6
Observed runoff at specific recurrence interval, mm							
2-yr	0.57	0.11	0.07	0.05	0.77	0.62	0.00
5-yr	1.31	0.38	2.06	0.98	2.15	2.16	0.01
10-yr	1.63	0.77	9.03	2.28	3.83		1.06
20-yr		0.88	9.33				
25-yr	9.38			3.83			
WEPP-simulated runoff at specific recurrence interval, mm							
2-yr	0.02	0.01			0	0	0.06
5-yr	0.76	0.39			0.03	0.06	1.11
10-yr	2.81	1.57			0.07	0.09	2.67
25-yr	15.9	12.2			0.34	0.64	8.97
WEPP-simulated sediment yield at specific recurrence interval, t/ha							
2-yr	0	0			0	0	0
5-yr	0.02	0.02			0	0	0.12
10-yr	0.11	0.13			0	0.01	0.52
25-yr	0.95	1.24			0.02	0.07	2.41

From upstream to downstream of Lee Coulee, there are four observation points, BPSFL (most upstream), BRTFL, BMMFL, and BS33FL (most downstream), and they were used as the outlets of our study watersheds (Fig. 1–4). BPSFL has a drainage area of 581 ha, and BS33FL 4067 ha, the largest of all the study watersheds. The other two observation points chosen as watershed outlets in Area B are on the two major tributaries of Lee Coulee: BLFFL on Fossil Fork (Fig. 5) and BBBFL on Bad Bob Gultch (Fig. 6). The watershed AFL50-1 in Area A has a collection area of 168 ha, the smallest of the seven study watersheds (Fig. 7).

Daily runoff values recorded at the monitoring points for various observation periods from 1984 to 2006 were from the Big Sky Mine Database 2007, in Microsoft Access files submitted by the mine to MTDEQ (Table 1).

Tables 2–8 show the yearly precipitation maximum series observed at the NOAA weather station at Colstrip, MT (45.883°, 106.633°, NOAA, 2011) and the yearly runoff maximum series observed at the study watersheds. Most of the maximum runoff values occurred during summer and fall; some occurred during the spring snow melt season. Maximum runoff is not always coincident with the maximum precipitation in the study area. Observed daily runoff at the BPSFL and the observed precipitation at the Colstrip Weather Station during (1984–2006) are shown in Fig. 8.1–11. Runoff was mainly observed during or after summer and fall thunderstorms or spring snowmelts. No evident pattern can be seen between the amount of precipitation and the occurrence of runoff events (Figs. 8 and 9).

WEPP simulations for the watersheds smaller than 1000 ha were conducted using the available weather data from the NOAA weather station at Colstrip, including observed daily precipitation and maximum and minimum temperatures for 1984–2009. The remaining climatic inputs, including precipitation duration, time to peak, peak intensity, solar radiation, dew-point temperature, and wind direction and velocity were generated using CLIGEN (Nicks et al., 1995) based on the statistics from the weather station at Branderberg, MT, the nearest weather station to the study area included in the WEPP database. Other model inputs were the default inputs in WEPP-Mine, including the National USGS 30-m Elevation DEM (Gesch et al., 2002; Gesch, 2007), the USGS 2006 National Land Cover grid (Homer et al., 2004) for landuse and management, and the SSURGO soil data (NRCS, 2011) for each study watershed. "Watershed only" simulations, which produced streamflow at the observation points, were conducted for 26 years covering the period (1984−2009) for which observed streamflow data were available.

WEPP-simulated runoff events are shown in Fig. 10.1–13. The simulated events do not match well with those observed. The main reasons could be that (i) the thunderstorms observed at the Colstrip weather station were localized, not always extending to the study area, and (ii) using CLIGEN-generated precipitation characteristics, instead of the actual, observed, may have altered the rainfall intensity of the thunderstorms. Hence, the assessment of WEPP-Mine performance in this study was conducted using return-period analysis, a statistical measurement commonly used for risk analysis.

The return periods of the runoff events were estimated by applying the Weibull formula to annual maximum series: $T = (N + 1)/m$, where T is the return period, N is the number of the observation or simulation years, and m is the rank of the annual maxima event. The results of the return-period analysis and a summary of the landuse and soils of each study watershed are presented in the section of WEPP simulation inputs and results. WEPP-simulated runoff for the return periods of 2, 5, 10, and 25 years generally fall in the range of the observed (Table 1). Future efforts should be devoted to improving site-specific climatic, soil, and management inputs for the individual test watersheds.

1. Study Watersheds

1.1 Watershed with observation point BPSFL

Area (ha): 583 (cells: 6480)
Number of Representative Hillslopes: 82
Number of Channels: 33
Number of Impoundments: 0
Outlet Location: −106.7167, 45.8244
Reference Point: 0
Minimum Source Channel Length (m): 100
Critical Source Area (ha): 10

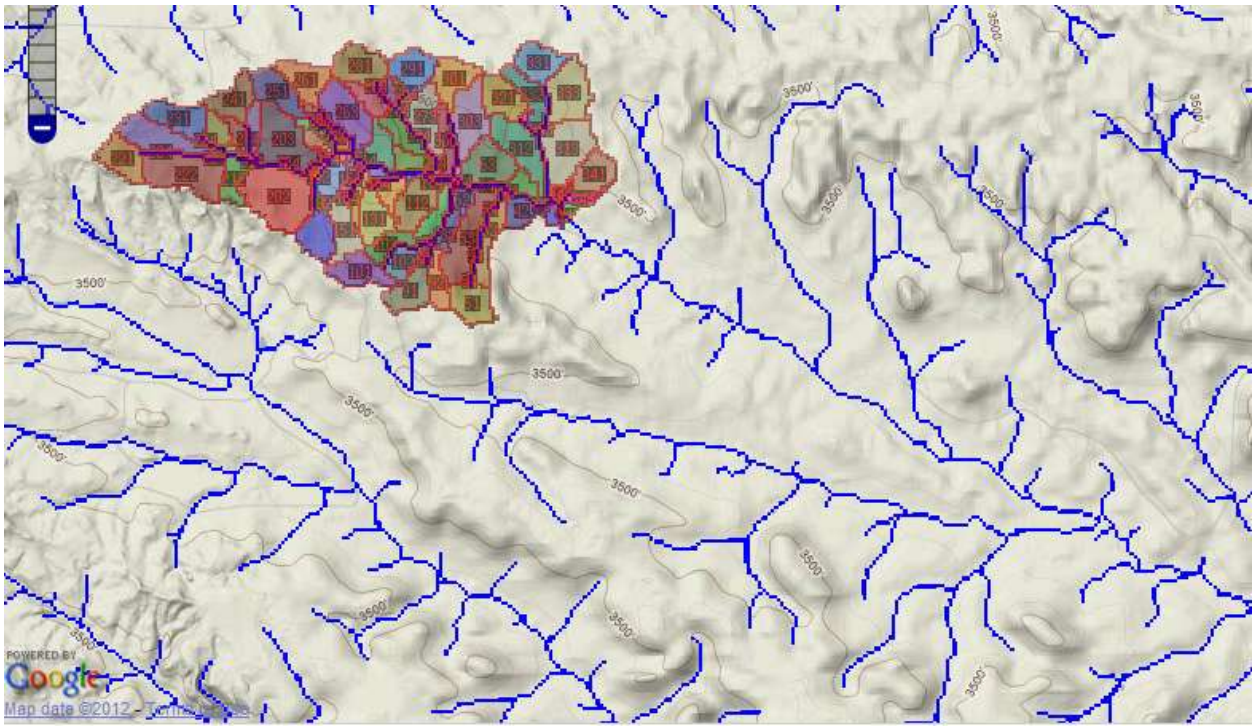

Fig. 1 The BPSFL watershed

Table 2. Annual maxima of precipitation at Colstrip weather station and observed streamflow at BPSFL

Water Year	Tot. Precip. mm	Max. Precip. mm	MaxP Month	MaxP Day	Tot. Runoff mm	Max. Runoff mm	MaxRF Month	MaxRF Day
1984	239	20.4	6	8				
1985	309	30.1	7	29	1.08	0.40	3	17
1986	370	42.1	9	24	1.99	1.28	2	24
1987	377	27.0	8	24	13.80	9.38	8	14
1988	185	16.3	9	18	4.39	1.63	9	18
1989	357	20.9	6	16	1.45	0.69	7	16
1990	302	37.5	5	24	0.53	0.27	8	24
1991	384	56.1	9	15	3.26	1.05	9	15
1992	342	28.6	8	23	1.25	0.38	6	30
1993	407	50.2	6	8	1.56	0.69	7	1
1994	333	31.6	9	15	0.56	0.21	9	14
1995	447	31.1	10	15	0.26	0.11	5	12
1996	316	31.6	5	24	0.06	0.05	7	25
1997	418	45.4	5	26	1.44	0.57	7	20
1998	350	26.0	9	12	1.01	0.46	8	18
1999	419	34.2	4	20	3.09	1.31	8	12
2000	362	30.1	6	9	1.34	0.72	6	9
2001	326	40.8	6	29	3.61	1.60	7	18
2002	387	45.1	7	16	0.30	0.29	7	17
2003	367	20.7	3	18	0.11	0.11	6	4
2004	291	26.8	10	29	2.07	1.20	2	18
2005	493	67.3	5	8	0.96	0.37	6	28
2006	398	49.2	10	5	0.10	0.04	7	2
2007	493	66.8	6	7				
2008	495	36.5	5	24				
2009	359	33.4	8	6				

Note: Precipitation was observed during 1984/01/01–2009/12/31 and runoff 1984/10/18–2006/12/31.

1.2 Watershed with observation point BRTFL

Area (ha): 994 (cells: 11046)
Number of Representative Hillslopes: 120
Number of Channels: 51
Number of Impoundments: 0
Outlet Location: −106.6918, 45.814
Reference Point: 0
Minimum Source Channel Length (m): 100
Critical Source Area (ha): 10

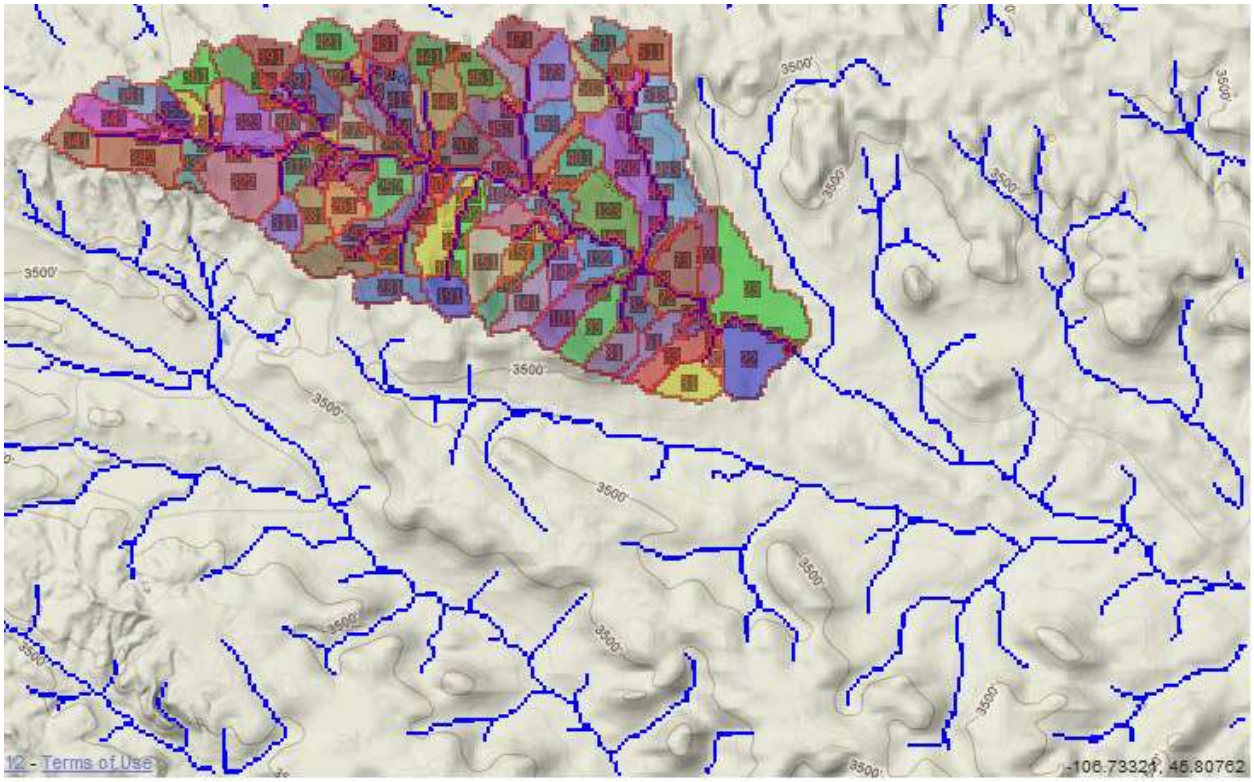

Fig. 2 The BRTFL watershed

Table 3. Annual maxima of precipitation at Colstrip weather station and observed streamflow at BRTFL

Water Year	Tot. Precip. Mm	Max. Precip. mm	MaxP Month	MaxP Day	Tot. Runoff mm	Max. Runoff mm	MaxRF Month	MaxRF Day
1984	239	20.4	6	8				
1985	309	30.1	7	29	2.33	0.26	3	17
1986	370	42.1	9	24	2.83	0.16	9	25
1987	377	27.0	8	24	0.77	0.08	5	26
1988	185	16.3	9	18	2.16	0.88	2	12
1989	357	20.9	6	16	1.07	0.38	3	8
1990	302	37.5	5	24	1.62	0.37	4	26
1991	384	56.1	9	15	2.50	0.08	4	16
1992	342	28.6	8	23	1.15	0.08	2	25
1993	407	50.2	6	8	4.89	0.77	3	2
1994	333	31.6	9	15	1.27	0.11	3	4
1995	447	31.1	10	15	0.87	0.13	10	16
1996	316	31.6	5	24	0.33	0.11	1	10
1997	418	45.4	5	26	0.00	0.00	2	3
1998	350	26.0	9	12	0.00	0.00	10	1
1999	419	34.2	4	20	0.00	0.00	10	1
2000	362	30.1	6	9	0.00	0.00	10	1
2001	326	40.8	6	29	0.00	0.00	10	1
2002	387	45.1	7	16				
2003	367	20.7	3	18				
2004	291	26.8	10	29				
2005	493	67.3	5	8				
2006	398	49.2	10	5				
2007	493	66.8	6	7				
2008	495	36.5	5	24				
2009	359	33.4	8	6				

Note: Precipitation was observed during 1984/01/01–2009/12/31 and runoff 1985/03/14–2001/05/16.

1.3 Watershed with observation point BMMFL

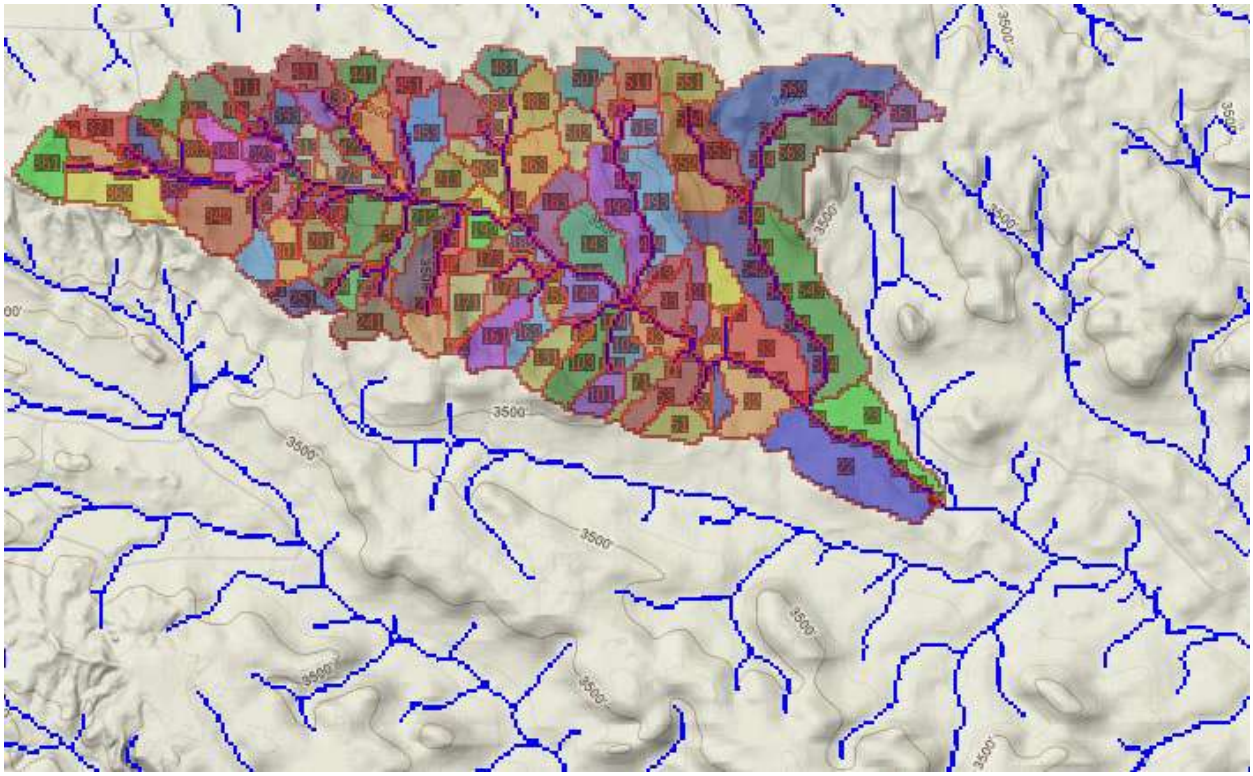

Fig. 3 The BMMFL watershed

Table 4. Annual maxima of precipitation at Colstrip weather station and observed streamflow at BMMFL

Water Year	Tot. Precip. mm	Max. Precip. mm	MaxP Month	MaxP Day	Tot. Runoff mm	Max. Runoff mm	MaxRF Month	MaxRF Day
1984	239	20.4	6	8				
1985	309	30.1	7	29	3.92	0.80	8	2
1986	370	42.1	9	24	3.89	2.06	2	24
1987	377	27.0	8	24	2.14	0.46	3	19
1988	185	16.3	9	18	10.88	2.52	2	17
1989	357	20.9	6	16	42.50	9.03	3	8
1990	302	37.5	5	24	0.13	0.04	1	9
1991	384	56.1	9	15	0.00	0.00	10	1
1992	342	28.6	8	23	0.00	0.00	10	1
1993	407	50.2	6	8	0.93	0.67	7	3
1994	333	31.6	9	15	10.50	9.33	3	3
1995	447	31.1	10	15	13.41	0.34	12	3
1996	316	31.6	5	24	3.00	0.31	5	21
1997	418	45.4	5	26	1.56	0.07	11	9
1998	350	26.0	9	12	0.00	0.00	10	1
1999	419	34.2	4	20	0.00	0.00	10	1
2000	362	30.1	6	9	0.00	0.00	8	15
2001	326	40.8	6	29	0.00	0.00	10	1
2002	387	45.1	7	16	0.01	0.01	9	8
2003	367	20.7	3	18	0.00	0.00	10	1
2004	291	26.8	10	29				
2005	493	67.3	5	8				
2006	398	49.2	10	5				
2007	493	66.8	6	7				
2008	495	36.5	5	24				
2009	359	33.4	8	6				

Note: Precipitation was observed during 1984/01/01–2009/12/31 and runoff 1984/10/18–2003/06/15.

1.4 Watershed with observation point BS33FL

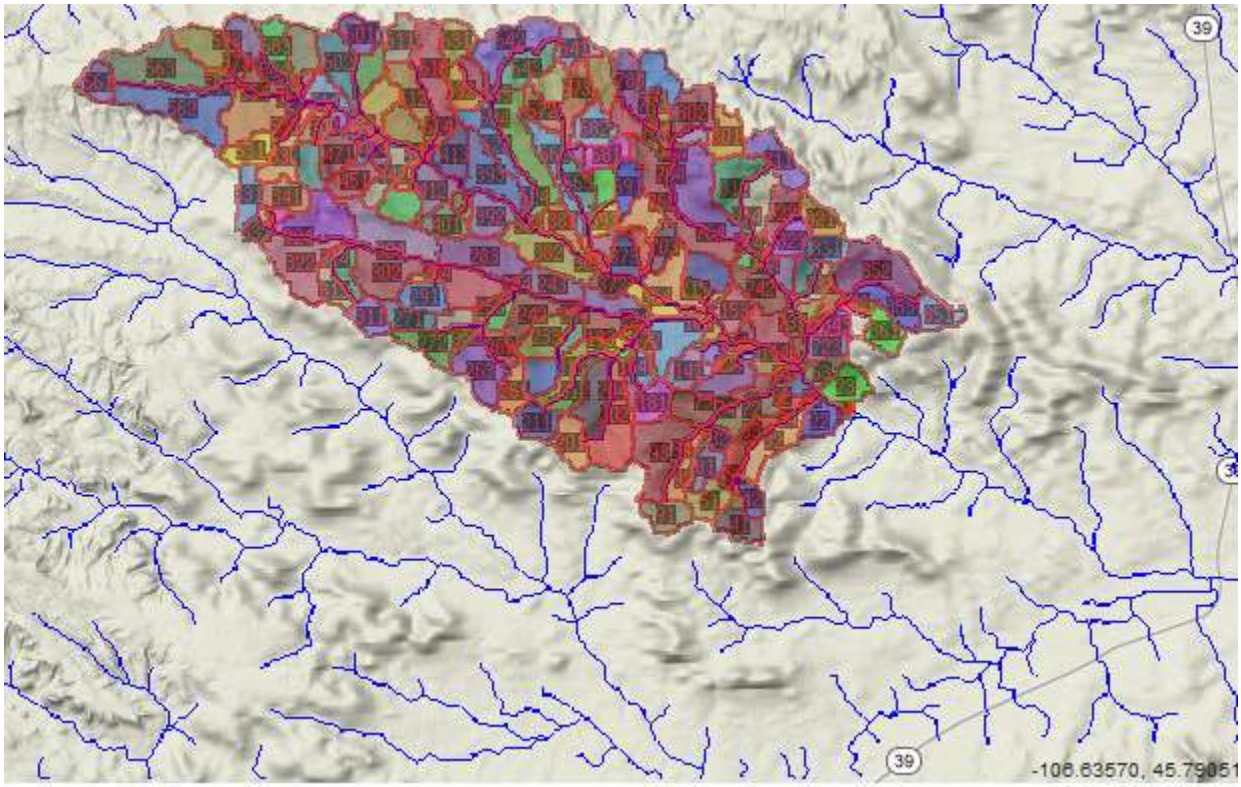

Fig. 4 The BS33FL watershed

Table 5. Annual maxima of precipitation at Colstrip weather station and observed streamflow at BMMFL

Water Year	Tot. Precip. mm	Max. Precip. mm	Max P Month	Max P Day	Tot. Runoff mm	Max. Runoff mm	Max RF Month	Max RF Day
1984	239	20.4	6	8	0	0	2	17
1985	309	30.1	7	29	3.55	1.74	2	28
1986	370	42.1	9	24	0.02	0.01	9	25
1987	377	27.0	8	24	2.59	2.28	8	26
1988	185	16.3	9	18	2.38	0.87	2	12
1989	357	20.9	6	16	6.34	3.83	3	8
1990	302	37.5	5	24	0.10	0.05	6	17
1991	384	56.1	9	15	0.25	0.14	9	14
1992	342	28.6	8	23	0.28	0.11	6	15
1993	407	50.2	6	8	0.57	0.23	3	6
1994	333	31.6	9	15	1.76	0.98	3	2
1995	447	31.1	10	15	0.04	0.03	3	12
1996	316	31.6	5	24	2.58	1.84	2	7
1997	418	45.4	5	26	0.15	0.09	7	19
1998	350	26.0	9	12	0.00	0.00	9	12
1999	419	34.2	4	20	0.00	0.00	8	12
2000	362	30.1	6	9	0.00	0.00	9	1
2001	326	40.8	6	29	0.00	0.00	10	1
2002	387	45.1	7	16	0.00	0.00	9	8
2003	367	20.7	3	18	0.00	0.00	6	4
2004	291	26.8	10	29	0.08	0.05	2	19
2005	493	67.3	5	8	0.38	0.05	5	10
2006	398	49.2	10	5	0.02	0.01	6	14
2007	493	66.8	6	7	0.00	0.00	10	31
2008	495	36.5	5	24				
2009	359	33.4	8	6				

Note: Precipitation was observed during 1984/01/01–2009/12/31 and runoff 1984/02/17–2006/12/31.

1.5 The BLFFL watershed

Area (ha): 769 (cells: 8542)
Number of Representative Hillslopes: 71
Number of Channels: 29
Number of Impoundments: 0
Outlet Location: −106.6721, 45.8014
Reference Point: 0
Minimum Source Channel Length (m): 100
Critical Source Area (ha): 10

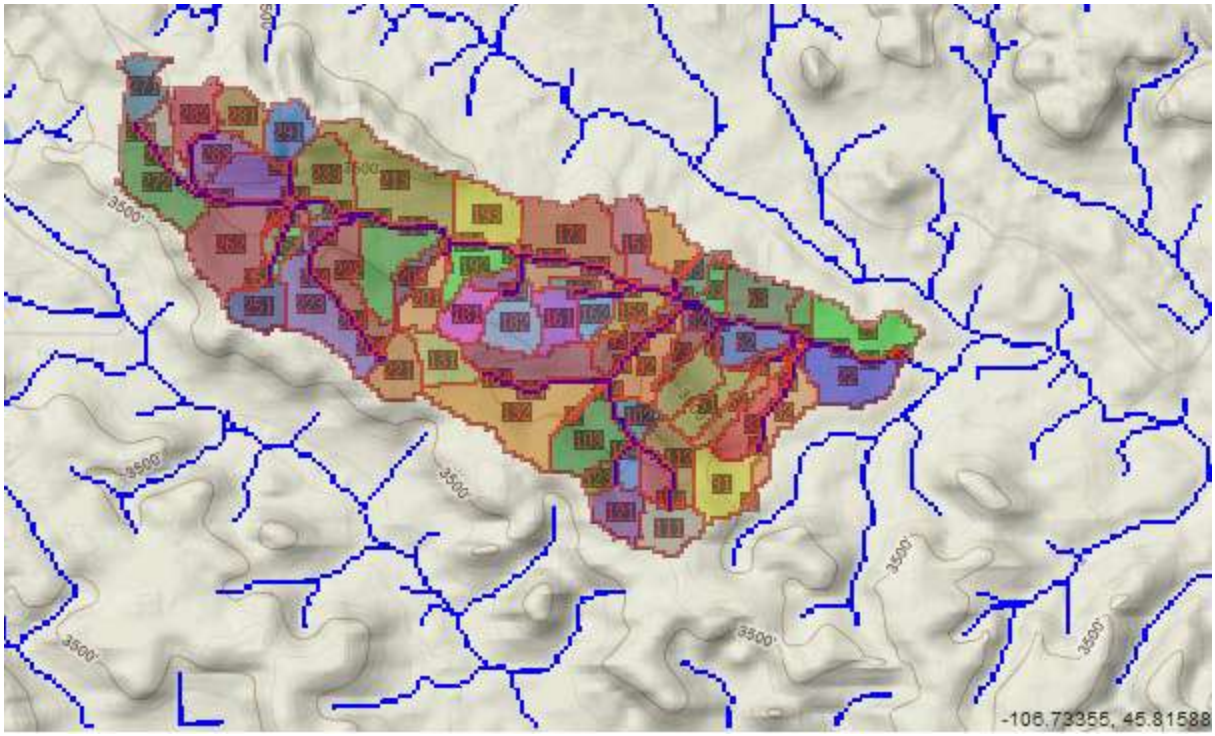

Fig.5 The BLFFL watershed

Table 6. Annual maxima of precipitation at Colstrip weather station and observed streamflow at BLFFL

Water Year	Tot. Precip. mm	Max. Precip. mm	MaxP Month	MaxP Day	Tot. Runoff mm	Max. Runoff mm	MaxRF Month	MaxRF Day
1984	239	20.4	6	8				
1985	309	30.1	7	29	9.52	5.98	8	2
1986	370	42.1	9	24	1.28	0.44	2	24
1987	377	27.0	8	24	7.52	3.83	7	31
1988	185	16.3	9	18	5.86	2.15	9	18
1989	357	20.9	6	16	1.69	0.77	6	10
1990	302	37.5	5	24	1.68	1.20	6	15
1991	384	56.1	9	15	3.29	1.31	9	15
1992	342	28.6	8	23	2.28	1.14	6	15
1993	407	50.2	6	8	1.53	0.49	7	2
1994	333	31.6	9	15	1.80	1.42	3	3
1995	447	31.1	10	15	0.57	0.15	10	16
1996	316	31.6	5	24	1.16	0.61	2	6
1997	418	45.4	5	26	0.00	0.00	10	1
1998	350	26.0	9	12	0.00	0.00	10	1
1999	419	34.2	4	20	0.00	0.00	10	1
2000	362	30.1	6	9				
2001	326	40.8	6	29				
2002	387	45.1	7	16				
2003	367	20.7	3	18				
2004	291	26.8	10	29				
2005	493	67.3	5	8				
2006	398	49.2	10	5				
2007	493	66.8	6	7				
2008	495	36.5	5	24				
2009	359	33.4	8	6				

Note: Precipitation was observed during 1984/01/01–2009/12/31 and runoff 1985/2/28–1999/5/11.

1.6 The BBBFL watershed

Area (ha): 800 (cells: 8889)
Number of Representative Hillslopes: 66
Number of Channels: 27
Number of Impoundments: 0
Outlet Location: −106.6415, 45.7965
Reference Point: 0
Minimum Source Channel Length (m): 100
Critical Source Area (ha): 10

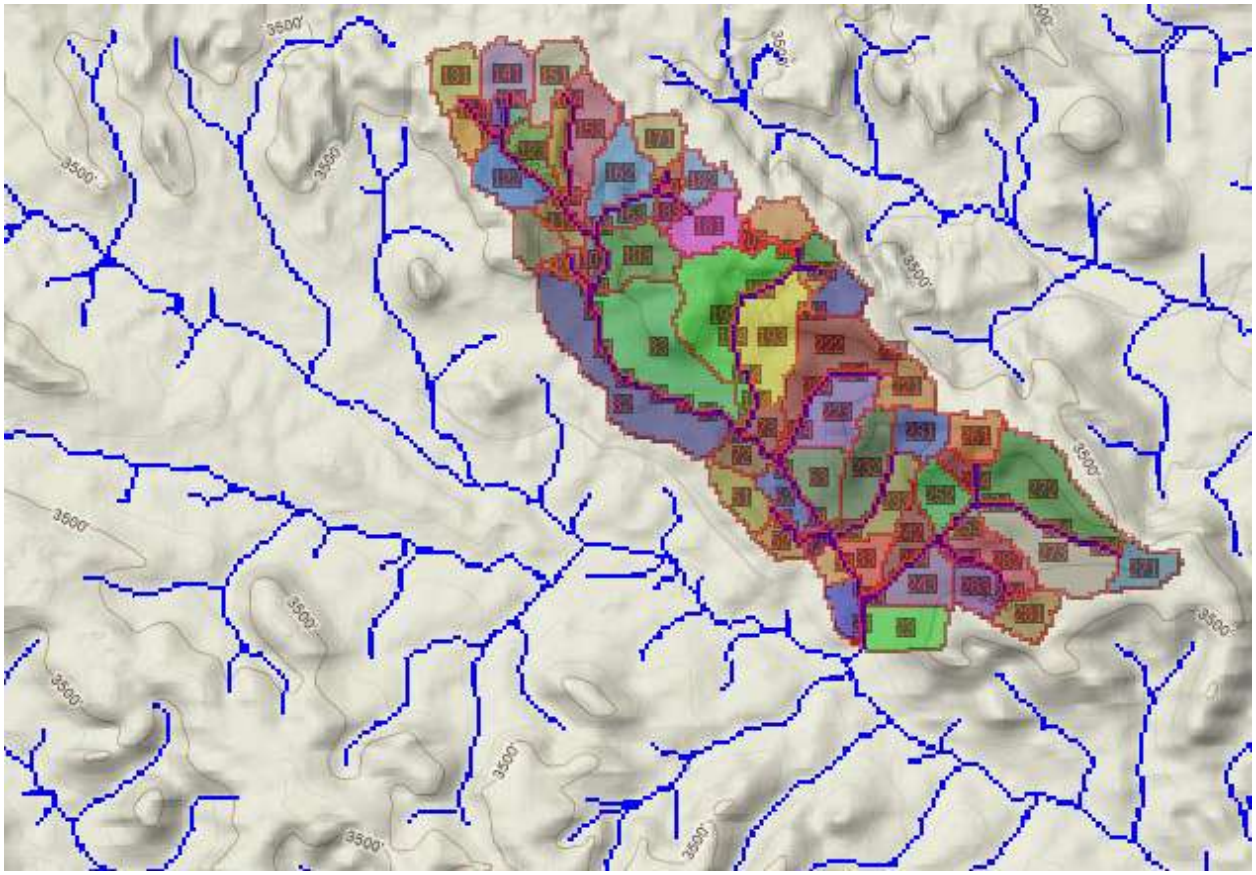

Fig.6 The BBBFL watershed

Table 7. Annual maxima of precipitation at Colstrip weather station and observed streamflow at BBBFL

Water Year	Tot. Precip. mm	Max. Precip. mm	MaxP Month	MaxP Day	Tot. Runoff mm	Max. Runoff mm	MaxRF Month	MaxRF Day
1984	239	20.4	6	8				
1985	309	30.1	7	29	0.41	0.17	2	28
1986	370	42.1	9	24	0.63	0.60	2	22
1987	377	27.0	8	24	0.67	0.62	8	26
1988	185	16.3	9	18	2.63	0.82	6	13
1989	357	20.9	6	16	3.40	2.16	3	8
1990	302	37.5	5	24				
1991	384	56.1	9	15				
1992	342	28.6	8	23				
1993	407	50.2	6	8				
1994	333	31.6	9	15				
1995	447	31.1	10	15				
1996	316	31.6	5	24				
1997	418	45.4	5	26				
1998	350	26.0	9	12				
1999	419	34.2	4	20				
2000	362	30.1	6	9				
2001	326	40.8	6	29				
2002	387	45.1	7	16				
2003	367	20.7	3	18				
2004	291	26.8	10	29				
2005	493	67.3	5	8				
2006	398	49.2	10	5				
2007	493	66.8	6	7				
2008	495	36.5	5	24				
2009	359	33.4	8	6				

Note: Precipitation was observed during 1984/01/01–2009/12/31 and runoff 1985/02/28–1989/09/30.

1.7 The AFL50-1 watershed

Area (ha): 166 (cells: 1846)
Number of Representative Hillslopes: 12
Number of Channels: 5
Number of Impoundments: 0
Outlet Location: −106.6019, 45.8355
Reference Point: 0
Minimum Source Channel Length (m): 100
Critical Source Area (ha): 10

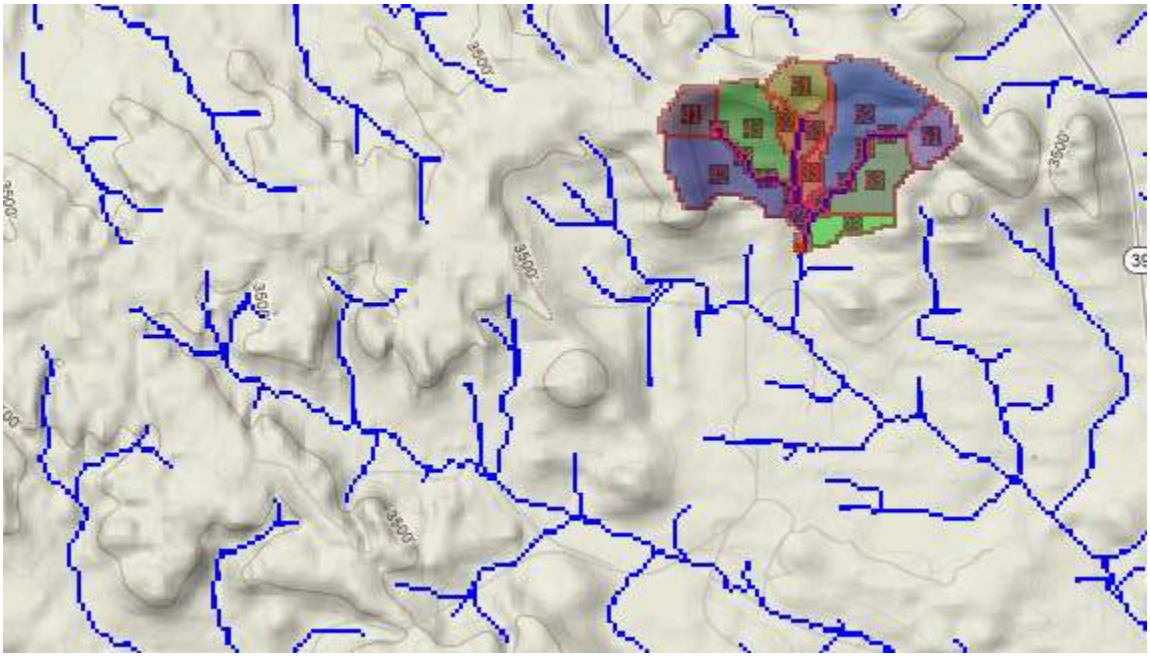

Fig.7 The AFL50-1 watershed

Table 8. Annual maxima of precipitation at Colstrip weather station and observed streamflow at AFL50-1

Water Year	Tot. Precip. mm	Max. Precip. mm	MaxP Month	MaxP Day	Tot. Runoff mm	Max. Runoff mm	MaxRF Month	MaxRF Day
1984	239	20.4	6	8				
1985	309	30.1	7	29				
1986	370	42.1	9	24				
1987	377	27.0	8	24				
1988	185	16.3	9	18				
1989	357	20.9	6	16				
1990	302	37.5	5	24				
1991	384	56.1	9	15				
1992	342	28.6	8	23				
1993	407	50.2	6	8				
1994	333	31.6	9	15				
1995	447	31.1	10	15				
1996	316	31.6	5	24				
1997	418	45.4	5	26				
1998	350	26.0	9	12				
1999	419	34.2	4	20				
2000	362	30.1	6	9				
2001	326	40.8	6	29	0.00	0.00	10	1
2002	387	45.1	7	16	0.00	0.00	10	1
2003	367	20.7	3	18	0.00	0.00	10	1
2004	291	26.8	10	29	0.00	0.00	10	1
2005	493	67.3	5	8	2.47	1.06	5	13
2006	398	49.2	10	5	0.02	0.01	4	2
2007	493	66.8	6	7				
2008	495	36.5	5	24				
2009	359	33.4	8	6				

Note: Precipitation was observed during 1984/01/01–2009/12/31 and runoff 2000/08/09–2006/12/31.

2. Observed Daily Precipitation and Runoff at BPSFL

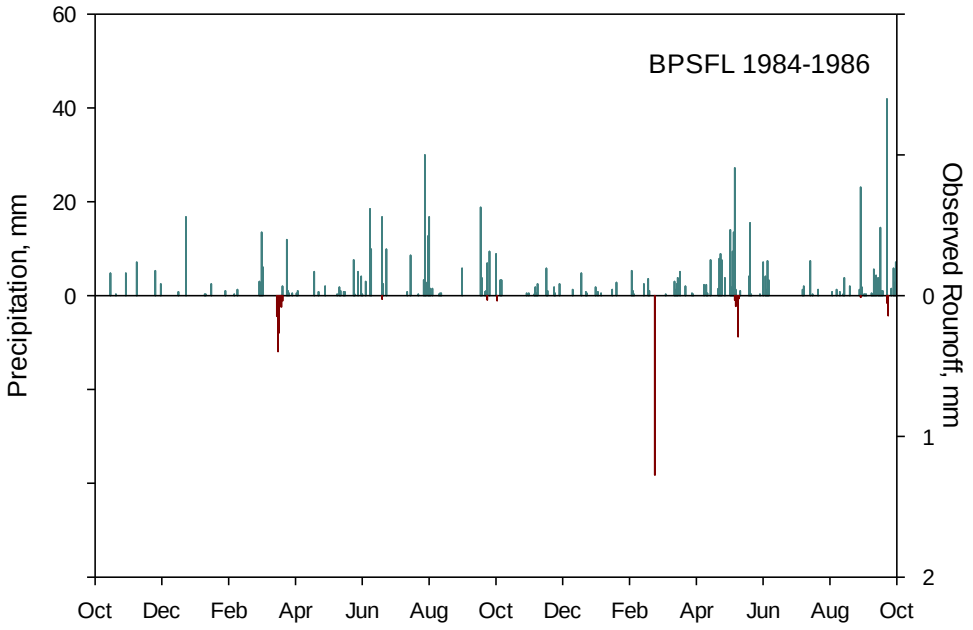

Fig. 8.1. Observed daily precipitation and runoff at BPSFL (1984–1986)

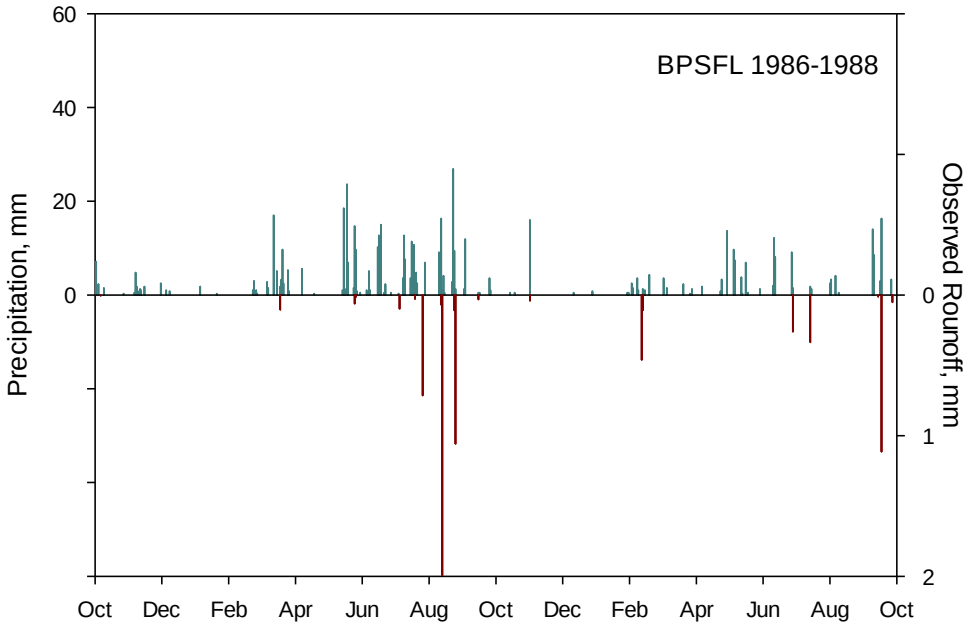

Fig. 8.2. Observed daily precipitation and runoff at BPSFL (1986–1988)

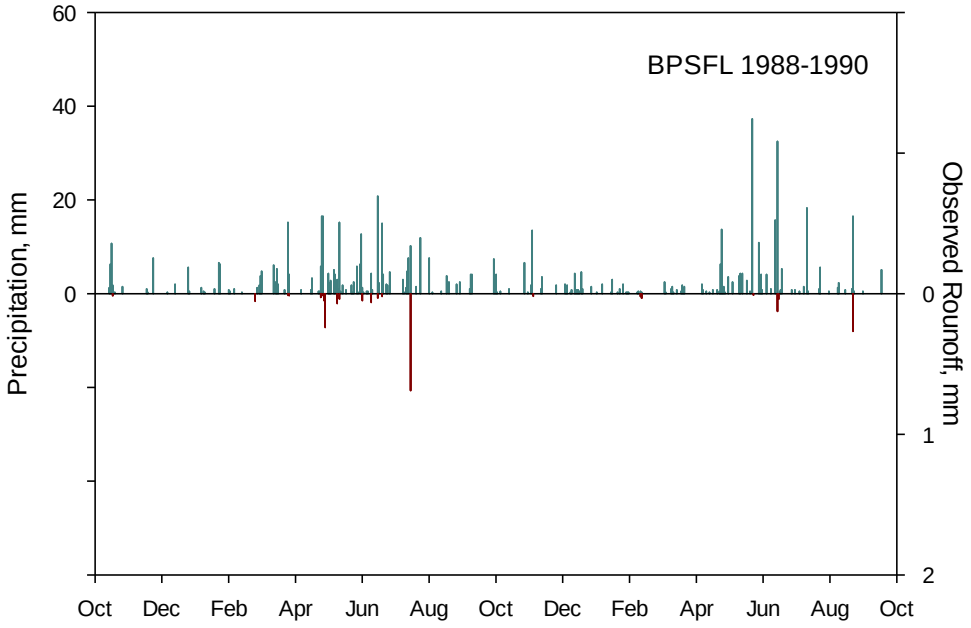

Fig. 8.3. Observed daily precipitation and runoff at BPSFL (1988–1990)

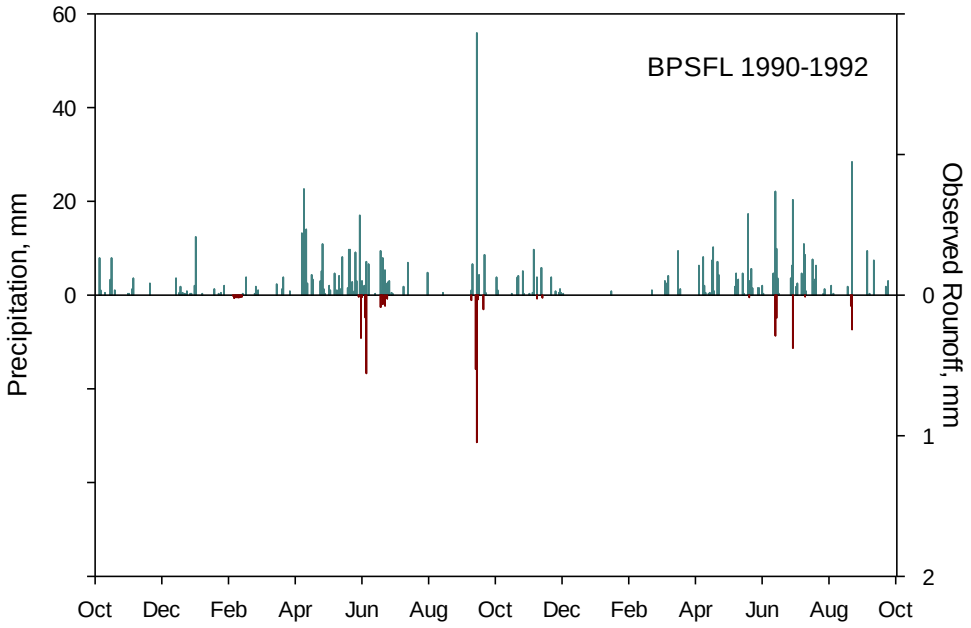

Fig. 8.4. Observed daily precipitation and runoff at BPSFL (1990–1992)

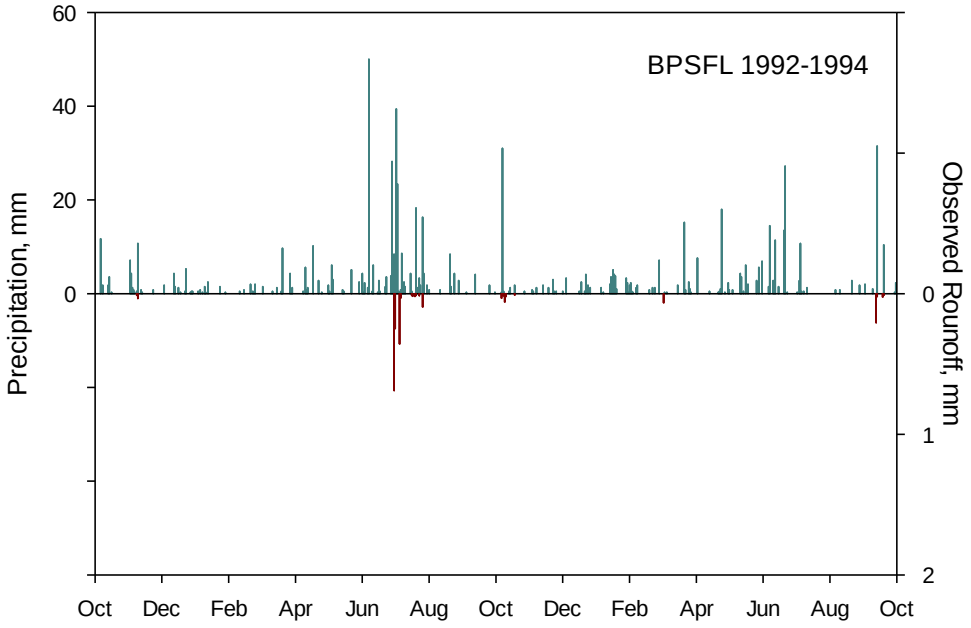

Fig. 8.5. Observed daily precipitation and runoff at BPSFL (1992–1994)

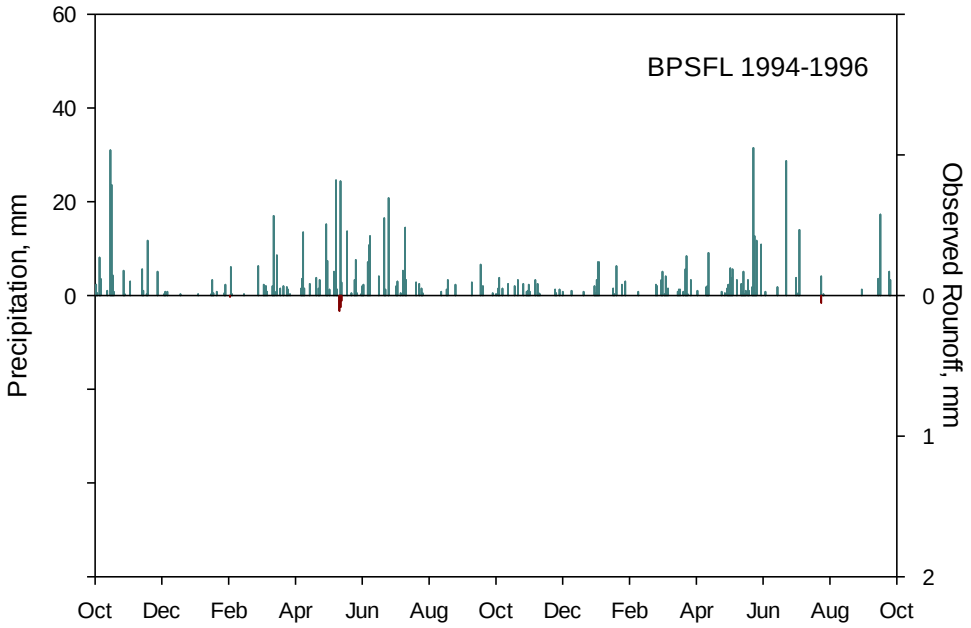

Fig. 8.6. Observed daily precipitation and runoff at BPSFL (1994–1996)

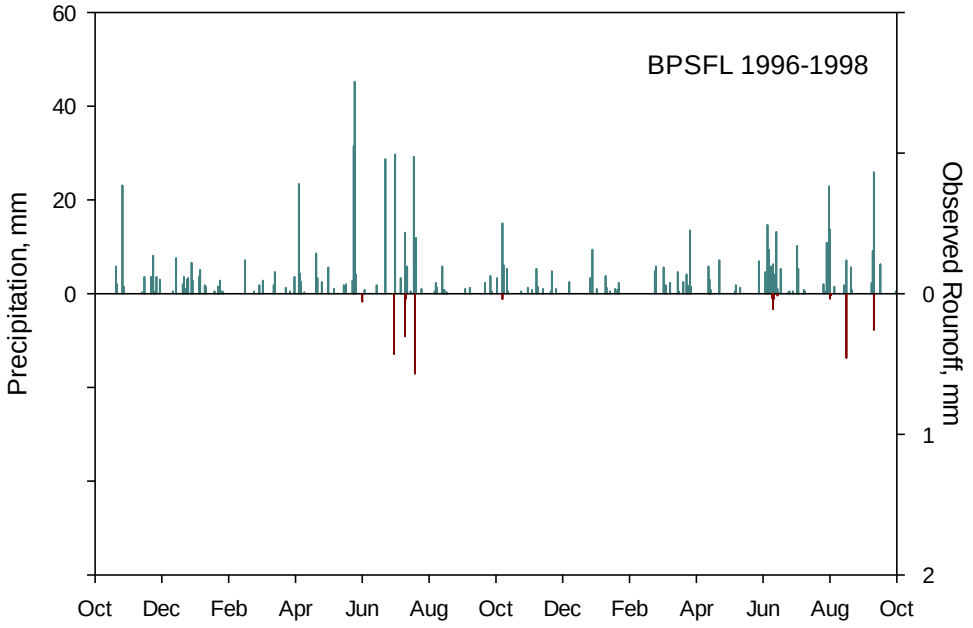

Fig. 8.7. Observed daily precipitation and runoff at BPSFL (1996–1998)

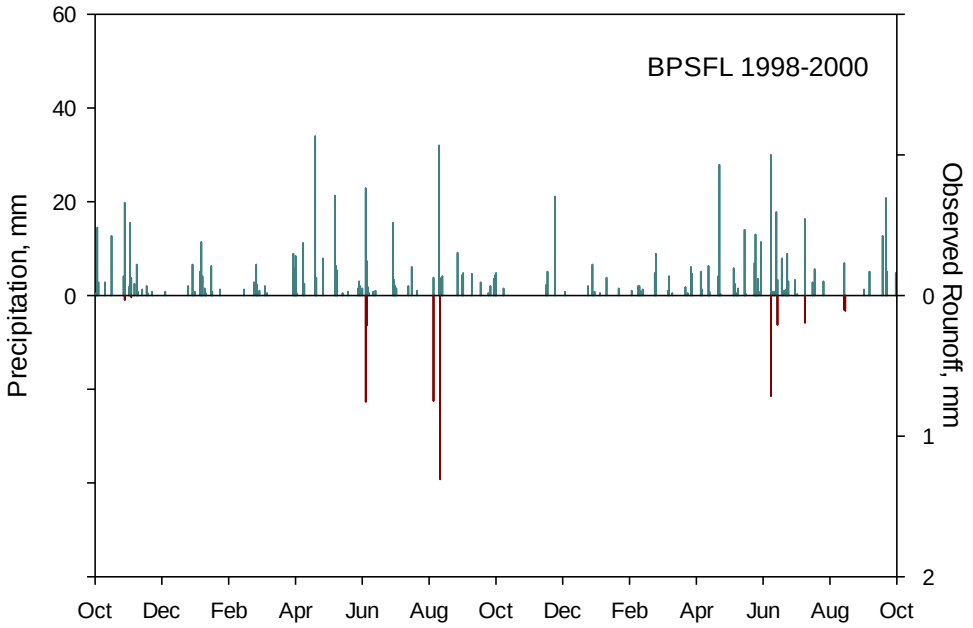

Fig. 8.8. Observed daily precipitation and runoff at BPSFL (1998–2000)

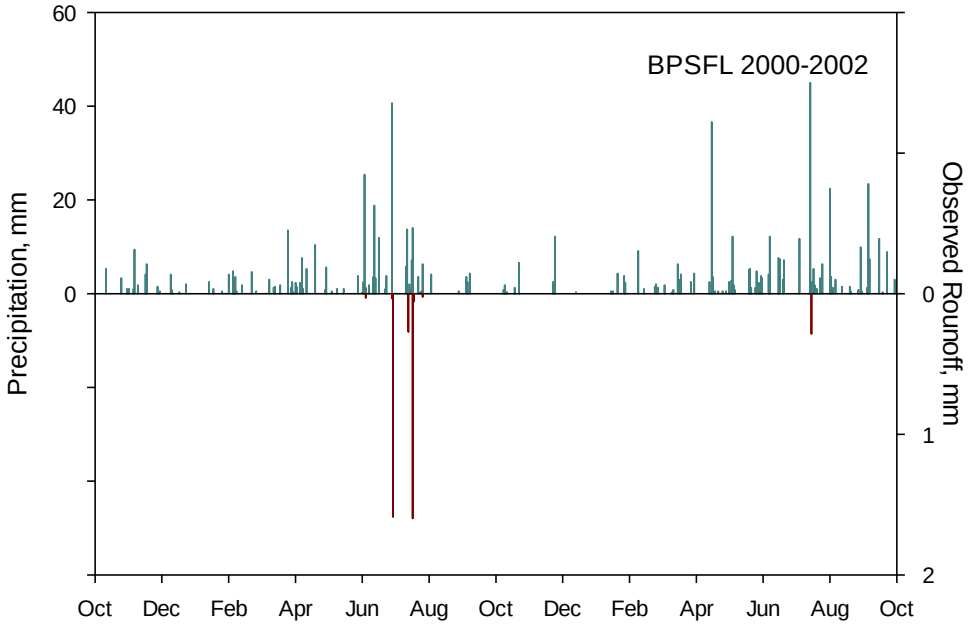

Fig. 8.9. Observed daily precipitation and runoff at BPSFL (2000–2002)

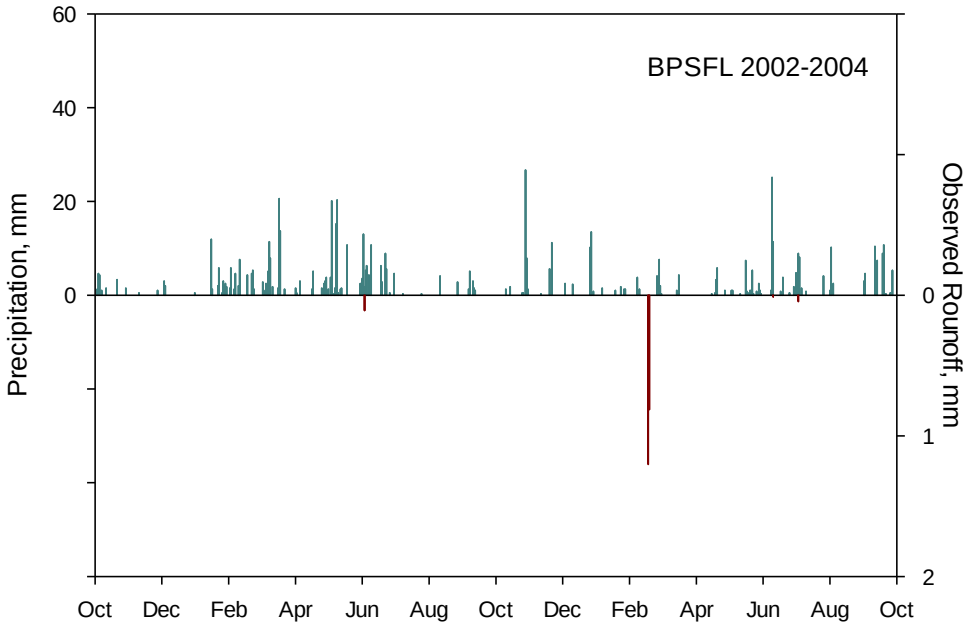

Fig. 8.10. Observed daily precipitation and runoff at BPSFL (2002–2004)

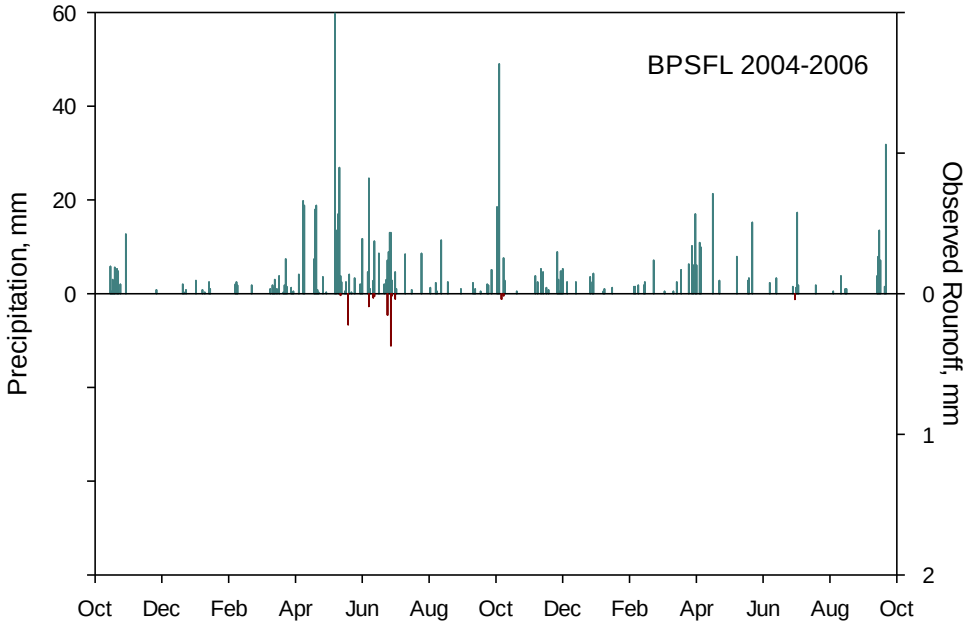

Fig. 8.11. Observed daily precipitation and runoff at BPSFL (2004–2006)

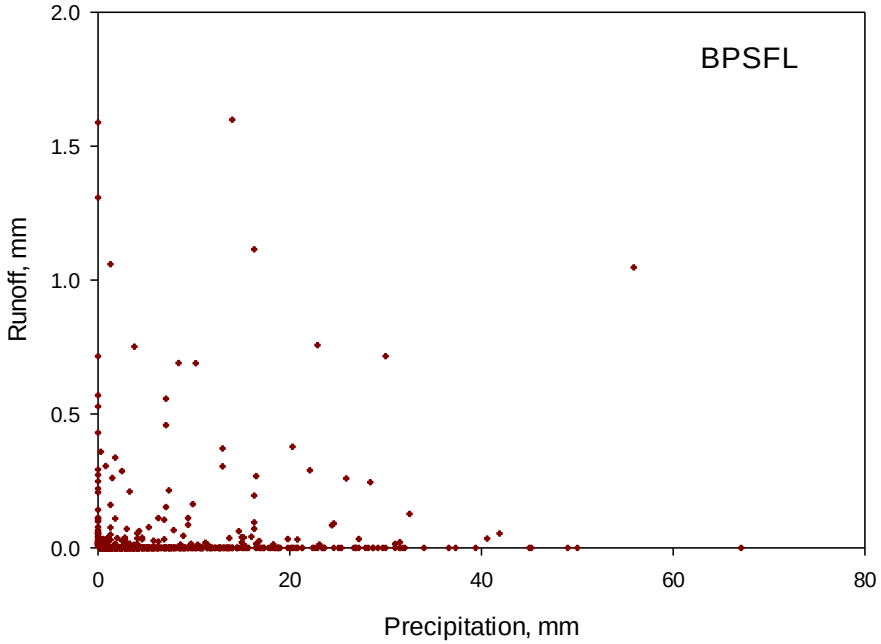

Fig. 9. Observed runoff at BPSFL and precipitation on the event day

3. Observed Daily Precipitation and Simulated Runoff for the BPSFL Watershed

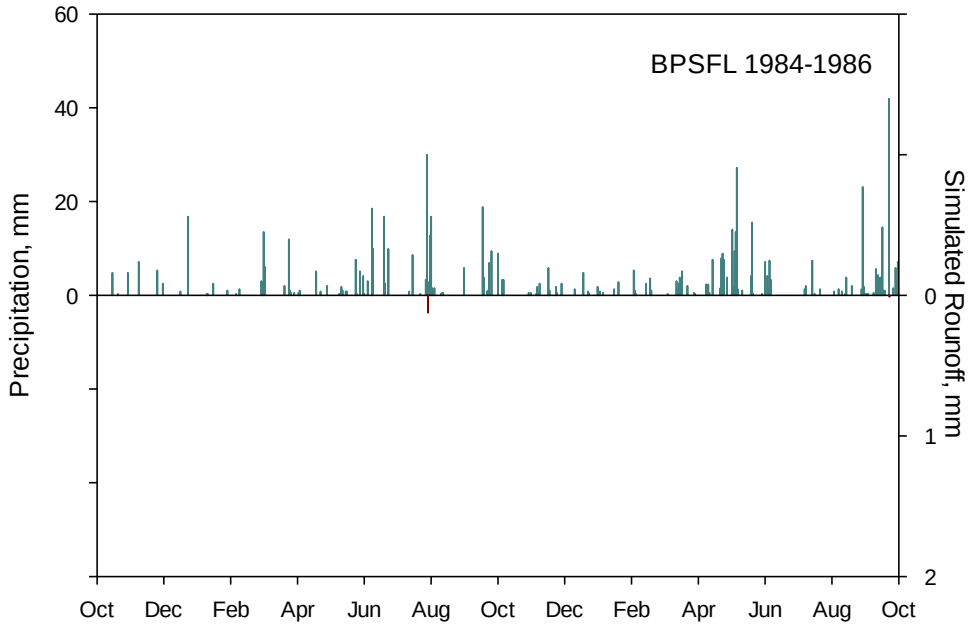

Fig. 10.1. Observed daily precipitation and simulated daily runoff at BPSFL (1984–1986)

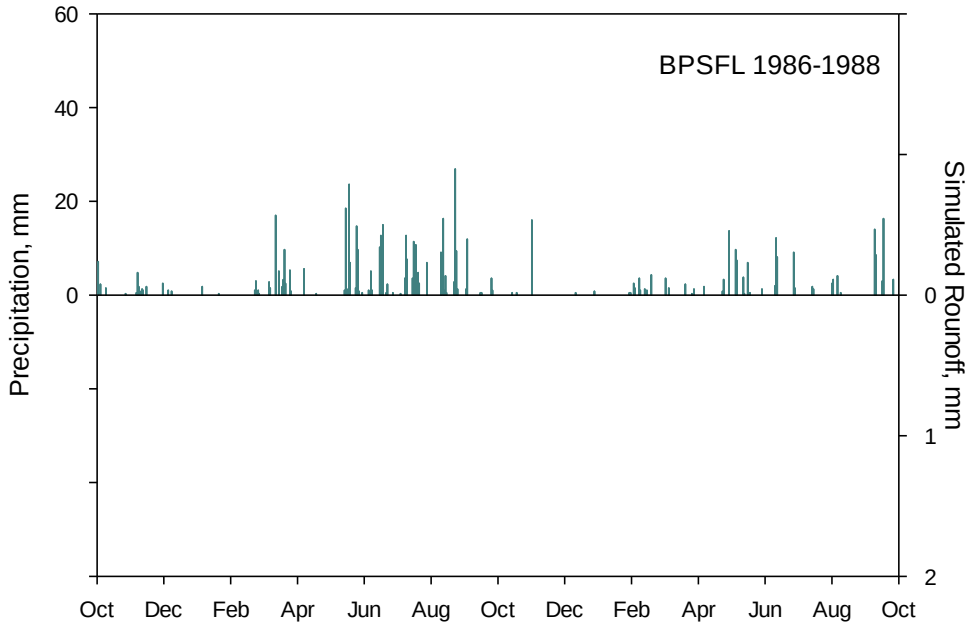

Fig. 10.2. Observed daily precipitation and simulated daily runoff at BPSFL (1986–1988)

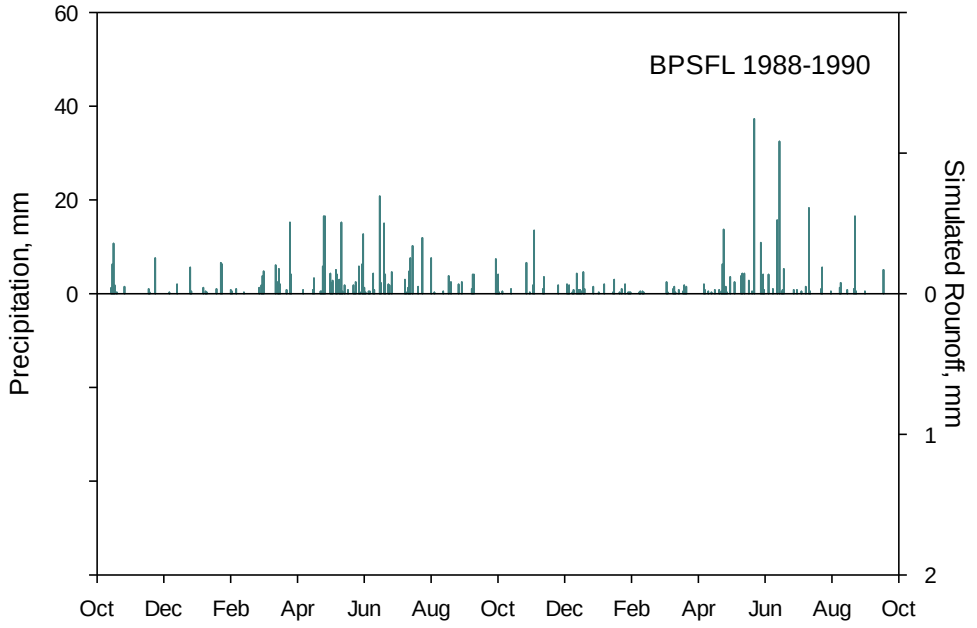

Fig. 10.3. Observed daily precipitation and simulated daily runoff at BPSFL (1988–1990)

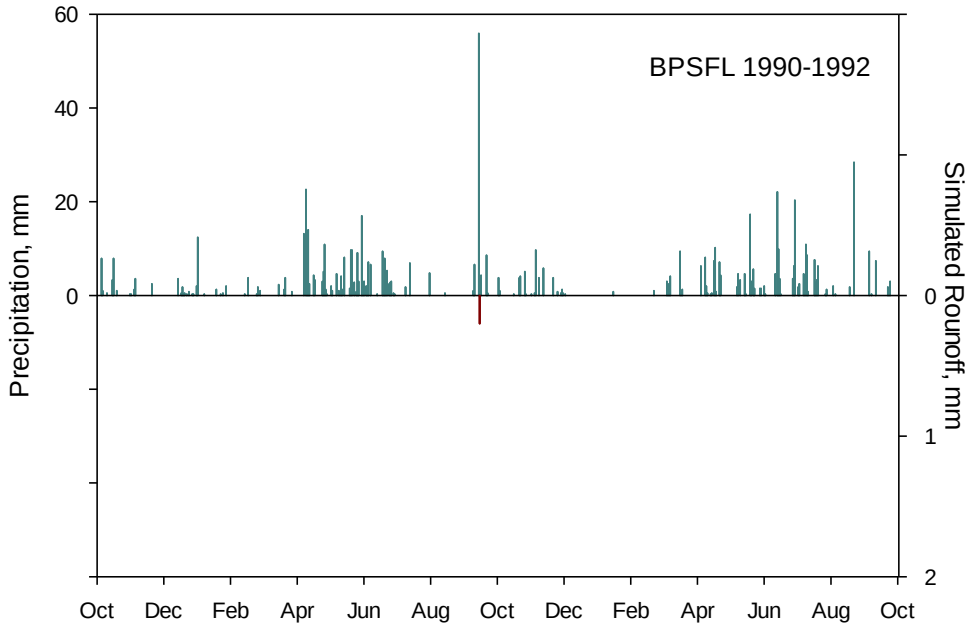

Fig. 10.4. Observed daily precipitation and simulated daily runoff at BPSFL (1990–1992)

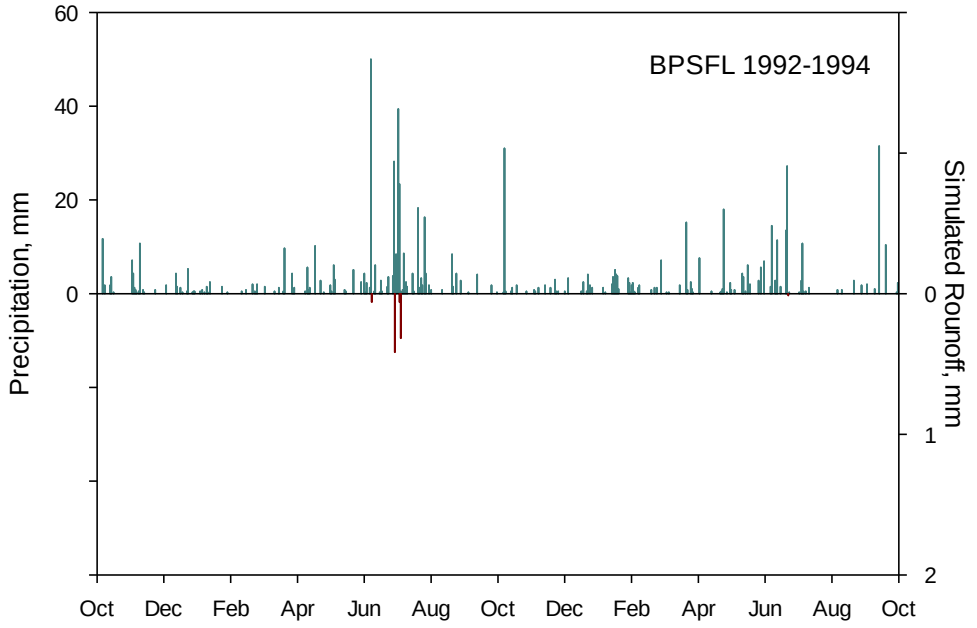

Fig. 10.5. Observed daily precipitation and simulated daily runoff at BPSFL (1992–1994)

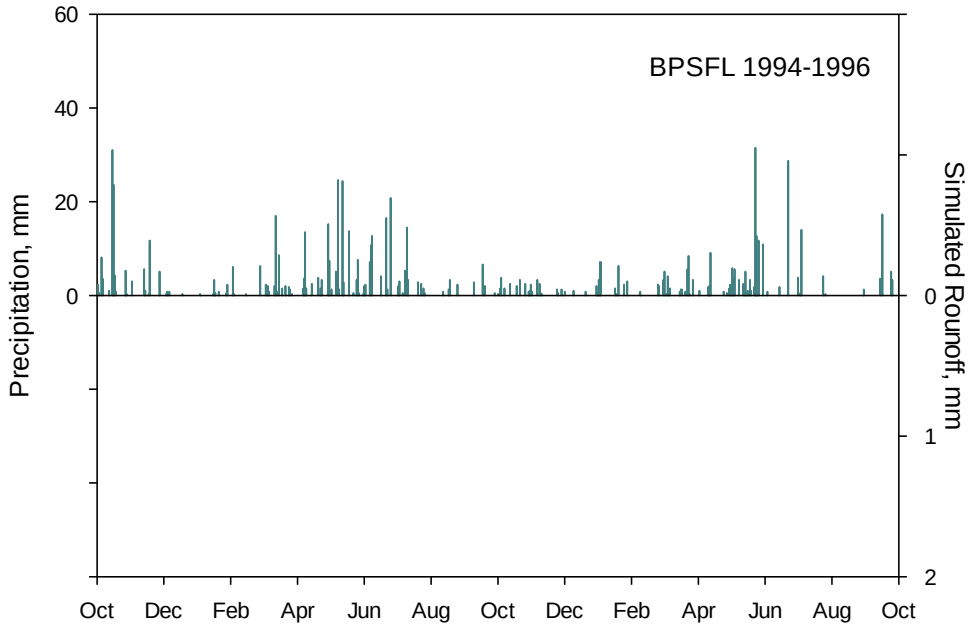

Fig. 10.6. Observed daily precipitation and simulated daily runoff at BPSFL (1994–1996)

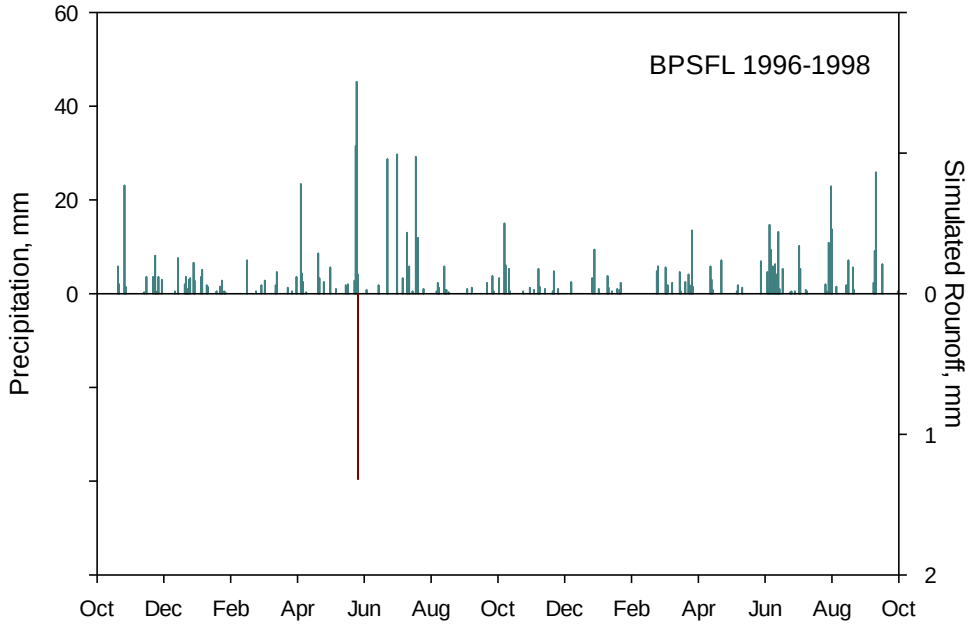

Fig. 10.7. Observed daily precipitation and simulated daily runoff at BPSFL (1996–1998)

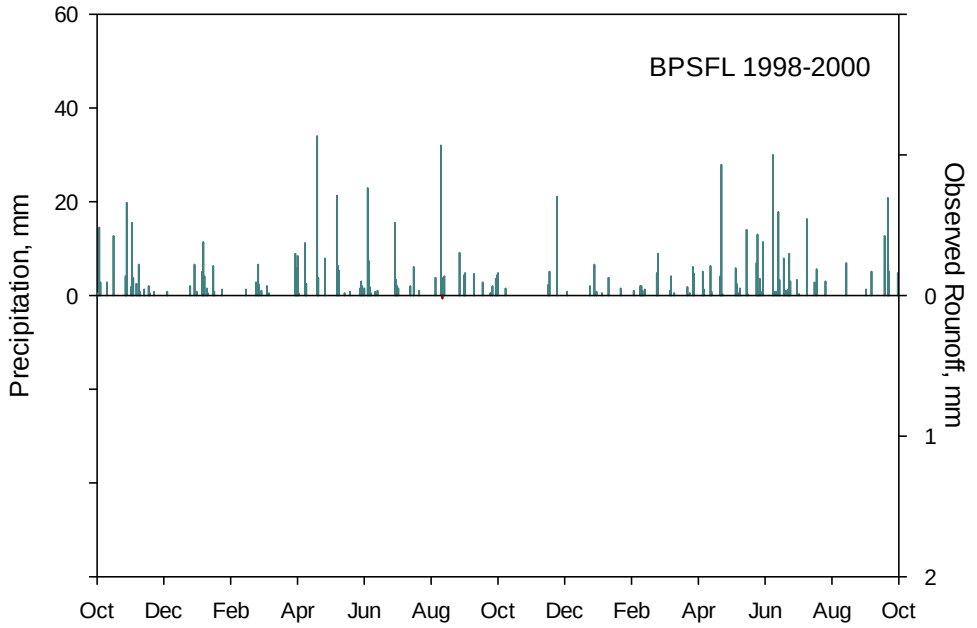

Fig. 10.8. Observed daily precipitation and simulated daily runoff at BPSFL (1998–2000)

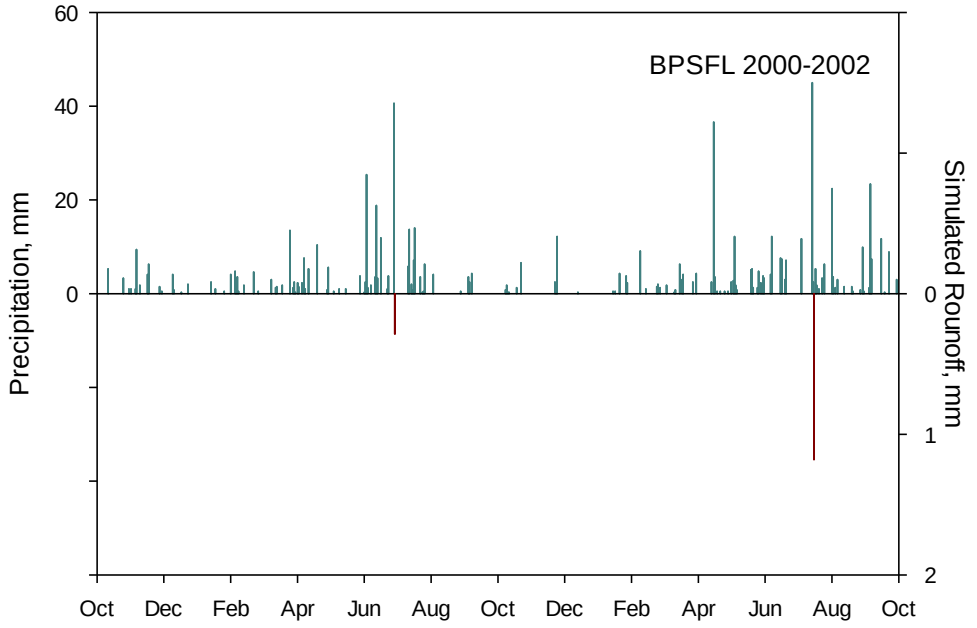

Fig. 10.9. Observed daily precipitation and simulated daily runoff at BPSFL (2000–2002)

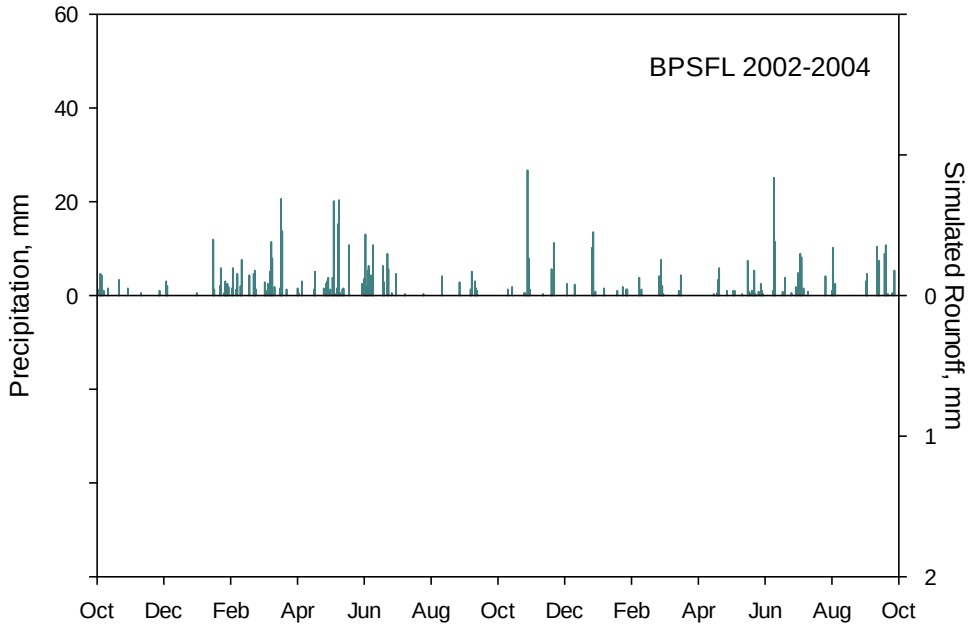

Fig. 10.10. Observed daily precipitation and simulated daily runoff at BPSFL (2002–2004)

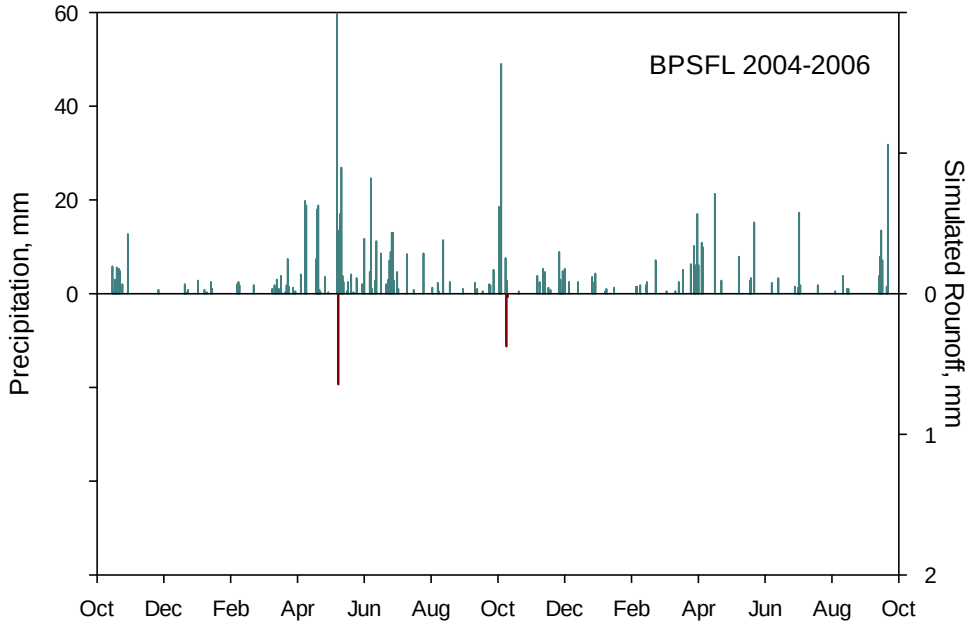

Fig. 10.11. Observed daily precipitation and simulated daily runoff at BPSFL (2004–2006)

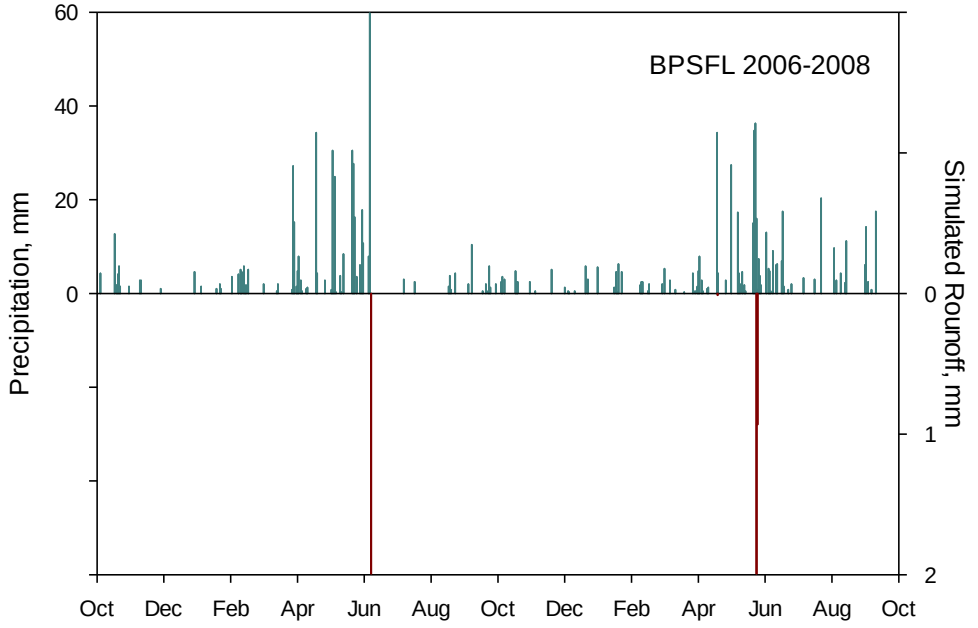

Fig. 10.12. Observed daily precipitation and simulated daily runoff at BPSFL (2006–2008)

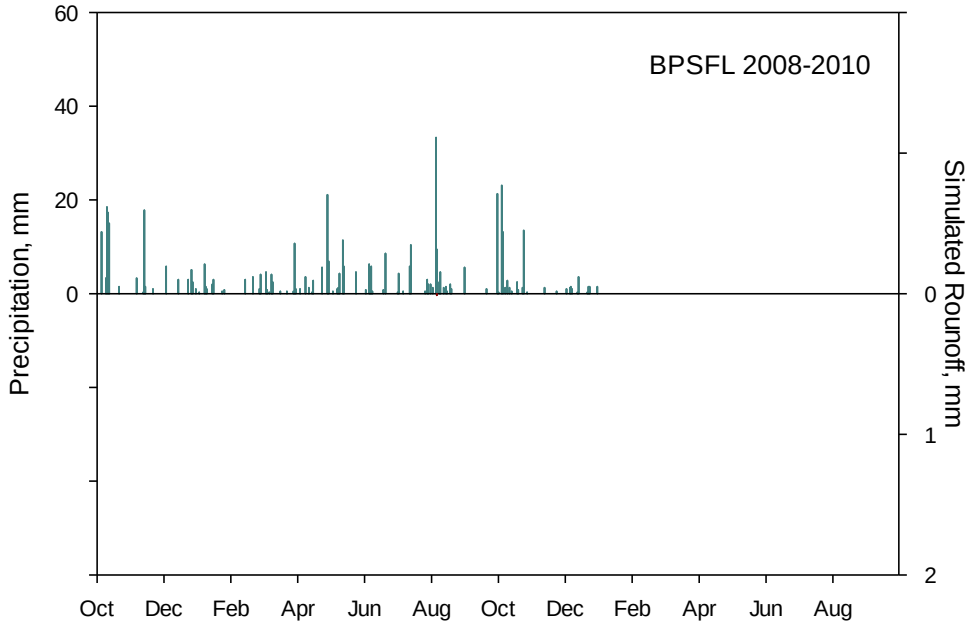

Fig. 10.13. Observed daily precipitation and simulated daily runoff at BPSFL (2008–2010)

4. WEPP Inputs and Simulation Results

4.1 BPSFL Watershed

Watershed Summary

Area (ha):	583 (cells: 6473)
Number of Representative Hillslopes:	77
Number of Channels:	31
Number of Impoundments:	0
Outlet Location:	−106.716, 45.8243
Reference Point:	0
Minimum Source Channel Length (m):	100
Critical Source Area (ha):	10

Landuse Summary

The watershed contains the following landuse as detemined by the USGS National Land Cover Database 2001 - http://www.mrlc.gov/nlcd.php

ID	Name	WEPP File	Number of Cells	Area(ha)	Percent Watershed
31	Barren Land	Good grass.rot	37	3.33	0.6
42	Evergreen Forest	Mature forest.rot	664	59.76	10.3
52	Shrub/Scrub	Shrubs.rot	1945	175.05	30.0
71	Grasslands/Herbaceous	Good grass.rot	3827	344.43	59.1

Soils Summary

The watershed contains the following soils as determined by the NRCS Soil Survey. The data is requested directly from the NRCS soils database. Information on the NRCS Soils Data structure and how it can be accessed are found at: http://sdmdataaccess.nrcs.usda.gov/

MuKey	Soil Name	Number of Cells	Area(ha)	Percent Watershed
347925	Havre, Harlake, and Glendive soils, channeled, 0 to 2 percent slopes	9	0.81	0.1
347932	Kobar silty clay loam, 2 to 8 percent slopes	41	3.69	0.6
347933	Kobar silty clay loam, 8 to 15 percent slopes	162	14.58	2.5
347947	Lonna silt loam, 2 to 8 percent slopes	251	22.59	3.9
347957	Lonna-Cambeth silt loams, 2 to 8 percent slopes	634	57.06	9.8
348028	Yamac loam, 2 to 8 percent slopes	571	51.39	8.8
348029	Yamac loam, 8 to 15 percent slopes	153	13.77	2.4
348038	Yamac-Busby complex, 8 to 15 percent slopes	433	38.97	6.7
348039	Yamac-Cabbart loams, 8 to 25 percent slopes	141	12.69	2.2
348040	Yamac-Delpoint loams, 4 to 15 percent slopes	503	45.27	7.8
348042	Birney, moist-Armells-Cabbart complex, 25 to 70 percent slopes	152	13.68	2.3

348075	Busby fine sandy loam, 2 to 8 percent slopes	134	12.06	2.1
348079	Busby-Twilight-Blackhall, warm, fine sandy loams, 2 to 8 percent slopes	262	23.58	4.0
348080	Busby-Twilight-Blackhall, warm, fine sandy loams, 8 to 25 percent slopes	149	13.41	2.3
348087	Cabbart-Rock outcrop-Yawdim complex, 15 to 70 percent slopes	804	72.36	12.4
348088	Cambeth silt loam, 2 to 8 percent slopes	20	1.8	0.3
348090	Cambeth-Cabbart silt loams, 4 to 15 percent slopes	5	0.45	0.1
348107	Delpoint-Yamacall-Cabbart loams, 8 to 25 percent slopes	1254	112.86	19.4

Number of events: 364

26 YEAR SIMULATION FOR WATERSHED

WEPP Watershed Simulation for Representative Hillslopes and Channels (watershed method, off-site assesment)

Note that return period of the events are eatimated by applying Weibull formula on annual maxima series.
T = (N + 1)/m
where T is the return period, N is the number of simulation years, and m is the rank of the annual maxima event.

Return Period of PRECIPITATION in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	23	9	23	31.8	0.000643	0.00103	0
5	26	5	14	45.2	1.43	1.4	0.0401
13	7	6	24	66.5	15.9	12.2	0.952
27	8	5	22	67.1	0.757	0.732	0.0173

Return Period of RUNOFF in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	24	9	3	41.9	0.0166	0.0212	7.29E−6
5	8	5	22	67.1	0.757	0.732	0.0173
13	24	5	25	36.3	2.81	2.64	0.109
27	7	6	24	66.5	15.9	12.2	0.952

Return Period of PEAK RUNOFF in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	24	9	3	41.9	0.0166	0.0212	7.29E−6
5	8	5	22	67.1	0.757	0.732	0.0173
13	24	5	25	36.3	2.81	2.64	0.109
27	7	6	24	66.5	15.9	12.2	0.952

Return Period of SEDIMENT YIELD in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	24	9	3	41.9	0.0166	0.0212	7.29E−6
5	8	5	22	67.1	0.757	0.732	0.0173
13	24	5	25	36.3	2.81	2.64	0.109
27	7	6	24	66.5	15.9	12.2	0.952

4.2 BRTFL Watershed

Watershed Summary

Area (ha):	994 (cells: 11045)
Number of Representative Hillslopes:	113
Number of Channels:	47
Number of Impoundments:	0
Outlet Location:	−106.6918, 45.8141
Reference Point:	0
Minimum Source Channel Length (m):	100
Critical Source Area (ha):	10

Landuse Summary

The watershed contains the following landuse as detemined by the USGS National Land Cover Database 2001 - http://www.mrlc.gov/nlcd.php

ID	Name	WEPP File	Number of Cells	Area(ha)	Percent Watershed
31	Barren Land	Good grass.rot	331	29.79	3.0
42	Evergreen Forest	Mature forest.rot	1010	90.9	9.1
52	Shrub/Scrub	Shrubs.rot	2900	261	26.3
71	Grasslands/Herbaceous	Good grass.rot	6804	612.36	61.6

Soils Summary

The watershed contains the following soils as determined by the NRCS Soil Survey. The data is requested directly from the NRCS soils database. Information on the NRCS Soils Data structure and how it can be accessed are found at: http://sdmdataaccess.nrcs.usda.gov/

	Soil Name	Number of Cells	Area(ha)	Percent Watershed
347925	Havre, Harlake, and Glendive soils, channeled, 0 to 2 percent slopes	139	12.51	1.3
347932	Kobar silty clay loam, 2 to 8 percent slopes	41	3.69	0.4
347933	Kobar silty clay loam, 8 to 15 percent slopes	162	14.58	1.5
347947	Lonna silt loam, 2 to 8 percent slopes	251	22.59	2.3
347957	Lonna-Cambeth silt loams, 2 to 8 percent slopes	634	57.06	5.7
348010	Ustic Torrifluvents, 0 to 2 percent slopes, frequently flooded	159	14.31	1.4
348028	Yamac loam, 2 to 8 percent slopes	1046	94.14	9.5
348029	Yamac loam, 8 to 15 percent slopes	153	13.77	1.4
348037	Yamacall-Busby complex, 2 to 8 percent slopes	1071	96.39	9.7
348038	Yamac-Busby complex, 8 to 15 percent slopes	974	87.66	8.8
348039	Yamac-Cabbart loams, 8 to 25 percent slopes	141	12.69	1.3

348040	Yamac-Delpoint loams, 4 to 15 percent slopes	503	45.27	4.6
348042	Birney, moist-Armells-Cabbart complex, 25 to 70 percent slopes	632	56.88	5.7
348075	Busby fine sandy loam, 2 to 8 percent slopes	838	75.42	7.6
348078	Busby-Rock outcrop complex, 8 to 15 percent slopes	111	9.99	1.0
348079	Busby-Twilight-Blackhall, warm, fine sandy loams, 2 to 8 percent slopes	292	26.28	2.6
348080	Busby-Twilight-Blackhall, warm, fine sandy loams, 8 to 25 percent slopes	939	84.51	8.5
348087	Cabbart-Rock outcrop-Yawdim complex, 15 to 70 percent slopes	804	72.36	7.3
348088	Cambeth silt loam, 2 to 8 percent slopes	20	1.8	0.2
348090	Cambeth-Cabbart silt loams, 4 to 15 percent slopes	5	0.45	0.0
348103	Armells-Cabbart complex, 25 to 70 percent slopes	56	5.04	0.5
348107	Delpoint-Yamacall-Cabbart loams, 8 to 25 percent slopes	1254	112.86	11.4
348111	Delpoint, moist-Delpoint-Cabbart loams, 25 to 70 percent slopes	795	71.55	7.2

Number of events: 72

26 YEAR SIMULATION FOR WATERSHED

WEPP Watershed Simulation for Representative Hillslopes and Channels (watershed method, off-site assesment)

Note that return period of the events are eatimated by applying Weibull formula on annual maxima series.
$T = (N + 1)/m$
where T is the return period, N is the number of simulation years, and m is the rank of the annual maxima event.

Return Period of PRECIPITATION in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	23	9	23	31.8	0.00503	0.00956	1.38E−6
5	26	5	14	45.2	0.877	1.25	0.0588
13	7	6	24	66.5	12.2	14.2	1.24
27	8	5	22	67.1	0.392	0.565	0.0222

Return Period of RUNOFF in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	24	5	7	37.3	0.0102	0.0185	7.72E−6
5	8	5	22	67.1	0.392	0.565	0.0222
13	24	5	25	36.3	1.57	2.22	0.125
27	7	6	24	66.5	12.2	14.2	1.24

Return Period of PEAK RUNOFF in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	24	5	7	37.3	0.0102	0.0185	7.72E−6
5	8	5	22	67.1	0.392	0.565	0.0222
13	24	5	25	36.3	1.57	2.22	0.125
27	7	6	24	66.5	12.2	14.2	1.24

Return Period of SEDIMENT YIELD in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	24	9	3	41.9	0.0133	0.0238	1.94E−5
5	8	5	22	67.1	0.392	0.565	0.0222
13	24	5	25	36.3	1.57	2.22	0.125
27	7	6	24	66.5	12.2	14.2	1.24

4.3 BLFFL Watershed

Watershed Summary

Area (ha):	761 (cells: 8451)
Number of Representative Hillslopes:	76
Number of Channels:	31
Number of Impoundments:	0
Outlet Location:	−106.674, 45.8013
Reference Point:	0
Minimum Source Channel Length (m):	100
Critical Source Area (ha):	10

Landuse Summary

The watershed contains the following landuse as detemined by the USGS National Land Cover Database 2001 – http://www.mrlc.gov/nlcd.php

ID	Name	WEPP File	Number of Cells	Area(ha)	Percent Watershed
31	Barren Land	Good grass.rot	1193	107.37	14.1
42	Evergreen Forest	Mature forest.rot	1890	170.1	22.4
52	Shrub/Scrub	Shrubs.rot	3321	298.89	39.3
71	Grasslands/Herbaceous	Good grass.rot	2042	183.78	24.2
90	Woody Wetlands	Good grass.rot	5	0.45	0.1

Soils Summary

The watershed contains the following soils as determined by the NRCS Soil Survey. The data is requested directly from the NRCS soils database. Information on the NRCS Soils Data structure and how it can be accessed are found at: http://sdmdataaccess.nrcs.usda.gov/

MuKey	Soil Name	Number of Cells	Area(ha)	Percent Watershed
347947	Lonna silt loam, 2 to 8 percent slopes	91	8.19	1.1
347948	Lonna silt loam, 8 to 15 percent slopes	263	23.67	3.1
347997	Birney-Cabbart complex, moist, 25 to 70 percent slopes	182	16.38	2.2
348008	Birney-Cooers-Kirby complex, 2 to 15 percent slopes	120	10.8	1.4
348028	Yamac loam, 2 to 8 percent slopes	366	32.94	4.3
348029	Yamac loam, 8 to 15 percent slopes	362	32.58	4.3
348033	Yamac-Birney complex, 2 to 8 percent slopes	400	36	4.7
348036	Yamac-Birney-Cabbart complex, 15 to 25 percent slopes	593	53.37	7.0
348040	Yamac-Delpoint loams, 4 to 15 percent slopes	452	40.68	5.3
348042	Birney, moist-Armells-Cabbart complex, 25 to 70 percent slopes	1901	171.09	22.5
348075	Busby fine sandy loam, 2 to 8 percent slopes	31	2.79	0.4
348076	Busby fine sandy loam, 8 to 15 percent slopes	753	67.77	8.9

348078	Busby-Rock outcrop complex, 8 to 15 percent slopes	565	50.85	6.7
348080	Busby-Twilight-Blackhall, warm, fine sandy loams, 8 to 25 percent slopes	392	35.28	4.6
348087	Cabbart-Rock outcrop-Yawdim complex, 15 to 70 percent slopes	10	0.9	0.1
348090	Cambeth-Cabbart silt loams, 4 to 15 percent slopes	188	16.92	2.2
348136	Denied access	1782	160.38	21.1

26 YEAR SIMULATION FOR WATERSHED

WEPP Watershed Simulation for Representative Hillslopes and Channels (watershed method, off-site assesment)

Note that return period of the events are eatimated by applying Weibull formula on annual maxima series.
$T = (N + 1)/m$
where T is the return period, N is the number of simulation years, and m is the rank of the annual maxima event.

Return Period of PRECIPITATION in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	23	9	23	31.8	1.93E−5	5.0E−5	0
5	26	5	14	45.2	0.0161	0.0245	5.46E−5
13	7	6	24	66.5	0.342	0.422	0.0228
27	8	5	22	67.1	0.0677	0.0932	0.000244

Return Period of RUNOFF in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	23	6	13	28.7	9.93E−5	0.00021	0
5	8	6	10	50	0.0325	0.047	0.000117
13	8	5	22	67.1	0.0677	0.0932	0.000244
27	7	6	24	66.5	0.342	0.422	0.0228

Return Period of PEAK RUNOFF in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	23	6	13	28.7	9.93E−5	0.00021	0
5	8	6	10	50	0.0325	0.047	0.000117
13	8	5	22	67.1	0.0677	0.0932	0.000244
27	7	6	24	66.5	0.342	0.422	0.0228

Return Period of SEDIMENT YIELD in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2				0	0	0	0
5	8	6	10	50	0.0325	0.047	0.000117
13	8	5	22	67.1	0.0677	0.0932	0.000244
27	7	6	24	66.5	0.342	0.422	0.0228

4.4 BBBFL Watershed

Watershed Summary

Area (ha):	800 (cells: 8893)
Number of Representative Hillslopes:	78
Number of Channels:	31
Number of Impoundments:	0
Outlet Location:	−106.6421, 45.7959
Reference Point:	0
Minimum Source Channel Length (m):	100
Critical Source Area (ha):	10

Landuse Summary

The watershed contains the following landuse as detemined by the USGS National Land Cover Database 2001 – http://www.mrlc.gov/nlcd.php

ID	Name	WEPP File	Number of Cells	Area(ha)	Percent Watershed
31	Barren Land	Good grass.rot	784	70.56	8.8
42	Evergreen Forest	Mature forest.rot	2888	259.92	32.5
52	Shrub/Scrub	Shrubs.rot	2542	228.78	28.6
71	Grasslands/Herbaceous	Good grass.rot	2609	234.81	29.3
82	Cultivated Crops	GeoWEPP/corn,soybean-fall mulch till.rot	7	0.63	0.1
90	Woody Wetlands	Good grass.rot	13	1.17	0.1
95	Emergent Herbaceous Wetlands	Good grass.rot	50	4.5	0.6

Soils Summary

The watershed contains the following soils as determined by the NRCS Soil Survey. The data is requested directly from the NRCS soils database. Information on the NRCS Soils Data structure and how it can be accessed are found at: http://sdmdataaccess.nrcs.usda.gov/

MuKey	Soil Name	Number of Cells	Area(ha)	Percent Watershed
347986	Birney channery loam, 15 to 25 percent slopes	207	18.63	2.3
347997	Birney-Cabbart complex, moist, 25 to 70 percent slopes	387	34.83	4.4
348008	Birney-Cooers-Kirby complex, 2 to 15 percent slopes	851	76.59	9.6
348028	Yamac loam, 2 to 8 percent slopes	979	88.11	11.0
348029	Yamac loam, 8 to 15 percent slopes	24	2.16	0.3
348036	Yamac-Birney-Cabbart complex, 15 to 25 percent slopes	89	8.01	1.0
348037	Yamacall-Busby complex, 2 to 8 percent slopes	12	1.08	0.1
348039	Yamac-Cabbart loams, 8 to 25 percent slopes	403	36.27	4.5
348042	Birney, moist-Armells-Cabbart complex, 25 to 70 percent slopes	907	81.63	10.2
348051	Birney, moist-Birney-Kirby channery loams, 15 to 25 percent slopes	101	9.09	1.1
348075	Busby fine sandy loam, 2 to 8 percent slopes	37	3.33	0.4
348076	Busby fine sandy loam, 8 to 15 percent slopes	110	9.9	1.2
348086	Cabbart-Armells-Rock outcrop complex, 25 to 70 percent slopes	680	61.2	7.6
348097	Cooers loam, 2 to 8 percent slopes	107	9.63	1.2
348103	Armells-Cabbart complex, 25 to 70 percent slopes	21	1.89	0.2
348114	Armells-Delpoint-Cabbart complex, 25 to 70 percent slopes	1314	118.26	14.8

Number of events: 165

26 YEAR SIMULATION FOR WATERSHED

WEPP Watershed Simulation for Representative Hillslopes and Channels (watershed method, off-site assesment)

Note that return period of the events are eatimated by applying Weibull formula on annual maxima series.
$T = (N + 1)/m$
where T is the return period, N is the number of simulation years, and m is the rank of the annual maxima event.

Return Period of PRECIPITATION in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	23	9	23	31.8	3.8E−5	9.0E−5	1.31E−7
5	26	5	14	45.2	0.0271	0.043	0.00176
13	7	6	24	66.5	0.641	0.825	0.0687
27	8	5	22	67.1	0.0872	0.128	0.00605

Return Period of RUNOFF in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	8	6	1	20.3	0.000343	0.00071	0
5	16	7	19	45	0.0591	0.089	0.00538
13	8	5	22	67.1	0.0872	0.128	0.00605
27	7	6	24	66.5	0.641	0.825	0.0687

Return Period of PEAK RUNOFF in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	8	6	1	20.3	0.000343	0.00071	0
5	16	7	19	45	0.0591	0.089	0.00538
13	8	5	22	67.1	0.0872	0.128	0.00605
27	7	6	24	66.5	0.641	0.825	0.0687

Return Period of SEDIMENT YIELD in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	20	4	16	34	0.000176	0.00039	1.18E−6
5	15	9	8	55.9	0.0689	0.103	0.00509
13	29	6	18	40.6	0.0729	0.108	0.0101
27	7	6	24	66.5	0.641	0.825	0.0687

4.5 AFL50-1 Watershed

Watershed Summary

Area (ha):	167 (cells: 1853)
Number of Representative Hillslopes:	42
Number of Channels:	19
Number of Impoundments:	0
Outlet Location:	−106.6022, 45.8362
Reference Point:	0
Minimum Source Channel Length (m):	60
Critical Source Area (ha):	4

Landuse Summary

The watershed contains the following landuse as detemined by the USGS National Land Cover Database 2001 - http://www.mrlc.gov/nlcd.php

ID	Name	WEPP File	Number of Cells	Area(ha)	Percent Watershed
31	Barren Land	Good grass.rot	4	0.36	0.2
42	Evergreen Forest	Mature forest.rot	209	18.81	11.3
52	Shrub/Scrub	Shrubs.rot	645	58.05	34.8
71	Grasslands/Herbaceous	Good grass.rot	995	89.55	53.7

Soils Summary

The watershed contains the following soils as determined by the NRCS Soil Survey. The data is requested directly from the NRCS soils database. Information on the NRCS Soils Data structure and how it can be accessed are found at: http://sdmdataaccess.nrcs.usda.gov/

MuKey	Soil Name	Number of Cells	Area(ha)	Percent Watershed
347929	Kirby-Cabbart-Rock outcrop complex, 25 to 70 percent slopes	820	73.8	44.3
347932	Kobar silty clay loam, 2 to 8 percent slopes	22	1.98	1.2
348028	Yamac loam, 2 to 8 percent slopes	54	4.86	2.9
348037	Yamacall-Busby complex, 2 to 8 percent slopes	16	1.44	0.9
348038	Yamac-Busby complex, 8 to 15 percent slopes	692	62.28	37.3
348042	Birney, moist-Armells-Cabbart complex, 25 to 70 percent slopes	128	11.52	6.9
348078	Busby-Rock outcrop complex, 8 to 15 percent slopes	40	3.6	2.2
348098	Cooers-Birney complex, 2 to 8 percent slopes	81	7.29	4.4

Number of events: 88

26 YEAR SIMULATION FOR WATERSHED

WEPP Watershed Simulation for Representative Hillslopes and Channels (watershed method, off-site assesment)

Note that return period of the events are eatimated by applying Weibull formula on annual maxima series.
T = (N + 1)/m
where T is the return period, N is the number of simulation years, and m is the rank of the annual maxima event.

Return Period of PRECIPITATION in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
(yr)				(mm)	(mm)	(m^3/s)	(t/ha)
2	23	9	23	31.8	0.0133	0.00981	0.00012
5	26	5	14	45.2	1.11	0.529	0.121
13	7	6	24	66.5	8.97	3.38	2.41
27	8	5	22	67.1	0.127	0.0765	0.00207

Return Period of RUNOFF in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
years				(mm)	(mm)	(m^3/s)	(t/ha)
2	24	5	25	36.3	0.06	0.0386	0.000711
5	26	5	14	45.2	1.11	0.529	0.121
13	16	7	19	45	2.67	1.26	0.515
27	7	6	24	66.5	8.97	3.38	2.41

Return Period of PEAK RUNOFF in Event-by-Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
(yr)				(mm)	(mm)	(m^3/s)	(t/ha)
2	24	5	25	36.3	0.06	0.0386	0.000711
5	26	5	14	45.2	1.11	0.529	0.121
13	16	7	19	45	2.67	1.26	0.515
27	7	6	24	66.5	8.97	3.38	2.41

Return Period of SEDIMENT YIELD in Event by Event Output							
Recurrence Interval	Day	Month	Year	Precipitation	Runoff	Peak	Sediment Yield
(yr)				(mm)	(mm)	(m^3/s)	(t/ha)
2	23	6	11	27.2	0.108	0.0665	0.000462
5	29	7	2	30	0.975	0.469	0.121
13	16	7	19	45	2.67	1.26	0.515
27	7	6	24	66.5	8.97	3.38	2.41

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