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Consequences of Historic Rainfall on Western Iowa Farmland

R. G. SPOMER, H. G. HEINEMANN, AND R. F. PIEST

USDA Soil and Water Conservation Research Division, Columbia, Missouri 65201

Abstract. Rainfall on five soil and water conservation research watersheds near Treynor, Iowa, varied from 18 to 22 inches for the period of May 28 to June 27, 1967. This unique series of events has a return period that exceeds 100 years, based on the 97-year Weather Bureau record at nearby Omaha, Nebraska.

Surface runoff from two corn cropped watersheds planted on an approximate contour approached or exceeded 50% of the storm rainfall during the period. Surface runoff was 8% or less for all rainfall events on a corn cropped, terraced watershed and 17% or less for all but one storm on a grassed watershed.

These rains occurred a few weeks after planting when the corn plants were only 6 inches tall; consequently, little or no erosion protection was provided for the bare, loose soil. Sheet rill erosion rates were 75 to 100 tons per acre on the contoured corn watersheds. By contrast, conservation practices on two other watersheds limited the sheet rill erosion to 2.5 tons per acre.

Gullies on the contoured corn watersheds eroded severely, whereas conservation practices on the other watersheds reduced gully erosion to an insignificant amount.

Engineers and conservationists engaged in the design of flood control structures, water supply systems, and erosion control measures require information on rainfall, runoff, and sediment yield. It is very unusual to find actual measurements of these factors for very high rainfall events such as occurred in southwestern Iowa in June 1967.

An alternately stalled and oscillating weather front caused record rains over a wide area of the western corn belt during the period May 28 to June 27, 1967. Gages located on four research watersheds near Treynor, Iowa, recorded 18 to 22 inches of rain during this period after corn planting when the soil was highly susceptible to erosion.

Soil erosion rates from corn watersheds farmed on the approximate contour were intolerably high, which showed that under such conditions, contours are inadequate for erosion control. However, runoff and erosion rates from both level terraced corn and grassed watersheds were reduced to acceptable levels. Observations of watershed performance under the severe test of the historic storm period are the substance of this report.

STUDY WATERSHEDS

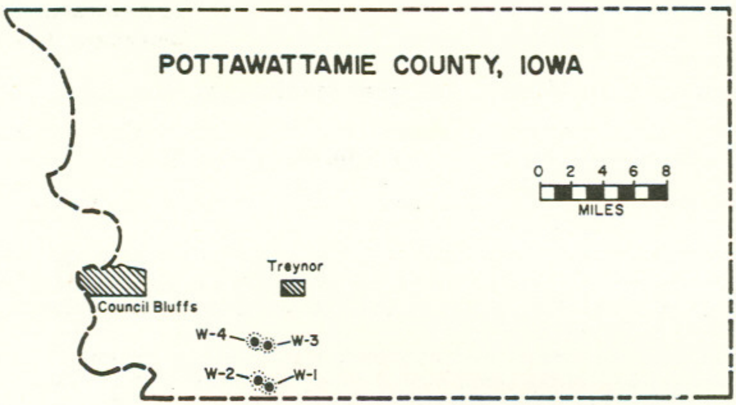
In 1964, a research program was begun to study the effect of land use and treatment on soil erosion, gully advance, flood flows, and water conservation in the Missouri Valley deep loess hills. This research is being conducted on four watersheds (Figure 1) in Pottawattamie County near Treynor, Iowa.

The soils on these watersheds are of the Monona-Ida-Napier series and are silty loams of loessial origin with moderate permeability. These loess soils overlay glacial till and range in depth from 80 feet at ridge tops to less than 15 feet in the valleys.

The topography of the watersheds varies from narrow valleys and ridges with 2 to 4% slopes to steep sidehills with 10 to 16% slopes. Each watershed is completely tillable, but severe sheet rill erosion occurs on the steep side slopes. Most valleys have deeply incised channels that terminate upslope in an active gully head.

Farm operations were standardized for this research. All terraces constructed on watershed 4 can store 2 inches of surface runoff from the contributing area. Ninety-two percent of watershed 4 is above the level terraces.

Eight recording rain gages are in operation, and water stages over calibrated, broad crested, *V* notch weirs are recorded continuously. Soil moisture is determined weekly during the growing season to a depth of 20 feet at representative sites, and groundwater levels are measured at eight locations.



WATERSHED DESCRIPTION

WATERSHED	SIZE	CROPPING	LAND TREATMENT
	ACRES		
1	74.5	Continuous Corn	Approx. Contoured
2	82.8	Continuous Corn	Approx. Contoured
3	107	Grass	None
4	150	Continuous Corn	Level Terraced

Fig. 1. Location and description of research watersheds.

Storm runoff samples collected at weir sites and at drainageway locations just upstream from gully heads are analyzed for sediment concentration. Data taken at the gully head locations quantify sheet rill erosion from the watersheds, whereas the difference between sediment concentration at the weir site and at the upstream site is a measure of gully erosion. Adjustments were made for inflow and sediment yield between sampling sites based on the contributing area. Gully erosion is also measured by engineering surveys and photogrammetric techniques to substantiate gully volume changes.

WATERSHED CONDITIONS PRIOR TO JUNE 1967

Precipitation during 1966 was 8 inches below the 28.6-inch yearly average, with only 1.1 inches of precipitation from October through December. The first 4 months in 1967 continued to be extremely dry, with a total of 4.5 inches of precipitation.

Plowing, seedbed preparing, and planting were accomplished while dry conditions prevailed. Watershed soil moisture measurements on April 19, 1967, showed 7 to 8 inches of available water in the top 5 feet of the soil profile. The top 2 feet of soil had approximately 3 to 4 inches of water available for plant growth, or about half of the available water in the top 5 feet of soil. Subsequent farm operations such as plowing contributed to depletion of this moisture. However, no additional soil moisture data are available for this period because access tubes for nuclear probe soil moisture measurements were removed for the plow–plant period.

Seedbed preparation during dry weather caused the large soil aggregates to dry rapidly; these clods could not be pulverized by disking, harrowing, or planting. Corn planting was completed by May 15 on watersheds 1, 2, and 4. Despite the dry conditions, emergence was fair but definitely spotty, with little growth of the young plants.

DISCUSSION

Rainfall. On May 28, a light rain began to fall. It continued through May 30 but produced no surface runoff. This general, low intensity, 3-inch rainfall relieved the moisture stress in the young corn plants and by June 4 the corn seedlings were approximately 6 inches high. They still did not offer effective soil surface protection from raindrop impact or soil erosion.

Fourteen rainfall events of 0.4 inch or more occurred between May 28 and June 27, with a total accumulation of 18 to 22 inches. This accumulation was 4 to 8 inches more than the previous high total of 13.94 inches for the 97-year record at Omaha, Nebraska (18 miles away), for the same period. It was 13 to 17 inches more than the May 28 to June 27 average rainfall for the 97-year period of record at Omaha. The return period for a rainfall of 18 to 22 inches in this locality during this 31-day period exceeds 100 years; that is, the chance that such a rainfall will occur in any given year is less than 1%. Approximately two-thirds of the average yearly rainfall of 28.6 inches for this locality was received during this period.

The return period for the largest event during the 31-day period (6 inches in 2 hours and 54 minutes on June 20) also exceeded 100 years, according to U.S. Weather Bureau information [*Hershfield,* 1961; *Miller,* 1964]. Precipitation amounts and related energy and intensity parameters for the major rainstorms during the period are presented in Tables 1 through 4.

Runoff. This 30-day storm period produced numerous runoff events on the research watersheds. These events provide an opportunity to compare runoff response from watersheds with different land treatments. Peak runoff rates and volumes for storms during the period are also summarized in Tables 1 through 4.

The mass curves in Figure 2 show that contour corn watersheds 1 and 2 tend to yield similar runoff amounts when rainfall is similar. Surface runoff during this wet period exceeded 50% of the rainfall 9 times on watersheds 1 and 2 (Tables 1 and 2). Runoff ranged to 74% of the rainfall at watershed 1 and to 87% of the rainfall at watershed 2. Values for watersheds 3 and 4 indicate that conservation practices reduce surface runoff substantially since runoff from grassed watershed 3 ranged to 34% of the rainfall (Table 3) and runoff from level terraced corn watershed 4 ranged to 6% (Table 4).

A uniform runoff response on watershed 4 for the period is shown in Figure 2. Surface runoff measured at the outlet was less than 0.8 inch of the 17.44 inches of rain during the period. Runoff response on watershed 3 was similar to that on watershed 4 but slightly greater; runoff reached 1 inch from 12 inches of rainfall by June 16. There was no similarity in runoff response between these watersheds during the 3.88-inch rainfall on June 20, which produced 1.3 inches of runoff on watershed 3 and 0.25 inch of runoff on watershed 4 (Tables 3 and 4). This is shown (Figure 2) by the sharp increase of the slope of the mass curve for watershed 3 and a very slight increase for watershed 4.

It appears that good grass cover is generally effective in reducing surface runoff to amounts that might be expected from a terraced area. However, when successive storms nearly saturate the soil profile and are followed by an intense storm, a large percentage of this rainfall can be expected to become surface runoff. For the storm of June 20, the grass cover did not effectively retard the water movement long enough to allow large amounts to infiltrate. Furthermore, the high antecedent soil moisture level also reduced infiltration rates on the grassed watershed.

The large event on June 20 at watersheds 1 and 2 produced the highest runoff rates and volumes recorded (Tables 1 and 2) with an increase of runoff in proportion to rainfall. This increase was expected because of high antecedent moisture conditions and a very intense storm. Storm rainfall intensities were 6.53 inches per hour for 5 minutes, 6.30 inches per hour for 10 minutes, and 4.69 inches per hour for 30 minutes. A total rainfall of 6.02 and 5.71 inches was recorded at watersheds 1 and 2, respectively, in a 2-hour 54-minute period.

Rainfall intensities, with runoff and sediment discharges for the storm of June 20 on the four research watersheds, are presented in Figure 3. The rapid runoff response following the initial rainfall is apparent on both watersheds 1 and 2. Runoff response is also shown to be sensitive to succeeding bursts of rainfall on these watersheds. The runoff from watershed 3 is shown

TABLE 1. 1967 Rainfall, Runoff, and Sediment Information by Storm, Watershed 1 (74.5 acres) near Treynor, Iowa

	Rainfall					Runoff				Sediment		
Date	Start*	End*	Amount, inches	Kinetic Energy, foot-tons/acre	Energy Intensity	Start*	End*	Amount, inches	Peak Rate, cfs	From Sheet Erosion, tons	From Gully Erosion, tons	From All Sources, tons
May												
28	0024	0934	0.52	410	241	†						
29	0811	1236	0.11	51	4	†						
29–30	1953	2040	1.62	1000	265	†						
31	1300	2135	0.84	534	260	†						
June												
1	2358	0305	0.06	31	8	†						
4–5	2326	0523	3.59	3402	7,353	2328	0600	1.79	145	1150	180	1330
7	1624	1848	1.69	1802	5,508	1659	1902	1.23	411	1020	90	1110
7	1848	2223	0.69	578	471	1902	2400	0.45	83	143	47	190
9	0106	0150	0.51	476	460	0114	0155	0.35	117	155	100	255
9	0150	0306	0.41	357	196	0155	0339	0.30	96	119	44	163
9–10	2036	0100	1.57	1422	2,772	2044	0200	1.16	212	550	158	708
11	2350	1200	0.19	137	45	0012	0200	0.05	24	14	12	26
11–12	2002	0025	0.83	720	548	2005	0121	0.51	113	129	113	242
14	0510	0711	0.81	792	1,063	0523	0809	0.50	235	228	146	374
15	1943	2137	0.51	428	281	2026	2200	0.19	60	60	53	113
16	0035	0203	0.19	148	30	0050	0239	0.11	12	19	4	23
20	2056	2350	6.02	6527	31,232	2104	2400	4.21	438	3700	420	4120
24	0130	0259	0.54	492	465	0140	0310	0.11	30	29	25	54
24	0259	0450	0.40	291	113	0310	0526	0.15	31	22	24	46
27	1508	1534	0.37	338	254	1520	1650	0.05	16	17	12	29

Storm was defined on the basis of practical hydrograph separation.
Energy intensity is a product of kinetic energy and high 30-minute rainfall intensity.
* Local time.
† Trace.

TABLE 2. 1967 Rainfall, Runoff, and Sediment Information by Storm, Watershed 2 (82.8 acres) near Treynor, Iowa

	Rainfall					Runoff				Sediment		
Date	Start*	End*	Amount, inches	Kinetic Energy, foot-tons/acre	Energy Intensity	Start*	End*	Amount, inches	Peak Rate, cfs	From Sheet Erosion, tons	From Gully Erosion, tons	From All Sources, tons
May												
28	0024	0919	0.50	379	206	†						
29	0815	1248	0.09	45	4	‡						
29–30	1957	2031	1.50	919	220	†						
31	1306	2122	0.78	488	176	†						
June												
1	2400	0311	0.08	40	10	‡						
4–5	2320	0558	3.62	3441	8,035	2325	0615	1.67	142	1220	260	1480
7	1602	1853	1.69	1857	5,698	1710	1902	1.01	346	832	188	1020
7	1853	2310	0.67	540	421	1902	2300	0.34	60	137	14	151
9	0101	0148	0.49	449	401	0111	0154	0.30	105	217	−39	178
9	0148	0544	0.52	393	200	0154	0646	0.28	84	108	26	134
9–10	2041	0017	1.43	1288	2,353	2042	0052	1.25	284	674	90	764
11	2350	0105	0.30	259	163	0003	0116	0.13	43	46	16	62
11–12	1948	0024	0.85	642	461	2005	0102	0.46	101	167	64	231
14	0513	0721	0.86	810	1,056	0522	0823	0.49	182	255	27	282
15	1943	2133	0.54	460	342	2024	2141	0.21	82	112	10	122
16	0006	0147	0.18	139	24	0053	0235	0.11	13	11	8	19
20	2056	2342	5.71	6165	29,575	2106	2352	3.76	406	2410	690	3100
24	0131	0302	0.54	487	460	0138	0324	0.04	10	11	4	15
24	0302	0455	0.38	271	96	0324	0540	0.07	13	11	8	19
27	1505	1536	0.33	292	189	1514	1631	0.01	2.4	1	0.7	1.7

Storm was defined on the basis of practical hydrograph separation.
Energy intensity is a product of kinetic energy and high 30-minute rainfall intensity.
* Local time.
† Trace.
‡ No runoff.

TABLE 3. 1967 Rainfall, Runoff, and Sediment Information by Storm, Watershed 3 (107 acres) near Treynor, Iowa

Date	Rainfall					Runoff				Sediment		
	Start*	End*	Amount, inches	Kinetic Energy, foot-tons/acre	Energy Intensity	Start*	End*	Amount, inches	Peak Rate, cfs	From Sheet Erosion, tons	From Gully Erosion, tons	From All Sources, tons
May												
28	0040	0923	0.36	260	57	†						
29	0824	1543	0.10	52	3	‡						
29–30	2011	2102	1.48	884	186	†						
31	1159	2329	0.71	432	134	†						
June												
1	0009	0557	0.16	96	18	†						
4–5	2307	0541	3.06	2790	6,445	2330	0700	0.24	27	4.6	9.6	14
7	1710	1828	0.95	980	1,705	1718	1857	0.16	40	4.7	9.3	14
7	1853	2001	0.63	547	459	1910	2100	0.06	8.3	1.3	0.7	2.0
9	0110	0147	0.50	476	447	0114	0159	0.01	4.1	0.3	0	0.4
9	0147	0343	0.44	354	184	0159	0352	0.04	4.8	0.9	0	1.1
9	2041	2311	1.41	1267	2,116	2048	2400	0.23	37	6.3	7.1	13
11	0002	0041	0.11	74	10	‡						
11–12	1949	0026	0.94	738	620	2006	0120	0.04	5.0	1.2	0.5	1.7
14	0510	0658	0.83	772	1,073	0523	0728	0.12	26	6.0	2.6	8.6
15	1946	2056	0.62	564	462	2023	2220	0.06	8.7	2.3	0.1	2.4
16	0040	0138	0.21	139	28	0054	0332	0.01	0.8	0.2	−0.1	0.1
20–21	2052	2348	3.88	3979	13,609	2100	0230	1.33	217	33	93.0	126
24	0135	0233	0.50	460	419	0142	0315	0.02	3.6	0.6	0.2	0.8
24	0300	0417	0.42	332	149	0315	0530	0.05	5.7	0.9	0.4	1.3
27	1507	1524	0.13	106	28	‡						

Storm was defined on the basis of practical hydrograph separation.
Energy intensity is a product of kinetic energy and high 30-minute rainfall intensity.
* Local time.
† Trace.
‡ No runoff.

TABLE 4. 1967 Rainfall, Runoff, and Sediment Information by Storm, Watershed 4 (150 acres) near Treynor, Iowa

	Rainfall					Runoff				Sediment		
Date	Start*	End*	Amount, inches	Kinetic Energy, foot-tons/acre	Energy Intensity	Start*	End*	Amount, inches	Peak Rate, cfs	From Sheet Erosion, tons	From Gully Erosion, tons	From All Sources, tons
May												
28	0040	0923	0.36	260	57	*						
29	0824	1543	0.10	52	3	†						
29–30	2011	2102	1.48	884	186	*						
31	1159	2329	0.71	432	134	*						
June												
1	0009	0557	0.16	96	18	†						
4–5	2307	0302	2.96	2741	6,332	2330	0350	0.11	25	94	−18	76
7	1710	1828	0.95	980	1,705	1718	1859	0.06	40	64	−5.0	59
7	1853	2001	0.63	547	459	1907	2132	0.04	11	15	−2.0	13
9	0110	0147	0.50	476	447	0113	0204	0.02	15	11	trace	11
9	0147	0343	0.44	354	184	0204	0401	0.02	7.9	4.4	1.6	6.0
9	2041	2311	1.41	1267	2,116	2052	2352	0.08	21	34	trace	34
11	0002	0041	0.11	74	10	†						
11–12	1949	0026	0.94	738	620	2008	0121	0.05	16	7.4	9.6	17
14	0510	0658	0.83	772	1,073	0521	0703	0.05	24	21	1.0	22
15	1946	2056	0.62	564	462	2012	2128	0.03	11	11	−1.0	10
16	0040	0138	0.21	139	28	0057	0235	0.01	1.4	1.7	−1.3	0.4
20–21	2052	2348	3.88	3979	13,609	2101	0041	0.25	42	117	−11	106
24	0135	0233	0.50	460	419	0140	0240	0.02	4	3.3	−0.9	2.4
24	0300	0417	0.42	332	149	0321	0510	0.02	4.4	2.9	−0.5	2.4
27	1507	1524	0.13	106	28	†						

Storm was defined on the basis of practical hydrograph separation.
Energy intensity is a product of kinetic energy and high 30-minute rainfall intensity.
* Local time.
† Trace.
‡ No runoff.

to be noticeably less, and the runoff from watershed 4 is insignificant. Some of this difference in runoff on watershed 3 and 4 was due to approximately 2 inches, less rainfall.

Erosion. All significant erosion on the research watersheds during 1967 occurred in June. The sequence of storms during this most susceptible erosion period caused extreme erosion damage to unprotected fields and was a severe test of the effectiveness of conservation practices.

In Tables 1 through 4, the erosivity of all rainstorms for this period is represented by kinetic energy, and by the erosion index parameter derived by *Wischmeier and Smith* [1958]. The erosion index is the kinetic energy of the rainfall times the maximum 30-minute rainfall intensity.

These erosivity measures can be compared with an average annual value [*Wischmeier and Smith,* 1965] of 16,500 units, or an average seasonal erosivity value for the period May 28 to June 27 of 5000 units. This comparison reveals that the actual soil losses could approximate 10 times the average expected for June and 3 times the annual average. Sediment discharge measurements substantiate these findings. The 99-ton-per-acre sediment yield from sheet rill erosion (hereafter referred to as sheet erosion) on watershed 1 during June is far higher than any previous measurement on this watershed.

Phenomenal volumes of sheet and gully erosion were produced by the unique series of rainstorms from May 28 to June 27. The 6-inch rain of June 20 caused 50 tons per acre of soil loss from sheet erosion from watershed 1; this exceeded the previous 45 tons per acre annual high of record (1965). The June 20 sediment yield from sheet erosion was somewhat less spectacular on watershed 2 (29 tons per acre). Sheet erosion rates were dramatically reduced on conservation watersheds 3 and 4 during the storm of June 20. A good grass cover held losses from sheet erosion to ⅓-ton per acre, whereas terraces restricted sheet erosion losses to ¾-ton per acre on land continuously row cropped to corn. Indications are that the soil conservation performance of a good grassed watershed is slightly superior to that of a level terraced, continuous corn watershed. This reduction of sheet erosion on conservation watersheds is also apparent in Figures 4 and 5, which show storm losses of watersheds 1 and 4 for the period.

The sediment transport rate at the weirs of the four watersheds is shown in Figure 3. At 74.5-acre watershed 1, the peak sediment transport rate was 206 tons per minute on the first rise of June 20. Although this rate decreased

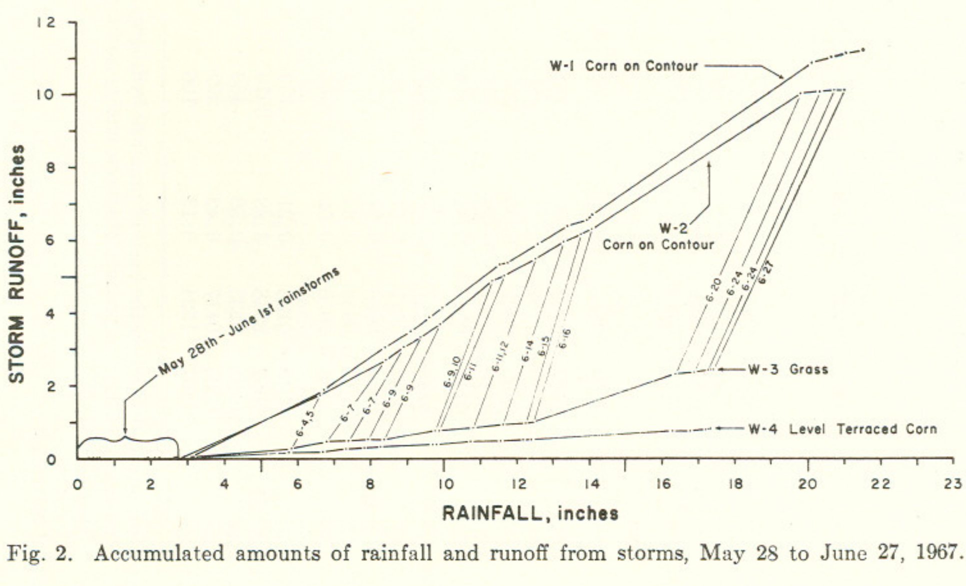


Fig. 2. Accumulated amounts of rainfall and runoff from storms, May 28 to June 27, 1967.

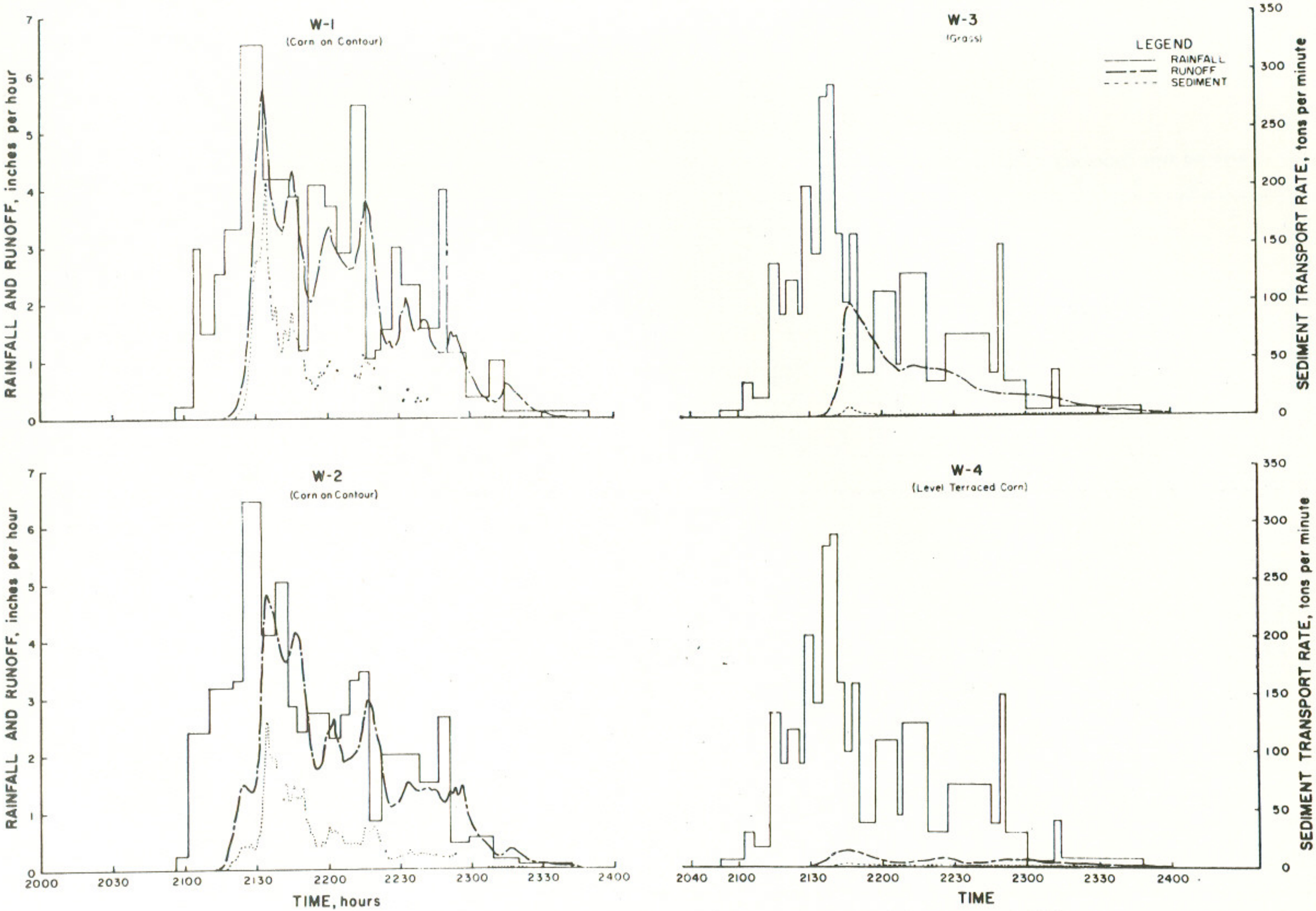


Fig. 3. Rainfall intensities, with runoff and sediment yield, Treynor watershed, June 20, 1967.

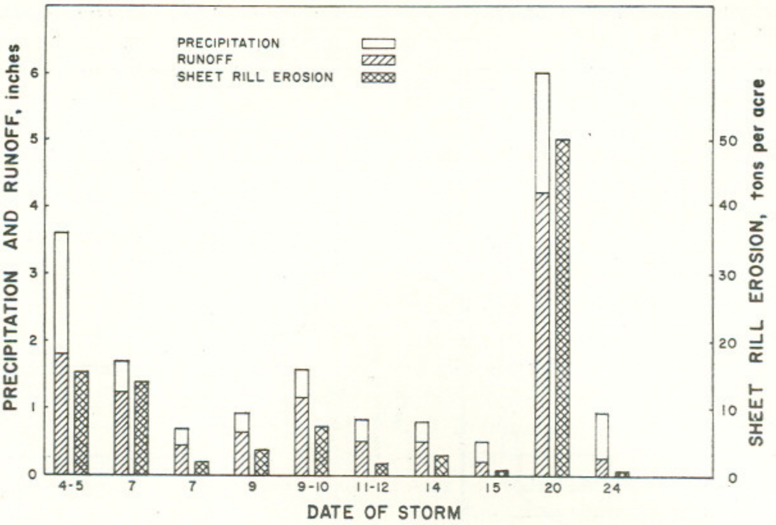


Fig. 4. Rainfall, runoff, and erosion rates for largest storms during June 1967, watershed 1.

sharply thereafter, it remained in excess of 25 tons per minute for much of the storm. The sediment transport rates at 82.8-acre watershed 2 were somewhat less for this storm and reached a peak of 132 tons per minute. This rate also decreased after the first peak but it too remained at or above 25 tons per minute for much of the storm. Sediment transport rates at watersheds 3 and 4 were negligible.

Gully erosion. Gully erosion amounts were excessive on watersheds 1 and 2 and they occasionally surpassed 100 tons per storm. They climaxed on June 20 with single storm totals of 420 and 690 tons, respectively. On watershed 3, gully erosion was insignificant except for the 93 tons of gully erosion on June 20.

Gully erosion for the 31-day period on watersheds 1 and 2 was approximately 1430 and 1370 tons, respectively. These values can be compared with 120 tons of gully erosion on watershed 3, whereas a slight fill was measured in the gully on watershed 4.

Gully erosion rates from both the terraced watershed and the grassed watershed were

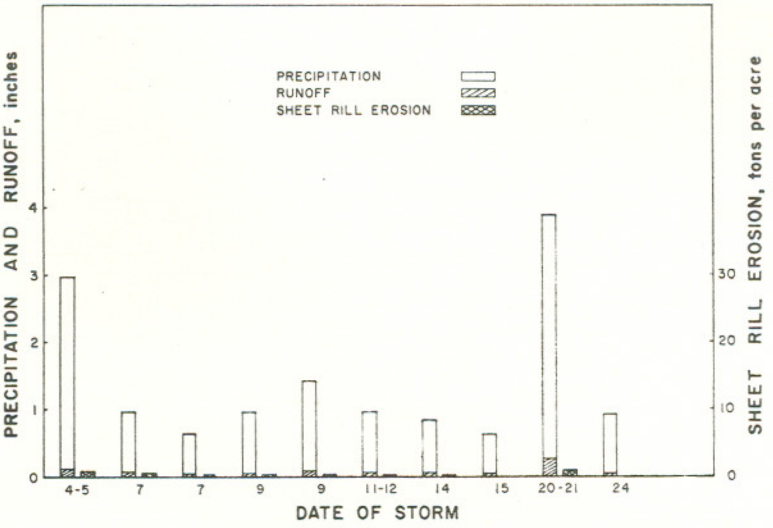


Fig. 5. Rainfall, runoff, and erosion rates for largest storms during June 1967, watershed 4.

drastically reduced. The rainstorm on June 20 accounted for one-third of the total gully sediment yield for the 31-day storm period on watershed 1, one-half of the yield on watershed 2, and three-fourths of the yield on watershed 3.

Note from Table 2 that the 690-ton sediment yield from gully erosion for the storm of June 20 at watershed 2 exceeded the 420 tons at watershed 1. This 690-ton removal occurred primarily from lateral deterioration and caving of the channel banks along the 700-foot reach of gully between the head cut and the weir; head cut erosion at watershed 2 was not significant. In contrast, the material voided from the gully head at watershed 1 was significant, as was the lateral bank erosion in the upstream 150 feet of the 400-foot channel between the gully head and the downstream measuring weir.

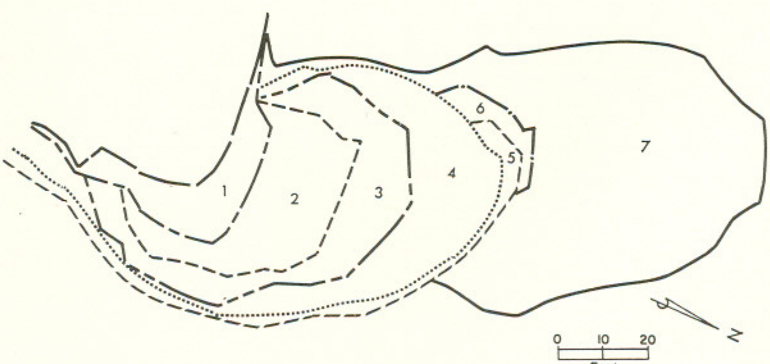
The plan view of the gully on watershed 1 (Figure 6) dramatically emphasizes the rapid advance of the head cut during the period June 4 to June 27. Gully erosion for this 24-day period is compared with previous gully erosion at this site since 1965. The head cut at watershed 1 advanced 50 feet from June 4 to June 27, 1967. This advance is spectacular, even when compared with the 60-foot advance of the head cut in 1965 that resulted from runoff during the intervals shown.

The actual mechanics of gully erosion, as related to soil characteristics and water flow energies, are poorly understood. The effect of saturated and unsaturated subsurface flow on gully bank stability is not known, and little is known about other factors that contribute to shear failures of gully banks. The role of soil water and gully cleanout by runoff, gravity, and soil shear strength are interacting variables that affect gully erosion, but their relative contributions remain to be quantified.

SUMMARY

A historic series of rains totaling 18 to 22 inches occurred during the 31 days from May 28 to June 27, 1967, on the research watersheds near Treynor, Iowa. The return period for rainfall of this magnitude exceeds 100 years, based on the 97-year record of the U.S. Weather Bureau of Omaha. The largest single rainfall was approximately 6 inches in 3 hours, and it also exceeded a return period of 100 years.

The rain occurred when the soil surface was highly susceptible to erosion and crops were too small to intercept rainfall or resist surface



AREA	PERIOD	SURFACE RUNOFF acre-feet	GULLY EROSION tons
1	NOV. 15, '64-APR. 14, '65	25	130
2	APR. 14, '65-JUNE 9, '65	17	510
3	JUNE 9, '65-AUG. 13, '65	12	160
4	AUG. 13, '65-NOV. 15, '65	14	350
5	NOV. 15, '65-JULY 15, '66	4	90
6	JULY 15, '66-MAY 30, '67	1	< 10
7	MAY 30, '67-JUNE 27, '67	70	1430
	TOTAL	143	2680

Fig. 6. Gully advance and erosion rate, by periods, with accompanying surface runoff.

runoff and erosion. Runoff frequently exceeded 50% of the rainfall on the approximate contour corn watersheds. Runoff from the grassed and level terraced corn watersheds was less than 17% of the rainfall except for the storm of June 20 when runoff from the grassed watershed was 34% of the rainfall.

Sediment yields from sheet and gully erosion were determined by taking samples at weir sites and immediately upstream from the gully head. Ninety-nine tons of soil per acre originated from sheet erosion sources on contour corn watershed 1 and 75 tons per acre on contour corn watershed 2 during the 31-day storm period. Yields of 0.6 ton per acre of sheet erosion from grassed watershed 3 and 2.6 tons per acre from level terraced corn watershed 4 for this storm period dramatize the effectiveness of conservation treatments to reduce sediment yield from sheet erosion. Sediment yields from sheet erosion were spectacular during the storm of June 20 when 50 and 29 tons per acre eroded from watersheds 1 and 2, respectively.

Gully erosion on watersheds 1 and 2 was just as impressive with about 1430 and 1370 tons eroded from the gullies from May 28 to June 27. Only 120 tons of total gully erosion was measured on watershed 3, of which 93 tons was eroded on June 20. Measurements of gully erosion on watershed 4 showed a slight filling of 27 tons for the storm period.

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