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A STUDY ON SOIL EROSION IN WESTERN TENNESSEE

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Introduction

The state of Tennessee has an abundant supply of surface and ground water. The availability, development and preservation of these water sources is very important for the social and economic development of the state. Soil erosion, resulting in sedimentation in streams, rivers and lakes poses a threat to the water quality of surface sources. Sediments from erosion of natural ground has been a serious problem in western Tennessee. Soil loss due to construction activity adds to the already existing high erosion rate in western Tennessee.

Soil erosion due to construction activity is generally similar to soil exposed by agricultural activities such as plowing with two possible exceptions: a) the length of time necessary for the vegetative cover to reestablish itself is in general longer for the construction activity; b) the land disturbance in the case of the agricultural use is on an annual or more frequent basis than a single land disturbance episode of construction activity (USDA 1974).

Literature Review

A study of the literature indicates that data for soil erosion due to gross erosion and agricultural activity are available for West Tennessee. The sediment loading rate for some soils in Tennessee is reported to be 200 tons/acre/year (USDA 1974). Lower Mississippi type I study (USDA 1977) indicates an average gross erosion of 13.3 tons/acre/year. The United States Department of Agriculture (USDA) Soil Conservation Service gives an estimated erosion rate of 27.5 tons/acre/year in the Reelfoot Creek basin (TDPH 1982). Gross erosion in the Obion–Forked Deer River basin which drains approximately one half of West Tennessee is estimated to be 15.1 tons/acre/year (Trimble and Carey 1984). The average soil erosion in the Reelfoot Creek basin is reported to be 27 tons/acre/year (Kung and Garrett 1986). Soil loss in Shelby County due to agricultural activity has been reported to be 18.38 tons/acre/year (8.2 tonnes/ha/year) (Moore and Klaine 1987).

Soil erosion (E) is influenced by many factors like soil type (S), soil cover (C), past erosion history (H), seasonal variation, (V), intensity (I), and duration of rainfall (R) and land modification (M). It can be expressed as

$$E=f(S,C,H,V,I,R,M) \quad ....(1)$$

A comprehensive study is needed to establish a functional relationship among these factors. Although construction activity (M') has been identified as a factor affecting soil erosion, a detailed study is needed to understand the effect of construction activity on the amount of soil loss. A study was undertaken at a site in Shelby County and the results are reported in this paper.

Study Area

Many construction sites in Shelby County were visited to determine their suitability for this study. A site with one runoff outlet was selected in the Farmington Meadows Subdivision in Germantown. This construction site, shown in Figure 1, is north of Neshoba Road and east of Brierbrook Road and west of Hobits Glen condominiums. Soil at this site is classified as silty loam (USDA 1970). A typical soil sample consists of 4% sand, 81% silt and 15% clay. The subdivision was developed in stages at the time of this study. Total drainage area was 92.17 acres. Construction was completed on 27.8 acres and was later sodded. This area drains into a concrete lined ditch and the storm water runs into the Wolf River at the northern side of the construction site.

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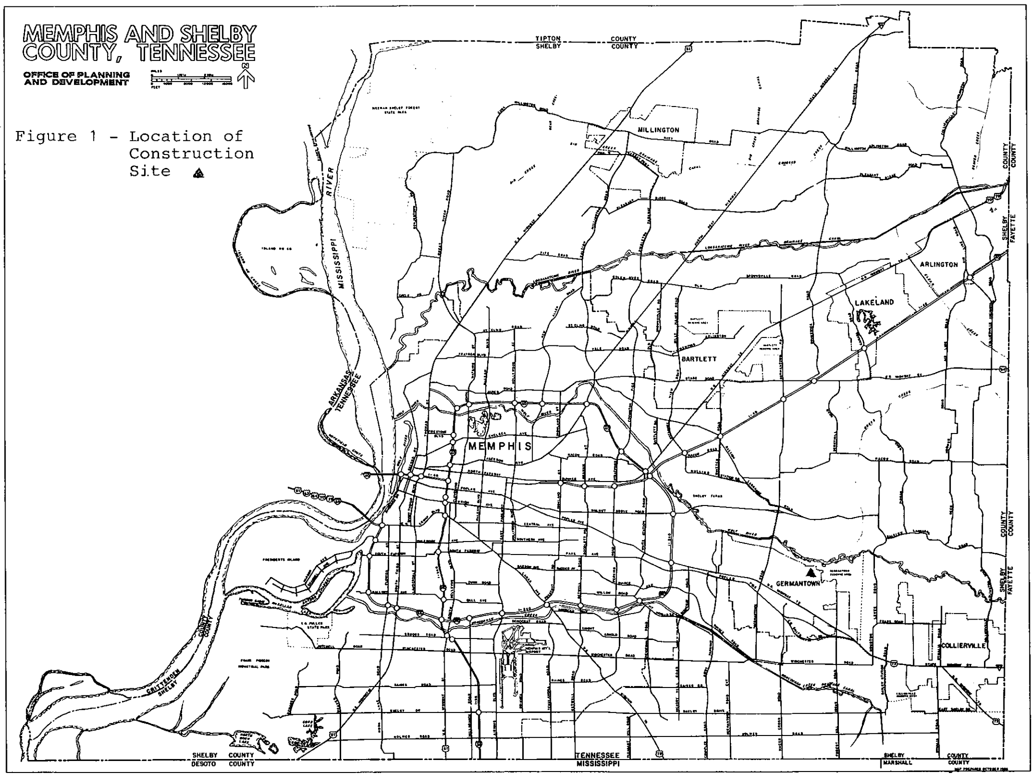

Figure 1. Location of Construction Site.

Rainfall and Flow Measurements

The United States Geological Survey (USGS) Water Resources Division, Memphis District, has measuring stations in Shelby County to determine rainfall and storm runoff. One such measuring station is located near the construction site at the intersection of Wolf River and Germantown Road. All rainfall readings were obtained from USGS.

Three rainfall events, one each in winter, spring and summer, were studied. A sharp crested rectangular wooden weir was installed in the drainage ditch, shown in Figure 2, and flow was determined from readings of the water level on the weir for two rainfall events. Manning's formula for open channel flow was used in determining the flow for the third rainfall event. Rainfall and runoff data for rainfall events 1 to 3 are given in Tables 1 to 3 respectively and are also shown in Figures 3 to 5.

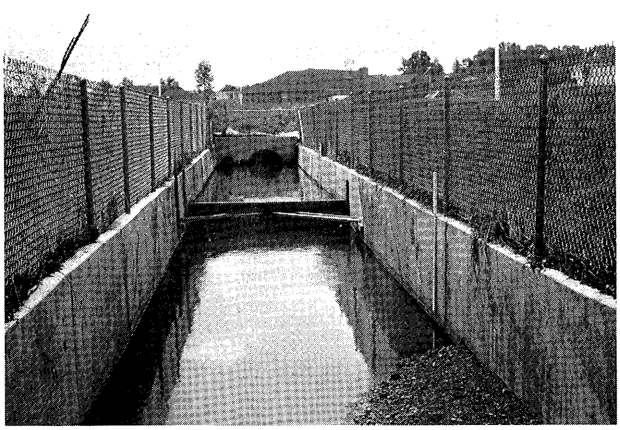

Figure 2. Sharp Crested Rectangular Weir Installation.

Sampling and Analysis

Grab samples were collected manually at frequent intervals and were transported to the laboratory. Suspended solids (SS) were determined using standard accepted procedures (EPA, 1974). The results are presented in Table 4. Assumed annual rainfall for the site is 54 inches. Sediment loadings for these events are given in Tables 1 to 3 and are also shown in Figures 3 to 5.

Discussion and Summary

Using these data, the soil erosion for the project was assessed and compared to determine the influence the construction activity has on the quantity of erosion. As expected, peak soil losses typically correspond to peak flow rates. The season seems to play an important role in

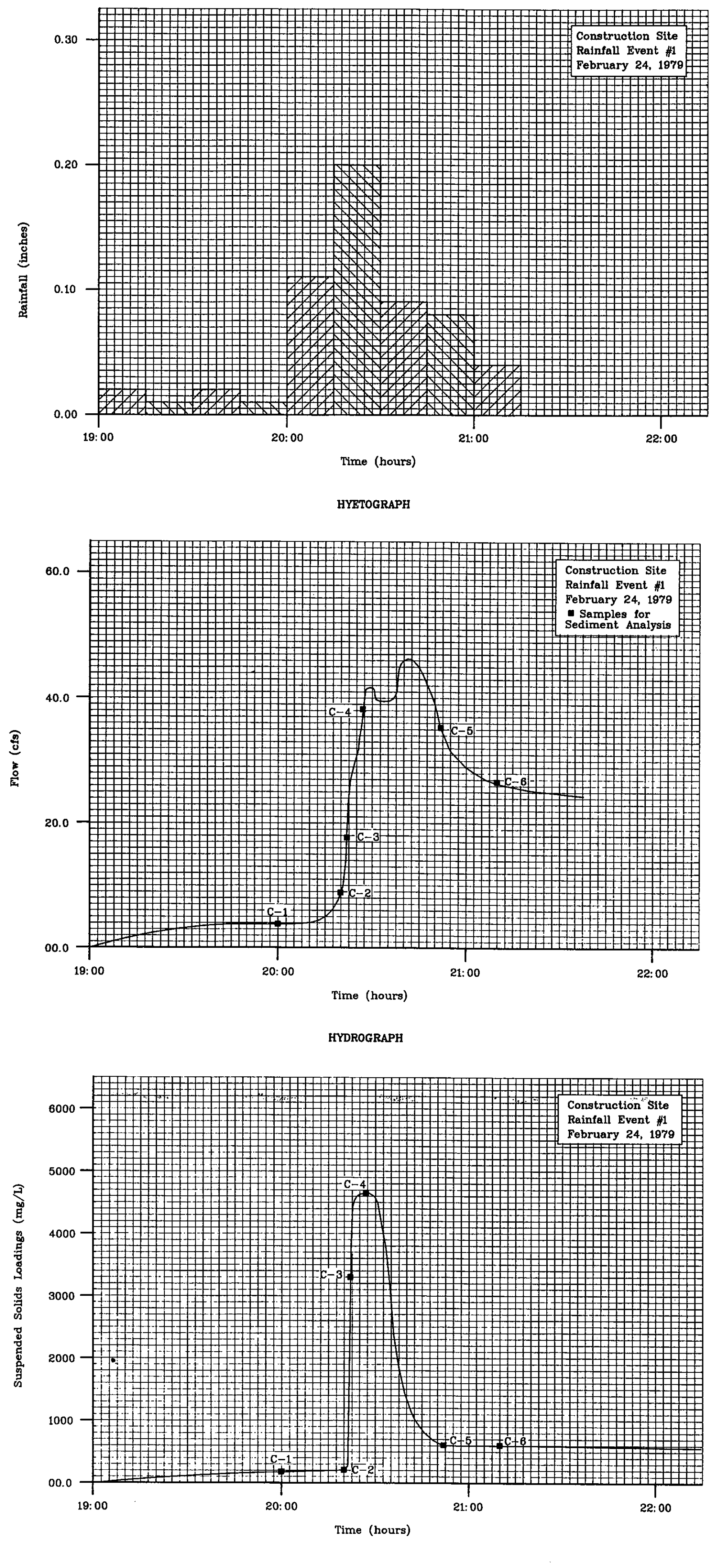

Figure 3. Rainfall Event #1.

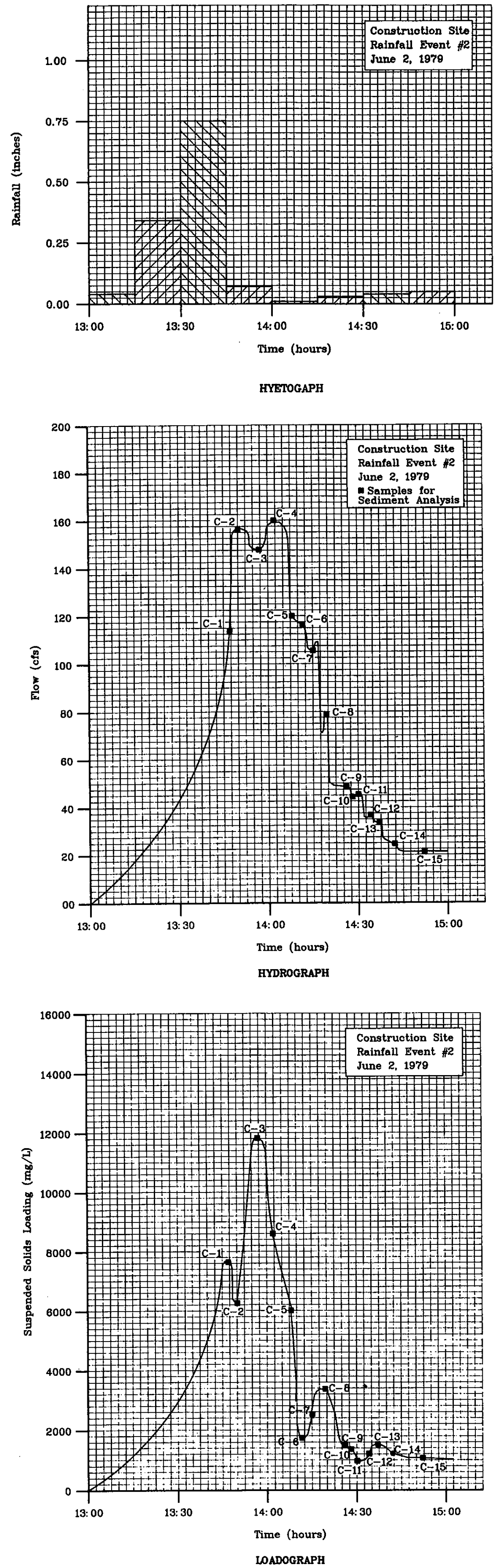

Figure 4. Rainfall Event #2.

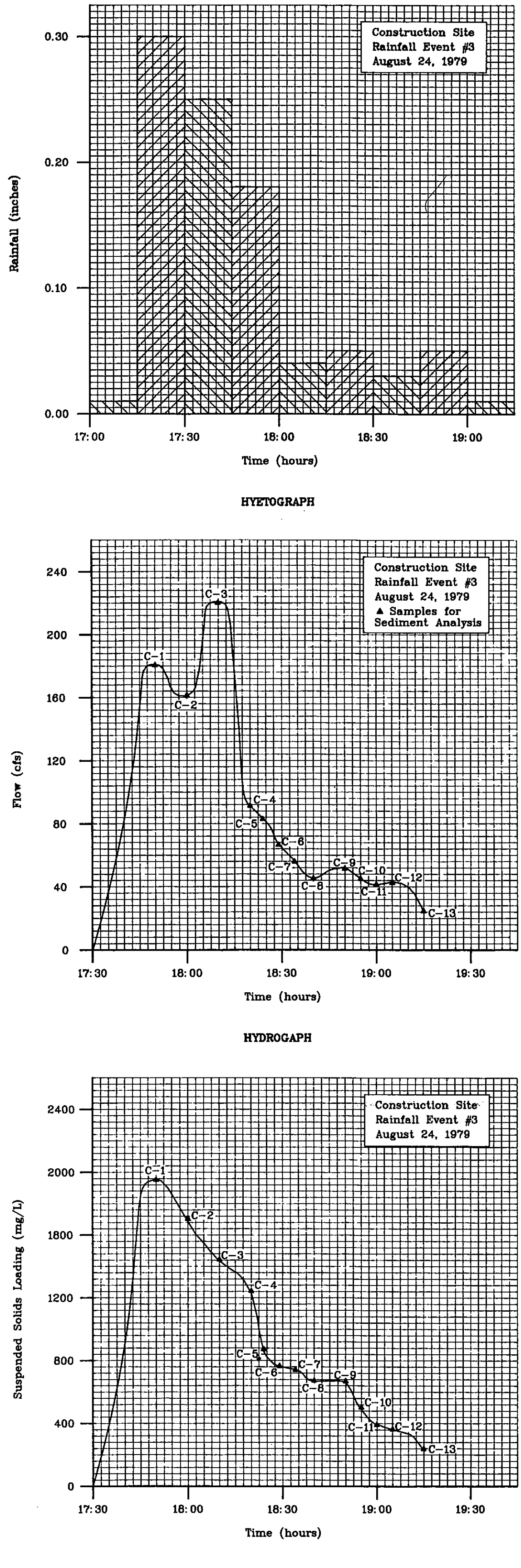

Figure 5. Rainfall Event #3.

Table 1. Construction Site
Rainfall Event #1 — February 2, 1979

RAINFALL DATA*	
Time, Hours:Minutes	Rainfall, Inches
19:00 to 19:15	0.02
19:15 to 19:30	0.01
19:30 to 19:45	0.02
19:45 to 20:00	0.01
20:00 to 20:15	0.11
20:15 to 20:30	0.20
20:30 to 20:45	0.09
20:45 to 21:00	0.08
21:00 to 21:15	0.04
Total	0.58 Inches

Table 1 b.

RUNOFF DATA				
Time Hrs:Min	Depth of Water On Weir, Feet	Flow CFS	Sample	Suspended Solids** mg/1
19:45	0.33	3.79		
20:00	0.33	3.79	C–1	172
20:15	0.40	5.05		
20:20	0.58	8.83	C–2	209
20:21	0.67	10.96		
20:22	0.92	17.63	C–3	3,301
20:23	1.17	25.29		
20:25	1.33	30.65		
20:27	1.54	38.18	C–4	4,648
20:29	1.63	41.58		
20:31	1.58	39.68		
20:36	1.58	39.68		
20:41	1.75	46.25		
20:48	1.63	41.58		
20:52	1.46	35.25	C–5	607
20:57	1.33	30.65		
21:10	1.21	26.59	C–6	602

*Data provided by U.S.G.S., Water Resources Division, Memphis Office.
Raingauge located at Wolf River at Germantown Road, Germantown.

**Methods for Chemical Analysis of Water and Wastes, Environmental Protection Agency, EPA-625-/6-74/003a, pages 268–269.

Table 2. Construction Site
Rainfall Event #2—June 2, 1979

RAINFALL DATA	
Time, Hours:Minutes	Rainfall, Inches
13:00 to 13:15	0.04
13:15 to 13:30	0.34
13:30 to 13:45	0.75
13:45 to 14:00	0.07
14:00 to 14:15	0.01
14:15 to 14:30	0.03
14:30 to 14:45	0.04
14:45 to 15:00	0.05
Total	1.33 Inches

TABLE 2B.

RUNOFF DATA					
Time Hrs:Min	Depth of Water Feet d1	Depth of Water Feet d2	Flow CFS	Sample	Suspended Solids mg/1
13:47	3.50	2.17	113.7*	C–1	7,560
13:50	4.00	2.42	156.28	C–2	6,270
13:57	4.00	2.75	147.82	C–3	11,850
14:02	4.17	2.92	160.07	C–4	8,610
14:08	3.75	2.83	120.08	C–5	6,010
14:12	3.67	2.67	116.91	C–6	1,740
14:15	3.50	2.50	105.63	C–7	2,530
14:17	3.36	2.42	108.85		
14:17:30	3.08	2.33	73.73		
14:18	3.00	2.17	71.23		
14:19	3.04	1.92	78.94	C–8	3,370
14:20	2.63	1.83	50.58		
14:26	2.58	1.75	48.68	C–9	1,500
14:28	2.50	1.67	44.38	C–10	1,370
14:30	2.50	1.58	45.45	C–11	980
14:32	2.33	1.50	35.84		
14:34	2.33	1.33	36.78	C–12	1,220
14:35	2.29	1.33	34.59		
14:37	2.29	1.25	33.68	C–13	1,530
14:38	2.25	1.21	28.31		
14:42	2.17	1.04	24.98	C–14	1,220
14:45	2.08	0.92	21.40		
14:47	2.08	0.83	21.40		
14:52	2.08	0.79	21.40	C–15	1,070

*Flow calculated using sharp crested submerged weir formula Reference: King, Wisler, and Woodburn, "Hydraulics," John Wiley & Sons, Fifth Edition, 1948.

soil erosion. It is severe in spring and less in summer for about the same quantity and duration of rainfall. The increase in sediment loading rate due to construction activity is estimated to be 15%. The results of this study are qualitative. Further extensive exploratory studies are needed to develop functional relationships and to make further generalizations.

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Table 3. Construction Site
Rainfall Event #3—August 24, 1979.

RAINFALL DATA

Time, Hours:Minutes	Rainfall, Inches
17:00 to 17:15	0.01
17:15 to 17:30	0.30
17:30 to 17:45	0.25
17:45 to 18:00	0.18
18:00 to 18:15	0.04
18:15 to 18:30	0.05
18:30 to 18:45	0.03
18:45 to 19:00	0.05
19:00 to 19:15	0.01
Total	0.92 Inches

RUNOFF DATA

Time Hrs:Min	Avg. Depth of Water , Ft.	Flow* CFS	Sample	Suspended Solids mg/1
17:50	2.29	180.94	C–1	1,955
18:00	2.55	161.65	C–2	1,700
18:10	2.26	220.55	C–3	1,447
18:20	2.00	91.74	C–4	1,242
18:24	1.84	83.22	C–5	873
18:29	1.59	66.92	C–6	764
18:34	1.42	56.22	C–7	739
18:40	1.25	45.44	C–8	670
18:50	1.34	51.68	C–9	668
18:55	1.25	45.44	C–10	500
19:00	1.17	41.79	C–11	389
19:05	1.05	42.88	C–12	364
19:15	0.84	24.85	C–13	239

*Weir was removed; flow calculated using Open Channel Flow Equations; Manning's formula.

Table 4. Measures of erosion factors at Shelby County construction site.

RAINFALL EVENT	#1	#2	#3
Season	winter	spring	summer
Rainfall (inches)	0.58	1.33	.92
Duration of rainfall (hrs:min)	2:15	3:00	2:15
Erosion rate (tons/acre/year)	15.10	55.12	23.40

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