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Drainage and Land Grading On A Bottom Land Field Area In West Tennessee

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SUMMARY

In 1962 improvements including a drainage canal, a drainage ditch, a levee, land grading, and a drainage pump were made on a 123.4-acre bottom land field at the West Tennessee Experiment Station. Prior to these improvements a system of open ditches and laterals provided only fair drainage for the area.

The pumping plant and culverts equipped with flap gates have been shown to be a necessity since the Forked Deer River has reached flood stage several times during the growing season.

The cost of the land grading was $128.90 per acre; and the cost of the pumping plant, levee, drainage canal cleaning, drop inlets, and station labor for installing these was $94.75 per acre resulting in a total cost for the complete system of $223.65 per acre. The land could not have been improved sufficiently for mechanized operations without taking measures similar to these described herein.

Rather extensive cutting and filling showed no significant adverse effects on corn silage yields during the first 3 years after land grading. However, the soils are deep alluvial soils with little profile development. Had the same earthwork been done on shallow soils with well-developed profiles, significant decreases in yields would probably have resulted.

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Drainage and Land Grading On A Bottom Land Field Area In West Tennessee

by

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INTRODUCTION

LAND grading is defined as the practice of changing the topography of a field by making cuts and fills according to a predetermined plan to improve surface drainage. Advantages of land grading are: the elimination of wet areas, improved surface drainage, suitability for surface irrigation, and conditions favoring mechanization for crop production. Because of improved surface drainage, crops can be planted earlier; and they also mature more uniformly and can be harvested at the most opportune time.

Land grading alone is not always sufficient to provide the desired improvements in surface drainage. An outlet for the water drained from the graded areas must be provided to a suitable drainageway. In bottom lands a system of levees, culverts with flap gates, and drainage pumps may be necessary to protect growing crops from inundation during floods.

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DRAINAGE IMPROVEMENTS

During 1962 and 1963, 123.4 acres of bottom land at the West Tennessee Experiment Station in Jackson were graded and other water control facilities constructed. Before 1962, the field had many shallow depressions and irregularities. Several open drainage ditches and laterals provided only fair surface drainage (Figure 1). The wet areas and open ditches made mechanized farming operations difficult.



Figure 1.—Bottom land field before improvements. (SCS Photo)

Soil Conservation Service personnel surveyed the area, developed plans and specifications for the grading work, and made the construction checks. Appreciation is expressed for the cooperation of the following SCS staff members: Wilburn Aden, Area Engineer for West Tennessee; and C. L. Daniels, Work Unit Conservationist for the Madison County Soil Conservation District.

The improvements included: land grading, drainage canal cleaning, drainage ditch construction, levee repair and construction, and the installation of a drainage pump. Figure 2 gives the layout of the improvements. The improvements will be discussed individually.

Drainage Canal

The entire length of the drainage canal from the Forked Deer River to higher ground, a distance of approximately 6,200 feet, was cleaned with a dragline. This canal serves a portion of the experi-

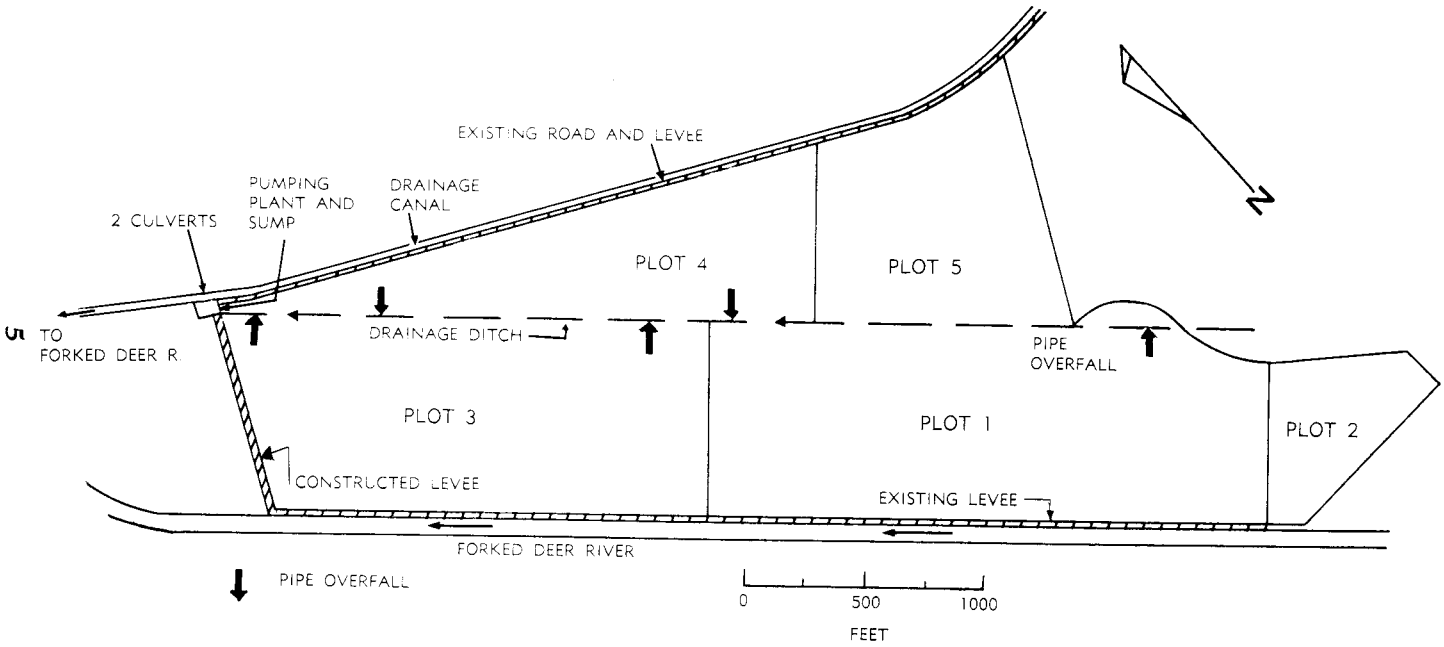


Figure 2.—Sketch of graded area with drainage improvements.

ment station plus a watershed of about 600 acres. The cleaning of this canal was necessary to provide a good outlet for waters draining from the bottom land.

Table 1. Summary of earthwork designs

Plot	Area	Excavation *	Fill	Max. cut	Max. fill	Downfield slope	Irrigation slope
	Acres	cu. yds.	cu. yds.	ft.	ft.	%	%
1	49.8	11,467	6,640	1.1	1.2	.11	.20
2	6.3	1,157	723	.7	.5	.16	.20
3	33.0	10,114	6.835	3.1	1.1	.10	.18
4	19.9	11 676	9,700	1.4	1.8	.05	.17
5	14.4	8,911	7,200	1.8	1.6	.25	.45
Total	123.4	43,325	31,098				

* Includes excavation from drainage ditch.

Drainage Ditch

To remove surface waters draining from the graded areas, a 3,400-foot drainage ditch was constructed with a dragline. This ditch was constructed straight and located along the natural drainageway of the bottom land. It divides the field into 89.1- and 34.3-acre tracts. The ditch (Figure 3) was designed to drain 3 inches from 150 acres in 24 hours. The grade was 0.11 percent; the bottom width varied from 0 to 4 feet; the side slopes were 1½:1; and the depth was 3½ feet.

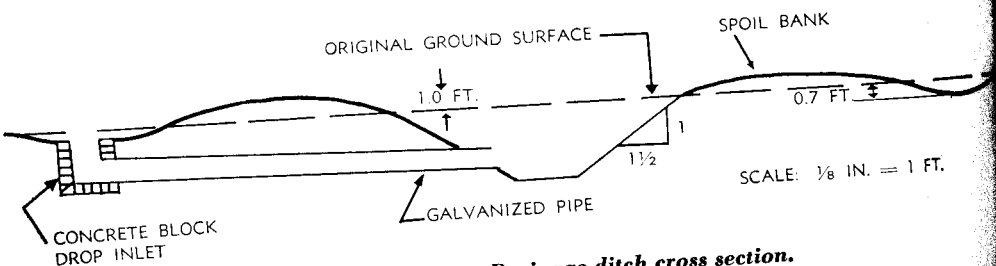


Figure 3.—Drainage ditch cross section.

The ditch is equipped with spoil banks which are shaped to provide a shallow waterway. This waterway diverts runoff into five overfalls where it is discharged through 18-inch culverts into the ditch. A cross section of the water collection and disposal system is given in Figure 3.

During periods of normal flow, the water level of the Forked Deer River is below the level of the fields, and drainage is provided by two 24-inch culverts which pass through the levee. The culverts are equipped with flap gates (Figure 4). When the level of the river exceeds that of the culverts, the flap gates automatically close.



Figure 4.—Flap gates on discharge end of gravity-flow pipes leading through levee from field to drainage canal.

Levee

In order to complete the levee system, new construction was necessary to join the existing Forked Deer River Levee and the farm road and levee on the northeast side of the bottom. The levee is approximately 900 feet long and varies from 3 to 5 feet in height. Its top width is approximately 16 feet. The Forked Deer River levee was also repaired.

Land Grading

The field was divided into five plots (Figure 2) for purposes of designing the cuts and fills for land grading. The plane method employing the least-squares technique was used in the designs. The

plane method gives an accurate balance between cut and fill volumes. The resulting least-squares computations were adjusted to account for shrinkage, settling, and material excavated from the drainage ditch.

Each area had a downfield slope and an irrigation slope which were perpendicular to each other. For the five plots the downfield slopes varied from 0.05 to 0.25 percent, and the irrigation slopes varied from 0.17 to 0.45 percent.

For the 123.4 acres the total design excavation was 43,325 cubic yards, and the total design fill was 31,098 cubic yards. The overall cut-fill ration was 1.39:1. Of the cuts, the overall average was 0.22 feet; and of the fills, the overall average was 0.18 feet. The average excavation per acre was 350 cubic yards. Table 1 summarizes the earthwork designs. The work was done mostly with tractors and scrapers.

The soils are largely Waverly, a poorly-drained soil; Falaya, which is somewhat poorly drained; and Collins, a moderately well-drained soil. All of these are developed in young alluvium and have weakly-developed profiles. The topsoil is rather deep, especially in the Falaya and Collins. The soils of the river terraces adjacent to the bottom lands have more shallow topsoils, and their profiles are

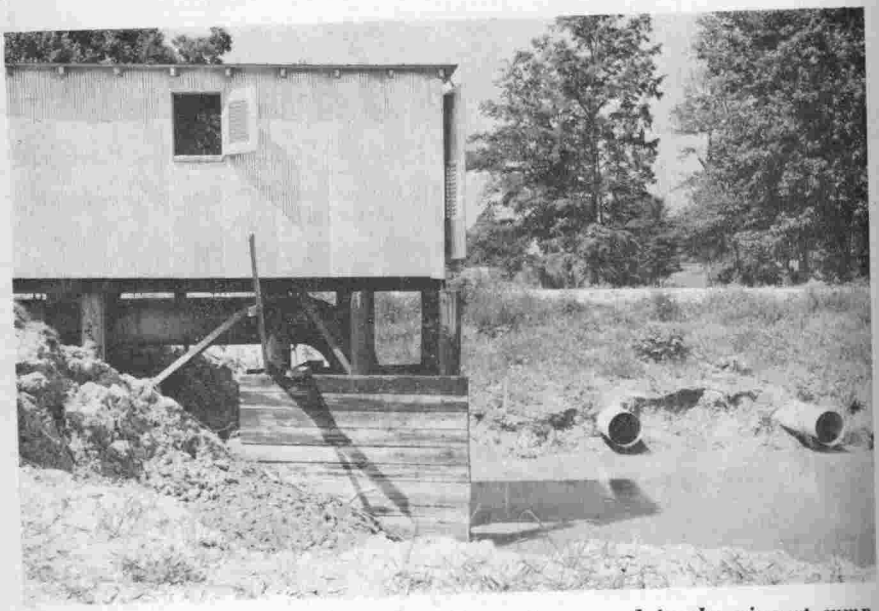


Figure 5a.—Pump house and intake pipe at sump. Also gravity-flow discharge pipes leading to drainage canal.→

better developed. Deep cuts in these terrace soils would probably cause decreases in yields of most crops.

Adequate fill material was not available in some areas. This resulted in the necessity for lowering the design elevation of at least one plot by approximately 0.2 foot so that adequate fill material would be available. Lowering a plot elevation after earthwork is in progress considerably increases the cost. For this work the average cut-fill ratio of 1.39:1 was somewhat low. Probably a ratio of approximately 1:5 would have allowed more rapid progress of the earthwork.

Drainage Pump

A propeller-type pump with a discharge capacity of 8,000 G.P.M. at 10 feet of head through a 23-inch pipe (Figures 5a and 5b) was installed. The pump is powered by a six-cylinder 80 H.P. gasoline engine having a piston displacement of 386 cubic inches. The engine is equipped with a snap-over-center clutch, and it is designed to operate continuously at 1800 R.P.M. The power is transmitted to the pump through a right-angle 5:2 ratio gear head. The design operating speed of the pump is approximately 800 R.P.M. The



Figure 5b.—Pump discharge pipe with a flow of approximately 8,000 gallons per minute.

pump requires a computed 35 H.P. Although the engine powering the pump should be adequate according to design criteria, it has a tendency to overheat during periods of continuous operation in hot weather.

For continuous pumping the engine must be operated at about two-thirds throttle. During the first 3 years the pump has had adequate capacity to remove excess surface water during growing seasons.

After the crops have been harvested, the pump is not usually operated until just before spring plowing. In the 1964 growing season the pump was operated during three floods for a total of 35 hours. During 1965 the pump was operated during two floods for a total of 9 hours. During the 3 years of test little if any crop damage was done by flooding.

EFFECTS OF CUTTING AND FILLING

From 1963 through 1965 the fields were planted to corn. During these years experiments were conducted to determine the effects of cutting and filling on corn silage yields. There were three soil conditions studied: 1) cuts of 0.5 feet or more, 2) relatively undisturbed, and 3) fills of 0.5 feet or more.

In 1963 the test consisted of three soil conditions, four dates of planting, two blocks per date of planting, and three replications per subplot. In 1964 and 1965 the tests consisted of three soil conditions and two dates of planting with replications making a total of 72 observations each year. However, the numbers of observations per soil condition and per date of planting were unequal in the 1964 and 1965 tests. Each plot was 15 feet by 30 feet in size. The plots were located over an 80-acre portion of the bottom.

The entire field was planted, fertilized, and cultivated in the conventional manner. Immediately before harvesting the silage, the plots were located, measured, and the green corn was cut by hand and weighed.

At the time of silage harvest, samples of chopped green matter were taken for determining the moisture content. These samples were oven dried. The computed moisture contents were used to convert the plot green weights to corresponding dry weights. Tables 2 and 3 give means of the yield data.

Table 2. Corn silage yields by date of planting and soil condition in tons of green matter per acre

Soil Condition	1963 Planting date [1]				1964 Planting date		1965 Planting date	
	May 11	May 16	June 7	June 13	May 25	June 3	May 10	May 13
Cut	22.0	16.9	11.0	10.5	17.6(16)[2]	13.5(8)	18.8(7)[2]	16.8(17)
Undisturbed	23.2	16.3	11.9	12.1	17.8(17)	14.6(7)	19.3(8)	18.7(16)
Fill	21.4	17.0	15.0	13.1	17.8(15)	13.1(9)	19.7(7)	18.7(17)
Mean	22.2	16.7	12.6	11.9	17.7	13.6	19.3	18.1

[1] Each yield value represents a mean ot 6 replications.

[2] The values inside the parentheses give the numbers of replications included in the means.

Table 3. Summary of corn silage yields in tons of green matter per acre

Soil Condition	Year			Mean
	1963 [1]	1964	1965 [2]	
Cut	15.1	16.2	17.4	16.2
Undisturbed	15.9	16.9	18.9	17.2
Fill	16.6	16.0	19.0	17.2
Mean	15.9	16.3	18.4	

[1] Lodging damage was severe.
[2] An excellent growing season.

In 1963 soil tests were made of the graded area. The following table summarizes the results of these tests from areas of 0.5 foot or more of cut and from 0.5 foot or more of fill. The averages are from 102 samples.

	pH	Available Phosphorus	Available Potassium
Cuts	5.1	13 (medium)	93 (low)
Fills	5.3	15 (medium)	186 (medium)

Apparently no substantial difference existed between pH and available phosphorus levels in the cut and fill areas. The difference between the available potassium levels could account for some of the yield differences shown in Table 3. Table 4 gives analyses of variance for the 1963 green- and dry-matter data.

In all of the analyses of variance, the soil condition X date interaction was found to be insignificant at the .01 level of probability for all cases. For this reason the degrees of freedom and the contributions to the total sums of squares due to the interactions were included in the pooled error for the analyses shown in Tables 4 and 5.

In 1963 the effects of the soil condition and the soil condition X date interactions were insignificant ($P>.05$) for yields of both the green and dry matter. The F tests for blocks within dates were significant ($P<.05$). The effects of the dates of planting were highly significant in both cases for 1963 ($P<.01$). It should be noted that the dates of planting ranged from May 11 to June 13.

Analyses for both green- and dry-matter yields were conducted for 1964 and 1965; however, as in 1963 (Table 4) little difference existed between the analyses of dry- and green-matter data for a given year. For this reason only the results for green matter are presented for 1964 and 1965 (Table 5).

Table 4. Analyses of variance for 1963 yield data

GREEN MATTER

Source of variation	Degrees of freedom	Sum of squares	Mean square
Date	3	516,435	172,145
Blocks within date	4	66,435	16,609
Soil condition	2	11,751	5,876
Pooled error	62	218,811	3,529
Total	71	813,432	

F=172,145/16,609=10.36 * for Date with Blocks within Date
F=172,145/3,529=48.8 ** for Date
F=5,876/3,529=1.67 (N.S.) for Soil Condition

DRY MATTER

Source of variation	Degrees of freedom	Sum of squares	Mean square
Date	3	38,613.2	12,871.1
Blocks within date	4	2,030.8	507.7
Soil condition	2	501.0	205.5
Pooled error	62	13,447.0	216.9
Total	71	54,592.0	

F=12,871.1/507.7=25.4 ** for Date with Blocks within Date
F=12,871.1/216.9=58.0 ** for Date
F=205.5/216.9=0.95 (N.S.) for Soil Condition

* Indicates significance at the .05 level of probability.
** Indicates significance at the .01 level of probability.

Table 5. Analyses of variance for 1964 and 1965 yields of green matter

1964, MAY 25 AND JUNE 3

Source of variation	Degrees of freedom	Sum of squares	Mean square
Date	1	113,513	113,513
Soil condition	2	4,173	2,087
Pooled error	68	174,577	2,567
Total	71	292,263	

F=113,513/2,567=44.2 ** for Date
F=2,087/2,567=0.81 (N.S.) for Soil Condition

1965, MAY 10 AND MAY 13

Source of variation	Degrees of freedom	Sum of squares	Mean square
Date	1	9,671	9,671
Soil condition	2	17,177	8,589
Pooled error	68	240,392	3,535
Total	71	267,240	

F=9,671/3,535=2.74 (N.S.) for Date
F=8,589/3,535=2.43 (N.S.) for Soil Condition

** Indicates significance at the .01 level of probability.

For 1964 and 1965 the effects of the soil conditions were not significant. For 1964 where the difference between planting dates was 9 days, the effect of the date of planting was significant. However, for 1965 where the difference between planting dates was only 3 days, the effect of the date of planting was not significant.

These analyses suggest that no significant decreases in corn silage yields resulted from cutting and filling in land grading. These data clearly show that delays in planting dates cause severe decreases in corn silage yields. Being able to plant earlier due to improved surface drainage is a big advantage gained from land grading.

COSTS

The costs through 1964 of the improvements are given in Table 6. The total cost for the complete system was $223.65 per acre. Had the pumping plant not been necessary, the cost would have been $168.12 per acre. The high cost was in part due to the necessity for

Table 6. Summary of construction costs

Item	Amount
Contractors' fees for land grading	$15,905.75
Contractor's fee for levee construction	850.00
Dragline work [1]	2,915.00
Culverts and materials for drop inlets	753.68
Pumping plant [2]	6,001.58
Station labor and equipment [3]	1,172.00
Total	$27,598.01

[1] 291.5 hours @ $10.00 per hour for cleaning drainage canal.
[2] Includes piling, frame, pump and engine, pump house, and labor for installing.
[3] 792 man hours at 75¢ and 289 tractor and equipment hours at $2.00 for installing drop inlets, removing stumps and fences, and helping with surveying.

constructing supplementary drainage facilities. The land grading itself was $128.90 per acre. The initial condition of the bottom land was such that extensive, and therefore costly, measures were necessary for the degree of improvement desired.

MAINTENANCE

In September, 1965 several areas in the 89.1-acre field were still low enough to cause some crop damage. These low areas were filled with sediment removed from the drainage ditch and with spoil

from a 1,665-foot extension of this drainage ditch. The cost of this work was $4,143.75 (135 hours of dragline work at $10.00 per hour and 223½ hours at $12.50 per hour for moving the spoil to the low areas). Between 0.5 feet and 1.8 feet of sediment, with an average depth of slightly less than 1 foot, had collected in the drainage ditch. Even with this sediment in the ditch, it still functioned properly. The major reason for removing the sediment from the ditch was to obtain material for filling the low places.



Figure 6.—Land plane being used to maintain and improve the topography after land grading.

To maintain the topography of the bottom land, a heavy offset disc harrow was used to prepare for planting. Using this harrow caused little lateral movement of soil. Also, a land plane (Figure 6) has been used annually. Each year the field has been planed in at least two different directions. The banks of the drainage ditch were mowed twice yearly, and the bushes growing near the water were cut.

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