

THE TECHNIQUE OF PLOT STUDY TO DETERMINE SOIL  
LOSSES AND RUNOFF UNDER FIELD CONDITIONS  
DUE TO FERTILIZER TREATMENT

THE TECHNIQUE OF PLOT STUDY TO DETERMINE SOIL  
LOSSES AND RUNOFF UNDER FIELD CONDITIONS  
DUE TO FERTILIZER TREATMENT

by

REUBEN B. HICKS

B.S. IN AGRICULTURAL ENGINEERING

V.P.I. 1935

-----

A MAJOR THESIS

Submitted to the

DEPARTMENT OF AGRICULTURAL ENGINEERING

VIRGINIA POLYTECHNIC INSTITUTE

BLACKSBURG, VIRGINIA

-----

In Partial Fulfillment of the Requirements

For the Degree of

MASTER OF SCIENCE

in

AGRICULTURAL ENGINEERING

JUNE

1937

APPROVED:

APPROVED:

Course Advisor

Dean of Agri.

-ACKNOWLEDGEMENT-

The author wishes to express his appreciation to Prof. C. E. Seitz, Head of Agricultural Engineering Department for making possible this investigation; to Prof. P. B. Potter, Associate Agricultural Engineer, for his careful guidance and interest; to Prof. J. H. Lillard, Assistant Agricultural Engineer, for his willingness to aid in all possible ways and for his highly constructive criticism during the progress of this work reported herein. He is also grateful for the helpful suggestions of Prof. J. W. Sjogren, Assistant Agricultural Engineer, Prof. S. H. Byrne and the entire Staff of the Agricultural Engineering Department of The Virginia Polytechnic Institute.

Reuben B. Hicks

Virginia Polytechnic Institute.

June 1937

## TABLE OF CONTENTS

	Page
Introduction-----	1
Objects-----	2
Theory-----	3
General Procedure-----	3
(a) Library Work-----	3
(b) Study of Materials-----	5
(c) Determining the Plot Location-----	8
History of Plot Area-----	8
Condition of Plot Area During Test-----	10
Explanation of Rains-----	10
Operation the Plots-----	11
Results and Conclusions-----	12
Bibliography-----	14

## ILLUSTRATIONS

Catchment Troughs and Walls-----	5a
Catchment Tanks-----	6a
Catchment Troughs-----	7a

THE TECHNIQUE OF PLOT STUDY TO DETERMINE SOIL  
LOSSES AND RUNOFF UNDER FIELD CONDITIONS  
DUE TO FERTILIZER TREATMENT

INTRODUCTION

For the past ten years certain experiment stations have conducted studies dealing with soil and water losses under a wide range of conditions, but no study has been conducted on plots under actual field cultural conditions. These investigations have been very valuable in that they have revealed much needed information but they have added very little knowledge of plot technique under field cultural conditions.

The size of the experimental plots for these studies has varied considerably from the small indoor laboratory plot to the complete watershed study. The indoor laboratory plot would exist under artificial conditions and could add little to methods and technique of the field plots, whereas the watershed investigation would take into account many factors not effecting field conditions. It is evident that a plot which would permit conduct of studies on the effect of fertilizer on soil and water losses under field conditions would be valuable. Such investigation is therefore undertaken in this thesis for a Master Degree.

It is believed that the information obtained from this investigation will have special value because it is the first of its kind to be obtained on Virginia soil and because the experiment will furnish needed data regarding the measurements of soil and water losses under the special field conditions due to fertilizer treatment.

#### OBJECTS

In order to permit a more complete study of soil erosion and its causes some type of portable field plot is needed.

Thus the objects of this investigation are as follows:

(1) To develop and propose technical methods for studying soil and water losses on plots under field cultural conditions.

(2) To test the practicability and usefulness of the methods developed by conducting studies\* on soil and water losses from plots of different fertilizer treatments.

---

\* Due to unfavorable weather conditions and the lack of time this part of the investigation could not be completed but will be continued and the results published later.

## THEORY

The erosion losses from control plots are not representative in all cases of erosion losses under actual field conditions due to the fact that the tillage operations and soil management has to be carried on in a some what different manner from that on the average farm.

In order to make the most use of the data obtained from erosion experiments it is essential to approach as near as possible actual field conditions. It is believed that a field plot which can be used on any slope, on any crop, and anywhere in the field will be very valuable in erosion studies. By correctly manageing this plot it would not interfere with any of the tillage or harvesting operations of the field or plot area. This plot should be installed and removed by moving a minimum amount of soil.

## GENERAL PROCEDURE

The procedure followed in conducting this experiment was as follows:

Library Work: All available publications on plot design and construction were carefully read and studied. The information found showed that there has been quite a wide variation in the

size of the plot area and the materials used in the plot structure.

In some cases complete watersheds have been used as a plot from which erosion losses were studied. The watersheds were sometimes as large as 40 acres in size.

F. C. Merkle at the Pennsylvania Experiment Station worked with the smallest plot that has been used in studying soil erosion. These plots were 12 inches wide, 32 inches long and 4 inches deep. The experiment was conducted in the laboratory and artificial rain was used.

F. C. Bartel at North Carolina Experiment Station reported on plots of different lengths and sizes in effort to establish the most suitable terrace intervals for that soil and climate.

R. E. Dickson, Texas Experiment Station worked with plots of different size. He was the first to use metal sides or retaining walls in his plot structure. The use of such walls enabled him to move his plots from place to place, but he did not attempt to study erosion losses under actual field cultural conditions.

The trend has been to study erosion losses from control plots; of course this method of study had its place in early investigations and in some types of work at the present time, but in order to obtain results from actual field conditions some type of field plot must be developed whereby erosion

losses can be studied under actual and practical field conditions. In all some 75 different articles were read and gleaned for ideas that might be followed or developed in this study.

Study Of Materials: Many materials were taken into consideration from which were chosen the ones that appeared to be the most suitable and practical for this work. It was decided to make the sides and upper end of the plot wall out of 2" by 10" lumber. This lumber was treated with a thin coat of wood preserver for two purposes. The wood preserver would keep insects from destroying the lumber and would protect the lumber from decay. The amount of wood preserver used was very important because an excess amount on the lumber would allow some to escape into the soil and be injurious to vegetation in the soil near the walls.

Boards two inches thick were used to add rigidity to the sides of the plot and at the same time prevent the weathering of the boards from causing them to warp, thus rendering them unfit for use. Boards ten inches wide were amply wide due to the fact that the aim of this investigation is to detect the movements of the soil on the surface rather than to any depth. By using ten inch boards six inches could be put in the soil with four inches above the surface.

(5a)

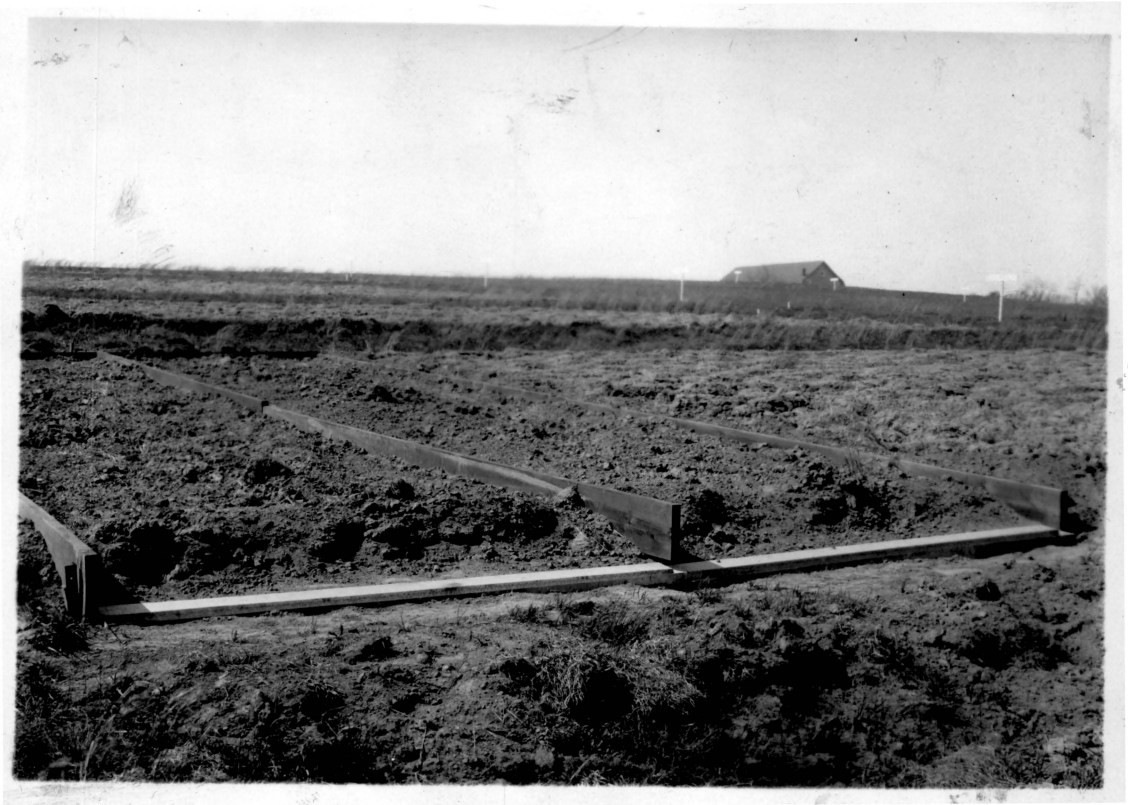
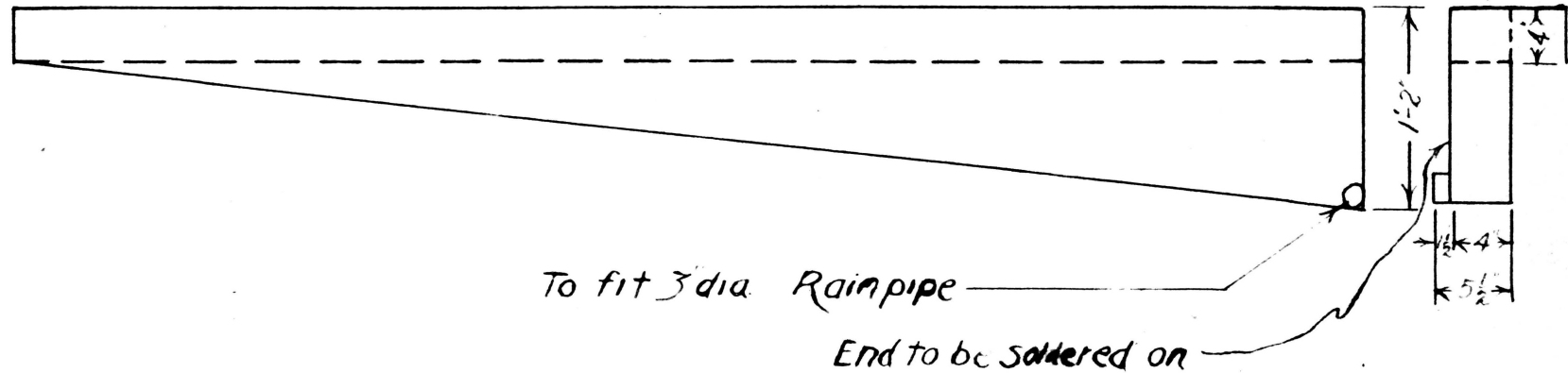
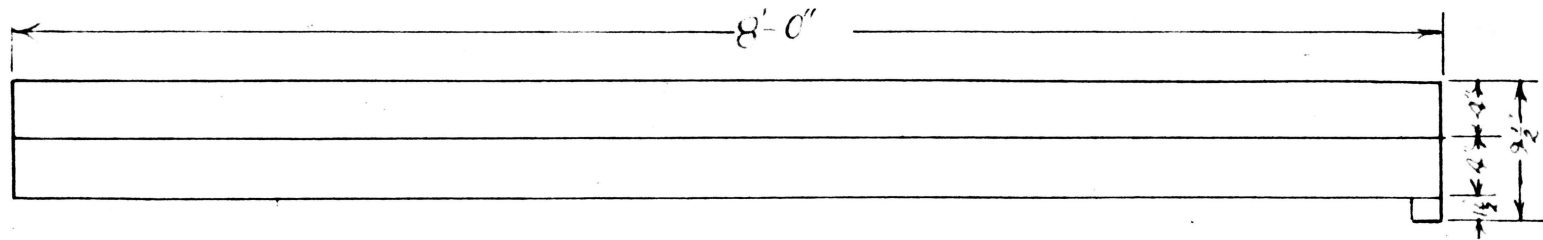


Plate 1--A view showing the walls and catchment trough of the plot. Note that it has all characteristics of a stationary control plot yet it is removable.



Catchment Trough  
to be made  
From 20 gauge metal

Scale 1"=1'-0"

SOIL CONSERVATION EXP'T	
AGRICULTURAL ENGINEERING DEPT	
Drawn by: R.B.H.	Aug. 20, 1936

Where more than one board was necessary to obtain the proper length it was easy to splice the two together by using a short piece of the same size board on the outside as shown in Section (a) of drawing No. 1. and fastening the pieces together with six  $3/8$ " bolts, using three in each end of the boards.

In each corner of the plot a piece of angle iron was used as a post. This angle iron may be of any convenient size and twenty inches long. Thus allowing sixteen inches of it to extend down into the ground. The ends of the boards were bolted to the angle iron post by two  $3/8$ " bolts in each board.

The catchment trough is probably the most important part of the plot that was designed. It was made from 20 gauge galvanized iron. The back lip was made to extend four inches down into the ground to prevent any possible runoff water from going under the trough instead of in it. There was a top piece of metal four inches wide over which the runoff water poured into the trough. The trough was designed with a 10% slope toward one end. At the lower end was attached a 3" conductor to take the runoff into a catchment tank. The conductor used was ordinary galvanized iron down spouting. By using such a conductor the distance between the trough and the catchment tank maybe great enough to

(6a)

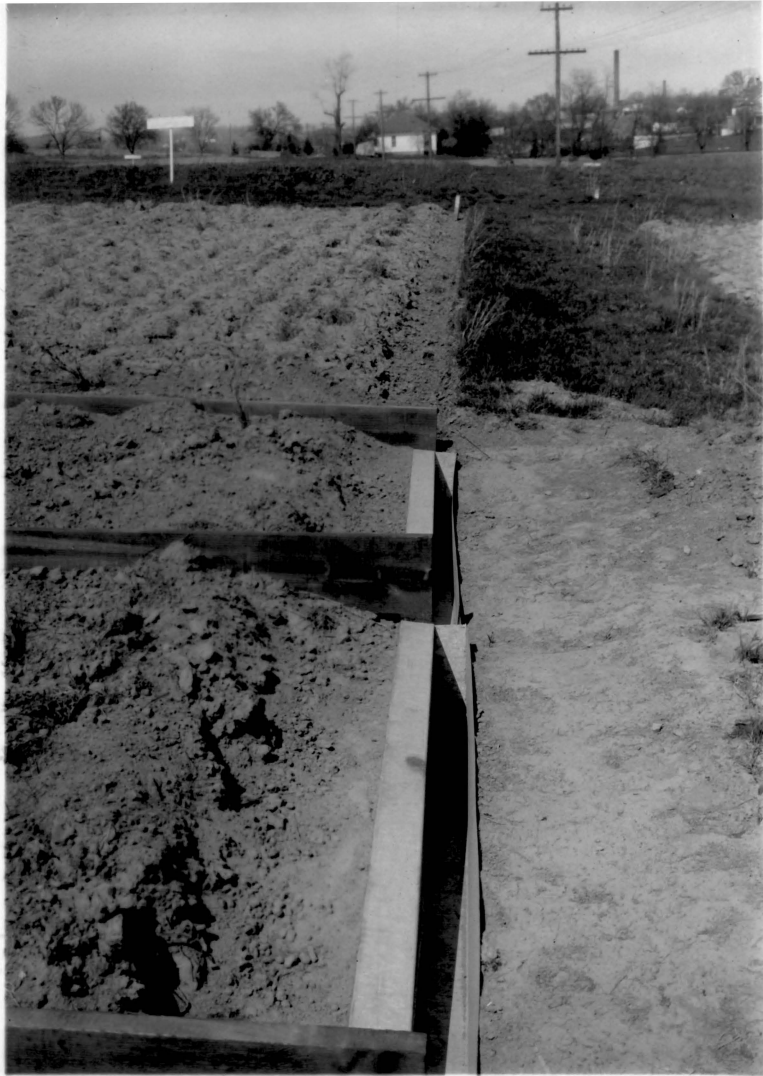
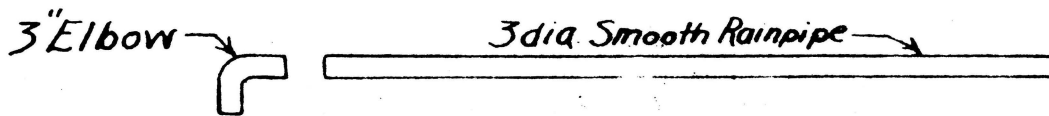
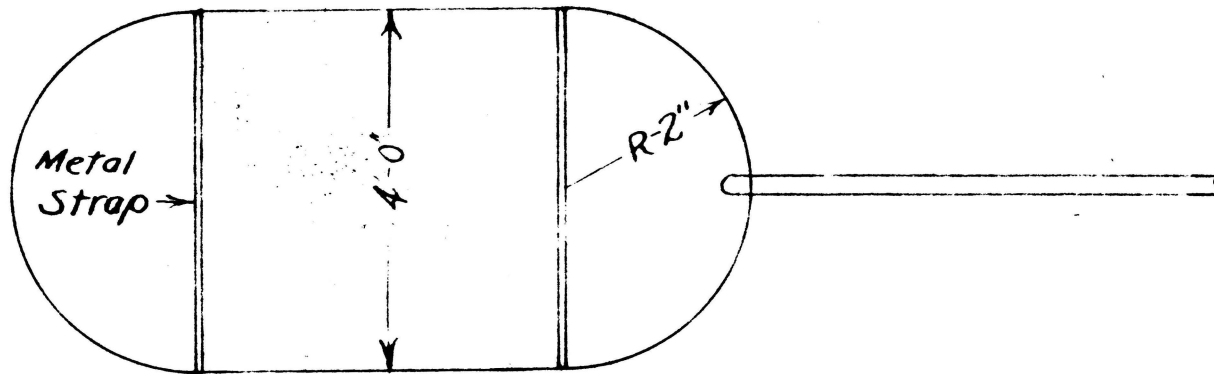
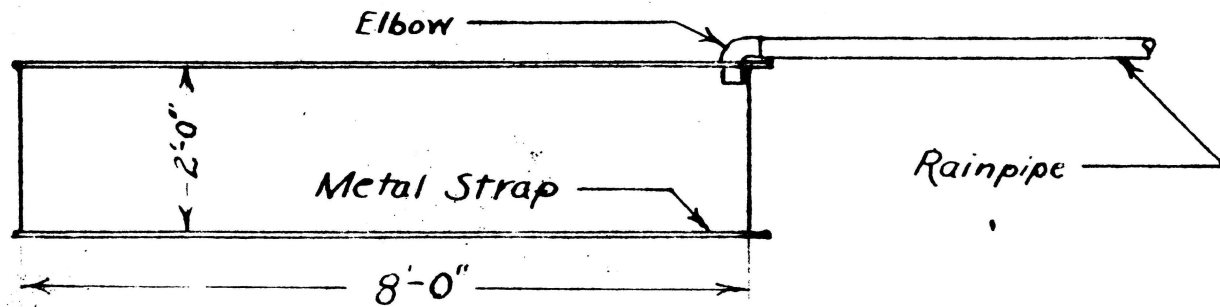


Plate 2--A view showing the catchment troughs installed.  
Note the rough state of fallow. The soil remained in this  
state all winter.



Runoff Catchment Tank & Pipe

Scale: 1" = 2'-0"

SOIL CONSERVATION EXP'T	
AGRICULTURAL ENGINEERING DEPT	
Drawn by: RBH	Aug. 22, 1936

obtain sufficient elevation to allow the tank to sit on the surface of the soil rather than to lower it into a hole. A large pail was placed in each tank under the mouth of the pipe carrying the erosion losses. This proved satisfactory for small rains due to the fact that not enough runoff would be obtained, in the case of small rains, to justify the use of the larger tank. In case of large rains the pail would overflow into the tank thus not effecting the results of the large rains.

A rain gauge was set up at the corner of the plots so as to obtain, as accurately as possible, the data on the amount of rainfall.

Any convenient water container of sufficient size may be used as a catchment tank. The ones used were ordinary watering tanks made of galvanized iron and had a capacity of 375 gallons.

The materials used in the plot structure and their cost were as follows:

1. catchment trough-----	\$10.00
1. catchment tank-----	12.00
30 ft. of 3" down spouting-----	2.55
40 ft. lumber 2" by 10"-----	3.00
1.-3" elbow-----	.23
10 ft. of angle iron-----	1.00

(7a)

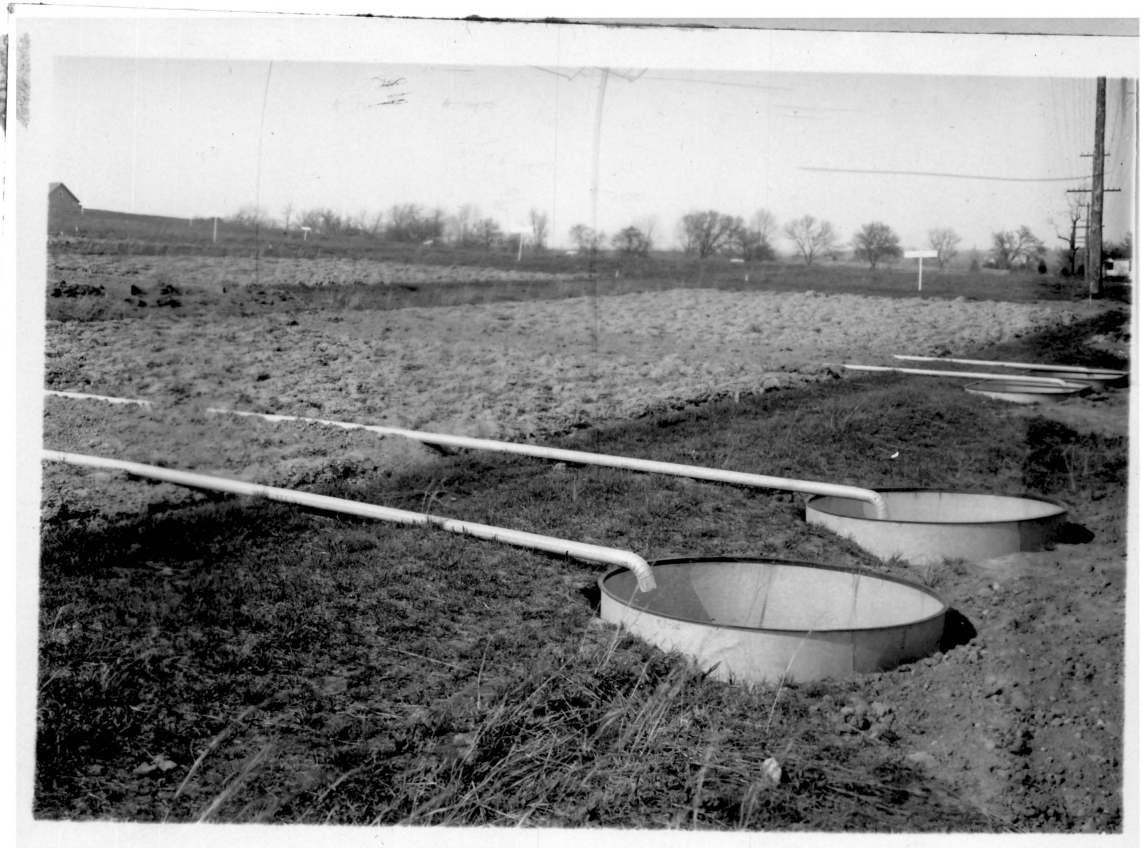
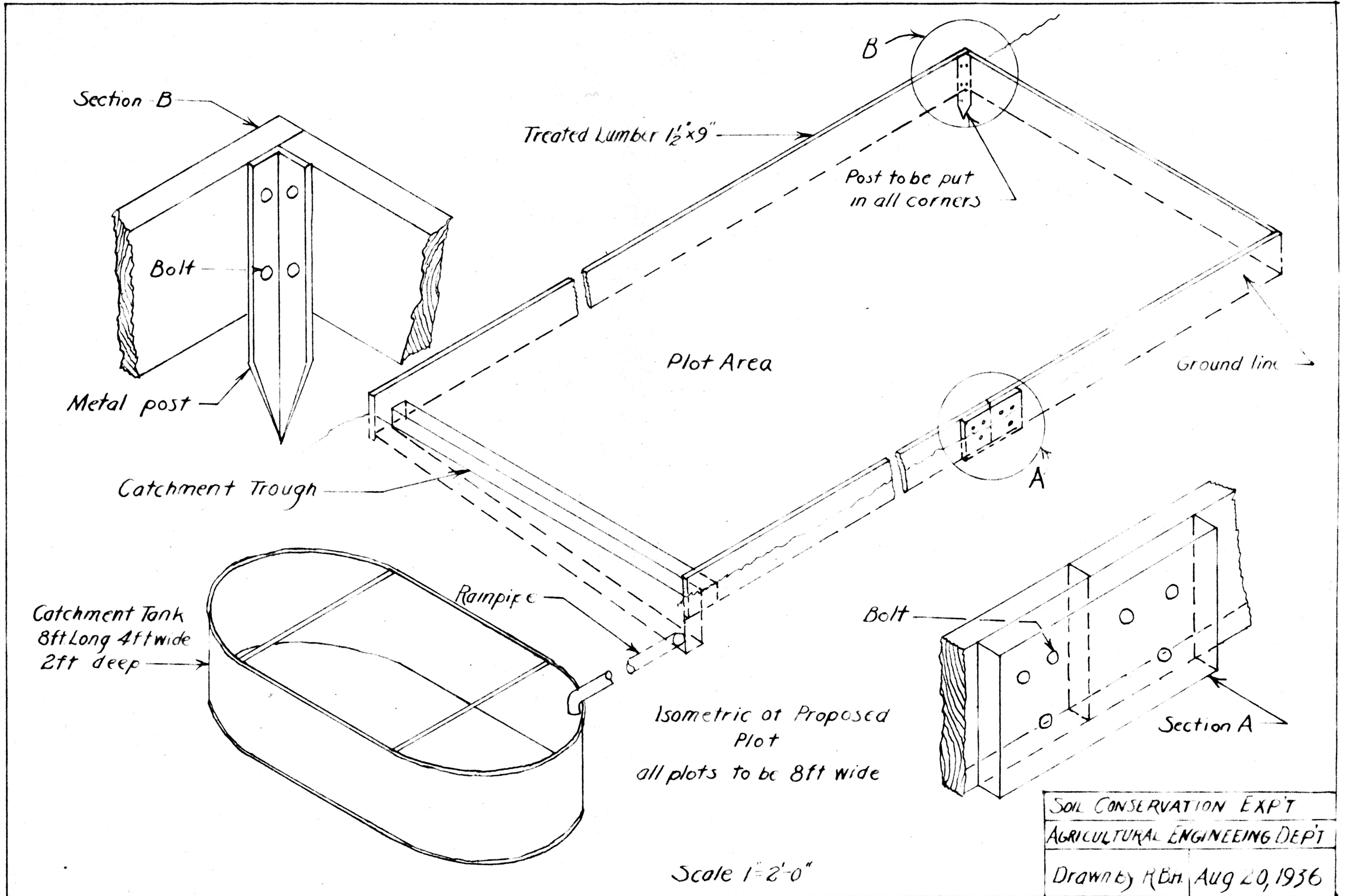


Plate 3--A view showing the catchment tanks. The pipes extend back up the hill and connect to the catchment troughs.



SOIL CONSERVATION EXPT	
AGRICULTURAL ENGINEERING DEPT	
Drawn by R.B.H.	AUG 20, 1936

24 bolts-----.30

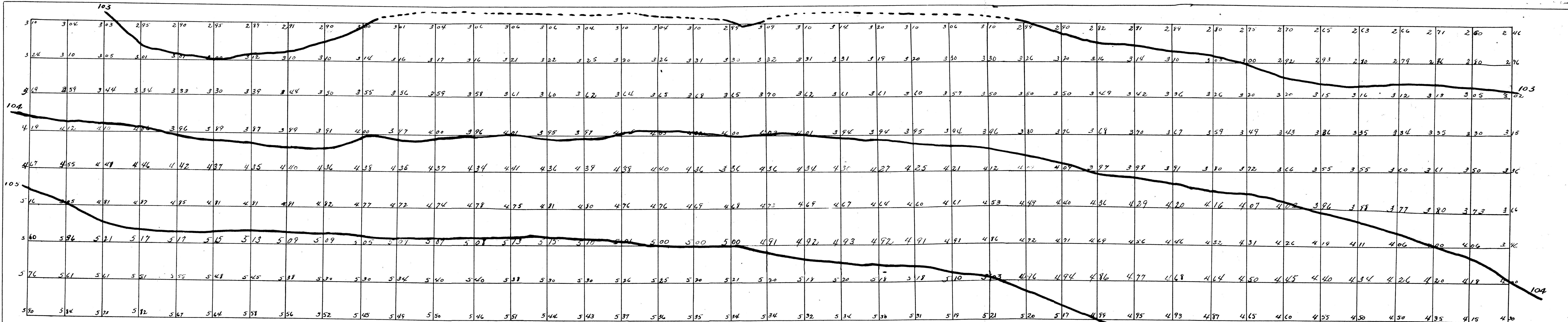
1.-10 gal pail-----2.00

The cost of the material used in the plot structure appears to be very low, but it must be remembered that this list does not include the equipment necessary for handling the soil and water losses after they have been caught in the catchment tank, nor does it include the equipment needed to analyze the runoff samples.

DETERMINING THE PLOT LOCATION: The area upon which the plot structures were to be constructed was 32 ft. wide and 160 ft. long. The complete area was staked off in four foot squares and elevations at each corner carefully taken. From these elevations was made a contour map of one foot intervals. The most suitable location for the plots was judged from the contour map. Areas of the same slope could not be obtained on treated and untreated portions of the plot, but the difference is very small and it is believed that it will not effect the erosion losses. The slope of the treated area was 7.75% and the slope of the untreated area 7.70%.

#### HISTORY OF PLOT AREA

Twenty-seven years ago the Virginia Agricultural Experiment Station started a series of studies on plots of different fertilizer treatment and its effect on crop



Scale: 1"=4'-0"

Map showing grid readings and location of contours on area from which plots are to be taken.

SOIL CONSERVATION EXP'T  
 AGRICULTURAL ENGINEERING DEPT. VPI  
 Drawn by: R.B. Hicks Nov. 3, 1936

production. As time went on the staff decided to make other studies on these plots with relation to fertilizer treatment and yield. From the standpoint of yield the tests have profoundly shown that there are great differences in yield due to the kind and amount of fertilizer used.

The following table will show what has been found: Sixteen tons of manure and 438 pounds of superphosphate were applied once in four years.

PLOT NO.	BUSHEL'S CORN		TOTAL	PERCENTAGE MARKETABLE	STOVER
	MARKETABLE	NONMARKETABLE			
PLOT 13	49.00	7.90	56.56	86.51	2.00
CHECK PLOT	9.51	7.70	14.22	58.42	.44

PLOT NO.	WHEAT BUS.	STRAW TONS	HAY TONS		AVERAGE ANNUAL ACRE RETURN
			1st year	2nd year	
PLOT 13	24.51	1.74	2.20	2.21	\$46.08
CHECK PLOT	7.99	.48	1.02	1.12	\$16.75

Mr. J. H. Lillard ran some test on "The Effect of Different Fertilizer Treatments on The Draft of The Plow" and found that the draft of the plow consistently decreased as the degree of completeness of fertilizer used increased. From this he decided that the fertilizer used must exert some effect on the physical structure of the soil. Thus it stands to reason that a difference in

structure of the soil would cause a difference in the amount of soil and water runoff.

#### CONDITION OF PLOT AREA DURING TEST

When the plots were plowed in mid-winter; the plowing was done on the contour and a large amount of organic matter was turned under. The soil was left in this rough state of fallow until May at which time it was disked, harrowed and seeded to corn.

#### EXPLANATION OF RAINS

Much rain fell during late winter and the moisture content of the soil was high, but in early spring there was a dry period of about six weeks at which time the moisture content of the soil became very low. The plot structure was installed during this dry period. In early April it began to rain and the occurrence of rain was as follows:

April 5-----	.24 inches
April 9-----	.22 inches
April 14-----	.24 inches
April 17-----	.12 inches
April 24 & 25-----	1.97 inches

Due to the dry condition of the soil when the first four rains occurred, all of the water was taken up by the soil and no runoff occurred. On April 24 it began raining and continued to do so for two days, and although nearly two inches of rain fell the intensity was never great and no runoff occurred.

#### OPERATING THE PLOTS

The labor required to manage this plot is very important due to the fact that a plot which requires a large amount of labor would be useless.

The plots were first installed in mid-winter and the ground was frozen thus requiring more work than would be normally required. Also the labor required to install the plot structure the first time is greater due to the fact that more soil has to be moved then, than will have to be moved any time after that.

Under ordinary conditions it would be wise to let the catchment tanks sit on the surface of the soil but in this case it was impossible because of a road that came so close to the plot that sufficient elevation between the catchment trough and the catchment tank could not be secured.

Installing the sides and upper end of the plot structure is very simple process. Use a hoe that is three inches wide and six inches long and dig trenches six inches deep where

the side walls and end are to be placed. Much care should be exercised when digging the trenches so that no more soil than necessary will be disturbed. Place the boards in the trenches and put as much soil back as necessary to fill up the remaining portion of the trench. The first time the plot structures were installed it required 32 man-hours. The next time it only required 9 man-hours. It is believed that for all future installations this will be sufficient time.

When removing the side walls and ends to allow some tillage operation to go on the walls and ends are lifted out of the ground and removed. This job required the service of two men working for one hour.

#### RESULTS AND CONCLUSIONS

The plot structures as designed has proven to be satisfactory from the standpoint of the labor required to manage it. It is true however that more labor will be required to manage this plot than would be required to manage a similar stationary plot, but it must be remembered that any type of portable plot equipment will require a relatively large amount of labor.

The equipment for the plots may be installed and removed without any interference with the tillage operations and crop. In the case of row crops the side walls and ends can be so

located that they will fall between the rows. In the case of small grain and hay, such as wheat, rye and the hay, this plot will prove very satisfactory. It could be installed after the small grain was seeded and would not require any labor to manage it until the grain was ready for harvesting.

This plot structure would also be very good to use in soil erosion studies conducted in pasture land. The structure could be installed and the catchment tank enclosed thus allowing the cattle to graze the plot in a normal manner.

Although this plot structure is portable it has all of the desirable characteristics of a stationary permanent plot. The side walls of the plot construction were made from 2" by 10" boards. It is believed that some type of metal sides would serve the purpose just as well.

No results or runoff data have been obtained from this investigation due to the lack of time and the weather conditions but the studies will be continued and the results published at some later time. This plot design has been approved and adopted by the T. V. A. and plots are actually in operation at the present time at Wytheville, Virginia, however, they have not been in operation a sufficient time to obtain any results.

BIBLIOGRAPHY

1. L. D. Bayer-Some Soil Factors Affecting Erosion. A.S.A.E. Jour. Vol. 14. No. 2. Page 51-52.
2. F. C. Bartel-Water Conservation Facts From the North Carolina Exp. Sta. A.S.A.E. Jour. Vol. 23. (1929) Pages 9-10.
3. F.C. Bartel-First Progress Report on Soil Erosion Experiments. N. C. Exp. Sta. Farm. West Raleigh, Wake Co. North Carolina A.S.A.E. Jour. Vol. 19. (1925) Page 2.
4. A. B. Conner & R. E. Dickson & D. Secates-Factors Influencing Runoff and Soil Erosion. Texas Exp. Sta. Bul. No. 411 (1930) Page 50.
5. R. E. Dickson-The Results and Significance of the Spur (Texas Sta.) Runoff and Erosion Experiments A.S.A.E. Jour. Vol. 21 No. 4. Page 415-422.
6. F.L.Duley-Controlling Surface Erosion of Farm Land. Missouri Exp. Sta. Bul. 211 (1924) Pages 23-24.
7. F. L. Duley-Soil Erosion From Early Plowed Wheat Land. Jour. Amer. Soc. Agron. Vol. 17. (1925) No. 11. Pages 731-734.
8. F. L. Duley & F. G. Ackerman-Runoff and Erosion From Plots of Different Lengths. Jour. Agri. Res. (U.S.) Vol. 48. (1934) No. 6. Pages 505-510.
9. F. L. Duley & C. E. Hayes-The Effect of the Degree of Slope on Runoff and Soil Erosion. Jour. Agri. Res. (U.S.) Vol. 45 (1933) No. 6. Page 349-360.
10. F. L. Duley & M. F. Miller-Erosion and Surface Runoff Under Different Soil Conditions. Missouri Exp. Sta. Bul. 63. (1923) Page 5-50.
11. H. V. Geib-A New Type of Installation For Measuring Soil and Water Losses From Control Plots. Jour. Amer. Soc. Agron. Vol. 25. (1933) No. 7. Page 429-440.

12. T. H. Holland-Soil Erosion Experiments at the Experiment Sta. Peradeniya. Ceylon Dept. Year Book Vol. 2. Page 56 (1926).
13. F. G. Merkle-An Equipment for Demonstration Soil Erosion and its Control. Jour. Amer. Soc. Agron. Vol. 26. (1934) No. 7. Page 626-628.
14. H. E. Meddleton-Propertied of Soil Which Influence Soil Erosion. U.S.D.A. Tech. Bul. No. 178. (1930) Page 16.
15. M. F. Miller-The Influence of Systems of Cropping and Methods of Culture on Surface Runoff and Soil Erosion. Res. Bul. 177 (1932) Page 32 Missouri Sta.
16. C. E. Ramser-Runoff From Small Agricultural Area. Jour. of Agri. Res. Vol. 34. No. 9 Washington D. C. (1927).
17. I. D. Wood & P. H. Steward-Soil Washing: The Causes and Methods of Prevention. Neb. Agri. Cerc. Ext. Cerc No. 123 (1924) Page 35.
18. -----Runoff Water Losses in Relation to Crop Procuction. Texas Sta. Report (1927) Pages 58, 59, 97, 98.
19. E. J. Weaver & W. C. Noll-Comparison of Runoff and Erosion in Prairie, Pasture and Cultivated Land. University of Neb. Bul. 11. The Dept. of Botany No. 96.