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SOIL EROSION IN IOWA

Erosion in shallow Southern Iowa loess

AGRICULTURAL EXPERIMENT STATION

IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

AGRONOMY SECTION

SOILS

AGRICULTURAL ENGINEERING SECTION

Ames, Iowa

SUMMARY

1. No particular method of preventing or controlling erosion can be recommended for all conditions. Each land owner must select that method which is best suited to the conditions on his farm.
2. Preventive methods are better than remedial ones. When erosion first commences it should be attended to at once.
3. No method is so permanent that it can be left to care for itself. To a large extent the continued efficiency of any method is directly dependent upon the attention given to the installation.
4. For medium sized and large gullies a carefully constructed earth dam with a surface inlet known as the Christopher or Dickey dam is the least expensive method and the most generally applicable to Iowa conditions.
5. No matter what type of dam is used a surface inlet should be provided to remove the water from above the dam. This will do away with a great deal of the difficulty encountered in the use of dams.
6. A proper foundation is essential in the construction of any type of dam. More difficulty is experienced because of neglect of this precaution than for any other reason.
7. A gullied farm is the sign of inefficiency, as the farmers in all parts of the state who are systematically attempting the control of erosion are succeeding.
8. Erosion can be controlled and it is to the interest of every farmer to prevent or control any erosion on his farm.

FOREWORD

The work reported in this bulletin was carried on under the immediate direction of the chiefs of the Soils and Agricultural Engineering Sections. The purpose of the bulletin is to call attention to the disastrous effects of erosion and to the need of control measures. Suggestions are offered also regarding various methods of control which may be used and attention is called especially to those methods which are being successfully employed in various parts of the state. The Soils and Agricultural Engineering Sections will be glad to give advice and assistance to any farmer with reference to the prevention or control of erosion on his farm.

SOIL EROSION IN IOWA

BY E. E. EASTMAN [1] AND J. S. GLASS [2]

Soil erosion is the carrying away of soil thru the free movement of water over the surface of the land. If all the rain falling on the soil were absorbed, erosion could not occur. But the precipitation is sometimes so rapid and so great and such a small portion is taken up by the soil, that many cultivated fields are subject to extensive losses by the washing action of water. Bare bluffs and hillsides are particularly in danger of erosion and gullies formed in such locations may extend for miles and render large areas partially or wholly unfit for cultivation.

Loess soils are apt to be injured by erosion when the topography is hilly or rough and it is these soils which are affected to the greatest extent in Iowa. Large acreages in the Missouri loess, the Mississippi loess and the Southern Iowa loess soil areas are frequently rendered untillable or even entirely useless because of excessive erosion. The adoption of proper methods of preventing or controlling the washing away of valuable land is therefore important.

Many Iowa farmers are confronted with the problem of preventing or controlling erosion. Standard methods of control have been adopted on some farms while in other instances methods have been devised to meet particular conditions. In some cases, however, the task of stopping the growth of a large gully and of filling it, or the control of injurious sheet erosion has seemed a hopeless task and the farmer has done nothing. As a result of this attitude on the part of thousands of farmers, great injury has been done to the soils of Iowa by erosion.

An exhaustive study of all of the installations in use could not be made but data have been secured on many representative Iowa farms. However, several types of installation, for the control of erosion, are described; special attention being given to their cost, practicability, permanence and efficiency. Suggestions, based on the actual experience of farmers, are offered for the help of those who may wish to use methods of control similar to those described herein.

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1 Associate Professor of Soils.
2 Assistant in Agricultural Engineering.
The senior author desires to acknowledge his great indebtedness to Prof. W. H. Stevenson for directing the work; and to Dr. P. E. Brown for revising and preparing the manuscript for publication.

A single method for the control of erosion cannot be recommended. It is believed and hoped, however, that from among the suggestions offered in this bulletin, a farmer may select some method that will meet the requirements on his farm.

There are practically no national or state laws for the control of erosion. This is due to legal difficulties involved and also to the fact that erosion problems vary so widely that it is impossible to devise control methods of general application. Hence individual farmers must be relied upon to handle conditions on their own farms. Many farmers in Iowa are controlling erosion by various simple but effective methods and everyone who is not already doing so should take immediate steps to reduce or stop the washing away of his soil.

TYPES OF EROSION

There are two types of erosion, known as gullying and sheet erosion. Hillside erosion is a form of sheet erosion.

GULLYING

On land which is rather steep and rolling or which contains well defined drainage channels, a large portion of the water from heavy rains flows into the drainage channels and, moving rapidly down them, picks up and carries away much of the

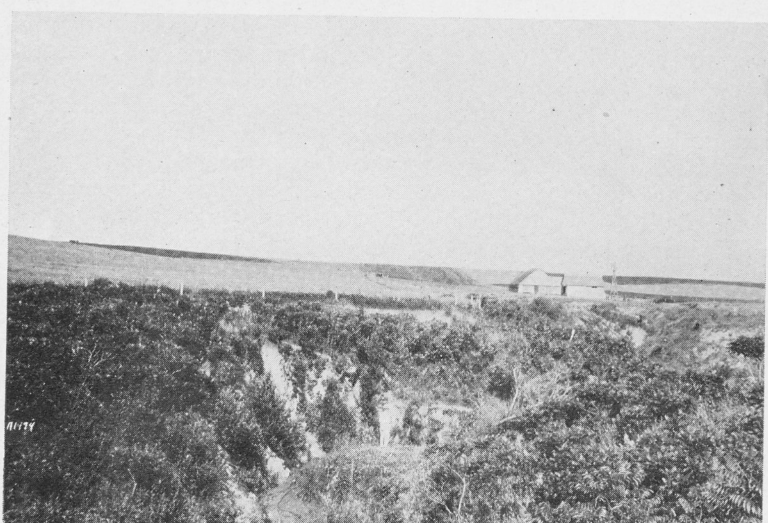


Fig. 1. An abandoned gully

Fig. 2. Soil to the left has been held in place and enriched by manure, while that to the right without manure, has suffered from sheet erosion

loose soil over which it passes. When these drainage channels occur in cultivated fields, washing away of the soil from the bottoms and sides of the channels may lead quickly to the formation of gullies, ditches, or ravines. This type of washing is known as gullying. It is the most striking type of erosion but it is probably the least harmful and it is usually the most easily controlled.

SHEET EROSION

Not all of the steep land that is under cultivation contains well-developed surface drainage channels, but the rain often falls upon a comparatively smooth surface. In such cases the water that is not taken up by the soil runs downward somewhat uniformly over the land. With a heavy rainfall the land is subjected to the action of a large volume of water, which, flowing down the slope, may pick up and carry with it much of the surface soil, depositing it at the bottom of the slope or carrying it away. Such removal of the surface soil, is known as sheet erosion. This form of erosion may lead to a complete loss of fertility and is difficult to control.

HILLSIDE EROSION

Hillside erosion occurs on slopes that are too steep for cultivation. If not in sod, the hillside may be rapidly washed away. When the slope is sodded and dotted with trees and shrubs, the "cutting out" of the sod by the hoofs of animals and the wearing of paths at different angles around the slopes may lead to the formation of a gully and the whole hillside may soon be affected. Hillside washes are not generally as important as either sheet or gully erosion for they are confined as a rule to small areas of uncultivated land.

CAUSES OF EROSION

The causes of erosion are variable and usually a number of factors are involved.

SLOPE OF THE LAND

The steepness of the land is perhaps the most important factor influencing the occurrence of erosion. Under similar rainfall conditions land having a steep slope will undergo much more washing than more nearly level land of the same character. Hence in all cases where erosion occurs, the method of control must take into account the slope of the land affected.

RAINFALL

Amt & distribution

The amount and distribution of the rainfall plays an important part in determining the occurrence of erosion. The greater portion of the water falling on the land must be taken up by the soil and the excess, unabsorbed portion, carried away slowly over the surface or thru a tile if no washing is to occur. Proper methods of soil treatment, such as tillage, liming, manuring and green manuring, will increase the ability of the soil to take up water. The slow movement of the excess unabsorbed water over the surface of the soil may be accomplished by contour plowing, or disking, lateral ditching or even terracing. Extensive surface drainage systems with a gradual fall are also often provided to handle the run-off and thus prevent erosion.

SOIL TREATMENT

Plowing

organic matter

Improper plowing of the land and the lack of organic matter in the soil often leads to the occurrence of erosion. If dead furrows that run at an angle down the slope are left in a field, they form artificial surface drainage channels which may develop into large gullies in a comparatively short time. The formation of such gullies may be prevented by changing the direction of plowing so that the furrows run as nearly as possible at right angles to the slope. If the shape of the field or some other local condition prevents plowing across the slope, the dead furrows should be plowed in or across in such a manner as to prevent the rapid passage of water down the slope. Care should always be exercised when plowing across the slope, not to go down hill when approaching a depression and uphill when across it as this causes the furrows to "V" or "lead" into the depression, and washing may occur.

The time of plowing also influences erosion. Fall plowing is one of the best methods of preventing erosion, if the soil is of such a nature or in such a condition that it will retain practically all the rain that falls upon it when it is not frozen. If the soil is clayey, however, and the taking up of water is very slow, fall plowing may loosen it up to such an extent that it will be more likely to be washed away by heavy rains. In such cases spring plowing would be advisable.

SOIL

Certain characteristics of the soil itself determine, to a considerable extent, whether or not it may erode badly.

TEXTURE

Coarse textured soils or those having large sized particles such as sands are able to take up a large part of the rainfall. Little water, therefore, washes over the surface of such land

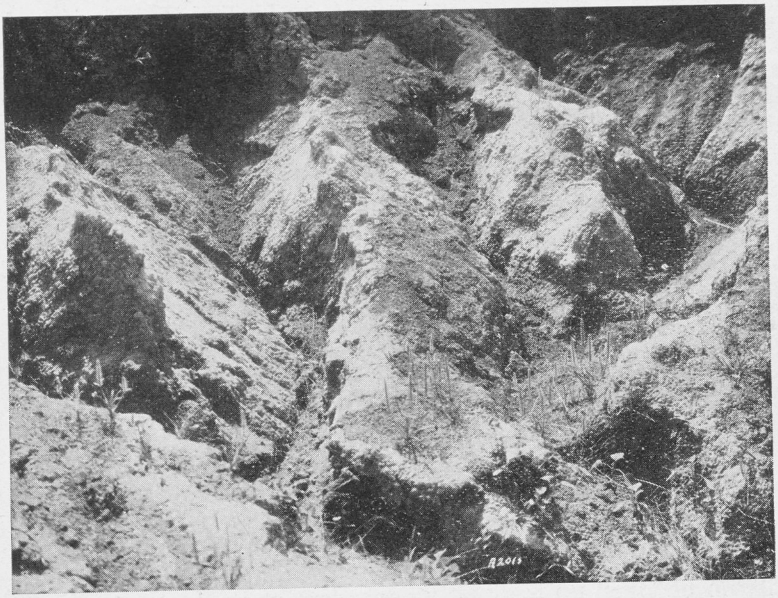


Fig. 3. A close up view of hillside erosion in southern Iowa

and erosion is not likely to occur. On steep slopes, however, or where any large amount of water washes over a coarse-textured soil, there is danger of considerable injury to the soil. On the other hand, fine textured soils, such as silts or clays take up water slowly. Much of the water from even a moderate rain, is likely to run off over the surface of such soils and the washing away of the soil may be considerable.

STRUCTURE

The arrangement of the particles of soil or its structure greatly influences its ability to take up water. In compact soils where the particles are crowded closely together the spaces between the soil particles are so small that water can enter but slowly. The rainwater is only partially taken up and a large portion of it must flow over the surface of the land, often leading to the occurrence of erosion. In open sandy soils where the spaces between the particles are larger, more of the rainfall is taken up. With normal precipitation and a gentle slope such soils are less likely to erode than the compact types.

The structure of the soil may be modified by ordinary farm operations. The best structure, called a "crumb" structure, because the soil particles are gathered together into groups or crumbs, may be brought about by tilling the soil at the proper time; by drainage, if the soil is compact; by the addition of manure, if it is low in organic matter; by liming, if it is high in clay and acid in reaction; and by exercising care to prevent puddling or extreme packing of the soil when wet. By these operations, the structure of the soil may be improved and the danger of erosion lessened.

ORGANIC MATTER CONTENT

Organic matter opens up heavy soils and increases their power to take up moisture. In the case of light, open soils it binds the particles together, while its ability to take up water is so great that it also renders such soils more absorptive. The organic matter content of soil plays an important part in preventing erosion both of heavy and of light soils, and care should always be exercised that the best amount be present. Applications of farm manure, green manures and crop residues increase the organic matter in soils and apart from numerous other beneficial effects they aid materially in reducing the washing away of soils.

PORE SPACE

The amount of water taken up by a soil, and the rate at which it can be taken up is directly dependent upon the total amount of pore space and upon the size of the individual pore spaces. These are both affected by the size of the particles, the arrangement of the particles and the amount of organic matter. Hence, the use of organic matter, the application of lime to heavy soils, proper cultivation, drainage, cropping or any other means which may improve the physical conditions of the soil, will increase the pore space, which in turn will increase the ability of the soil to take up water and erosion will be lessened.

TENACITY

Erosion may occur quite readily in soils which contain sufficient water to bring them to their greatest stickiness or maximum tenacity. The organic matter content, the degree of compactness and also the type of the soil, influencing as they do the moisture content will have a direct effect on the tenacity of the soil and hence on erosion. Methods of soil treatment which increase the ability of soils to hold moisture without reaching their greatest stickiness decrease the tendency toward erosion. Other things being equal, the greater the tenacity of a soil, the less likely is erosion to occur.

RESULTS OF EROSION

The importance of erosion is readily apparent. Invariably it brings about diminished crop yields due to plant food removal and to the actual washing away of tillable land. The cost of farming operations is also increased and farm values are decreased.

PLANT FOOD REMOVAL

Water washing over the surface of the land may remove a large proportion of the small particles of soil and as these contain much plant food the loss of valuable constituents may be considerable. The coarser portions of the soil which are left behind are much poorer in plant food. Furthermore when surface soils are partially or wholly washed away the underlying, unweathered subsoil is exposed and several years may be required to make such subsoil productive. If the underlying material is in a rather fine state of division, of considerable depth, and high in plant food, fertile soil may be produced with proper treatment in a comparatively short time. This is, however, not often the case in Iowa. The soils in the state which are subject to sheet erosion are usually underlaid by subsoils which are quite unproductive and, when exposed, their change into fertile soil involves long and expensive treatment.

WASHING AWAY OF LAND BY GULLYING

The amount of material that can be carried by the water from a heavy rain when directed into a channel of loose, fine soil material is enormous and as the banks of such a gully are undermined and cave in, it rapidly becomes larger and deeper. Many small gullies may develop rapidly and land which may be valuable for crop production may quickly be made entirely untillable.

AN UNPROFITABLE CHANGE IN FARMING OPERATIONS

Corn is the "money crop" in Iowa and the larger acreage the farmer has in this crop, the better he is satisfied. Lands that are steep or cut up are not desirable for corn because of the increased difficulty and cost of cultivating. There is also actually less land seeded to corn and hence crop production is reduced. When farm land becomes badly cut up, the growing of corn is at best replaced by timothy and clover (or alfalfa) or blue grass may be seeded. The area in meadow and pasture will then become relatively too large for the most profitable type of farming.

DEPRECIATION IN FARM VALUES

The selling value of a farm depends very largely on its productive power. It is obvious, therefore, that the decrease in the

Fig. 4. The removal of forests prepares the way for erosion

productivity of farm land caused by erosion will bring about a distinct depreciation in farm values. Even when its productivity is not markedly decreased, the selling value of land may be lowered considerably by the presence of gullies. They are unsightly and especially objectionable to those who are unaccustomed to them. Other factors being equal, the prospective purchaser will always choose a farm that is free of gullies and less subject to washing.

EROSION IN IOWA

There are five distinct soil areas in Iowa and the soils in these areas differ in origin, characteristics, topography and crop adaptation. Hence there is a distinct relation between the occurrence of erosion and the soil areas in the state.

SOUTHERN IOWA LOESS AREA

The soil in southern Iowa like all loess soils is loose and easily picked up by flowing water. It does not possess that property of standing in straight cuts, which is one of the characteristics of loess. Gullies may be formed by a single rain and as the soil near a cut slumps off, or slides into the cut, even a small stream may quickly develop a large valley.

The soil in this area is popularly called "clay" but it is in fact usually a shallow silt loam, underlain by a rather impervious subsoil. The heavy rains are only partially taken up by the soil and a large portion of the rain water flows off over the surface of the land carrying with it much of the surface soil and exposing a rather unproductive subsoil. The fertility of the soil is thus materially reduced and long continued and expensive treatment with manure and other fertilizing materials is necessary to make the exposed soil productive.

Much of the rolling and rough land in southern Iowa that is subject to erosion, especially that near the rivers, was originally in timber and should probably be reforested or seeded down to grass. If this were done little erosion would ever occur, providing cattle trails, areas rooted up by hogs and small gullies were given careful attention. Unfortunately, however, farmers are unwilling to reforest and seed down much of this land because, in many cases, large portions of their farms are subject to erosion and comparatively small acreages would be left for cultivated crops.

There are, of course, many soils in southern Iowa that are not being washed away and in many localities the "clay

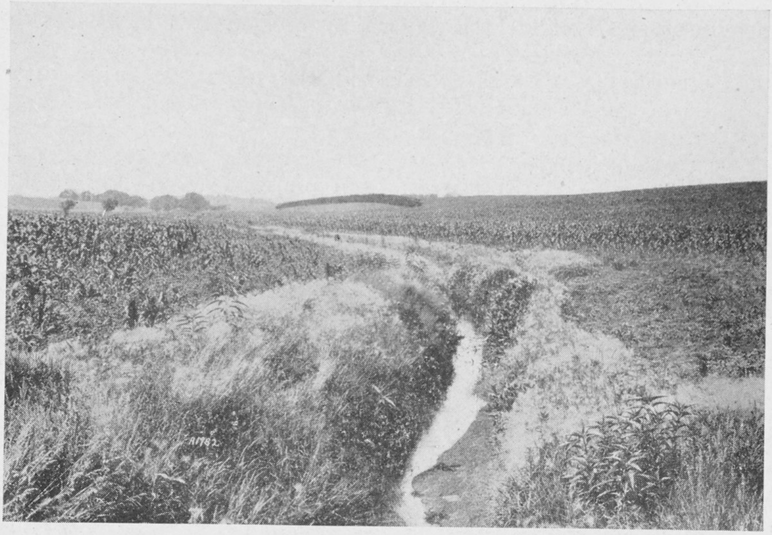


Fig. 5. Open, or surface drain

hill'' problem is not important. This discussion must not be understood to mean that all Southern Iowa loess soil is eroding and becoming unproductive. Such is not the case. Much of the land in this area, however, is subject to erosion because of the soil and topographic conditions and erosion is undoubtedly more common in southern Iowa than in any other section of the state.

MISSOURI LOESS SOIL

Along the Missouri river the loess is typical in that it stands in straight cuts, takes up rain water readily and is usually very deep. The loose nature of the soil, however, and the steepness of the hills may lead to the formation of gullies that in places become deep and narrow. Near the Missouri river as a rule the erosion problem is not important. At a distance of from two to three counties east of the river the loess thins out and sometimes even disappears and in such cases serious erosion may occur. As a whole, the Missouri loess area is not so generally affected as the Southern Iowa loess area but where erosion does occur it is quite as injurious.

MISSISSIPPI LOESS AREA

The same conditions prevail in general in the Mississippi loess soil area as in the Missouri loess area. There is, however, usually somewhat less erosion. This is due to the fact that the loess does not thin out in those portions of the area at a distance from the river. Furthermore, the topography of the southern part of the area is rather level and relatively little washing can occur there. In the northern part of the area altho the land is quite rough, most of the slopes are kept in pasture or timber and seldom cultivated and hence even there erosion does not take place to any considerable extent. In general it may be said that erosion has little importance in the Mississippi loess area.

THE IOWAN DRIFT AREA

The soils covering the northern central portion of the state, known as the Iowan drift, are in general more tenacious than the loess soils, that is, they hold together better. They are also more compact and hence are less easily washed away. With proper treatment and cultivation they can be made to take up a sufficient amount of the rainfall to prevent excessive run-off. Erosion, therefore, is not likely to occur in this area to any considerable extent. Of course if the surface soil is shallow or improper soil treatment has brought about a deficiency in organic matter, an injurious washing of the soil may result.

THE WISCONSIN DRIFT AREA

The soil in the northwestern central portion of the state like that just to the east of it, is a drift soil. The area is naturally poorly drained, the streams being few in number and having but few tributaries. The soil is so level, so tenacious and possesses such a high ability to take up water that erosion usually occurs only in the immediate vicinity of streams and then only to a slight extent. Poor management of these soils has led in a few cases to a small amount of washing but in general the Wisconsin drift soil area is practically free from erosion.

METHODS OF CONTROLLING AND PREVENTING EROSION

In this investigation various methods of controlling erosion have been studied on farms where they were in use with special attention to the soil and topographic situation, the method of installation, the cost and the practicability. Maps showing the "lay of the land" and the location of the control method have been prepared for each installation.[1] One of these will be found in an insert at the end of this bulletin.

[1] The size of tile which should be used for draining any area, and other information regarding installations for the prevention or control of erosion on individual farms may be secured from the agricultural engineering section of the Iowa Agricultural Experiment Station.

No one method of controlling erosion can be recommended for all conditions. The topography, soil and general farm conditions must all be considered in selecting a control method; and that method should be chosen which is best suited to the particular conditions. Concrete dams are used probably to a greater extent than any other method for controlling erosion but earth dams supplied with a line of tile with surface inlet would generally prove quite as satisfactory and involve much less expense. The methods described here are all proving successful on Iowa farms but this indicates merely that the unsuccessful methods are not described.

The cost of the various methods is calculated on the basis of prices at Ames, August 1, 1917, assuming that all material used must be purchased and all labor hired by the day. It must be understood, therefore, that the cost of the installations is greater than would actually be the case on the average farm. The farmer may determine the cash cost of a similar installation on his own farm by subtracting from the total cost given here, those items which do not involve an actual outlay of money.

EROSION DUE TO DEAD FURROWS

Dead furrows or back-furrows when running with the slope or at a considerable angle with it, frequently result in the formation of gullies. It is customary to "plow in" such gullies, and in level areas where the soil is deep, this "plowing in" process may be quite effective in filling in the gullies. In rolling areas, however, where the soil is rather shallow, the gullies may not be entirely filled up by "plowing in." Even if they can be cultivated and perhaps a row of corn planted in them, a depression may remain from which the loose soil will be rather readily washed out in the following fall or spring. Each time this washing out occurs, the "plowing in" process becomes less effective and finally a large gully may be formed.

The best procedure, therefore, is to supplement the "plowing in" with a series of "staked in" dams or earth dams, supplied with surface inlets. The method of "staking in" is somewhat preferable as less work is required in its installation and there is less danger of its washing out.

The "staking in" process consists in driving in several series of stakes across the depression and up the entire hillside at intervals of from fifteen to fifty yards according to the slope. The stakes in each series should be placed three to four inches apart and the tops of the stakes should extend well above the surrounding land even tho they may cause a little inconvenience in cultivating.

Where fall seeding is practiced the "staking in" can be done after the crop has been seeded and gullying by the fall and spring rains will thus be prevented. The stakes used may be made from material obtained from the pruning of trees, from the cutting of posts, or from discarded lumber. Altho the stakes alone will hold the "plowed in" soil in place fairly well, it is better to weave some brush about them, allowing the tops of the brush to point downstream. Additional brush may also be placed above the stakes, with the tops pointing downstream.

Dead furrow gullies may be filled in within a season or two by this "staking in" alone, but, if the gully is small, less time is required to remove all traces of it by first "plowing in" and then "staking in" up the entire slope affected. If the surface soil is not shallow practically no decrease in fertility will occur and the later formation of a gully in the same place will be effectually prevented.

A modification of the system of "staking in," which has been used with success by one of the progressive farmers of the state consists in "staking in" the brush without the use of stakes. The brush is cut so that a heavy branch pointing downward, is left near the top. This branch is caught between a

Fig. 6. Small gullies on land that is in grain

fork in the lower part of the brushpile, or hooked over one of the main stems and driven well into the ground. Enough brush is staked in this manner to extend entirely across the gully but it need not necessarily reach to the top of the gully as another row of brush can be put in when the filling has reached the top of the first line.

The brush is placed with the tops pointed downstream and such materials as cornstalks and branches carried in the water pass over the brush and there is no possibility of clogging up the dam or causing its destruction. This method has proved quite satisfactory on the farm where it has been used. According to the owner's statement, a gully which was so large a few years ago that a team and wagon could be driven up it unobserved by a person a few rods away, has been completely filled in.

SMALL GULLIES

Gullies may occur in cultivated land, on steep hillsides in grass or other vegetation, in the bottomlands and in fact at any place where water runs over the surface of the land. If small gullies are permitted to go unchecked, they may develop into large gulches, then into ravines, and ultimately into valleys. The growth occurs both in length and width and consequently it may be of interest to an upland farmer to see that gullies are not formed on the farm below, for if unchecked they may rapidly bring destruction to the upland soil. The prevention of erosion is, therefore, often a matter of more than individual interest and may demand the attention of an entire community.

It is not practicable to attempt to fill in small gullies by dumping soil into them, for an immense amount of labor is involved, and the effect will not be permanent. Various methods may be employed, however, and from those described one may be chosen which will be suitable for almost any condition.

"STAKING IN"

The simplest method of controlling small or moderate sized gullies and the one that gives the most general satisfaction is the "staking in" operation which has been recommended for the control of dead furrow gullies. The stakes should vary in size, of course, with the size of the gully; if the gully is large they may be nearly the size of fence posts. The size and quantity of brush woven about the stakes and placed about them should likewise vary with the size of the gully to be filled. The use of brush with the stakes is desirable and it should be staked to the ground or held down by a covering of earth. If this is not done, the water may run beneath the brush instead of thru it, and the gully will increase in size.

CONTROL METHOD F I ("STAKING IN")

series of brush piles

This installation consists of a gully "staked in" with brush in a manner devised by the land owner. It is located on a farm four miles northwest of Shenandoah in Page county and the area involved is about 13 acres. The area consists of steep hillsides along a rather narrow valley the whole forming a rather large ravine, of which the sides and also the bottom can be cultivated in consequence of the success attending the installation of this system of "staking in." The soil is a gray to brown silt loam, low in organic matter, resting on a brown clay and it is not as fertile as the surrounding area owing to the large amount of washing which has taken place. The entire area is under cultivation, the field being occupied by oats the year of the inspection.

The installation consists of a series of "staked in" brush dams down the drainageway where the washing occurred. The brush was placed in the gully with the tops downstream and was firmly held in place by means of stakes cut from bush in such a manner that a fork was left near the top of each stake.

The stakes were cut from old brush that had accumulated around the farm. The cost of the installation consists entirely, therefore, of the labor involved. Two men at $3.00 per day could do the work in one day making the cost of the installation $6.00.

The installation was successful in this case and with proper attention to details this method may safely be used for small ditches. For small cost, ease of installation and efficiency this "staking in" method is probably the equal of any method now in use in Iowa.

CONTROL METHOD B I ("TILING AND PLOWING IN")

This method of control consists in "tiling and plowing in" a gully occurring on a farm three-fourths of a mile north of Osceola in Clark county.

The land near the lower part of the area affected is steeply rolling but toward the upper part it becomes less hilly and gradually widens out into a broad upland or level prairie. In the gully and the small swampy areas, the soil varies from a black silty clay loam to a clay, or even a muck of shallow depth over a light brown clay. The principal portion of the area is in bluegrass pasture, the remainder being in timothy and clover. The drainage area is approximately 41.1 acres, the larger part

Fig. 7. Ditch resulting from the washing out of tile

of which is so high above the gully that the conditions are quite favorable for the occurrence of erosion.

Before remedial measures were taken the gully was about 15 feet wide, from 7 to 14 feet deep and about 700 feet in length. Fifteen years ago the gully was filled in and a line of 6 inch tile was laid down its course and also nearly to the head of each of two draws that lead into this gully, giving a total of 1800 feet of tile. Approximately 400 feet of the lower portion of the tile has since washed out and consequently a small gully has developed. The upper portion of the tile, however, is still in good condition.

The method of "plowing in" the gully was carried out in the usual way. The earth on either side of the gully was plowed loose and turned into the ditch. Scrapers were used to level up the work and establish an even slope from the hillside to the bottom of the ditch. The fill was allowed to settle, after which a 6 inch tile was laid up the entire length of the gully at a depth of about two feet. The whole area was then seeded to bluegrass and timothy.

In estimating the cost of this method the owner's statement that it took two teams and three men five days for the work is used as a basis. There was 1800 feet of 6 inch drain tile laid 2 feet deep. This cost must be added to that of filling the ditch.

2 teams,	5 days at $3.00 = $30.00	
3 men,	5 days at $3.00 = $45.00	
Cost of filling ditch		$75.00
1800, 6 inch tile at $50 per M		= $90.00
Laying 109 rods tile, cut 2 ft. at 45c per rod		= 49.05
Filling 109 rods ditch (with team) at 5c per rod		= 5.45
Total cost		$219.50

This "plowed in" gully has resisted erosion for a number of years and has provided valuable pasture land. If no method of control had been employed, a large area of land would undoubtedly have been rendered useless.

The tile should have been laid below the frost line and if this had been done heaving would have been prevented and the entire installation would in all probability still be in good working order. Where such a method is to be employed this precaution in laying the tile should be observed to insure the permanence of the installation.

The loess in the area where this method of control was used, was deep and hence the "plowing in" could be practiced without a serious loss in fertility in the soil. Under other soil conditions, that is, where the surface soil is shallow, the turning up of infertile subsoil in the "plowing in" process would lead to a considerable reduction in fertility and several years of treatment would be necessary to make it productive. The method may not always give entirely satisfactory results, therefore, and should be used only where it is adapted to the particular conditions.

CONTROL METHOD C I (BRUSH) with culvert

This method consists in filling in a ditch with brush and old hay and a specially designed culvert is employed to prevent cutting back. It is in use on a farm six miles northeast of Osceola in Clark county and is giving fairly satisfactory results.

The total drainage area amounts to 60 acres of land, all under cultivation. The area consists of a rather broad bottom surrounded by steeply rolling hills. The soil on the hillsides is a dark brown silt loam over dark gray to mottled clay. The bottom soil is a black clay loam over black clay. The hillsides are of loessial material, which is rather deep on the slopes but thins out to about a foot in depth near the black bottom soil. The crops grown on the area were corn, oats, timothy and clover.

Three years ago the filling up of the gully was undertaken. Osage Orange brush and old hay were tightly packed into the ditch and about two feet of earth plowed into the fill from the sides of the bank. The next year the county put in a concrete culvert which was adapted to the fill and to the ditch on the lower side of the road. This gives the floor of the culvert a slope of about 30 degrees. The fill at the high end of the culvert is 30 feet above the bottom of the gully just across the road. By installing the culvert in this manner it serves both as a culvert and as a retaining wall.

The expense of the culvert was borne by the county and can not, therefore, be considered in the cost of this method. As the ditch originally furnished a dumping ground for waste material, the cost of stopping the erosion was merely that of "plowing in" soil over the brush. The ditch was about 800 feet long and 10 feet wide and was "plowed in" to a depth of 2 feet. The owner's statement of the time required to do the work was "several" days. It is assumed, therefore, that the brush work would take two men and one team four days and the filling, one man and team two days.

Brush work		
2 men 4 days at	$3.00 =	$24.00
1 team 4 days at	3.00 =	12.00
Filling		
1 man 2 days at	$3.00 =	$ 6.00
1 team 2 days at	3.00 =	6.00
	Total cost	$48.00

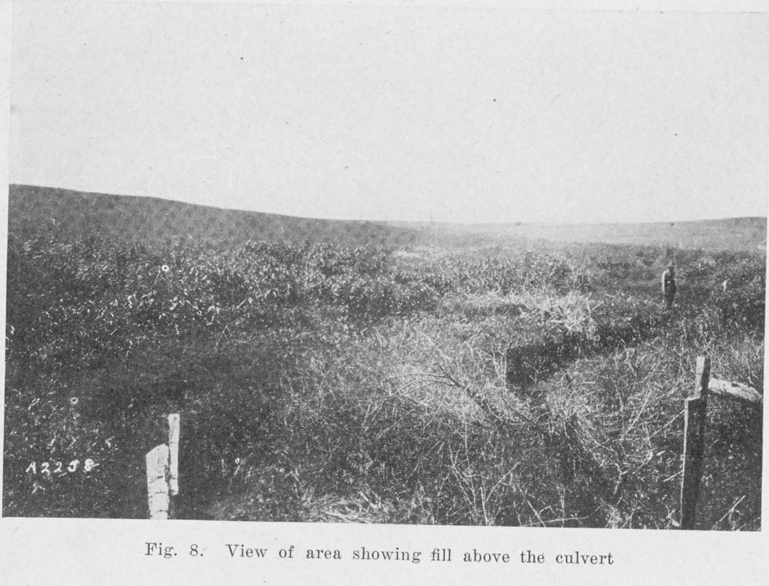


Fig. 8. View of area showing fill above the culvert

Fig. 9. View below the culvert showing the large gully

This method of controlling erosion was cheap and fairly satisfactory. It shows also very distinctly how the county engineer may plan culvert installations to serve a twofold purpose, without additional cost to the county. The indiscriminate dumping of brush or rubbish into a gully is not nearly as efficient however, for controlling erosion as piling brush with the tops pointing downstream and staking it down and the method cannot be generally recommended.

growing of trees
outlet over top

THE EARTH DAM

An earth dam or mound of earth across a gully is sometimes used for controlling erosion but usually this will prove neither efficient nor permanent unless it is supplied with a surface inlet, which will prevent the water accumulating above the dam after heavy rains and cutting out the sides of the dam. When this cutting occurs the dam itself will soon be washed away and the gully formed again. For this reason the earth dam has often caused disappointment to farmers and unless provision has been made for removing water under the dam, the labor and expense of construction is usually lost.

A modification of the earth dam which is used to some extent in southwestern Iowa consists in making a rather broad, heavy dam with the top surface 15 to 20 feet wide and left smooth and practically level. In the top of this dam, not more than six to twelve inches below the surface, are

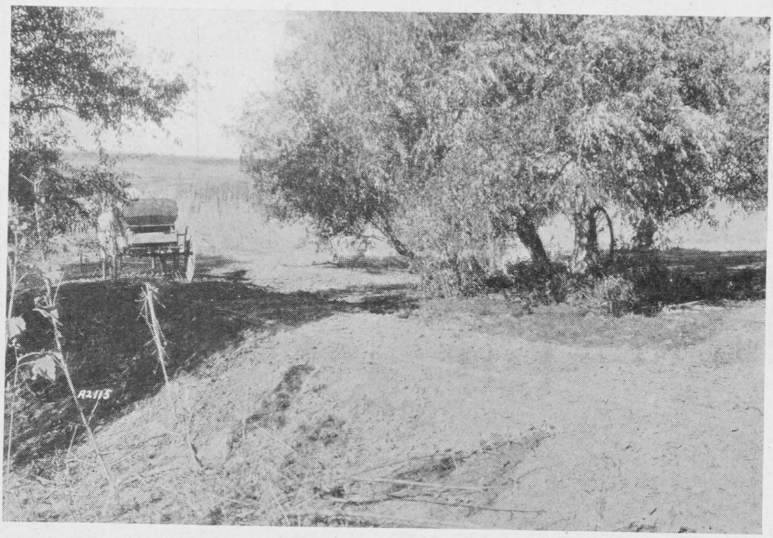


Fig. 10. Results obtained by the "Christopher" or "Dickey" dam

imbedded long trees or poles lengthwise of the dam or at right angles to the stream. Willows are frequently used for this purpose.

The dam is so constructed that the water can flow over the top. The long poles or trees will prevent surface washing. When the dam is completed, it is seeded with grain and grass seed. The seeding will help to prevent washing until a sod is formed. After the ditch above the dam fills in, that can also be seeded and a sod formed in due time. This is a simple and economical form of constructing a dam in places where the land can be left in grass. If it were to be plowed up later, a dam of this sort would not prevent future washing.

THE "CHRISTOPHER" OR "DICKEY" DAM

When the earth dam is provided with an outlet for removing water under the dam the objections to its use are very largely removed, and it may be very effective in controlling erosion. This dam, known as the "Christopher" or "Dickey" dam, has, therefore, become quite generally used.

An earth dam is supplemented by a line of tile down the gully and beneath the dam, an elbow or a "T" is inserted in the tile just above the dam. This "T," called the surface inlet, is usually made of such a length that it extends two or three feet above the bottom of the gully. As the water flowing down the gully is checked by the dam it rises until the level of the upturned tile, or surface inlet is reached when it flows thru the tile and out under the dam. A large sized tile should be used for this purpose in order to provide for flood waters and the dam should be provided with a concrete or plank spillway or runoff to prevent any cutting back by the water flowing from the tile. In the time required for the rising water to reach the surface inlet practically all of the sediment in it will be deposited above the dam. The small amount carried over the first dam may be caught by a second and hence after passing thru a series of three or four dams only the finest clay which will not settle out is carried away in the water. When the gully is filled up to the level of the surface inlet, another section of tile should be added and the filling will continue until a level is reached at which the area may be cultivated or restored to pasture.

The earth dam should be made somewhat higher and wider than the gully and higher in the center than at the sides to reduce the danger of washing and it is advisable to grow some crop upon it, such as sorghum, or even oats or rye and later to seed it to grass. In some cases a ditch is provided around one side, to prevent the washing out of the dam. This can only be advisable, however, in the case of extra large dams or when a sufficiently large tile has not been placed beneath the dam. If there is a constant stream of water flowing down the gully a useful addition to this method of control is made by running the line of tile into a water trough below the lowest dam. Considering the cost, maintenance, permanence and efficiency the

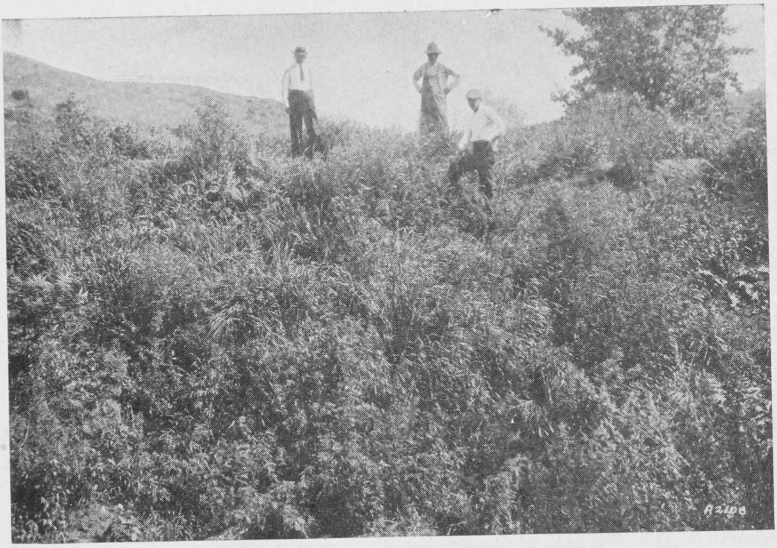


Fig. 11. Lower side of "Christopher" or "Dickey" dam for checking and filling large gully

Christopher or Dickey dam may be regarded as undoubtedly the best method of filling ditches and gullies and as especially adapted to the larger gullies. The fact that the dam is of earth is an important point for when filling is completed there is nothing to interfere with agricultural operations.

CONTROL METHOD E 1 (CHRISTOPHER OR DICKEY DAM)

This installation consists of three earth dams in series, each supplied with a surface intake and tile thru the dam. It is located on a farm two miles north of Anthon in Woodbury county.

The drainage area is about 95 acres, of which not more than one-third is under cultivation. The area consists of extremely steep hills leading into a narrow valley, the bottom of which is occupied by an enormous gully 1000 feet in length, 10 to 25 feet wide and 4 to 30 feet deep. The upper parts of the hills are being cultivated while the lower portions of the area are wooded. The soil consists of a brown silt loam or a gray silt loam over a light-brown clay, both being derived from loess. Erosion has removed the loess from some of the hillsides and exposed some glacial rock and gravel but not much clay. The bottom of the main ravine consists of soil derived from reworked loessial and glacial material, principally the former, which it closely resembles and the soil is fairly fertile where it is sufficiently level for cultivation. The steeper ravines and the hills are covered with bluegrass and scrub underbrush of hazel, scrub oak, crab apples and hickory sprouts. while the upper and more level portion is in corn, oats and alfalfa mixed with sweet clover.

The installation consists of 3 earth embankments or dams thru each of which a tile supplied with a vertical intake is placed. The upstream side of each dam is protected around the surface inlet by a concrete face, but no provision is made for overflow. These dams are placed about 200 yds. apart, the lower one being at the foot of the area.

In the installation, a solid foundation was first secured on which to lay the tile that is carried thru and beneath the dam. After laying the tile, the forms for the concrete face and spillway were placed in position. After the concrete had hardened the earth dam was made by hauling in the soil. Finally the vertical intake to the tile was placed in position and braced by four posts and heavy wire.

Three dams were used in this installation but as many should be installed in other cases as are necessary to bring the ditch to the level of the surrounding land for its entire length, when the filling is completed.

The cost of the installation may be calculated as follows:

The earth fill was 48 feet long, 12 feet high and 9 feet wide on top. The upstream side is protected by a concrete wall, 14 feet long, 8½ feet high and 1 foot thick.

50 ft. of 18″ tile at 75c	$37.50
Hauling tile 2 miles ½ day at $6.00	3.00
Placing tile 2 men ½ day at $3.00	3.00
Total cost	$ 43.50
Concrete work:	
(Cost per cu. yd. taken from method A I)	
4.4 cu. yds. at $15.83 =	$ 69.65
Earth work at 25c per cu. yd.	
84 cu. yds. short haul (100 ft.) at 25c =	21.00
Cost of each dam	$134.15
Cost of Installation (3 dams)	$402.45

Altho the cost was considerable, the large acreage that is under control makes the installation distinctly profitable. It is giving entire satisfaction and, according to present indications, the gully will be entirely filled within the next few years.

CONTROL METHOD E 2 (CHRISTOPHER OR DICKEY DAM)

This installation, consisting of a dam supplied with surface intake and tile thru the dam, will be built to control the erosion occurring on a farm five miles west of Marshalltown in Marshall county.

The total area which will be affected by the method of control amounts to 262.8 acres of which at least three-fourths is under cultivation. The area consists of steep, unwooded hillsides draining into a broad, flat, poorly drained valley, which is marshy at the upper end. The lower end of the valley which is badly eroded is a more level, cultivated area. The soil on the hillsides is a silt loam, derived, probably from loess. At certain points the surface soil has been entirely washed away, exposing a glacial subsoil consisting of a heavy red or bluish clay. In the valley the soil consists largely of reworked loess. Most of the area is in cultivated crops such as corn, oats, potatoes, timothy and millet, the remainder being in bluegrass pasture.

The plans for this installation are similar to those of the method just described. The dam, however, is to be 100 feet long and 8 feet high, somewhat longer than in control method E 1 and not quite so high.

At the present time a 12-inch tile runs from the proposed location of the dam to a suitable outlet in a creek about one-fourth mile distant. Two lines of 6 inch tile, about 100 feet long will be laid in the depression above the dam in order to furnish underdrainage for that area. These two lines of tile will discharge into the 12 inch tile. To handle surface water at flood times an 18 inch tile is to be installed as a surface intake to carry the water under the dam. Only one dam will be necessary in this case as the installation is planned to prevent erosion rather than to fill an existing gully.

The cost of the installation is divided into three divisions, earth work, tile, and concrete.

Earth work (figured as in E 1)		
534 cu. yds. at 25c		= $133.50
Concrete (as in A 1)		
4.4 cu. yds. at $15.83		= 69.65
Tile		
40′ of sewer tile at 75c per ft.	= $30.00	
200′ of 6″ drain tile at $50.00 per M	= 10.00	
Cost of tile		$ 40.00
Hauling 3 loads 5 miles 1.5 days at $6.00 (team and driver)		= 9.00
Layer sewer tile 2 men ½ day at $3.00		= 3.00
Laying and filling ditch 6″ tile 3′ deep at 50c per rod		= 6.50
Cost of project		$261.65

The use of a dam, with surface inlet, is considered the most practical installation for this area in order to secure the control of erosion of the low land. Other methods might have been chosen but an open ditch would not be desirable as it would undoubtedly lead to the formation of a large gully in a few years. Underground tiling would not be practical as the volume of water passing over the land is too great to be handled in that way;

Fig. 12. A stone dam that has filled a gully

Fig. 13. View of stone dam from below

neither could the water be spread out over the surface of the land as the valley at that point is too narrow. A concrete dam with a spillway had proved impractical and had washed out owing to the impossibility of securing a solid foundation without great expense.

It is believed that the Christopher or Dickey dam will undoubtedly prove the cheapest and most satisfactory method which could be used to control erosion in the low-lying land in this particular area. Other methods must also be adopted if the erosion of the higher lands is to be controlled, as the conditions are so variable that no one method will serve for the entire area.

THE STONE OR RUBBLE DAM

+ small tile thru dam

In areas where stones abound they are frequently used in constructing dams for the control of erosion. Such dams have generally proved quite satisfactory, when tile openings have been provided in them at various heights. As the water collects above the dam it rises to the height of the first series of tile openings where it runs out. In the process of rising, however, practically all the suspended material is deposited as in the Dickey system. Tile openings are provided at various heights in the dam to give an additional measure of safety. If the tile at a certain height is incapable of carrying off the excess of water, then the tile above will be called into service. Hence the tile running thru stone dams are usually rather small. In a gully five or six feet wide, four inch tile is ordinarily used, about four in the first row, three in the second, two in the third and sometimes one opening at the top. The efficiency of the stone dam depends rather definitely upon the method of construction. If it is laid up too loosely, its efficiency is reduced and it may be washed out. Under Iowa conditions it can be used only infrequently.

CONTROL METHOD D 1 (STONE OR RUBBLE DAM)

This method of controlling erosion consists of a stone or rubble dam across a gully on the state farm, two miles southeast of Mt. Pleasant in Henry county.

The area which drains into this gully above the dam is about 38.1 acres. It contains several small gullies all emptying into a larger drainageway, which is prevented from eroding by a stone dam at the lower end. Above, the area widens out into typical, upland prairie. The soil is a brown silt loam over brown clay. In some small areas a light colored soil occurs overlying a light brown clay, and these spots are rather low in fertility. The entire area is under cultivation, corn and timothy mixed with clover at present occupying the land.

The installation consists simply of a stone dam at the lower end of the drainage area. The sediment in the water is thus in part filtered out from the water which flows thru or over the dam. In making the installation, the ground was leveled off and

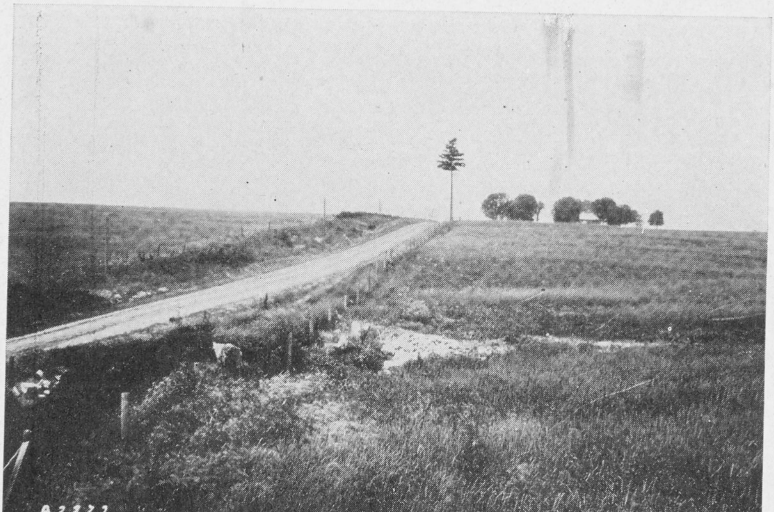


Fig. 14. View of stone dam from above, showing the fill and topography

Fig. 15. The filling accomplished by a straw dam, above the dam

the stones laid without special attention to coursing them, giving more the appearance of a pile of rock than of a dam. An upstream curvature was given to the pile but no provision was made to prevent undercutting.

The material used in the dam was picked up on the farm and consequently the only cost involved in the installation was that for the labor. Eight wagon loads of rock were used in the dam, all of which were hauled approximately one mile.

Hauling 8 loads, 1 day's work for 2 men and 1 team. Placing dam, 1 day's work for 2 men.

1 team and driver	1 day at $6.00	$ 6.00
1 man	1 day at $3.00	3.00
2 men	1 day at $3.00	6.00
	Total cost	$15.00

The installation is without question a success, for erosion has been stopped and the gully partially filled up. Where similar conditions prevail, therefore, the stone or rubble dam may prove a cheap and efficient method of controlling erosion. It is best adapted to areas having a gentle or moderate slope such as was the case in the installation described. On a steep slope where a large quantity of water descends at a high velocity, a loose stone dam would easily be washed away.

In order to avoid undercutting, it is advisable in installing a stone dam to excavate to a heavy soil for a solid foundation. In the installation described here, this was not done but the

Fig. 16. The filling accomplished by a straw dam, below the dam

foundation rested on a rather solid clay which occurred near the surface and if this had not been the case washing out of the dam might have resulted. In general it is true that a little extra labor in excavating for the foundation may be well warranted in insuring the permanence and success of such a dam.

THE STRAW DAM

A simple method of preventing erosion in small gullies is to fill them with straw. This may be done at threshing time with some saving of time and labor. The straw is usually piled near the lower part of the gully, but if the gully is rather long, or branching it should be placed near the middle, or below the junction of the branches. The pile should be made so large that it will not wash out readily when its bulk is decreased by decomposition and settling. The rate of decay of the straw is usually about the same as the rate of filling of the gully. When the gully is entirely filled, therefore, the land is quite uniform and the difficulty in cultivating, which sometimes occurs when concrete dams are employed, is avoided.

There is one great objection to the use of straw for the control of erosion and that is the value of the straw as a feed, as a bedding material, and as a fertilizer. The straw dam is undoubtedly an expensive means of controlling erosion; but its use may sometimes be warranted because of its effectiveness, the ease with which is may be installed and the small amount of care which it requires.

THE RUBBISH DAM

The use of rubbish is unsightly and in the main unsatisfactory. A great variety of materials may be employed in this method. It is most frequently used near cities and towns and the material is usually dumped at the head of the ravine. Little effect in preventing erosion results from such careless use of rubbish even if a sufficient amount is used to fill the cut. The rubbish dam may be used, however, when combined with the Dickey system just as the earth or stone dam, provided it is made sufficiently compact to retain sediment and to withstand the washing effect of the water.

THE WOVEN WIRE DAM

The use of woven-wire especially in connection with brush or rubbish has proved satisfactory for preventing erosion in small gullies where the velocity and quantity of water is not great. The woven wire, used in this method takes the place of the stakes, the principle of construction being otherwise the same as in the "staking in" system. Owing to the difficulty involved in making a close connection between the wire and the banks of the gullies, the method is best adapted to shallow, flat ditches, where the edge of the gully is not sharply defined. Such

Fig. 17. A sod strip in cultivated land to prevent erosion

ditches occur mainly in bottomlands or on flat areas adjacent to higher lands and hence it is only in these areas that the use of the woven wire dam may be satisfactory but it should be supplemented with brush or rubbish even in such cases if its efficiency is to be guaranteed.

THE USE OF SOD STRIPS

The presence of certain natural surface drainageways cannot be avoided, especially in rolling land and in order to protect these channels from washing into gullies, it is often advisable to leave the drainageway lined with a narrow strip of sod. This serves to hold the soil in place, and does not interfere with the ordinary operations of cultivation. The amount of land lost by this method of control is relatively small as the strips are usually only a rod or two in width. Bluegrass is the best crop to use for the sod because of the ease with which the implements may pass over it, but timothy, redtop, clover or alfalfa may serve quite as well and for quick results sorghum may be employed if it is planted thickly. This method of controlling erosion might be employed to advantage in many cases especially to check the washing away of the soil in the earlier stages of gully formation.

THE CONCRETE DAM

One of the most effective means of controlling erosion is by the concrete dam, provided the surface inlet or Dickey system

Fig. 18. View between the two dams

Fig. 19. A lateral gully resulting from a single rain

is used in connection with it. If the dam is correctly designed and properly located the filling up of the gully by its use is practically assured.

There are, however, certain objections to concrete dams which prevent their common use. The construction of the dams themselves and of the long overflow pavements which are necessary, if the Dickey system is used, involves considerable expense. Then too, they may overturn if not properly designed and the services of an expert engineer are required to insure a correct design. The concrete dam must also be cared for if it is not to be washed out, altho this latter danger may be largely avoided if the dam is properly designed and constructed. They are attractive, however, especially when a watering trough is placed on the lower side and they may undoubtedly be used to advantage in special cases.

CONTROL METHOD A 1 (CONCRETE DAM AND DRAIN TILE)

This method consists of two concrete dams supplemented by a line of 12 inch tile. It is proving quite satisfactory in controlling the erosion in a cultivated field on a farm four miles southeast of Norwalk in Warren county.

The land in the area is steeply rolling or hilly. The soil on the hillside is a dark brown silt loam underlaid by a light brown clay. This is a typical soil in the Southern Iowa loess area. The soil in the bottom of the drainage area varies from a black silty clay loam to muck, both underlaid by black clay. These soils would be very fertile if the tiling were continued above and below the dams as well as between them, and this could be done with little difficulty. Except for the land that is in farmsteads and that in marshes, the entire area influenced by this method of control is cultivated, corn, oats, alfalfa, wheat and potatoes being the crops at present occupying the land.

The total drainage area includes approximately 110 acres. Probably two acres were rendered useless by the ditch which extended from the public highway where the upper dam was located to the point where the lower dam was placed. The topography is such that the southwest corner of the field was subject to washing from the higher land across the road. According to the owner's statement, when the installation was made in 1914, a gully had formed which was 700 feet long, and wide and deep enough to hide a team and wagon.

An installation of two concrete dams connected by a 12 inch drain tile was made, no reinforcement being used in the construction of either dam. The upper dam was supplied with a surface inlet of concrete which empties into the 12 inch tile. The tile passes directly thru the bottom of the lower dam, and the water is conducted under the road thru an 18 inch concrete culvert. Provision was made for overflow at the upper dam at the position of the surface inlet but no such provision was made for overflow at the lower dam.

Fig. 20. Upper dam and surface intake. Note the cracks in the dam due to settling

The upper dam was evidently not supplied with as solid a foundation as was necessary since a slight amount of washing has occurred around the end of the dam nearest the surface inlet and the dam itself has cracked due to uneven settling and to the pressure of the sediment accumulated above it. The foundation should have been placed well into the subsoil and the bottom and the sides of the dam would then have been better protected against washing out. The lower dam which was set under similar conditions seems to be in better condition, due probably to the foundation resting upon a more solid subsoil.

The first tile was embedded in the base of the upper dam and the line of tile laid from this point down thru the lower dam. The sides of the ditch were plowed in, covering the tile and all the available brush was piled in on top of this. More soil was then plowed in, over the brush, until cultivation was possible.

The water coming down from the higher land is partly taken care of by the 12 inch tile while the excess flows over the top of the upper dam. The time required for the water to accumulate above the dam in a large enough amount to flow over the top is sufficient to permit of the settling out of much of the sediment while that carried over the first dam settles out above the second dam. The fall from the upper to the lower dam is such that a small amount of washing has occurred. The production of crops, however, except close to the upper dam has not been interfered with. The cost of the installation may be calculated as follows:

Cost of concrete work for the upper dam

Wall 24'x8" = 80 cu. feet plus 12.2 cu. ft. in the intake, making 92.2 cu. ft. in all or 3.42 cu. yds.[1]

3.42 x 6 = 20.5 sacks cement at $.65	$13.35
3.42 x .44 = 1.51 cu. yds. sand at $1.50	2.27
3.42 x .89 = 3.02 cu. yds. rock at $1.75	5.29
Cost of materials	$20.91

Hauling Materials

Cement, 1 load 4 mi.	.5 day	
Sand, 1.5 loads 4 mi.	.75 day	
Rock, 3 loads 4 mi.	1.5 day	
Days hauling	2.75 at $6.00 per day	$16.50
Form lumber 300' at $40 per M, $12, charge		10.00
Labor (estimate per cu. yd. Taylor and Thompson) $2 x 3.42		= 6.84
Total cost one dam		$54.25

Cost per cu. yard $15.83

[1] This estimate is for a 1-2-4-mixture of concrete which requires the following per cubic yard: 6 sacks cement, 0.44 cu. yd. sand, 0.89 cu. yd. rock.

Total cost of concrete (two dams)	$108.50
700 tile at $180 per M	$126.00
Hauling tile, 3 loads 1.5 day at $6.00	9.00
Laying tile, 2 men, 3 days at $3.00	$18.00
Filling ditch, 2 men and teams 3 days at $6.00	36.00
1 man 3 days at $3.00	9.00
Total cost of project	$306.50

A few suggestions may be given here which should be followed in making similar installations in order to insure their efficiency.

In the first place a solid foundation should be secured, in order to prevent the washing out around and under the dam and also to lessen the danger of the dam cracking from uneven settling. For all installations, the dam should be arched down stream to throw the water to the middle and thus prevent it from washing around the ends. In constructing such dams the use of reinforcement is always advisable, the material to be used varying according to the size of the dam. For small dams heavy woven wire, running the length of the dam may be used.

The top of such dams should be made about one foot higher than the surface inlet in order to facilitate the entrance of water into the inlet. In most cases it is advisable to provide a surface inlet at the lower as well as at the upper dam.

If a larger tile were used than in the present case there would

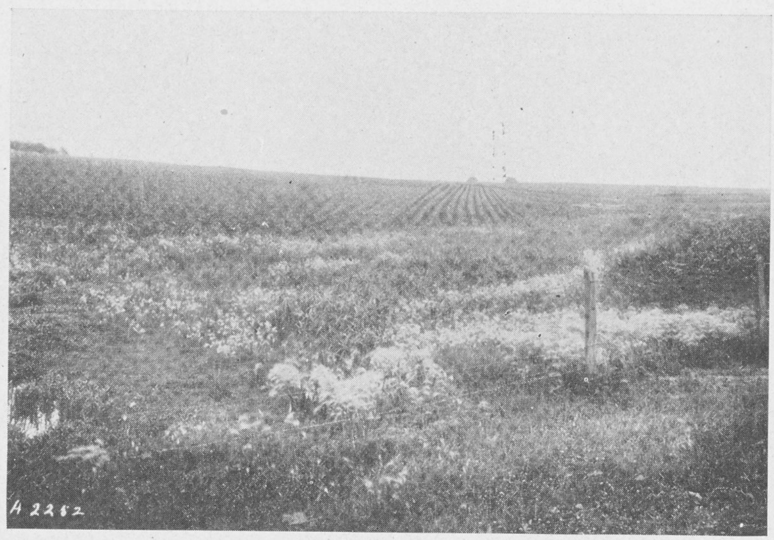


Fig. 21. View above the upper dam. Note untillable land and slough grass, due to the impounding of water above the dam. Tiling would remedy this condition

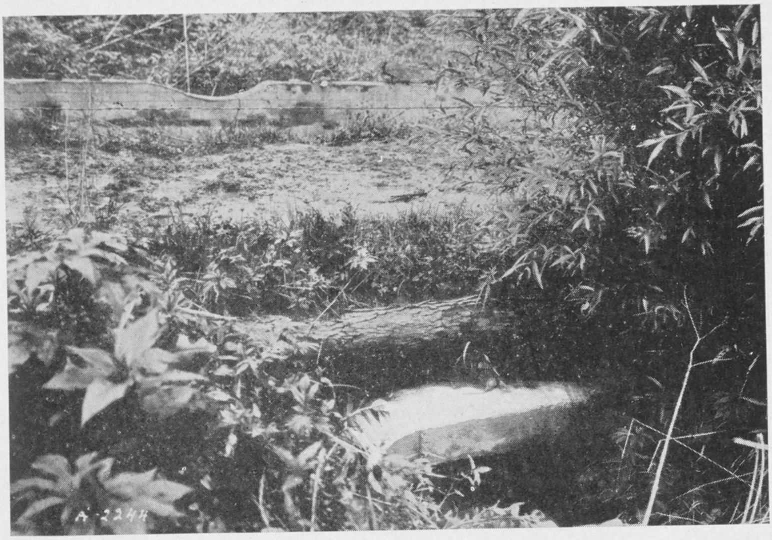


Fig. 22. Lower dam and outlet beneath the road

be less danger of washing as the surface inlet and tile would handle a larger proportion of the water above the dam. A 16 inch tile would probably have proven more satisfactory here, as it would, except in cases of extremely heavy rainfall, carry all the water and thus prevent any from washing over the top of the dam.

This system has been installed for three years and it may be considered efficient. Erosion has been prevented and the crops (alfalfa and oats) are as good on the land that was formerly a gully as they are on the remainder of the field. The value of these crops and of the greater crop yields secured on the whole field is rapidly paying for the installation. The Christopher or Dickey dam described as control method E I might have been used, however, and would have been much cheaper and have given just as good results if properly installed.

CONTROL METHOD A 2 (CONCRETE DAMS)

This method consists of eight concrete dams installed along the course of a gully occurring in pasture land on a farm in Dallas County, one and one half miles east of Dexter on the White Pole road.

In topography, the area is quite hilly, draining into two draws which meet above the lowest dam and below this the drainageway becomes a very large gully.

The soil varies from a brown silt loam on the hills to a dark brown or black clay in the bottoms, underlaid by a brown silty

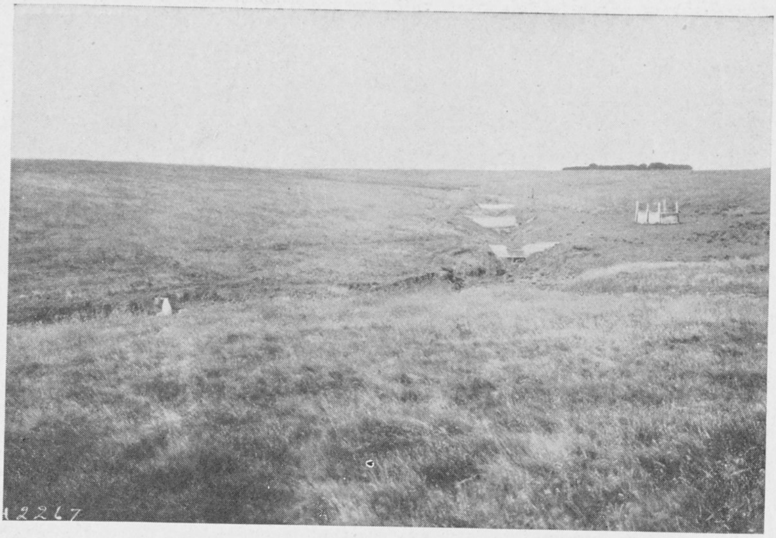


Fig. 23. Looking up the series of eight concrete dams

clay. About one-half the area is in bluegrass pasture while the more level land was cultivated and in corn at the time of the inspection.

The total area affected by the erosion which this installation controls amounted to about 47.3 acres. The gully 6 to 12 feet wide and from 2 to 8 feet in depth, extended up the ravine for about 800 feet.

Eight concrete dams were placed in succession down the gully, each having a notch placed in the upper part to allow the water to flow over the center of the dam. Each dam is prevented from undermining by means of a concrete spillway below the dam on the down-stream side.

The cost of the installation may be calculated on the basis of the size of the dam halfway up the series, those above being on the average as much smaller as those below are larger than the one chosen.

This dam is 21 feet long, 3 feet 8½ inches high and 8½ inches in thickness and thus contains a total of 57.6 cubic feet or 2.13 cubic yards. In the previous method it was found that the average cost of concrete work per cubic yard amounted to $15.83 including materials, forms and labor. At this price each of the dams would cost (2.13 x $15.83) $33.72. The complete cost for the 8 dams would, therefore, be (8 x $33.72) $269.76.

The cost of this installation was relatively high but the gullying of good pasture land is prevented and the installation, therefore, is rapidly paying for itself.

The method as used here is largely successful altho two of the dams have failed. The only modification which might be suggested is that some means be provided for conducting the water thru and under the dams at the same time permitting the sediment to settle out above them.

CONTROL METHOD A 3 (CONCRETE DAMS)

This method consists of six dams in a series down the course of a gully. It is a very similar installation to the one just described and hence is not discussed here. It is proving quite satisfactory in controlling the erosion to which the area was subject.

CONTROL METHOD A 4 (CONCRETE DAM)

This method consists of a concrete dam so placed as to prevent the erosion of a gully in a cultivated field on a farm four miles north of Ottumwa, in Wapello county.

The soil consists of a dark brown silt loam over a lighter brown clay. Corn is the crop generally grown altho oats are sometimes grown on the higher portion of the land. The topography shows a narrow ravine draining rather steep hills on either side.

The area concerned is 6.3 acres and it was being cut into

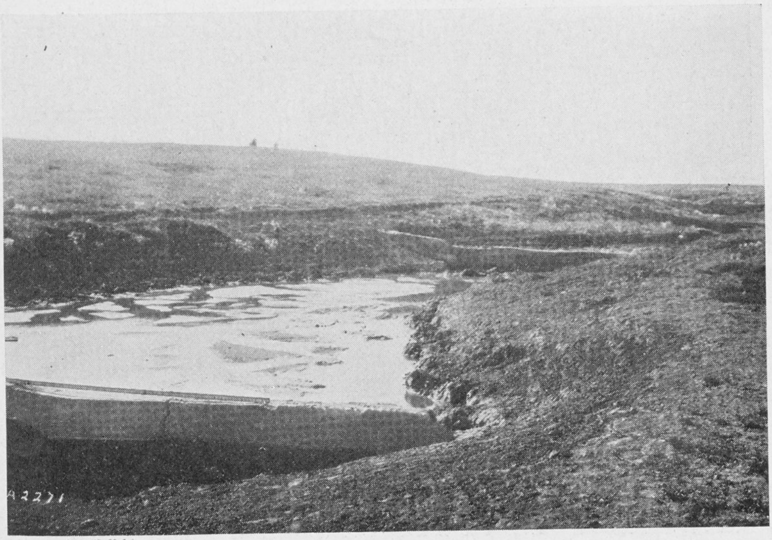


Fig. 24. View showing the fill above dams and the spillway below the dams

two parts by the gully. The slope is not very steep but deep gullies would soon be formed were it not for the concrete dam at the lower part of the area as is evidenced by the fact that the bottom of the gully a short distance below the dam is 30 feet lower than the fill at the dam. The original gully extended about 200 feet into the field and was growing rapidly.

The installation consists of one concrete dam, 24 feet long, 7 feet high, and 1 foot thick and since it was built on the fence line, the fence posts were imbedded in the concrete. No reinforcing was used in the dam.

The cost of the installation may be calculated on the basis of the estimate made in method A I as follows:

The dam is 24′ x 7′ x 1′ and contains therefore 168 cu. ft. or 6.2 cu. yds.
The cost per cu. yd. was $15.83.
6.2 x $15.83 = $98.15 total cost of installation.

This dam permits of the growing of crops on three acres of land which would otherwise be untillable and it is preventing a field from being cut into two parts. The installation is unquestionably proving successful, therefore, and is paying for itself.

CONTROL METHOD A 5 (CONCRETE DAM AND HOG WALLOW)

This method for the control of erosion on a farm 4½ miles southwest of Wayland in Henry county, consists of a concrete dam combined with a hog-wallow and a water-gap.

Fig. 25. View of concrete dam

Fig. 26. View below dam, showing the difference in topography as contrasted with the view above the dam

The soil in the area is a dark brown to black silt loam to silty clay loam over a dark brown silty loam. The total drainage area includes 173.9 acres of rather level upland marked by wide, shallow drainage channels. About one-half of the area, consisting of the more sloping portions, is in bluegrass pasture while the remainder is cultivated and during the past season was in corn.

The installation consists of a concrete wall, 37 feet long, 3 feet high and 8 inches thick, thru which an 8 inch drain tile empties into a basin or hog wallow built with a sloping concrete floor. The wall on the opposite side of the basin makes the water gap and it is the same in size as the dam. The water-gap is 2x9 feet and the gate in the water-gap was made by mounting woven wire fencing upon a gas pipe frame. The basin or hog wallow is 14 feet long, 9½ feet wide and 6 inches deep.

The total amount of concrete work is 9 cubic yards. Taking the cost per cubic yard from control method A I, the total cost of the installation is found to amount to (9 x $15.83) $142.47. This cost does not include the drains, which should not be considered a part of the control method.

This installation is a very practicable method for the control of erosion under the topographical conditions on this farm and the system of farming (stock raising) followed. The use of concrete is advisable in this case as stock, particularly hogs would make it difficult to keep an earth dam in repair, when located in a feed lot or pasture.

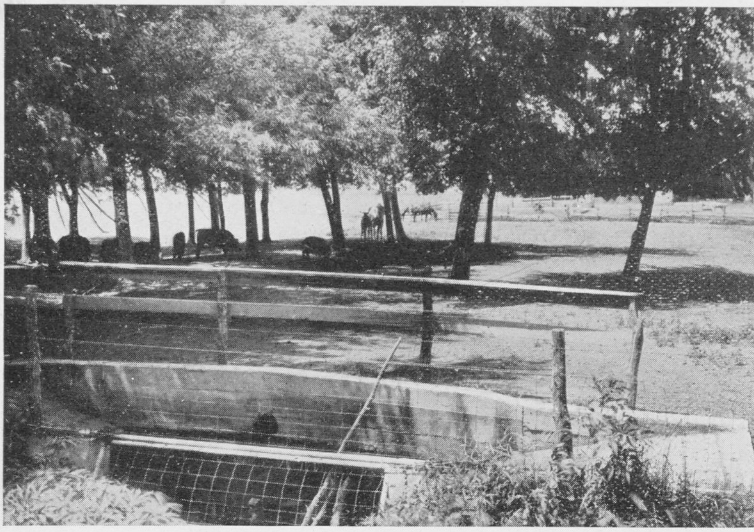


Fig. 27. View of the combined dam, hog-wallow and water-gap

The fall is so small in this particular case that one dam is sufficient to hold the soil in place. In similar sized areas with a greater fall more than one dam would be necessary to prevent erosion because of the greater quantity of water which would pass over the soil. Such an installation as that described here can probably be made on many livestock farms and should prove quite satisfactory.

DRAINAGE

The ready removal of excess water from the soil may be accomplished by a system of tile drainage properly installed and this removal of water to the depth of the tile increases the power of the soil to take up water thus decreasing the tendency toward erosion. In some places tiling alone may be sufficient to control erosion but generally other means are also required.

LARGE GULLIES

The erosion in large gullies which are often called ravines may in general be controlled by the same methods as in the case of small gullies. When first seen large gulches often appear of such a size that filling them seems absolutely impossible. The results obtained by several farmers in the state indicate, however, that the erosion in such large gullies can be controlled and they can eventually be filled by the Christopher or Dickey dam, already described in the discussion of small gullies.

The construction of an earth dam across a large gulch is, of course, quite an undertaking but the beneficial effects in stopping erosion well warrant the labor involved. Several years may be required to fill the gully but considering the amount of sediment needed, the rate of filling is really remarkably rapid and if properly installed the Dickey dam will eventually bring about the entire disappearance of the gully. It is the only method that can be recommended for controlling and filling large gullies.

BOTTOMLANDS

Erosion frequently occurs in bottomlands thruout the state and especially where low-lying areas are traversed by small streams the land may be very badly cut up and rendered almost entirely valueless for farming purposes.

STRAIGHTENING AND TILING

The straightening of the large streams in bottomland areas may be accomplished by any community and, while the cost is considerable, large areas of land may thus be reclaimed. The expense of the individual landowners will very often be well warranted and more than offset by the returns obtained from the use of the land.

In the case of small streams, tiling may be the only method necessary for reclaiming useless bottomland and it often proves

Fig. 28. Filling a large gully

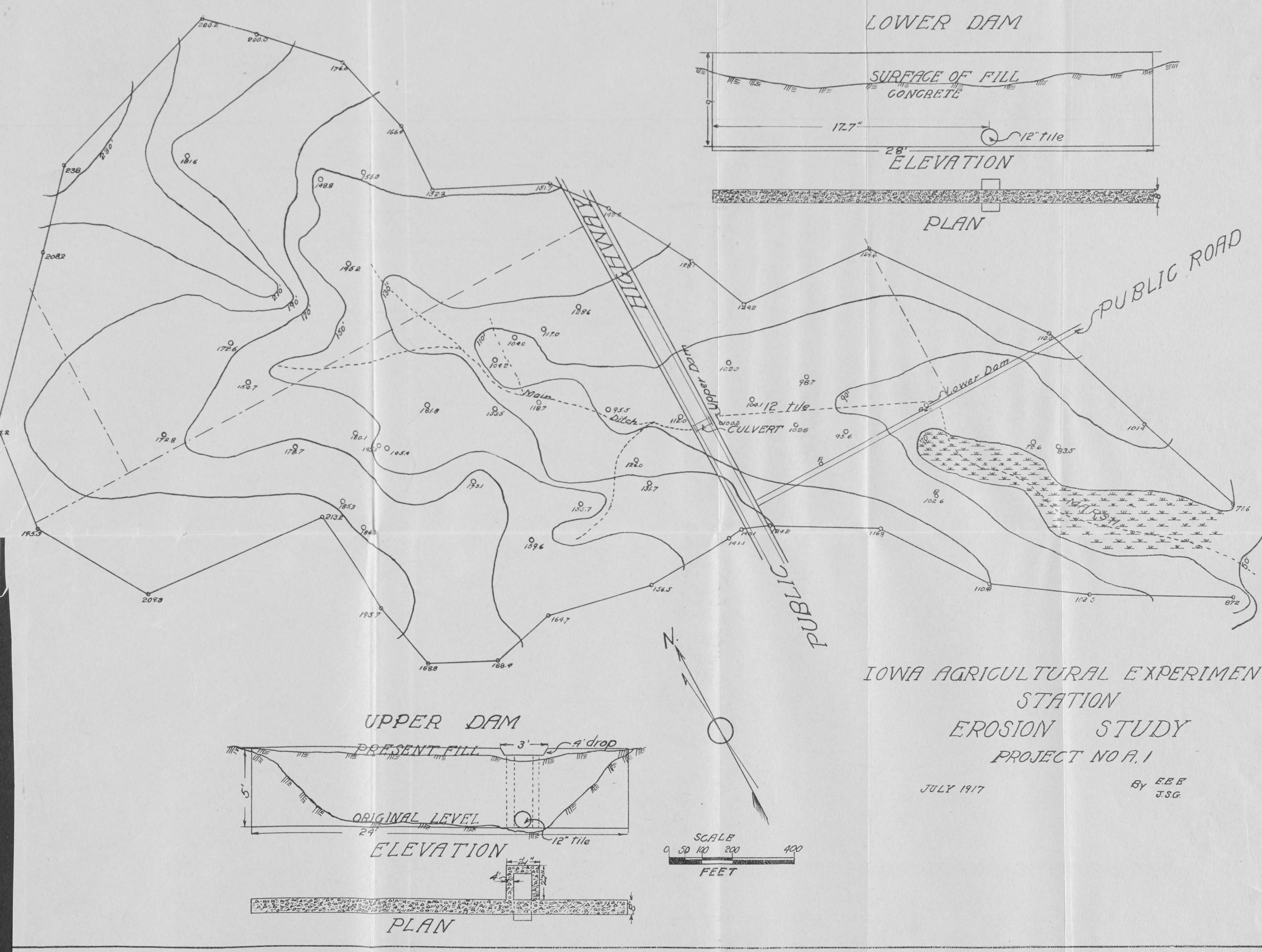
very efficient. Provision should always be made in tiling such land to carry off spring floods thru surface drainageways as well as by the tile.

TREES

Erosion is sometimes controlled by rows of trees which extend up the drainage channels and even into the cultivated fields. Willows are the trees commonly used in this way but others may also serve as well for the purpose. This practice has several good features but for some reasons it is undesirable. Many ravines are undoubtedly kept from cutting back into adjacent fields by trees and by the undergrowth which usually accompanies them but often the row of trees extends much further into cultivated fields than is necessary. Furthermore trees growing in the midst of cultivated land not only interfere seriously with tillage because of the presence of short or irregular rows but they may also seriously injure the crops in their immediate vicinity because of the shade which they give and because of the water which they remove from the soil.

Injury to crops from this latter effect may be quite noticeable when the rainfall is light. Uncultivated areas surrounding rows of trees may also serve as breeding places for insect or plant diseases and thus bring about crop injury. In loess soils with steep slopes, the growth of trees to prevent erosion is practically useless. Undercutting goes on around and under them and

Fig. 29. An example of a straightened gully



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J.S.G.

Fig. 30. A line of trees in a natural drainage channel

erosion is not checked. In general it may be said that in pastures, bottomlands and gulches the presence of trees may sometimes be effective in controlling erosion but the method cannot be recommended.

HILLSIDE EROSION

Hillside erosion may be controlled by several methods of soil management all of which are of value not only in preventing the injurious washing of soils but in aiding materially in securing satisfactory crop growth.

THE USE OF ORGANIC MATTER

The addition of organic matter to the soil is the most effective means of increasing the ability of the soil to take up water and in preventing erosion. Farm manure should be applied or green manures employed if farm manure is not available in sufficient amounts. Crop residues such as straw and corn stalks may also be turned under in soils to increase their organic matter content.

THE GROWING OF CROPS

The growing of crops such as alfalfa, that remain on the land continuously for a period of two or more years, is often advisable on steep hillsides. Alsike clover, sweet clover, timothy and red top are also quite satisfactory for use in such locations. The root systems of such crops as these hold the soil together and the washing action of rainfall is reduced to a marked extent.

In order to keep up the content of organic matter in hillside soils it is frequently advisable to grow alfalfa or some other legume in a short rotation with a cultivated crop like corn. Farm manure and crop residues are also recommended for use as in most cases the growing crops will not keep up the organic matter content of a soil to a satisfactory amount.

CONTOUR DISKING

Disking around a hill instead of up and down the slope or at an angle to it is frequently effective in preventing erosion. Especially is this true on a rolling, rather hilly farm in the Southern Iowa loess soil area. On this particular farm the method is especially valuable because the contour lines run diagonally with the corn rows which run the long way of the field.

Contour disking is practiced to advantage on stalk ground in the spring, preparatory to seeding small grain and also on fall plowed land that is to be planted to corn. On stalk land the disking tears down the corn ridges and breaks up any drain-

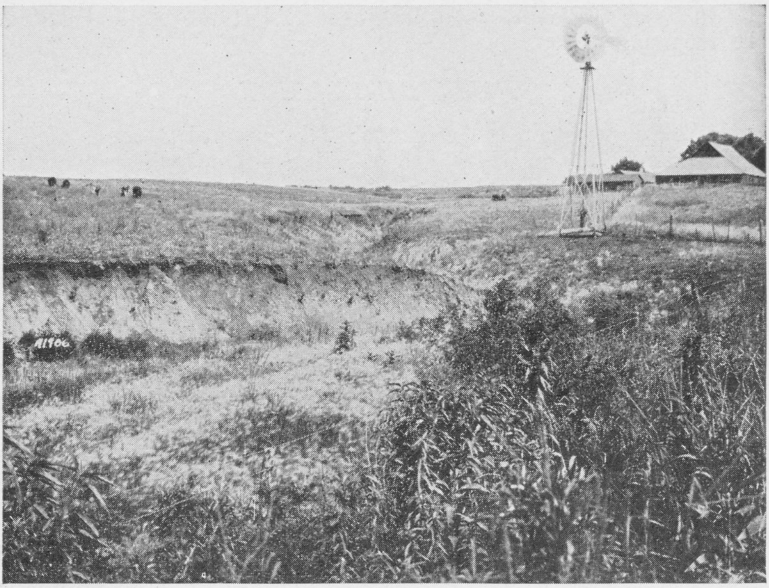

Fig. 31. Unnecessarily eroded bottom land

age channels which may occur down the slope and which may form gullies or cause sheet erosion. On fall plowed land it prevents the washing away of the soil by the fall and spring rains in large measure. It is advisable in contour disking to do the turning row along the fence first as the horses and disk when turning will pack and cover the center mark of the disk, thus leaving no depression to form a water channel.

DEEP PLOWING

The value of deep plowing in increasing the power of the soil to take up water and hence in decreasing erosion has been mentioned. It is especially advantageous if it is done in the fall as the soil is then put in condition to absorb and hold the largest possible amount of the late fall and early spring rains. Deep plowing should undoubtedly be practiced whenever conditions permit but certain precautions are necessary if it is to prove entirely satisfactory. It is not advisable as a rule to change from shallow plowing to deep plowing at a single operation as too much subsoil may be mixed with the surface soil in which case the productive power of the soil may be reduced for a comparatively long period. A gradual deepening of the surface soil by increasing the depth of plowing will, however, be of value both in increasing the feeding zone of plant roots and in making the soil more absorptive and therefore, less subject to erosion.