# Effects of Gully Plugs and Contour Furrows on Erosion and Sedimentation in Cisco Basin, Utah

GERALD F. GIFFORD, DEE B. THOMAS, AND GEORGE B. COLTHARP

**Highlight: The effects of contour furrows and gully plugs on erosion and sedimentation within the Cisco Basin, Utah, were evaluated over a 3- to 4-year period. Soils on the study area were generally less than 10 cm deep and were developed from Mancos shale and sandstone. Contour furrows and gully plugs together held all runoff and sediment, while contour furrows alone held only a portion of the runoff and sediment. Difficulties in constructing furrows on the contour resulted in a shortened useful life of the structures. Projected life expectancy of the contour furrows ranged from 6 to 12 years; for the gully plugs the projected life expectancy was from 14 to 33 years.**

Thousands of acres of land in the Colorado Plateau physiographic province contribute large quantities of sediment and very little water to downstream reaches of the Colorado River and its tributaries. This sediment yield and flash-type runoff not only perpetuate the low productivity of the rangelands but damage farmland irrigation works and flood-control projects downstream (Lusby 1970). Much of the sediment originates as a result of convective storms from areas where soils are poorly developed and generally consist of a shallow, weathered mantle overlying the Mancos Shale, such as found within the Cisco Basin in eastern Utah. Since 1958 the Bureau of Land Management and Bureau of Reclamation have cooperatively treated about 6,000 acres in the Cisco area. These treatments consisted of constructing approximately 25,000 gully plugs and furrows (Cox 1972).

The general objective of this study was to evaluate the effects of contour furrows and gully plugs on erosion and sedimentation within the Cisco Basin. A review of the impact of contour furrows and gully plugs on runoff and erosion as determined from other published studies has recently been presented by Gifford (1975).

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Authors are associate professor rangeland hydrology, graduate research assistant, and associate professor rangeland hydrology, respectively, Watershed Science Unit, College of Natural Resources, Utah State University, Logan 84322. Dr. Coltharp is currently associate professor of forestry, University of Kentucky, and Mr. Thomas is currently with the U.S. Forest Service.

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## Site Description

The areas selected for study are located approximately 5 miles to the west and south of the town of Cisco, Grand County, Utah. This area, known as Cisco Basin, is bounded on the north by the Book Cliffs and on the south by the Colorado River. It is typical of the upper Colorado River Drainage basin of western Colorado and much of Carbon, Emery, Garfield, Grand, Kane, San Juan, Uintah, and Wayne counties in eastern Utah. Mean elevation above sea level is 1,280 to 1,340 meters.

The climate of the Cisco Basin is semiarid, characterized by erratic precipitation occurring largely from thunderstorms during late summer and early fall. Precipitation important for vegetation growth comes during late winter and early spring but drops off to the driest months of June and July. Annual precipitation has varied from 4.11 cm to 35.53 cm and averages 15.59 cm (Hancock 1968).

The geology of Cisco Basin has been summarized by Ibrahim (1963). The area is part of the Colorado Plateau Province, which is characterized by an intricate system of highly dissected table lands of horizontal or slightly inclined sedimentary strata. Cisco Basin is located mainly on the top formation of Mancos shale, a thick formation of lead-gray marine shale which contains veinlets of gypsum.

As for vegetation, Cisco Basin is in the shadscale zone, which is dominated by different *Atriplex* species. There are four vegetation types in the Cisco Basin, each of which is an edaphically controlled climax community (Ibrahim 1963). The shadscale-galleta grass (*Atriplex confertifolia-Hilaria jamesii*) community is found on the uppermost pediment remnants. Ground cover is more dense than in the other three communities and the soil is sandy loam in texture. The other three plant communities are Nuttall saltbush-galleta grass (*Atriplex nuttallii* var. *nuttallii-Hilaria jamesii*), saltsage-woody aster (*Atriplex nuttallii* var. *gardneri-Aster xylorrhiza*), and mat saltbush (*Atriplex corrugata*). These three plant communities are developed on soils derived from the Mancos shale.

The soils of the Utah East Desert are of the following three Orders: Aridisols, Entisols, and Vertisols. Parent material in the study areas is typically Mancos shale except for the shadscale-galleta grass community, which is sandstone. These soils have been described fully by Ibrahim (1963). The soils are generally less than 10 cm deep and undeveloped, though the mat saltsage area has soil approximately 25 cm deep.

## Methods and Procedures

### Treatments

Four areas were used for study. Study areas I and IV were treated with contour furrows using a Holt trencher at a furrow density of 440 and 849 m/ha, respectively, in the spring of 1966. Actual furrow size when first constructed was about 0.15 m deep by 0.45 m wide by 3 to 10 m in length. Areas II (treated in the spring of 1964) and III (treated in the spring of 1962) were treated with both contour furrows and gully plugs. The gully plugs were made by a D-7 Caterpillar bulldozer and averaged 3.4 m wide, 4 m long, and 0.5 m deep on Area III and 4.7 m wide, 5.3 m long, and 0.9 m deep on Area II. The dams were all about one meter high, were built in a crescent shape, and were compacted by the tracks during construction. On Area II the gully plugs were installed at a density of 4.2/ha, while the contour furrows were installed at a density of 1,650 m/ha. On Area III the gully plugs were installed at a rate of 8.65/ha and contour furrows were installed at a rate of 1,162 m/ha. At the time of treatment all areas were broadcast seeded to crested wheatgrass (*Agropyron cristatum*) and Indian ricegrass (*Oryzopsis hymenoides*), though generally only the crested wheatgrass became established around the treatments.

### Erosion Transects

Erosion transects covered a 1.83-m span, and measurements were made from a metal bar (with 18 holes spaced equidistant along it) placed across the top of the end stakes. Measurements were taken by sliding a rod down through guide holes in the reference plane to the first contact with the soil surface and then measuring the distance from the soil surface to the top of the reference plane. Readings were taken in the fall, winter, spring, and then periodically during the summer season; particularly after storms producing overland flow of water (Fig. 1).

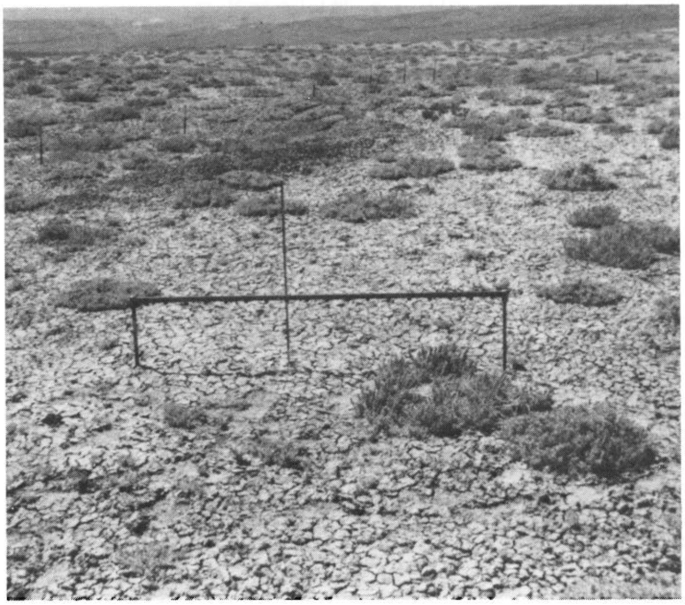

**Fig. 1.** *Erosion transect used for determining soil loss or deposition during various seasons on the Cisco study site.*

Ten transects were placed across the furrows in each of Areas I, II, III, and IV; ten were located across small active gullies; and ten were placed in areas not affected by any treatment, to act as control, with the exception of Area I, where 13 were located. Ten pits in areas II and III were selected for erosion transect measurements. In the bottom of these gully plugs three transects were located in the form of a **T**, for a total 30 additional transects on each area. Those above-described erosion transects were referred to as *furrow transects, gully transects, control transects,* and *pit transects*.

### Pit Stakes

In each of areas II and III, 40 pits were randomly selected and a steel fence post was driven into the ground in the lowest part of the basin (Fig. 2). The stakes were measured from the top of the stake to the ground surface at the base of the stake during fall, winter, spring, and after summer storms. The purpose of these stakes was to determine the rate at which the pits were being filled with sediment, so that life expectancy of the pit treatment might be determined.

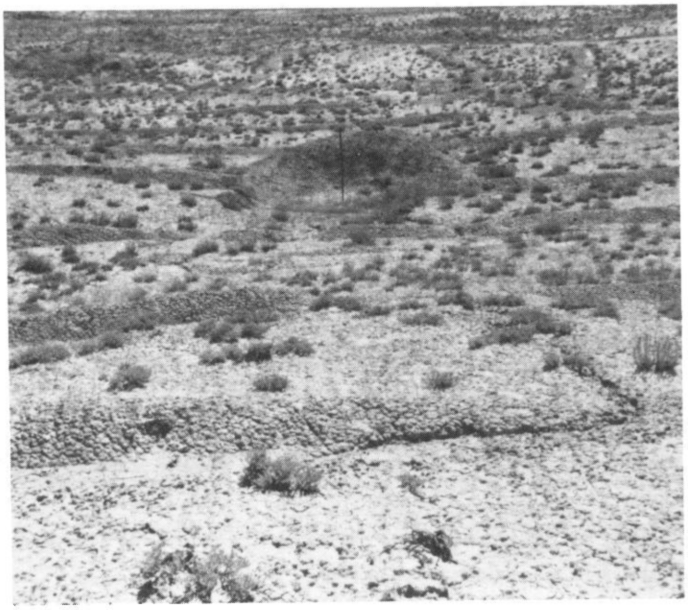

**Fig. 2.** *Gully plug with a pit stake (steel fence post) driven into ground in the lowest part of the basin.*

## Results and Discussion

### Area I

Erosion transects on Area I (sandy loam soils) were initially measured on July 10, 1966. Over the measurement period of September, 1966, to September, 1969, the furrow transects showed an average deposition of 0.42 cm in the furrow bottoms and an average decrease of 0.98 cm from the top of the spoil bank. The deposition in the furrows amounted to a total of 5.7 metric tons (MT) of sediment caught per ha, or an average of 1.9 MT/ha/year (Table 1).

**Table 1. Contour furrow storage and life expectancy.**

| Area | Total storage[1] (MT/ha)[2] | Effective storage[3] (MT/ha)[2] | Rate of filling (MT/ha)[2] | Life expectancy (years) |
|---|---|---|---|---|
| I | 45.6 | 22.8 | 1.9 | 12 |
| II | 168.7 | 84.4 | 7.2 | 12 |
| III | 120.3 | 60.2 | 5.7 | 11 |
| IV | 82.8 | 41.4 | 6.0 | 6 |

[1] Total storage is the volume of sediment the furrows could hold if they could be completely filled with sediment.
[2] Metric tons per hectare.
[3] Effective storage is the total volume of sediment the furrows are capable of holding due to the slight slope of the furrows.

### Area II

Furrow transects on Area II (silty clay loam soils) showed an average deposition of 0.44 cm in the furrow bottoms and an average decrease of 0.97 cm from the top of the spoil bank. The deposition in the furrows amounted to 21.6 MT/ha of sediment, or an average of 7.2 MT/ha/year. With the furrows filling at the rate of 0.44 cm/year, it would take 12 years for the furrows to fill to one-half of their capacity and reach their life expectancy (Table 1).

The measurements of pit stakes in gully plugs over a period of 4 years, from September, 1965, to September, 1969, indicated an average deposition of 4.5 cm/year, which is equivalent to 1.7 MT of sediment per year per pit or 7.1 MT/ha/year. From observation of pits in the areas treated prior to the study (north of Cisco) it was apparent that when a pit fills with sediment to approximately three-fourths of its storage capacity, its life expectancy is reached. With the pits in this area filling at the rate of 4.5 cm/year, it would take 14 years to fill to their useful capacity (Table 2). The total storage capacity of the furrows and pits in Area II is 367.0 MT/ha. At the present rate of sedimentation, the structures are accumulating a total of 14.3 MT/ha of sediment per year.

**Table 2. Pit storage and life expectancy.**

| Area | Pits per hectare | Effective storage (MT/ha)[1] | Rate of filling MT/ha/year | cm/year | Life expectancy (years)[2] |
|---|---|---|---|---|---|
| II | 4.2 | 100.0 | 7.1 | 4.53 | 14 |
| III | 8.6 | 60.5 | 1.8 | 1.12 | 33 |

[1] Metric tons per hectare.
[2] Based on filling to three-fourths pit capacity.

### Area III

The furrow transects on Area III (silty clay soils) indicated that deposition in the furrows amounts to 17.1 MT/ha of sediment caught and an average rate of 5.7 MT/ha of sediment per year (Table 1). Many furrows on both areas II and III had already failed by the end of the study due to poor construction methods (furrows not on the contour). Severe cracking of the soil in this area caused many furrows to fail due to piping. With the furrows in this area filling at the rate of 0.49 cm/year, (based on 4 years data) the projected life expectancy of the furrows was 11 years (Table 1).

The average size of gully plugs in Area III was 3.4 m wide by 4.0 m long by 0.49 m in depth. With the pits filling at the rate of 1.12 cm/year, as determined by measurements of the pit stakes, it will take 33 years to reach the three-fourths capacity mark, which is considered the effective life of the treatment, as discussed for Area II. During the study period the pits filled at the average rate of 0.2 MT/pit/year, of 1.8 MT/ha of sediment per year (Table 2). The total sediment caught by both furrows and pits was 6.9 MT/ha/year with the furrows catching nearly six times as much sediment as the pits were collecting at the time.

### Area IV

The average size of furrows on Area IV (silty clay soils) was 9.30 m long by 0.62 m wide by 0.10 m in depth. The total holding capacity of these furrows was 56.3 $m^3$/ha or 82.8 MT/ha. When filled to capacity (50% of constructed capacity), they will hold 41.4 MT/ha of sediment. These structures were filling at the rate of 0.85 cm per year, which was the fastest rate of filling of any of the furrows on the four treated areas. At this rate of filling, the furrows will reach their life expectancy in just 6 years (Table 1).

## Summary and Conclusions

Active erosion in the Upper Colorado River Drainage, of which the eastern Utah desert is typical, results in rapid sedimentation of Lake Powell and other man-made structures on the Colorado River. The sedimentation of these reservoirs will materially reduce their storage capacity and useful life. To reduce the rapid rate of sedimentation, contour furrows and gully plugs have been constructed on some of the more seriously eroded lands in the Cisco Basin to hold the sediment on site.

Contour furrows and gully plugs were found to be effective in catching and holding sediment; however, difficulties in constructing the furrows on the contour resulted in a shortened useful life of the structures. Areas II and III treated with both contour furrows and gully plugs held all runoff and sediment on site, while Areas I and IV treated with contour furrows alone, held only a portion of the runoff and sediment. It was apparent from the study that the greater the density of furrows and gully plugs, the longer the life expectancy of the treatments. It was also apparent that the amount of sediment moving in an area has a substantial effect on the life expectancy of the treatments. The rate of sediment accumulation in gully plugs and furrows combined varied from 1.9 MT/ha/year on Area I to 14.3 MT/ha/year on Area II.

Projected life expectancy of the contour furrows ranged from 6 to 12 years; for the gully plugs the range was from 14 to 33 years.

Using data from this study and data from other studies on the same area (Hancock 1968; Wein and West 1972, 1973), an economic analysis (Workman and Keith 1975) indicated that for every one dollar invested in the project there was only 12 cents returned in benefits.

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