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Rangeland Ponding Dikes: Design Criteria

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Abstract

Water ponding is used for controlling onsite and runon water while increasing infiltration and soil water storage. The dikes are constructed in a crescent or horseshoe shape, with the first dike constructed at the highest elevation on the site and additional dikes at progressively lower elevations. Some factors affecting dike construction, layout and spacing are water ponding depth, percent slope, soil type, and site topography. Such dikes have improved soil water regime on arid rangelands by increasing the infiltration opportunity and have decreased the soil erosion potential by controlling overland flow.

Degenerated rangelands producing low amounts of herbage present a serious problem in the arid Southwest. Low, sporadic rainfall and high summer temperatures plus an eroded soil surface make improving rangeland in the Southwest very difficult.

On some sites the erosive forces of wind and water remove the surface soil, exposing a subsoil that is, or subsequently becomes, impermeable to water (Tromble et al. 1977). Such areas are commonly near basin floors and usually have silty or clayey soils, which seal rapidly under the impact of raindrops.

The most outstanding characteristic of these arid sites is their extremely low production of herbage. These sites are essentially wasteland supporting little vegetation (Cunningham et al. 1974). They have some value as catchments for earthen tanks, although the high yields of runoff from the impermeable surface mean that only a relatively small surface area is needed to fill a tank.

Hubbell and Gardner (1944) stated that cattle and sheep prefer areas flooded by water spreading, and that these areas can withstand heavy grazing without being overutilized. Peterson and Branson (1962) evaluated structures built by the Civilian Conservation Corps in New Mexico and Arizona. Although many of the structures failed within the first years, Peterson and Branson reported that in many instances vegetation composition had been improved. Valentine (1947) analyzed a number of schemes for manipulating runoff on dry rangelands and reported that in some cases little or no response was obtained because of soil factors.

Water ponding is a method used for controlling onsite and runon surface water flow while increasing infiltration and soil

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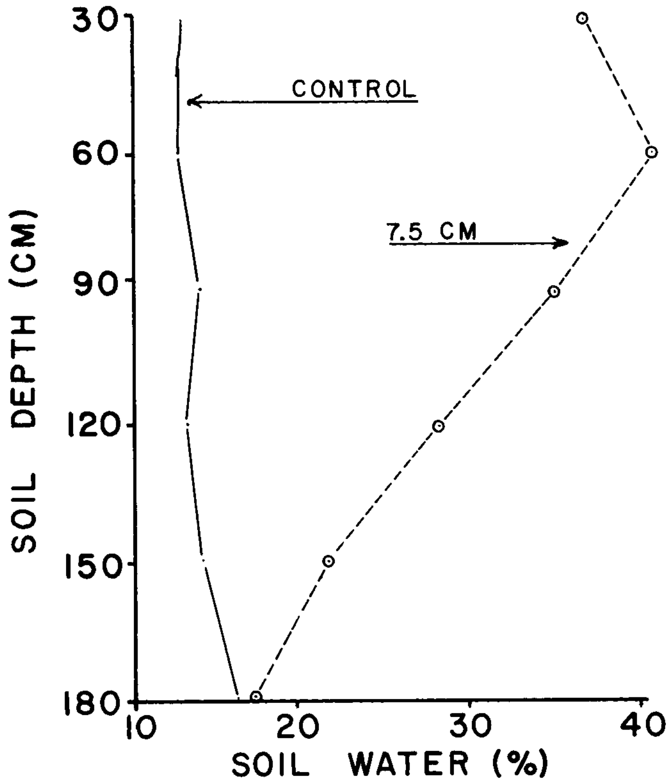

Fig. 1. *Soil water profiles for the control treatment and the 7.5-cm water ponding dikes on July 31, 1979.*

water storage (Tromble, in press). This method involves the ponding of shallow sheets of water on land subsequent increased infiltration to achieve additional storage of soil water for plant growth.

In this paper I discuss a technique of water ponding on range that uses a series of crescent-shaped dikes and describe general criteria for design and construction of the dikes.

Improving the Soil Water Regime

A major problem in reclamation of barren eroded soils is providing and maintaining an adequate supply of soil water in the plant rooting zone. This problem is accentuated on arid rangelands because of the low total quantity of rainfall, low infiltration, and high runoff rates. Tromble et al. (1977) reported that infiltration rates were low, and rainfall events of 5 mm produced runoff from barren rangeland sites in southern New Mexico.

Water ponding at a depth of 7.5 cm increased the amount of soil water storage in a silt loam soil as shown in Figure 1. Soil water was not limiting to plant growth at or below the 20-cm soil depth in the ponding sites. Ponding water also greatly lengthened the time soil water was available for plant growth. Although the 7.5-cm water ponding depth increased soil water throughout the measured soil profile, soil water gradually decreased in the soil profile below 60-cm depth. This indicates that ponding water at 7.5 cm in depth would provide additional water in the plant rooting zone but would limit water lost to deep seepage on silty loam soil.

Periodic sampling of soil water on a control site indicated that very little water infiltrated the soil surface even after heavy rains. Consequently the soils remain more or less permanently in a near air-dry state, so that revegetation would be extremely difficult. Observations made on barren areas support this and suggest that such barren areas are essentially a permanent feature in arid regions. Infiltration data (unpublished) for the control and the water ponding area indicated that infiltration rates remained low 2 years after treatment. The advantage of water ponding in this situation is the increase in the length of time over which water is ponded and available for infiltrating the soil. Once runoff is controlled and erosion reduced either natural regeneration of forage species can occur or accepted range seeding techniques can be used for revegetation of the treated areas.

Design and Construction

The dikes are designed to form a crescent or horseshoe shape with water spilling around either or both ends. Water may be guided across the slope by dikes designed so that one dike spills into the next lower dike. Placement of dikes on a slope begins at the highest point and progresses toward the lower areas so that the dikes are not overtopped and subsequently washed out. Identifying the points with flags as they are surveyed will reduce the confusion that could result when many dikes are laid out before construction is begun.

Dikes should be surveyed by use of either a dumpy level or similar survey equipment. Normal surveying procedures are followed with survey points flagged every 30 m. If the site is extremely variable in relief and slope, points may have to be more closely space. Each dike is surveyed as a succession of flagged points with the end points upslope to allow the desired water ponding depth. Length of the dike can be varied to fit the site best. Once the maximum ponding depth has been surveyed, points can be surveyed on the same level to include a greater area within the pond before establishing the other end point of the dike. If enough area for water ponding has already been included within the dike, or if site constraints limit dike length, dike end points may be established as soon as maximum depth has been attained. Normally, individual dikes should not exceed 300 to 500 m in length, because the water flow for longer dikes becomes increasingly large and difficult to control. Thus, a series of shorter dikes across the slope with gaps between them that permit passage of surplus water is the preferable arrangement.

The direction of water flow can be regulated by locating one end of the dike higher than the other so that water flows out the lower end (see Fig. 2). If the dike is constructed with both ends at the same elevation as in Figure 2-B water will flow in both directions. The scheme as shown in Figure 2-B would not guide water across the slope.

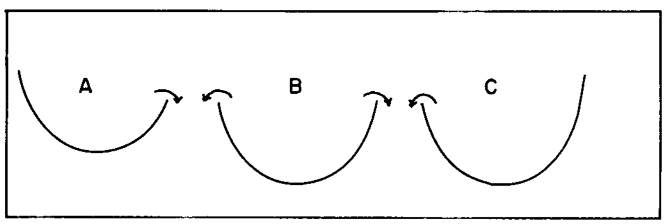

Fig. 2. *Schematic of dikes showing direction of water flow (A) around the right end, (B) around both ends, and (C) around the left end of the dike.*

As Figure 3 illustrates, water that normally would flow around the left end of the upper dike to the dike directly below it, can be diverted by construction of a wing dike across the slope. Wing dikes should be surveyed to have a slight slope so that the water flows unimpeded but not rapidly enough to cause serious soil erosion.

The distance between each series of dikes is a function of the slope and water ponding depth. Enough distance between dikes can be left to provide a source area for runoff water. Usually a 2:1 or 1:1 water runoff area to ponding area is satisfactory. The depth of water ponding is governed by the slope of the site, the infiltration rate of the soil, and the susceptability of the plants to drowning. For example, on silt loam soils having a low infiltration rate and a slope of less than 1%, a water ponding depth of 7 to 8 cm has proven satisfactory. Ponding depth may vary on a given site and from one site to another. It is generally economically impractical to pond water over all of a site. There are usually portions that can not be included within the ponding area because of the complexities of

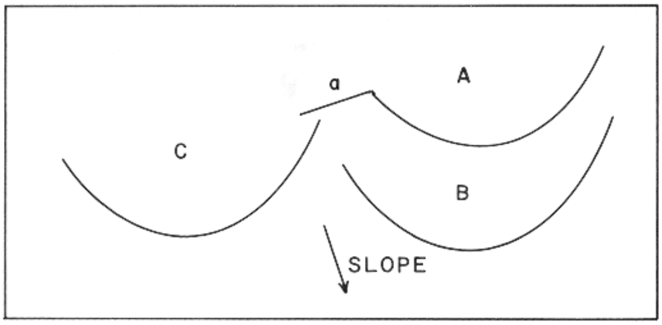

Fig. 3. *Schematic of dikes showing the use of a wing dike to transport the flow of water in a particular direction.*

site relieaf. These unponded areas provide runoff for the ponded portions and thus form an integral part of the overall ponding system.

Ponding water at a depth of 7 to 8 cm has stimulated plant growth on silt-loam soils, plant production has more than doubled as compared with untreated areas (unpublished data). Although the range of water ponding depths varies, less permeable soil requires ponding water at shallower depths than soils with greater permeability, because prolonged ponding may kill desirable plants.

Equipment used for the construction of dikes may vary, but the dikes constructed using a motor grader have proven more practical and economically satisfactory in trials on the Jornada Experimental Range (Fig. 4). Satisfactory dikes may be constructed using a farm tractor and plow, but usually these are smaller and require considerable maintenance. The surveyed line represents the lower toe of the constructed dike. The number of passes the motor grader makes depends upon the soil type and water content and the desired height of the dike. When completed, the dike should have a round rather than a V-type crest since the rounded crest is less affected by livestock trampling. The dikes should be constructed high enough to allow for settling of the loose soil material and should have a minimum freeboard of about 30 cm after settling. For example, for water ponded at the 7 cm depth, the constructed height of the dike after settling should be about 37 cm above the original ground level. Broad-based dikes with a bottom width of 2 to 3 m are more stable than narrower dikes.

Construction of the dikes from the downslope side has the advantage of better utilizing rainfall from small showers. When the dike is constructed or partially constructed from the upslope side, runoff from small showers is usually contained in the upslope furrow.

Sharp curves in the dikes should be avoided if possible. Dikes with sharp curves are difficult to construct using a motor grader, and the portion of the dike with the sharp curve tends to have a V-shaped crest, which is more vulnerable to degradation. It would be preferable to survey each dike to form smooth, easily constructed curves even though the grade along the dike is somewhat irregular.

Fig. 4. *Dike construction using a motor grader. The dike is being constructed from the lower side.*

Summary and Conclusions

Water ponding is a rangeland improvement technique adapted to gently sloping terrain for improving the soil water regime. Design of the dikes is regulated by the slope of the land and the particular soil type of the site. Layout of a complete system is rapid and is accomplished using an inexpensive dumpy level. Flow of water is controlled and can be maneuvered over the landscape. Controlling the flow of water reduces erosion and sedimentation.

Dikes should have a rounded crest which is less susceptible to degeneration and trampling by livestock. Finished dikes should have approximately 30 cm of freeboard above the ponded water surface to reduce overtopping by wave action and allow for erosion by wind and water. Revegetation in the ponding areas can occur either through natural regeneration or by use of accepted range seeding techniques.

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