Reprinted from the
Proceedings of the First International Rangeland Congress
1978 • Pages 292-294
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Water Harvesting: An Aid to Range Management

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Highlight

Water harvesting — the collection of natural precipitation from specially prepared watershed areas — has provided water for livestock and wildlife in parts of northwestern Arizona where perennial streams are absent, and springs and groundwater are rare. Two separate units with paraffin-wax-treated catchment aprons and 300,000-liter storage tanks, have provided water continuously, since their installation in September 1974, at costs of $4.15 and $3.90/1000 liters, which is less than piping or hauling costs in this area.

The establishment of these two reliable water supplies has allowed initiation of rest-rotation-grazing systems, thus improving range forage conditions, management alternatives, and range suitability or utilization, even during droughts.

Thousands of hectares of western rangeland are inefficiently used because of poorly-spaced or inadequate water supplies — water, rather than forage, is limiting optimum livestock production. Water harvesting — the process of collecting natural precipitation from a prepared watershed — could provide the needed water supplies, and thus better management alternatives for many of these areas.

Water harvesting has been successfully used for years to supplement water supplies in northwestern Arizona. It is one of the most feasible methods for supplying water to livestock in much of this area, because perennial streams and springs are rare, and groundwater is inaccessible due to depth and isolation of perched water aquifers. Installation of an adequate grid of watering spots through pipelines and hauling is expensive because of the great distances between existing reliable supplies. Earthen reservoirs are often used, but are rarely dependable because of high seepage, evaporation losses, and low runoff.

Two water harvesting systems, with paraffin-wax-treated catchment aprons, were installed in the northwest portion of Arizona — the Arizona Strip — in September 1974, at costs substantially less than those of common catchment materials, like concrete, rubber, and sheet metal. This paper reports on the materials used, the costs of installing and maintaining the total system, and the management alternatives provided.

Description of Water Harvesting Systems

Slope catchment (0.4 ha) is located about 72 km south of St. George, Utah, in Hurricane Wash. Average annual precipitation is about 30 cm, approximately half of which falls in winter as rain and snow showers, and the other half in summer as thundershowers (Sellars and Hill 1974). The catchment apron was constructed on a clay loam soil with a 5 to 8 percent slope.

The Snap Point catchment (0.3 ha) is located about 160 km south of St. George in an area that receives a 30- to 40-cm annual precipitation with a seasonal distribution similar to that at Hurricane Wash. The catchment is constructed on a sandy clay loam soil at a 5 to 8 percent slope.

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The report is a contribution of the U.S. Department of Agriculture, Agricultural Research Service, and U.S. Department of Interior, Bureau of Land Management.

The apron treatment, storage tank, evaporation-suppressing cover, connecting pipes, and fencing were the same at both sites. The treatment consisted of applying 53 C average melting point (AMP) paraffin wax to the soil surface at a rate of 0.92 kg/m². The block wax was hand loaded into a 7,570-l-capacity asphalt distributor truck and then melted to 132 C with the truck's burners. Once the entire 3000- to 4000-l load was melted (4 hr), it was sprayed onto the catchment area in only 30 min through the truck's spreader bar.

Water collected is stored in a 300,000-l tank with steel sides and concrete bottom. The multiplate corrugated sectional steel sides were bolted together and their joints sealed at the site. After assembly, a 15-cm reinforced concrete floor was poured using ready-mix concrete. Water is conveyed from the catchment apron to the tank by a 38-cm-diameter corrugated steel pipe. Evaporation is controlled by a floating cover made of 0.6-cm-thick closed cell synthetic rubber that is slightly smaller in diameter than the steel tank. The floating cover is protected from blowing or floating off the tank by galvanized wires stretched across the top, and by a series of holes in the tank wall, near the top, for overflow. Water is supplied to a trough through a 3-cm plastic pipe, using a float valve in an underground freezeproof float box for water level control. The entire water harvesting system, except the trough, is surrounded by a 2.4-m-high net wire fence to prevent damage by livestock and wildlife.

Estimated Water Balance

An estimated water balance — inflow minus outflow equals change in storage — was calculated for each site based on available data. Inflow, or the amount of water collected, was determined from annual rainfall amounts and runoff efficiencies of the catchment aprons. Although rainfall measurements are made at several locations near the catchments, readings were somewhat sporadic, since they were only taken when these remote areas were visited for other purposes.

We estimated runoff efficiency — inflow — for the first year to be 90 percent based on measured rainfall and runoff from similarly treated plots at the U.S. Water Conservation Laboratory's experimental test site (Fink, Cooley, and Frasier 1973), and observations of runoff during rainfall at the sites. Measurements obtained using portable simulated rainfall equipment on each site during the second and third years showed the runoff efficiency at Slope remained at 90 percent, while that at Snap Point gradually decreased to 75 percent.

Outflow consisted of water evaporated, used, including any water hauled from the site, or that spilled or overflowed, which occurred several times. Evaporation from the storage tanks was estimated using data presented by Cooley (1970) and the evaporation reduction efficiency reported by Cooley and Myers (1973) for similar foamed rubber covers. Spilled water was estimated from observations at the sites.

We estimated the amount of water used from data on the number of cattle in the area, the length of time they were there, and reported amounts of water consumed each day in other studies (Schulz and Austin 1976). About 40,000 l of water was hauled from the Slope catchment facility to aid in compaction of watershed aprons and the curing of concrete tank bottoms of two newly constructed wax apron catchments.

The amount of water in storage near the 1st of September each year was recorded by U.S. Water Conservation Laboratory personnel during annual inspection visits.

A summary of all inflow, outflow, and storage factors for each site is presented in Table 1 on an annual basis for the 3 years of operation. During the first 2 years of operation at Snap Point, other water was available in the area, and we assumed that water used by the cows was equally divided between the two sources. In the third year, the Snap Point system furnished essentially all of the water when the other sources were unreliable due to drought. Total water in storage is equal to the amount carried over from the previous year plus the amount gained or lost during the current year.

Cost of Water Harvesting Systems

Adequate cost records for equipment, labor, and material were kept during construction of these two systems. Table 2 presents the cost data for Slope catchment. Costs for Snap Point were similar, totaling $8925 for the slightly smaller unit. Contract costs in 1976 for constructing similar units were about $15,000/unit.

Cost of Water Provided

More important than the cost of the water harvesting system is the cost of the water provided by the unit. The cost of usable water can be estimated by dividing the total cost of the systems (Table 2) by the total amount of water required during the 3 years of operation, plus the amount of water in storage in September 1977. As shown in Table 3, this would amount to $4.15 and $3.93/1000 l for Slope and Snap Point catchments, respectively. Thus, the water provided would cost less than water supplied by piping at $1200 to $3000/km (Peden 1971), or the $4 to $10/1000 l to haul water (Roberts 1971).

A more realistic approach would be to amortize the cost of the systems over at least 10 years. Maintenance and retreatment cost must be added to initial costs in this case. Estimated costs based on these assumptions were calculated to be $1.52 to $1.92 per 1000 l (Cooley, et al. 1976).

Regardless of the method used to determine the cost of the water collected, this method of supplying water is competitive with other methods, like hauling or piping. Of even greater economic benefit is the water saved by the floating foamed rubber cover. As shown in Table 2, these covers cost $350 each. Amortized over a 10-year period, this amounts to about $52/year. Evaporation rates at both sites were estimated to be over 180 cm/year (Cooley 1970), which would amount to 190,000 l of water. Cooley and Myers (1973) found that these floating

Table 2. Cost of water harvesting system (September 1974).

Apron:	Paraffin wax	1250
	Truck and driver (5 hrs at $38/hr)	190
	Soil sterilant	100
		$1540
	(Cost per square meter of apron ($.39/m²))	
Tank:	300,000 liter, steel sides	2900
	Concrete bottom (20 m²)	670
	Reinforcing wire, seam sealer, etc.	265
	Floating 0.6-cm foamed rubber cover	350
		$4185
	(Cost per 1000 liters of storage ($13.95/1000 liters))	
Other:	38-cm culvert with flared end	1000
	76 m of 3-cm pipe, water trough	175
	2.4 m net fencing and barbed wire	450
		$1625
Installation: BLM crews and equipment		$1800
Total cost of system		$9150

Table 1. Estimated water balance (liters) for 3 years at Slope and Snap Point catchments.

Slope Catchment

	Sep 74 - Sep 75		Sep 75 - Sep 76		Sep 76 - Sep 77	
Inflow	27 cm rainfall @ 90% runoff =	1,000,000	20 cm rainfall @ 90% runoff =	730,000	16 cm rainfall @ 90% runoff =	585,000
Outflow	Evaporated =	20,000	Evaporated =	20,000	Evaporated =	20,000
	Used — 70 head for 270 days @ 38 l/day =	720,000	Used — 100 head for 150 days @ 38 l/day =	570,000	Used — 100 head for 150 days @ 38 l/day =	570,000
	Hauled =	—	Hauled =	30,000	Hauled =	10,000
	Spilled	20,000	Spilled	60,000	Spilled	30,000
	Total =	760,000	Total =	680,000	Total =	630,000
Change in Storage	1,000,000 − 760,000 = 240,000		730,000 − 680,000 = 50,000		585,000 − 630,000 = − 45,000	
Total in Storage	0 + 240,000 = 240,000		240,000 + 50,000 = 290,000		290,000 − 45,000 = 245,000	

Snap Point Catchment

	Sep 74 - Sep 75		Sep 75 - Sep 76		Sep 76 - Sep 77	
Inflow	27 cm rainfall @ 90% runoff =	750,000	30 cm rainfall @ 80% runoff =	740,000	38 cm rainfall @ 75% runoff =	870,000
Outflow	Evaporated =	20,000	Evaporated =	20,000	Evaporated =	20,000
	Used — ½ of 150 head for 200 days @ 38 l/day =	570,000	Used — ½ of 150 head for 200 days @ 38 l/day =	570,000	Used — 200 head for 150 days @ 26 l/day =	770,000
	Spilled	30,000	Spilled	20,000	Spilled	40,000
	Total =	620,000	Total =	610,000	Total =	830,000
Change in Storage	750,000 − 620,000 = 130,000		740,000 − 610,000 = 130,000		870,000 − 830,000 = 40,000	
Total in Storage	0 + 130,000 = 130,000		130,000 + 130,000 = 260,000		260,000 + 40,000 = 300,000	

Table 3. Cost of required water collected at Slope and Snap Point catchments.

	Slope	Snap Point
Water Used Plus Evaporated		
74-75	740,000	590,000
75-76	620,000	590,000
76-77	600,000	790,000
Water in Storage September 1977	245,000	300,000
Total Water Available	2,205,000	2,270,000
Cost of Water Provided	\$9150 / 2,205,000 liters = \$4.15/1000 liters	\$8925 / 2,270,000 liters = \$3.93/1000 liters

foam rubber covers reduced evaporation losses ~~to~~ by about 90 percent, which would save over 170,000 l/yr of water at each site, costing about \$0.31/1000 l, or less than one-fifth the cost of collecting the water originally.

Improved Use of Range Forage

The Slope catchment was constructed as an alternate water supply for a large earthen reservoir, which is unreliable and has only contained water for approximately 4 months during the past 2 years. The Slope catchment has provided a continuous water supply, which allowed establishment of a rest-rotation-grazing system and improved livestock distribution, which is necessary for proper gain or maintenance of a cow-calf operation.

The Snap Point catchment services about 3600 ha. The nearest source of generally permanent water is located 10 km away. This pasture is one of three now grazed during the winter using a rest-rotation-grazing system. Before the catchment was constructed, the user could only winter about 30 to 50 cows with calves, who had to rely on water from a small spring, earthen reservoirs, or snow, or have water hauled to them. Since construction of the catchment, 200 cows with calves can be wintered for 5 to 6 months. The improved livestock distribution and the initiation of a rotational grazing system, permitted by this catchment, have allowed the deteriorated rangelands immediately around the limited traditional water sources to improve considerably.

Discussion

Bureau of Land Management range managers have found that unless they have a dependable water supply in each pasture, grazing systems never seem to operate on schedule. The availability of water usually dictates the grazing treatments, which often do not agree with sound management practices. Reliable water sources substantially increase the management options available to a range manager when drought, insects, fire, etc., injure the vegetative resource.

Ranchers have remarked that these water harvesting systems are as good as, or better than, a spring. During the drought of the past couple of years, without these catchments, users would have had to move their cattle to non-federal rangeland. This would have placed a tremendous financial burden on them, and undoubtedly have forced them to greatly reduce the size of their base herds.

These two water harvesting systems have proven to be well worth their cost to local ranchers. Besides the many units being installed on public lands since 1974, local ranchers, after consulting with Bureau of Land Management and Agricultural Research Service personnel, are installing their own. Thus, water harvesting has provided water where other means were not feasible, and has increased range management options and improved range usage.

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