RELIABILITY OF SUPPLEMENTAL IRRIGATION SYSTEMS

by

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B.S., University of Kansas, 1978

A MASTER'S REPORT

submitted in partial fulfillment of

the requirements for the degree

MASTER OF SCIENCE

Department of Civil Engineering

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1981

Approved:

Major Professor

SUMMARY

By daily simulation, using historic weather data, a computer model evaluates reliability of a supplemental irrigation system in Riley County, Kansas. Irrigation application rate and drainage area are found to influence system reliability.

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INTRODUCTION

Rainfall in the Manhattan area peaks during May to July and then drops off for the rest of the growing season. Stress in crops and possibly reduced yields, due to poor distribution of rainfall during the growing season, occurs. This often leads farmers to consider surface and subsurface irrigation water supplies.

Due to the topography, most irrigation in Riley County is confined to the Kansas River valley. The eastern half is often steep and rocky, typical of the flint hills. A loess mantle overlies the western half, mitigating the undulation and permitting tillage in deep silty clay loams. This mixed land use pattern offers small cropland fields interspersed with pasture and hayland.

The subject of this paper is such a watershed area. The L. and M. Jahnke farm, located in west central Riley County, has a dam site with 55 acres of contributing drainage area. The area is composed of approximately 50% cropland and 50% pasture. The proposed irrigation plot is 18 acres of alfalfa.

The proposed system is evaluated using a continuous simulation hydrologic model as presented in (1). The system is composed of a storage pond and an irrigation field plot. The pond stores runoff from the drainage area. The model pond is idealized as a trapezoidal volume. The model maintains an account of direct precipitation, evaporation, exfiltration, overflows, and irrigation demands for the pond.

The model field plot soil moisture is monitored. Irrigation applications, direct precipitation, infiltration, runoff, and interception are accounted for during the simulation period. Irrigation applications

are made whenever the soil moisture drops below a specified percentage of field capacity.

DISCUSSION

The computer model was calibrated for the Manhattan area by adjusting coefficients in the Penman equation as described in (1). Adjustments were made until 15.6 inches of net evaporation were obtained. This closely matches the average annual evaporation and rainfall as in (2) and (3).

The actual drainage area is composed of Irwin and Wymore soils as shown in (4). Both are irrigation design group 1 or 0.1 inch/hour intake family as described in (6). Pasture and terraced cropland on these soils yield nearly the same runoff. Therefore, the drainage area is considered as all pasture.

The storage pond was modeled as a trapezoidal volume with 12:1 side slopes, 125 x 125 foot bottom, and 13 foot deep. This approximates actual surface area to within 0.27 acres and actual volume to within 0.07 acre-foot. Seepage was assumed to be 0.06 inches/day.

The irrigation plot is 18 acres of alfalfa on irrigation design group 2 soil. Irrigation applications were 1.5 inches/day and 1.0 inch/day for two trial simulations.

Results of Simulation

The model was run for 29 years of historic weather events on a daily basis. The pond was considered to have failed whenever an irrigation application was attempted, but the pond was empty, making the full application rate, or a fraction thereof, unavailable.

The system was checked with a 900 acre drainage area in order to determine the reliability of the system.

Reliability is defined as:

$$\text{Reliability} = \frac{29 \text{ years} - \text{number of years failed}}{29 \text{ years}} \times 100\%.$$

The results are shown in Figure No. 1.

The system has a 58.6% reliability with 1 inch/day applications and 55.2% reliability with 1.5 inch/day applications. Doubling the size of the drainage area yields approximately 10% increased reliability. After about 200 acres of drainage, diminishing returns of reliability occur.

Figure No. 1 shows 1.0 inch/day and 1.5 inch/day reliability curves plotted on log-normal probability paper. Also, the 80% and 50% chance yield versus required drainage area is plotted. This was computed based on net, seasonal irrigation requirements from (5) and average annual yield values from (6).

For example, the 80% chance, net, irrigation requirement for alfalfa in Riley County is 18.2 inches. Irrigating 18 acres, the operator would need 327.6 acre-inches of water stored in a pond. The 80% chance yield from a drainage area with a CN of 82 and a II AMC is 1.1 inches. The storage pond would need 327.6 acre-inches/1.1 inches or 298 acres. The 50% chance drainage area is computed similarly.