DRAFT

| Sammis Equation Comparisons | | | | | |
|---|---|---|---|---|---|
| | | | | | |
| year | | ET(cm) | | Yield(m.tons/ha) | |
| | | | | | |
| 1982 | | 93 | | 8.5 | |
| 1982 | | 119 | | 18 | |
| 1982 | | 136 | | 21 | |
| | | | | | |
| 1981 | | 120 | | 12.3 | |
| 1981 | | 142 | | 17.5 | |
| 1981 | | 157 | | 19.5 | |
| | | | | | |
| 1976 | | 107.5 | | 9.8 | |
| 1976 | | 166.1 | | 19.23 | |
| | | | | | |
| 1977 | | 157.7 | | 14.73 | |
| 1977 | | 124.2 | | 16.83 | |
| | | | | | |
| Sammis eq. | | 200 | | 25.32 | |
| Sammis eq. | | 50 | | 5.38 | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | Yield = 0% moisture content | | | | |

# DRAFT

## Crop-Production Functions

The New Mexico Water Resources Research Institute Report No. 115, December 1979, titled "Consumptive Use and Yields of Crops in New Mexico", presents some results of research to develop relationships between crop yields and water use. This research covered selected crops produced in New Mexico and grown in Eddy, Curry, Dona Ana, San Juan, and Valencia counties. Crops that were grown included alfalfa, sorghum, cotton, barley, bluegrass, corn, and wheat. Not all crops were grown at all locations. The study years were 1976, 1977, and only Las Cruces in 1978.

This memo is focused on alfalfa and the use of the crop-production function as explained in the "Water Use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 2000", NMOSE, Technical Report 51, February 2003. The February 2003 report used the crop-production function in Bernalillo, Curry, De Baca, Dona Ana, Grant, Harding, Hidalgo, Lea, Luna, Roosevelt, Sandoval, San Juan, San Miguel, Santa Fe, Sierra, Socorro, Torrance, Union, and Valencia counties. The report "Irrigated Agriculture Water Use and Acreage in New Mexico Counties and River Basins, 1993-1995", NMOSE Technical Report No. 50, September 1998, used the same crop-production function in Bernalillo, Catron (San Augustin Plains), Curry, Dona Ana, Otero (Rio Grande Basin only), Sandoval (MRGCD only), San Juan (NIIP only), Socorro (San Augustin Plains), Torrance, and Union (groundwater irrigation only) counties.

All sites in 1976 and 1977 grew alfalfa, Mesilla variety, in lysimeters with surface flooding. In 1976 some alfalfa was new, planted in the spring of 1976, and some was new, planted in the fall of 1975, with planting dates depending upon the locations. In 1977 all alfalfa was mature. The 1978 alfalfa, Hairy Peruvian variety, was planted in the fall of 1977 and irrigated with a sprinkler-line source. All sites had evapotranspiration and yields measured. Yields were dry weight, oven dried near zero percent moisture.

Using the evapotranspiration and yield data, the points were plotted and a linear crop-production function developed. The crop-production function using both the lysimeter data and the sprinkler-line source data has a Coefficient of Determination of 0.89. When only the sprinkler-line source data is used, the Coefficient of Determination is 0.97. "Using all of the points is considered to give the best results for the alfalfa crop-production functions for the whole state." The crop-production function, as shown in the 'Water Use by Categories…' report, is Y (tons/acre) = -0.5904 + 0.1572ET (inch).

The WRRI Report No. 115 further states, "It should be noted that the crop-production functions for alfalfa, cotton, grain sorghum, and corn represent studies at more than one location within the state. It appears that as an initial estimate the crop-production function for alfalfa can be used throughout the state."

For comparison purposes, the ISC calculated evapotranspiration for seven years using the Original Blaney-Criddle method, the Modified Blaney-Criddle method, and the alfalfa crop-production function. Results of this comparison are shown in Table 1.

Table 1. Evapotranspiration Comparison NIIP Unit 3, Farmington Weather

| Year | OBC – ET (in) | Alfalfa Function – ET (in) | MBC – ET (in) |
|---|---|---|---|
| 1981 | 30.79 | 34.29 x | 34.20 |
| 1982 | 28.39 | 27.93 | 30.89 x |
| 1983 | 28.21 | 30.47 | 33.00 x |
| 1985 | 30.78 | 37.47 x | 35.82 |
| 1986 | 30.66 | 38.74 x | 33.00 |
| 1987 | 33.22 | 40.02 x | 35.12 |
| 1988 | 33.69 | 37.47 x | 36.30 |
| Avg. | 30.8 | 35.2 | 34.0 |

x = 36.0 w/ MBC & set min w/ Function (bias - ignore data scatter w/ avg. lines)

WRRI Report No. 115 states, "For alfalfa, the consumptive use is approximately the same by the two methods with the Blaney-Criddle method having slightly higher values". The Blaney-Criddle method referred to is the Original Blaney-Criddle method. These are not the results obtained by the ISC comparison. In most years, the alfalfa function gave a higher ET than either Original or Modified Blaney-Criddle. Averaging the years from 1985 to 2000 showed the alfalfa function 4.61 inches higher than the Modified Blaney-Criddle.

The statement "The use of crop-production functions, having high coefficients of determination, appears to be one of the better methods of estimating consumptive use in an area, provided reasonable estimates of yields can be determined for that area", appears in WRRI Report No. 115. Current estimates of yield are usually the average county yields published in the New Mexico Agricultural Statistics. These estimates are from surveys of producers and contain producer-generated numbers.

New Mexico Water Resources Research Institute Report No. 155 is titled "Water Use Production Functions of Selected Agronomic Crops in Northwestern New Mexico, Phase II, dated October 1982. This report discusses water-production functions for spring barley, pinto beans, and alfalfa. The alfalfa (cultivar "WL-309) was planted at the San Juan Branch Agricultural Experiment Station in the fall of 1980 (8/22/80). The experimental plot was irrigated with a sprinkler-line source and contained three lysimeters. Evapotranspiration measurements began in April of 1981 (4/09/81). The water-production function was based on the best least-squares fit of the data points, and the 1981 equation is Y (metric tons/ha) = -6.32 + 0.164(ET,cm); yield adjusted to 0% moisture.

The WRRI Report No. 159, titled "Water Use Production Functions of Selected Agronomic Crops in Northwestern New Mexico, Phase III, dated February 1983, also dealt with alfalfa, spring barley, corn, and pinto beans. The 1982 data collected for this report resulted in the alfalfa equation Y (metric tons/ha) = -17.73 + 0.284(ET,cm); assume yield adjusted to 0% moisture.

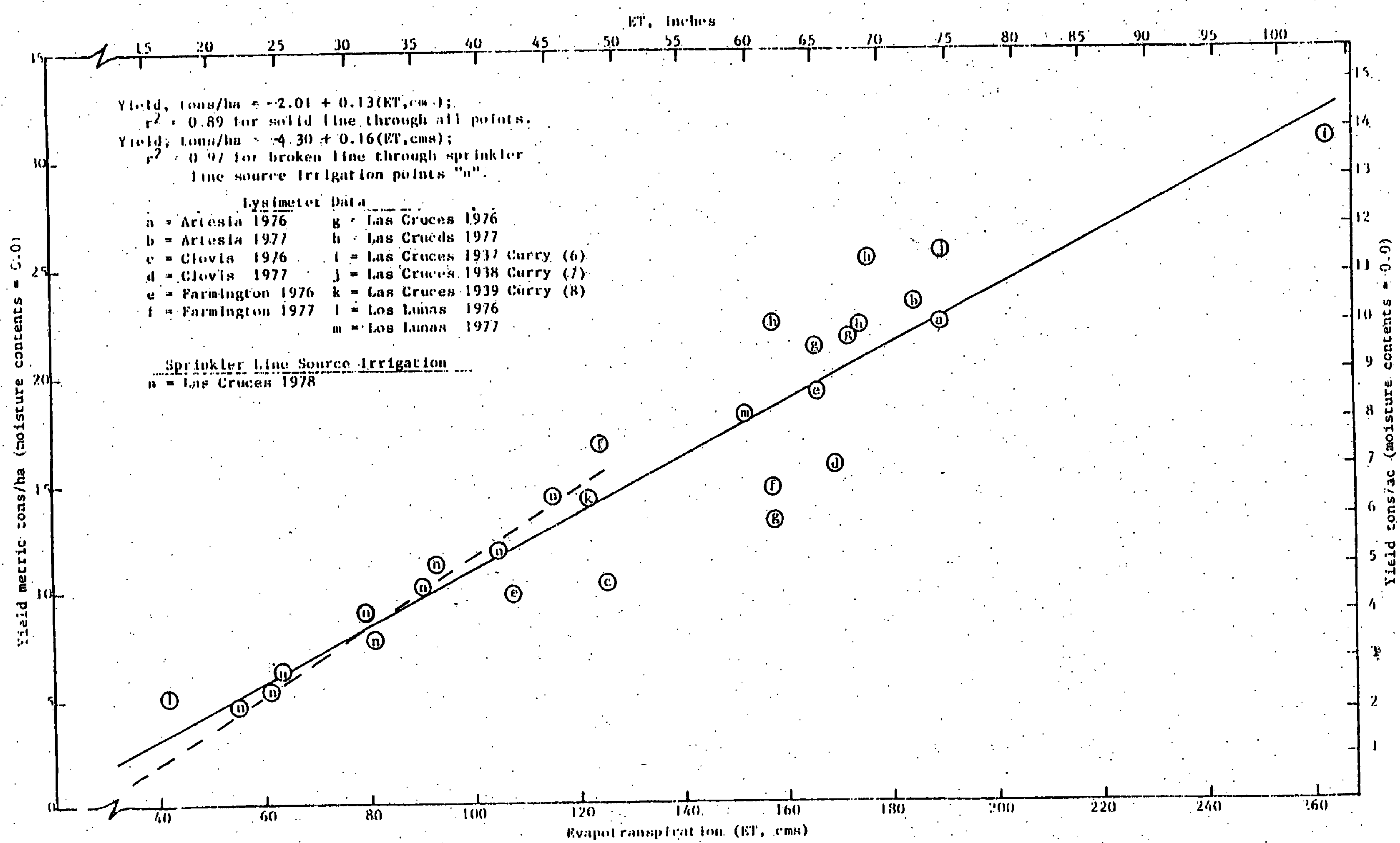


Figure 7. Crop-production function for alfalfa.

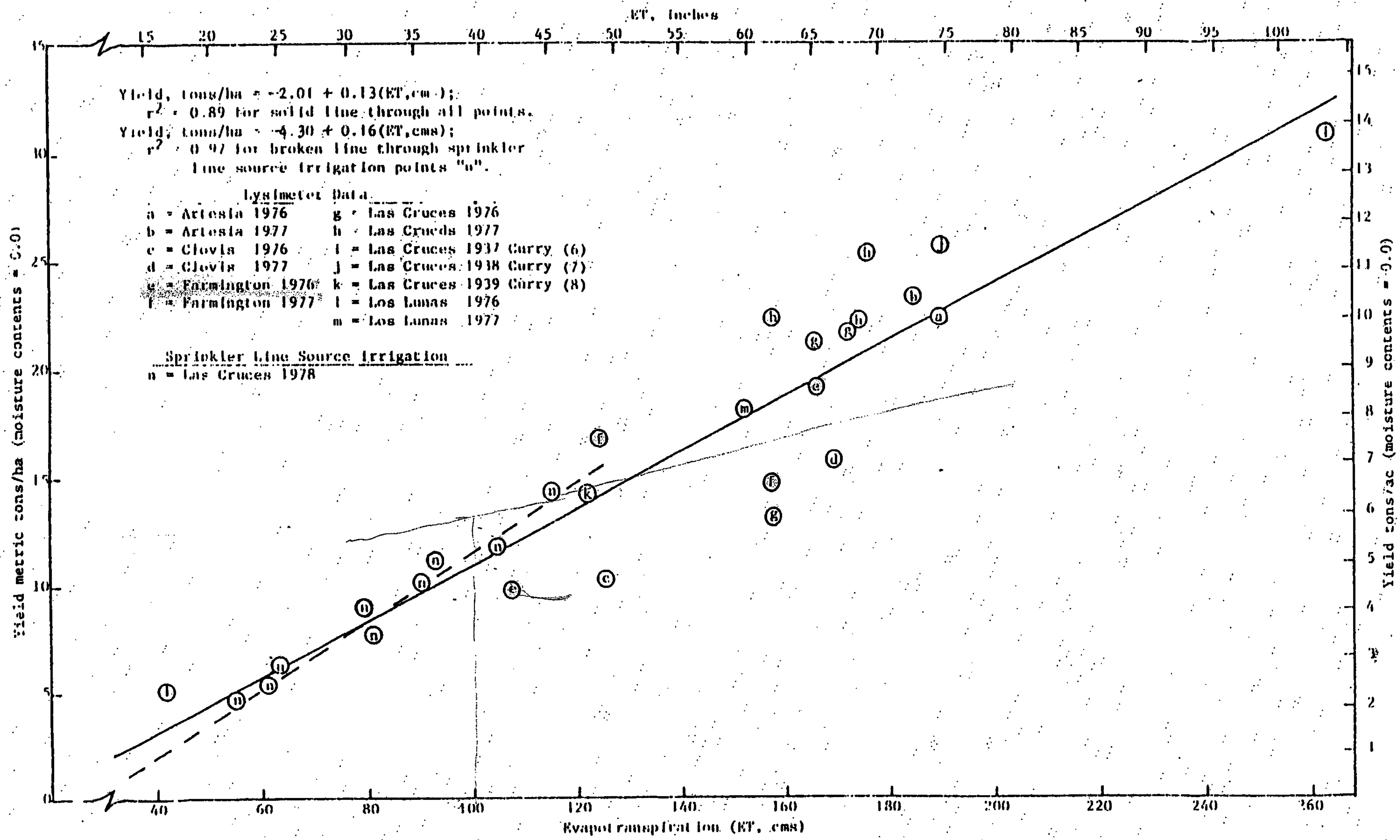


Figure 7. Crop-production function for alfalfa.

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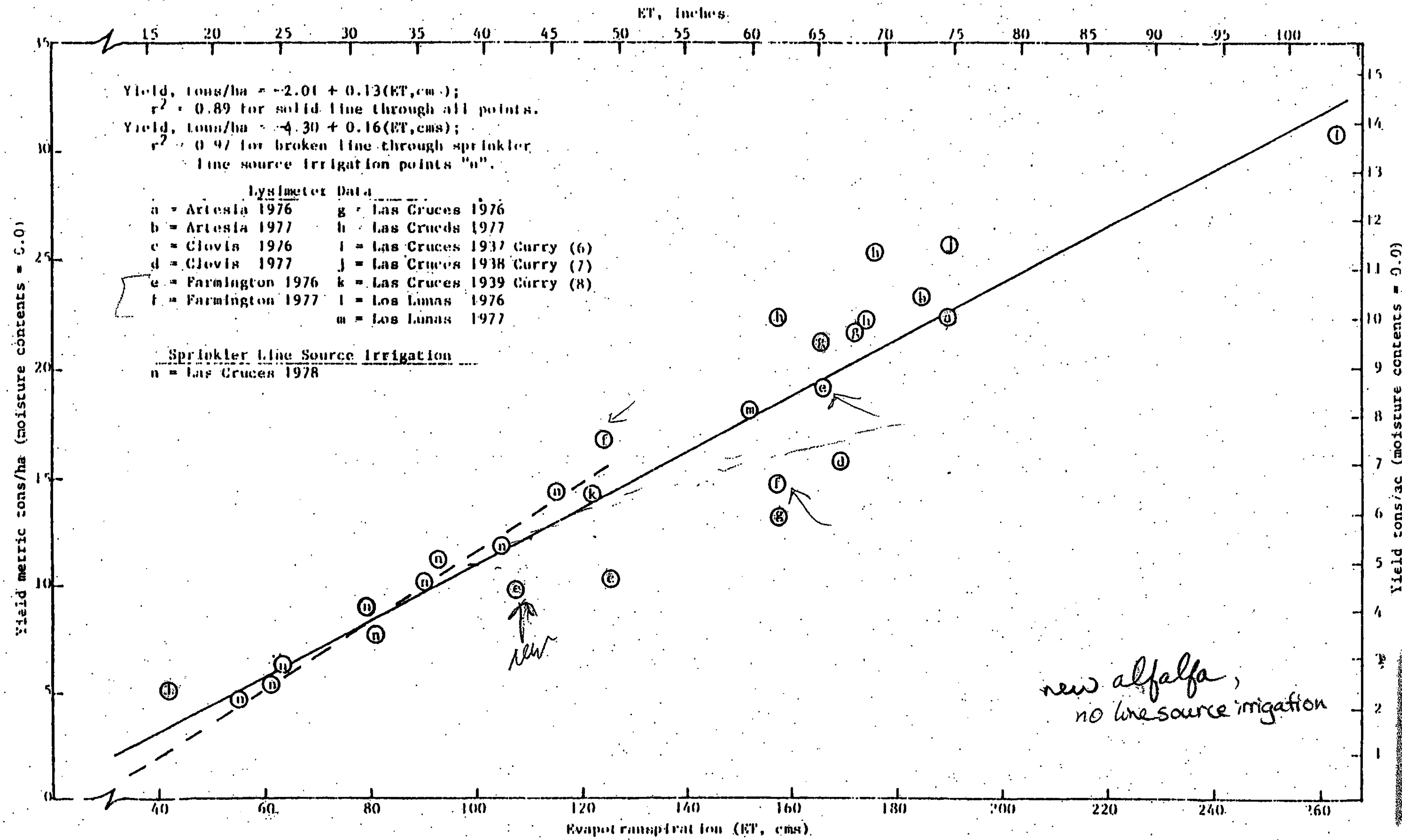


Figure 7. Crop-production function for alfalfa.

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# Estimating Evapotranspiration with Water-Production Functions or the Blaney-Criddle Method

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## ABSTRACT

SEASONAL evapotranspiration ($E_T$) for cotton (*Gossypium hirsutum* L.), corn (*Zea mays* L.), alfalfa (*Medicago sativa* L.), and barley (*Hordeum vulgare* L.) can be estimated with either the Blaney-Criddle method or county yield data with a water-production function. As used here, a water-production function is an empirical relationship between yield and evapotranspiration. Blaney-Criddle crop coefficients vary depending upon crop season $E_T$ and yield. The original Blaney-Criddle coefficients (K) resulted in $E_T$ estimates that were very close, except for corn, to the $E_T$ determined from maximum county yields and linear water-production functions. The modified Blaney-Criddle method described by Doorenbos and Pruitt (1977), overestimated seasonal $E_T$ compared to $E_T$ computed using maximum county yields and linear water-production functions. Blaney-Criddle crop coefficients determined from plot studies in NM, AZ, and CA are larger than the original coefficients and result in estimates of yearly $E_T$ that are greater than those determined using county yields and the linear water-production functions. Blaney-Criddle crop coefficients representing non-irrigated $E_T$ and yield levels are less than 35 percent of the K value for small-irrigated plot studies.

## INTRODUCTION

Since water is a scarce resource in the western United States, plans have been developed for the allocation of agricultural water based on the yearly $E_T$ of crops. The Blaney-Criddle formula (Blaney and Criddle, 1950) has been widely used for determining yearly $E_T$. The method requires the percent daytime hours, the mean monthly temperature, and a crop coefficient. The Blaney-Criddle method is widely used for computing $E_T$ for selected crops because temperature data are readily available. Criddle (1958) derived crop coefficients to calculate the average yearly $E_T$ for selected crops, within a given region, based on field measurements. His original research did not consider the relationship between $E_T$ and yield, and the effect of different levels of moisture stress on his derived crop coefficients.

Subsequently, Blaney-Criddle coefficients higher than those originally presented by Criddle (1958) were derived from measurements on non-stressed plants by investigators in CA (MacGillivray, 1975); NM (Gregory and Hanson, 1976; Sammis et al., 1979); and AZ (Erie et al., 1965). Since the conception of the Blaney-Criddle formula, research by Hanks et al. (1977), Retta and Hanks (1980); Stewart et al. (1969, 1973, 1974, 1975); and Sammis (1981) has shown that seasonal $E_T$, although estimated by weather variables, can generally be described by a linear water-production function relating $E_T$ to yield. Consequently, a range of seasonal crop coefficients can be developed depending on the desired yield.

The purpose of this research was to determine if the Blaney-Criddle approach using the original Blaney-Criddle coefficients could be used to estimate the seasonal $E_T$ necessary to produce historical average county yields, and to determine the range in Blaney-Criddle coefficients that would result from yields derived from dryland farming to high intensitive agriculture planted in small plots.

## MATERIALS AND METHODS

Water-production functions for cotton, alfalfa, corn, and barley were determined using line source sprinkler systems similar to that described by Hanks et al. (1976). The sprinklers applied a decreasing amount of water from the sprinkler line to the edges of the plot, resulting in a corresponding decrease of the $E_T$ rate and yield from the line outward. A water balance was determined for selected distances from the line where:

$$E_T = I + R - D \pm \Delta SM \quad [1]$$

where:

$E_T$ = evapotranspiration, cm
I = irrigation water applied, cm
R = rainfall, cm
D = drainage, cm
$\Delta SM$ = change in soil moisture (SM), cm

Irrigation water (I) was volumetrically measured at selected distances from the sprinkler line with cans 10 cm in diameter. Rainfall (R) was measured with a rain gauge. The change in soil moisture (SM) was measured using a neutron probe. The irrigation system was operated based on the data from lysimeters at each site so that deep drainage (D) was minimal at the sprinkler line. The irrigation was applied at night or early in the morning when the winds were calm and the evaporation

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losses from the catchman cans were minimal. The evapotranspiration data determined for each line source sprinkler were used in linear regression models with equivalent yield data to define the water-production functions for corn, cotton, alfalfa, and barley.

The alfalfa and cotton studies were conducted in Las Cruces, NM (Sammis, 1981). The alfalfa plot was planted in October, 1977 with the varieties of Moapa and Hairy Peruvian, and received 103 kg/ha of phosphorus each year. The plot was initially flood-irrigated for stand establishment, and then it was irrigated weekly using the line source sprinkler system. The alfalfa crop was harvested five times in each of 1978, 1979, and 1980. At each cutting, the alfalfa was harvested from three subplots at each level of evapotranspiration. Strips 1 m wide and 10 m long were taken from each sub-plot to measure yield at 100 cm distances from the sprinkler line to the outer edge of the sprinkler area. Evapotranspiration was calculated for each yield plot throughout the growing season using the water balance method described by equation [1]. Acala cotton plots were planted May 5, 1978 and April 19, 1979, and received 120 kg/ha of nitrogen and 120 kg/ha of phosphorus. The cotton plots received a pre-plant irrigation to ensure even germination and, subsequently, was irrigated weekly using a line source sprinkler system. Each cotton row was divided into three sub-plots each 10 m long, and harvested separately by hand at the end of the growing season on October 18, 1978 and November 28, 1979. The soil type for the cotton and alfalfa plots was a Belen clay loam (clayey over loamy, montmorillonitic [calcareous], thermic vertic torrifluvent).

The line source sprinkler study on corn, (Northrup King hybrid PX 74) was conducted at Clovis, NM, 1980. The plots were planted on April 10, and received a pre-plant irrigation to fill the potential root zone. These were harvested with a combine on October 4. Evapotranspiration was computed and yield was measured at 200 cm distances from the sprinkler line to the edge of the plot. The soil type was a Pullman clay loam (fine loamy, mixed, thermic Torretic paleustall). Each corn plot, as part of a nitrogen response study, received different levels of fertilizer: plots 1 through 5 received 0, 112, 224, 336 kg/ha, respectively. There was 144 kg/ha residual N in the soil profile. The line source sprinkler study on spring barley ('Steptoe'), was conducted at Farmington, NM. The soil type at the site was classified as a Nagessi sandy loam (typic calciorthid coarse loamy mixed, mesic family). There was no pre-plant irrigation, but at planting on April 9, 1980, the plot was irrigated and 196 kg/ha of nitrogen applied. Harvest was on August 1. Measurement of yield and evapotranspiration were obtained in the manner described for corn.

In 1976 and 1977 lysimeter studies to determine yield and evapotranspiration relationships under negligible moisture stress conditions were conducted for corn, barley, alfalfa, and cotton at the respective locations indicated above. The lysimeter data were combined with the sprinkler line source data used in the linear regression model to define the water-production function. The lysimeters, 1.8 m × 1.8 m × 1.2 m deep, were a non-weighing type. $E_T$ was determined by the water balance technique using equation [1], where irrigation and drainage were mesured volumetrically. Rainfall and soil moisture were measured as described for the line source sprinkler system (Sammis et al., 1979).

Yearly $E_T$ at each site was computed using the Blaney-Criddle equation:

$$E_T = 25.4\,K\,\Sigma\,\frac{pT}{100} \quad [2]$$

where:

$E_T$ = evapotranspiration (mm) of a crop for a given time period
K = Blaney-Criddle coefficient
T = mean monthly temperature, °F
p = monthly percentage of day time hours of the year

The required weather data were obtained from the 30-yr averages reported by Blaney and Hanson (1965). The original Blaney-Criddle coefficients for corn (*Zea mays L.*), barley (*Hordeum vulgare L.*), alfalfa (*Medicago sativa L.*), and cotton (*Gossypium hirsutum L.*) for NM were taken from the same report.

Doorenbos and Pruitt (1977) tried to improve on the original Blaney-Criddle formula by including the effect of wind, relative humidity, and sunshine hours on $E_T$ and, thus, adjust the Blaney-Criddle formula to represent a reference crop $E_T$ that could be multiplied by their crop coefficient (k). The modified Blaney-Criddle approach is described in equations [3] and [4], as follows:

$$E_{T_0} = c\,[p\,(0.46T + 8)] \quad [3]$$

where:

$E_{T_0}$ = reference crop evapotranspiration in mm/day for the month considered
T = mean daily temperature in °C over the month considered
p = mean daily percentage of total annual daytime hours
c = adjustment factor which depends on minimum relative humidity, sunshine hours and daytime wind estimates averaged over the month considered

and,

$$E_T = k \cdot E_{T_0} \quad [4]$$

where:

k = crop coefficient which changes depending on the stage of growth

Climatic stations which measured 24-h wind run at 2 m and humidity using a hydrothermograph were operated at three research sites from 1977 to 1981, and their data were combined with the 30-yr of temperature data by Blaney and Hanson (1965) to compute $E_T$. The percent of possible sunshine was taken from the Yearbook of Agriculture (1941).

## RESULTS AND DISCUSSION

The water-production functions for alfalfa, cotton, corn, and barley are presented in Table 1. The water-production functions for corn plots were the same at the 95 percent level of confidence and so were combined to form a common water-production function. The coefficient of determination was low for cotton because of weather conditions that resulted in mature plants but low yields. The water-production functions also include the



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TABLE 1. WATER-PRODUCTION FUNCTIONS FOR SELECTED CROPS IN NEW MEXICO.

| Crop | Equation | Range of $E_T$* | Coefficient of Determination |
|---|---|---|---|
| | | cm | |
| Alfalfa† | yield (t/ha) = —1.24 + 0.13 $E_T$ (cm) | 38-175 | 0.79 |
| Cotton‡ | yield (kg/ha) = 134 + 14.25 $E_T$ (cm) | 16-87 | 0.66 |
| Corn§ | yield (kg/ha) = —8287 + 182.62 $E_T$ (cm) | 45-100 | 0.90 |
| Barley¶ | yield (kg/ha) = —2451 + 124.58 $E_T$ (cm) | 20-60 | 0.95 |

* The range of evapotranspiration ($E_T$) measurements used to derive the water-production functions.
† Derived from 1978, 1979, 1980 sprinkler line source irrigation study and 1976, 1977 lysimeter study. Yield is at zero percent moisture content.
‡ Derived from 1978, 1979 sprinkler line source irrigation study and 1976, 1977 lysimeter study.
§ Derived from 1980 average of four sprinkler line source irrigation studies and 1976, 1977 lysimeter study. Represents a dry year when most of the $E_T$ was applied by irrigation. Yield at 15.5 percent moisture content.
¶ Derived from 1980 sprinkler line source irrigation study. Yield at 14 percent moisture ccontent.

soil evaporation component of evapotranspiration. Soil evaporation may vary under different irrigation methods, amounts, and times between irrigations, consequently, changing the parameters in the linear water-production function. The relationship between transpiration and yield should remain constant for different irrigation schemes for a given location. Consequently, the degree of change in the water-production function, due to changes in soil evaporation, will depend on what percentage of the total evapotranspiration is soil evaporation.

The alfalfa water-production function was shown by Sammis (1981) to be applicable at five locations in NM. The function is presented for alfalfa yield expressed at 0 percent moisture. Table 2 presents the average and the maximum county yields from 1959 to 1977 (New Mexico Agricultural Statistics, 1962-1977). These yields were adjusted to 0 percent moisture content assuming they were at 15 percent moisture content at harvest time. Table 2 also presents the yearly average and yearly maximum $E_T$ computed using the alfalfa water-production function, and the $E_T$ calculated from the Blaney-Criddle and modified Blaney-Criddle methods.

Criddle (1958), and Blaney and Hanson (1965), derived their original crop coefficient of 0.85 for alfalfa to determine average yearly $E_T$ over a large area. Also, it is only applicable for computation of $E_T$ during the frost-free period. The USDA Technical Report TR-21 (1967) presented a method to extend the computation of the Blaney-Criddle formula to compute $E_T$ for the entire year. This method assumes that alfalfa starts to grow when the spring temperatures reach 10 °C, and ceases to grow when fall temperatures reach −2 °C. $E_T$ for time periods outside the frost-free period but within the period when temperatures indicate growth, are calculated using a K of 0.5.

Estimates of $E_T$ using the water-production function and average long term county yields, are between 13 and 27 percent lower than those computed by the Blaney-Criddle method. $E_T$ computed using the water-production function and maximum county yields for the locations in NM, except Farmington, are within 9 percent of those computed using the Blaney-Criddle method. At Farmington, NM it was found that the same method, when applied to maximum county yields, underestimated $E_T$ by 16 percent compared to the Blaney-Criddle method. Studies on small plots of land in AZ (Erie et al., 1965) and NM (Hanson, 1967) have resulted in computed values for K for alfalfa greater than 1. The higher coefficients are due to greater $E_T$ than that measured in farmers' fields in the original study reported by Criddle (1958). Since there is a linear relationship between yield and $E_T$, the higher K and subsequent higher measured $E_T$ indicates that on the plot studies the yields were greater than those in a farmer's field. Measured $E_T$ in farmers' fields in CA resulted in a seasonal K (March to October) of 0.87, which is close to the measured value of 0.85 reported by Blaney and Hanson (1965) in NM and by Criddle (1958) for the western United States.

The computed Blaney-Criddle $E_T$ using the modified form by Doorenbos and Pruitt (1977), is also presented in Table 2. A k of 0.95 was used to adjust $E_T$, computed for the growing season including the time periods outside the frost-free period. These values are between 7 and 28 percent higher than the original Blaney-Criddle computed $E_T$. The largest difference is at Clovis, NM where average wind speeds are between 4 and 5 m/s, causing an increase in the computed $E_T$. The modified Blaney-Criddle formula tends to overestimate $E_T$ compared to maximum county yields. Doorenbos and Pruitt comment that the k values they report were only appropriate for determining $E_T$ for a field that is achieving full production potential under the growing environment when water is non-limiting. This is not the irrigation condition

TABLE 2. YEARLY EVAPOTRANSPIRATION ($E_T$) OF ALFALFA COMPUTED BY THE BLANEY-CRIDDLE METHOD AND BY THE WATER-PRODUCTION FUNCTION IN DIFFERENT LOCATIONS IN NEW MEXICO.

| Location | Average County Yield 1959-1977* | Maximum County Yield 1959-1977* | Annual $E_T$ associated with average and maximum county yields† | | Blaney-Criddle $E_T$ for the year‡ | Modified Blaney-Criddle $E_T$ for the year |
|---|---|---|---|---|---|---|
| | | | Average | Maximum | | |
| | t/ha | t/ha | cm | cm | cm | cm |
| Artesia | 10.4 | 11.9 | 90 | 101 | 104 | 111 |
| Clovis | 8.7 | 12.1 | 77 | 102 | 94 | 121 |
| Farmington | 6.4 | 7.6 | 59 | 68 | 81 | 95 |
| Las Cruces | 9.8 | 11.3 | 85 | 97 | 100 | 118 |
| Los Lunas | 7.5 | 9.2 | 67 | 80 | 83 | 92 |

* Adjusted to zero percent moisture based on a 15 percent moisture content at harvest time.
† $E_T$ computed using the water-production function.
‡ Computed using a Blaney-Criddle coefficient of 0.85 and USDA method in Technical Report SCS-21 for days outside frost-free period.

TABLE 3. BLANEY-CRIDDLE COEFFICIENTS FOR ALFALFA FOR SELECTED VALUES OF YIELD AND COMPUTED EVAPOTRANSPIRATION ($E_T$) USING THE WATER-PRODUCTION FUNCTION.

| | Las Cruces | | |
|---|---|---|---|
| Yields 0% Moisture | Yearly $E_T$ | Seasonal $E_T$* 04/09-10/28 | Seasonal K 04/09-10/28 |
| metric ton/ha | cm | cm | |
| 1.6 | 24 | 22 | 0.20† |
| 6.9 | 63 | 56 | 0.52 |
| 10.8 | 93 | 83 | 0.77 |
| 11.3 | 97 | 87 | 0.80‡ |
| 12.3 | 104 | 94 | 0.86 |
| 14.7 | 123 | 110 | 1.02 |
| 18.6 | 153 | 137 | 1.27 |
| 21.4 | 174 | 157 | 1.44§ |

*Seasonal $E_T$ equal to yearly $E_T$ −10% (applies to frost-free period) based on monthly measured $E_T$ from lysimeter studies in 1976 and 1977. Also, estimates of $E_T$ outside the frost-free period based on Technical Report SCS-21.

†Computed Blaney-Criddle seasonal K based on yield under dry land farming.

‡Computed Blaney-Criddle seasonal K based on maximum county yield.

§Computed Blaney-Criddle seasonal K based on maximum yield measured in a lysimeter.

encountered in a field necessary to produce maximum county yield.

A range of yield data, based on yield measured in Las Cruces with no irrigation, and on maximum yield measured in the lysimeter, was used to compute the yearly $E_T$ calculated with the water-production function (Table 3). This yearly $E_T$ was adjusted to the $E_T$ during the frost-free period by subtracting the estimated $E_T$ outside the frost-free period equal to 10 percent of the yearly $E_T$. Based on the estimated seasonal $E_T$, K was computed using equation [2], and K ranged from 0.20 for a yield of 1.6 t ha$^{-1}$ to 1.44 for a yield of 21.4 t ha$^{-1}$. Lysimeters and small plots, because of intensive agriculture and the availability of local advective energy, produce higher yields and subsequently higher measurements of $E_T$ than is normally encountered on a large scale farming operation. Consequently, the crop coefficient of 1.44 determined from the lysimeter study, if used in the Blaney-Criddle equation, would overestimate farm $E_T$. However, Table 2 and 3 point out that the Blaney-Criddle crop coefficient varies and that the appropriate K, depending on the desired yield, should be used to compute $E_T$. The original crop coefficient of 0.85 reported by Blaney and Hanson (1965) will estimate an $E_T$ that will result in predicted yields greater than average county yields, and even slightly greater than the maximum county yields reported at four locations of NM. In areas of dry land farming alfalfa yields will be proportional to the yearly rainfall, and if yields are 1.6 kg/ha a K of 0.20 would be the correct coefficient to use to compute seasonal $E_T$. Yearly $E_T$ of alfalfa can also be estimated by the modified Blaney-Criddle formula, but as stated earlier these calculations will result in $E_T$ estimates for fields where production is greater than maximum county average. If the modified form of the equation is used, the k coefficients also need to be adjusted to be appropriate for fields under moisture stress conditions.

The water-production function calculation of $E_T$ for cotton (Table 4) based on maximum county yields, estimates an $E_T$ that is 14 percent less at Artesia, and 19 percent less at Las Cruces than $E_T$ predicted by the Blaney-Criddle method using a K of 0.62. If the average county yields are used, the differences become respectively, 42 percent for Artesia and 36 percent for Las Cruces. The Blaney-Criddle formula was applied for a growing season from April 11 to October 17 at Las Cruces, and from April 10 to November 2 at Artesia (Blaney and Hanson, 1965). Determination of the number of days for the average growing season is critical because the Blaney-Criddle formula used a seasonal crop coefficient giving the same weight to the summation of $E_T$, regardless of when in the growing season it occurs. Using the modified Blaney-Criddle formula, the k changes with the stage of development, and a difference of a few days in the beginning or ending of the growing season is not as critical. The modified Blaney-Criddle predicts $E_T$ greater than the original Blaney-Criddle formula at both locations. It predicts an $E_T$ of 87 cm cotton for Artesia, 3 cm less than the 2-yr average $E_T$ measured in lysimeters which produced average yields of 1248 kg/ha, considerably greater than county yields (Sammis, 1981). At Las Cruces the modified Blaney-Criddle predicts as $E_T$ of 94 cm, 11 cm greater than measured in lysimeters producing a yield 1430 kg/ha (Sammis, 1981). Average county yield is 763 kg/ha. It appears that the crop coefficient for cotton used with the modified Blaney-Criddle formula is more appropriate for Phoenix, AZ, when the seasonal $E_T$ is 105 cm (Erie et al., 1965).

Table 5 presents the $E_T$ and K values for selected levels of yield based on the cotton water-production function. The highest yield, taken from the lysimeters, resulted in a K of 0.89. Lysimeter measurements gave 0.80, and Erie et al. (1965) reported 0.76 for AZ, and MacGillivray (1975) 0.77 for CA. Cotton yield of 378 kg/ha resulting from only a pre-plant irrigation plus rainfall of 17 cm, resulted in a K of 0.16. This K value represents the lowest value capable of producing a crop under the climatic conditions at Las Cruces. Because cotton growth is very sensitive to weather conditions, the water-production function and Blaney-Criddle crop coefficients and modified Blaney-Criddle crop coefficients are unique to the area in which they are determined and not transfer-

TABLE 4. YEARLY EVAPOTRANSPIRATION ($E_T$) OF COTTON COMPUTED BY THE BLANEY-CRIDDLE METHOD AND THE WATER-PRODUCTION FUNCTION METHOD AT TWO LOCATIONS IN NEW MEXICO.

| Location | Average County Yield 1959-1971 | Maximum County Yield 1959-1977 | Annual $E_T$ associated with average and maximum county yields*: Average | Maximum | Blaney-Criddle $E_T$ for the growing season† | Modified Blaney-Criddle $E_T$ for the growing season‡ |
|---|---|---|---|---|---|---|
| | kg/ha | kg/ha | cm | cm | cm | cm |
| Artesia | 732 | 1017 | 42 | 62 | 72 | 87 |
| Las Cruces | 763 | 931 | 44 | 56 | 69 | 94 |

*$E_T$ computed using the water-production function.

†Based on a Blaney-Criddle coefficient of 0.62. The growing season was 4/11-10/27 for Las Cruces, and 4/10-11/2 for Artesia. The $E_T$ also includes 2.6 cm of evaporation loss due to a pre-plant irrigation.

‡Includes a 2.6 cm of evaporation loss due to a pre-plant irrigation.



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TABLE 5. BLANEY-CRIDDLE COEFFICIENTS (K) FOR COTTON, CORN, AND BARLEY FOR SELECTED VALUES OF YIELDS AND COMPUTED EVAPOTRANSPIRATION ($E_T$) USING THE WATER-PRODUCTION FUNCTION.

| Crop | Location | Yields | Seasonal $E_T$ | Seasonal K |
|---|---|---|---|---|
| | | kg/ha | cm | |
| Cotton | Las Cruces | 378 | 17 | 0.16* |
| | | 600 | 33 | 0.30 |
| | | 800 | 47 | 0.43 |
| | | 931 | 56 | 0.52† |
| | | 1200 | 75 | 0.69 |
| | | 1491 | 96 | 0.89‡ |
| Corn | Clovis | 67 | 45 | 0.47* |
| | | 2000 | 56 | 0.57 |
| | | 4000 | 67 | 0.68 |
| | | 6000 | 78 | 0.80 |
| | | 7965 | 89 | 0.91† |
| | | 10004 | 100 | 1.02‡ |
| Spring Barley | Farmington | 178 | 21 | 0.35* |
| | | 1000 | 28 | 0.47 |
| | | 2000 | 36 | 0.61 |
| | | 2957 | 43 | 0.74† |
| | | 4000 | 52 | 0.88 |
| | | 5051 | 60 | 1.02‡ |

*Computed Blaney-Criddle seasonal K based on yields obtained from dry land farming plus an irrigation at planting time.
†Computed Blaney-Criddle seasonal K based on maximum county yield.
‡Computed Blaney-Criddle seasonal K based on maximum yield in a lysimeter or measured at the line in the sprinkler line source study.

able to other locations (Sammis, 1981).

The corn water-production function for the Clovis area underestimated $E_T$ (Table 6), compared to the Blaney-Criddle method using a K of 0.75, by 3 percent based on average county yields, and overestimated evapotranspiration by 22 percent based on maximum county yields. The original coefficient for corn reported by Criddle (1958), and by Blaney and Hanson (1965), was not derived in the Clovis area where a large amount of advective energy exists. Consequently, in this case the original K is probably low. The modified Blaney-Criddle estimates $E_T$ 7 percent greater than the Blaney-Criddle method, but still less than the requirements for maximum county yield. However, the water-production function was derived in a year when 83 percent of the maximum seasonal $E_T$ was supplied by irrigation representing an extremely dry weather condition. If evaporation losses are less in years when a greater percentage of the $E_T$ is supplied by rainfall, the $E_T$ requirement may be closer to the original and modified Blaney-Criddle computed $E_T$.

Table 5 gives values of seasonal $E_T$ and K for selected values of yield. The maximum county yield for the Clovis area calculated from the water-production function gives a K of 0.91. For corn in plot studies at Davis, CA, MacGillivray (1975) reported 0.87. Under an irrigation at planting and rainfall of 17 cm, corn yield at Clovis in 1980 was 67 kg/ha, resulting in a computed K of 0.47. This seasonal $E_T$ results in viable plants but no effective yield because the rainfall was below average for the year. An appropriate K should be selected for the desired yield and this yield must be compatable with the economics of producing the crop.

Table 6 presents data for barley (both spring and winter sown) in Farmington, NM for average and maximum county yields, and for average and maximum $E_T$ using the water-production function, along with the Blaney-Criddle determination of $E_T$ using a K of 0.70. Using maximum county yield the two estimates agree to within 5 percent; using average yield they differ by 7 percent. Coefficients for winter barley (November to June) determined in CA and AZ are respectively 0.56, MacGillivray (1975), and 1.09, Erie et al. (1965). The modified Blaney-Criddle formula results in higher estimates of $E_T$ than the Blaney-Criddle formula or maximum county yield using the water-production function. Again, the modified Blaney-Criddle formula represents well watered conditions.

Table 5 gives values for K and for seasonal $E_T$ computed using the water-production function for barley at selected levels of yield. The highest measured yield from the sprinkler line source study gives a K of 1.02; by comparison, maximum county yield gives a K of 0.74.

## SUMMARY AND CONCLUSIONS

The original Blaney-Criddle coefficients result in $E_T$ estimates that are very close, except for corn, to those determined from maximum county yields and the water-production functions. However, they are considerably lower than those derived from lysimeter studies, small plot studies, or sprinkler line source studies under negligible moisture stress conditions. The Blaney-Criddle approach can be used satisfactorily to determine county average $E_T$ for a crop, but it cannot be used on a field by field determination of $E_T$ because of the variability in yields. $E_T$ by field is better determined by measuring yield and using the water-production function to calculate $E_T$. County values for $E_T$ can also be satisfactorily determined using maximum county yields provided the water-production function is applicable to the area to which it is applied. The modified Blaney-Criddle method overestimated $E_T$ compared to maximum county yield except for corn. This result was expected because the modified Blaney-Criddle K value represents a computed $E_T$ of a disease-free crop grown under non-restricting soil conditions, including soil water and fertility. This condition

TABLE 6. YEARLY EVAPOTRANSPIRATION ($E_T$) OF CORN AND SPRING BARLEY COMPUTED BY THE BLANEY-CRIDDLE METHOD AND THE WATER-PRODUCTION FUNCTION.

| Location and Crop | Average County Yield 1959-1977 | Maximum County Yield 1959-1977 | Annual $E_T$ associated with average and maximum county yield* — Average | Maximum | Blaney-Criddle $E_T$ for the growing season | Modified Blaney-Criddle $E_T$ for the growing season |
|---|---|---|---|---|---|---|
| | kg/ha | kg/ha | cm | cm | cm | cm |
| Clovis Corn | 4714 | 7965 | 71 | 89 | 75† | 78 |
| Farmington Barley | 2263 | 2957 | 38 | 43 | 41‡ | 52 |

*$E_T$ computed using the water-production function.
†Based on corn planted April 10 and harvested October 4. Physiological maturity occurred September 18.
‡Based on barley planted April 9 and harvested August 1. Physiological maturity occurred July 18.



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is usually not met in fields producing average county yields. The range of the Blaney-Criddle K values represent a three-fold increase from minimum yields under extreme moisture stress to maximum yields obtained in small plots and lysimeters. The large range in K values points out the care that must be taken in selecting the appropriate Blaney-Criddle crop coefficient if other than maximum county yields are desired for the project, farm, or small plot of land.

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# Yield of Alfalfa and Cotton as Influenced by Irrigation[1]

Theodore W. Sammis[2]

## ABSTRACT

Water resource planners need water-producton functions, the relationship between yield and evapotranspiration, to determine the economic impact of various water allocation decisions. They also need to know the transferability of the functions within and between states.

Cotton (*Gossypium hirsutum* L.) and alfalfa (*Medicago sativa* L.) were irrigated at Las Cruces, New Mexico, with a range of water levels using a sprinkler-line source to determine yield and evapotranspiration under deficit irrigation. Also, alfalfa was grown at five locations and cotton was grown at two locations in New Mexico, including Las Cruces, in nonweighing lysimeters that were flood irrigated to measure the yield and evapotranspiration under nonlimiting soil-moisture conditions.

A linear water-production function was observed for alfalfa. This function appeared to be transferable to any location in New Mexico, based on data from five locations within the state, and was statistically the same as alfalfa water-production functions for Nevada, Nebraska, and North Dakota.

A linear water-production function was also observed for cotton, but this function was applicable only for the growing areas in southern New Mexico where the study was conducted. The cotton water-production function for New Mexico was statistically different from the reported water-production function of the similar study conducted in California. The cotton water-production function had a lower coefficient of determination than the alfalfa water-production function since cotton was harvested for lint and seed rather than biomass. This study indicated that biomass production may require the same amount of evapotranspiration regardless of site and management differences, as in the case of alfalfa, but that lint or seed production per unit of water will vary from place to place.

*Additional index words:* Alfalfa, Cotton, Evapotranspiration, Water-production function.

MOST western states have initiated a policy to determine the most beneficial utilization and allocation of their scarce water resources. In years of below-normal water supplies, knowledge about the effects of water shortages on yield and the most beneficial ways of allocating water becomes important to the economic well-being of an area.

With water-production functions, defined as the relationship between evapotranspiration and crop yield, planners can determine the economic impact of various alternate water allocation decisions. In addition, water-production functions give guidelines for determining the capacity of irrigation systems, procedures for scheduling irrigations, and a means of comparing relative water-use efficiencies.

In the past, research has been conducted on the irrigation requirements of alfalfa (*Medicago sativa* L.) and cotton (*Gossypium hirsutum* L.) and their corresponding yields (5, 6, 7, 11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22). This relationship is not the same as a water-production function. Irrigation requirements depend upon evapotranspiration, efficiency of the irrigation system and upon management practices.

In many studies yield did not proportionally increase with applied water because all water was not beneficially used by the crop; some became deep drainage water. The studies resulted in a curvilinear functional relationship between applied water and yield. Past studies have concentrated more on the upper and near-optimal irrigation levels and yields, and have not measured the response of alfalfa and cotton to severe moisture stress.

The objective of this research was to develop water-production functions for alfalfa and cotton and to determine if the relationship between yield and evapotranspiration could be described by a linear function. Research was conducted making water the only limiting variable in controlling growth. High yields and evapotranspiration rates, due to intensive management practices, were accomplished with small lysimeter plots. Lysimeter studies were conducted to collect data on the upper end of the water-production function unobtainable by other research methods. A sprinkler-line source was used to define the water-production function in the range of limited water.

Past research has also been oriented at determining water use for a crop in a specific area. The transferability of this knowledge is usually limited by lack of validation in other locations. The study reported here was conducted in different areas of New Mexico to determine the transferability about the state of the measured water-production functions for alfalfa and cotton.

## MATERIALS AND METHODS

Lysimeter studies with alfalfa and cotton were conducted throughout New Mexico at five research centers of the New Mexico Agricultural Experiment Station. Sprinkler-line source studies with alfalfa and cotton were conducted only at the Plant Science Research Center near Las Cruces, New Mexico.

Nonweighing lysimeters were constructed by digging a hole 1.8 × 1.8 m and 1.21 m deep. The hole was then lined with 1.9 cm thick plywood and five layers of 4-mil black plastic. Suction candles and drainage pipe, 1.27 cm in diameter, were installed at the bottom of each hole. The bottom of the lysimeter was then covered with 15 cm of sand and the remainder was backfilled with the original soil material in the order that it was removed. The soil type at the sites varied from fine sand to clay loam.

Neutron probe access tubes were installed and soil moisture was measured weekly at 15-cm depth increments. Rainfall was measured at nearby weather stations. Measured quantities of irrigation water were applied from 189-liter barrels. Excess irrigation water was applied weekly by surface flooding to insure that the soil profile in the lysimeter would be wet to field capacity. Drainage water was removed with a vacuum pump.

'Mesilla' alfalfa was planted in 1976 in single lysimeters at the San Juan Branch Station in Farmington, Middle Rio Grande Branch Station in Los Lunas, Southeastern Branch Station in Artesia, Plains Branch Station in Clovis, and in three lysimeters at the Plant Science Research Center near Las Cruces. The surrounding fields at each location were also planted in alfalfa.

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Table 1. Yield and evapotranspiration of alfalfa grown with the sprinkler-line source data.

| Year 1978 | | Year 1979 | |
|---|---|---|---|
| Evapotranspiration | Alfalfa yield 0% moisture content | Evapotranspiration | Alfalfa yield 0% moisture content |
| cm | metric ton/ha | cm | metric ton/ha |
| 54.66† | 4.27 | 70.79† | 7.56 |
| 60.96 | 5.45 | 79.83 | 12.41 |
| 63.85 | 6.40 | 83.34 | 14.84 |
| 81.20 | 7.75 | 85.67 | 15.55 |
| 79.67 | 9.03 | 95.33 | 16.07 |
| 89.99 | 10.19 | 108.64 | 17.28 |
| 92.61 | 11.40 | 115.24 | 18.74 |
| 104.67 | 11.78 | 130.38 | 19.65 |
| 115.01‡ | 14.49 | 129.92 | 19.95 |
| | | 136.91 | 18.87 |
| | | 145.74‡ | 22.10 |
| | | 133.53 | 20.35 |
| | | 137.87 | 19.16 |
| | | 130.43 | 16.85 |
| | | 137.11 | 15.61 |
| | | 126.60 | 14.74 |
| | | 115.27 | 15.09 |
| | | 115.34 | 14.95 |
| | | 103.12 | 12.31 |
| | | 108.48 | 10.01 |
| | | 86.87† | 7.83 |

† Row or area farthest away from sprinkler.
‡ Row or area nearest sprinkler line.

Irrigation water quality at the sites varied from 0.46 to 1.23 mmhos/cm. Fertilizer was applied at a rate of 120 kg/ha of P to the alfalfa. Evapotranspiration was calculated for each crop by a water-balance method,

$$ET = I + R - D \pm \Delta SM \quad [1]$$

where

$ET$ = evapotranspiration
$I$ = irrigation, cm
$R$ = rainfall, cm
$D$ = drainage, cm
$\Delta SM$ = change in soil moisture, cm.

Yields from the lysimeters, dried at 60 C, expressed as almost 0% moisture, were measured after each cutting.

Alfalfa varieties (mixed 'Moapa' and 'Hairy Peruvian') were grown in plots approximately 30 × 50 m at the site near Las Cruces. Plants near the sprinkler line received sufficient water to prevent stress. Decreasing amounts of water were received by plants located away from the line. Various levels of water stress were generated in this way. The sprinkler-line source design is described by Hanks et al. (9).

The alfalfa field was planted in October 1977 and fertilized with 40 kg/ha of N and 103 kg/ha of P. The field was again fertilized in March 1979 with 103 kg/ha of P. The field was flood irrigated at planting and again in March 1978 which gave a good stand. The alfalfa crop was harvested five times in 1978 and 1979. The first cutting in 1978 was made before evapotranspiration measurements were started on 1 May 1978. This cutting consisted of mustard plants (*Desurainia sophia*) that had overgrown the emerging alfalfa plants and was not included in the analysis. After the first cutting, the field was irrigated with the sprinkler-line source. At each subsequent harvest, alfalfa was harvested from three plots. Cuttings in strips 1 m wide and 10 m long were taken in each plot to measure yield at varying distances from the sprinkler line to the outer edge of the sprinkler area. Evapotranspiration was also calculated for each yield plot throughout the growing season using the water-balance method described in Eq. [1]. Applied water was measured with catchment cans and soil moisture with a neutron probe. The irrigation system was operated, based on lysimeter data from previous years, so that crop evapotranspiration was satisfied and deep drainage was minimal at the sprinkler line.

Table 2. Linear water production of alfalfa for studies in New Mexico, Nevada, North Dakota, and Nebraska.

| Equation no. | Water-production functions | Coefficient of determination | Location and year |
|---|---|---|---|
| | metric ton/ha† cm | | |
| 1 | yield = −4.30 + 0.16 ET‡ | 0.97* | Las Cruces—1978 sprinkler-line source |
| 2 | yield = 0.43 + 0.14 ET | 0.57 | Las Cruces—1979 sprinkler-line source |
| 3 | yield = 0.14 + 0.12 ET | 0.78a | Las Cruces—1978 to 1979 sprinkler line plus lysimeter—1975–1976 |
| 4 | yield = 0.53 + 0.14 ET | 0.97a | Nevada, Tovey (20) Average of 1960 to 1961 data forced through the origin |
| 5 | yield§ = −0.83 + 0.16 ET | 0.97a | North Dakota—1978 Bauder et al. (1) |
| 6 | yield = 1.84 + 0.13 ET | 0.99a | Nebraska—1970 Daigger et al. (6) |
| 7 | yield = 1.39 + 0.12 ET | 0.85a | Composite of Las Cruces, Nebraska, North Dakota, Nevada 1960–1961 data |

* Equations 3 through 6 followed by the same letter are not significantly different at the 0.05% level. Only the composited data from each site were compared statistically. † All yield is a near 0% moisture except Tovey (20) which did not report a moisture content. ‡ ET = evapotranspiration. § Includes 1973, 1974, and 1976 data.

Runoff was negligible because the water-application rate did not exceed the infiltration rate. The groundwater table was [illegible] m at the site so that upward flow was negligible during the growing season. The alfalfa plot was irrigated weekly throughout the growing season and salinity of the applied water varied from 2.18 mmhos/cm in 1978 to 3.75 mmhos/cm in 1979. Rainfall was 18 cm during the 1978 growing season and 30 cm in the 1979 growing season.

Acala cotton '1517-V' was planted in lysimeters located in cotton fields adjacent to the alfalfa fields at the Plant Science Research Center near Las Cruces and the Artesia experiment station. The construction and operation of the lysimeters were the same as described for the alfalfa lysimeters, except that 120 kg/ha of N and 120 kg/ha of P was applied during the growing season.

Cotton, irrigated with the sprinkler-line source method, was planted 5 May 1978 and 19 Apr. 1979 with 101-cm row spacing. During the growing season, 120 kg/ha of N and 120 kg/ha of P were applied to the field. The cotton plot was preirrigated for germination and subsequently irrigated weekly. Catchment cans were installed with a 101 cm spacing in a line at a right angle to the sprinkler line, one can per row. Yield and evapotranspiration data were taken only on the west side of the sprinkler-line source in 1978. The cotton plot was subdivided into three subplots, each being 10 m long parallel to the line. Rows from these subplots were harvested separately by hand at the end of the growing season, 18 Oct. 1978 and 28 Nov. 1979.

Data for the evapotranspiration calculations (Eq. [1]) were obtained in the manner described for alfalfa. Total precipitation during the cotton growing season was 17 cm in 1978 and [illegible] cm in 1979.

## RESULTS AND DISCUSSION

*Alfalfa.* Alfalfa yield and evapotranspiration (ET) data obtained with the sprinkler-line source irrigation method are presented in Table 1. Yield is a linear function of evapotranspiration (Table 2, Eq. [1] and [2] with a coefficient of determination of 0.97 for 1978 and 0.57 for 1979.

The lysimeter data for alfalfa from all sites and years are presented in Table 3. The regression equations for the sprinkler-line source and lysimeter data [illegible] Yield and evapotranspiration of new and mature alfalfa [illegible] in lysimeters.

| [illegible] | Year | Planting date | Lysimeter | Evapotranspiration measured | Time duration |
|---|---|---|---|---|---|
| | | | Yield metric ton/ha† | cm | |
| [illegible] | | | | | |
| [illegible] | 1976 | 8/29/75 | 22.46 | 189.7 | 1/21–12/31 |
| [illegible] | 1977 | 12/03/76 | 23.38 | 184.6 | 1/01–12/19 |
| [illegible] | | | | | |
| [illegible] | 1976 | 3/24/76 | 10.35 | 125.6 | 4/26–12/31 |
| [illegible] | 1977 | 3/24/76 | 15.87 | 169.7 | 1/01–12/08 |
| Farmington | | | | | |
| [illegible] north site | 1976 | 4/13/76 | 9.80 | 107.5 | 4/26–11/12 |
| [illegible] south site | 1976 | Spring 75 | 19.23 | 166.1 | 4/26–11/12 |
| [illegible] south site | 1977 | Spring 75 | 14.73 | 157.7 | 3/24–11/21 |
| [illegible] north site | 1977 | 4/13/76 | 16.83 | 124.2 | 3/24–11/21 |
| [illegible] | | | | | |
| [illegible] Site B | 1976 | 11/05/75 | 21.90 | 171.6 | 1/01–10/29 |
| [illegible] | 1976 | 2/04/76 | 13.27 | 156.5 | 2/09–12/06 |
| [illegible] | 1976 | 2/09/76 | 21.46 | 165.4 | 2/09–12/06 |
| [illegible] Site B | 1977 | 11/05/75 | 22.55 | 157.5 | 1/05–12/13 |
| [illegible] Site A | 1977 | 2/04/76 | 25.60 | 174.9 | 1/05–12/13 |
| [illegible] Site C | 1977 | 2/09/76 | 22.04 | 173.9 | 1/05–12/13 |
| [illegible] | | | | | |
| [illegible] | 1976 | 6/29/76 | 5.16 | 41.7 | 7/28–11/16 |
| [illegible] | 1977 | 11/16/76 | 18.16 | 151.8 | 1/18–12/21 |

† [illegible] weight, near zero percent moisture content.

are statistically similar ($P \leqslant 0.05$) and, therefore, can be combined. The function is described in Table 2, Eq. [3] and shown in Fig. 1. The coefficient of determination was 0.78. The relationship between yield and evapotranspiration in New Mexico shows that 8.3 cm of water are required to produce 1 ton/ha of alfalfa.

The lysimeter data represent different climatic conditions, growing season lengths around the state, and new as well as established crops. All data fall generally on the same production-function line with the variation being as high from year to year as from location to location. The data also include three data points from a lysimeter study conducted by Curry (2, 3, 4) in Las Cruces where the alfalfa was irrigated by maintaining a water table 91 cm deep in lysimeters. These data are close to the function as shown in Fig. 1.

Equation [3] in Table 2 represents an average water-production function for alfalfa throughout New Mexico. Because of this, a conjecture arises that the same function might be transferred to other states.

Lysimeter studies were conducted by Tovey (20) in Nevada, using water tables of varying height, both irrigated and non-irrigated, and different soil textures as treatments. His 1959 data were statistically different at the 0.05% level of confidence from 1960 and 1961 data. The water-production functions derived from his data are described by the regression equations listed in Table 4. The data do not include values at

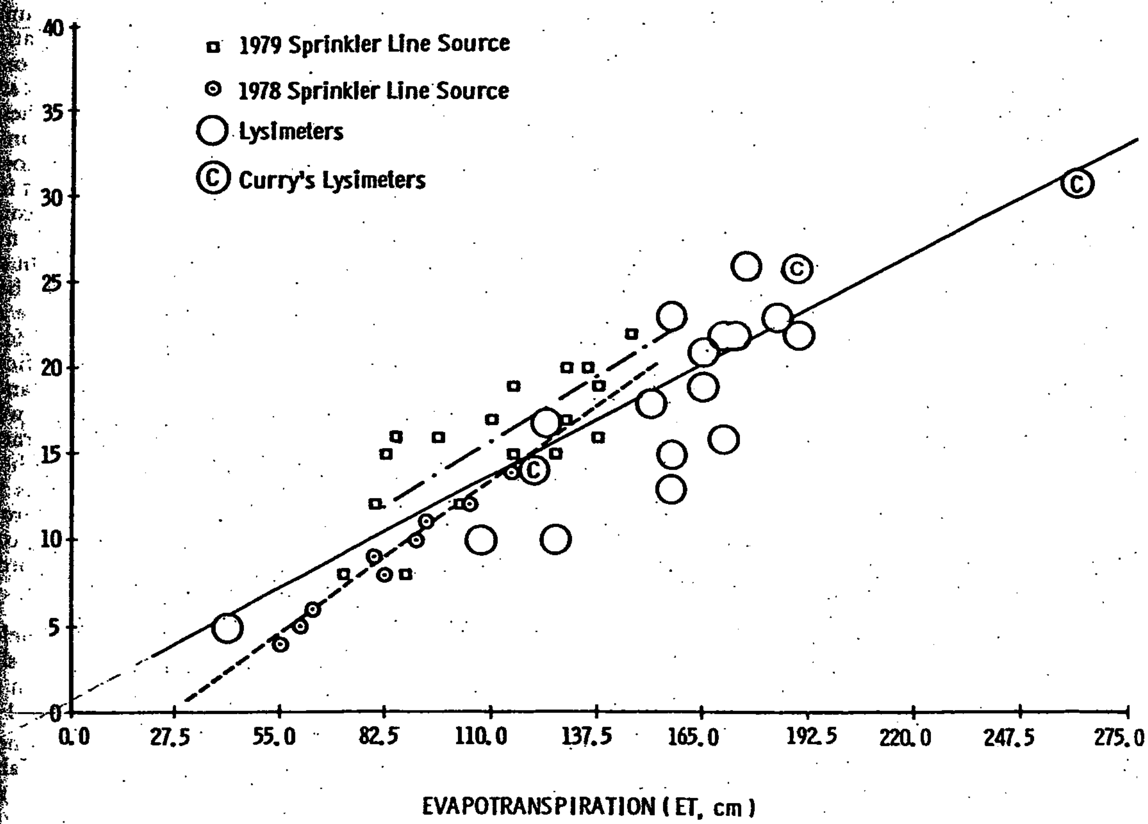


Fig. 1. Water-production function for alfalfa New Mexico.

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**Table 4. Water-production functions of individual cuttings for alfalfa based upon data from Tovey (20) collected in Nevada and data collected at Las Cruces, New Mexico.**

| Location | Year | Cutting | Water-production functions | Coefficient of determination |
|---|---|---|---|---|
| | | | metric ton/ha cm | |
| Las Cruces | 1978 | 2 | yield = −1.22 + 0.13 ET a* | 0.70 |
| | | 3 | yield = −0.69 + 0.12 ET a | 0.83 |
| | | 4 | yield = 0.20 + 0.12 ET b | 0.80 |
| | | 5 | yield = 0.08 + 0.16 ET c | 0.29 |
| | Yearly total | | yield = −4.30 + 0.16 ET | 0.97 |
| Las Cruces | 1979 | 1 | yield = −1.00 + 0.09 ET d | 0.38 |
| | | 2 | yield = 1.46 + 0.11 ET ab | 0.40 |
| | | 3 | yield = 2.25 + 0.10 ET a | 0.48 |
| | | 4 | yield = −0.77 + 0.18 ET c | 0.65 |
| | | 5 | yield = 0.09 + 0.16 ET bc | 0.50 |
| | Yearly total | | yield = 0.43 + 0.14 ET | 0.57 |
| Nevada | 1959 | 1 | yield = 3.00 + 0.12 ET | 0.54 |
| | | 2 | yield = 4.73 + 0.05 ET | 0.04 |
| | | 3 | yield = 3.80 + 0.06 ET | 0.26 |
| | Yearly total† | | yield = 9.70 + 0.10 ET | 0.51 |
| Nevada | 1960 | 1 | yield = 2.80 + 0.06 ET | 0.49 |
| | | 2 | yield = 1.81 + 0.10 ET | 0.68 |
| | | 3 | yield = 1.41 + 0.08 ET | 0.83 |
| | Yearly total† | | yield = 5.60 + 0.08 ET | 0.51 |
| Nevada | 1961 | 1 | yield = 3.26 + 0.06 ET | 0.50 |
| | | 2 | yield = 1.03 + 0.15 ET | 0.76 |
| | | 3 | yield = 1.43 + 0.07 ET | 0.80 |
| | Yearly total† | | yield = 5.10 + 0.09 ET | 0.87 |

* Equations followed by different letters are significantly different at the 0.05% level. † Not forced through the origin.

the low end of the water-production function and only in 1961 is the variation explained satisfactorily by a linear function. If evaporation losses are assumed negligible, then the data should pass through the origin.

When the water-production function is forced through the origin by adding four zero data points to the data base, the coefficient of determination increases and the slope of the average of the 1960 to 1961 water-production function statistically ($P \leqslant 0.05$) is the same as the composite Las Cruces' water-production function.

Bauder et al (1) conducted a study on alfalfa water use and production in southeastern North Dakota. Each year had four levels of evapotranspiration and yield. The water-production function (Table 2, Eq. [5] has a linear coefficient of determination of 0.97 and is statistically the same as the Las Cruces data.

Daigger et al. (6), in Nebraska, collected three years of data on alfalfa yield and evapotranspiration, one data point each year. The linear function of that data (Table 2, Eq. [6]) has a coefficient of determination of 0.99 nd is statistically the same as the Las Cruces water-production function.

Statistical analyses show that a common water-production function of alfalfa for four states can be represented by Eq. [7] in Table 2 which has a coefficient of determination of 0.85.

The combined water-production function shows that 8.3 cm of water are required to produce 1 ton/ha of alfalfa, the same amount of water required to produce 1 ton/ha based only on New Mexico data.

The production function is different for different cuttings. Table 4 shows the alfalfa water-production function for the second, third, fourth, and fifth cuttings measured at Las Cruces with the sprinkler-line source data in 1978 and for all five cuttings in 1979. The slopes (water-use efficiency) in 1978 vary from 0.12 ton/ha/cm to 0.16 ton/ha/cm. When water-production functions in 1978 for the different cuttings are compared, only the second and third cuttings are statistically the same with the fifth cutting having the highest water-use efficiency. In 1979, the coefficients of determination for the water-production function of the individual cuttings have a greater variation than in 1978 with the slopes varying from 0.09 ton/ha/cm to 0.18 ton/ha/cm. Again, based on the statistical analyses, the last two cuttings have the highest water-use efficiency. The water-production functions for the individual cuttings have lower than desired coefficients of determination and additional information is needed before a recommendation can be made concerning when to apply a limited water supply to maximize yearly alfalfa production. However, the data supports the idea that photosynthesis efficiency may be higher for the last cuttings in Las Cruces since the air temperatures may be closer to the optimal level for photosynthesis. The first cutting's water-use efficiency in 1979 is low because the data include growth and evapotranspiration during the winter months when the plants have been semi-dormant and temperatures are lower than the optimal level for photosynthesis. Table 4 also shows water-production functions for each cutting in the Nevada study, not forced through the origin. These vary from year to year with no consistent trend as to which cutting had the highest production per unit of water.

**Table 5. Yield and evapotranspiration of cotton growth with sprinkler-line source irrigation.**

| 1978 | | 1979 | |
|---|---|---|---|
| Evapotranspiration | Lint yield | Evapotranspiration | Lint yield |
| cm | kg/ha | cm | kg/ha |
| 16.87† | 376.60 | 32.18 | 760.73 |
| 20.19 | 380.87 | 34.21 | 749.97 |
| 24.52 | 418.72 | 48.39 | 813.46 |
| 32.55 | 540.80 | 47.68 | 776.33 |
| 27.27 | 582.91 | 55.91 | 821.51 |
| 33.59 | 658.60 | 58.14 | 880.71 |
| 34.18 | 617.70 | 63.27 | 870.48 |
| 42.14 | 747.71 | 55.83 | 872.99 |
| 44.36 | 780.06 | 50.19 | 753.56 |
| 46.68‡ | 824.62 | 52.32 | 787.27 |
| | | 48.84 | 842.51 |
| | | 45.03 | 804.85 |
| | | 43.79 | 779.02 |
| | | 42.62 | 687.56 |
| | | 45.47 | 726.58 |

† Row or area farthest away from sprinkler line.
‡ Row or area near sprinkler line.

*Cotton.* The sprinkler-line source data of yield versus evapotranspiration for cotton (Table 5) is shown in Table 6 and Fig. 2 as a linear function with a coefficient of determination of 0.94 in 1978 and 0.51 in 1979.

The regression equations of the sprinkler-line source in 1978 and 1979 and the lysimeter data in Table 7 are statistically the same ($P \leqslant 0.05$); therefore, they can be combined.

The coefficient of determination of this function is only 0.66 due to the large scatter in the lysimeter data and sprinkler data in 1979. Some rows from the sprink-

**Table 6. Linear water production of cotton in New Mexico and California.**

| Equation no. | Water-production function | Coefficient of determination | Location and year |
|---|---|---|---|
| | kg/ha cm | | |
| [illegible] | Yield = 86.02 + 15.72 ET | 0.98 a* | Las Cruces—1978 sprinkler line |
| [illegible] | Yield = 563.69 + 4.80 ET | 0.51a | Las Cruces—1979 sprinkler line |
| [illegible] | Yield = 134.87 + 14.25 ET | 0.66a | Las Cruces—1978 to 1979 sprinkler-line source and lysimeter |
| [illegible] | Yield = −498.00 + 31.40 ET | 0.96b | California West-Side Field station |

* Equations followed by a different letter are significantly different at the [illegible] level.

**Table 7. Yield and evapotranspiration of cotton grown in lysimeters.**

| Location | Year | Planting date | Lysimeter | Evapotranspiration measured | Time duration |
|---|---|---|---|---|---|
| | | | kg/ha | cm | |
| [illegible] | 1976 | 4/13/76 | 1,006 | 70.2 | 4/12–10/25 |
| [illegible] | 1977 | 4/20/77 | 1,491 | 111.2 | 4/25–10/17 |
| Las Cruces | | | | | |
| [illegible] | 1976 | 5/06/76 | 861 | 87.0 | 5/04–10/30 |
| [illegible] | 1976 | 5/06/76 | 1,044 | 84.1 | 5/04–10/30 |
| [illegible] | 1976 | 5/06/76 | 960 | 80.2 | 5/04–10/30 |
| [illegible] | 1977 | 4/22/77 | 2,063 | 83.0 | 4/23–10/25 |
| [illegible] | 1977 | 4/22/77 | 2,134 | 85.8 | 4/23–10/25 |
| [illegible] | 1977 | 4/22/77 | 1,522 | 78.7 | 4/23–10/25 |

ler-line source study in 1979 were not included in the analysis, due to flooding that occurred in the end of those rows when a border around the field failed and let surface water from an adjacent field enter the plot area. Data from light irrigation treatments previously reported by Hanson (10) are also included with the lysimeter data.

The Artesia lysimeter data are closer to the line than the 1977 lysimeter data at Las Cruces. Part of the scatter is due to the small sample size from a lysimeter and to the variability among lysimeters as a result of management practices. When lysimeters are used to measure evapotranspiration-yield relationships for a seed crop, small sample size and variability from plot to plot become critical factors in the reliability of the data. The sprinkler-line data represent an increase in sample size and consistent management practices.

Figure 3 presents the water-production function data for cotton measured in 1976 (5) at the University of California, West Side Field Station. The data were obtained from a sprinkler-line source experiment similar to the experiment reported here. These data fit the relationship described in Table 6, Eq. [4].

The slope of the water-production function for the California cotton is greater than that for the function described by data taken in New Mexico. It requires 0.03 cm of water to make 1 kg/ha of cotton in California and 0.07 cm in Las Cruces, indicating that a water-production function for cotton is not transferable.

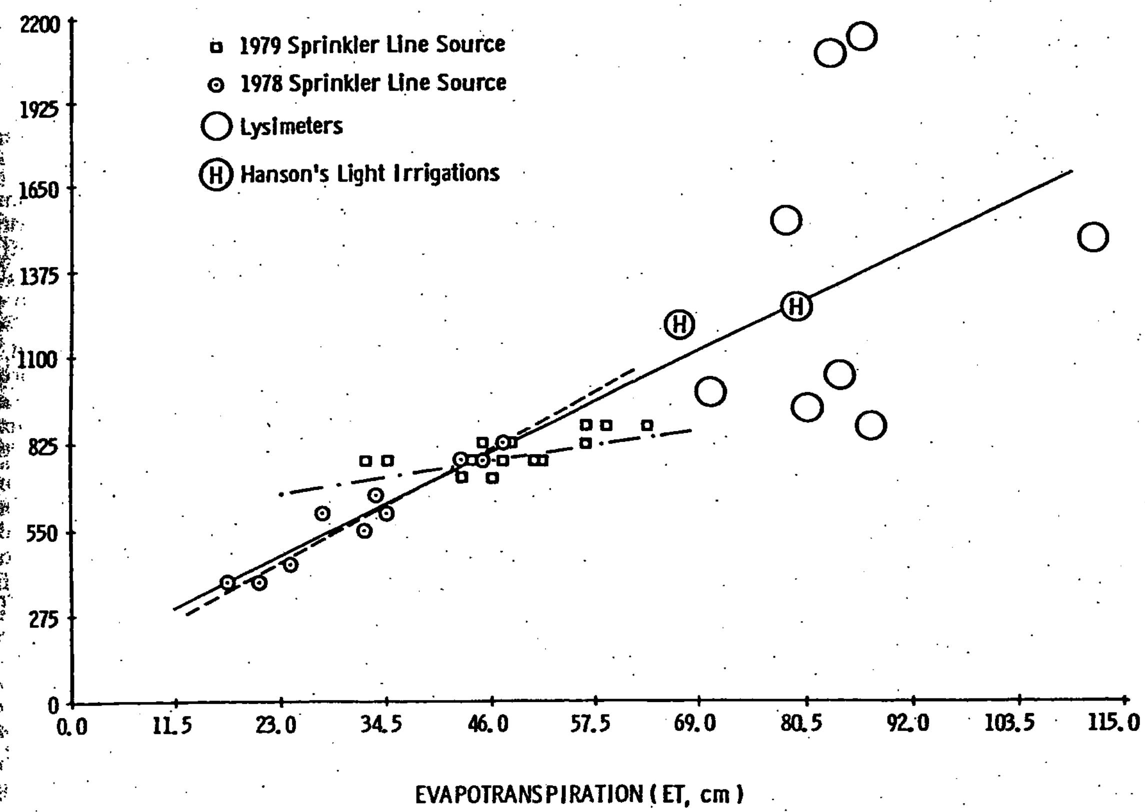


Fig. 2. Water-production function for cotton, New Mexico.

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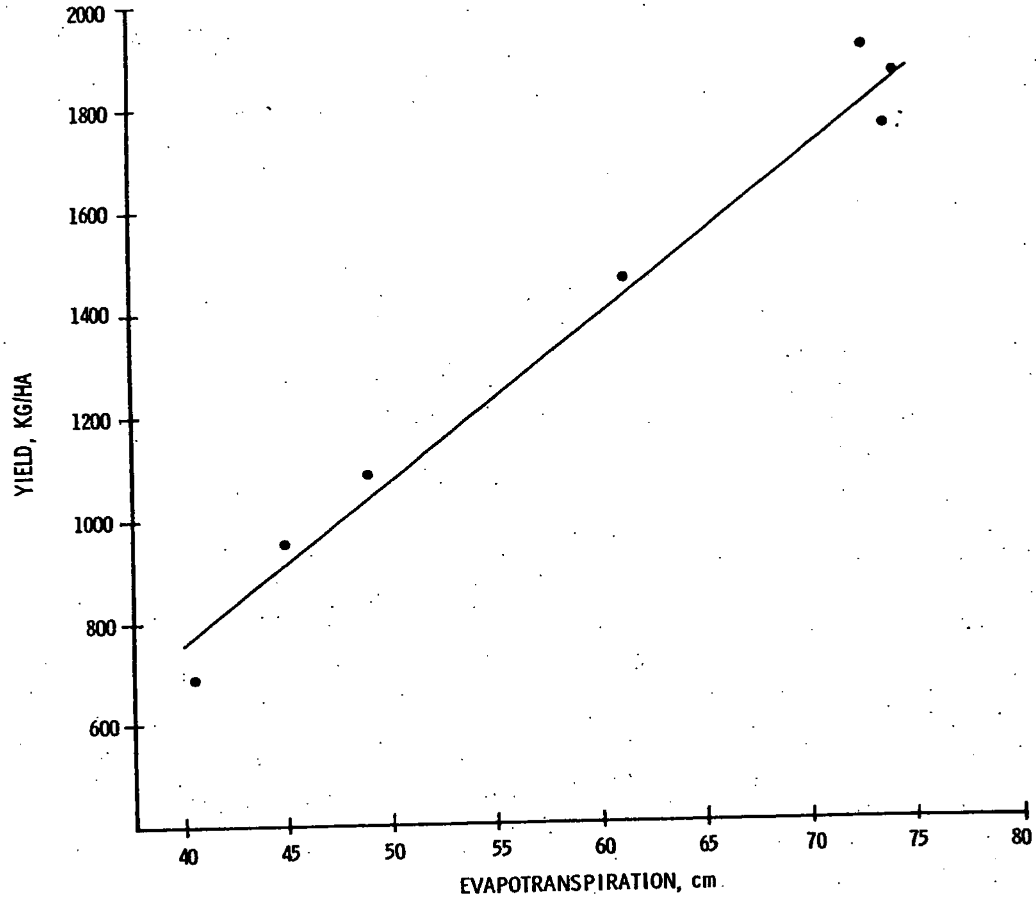


**Fig. 3. Water-production function for SJ2 cotton, University of California West-Side Field Station, 1976.**

## CONCLUSIONS

An alfalfa linear water-production function was derived for New Mexico which appears to be transferable to any location in the state. A common water-production function was derived which is statistically the same as the individual derived water-production functions for New Mexico, Nevada, Nebraska, and North Dakota. This shows that the relationship between alfalfa growth and evapotranspiration is independent of where the alfalfa is grown.

Water-production functions are different for each cutting with the water-use efficiency being higher for the last two cuttings. This indicates that water-use efficiency of alfalfa grown in Las Cruces is higher toward the end of the season than during the hot summer months. The water-production functions of the individual cuttings from the Nevada data show no consistent trend.

The defined linear cotton water-production function is applicable for two areas in southern New Mexico where the crop is grown. The water-production function has more scatter in the data than the alfalfa water-production function because a seed crop is harvested for cotton instead of total biomass.

Results of this study indicate that total biomass production may require the same amount of evapotranspiration regardless of site and management differences as is the case in harvesting alfalfa, but that lint or seed production per unit of water will vary from place to place. This is supported by corn studies in Colorado, Utah, Arizona, and California by Hanks, et al. (8). These studies show that corn dry-matter production per unit of evapotranspiration was more consistent than grain yield per unit of evapotranspiration which varied from location to location and year to year.

The data on alfalfa and cotton support the use of lysimeter to define the wetter portion of the water-production function and the use of the sprinkler line source to define the lower end of the function. The data from the lysimeters, compared with data from the sprinkler-line source, also emphasize the need for larger samples when lysimeters are used.

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# Growth Response of Alfalfa to Duration of Soil Flooding and to Temperature[1]

Todd E. Thompson and Gary W. Fick[2]

## ABSTRACT

Alfalfa (*Medicago sativa* L.) is very sensitive to excessive soil water, yet few studies have been done under controlled conditions to quantify the extent of this sensitivity. The objective of these studies was to investigate the effect of wet soil conditions on alfalfa production. The growth of roots and tops was determined in a factorial greenhouse and growth chamber experiment with treatments for duration of flooding and temperature. Five-week-old alfalfa plants, potted in pasteurized soil, were flooded to the soil surface for 4, 8, 12, 16, and 20 days at temperatures of 16, 21, and 27 C, and for 3, 6, 9 and 12 days at 32 C. Root and top dry weights (DW) of flooded and control plants were measured upon draining. Three weeks after draining, the plants were cut to a 2.5-cm stubble and top DW was measured. After 2 subsequent weeks of regrowth, top and root DW's were again measured.

Results demonstrated that root growth stopped during flooding. As measured over the 3 weeks following drainage, the rate of top growth of plants was reduced by 50% with 8 days of flooding at 16 C, 4 days at 21 C, 3 days at 27 C, and 2 days at 32 C. No net top growth occurred during the 3 weeks following drainage in plants flooded for over 14 days at 16 C, 10 days at 21 C, 8 days at 27 C, and 6 days at 32 C. In most cases, the negative response to flooding occurred before the disease *Phytophthora megasperma* Drechs. is thought to have been able to have an influence. This argues for a physiological as opposed to a pathological basis for the injury.

*Additional index words:* Anaerobiosis, *Medicago sativa* L., *Phytophthora megasperma* Drechs., Root growth, Wet soil.

YIELDS of alfalfa (*Medicago sativa* L.) are significantly reduced by wet or flooded soil conditions. In New York, where poorly-drained soils are widespread, an estimated two thirds of the alfalfa hectarage is on only moderately-well drained to poorly drained soils (Seaney, R. R. 1979. Managing forage for yield and quality. Cornell Univ. Anim. Sci. Mimeo Series No. 40). On these soils, high water table levels which accompany spring thaws and exceptionally heavy rains can inhibit alfalfa growth. In areas of irrigated alfalfa production in the western USA, periodic inundations can create short-term flooded conditions which also inhibit growth (12). Such wet soil conditions can reduce stand vigor indirectly by intensifying overwinter stand loss due to heaving (16) and by promoting the occurrence of fungal root infections (7, 13); however, they also appear to reduce yields directly by interfering with normal plant physiological processes.

The mechanism of this interference in alfalfa is not understood, but a few studies have measured physiological changes during flooding. Murata et al. (11) demonstrated decreases in both photosynthetic and respiration rates of flooded alfalfa seedlings. Rogers

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**New Mexico-- San Juan Basin (Upper Colorado CU+L)**

Aztec Weather Station minus 10 degrees

| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Real Temp at Aztec Station MBC/OBC | Modifed USBR/ Original USBR |
|---|---|---|---|---|---|---|
| NM - 1 | 1976 | 2102 | 2109 | 2315 | | 0.91 |
| | 1977 | 2044 | 2051 | 2034 | | 1.01 |
| | 1978 | 2558 | 2561 | 2751 | | 0.93 |
| | 1979 | 2331 | 2343 | 2601 | | 0.90 |
| | 1980 | 2498 | 2501 | 2517 | | 0.99 |
| | | | | | | |
| NM - 2 | 1976 | 44826 | 45082 | 43012 | | 1.05 |
| | 1977 | 44783 | 44904 | 40089 | | 1.12 |
| | 1978 | 49101 | 49287 | 43852 | | 1.12 |
| | 1979 | 42981 | 43160 | 41818 | | 1.03 |
| | 1980 | 45343 | 45508 | 42272 | | 1.08 |
| | | | | | | |
| NM - 2a | 1976 | 9550 | 9598 | 9112 | | 1.05 |
| | 1977 | 9410 | 9434 | 8076 | | 1.17 |
| | 1978 | 10748 | 11064 | 9638 | | 1.15 |
| | 1979 | 9587 | 9677 | 9105 | | 1.06 |
| | 1980 | 9009 | 9028 | 8708 | | 1.04 |
| | | | | | | |
| NM - 3+4 | 1976 | 31465 | 17675 | 19885 | 1.18 | 0.89 |
| Animas | 1977 | 26269 | 14477 | 16444 | 1.16 | 0.88 |
| & La Plata | 1978 | 32706 | 19688 | 24601 | 1.03 | 0.80 |
| | 1979 | 37058 | 22497 | 27561 | 1.05 | 0.82 |
| | 1980 | 37463 | 22293 | 25851 | 1.11 | 0.86 |
| | | | | | | |
| NM - 5+5a | 1976 | 2136 | 2152 | 2434 | | 0.88 |
| | 1977 | 1320 | 1332 | 1163 | | 1.15 |
| | 1978 | 1304 | 1316 | 1397 | | 0.94 |
| | 1979 | 2335 | 2357 | 2016 | | 1.17 |
| | 1980 | 2110 | 2126 | 1911 | | 1.11 |

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## Upper Colorado Basin CU+L Comparisons (Average 1976-1980)

| State | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Modified USBR/ Original USBR | Modified SCS/ Original USBR |
|---|---|---|---|---|---|---|
| | | 17% ID | x.18 = 15,400 ID | 16% ID | | |
| New Mexico | 92207 | 92674 | 85557 | 95523 | 1.06 | 1.10 |
| Wyoming | 196712 | 197073 | 223787 | 215090 | 0.92 | 1.00 |
| Utah | 367978 | 369571 | 386963 | 385873 | 0.99 | 1.03 |
| Colorado | | | | | | |
| Green River | 88398 | 88920 | 97353 | 98606 | 0.94 | 1.03 |
| Upper Mainstem | 710948 | 716953 | 743641 | 757973 | 0.93 | 1.00 |
| San Juan | 138566 | 139131 | 149963 | 150091 | 0.92 | 1.00 |
| Total Colorado | 937912 | 945004 | 990957 | 1006670 | 0.95 | 1.02 |
| | | 1.604 | 1.687 | 1.703 | ↑ diff = 82.9 TAF (USBR eff. prec. used until 1996) | |



OSE-0675

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## 1965 Comprehensive Framework Study Comparison

| Hydrologic Area | Total Acre Feet: Comprehensive Framework Study (reported) | Comprehensive Framework Study (corrected) | Original Blaney Criddle USBR rain | Modified Blaney Criddle SCS rain | Modified Blaney Criddle USBR rain | Modified SCS/ Original USBR | Modified USBR/ Original USBR | CIR (ft): Comprehensive Framework Study | Original Blaney Criddle USBR rain | Modified Blaney Criddle SCS rain | Modified Blaney Criddle USBR rain | Modified SCS/ Original USBR | Modified USBR/ Original USBR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 NM | 1100 | | 1071 | 1115 | 1024 | 1.04 | 0.96 | 1.19 | 1.19 | 1.24 | 1.14 | 1.04 | 0.96 |
| 2 NM | 31800 | | 27840 | 30505 | 29110 | 1.10 | 1.05 | 1.97 | 1.77 | 1.94 | 1.85 | 1.10 | 1.05 |
| 3 NM | 27300 | | 27229 | 29696 | 28652 | 1.09 | 1.05 | 1.75 | 1.75 | 1.9 | 1.84 | 1.09 | 1.05 |
| 4 NM | 4400 | 4800 | 4765 | 5273 | 5144 | 1.11 | 1.08 | 1.06 | 1.06 | 1.17 | 1.14 | 1.10 | 1.08 |
| 5 NM | 3300 | | 3267 | 3428 | 3331 | 1.05 | 1.02 | 0.78 | 0.78 | 0.82 | 0.79 | 1.05 | 1.01 |
| 2a NM | 6200 | | 6457 | 7042 | 6706 | 1.09 | 1.04 | 2.00 | 1.75 | 1.9 | 1.81 | 1.09 | 1.03 |
| 5a NM | 300 | 230 | 230 | 253 | 247 | 1.10 | 1.07 | 0.77 | 0.77 | 0.84 | 0.82 | 1.09 | 1.06 |
| | | | 70,859 | 77,312 | 74,214 | | | | | | | | |

Areas 2NM, 2aNM - Did not have original temp., precip. data to match
Area 4NM, Error in reported Comp. Framework S. #'s for short alfalfa, short pasture
Area 5aNM, Error in reported Comp. Framework S. 3's for short pasture

**Whipple, John J., OSE**

| | | | |
|---|---|---|---|
| **From:** | Magnuson, Molly L., OSE | **Sent:** | Tue 12/20/2005 3:00 PM |
| **To:** | Whipple, John J., OSE | | |
| **Cc:** | | | |
| **Subject:** | Comparisons | | |
| **Attachments:** | | | |

John,
Using the USBR effective rainfall method and comparing Original to Modified Blaney-Criddle, the modified is 8-9 percent higher than the original, for NM.
Molly

Animas acres
to high-
overstated dep's
1966-1977
[illegible] in NM-
understated dep's
1960-77
[illegible]?

Bonytail (Gila elegans)
Endangered Colorado River fish distinguished by streamlined body that becomes pencil-thin near its tail. Extremely rare in the wild.

[illegible] CRSP 1962-77
[illegible] not after
salvage?
[illegible] in CBS?

Upper Colorado River Endangered Fish Recovery Program
ColoradoRiverRecovery.fws.gov

John- [illegible]
Here is a comparison
using tempat Aztec-1b,
a table showing totals
by state, and a
table for 65 study
including MBC w/
USBR rainfall.
Molly

REVISED DRAFT

ISC calc's using USBR uncorrected data

## Upper Colorado Basin CU+L Comparisons 1971-1980

Crop Consumptive Use

| State | Year | CU +L (acre-feet) | Modified Blaney-Criddle USBR eff. Precip (af) (CU+L match) | Modified Blaney-Criddle USBR eff. precip (af) (scs rec.temp) | Modified Blaney-Criddle SCS eff. precip (af) (scs rec.temp) | Original Blaney-Criddle USBR eff.precip (af) (scs rec.temp) | Modified USBR/ Original USBR | Modified SCS/ Original USBR |
|---|---|---|---|---|---|---|---|---|
| New Mexico | | | | | | | | |
| Note 1. | 1971 | 67492 | 67830 | 69818 | 72369 | 63964 | 1.09 | 1.13 |
| | 1972 | 77858 | 78323 | 79517 | 81118 | 75817 | 1.05 | 1.07 |
| | 1973 | 73282 | 74027 | 75594 | 78690 | 74921 | 1.01 | 1.05 |
| | 1974 | 80534 | 81390 | 83328 | 85375 | 77199 | 1.08 | 1.11 |
| | 1975 | 74187 | 74777 | 76462 | 79022 | 73971 | 1.03 | 1.07 |
| | 1976 | 90079 | | 90591 | 93223 | 84724 | 1.07 | 1.10 |
| | 1977 | 83826 | | 84111 | 85670 | 74166 | 1.13 | 1.16 |
| | 1978 | 96417 | | 96776 | 100704 | 89164 | 1.09 | 1.13 |
| | 1979 | 94292 | | 94765 | 97636 | 91037 | 1.04 | 1.07 |
| | 1980 | 96423 | | 96701 | 99923 | 89263 | 1.08 | 1.12 |
| | Average | 83439 | | 84766 | 87373 | 79423 | 1.07 | 1.10 |
| Wyoming | | | | | | | | |
| | 1971 | 251881 | 252252 | 260933 | 278233 | 340755 | 0.77 | 0.82 |
| | 1972 | 217968 | 218383 | 235031 | 261507 | 316383 | 0.74 | 0.83 |
| | 1973 | 215370 | 215613 | 226467 | 251793 | 286575 | 0.79 | 0.88 |
| | 1974 | 263990 | 264208 | 295429 | 307603 | 340027 | 0.87 | 0.90 |
| | 1975 | 189570 | 188195 | 206483 | 229980 | 267404 | 0.77 | 0.86 |
| | 1976 | 186810 | | 186896 | 214813 | 210613 | 0.89 | 1.02 |
| | 1977 | 121779 | | 122282 | 134514 | 132451 | 0.92 | 1.02 |
| | 1978 | 223971 | | 224380 | 242752 | 267058 | 0.84 | 0.91 |
| | 1979 | 231878 | | 232631 | 247234 | 266933 | 0.87 | 0.93 |
| | 1980 | 219120 | | 219178 | 236135 | 241879 | 0.91 | 0.98 |
| | Average | 212234 | | 220971 | 240456 | 267008 | 0.83 | 0.90 |
| Utah | | | | | | | | |
| | 1971 | 456629 | 455286 | 463272 | 480562 | 469417 | 0.99 | 1.02 |
| | 1972 | 454858 | 453379 | 464621 | 481075 | 488251 | 0.95 | 0.99 |
| | 1973 | 464977 | 463628 | 467517 | 487382 | 492398 | 0.95 | 0.99 |
| | 1974 | 478413 | 477703 | 485254 | 494071 | 477041 | 1.02 | 1.04 |
| | 1975 | 365402 | 364993 | 378450 | 401890 | 410192 | 0.92 | 0.98 |
| | 1976 | 386945 | | 388902 | 405343 | 396743 | 0.98 | 1.02 |
| | 1977 | 206047 | | 207961 | 217528 | 224439 | 0.93 | 0.97 |
| | 1978 | 410789 | | 412977 | 429933 | 442367 | 0.93 | 0.97 |
| | 1979 | 433065 | | 435518 | 449220 | 459724 | 0.95 | 0.98 |
| | 1980 | 403046 | | 402496 | 427339 | 411542 | 0.98 | 1.04 |
| | Average | 406017 | | 410697 | 427434 | 427211 | 0.96 | 1.00 |

Upper Colorado Basin CU+L Comparisons 1971-1980

Crop Consumptive Use

| State | Year | CU +L (acre-feet) | Modified Blaney-Criddle USBR eff. Precip (af) (CU+L match) | Modified Blaney-Criddle USBR eff. precip (af) (scs rec.temp) | Modified Blaney-Criddle SCS eff. precip (af) (scs rec.temp) | Original Blaney-Criddle USBR eff.precip (af) (scs rec.temp) | Modified USBR/ Original USBR | Modified SCS/ Original USBR |
|---|---|---|---|---|---|---|---|---|
| Colorado | 1971 | 984498 | 980281 | 1016226 | 1080961 | 1042582 | 0.97 | 1.04 |
| Note 2. | 1972 | 985070 | 978478 | 1014787 | 1076032 | 1085164 | 0.94 | 0.99 |
| | 1973 | 829117 | 819055 | 860069 | 948947 | 921323 | 0.93 | 1.03 |
| | 1974 | 1040458 | 1021440 | 1064660 | 1114445 | 1084711 | 0.98 | 1.03 |
| | 1975 | 923687 | 920660 | 970333 | 1032387 | 1041043 | 0.93 | 0.99 |
| | 1976 | 904767 | | 911190 | 980707 | 949920 | 0.96 | 1.03 |
| | 1977 | 808712 | | 811503 | 862777 | 846071 | 0.96 | 1.02 |
| | 1978 | 978484 | | 982823 | 1042642 | 1034877 | 0.95 | 1.01 |
| | 1979 | 991349 | | 1005470 | 1072556 | 1083388 | 0.93 | 0.99 |
| | 1980 | 1006249 | | 1014033 | 1074668 | 1040533 | 0.97 | 1.03 |
| | Average | 945239 | | 965109 | 1028612 | 1012961 | 0.95 | 1.02 |
| | | | | | | | | |
| Upper Basin Total | | | | | | | | |
| | 1971 | 1760500 | 1755649 | 1810857 | 1912769 | 1917407 | 0.94 | 1.00 |
| | 1972 | 1735754 | 1728563 | 1794775 | 1900574 | 1966524 | 0.91 | 0.97 |
| | 1973 | 1582746 | 1572323 | 1630153 | 1767378 | 1775764 | 0.92 | 1.00 |
| | 1974 | 1863395 | 1844741 | 1929463 | 2002299 | 1979817 | 0.97 | 1.01 |
| | 1975 | 1552846 | 1548625 | 1632338 | 1743897 | 1793312 | 0.91 | 0.97 |
| | 1976 | 1568601 | | 1577579 | 1694086 | 1642000 | 0.96 | 1.03 |
| | 1977 | 1220364 | | 1225857 | 1300489 | 1277127 | 0.96 | 1.02 |
| | 1978 | 1709661 | | 1716956 | 1816031 | 1833466 | 0.94 | 0.99 |
| | 1979 | 1750584 | | 1768384 | 1866646 | 1901082 | 0.93 | 0.98 |
| | 1980 | 1724838 | | 1732408 | 1838065 | 1783217 | 0.97 | 1.03 |
| | Average | 1646929 | | 1681877 | 1784223 | 1786972 | 0.94 | 1.00 |
| | | | | | | | | |
| Note 1. | New Mexico totals do not include NIIP | | | | | | | |
| | | | | | | | | |
| Note 2. | Some Colorado CU+L to CU+L match differences explained by USBR tabulation errors. | | | | | | | |



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## Upper Colorado Basin CU+L Comparisons 1971-1980

w/ 1976-1980 Incidental Depletion Percentages Applied

| State | Year | CU +L (acre-feet) | Modified Blaney-Criddle USBR eff. Precip (af) (CU+L match) | Modified Blaney-Criddle USBR eff. precip (af) (scs rec.temp) | Modified Blaney-Criddle SCS eff. precip (af) (scs rec.temp) | Original Blaney-Criddle USBR eff.precip (af) (scs rec.temp) | Modified USBR/ Original USBR | Modified SCS/ Original USBR |
|---|---|---|---|---|---|---|---|---|
| New Mexico | | | | | | | | |
| Note 1. | 1971 | 80339 | 80739 | 83089 | 86122 | 76090 | 1.09 | 1.13 |
| | 1972 | 92664 | 93215 | 94625 | 96532 | 90151 | 1.05 | 1.07 |
| | 1973 | 87156 | 88033 | 89889 | 93562 | 89042 | 1.01 | 1.05 |
| | 1974 | 95962 | 96971 | 99245 | 101689 | 91966 | 1.08 | 1.11 |
| | 1975 | 88326 | 89014 | 91010 | 94062 | 88017 | 1.03 | 1.07 |
| | 1976 | 107600 | | 108146 | 111276 | 101176 | 1.07 | 1.10 |
| | 1977 | 100100 | | 100547 | 102404 | 88667 | 1.13 | 1.15 |
| | 1978 | 115200 | | 115629 | 120307 | 106467 | 1.09 | 1.13 |
| | 1979 | 112500 | | 113001 | 116420 | 108576 | 1.04 | 1.07 |
| | 1980 | 115100 | | 115340 | 119189 | 106491 | 1.08 | 1.12 |
| | Average | 99495 | | 101052 | 104156 | 94664 | 1.07 | 1.10 |
| | | | | | | | | |
| Wyoming | | | | | | | | |
| | 1971 | 275214 | 275619 | 285771 | 304714 | 373090 | 0.77 | 0.82 |
| | 1972 | 238165 | 238619 | 257695 | 286656 | 346698 | 0.74 | 0.83 |
| | 1973 | 235305 | 235571 | 247980 | 275719 | 313718 | 0.79 | 0.88 |
| | 1974 | 288455 | 288691 | 323673 | 336988 | 372456 | 0.87 | 0.90 |
| | 1975 | 207112 | 205621 | 226273 | 251960 | 292948 | 0.77 | 0.86 |
| | 1976 | 204000 | | 204199 | 234707 | 230116 | 0.89 | 1.02 |
| | 1977 | 133100 | | 133594 | 146958 | 144703 | 0.92 | 1.02 |
| | 1978 | 244800 | | 245172 | 265247 | 291813 | 0.84 | 0.91 |
| | 1979 | 253500 | | 254184 | 270137 | 291664 | 0.87 | 0.93 |
| | 1980 | 239300 | | 239489 | 258015 | 264302 | 0.91 | 0.98 |
| | Average | 231895 | | 241803 | 263110 | 292151 | 0.83 | 0.90 |
| | | | | | | | | |
| Utah | | | | | | | | |
| | 1971 | 549094 | 547471 | 557083 | 577843 | 564438 | 0.99 | 1.02 |
| | 1972 | 547185 | 545399 | 558923 | 578698 | 587334 | 0.95 | 0.99 |
| | 1973 | 559199 | 557569 | 562215 | 586039 | 592193 | 0.95 | 0.99 |
| | 1974 | 575241 | 574339 | 583391 | 593975 | 573446 | 1.02 | 1.04 |
| | 1975 | 439300 | 438796 | 455034 | 486342 | 493240 | 0.92 | 0.99 |
| | 1976 | 465100 | | 467642 | 487366 | 477002 | 0.98 | 1.02 |
| | 1977 | 247900 | | 250175 | 261674 | 270026 | 0.93 | 0.97 |
| | 1978 | 493400 | | 496271 | 516626 | 531587 | 0.93 | 0.97 |
| | 1979 | 520200 | | 523109 | 539536 | 552242 | 0.95 | 0.98 |
| | 1980 | 484100 | | 483553 | 513406 | 494357 | 0.98 | 1.04 |
| | Average | 488072 | | 493740 | 514151 | 513587 | 0.96 | 1.00 |

**Upper Colorado Basin CU+L Comparisons 1971-1980**

w/ 1976-1980 Incidental Depletion Percentages Applied

| State | Year | CU +L (acre-feet) | Modified Blaney-Criddle USBR eff. Precip (af) (CU+L match) | Modified Blaney-Criddle USBR eff. precip (af) (scs rec.temp) | Modified Blaney-Criddle SCS eff. precip (af) (scs rec.temp) | Original Blaney-Criddle USBR eff.precip (af) (scs rec.temp) | Modified USBR/ Original USBR | Modified SCS/ Original USBR |
|---|---|---|---|---|---|---|---|---|
| Colorado | 1971 | 1185221 | 1179862 | 1222288 | 1299668 | 1253759 | 0.97 | 1.04 |
| Note 2. | 1972 | 1187033 | 1178694 | 1221555 | 1294950 | 1305764 | 0.94 | 0.99 |
| | 1973 | 995874 | 984117 | 1032943 | 1138864 | 1106708 | 0.93 | 1.03 |
| | 1974 | 1251302 | 1228502 | 1280763 | 1340613 | 1306845 | 0.98 | 1.03 |
| | 1975 | 1109953 | 1105556 | 1165082 | 1238956 | 1248848 | 0.93 | 0.99 |
| | 1976 | 1090300 | | 1098042 | 1180771 | 1145551 | 0.96 | 1.03 |
| | 1977 | 977600 | | 981164 | 1042403 | 1022231 | 0.96 | 1.02 |
| | 1978 | 1182400 | | 1187737 | 1259447 | 1251849 | 0.95 | 1.01 |
| | 1979 | 1203000 | | 1209304 | 1289864 | 1302663 | 0.93 | 0.99 |
| | 1980 | 1213700 | | 1223411 | 1296303 | 1256086 | 0.97 | 1.03 |
| | Average | 1139638 | | 1162229 | 1238184 | 1220030 | 0.95 | 1.01 |
| | | | | | | | | |
| Upper Basin Total | | | | | | | | |
| | 1971 | 2089868 | 2083691 | 2148231 | 2268347 | 2267377 | 0.95 | 1.00 |
| | 1972 | 2065047 | 2055927 | 2132798 | 2256836 | 2329947 | 0.92 | 0.97 |
| | 1973 | 1877534 | 1865290 | 1933027 | 2094184 | 2101661 | 0.92 | 1.00 |
| | 1974 | 2210960 | 2188503 | 2287072 | 2373265 | 2344713 | 0.98 | 1.01 |
| | 1975 | 1844691 | 1838987 | 1937399 | 2071320 | 2123053 | 0.91 | 0.98 |
| | 1976 | 1867000 | | 1878029 | 2014120 | 1953845 | 0.96 | 1.03 |
| | 1977 | 1458700 | | 1465480 | 1553439 | 1525627 | 0.96 | 1.02 |
| | 1978 | 2035800 | | 2044809 | 2161627 | 2181716 | 0.94 | 0.99 |
| | 1979 | 2089200 | | 2099598 | 2215957 | 2255145 | 0.93 | 0.98 |
| | 1980 | 2052200 | | 2061793 | 2186913 | 2121236 | 0.97 | 1.03 |
| | Average | 1959100 | | 1998824 | 2119601 | 2120432 | 0.94 | 1.00 |
| | | | | | | | | |
| Note 1. | New Mexico totals do not include NIIP | | | | | | | |
| Note 2. | Some Colorado CU+L to CU+L match differences explained by USBR tabulation errors. | | | | | | | |



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**TABLE UC–3—Colorado River System Consumptive Uses and Losses Report, P.L. 90–537**
**Upper Colorado River Basin Estimated Water Use by State, Major Tributary, and Type of Use 1971**

(1,000 A.F.)

| State | Tributary or Reporting Area | AGRICULTURE: Irrigation | AGRICULTURE: Irrigation Reservoir Evaporation | AGRICULTURE: Stockpond Evaporation & Livestock | AGRICULTURE: Total | MUNICIPAL AND INDUSTRIAL[1]: Mineral Resources | MUNICIPAL AND INDUSTRIAL[1]: Thermal Electric Power | MUNICIPAL AND INDUSTRIAL[1]: Other[2] | MUNICIPAL AND INDUSTRIAL[1]: Total | FISH & WILDLIFE RECREATION[1] | EXPORT[1]: Outside System | EXPORT[1]: Within System | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arizona | San Juan-Colo. | 2.5 | 3.0 | 1.1 | 6.6 | 0.0 | 0.0 | 2.9 | 2.9 | 1.6 | — | — | 11.1 |
| Colorado | Green River | 130.0 130.0 | 2.1 | 6.1 | 138.2 | 4.6 | 4.9 | 1.9 | 11.4 | 3.7 | — | — | 153.3 |
| | Upper Main Stem | 890.9 889.7 | 20.3 | 11.1 | 921.1 | 11.2 | 0.3 | 13.3 | 24.8 | 2.7 | 412.8 | 142.6 | 1,494.8 |
| | San Juan-Colo. | 164.3 164.3 | 7.9 | 5.3 | 177.5 | 2.1 | 0.0 | 3.0 | 5.1 | 0.9 | 2.2 | −142.6 | 52.3 |
| | Total | 1,184.0 | 30.3 | 22.5 | 1,236.8 | 17.9 | 5.2 | 18.2 | 41.3 | 7.3 | 415.0 | — | 1,700.4 |
| New Mexico | San Juan-Colo. | 80.3 80.9 | 18.9 | 2.8 | 102.6 | 2.4 | 15.7 | 3.9 | 22.0 | 0.6 | 54.4 | — | 179.6 |
| Utah | Green River | 500.4 | 25.5 | 4.2 | 530.1 | 7.2 | 1.9 | 4.2 | 13.3 | 6.9 | 111.8 | — | 662.1 |
| | Upper Main Stem | 9.6 | 0.1 | 0.5 | 10.2 | 1.4 | 0.0 | 0.8 | 2.2 | 0.0 | — | — | 12.4 |
| | San Juan-Colo. | 39.2 | 14.7 | 1.9 | 55.8 | 1.2 | 0.0 | 1.3 | 2.5 | 0.9 | −4.2 | — | 55.0 |
| | Total | 549.1 549.2 | 40.3 | 6.6 | 596.1 | 9.8 | 1.9 | 6.3 | 18.0 | 7.8 | 107.6 | — | 729.5 |
| Wyoming | Green River | 275.2 275.2 | 27.2 | 5.0 | 307.4 | 11.1 | 5.7 | 3.3 | 20.1 | 0.2 | 6.0 | — | 333.7 |
| Upper Basin | Green River | 905.6 | 54.8 | 15.3 | 975.7 | 22.9 | 12.5 | 9.4 | 44.8 | 10.8 | 117.8 | — | 1,149.1 |
| | Upper Main Stem | 899.3 | 20.4 | 11.6 | 931.3 | 12.6 | 0.3 | 14.1 | 27.0 | 2.7 | 412.8 | 142.6 | 1,507.2 |
| | San Juan-Colo. | 286.9 | 44.5 | 11.1 | 342.5 | 5.7 | 15.7 | 11.1 | 32.5 | 4.0 | 52.4 | −142.6 | 298.0 |
| | Total | 2,091.8 | 119.7 | 38.0 | 2,249.5 | 41.2 | 28.5 | 34.6 | 104.3 | 17.5 | 583.0 | — | 2,954.3 |

[1] Includes evaporation from related reservoirs.
[2] Includes urban, rural, and other industrial uses.

## TABLE UC-4—Colorado River System Consumptive Uses and Losses Report, P.L. 90-537
## Upper Colorado River Basin Estimated Water Use by State, Major Tributary, and Type of Use 1972

(1,000 A.F.)

| | | AGRICULTURE | | | | MUNICIPAL AND INDUSTRIAL [1] | | | | | EXPORT [1] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State | Tributary or Reporting Area | Irrigation | Irrigation Reservoir Evaporation | Stockpond Evaporation & Livestock | Total | Mineral Resources | Thermal Electric Power | Other [2] | Total | FISH & WILDLIFE RECREATION [1] | Out-side System | With-in System | TOTAL |
| Arizona | San Juan-Colo. | 2.9 | 2.9 | 1.1 | 6.9 | 0.0 | 0.0 | 3.6 | 3.6 | 1.7 | — | — | 12.2 |
| Colorado | Green River | 108.8 108.8 | 1.6 | 5.1 | 115.5 | 4.6 | 4.9 | 2.0 | 11.5 | 2.8 | — | — | 129.8 |
| | Upper Main Stem | 891.1 891.1 | 18.1 | 12.0 | 921.2 | 11.3 | 0.3 | 13.6 | 25.2 | 2.5 | 488.8 | 128.4 | 1,558.2 |
| | San Juan-Colo. | 187.0 187.0 | 7.5 | 5.6 | 200.1 | 2.2 | 0.0 | 3.1 | 5.3 | 0.9 | 1.7 | −128.4 | 87.5 |
| | Total | 1,186.9 | 27.2 | 22.7 | 1,236.8 | 18.1 | 5.2 | 18.7 | 42.0 | 6.2 | 490.5 | — | 1,775.5 |
| New Mexico | San Juan-Colo. | 92.7 93.3 | 18.0 | 2.9 | 114.2 | 2.6 | 20.8 | 4.1 | 27.5 | 0.7 | 41.1 | — | 183.5 |
| Utah | Green River | 504.0 | 25.6 | 4.3 | 533.9 | 7.3 | 1.7 | 4.3 | 13.3 | 7.1 | 130.6 | — | 684.9 |
| | Upper Main Stem | 8.9 | 0.1 | 0.4 | 9.4 | 1.4 | 0.0 | 0.8 | 2.2 | 0.0 | — | — | 11.6 |
| | San Juan-Colo. | 34.4 | 15.6 | 2.0 | 52.0 | 1.1 | 0.0 | 1.4 | 2.5 | 1.0 | −3.4 | — | 52.1 |
| | Total | 545.4 547.3 | 41.3 | 6.7 | 595.3 | 9.8 | 1.7 | 6.5 | 18.0 | 8.1 | 127.2 | — | 748.6 |
| Wyoming | Green River | 238.2 238.2 | 31.7 | 4.9 | 274.8 | 12.0 | 4.5 | 3.4 | 19.9 | 0.2 | 8.7 | — | 303.6 |
| Upper Basin | Green River | 851.0 | 58.9 | 14.3 | 924.2 | 23.9 | 11.1 | 9.7 | 44.7 | 10.1 | 139.3 | — | 1,118.3 |
| | Upper Main Stem | 900.0 | 18.2 | 12.4 | 930.6 | 12.7 | 0.3 | 14.4 | 27.4 | 2.5 | 488.8 | 128.4 | 1,569.8 |
| | San Juan-Colo. | 317.6 | 44.0 | 11.6 | 373.2 | 5.9 | 20.8 | 12.2 | 38.9 | 4.3 | 39.4 | −128.4 | 335.3 |
| | Total | 2,068.6 | 121.1 | 38.3 | 2,228.0 | 42.5 | 32.2 | 36.3 | 111.0 | 16.9 | 667.5 | — | 3,023.4 |

[1] Includes evaporation from related reservoirs.
[2] Includes urban, rural, and other industrial uses.



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**TABLE UC–5—Colorado River System Consumptive Uses and Losses Report, P.L. 90–537**
**Upper Colorado River Basin Estimated Water Use by State, Major Tributary, and Type of Use 1973**

(1,000 A.F.)

| State | Tributary or Reporting Area | AGRICULTURE | | | | MUNICIPAL AND INDUSTRIAL [1] | | | | FISH & WILDLIFE RECREATION [1] | EXPORT [1] | | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Irrigation | Irrigation Reservoir Evaporation | Stockpond Evaporation & Livestock | Total | Mineral Resources | Thermal Electric Power | Other [2] | Total | | Out-side System | With-in System | |
| Arizona | San Juan-Colo. | 4.0 | 2.4 | 0.9 | 7.3 | 0.0 | 0.0 | 3.2 | 3.2 | 0.9 | — | — | 11.4 |
| Colorado | Green River | 95.2 95.2 | 1.5 | 4.9 | 101.6 | 4.7 | 4.9 | 2.1 | 11.7 | 2.6 | — | — | 115.9 |
| | Upper Main Stem | 731.5 732.3 | 19.0 | 12.5 | 763.8 | 11.4 | 0.8 | 13.9 | 26.1 | 2.7 | 439.1 | 106.6 | 1,329.8 |
| | San Juan-Colo. | 169.1 169.1 | 5.6 | 3.7 | 178.4 | 2.2 | 0.0 | 3.3 | 5.5 | 0.7 | 4.0 | −106.6 | 90.5 |
| | Total | 996.6 | 26.1 | 21.1 | 1,043.8 | 18.3 | 5.7 | 19.3 | 43.3 | 6.0 | 443.1 | | 1,536.2 |
| New Mexico | San Juan-Colo. | 87.2 87.8 | 26.8 | 2.3 | 116.9 | 2.7 | 20.3 | 4.3 | 27.3 | 0.5 | 174.9 | — | 319.6 |
| Utah | Green River | 502.1 | 24.1 | 3.6 | 529.8 | 7.3 | 1.9 | 4.3 | 13.5 | 6.2 | 106.8 | — | 656.3 |
| | Upper Main Stem | 9.1 | 0.1 | 0.4 | 9.6 | 1.4 | 0.0 | 0.9 | 2.3 | 0.0 | — | — | 11.9 |
| | San Juan-Colo. | 48.2 | 14.4 | 1.6 | 64.2 | 1.2 | 0.0 | 1.5 | 2.7 | 0.9 | −6.0 | — | 61.8 |
| | Total | 559.1 559.4 | 38.6 | 5.6 | 603.6 | 9.9 | 1.9 | 6.7 | 18.5 | 7.1 | 100.8 | — | 730.0 |
| Wyoming | Green River | 235.3 235.3 | 30.8 | 4.7 | 270.8 | 12.8 | 7.6 | 3.5 | 23.9 | 0.2 | 8.7 | — | 303.6 |
| Upper Basin | Green River | 832.6 | 56.4 | 13.2 | 902.2 | 24.8 | 14.4 | 9.9 | 49.1 | 9.0 | 115.5 | — | 1,075.8 |
| | Upper Main Stem | 741.4 | 19.1 | 12.9 | 773.4 | 12.8 | 0.8 | 14.8 | 28.4 | 2.7 | 439.1 | 106.6 | 1,341.7 |
| | San Juan-Colo. | 309.1 | 49.2 | 8.5 | 366.8 | 6.1 | 20.3 | 12.3 | 38.7 | 3.0 | 172.9 | −106.6 | 483.3 |
| | Total | 1,883.1 | 124.7 | 34.6 | 2,042.4 | 43.7 | 35.5 | 37.0 | 116.2 | 14.7 | 727.5 | — | 2,900.8 |

[1] Includes evaporation from related reservoirs.
[2] Includes urban, rural, and other industrial uses.



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## TABLE UC-6—Colorado River System Consumptive Uses and Losses Report, P.L. 90-537
## Upper Colorado River Basin Estimated Water Uses by State, Major Tributary, and Type of Use 1974

(1,000 A.F.)

| | | AGRICULTURE | | | | MUNICIPAL AND INDUSTRIAL [1] | | | | | EXPORT [1] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| State | Tributary or Reporting Area | Irrigation | Irrigation Reservoir Evaporation | Stockpond Evaporation & Livestock | Total | Mineral Resources | Thermal Electric Power | Other [2] | Total | FISH & WILDLIFE RECREATION [1] | Outside System | Within System | TOTAL |
| Arizona | San Juan-Colo. | 4.3 | 3.0 | 1.2 | 8.5 | 0.0 | 5.3 | 3.7 | 9.0 | 1.7 | — | — | 19.2 |
| Colorado | Green River | 112.6 112.6 | 1.7 | 5.6 | 119.9 | 4.7 | 2.9 | 2.2 | 9.8 | 3.1 | — | — | 132.8 |
| | Upper Main Stem | 946.9 946.9 | 20.2 | 12.9 | 980.0 | 11.6 | 0.8 | 14.2 | 26.6 | 2.8 | 500.8 | 119.9 | 1,627.0 |
| | San Juan-Colo. | 191.8 191.8 | 7.6 | 4.9 | 204.3 | 2.2 | 0.0 | 3.4 | 5.6 | 0.9 | 1.2 | −119.9 | 95.2 |
| | Total | 1,251.3 | 29.5 | 23.4 | 1,304.2 | 18.5 | 3.7 | 19.8 | 42.0 | 6.8 | 502.0 | — | 1,855.0 |
| New Mexico | San Juan-Colo. | 96.0 96.5 | 20.0 | 3.0 | 119.5 | 2.9 | 24.6 | 4.5 | 32.0 | 0.7 | 47.7 | — | 199.9 |
| Utah | Green River | 524.5 | 31.8 | 4.8 | 561.1 | 7.4 | 1.8 | 4.3 | 13.5 | 9.2 | 127.0 | — | 710.8 |
| | Upper Main Stem | 9.9 | 0.1 | 0.5 | 10.5 | 1.4 | 0.0 | 0.9 | 2.3 | — | — | — | 12.8 |
| | San Juan-Colo. | 41.0 | 18.8 | 2.0 | 61.8 | 1.1 | 0.0 | 1.6 | 2.7 | 1.1 | −4.1 | — | 61.5 |
| | Total | 575.2 575.4 | 50.7 | 7.3 | 633.4 | 9.9 | 1.8 | 6.8 | 18.5 | 10.3 | 122.9 | — | 785.1 |
| Wyoming | Green River | 288.5 288.5 | 33.4 | 5.2 | 327.1 | 13.7 | 10.1 | 3.7 | 27.5 | 0.2 | 8.7 | — | 363.5 |
| Upper Basin | Green River | 925.6 | 66.9 | 15.6 | 1,008.1 | 25.8 | 14.8 | 10.2 | 50.8 | 12.5 | 135.7 | — | 1,207.1 |
| | Upper Main Stem | 956.8 | 20.3 | 13.4 | 990.5 | 13.0 | 0.8 | 15.1 | 28.9 | 2.8 | 500.8 | 119.9 | 1,639.8 |
| | San Juan-Colo. | 333.6 | 49.4 | 11.1 | 394.1 | 6.2 | 29.9 | 13.2 | 49.3 | 4.4 | 44.8 | −119.9 | 375.8 |
| | Total | 2,216.0 | 136.6 | 40.1 | 2,392.7 | 45.0 | 45.5 | 38.5 | 129.0 | 19.7 | 681.3 | — | 3,222.7 |

[1] Includes evaporation from related reservoirs.
[2] Includes urban, rural, and other industrial uses.

**TABLE UC-7—Colorado River System Consumptive Uses and Losses Report, P.L. 90-537 Upper Colorado River Basin Estimated Water Use by State, Major Tributary, and Type of Use 1975[3]**

(1,000 A.F.)

| State | Tributary or Reporting Area | AGRICULTURE: Irrigation | AGRICULTURE: Irrigation Reservoir Evaporation | AGRICULTURE: Stockpond Evaporation & Livestock | AGRICULTURE: Total | MUNICIPAL AND INDUSTRIAL[1]: Mineral Resources | MUNICIPAL AND INDUSTRIAL[1]: Thermal Electric Power | MUNICIPAL AND INDUSTRIAL[1]: Other[2] | MUNICIPAL AND INDUSTRIAL[1]: Total | FISH & WILDLIFE RECREATION[1] | EXPORT[1]: Out-Side System | EXPORT[1]: With-in System | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arizona | San Juan-Colo. | 5.1 | 2.5 | 0.9 | 8.5 | 0.0 | 12.4 | 2.9 | 15.3 | 1.4 | — | — | 25.2 |
| Colorado | Green River | 100.2 100.2 | 1.6 | 5.2 | 107.0 | 4.7 | 3.2 | 2.2 | 10.1 | 2.8 | — | — | 119.9 |
| | Upper Main Stem | 825.7 826.1 | 16.5 | 10.7 | 853.3 | 11.7 | 0.8 | 14.5 | 27.0 | 2.3 | 559.8 | 120.3 | 1,556.5 |
| | San Juan-Colo. | 184.0 196.3 | 5.7 | 3.8 | 205.8 | 2.2 | 0.0 | 3.6 | 5.8 | 0.7 | 2.8 | −120.3 | 101.0 |
| | Total | 1,122.6 | 23.8 | 19.7 | 1,166.1 | 18.6 | 4.0 | 20.3 | 42.9 | 5.8 | 562.6 | — | 1,777.4 |
| New Mexico | San Juan-Colo. | 88.3 89.0 | 23.6 | 2.4 | 115.0 | 3.0 | 21.9 | 4.8 | 29.7 | 0.5 | 145.2 | — | 290.4 |
| Utah | Green River | 393.8 | 24.0 | 4.5 | 422.3 | 7.4 | 7.0 | 4.4 | 18.8 | 6.6 | 107.2 | — | 554.9 |
| | Upper Main Stem | 8.7 | 0.1 | 0.4 | 9.2 | 1.4 | 0.0 | 0.9 | 2.3 | — | — | — | 11.5 |
| | San Juan-Colo. | 36.9 | 12.6 | 1.7 | 51.2 | 1.2 | 0.0 | 1.6 | 2.8 | 0.8 | −6.1 | — | 48.7 |
| | Total | 439.3 439.4 | 36.7 | 6.6 | 482.7 | 10.0 | 7.0 | 6.9 | 23.9 | 7.4 | 101.1 | — | 615.1 |
| Wyoming | Green River | 207.1 207.1 | 28.1 | 4.9 | 253.2 | 14.6 | 12.9 | 3.8 | 31.3 | 0.2 | 6.6 | — | 291.3 |
| Upper Basin | Green River | 714.2 | 53.7 | 14.6 | 782.5 | 26.7 | 23.1 | 10.4 | 60.2 | 9.6 | 113.8 | — | 966.1 |
| | Upper Main Stem | 834.8 | 16.6 | 11.1 | 862.5 | 13.1 | 0.8 | 15.4 | 29.3 | 2.3 | 559.8 | 120.3 | 1,568.0 |
| | San Juan-Colo. | 327.3 | 44.4 | 8.8 | 380.5 | 6.4 | 34.3 | 12.9 | 53.6 | 3.4 | 141.9 | −120.3 | 465.3 |
| | Total | 1,876.3 | 114.7 | 34.5 | 2,025.5 | 46.2 | 58.2 | 38.7 | 143.1 | 15.3 | 815.5 | — | 2,999.4 |

[1] Includes evaporation from related reservoirs.
[2] Includes urban, rural, and other industrial uses.
[3] Provisional.



OSE-0686

Colorado Green River (Upper Colorado CU+L)

| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Modified USBR/ Original USBR | Modified SCS/ Original USBR |
|---|---|---|---|---|---|---|---|
| C 1 | 1976 | 19990 | 20110 | 23791 | 25041 | 0.85 | 1.05 |
| | 1977 | 14701 | 14815 | 20782 | 18490 | 0.71 | 0.89 |
| | 1978 | 24475 | 24357 | 27692 | 28029 | 0.88 | 1.01 |
| | 1979 | 25050 | 25123 | 30396 | 28568 | 0.83 | 0.94 |
| | 1980 | 26525 | 27662 | 31304 | 30621 | 0.88 | 0.98 |
| | Average | 22148 | 22413 | 26793 | 26150 | 0.84 | 0.98 |
| C 2 | 1976 | 7641 | 7672 | 7836 | 8281 | 0.98 | 1.06 |
| | 1977 | 6834 | 6873 | 7990 | 7413 | 0.86 | 0.93 |
| | 1978 | 7397 | 7430 | 7724 | 8122 | 0.96 | 1.05 |
| | 1979 | 8030 | 8059 | 8703 | 8617 | 0.93 | 0.99 |
| | 1980 | 6609 | 6636 | 6445 | 7341 | 1.03 | 1.14 |
| | Average | 7302 | 7334 | 7740 | 7955 | 0.95 | 1.03 |
| C 3 | 1976 | 25540 | 25650 | 25313 | 28480 | 1.01 | 1.13 |
| | 1977 | 24327 | 24531 | 25942 | 26379 | 0.95 | 1.02 |
| | 1978 | 30652 | 30775 | 29808 | 33017 | 1.03 | 1.11 |
| | 1979 | 28821 | 28909 | 31761 | 31793 | 0.91 | 1.00 |
| | 1980 | 29870 | 29904 | 34012 | 32805 | 0.88 | 0.96 |
| | Average | 27842 | 27954 | 29367 | 30495 | 0.95 | 1.04 |
| C 3a | 1976 | 3535 | 3560 | 3772 | 3746 | 0.94 | 0.99 |
| | 1977 | 2796 | 2821 | 2808 | 2978 | 1.00 | 1.06 |
| | 1978 | 3853 | 3838 | 4184 | 4080 | 0.92 | 0.98 |
| | 1979 | 3805 | 3830 | 3795 | 3979 | 1.01 | 1.05 |
| | 1980 | 3186 | 3204 | 2806 | 3402 | 1.14 | 1.21 |
| | Average | 3435 | 3451 | 3473 | 3637 | 0.99 | 1.05 |
| C 4 | 1976 | 2028 | 2035 | 2202 | 2436 | 0.92 | 1.11 |
| | 1977 | 2117 | 2125 | 2616 | 2527 | 0.81 | 0.97 |
| | 1978 | 2705 | 2718 | 2686 | 3142 | 1.01 | 1.17 |
| | 1979 | 2966 | 2975 | 3659 | 3244 | 0.81 | 0.89 |
| | 1980 | 2890 | 2918 | 2939 | 3186 | 0.99 | 1.08 |
| | Average | 2541 | 2554 | 2820 | 2907 | 0.91 | 1.03 |
| C 5 | 1976 | 18179 | 18341 | 19565 | 20745 | 0.94 | 1.06 |
| | 1977 | 17849 | 17936 | 19330 | 19567 | 0.93 | 1.01 |
| | 1978 | 23047 | 23114 | 26943 | 24886 | 0.86 | 0.92 |
| | 1979 | 22192 | 22237 | 23493 | 24366 | 0.95 | 1.04 |
| | 1980 | 20026 | 20068 | 22111 | 22096 | 0.91 | 1.00 |
| | Average | 20259 | 20339 | 22288 | 22332 | 0.91 | 1.00 |
| C 6 | 1976 | 4781 | 4800 | 4193 | 5076 | 1.14 | 1.21 |
| | 1977 | 3402 | 3413 | 3286 | 3553 | 1.04 | 1.08 |
| | 1978 | 5699 | 5611 | 5721 | 5894 | 0.98 | 1.03 |
| | 1979 | 5798 | 5860 | 6351 | 6113 | 0.92 | 0.96 |
| | 1980 | 4675 | 4690 | 4806 | 5019 | 0.98 | 1.04 |
| | Average | 4871 | 4875 | 4871 | 5131 | 1.00 | 1.05 |
| Total CO Green River Average | | 88398 | 88920 | 97353 | 98606 | 0.91 | 1.01 |

| Colorado Green River (Upper Colorado CU+L) Irrigation Depletions w/CU+L Incidental Depletions | | | | | | | |
|---|---|---|---|---|---|---|---|
| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Ratio -- Modified USBR rain/Original USBR rain | Ratio -- Modified SCS rain/Original USBR rain |
| C 1 | 1976 | 24800 | 24997 | 29572 | 31125 | 0.85 | 1.05 |
| | 1977 | 18300 | 18415 | 25832 | 22983 | 0.71 | 0.89 |
| | 1978 | 30400 | 30276 | 34421 | 34840 | 0.88 | 1.01 |
| | 1979 | 31100 | 31228 | 37782 | 35510 | 0.83 | 0.94 |
| | 1980 | 33000 | 34384 | 38910 | 38062 | 0.88 | 0.98 |
| | Average | 27520 | 27860 | 33303 | 32504 | 0.84 | 0.98 |
| C 2 | 1976 | 9500 | 9536 | 9740 | 10294 | 0.98 | 1.06 |
| | 1977 | 8500 | 8543 | 9932 | 9215 | 0.86 | 0.93 |
| | 1978 | 9200 | 9235 | 9601 | 10095 | 0.96 | 1.05 |
| | 1979 | 10000 | 10018 | 10818 | 10711 | 0.93 | 0.99 |
| | 1980 | 8200 | 8249 | 8011 | 9125 | 1.03 | 1.14 |
| | Average | 9080 | 9116 | 9620 | 9888 | 0.95 | 1.03 |
| C 3 | 1976 | 31700 | 31883 | 31464 | 35400 | 1.01 | 1.13 |
| | 1977 | 30200 | 30492 | 32246 | 32789 | 0.95 | 1.02 |
| | 1978 | 38100 | 38253 | 37051 | 41041 | 1.03 | 1.11 |
| | 1979 | 35800 | 35934 | 39479 | 39519 | 0.91 | 1.00 |
| | 1980 | 37100 | 37171 | 42277 | 40776 | 0.88 | 0.96 |
| | Average | 34580 | 34747 | 36503 | 37905 | 0.95 | 1.04 |
| C 3a | 1976 | 4200 | 4179 | 4428 | 4398 | 0.94 | 0.99 |
| | 1977 | 3300 | 3312 | 3297 | 3496 | 1.00 | 1.06 |
| | 1978 | 4500 | 4505 | 4912 | 4790 | 0.92 | 0.98 |
| | 1979 | 4500 | 4497 | 4455 | 4671 | 1.01 | 1.05 |
| | 1980 | 3700 | 3762 | 3294 | 3994 | 1.14 | 1.21 |
| | Average | 4040 | 4051 | 4077 | 4270 | 0.99 | 1.05 |
| C 4 | 1976 | 2500 | 2530 | 2737 | 3028 | 0.92 | 1.11 |
| | 1977 | 2600 | 2641 | 3252 | 3141 | 0.81 | 0.97 |
| | 1978 | 3400 | 3378 | 3338 | 3905 | 1.01 | 1.17 |
| | 1979 | 3700 | 3697 | 4548 | 4033 | 0.81 | 0.89 |
| | 1980 | 3600 | 3626 | 3653 | 3960 | 0.99 | 1.08 |
| | Average | 3160 | 3174 | 3506 | 3613 | 0.91 | 1.03 |
| C 5 | 1976 | 22600 | 22797 | 24320 | 25785 | 0.94 | 1.06 |
| | 1977 | 22200 | 22295 | 24027 | 24321 | 0.93 | 1.01 |
| | 1978 | 28600 | 28730 | 33490 | 30933 | 0.86 | 0.92 |
| | 1979 | 27600 | 27641 | 29202 | 30287 | 0.95 | 1.04 |
| | 1980 | 24900 | 24944 | 27484 | 27465 | 0.91 | 1.00 |
| | Average | 25180 | 25281 | 27705 | 27758 | 0.91 | 1.00 |
| C 6 | 1976 | 5900 | 5967 | 5212 | 6309 | 1.14 | 1.21 |
| | 1977 | 4200 | 4242 | 4084 | 4417 | 1.04 | 1.08 |
| | 1978 | 7100 | 6975 | 7111 | 7326 | 0.98 | 1.03 |
| | 1979 | 7200 | 7284 | 7895 | 7599 | 0.92 | 0.96 |
| | 1980 | 5800 | 5829 | 5974 | 6239 | 0.98 | 1.04 |
| | Average | 6040 | 6059 | 6055 | 6378 | 1.00 | 1.05 |
| Total CO Green River Average | | 109600 | 110289 | 120770 | 122316 | 0.91 | 1.01 |

# REVISED DRAFT

Colorado San Juan River (Upper Colorado CU+L)

| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Modified USBR/ Original USBR | Modified SCS/ Original USBR |
|---|---|---|---|---|---|---|---|
| C 21 | 1976 | 8373 | 8398 | 8198 | 10049 | 1.02 | 1.23 |
| | 1977 | 4817 | 4836 | 6479 | 6082 | 0.75 | 0.94 |
| | 1978 | 9799 | 9836 | 13136 | 11258 | 0.75 | 0.86 |
| | 1979 | 13709 | 13751 | 19288 | 15550 | 0.71 | 0.81 |
| | 1980 | 12488 | 12515 | 13352 | 13915 | 0.94 | 1.04 |
| | Average | 9837 | 9867 | 12091 | 11371 | 0.82 | 0.94 |
| C 22 | 1976 | 36983 | 37219 | 35563 | 42402 | 1.05 | 1.19 |
| | 1977 | 31119 | 31347 | 34183 | 33888 | 0.92 | 0.99 |
| | 1978 | 38880 | 39033 | 38692 | 42327 | 1.01 | 1.09 |
| | 1979 | 45924 | 46084 | 53772 | 49658 | 0.86 | 0.92 |
| | 1980 | 42270 | 42513 | 44005 | 45344 | 0.97 | 1.03 |
| | Average | 39035 | 39239 | 41243 | 42724 | 0.95 | 1.04 |
| C 22a | 1976 | 28972 | 29109 | 31256 | 33328 | 0.93 | 1.07 |
| | 1977 | 30067 | 30247 | 31288 | 32577 | 0.97 | 1.04 |
| | 1978 | 28944 | 29174 | 32597 | 32212 | 0.89 | 0.99 |
| | 1979 | 32104 | 32229 | 36776 | 34635 | 0.88 | 0.94 |
| | 1980 | 29729 | 30093 | 32471 | 32332 | 0.93 | 1.00 |
| | Average | 29963 | 30170 | 32878 | 33017 | 0.92 | 1.00 |
| C 23 | 1976 | 14854 | 14945 | 15830 | 14945 | 0.94 | 0.94 |
| | 1977 | 7797 | 7856 | 8242 | 7856 | 0.95 | 0.95 |
| | 1978 | 13764 | 13830 | 15020 | 13830 | 0.92 | 0.92 |
| | 1979 | 16021 | 15599 | 17317 | 15599 | 0.90 | 0.90 |
| | 1980 | 15636 | 15706 | 16275 | 15706 | 0.97 | 0.97 |
| | Average | 13614 | 13587 | 14537 | 13587 | 0.93 | 0.93 |
| C 24 | 1976 | 9520 | 9558 | 11005 | 10372 | 0.87 | 0.94 |
| | 1977 | 7178 | 7199 | 7585 | 7715 | 0.95 | 1.02 |
| | 1978 | 8518 | 8524 | 8459 | 9199 | 1.01 | 1.09 |
| | 1979 | 11688 | 11863 | 12211 | 12583 | 0.97 | 1.03 |
| | 1980 | 8829 | 8848 | 8781 | 9554 | 1.01 | 1.09 |
| | Average | 9147 | 9198 | 9608 | 9885 | 0.96 | 1.03 |
| C 24a | 1976 | 40910 | 41041 | 45857 | 44241 | 0.89 | 0.96 |
| | 1977 | 30101 | 30157 | 33166 | 32480 | 0.91 | 0.98 |
| | 1978 | 31396 | 31442 | 31177 | 33818 | 1.01 | 1.08 |
| | 1979 | 41151 | 41265 | 44668 | 43844 | 0.92 | 0.98 |
| | 1980 | 41291 | 41438 | 43168 | 43156 | 0.96 | 1.00 |
| | Average | 36970 | 37069 | 39607 | 39508 | 0.94 | 1.00 |
| Total CO San Juan Average | | 138566 | 139131 | 149963 | 150091 | 0.93 | 1.00 |

| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Original Blaney-Criddle (af) USBR rainfall | Ratio — Modified USBR rain/Original USBR rain | Ratio — Modified SCS rain/Original USBR rain |
|---|---|---|---|---|---|---|---|
| Colorado San Juan River (Upper Colorado CU+L) Irrigation Depletions w/CU+L Incidental Depletions | | | | | | | |
| C 21 | 1976 | 8800 | 8827 | 10561 | 8616 | 1.02 | 1.23 |
| | 1977 | 5100 | 5083 | 6392 | 6810 | 0.75 | 0.94 |
| | 1978 | 10300 | 10338 | 11832 | 13806 | 0.75 | 0.86 |
| | 1979 | 14400 | 14452 | 16343 | 20272 | 0.71 | 0.81 |
| | 1980 | 13100 | 13154 | 14625 | 14033 | 0.94 | 1.04 |
| | Average | 10340 | 10371 | 11951 | 12707 | 0.82 | 0.94 |
| C 22 | 1976 | 38900 | 39117 | 44565 | 37377 | 1.05 | 1.19 |
| | 1977 | 32700 | 32946 | 35617 | 35926 | 0.92 | 0.99 |
| | 1978 | 40900 | 41024 | 44486 | 40665 | 1.01 | 1.09 |
| | 1979 | 48300 | 48435 | 52191 | 56514 | 0.86 | 0.92 |
| | 1980 | 44400 | 44682 | 47657 | 46250 | 0.97 | 1.03 |
| | Average | 41040 | 41241 | 44903 | 43346 | 0.95 | 1.04 |
| C 22a | 1976 | 30400 | 30593 | 35027 | 32851 | 0.93 | 1.07 |
| | 1977 | 31600 | 31790 | 34238 | 32884 | 0.97 | 1.04 |
| | 1978 | 30400 | 30662 | 33854 | 34259 | 0.90 | 0.99 |
| | 1979 | 33700 | 33873 | 36402 | 38651 | 0.88 | 0.94 |
| | 1980 | 31200 | 31628 | 33981 | 34127 | 0.93 | 1.00 |
| | Average | 31460 | 31709 | 34700 | 34554 | 0.92 | 1.00 |
| C 23 | 1976 | 15600 | 15707 | 15707 | 16638 | 0.94 | 0.94 |
| | 1977 | 8200 | 8257 | 8257 | 8663 | 0.95 | 0.95 |
| | 1978 | 14500 | 14535 | 14535 | 15786 | 0.92 | 0.92 |
| | 1979 | 16800 | 16394 | 16394 | 18200 | 0.90 | 0.90 |
| | 1980 | 16400 | 16507 | 16507 | 17105 | 0.97 | 0.97 |
| | Average | 14300 | 14280 | 14280 | 15278 | 0.93 | 0.93 |
| C 24 | 1976 | 10500 | 10504 | 11399 | 12094 | 0.87 | 0.94 |
| | 1977 | 7900 | 7912 | 8478 | 8336 | 0.95 | 1.02 |
| | 1978 | 9400 | 9367 | 10109 | 9297 | 1.01 | 1.09 |
| | 1979 | 12800 | 13038 | 13828 | 13420 | 0.97 | 1.03 |
| | 1980 | 9700 | 9724 | 10500 | 9651 | 1.01 | 1.09 |
| | Average | 10060 | 10109 | 10863 | 10560 | 0.96 | 1.03 |
| C 24a | 1976 | 45000 | 45104 | 48621 | 50396 | 0.89 | 0.96 |
| | 1977 | 33100 | 33142 | 35696 | 36450 | 0.91 | 0.98 |
| | 1978 | 34500 | 34555 | 37166 | 34264 | 1.01 | 1.08 |
| | 1979 | 45200 | 45350 | 48185 | 49090 | 0.92 | 0.98 |
| | 1980 | 45400 | 45540 | 47428 | 47442 | 0.96 | 1.00 |
| | Average | 40640 | 40738 | 43419 | 43528 | 0.94 | 1.00 |
| Total CO San Juan Average | | 147840 | 148448 | 160116 | 159975 | 0.93 | 1.00 |

| | Colorado River Upper Mainstem (Upper Colorado CU+L) | | | | | | |
|---|---|---|---|---|---|---|---|
| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Modified USBR/ Original USBR | Modified SCS/ Original USBR |
| C 7 | 1976 | 14126 | 14173 | 17983 | 15545 | 0.79 | 0.86 |
| | 1977 | 10376 | 10398 | 15318 | 12352 | 0.68 | 0.81 |
| | 1978 | 14486 | 14565 | 19020 | 15767 | 0.77 | 0.83 |
| | 1979 | 11530 | 11589 | 16024 | 13386 | 0.72 | 0.84 |
| | 1980 | 12575 | 12610 | 16416 | 14313 | 0.77 | 0.87 |
| | Average | 12619 | 12667 | 16952 | 14273 | 0.75 | 0.84 |
| C 8 | 1976 | 20767 | 20826 | 25356 | 25002 | 0.82 | 0.99 |
| | 1977 | 27552 | 27180 | 33410 | 30649 | 0.81 | 0.92 |
| | 1978 | 31265 | 31321 | 37589 | 34232 | 0.83 | 0.91 |
| | 1979 | 25558 | 25674 | 32794 | 30319 | 0.78 | 0.92 |
| | 1980 | 24680 | 24794 | 22017 | 28482 | 1.13 | 1.29 |
| | Average | 25964 | 25959 | 30233 | 29737 | 0.86 | 0.98 |
| C 9 | 1976 | 13791 | 13850 | 15981 | 14933 | 0.87 | 0.93 |
| | 1977 | 12778 | 12235 | 13382 | 12925 | 0.91 | 0.97 |
| | 1978 | 14676 | 14710 | 13661 | 15250 | 1.08 | 1.12 |
| | 1979 | 13597 | 13643 | 15626 | 14846 | 0.87 | 0.95 |
| | 1980 | 16008 | 16035 | 16880 | 16651 | 0.95 | 0.99 |
| | Average | 14170 | 14095 | 15106 | 14921 | 0.93 | 0.99 |
| C 9a | 1976 | 8541 | 8603 | 11849 | 9564 | 0.73 | 0.81 |
| | 1977 | 8036 | 8081 | 10284 | 8662 | 0.79 | 0.84 |
| | 1978 | 10770 | 10830 | 11274 | 11282 | 0.96 | 1.00 |
| | 1979 | 9800 | 9835 | 13092 | 10620 | 0.75 | 0.81 |
| | 1980 | 11206 | 11233 | 13673 | 11743 | 0.82 | 0.86 |
| | Average | 9671 | 9716 | 12034 | 10374 | 0.81 | 0.86 |
| C 10 | 1976 | 12614 | 12671 | 10976 | 14309 | 1.15 | 1.30 |
| | 1977 | 12868 | 12914 | 13636 | 14328 | 0.95 | 1.05 |
| | 1978 | 13461 | 13486 | 14574 | 15030 | 0.93 | 1.03 |
| | 1979 | 10793 | 10810 | 11925 | 12601 | 0.91 | 1.06 |
| | 1980 | 13754 | 13786 | 10604 | 14962 | 1.30 | 1.41 |
| | Average | 12698 | 12733 | 12343 | 14246 | 1.03 | 1.15 |
| C10a | 1976 | 18918 | 18990 | 18878 | 20568 | 1.01 | 1.09 |
| | 1977 | 15415 | 15497 | 17586 | 17261 | 0.88 | 0.98 |
| | 1978 | 19189 | 19243 | 21286 | 20719 | 0.90 | 0.97 |
| | 1979 | 22371 | 22387 | 24692 | 24614 | 0.91 | 1.00 |
| | 1980 | 21348 | 21397 | 23804 | 22941 | 0.90 | 0.96 |
| | Average | 19448 | 19503 | 21249 | 21221 | 0.92 | 1.00 |
| C11 | 1976 | 53824 | 54033 | 55541 | 57445 | 0.97 | 1.03 |
| | 1977 | 39291 | 39528 | 37796 | 40880 | 1.05 | 1.08 |
| | 1978 | 62316 | 62475 | 65042 | 65087 | 0.96 | 1.00 |
| | 1979 | 67390 | 67661 | 71038 | 71317 | 0.95 | 1.00 |
| | 1980 | 60856 | 61044 | 62409 | 65349 | 0.98 | 1.05 |
| | Average | 56735 | 56948 | 58365 | 60016 | 0.98 | 1.03 |

Colorado River Upper Mainstem (Upper Colorado CU+L)

| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Modified USBR/ Original USBR | Modified SCS/ Original USBR |
|---|---|---|---|---|---|---|---|
| C 12 | 1976 | 35482 | 35803 | 34591 | 37587 | 1.04 | 1.09 |
| | 1977 | 26137 | 26484 | 27513 | 28565 | 0.96 | 1.04 |
| | 1978 | 30996 | 30472 | 33440 | 32812 | 0.91 | 0.98 |
| | 1979 | 30132 | 39423 | 40904 | 41737 | 0.96 | 1.02 |
| | 1980 | 39053 | 39552 | 39783 | 41931 | 0.99 | 1.05 |
| | Average | 32360 | 34347 | 35246 | 36526 | 0.97 | 1.04 |
| C 13 | 1976 | 153601 | 155409 | 143037 | 159947 | 1.09 | 1.12 |
| | 1977 | 152084 | 152874 | 139533 | 156140 | 1.10 | 1.12 |
| | 1978 | 162314 | 163014 | 152540 | 168237 | 1.07 | 1.10 |
| | 1979 | 164361 | 165200 | 149752 | 169860 | 1.10 | 1.13 |
| | 1980 | 162563 | 163684 | 153762 | 169152 | 1.06 | 1.10 |
| | Average | 158985 | 160036 | 147725 | 164667 | 1.08 | 1.11 |
| C 14 | 1976 | 31645 | 31848 | 38056 | 38597 | 0.84 | 1.01 |
| | 1977 | 27265 | 25744 | 28431 | 29064 | 0.91 | 1.02 |
| | 1978 | 52884 | 53323 | 70223 | 56762 | 0.76 | 0.81 |
| | 1979 | 52773 | 52980 | 65465 | 57347 | 0.81 | 0.88 |
| | 1980 | 55655 | 56545 | 67674 | 59533 | 0.84 | 0.88 |
| | Average | 44044 | 44088 | 53970 | 48261 | 0.82 | 0.89 |
| C 15 | 1976 | 92002 | 92830 | 98103 | 97313 | 0.95 | 0.99 |
| | 1977 | 92196 | 93056 | 95425 | 97413 | 0.98 | 1.02 |
| | 1978 | 97746 | 98349 | 102183 | 104378 | 0.96 | 1.02 |
| | 1979 | 89969 | 90725 | 98309 | 97663 | 0.92 | 0.99 |
| | 1980 | 105596 | 106471 | 101245 | 112535 | 1.05 | 1.11 |
| | Average | 95502 | 96286 | 99053 | 101860 | 0.97 | 1.03 |
| C 16 | 1976 | 19784 | 19649 | 23880 | 21425 | 0.82 | 0.90 |
| | 1977 | 16365 | 16482 | 19348 | 18061 | 0.85 | 0.93 |
| | 1978 | 19855 | 20340 | 23143 | 22166 | 0.88 | 0.96 |
| | 1979 | 18341 | 18399 | 22260 | 20420 | 0.83 | 0.92 |
| | 1980 | 19755 | 19829 | 23126 | 21217 | 0.86 | 0.92 |
| | Average | 18820 | 18940 | 22351 | 20658 | 0.85 | 0.92 |
| C 17 | 1976 | 165861 | 167037 | 175376 | 172082 | 0.95 | 0.98 |
| | 1977 | 148504 | 149953 | 152554 | 155150 | 0.98 | 1.02 |
| | 1978 | 171950 | 173209 | 179551 | 179940 | 0.96 | 1.00 |
| | 1979 | 165645 | 167090 | 176430 | 173784 | 0.95 | 0.99 |
| | 1980 | 170776 | 172220 | 178520 | 179478 | 0.96 | 1.01 |
| | Average | 164547 | 165902 | 172486 | 172087 | 0.96 | 1.00 |
| C 17a | 1976 | 7843 | 8012 | 7631 | 8299 | 1.05 | 1.09 |
| | 1977 | 10009 | 10072 | 9307 | 10266 | 1.08 | 1.10 |
| | 1978 | 9155 | 9221 | 8708 | 9505 | 1.06 | 1.09 |
| | 1979 | 9929 | 9995 | 9628 | 10276 | 1.04 | 1.07 |
| | 1980 | 8948 | 9029 | 8654 | 9299 | 1.04 | 1.07 |
| | Average | 9177 | 9266 | 8786 | 9529 | 1.05 | 1.08 |

| | Colorado River Upper Mainstem (Upper Colorado CU+L) | | | | | | |
|---|---|---|---|---|---|---|---|
| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Modified USBR/ Original USBR | Modified SCS/ Original USBR |
| C 18 | 1976 | 4684 | 4711 | 4605 | 5552 | 1.02 | 1.21 |
| | 1977 | 3282 | 3133 | 4311 | 3997 | 0.73 | 0.93 |
| | 1978 | 4980 | 4998 | 5159 | 5355 | 0.97 | 1.04 |
| | 1979 | 4303 | 4327 | 4553 | 5126 | 0.95 | 1.13 |
| | 1980 | 5330 | 5359 | 5309 | 5917 | 1.01 | 1.11 |
| | Average | 4516 | 4506 | 4787 | 5189 | 0.94 | 1.08 |
| C 18a | 1976 | 4057 | 4092 | 5265 | 4933 | 0.78 | 0.94 |
| | 1977 | 2774 | 2813 | 3449 | 3365 | 0.82 | 0.98 |
| | 1978 | 4446 | 4474 | 5220 | 4953 | 0.86 | 0.95 |
| | 1979 | 4622 | 4643 | 5658 | 5107 | 0.82 | 0.90 |
| | 1980 | 4269 | 4293 | 5064 | 4765 | 0.85 | 0.94 |
| | Average | 4034 | 4063 | 4931 | 4625 | 0.82 | 0.94 |
| C 19 | 1976 | 15393 | 15591 | 16834 | 17160 | 0.93 | 1.02 |
| | 1977 | 14084 | 14273 | 14065 | 15210 | 1.01 | 1.08 |
| | 1978 | 18014 | 18157 | 17709 | 19757 | 1.03 | 1.12 |
| | 1979 | 20276 | 20475 | 20135 | 21532 | 1.02 | 1.07 |
| | 1980 | 18551 | 18513 | 17425 | 19764 | 1.06 | 1.13 |
| | Average | 17264 | 17402 | 17234 | 18685 | 1.01 | 1.08 |
| C 20 | 1976 | 9396 | 9463 | 10156 | 10043 | 0.93 | 0.99 |
| | 1977 | 5994 | 6076 | 6335 | 6383 | 0.96 | 1.01 |
| | 1978 | 9650 | 9734 | 9327 | 10296 | 1.04 | 1.10 |
| | 1979 | 11203 | 11307 | 11177 | 11826 | 1.01 | 1.06 |
| | 1980 | 9951 | 10077 | 10145 | 10709 | 0.99 | 1.06 |
| | Average | 9239 | 9331 | 9428 | 9851 | 0.99 | 1.04 |
| C 20a | 1976 | 1132 | 1161 | 1441 | 1261 | 0.81 | 0.88 |
| | 1977 | 597 | 554 | 691 | 601 | 0.80 | 0.87 |
| | 1978 | 1202 | 1220 | 1389 | 1300 | 0.88 | 0.94 |
| | 1979 | 1497 | 1523 | 1736 | 1626 | 0.88 | 0.94 |
| | 1980 | 1351 | 1367 | 1548 | 1450 | 0.88 | 0.94 |
| | Average | 1156 | 1165 | 1361 | 1248 | 0.86 | 0.92 |
| Total CO Mainstem Average | | 710948 | 716953 | 743641 | 757973 | 0.96 | 1.02 |

DRAFT

| | Colorado River Upper Mainstem (Upper Colorado CU+L) Irrigation Depletions w/ CU+L Incidental Losses | | | | | | |
|---|---|---|---|---|---|---|---|
| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Ratio Modified USBR rain/Original USBR rain | Ratio Modified SCS rain/Original USBR rain |
| C 7 | 1976 | 16800 | 16851 | 21382 | 18483 | 0.79 | 0.86 |
| | 1977 | 12300 | 12364 | 18213 | 14687 | 0.68 | 0.81 |
| | 1978 | 17200 | 17317 | 22615 | 18748 | 0.77 | 0.83 |
| | 1979 | 13700 | 13779 | 19052 | 15916 | 0.72 | 0.84 |
| | 1980 | 15000 | 14993 | 19519 | 17018 | 0.77 | 0.87 |
| | Average | 15000 | 15061 | 20156 | 16970 | 0.75 | 0.84 |
| C 8 | 1976 | 24700 | 24762 | 30149 | 29727 | 0.82 | 0.99 |
| | 1977 | 32800 | 32318 | 39724 | 36441 | 0.81 | 0.92 |
| | 1978 | 37200 | 37241 | 44693 | 40702 | 0.83 | 0.91 |
| | 1979 | 30400 | 30526 | 38992 | 36050 | 0.78 | 0.92 |
| | 1980 | 29300 | 29480 | 26178 | 33865 | 1.13 | 1.29 |
| | Average | 30880 | 30865 | 35947 | 35357 | 0.86 | 0.98 |
| C 9 | 1976 | 16400 | 16467 | 19002 | 17756 | 0.87 | 0.93 |
| | 1977 | 15200 | 14547 | 15911 | 15367 | 0.91 | 0.97 |
| | 1978 | 17400 | 17490 | 16243 | 18132 | 1.08 | 1.12 |
| | 1979 | 16200 | 16222 | 18579 | 17652 | 0.87 | 0.95 |
| | 1980 | 19000 | 19066 | 20070 | 19798 | 0.95 | 0.99 |
| | Average | 16840 | 16758 | 17961 | 17741 | 0.93 | 0.99 |
| C 9a | 1976 | 10200 | 10228 | 14088 | 11372 | 0.73 | 0.81 |
| | 1977 | 9600 | 9608 | 12227 | 10300 | 0.79 | 0.84 |
| | 1978 | 12800 | 12877 | 13405 | 13414 | 0.96 | 1.00 |
| | 1979 | 11700 | 11694 | 15567 | 12627 | 0.75 | 0.81 |
| | 1980 | 13300 | 13356 | 16257 | 13963 | 0.82 | 0.86 |
| | Average | 11520 | 11553 | 14309 | 12335 | 0.81 | 0.86 |
| C 10 | 1976 | 15000 | 15066 | 13050 | 17013 | 1.15 | 1.30 |
| | 1977 | 15300 | 15354 | 16213 | 17036 | 0.95 | 1.05 |
| | 1978 | 16000 | 16034 | 17328 | 17870 | 0.93 | 1.03 |
| | 1979 | 12800 | 12853 | 14179 | 14983 | 0.91 | 1.06 |
| | 1980 | 16400 | 16391 | 12609 | 17789 | 1.30 | 1.41 |
| | Average | 15100 | 15140 | 14676 | 16938 | 1.03 | 1.15 |

**Colorado River Upper Mainstem (Upper Colorado CU+L) Irrigation Depletions**
w/ CU+L Incidental Losses

| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Ratio Modified USBR rain/Original USBR rain | Ratio Modified SCS rain/Original USBR rain |
|---|---|---|---|---|---|---|---|
| C10a | 1976 | 22500 | 22579 | 22446 | 24455 | 1.01 | 1.09 |
| | 1977 | 18300 | 18425 | 20910 | 20524 | 0.88 | 0.98 |
| | 1978 | 22800 | 22880 | 25309 | 24635 | 0.90 | 0.97 |
| | 1979 | 26600 | 26618 | 29359 | 29266 | 0.91 | 1.00 |
| | 1980 | 25400 | 25441 | 28303 | 27277 | 0.90 | 0.96 |
| | | | | | | | |
| | Average | 23120 | 23189 | 25265 | 25231 | 0.92 | 1.00 |
| | | | | | | | |
| C11 | 1976 | 64000 | 64245 | 66039 | 68302 | 0.97 | 1.03 |
| | 1977 | 46700 | 46999 | 44939 | 48607 | 1.05 | 1.08 |
| | 1978 | 74100 | 74283 | 77335 | 77388 | 0.96 | 1.00 |
| | 1979 | 80100 | 80449 | 84464 | 84796 | 0.95 | 1.00 |
| | 1980 | 72400 | 72581 | 74204 | 77699 | 0.98 | 1.05 |
| | | | | | | | |
| | Average | 67460 | 67711 | 69396 | 71358 | 0.98 | 1.03 |
| | | | | | | | |
| C 12 | 1976 | 42200 | 42569 | 41129 | 44691 | 1.04 | 1.09 |
| | 1977 | 31100 | 31490 | 32713 | 33964 | 0.96 | 1.04 |
| | 1978 | 36900 | 36231 | 39761 | 39014 | 0.91 | 0.98 |
| | 1979 | 46500 | 46874 | 48635 | 49625 | 0.96 | 1.02 |
| | 1980 | 46400 | 47028 | 47302 | 49856 | 0.99 | 1.05 |
| | | | | | | | |
| | Average | 40620 | 40838 | 41908 | 43430 | 0.97 | 1.04 |
| | | | | | | | |
| C 13 | 1976 | 182600 | 184781 | 170071 | 190177 | 1.09 | 1.12 |
| | 1977 | 180800 | 181767 | 165905 | 185650 | 1.10 | 1.12 |
| | 1978 | 193000 | 193824 | 181370 | 200034 | 1.07 | 1.10 |
| | 1979 | 195400 | 196422 | 178055 | 201963 | 1.10 | 1.13 |
| | 1980 | 193300 | 194620 | 182823 | 201122 | 1.06 | 1.10 |
| | | | | | | | |
| | Average | 189020 | 190283 | 175645 | 195789 | 1.08 | 1.11 |
| | | | | | | | |
| C 14 | 1976 | 40800 | 41020 | 49016 | 49714 | 0.84 | 1.01 |
| | 1977 | 35100 | 33158 | 36620 | 37434 | 0.91 | 1.02 |
| | 1978 | 68100 | 68681 | 90447 | 73110 | 0.76 | 0.81 |
| | 1979 | 68000 | 68239 | 84319 | 73863 | 0.81 | 0.88 |
| | 1980 | 71700 | 72831 | 87164 | 76678 | 0.84 | 0.88 |
| | | | | | | | |
| | Average | 56740 | 56786 | 69513 | 62160 | 0.82 | 0.89 |

DRAFT

| | Colorado River Upper Mainstem (Upper Colorado CU+L) Irrigation Depletions w/ CU+L Incidental Losses | | | | | | |
|---|---|---|---|---|---|---|---|
| Basin | Year | CU + L (acre-feet) | Modified Blaney-Criddle (af) USBR rainfall | Original Blaney-Criddle (af) USBR rainfall | Modified Blaney-Criddle (af) SCS rainfall | Ratio Modified USBR rain/Original USBR rain | Ratio Modified SCS rain/Original USBR rain |
| C 15 | 1976 | 118500 | 119566 | 126357 | 125339 | 0.95 | 0.99 |
| | 1977 | 118700 | 119857 | 122908 | 125468 | 0.98 | 1.02 |
| | 1978 | 125900 | 126673 | 131612 | 134439 | 0.96 | 1.02 |
| | 1979 | 115900 | 116854 | 126622 | 125789 | 0.92 | 0.99 |
| | 1980 | 136000 | 137134 | 130404 | 144945 | 1.05 | 1.11 |
| | | | | | | | |
| | Average | 123000 | 124017 | 127581 | 131196 | 0.97 | 1.03 |
| | | | | | | | |
| C 16 | 1976 | 25500 | 25307 | 30757 | 27595 | 0.82 | 0.90 |
| | 1977 | 21100 | 21229 | 24920 | 23262 | 0.85 | 0.93 |
| | 1978 | 25600 | 26198 | 29809 | 28550 | 0.88 | 0.96 |
| | 1979 | 23600 | 23698 | 28671 | 26301 | 0.83 | 0.92 |
| | 1980 | 25400 | 25540 | 29786 | 27328 | 0.86 | 0.92 |
| | | | | | | | |
| | Average | 24240 | 24394 | 28789 | 26607 | 0.85 | 0.92 |
| | | | | | | | |
| C 17 | 1976 | 213600 | 215143 | 225884 | 221641 | 0.95 | 0.98 |
| | 1977 | 191300 | 193139 | 196490 | 199833 | 0.98 | 1.02 |
| | 1978 | 221500 | 223093 | 231262 | 231762 | 0.96 | 1.00 |
| | 1979 | 213400 | 215212 | 227242 | 223833 | 0.95 | 0.98 |
| | 1980 | 220000 | 221819 | 229934 | 231167 | 0.96 | 1.01 |
| | | | | | | | |
| | Average | 211960 | 213681 | 222162 | 221647 | 0.96 | 1.00 |
| | | | | | | | |
| C 17a | 1976 | 10200 | 10319 | 9829 | 10689 | 1.05 | 1.09 |
| | 1977 | 12900 | 12973 | 11987 | 13223 | 1.08 | 1.10 |
| | 1978 | 11800 | 11876 | 11217 | 12243 | 1.06 | 1.09 |
| | 1979 | 12800 | 12873 | 12400 | 13236 | 1.04 | 1.07 |
| | 1980 | 11500 | 11629 | 11146 | 11978 | 1.04 | 1.07 |
| | | | | | | | |
| | Average | 11840 | 11934 | 11316 | 12274 | 1.05 | 1.08 |
| | | | | | | | |
| C 18 | 1976 | 5000 | 5031 | 4919 | 5929 | 1.02 | 1.21 |
| | 1977 | 3500 | 3538 | 4604 | 4269 | 0.77 | 0.93 |
| | 1978 | 5300 | 5338 | 5510 | 5719 | 0.97 | 1.04 |
| | 1979 | 4600 | 4621 | 4863 | 5475 | 0.95 | 1.13 |
| | 1980 | 5700 | 5723 | 5670 | 6319 | 1.01 | 1.11 |

| | Colorado River Upper Mainstem (Upper Colorado CU+L) Irrigation Depletions | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | w/ CU+L Incidental Losses | | | | | | | |
| Basin | Year | | CU + L (acre-feet) | | Modified Blaney-Criddle (af) USBR rainfall | | Original Blaney-Criddle (af) USBR rainfall | | Modified Blaney-Criddle (af) SCS rainfall | | Ratio Modified USBR rain/Original USBR rain | Ratio Modified SCS rain/Original USBR rain |
| | Average | | 4820 | | 4850 | | 5113 | | 5542 | | 0.95 | 1.08 |
| | | | | | | | | | | | | |
| C 18a | 1976 | | 4300 | | 4370 | | 5623 | | 5269 | | 0.78 | 0.94 |
| | 1977 | | 3000 | | 3004 | | 3683 | | 3594 | | 0.82 | 0.98 |
| | 1978 | | 4700 | | 4778 | | 5575 | | 5289 | | 0.86 | 0.95 |
| | 1979 | | 4900 | | 4959 | | 6043 | | 5454 | | 0.82 | 0.90 |
| | 1980 | | 4600 | | 4585 | | 5408 | | 5089 | | 0.85 | 0.94 |
| | | | | | | | | | | | | |
| | Average | | 4300 | | 4339 | | 5266 | | 4939 | | 0.82 | 0.94 |
| | | | | | | | | | | | | |
| C 19 | 1976 | | 16400 | | 16651 | | 17979 | | 18327 | | 0.93 | 1.02 |
| | 1977 | | 15000 | | 15243 | | 15021 | | 16245 | | 1.01 | 1.08 |
| | 1978 | | 19200 | | 19391 | | 18913 | | 21100 | | 1.03 | 1.12 |
| | 1979 | | 21700 | | 21867 | | 21504 | | 22996 | | 1.02 | 1.07 |
| | 1980 | | 19800 | | 19772 | | 18609 | | 21108 | | 1.06 | 1.13 |
| | | | | | | | | | | | | |
| | Average | | 18420 | | 18585 | | 18405 | | 19955 | | 1.01 | 1.08 |
| | | | | | | | | | | | | |
| C 20 | 1976 | | 10000 | | 10106 | | 10847 | | 10726 | | 0.93 | 0.99 |
| | 1977 | | 6400 | | 6489 | | 6766 | | 6817 | | 0.96 | 1.01 |
| | 1978 | | 10300 | | 10396 | | 9961 | | 10997 | | 1.04 | 1.10 |
| | 1979 | | 12000 | | 12076 | | 11937 | | 12630 | | 1.01 | 1.06 |
| | 1980 | | 10600 | | 10762 | | 10835 | | 11437 | | 0.99 | 1.06 |
| | | | | | | | | | | | | |
| | Average | | 9860 | | 9966 | | 10069 | | 10521 | | 0.99 | 1.04 |
| | | | | | | | | | | | | |
| C 20a | 1976 | | 1200 | | 1240 | | 1539 | | 1347 | | 0.81 | 0.88 |
| | 1977 | | 600 | | 592 | | 738 | | 642 | | 0.80 | 0.87 |
| | 1978 | | 1300 | | 1303 | | 1483 | | 1389 | | 0.88 | 0.94 |
| | 1979 | | 1600 | | 1627 | | 1854 | | 1736 | | 0.88 | 0.94 |
| | 1980 | | 1400 | | 1460 | | 1654 | | 1548 | | 0.88 | 0.94 |
| | | | | | | | | | | | | |
| | Average | | 1220 | | 1244 | | 1454 | | 1332 | | 0.86 | 0.92 |
| | | | | | | | | | | | | |
| Total CO Mainstem Average | | | 875960 | | 881195 | | 914932 | | 931325 | | 0.96 | 1.02 |