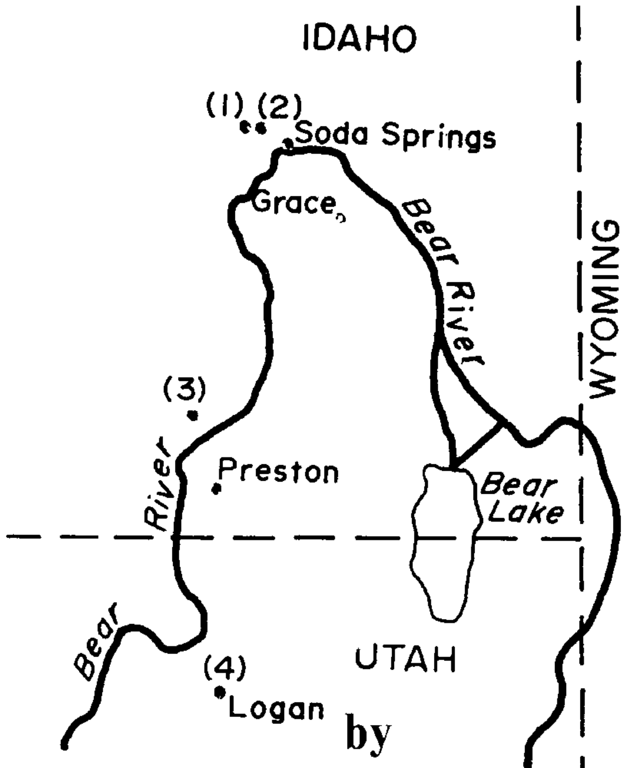
Research Technical Completion Report   Project A-076-IDA

WEATHER AND CONSUMPTIVE USE IN THE BEAR RIVER BASIN, IDAHO DURING 1982



by

R.G. Allen
C.E. Brockway

College of Engineering
College of Agriculture

Idaho Water and Energy Resources Research Institute
University of Idaho
Moscow, Idaho
December 1982

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submitted to

U.S. Department of the Interior
Bureau of Reclamation

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Idaho Water and Energy Resources Research Institute
University of Idaho, Moscow, Idaho

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Cooperators during this project included Mr. Robert Geddes, Banida, Idaho and Mr. Don Rigby, Bancroft, Idaho, who provided field locations for weather sensors and neutron probe access tubes. The cooperation of these two men is appreciated.

Dr. Robert Hill, Utah State University, provided technical assistance and neutron probe information during this study and provided weather information for Logan, Utah.

Mr. Garry Grabow, Utah State University, was responsible for all weekly site visitation, monitoring, maintenance and neutron probe operation. His thorough and dependable field work resulted in high quality weather and soil moisture depletion measurements.

Dr. James Wright, USDA-ARS at Kimberly, provided weather data for the Kimberly site and advice in application of the Wright-1982 reference evapotranspiration method and mean crop coefficients.

Radio station KACH and Utah Power and Light Company provided air temperature and precipitation data from their permanent weather stations. Campbell Scientific, Inc. of Logan, Utah provided wind data for Mendon, Utah.

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ABSTRACT

Temporary weather stations located in the western portion of the Bear River basin in southeastern Idaho were monitored during the 1982 growing season. Hourly measurements of solar radiation, wind travel, air temperature and dewpoint temperature were recorded. Solar radiation in the area was similar to measurements at Logan, Utah and Kimberly, Idaho during the same period. Measured wind travel and air temperatures in the Bear River basin varied with site location.

Consumptive use estimated for crops around each of three weather sites was compared to soil moisture depletion measured with a neutron probe. Consumptive use methods evaluated included the Wright-1982, FAO-Blaney-Criddle, Jensen-Haise, SCS-Blaney-Criddle and a regional aridity approach to estimating consumptive use reported by Morton (1976) and Brutsaert and Stricker (1979). Performance of consumptive use methods depended on whether crops were irrigated or dryland crops.

INTRODUCTION

The Bear River Compact, approved by Congress in 1958, established a nine- member commission that administers the distribution of Bear River water among the signatory States of Utah, Wyoming, and Idaho. In addition to establishing criteria for the distribution of direct flow and stored water for each of these States, the compact also stipulates that it is the policy of the States to encourage additional projects for the development of the water resources of the Bear River to the maximum beneficial use and with a minimum of waste. To enable maximum beneficial use of unappropriated water within the Bear River system through development of additional irrigated farmland, among other uses, reliable and acceptable estimates of consumptive use and irrigation requirements by irrigated crops within the Bear River system are needed.

This study was initiated to provide measurements of weather parameters in agricultural settings for use in estimating consumptive use requirements and for comparision with air temperature measurements from nonagricultural, permanent weather stations in the region. In addition, soil moisture depletion by crops in the Bear River basin was measured to compare calculated with measured consumptive use requirements.

It was originally planned to measure soil moisture depletion and weather parameters over native rangeland within the basin. However, the majority of new irrigation development in the basin will result from conversion of land currently under dryland cultivation. Therefore, soil moisture depletion (consumptive use) and weather parameters were measured over dryland wheat and alfalfa, rather than over native rangeland.

Bear River Basin

The Bear River is the largest river in the western hemisphere, with respect to discharge, whose water does not flow to an ocean (Dion, 1969). All discharge from the Bear River basin enters the Great Salt Lake in northern Utah. After flowing over 500 miles from its source in the Uinta Mountains of Utah and crossing state boundaries five times, the Bear River terminates only 90 miles west of its source.

The climate of the Bear River basin is characterized as semiarid continental, in that winters are cold, summers are hot, and precipitation is sparse. The mean annual temperature at five climatological stations in the basin averages 5.9 ^{o} C. Typically, the frost-free growing season lasts for about 100 days between late May and early September.

Precipitation within the Bear River basin is distributed unevenly with regard to both time and area. Most of the water available to the streams, reservoirs, and aquifers in the basin is derived from winter snow. Rainfall that occurs during the relatively short summer growing season seldom is enough to satisfy the moisture requirements of the crops grown on the lowlands. While precipitation is generally sufficient for dryland farming of hardy crops such as wheat and alfalfa and grass hay, irrigation is required where a wider variety of crops are grown and higher yields are obtained.

Data obtained at U. S. Weather Bureau stations at Preston, Grace and Montpelier show that the average monthly precipitation in the agricultural regions ranges from a high of 49 mm (1.93 inches) in April to a low of 17 mm (0.65 inches) in July. The range in annual precipitation at these stations is from about 215 mm (8.5 inches) to about 600 mm (23.8 inches).

The areal distribution of precipitation is controlled chiefly by elevation and ranges from less that 250 mm (10 inches) in Bear Lake Valley to more than 1150 mm (45 inches) on the Bear River range (Dion, 1969). The amount of precipitation on the entire basin averages about 280 million cubic meters (2.3 million acre-feet) per year.

The principal uses of water in the Bear River basin, in order of quantities used, are for hydroelectric power, irrigation, domestic, stock, and industrial purposes.

Agricultural land is irrigated primarily with water from reservoirs and streams. A large number of relatively small irrigation companies serve small parcels of land. Reservoirs built exclusively for irrigation purposes have a total active capacity of less than 4.3 million cubic meters (35,000 acre-feet) and are inadequate to service the approximately 60,000 irrigated hectares (150,000 irrigated acres) in the basin. The quantity of water diverted from the main stem of Bear River averages more than 30 million cubic meters) 250,000 acre-feet annually (Dion, 1969). Dion (1969) estimated total consumptive use supplied by irrigation within the basin averages 20 million cubic meters (165,000 acre-feet) per year. The majority of irrigated lands in the Idaho portion of the basin lie in the Soda Springs-Grace area and in the Preston area.

WEATHER STATION SITE DESCRIPTIONS

Three weather sensing and recording stations were located at cultivated sites within the Idaho portion of the Bear River Basin in southeast Idaho during 1982. These stations were used to measure and record hourly and daily weather and were equipped with access tubes to allow measurement of soil moisuture depletion using neutron probes. Names, locations and weather parameters recorded at stations are listed in Table 1. Also included are descriptions of weather stations operated by the USDA-ARS at the research center at Kimberly, Idaho and by Utah State University at Logan, Utah during the same period. Period of measurement for the Bear River stations was May 7 through October 26, 1982. Locations of sites are shown in figure 1.

The Preston site (site 1) was located 12 km north-northwest of the city of Preston, Idaho, near the center of a dryland alfalfa field. This site was surrounded by alfalfa on all sides for over 150 meters. The crop was harvested only once during the 1982 season on June 20. The soil type at the Preston site was a deep, lacustrine, silty clay loam with slope less than 1%. Neutron probe access tubes were augered to depths of 2.7 meters (9 feet), where dry soil was encountered. The alfalfa was estimated to have "greened up" about April 20 and ceased growth and water use October 12. However, growth and water use remained quite low after the hay cutting during July, August and early September due to moisture stress.

The Talmage alfalfa site (site 2) was located 2 km north of the Talmage railroad siding between Soda Springs and Bancroft, in a sprinkler irrigated alfalfa setting with over 200 meters of irrigated alfalfa on all sides. The alfalfa crop was harvested twice, on July 20 and August 25,

Table 1. Names, locations and weather information measured at weather sites in southern Idaho and Utah during 1982.

Name	Crop	Location	Latit.	Elev (m)
1. Preston, Idaho (12 km NW) hourly solar radiation, air temperature, wind travel, relative humidity, soil temperature.	Dryland Alfalfa	T14S,R39E,s8	42^{o} 13′	1460
2. Talmage, Idaho hourly solar radiation, air temperature, wind travel, relative humidity, soil temperature.	Irrigated Alfalfa	T9S, R40E,s27	42^{o} 42′	1700
3. Talmage, Idaho hourly air temperature, wind travel, relative humidity, soil temperature.	Dryland W. Wheat	T9S, R40E,s27	42^{o} 42′	1700
4. Logan, Utah (North Farm) daily solar radiation, air temperature, wet and dry bulb temperature, wind run, pan evaporation.	Grass	T12N,R1E	41^{o} 46′	1358
5. Kimberly, Idaho USDA-ARS hourly solar radiation, air temperature, dewpoint, wind run, soil temperature, daily pan evaporation.	Grass	T10S,R18E,s21	42^{o} 30′	1200

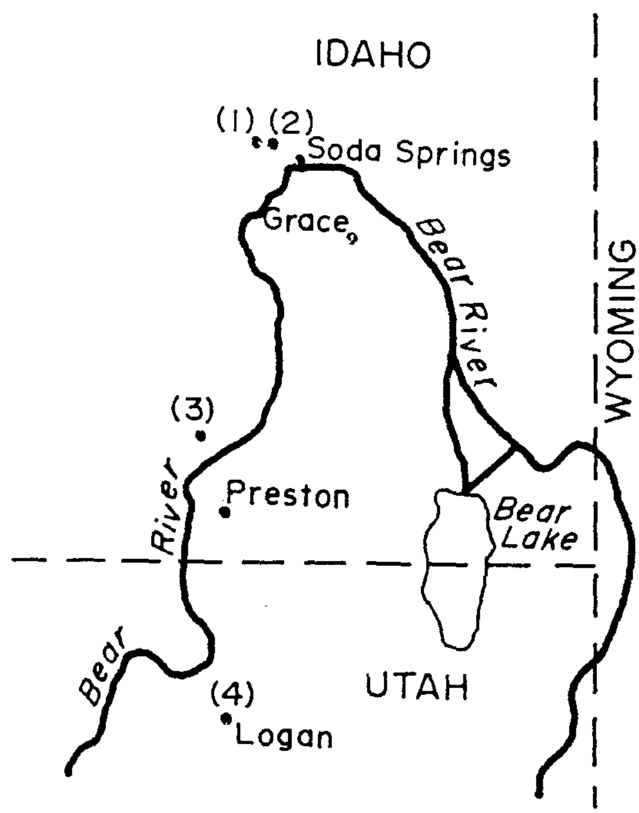

Figure 1. Locations of weather stations in the Bear River region, Idaho during 1982.

during 1982 and was irrigated about June 9 and August 10. Application amounts were estimated to be 64 and 69 mm (2.5 and 2.7 inches) respectively as is discussed in the soil moisture depletion section of this report. Access tubes at site 2 were augered to 2.1 and 2.4 meters (7 and 8 feet), where lava rock was encountered. The Talmage alfalfa was estimated to have "greened up" about May 5 and ceased growth and water use October 12.

The Talmage dryland site (site 3) was located in a dryland winter wheat field about 1 km east of site 2. The site was surrounded by dryland wheat mixed with small areas of lava rock and sagebrush for about 200 meters in all directions. The wheat crop was estimated to have "greened up" about April 20 and reached full cover June 20. The wheat crop was harvested August 23 and did experience some moisture stress during the growing season. The Talmage sites have a silt loam surface soil and a compact, highly calcareous silt loam subsoil overlying basalt bedrock. This soil is predominately aeolian in origin. Access tubes were augered to 1.8 and 2.7 meters (6 and 9 feet), at site three where lava rock was encountered.

Weather instrumentation at sites 1, 2 and 3 consisted of microprocessor based controller/recorder units with cassette storage. Air temperature, relative humidity, solar radiation and wind speed and direction were measured using electronically activated sensors interrogated at intervals of one minute duration. Values from each minute period were averaged over one hour and stored to memory. Hourly and daily maximum and minimum one-minute values of air temperature were also recorded. All sensors were mounted at two meters above ground surface. Measurements of crop height were recorded for adjustment of wind measurements to an equivalent 2-meter standard height. Hourly estimates of dewpoint temperatures were calculated using average hourly values of recorded air temperature and relative humidity. Sites 1 and 2 were equipped with two types of relative humidity sensors for insurance against sensor malfunction and for increased data integrity.

The Logan, Utah weather station (site 4) is located at the North Farm experiment station operated by Utah State University. The farm is situated near the Greenville railroad siding, about 8 km north of Logan. Daily measurements of solar radiation, wind run, maximun and minimum air temperature, wet and dry bulb temperature and precipitation were recorded. Wind was measured at about 0.6 meters height above ground level over an evaporation pan, necessitating adjustment of measurements to reflect wind at a 2 meter height. Weather data for Logan was made available by Dr. Robert Hill (1982) of the Irrigation and Agricultural Engineering Department of Utah State University (Hill, 1982).

The weather station equipment at Kimberly (site 5) was similar to sites 1, 2 and 3, with the exception that dewpoint, rather than relative humidity, was measured using an aspirated electronic dewpoint sensor. The Kimberly sensors were located at 2 meters above clipped turf grass. Weather data at Kimberly for 1982 was collected and made available by Wright and Stevens (1982).

Site Visitation

Sites 1, 2 and 3 were visited at one-week intervals. During each visit, psychrometer readings were taken with a hand-held pyschrometer to verify electronic measurements of air temperature and relative humidity. Soil moisuture was measured with neutron probes and routine maintenance was performed. Cassette tapes were exchanged every two weeks.

Data Reduction

Information stored on cassette tapes was transferred onto the computing system maintained at the USDA-ARS Snake River Conservation Research Center at Kimberly, Idaho. Data values were checked for quality and any missing values were estimated. Hourly and daily data files were created from the cassette information using a computer routine entitled BEARN. Hourly files were archived onto 9-track magnetic tape.

Kimberly hourly weather data was provided by Wright and Stevens (1982), USDA/ARS at Kimberly. Daily weather data for the Logan, Utah area was supplied by Hill (1982), Utah State University.

Relative humidity (RH) measurements recorded by sensors at sites 1, 2 and 3 were compared with values estimated using sling pyschrometer information. Hourly variation in relative humidity and calculated dewpoints were also evaluated. Based on comparisions, relative humdidity measurements by the "best" sensor at each of sites 1 and 2 were selected as representative of the sites. Comparisons of dewpoint temperatures calculated from humidity sensors and a sling psychrometer are shown in figures 2, 3, and 4 for sites 101, 102 and 103 (Preston, Talmage alfalfa and Talmage wheat). The terms HUMI and PHYS represent Humicap relative humidity probes and Physchem relative humidity probes, respectively. The term PSYC represents sling psychrometer measurements made during station visits. Humicap recordings during late July and early August were unreasonably high at the Preston site (figure 2) due to a cable malfunction. The reason for differences between Humicap RH sensor readings

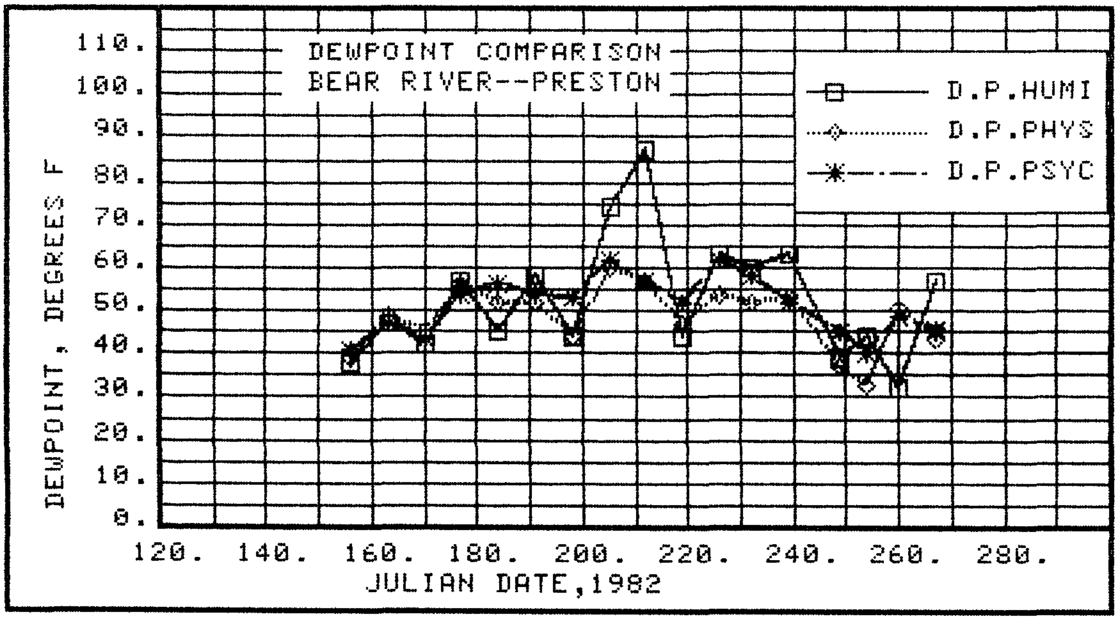

Figure 2. Comparison of calculated dewpoint temperatures at the Preston dryland alfalfa site (site 1) during 1982.

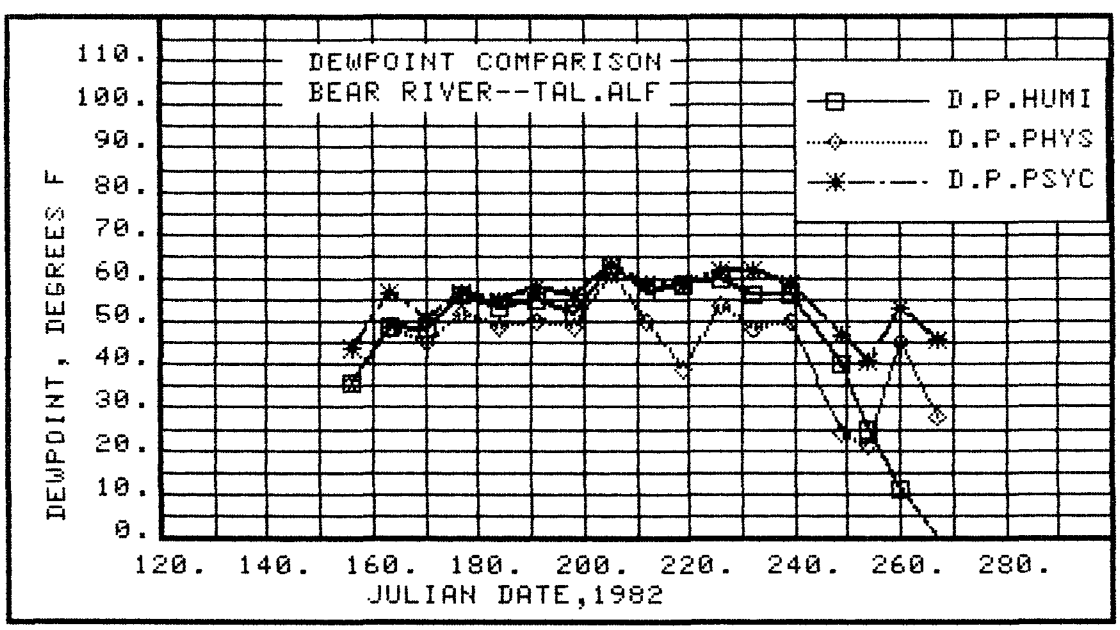

Figure 3. Comparison of calculated dewpoint temperatures at the Talmage irrigated alfalfa site (site 2) during 1982.

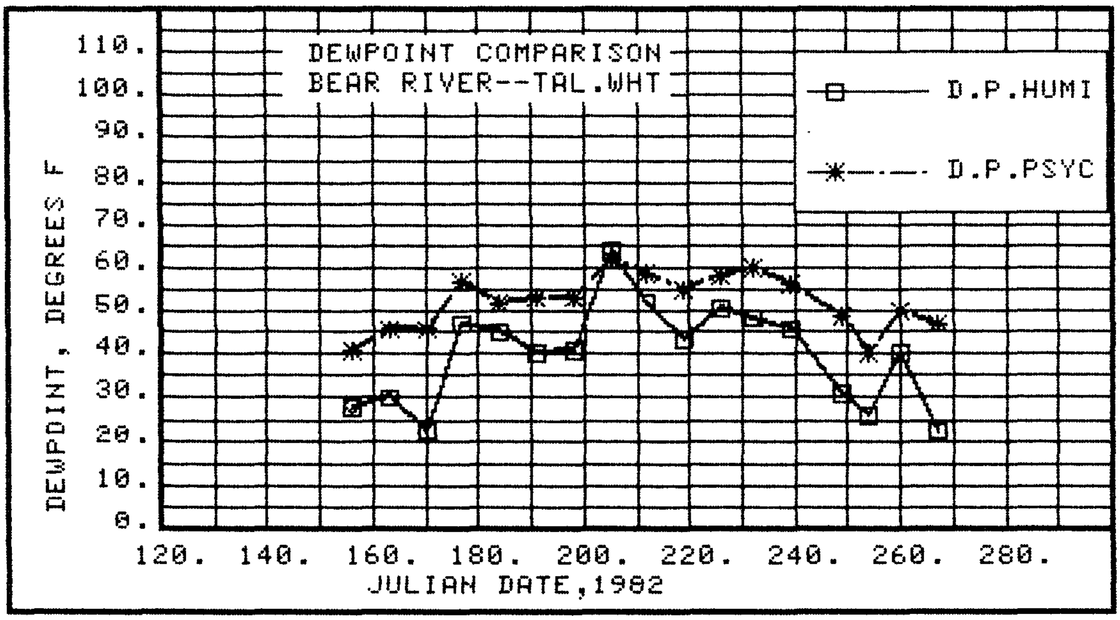

Figure 4. Comparison of calculated dewpoint temperatures at the Talmage dryland winter wheat site (site 3) during 1982.

and sling psychrometer readings at site 103 (figure 4) is not clear. The RH sensor and data logger were electronically tested several times during the season.

WEATHER SUMMARY FOR BEAR RIVER SITES 1, 2, AND 3

Daily weather measurements for the Bear River sites 1, 2, and 3, Kimberly and Logan are summarized in Table 2 on a monthly basis. Daily measurements of solar radiation, windrun, maximum and minimum air temperature, dewpoint temperature, minimum relative humidity, and daytime (7 am - 7 pm) wind speed are shown in figures 5 through 10 and ten-day running averages are shown in figures 11 through 16.

As shown in Table 2 and figures 5 and 11, solar radiation measurements at Preston and Talmage were nearly identical. Missing data at the Preston site (May 22-28, September 11-20) is the major cause of variation between the two sites. No radiation data was measured at the Talmage Wheat site (site 3).

Wind run measured the two Talmage sites during 1982 (figures 6 and 12) was similar due to the proximity of the two stations. Wind run at Preston was similar to wind run at Talmage during May, June, September and October and was about 40% greater than at Talmage during July and August. Wind speeds were much greater at Preston than at Talmage during high wind days. Differences in wind speeds are no doubt primarily due to differences in relief of the areas surrounding the sites. All sites are bordered on the east and west by mountain ranges. The predominate wind direction during summer is from the west.

Air temperature at the three Bear River sites fluctuated in similar manner (figure 7) during the growing season. Temperatures were consistantly higher at Preston than at Talmage, primarily due to the lower elevation at Preston and partly as a result of moisture stress of the

Table 2. Monthly summary of weather measurements at Bear River sites 1, 2 and 3 and at Kimberly, Idaho and Logan, Utah during 1982.

Station	Month	Solar ly/d	Wind km/d	Tmax C	Tmin C	Dew C	Precip mm
Preston Dry.Alfalfa	5	585.	185.	17.8	0.0	4.4	41.9*
Talmage Irr.Alfalfa	5	542.	203.	16.3	-.5	1.7	47.0**
Talmage Dry.W.Wheat	5	542.	201.	16.3	.2	-2.8	47.0**
Logan, Utah N.Farm	5	593.	58.	20.2	5.2	5.9	
Campbell Inc			81.				
Kimberly USDA-ARS	5	578.	244.	18.1	4.7	2.8	
Preston Dry.Alfalfa	6	603.	164.	23.8	5.1	8.9	46.7
Talmage Irr.Alfalfa	6	596.	153.	21.9	3.6	7.8	51.1
Talmage Dry.W.Wheat	6	596.	151.	21.9	4.6	2.8	51.1
Logan, Utah N.Farm	6	638.	67.	26.2	10.0	8.7	
Kimberly USDA-ARS	6	604.	229.	23.6	9.5	6.9	
Preston Dry.Alfalfa	7	581.	180.	28.2	10.4	10.6	37.6
Talmage Irr.Alfalfa	7	574.	132.	26.0	7.3	11.7	65.3
Talmage Dry.W.Wheat	7	574.	116.	26.4	8.0	7.8	65.3
Logan, Utah N.Farm	7	597.	0.	29.6	13.0	12.9	
Campbell Inc			113.				
Kimberly USDA-ARS	7	580.	152.	26.3	12.3	9.8	
Preston Dry.Alfalfa	8	561.	182.	30.9	10.6	8.9	21.3
Talmage Irr.Alfalfa	8	562.	150.	27.6	8.0	10.6	30.2
Talmage Dry.W.Wheat	8	562.	148.	29.7	8.7	6.1	30.2
Logan, Utah N.Farm	8	550.	0.	31.6	13.5	11.7	
Campbell Inc			118.				
Kimberly USDA-ARS	8	548.	180.	28.8	12.9	9.7	
Preston Dry.Alfalfa	9	279.	180.	21.6	6.7	8.9	113.8
Talmage Irr.Alfalfa	9	363.	166.	19.2	3.1	4.4	75.7
Talmage Dry.W.Wheat	9	363.	188.	20.1	3.2	3.3	75.7
Logan, Utah N.Farm	9	344.	47.	23.5	14.4	9.1	
Campbell Inc			104.				
Kimberly USDA-ARS	9	383.	231.	20.7	7.8	5.7	
Preston Dry.Alfalfa	10	271.	145.	14.4	-1.8	-.6	21.6
Talmage Irr.Alfalfa	10	271.	187.	13.4	-2.2	-2.2	25.4
Talmage Dry.W.Wheat	10	271.	182.	13.4	-3.1	-2.2	25.4

* Precipitation recorded at KACH radio station at Preston.
** Weighted average of precipitation at Soda Springs UP&L (0.7) and Grace UP&L (0.3) power sites.

Table 2. continued.

Station	Month	Min. RH %	Daytime Wind m/sec	D/N	Ave. Temp C	Soil Temp (C)
Preston Dry.Alfalfa	5	34.	2.85*	2.63**	9.5	9.5
Talmage Irr.Alfalfa	5	35.	3.52	3.91	8.1	8.2
Talmage Dry.W.Wheat	5	23.	3.29	2.61	8.3	8.6
Preston Dry.Alfalfa	6	33.	2.53	2.34	14.9	14.9
Talmage Irr.Alfalfa	6	37.	2.47	3.21	12.9	12.7
Talmage Dry.W.Wheat	6	23.	2.34	2.34	13.5	13.5
Preston Dry.Alfalfa	7	29.	2.88	2.80	19.3	19.2
Talmage Irr.Alfalfa	7	37.	2.32	4.45	16.5	16.5
Talmage Dry.W.Wheat	7	25.	1.94	3.03	17.0	17.1
Preston Dry.Alfalfa	8	18.	3.00	2.86	21.0	21.0
Talmage Irr.Alfalfa	8	32.	2.53	6.45	17.8	17.8
Talmage Dry.W.Wheat	8	18.	2.49	3.24	19.2	19.2
Preston Dry.Alfalfa	9	40.	2.57	1.99	14.2	14.2
Talmage Irr.Alfalfa	9	36.	2.60	3.16	11.1	11.2
Talmage Dry.W.Wheat	9	34.	2.81	2.12	11.6	11.7
Preston Dry.Alfalfa	10	40.	2.40	3.03	5.5	5.5
Talmage Irr.Alfalfa	10	36.	3.07	6.73	5.4	5.5
Talmage Dry.W.Wheat	10	36.	2.86	2.54	4.6	4.6

* Daytime wind is from 7 am to 7 pm.
** Ratio of daytime wind to nighttime wind.

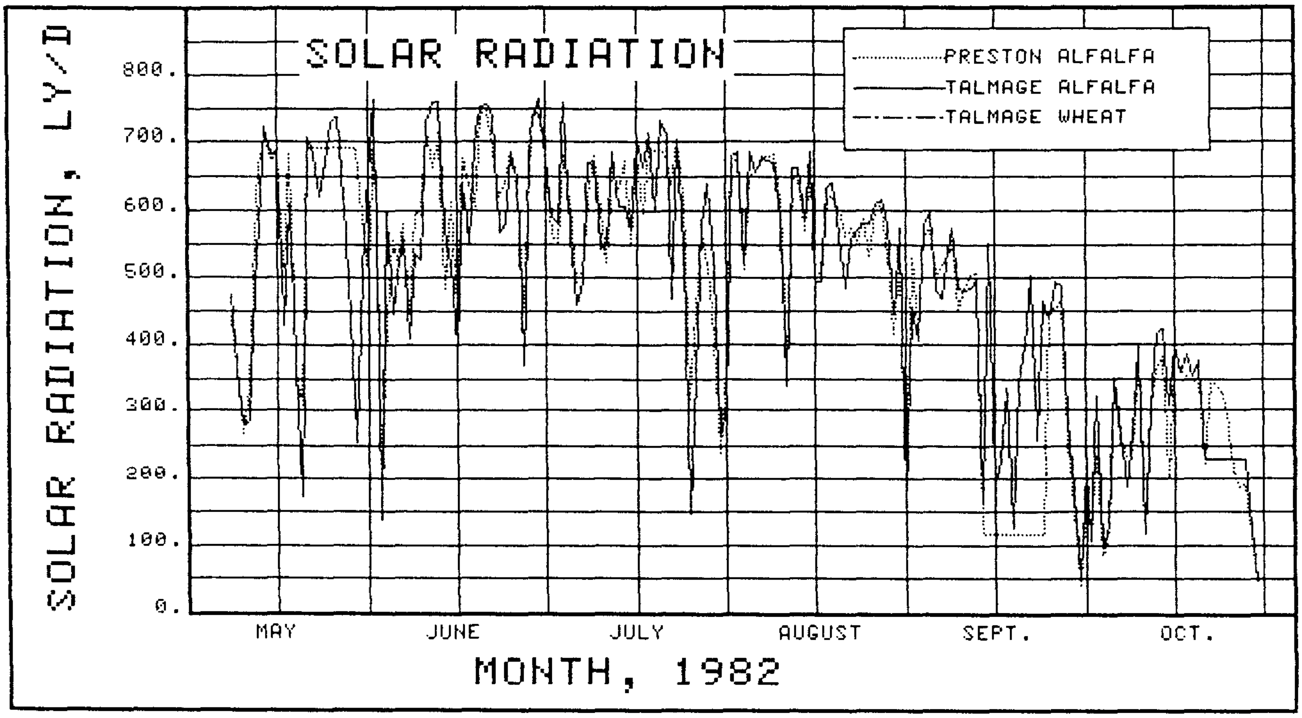

Figure 5. Daily solar radiation at Bear River sites 1, 2 and 3 during 1982.

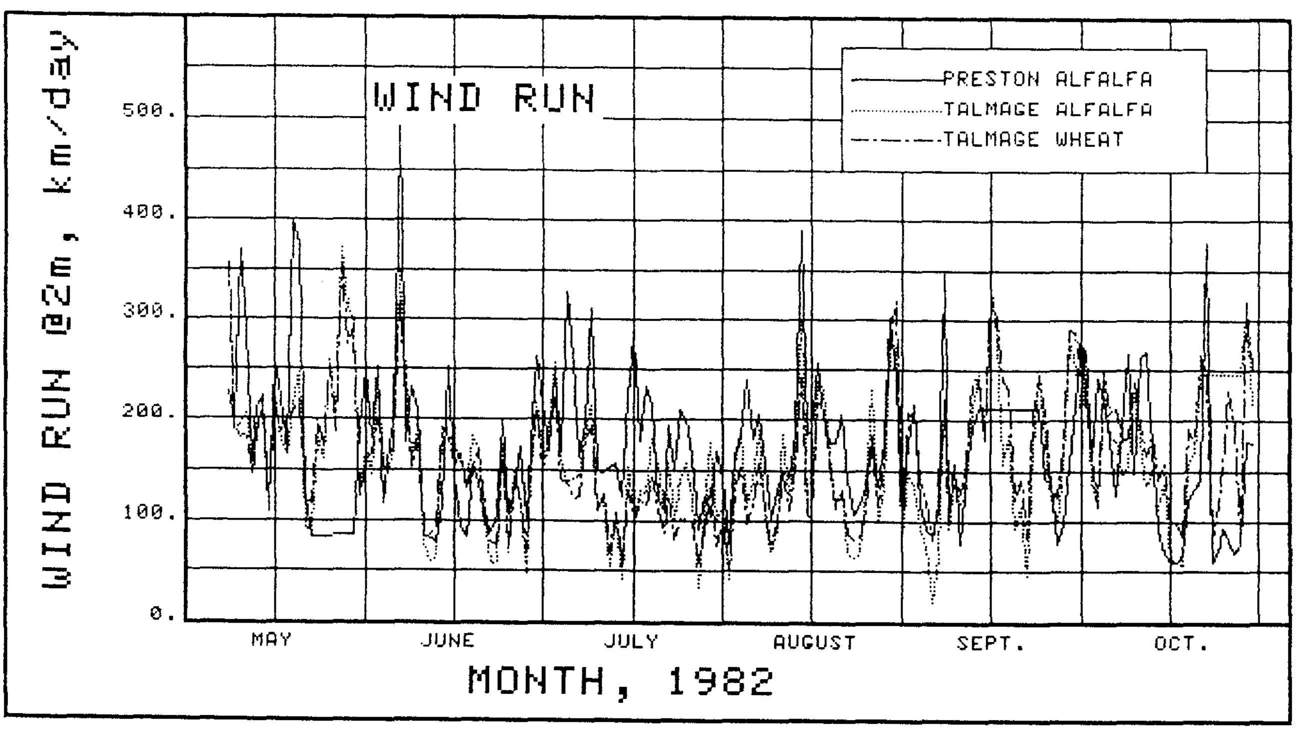

Figure 6. Daily wind run at Bear River sites 1, 2 and 3 during 1982.

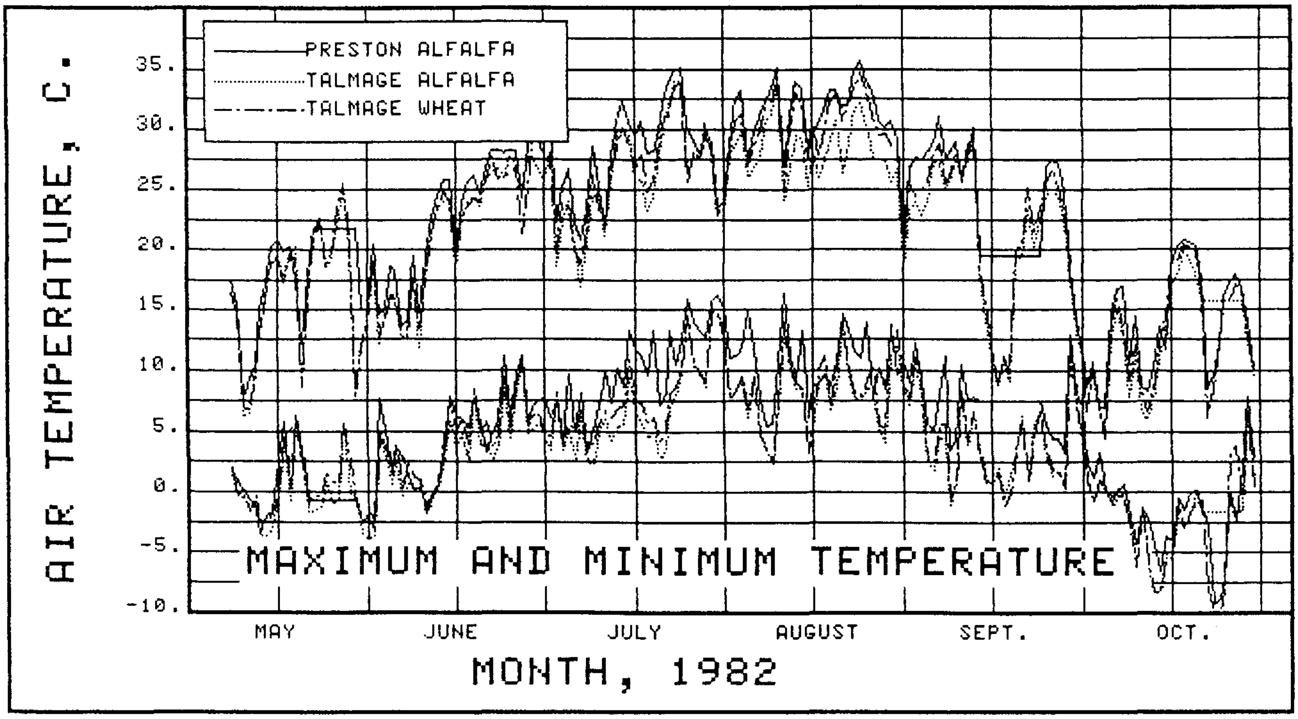

Figure 7. Daily maximum and minimum air temperatures at Bear River sites 1, 2 and 3 during 1982.

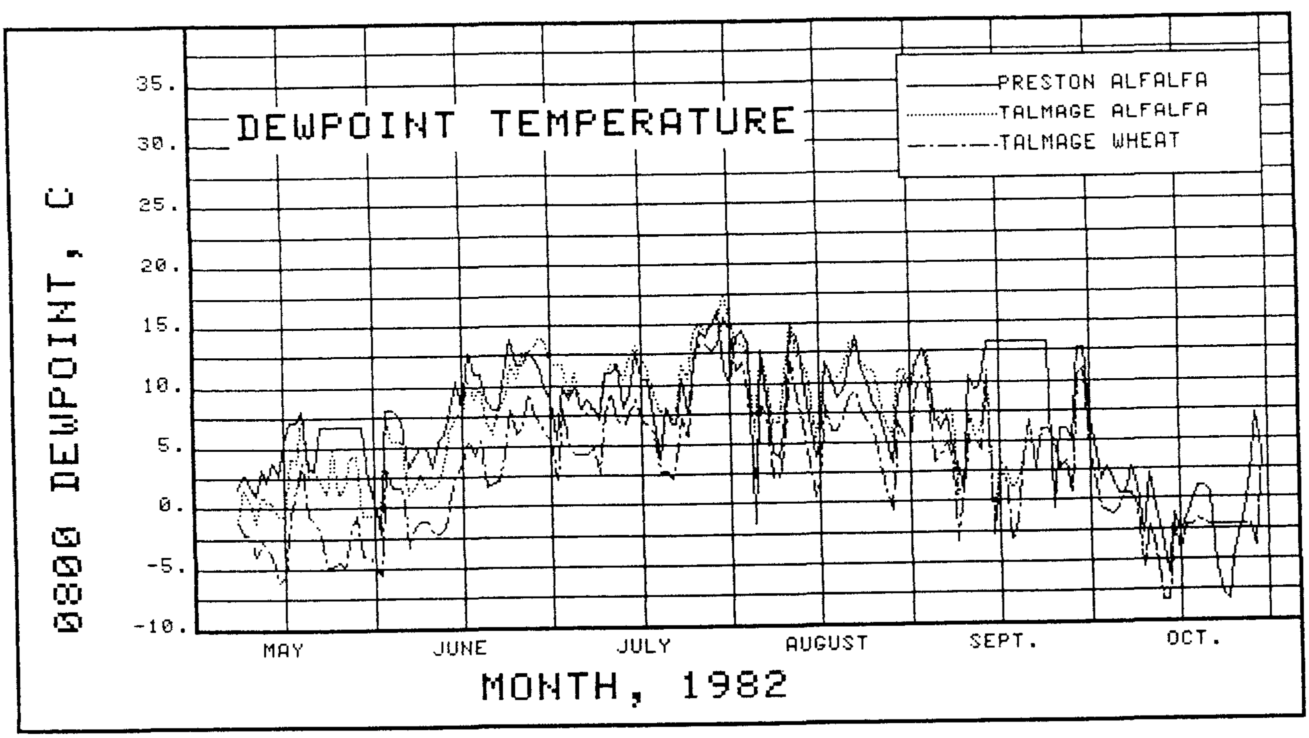

Figure 8. Daily calculated dewpoint temperatures at Bear River sites 1, 2 and 3 during 1982.

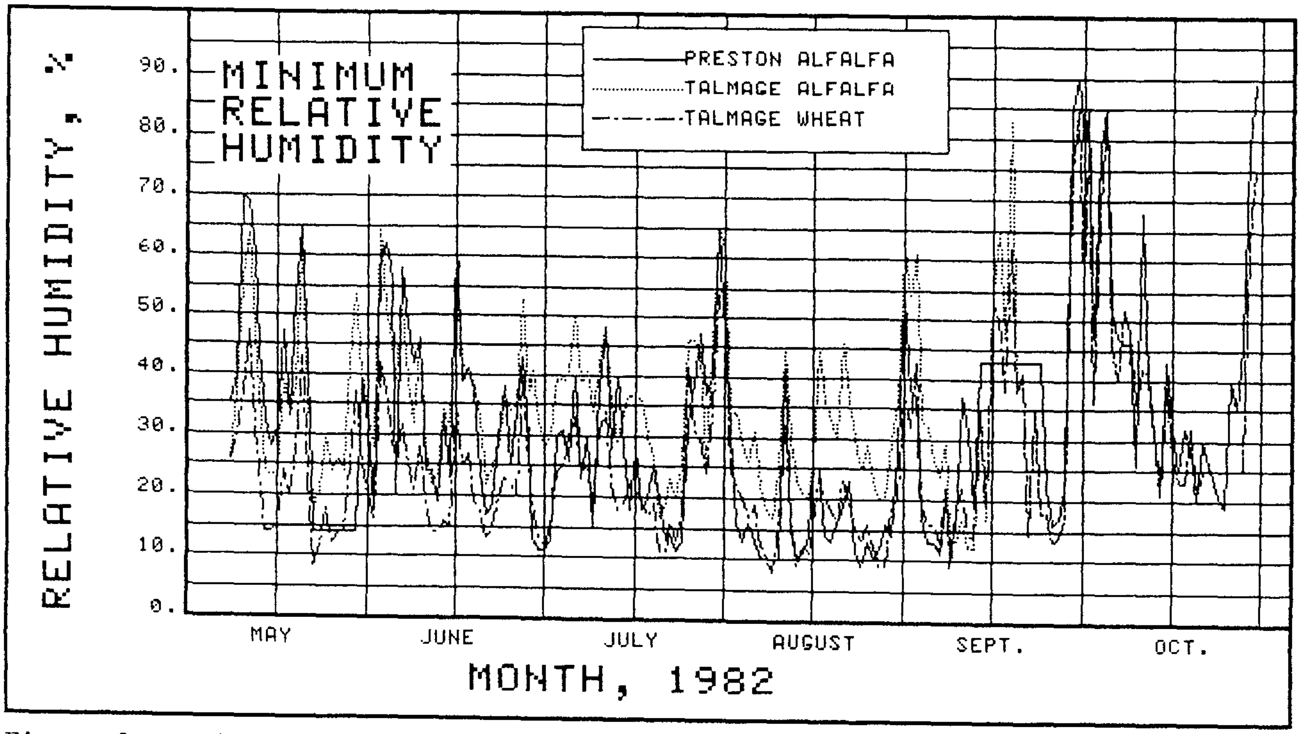

Figure 9. Daily minimum relative humidity at Bear River sites 1, 2 and 3 during 1982.

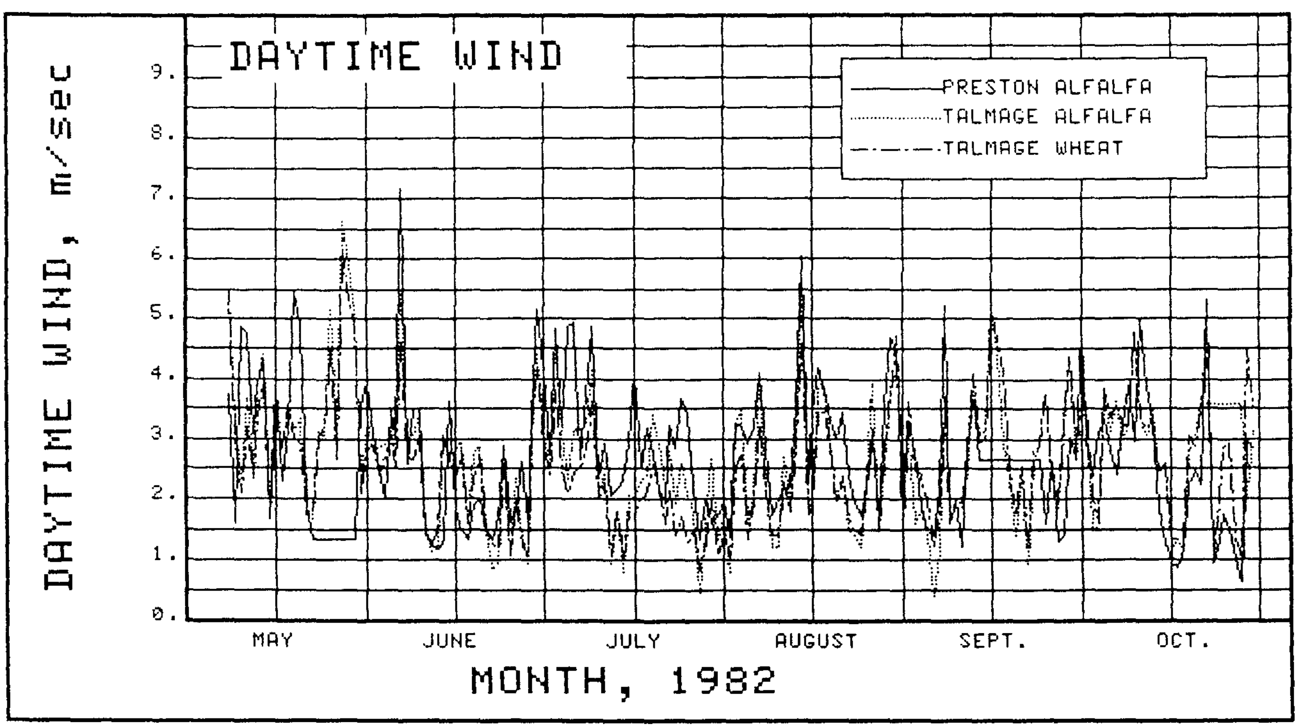

Figure 10. Daily daytime wind speed at Bear River sites 1, 2 and 3 during 1982.

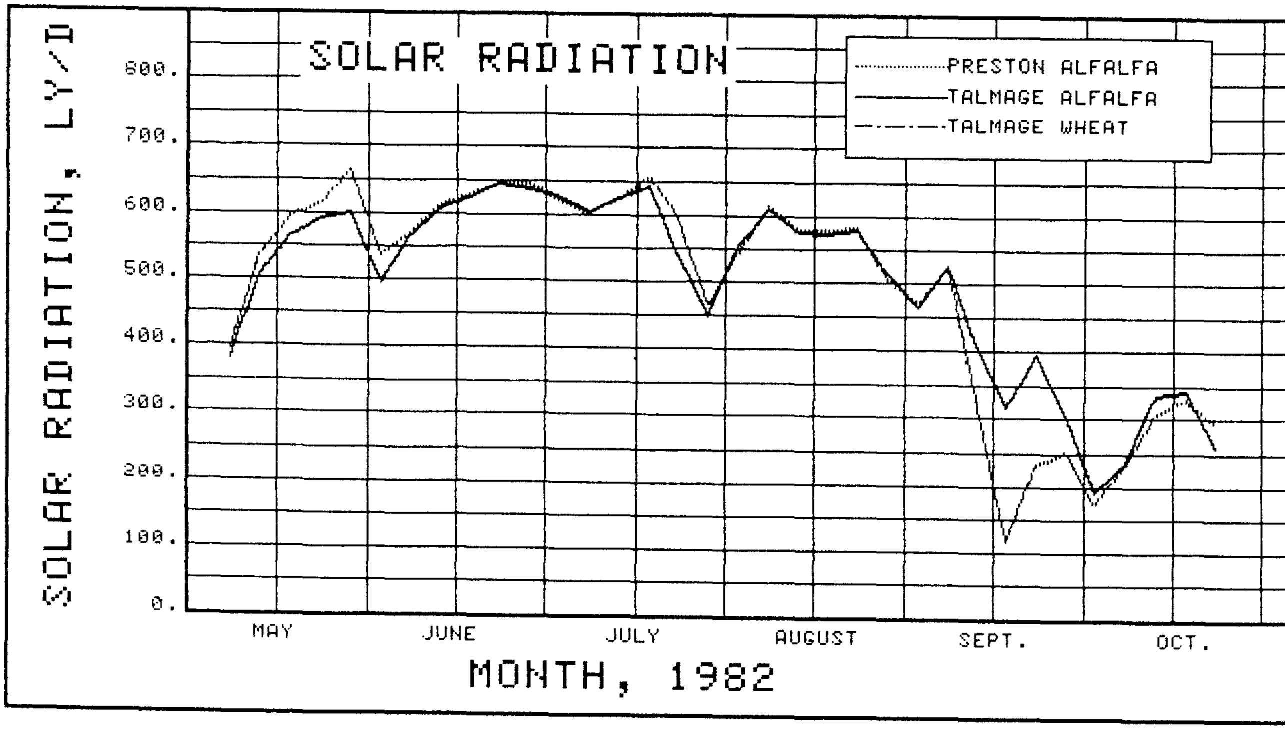

Figure 11. Ten-day average solar radiation at Bear River sites 1, 2 and 3 during 1982.

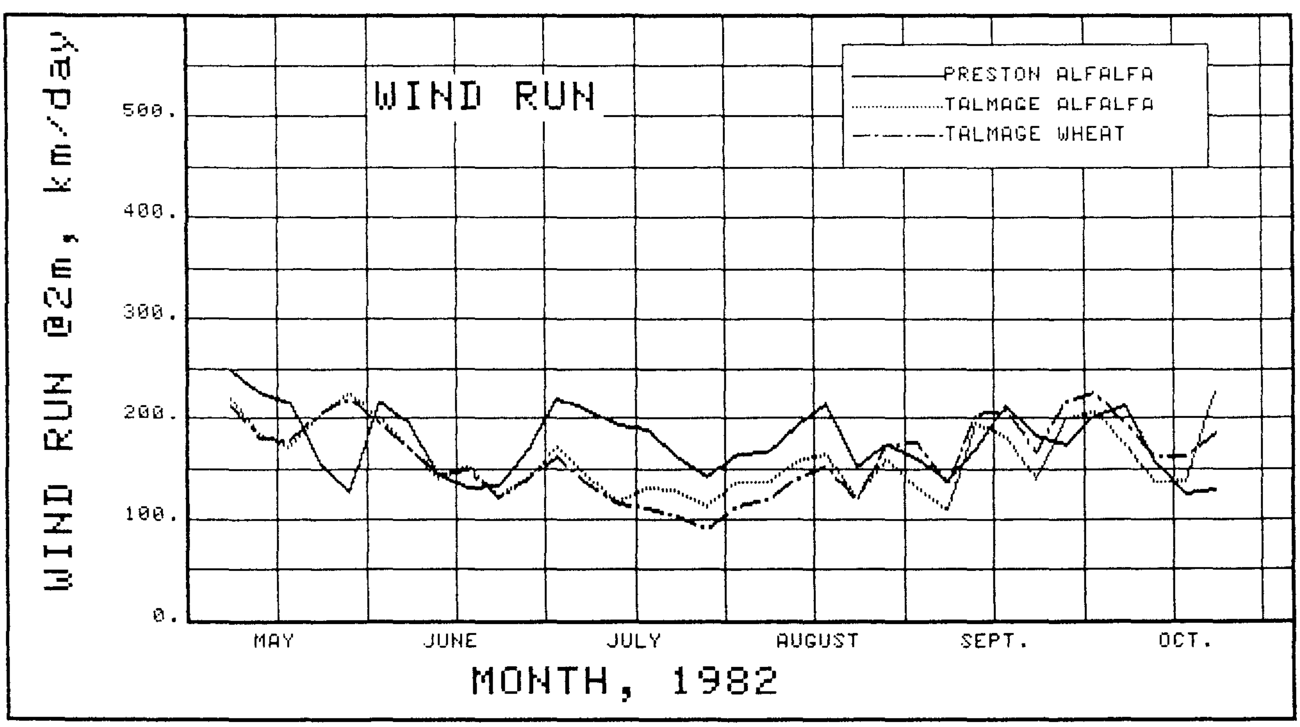

Figure 12. Ten-day average wind run at Bear River sites 1, 2 and 3 during 1982.

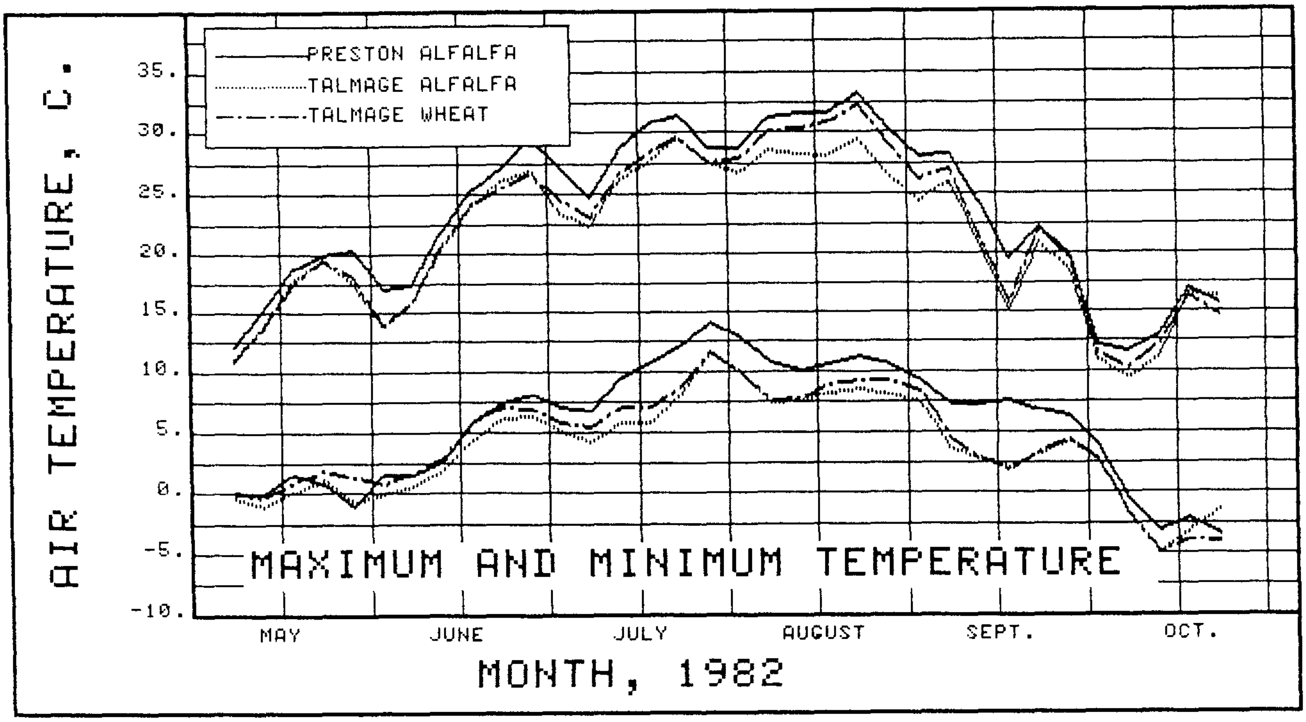

Figure 13. Ten-day average maximum and minimum air temperatures at Bear River sites 1, 2 and 3 during 1982.

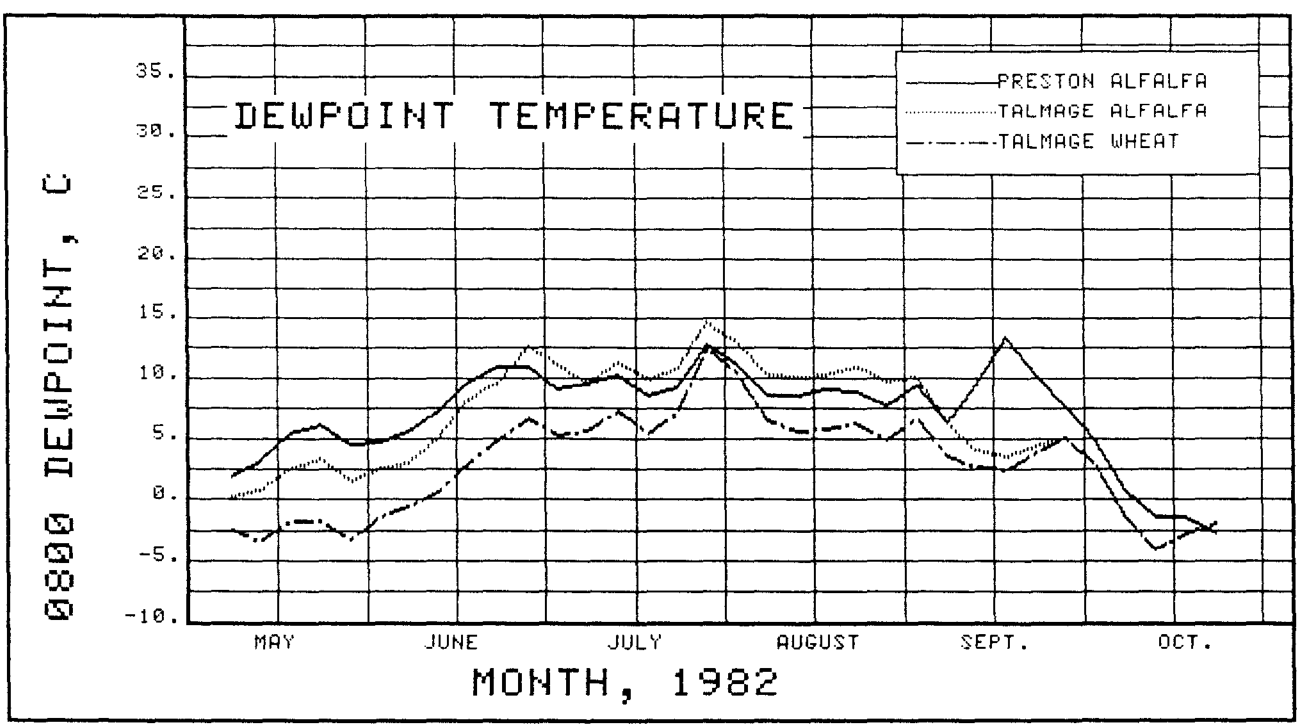

Figure 14. Ten-day average calculated dewpoint temperatures at Bear River sites 1, 2 and 3 during 1982.

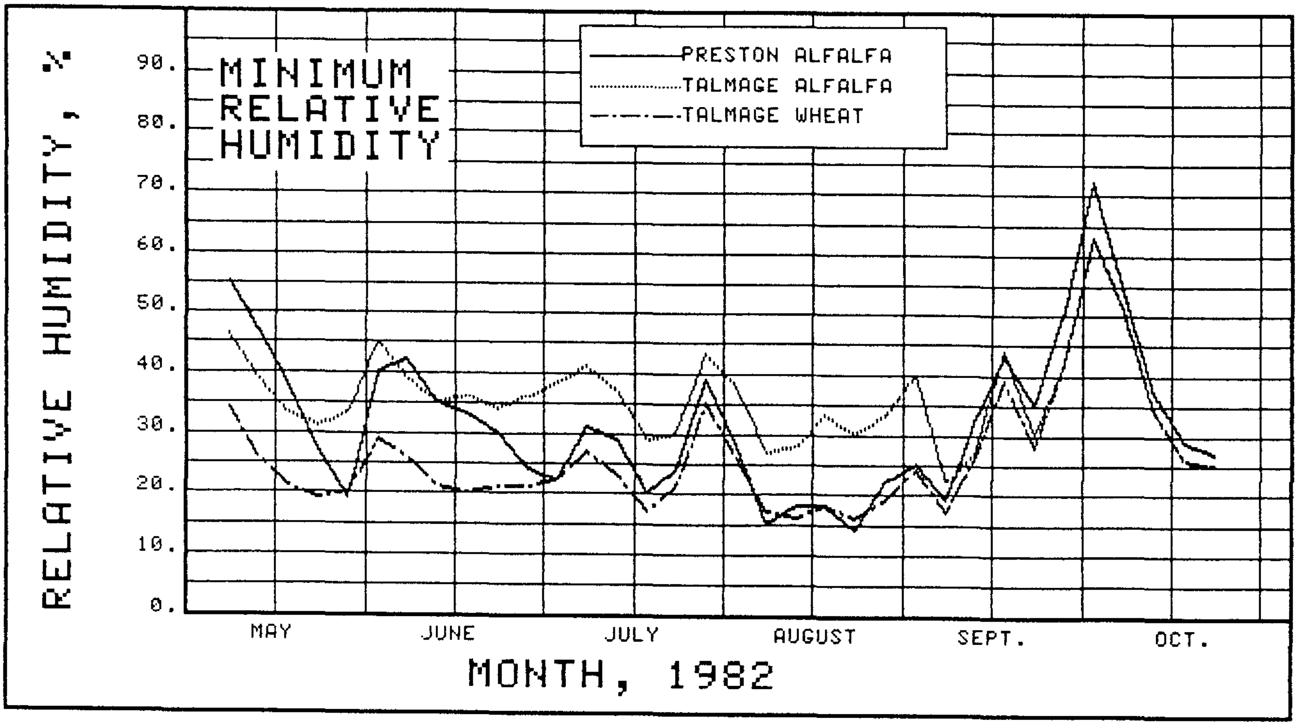

Figure 15. Ten-day average minimum relative humidity at Bear River sites 1, 2 and 3 during 1982.

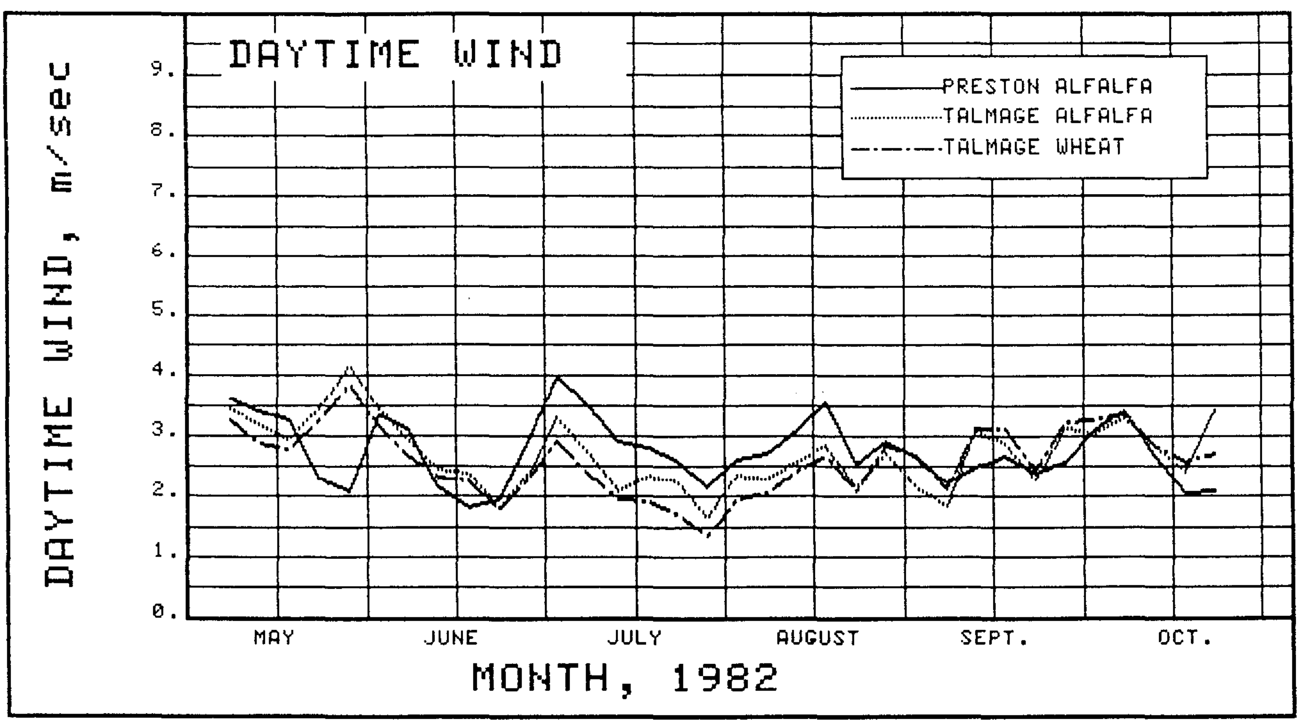

Figure 16. Ten-day average daytime wind speed at Bear River sites 1, 2 and 3 during 1982.

dryland alfalfa crop at the Preston site during the second half of the growing season. This stress caused a reduction in evapotranspiration (ET) by the crop, resulting in a lower conversion of radiant and advective energy to latent heat, with a corresponding greater conversion of energy to sensible heat as reflected by a higher air temperature. Temperatures at the Preston site averaged 2 degrees Celsius higher than temperatures over irrigated alfalfa at Talmage (site 2) over the growing season. This difference is equivalent to a lapse rate of 0.8^{o}C per 100 meters, which is typical.

Air temperatures recorded at the Talmage sites (2 and 3) were similar with the exception of higher maximum air temperatures over the wheat crop (site 3) during August after ripening of the wheat and reduction of ET. Air temperatures were expected to run higher over the wheat during most of the season due to lower ET by the wheat crop.

It was anticipated that the fetch around site 3 (700 meters) would be sufficient to provide adequate mixing of surface air with the lower atmosphere, thereby dissipating air cooled by irrigated crops in the area and allowing air over the dryland crop to reach an equilibrium temperature expected over a large area of dryland wheat. However, it is possible that the air mass directly above the wheat retained a history of the cooling effect of adjacent irrigation. This would explain the simularity between air temperatures recorded at the Talmage sites. Two temperature sensors were monitored at all sites. At all stations, average daily temperatures measured by the dual sensors were usually within 0.3 degrees Celsius of each other.

Dewpoint temperatures at the Bear River sites were estimated using measured relative humidity and hourly air temperature. Estimated dewpoint temperature at 0800 hours is shown in figures 8 and 14 and is summarized in Table 2. Dewpoints were similar over alfalfa at Preston and alfalfa at the Talmage site (sites 1 and 2). The increase in dewpoint at Preston during September is a result of estimating missing data. The decreased dewpoint over dryland wheat at Talmage, compared to alfalfa (site 3 versus site 2) may be a result of depressed ET by the dryland crop as previously discussed. However, it may be due to relative humidity sensor bias as indicated by comparison with measurements with a sling psychrometer (figure 4). Because it was uncertain as to the main cause of a lower estimated dewpoint at the Talmage wheat site, estimated dewpoint was not adjusted. Estimated dewpoint temperatures averaged 3 degrees Celsius lower over dryland wheat at Talmage than over irrigated alfalfa in the same area. It is interesting to note that minimum daily relative humidity measured over wheat at Talmage averaged about the same as at the Preston site during July, August and September (figures 9 and 15) during which both sites experienced moisture stress. Minimum daily relative humidity averaged 12% higher at site 2 (Talmage alfalfa) compared to sites 1 and 3 during July and August.

Variation in daytime (7am - 7pm) wind speed followed approximately the same distribution as did 24-hour wind speeds. Daytime wind speeds averaged 2.7, 2.8 and 2.6 meters per second at sites 1, 2 and 3 from May through October.

Day/night wind ratios calculated for the sites are included in Table 2. The ratios indicate that winds in the Bear River area are usually three times stronger during daytime hours than at night.

Average monthly soil temperatures were almost identical to average monthly air temperatures at all sites (Table 2).

Comparison of Sites 1, 2, and 3 with Permanent Weather Stations

Monthly average maximum, minimum and average air temperatures measured at the Bear River sites 1, 2, and 3 and at permanent stations are summarized in Table 3. The permanent weather station in the vicinity of the Preston temporary sites is Preston KACH radio station located 3 miles northeast of Preston and about 13 kilometers southeast of site 1. This station is a National Weather Service (NOAA) station and has been in service for less than two years. The station is in a rolling rural setting surrounded by dryland wheat with wet marshy areas directly adjacent to the temperature sensor.

The permanent weather stations in the vicinity of the Talmage agricultural sites are located at the Grace and Soda Springs hydropower plants operated by the Utah Power and Light Company (UP&L). Both sites are situated near the Bear River, in a canyon setting surrounded by nonirrigated grass or brush. The Grace UP&L station is a NOAA (National Weather Service) station, whereas the Soda Springs UP&L station is not. The Soda Springs UP&L station was included in this study over the Soda Springs KBRV radio station, a NOAA weather station, because of proximity of the UP&L station to the Talmage sites (9 km to the south and east). The Soda Springs UP&L station is bordered to the south by Soda Point, the northern projection of the Wasatch mountain range. The Grace Plant is about 18 km south of the Talmage sites. Comparisons between weather at the Talmage and UP&L sites were based on a weighted average of 0.7 times the

Table 3. Monthly summary of air temperatures measured at Bear River sites 1, 2 and 3 and at permanent weather sites within the Bear River basin during 1982.

Station	Month	Agricultural Site Tmax C	Agricultural Site Tmin C	Agricultural Site Tave C	Permanent Station* Tmax C	Permanent Station* Tmin C	Permanent Station* Tave C
Preston Dry.Alfalfa	5	17.8	0.0	9.5	17.8	2.2	10.0
Talmage Irr.Alfalfa	5	16.3	-.5	8.1	17.2	2.2	10.0
Talmage Dry.W.Wheat	5	16.3	.2	8.3	17.2	2.2	10.0
Preston Dry.Alfalfa	6	23.8	5.1	14.9	23.9	6.7	15.6
Talmage Irr.Alfalfa	6	21.9	3.6	12.9	23.3	6.7	15.0
Talmage Dry.W.Wheat	6	21.9	4.6	13.5	23.3	6.7	15.0
Preston Dry.Alfalfa	7	28.2	10.4	19.3	27.8	11.1	19.4
Talmage Irr.Alfalfa	7	26.0	7.3	16.5	27.2	10.6	18.9
Talmage Dry.W.Wheat	7	26.4	8.0	17.0	27.2	10.6	18.9
Preston Dry.Alfalfa	8	30.9	10.6	21.0	30.6	11.1	21.1
Talmage Irr.Alfalfa	8	27.6	8.0	17.8	30.0	11.7	20.6
Talmage Dry.W.Wheat	8	29.7	8.7	19.2	30.0	11.7	20.6
Preston Dry.Alfalfa	9	21.6	6.7	14.2	21.1	6.7	13.9
Talmage Irr.Alfalfa	9	19.2	3.1	11.1	20.6	6.1	13.3
Talmage Dry.W.Wheat	9	20.1	3.2	11.6	20.6	6.1	13.3
Preston Dry.Alfalfa	10	14.4	-1.8	5.5	12.8	-1.7	5.6
Talmage Irr.Alfalfa	10	13.4	-2.2	5.4	11.7	-1.7	5.0
Talmage Dry.W.Wheat	10	13.4	-3.1	4.6	11.7	-1.7	5.0

* Permanent sites were Preston KACH Radio Station and a weighted average of Grace UP&L (30%) and Soda Springs UP&L (70%) weather stations.

Soda Springs data and 0.3 times the Grace data, according to distances of the UP&L sites from the Talmage sites.

Maximum and minimum daily air temperatures at the three permanent sites were quite similar throughout the growing season as is indicated in figure 17. Figure 18 includes 10-day running averages of air temperatures at the permanent sites, allowing differences between stations to be seen. Minimum air temperatures at all three sites were similar during May through October, whereas maximum air temperatures at Soda Springs were less than at Preston. The lower maximum temperature at Soda Springs is primarily a result of the higher elevation of the Soda Springs site. The average maximum air temperature at Grace exceeded that at Soda Springs (figure 18) by about $2^{o}C$ during the entire season, most likely due to dryness (aridity) of the Grace site as compared to the Soda Springs site.

Daily air temperature measurements at Bear River sites 1, 2 and 3 followed the same daily fluctuations as did measurements at the permanent stations. Ten-day average maximum, minimum and average air temperatures at Preston site 1 agreed well with the Preston KACH station, as shown in figure 19, indicating that the KACH station is fairly representative of an agricultural environment.

Ten-day average maximum, minimum and average air temperatures at the Talmage alfalfa site (2) were consistantly lower than weighted averages computed from the same measurements recorded at the Soda Springs and Grace power stations (figure 20). Similarly, air temperatures at the Talmage dryland winter wheat site were lower than at the two power stations, with the exception of maximum air temperature over the wheat which approached the maximum temperatures at Grace and Soda Springs during August, September

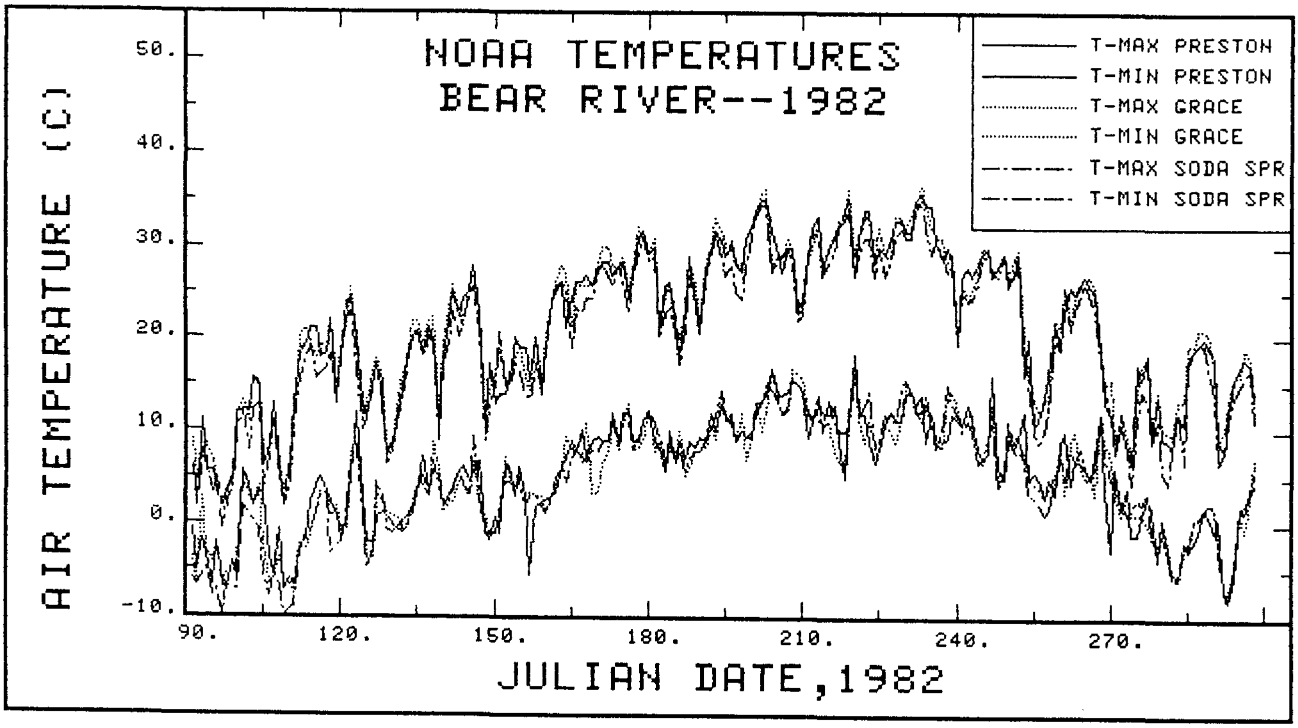

Figure 17. Daily maximum and minimum air temperatures recorded at Preston, Grace and Soda Springs permanent weather stations during 1982.

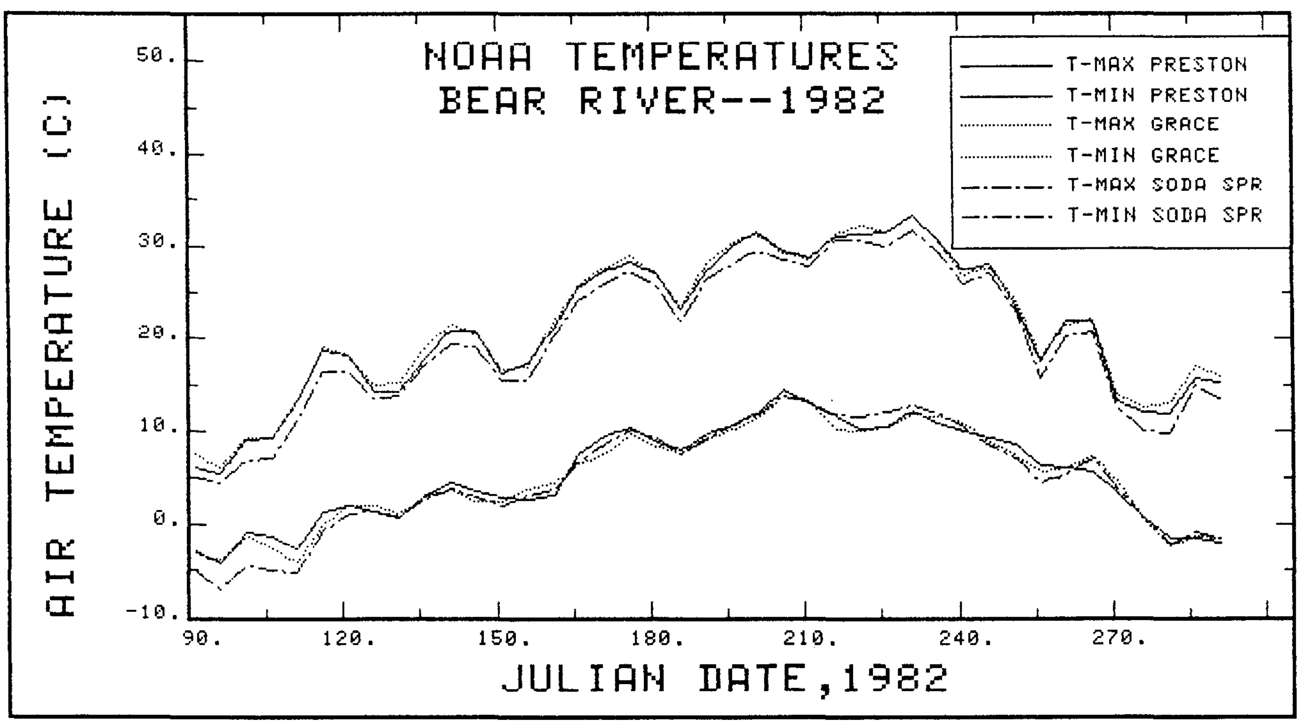

Figure 18. Ten-day average maximum and minimum air temperatures recorded at Preston, Grace and Soda Springs permanent weather stations during 1982.

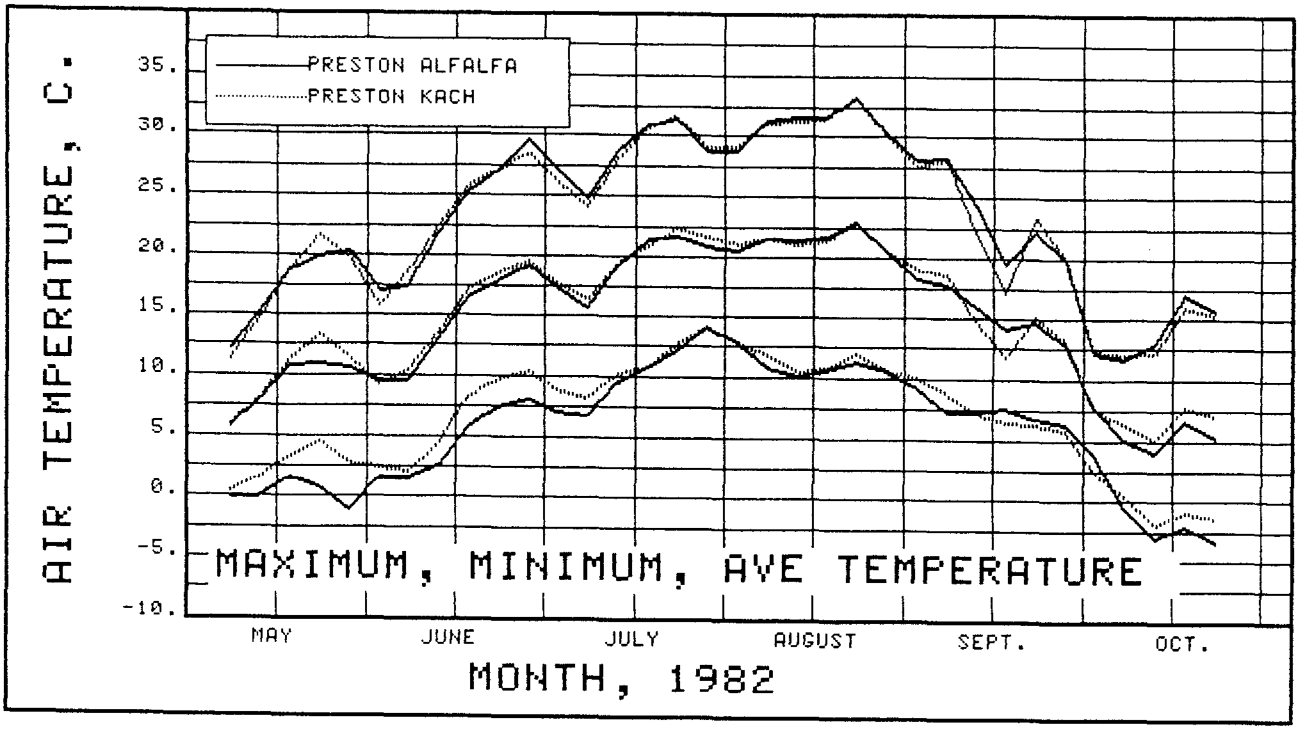

Figure 19. Ten-day average maximum and minimum air temperatures at Preston site 1 and Preston KACH during 1982.

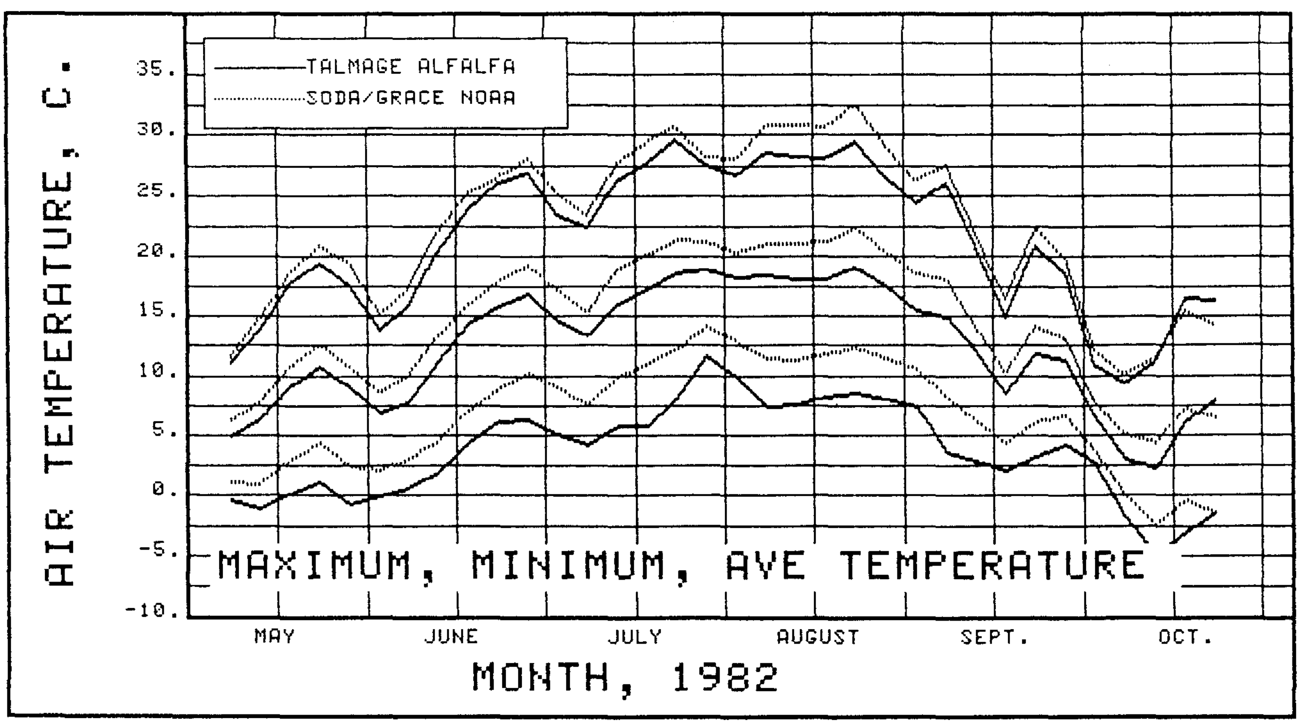

Figure 20. Ten-day average maximum and minimum air temperatures at Talmage site 2 and Grace/Soda Springs during 1982.

and October due to drying of the wheat and reduction of energy conversion to latent heat (figure 21). The large depression of minimum air temperature at the Talmage alfalfa site as compared to the Soda Springs/Grace sites, averaging 3.2°C during May through September, was due primarily to the evaporative cooling effect by the alfalfa crop during nighttime hours. This same effect was also apparent at the wheat site possibly as a result of air masses travelling from adjacent irrigated areas.

Ten-day average depression of mean daily air temperature at the agricultural sites (CR21) as compared to the permanent stations (NOAA) are shown in figure 22. Average air temperatures at the Talmage alfalfa site were 2 to 3 degrees Celsius lower than at the Soda Springs/Grace Utah Power and Light sites. This difference is important when estimating consumptive use requirements using air temperature data from the permanent sites. An elevation of 3°C in mean temperature at nonagricultural sites can cause an overestimation of consumptive use by as much as 10 percent (Allen and Brockway, 1982).

Ten-day average soil temperatures are shown in figure 23 for Bear River sites 1, 2 and 3. Mean soil temperatures at Preston were greater than at Talmage, again, primarily due to the lower elevation at Preston (240 meters lower).

Precipitation amounts during the 1982 growing season are shown in figure 24 for the three permanent stations. A tipping bucket raingage was installed at the Talmage alfalfa site (2), but did not function properly. Precipitation patterns were quite similar among the three stations during 1982 due primarily to the effect of large weather fronts moving through the

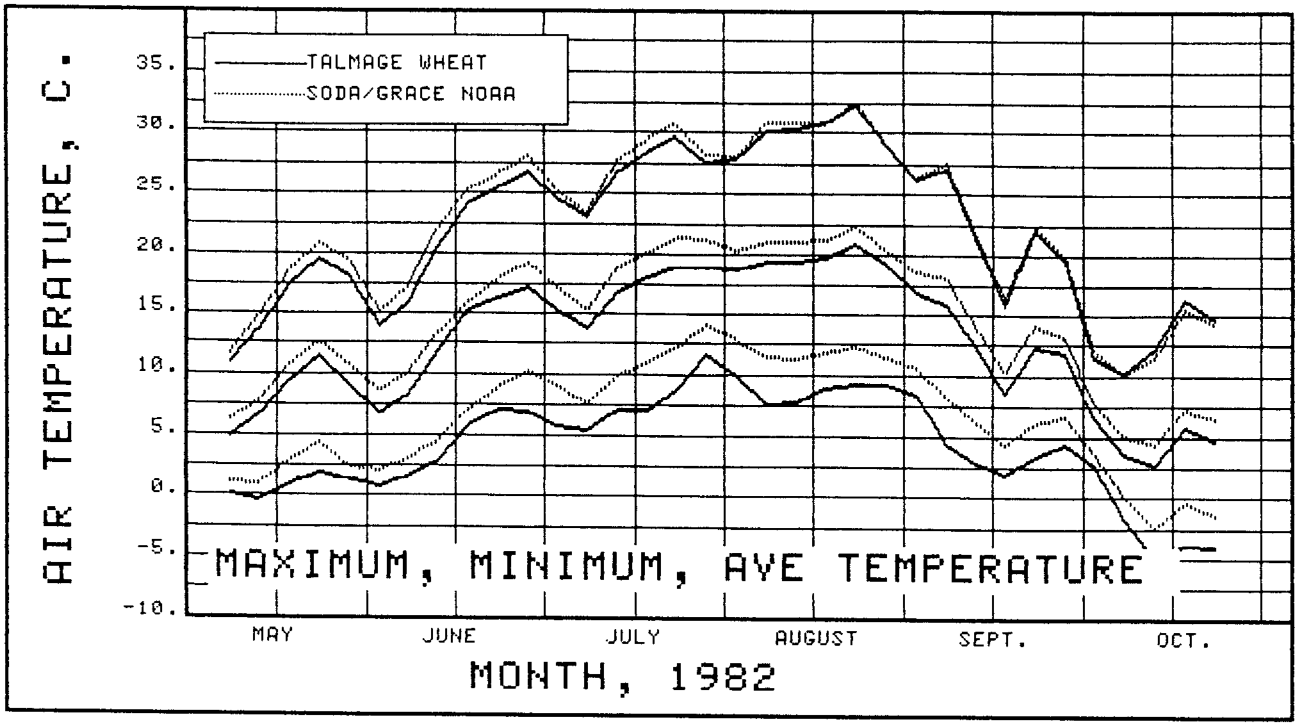

Figure 21. Ten-day average maximum and minimum air temperatures at Talmage site 3 and Grace/Soda Springs during 1982.

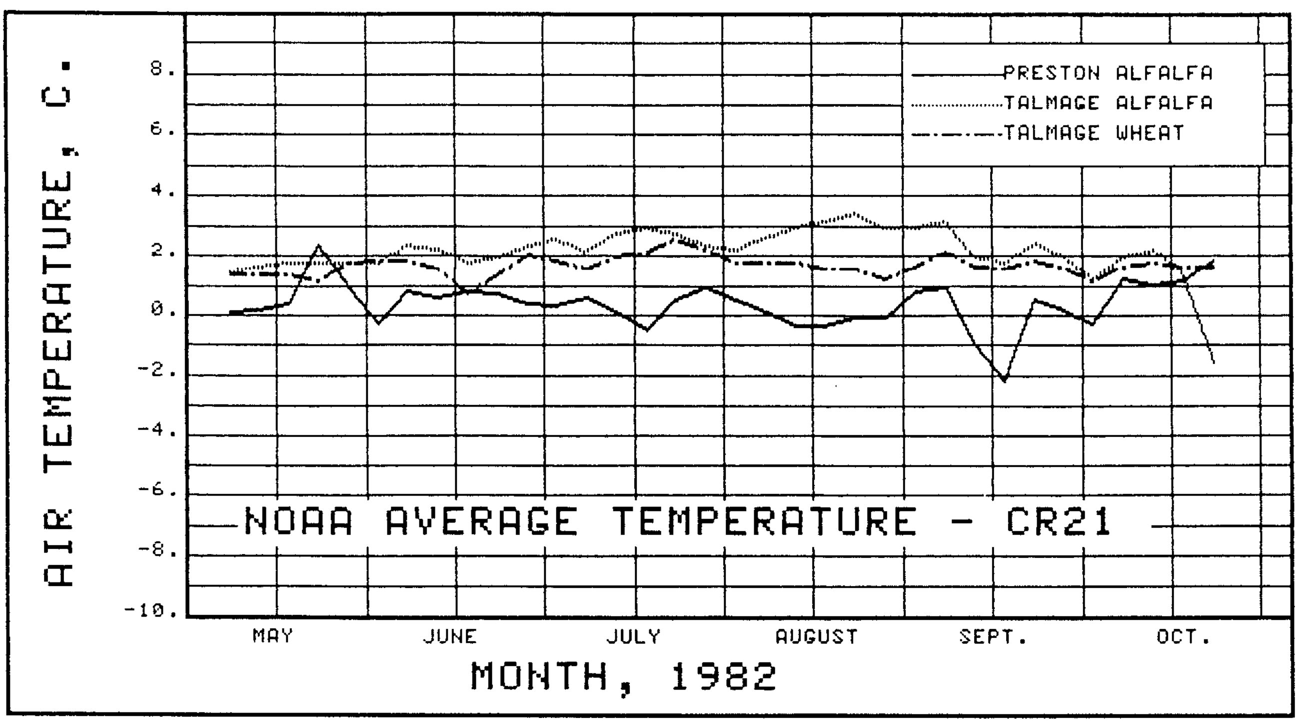

Figure 22. Ten-day average differences in mean daily air temperatures between Bear River sites 1, 2 and 3 and permanent weather stations during 1982.

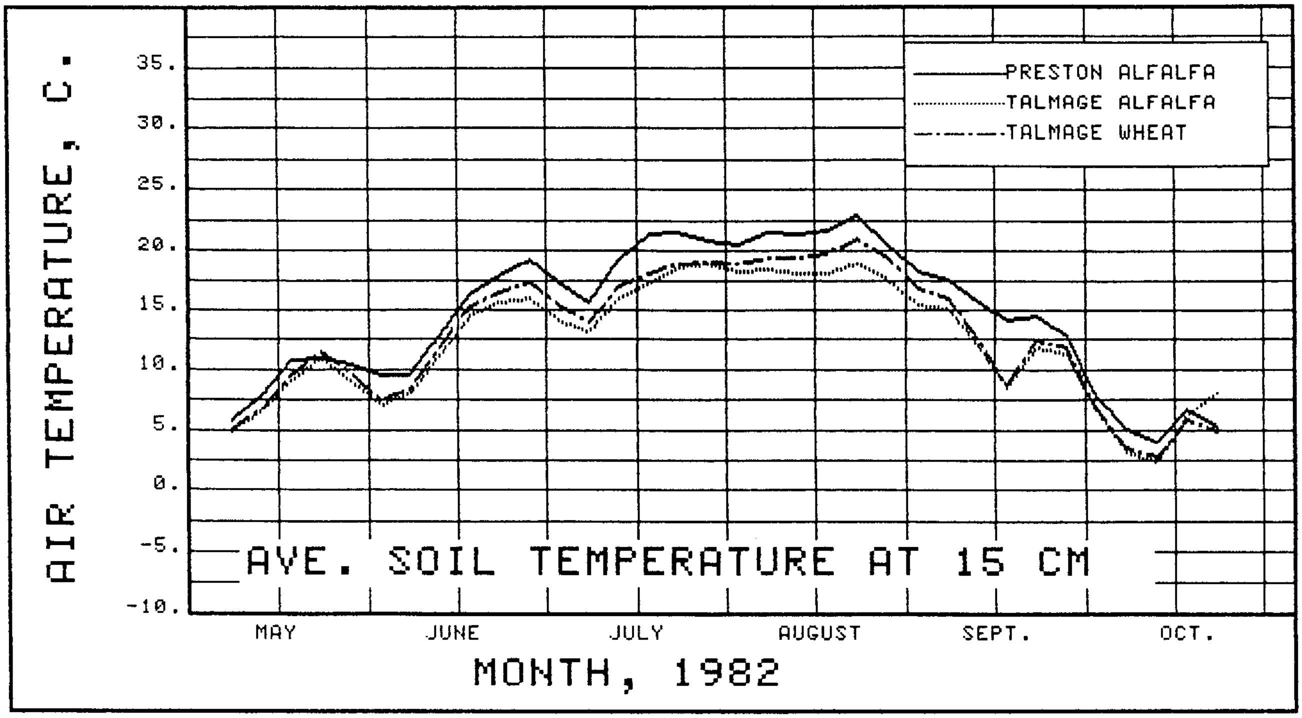

Figure 23. Ten-day average soil temperatures at Bear River sites 1, 2 and 3 during 1982.

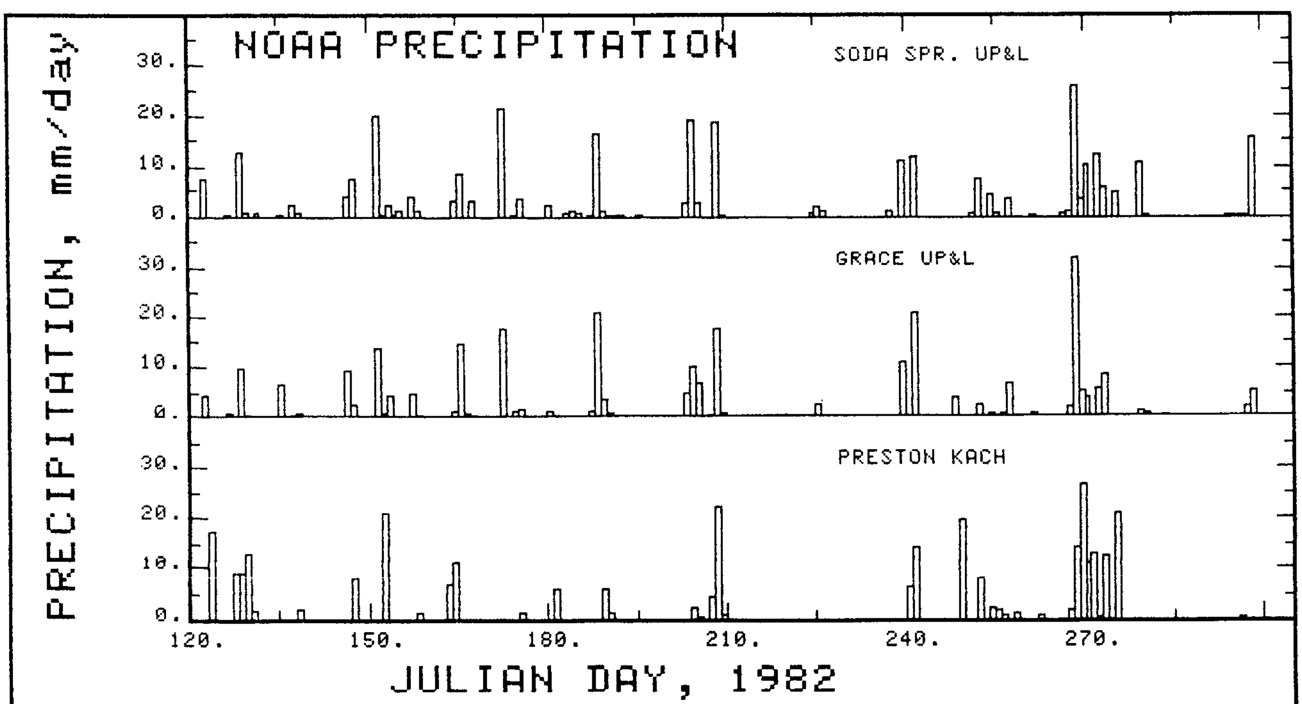

Figure 24. Daily precipitation amounts at Soda Springs, Grace, and Preston permanent weather stations during 1982.

region. Monthly precipitation totals for Preston and a weighted Soda Springs/Grace average are included in Table 2. The 1982 year was much wetter than average during July, August and September. Normal monthly precipitation amounts at Grace total 34, 47, 52, 18, 24, 27 and 25 milimeters during April through October. During the same period in 1982, monthly precipitation amounts at Grace totaled 34, 36, 51, 69, 36, 75 and 10 millimeters.

REFERENCE EVAPOTRANSPIRATION: WRIGHT-1982 vs FAO-BLANEY-CRIDDLE

Weather measurements at Bear River sites 1, 2 and 3 were used to calculate an alfalfa reference evapotranspiration (ET_r) estimate which can be multiplied by crop coefficients (k_c), which change with date and stage of crop growth, to calculate ET or consumptive use for specific crops. Consumptive use for alfalfa hay is calculated by multiplying the alfalfa reference ET by a coefficient reflecting cutting and growth patterns. Calculation and use of alfalfa-based crop coefficients for use in arid climates is described in detail by Wright (1981, 1982) based on research at Kimberly, Idaho.

Alfalfa reference ET was calculated on a daily basis using two different ET methods. The first method used, termed Wright-1982, is a modification of the Penman combination-energy equation (Wright, 1982). The main modification to this method has been development of wind function coefficients which vary with time of season. These coefficients were developed using precision lysimeter measurements of alfalfa ET at Kimberly. Application of the Wright-1982 method has been described in detail by Wright (1982) and Burman et al (1980). Data requirements for the Wright-1982 equation include daily solar radiation, wind speed, maximum and minimum air temperature and dewpoint temperature at 8 o-clock a.m.

The second ET method used to calculate alfalfa reference ET is the FAO-Blaney-Criddle method developed by Doorenbos and Pruitt (1977) as part of a United Nations Food and Agricultural Organization research project. The FAO-Blaney-Criddle (FAO-BC) method, which was developed to estimate ET by a grass reference, was adapted for use in Idaho to estimate alfalfa ET_r by Allen and Brockway (1982). Alfalfa reference ET is estimated with the

FAO-BC by applying monthly alfalfa reference ratios developed at Kimberly and an elevation correction which accounts for the effect of atmospheric density on nighttime air temperature. The reference ratios (RR) suggested by Allen and Brockway for southern Idaho are 1.21, 1.14, 1.07, 1.01, 1.00, 1.08 and 1.22 for the months April through October. The elevation correction (EC) for the FAO-BC is applied by increasing estimated ET_r by 10 percent per 1000 meters elevation. Data requirements of the FAO-BC method include percent sunshine hours (solar radiation), daytime windspeed, minimum daytime humidity and mean air temperature. If sunshine, wind and humidity data for the FAO-BC are not available they can be estimated, although accuracy is reduced and sensitivity to daily weather fluctuation is decreased.

Daily ET_r calculated with Wright-1982 and the FAO-BC using weather recorded at the Talmage irrigated alfalfa (2) site is shown in figure 25. Results indicate that sensitivities of the Wright-1982 and FAO-BC methods to changes in weather are quite similar. The similarity in sensitivity is quite remarkable, considering the differences in development and relationships used within each method. The Wright-1982 is predominantly a theoretical equation incorporating energy and mass balance relationships, whereas the FAO-BC is a simple, linear equation developed emperically. The FAO-BC does overestimate ET_r compared to Wright-1982 on days with high mean air temperature (figures 7 and 25). However, it appears that the FAO-BC could be used on a daily basis for activities such as irrigation scheduling in the Bear River Region of Idaho, provided solar radiation, wind speed and relative humidity data are available on a daily basis.

Ten-day running average calculations of alfalfa reference ET are shown in figures 26, 27 and 28 for Preston (site 1), Talmage irrigated alfalfa

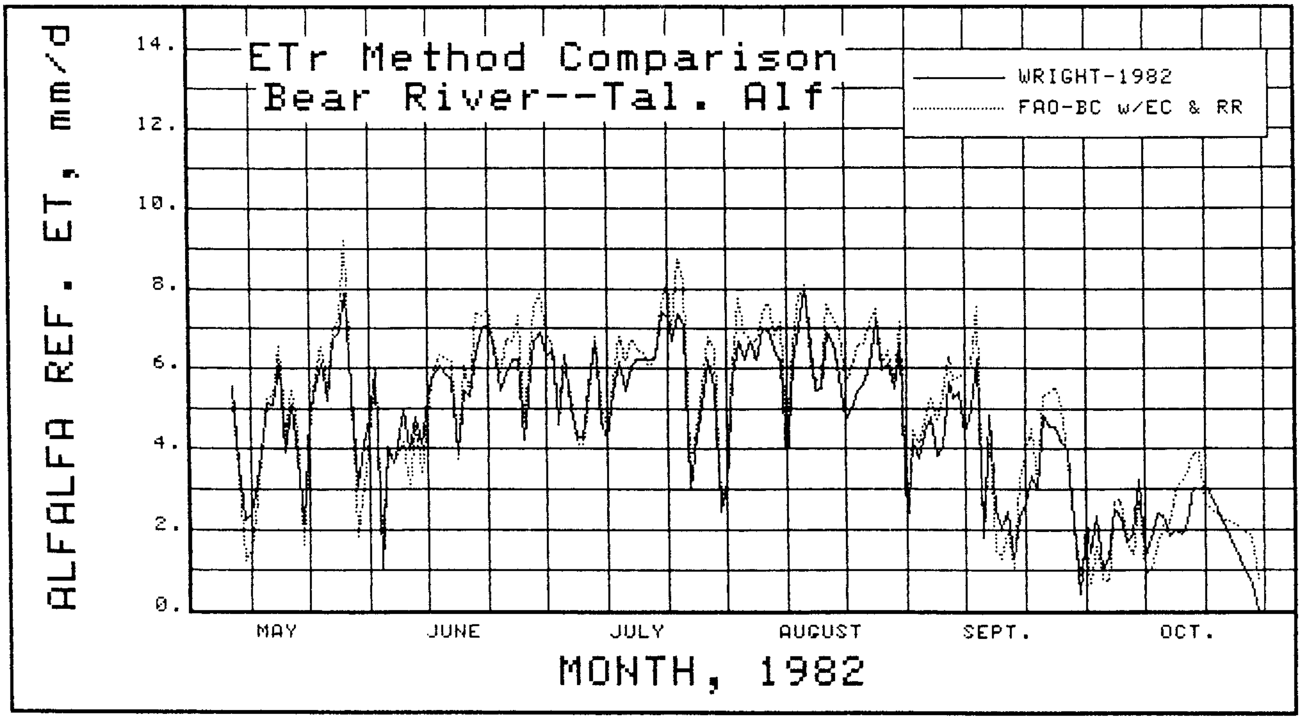

Figure 25. Daily estimated alfalfa reference evapotranspiration at Talmage irrigated alfalfa site (2) using Wright-1982 and the FAO-Blaney-Criddle with elevation correction and Kimberly reference ratios.

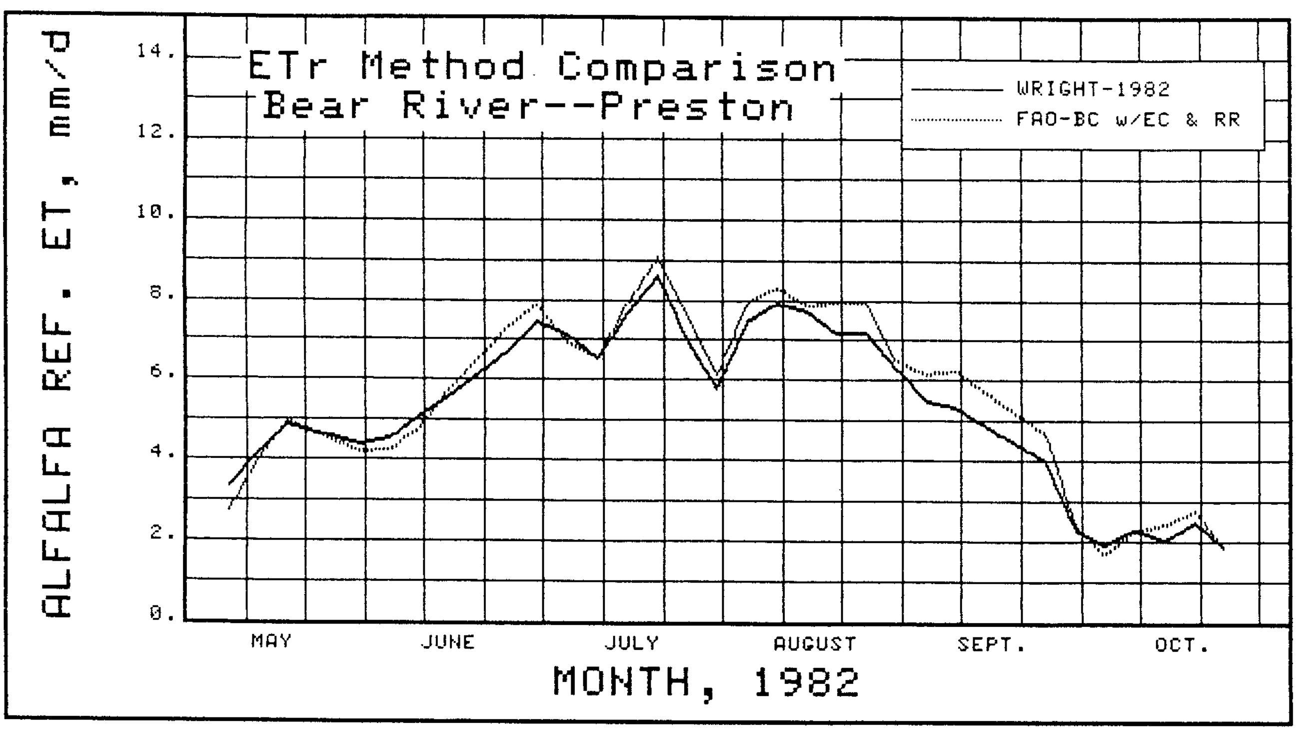

Figure 26. Ten-day average alfalfa reference evapotranspiration estimated for Preston (site 1) using Wright-1982 and the FAO-Blaney-Criddle with elevation correction and Kimberly reference ratios.

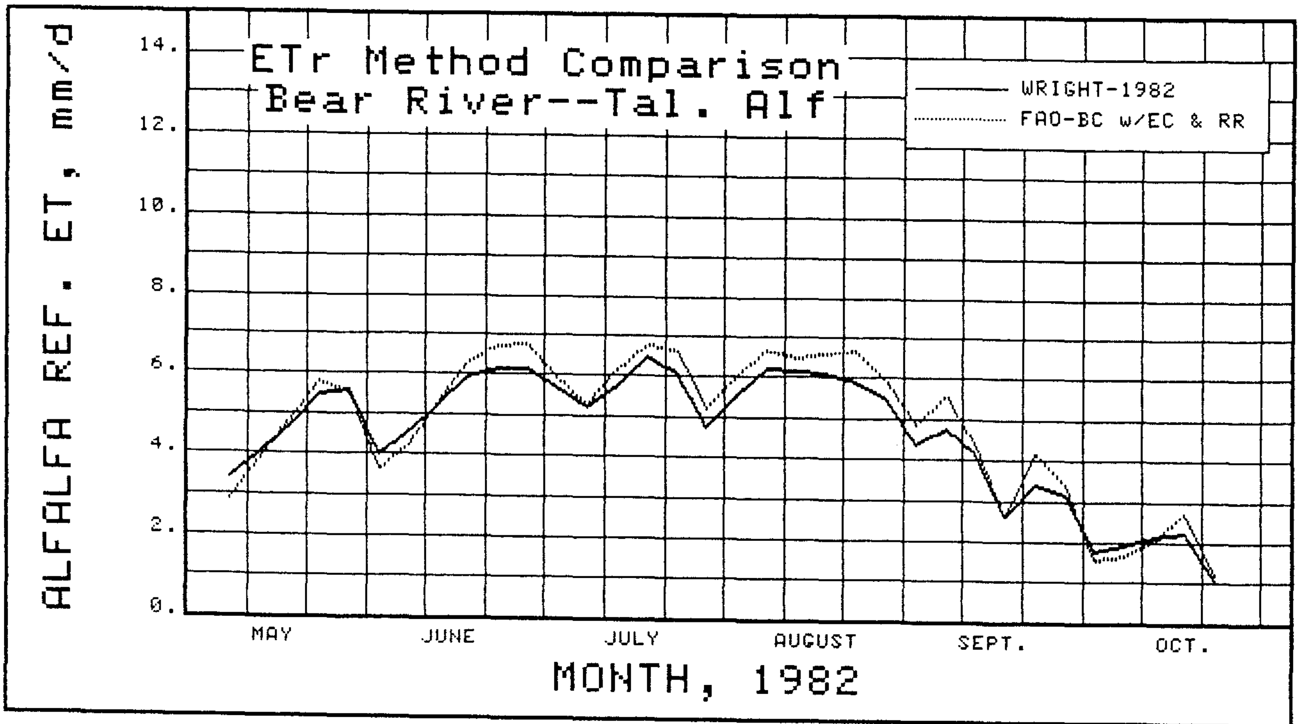

Figure 27. Ten-day average alfalfa reference evapotranspiration estimated for Talmage alfalfa (site 2) using Wright-1982 and the FAO-Blaney-Criddle with elevation correction and Kimberly reference ratios.

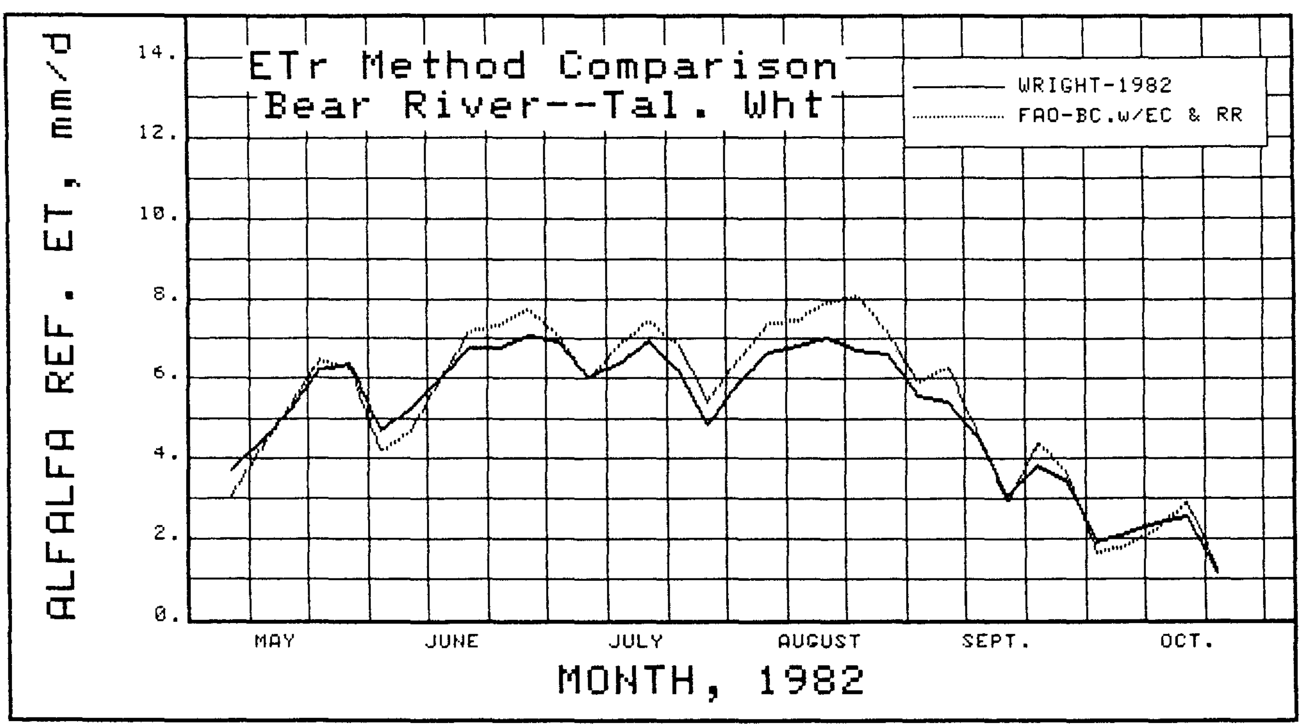

Figure 28. Ten-day average alfalfa reference evapotranspiration estimated for Talmage winter wheat (site 3) using Wright-1982 and the FAO-Blaney-Criddle with elevation correction and Kimberly reference ratios.

(site 2) and Talmage dryland wheat (site 3). Estimations of ET_r using Wright-1982 and the FAO-BC seem to be in good agreement at all three sites for the months May, June and October. The FAO-BC estimates higher than Wright-1982 during July, August and September, suggesting that perhaps alfalfa reference ratios for the FAO-BC for July through September may need to be lowered for use within the Bear River region. Monthly averages of the Wright-1982 and FAO-BC are included in the first two columns of Table 4. Overall, agreement between the two methods is very good.

EVAPOTRANSPIRATION ESTIMATES FOR THE BEAR RIVER REGION

Ten-day running averages of alfalfa reference ET at Bear River sites 1, 2 and 3 estimated using Wright-1982 and the FAO-BC are shown in figures 29 and 30. Differences in ET_r between sites are basically the same, regardless of which reference method is used.

Estimated ET_r at the Preston site (1) was greater than at either Talmage site during July and August due to greater daily wind travel at Preston during that time period and due to higher air temperatures resulting primarily from the lower elevation (figures 12 and 13). Reference ET estimated by Wright-1982 averaged 1.4 mm/day (1.7 inches/month) higher at Preston than at the Talmage alfalfa site (site 2) during that two month period. Low ET_r at Preston during September is a result of high dewpoint temperature and low solar radiation. These parameters had to be estimated for Preston during a part of September due to a tape recorder malfunction.

Estimates of ET_r using weather data from the Talmage wheat site (3) exceeded estimates for the Talmage alfalfa site (2) primarily due to lower dewpoint temperatures recorded over the dryland wheat. The dewpoint data recorded at site 3 may be lower than actual, as was discussed previously. The ET_r curve calculated at site 3 does emphasize the effect which vapor pressure deficit (reflected in dewpoint and air temperature) has upon the evaporative demand of the microclimate. The curve also helps to emphasize the importance of obtaining quality weather data from an irrigated agricultural site and the effect of a low evaporative surface or crop (dryland wheat) on estimated ET_r.

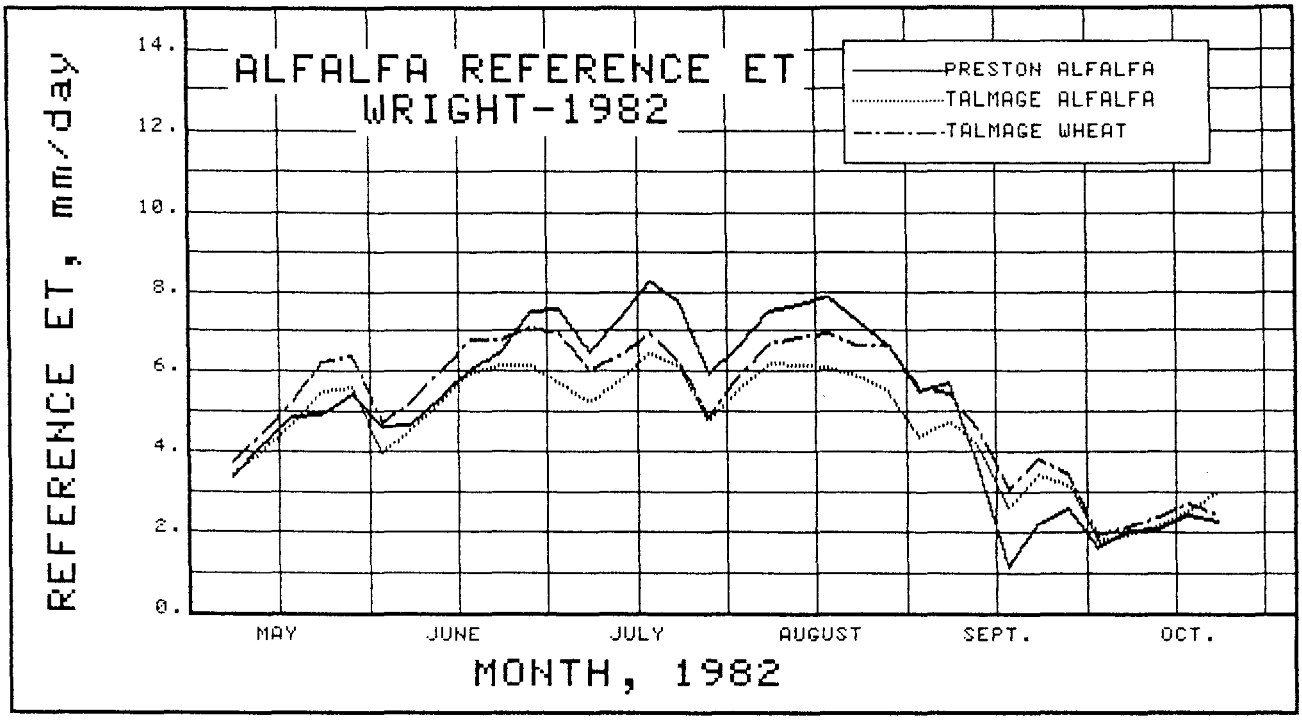

Figure 29. Ten-day average alfalfa reference evapotranspiration estimated at Bear River sites 1, 2 and 3 using Wright-1982.

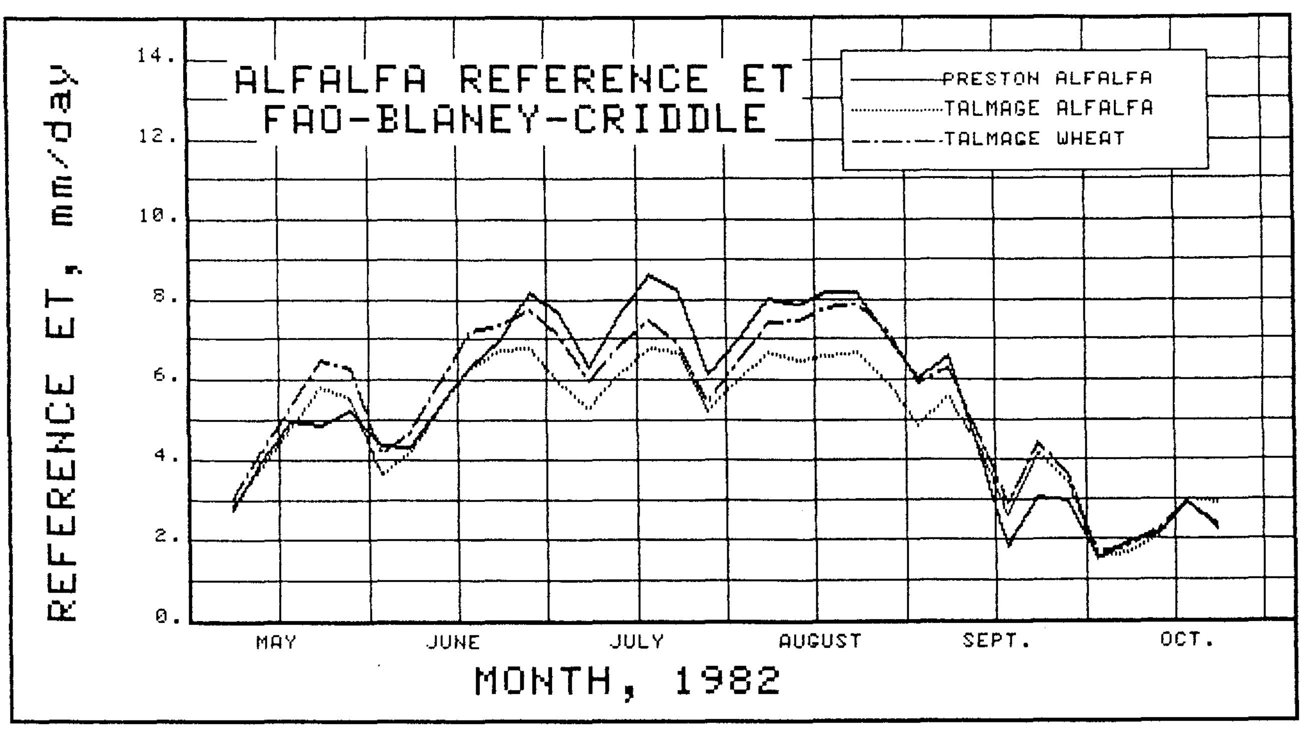

Figure 30. Ten-day average alfalfa reference evapotranspiration estimated at Bear River sites 1, 2 and 3 using the FAO-Blaney-Criddle with elevation correction and Kimberly reference ratios.

Ten-day average evapotranspiration expected for irrigated crops at the three Bear River sites are shown in figure 31. These estimates were calculated using Wright-1982 and "mean" crop coefficients developed and reported by Wright (1981). The mean coefficients include surface evaporation effects resulting from precipitation and irrigation. Cropping dates used in calculating the coefficients were 4/18, 5/5 and 4/20 for initiation of plant growth for the Preston alfalfa, Talmage alfalfa and Talmage wheat, respectively, 6/19 for effective cover of the Talmage wheat, 6/24 for the one hay cutting at Preston and 7/19 and 8/25 for the two hay cuttings at the Talmage alfalfa site. The alfalfa crops were assumed to die down on October 12th, when air temperature first decreased to -7 degrees Celsius (20^{o}F). The wheat crop was harvested about 8/25.

Also shown in figure 31 is estimated ET by the winter wheat using a reference ET calculated using weather measurements from site 2 (irrigated alfalfa). The result of using irrigated weather to estimate crop ET, as is suggested by Wright (1982), is demonstrated by the lower curve for wheat (2) compared to wheat (3) shown in figure 31. The seasonal consumptive use for wheat using site 2 weather (530 mm) was 62 mm (2.4 inches) less than estimated wheat consumptive use using weather at site 3 (dryland wheat). Both estimates of wheat consumptive use are higher than measured, as is discussed in a subsequent section, due to moisture stress by the dryland wheat crop.

Estimated ET by alfalfa at sites 1 and 2 (figure 31) show expected effects of cutting on crop ET.

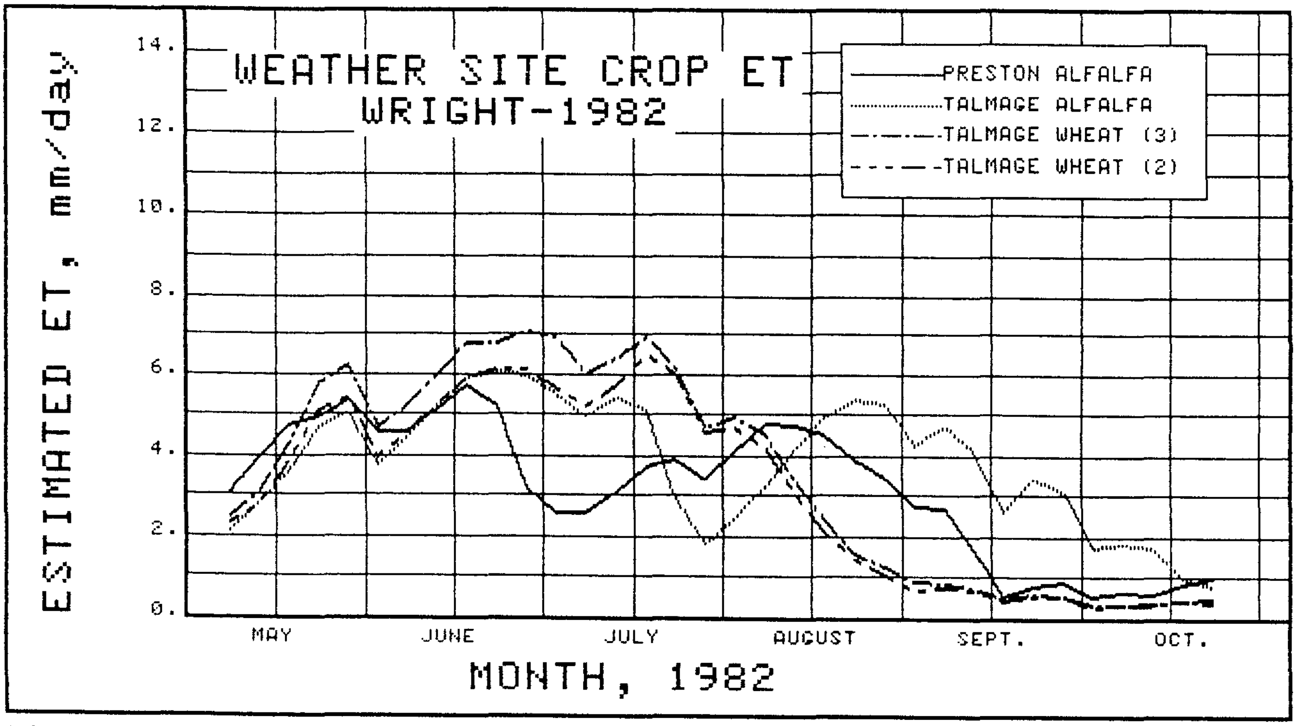

Figure 31. Ten-day average irrigated crop evapotranspiration estimated at Bear River sites 1, 2 and 3 using Wright-1982 and mean crop coefficients during 1982.

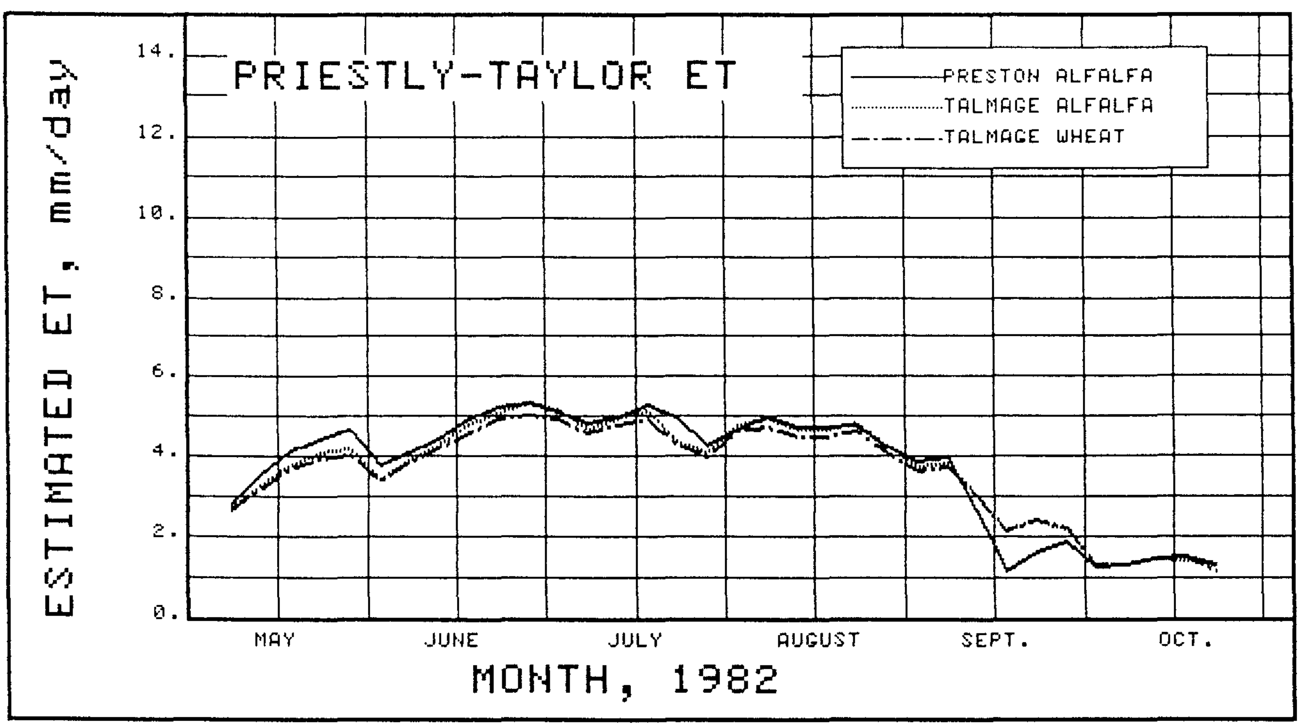

Figure 32. Ten-day average potential evapotranspiration estimated using the Priestly-Taylor method at Bear River sites 1, 2 and 3 during 1982.

ESTIMATED EVAPOTRANSPIRATION USING AN ARIDITY APPROACH

An advection-aridity approach to estimating actual ET from an arid region was pioneered by Morton (1969, 1976, 1978) and applied by Brutsaert and Stricker (1979). This approach, which is most applicable to large, homogeneous regions, considers the effect of moisture-limited regional ET upon the evaporative power of the atmosphere. Within any large region with unlimited soil moisture, it is proposed that as the atmosphere becomes moisture saturated due to regional evapotranspiration, that the evaporative power of the air will decrease until a level is reached where evaporative power and regional evapotranspiration is in equilibrium with incoming, nonadvective energy to the atmosphere, primarily solar radiation. This phenomenom commonly occurs in areas east of the Mississippi river, where relative humidities approach 100% (zero vapor pressure deficit).

As regional soil moisture or vegetative evaporative control begins to limit regional ET to levels less than equilibrium ET (ET_{po}), evaporative energy within the atmosphere in excess of that used for regional ET begins to be manifested as an increasing vapor pressure deficit and increasing air temperature. These increases, in turn, result in a higher evaporative demand by the atmosphere upon the region (ET_p).

If an energy balance is formulated, where q is equal to the difference in latent heat energy equivalent between the equilibrium ET level (ET_{po}) and actual, regional ET levels (ET_a), then

$$q = ET_{po} - ET_a \qquad (1)$$

Conversely, this same difference in energy equivalent should be manifested in increased evaporative potential over the region (ET_p), compared to the equilibrium level, or

$$q = ET_p - ET_{po} \quad (2)$$

Combining equations 1 and 2,

$$ET_a = 2\ ET_{po} - ET_p \quad (3)$$

or, actual, regional evapotranspiration can be estimated as the difference between twice the equilibrium ET level and the measured potential evaporative level, based on the principle of conservation of energy.

The aridity concept expressed in equation 3 was applied and tested by Morton (1976, 1978) in regions of central Canada and the southwestern United States. Brutseart and Stricker (1979) applied the concept to watersheds in Western Europe to estimate regional ET and crop losses during the 1976 drought. All applications provided reasonable estimates of regional ET, with the conclusion that estimates are best for large, arid regions in which equilibrium conditions for ET_p and ET_a are experienced.

The Priestly-Taylor (1972) ET method (ET_{pt}) has been found to offer good estimates of ET_{po} (equilibrium ET) in areas of unlimited soil moisture. This equation is of the form

$$ET_{pt} = alpha(delta/(delta + gamma)) \quad (R_n - G) \quad (4)$$

where delta is the average slope of the saturation vapor pressure curve at maximum and minimum daily air temperature

gamma is the psychrometric constant

R_n is the net radiation near ground surface, mm/day water equivalent

G is the soil heat flux, mm/day water equivalent

alpha is an empirical calibration coefficient for large saturated land and advection free water surfaces, equal to 1.26.

The Priestly-Taylor method is essentially equivalent to the first term of the Penman combination equation (Wright, 1982), with the exception of the alpha term. Accordingly, the second term of the Penman or Wright-1982 method does approach zero in a saturated environment where the vapor pressure deficit and hence the second term approaches zero. In this study, equilibrium ET (ET_{po}) was estimated using the Priestly-Taylor method (ET_{pt}) and potential evaporative power of the air (ET_p) was estimated using Wright-1982 (ET_r), so that equation 3 becomes

$$ET_a = 2(ET_{pt}) - ET_r \qquad (5)$$

An ET_a using equation 5 was calculated for all three sites. Equation 5 assumes that the study area is sufficiently large and homogeneous and that equilibrium conditions for ET_a and ET_r have occurred. These assumptions were not met at all sites, as is discussed subsequently.

In a similar aridity approach, actual ET by the dryland wheat crop was estimated by applying equation 3, assuming, in this case, that the ET_r at the irrigated alfalfa site constituted an equilibrium ET_{po} level for a well-watered crop in the Talmage area and that the evaporative potential of the air due to decreased ET by the wheat crop can be expressed as ET_r calculated using weather at the wheat site. Expressed in equation form,

$$ET_{a3} = 2\ ET_{r2} - ET_{r3} \qquad (6)$$

where ET_{a3} = actual ET by the dryland wheat crop at site 3

ET_{r2} = reference ET estimated using weather measured at the irrigated alfalfa site (2)

ET_{r3} = reference ET estimated using weather measured at the dryland wheat site (3).

Estimates of ET_{po} using the Priestly-Taylor were very similar for sites 1, 2 and 3, since they are based primarily on solar radiation (figure 32). Estimated ET_r using Wright-1982 is shown in figure 29.

Actual crop ET at site 2 estimated using equation 5 was compared to actual crop ET estimated using Wright-1982 and mean hay crop coefficients. As shown in figure 33, equation 5 underestimated alfalfa ET throughout most of the season by about thirty percent. This underestimation may be primarily due higher temperatures and vapor pressure deficits over the irrigated alfalfa than would be expected if the surrounding region (10,000 km^2) were planted completely to an irrigated alfalfa crop. If this is true, then the higher temperatures and vapor pressure deficits experienced at the alfalfa site were caused primarily from advective transport from nonirrigated areas. Based on seasonal averages (Table 4) an alpha value of 1.46 used in equation 4 would provide a seasonal estimate of crop ET using the aridity concept equivalent to that estimated using Wright-1982 and mean hay coefficients.

Actual evapotranspiration by the dryland wheat crop at Talmage site 3 was estimated using aridity concept equations 5 and 6. These estimates were compared to wheat ET estimated using a reference ET calculated using Wright-1982 and site 2 (irrigated alfalfa) weather data as shown in figure 34. Monthly summaries are included in Table 4. Values of wheat ET estimated using reference ET estimates for sites 1 and 2 were similar to those estimated using Wright-1982 and a crop coefficient during May, June and July, but were greater than actual during August, September and October when the crop was ripe and ET was low. ET estimated using the aridity

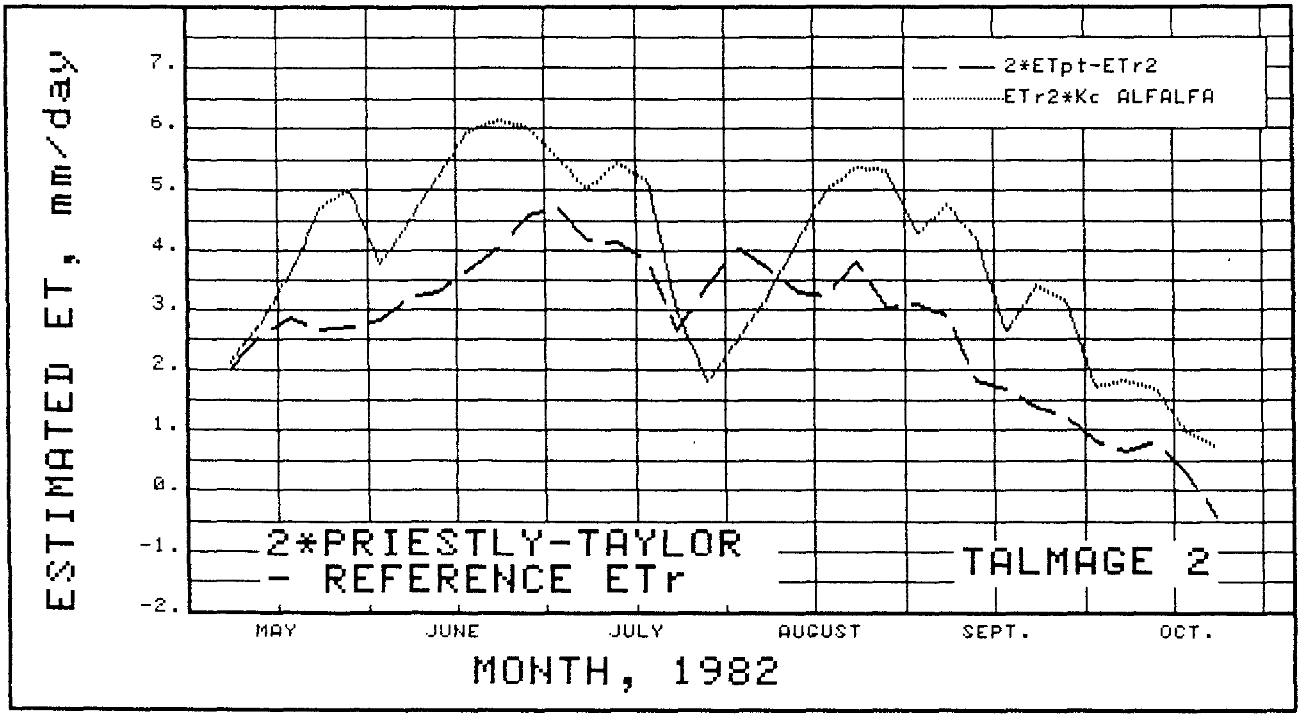

Figure 33. Ten-day average actual crop evapotranspiration estimated for the Talmage alfalfa site (2) using an aridity model and using Wright-1982 and mean hay coefficients.

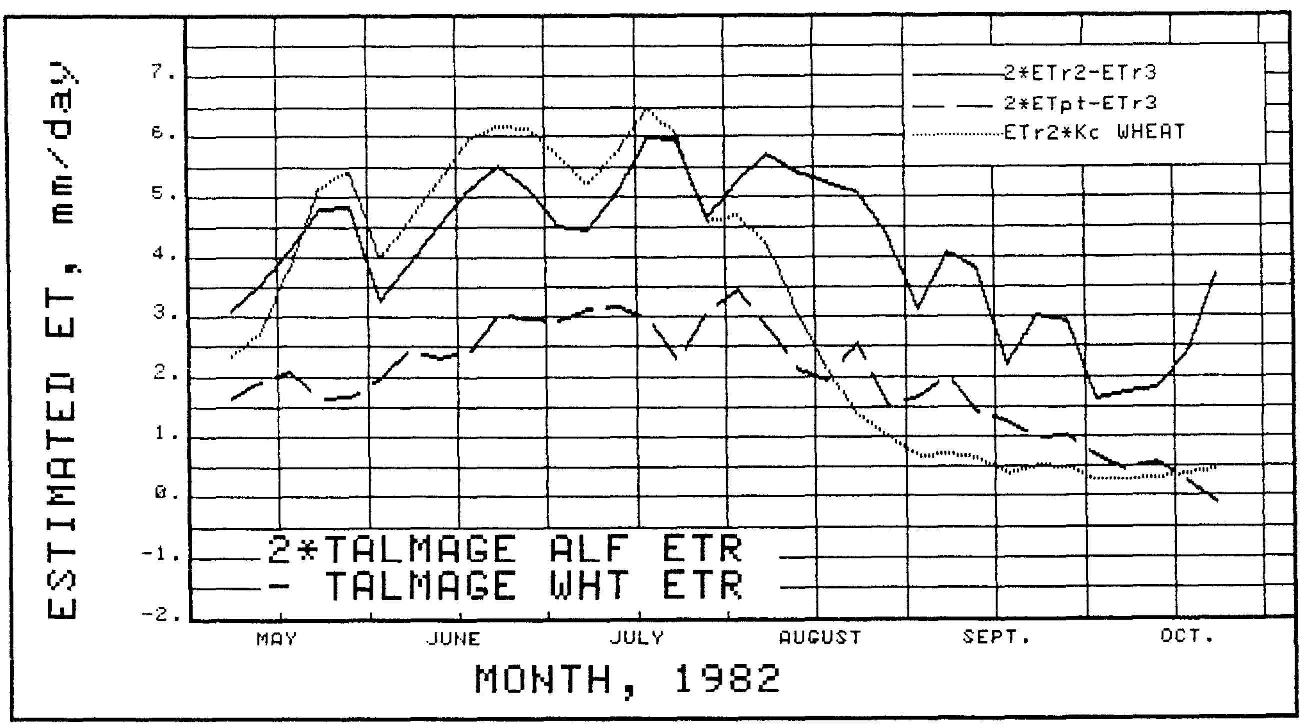

Figure 34. Ten-day average actual crop evapotranspiration estimated for the Talmage dryland wheat site (3) using an aridity model and using Wright-1982 and mean winter wheat coefficients.

Table 4. Summary of evapotranspiration estimated using various methods at Bear River sites 1, 2 and 3 and at Kimberly, Idaho during 1982.

Site	Month	Wright mm/d	FAO-BC mm/d	Pr-Tay mm/d	Jensen mm/d	SCS"U" mm/d	Wr.Crop mm/d	FAOCrop mm/d
Preston	May*	4.76	4.60	4.07	4.60	2.12	4.63	4.47
Tal. Alf	May*	4.76	4.70	3.68	3.87	1.93	3.82	3.77
Tal. Wht	May*	5.36	5.23	3.58	4.30	2.00	4.56	4.00
Kimberly	May*	5.67	5.83					
Preston	June	5.91	6.14	4.65	6.18	3.57	4.48	4.65
Tal. Alf	June	5.39	5.63	4.54	5.46	3.14	5.31	5.55
Tal. Wht	June	6.22	6.37	4.36	6.03	3.26	6.22	5.63
Kimberly	June	6.93	6.85					
Preston	July	6.94	7.14	4.84	7.09	4.78	3.27	3.36
Tal. Alf	July	5.57	5.91	4.70	6.05	4.01	3.97	4.21
Tal. Wht	July	6.03	6.42	4.56	6.68	4.17	5.95	5.83
Kimberly	July	6.43	6.61					
Preston	Aug.	7.18	7.63	4.62	7.22	4.85	4.15	4.41
Tal. Alf	Aug.	5.82	6.32	4.61	6.26	4.02	4.48	4.86
Tal. Wht	Aug.	6.65	7.35	4.42	7.09	4.41	2.59	2.46
Kimberly	Aug.	6.80	6.69					
Preston	Sept.	2.98	3.57	2.18	2.99	2.85	1.25	1.50
Tal. Alf	Sept.	3.43	3.74	2.55	3.21	2.26	3.40	3.71
Tal. Wht	Sept.	3.85	4.08	2.54	3.55	2.36	.58	.56
Kimberly	Sept.	4.70	4.34					
Preston	Oct.*	2.03	2.20	1.26	1.78	1.22	.53	.57
Tal. Alf	Oct.*	2.41	2.33	1.26	1.62	1.12	1.22	1.18
Tal. Wht	Oct.*	2.32	2.23	1.23	1.74	1.09	.35	.35
		(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Preston	Ma-Se*	803.	840.	584.	813.	526.	506.	525.
Tal. Alf	Ma-Se*	714.	753.	576.	717.	445.	596.	628.
Tal. Wht	Ma-Se*	803.	844.	557.	798.	470.	575.	536.
Kimberly	Ma-Se*	877.	872.					
Preston	Ma-Oc*	867.	912.	626.	872.	571.	526.	
Tal. Alf	Ma-Oc*	790.	829.	620.	773.	484.	644.	
Tal. Wht	Ma-Oc*	880.	919.	601.	859.	509.	587.	

Wright = Wright (1982), a Penman-type combination energy equation.
FAO-BC = FAO-Blaney-Criddle temperature method used with an elevation correction and Kimberly reference ratios.
Pr-Tay = Priestly-Taylor method.
Jensen = Jensen-Haise radiation method
SCS"U" = SCS-Blaney-Criddle "U" factor.
Wr. Crop = Wright (1982) multiplied by Wright (1981) mean crop coef.

* See footnote on Table 4 continuation on following page.

Table 4. Continued.

Site	Month	Je.Crop mm/d	SCSCrop mm/d	Aridity mm/d	Wr.Arid mm/d	Wht-2 mm/d
Preston	May*	4.50	2.28	3.38		
Tal. Alf	May*	3.11	2.09	2.60		
Tal. Wht	May*	3.30	2.70	1.80	4.16	4.05
Preston	June	4.73	4.03	3.39		
Tal. Alf	June	5.39	3.55	3.69		
Tal. Wht	June	5.46	4.35	2.50	4.56	5.39
Preston	July	3.36	5.30	2.74		
Tal. Alf	July	4.31	4.45	3.83		
Tal. Wht	July	5.95	4.43	3.09	5.11	5.50
Preston	Aug.	4.17	5.14	2.06		
Tal. Alf	Aug.	4.83	4.26	3.40		
Tal. Wht	Aug.	2.46	1.11	2.19	4.99	2.27
Preston	Sept.	1.26	2.82	1.38		
Tal. Alf	Sept.	3.18	2.24	1.67		
Tal. Wht	Sept.	.48	.00	1.23	3.01	.52
Preston	Oct.*	.46	1.11	.49		
Tal. Alf	Oct.*	.83	1.02	.11		
Tal. Wht	Oct.*	.24	.00	.14	2.50	.36
		(mm)	(mm)	(mm)	(mm)	(mm)
Preston	Ma-Se*	514.	568.	365.		
Tal. Alf	Ma-Se*	597.	481.	437.		
Tal. Wht	Ma-Se*	516.	367.	312.	624.	512.
Preston	Ma-Oc*	532.	611.			
Tal. Alf	Ma-Oc*	635.	518.			
Tal. Wht	Ma-Oc*	524.	367.			

FAOCrop = FAO-BC alfalfa reference multiplied by Wright (1981) mean crop coefficient.
Je.Crop = Jensen-Haise multiplied by Wright (1981) mean crop coef.
SCSCrop = SCS-Blaney-Criddle multiplied by SCS monthly crop coef.
Aridity = 2(Pr-Tay) - Wright. This equation is based on an energy balance.
Wr.Arid = 2(Wright for site 2) - Wright for site 3. This equation is based on an energy balance.
Wht-2 = Wright (1982) for site 2 multiplied by mean winter wheat coefficient for site 3.

* Estimates for May are for the period 5/7 - 5/31, for October are for the period 10/1 - 10/26. Ma-Se is the period from 5/8 - 9/23 (to correspond with neutron measurements in Table 6) and Ma-Oc is the period from 5/8 - 10/26.

concept with a Priestly-Taylor estimate as the equilibrium greatly underestimated wheat ET, as compared to conventional estimates during periods of active crop growth.

MEASURED SOIL-MOISTURE DEPLETION

Two neutron probe access tubes were installed at Bear River sites 1, 2 and 3 in early May, 1982. The tubes were 5 cm (2 inch) diameter aluminum tubing augured into the soil to depths at which bedrock was encountered at sites 2 and 3 (2.7, 2.2, 1.8 and 2.4 meters) and to depths at which dry soil was encountered at site 1 (2.5 and 2.7 meters).

The access holes (tubes) were monitored on a weekly basis using a "Campbell" neutron probe owned and operated by Utah State University, Logan, Utah. Soil moisture readings were taken at 13 cm and 30 cm depths (6 and 12 inches) and at 30 cm (12 inch) depth increments below 30 cm. Neutron probe readings were entered onto the computer system at the USDA-ARS Snake River Conservation Research Center at Kimberly, where they were converted and tabulated into total and mean daily soil moisture depletion files (Appendix Tables A-2 and A-3).

Gravimetric soil samples were also taken at 30 cm increments depths during access tube installation. These samples were transported to Kimberly where they were weighed, oven dried and reweighed. Soil sample volumes were estimated by dividing oven dry weights by 1.33, the estimated specific gravity of the Bear River soils. Comparisons between gravimetric measurements of soil moisture and neutron measurements are summarized in appendix Table A-1. Neutron measurements included in Table A-1 resulted from adjusting readings according to a probe recalibration completed by Utah State University during July of 1982.

Calculated ratios of gravimetric moisture measurements to neutron moisture measurements listed in Table A-1 indicate some variation between measurement methods. However, average ratios calculated for each access hole approached values equal to 1.0. The average ratio over all holes is equal to 0.99, indicating good agreement between gravimetrically measured soil moisture and the current neutron probe calibration.

Weekly soil moisture depletion rates calculated for each access hole were adjusted upward for each weekly measurement period, based on precipitation amounts recorded at nearby permanent weather stations. Rainfall measurements at Preston KACH radio station were added to neutron measurements at site 1 (Preston) and a weighted average of Grace (30%) and Soda Springs (70%) UP&L weather station rainfall measurements were added to the Talmage sites according to distances from Talmage to the Grace and Soda Springs UP&L sites. Precipitation amounts at the stations were assumed to be 100% effective in offsetting crop ET losses. This assumption was based on occurrences of fairly low rainfall amounts and intensities (figure 24), the maintenance of soil moisture levels within crop root zones below field capacity levels, and on gentle land slopes at all weather sites, especially at Preston. Precipitation amounts on days during which neutron measurements were made were split equally between neutron measurement periods. Neutron measurements were normally made between 10 am and 2 pm.

Soil moisture depletion rates and cummulative moisture depletion at 30 cm (1 foot) depths for each access hole are listed in Appendix Tables A-2 and A-3. Data in these tables do not include effective precipitation.

Soil moisture depletion rates based on total hole summations are summarized in Table 5 for measurement periods. Depletion rates in Table 5 include the addition of effective precipitation.

Negative depletion rates at the Talmage alfalfa site (2) during the

Table 5. Soil moisture depletion rates at neutron access sites, including precipitation amounts, Bear River study, 1982.

		Preston (1) dryland alfalfa			Talmage (2) irrigated alfalfa			Talmage (3) dryland w.wheat		
		Depl (mm/day)			Depl (mm/day)			Depl (mm/day)		
Beg Day	End Day	Hole1	2	Ave	Hole1	2	Ave	Hole1	2	Ave
127	142	1.33	1.67	1.50	3.33	1.51	2.42	2.54	3.25	2.90
142	149	4.87	3.26	4.06	8.05	6.57	7.31	5.85	3.18	4.52
149	156	9.27	5.36	7.31	2.38	2.65	2.52	6.21	8.36	7.28
156	163	-.59	.73	.06	-4.31	-1.37	-2.84*	2.02	2.04	2.03
163	170	5.98	10.09	8.03	3.67	5.91	4.79	5.47	3.66	4.57
170	177	1.62	.25	.94	11.01	6.92	8.97	6.26	5.80	6.03
177	184	3.31	2.71	3.01	3.70	.32	2.01	4.57	4.69	4.63
184	191	-10.57	-8.41	-9.47	8.04	4.20	6.12	3.68	5.71	4.70
191	198	1.49	2.56	2.03	7.16	4.37	5.77	.90	-.08	.41
198	205	.75	.22	.48	4.61	2.02	3.32	5.55	5.23	5.39
205	212	6.10	1.88	3.99	1.78	1.25	1.51	3.04	1.61	2.33
212	219	-.32	13.51	6.60	1.41	2.76	2.08	-.28	-1.09	-.68
219	226	-1.88	-11.76	-6.83	5.26	2.14	3.70	-.19	.71	.26
226	232	2.12	.38	1.25	-7.40	-7.67	-7.54*	.12	-.15	-.02
232	239	2.37	1.83	2.10	6.27	5.15	5.71	.71	-.89	-.09
239	249	3.32	3.82	3.57	2.22	3.01	2.61	1.68	2.20	1.94
249	254	4.34	6.18	5.26	3.03	1.65	2.34	1.57	4.50	3.04
254	267	.35	-.16	.09	1.57	.79	1.18	1.18	.06	.62

* Irrigation at Talmage alfalfa site 2 during measurement period was estimated as 64 and 69 mm, respectively. Values for period 156-163 become 4.76, 7.70 and 6.23 mm/day. Values for period 226-232 become 4.03, 3.76 and 3.89 mm/day.

fourth and fourteenth measurement periods resulted from irrigations during these two periods. Irrigation amounts were estimated to be 69 and 64 mm (2.7 and 2.5 inches) for the two irrigations. Negative depletion rates at the Preston site especially during the eighth measurement period are apparently due to the occurrence of thunder storms at the measurement site which were not recorded at the Preston KACH radio station.

Fluctuations in depletion rates between periods are most likely due to a combination of errors in dividing precipitation occurring on the day of soil moisture measurement and errors in individual neutron probe measurements. However, both these errors are self-compensating from period to period, so that by smoothing the moisture depletion data by calculating a running average, these measurement errors are reduced.

CALCULATED VERSUS MEASURED CONSUMPTIVE USE

A three-period running average was calculated using measured soil moisture depletion rates shown in Table 5 and using ET estimated during measurement periods. Comparisons between measured soil depletion rates and rates estimated using various ET methods and approaches are shown in graphical form in Appendix A, figures 1 through 11. Comparisons between smoothed measured soil moisture depletions and depletions predicted using a Wright-1982 alfalfa reference and appropriate crop coefficients are presented in figures 35 through 38 for Preston and the Talmage alfalfa and wheat sites.

In comparing measured versus calculated soil moisture depletion at the Preston dryland alfalfa site, depletion values are in reasonable agreement during June during which the alfalfa experienced rapid growth and water use. The effect of unaccounted precipitation during July on measured depletions prevented any comparisons during that month. Measured soil moisture depletions were less than estimated during August due to a slowing of crop growth and water use resulting from moisture stress. Precipitation beginning in September (figure 24) initiated some new growth and water use at the dryland site. Overestimation of depletion in early May resulted from using too early of a greenup date (April 18th) and underestimation in September resulted from using too early of a die down (frost kill) date (Oct 12th). These dates could be adjusted to provide closer estimates of soil depletion. In summary, the Wright-1982 method with Wright's mean crop coefficients (Wright 1981) appears to predict soil moisture depletion reasonably well at the dryland site during periods of nonlimiting soil moisture levels, pending selection of different greenup and harvest dates.

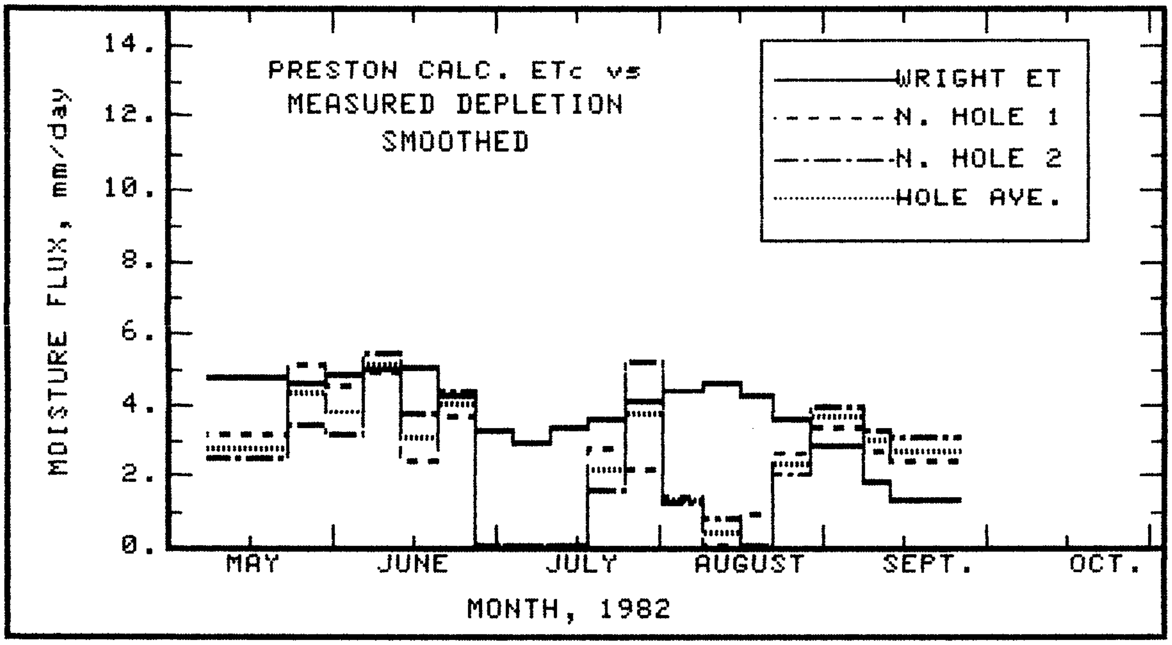

Figure 35. Smoothed rates of soil moisture depletion by dryland alfalfa at the Preston site (1) estimated using Wright-1982 and Wright "mean" crop coefficients and rates measured using a neutron probe during 1982.

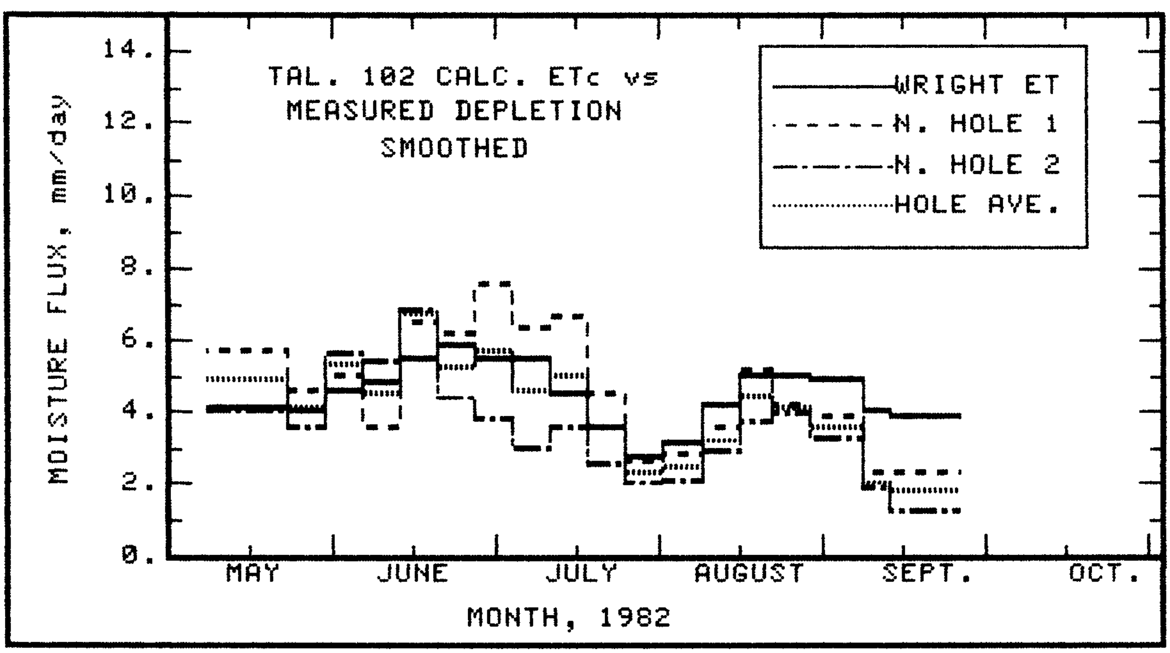

Figure 36. Smoothed rates of soil moisture depletion by irrigated alfalfa at the Talmage site (2) estimated using Wright-1982 and Wright "mean" crop coefficients and rates measured using a neutron probe during 1982.

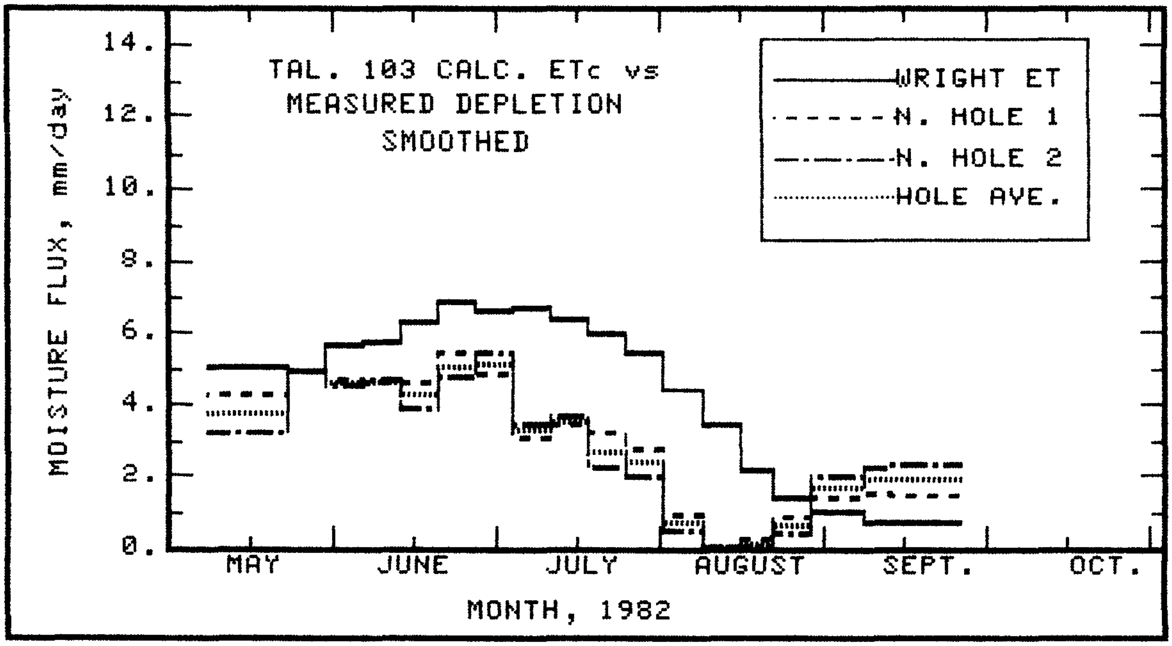

Figure 37. Smoothed rates of soil moisture depletion by dryland winter wheat at the Talmage site (3) estimated using Wright-1982 and Wright "mean" crop coefficients and rates measured using a neutron probe during 1982.

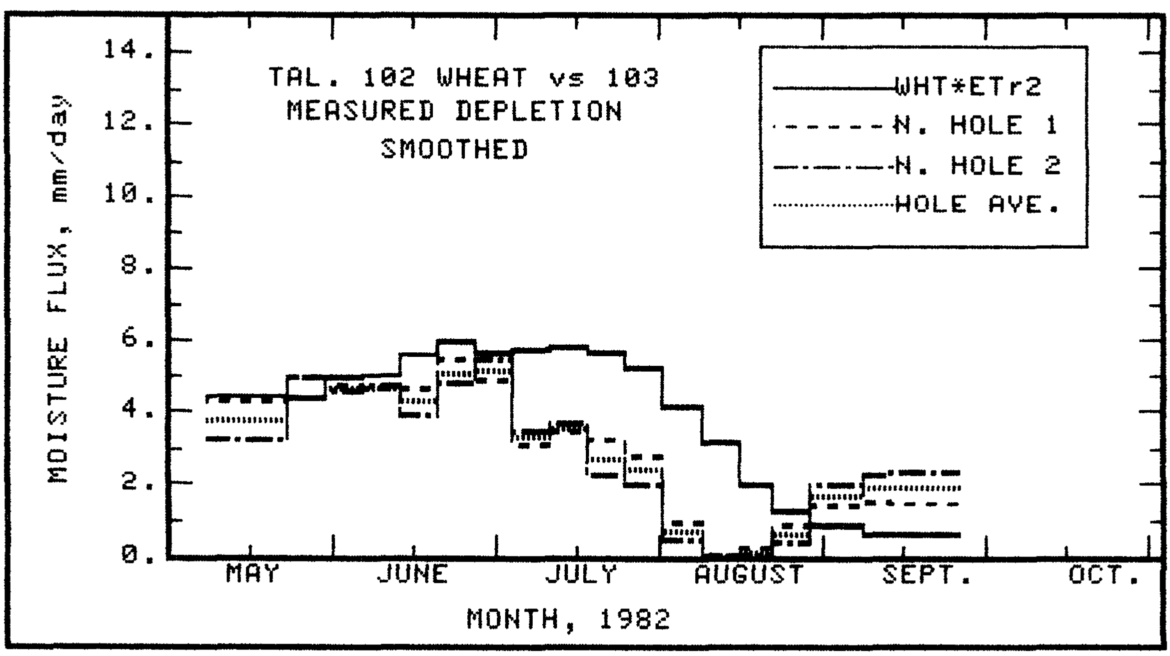

Figure 38. Smoothed rates of soil moisture depletion by dryland winter wheat at the Talmage site (3) estimated using Wright-1982 calculated using site 2 weather data with Wright "mean" crop coefficients and rates measured using a neutron probe during 1982.

Lack of precipitation records directly adjacent to the measurement site precluded making more refined comparisons with Preston data.

Comparison of measured versus calculated soil moisture depletion at the Talmage irrigated alfalfa site (figure 36) indicates that greenup and die down dates estimated for this site (May 5th and October 12th) may be later than actual dates of occurrence. The alfalfa was cultivated about May 1, and growth after this date may have been more rapid than reflected by the hay coefficient. The estimate for the greenup date caused estimated ET to fall below measured depletion during the first half of May and the late date estimated for diedown caused overestimation of ET compared to measured during September. During June, July and August, however, alfalfa ET estimated using Wright-1982 (alfalfa reference) and mean hay coefficients including effects of cutting developed by Wright (1981) compare well with measured soil moisture depletions.

Large differences in neutron readings between neutron access tubes (holes) occurred at site 2 during the month of July. The large differences are apparently due to either deep percolation of soil moisture at hole 1 (2.7 meters deep) or reduced water use around hole 2 due to soil moisture stress. It was noted during site visits that alfalfa surrounding hole 2 at site 2 did appear moisture stressed during July and August. This stress resulted from under irrigation of the area around the hole due to poor location of the wheelline sprinkler lateral (caused primarily by interference of lateral movement due to weather sensor location). In addition, total soil moisture around hole 2 was significantly less at the start of the season than total soil moisture around hole 1 (340 vs 640 mm).

The probability of large deep percolation losses from hole 1 was judged to be low for two reasons. One, the access tube was inserted to bedrock which should have acted as a barrier to further downward movement of soil moisture until soil moisture directly above the bedrock approached field capacity (one-third bar of pressure). Two, the alfalfa crop received just one irrigation of an estimated 68 mm (2.7 inches) before the month of July. In addition, moisture levels at the 215 and 240 cm depths (84 and 96 inches) continually decreased during the growing season with no indication of downward movement of moisture within the soil profile.

Because of reasoning presented in the two preceding paragraphs, soil moisture depletion rates indicated by the hole 1 measurements presented in figure 36 are probably the most representative of water use by a well-watered, actively growing alfalfa crop. Measured moisture depletion from hole 1 during June and July which exceeds estimated depletions using Wright-1982 may have resulted from precipitation which was less than 100% effective in replacing depleted soil moisture or from error introduced in extrapolating precipitation from the Grace and Soda Springs UP&L weather sites. In addition, the hay coefficient used with Wright-1982 during July reflects the effect of the hay cutting. However, alfalfa plants directly adjacent to the neutron access tubes were not cut back to the same extent as the rest of the field. Therefore, the crop coefficent during July may have overestimated the reduction in ET due to cutting.

Overall, alfalfa hay ET predicted using Wright-1982 and mean hay coefficients compares well with actual measurements. The decrease in ET and soil moisture depletion during August indicates the effect of the second hay cutting on ET and water use.

Evapotranspiration by the dryland wheat crop at Talmage site 3 was estimated using "mean" crop coefficients for winter wheat reported by Wright (1981) with alfalfa reference ET estimates for both site 2 (irrigated alfalfa) and site 3 (dryland wheat). Because the crop coefficients reported by Wright (1981, 1982) are to be based on reference ET calculated using weather measured over an actively growing alfalfa or grass crop, using reference ET estimates from site 2 with winter wheat coefficients should provide better estimates of soil moisture depletion, as can be seen in reviewing figures 37 and 38 (site 3 ET_r and site 2 ET_r). Estimated crop ET using ET_r calculated for the wheat site did over predict moisture depletion through most of the season (figure 37). Using ET_r calculated for the nearby alfalfa site, however, resulted in close agreement between estimated and measured soil moisture depletion during May and June.

The overestimation during July and August may have been due to a reduction in actual ET by the wheat crop after July 1, as compared to potential crop ET (represented by Wright-1982 in figure 38), resulting from soil moisture stress. However, there seemed to be sufficient moisture in the soil profile at the 140 cm (54 inch) depth, especially around hole 2, to supply evaporative demands. Overestimation of ET during July and August could be reduced by using an earlier date for effective cover than June 19th, the date of heading. Most of the difference between estimated and measured depletion may be accounted for by readjustment of crop stage development dates, although heading, which occurred about June 19th, has been suggested by Wright (1982) for use as the date of effective cover.

Monthly Comparisons

Figures 39 through 54 show monthly comparisons between crop water use estimated using various evapotranspiration methods and measured soil water depletion at sites 1, 2 and 3. Five evapotranspiration methods compared in figures 39 through 43 using Preston site 1 weather data and neutron probe measurements are 1) Wright-1982 with mean hay coefficients developed by Wright (1981); 2) FAO-Blaney-Criddle with elevation correction and Kimberly reference ratios and mean hay coefficients developed by Wright (1981) ; 3) Jensen-Haise (Jensen, 1974) with mean hay coefficients developed by Wright (1981); 4. SCS-modified Blaney-Criddle (Technical Release 21) with SCS monthly alfalfa hay coefficients; and 5) an aridity equation (equation 5) using Priestly-Taylor and Wright-1982 with no crop coefficients.

Average estimates of monthly ET are presented in Table 4 and measured monthly soil moisture depletion rates are presented in Table 6. In comparing the fit of the five ET methods to measured depletion at Preston, it can be seen that Wright-1982, the FAO-BC and Jensen-Haise all provide similar results, with water use over predicted in most months, especially during July and August during which the alfalfa crop was moisture stressed. July at Preston must be discounted due to a problem in accounting for precipitation during that month.

The Wright, FAO-BC and Jensen-Haise all overpredicted moisture use in May and June by about 70 percent. This overprediction may have resulted from using too early a date for greenup (April 18th). The SCS-Blaney-Criddle method with monthly coefficients suggested in SCS Technical Release Number 21, predicts measured moisture depletion very well during May and June, but grossly overpredicts depletion during July and

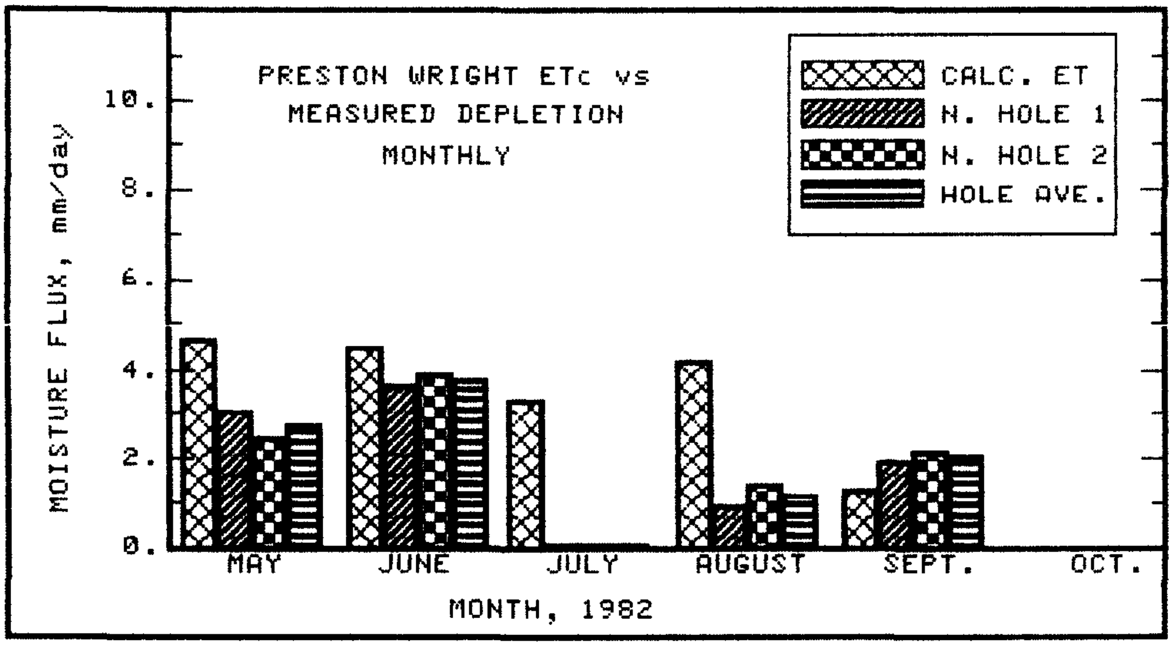

Figure 39. Monthly rates of measured soil moisture depletion and estimated depletion rates using Wright-1982 and mean hay coefficients at the Preston dryland alfalfa site (1) during 1982.

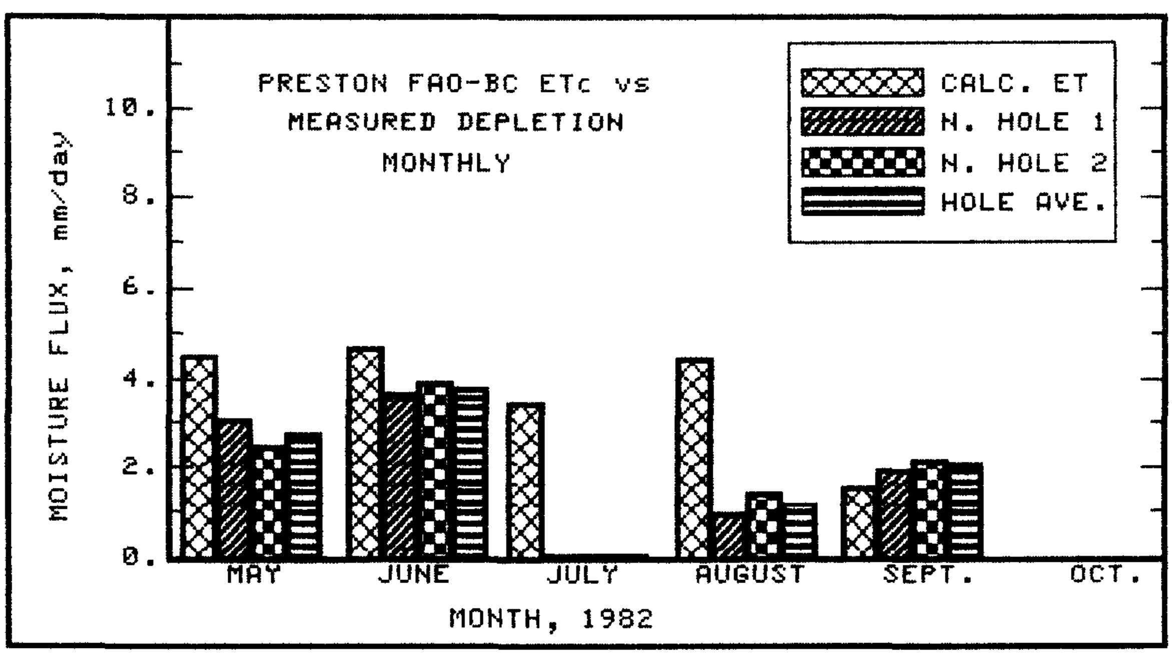

Figure 40. Monthly rates of measured soil moisture depletion and estimated depletion rates using the FAO-Blaney-Criddle and mean hay coefficients at the Preston dryland alfalfa site (1) during 1982.

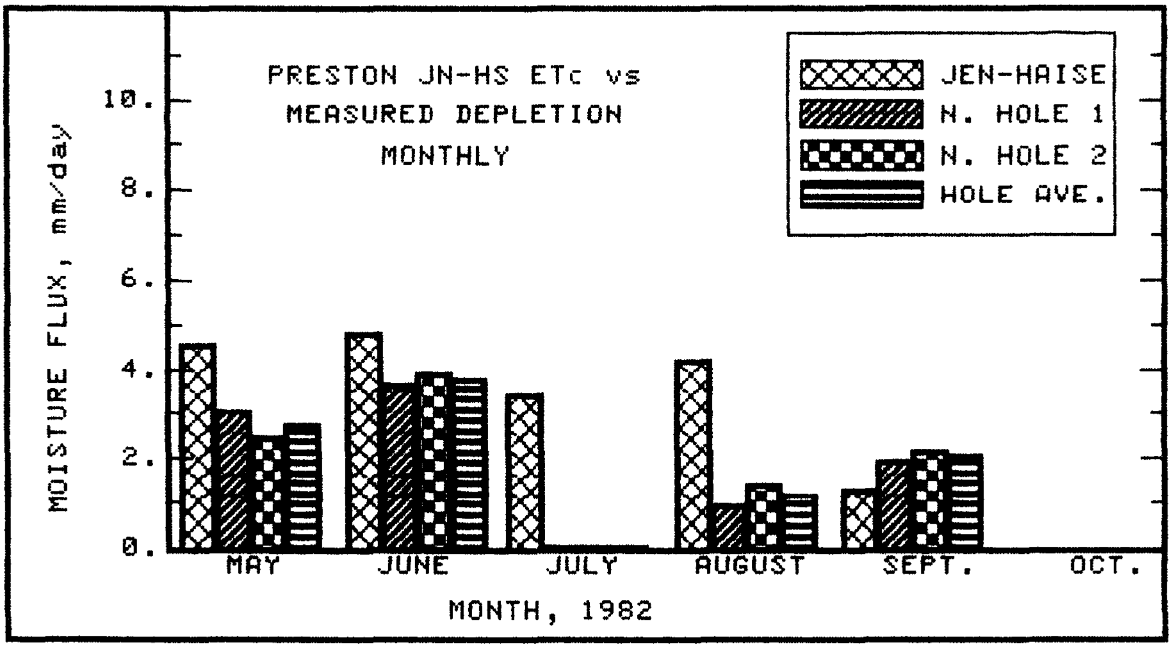

Figure 41. Monthly rates of measured soil moisture depletion and estimated depletion rates using Jensen-Haise and mean hay coefficients at the Preston dryland alfalfa site (1) during 1982.

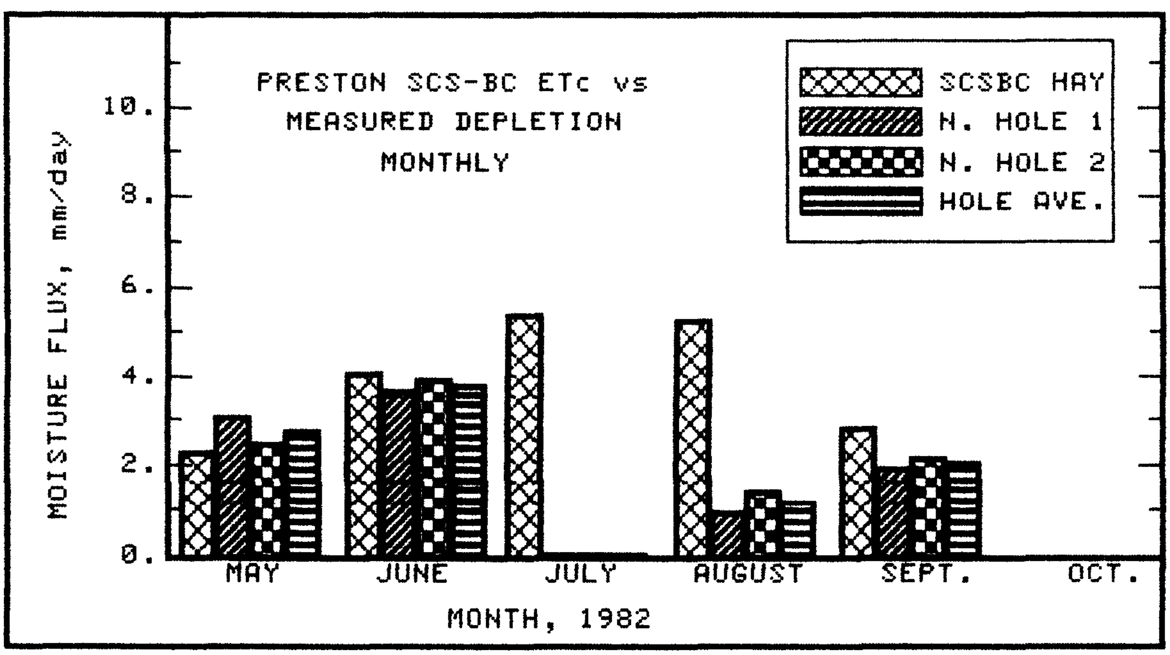

Figure 42. Monthly rates of measured soil moisture depletion and estimated depletion rates using the SCS-Blaney-Criddle and SCS hay coefficients at the Preston dryland alfalfa site (1) during 1982.

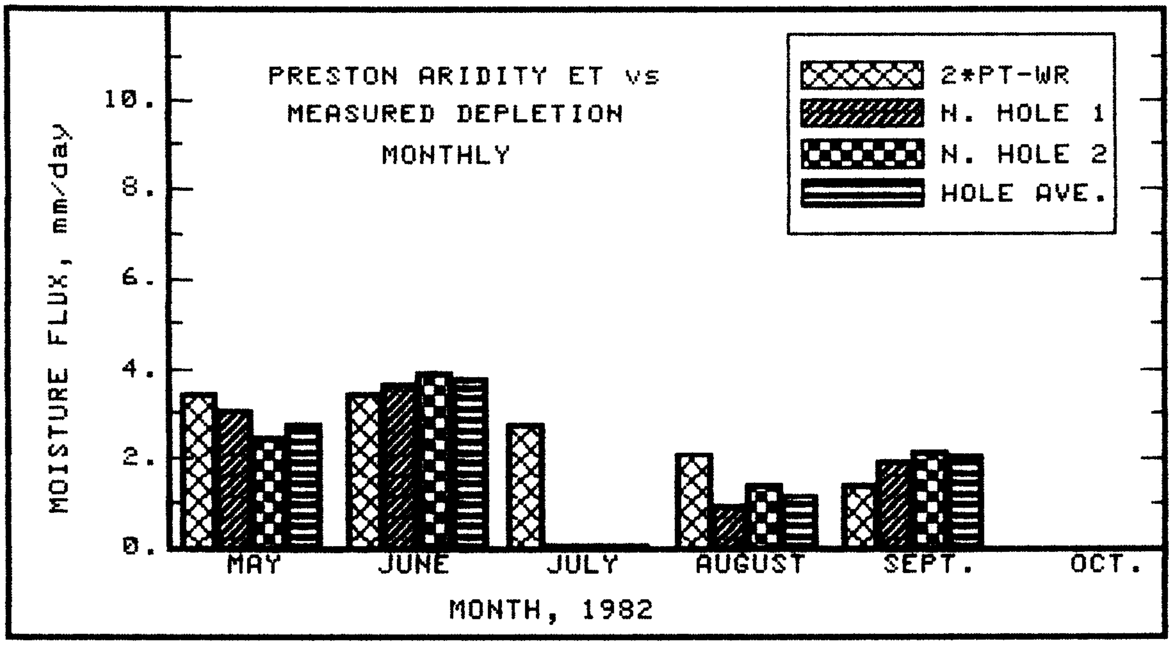

Figure 43. Monthly rates of measured soil moisture depletion and estimated depletion rates using an aridity ET concept at the Preston dryland alfalfa site (1) during 1982.

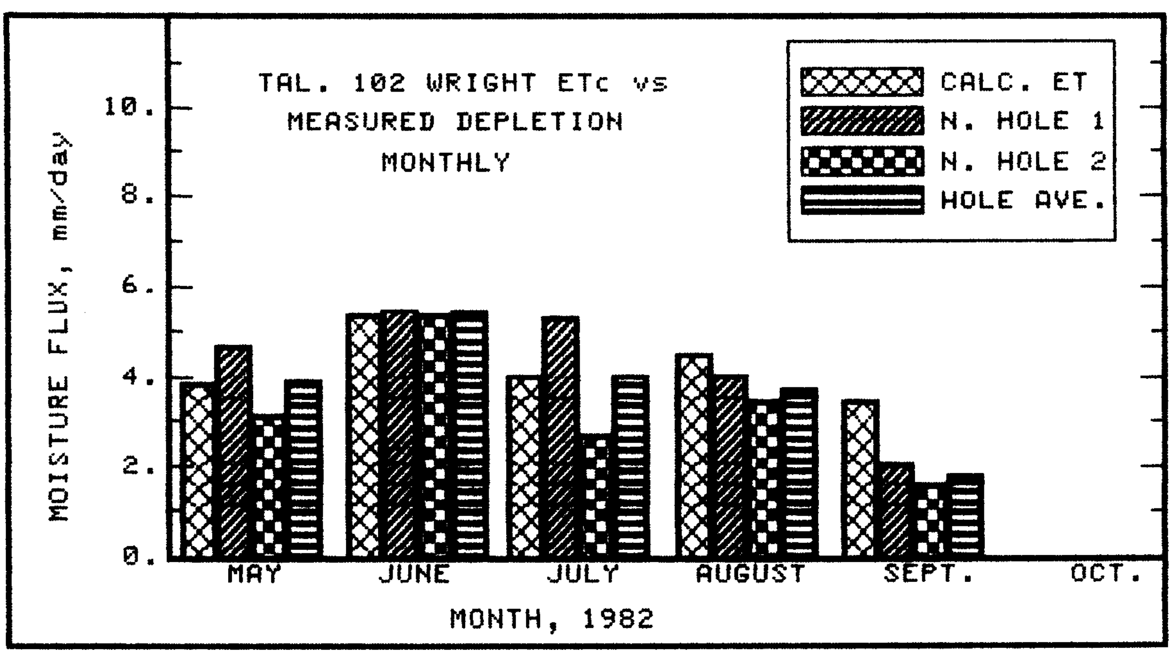

Figure 44. Monthly rates of measured soil moisture depletion and estimated depletion rates using Wright-1982 and mean hay coefficients at the Talmage irrigated alfalfa site (2) during 1982.

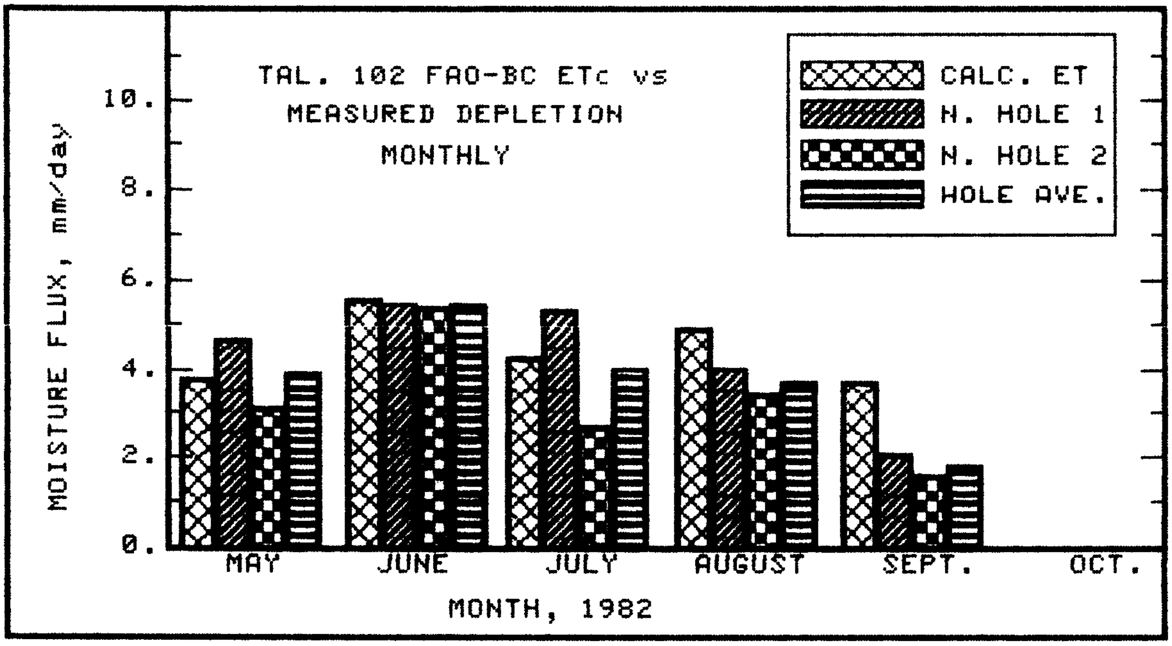

Figure 45. Monthly rates of measured soil moisture depletion and estimated depletion rates using the FAO-Blaney-Criddle and mean hay coefficients at the Talmage irrigated alfalfa site (2) during 1982.

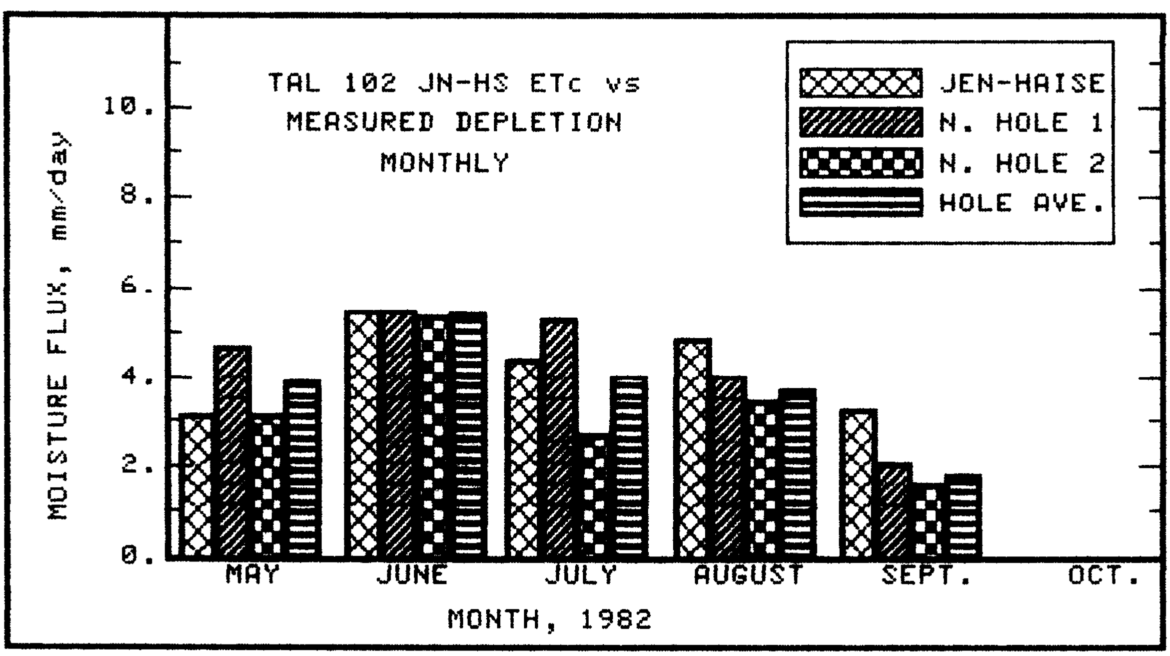

Figure 46. Monthly rates of measured soil moisture depletion and estimated depletion rates using Jensen-Haise and mean hay coefficients at the Talmage irrigated alfalfa site (2) during 1982.

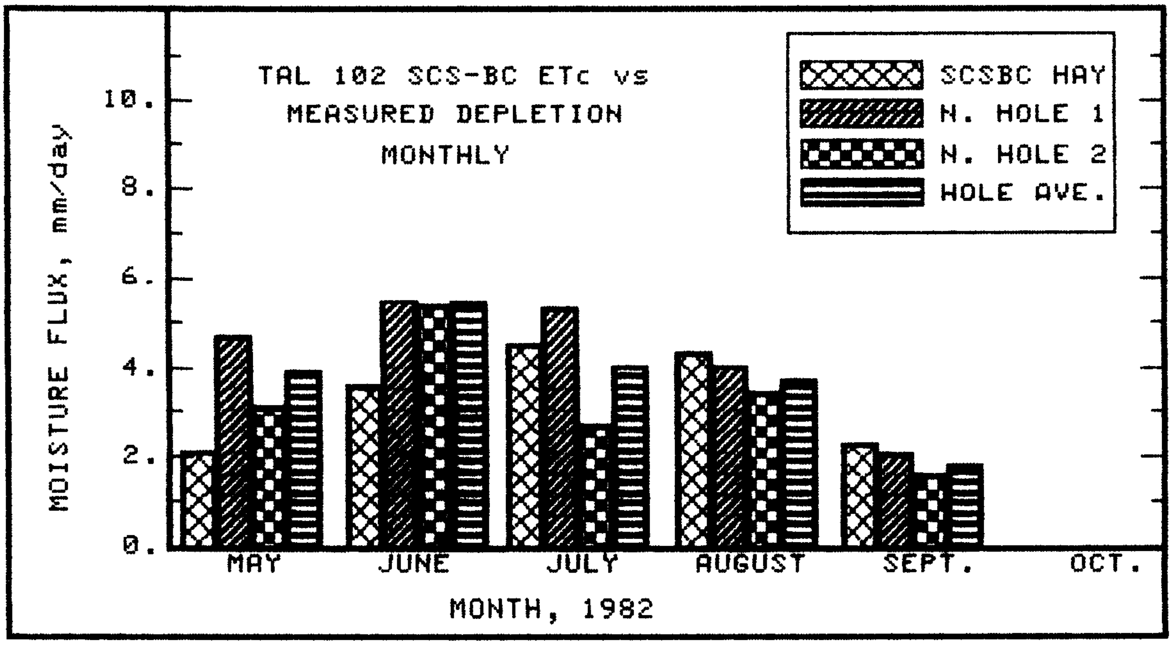

Figure 47. Monthly rates of measured soil moisture depletion and estimated depletion rates using the SCS-Blaney-Criddle and SCS hay coefficients at the Talmage irrigated alfalfa site (2) during 1982.

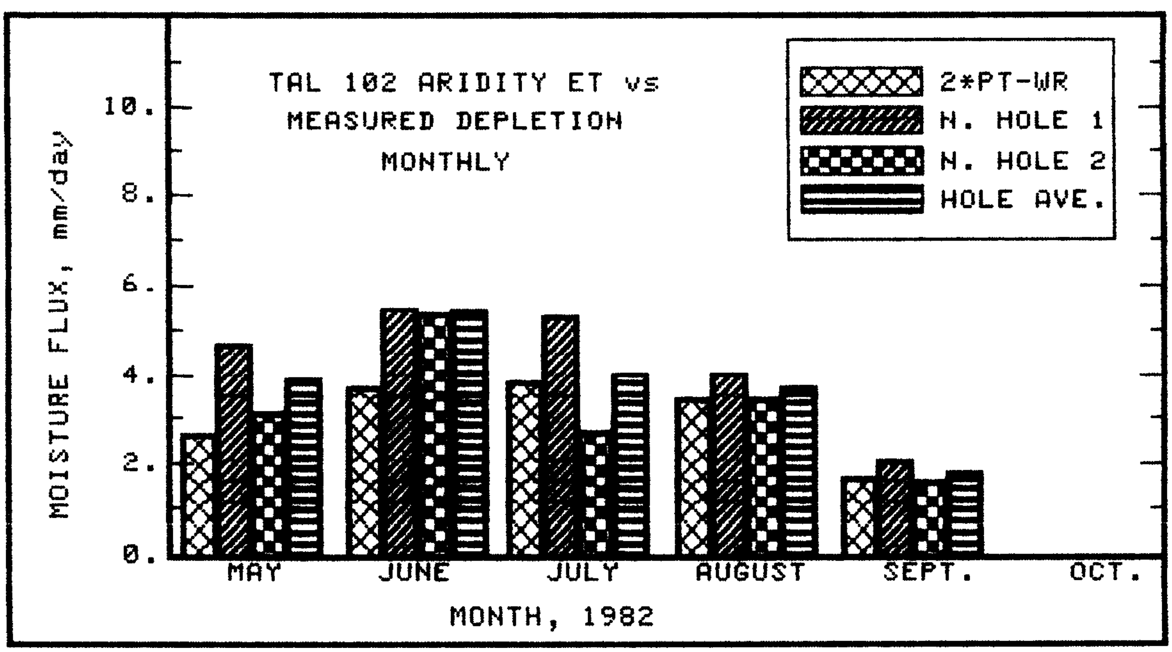

Figure 48. Monthly rates of measured soil moisture depletion and estimated depletion rates using an aridity ET concept at the Talmage irrigated alfalfa site (2) during 1982.

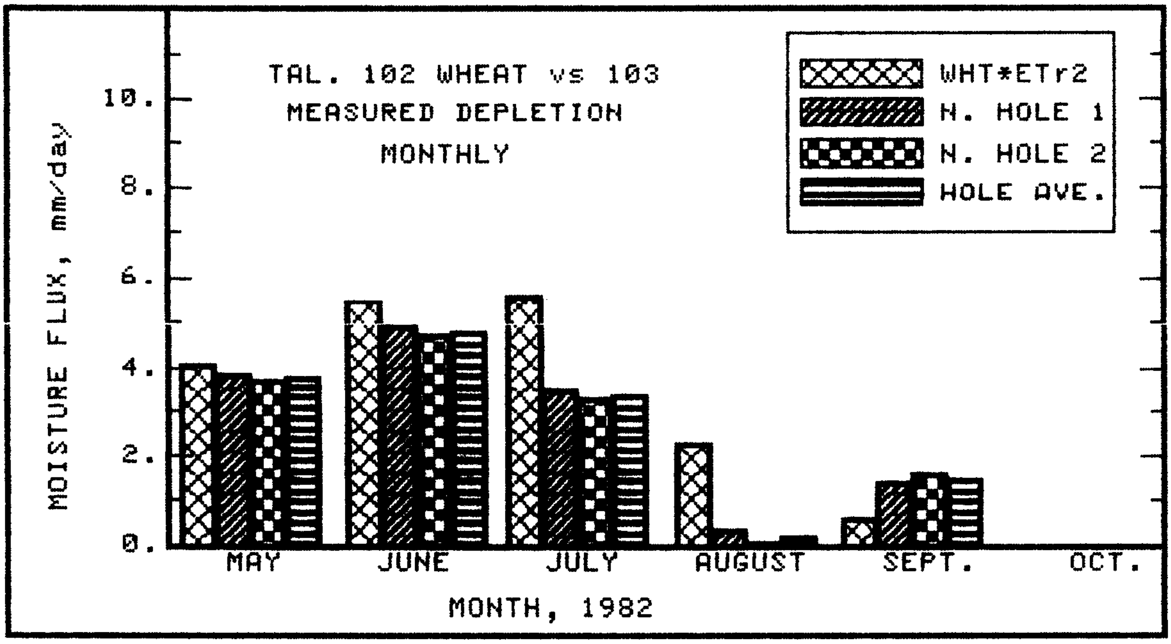

Figure 49. Monthly rates of measured soil moisture depletion and estimated depletion rates using Wright-1982 and mean winter wheat coefficients at the Talmage dryland winter wheat site (3) during 1982.

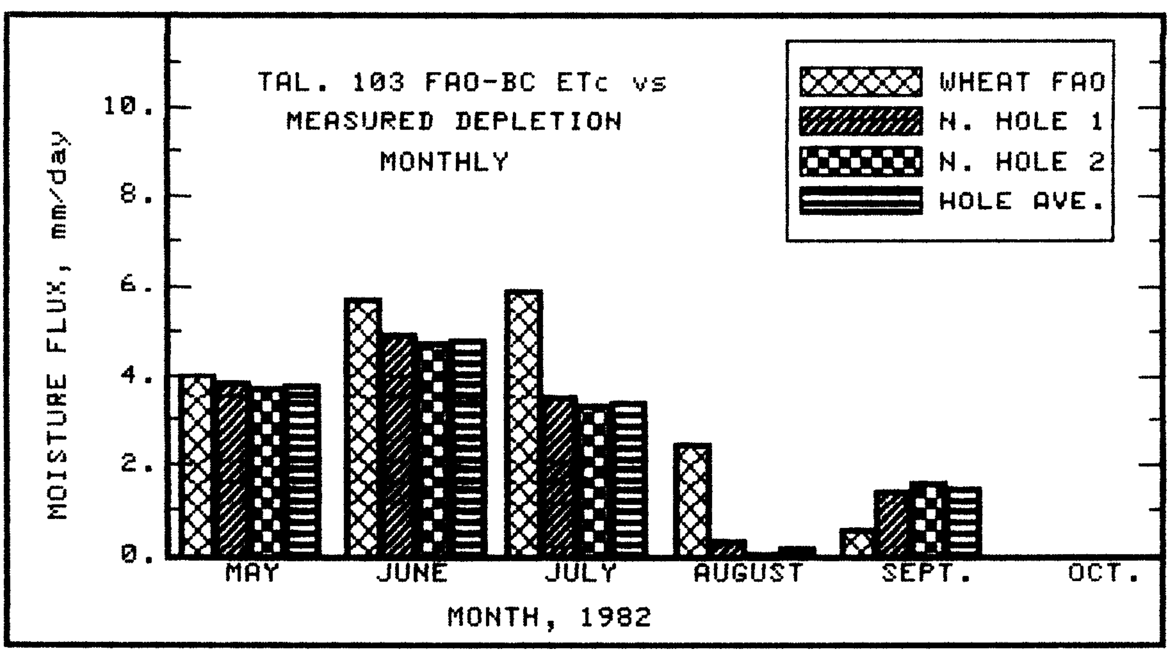

Figure 50. Monthly rates of measured soil moisture depletion and estimated depletion rates using the FAO-Blaney-Criddle and mean winter wheat coefficients at the Talmage dryland winter wheat site (3) during 1982.

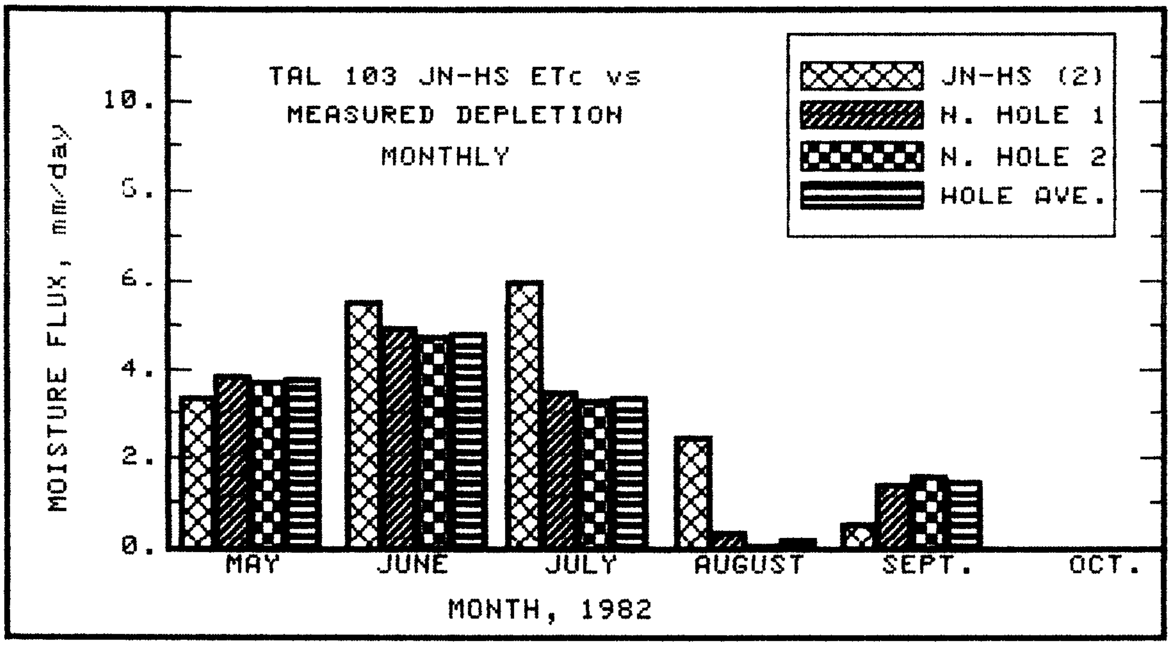

Figure 51. Monthly rates of measured soil moisture depletion and estimated depletion rates using Jensen-Haise and mean winter wheat coefficients at the Talmage dryland winter wheat site (3) during 1982.

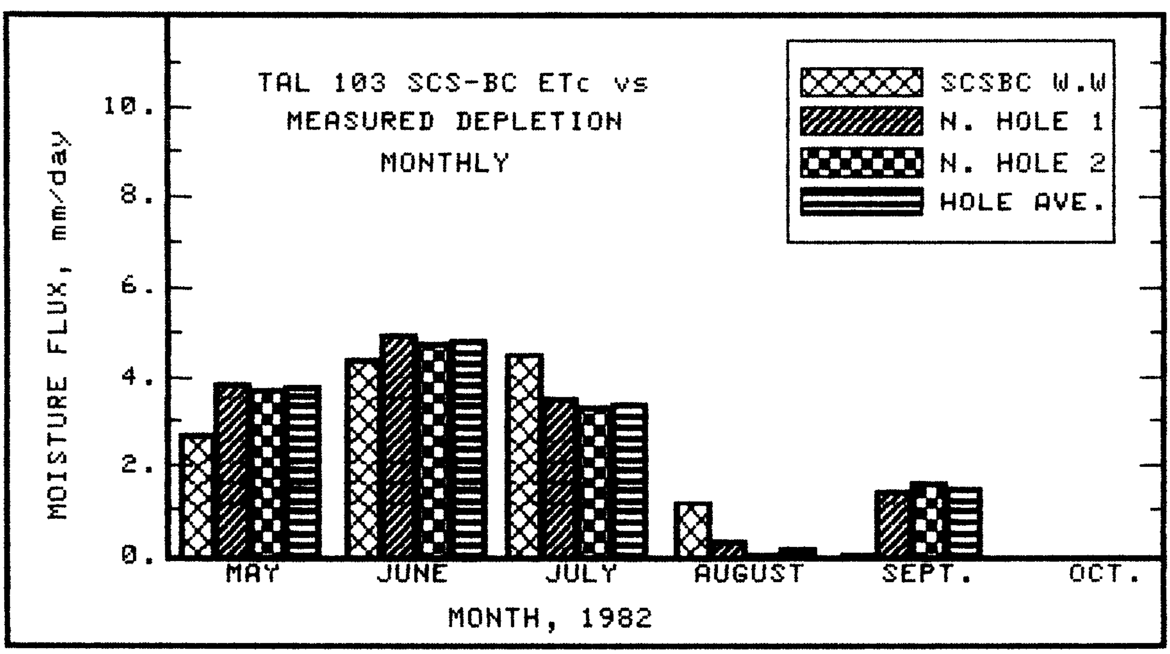

Figure 52. Monthly rates of measured soil moisture depletion and estimated depletion rates using the SCS-Blaney-Criddle and SCS winter wheat coefficients at the Talmage dryland winter wheat site (3) during 1982.

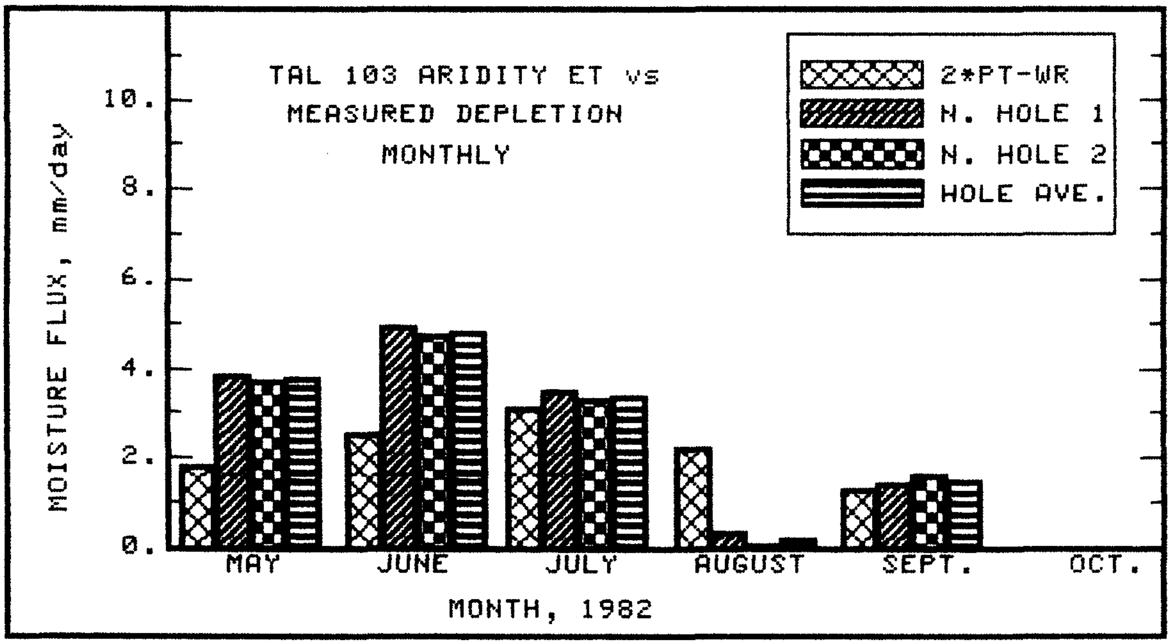

Figure 53. Monthly rates of measured soil moisture depletion and estimated depletion rates using an aridity ET concept at the Talmage dryland winter wheat site (3) during 1982.

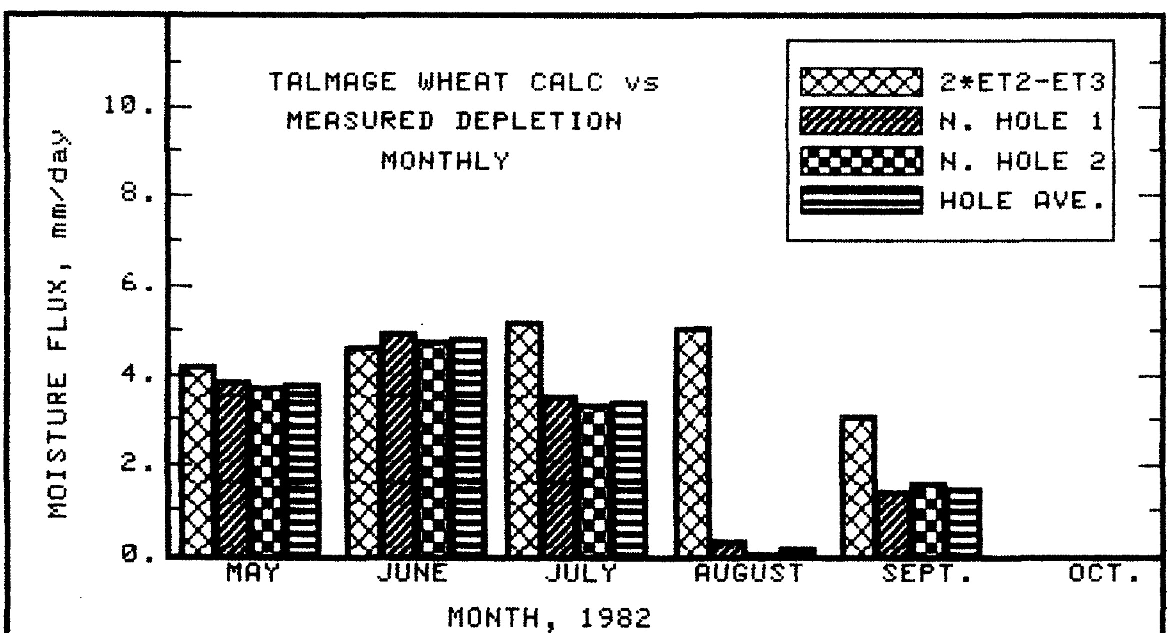

Figure 54. Monthly rates of measured soil moisture depletion and estimated depletion rates using an aridity ET concept with Wright-1982, only, at the Talmage dryland winter wheat site (3) during 1982.

Table 6. Monthly summary of soil moisture depletion rates at neutron access sites, including precipitation and irrigation, at Bear River sites 1, 2 and 3 during 1982.

	Preston Dryland Alfalfa			Talmage Irrigated Alfalfa			Talmage Dryland Winter Wheat		
Month	Hole 1	Hole 2	Ave.	Hole 1	Hole 2	Ave.	Hole 1	Hole 2	Ave.
May*	3.02	2.44	2.73	4.63	3.08	3.85	3.81	3.66	3.74
June	3.62	3.84	3.73	5.43	5.27	5.35	4.85	4.70	4.78
July	-.18	-.58	-.38	5.23	2.70	3.97	3.42	3.27	3.35
Aug.	.88	1.37	1.12	3.99	3.39	3.68	.29	-.03	.13
Sept.	1.92	2.16	2.04	2.04	1.52	1.78	1.39	1.52	1.45
Oct.*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ma-Se**	249.	250.	249.	609.	458.	533.	385.	366.	376.

* Period of neutron measurement was May 7, 1982 - Sept 24, 1982.

** Ma-Se sum includes period from May 8, 1982 - Sept 23, 1982.

August for the dryland hay crop. Surprisingly, the aridity method (equation 5) gives the best estimates of water use by the dryland crop over the season (figure 43).

The Wright-1982, FAO-BC and Jensen-Haise methods all provide reasonable estimates of consumptive use at site 2 (irrigated alfalfa), as compared to measured use (figures 44, 45 and 46). Both the SCS-Blaney-Criddle and aridity approach (equation 5) provide good estimates during July, August and September, but underestimate consumptive use during May and June.

Measured consumptive use by the dryland wheat at site 3 was less than predicted by Wright-1982, FAO-BC and Jensen-Haise methods (figures 49, 50 and 51) especially during July and August. Overestimation was greatest by the Jensen-Haise method. The SCS-Blaney-Criddle produced better estimates during July and August (figure 52), but understimated consumptive use during May and early June. The aridity approach (equation 5) predicted good results in July, only, when the wheat crop was ripening (figure 53).

Equation 6, an aridity approach using ET_r estimated using Wright-1982 at sites 2 and 3, provided good estimates of soil moisture depletion during May and June (figure 42), but grossly overestimated during July, August and September.

In summary, the Wright-1982 method with mean crop coefficients does a little better than the FAO-BC and Jensen-Haise in estimating consumptive use in the Bear River Region of Idaho. All three of these methods give good estimates during periods of crop growth in the absence of moisture stress. The SCS-Blaney-Criddle gave good estimates of consumptive use by the dryland crops monitored, but underestimated consumptive use at the irrigated site and at the dryland wheat site during periods of rapid growth unlimited by soil moisture.

In general, the aridity concept for estimating regional ET seems to show merit in estimating water use by dryland crops. Results of the concept application were quite good, considering that no method calibration was done, that the Priestly-Taylor was assumed to represent ET_{po} for the Bear River Basin, and that Wright-1982 was assumed to represent ET_p, the actual, potential evaporative power of the air. One benefit of the aridity concept is that no crop coefficients are required, since decreased crop ET as compared to a reference should be reflected in increased air temperature and decreased dewpoint.

As far as the best method in terms of seasonal estimates of consumptive use, Wright-1982 with mean hay coefficients estimated closest to measured moisture depletion at Talmage alfalfa hole 1. Jensen-Haise and FAO-Blaney Criddle provided close estimates, also. The aridity method estimated seasonal ET at the Preston site which was closest to measured use (280 millimeters excluding July compared to 249 mm). The SCS-Blaney-Criddle most closely estimated moisture use by the dryland wheat (Tables 4 and 6).

COMPARISON OF WEATHER AT BEAR RIVER SITES WITH WEATHER AT KIMBERLY AND LOGAN

Solar radiation, wind run, maximum and minimum air temperature and dewpoint temperature measurements at Bear River sites 1 and 2 (Preston and Talmage alfalfa sites) were compared with similar measurements at Logan, Utah and Kimberly, Idaho. These comparisons were made to assess whether or not historical weather data from Logan and Kimberly could be used for the purpose of estimating historical consumptive use in the Bear River area.

Solar radiation is no longer measured at the Pocatello NOAA station. Due to the lack of current radiation at Pocatello and due to the aridity of the nonagricultural area around the site, weather data from Pocatello was not included in this analyses.

Ten-day running averages of solar radiation, wind, air and dewpoint temperature measurements for sites 1 and 2 and Logan and Kimberly are shown in figures 55 through 58. Monthly averages for these stations are included in Table 2.

As shown in figure 55, solar radiation measurements from all stations were quite similar during the May through September period. Low values in September at the Preston site are due to missing data. Kimberly solar radiation was lower than in the Bear River region during early July, only.

Wind run data shown in figure 56 indicates a wide disparity between wind travel at Logan and wind travel further north at Preston and Talmage and at Kimberly. The Utah State University North Farm, near the Greenville railroad siding is about 8 km north of Logan. Wind at that site was

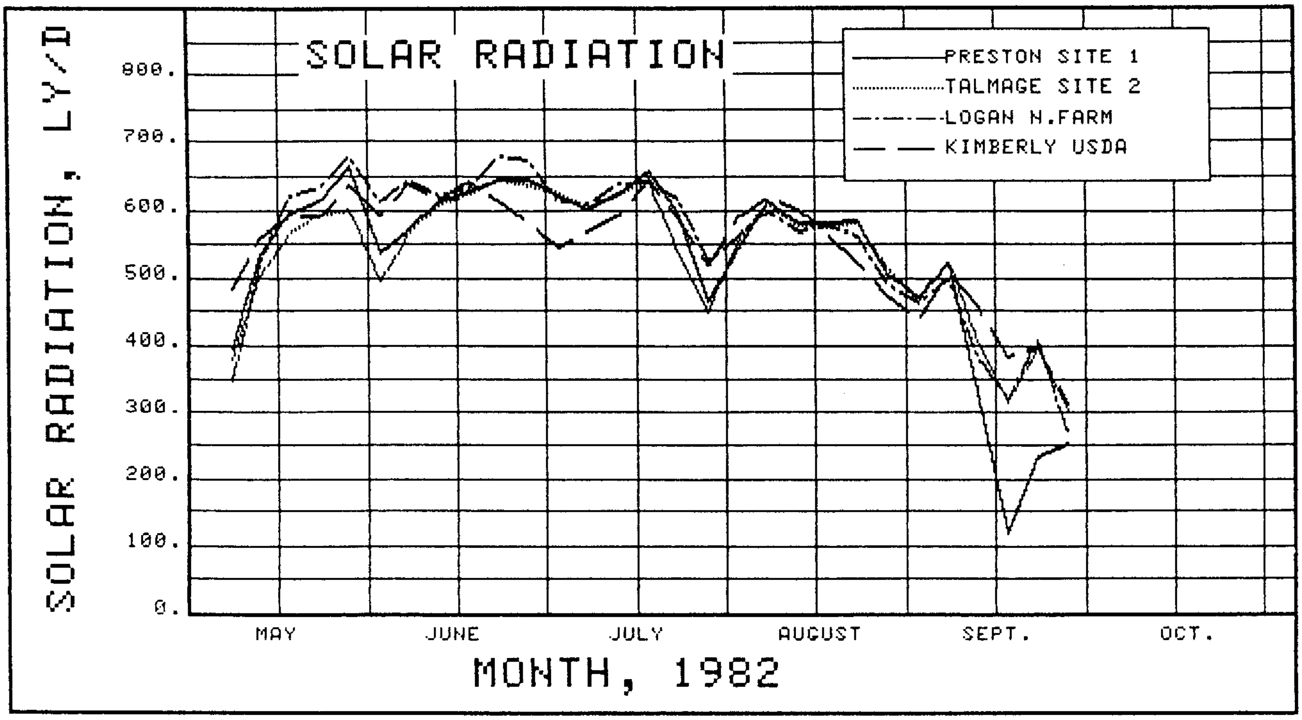

Figure 55. Ten-day average solar radiation at Bear River sites 1 and 2 and at Logan, Utah and Kimberly, Idaho during 1982.

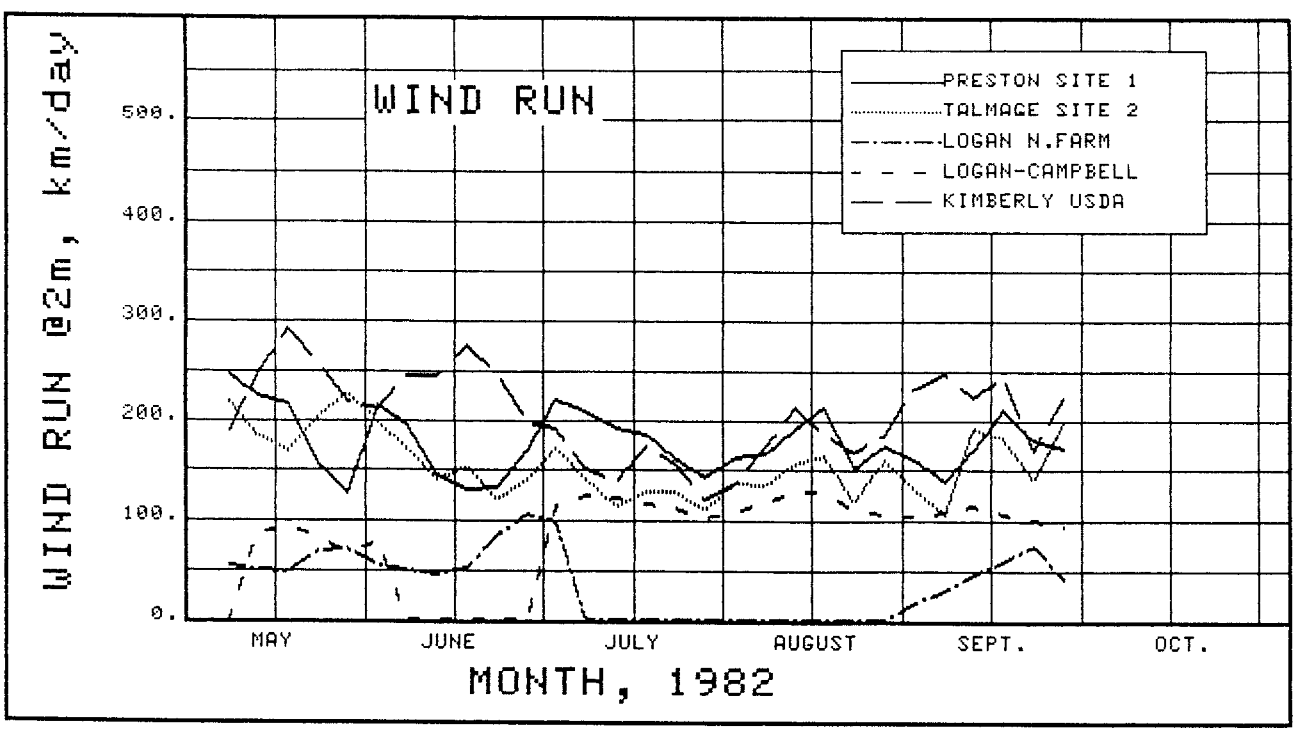

Figure 56. Ten-day average wind run at Bear River sites 1 and 2 and at Logan, Utah and Kimberly, Idaho during 1982.

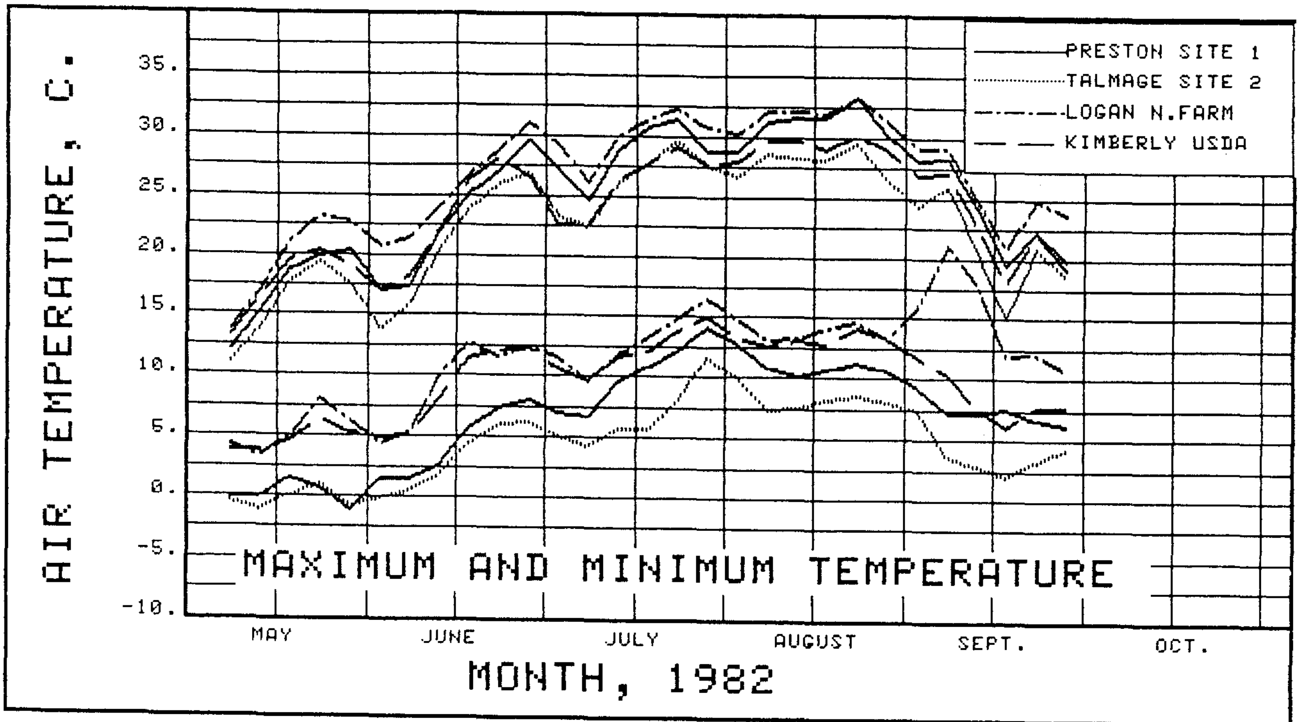

Figure 57. Ten-day average maximum and minimum air temperatures at Bear River sites 1 and 2 and at Logan, Utah and Kimberly, Idaho during 1982.

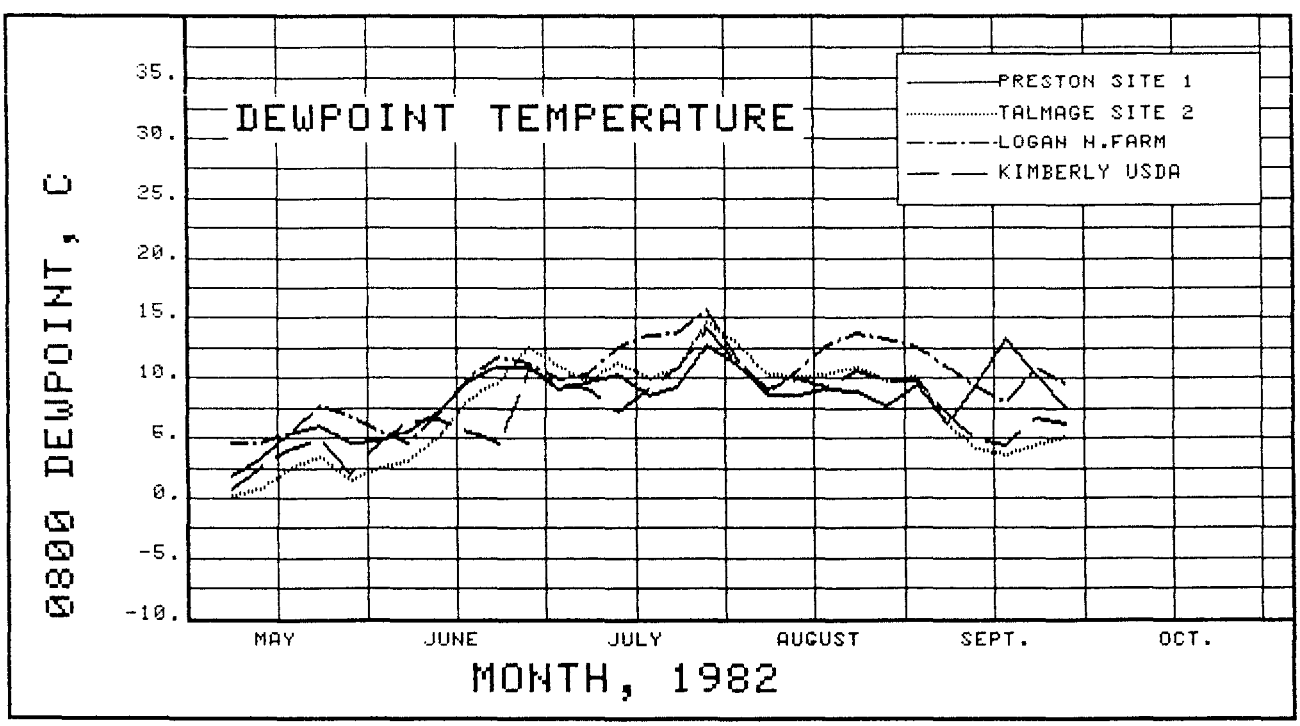

Figure 58. Ten-day average calculated or measured dewpoint temperatures at Bear River sites 1 and 2 and at Logan, Utah and Kimberly, Idaho during 1982.

measured at 0.6 meters over an evaporation pan in an area bordered by trees (Hill, 1982). Wind data for this site was adjusted to values expected at a 2 meter height using a power relationship reported by Jensen (1974). Measurements during July and August at the North Farm site were not reported.

Wind travel measured in the Logan area during 1982 by Tanner (1982) of Campbell Scientific Inc. of Logan, Utah is also included in figure 56. The anemometer was located about 12 km west of Logan near Mendon, Utah near the Wellsville mountain range. Wind data at the Campbell site during June is missing. Wind travel during May at the Mendon site is similar to wind travel at the North Farm, both sites having less than half the wind travel measured at Preston and Talmage. Wind at the Campbell site did increase during July, August and September, approaching values averaging about 35 and 45 km/day less than wind measured at Talmage and Preston.

The integrity of the anemometer measurements at the North Farm site for use in estimating consumptive use is doubtful, primarily due to the instrument height and local environment. Installation of an anemometer at a 2 meter height in an exposed location could provide better wind travel measurements for use in estimating consumptive use. The Wellsville Mountain Range west of Logan may have a buffering effect on wind travel in the Logan area (Hill, 1982). However, both Preston and Talmage are bordered to the west by more extensive ranges than the Wellsville range (Bannock and Portneuf ranges, respectively).

Wind travel measured at Kimberly compares well with wind travel at Talmage and Preston, especially during July and August. Winds were greater at Kimberly during May, June and September.

Maximum air temperature measurements included in figure 37 indicate higher maximum temperatures at Logan than at the Bear River sites during all months. Maximum temperatures at Kimberly were close to temperatures at the Talmage alfalfa site and averaged between maximum temperatures at the Preston and Talmage sites.

Minimum daily air temperatures (figure 57) were higher at both Kimberly and Logan than at the Bear River sites. The lower daily minima at site 1 and 2 are most likely due to greater losses of long wave radiation during nighttime hours due to the higher elevations of these sites. The high minimum temperatures reported for Logan during September are apparently a result of a faulty instrument or recording errors.

Dewpoint temperatures shown in figure 58 indicate that the dewpoint of air at Kimberly, Idaho is similar to that of air at the Bear River sites. Dewpoint temperatures recorded at Logan averaged about 2 degrees higher than at the other stations during July and August (Table 2).

Reference Evapotranspiration Estimates

Reference evapotranspiration estimates for Kimberly and sites 1 and 2 are shown in figures 59 and 60 for the Wright-1982 and FAO-BC methods. Estimates for Kimberly were between those for Preston and Talmage except during May, June and September, when wind travel at Kimberly was high. Monthly reference ET estimates for the Kimberly and Bear River sites are listed in Table 4. Results indicate that reference ET from Kimberly could possibly be substituted for Talmage and Preston areas after July 1, with errors introduced by substitution being less than about 10 percent.

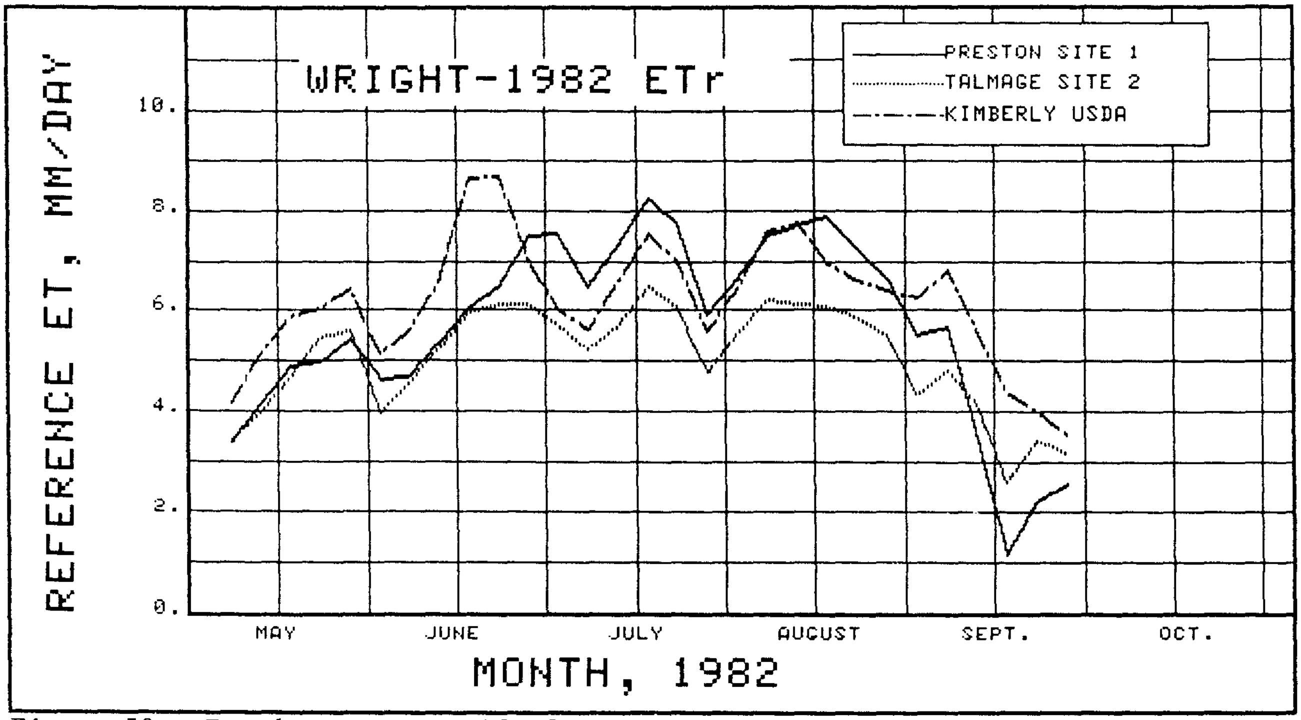

Figure 59. Ten-day average alfalfa reference evapotranspiration estimated using Wright-1982 for Bear River sites 1 and 2 and Kimberly, Idaho during 1982.

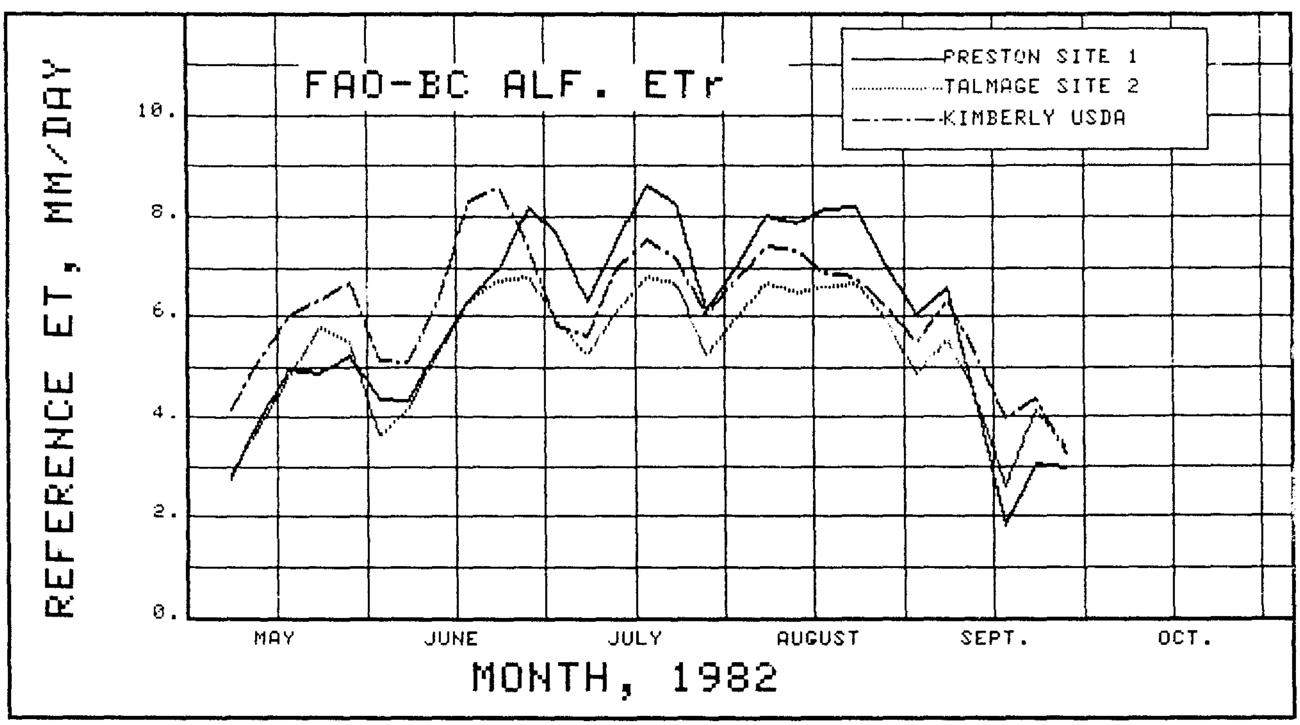

Figure 60. Ten-day average alfalfa reference evapotranspiration estimated using FAO-Blaney-Criddle for Bear River sites 1 and 2 and Kimberly, Idaho during 1982.

Reference evaportranspiration was not estimated using Logan data due to uncertainty of the wind data and due to missing periods.

SUMMARY

Solar radiation measured at three portable, electronic weather stations located in the Bear River basin of Idaho during 1982 was similar at each site. Wind travel was greater near the Preston site (site 1) than near Talmage (sites 2 and 3). Maximum and minimum air temperatures were also greater at Preston. Dewpoint temperatures at Preston were similar to dewpoints at the Talmage irrigated alfalfa site, whereas calculated dewpoint temperatures at the Talmage dryland wheat site were lower, possibly as a result of the effect of moisture stress on vapor pressure. Minimum relative humidity measurements at the Preston dryland alfalfa and Talmage wheat sites were similar during periods of moisture stress at both sites.

Air temperatures at the Talmage agricultural sites were lower than air temperatures recorded at nearby, permanent, nonagricultural weather sites during the 1982 growing season. This result underlines the importance of local environment on measurement of air temperatures and vapor pressures. Mean daily temperatures ranged from 2 to 3°C higher at Grace and Soda Springs Utah Power and Light weather sites than at the Talmage irrigated alfalfa site.

Precipitation patterns and amounts at Preston, Grace and Soda Springs permanent sites were similar during the 1982 growing season. However, some precipitation apparently occurred at the Preston agricultural site which was not recorded at the Preston permanent site during July, as indicated by soil moisture depletion records.

The Wright-1982, FAO-Blaney-Criddle and Jensen-Haise

evapotranspiration methods all estimated similar values of reference evapotranspiraton at each agricultural site in the Bear River basin. Comparisons with measured soil moisture depletion at the sites indicates that the Wright-1982, FAO-BC or Jensen-Haise can provide good estimates of consumptive use during periods when crops are not subjected to moisture stress resulting from low soil moisture levels. The SCS-Blaney-Criddle method and an aridity ET concept provided better estimates of consumptive use during periods of moisture stress.

Comparison of weather data with weather at Kimberly and Logan, Utah indicates that solar radiation and perhaps dewpoint temperature data can be extrapolated from these permanent weather stations.

Wind and air temperatures at Logan and Kimberly differed from those at the Bear River sites. In addition these two parameters appear to vary significantly with location within the Bear River basin.

Recommendations

Based on weather and soil moisture depletions measured during the 1982 growing season near Preston and Talmage, Idaho, it is recommended that the Wright-1982, FAO-Blaney-Criddle or Jensen-Haise method be used to estimate alfalfa reference ET on a monthly basis, with the Wright-1982 and FAO-Blaney- Criddle recommended for estimating reference ET for short term periods. Mean crop coefficients reported by Wright (1981) should be used with the alfalfa reference ET to provide consumptive use estimates for irrigated crops in the area. Further study is needed to ascertain recommended adjustments in crop stage development dates to provide better consumptive use estimates early and late in the growing season.

The SCS-Blaney-Criddle method and the Priestly-Taylor method, as used in the aridity concept of regional ET, are recommended for use in estimating consumptive use by dryland winter wheat and dryland alfalfa, respectively in the Bear River basin of Idaho. Further study in application and calibration of the aridity concept for estimating consumptive use is warranted.

Differences in consumptive use estimated using Wright-1982 and the SCS-Blaney-Criddle may be useful in calculating actual irrigation requirements of crops in the Bear River area.

Use of crop-water production functions may prove useful in estimating reduction of consumptive use due to moisture stress. Yield functions have been proposed for various crops at locations in the western United States and could be used to reduce consumptive use estimates based on crop yields. In addition, mathematical relationships describing crop evapotranspiration reduction as a function of soil moisture could be used in conjunction with neutron soil moisture measurements to adjust consumptive use estimates for dryland crops.

It is difficult to postulate relationships between weather and consumptive use based on one season of data collection. Therefore, it is recommended that a study similar to this one be continued in an effort to determine long term average relationships among parameters.

Interpretation of neutron soil moisture measurements would be facilitated by inclusion of a third access hole at each site and by locating accurate precipitation gages at each measurement site (and access hole if sprinkler irrigated). In addition, it is important that alfalfa directly adjacent to access tubes is cut on the same date and to the same degree as is the rest of the field. Failure to cut the crop adjacent to the tubes can result in consumptive use measured at each tube which is higher than the surrounding field for two to three weeks and lower consumptive use at each tube after that, as regrowth is inhibited by mature top growth. This phenomenon may have occurred at site 2 (Talmage irrigated alfalfa) during July and August.

Placement of two types of relative humidity sensors at each weather site in addition to weekly or biweekly psychrometer readings was quite beneficial in evaluating sensor performance and diurnal stability and in providing a backup in the event of sensor malfunction.

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A P P E N D I X

LIST OF TABLES IN APPENDIX A

Table A-1. Comparison of Gravimetric Moisture Samples to Neutron Probe Measurements, Bear River Study, May 6-8, 1982.

TARE #	WT. H2O	WT. SOIL	% DRY	% VOL	GRAVIMETRIC IN/FT**	NEUTRON IN/FT	GRAVIMETRIC/ NEUTRON	DEPTH INCHES	COMMENT
PRESTON DRYLAND ALFALFA #1 (NO #2) 5/8/82									
191	20.83	94.67	22.00	29.26	3.51	--	--	2	0-4 MOIST, CLAY-LIKE
206	20.71	91.07	22.74	30.25	3.63	3.22	1.13	6	
184	17.52	80.77	21.69	28.85	3.46	3.59	.97	12	
248	24.51	114.71	21.37	28.42	3.41	3.86	.88	24	
214	28.44	130.67	21.76	28.95	3.47	3.86	.90	36	
217	20.05	94.06	21.32	28.35	3.40	3.65	.93	48	
226	13.02	72.63	17.93	23.84	2.86	2.82	1.01	60	
187	17.57	133.04	13.21	17.56	2.11	2.20	.96	72	
213	12.54	107.42	11.67	15.53	1.86	2.35	.79	84	DRY

AVERAGE GRAVITATIONAL MEASUREMENT/NEUTRON MEASUREMENT---- .95

Table A-1, Continued.

TALMAGE DRYLAND WHEAT #1   5/7/82

TARE #	WT. H2O	WT. SOIL	% DRY	% VOL	GRAVIMETRIC IN/FT**	NEUTRON IN/FT	GRAVIMETRIC/ NEUTRON	DEPTH INCHES	COMMENT
40	13.12	108.32	12.11	16.11	1.93	--	--	2	0-4
512	15.18	103.90	14.61	19.43	2.33	2.38	.98	6	
25	12.38	73.43	16.86	22.42	2.69	2.71	.99	12	BROWN-BLACK
519	16.24	87.82	18.49	24.59	2.95	3.06	.96	24	
45	12.79	72.81	17.57	23.36	2.80	2.89	.97	36	
208	20.67	103.66	19.94	26.52	3.18	3.36	.95	48	
236	29.94	138.87	21.56	28.67	3.44	3.24	1.06	60	VERY MOIST SANDY LOAM
237	20.42	152.57	13.38	17.80	2.14	2.81	.76	72	ROCK, MOIST LOAMY SAND

AVERAGE GRAVITATIONAL MEASUREMENT/NEUTRON MEASUREMENT---- .96

TALMAGE DRYLAND WHEAT #2   5/7/82

TARE #	WT. H2O	WT. SOIL	% DRY	% VOL	GRAVIMETRIC IN/FT**	NEUTRON IN/FT	GRAVIMETRIC/ NEUTRON	DEPTH INCHES	COMMENT
250	13.01	106.10	12.26	16.31	1.96	--	--	2	0-4
199	14.62	109.73	13.32	17.72	2.13	1.93	1.10	6	
231	15.15	106.61	14.21	18.90	2.27	2.32	.98	12	
224	16.88	103.91	16.24	21.61	2.59	3.04	.85	24	
211	18.76	100.10	18.74	24.93	2.99	3.22	.93	36	
202	23.60	104.01	22.69	30.18	3.62	3.38	1.07	48	VERY MOIST SANDY LOAM
197	22.45	119.09	18.85	25.07	3.01	2.99	1.01	60	LOAMY SAND
258	19.34	102.47	18.87	25.10	3.01	3.14	.96	72	HARD
196	26.96	112.90	23.88	31.76	3.81	3.59	1.06	84	
181	22.13	95.39	23.20	30.86	3.70	4.03	.92	96	SANDY LOAM, EASIER AT 86
190	34.31	118.51	28.95	38.51	4.62	--	--	98	THIN, FINE LAYER OF CLAY OVER BASALT

AVERAGE GRAVITATIONAL MEASUREMENT/NEUTRON MEASUREMENT---- .98

** Specific Gravity of soils at Preston and Talmage sites was assumed to be 1.33.

Table A-1, Continued.

TALMAGE ALFALFA #1 5/6/82

TARE #	WT. H2O	WT. SOIL	% DRY	% VOL	GRAVIMETRIC IN/FT**	NEUTRON IN/FT	GRAVIMETRIC/ NEUTRON	DEPTH INCHES	COMMENT
263	5.09	31.24	16.29	21.67	2.60	2.45	1.06	8	
188	14.01	84.13	16.65	22.15	2.66	2.68	.99	13	12-15
243	12.61	75.33	16.74	22.26	2.67	3.46	.77	22	20-24
239	14.81	73.55	20.14	26.78	3.21	3.13	1.03	32	30-34
194	21.05	116.69	18.04	23.99	2.88	2.88	1.00	47	46-48
251	13.40	79.97	16.76	22.29	2.67	2.77	.97	60	
260	16.80	81.13	20.71	27.54	3.30	3.22	1.02	72	
215	26.35	125.06	21.07	28.02	3.36	3.25	1.03	86	84-88
50	11.16	82.46	13.53	18.00	2.16	1.75	1.23	96	
35	10.07	119.97	8.39	11.16	1.34	--	--	108	
191	6.00	60.08	9.99	13.28	1.59	--	--	108	BOTTOM ROCK

AVERAGE GRAVITATIONAL MEASUREMENT/NEUTRON MEASUREMENT----1.00

TALMAGE ALFALFA #2 5/7/82

TARE #	WT. H2O	WT. SOIL	% DRY	% VOL	GRAVIMETRIC IN/FT**	NEUTRON IN/FT	GRAVIMETRIC/ NEUTRON	DEPTH INCHES	COMMENT
198	23.92	143.20	16.70	22.22	2.67	--	--	2	0-4
203	21.70	133.85	16.21	21.56	2.59	2.43	1.07	6	
182	16.85	97.42	17.30	23.00	2.76	2.60	1.06	12	
209	20.64	122.88	16.80	22.34	2.68	2.53	1.06	24	
210	22.01	143.39	15.35	20.42	2.45	2.15	1.14	36	LARGE ROOTS
193	7.06	69.53	10.15	13.50	1.62	1.39	1.17	48	ROOTS AT 46 INCHES, SANDIER
186	9.83	121.16	8.11	10.79	1.29	1.22	1.05	60	ROOT AT 54 INCHES,
212	8.66	98.21	8.82	11.73	1.41	1.31	1.08	72	SUBANGULAR BLOCKY
183	11.27	130.68	8.62	11.47	1.38	1.43	.96	84	HARD DIGGING
227	6.88	84.64	8.13	10.81	1.30	--	--	88	BOTTOM BASALT

AVERAGE GRAVITATIONAL MEASUREMENT/NEUTRON MEASUREMENT----1.07

Table A-2. Neutron Access Hole Soil Moisture Depletion Rates, Bear River Study, University of Idaho, 1982.

(NO PRECIPITATION INCLUDED)

			PRESTON 101						TALMAGE 102						TALMAGE 103					
DEP (FT)	BDAY	EDAY	ENDING H20 (IN) HOLE1	2	AVE	DEPL (MM/DAY) HOLE1	2	AVE	ENDING H20 (IN) HOLE1	2	AVE	DEPL (MM/DAY) HOLE1	2	AVE	ENDING H20 (IN) HOLE1	2	AVE	DEPL (MM/DAY) HOLE1	2	AVE
1	0	127	3.32	3.13	3.23	0.00	0.00	0.00	2.50	2.47	2.49	0.00	0.00	0.00	2.46	2.03	2.24	0.00	0.00	0.00
1	127	142	3.14	2.88	3.01	.32	.47	.39	2.41	2.35	2.38	.15	.22	.18	2.00	1.72	1.86	.78	.53	.65
1	142	149	2.83	2.80	2.81	1.12	.30	.71	1.93	1.97	1.95	1.75	1.36	1.55	1.63	1.57	1.60	1.32	.53	.93
1	149	156	2.45	2.45	2.45	1.38	1.24	1.31	2.45	2.33	2.39	-1.88	-1.30	-1.59	1.95	1.98	1.97	-1.16	-1.49	-1.33
1	156	163	2.62	2.62	2.62	-.61	-.61	-.61	3.17	2.84	3.00	-2.61	-1.85	-2.23	1.71	1.71	1.71	.90	.99	.94
1	163	170	2.49	2.24	2.37	.47	1.39	.93	2.63	2.08	2.35	1.97	2.76	2.37	1.40	1.26	1.33	1.11	1.63	1.37
1	170	177	2.43	2.21	2.32	.23	.11	.17	2.14	1.56	1.85	1.77	1.90	1.83	1.24	1.19	1.21	.59	.26	.42
1	177	184	2.30	2.23	2.27	.47	-.10	.19	1.90	1.90	1.90	.85	-1.26	-.20	1.24	1.09	1.17	-.02	.36	.17
1	184	191	2.22	2.31	2.27	.28	-.28	0.00	1.86	1.65	1.75	.16	.93	.55	1.29	1.24	1.27	-.20	-.53	-.36
1	191	198	2.18	2.23	2.21	.17	.28	.22	1.74	1.29	1.51	.44	1.30	.87	1.32	1.12	1.22	-.10	.41	.16
1	198	205	2.19	2.19	2.19	-.05	.16	.05	1.66	1.26	1.46	.27	.10	.19	1.23	1.16	1.19	.34	-.13	.11
1	205	212	2.30	2.30	2.30	-.39	-.41	-.40	1.96	1.85	1.90	-1.07	-2.15	-1.61	1.45	1.48	1.47	-.82	-1.16	-.99
1	212	219	2.23	2.17	2.20	.26	.47	.37	1.71	1.40	1.55	.91	1.65	1.28	1.43	1.50	1.47	.07	-.09	-.01
1	219	226	2.19	2.18	2.19	.13	-.02	.05	1.65	1.27	1.46	.22	.45	.34	1.46	1.43	1.45	-.11	.25	.07
1	226	232	2.08	2.15	2.12	.47	.12	.29	2.98	2.78	2.88	-5.63	-6.40	-6.01	1.40	1.41	1.40	.26	.11	.18
1	232	239	1.90	2.04	1.97	.67	.39	.53	2.39	1.64	2.02	2.13	4.13	3.13	1.42	1.41	1.41	-.07	0.00	-.07
1	239	249	2.10	2.11	2.10	-.52	-.17	-.34	2.46	1.43	1.95	-.19	.54	.18	1.54	1.57	1.56	-.30	-.42	-.36
1	249	254	2.17	2.13	2.15	-.34	-.11	-.22	2.23	1.37	1.80	1.17	.32	.75	1.40	1.63	1.51	.72	-.29	.21
1	254	267	2.20	2.24	2.22	.39	.03	.21	2.30	1.37	1.83	.91	.51	.71	1.55	1.95	1.75	-.31	-.63	-.47
2	0	127	7.04	6.71	6.87	0.00	0.00	0.00	5.57	5.04	5.31	0.00	0.00	0.00	5.34	4.71	5.03	0.00	0.00	0.00
2	127	142	6.92	6.39	6.65	.22	.58	.40	5.33	4.81	5.07	.41	.39	.40	4.64	4.23	4.43	1.19	.81	1.00
2	142	149	6.30	6.12	6.21	2.27	.97	1.62	4.57	4.09	4.33	2.77	2.61	2.69	3.95	3.91	3.93	2.48	1.18	1.83
2	149	156	5.60	5.46	5.53	2.52	2.40	2.46	4.61	4.40	4.50	-.15	-1.11	-.63	3.87	3.90	3.88	.32	.03	.17
2	156	163	5.84	5.67	5.76	-.87	-.78	-.83	6.06	4.93	5.49	-5.23	-1.93	-3.58	3.62	3.51	3.57	.89	1.40	1.14
2	163	170	5.50	5.11	5.30	1.25	2.05	1.65	5.33	3.99	4.66	2.65	3.39	3.02	3.18	2.92	3.05	1.59	2.17	1.88
2	170	177	5.38	5.03	5.20	.44	.30	.37	4.44	3.30	3.87	3.20	2.53	2.87	2.82	2.83	2.82	1.31	.32	.82
2	177	184	5.20	5.02	5.11	.64	.04	.34	3.82	3.62	3.72	2.26	-1.18	.54	2.84	2.45	2.64	-.05	1.38	.66
2	184	191	5.16	5.01	5.08	.14	.04	.09	3.68	3.33	3.50	.52	1.04	.78	2.86	2.61	2.73	-.08	-.60	-.34
2	191	198	5.01	4.98	5.00	.54	.08	.31	3.47	2.77	3.12	.74	2.05	1.40	2.94	2.54	2.74	-.28	.26	-.01
2	198	205	4.98	5.04	5.01	.10	-.20	-.05	3.42	2.70	3.06	.20	.25	.22	2.79	2.53	2.66	.51	.03	.27
2	205	212	5.10	5.03	5.06	-.40	.02	-.19	3.70	3.33	3.51	-1.02	-2.29	-1.65	2.96	2.88	2.92	-.61	-1.27	-.94
2	212	219	4.97	4.86	4.92	.44	.62	.53	3.40	2.88	3.14	1.09	1.62	1.36	3.05	3.06	3.05	-.30	-.64	-.47
2	219	226	5.07	5.00	5.04	-.36	-.49	-.42	3.32	2.71	3.02	.27	.61	.44	3.16	2.90	3.03	-.40	.57	.08
2	226	232	4.86	4.92	4.89	.92	.34	.63	6.08	4.34	5.21	-11.7	-6.87	-9.28	3.06	2.87	2.97	.40	.13	.26
2	232	239	4.62	4.71	4.67	.84	.75	.80	4.66	3.11	3.88	5.16	4.45	4.81	3.12	2.96	3.04	-.19	-.31	-.25
2	239	249	4.82	4.80	4.81	-.49	-.22	-.36	4.58	2.91	3.75	.19	.51	.35	3.22	3.15	3.18	-.27	-.48	-.38
2	249	254	4.94	4.76	4.85	-.64	.18	-.23	4.26	2.82	3.54	1.63	.46	1.05	3.11	3.15	3.13	.59	-.04	.28
2	254	267	5.00	5.01	5.00	-.47	-.41	-.44	4.26	2.87	3.56	1.16	.29	.72	3.27	3.50	3.39	-.32	-.68	-.50

Table A-2, Continued.

(NO PRECIPITATION INCLUDED)

			PRESTON 101						TALMAGE 102						TALMAGE 103					
DEP	BDAY	EDAY	ENDING H2O		(IN)	DEPL	(MM/DAY)		ENDING H2O		(IN)	DEPL	(MM/DAY)		ENDING H2O		(IN)	DEPL	(MM/DAY)	
(FT)			HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE
3	0	127	10.90	10.40	10.65	0.00	0.00	0.00	8.87	7.38	8.12	0.00	0.00	0.00	8.31	7.84	8.08	0.00	0.00	0.00
3	127	142	10.85	10.11	10.48	.09	.52	.31	8.43	7.05	7.74	.75	.55	.65	7.57	7.26	7.42	1.26	.98	1.12
3	142	149	10.01	9.72	9.86	3.05	1.42	2.24	7.47	6.06	6.77	3.47	3.58	3.53	6.76	6.93	6.85	2.94	1.20	2.07
3	149	156	9.07	8.95	9.01	3.40	2.78	3.09	7.68	6.26	6.97	-.77	-.73	-.75	6.47	6.80	6.63	1.05	.48	.76
3	156	163	9.20	9.05	9.12	-.45	-.34	-.40	8.96	6.82	7.89	-4.62	-2.02	-3.32	6.23	6.42	6.32	.89	1.37	1.13
3	163	170	8.54	8.13	8.33	2.39	3.34	2.86	8.35	5.76	7.05	2.20	3.86	3.03	5.68	5.82	5.75	1.99	2.20	2.10
3	170	177	8.27	8.07	8.17	.98	.20	.59	7.36	4.83	6.09	3.59	3.37	3.48	5.03	5.57	5.30	2.33	.88	1.61
3	177	184	8.09	7.95	8.02	.65	.42	.54	6.42	5.18	5.80	3.42	-1.30	1.06	4.75	4.97	4.86	1.02	2.17	1.59
3	184	191	8.01	7.97	7.99	.30	-.06	.12	6.04	4.78	5.41	1.36	1.46	1.41	4.72	5.07	4.90	.10	-.34	-.12
3	191	198	7.82	7.83	7.82	.69	.50	.59	5.52	4.17	4.85	1.91	2.20	2.06	4.69	4.95	4.82	.13	.43	.28
3	198	205	7.75	7.97	7.86	.22	-.51	-.14	5.40	3.95	4.68	.41	.83	.62	4.41	4.77	4.59	1.00	.66	.83
3	205	212	7.85	7.98	7.91	-.33	-.03	-.18	5.64	4.71	5.18	-.87	-2.77	-1.82	4.61	5.18	4.89	-.73	-1.48	-1.11
3	212	219	7.73	7.69	7.71	.42	1.07	.75	5.34	4.20	4.77	1.09	1.85	1.47	4.66	5.41	5.04	-.17	-.85	-.51
3	219	226	7.96	7.89	7.92	-.85	-.72	-.79	5.25	3.97	4.61	.34	.84	.59	4.74	5.32	5.03	-.30	.34	.02
3	226	232	7.56	7.78	7.67	1.72	.44	1.08	7.97	5.62	6.80	-11.5	-7.02	-9.27	4.64	5.36	5.00	.45	-.18	.13
3	232	239	7.16	7.65	7.40	1.43	.49	.96	6.65	4.42	5.54	4.78	4.37	4.58	4.80	5.51	5.16	-.59	-.55	-.57
3	239	249	7.40	7.51	7.46	-.61	.35	-.13	6.57	4.18	5.38	.21	.61	.41	4.86	5.64	5.25	-.15	-.32	-.24
3	249	254	7.48	7.08	7.28	-.37	2.16	.90	6.23	4.11	5.17	1.74	.38	1.06	4.76	5.56	5.16	.51	.38	.45
3	254	267	7.56	7.79	7.67	.39	-.31	.04	6.24	4.14	5.19	.92	.18	.55	4.80	5.98	5.39	-.09	-.81	-.45
4	0	127	14.65	14.02	14.34	0.00	0.00	0.00	11.87	9.14	10.51	0.00	0.00	0.00	11.44	11.14	11.29	0.00	0.00	0.00
4	127	142	14.69	13.89	14.29	-.06	.23	.08	11.21	8.78	10.00	1.13	.61	.87	10.61	10.46	10.54	1.40	1.15	1.27
4	142	149	13.72	13.38	13.55	3.51	1.84	2.68	10.07	7.68	8.88	4.11	4.01	4.06	9.69	10.13	9.91	3.36	1.19	2.27
4	149	156	12.60	12.54	12.57	4.07	3.06	3.57	10.32	7.92	9.12	-.91	-.88	-.89	9.19	9.63	9.41	1.82	1.81	1.82
4	156	163	12.71	12.56	12.64	-.40	-.09	-.24	11.43	8.43	9.93	-4.01	-1.83	-2.92	8.93	9.33	9.13	.94	1.08	1.01
4	163	170	11.80	11.19	11.50	3.29	4.98	4.13	10.84	7.35	9.09	2.14	3.92	3.03	8.28	8.74	8.51	2.34	2.17	2.25
4	170	177	11.36	11.18	11.27	1.62	.05	.83	9.72	6.37	8.05	4.05	3.53	3.79	7.54	8.37	7.96	2.70	1.32	2.01
4	177	184	11.03	10.89	10.96	1.19	1.05	1.12	8.52	6.59	7.56	4.37	-.79	1.79	7.13	7.54	7.34	1.49	3.01	2.25
4	184	191	10.94	11.05	11.00	.32	-.60	-.14	7.90	6.19	7.05	2.26	1.45	1.85	6.94	7.53	7.24	.68	.04	.36
4	191	198	10.72	10.72	10.72	.80	1.20	1.00	7.22	5.41	6.32	2.46	2.84	2.65	6.82	7.43	7.13	.43	.37	.40
4	198	205	10.61	10.83	10.72	.42	-.39	.02	7.07	5.16	6.12	.54	.89	.72	6.35	7.05	6.70	1.70	1.40	1.55
4	205	212	10.61	10.98	10.79	.00	-.54	-.27	7.42	5.99	6.70	-1.26	-3.00	-2.13	6.47	7.58	7.02	-.41	-1.94	-1.18
4	212	219	10.54	10.46	10.50	.25	1.90	1.08	7.07	5.40	6.23	1.28	2.16	1.72	6.54	7.81	7.18	-.29	-.83	-.56
4	219	226	10.72	10.78	10.75	-.68	-1.18	-.93	6.95	5.18	6.06	.44	.78	.61	6.73	7.70	7.21	-.66	.40	-.13
4	226	232	10.36	10.77	10.56	1.54	.06	.80	9.46	6.76	8.11	-10.6	-6.69	-8.65	6.63	7.76	7.20	.40	-.28	.06
4	232	239	9.90	10.50	10.20	1.67	.97	1.32	8.16	5.60	6.88	4.71	4.22	4.47	6.70	8.01	7.35	-.24	-.89	-.57
4	239	249	10.10	10.36	10.23	-.50	.36	-.07	8.08	5.38	6.73	.19	.54	.37	6.95	8.20	7.57	-.63	-.48	-.55
4	249	254	10.21	9.87	10.04	-.57	2.49	.96	7.82	5.30	6.56	1.35	.42	.88	6.82	7.95	7.38	.62	1.27	.94
4	254	267	10.33	10.62	10.47	.19	-.37	-.09	7.85	5.34	6.60	.81	.08	.45	6.80	8.34	7.57	.04	-.78	-.37

Table A-2, Continued.

(NO PRECIPITATION INCLUDED)

DEP (FT)	BDAY	EDAY	PRESTON 101 ENDING H2O (IN) HOLE1	2	AVE	DEPL (MM/DAY) HOLE1	2	AVE	TALMAGE 102 ENDING H2O (IN) HOLE1	2	AVE	DEPL (MM/DAY) HOLE1	2	AVE	TALMAGE 103 ENDING H2O (IN) HOLE1	2	AVE	DEPL (MM/DAY) HOLE1	2	AVE
5	0	127	17.89	17.24	17.57	0.00	0.00	0.00	14.69	10.45	12.57	0.00	0.00	0.00	14.74	14.32	14.53	0.00	0.00	0.00
5	127	142	18.04	17.30	17.67	-.26	-.10	-.18	13.81	10.14	11.98	1.49	.52	1.00	13.82	13.55	13.69	1.54	1.30	1.42
5	142	149	17.02	16.69	16.86	3.70	2.18	2.94	12.56	8.99	10.78	4.52	4.20	4.36	12.75	13.16	12.95	3.91	1.42	2.67
5	149	156	16.01	16.08	16.05	3.65	2.23	2.94	12.76	9.22	10.99	-.72	-.86	-.79	12.29	12.56	12.43	1.66	2.16	1.91
5	156	163	16.02	16.15	16.08	-.02	-.24	-.13	13.74	9.77	11.76	-3.56	-1.99	-2.77	12.00	12.23	12.12	1.05	1.19	1.12
5	163	170	15.03	14.27	14.65	3.60	6.80	5.20	13.27	8.74	11.01	1.71	3.72	2.72	11.27	11.60	11.44	2.63	2.29	2.46
5	170	177	14.48	14.14	14.31	1.97	.50	1.23	11.98	7.78	9.88	4.69	3.48	4.09	10.50	11.03	10.76	2.82	2.06	2.44
5	177	184	13.98	13.69	13.84	1.80	1.60	1.70	10.59	7.88	9.23	5.05	-.34	2.35	9.70	10.12	9.91	2.88	3.31	3.09
5	184	191	13.90	14.03	13.97	.30	-1.23	-.47	9.91	7.47	8.69	2.46	1.50	1.98	9.49	9.88	9.68	.76	.88	.82
5	191	198	13.65	13.53	13.59	.91	1.82	1.37	9.08	6.63	7.85	3.02	3.04	3.03	9.25	9.75	9.50	.88	.46	.67
5	198	205	13.47	13.66	13.56	.66	-.46	.10	8.83	6.37	7.60	.88	.95	.92	8.76	9.37	9.06	1.78	1.39	1.59
5	205	212	13.32	13.90	13.61	.56	-.89	-.16	9.21	7.22	8.22	-1.38	-3.10	-2.24	8.76	9.76	9.26	-.00	-1.44	-.72
5	212	219	13.25	12.83	13.04	.26	3.88	2.07	8.90	6.58	7.74	1.14	2.31	1.73	8.80	10.00	9.40	-.16	-.87	-.51
5	219	226	13.44	13.65	13.54	-.69	-2.97	-1.83	8.54	6.33	7.43	1.29	.93	1.11	8.99	9.92	9.45	-.66	.30	-.18
5	226	232	13.18	13.63	13.41	1.10	.07	.58	10.95	7.91	9.43	-10.2	-6.69	-8.44	8.97	10.04	9.51	.05	-.49	-.22
5	232	239	12.71	13.17	12.94	1.70	1.67	1.69	9.68	6.82	8.25	4.62	3.93	4.27	9.04	10.34	9.69	-.23	-1.09	-.66
5	239	249	12.78	13.10	12.94	-.20	.18	-.01	9.60	6.47	8.04	.20	.89	.54	9.26	10.45	9.86	-.56	-.29	-.43
5	249	254	12.87	12.63	12.75	-.42	2.42	1.00	9.27	6.47	7.87	1.66	.01	.84	9.19	10.23	9.71	.32	1.14	.73
5	254	267	13.10	13.20	13.15	-.35	.17	-.09	9.39	6.50	7.95	.68	.02	.35	9.06	10.52	9.79	.26	-.57	-.15
6	0	127	20.41	19.95	20.18	0.00	0.00	0.00	17.69	11.72	14.70	0.00	0.00	0.00	17.75	17.38	17.57	0.00	0.00	0.00
6	127	142	20.60	20.11	20.36	-.36	-.30	-.33	16.61	11.49	14.05	1.83	.38	1.10	16.94	16.51	16.72	1.38	1.48	1.43
6	142	149	19.57	19.47	19.52	3.74	2.33	3.03	15.25	10.25	12.75	4.93	4.51	4.72	16.94	16.07	16.07	0.00	1.59	1.59
6	149	156	18.59	18.67	18.63	3.58	2.89	3.23	15.24	10.44	12.84	.03	-.68	-.33	14.94	15.21	15.08	7.23	3.13	5.18
6	156	163	18.58	18.74	18.66	.03	-.26	-.12	16.19	10.96	13.57	-3.42	-1.90	-2.66	14.59	14.81	14.70	1.28	1.44	1.36
6	163	170	17.56	16.73	17.15	3.71	7.29	5.50	15.76	10.00	12.88	1.53	3.49	2.51	13.69	14.23	13.96	3.25	2.12	2.69
6	170	177	17.07	16.56	16.82	1.76	.61	1.19	14.26	9.04	11.65	5.46	3.46	4.46	12.91	13.70	13.30	2.84	1.92	2.38
6	177	184	16.47	16.07	16.27	2.19	1.78	1.99	13.05	9.09	11.07	4.39	-.17	2.11	11.77	12.62	12.20	4.15	3.90	4.03
6	184	191	16.47	16.47	16.47	0.00	-1.43	-1.43	12.14	8.67	10.41	3.30	1.52	2.41	11.59	12.29	11.94	.63	1.20	.92
6	191	198	16.15	15.93	16.04	1.17	1.96	1.57	11.12	7.68	9.40	3.72	3.59	3.66	11.35	12.19	11.77	.86	.36	.61
6	198	205	15.90	16.05	15.97	.90	-.45	.22	10.90	7.42	9.16	.77	.96	.87	10.68	11.80	11.24	2.43	1.42	1.93
6	205	212	15.71	16.42	16.07	.70	-1.36	-.33	11.25	8.36	9.81	-1.27	-3.43	-2.35	10.67	12.27	11.47	.04	-1.70	-.83
6	212	219	15.63	15.33	15.48	.28	3.96	2.12	10.88	7.69	9.28	1.37	2.44	1.90	10.76	12.43	11.60	-.31	-.60	-.46
6	219	226	15.90	16.03	15.96	-.97	-2.54	-1.75	10.11	7.42	8.76	2.77	.99	1.88	10.93	12.31	11.62	-.63	.47	-.08
6	226	232	15.65	16.01	15.83	1.05	.09	.57	12.32	9.06	10.69	-9.36	-6.97	-8.17	10.92	12.46	11.69	.05	-.65	-.30
6	232	239	15.09	15.63	15.36	2.04	1.38	1.71	11.01	7.92	9.46	4.78	4.15	4.46	10.97	12.79	11.88	-.18	-1.21	-.69
6	239	249	15.07	15.31	15.19	.03	.82	.43	10.96	7.63	9.29	.12	.74	.43	11.15	12.86	12.00	-.46	-.17	-.32
6	249	254	15.06	14.95	15.01	.05	1.80	.93	10.67	7.56	9.11	1.47	.38	.92	11.17	12.59	11.88	-.09	1.37	.64
6	254	267	15.47	15.61	15.54	-.66	-.02	-.34	10.89	7.62	9.25	.63	.13	.38	10.90	12.93	11.91	.53	-.67	-.07

Table A-2, Continued.

(NO PRECIPITATION INCLUDED)

DEP (FT)	BDAY	EDAY	PRESTON 101 ENDING H2O (IN) HOLE1	2	AVE	PRESTON 101 DEPL (MM/DAY) HOLE1	2	AVE	TALMAGE 102 ENDING H2O (IN) HOLE1	2	AVE	TALMAGE 102 DEPL (MM/DAY) HOLE1	2	AVE	TALMAGE 103 ENDING H2O (IN) HOLE1	2	AVE	TALMAGE 103 DEPL (MM/DAY) HOLE1	2	AVE
7	0	127	22.68	22.28	22.48	0.00	0.00	0.00	20.93	13.08	17.00	0.00	0.00	0.00	0.00	20.75	20.75	0.00	0.00	0.00
7	127	142	22.92	22.44	22.68	-.43	-.29	-.36	19.64	13.08	19.64	2.17	0.00	2.17	0.00	19.81	19.81	0.00	1.59	1.59
7	142	149	21.88	21.81	21.84	3.77	2.29	3.03	18.19	13.08	18.19	5.29	0.00	5.29	0.00	19.38	19.38	0.00	1.57	1.57
7	149	156	20.78	21.16	20.97	4.00	2.35	3.18	18.15	11.72	14.93	.15	4.96	2.55	0.00	18.20	18.20	0.00	4.26	4.26
7	156	163	20.80	21.27	21.03	-.07	-.40	-.23	18.94	12.28	15.61	-2.90	-2.06	-2.48	0.00	17.88	17.88	0.00	1.16	1.16
7	163	170	19.80	19.11	19.45	3.61	7.86	5.73	18.50	11.28	14.89	1.60	3.64	2.62	0.00	17.28	17.28	0.00	2.19	2.19
7	170	177	19.30	19.04	19.17	1.84	.24	1.04	17.02	10.32	13.67	5.38	3.49	4.44	0.00	16.74	16.74	0.00	1.95	1.95
7	177	184	18.69	18.55	18.62	2.22	1.78	2.00	15.73	10.35	13.04	4.68	-.12	2.28	0.00	15.63	15.63	0.00	4.05	4.05
7	184	191	18.75	18.97	18.86	-.24	-1.52	-.88	14.73	10.01	12.37	3.64	1.24	2.44	0.00	15.05	15.05	0.00	2.10	2.10
7	191	198	18.41	18.39	18.40	1.25	2.09	1.67	13.57	8.87	11.22	4.18	4.15	4.16	0.00	15.18	15.18	0.00	-.48	-.48
7	198	205	18.17	18.41	18.29	.87	-.08	.39	13.24	8.55	10.89	1.22	1.14	1.18	0.00	14.70	14.70	0.00	1.75	1.75
7	205	212	17.90	18.88	18.39	.98	-1.69	-.35	13.49	9.62	11.56	-.93	-3.89	-2.41	0.00	15.11	15.11	0.00	-1.50	-1.50
7	212	219	17.84	17.22	17.53	.20	6.02	3.11	13.12	8.89	11.01	1.35	2.66	2.00	0.00	15.24	15.24	0.00	-.47	-.47
7	219	226	18.32	18.46	18.39	-1.72	-4.52	-3.12	12.02	8.47	10.25	3.99	1.52	2.76	0.00	15.13	15.13	0.00	.40	.40
7	226	232	17.93	18.31	18.12	1.65	.65	1.15	13.98	10.26	12.12	-8.29	-7.55	-7.92	0.00	15.33	15.33	0.00	-.83	-.83
7	232	239	17.32	18.06	17.69	2.19	.91	1.55	12.64	9.09	10.86	4.87	4.23	4.55	0.00	15.70	15.70	0.00	-1.36	-1.36
7	239	249	17.22	17.68	17.45	.25	.95	.60	12.54	8.76	10.65	.25	.84	.54	0.00	15.69	15.69	0.00	.02	.02
7	249	254	17.23	17.34	17.29	-.05	1.75	.85	12.29	8.74	10.52	1.29	.09	.69	0.00	15.33	15.33	0.00	1.83	1.83
7	254	267	17.60	17.89	17.75	-.08	-.18	-.13	12.45	8.78	10.61	.92	.13	.53	0.00	15.62	15.62	0.00	-.57	-.57
8	0	127	25.24	24.31	24.77	0.00	0.00	0.00	23.43	0.00	23.43	0.00	0.00	0.00	0.00	24.56	24.56	0.00	0.00	0.00
8	127	142	25.60	24.48	25.04	-.65	-.31	-.48	22.07	0.00	22.07	2.31	0.00	2.31	0.00	24.56	0.00	0.00	0.00	0.00
8	142	149	24.56	23.89	24.23	3.75	2.14	2.94	20.48	0.00	20.48	5.75	0.00	5.75	0.00	24.56	0.00	0.00	0.00	0.00
8	149	156	22.84	23.24	23.04	6.26	2.35	4.30	20.65	0.00	20.65	-.60	0.00	-.60	0.00	21.58	21.58	0.00	10.81	10.81
8	156	163	23.18	23.22	23.20	-1.22	.09	-.57	21.35	0.00	21.35	-2.54	0.00	-2.54	0.00	21.23	21.23	0.00	1.28	1.28
8	163	170	22.08	20.99	21.54	3.97	8.08	6.02	20.93	0.00	20.93	1.53	0.00	1.53	0.00	20.80	20.80	0.00	1.55	1.55
8	170	177	21.69	20.98	21.33	1.42	.05	.74	19.56	0.00	19.56	4.94	0.00	4.94	0.00	20.16	20.16	0.00	2.32	2.32
8	177	184	21.01	20.46	20.73	2.48	1.88	2.18	18.04	0.00	18.04	5.53	0.00	5.53	0.00	18.99	18.99	0.00	4.24	4.24
8	184	191	21.19	20.92	21.05	-.64	-1.66	-1.15	16.85	0.00	16.85	4.31	0.00	4.31	0.00	18.28	18.28	0.00	2.58	2.58
8	191	198	20.85	20.30	20.57	1.24	2.25	1.74	15.55	0.00	15.55	4.73	0.00	4.73	0.00	18.33	18.33	0.00	-.17	-.17
8	198	205	20.58	20.39	20.48	.98	-.33	.32	15.17	9.56	12.37	1.38	0.00	1.38	0.00	17.76	17.76	0.00	2.06	2.06
8	205	212	20.13	20.88	20.50	1.62	-1.76	-.07	15.45	9.56	15.45	-1.02	0.00	-1.02	0.00	18.15	18.15	0.00	-1.40	-1.40
8	212	219	20.21	19.25	19.73	-.31	5.90	2.80	15.01	9.56	15.01	1.58	0.00	1.58	0.00	18.43	18.43	0.00	-1.03	-1.03
8	219	226	20.71	20.39	20.55	-1.80	-4.15	-2.97	13.77	9.56	13.77	4.52	0.00	4.52	0.00	18.35	18.35	0.00	.29	.29
8	226	232	20.32	20.32	20.32	1.63	.29	.96	15.66	9.56	15.66	-8.00	0.00	-8.00	0.00	18.42	18.42	0.00	-.30	-.30
8	232	239	19.62	19.88	19.75	2.55	1.61	2.08	14.16	9.56	14.16	5.43	0.00	5.43	0.00	18.90	18.90	0.00	-1.72	-1.72
8	239	249	19.52	19.59	19.56	.26	.73	.50	14.12	9.56	14.12	.10	0.00	.10	0.00	18.87	18.87	0.00	.06	.06
8	249	254	19.50	19.20	19.35	.12	1.97	1.04	13.80	9.56	13.80	1.65	0.00	1.65	0.00	18.34	18.34	0.00	2.69	2.69
8	254	267	19.93	19.84	19.88	-.30	-.41	-.35	13.97	9.56	13.97	.79	0.00	.79	0.00	18.64	18.64	0.00	-.58	-.58

Table A-2, Continued.

(NO PRECIPITATION INCLUDED)

DEP (FT)	BDAY	EDAY	PRESTON 101 ENDING H20 (IN) HOLE1	2	AVE	PRESTON 101 DEPL (MM/DAY) HOLE1	2	AVE	TALMAGE 102 ENDING H20 (IN) HOLE1	2	AVE	TALMAGE 102 DEPL (MM/DAY) HOLE1	2	AVE	TALMAGE 103 ENDING H20 (IN) HOLE1	2	AVE	TALMAGE 103 DEPL (MM/DAY) HOLE1	2	AVE
9	0	127	0.00	25.24	25.24	0.00	0.00	0.00	0.00	25.18	25.24	0.00	0.00	0.00	0.00	17.75	25.24	0.00	0.00	0.00
9	127	142	0.00	25.60	25.60	0.00	-.65	-.65	0.00	23.90	25.60	0.00	2.17	2.17	0.00	16.94	25.60	0.00	1.38	1.38
9	142	149	0.00	24.56	24.56	0.00	3.75	3.75	0.00	22.14	24.56	0.00	6.40	6.40	0.00	15.78	24.56	0.00	4.20	4.20
9	149	156	0.00	24.56	0.00	0.00	0.00	0.00	22.36	22.14	22.36	0.00	0.00	0.00	0.00	15.78	0.00	0.00	0.00	0.00
9	156	163	0.00	24.56	0.00	0.00	0.00	0.00	22.36	22.14	0.00	0.00	0.00	0.00	0.00	15.78	0.00	0.00	0.00	0.00
9	163	170	0.00	24.56	0.00	0.00	0.00	0.00	22.36	22.14	0.00	0.00	0.00	0.00	0.00	15.78	0.00	0.00	0.00	0.00
9	170	177	0.00	24.56	0.00	0.00	0.00	0.00	21.26	22.14	21.26	4.00	0.00	4.00	0.00	15.78	0.00	0.00	0.00	0.00
9	177	184	0.00	24.56	0.00	0.00	0.00	0.00	21.26	22.14	0.00	0.00	0.00	0.00	0.00	15.78	0.00	0.00	0.00	0.00
9	184	191	24.22	23.06	23.64	0.00	5.45	5.45	21.26	22.14	0.00	0.00	0.00	0.00	0.00	15.78	0.00	0.00	0.00	0.00
9	191	198	23.81	22.35	23.08	1.49	2.56	2.03	17.02	22.14	17.02	15.39	0.00	15.39	0.00	15.78	0.00	0.00	0.00	0.00
9	198	205	23.70	22.39	23.05	.39	-.14	.12	16.61	22.14	16.61	1.49	0.00	1.49	0.00	15.78	0.00	0.00	0.00	0.00
9	205	212	23.11	22.97	23.04	2.14	-2.08	.03	16.94	22.14	16.94	-1.22	0.00	-1.22	0.00	15.78	0.00	0.00	0.00	0.00
9	212	219	23.20	22.97	23.20	-.34	0.00	-.34	16.56	22.14	16.56	1.38	0.00	1.38	0.00	15.78	0.00	0.00	0.00	0.00
9	219	226	23.73	22.51	23.12	-1.92	1.66	-.13	15.23	22.14	15.23	4.82	0.00	4.82	0.00	15.78	0.00	0.00	0.00	0.00
9	226	232	23.24	22.42	22.83	2.10	.36	1.23	17.00	22.14	17.00	-7.47	0.00	-7.47	0.00	15.78	0.00	0.00	0.00	0.00
9	232	239	22.59	21.93	22.26	2.35	1.81	2.08	15.52	22.14	15.52	5.38	0.00	5.38	0.00	15.78	0.00	0.00	0.00	0.00
9	239	249	22.49	21.63	22.06	.25	.75	.50	15.49	22.14	15.49	.08	0.00	.08	0.00	15.78	0.00	0.00	0.00	0.00
9	249	254	22.38	21.16	21.77	.56	2.40	1.48	15.22	22.14	15.22	1.37	0.00	1.37	0.00	15.78	0.00	0.00	0.00	0.00
9	254	267	22.84	21.88	22.36	-.20	-.71	-.46	15.31	22.14	15.31	.92	0.00	.92	0.00	15.78	0.00	0.00	0.00	0.00
To	0	127	25.24	24.31	24.77	-.20	-.71	-.46	25.18	13.56	19.37	.92	.14	.53	17.75	25.23	21.49	.53	-.59	-.03
To	127	142	25.60	24.48	25.04	-.65	-.31	-.48	23.90	13.35	18.63	2.17	.35	1.26	16.94	23.99	20.46	1.38	2.09	1.74
To	142	149	24.56	23.89	24.23	3.75	2.14	2.94	22.14	12.00	17.07	6.40	4.92	5.66	15.78	23.57	19.67	4.20	1.53	2.87
To	149	156	22.84	23.24	23.04	6.26	2.35	4.30	22.36	12.14	17.25	-.80	-.53	-.66	14.94	22.14	18.54	3.03	5.19	4.11
To	156	163	23.18	23.22	23.20	-1.22	.09	-.57	23.75	12.72	18.24	-5.05	-2.11	-3.58	14.59	21.78	18.19	1.28	1.30	1.29
To	163	170	22.08	20.99	21.54	3.97	8.08	6.02	23.35	11.71	17.53	1.45	3.69	2.57	13.69	21.38	17.54	3.25	1.44	2.35
To	170	177	21.69	20.98	21.33	1.42	.05	.74	21.26	10.74	16.00	7.59	3.50	5.55	12.91	20.73	16.82	2.84	2.38	2.61
To	177	184	21.01	20.46	20.73	2.48	1.88	2.18	20.35	10.77	15.56	3.28	-.10	1.59	11.77	19.55	15.66	4.15	4.27	4.21
To	184	191	24.22	23.06	23.64	-11.6	-9.44	-10.5	18.98	10.45	14.72	4.99	1.15	3.07	11.59	18.82	15.21	.63	2.66	1.65
To	191	198	23.81	22.35	23.08	1.49	2.56	2.03	17.02	9.26	13.14	7.12	4.33	5.73	11.35	18.85	15.10	.86	-.12	.37
To	198	205	23.70	22.39	23.05	.39	-.14	.12	16.61	9.56	13.08	1.49	-1.10	.20	10.68	18.27	14.48	2.43	2.11	2.27
To	205	212	23.11	22.97	23.04	2.14	-2.08	.03	16.94	10.04	13.49	-1.22	-1.75	-1.49	10.67	18.65	14.66	.04	-1.39	-.67
To	212	219	23.20	19.25	21.23	-.34	13.49	6.58	16.56	9.29	12.93	1.38	2.73	2.05	10.76	18.96	14.86	-.31	-1.12	-.71
To	219	226	23.73	22.51	23.12	-1.92	-11.8	-6.87	15.23	8.82	12.03	4.82	1.70	3.26	10.93	18.89	14.91	-.63	.27	-.18
To	226	232	23.24	22.42	22.83	2.10	.36	1.23	17.00	10.65	13.83	-7.47	-7.74	-7.61	10.92	18.94	14.93	.05	-.22	-.09
To	232	239	22.59	21.93	22.26	2.35	1.81	2.08	15.52	9.48	12.50	5.38	4.26	4.82	10.97	19.43	15.20	-.18	-1.78	-.98
To	239	249	22.49	21.63	22.06	.25	.75	.50	15.49	9.14	12.31	.08	.87	.47	11.15	19.40	15.28	-.46	.06	-.20
To	249	254	22.38	21.16	21.77	.56	2.40	1.48	15.22	9.14	12.18	1.37	-.01	.68	11.17	18.85	15.01	-.09	2.84	1.38
To	254	267	22.84	21.88	22.36	-.20	-.71	-.46	15.31	9.17	12.24	.92	.14	.53	10.90	19.15	15.02	.53	-.59	-.03

Table A-3. Neutron Access Hole Soil Moisture Cummulative Depletion, Bear River Study, University of Idaho, 1982.

(NO PRECIPITATION INCLUDED)

			PRESTON 101						TALMAGE 102						TALMAGE 103					
DEP (FT)	BDAY	EDAY	ENDING H2O HOLE1	2	(IN) AVE	CUMM DEPL HOLE1	2	(IN) AVE	ENDING H2O HOLE1	2	(IN) AVE	CUMM DEPL HOLE1	2	(IN) AVE	ENDING H2O HOLE1	2	(IN) AVE	CUMM DEPL HOLE1	2	(IN) AVE
1	0	127	3.32	3.13	3.23	0.00	0.00	0.00	2.50	2.47	2.49	0.00	0.00	0.00	2.46	2.03	2.24	0.00	0.00	0.00
1	127	142	3.14	2.88	3.01	.17	.26	.22	2.41	2.35	2.38	.09	.13	.11	2.00	1.72	1.86	.46	.31	.39
1	142	149	2.83	2.80	2.81	.48	.34	.41	1.93	1.97	1.95	.57	.50	.54	1.63	1.57	1.60	.82	.46	.64
1	149	156	2.45	2.45	2.45	.86	.68	.77	2.45	2.33	2.39	.05	.14	.10	1.95	1.98	1.97	.50	.05	.28
1	156	163	2.62	2.62	2.62	.69	.51	.60	3.17	2.84	3.00	-.67	-.37	-.52	1.71	1.71	1.71	.75	.32	.54
1	163	170	2.49	2.24	2.37	.82	.90	.86	2.63	2.08	2.35	-.12	.40	.14	1.40	1.26	1.33	1.06	.77	.91
1	170	177	2.43	2.21	2.32	.89	.93	.91	2.14	1.56	1.85	.36	.92	.64	1.24	1.19	1.21	1.22	.84	1.03
1	177	184	2.30	2.23	2.27	1.02	.90	.96	1.90	1.90	1.90	.60	.57	.59	1.24	1.09	1.17	1.22	.94	1.08
1	184	191	2.22	2.31	2.27	1.09	.82	.96	1.86	1.65	1.75	.64	.83	.74	1.29	1.24	1.27	1.16	.80	.98
1	191	198	2.18	2.23	2.21	1.14	.90	1.02	1.74	1.29	1.51	.76	1.19	.98	1.32	1.12	1.22	1.14	.91	1.02
1	198	205	2.19	2.19	2.19	1.13	.94	1.04	1.66	1.26	1.46	.84	1.22	1.03	1.23	1.16	1.19	1.23	.87	1.05
1	205	212	2.30	2.30	2.30	1.02	.83	.92	1.96	1.85	1.90	.54	.62	.58	1.45	1.48	1.47	1.01	.55	.78
1	212	219	2.23	2.17	2.20	1.09	.96	1.03	1.71	1.40	1.55	.79	1.08	.94	1.43	1.50	1.47	1.03	.53	.78
1	219	226	2.19	2.18	2.19	1.12	.96	1.04	1.65	1.27	1.46	.86	1.20	1.03	1.46	1.43	1.45	.99	.60	.80
1	226	232	2.08	2.15	2.12	1.23	.98	1.11	2.98	2.78	2.88	-.48	-.31	-.39	1.40	1.41	1.40	1.06	.62	.84
1	232	239	1.90	2.04	1.97	1.42	1.09	1.25	2.39	1.64	2.02	.11	.83	.47	1.42	1.41	1.41	1.04	.62	.83
1	239	249	2.10	2.11	2.10	1.22	1.03	1.12	2.46	1.43	1.95	.04	1.04	.54	1.54	1.57	1.56	.92	.46	.69
1	249	254	2.17	2.13	2.15	1.15	1.00	1.08	2.23	1.37	1.80	.27	1.11	.69	1.40	1.63	1.51	1.06	.40	.73
1	254	267	2.20	2.24	2.22	1.11	.90	1.00	2.30	1.37	1.83	.20	1.11	.65	1.55	1.95	1.75	.90	:08	.49
2	0	127	7.04	6.71	6.87	0.00	0.00	0.00	5.57	5.04	5.31	0.00	0.00	0.00	5.34	4.71	5.03	0.00	0.00	0.00
2	127	142	6.92	6.39	6.65	.12	.32	.22	5.33	4.81	5.07	.24	.23	.23	4.64	4.23	4.43	.70	.48	.59
2	142	149	6.30	6.12	6.21	.74	.59	.67	4.57	4.09	4.33	1.00	.95	.98	3.95	3.91	3.93	1.39	.80	1.10
2	149	156	5.60	5.46	5.53	1.44	1.25	1.34	4.61	4.40	4.50	.96	.64	.80	3.87	3.90	3.88	1.47	.81	1.14
2	156	163	5.84	5.67	5.76	1.20	1.03	1.12	6.06	4.93	5.49	-.48	.11	-.19	3.62	3.51	3.57	1.72	1.20	1.46
2	163	170	5.50	5.11	5.30	1.54	1.60	1.57	5.33	3.99	4.66	.25	1.04	.65	3.18	2.92	3.05	2.16	1.79	1.98
2	170	177	5.38	5.03	5.20	1.66	1.68	1.67	4.44	3.30	3.87	1.13	1.74	1.44	2.82	2.83	2.82	2.52	1.88	2.20
2	177	184	5.20	5.02	5.11	1.84	1.69	1.77	3.82	3.62	3.72	1.75	1.42	1.59	2.84	2.45	2.64	2.50	2.26	2.38
2	184	191	5.16	5.01	5.08	1.88	1.70	1.79	3.68	3.33	3.50	1.90	1.70	1.80	2.86	2.61	2.73	2.48	2.10	2.29
2	191	198	5.01	4.98	5.00	2.03	1.72	1.88	3.47	2.77	3.12	2.10	2.27	2.19	2.94	2.54	2.74	2.40	2.17	2.29
2	198	205	4.98	5.04	5.01	2.06	1.67	1.86	3.42	2.70	3.06	2.16	2.34	2.25	2.79	2.53	2.66	2.55	2.18	2.36
2	205	212	5.10	5.03	5.06	1.95	1.67	1.81	3.70	3.33	3.51	1.88	1.71	1.79	2.96	2.88	2.92	2.38	1.83	2.10
2	212	219	4.97	4.86	4.92	2.07	1.84	1.96	3.40	2.88	3.14	2.18	2.16	2.17	3.05	3.06	3.05	2.29	1.65	1.97
2	219	226	5.07	5.00	5.04	1.97	1.71	1.84	3.32	2.71	3.02	2.25	2.32	2.29	3.16	2.90	3.03	2.18	1.81	2.00
2	226	232	4.86	4.92	4.89	2.19	1.79	1.99	6.08	4.34	5.21	-.51	.70	.10	3.06	2.87	2.97	2.28	1.84	2.06
2	232	239	4.62	4.71	4.67	2.42	1.99	2.21	4.66	3.11	3.88	.92	1.93	1.42	3.12	2.96	3.04	2.22	1.75	1.99
2	239	249	4.82	4.80	4.81	2.23	1.91	2.07	4.58	2.91	3.75	.99	2.13	1.56	3.22	3.15	3.18	2.12	1.56	1.84
2	249	254	4.94	4.76	4.85	2.10	1.94	2.02	4.26	2.82	3.54	1.31	2.22	1.77	3.11	3.15	3.13	2.23	1.56	1.89
2	254	267	5.00	5.01	5.00	2.04	1.70	1.87	4.26	2.87	3.56	1.32	2.17	1.74	3.27	3.50	3.39	2.07	1.21	1.64

Table A-3., Continued.

(NO PRECIPITATION INCLUDED)

			PRESTON 101						TALMAGE 102						TALMAGE 103					
DEP (FT)	BDAY	EDAY	ENDING H2O (IN) HOLE1	2	AVE	CUMM DEPL (IN) HOLE1	2	AVE	ENDING H2O (IN) HOLE1	2	AVE	CUMM DEPL (IN) HOLE1	2	AVE	ENDING H2O (IN) HOLE1	2	AVE	CUMM DEPL (IN) HOLE1	2	AVE
3	0	127	10.90	10.40	10.65	0.00	0.00	0.00	8.87	7.38	8.12	0.00	0.00	0.00	8.31	7.84	8.08	0.00	0.00	0.00
3	127	142	10.85	10.11	10.48	.05	.29	.17	8.43	7.05	7.74	.44	.32	.38	7.57	7.26	7.42	.74	.58	.66
3	142	149	10.01	9.72	9.86	.89	.68	.79	7.47	6.06	6.77	1.40	1.31	1.36	6.76	6.93	6.85	1.55	.91	1.23
3	149	156	9.07	8.95	9.01	1.83	1.44	1.64	7.68	6.26	6.97	1.19	1.11	1.15	6.47	6.80	6.63	1.84	1.04	1.44
3	156	163	9.20	9.05	9.12	1.71	1.35	1.53	8.96	6.82	7.89	-.09	.56	.23	6.23	6.42	6.32	2.09	1.42	1.75
3	163	170	8.54	8.13	8.33	2.36	2.27	2.32	8.35	5.76	7.05	.52	1.62	1.07	5.68	5.82	5.75	2.64	2.03	2.33
3	170	177	8.27	8.07	8.17	2.63	2.33	2.48	7.36	4.83	6.09	1.51	2.55	2.03	5.03	5.57	5.30	3.28	2.27	2.77
3	177	184	8.09	7.95	8.02	2.81	2.44	2.63	6.42	5.18	5.80	2.45	2.19	2.32	4.75	4.97	4.86	3.56	2.87	3.21
3	184	191	8.01	7.97	7.99	2.90	2.43	2.66	6.04	4.78	5.41	2.83	2.59	2.71	4.72	5.07	4.90	3.59	2.77	3.18
3	191	198	7.82	7.83	7.82	3.09	2.56	2.82	5.52	4.17	4.85	3.35	3.20	3.28	4.69	4.95	4.82	3.63	2.89	3.26
3	198	205	7.75	7.97	7.86	3.15	2.42	2.78	5.40	3.95	4.68	3.47	3.43	3.45	4.41	4.77	4.59	3.90	3.07	3.49
3	205	212	7.85	7.98	7.91	3.06	2.42	2.74	5.64	4.71	5.18	3.23	2.67	2.95	4.61	5.18	4.89	3.70	2.66	3.18
3	212	219	7.73	7.69	7.71	3.17	2.71	2.94	5.34	4.20	4.77	3.53	3.18	3.35	4.66	5.41	5.04	3.65	2.43	3.04
3	219	226	7.96	7.89	7.92	2.94	2.51	2.72	5.25	3.97	4.61	3.62	3.41	3.52	4.74	5.32	5.03	3.57	2.52	3.05
3	226	232	7.56	7.78	7.67	3.34	2.62	2.98	7.97	5.62	6.80	.90	1.75	1.32	4.64	5.36	5.00	3.68	2.48	3.08
3	232	239	7.16	7.65	7.40	3.74	2.75	3.24	6.65	4.42	5.54	2.22	2.96	2.59	4.80	5.51	5.16	3.51	2.33	2.92
3	239	249	7.40	7.51	7.46	3.50	2.89	3.19	6.57	4.18	5.38	2.30	3.19	2.75	4.86	5.64	5.25	3.45	2.20	2.83
3	249	254	7.48	7.08	7.28	3.42	3.31	3.37	6.23	4.11	5.17	2.64	3.27	2.96	4.76	5.56	5.16	3.55	2.28	2.92
3	254	267	7.56	7.79	7.67	3.34	2.61	2.98	6.24	4.14	5.19	2.64	3.23	2.93	4.80	5.98	5.39	3.51	1.86	2.69
4	0	127	14.65	14.02	14.34	0.00	0.00	0.00	11.87	9.14	10.51	0.00	0.00	0.00	11.44	11.14	11.29	0.00	0.00	0.00
4	127	142	14.69	13.89	14.29	-.04	.13	.05	11.21	8.78	10.00	.67	.36	.51	10.61	10.46	10.54	.82	.68	.75
4	142	149	13.72	13.38	13.55	.93	.64	.79	10.07	7.68	8.88	1.80	1.46	1.63	9.69	10.13	9.91	1.75	1.01	1.38
4	149	156	12.60	12.54	12.57	2.05	1.48	1.77	10.32	7.92	9.12	1.55	1.22	1.38	9.19	9.63	9.41	2.25	1.51	1.88
4	156	163	12.71	12.56	12.64	1.94	1.46	1.70	11.43	8.43	9.93	.44	.72	.58	8.93	9.33	9.13	2.51	1.80	2.16
4	163	170	11.80	11.19	11.50	2.85	2.83	2.84	10.84	7.35	9.09	1.03	1.80	1.41	8.28	8.74	8.51	3.16	2.40	2.78
4	170	177	11.36	11.18	11.27	3.30	2.84	3.07	9.72	6.37	8.05	2.15	2.77	2.46	7.54	8.37	7.96	3.90	2.77	3.33
4	177	184	11.03	10.89	10.96	3.62	3.13	3.38	8.52	6.59	7.56	3.35	2.55	2.95	7.13	7.54	7.34	4.31	3.59	3.95
4	184	191	10.94	11.05	11.00	3.71	2.96	3.34	7.90	6.19	7.05	3.97	2.95	3.46	6.94	7.53	7.24	4.50	3.61	4.05
4	191	198	10.72	10.72	10.72	3.93	3.29	3.61	7.22	5.41	6.32	4.65	3.73	4.19	6.82	7.43	7.13	4.62	3.71	4.16
4	198	205	10.61	10.83	10.72	4.05	3.19	3.62	7.07	5.16	6.12	4.80	3.98	4.39	6.35	7.05	6.70	5.09	4.09	4.59
4	205	212	10.61	10.98	10.79	4.05	3.04	3.54	7.42	5.99	6.70	4.45	3.15	3.80	6.47	7.58	7.02	4.97	3.56	4.27
4	212	219	10.54	10.46	10.50	4.12	3.56	3.84	7.07	5.40	6.23	4.80	3.75	4.28	6.54	7.81	7.18	4.89	3.33	4.11
4	219	226	10.72	10.78	10.75	3.93	3.24	3.58	6.95	5.18	6.06	4.92	3.96	4.44	6.73	7.70	7.21	4.71	3.44	4.08
4	226	232	10.36	10.77	10.56	4.29	3.25	3.77	9.46	6.76	8.11	2.41	2.38	2.40	6.63	7.76	7.20	4.81	3.37	4.09
4	232	239	9.90	10.50	10.20	4.75	3.52	4.14	8.16	5.60	6.88	3.71	3.55	3.63	6.70	8.01	7.35	4.74	3.13	3.94
4	239	249	10.10	10.36	10.23	4.56	3.66	4.11	8.08	5.38	6.73	3.79	3.76	3.77	6.95	8.20	7.57	4.49	2.94	3.72
4	249	254	10.21	9.87	10.04	4.45	4.15	4.30	7.82	5.30	6.56	4.05	3.84	3.95	6.82	7.95	7.38	4.62	3.19	3.90
4	254	267	10.33	10.62	10.47	4.33	3.40	3.86	7.85	5.34	6.60	4.02	3.81	3.91	6.80	8.34	7.57	4.63	2.79	3.71

Table A-3., Continued.

(NO PRECIPITATION INCLUDED)

			PRESTON 101						TALMAGE 102						TALMAGE 103					
			ENDING H2O (IN)			CUMM DEPL (IN)			ENDING H2O (IN)			CUMM DEPL (IN)			ENDING H2O (IN)			CUMM DEPL (IN)		
DEP (FT)	BDAY	EDAY	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE
5	0	127	17.89	17.24	17.57	0.00	0.00	0.00	14.69	10.45	12.57	0.00	0.00	0.00	14.74	14.32	14.53	0.00	0.00	0.00
5	127	142	18.04	17.30	17.67	-.15	-.05	-.10	13.81	10.14	11.98	.88	.31	.59	13.82	13.55	13.69	.91	.77	.84
5	142	149	17.02	16.69	16.86	.87	.55	.71	12.56	8.99	10.78	2.13	1.46	1.79	12.75	13.16	12.95	1.99	1.16	1.58
5	149	156	16.01	16.08	16.05	1.88	1.16	1.52	12.76	9.22	10.99	1.93	1.23	1.58	12.29	12.56	12.43	2.45	1.76	2.10
5	156	163	16.02	16.15	16.08	1.88	1.10	1.49	13.74	9.77	11.76	.95	.68	.81	12.00	12.23	12.12	2.74	2.08	2.41
5	163	170	15.03	14.27	14.65	2.87	2.97	2.92	13.27	8.74	11.01	1.42	1.71	1.56	11.27	11.60	11.44	3.46	2.72	3.09
5	170	177	14.48	14.14	14.31	3.41	3.11	3.26	11.98	7.78	9.88	2.71	2.67	2.69	10.50	11.03	10.76	4.24	3.29	3.76
5	177	184	13.98	13.69	13.84	3.91	3.55	3.73	10.59	7.88	9.23	4.10	2.57	3.34	9.70	10.12	9.91	5.03	4.20	4.62
5	184	191	13.90	14.03	13.97	3.99	3.21	3.60	9.91	7.47	8.69	4.78	2.98	3.88	9.49	9.88	9.68	5.24	4.44	4.84
5	191	198	13.65	13.53	13.59	4.24	3.71	3.97	9.08	6.63	7.85	5.61	3.82	4.72	9.25	9.75	9.50	5.48	4.57	5.03
5	198	205	13.47	13.66	13.56	4.42	3.59	4.00	8.83	6.37	7.60	5.86	4.08	4.97	8.76	9.37	9.06	5.98	4.95	5.46
5	205	212	13.32	13.90	13.61	4.57	3.34	3.96	9.21	7.22	8.22	5.48	3.23	4.35	8.76	9.76	9.26	5.97	4.56	5.26
5	212	219	13.25	12.83	13.04	4.65	4.41	4.53	8.90	6.58	7.74	5.79	3.87	4.83	8.80	10.00	9.40	5.93	4.32	5.12
5	219	226	13.44	13.65	13.54	4.45	3.59	4.02	8.54	6.33	7.43	6.15	4.12	5.14	8.99	9.92	9.45	5.75	4.40	5.07
5	226	232	13.18	13.63	13.41	4.71	3.61	4.16	10.95	7.91	9.43	3.74	2.54	3.14	8.97	10.04	9.51	5.76	4.28	5.02
5	232	239	12.71	13.17	12.94	5.18	4.07	4.63	9.68	6.82	8.25	5.01	3.63	4.32	9.04	10.34	9.69	5.70	3.98	4.84
5	239	249	12.78	13.10	12.94	5.11	4.14	4.62	9.60	6.47	8.04	5.09	3.98	4.53	9.26	10.45	9.86	5.48	3.86	4.67
5	249	254	12.87	12.63	12.75	5.02	4.62	4.82	9.27	6.47	7.87	5.42	3.98	4.70	9.19	10.23	9.71	5.54	4.09	4.81
5	254	267	13.10	13.20	13.15	4.79	4.04	4.42	9.39	6.50	7.95	5.30	3.95	4.62	9.06	10.52	9.79	5.68	3.80	4.74
6	0	127	20.41	19.95	20.18	0.00	0.00	0.00	17.69	11.72	14.70	0.00	0.00	0.00	17.75	17.38	17.57	0.00	0.00	0.00
6	127	142	20.60	20.11	20.36	-.20	-.16	-.18	16.61	11.49	14.05	1.08	.22	.65	16.94	16.51	16.72	.82	.87	.85
6	142	149	19.57	19.47	19.52	.83	.48	.66	15.25	10.25	12.75	2.44	1.47	1.95	16.94	16.07	16.07	.82	1.31	1.06
6	149	156	18.59	18.67	18.63	1.82	1.28	1.55	15.24	10.44	12.84	2.45	1.28	1.86	14.94	15.21	15.08	2.81	2.17	2.49
6	156	163	18.58	18.74	18.66	1.82	1.20	1.51	16.19	10.96	13.57	1.50	.76	1.13	14.59	14.81	14.70	3.16	2.57	2.87
6	163	170	17.56	16.73	17.15	2.85	3.21	3.03	15.76	10.00	12.88	1.92	1.72	1.82	13.69	14.23	13.96	4.06	3.16	3.61
6	170	177	17.07	16.56	16.82	3.33	3.38	3.36	14.26	9.04	11.65	3.43	2.67	3.05	12.91	13.70	13.30	4.84	3.69	4.26
6	177	184	16.47	16.07	16.27	3.94	3.87	3.91	13.05	9.09	11.07	4.64	2.63	3.63	11.77	12.62	12.20	5.99	4.76	5.37
6	184	191	16.47	16.47	16.47	3.94	3.48	3.71	12.14	8.67	10.41	5.55	3.04	4.30	11.59	12.29	11.94	6.16	5.09	5.63
6	191	198	16.15	15.93	16.04	4.26	4.02	4.14	11.12	7.68	9.40	6.57	4.03	5.30	11.35	12.19	11.77	6.40	5.19	5.79
6	198	205	15.90	16.05	15.97	4.51	3.90	4.20	10.90	7.42	9.16	6.78	4.30	5.54	10.68	11.80	11.24	7.07	5.58	6.33
6	205	212	15.71	16.42	16.07	4.70	3.52	4.11	11.25	8.36	9.81	6.44	3.35	4.89	10.67	12.27	11.47	7.08	5.11	6.10
6	212	219	15.63	15.33	15.48	4.78	4.62	4.70	10.88	7.69	9.28	6.81	4.03	5.42	10.76	12.43	11.60	6.99	4.95	5.97
6	219	226	15.90	16.03	15.96	4.51	3.92	4.21	10.11	7.42	8.76	7.58	4.30	5.94	10.93	12.31	11.62	6.82	5.08	5.95
6	226	232	15.65	16.01	15.83	4.76	3.94	4.35	12.32	9.06	10.69	5.36	2.65	4.01	10.92	12.46	11.69	6.83	4.92	5.88
6	232	239	15.09	15.63	15.36	5.32	4.32	4.82	11.01	7.92	9.46	6.68	3.79	5.24	10.97	12.79	11.88	6.78	4.59	5.69
6	239	249	15.07	15.31	15.19	5.33	4.64	4.99	10.96	7.63	9.29	6.73	4.09	5.41	11.15	12.86	12.00	6.60	4.53	5.56
6	249	254	15.06	14.95	15.01	5.34	4.99	5.17	10.67	7.56	9.11	7.02	4.16	5.59	11.17	12.59	11.88	6.58	4.80	5.69
6	254	267	15.47	15.61	15.54	4.93	4.34	4.64	10.89	7.62	9.25	6.80	4.10	5.45	10.90	12.93	11.91	6.85	4.45	5.65

Table A-3., Continued.

(NO PRECIPITATION INCLUDED)

			PRESTON 101						TALMAGE 102						TALMAGE 103					
DEP (FT)	BDAY	EDAY	ENDING H2O (IN) HOLE1	2	AVE	CUMM DEPL (IN) HOLE1	2	AVE	ENDING H2O (IN) HOLE1	2	AVE	CUMM DEPL (IN) HOLE1	2	AVE	ENDING H2O (IN) HOLE1	2	AVE	CUMM DEPL (IN) HOLE1	2	AVE
7	0	127	22.68	22.28	22.48	0.00	0.00	0.00	20.93	13.08	17.00	0.00	0.00	0.00	0.00	20.75	20.75	0.00	0.00	0.00
7	127	142	22.92	22.44	22.68	-.24	-.16	-.20	19.64	13.08	19.64	1.28	0.00	.64	0.00	19.81	19.81	0.00	.94	.47
7	142	149	21.88	21.81	21.84	.80	.47	.64	18.19	13.08	18.19	2.74	0.00	1.37	0.00	19.38	19.38	0.00	1.37	.68
7	149	156	20.78	21.16	20.97	1.90	1.12	1.51	18.15	11.72	14.93	2.78	1.37	2.07	0.00	18.20	18.20	0.00	2.54	1.27
7	156	163	20.80	21.27	21.03	1.89	1.01	1.45	18.94	12.28	15.61	1.98	.80	1.39	0.00	17.88	17.88	0.00	2.86	1.43
7	163	170	19.80	19.11	19.45	2.88	3.17	3.03	18.50	11.28	14.89	2.42	1.80	2.11	0.00	17.28	17.28	0.00	3.47	1.73
7	170	177	19.30	19.04	19.17	3.39	3.24	3.31	17.02	10.32	13.67	3.91	2.76	3.34	0.00	16.74	16.74	0.00	4.00	2.00
7	177	184	18.69	18.55	18.62	4.00	3.73	3.86	15.73	10.35	13.04	5.20	2.73	3.96	0.00	15.63	15.63	0.00	5.12	2.56
7	184	191	18.75	18.97	18.86	3.93	3.31	3.62	14.73	10.01	12.37	6.20	3.07	4.64	0.00	15.05	15.05	0.00	5.70	2.85
7	191	198	18.41	18.39	18.40	4.28	3.89	4.08	13.57	8.87	11.22	7.35	4.22	5.78	0.00	15.18	15.18	0.00	5.57	2.78
7	198	205	18.17	18.41	18.29	4.52	3.87	4.19	13.24	8.55	10.89	7.69	4.53	6.11	0.00	14.70	14.70	0.00	6.05	3.02
7	205	212	17.90	18.88	18.39	4.79	3.40	4.09	13.49	9.62	11.56	7.43	3.46	5.45	0.00	15.11	15.11	0.00	5.64	2.82
7	212	219	17.84	17.22	17.53	4.84	5.06	4.95	13.12	8.89	11.01	7.80	4.19	6.00	0.00	15.24	15.24	0.00	5.51	2.75
7	219	226	18.32	18.46	18.39	4.37	3.81	4.09	12.02	8.47	10.25	8.90	4.61	6.76	0.00	15.13	15.13	0.00	5.62	2.81
7	226	232	17.93	18.31	18.12	4.76	3.97	4.36	13.98	10.26	12.12	6.95	2.83	4.89	0.00	15.33	15.33	0.00	5.42	2.71
7	232	239	17.32	18.06	17.69	5.36	4.22	4.79	12.64	9.09	10.86	8.29	3.99	6.14	0.00	15.70	15.70	0.00	5.05	2.52
7	239	249	17.22	17.68	17.45	5.46	4.59	5.03	12.54	8.76	10.65	8.39	4.32	6.35	0.00	15.69	15.69	0.00	5.06	2.53
7	249	254	17.23	17.34	17.29	5.45	4.94	5.19	12.29	8.74	10.52	8.64	4.34	6.49	0.00	15.33	15.33	0.00	5.42	2.71
7	254	267	17.60	17.89	17.75	5.08	4.39	4.74	12.45	8.78	10.61	8.48	4.30	6.39	0.00	15.62	15.62	0.00	5.12	2.56
8	0	127	25.24	24.31	24.77	0.00	0.00	0.00	23.43	0.00	23.43	0.00	0.00	0.00	0.00	24.56	24.56	0.00	0.00	0.00
8	127	142	25.60	24.48	25.04	-.36	-.17	-.27	22.07	0.00	22.07	1.36	0.00	.68	0.00	24.56	0.00	0.00	0.00	0.00
8	142	149	24.56	23.89	24.23	.67	.42	.55	20.48	0.00	20.48	2.95	0.00	1.47	0.00	24.56	0.00	0.00	0.00	0.00
8	149	156	22.84	23.24	23.04	2.40	1.07	1.73	20.65	0.00	20.65	2.78	0.00	1.39	0.00	21.58	21.58	0.00	2.98	1.49
8	156	163	23.18	23.22	23.20	2.06	1.09	1.58	21.35	0.00	21.35	2.08	0.00	1.04	0.00	21.23	21.23	0.00	3.33	1.67
8	163	170	22.08	20.99	21.54	3.16	3.32	3.24	20.93	0.00	20.93	2.50	0.00	1.25	0.00	20.80	20.80	0.00	3.76	1.88
8	170	177	21.69	20.98	21.33	3.55	3.33	3.44	19.56	0.00	19.56	3.87	0.00	1.93	0.00	20.16	20.16	0.00	4.40	2.20
8	177	184	21.01	20.46	20.73	4.23	3.85	4.04	18.04	0.00	18.04	5.39	0.00	2.69	0.00	18.99	18.99	0.00	5.57	2.78
8	184	191	21.19	20.92	21.05	4.05	3.39	3.72	16.85	0.00	16.85	6.58	0.00	3.29	0.00	18.28	18.28	0.00	6.28	3.14
8	191	198	20.85	20.30	20.57	4.39	4.01	4.20	15.55	0.00	15.55	7.88	0.00	3.94	0.00	18.33	18.33	0.00	6.23	3.12
8	198	205	20.58	20.39	20.48	4.66	3.92	4.29	15.17	9.56	12.37	8.26	-9.56	-.65	0.00	17.76	17.76	0.00	6.80	3.40
8	205	212	20.13	20.88	20.50	5.11	3.43	4.27	15.45	9.56	15.45	7.98	-9.56	-.79	0.00	18.15	18.15	0.00	6.41	3.21
8	212	219	20.21	19.25	19.73	5.02	5.06	5.04	15.01	9.56	15.01	8.42	-9.56	-.57	0.00	18.43	18.43	0.00	6.13	3.06
8	219	226	20.71	20.39	20.55	4.53	3.92	4.22	13.77	9.56	13.77	9.66	-9.56	.05	0.00	18.35	18.35	0.00	6.21	3.10
8	226	232	20.32	20.32	20.32	4.91	3.99	4.45	15.66	9.56	15.66	7.77	-9.56	-.89	0.00	18.42	18.42	0.00	6.14	3.07
8	232	239	19.62	19.88	19.75	5.62	4.43	5.02	14.16	9.56	14.16	9.27	-9.56	-.15	0.00	18.90	18.90	0.00	5.66	2.83
8	239	249	19.52	19.59	19.56	5.72	4.72	5.22	14.12	9.56	14.12	9.31	-9.56	-.13	0.00	18.87	18.87	0.00	5.68	2.84
8	249	254	19.50	19.20	19.35	5.74	5.10	5.42	13.80	9.56	13.80	9.63	-9.56	.03	0.00	18.34	18.34	0.00	6.21	3.11
8	254	267	19.93	19.84	19.88	5.31	4.47	4.89	13.97	9.56	13.97	9.46	-9.56	-.05	0.00	18.64	18.64	0.00	5.92	2.96

Table A-3., Continued.

(NO PRECIPITATION INCLUDED)

			PRESTON 101						TALMAGE 102						TALMAGE 103					
			ENDING H20 (IN)			CUMM DEPL (IN)			ENDING H20 (IN)			CUMM DEPL (IN)			ENDING H20 (IN)			CUMM DEPL (IN)		
DEP (FT)	BDAY	EDAY	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE	HOLE1	2	AVE
9	0	127	0.00	25.24	25.24	0.00	0.00	0.00	0.00	25.18	25.24	0.00	0.00	0.00	0.00	17.75	25.24	0.00	0.00	0.00
9	127	142	0.00	25.60	25.60	0.00	-.36	-.18	0.00	23.90	25.60	0.00	1.28	.64	0.00	16.94	25.60	0.00	.82	.41
9	142	149	0.00	24.56	24.56	0.00	.67	.34	0.00	22.14	24.56	0.00	3.05	1.52	0.00	15.78	24.56	0.00	1.98	.99
9	149	156	0.00	24.56	0.00	0.00	.67	.34	22.36	22.14	22.36	-22.4	3.05	-9.66	0.00	15.78	0.00	0.00	1.98	.99
9	156	163	0.00	24.56	0.00	0.00	.67	.34	22.36	22.14	0.00	-22.4	3.05	-9.66	0.00	15.78	0.00	0.00	1.98	.99
9	163	170	0.00	24.56	0.00	0.00	.67	.34	22.36	22.14	0.00	-22.4	3.05	-9.66	0.00	15.78	0.00	0.00	1.98	.99
9	170	177	0.00	24.56	0.00	0.00	.67	.34	21.26	22.14	21.26	-21.3	3.05	-9.11	0.00	15.78	0.00	0.00	1.98	.99
9	177	184	0.00	24.56	0.00	0.00	.67	.34	21.26	22.14	0.00	-21.3	3.05	-9.11	0.00	15.78	0.00	0.00	1.98	.99
9	184	191	24.22	23.06	23.64	-24.2	2.18	-11.0	21.26	22.14	0.00	-21.3	3.05	-9.11	0.00	15.78	0.00	0.00	1.98	.99
9	191	198	23.81	22.35	23.08	-23.8	2.88	-10.5	17.02	22.14	17.02	-17.0	3.05	-6.99	0.00	15.78	0.00	0.00	1.98	.99
9	198	205	23.70	22.39	23.05	-23.7	2.84	-10.4	16.61	22.14	16.61	-16.6	3.05	-6.78	0.00	15.78	0.00	0.00	1.98	.99
9	205	212	23.11	22.97	23.04	-23.1	2.27	-10.4	16.94	22.14	16.94	-16.9	3.05	-6.95	0.00	15.78	0.00	0.00	1.98	.99
9	212	219	23.20	22.97	23.20	-23.2	2.27	-10.5	16.56	22.14	16.56	-16.6	3.05	-6.76	0.00	15.78	0.00	0.00	1.98	.99
9	219	226	23.73	22.51	23.12	-23.7	2.73	-10.5	15.23	22.14	15.23	-15.2	3.05	-6.09	0.00	15.78	0.00	0.00	1.98	.99
9	226	232	23.24	22.42	22.83	-23.2	2.81	-10.2	17.00	22.14	17.00	-17.0	3.05	-6.98	0.00	15.78	0.00	0.00	1.98	.99
9	232	239	22.59	21.93	22.26	-22.6	3.31	-9.64	15.52	22.14	15.52	-15.5	3.05	-6.24	0.00	15.78	0.00	0.00	1.98	.99
9	239	249	22.49	21.63	22.06	-22.5	3.61	-9.44	15.49	22.14	15.49	-15.5	3.05	-6.22	0.00	15.78	0.00	0.00	1.98	.99
9	249	254	22.38	21.16	21.77	-22.4	4.08	-9.15	15.22	22.14	15.22	-15.2	3.05	-6.09	0.00	15.78	0.00	0.00	1.98	.99
9	254	267	22.84	21.88	22.36	-22.8	3.35	-9.74	15.31	22.14	15.31	-15.3	3.05	-6.13	0.00	15.78	0.00	0.00	1.98	.99
To	0	127	25.24	24.31	24.77	0.00	0.00	0.00	25.18	13.56	19.37	0.00	0.00	0.00	17.75	25.23	21.49	0.00	0.00	0.00
To	127	142	25.60	24.48	25.04	-.36	-.17	-.27	23.90	13.35	18.63	1.28	.20	.74	16.94	23.99	20.46	.82	1.24	1.03
To	142	149	24.56	23.89	24.23	.67	.42	.55	22.14	12.00	17.07	3.05	1.56	2.30	15.78	23.57	19.67	1.98	1.66	1.82
To	149	156	22.84	23.24	23.04	2.40	1.07	1.73	22.36	12.14	17.25	2.83	1.42	2.12	14.94	22.14	18.54	2.81	3.09	2.95
To	156	163	23.18	23.22	23.20	2.06	1.09	1.58	23.75	12.72	18.24	1.43	.83	1.13	14.59	21.78	18.19	3.16	3.45	3.30
To	163	170	22.08	20.99	21.54	3.16	3.32	3.24	23.35	11.71	17.53	1.83	1.85	1.84	13.69	21.38	17.54	4.06	3.85	3.95
To	170	177	21.69	20.98	21.33	3.55	3.33	3.44	21.26	10.74	16.00	3.93	2.82	3.37	12.91	20.73	16.82	4.84	4.50	4.67
To	177	184	21.01	20.46	20.73	4.23	3.85	4.04	20.35	10.77	15.56	4.83	2.79	3.81	11.77	19.55	15.66	5.99	5.68	5.83
To	184	191	24.22	23.06	23.64	1.02	1.25	1.13	18.98	10.45	14.72	6.20	3.10	4.65	11.59	18.82	15.21	6.16	6.41	6.29
To	191	198	23.81	22.35	23.08	1.43	1.95	1.69	17.02	9.26	13.14	8.17	4.30	6.23	11.35	18.85	15.10	6.40	6.38	6.39
To	198	205	23.70	22.39	23.05	1.54	1.91	1.73	16.61	9.56	13.08	8.58	3.99	6.29	10.68	18.27	14.48	7.07	6.96	7.01
To	205	212	23.11	22.97	23.04	2.13	1.34	1.73	16.94	10.04	13.49	8.24	3.51	5.88	10.67	18.65	14.66	7.08	6.58	6.83
To	212	219	23.20	19.25	21.23	2.03	5.06	3.55	16.56	9.29	12.93	8.62	4.26	6.44	10.76	18.96	14.86	6.99	6.27	6.63
To	219	226	23.73	22.51	23.12	1.51	1.80	1.65	15.23	8.82	12.03	9.95	4.73	7.34	10.93	18.89	14.91	6.82	6.34	6.58
To	226	232	23.24	22.42	22.83	2.00	1.88	1.94	17.00	10.65	13.83	8.19	2.90	5.55	10.92	18.94	14.93	6.83	6.29	6.56
To	232	239	22.59	21.93	22.26	2.65	2.38	2.52	15.52	9.48	12.50	9.67	4.08	6.87	10.97	19.43	15.20	6.78	5.80	6.29
To	239	249	22.49	21.63	22.06	2.75	2.68	2.71	15.49	9.14	12.31	9.70	4.42	7.06	11.15	19.40	15.28	6.60	5.83	6.21
To	249	254	22.38	21.16	21.77	2.86	3.15	3.00	15.22	9.14	12.18	9.97	4.42	7.19	11.17	18.85	15.01	6.58	6.38	6.48
To	254	267	22.84	21.88	22.36	2.40	2.42	2.41	15.31	9.17	12.24	9.88	4.39	7.13	10.90	19.15	15.02	6.85	6.08	6.47

LIST OF FIGURES IN APPENDIX A

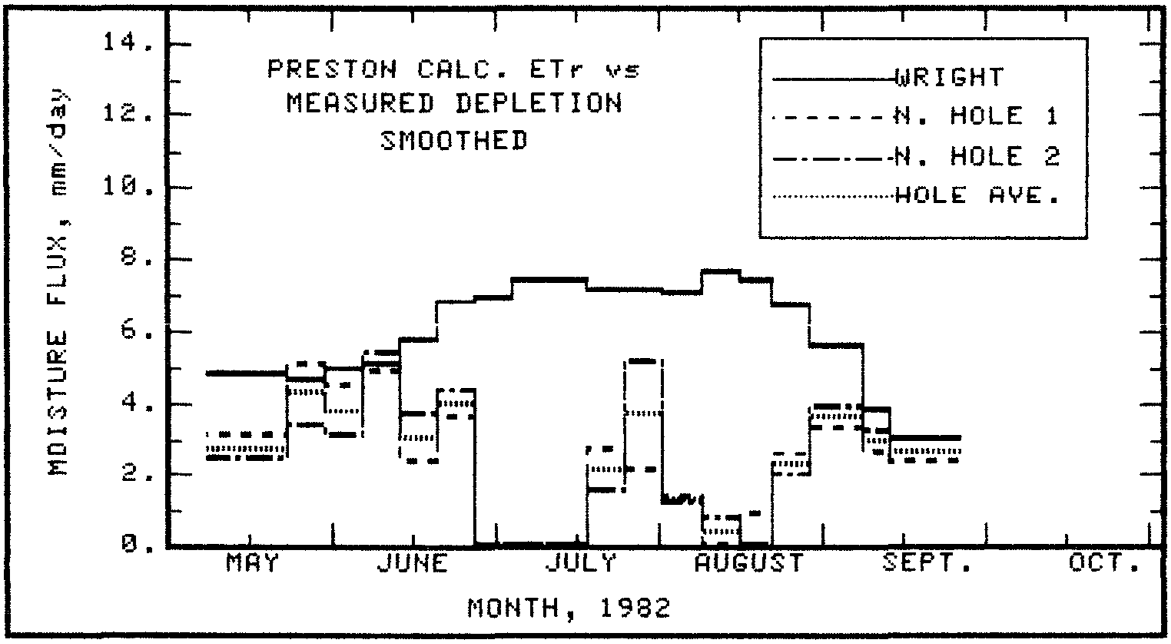

Figure A-1. Smoothed rates of measured soil moisture depletion and reference evapotranspiration rates estimated using Wright-1982 at the Preston dryland alfalfa site (1) during 1982.

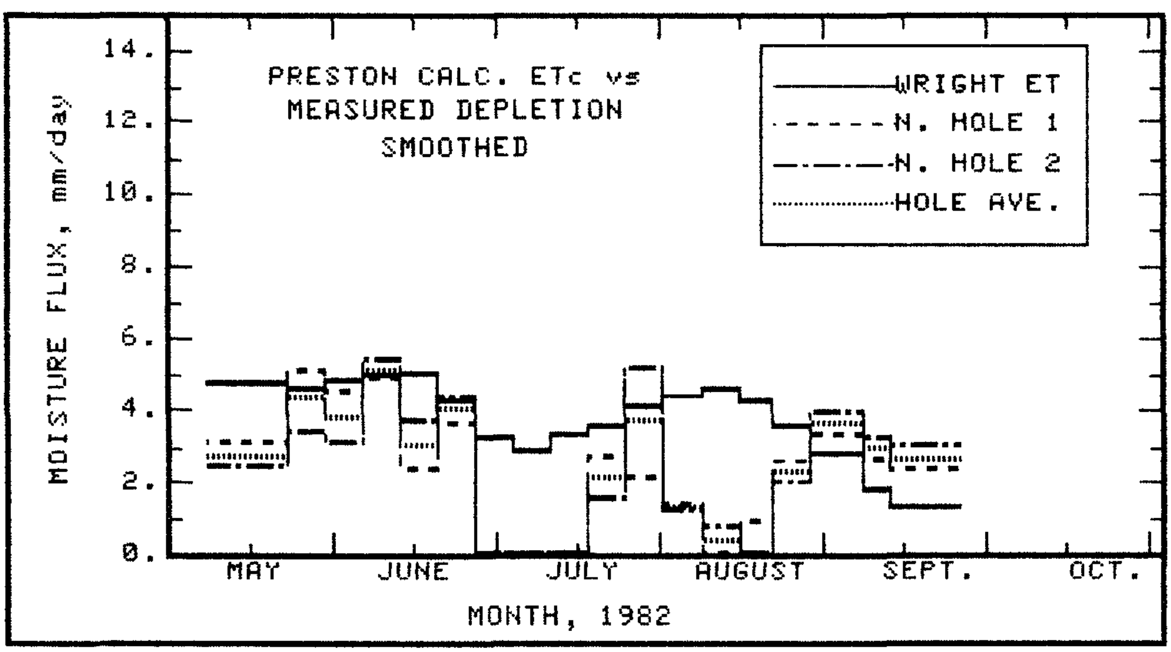

Figure A-2. Smoothed rates of measured soil moisture depletion and estimated depletion rates using Wright-1982 and mean hay coefficients at the Preston dryland alfalfa site (1) during 1982.

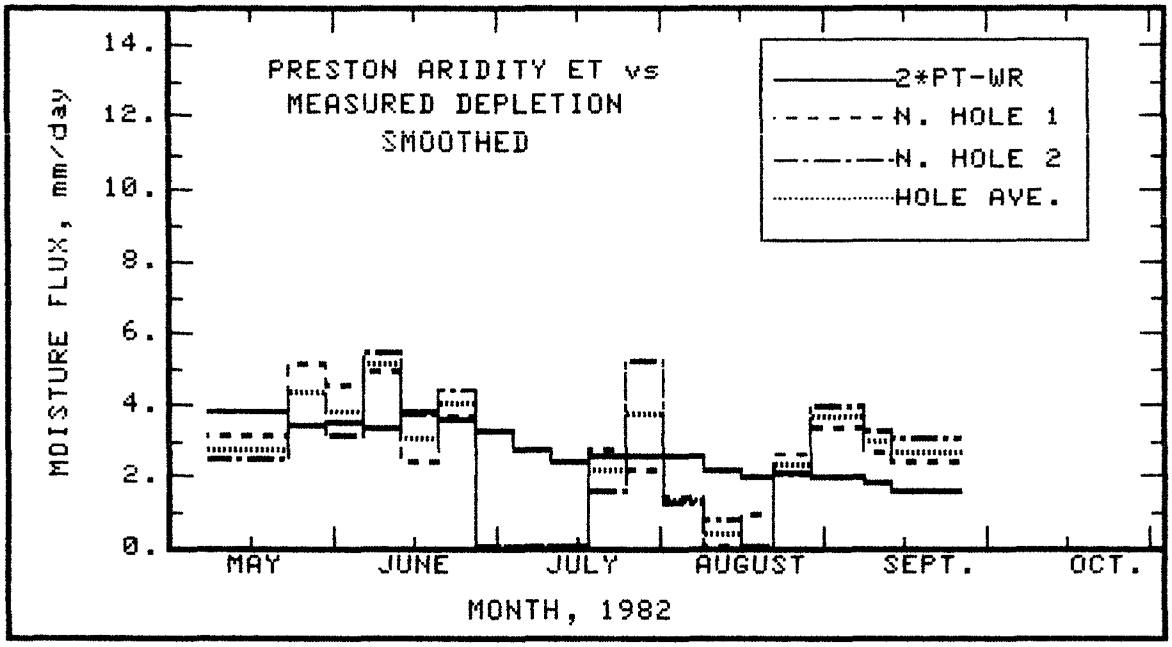

Figure A-3. Smoothed rates of measured soil moisture depletion and estimated depletion rates using an aridity ET concept at the Preston dryland alfalfa site (1) during 1982.

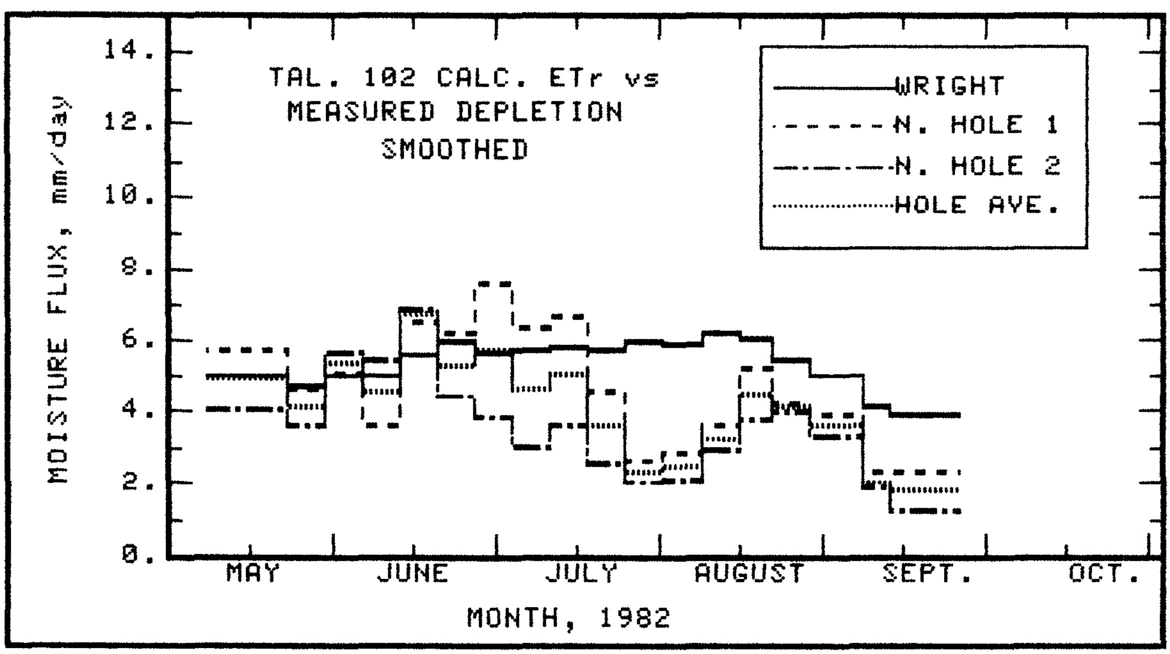

Figure A-4. Smoothed rates of measured soil moisture depletion and alfalfa reference evapotranspiration estimated using Wright-1982 at the Talmage irrigated alfalfa site (2) during 1982.

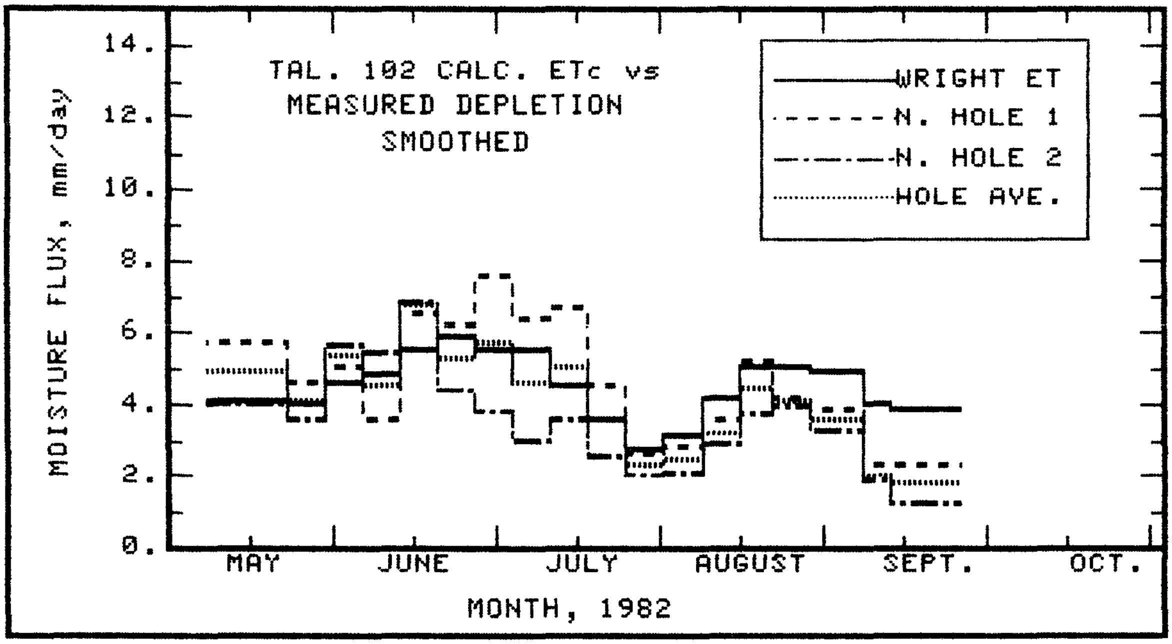

Figure A-5. Smoothed rates of measured soil moisture depletion and estimated depletion rates using Wright-1982 and mean hay coefficients at the Talmage irrigated alfalfa site (2) during 1982.

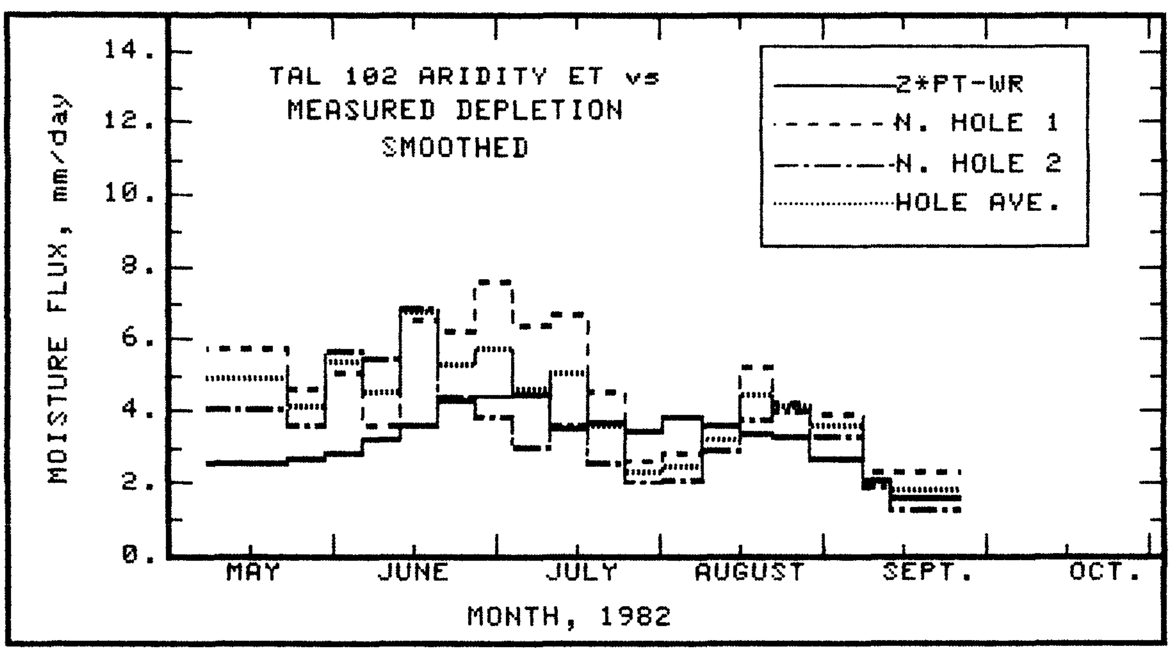

Figure A-6. Smoothed rates of measured soil moisture depletion and estimated depletion rates using an aridity ET concept at the Talmage irrigated alfalfa site (2) during 1982.

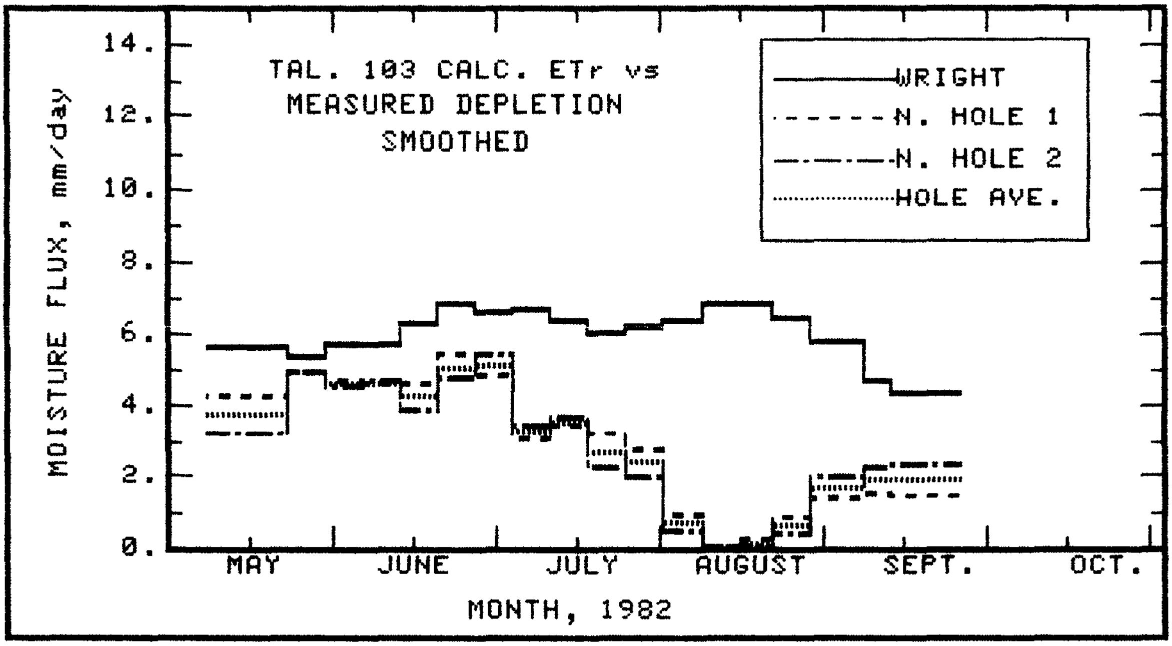

Figure A-7. Smoothed rates of measured soil moisture depletion and alfalfa reference evapotranspiration estimated using Wright-1982 at the Talmage dryland winter wheat site (3) during 1982.

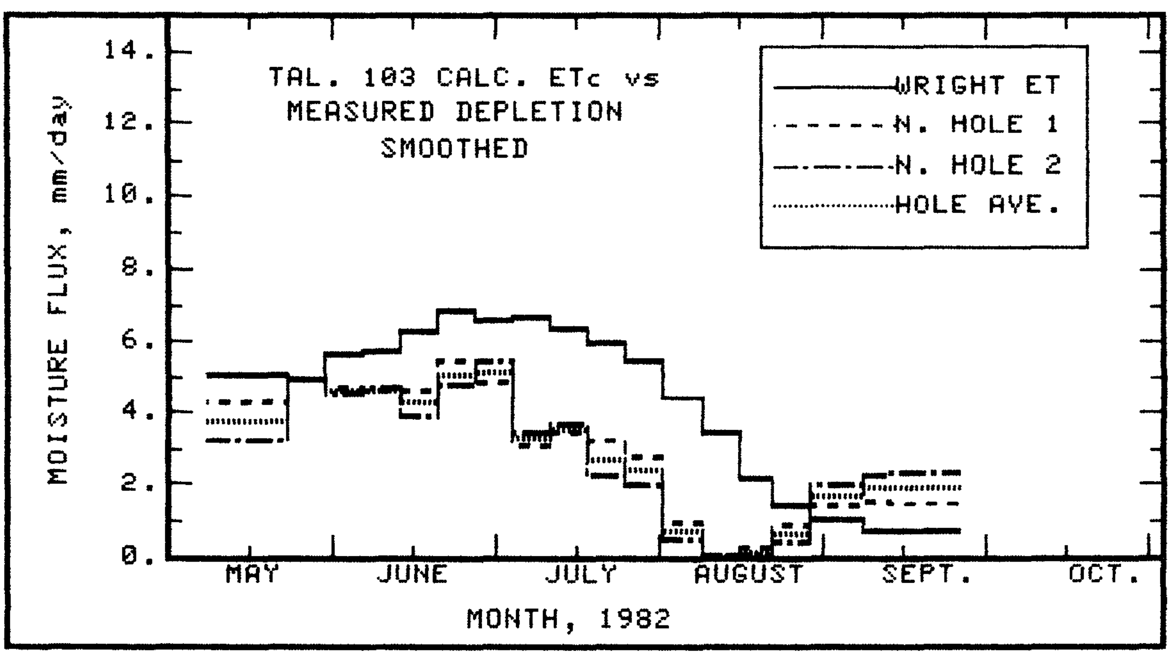

Figure A-8. Smoothed rates of measured soil moisture depletion and estimated depletion rates using Wright-1982 and mean winter wheat coefficients at the Talmage dryland winter wheat site (3) during 1982.

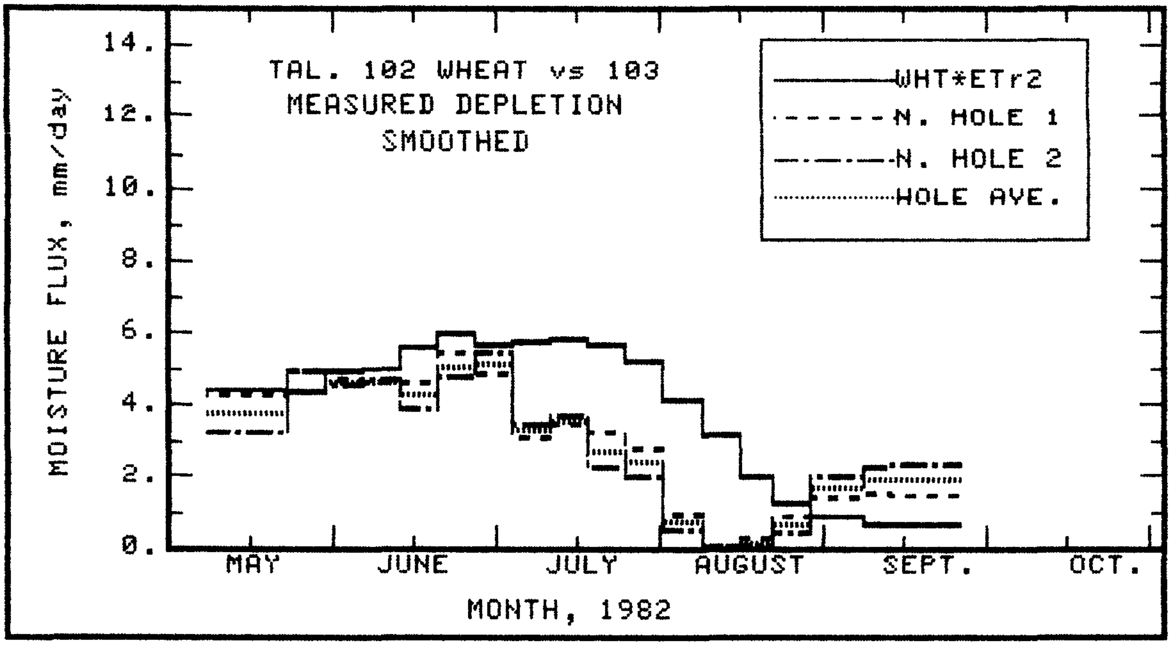

Figure A-9. Smoothed rates of measured soil moisture depletion and at the Talmage dryland winter wheat site (3) and estimated depletion rates using Wright-1982 calculated at site 2 and mean winter wheat coefficients at the Talmage dryland winter wheat site (3) during 1982.

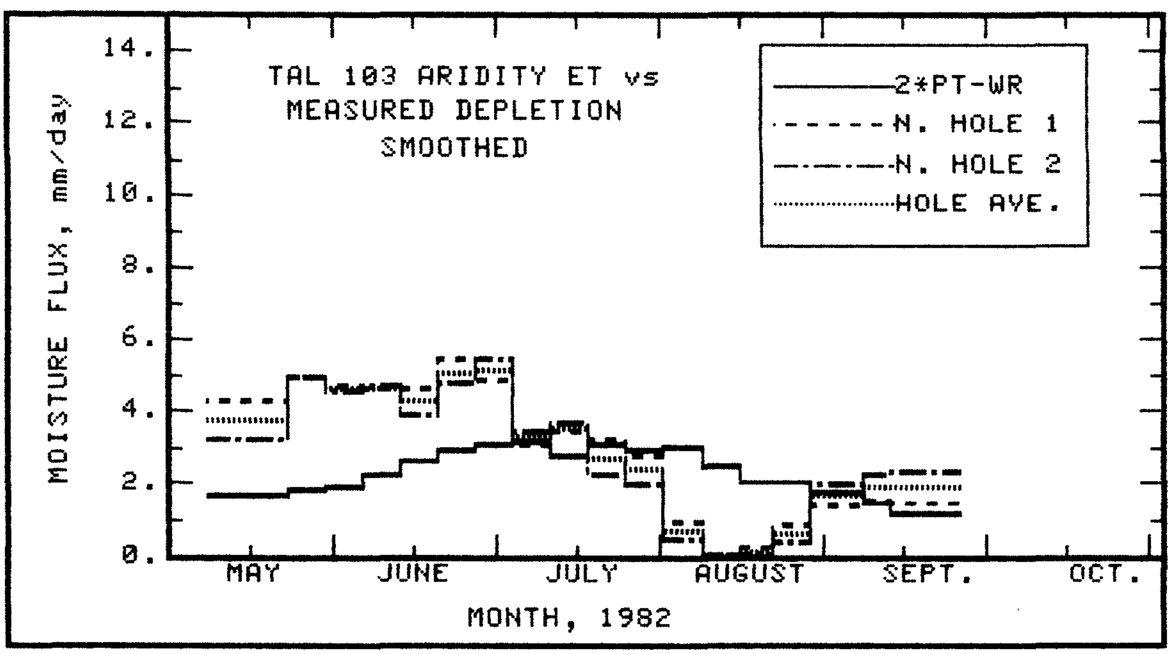

Figure A-10. Smoothed rates of measured soil moisture depletion and estimated depletion rates using an aridity ET concept at the Talmage dryland winter wheat site (3) during 1982.

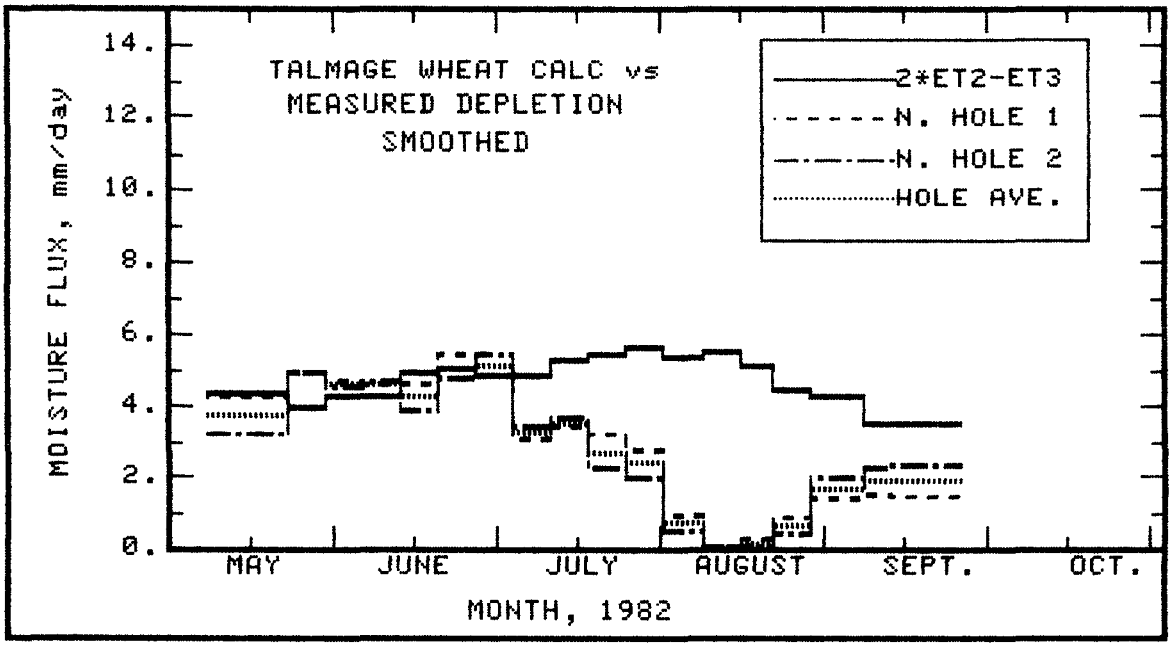

Figure A-11. Smoothed rates of measured soil moisture depletion and estimated depletion rates using an aridity ET concept with Wright-1982, only, at the Talmage dryland winter wheat site (3) during 1982.

Selected Water Resources Abstracts

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16. Abstract

Temporary weather stations located in the western portion of the Bear River Basin in southeastern Idaho were monitored during the 1982 growing season. Hourly measurements of solar radiation, wind travel, air temperature and dewpoint temperature were recorded. Solar radiation in the area was similar to measurements at Logan, Utah and Kimberly, Idaho during the same period. Measured wind travel and air temperatures in the Bear River Basin varied with site location.

Consumptive use estimated for crops around each of three weather sites was compared to soil moisture depletion measured with a neutron probe. Consumptive use methods evaluated included the Wright-1982, FAO-Blaney-Criddle, Jensen-Haise, SCS-Blaney-Criddle and a regional aridity approach to estimating consumptive use reported by Morton (1976) and Brutsaert and Stricker (1979). Performance of consumptive use methods depended on whether crops were irrigated or dryland crops.

17a. Descriptors

*Idaho, *Consumptive Use, Weather, Evapotranspiration, *Irrigation, *Dryland, Soil Moisture, Neutron Probe, FAO-Blaney-Criddle, Penman, SCS-Blaney-Criddle, Jensen-Haise, Aridity, Soil Radiation, Wind, Temperature, Vapor Pressure, Alfalfa, Winter Wheat.

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